TRI-PARTY AGREEMENT

Change Notice Number TPA-CN- 0887	TPA CHANGE NOTICE FORM	Date: August 31, 2020
Document Number, Title, and Revision: **DOE/RL-2001-27**, Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit, **Rev 2**, **Appendix A**, Sampling and Analysis Plan for the 100-NR-2 Groundwater Operable Unit, **Insert A2**, Saturated Aquifer and Vadose Zone Jet Injection Projects, **Insert A3**, Sampling Interval Information for Wells and Aquifer Tubes within the 100-NR-2 Groundwater Operable Unit.		Date Document Last Issued: July 2016
Approved Change Notices Against this Document:TPA-CN-0747, TPA-CN-0751, TPA-CN-0791		
Originator Art Lee		Phone: (509) 372-1763

Description of Change:
Removed references to RCRA monitoring from DOE/RL-2001-27, Rev. 2 and updated wells, aquifer tubes, and sampling frequencies in Appendix A. Changes were also made to remove oxidation-reduction potential field measurements, update constituent analytical methods, PQLs, and action levels in Appendix A.

M.W. Cline (**DOE**) and K. Welsch / C. Cameron (**Lead Regulatory Agency**) agree that the proposed change modifies an approved work plan/document and will be processed in accordance with the Tri-Party Agreement Action Plan, Section 9.0, *Documentation and Records,* and not Chapter 12.0, *Changes to the Agreement*.

Changes to DOE/RL-2001-27, Rev. 2:
1. Deleted or modified text with reference to RCRA sites.
2. Added "(ERA)" to define acronym.
3. Deleted reference PNNL-13914.

Changes to DOE/RL-2001-27, Rev 2, Appendix A:
1. Table of Contents: Deleted references to Figures A-20, A-21, and A-22. Renumbered Figure A-23 to A-20. Deleted Table A-18, Renumbered Tables A-19 and A-20. Renumbered pages.
2. Terms: deleted "RCRA"
3. Deleted text with references to RCRA sites in multiple locations within document text.
4. Deleted reference "OSWER 9283.1-46, which relates to RCRA Facilities.
5. Removed oxidation-reduction potential field measurements from Tables A-3, A-10, A-11, and A-12
6. Table A-3. Deleted asterisk from table and footnote "a. Constituents all apply to CERCLA unless noted otherwise. Constituents monitored for RCRA are those identified with an asterisk (*)."

Additions are shown using double underline. Deletions are shown using ~~strikeout~~.

Note: Include affected page number(s): DOE/RL-2001-27, Rev. 2: pages 1-2, 1-4, 1-5, 1-9, 1-12, 2-3, 8-9

DOE/RL-2001-27, Rev. 2, Appendix A: Affected pages are A-v through A-viii, A-x, A-3, A-7, A-29 through A-33, A-44 through A-55, A-62, A-63, A-65 through A-74, A-76 through A-94, A-96, A-97, A-106 through A-110, A-114, A-115, A-122 through A-125

DOE/RL-2001-27, Rev 2, Appendix A, Insert A1: pages 40, 44, 49, 54, 57, 63, 65, and 103

DOE/RL-2001-27, Rev 2, Appendix A, Insert A2: pages 8, 9, 11 through 18, and 39

DOE/RL-2001-27, Rev 2, Appendix A, Insert A3: pages 4, 5, and 6

Continued on Page 2

Approvals:

Signature	Date	Decision	
Michael W. Cline — Digitally signed by Michael W. Cline Date: 2020.09.03 06:17:01 -07'00' DOE Project Manager	Date	[X] Approved [ ] Disapproved	Page 1 of 3
CRAIG CAMERON — Digitally signed by CRAIG CAMERON Date: 2020.09.03 16:13:33 -07'00' EPA Project Manager	Date	[X] Approved [ ] Disapproved	
Digitally signed by Welsch, Kim (ECY) Date: 2020.09.03 14:19:51 -07'00' Ecology Project Manager	Date	[X] Approved [ ] Disapproved	

Changes to DOE/RL-2001-27, Rev 2, Appendix A (continued):

7. Table A-3. Deleted footnotes which were applicable to RCRA monitoring.
8. Table A-3. Deleted rows for Total Organic Carbon and Total Organic Halides.
9. Table A-6. Insert EPA Method 1664 in place of EPA Method 9070.
10. Table A-6. Updated PQL values to Revision 2 of ECF-HANFORD-18-0058.
11. Table A-6. Updated action level values with values from DOE/RL-2012-15, Draft B.
12. Table A-6. Deleted rows for Contamination Indicator Parameters – total organic carbon and total organic halides.
13. Tables A-7 and A-8. Update tables with Quality Control Requirements and Acceptance Criteria from current revision (revision 16) of CHPRC-00189, *Environmental Quality Assurance Program Plan*.
14. Table A-8. Insert Acceptance Criteria for EPA Method 1664 Oil and Grease
15. Table A-8. Delete Acceptance Criteria for Total Organic Halogen and Total Organic Carbon.
16. Table A-8. Add comment: "o = result may be biased: associated laboratory control sample result was outside the acceptance limits – laboratory applied"
17. Table A-10, Replaced table field header from "TPH Oil and Grease" to "Oil and Grease."
18. Table A-10. Changed monitoring of RCRA wells to monitoring for strontium-90, nitrate, and/or metals.
19. Table A-10. Added monitoring of well 199-N-104A for strontium-90 and nitrate monitoring.
20. Updated aquifer tube names to include replacements installed in November 2015 to replaced failed aquifer tubes:
    a. N116mArray-8.5A C9590
    b. N116mArray-12A C9589
    c. N116mArray-13A C9587
    d. N116mArray-14A C9588
    e. C6136 C9586
21. Remove requirements for TPH sampling for wells and aquifer tubes outside of TPH plume area:
    f. 199-N-122, 199-N-123, 199-N-146, 199-N-147, 199-N-201, 199-N-210, 199-N-211, 199 N 229, 199-N-230, 199 N 247, 199-N-248, 199 N 350, 199-N-351, 199 N 352, 199 N 353,
    g. C6324, C7881, N116mArray-2A, N116mArray-3A. N116mArray-4A, N116mArray-6A, N116mArray-8A, N116mArray-9A, NVP2-116.0
22. Added sampling of treated PRB injection wells every 5 years with deeper screened wells sampled during low river and shallow screened wells sampled during high river periods.
23. Reduced sample frequency of PRB monitoring wells of untreated PRB segments to biennially.
24. Reduced sample frequency of the 6 RD/RAWP installed wells from quarterly to:
    a. semi-annually for 199-N-374
    b. annually during low river for wells 199-N-371 and 199-N-372.
    c. semi-annually for wells 199-N-373 and 199-N-377 (observing for river stage fluctuation for Cr(VI) and TPH).
    d. annually for nitrate analysis for the 6 wells
    e. remove tritium analysis for wells 199-N-373, 199-N-376, and 199-N-377.
25. Table A-10. Revised footnotes.
    h. renumbered footnotes based on changes to sample frequencies
    i. identify shallow and deep screened PRB injection wells
    j. added footnote to provide sampling options for broken aquifer tubes.
26. Tables A-11 through Table A-17 updated to reflect changes made in Table A-10.
27. Table A-18 deleted.
28. Table A-20 updated to reflect current and proposed automated water level network wells.
29. Table A-19 and A-20 renumbered to A-18 and A-19. Corrected call outs for tables.
30. Figures A-20, A-21, and A-22 deleted. Corrected call outs and renumbered Figure A-23 to A-20.

Changes to DOE/RL-2001-27, Rev 2, Appendix A, Insert A1:

1. Table A1-7. Remove oxidation-reduction potential from field methods in table footnote
2. Table A1-8. Remove oxidation-reduction potential from field methods in table footnote
3. Table A1-9. Remove oxidation-reduction potential from field methods in table footnote
4. Table A1-10. Remove oxidation-reduction potential from field methods in table footnote
5. Table A1-11. Remove oxidation-reduction potential from field methods in table footnote
6. Table A1-13. Remove oxidation-reduction potential from field methods in table footnote
7. Section A1.8.3.6. Remove oxidation-reduction potential from listed field parameters
8. Table A1-16. Remove oxidation-reduction potential from field methods in table footnote

Changes to DOE/RL-2001-27, Rev 2, Appendix A, Insert A2:

1. Table A2-2. Within the table insert C9590 in place of N116mArray-8.5A;
2. Table A2-2. Within the table insert C9589 in place of N116mArray-12A.
3. Table A2-2. Insert C9587 in place of N116mArray-13A.
4. Table A2-2. Deleted footnote "b"
5. Table A2-2. Insert aquifer tubes C6135, C9586 and C9588.
6. Table A2-4. Insert C9586 in place of C6136.
7. Table A2-4. Insert C6135, C9587, C9588, C9589 and C9590. Sampling requirement for C6135 are the same as C6132. Sampling requirements for other are like N116mArray-9A. Changed sampling schedule for existing wells.
8. Table A2-6. Insert C9586 in place of C6136.

Changes to DOE/RL-2001-27, Rev 2, Appendix A, Insert A3:

1. Table A3-1. Add aquifer tube and well construction data for 199-N-371, 199-N-372, 199-N-373, 199-N-374, 199-N-376, 199-N-377, C9586, C9587, C9588, C9589 and C9590. The installations monitor the top of the unconfined aquifer.
2. Table A3-1. Deleted footnote "NA = not available (planned well or aquifer tube)"

Justification and Impacts of Change:

The proposed changes are to better align the sample frequencies to the monitoring needs for the 100-NR-2 groundwater OU and updates laboratory quality control requirements and acceptance criteria. The change provides for continued monitoring of wells that were used for monitoring RCRA sites that have recently been removed from the Hanford Permit. Continued monitoring of these wells will support ongoing CERCLA activities. The change provides for expanded monitoring of 100-N shoreline by including monitoring at PRB injection wells with sampling frequency adjusted to suit the contaminants of interest. Several damaged aquifer tubes have been replaced and SAP changes are made to identify the new aquifer tube names along with updates for the aquifer tube/well construction information.

Review of quarterly sample data and trends for the 6 wells installed around the reactor facility in 2016 indicate that the sampling frequency can be reduced as identified in the SAP. This changes also reduces unnecessary analysis of TPH at wells and aquifer tubes located away from the TPH plume and TPH results have been below detection.

Oxidation-reduction potential is removed from the list of sampling field measurements. Oxidation-reduction measurements are performed in the field because the oxidation-reduction potential will change in transit to the laboratory. Oxidation-reduction measurements taken over the years have been highly variable because of sensitivity to off-gas, or entraining gas from the atmosphere resulting in uncertainty in measurements. The bulk aquifer is oxic, so field dissolved oxygen measurements are more reliable for providing meaningful data for indicator of water chemistry.

Changes to the 100-K pump-and-treat configuration have converted several 100-K wells identified for 100-N water level monitoring to extraction or injection wells. This change updates the water level monitoring network and proposed wells to include in the automated water level network.

The 100-N Area is divided into two operable units (OUs), identified as 100-NR-1 and 100-NR-2 (Figure 1-2). The 100-NR-1 OU consists of the 100-N source waste sites and includes four former treatment, storage, and disposal (TSD) units (Figure 1-3): 116-N-1 (1301-N Liquid Waste Disposal Facility [LWDF]), 116-N-3 (1325-N LWDF), 120-N-1 (1324-NA Percolation Pond), and 120-N-2 (1324-N surface impoundment). The four TSD units were removed from the Hanford Site RCRA permit in the year 2018~~These four TSD units are regulated under the *Resource Conservation and Recovery Act of 1976* (RCRA)~~. Interim remedial actions for the 100-NR-1 OU waste sites (Figure 1-3) are addressed in DOE/RL-2005-93, *Remedial Design Report/Remedial Action Work Plan for the 100-N Area*.

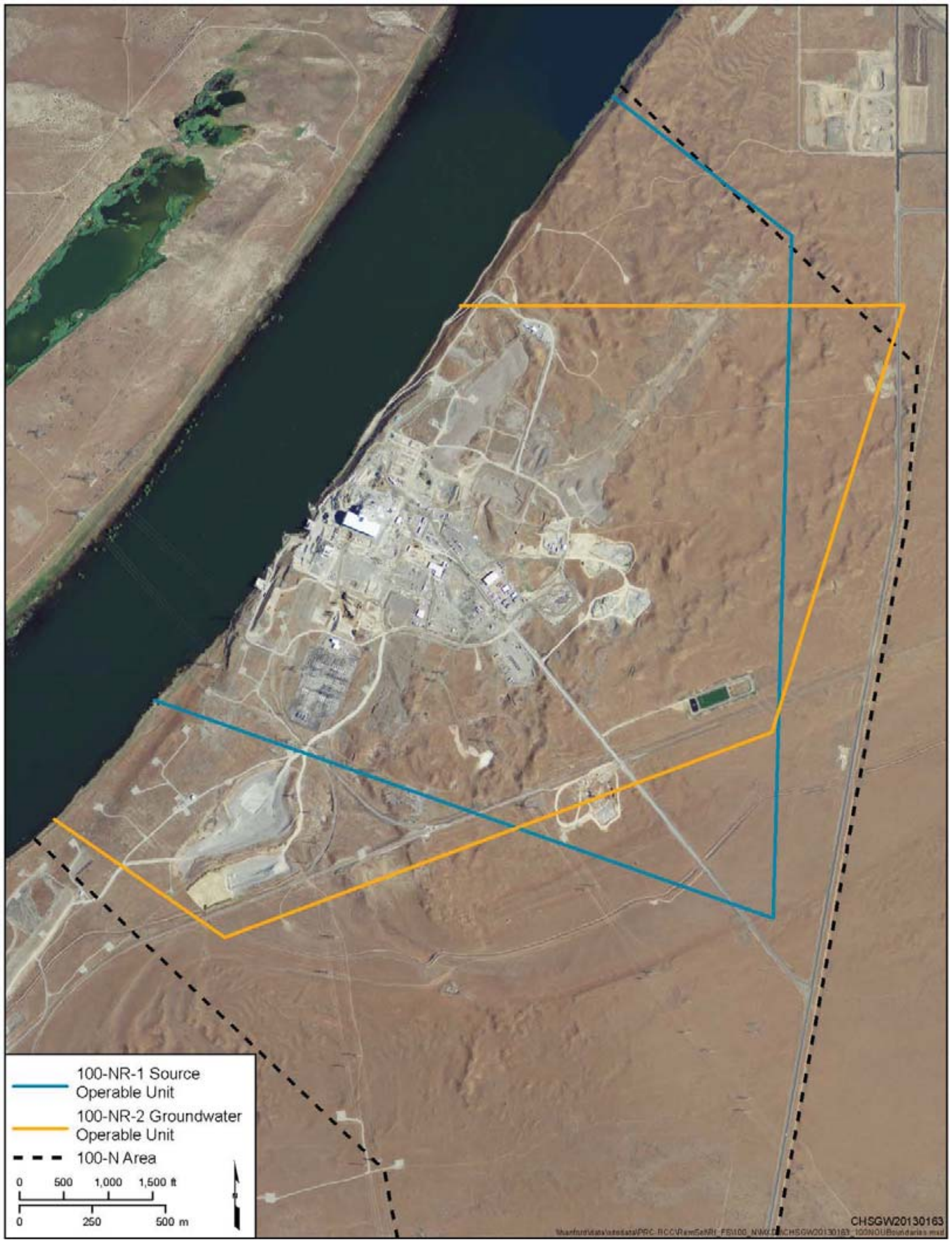

Figure 1-2. 100-N Area OU Boundary Map

The contaminated groundwater beneath the 100-N Area constitutes the 100-NR-2 OU. Groundwater contaminants of concern (COCs) include nitrate, sulfate, total petroleum hydrocarbon (TPH), hexavalent chromium (Cr(VI)), manganese, tritium, and strontium-90. Of primary concern in the 100-NR-2 OU is the presence of strontium-90 at concentrations above the drinking water standard (DWS) that enters the nearby Columbia River via natural groundwater upwelling through the river bottom. Historically, groundwater also entered the river through riverbank seeps identified as N-Springs. The site-related riverbank seeps, resulting from historical groundwater elevation mounding beneath the 100-N Area, are no longer present.

On September 30, 1999, EPA/ROD/R10-99/112, *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington* (hereafter referred to as the Interim Action Record of Decision [ROD]) was signed by the U.S. Department of Energy (DOE), Richland Operations Office (RL); the Washington State Department of Ecology (Ecology); and the U.S. Environmental Protection Agency (EPA). The 1999 Interim Action ROD addressed the source waste sites, the shoreline site, the petroleum hydrocarbon site, and groundwater. The RCRA TSD waste sites ~~are~~ were addressed in a separate ROD (EPA/ROD/R10-00/120, *Interim Remedial Action Record of Decision for the 100-NR-1 Operable Unit, Hanford Site, Benton County, Washington*). The 1999 Interim Action ROD required pump and treat (P&T) for strontium-90, institutional controls (ICs), and further technology evaluation for strontium-90 removal from groundwater. The original remedial design/remedial action work plan (RD/RAWP) for the 100-NR-2 OU (DOE/RL-2001-27, Rev. 0) provided the details necessary for implementing the interim remedy.

Based on the results of the strontium-90 technology evaluations and subsequent field evaluations, the 1999 Interim Action ROD was amended on September 30, 2010 (EPA, 2010, *U.S. Department of Energy, 100-NR-1 and NR-2 Operable Units Hanford Site – 100 Area Benton Country, Washington Amended Record of Decision, Decision Summary and Responsiveness Summary*, hereafter referred to as the Interim Action ROD, as amended). The Interim Action ROD, as amended, replaced the strontium-90 groundwater P&T system with a subsurface apatite permeable reactive barrier (PRB). The rationale for amending the 1999 Interim Action ROD is described in DOE/RL-2009-54, *Proposed Plan for Amendment of 100-NR-1/NR-2 Interim Action Record of Decision*. This RD/RAWP provides information associated with the development of a remedial design and remedial action implementation strategy for the remedy selected in the Interim Action ROD, as amended, for the 100-NR-2 OU.

The remedial design establishes the general size, scope, and character of the project and identifies the technical requirements of the remedial action. The RD/RAWP presents the design basis and the remedial design, and it describes the remedial action work elements, including construction methods, construction management and oversight, estimated construction schedules and cost, operations and maintenance (O&M), and remedy performance metrics. Implementation of the remedy selected in the Interim Action ROD, as amended (EPA, 2010), in conjunction with remedial actions to be identified in a final ROD, will contribute to progress in meeting the remedial action objectives (RAOs).

1.1 Purpose

In accordance with the TPA (Ecology et al., 1989a), a remedial design report (RDR) and an RAWP are required to describe how the selected remedy and related activities specified in the Interim Action ROD, as amended, will be implemented. The purpose of this RD/RAWP is to describe the design and implementation of the interim remedial action pertaining to the 100-NR-2 OU, as described in the Interim Action ROD, as amended (EPA, 2010). A sampling and analysis plan (SAP) is also required for selected remedies. Sampling and analysis to support saturated and vadose zone apatite injection activities, and the requirements for performance monitoring of the PRB for the 100-NR-2 OU are included in the SAP (provided as Appendix A).

This document is a companion document to the 100-N Area RDR/RAWP (DOE/RL-2005-93, Rev. 1), which describes interim actions under way to address vadose zone soil contamination.

1.2 Scope

This RD/RAWP includes the remedial actions that will be implemented to meet the requirements of the Interim Action ROD, as amended (EPA, 2010). The amended interim action remedy for the 100-NR-2 OU is a combination of in situ groundwater treatment using an apatite PRB, monitored natural attenuation (MNA), petroleum hydrocarbon recovery, and ICs. A majority of the interim remedial actions described in this RD/RAWP are specific to strontium-90 and emplacement of sufficient apatite mass to provide for a 300-year design life.

The TPA (Ecology et al., 1989a) specifically lists the remedial design and the RAWP as two separate documents. The remedial design and remedial action activities for the 100-NR-1 OU are presented in the 100-N Area RDR/RAWP (DOE/RL-2005-93). The remedial design and remedial action activities associated with the RCRA TSD units are presented in DOE/RL-2000-16, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-1 Treatment, Storage, and Disposal Units*. Because of the potential for impact to the groundwater from the source and TSD waste sites, all interim remedial actions and final remedial actions in the 100-N Area will require a coordinated effort, as described in the Interim Action ROD, as amended (EPA, 2010). This document streamlines this requirement by combining the remedial design and RAWP into a single submittal. This document addresses the following:

- Installation of the apatite PRB in the saturated zone and vadose zone
- Decommissioning of the existing treatment components for the 100-NR-2 OU P&T system installed in 1994 under an ERA
- Petroleum hydrocarbon recovery
- ICs for the 100-N Area
- Groundwater monitoring and reporting to assess effectiveness of the apatite PRB in reducing strontium-90 flux to the Columbia River
- Other O&M activities necessary to maintain the integrity of all interim remedial actions, including the apatite PRB, until a final remedy is selected and implemented

~~The remedial design and remedial action activities for the 100-NR-1 OU are presented in the 100-N Area RDR/RAWP (DOE/RL-2005-93). The remedial design and remedial action activities associated with the RCRA TSD units are presented in DOE/RL-2000-16, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-1 Treatment, Storage, and Disposal Units*. However, because of the RCRA Permit requirements (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*) and the potential for impact to the groundwater from the source and TSD waste sites, all interim remedial actions and final remedial actions in the 100-N Area will require a coordinated effort, as described in the Interim Action ROD, as amended (EPA, 2010).~~

A remedial ~~action~~investigation/feasibility study (RI/FS) work plan for the entire 100 Area was prepared in 2008 and was approved in 2010 (DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*). This document outlined the overall process for developing

1986 to 1991. Discharges to the 1301-N and 1325-N LWDFs[1] ceased in 1985 and 1991, respectively (DOE/RL-95-110).

An inventory of the strontium-90 discharged to the LWDFs (Figure 1-4) shows its fate and distribution within the 100-NR-1 and 100-NR-2 OUs based on 1995 values presented in DOE/RL-2008-46-ADD5. The following assumes a strontium-90 half-life of 29.1 years, 755 Ci remain in the vadose zone soil, and 58 Ci in the unconfined aquifer as of January 2013 (DOE/RL-2012-15, Draft A, *Remedial Investigation/ Feasibility Study for 100-NR-1 and 100-NR-2 Operable Units*).

- An estimated 2,998 Ci of strontium-90 were contained in the liquid effluent discharged to the LWDFs during N Reactor operation.
- 46 Ci of strontium-90 were estimated to have entered the Columbia River through the LWDF and groundwater flow pathway.
- Approximately 1,126 Ci of strontium-90 decayed through 1995.
- An estimated 572 Ci of strontium-90 were contained in the soil removed from the 116-N-1 and 116-N-3 LWDFs.
- An estimated 1,254 Ci (decayed to 1995 levels) remained in the subsurface, with 1,165 Ci present in the vadose zone soil beneath the LWDFs and 89 Ci in the underlying unconfined aquifer.

A conceptual model for strontium-90 release from the LWDFs (Figure 1-5) illustrates how strontium-90 discharged to the LWDFs was carried vertically downward through the soil column by infiltrating water and, under the influence of an elevated hydraulic gradient, was transported toward the river. Strontium-90 adsorbed to aquifer solids in the periodically rewetted zone (PRZ) (or zone of water table fluctuation) is subject to remobilization during river-stage fluctuations.

Other nonradiological contaminants were also discharged to the LWDFs. The following contaminants were identified as groundwater COCs for the 100-NR-2 OU in the Interim Action ROD (EPA/ROD/R10-99/112): manganese, Cr(VI), nitrate, sulfate, strontium-90, tritium, total petroleum hydrocarbon-diesel (TPH-D), and TPH-gasoline (TPH-G).

1.3.2 Response Action Status — Interim Action Record of Decision

Because of concern regarding the release of strontium-90 to the Columbia River, Ecology and EPA issued Ecology and EPA, 1994, “Action Memorandum: N Springs Expedited Response Action (ERA) Cleanup Plan, U.S. Department of Energy Hanford Site, Richland, WA,” to RL on September 23, 1994. The ERA required RL to take immediate action, which consisted of installing and operating a groundwater P&T system and a sheet-pile barrier wall at N-Springs.

In a letter dated March 23, 1995 (Stanley and Sherwood, 1995, “Re: USDOE Request to Change N Springs Action Memorandum”), Ecology and EPA agreed that a sheet-pile construction test in December 1994 showed that the installation of the jointed hinge, sheet-pile wall could not be achieved in the manner specified. Ecology and EPA directed RL to proceed with installation of the P&T system. Additionally, RL was directed to continue accurately assessing the flux of strontium-90 to the river, further characterize geologic and hydrologic conditions, and assess design and installation alternatives related to modified barriers and expected performance.

[1] The 1301-N and 1325-N LWDFs (active site designation) are also referred to in this document by their respective 116-N-1 and 116-N-3 TSD post-remediation designations.

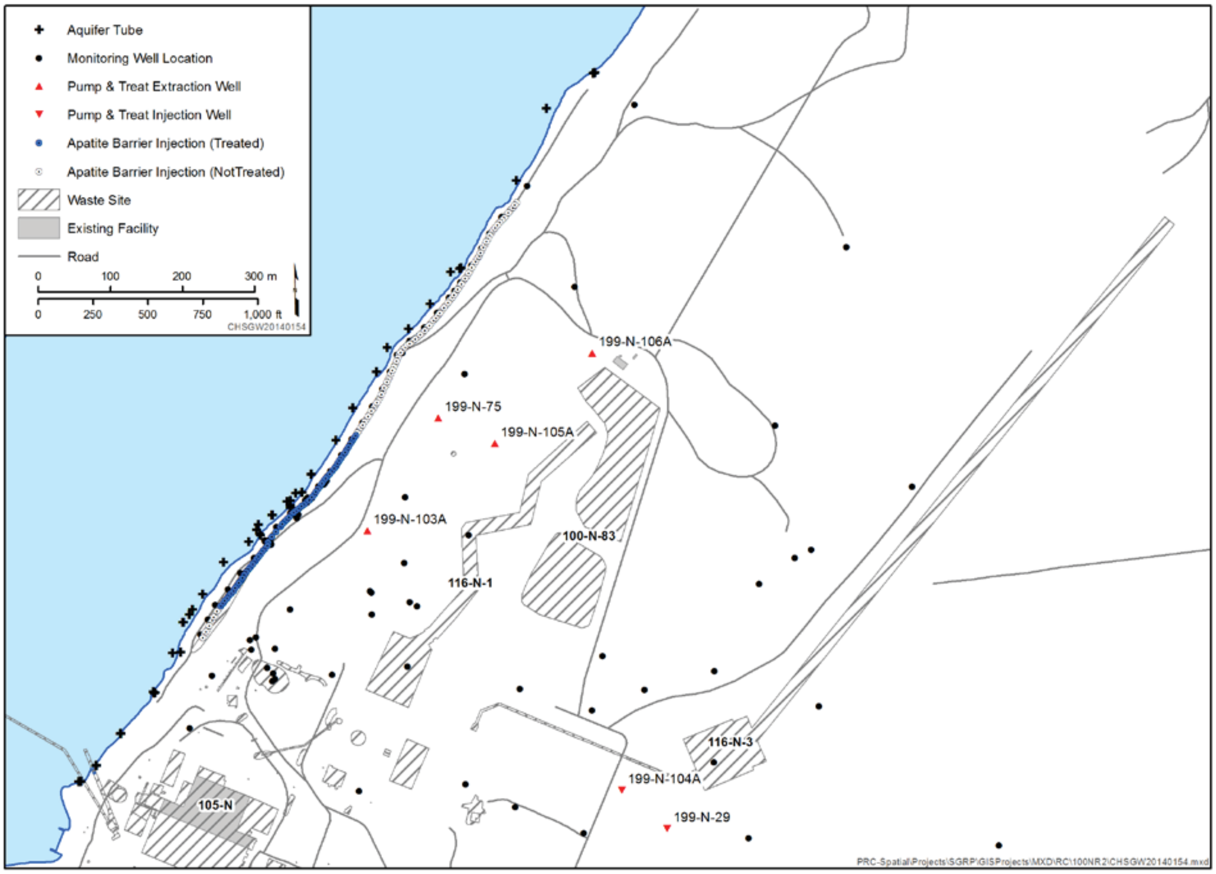

Figure 1-6. Location of 100-NR-2 OU P&T System Wells

The original ERA performance monitoring requirements were modified twice using TPA change control procedures; the first modification occurred under TPA Change Control Form M-16-96-04, which was approved on August 2, 1996 (Ecology et al., 1989a). This agreement was superseded by 100 National Priorities List (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List") Agreement/Change Control Form, Control No. 113, which was approved on March 25, 1997. It required monitoring of strontium-90 concentrations in the P&T system influent and effluent. Collecting water quality data from wells or similar monitoring sites to monitor the performance of the P&T system was not required under this agreement.

Additional groundwater monitoring that is not related to the performance of the ERA P&T system includes obtaining data to support remediation decisions under CERCLA, ~~TSD facility requirements under RCRA,~~ the Interim Action ROD (EPA/RPD/R10-99/112) requirement for petroleum hydrocarbon monitoring, and Sitewide surveillance under the *Atomic Energy Act of 1954*. A consolidated program to meet these requirements has been developed, and an agreement is documented in TPA (Ecology et al., 1989a) Change Control Form M-15-96-08, dated October 1996.

The ERA performance monitoring program and the consolidated groundwater monitoring program are described in BHI-00164, *N-Springs Expedited Response Action Performance Monitoring Plan*. Following shutdown of the ERA P&T system in 2006, performance monitoring of the system was discontinued.

- **Slow substitution into the apatite structure:** Initially, the precipitate formed is amorphous apatite; however, over time it transforms into a more stable apatite crystal, permanently sequestering the metals (months to years timescale).

Stable strontium and other competing cations in groundwater, especially the divalent transition metals (e.g., cadmium, zinc, iron, lead, and manganese), can also be incorporated in the apatite structure. The average concentrations of stable strontium and competing cations present in groundwater will dictate the mass of apatite needed for long-term sequestration. The effect of competing cation concentrations is to reduce the in situ apatite longevity for a given mass loading. To achieve a desired longevity (e.g., a 300-year period during which most of the strontium-90 will have decayed), the loading rate has been increased to account for the competing cation effect.

To date, apatite has been used to install a 274 m (900 ft) PRB in the saturated zone. Information and experience gained from this work have been used to optimize the injection design for the full-scale buildout of the apatite PRB to its final 760 m (2,500 ft) length (see Section 3.1.1). To complete the selected remedy, a 305 m (1,000 ft) long PRB will be installed to target the vadose zone and PRZ that provides a continuing source of strontium-90 contamination to groundwater (see Section 3.1.2).

2.1.2 Decommissioning of the Pump and Treat System

Concurrent or following extension of the apatite PRB, DOE will decommission the treatment components of the existing 100-NR-2 OU groundwater P&T system. The decommissioning work will include removing any residual IX media and disposing this material at the ERDF, dismantling all noncontact treatment system hardware and salvaging reusable components, and cutting the high-density polyethylene conveyance piping into short lengths for transportation and disposal at ERDF. Wells will remain in place and will be reconfigured for monitoring purposes. The status of the decommissioning work will be provided at unit managers' meetings, and a summary of the decommissioning work will be provided in a future Hanford Site groundwater monitoring and performance report or an interim action status report.

2.1.3 Groundwater Monitoring Program

The sampling requirements and groundwater monitoring wells and aquifer tubes comprising the 100-NR-2 OU network are listed in the 100-NR-2 Data Quality Objectives Summary Report (Appendix A, Insert A1). Long-term and routine monitoring for the 100-NR-2 OU under CERCLA are defined in Table A-10 in the SAP (Appendix A), and lists the specific constituents to be analyzed and the sampling frequency for those wells that have been selected for monitoring.

~~The 116-N-1 Facility is included in the Hanford Facility RCRA Permit (WA7890008967), which states that RCRA monitoring during closure activities will follow the requirements of BHI-00725, *100-N Pilot Project Proposed Consolidated Groundwater Monitoring Program*. The plan and a subsequent supplemental plan (PNNL-13914, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*) were used to define sampling that was performed to satisfy RCRA requirements. These same plans were also used for the three remaining TSD units in the 100-N Area (116-N-3, 120-N-1, and 120-N-2).~~

2.1.4 Monitored Natural Attenuation

MNA is another important component of the selected remedy for strontium-90. MNA is the reliance on natural processes, within the context of a carefully controlled and monitored cleanup, to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in affected media. MNA will play an important role in upland groundwater remediation of strontium-90 (radioactive decay and sorption to aquifer materials). Because strontium-90 is strongly retarded and has a relatively short half-life, the majority of the strontium-90 present in the aquifer and associated sediments upgradient of the apatite

Migratory Bird Treaty Act of 1918, 16 USC 703-712, Ch. 128, July 13, 1918, 40 Stat. 755, as amended. Available at: http://www.animallaw.info/statutes/stusmba.htm.

National Environmental Policy Act of 1969, 42 USC 4321, et seq. Available at: http://www.epw.senate.gov/nepa69.pdf.

National Historic Preservation Act of 1966, Pub. L. 89-665, as amended, 16 USC 470, et seq. Available at: http://www.achp.gov/docs/nhpa%202008-final.pdf.

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-10899, 1996, *Strontium-90 Adsorption-Desorption Properties and Sediment Characterization at the 100 N-Area*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197189372.

PNNL-13127, 2000, *Strontium-90 at the Hanford Site and its Ecological Implications*, Pacific Northwest National Laboratory, Richland, Washington, May. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13127.pdf.

~~PNNL-13914, 2002, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*, Pacific Northwest National Laboratory, Richland, Washington, May. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D2756558.~~

PNNL-16891, 2007, *Hanford 100-N Area Apatite Emplacement: Laboratory Results of Ca-Citrate-PO_4 Solution Injection and Sr-90 Immobilization in 100-N Sediments*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16891.pdf.

PNNL-16894, 2007, *Investigation of the Strontium-90 Contaminant Plume along the Shoreline of the Columbia River at the 100-N Area of the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16894.pdf.

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Contents

Figures

Tables

Inserts

IATA	International Air Transport Association
IC	ion chromatography
ICP	inductively coupled plasma
ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICP/MS	inductively coupled plasma/mass spectrometry
LCS	laboratory control sample
LRA	lead regulatory agency
MB	method blank
MDA	minimum detectable activity
MDL	method detection limit
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
MTCA	"Model Toxics Control Act—Cleanup" (WAC 173-340)
N/A	not applicable
NAPL	nonaqueous-phase liquid
NCO	nuclear chemical operator
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PNNL	Pacific Northwest National Laboratory
PPE	personal protective equipment
PRB	permeable reactive barrier
PSQ	principal study question
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RAO	remedial action objective
~~RCRA~~	~~*Resource Conservation and Recovery Act of 1976*~~
RCT	radiological control technician
RD/RAWP	remedial design/remedial action work plan

Atomic Energy Act of 1954 (AEA) ~~and *Resource Conservation and Recovery Act of 1976* (RCRA)~~ groundwater monitoring ~~are~~ is also conducted within the 100-NR-2 Groundwater OU in accordance with DOE/RL-2015-56, *Hanford Atomic Energy Act Sitewide Groundwater Monitoring Plan*. ~~Groundwater monitoring is performed at four RCRA (i.e., WAC 173-303, "Dangerous Waste Regulations") treatment, storage, and disposal (TSD) sites 1324-N/NA (120-N-1, 120-N-2), 1301-N (116-N-1), and 1325-N (116-N-3). RCRA monitoring is conducted according to WHC-SD-EN-AP-038, *Groundwater Monitoring Plan for 1301-N, 1324-N, 1324-NA, and 1325-N Sites*, and supplemented by PNNL-13914, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*. For information purposes, the RCRA groundwater monitoring requirements for the four RCRA sites are included with the CERCLA groundwater monitoring requirements identified in this SAP. To clarify sampling requirements applicable to the AEA, a groundwater monitoring plan is currently being developed.~~

This SAP was prepared based on the 100-NR-2 OU groundwater data quality objective (DQO) process in Insert A1 and information from the following documents/databases:

- DOE/RL-2012-15, *Remedial Investigation/Feasibility Study for the 100-NR-1 and 100-NR-2 Operable Units* (Draft A)
- DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*
- DOE/RL-2001-27, *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, Rev. 1, Appendix A, "100-NR-2 Groundwater Operable Unit Sampling and Analysis Plan for Interim Actions Associated with Saturated and Vadose Injection Projects, Long-Term/Routine Monitoring, and Barrier Performance Monitoring"
- DOE/RL-2005-93, *Remedial Design Report/Remedial Action Work Plan for the 100-N Area*, Rev. 1, Appendix H, "Phase II Testing Performance Monitoring Plan for the UPR-100-N-17 Bioremediation," October 2013
- EPA/ROD/R10-99/112, *Interim Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site Benton County, Washington*
- EPA 2010, *100-NR-1 and NR-2 Operable Units Hanford Site – 100 Area Benton Country, Washington Amended Record of Decision, Decision Summary and Responsiveness Summary*
- Hanford Environmental Information System (HEIS)

This SAP consists of five chapters with the remainder of this section addressing the project scope and objectives, background, DQOs, contaminants, and the project schedule. Chapter 2 discusses the quality assurance (QA) requirements. Chapter 3 provides the field sampling plan. Chapters 4 and 5 address waste management and health and safety requirements. Insert A1 contains the "Data Quality Objectives Summary Report for 100-NR-2 OU Groundwater Monitoring." Insert A2 provides additional information on the PRB and characterization requirements applicable to its installation and extension. Insert A3 provides information on the hydrogeologic unit monitored.

A1.1 Project Scope and Objectives

The scope of this SAP includes CERCLA 100-NR-2 OU long-term groundwater monitoring, apatite PRB performance monitoring, and groundwater monitoring associated with in situ bioremediation/bioventing performance monitoring. The objectives of this SAP are to collect the required data to:

network from the period from January 2009 through December 2014 were reviewed in the development of this SAP. The locations of monitoring wells and aquifer tubes with respect to the year 2013 plume configurations were analyzed with the objective of optimizing the current well network and sampling requirements. The analysis was directed at defining those wells and aquifer tubes needed for contaminant monitoring and determination of an appropriate sampling frequency. Throughout the remainder of this document, when discussing "wells," aquifer tubes are also included.

The monitoring networks identified in this SAP are designed to collect groundwater data sufficient to achieve project objectives defined in Section A1.1. This monitoring will be conducted until a final 100-NR-2 ROD is issued. In the interim, data collection requirements may require modification based on the data collected, operational changes in the performance monitoring networks, and refinement of contaminant distribution models. Changes to this SAP will be approved by DOE, the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (EPA).

Long-term and performance groundwater monitoring data will be reported in the annual Hanford Site groundwater report. The data gathered under this plan help satisfy the requirements of CERCLA (40 CFR 300.430(b), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy"). Table A-2 identifies the existing documents that have sampling requirements associated with the 100-NR-2 OU and identifies which existing document is completely or partially superseded by this SAP.

CERCLA groundwater monitoring requirements in the 100-NR-2 OU are addressed by this new plan. ~~Programmatic requirements for RCRA groundwater monitoring associated with the 1301-N Radioactive Liquid Waste Disposal Trench, 1324-N Surface Impoundment/1324-NA Percolation Pond, and 1325-N Liquid Effluent Disposal Facility are found in a separate plan. A groundwater monitoring plan is currently being developed to clarify sampling requirements applicable to the AEA.~~ The data collected for ~~RCRA and~~ AEA groundwater monitoring are considered as supplementary groundwater quality information to the CERCLA OU process.

DOE/RL-2012-59, *Surveillance Groundwater Monitoring on the Hanford Site*, issued in October 2013, includes monitoring specifications of the upper basalt confined aquifer and the Ringold confined aquifer. Groundwater within the upper basalt confined aquifer is monitored because it is a potential pathway for contaminants to move offsite. The confined to semi-confined aquifer within the Ringold Unit A is present beneath most of the Hanford Site. Confined aquifer sampling will continue according to DOE/RL-2012-59 and is not within the scope of this SAP.

Hexavalent chromium is present in the groundwater in the 100-NR-2 OU above the ambient water quality criteria of 10 µg/L. The source of the contamination is attributed to the adjacent, upgradient 100-K Area and 100-N Area reactor operations. Because there are two source areas, responsibility for the monitoring of hexavalent chromium is shared by the 100-KR-4 and 100-NR-2 Groundwater OU projects. Hexavalent chromium within the 100-NR-2 OU boundary that is considered to have a source in the adjacent 100-K Area is addressed in the 100-KR-4 OU SAP. Hexavalent chromium within the 100-NR-2 OU boundary that is considered to have a 100-N Area source is addressed within this SAP.

Groundwater monitoring wells on the Hanford Site provide essential access to the subsurface for environmental data collection. When the effective life of a well is reached, wells should be decommissioned and replaced, if applicable. Decommissioning is commonly required when wells are improperly constructed, improperly abandoned, unprotected, and neglected. These conditions may create preferential pathways to the aquifer and vadose zone and cause mixing of aquifers and compromise the collection of representative environmental data.

The key assumptions of the plan are as follows:

1. The monitoring plan developed through this DQO will address CERCLA groundwater monitoring requirements.
2. Some of the existing 100-N groundwater monitoring wells may not be sufficient in their construction and/or locations to support the various monitoring needs identified in the project objectives.
3. Given the overlapping nature of several of the groundwater plumes, some monitoring wells may serve multiple needs. The wells used historically for monitoring the various 100-N groundwater plumes and general groundwater quality are listed in Table 6-20 of the RI/FS for the 100-NR-1 and 100-NR-2 OUs (DOE/RL-2012-15, Draft A) and are included in the DQO.
4. Hexavalent and total chromium are present in 100-NR-2 OU groundwater, and total chromium is identified as a COPC. Their presence is primarily due to groundwater contamination from the 100-KR-4 OU. Therefore, minimal groundwater monitoring and plume tracking is proposed.
5. New wells will be needed to supplement or replace existing monitoring wells. New wells will be constructed according to WAC 173-160. Monitoring well locations, construction, sampling frequency, and target analytes for groundwater monitoring will require approval from the U.S. Department of Energy, Richland Operations Office (DOE-RL), Ecology, and EPA (all SAP signatories).
6. A process will be considered for "triggers" to monitoring modifications (e.g., add/subtract wells and/or analytes; increase/decrease sampling frequencies). Consider OSWER 9355.0-129, *Guidance for Evaluating Completion of Groundwater Restoration Remedial Action*; OSWER 9283.1-44, *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*~~; OSWER 9283.1-46, *Groundwater Statistics Tool User's Guide*; and EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities; Unified Guidance*~~, as possible guidance in developing these "triggers." Monitoring requirements in this SAP may change in the future based on triggers.
7. New aquifer tubes may be needed to supplement or replace the existing aquifer tubes.
8. Vadose zone characterization is not within the scope of the 100-NR-2 OU groundwater monitoring DQO. Vadose zone sampling conducted during new well drilling activities will be documented and conducted as part of the associated drilling process.
9. Apatite barrier baseline and short-term PRB injection monitoring was fully assessed as part of the RD/RAWP SAP (Rev. 1); it will not be discussed further in the DQO summary report.
10. DOE/RL-2005-93 includes some required groundwater sampling. It was aligned with the TPH vadose remediation (i.e., bioventing) sampling and analysis but did not have a stated purpose. This DQO will address the purpose of the groundwater sampling aligned with bioventing.
11. Smart sponge requirements for weighing and reporting removal quantities of TPH light nonaqueous-phase liquids are documented in the 100-NR-2 RD/RAWP (Rev. 1). More detail about placement, removal, weighing, and reporting will be added to the SAP but not included as part of the DQO.

Table 16 in the 100-NR-2 DQO summary report (Insert A1) identifies groundwater wells, aquifer tubes, and other information applicable to the 100-NR-2 OU groundwater monitoring network. Quality requirements for the environmental data collection are addressed in Chapter A2, "Quality Assurance Project Plan." It includes planning, implementation, and assessment of sampling tasks, field measurements, and laboratory analysis.

A1.4 Groundwater Monitoring Constituents

Specific constituents for CERCLA ~~and RCRA~~ groundwater monitoring are provided in Table A-3. The CERCLA contaminants listed are those identified in the DQO summary report (Insert A1). ~~The constituents for RCRA monitoring are identified in the RCRA groundwater monitoring documents (WHC-SD-EN-AP-038 and PNNL-13914).~~

Table A-3. Analytes for 100-NR-2 OU Groundwater Monitoring[a]

Constituent	Chemical Abstract Service Number
Inorganics – Metals	
Aluminum	7429-90-5
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Cadmium	7440-43-9
Calcium	7440-70-2
Chromium	7440-47-3
Cobalt	7440-48-4
Copper	7440-50-8
Hexavalent Chromium	18540-29-9
Iron*	7439-89-6
Lead	7439-92-1
Magnesium	7439-95-4
Manganese*	7439-96-5
Molybdenum	7439-98-7
Nickel	7440-02-0
Phosphorous	7723-14-0
Potassium	7440-09-7
Sodium*	7440-23-5
Silver	7440-22-4
Selenium	7782-49-2
Strontium	7440-24-6
Vanadium	7440-62-2
Zinc	7440-66-6
Inorganics – Anions	

Table A-3. Analytes for 100-NR-2 OU Groundwater Monitoring[a]

Constituent	Chemical Abstract Service Number
Bromide	24959-67-9
Chloride*	16887-00-6
Fluoride	16984-48-8
Nitrogen in Nitrate	14797-55-8 – NO3-N
Nitrogen in Nitrite	14797-65-0A – NO2-N
Phosphorus in Phosphate	14265-44-2 – PO4-P
Sulfate*	14808-79-8
Organics	
TPH-Diesel Range	68334-30-5, TPHDIESEL
TPH-Gasoline Range	8006-61-9, TPHGASOLINE
TPH-Motor Oil	TPH/OILH
Oil and Grease	CASID30133/OIL/GREASE
~~Total Organic Carbon~~[b]	~~7440-44-0~~
~~Total Organic Halides~~[b]	~~59473-04-0~~
BTEX	
Benzene	71-43-2
Ethylbenzene	100-41-4
Toluene	108-88-3
Xylene	1330-20-7
Polycyclic Aromatic Hydrocarbons	
Acenaphthene	83-32-9
Acenaphthylene	208-96-8
Anthracene	120-12-7
Benzo(a)anthracene	56-55-3
Benzo(a)pyrene	50-32-8
Benzo(b)fluoranthene	205-99-2
Benzo(ghi)perylene	191-24-2
Benzo(k)fluoranthene	207-08-9
Chrysene	218-01-9
Dibenzo(a,h)anthracene	53-70-3
Fluoranthene	206-44-0
Fluorene	86-73-7
Indeno(1,2,3-cd)pyrene	193-39-5
Naphthalene	91-20-3
Phenanthrene	85-01-8

Table A-3. Analytes for 100-NR-2 OU Groundwater Monitoring[a]

Constituent	Chemical Abstract Service Number
Pyrene	129-00-0
Radionuclides and Indicators	
Strontium-90	10098-97-2
Tritium	10028-17-8
Gross alpha*	12587-46-1
Gross beta	12587-47-2
Field Measurements	
Alkalinity*	Not applicable
Dissolved Oxygen	Not applicable
~~Oxidation-Reduction Potential~~	~~Not applicable~~
pH*	Not applicable
Specific Conductance*	Not applicable
Temperature	Not applicable
Sheen and Odor	Not applicable
Turbidity*	Not applicable
Depth to Groundwater*	Not applicable

~~a. Constituents all apply to CERCLA unless noted otherwise. Constituents monitored for RCRA are those identified with an asterisk (*).~~

~~b. Applicable only to RCRA monitoring.~~

BTEX = benzene, ethylbenzene, toluene, and xylenes

TPH = total petroleum hydrocarbons

A1.5 Project Schedule

This SAP will direct CERCLA monitoring activities needed for the 100-NR-2 OU until an update is needed or the final ROD is issued. The yearly sampling schedule will be established by the Sample Management and Reporting (SMR) organization through processes and software applications, such as the *Sample Management Integrated Lifecycle Environment* (SMILE), which optimizes the overall number of sampling trips and limits schedule redundancy. The SMR organization tracks overlapping requirements so single sampling events can co-sample wells and optimize schedules.

A2 Quality Assurance Project Plan

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the QA elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*, and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). Sections 6.5 and 7.8 of Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*, require the QA/quality control (QC) and sampling and analysis activities to specify the QA requirements for treatment, storage, and disposal units, as well as for past-practice processes. This QAPjP also describes the applicable requirements and controls based on guidance found in Ecology Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to Hanford Site OU groundwater monitoring activities: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Validation and Usability.

A2.1 Project Management

This section addresses project goals, the management approaches planned, and planned output documentation.

A2.1.1 Project/Task Organization

The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and shipping samples to the laboratory. The contractor is also responsible for preparing and maintaining configuration control of the SAP and assisting the DOE-RL project manager in obtaining approval of the SAP and future proposed revisions. Project organization (regarding routine groundwater monitoring) is described in the following sections and illustrated in Figure A-11. Sections A2.1.1.5 through A2.1.1.14 describe contractor roles and responsibilities.

A2.1.1.1 Regulatory Lead

The lead regulatory agency (LRA) is responsible for regulatory oversight of cleanup projects and activities. The LRA has SAP approval authority for the OUs they manage. The LRA works with DOE-RL to resolve concerns over the work described in this SAP in accordance with the Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*).

A2.1.1.2 DOE-RL Project Manager

The DOE-RL Project Manager is responsible for the following:

- Monitoring the contractor's performance of activities under CERCLA, ~~RCRA, the~~ AEA, and the Tri-Party Agreement (Ecology et al., 1989a,) for the Hanford Site
- Obtaining LRA approval of the SAP
- Authorizing field sampling activities
- Approving the SAP
- Functioning as primary interface with regulators

A2.1.1.3 DOE-RL Technical Lead

The DOE-RL Technical Lead is responsible for the following:

- Providing day-to-day oversight of the contractor's work scope performance
- Working with the contractor and the regulatory agencies to identify and resolve technical issues
- Providing technical input to the DOE-RL Project Manager

A2.1.1.4 Operable Unit Project Manager

The OU Project Manager (or designee) is responsible and accountable for the following:

Table A-6. Performance Requirements for Groundwater Analysis[a]

Constituent	Chemical Abstract Services Number	Action Level[b]	Analytical Method[c]	Required Quantitation Limit
Radionuclides (pCi/L)				
Strontium-90	10098-97-2	8	Strontium-89/90-Total Rad Sr	2
Tritium	10028-17-8	20,000	Tritium liquid scintillation (mid-level)	400
Gross beta	12587-47-2	4 mrem/yr	9310_ALPHABETA_GPC	4
Gross alpha	12587-46-1	15	9310_ALPHABETA_GPC	3
Inorganics – Metals (µg/L)				
Aluminum	7429-90-5	87	ICP Metals – 6010 or 6020**	52.5 50
Antimony	7440-36-0	6	ICP Metals – 6010 or 6020 LL	5 5.25
Arsenic	7440-38-2	0.058[d]	ICP Metals – 6010 or 6020 LL	*5.25 2
Barium	7440-39-3	2,000	ICP Metals – 6010 or 6020	20 5.25
Cadmium	7440-43-9	0.225[d]	ICP Metals – 6010 or 6020	*1.05 2
Calcium	7440-70-2	No value	ICP Metals – 6010 or 6020	1,000 1,050
Chromium	7440-47-3	65	ICP Metals – 6010 or 6020	10.5
Cobalt	7440-48-4	4.8	ICP Metals – 6010 or 6020 LL	3 2.6
Copper	7440-50-8	97.8	ICP Metals – 6010 or 6020	5 8
Iron	7439-89-6	31,000[d]	ICP Metals – 6010 or 6020	50 105
Lead	7439-92-1	2.1	ICP Metals – 6010 or 6020	2.1 *15
Magnesium	7439-95-4	No value	ICP Metals – 6010 or 6020	750 1,050
Manganese	7439-96-5	50384	ICP Metals – 6010 or 6020	10.5 5

Table A-6. Performance Requirements for Groundwater Analysis[a]

Constituent	Chemical Abstract Services Number	Action Level[b]	Analytical Method[c]	Required Quantitation Limit
Molybdenum	7439-98-7	80	ICP Metals – 6010 or 6020	20 5.25
Nickel	7440-02-0	5245	ICP Metals – 6010 or 6020	40 21
Phosphorous	7723-14-0	0.32	ICP Metals – 6010 or 6020 LL	*105 4
Potassium	7440-09-7	No value	ICP Metals – 6010 or 6020	4,0005,250
Selenium	7782-49-2	50[d]	ICP Metals – 6010 or 6020	4 10.5
Silver	7440-22-4	2.46[d]	ICP Metals – 6010 or 6020 LL	2.1 2
Sodium	7440-23-5	No value	ICP Metals – 6010 or 6020	500 1,050
Strontium	7440-24-6	9,600	ICP Metals – 6010 or 6020	10.5
Vanadium	7440-62-2	80	ICP Metals – 6010 or 6020	25 52.5
Zinc	7440-66-6	91	ICP Metals – 6010 or 6020	10 21
Hexavalent chromium	18540-29-9	10	EPA 7196	5 10.5
Inorganics – Anions (µg/L)				
Bromide	24959-67-9	No value	Anions by IC – 300.0 or 9056	250 262.5
Chloride	16887-00-6	230,000	Anions by IC – 300.0 or 9056	400
Fluoride	16984-48-8	960	Anions by IC – 300.0 or 9056	500 525
Nitrogen in nitrate	14797-55-8 NO3-N	10,000	Anions by IC – 300.0 or 9056	100 525
Nitrogen in nitrite	14797-65-0A NO2-N	1,000	Anions by IC – 300.0 or 9056	100 525
Phosphorus in phosphate	14265-44-2 PO4-P	No value	Anions by IC – 300.0 or 9056	500 787.5
Sulfate	14808-79-8	250,000	Anions by IC – 300.0 or 9056	550 1,050

Table A-6. Performance Requirements for Groundwater Analysis[a]

Constituent	Chemical Abstract Services Number	Action Level[b]	Analytical Method[c]	Required Quantitation Limit
Total Petroleum Hydrocarbons (µg/L)				
TPH-Gasoline range	8006-61-9, TPHGASOLINE	10800	WTPH-G	500
TPH-Diesel range	68334-30-5, TPHDIESEL	500	WTPH-D	500
TPH-Motor oil	TPH/OILH	No value500	WTPH-D	500
Oil and grease	CASID30133	No value500	EPA Method 9070 1664	*5,000 5,250
Volatile Organic Analysis (µg/L)				
Benzene	71-43-2	0.8	EPA Method 8260	*1 5
Ethylbenzene	100-41-2	4	EPA Method 8260	4
Toluene	108-88-3	640	EPA Method 8260	5
Xylenes (total)	1330-20-7	1,600	EPA Method 8260	10
Polynuclear Aromatic Hydrocarbons (µg/L)				
Acenaphthene	83-32-9	480	EPA Method 8270 or 8270 SIM	10
Acenaphthylene	208-96-8	No value	EPA Method 8270 or 8270 SIM	10
Anthracene	120-12-7	2,400	EPA Method 8270 or 8270 SIM	10
Benzo(a)anthracene	56-55-3	0.8812	EPA Method 8270 or 8270 SIM LL-PAH	0.3 *0.3
Benzo(a)pyrene	50-32-8	0.08812	EPA Method 8270 or 8270 SIM LL-PAH	*0.16 0.5
Benzo(b) fluoranthene	205-99-2	0.8812	EPA Method 8270 or 8270 SIM LL-PAH	0.5 *0.5

Table A-6. Performance Requirements for Groundwater Analysis[a]

Constituent	Chemical Abstract Services Number	Action Level[b]	Analytical Method[c]	Required Quantitation Limit
Benzo(k) fluoranthene	207-08-9	0.88~~12~~	EPA Method ~~8270 or~~ 8270 SIM~~ LL-PAH~~	0.5 ~~*0.5~~
Benzo(g,h,i) perylene	191-24-2	No value	EPA Method ~~8270 or~~ 8270 SIM	1 ~~5.5~~
Chrysene	218-01-9	1.2	EPA Method ~~8270 or~~ 8270 SIM	0.1 ~~*5~~
Dibenzo(a,h) anthracene	53-70-3	0.88~~12~~	EPA Method ~~8270 or~~ 8270 SIM~~ LL-PAH~~	0.16 ~~*1~~
Fluoranthene	206-44-0	640	EPA Method ~~8270 or~~ 8270 SIM	5 ~~10~~
Fluorene	86-73-7	320	EPA Method ~~8270 or~~ 8270 SIM	3 4
Indeno (1,2,3-cd)pyrene	193-39-5	0.88~~12~~	EPA Method ~~8270 or~~ 8270 SIM~~ LL-PAH~~	0.3 ~~*0.3~~
Phenanthrene	85-01-8	No value	EPA Method ~~8270 or~~ 8270 SIM	10
Pyrene	129-00-0	240	EPA Method ~~8270 or~~ 8270 SIM	5 ~~10~~
Naphthalene	91-20-3	160	EPA Method ~~8270 or~~ 8270 SIM	10
~~Contamination Indicator Parameters (40 CFR 265.92[b][3]) (µg/L)~~				
~~Total Organic Carbon~~	~~7440-44-0~~	~~No value~~	~~SW-846 Method 9060~~	~~1000~~
~~Total Organic Halides~~	~~59473-04-0~~	~~No value~~	~~SW-846 Method 9020~~	~~10~~
Laboratory Indicators				
Alkalinity	CASID10164	NA	Alkalinity EPA Method 310.1	~~5,000~~5,250 µg/L
Corrosivity (pH)	12408-02-5	NA	EPA Method 9040	N/A

Table A-6. Performance Requirements for Groundwater Analysis[a]

Constituent	Chemical Abstract Services Number	Action Level[b]	Analytical Method[c]	Required Quantitation Limit
Apatite Formation Testing (Sediment)				
Apatite	N/A	NA	Fluorescence of substituted apatites	N/A[e]
Phosphate	14265-44-2	NA	Acid dissolution of sediment and phosphate measurement	N/A[e]
Strontium-90	10098-97-2	NA	Strontium-89/90 – Total Rad-Sr	N/A[e]

a. For convenience, this table also includes information for apatite formation testing of sediments to support requirements identified in Insert A2.

b. Action Level is the lower of EPA MCLs for drinking water quality, WAC 173-340-720, "Model Toxics Control Act —Cleanup," "Groundwater Cleanup Standards," Method B; WAC 173-200, "Water Quality Standards for Groundwaters of the State of Washington," or Criteria For Chronic Exposure In Freshwater, WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington (AWQC)."

c. For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples.* For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*. Equivalent methods may be substituted.

d. Action level is less than the DOE/RL-96-61 background value.

e. PNNL's laboratory procedures and quality assurance plan will apply to all analyses performed by PNNL.

*Required quantitation limit is greater than the cleanup level for one or more of the following: MCL, WAC, or AWQC

** EPA Method 6020 is an equivalent method to EPA Method 6010 and provides lower detection levels.

AWQC	= ambient water quality criteria	MCL	= maximum contaminant level
GPC	= gas proportional counting	TPH	= total petroleum hydrocarbons
IC	= ion chromatography	SIM	= selective ion monitoring
N/A	= not applicable	WTPH	= Washington total petroleum hydrocarbons
PNNL	= Pacific Northwest National Laboratory	~~LL~~	~~= low level~~

1

Table A-7. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated
Field Quality Control		
Field duplicates	1 in 20 well trips	Precision, including sampling and analytical variability
Field splits (SPLIT)	As needed When needed, the minimum is one for every analytical method, for analyses performed where detection limit and precision and accuracy criteria have been defined in the Analytical Performance Requirements table	Inter-laboratory comparability Precision, including sampling, analytical, and inter-laboratory
Full trip blanks (FTB)	1 in 20 well trips	Cross-cContamination from containers, preservative reagents, storage, or transportation
Field transfer blanks (FXR)	One each day that VOCs are sampled; additional field transfer blanks are collected if VOC samples are acquired on the same day for multiple laboratories	Contamination from sampling site
Equipment blanks (EB)	As needed[a,b] If only disposable equipment is used or equipment is dedicated to a particular well, then an EB is not required. Otherwise, 1 for every 20 samples [a]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical Laboratory Batch Quality Control[cb]		
Laboratory duplicates	1 per analytical batch[de]	Laboratory reproducibility and precision
Matrix spikes (MS)	1 per analytical batch[de]	Matrix effect/laboratory accuracy
Matrix spike duplicates (MSD)	1 per analytical batch[de]	Laboratory reproducibility, and Method accuracy and precision
Laboratory control samples (LCS)	1 per analytical batch[de]	Evaluate laboratory accuracy
Method blanks (MB)	1 per analytical batch[de]	Laboratory contamination
Surrogates (SUR)	Added to each sample and quality control 1 per analytical batch[e]	Recovery/yield for organic compounds
Tracers	Added to each sample and quality control 1 per analytical batch[e]	Recovery/yield
Carrier	Added to each sample and quality control[d]	Recovery/yield

a. For portable pumps, EBs are collected 1 for every 10 well trips. Whenever a new type of nondedicated equipment is used, an EB will be collected every time sampling occurs until it can be shown that less frequent collection of EBs is adequate to monitor the decontamination methods for the nondedicated equipment.

Table A-7. Project Quality Control Requirements

Sample Type	Frequency	Characteristics Evaluated

b. Vendor provided borehole equipment is considered dedicated equipment and equipment blanks are not typically acquired in this instance.

c. A batch is a group of up to 20 samples that behave similarly with respect to the sampling or testing procedures being employed and which are processed as a unit. Batching across projects is allowed for similar matrices (e.g., all Hanford Site groundwater).

d~~e~~. Unless not required, or different frequency is called out, in laboratory analysis methods.

Table A-8. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity ~~Conductivity~~ Hexavalent chromium ~~pH~~	MB ~~MB[b]~~	<MDL <5% Sample concentration	Flag with "C" ~~Flagged with "C"~~
	LCS	80%-120% recovery ~~80 – 120% recovery[e]~~	Flag with "o"[a] ~~Data reviewed[d]~~
	DUP[b] or MS / MSD[c] ~~Laboratory duplicate or MS/MSD~~	<20% RPD	Review data[d] ~~Data reviewed[d]~~
	MS / MSD[c] ~~MS[b]~~	75%-125% recovery ~~75 – 125% recovery[e]~~	Flag with "N" ~~Flagged with "N"~~
	EB, FTB ~~EB~~	≤ MDL ≤ 5% sample concentration ~~<2 Times MDL~~	Flag with "Q" ~~Flagged with "Q"~~
	Field Duplicate[b] ~~Field duplicate~~	≤ 20% RPD ~~≤20% RPD[e]~~	Review data[d] ~~Flagged with "Q"~~
Anions			
Anions by IC	MB	<MDL <5% Sample concentration	Flag with "C" ~~Flagged with "C"~~
	LCS	80%-120% recovery ~~80 – 120% recovery[e]~~	Flag with "o" [a] ~~Data reviewed [d]~~
	DUP[b] or MS / MSD[c] ~~Laboratory duplicate or MS/MSD~~	≤20% RPD	Review data[d] ~~Data reviewed [d]~~
	MS / MSD[c] ~~MS~~	75%-125% recovery ~~75 – 125% recovery[e]~~	Flag with "N" ~~Flagged with "N"~~
	EB, FTB	≤ MDL ≤ 5% sample concentration ~~<2X MDL~~	Flag with "Q" ~~Flagged with "Q"~~

Table A-8. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action
	Field Duplicate[b] ~~Field duplicate~~	≤ 20% RPD ~~≤20% RPD[e]~~	Review data[d] ~~Flagged with "Q"~~
Metals			
ICP Metals ICP/MS metals Mercury	MB	< MDL < 5% sample concentration ~~<Required detection limit~~ ~~<5% Sample concentration~~	Flag with "C" ~~Flagged with "C"~~
	LCS	80%-120% recovery ~~80 – 120% recovery[e]~~	Flag with "o" [a] ~~Data reviewed[d]~~
	DUP[b] or MS / MSD[c] ~~MS~~	≤ 20% RPD ~~75 – 125% recovery[e]~~	Review data[d] ~~Flagged with "N"~~
	~~MSD~~	~~75 – 125% recovery[e]~~	~~Flagged with "N"~~
	MS / MSD[c] ~~MS/MSD~~	75%-125% recovery ~~≤20% RPD~~	Flag with "N" ~~Data reviewed[d]~~
	EB, FTB	< MDL < 5% sample concentration ~~<2X MDL~~	Flag with "Q" ~~Flagged with "Q"~~
	Field Duplicate[b] ~~Field duplicate~~	≤ 20% RPD ~~≤20% RPD[e]~~	Review data[d] ~~Flagged with "Q"~~
Volatile Organic Compounds			
~~Volatile Organics by GC/MS~~ Total petroleum hydrocarbons by GC	MB	< MDL < 5% sample concentration ~~<MDL[f]~~ ~~<5% Sample concentration~~	Flag with "B" ~~Flagged with "B"~~
	LCS	70%-130% recovery or % recovery statistically derived[e] ~~Statistically derived[e]~~	Flag with "o"[a] ~~Data reviewed[d]~~
	DUP[b] or MS / MSD[c] ~~MS~~	≤ 20% RPD ~~% Recovery statistically derived[e]~~	Review data[d] ~~Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD~~
	~~MSD~~	~~% Recovery statistically derived[e]~~	~~Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD~~
	MS / MSD[c] ~~MS/MSD~~	70%-130% recovery ~~%RPD statistically derived[e]~~	Flag with "N" ~~Data reviewed[d]~~
	SUR	60%-140% recovery ~~Statistically derived[e]~~	Review data[d] ~~Data reviewed[d]~~

Table A-8. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action
	EB, FTB ~~EB, FTB, FXR~~	≤ MDL ≤ 5% sample concentration ~~<MDL[f]~~	Flag with "Q" ~~Flagged with "Q"~~
	Field Duplicate[b] ~~Field duplicate~~	≤ 20% RPD ~~≤20% RPD[e]~~	Review data[d] ~~Flagged with "Q"~~
Volatile Organics by GC/MS	MB	≤ MDL[f] ≤ 5% sample concentration	Flag with "B"
	LCS	70%-130% recovery or % recovery statistically derived[e]	Flag with "o"[a]
	DUP[b] or MS / MSD[c]	≤ 20% RPD	Review data[d]
	MS / MSD[c]	70%-130% recovery	Flag with "T"
	SUR	70%-130% recovery	Review data[d]
	EB, FTB, FXR	≤ MDL[f] ≤ 5% sample concentration	Flag with "Q"
	Field Duplicate[b]	≤ 20% RPD	Review data[d]
Semivolatile Organic Compounds (Includes PAH)			
Semivolatiles by GC/MS	MB	≤ MDL[f] ≤ 5% sample concentration ~~<MDL[f] <5% Sample concentration~~	Flag with "B" ~~Flagged with "B"~~
	LCS	70%-130% recovery or % recovery statistically derived[e] ~~Statistically derived[e]~~	Flag with "o" [a] ~~Data reviewed[d]~~
	DUP[b] or MS / MSD[c] ~~MS~~	≤ 20% RPD ~~% Recovery statistically derived[e]~~	Review data[d] ~~Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD~~
	~~MSD~~	~~% Recovery statistically derived[e]~~	~~Flagged with "T" if analyzed by GC/MS, otherwise "N" based on FEAD~~
	MS / MSD[c] ~~MS/MSD~~	% recovery statistically derived[e] ~~% RPD statistically derived[e]~~	Flag with "T" ~~Data reviewed[d]~~
	SUR	% recovery statistically derived[e] ~~Statistically derived[e]~~	Review data[d] ~~Data reviewed[d]~~

Table A-8. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action
	EB, FTB	< MDL[g] < 5% sample concentration ~~<2X MDL~~[f]	Flag with "Q" ~~Flagged with "Q"~~
	Field Duplicate[b] ~~Field duplicate~~	< 20% RPD ~~≤20% RPD~~[e]	Review data[d] ~~Flagged with "Q"~~
General Chemical Analysis			
~~Total Organic Carbon~~	~~MB~~	~~<MDL~~ ~~<5% Sample concentration~~	~~Flagged with "C"~~
	~~LCS~~	~~80–120% recovery~~	~~Data reviewed~~[d]
	~~Laboratory Duplicate or MS/MSD~~	~~≤20% RPD~~[e]	~~Data reviewed~~[d]
	~~MS or PS, and MSD (if MS/MSD)~~	~~75–125% recovery~~	~~Flagged with "N"~~
	~~EB, FTB~~	~~<2 times MDL~~	~~Flagged with "Q"~~
	~~Field Duplicate~~	~~≤20% RPD~~[e]	~~Flagged with "Q"~~
~~Total Organic Halogen~~ ~~Oil and Grease~~	~~MB~~	~~<MDL~~ ~~<5% Sample concentration~~	~~Flagged with "C"~~
	~~LCS~~	~~80–120% recovery~~	~~Data reviewed~~[d]
	~~Laboratory Duplicate or MS/MSD~~	~~≤20% RPD~~[e]	~~Data reviewed~~[d]
	~~MS and MSD (if MS/MSD)~~	~~75–125% recovery~~	~~Flagged with "N"~~
	~~EB, FTB~~	~~<2 Times MDL~~	~~Flagged with "Q"~~
	~~Field Duplicate~~	~~≤20% RPD~~[e]	~~Flagged with "Q"~~
Oil and Grease	MB	< MDL < 5% sample concentration	Flag with "C"
	LCS	80%-120% recovery	Flag with "o" [a]
	DUP[b] or MS / MSD[c]	< 20% RPD	Review data[d]
	MS / MSD[c]	75%-125% recovery	Flag with "N"
	EB, FTB	< MDL < 5% sample concentration	Flag with "Q"
	Field Duplicate[b]	< 20% RPD	Review data[d]

Table A-8. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action
Radiochemical Analyses			
Gross alpha Gross beta Strontium-90~~89/90~~ Tritium Tritium (low level)	MB	< MDC < 5% sample activity concentration ~~<Minimum detectable concentration <5% Sample concentration~~	Flag with "B" ~~Flagged with "C"~~
	LCS	80%-120% recovery or statistically derived limits[c] ~~70 – 130% recovery~~	Flag with "o"[a] ~~Data reviewed[d]~~
	DUP[b] ~~Laboratory duplicate[e]~~	≤20% RPD	Review data[d] ~~Data reviewed[d]~~
	MS (for Tritium)~~[g]~~	75%-125% recovery ~~60 – 140% recovery~~	Flag with "N" ~~Flagged with "N"~~
	Tracer (~~where applicable~~for Stronium-90)	30%-105% recovery ~~20 – 105% recovery~~	Review data[d] ~~Data reviewed[d]~~
	Carrier (~~where applicable~~for Strontium-90)	40%-110% recovery ~~30 – 105% recovery~~	Review data[d] ~~Data reviewed[d]~~
	EB, FTB	< MDC < 5% sample activity concentration ~~<2 Times MDA~~	Flag with "Q" ~~Flagged with "Q"~~
	Field Duplicate[b] ~~Field duplicate~~	< 20% RPD ~~<20% RPD[e]~~	Review data[d] ~~Flagged with "Q"~~

~~a. Specific analytes and method for determination are available from the Sample Management and Reporting organization.~~

~~b. Does not apply to pH, conductivity, total residue, total suspended solids, total dissolved solids, or alkalinity.~~

~~c. Determined by the laboratory based on historical data or statistically derived control limits. Limits are reported with the data. Where specific acceptance criteria are listed, those acceptance criteria may be used in place of statistically derived acceptance criteria.~~

~~d. After review, corrective actions are determined on a case-by-case basis.~~

~~e. Applies only in cases where both results are greater than 5 times the minimum detectable concentration.~~

~~f. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is <5 times the MDL.~~

~~g. Applies only to tritium.~~

a. The reporting laboratory will apply the "o" flag with SMR concurrence.

b. Applies when at least one result is greater than the laboratory PQL (chemical analyses) or greater than five times the MDC (radiochemical analyses).

c. Either a sample duplicate or a MSD is to be analyzed to determine measurement precision (if there is insufficient sample volume, an LCSD is analyzed with the acceptance criteria defaulting to the DUP/MSD criteria

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data.

Table A-8. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	Quality Control Element	Acceptance Criteria	Corrective Action

e. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.

f. For the common laboratory contaminants acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criterion is less than five times the MDL.

EB = equipment blank
~~FEAD = format for electronic analytical data~~
FTB = full trip blank
FXR = field transfer blank
GC = gas chromatography
GC/MS = gas chromatography-mass spectrometry
IC = ion chromatography
ICP = inductively coupled plasma
ICP/MS = inductively coupled plasma-mass spectrometry
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
RPD = relative percent difference
SUR = surrogate

Data Flags:

B, C = possible laboratory contamination: analyte was detected in the associated method blank – laboratory applied. The B flag is used for organic analytes and radioanalytes. The C flag is used for general chemical parameters and inorganic analytes.~~B (organics)/C (inorganics/wetchem) = Analyte was detected in both the associated quality control blank and the sample)~~

N = result may be biased: associated MS result was outside the acceptance limits (all methods except GC-MS) – laboratory applied.~~N = All except GC/MS – matrix spike outlier~~

~~O~~o = results may be biased: associated laboratory control sample result was outside the acceptable limits – laboratory applied

T = result may be biased: associated MS result was outside the acceptance limits (GC-MS only) – laboratory applied.~~T = VOA and Semi-VOA GC/MS – Matrix spike outlier~~

Q = problem with associated field QC samples: results were out of limits – SMR review.~~Q = Associated QC sample is out of limits~~

A2.2.3.1 Field QC Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure reliable data are obtained. Field QC samples include field duplicates, split samples, and three types of field blanks (full trip, field transfer, and equipment). Field blanks are typically prepared using high-purity reagent water. The QC sample definitions and their required frequency for collection are described in this section.

Field Duplicates: Independent samples collected as close as possible to the same time and same location as the schedule sample, and are intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.

Field Splits (SPLIT): Two samples collected as close as possible to the same time and same location and are intended to be identical. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are inter-laboratory comparison samples used to evaluate comparability between laboratories.

Full Trip Blanks (FTBs): Bottles prepared by the sampling team prior to traveling to the sampling site. The preserved bottle set is either for volatile organic analysis (VOA) only or identical to the set that will be collected in the field. It is filled with high-purity reagent water (or dead water from Well 699-S11-E12AP for low-level tritium FTBs) and the bottles are sealed and transported, unopened, to

A3 Field Sampling Plan

This chapter lists the groundwater wells and aquifer tubes to be monitored, the sampling frequency, and the constituents to be analyzed.

A3.1 Sampling Objectives

The objectives of groundwater monitoring in this OU are to:

- Determine the effectiveness of the PRB to reduce Sr-90 concentrations. This evaluation includes remedy performance monitoring for the combined saturated zone and vadose zone PRB.
- In conjunction with the bioremediation of petroleum, monitor the groundwater underlying the area of TPH contamination to support an evaluation of the bioventing system for achieving compliance with the cleanup standards.
- Better define the nature (type and concentration) and extent (distribution) of Sr-90, tritium, nitrate, TPH, chromium, and hexavalent chromium contamination. These contaminants exceed one or more of the following: drinking water standard, ambient water quality criteria, or WAC 173-340, "Model Toxics Control Act—Cleanup" (MTCA B), groundwater cleanup standard.
- Determine the concentrations of chromium and hexavalent chromium in the confined aquifer in Well 199-N-80.
- Determine if antimony, cadmium, and cobalt contamination are present above action/cleanup levels. The occurrence of antimony, cadmium, and cobalt in groundwater is uncertain because these analytes historically have been detected in groundwater at concentrations above their respective action level; however, their presence was not associated with a specific location or a trend and the analytical methods used were not sufficient for risk characterization purposes.

These objectives are accomplished by sampling groundwater at designated wells and aquifer tubes and analyzing the samples for the COCs, COPCs, and analytes of interest.

A3.2 Sample Location, Frequency, and Constituents Monitored

The sampling requirements and groundwater monitoring wells comprising the 100-NR-2 OU networks are listed in the 100-NR-2 OU DQO summary report (Insert A1). Insert A3 provides information on the aquifer intervals monitored by the wells. Table A-10 lists the specific constituents to be analyzed and the sampling frequency for those wells that have been selected for monitoring. This comprehensive list (Table A-10) contains the sampling requirements for the 100-NR-2 OU program inclusive of the PRB, bioventing, Sr-90, TPH, nitrate, tritium, and hexavalent chromium/metals networks. Where a well is sampled for more than one network, the sampling frequency in Table A-10 reflects the shortest sampling frequency of the networks. Specific sampling requirements (e.g., sampling frequency and constituents analyzed) applicable to each network are shown in Tables A-11 through A-1~~8~~7 and are a subset of Table A-10.

Insert A1 also contains the criteria used to identify the wells needed to answer each of the PSQs of the DQO and to determine the sampling frequency to be employed. Some wells are co-sampled with other monitoring programs (e.g., monitored to meet ~~RCRA~~ AEA requirements). Monitoring requirements for those other monitoring programs are described in separate plans. The reported data from these networks are supplementary to information gathered under this SAP. The breakdown of the well networks to answer individual PSQs is discussed in Section A3.2.1 and summarized below.

- Sampling requirements to address PSQ 1 (Is the Sr-90 permeable reactive [apatite] barrier performing as intended) are listed in Table A-11 and discussed in Section 3.2.1.1. The data will also provide supplemental information for PSQs 3, 4, 5, and 7.
- Sampling requirements to address PSQ 2 (Are TPH remedies contributing to groundwater quality improvement) are listed in Table A-12 and discussed in Section 3.2.1.2. The data will also provide supplemental information for PSQs 3, 4, 5, and 7.
- Sampling requirements to address PSQ 3 (Is there evidence of Interim Action ROD COC plume, concentration, area, or location changes) are listed in Tables A-13 through A-17 and discussed in Section 3.2.1.3.
- Sampling requirements to address PSQ 4 (Are increasing concentrations in groundwater indicating newly identified or continuing sources of contamination [e.g., Sr-90 and tritium near the 1908-N Outfall]) are listed in Tables A-13 through A-~~18~~ 17 and discussed in Section 3.2.1.4.
- Sampling requirements to address PSQ 5 (Is there evidence that Columbia River water quality is being protected) are listed in Tables A-11 through A-17 and discussed in Section 3.2.1.5.
- Sampling requirements to address PSQ 6 (How do adjacent operable units influence 100-NR-2 remedies) are listed in Tables A-13 through A-17 and discussed in Section 3.2.1.6.
- Sampling requirements to address PSQ 7 (Is there additional information needed for a final ROD) are listed in Tables A-11 through A-17 and discussed in Section 3.2.1.7.

A3.2.1 Monitoring Network

This SAP organizes the wells within the 100-NR-2 Groundwater OU according to the PSQ that they are associated with. An analysis of the network to identify those wells needed for use in monitoring specific COC plumes is presented in Insert A1. Traditional statistical sampling designs were not identified in the DQO summary report.

A3.2.1.1 PSQ 1: Is the Sr-90 permeable reactive (apatite) barrier performing as intended?

The apatite PRB (Figure A-12), located downgradient of the highest area of Sr-90 contamination, was formed by injecting a calcium citrate phosphate solution into the aquifer through a network of vertical wells installed at the river shoreline (i.e., the barrier well network). After the solution is injected, biodegradation of the citrate releases calcium, which results in formation of apatite (a calcium phosphate $[Ca_{10}(PO_4)_6(OH)_2]$ mineral). Sr-90 ions in groundwater substitute for calcium ions in the apatite and eventually become trapped as part of the mineral matrix during apatite crystallization. The Sr-90 in groundwater is sorbed and then incorporated into the apatite crystalline structure within the soils and aquifer sediments as groundwater flows through the barrier. The 2013 data indicate that Sr-90 concentrations have been reduced. Based on previous monitoring data, the PRB is expected to achieve a 90 percent reduction in Sr-90 concentrations in the monitoring wells.

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
Monitoring Wells																									
A4669	199-N-2	Nitrate, Sr-90, metalsRCRA	TU	N1964	A	A	--	A	A	--	--	--	--	--	--	--	--	– A5	--	--	–	SA	SA	SA	--
A4679	199-N-3	BV, nitrate, TPH, RCRASr-90, metals	TU	N1964	A	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	--	--	– A5	--	SA	SA	SA	SA	SA	SA
A4664	199-N-14	Nitrate, Sr-90, metals	TU	N1969	A	A	--	–A	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A4668	199-N-19	BV, nitrate, TPH	TU	N1981	--	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	--	--	--	--	SA	SA	SA	SA	SA	SA
A4671	199-N-21	Sr-90	TU	N1981	--	--	--	--	--	--	--	--	--	--	--	--	--	A5	--	--	–	A5	A5	A5	--
A4676	199-N-27	Nitrate, Sr-90	TU	N1983	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A4677	199-N-28	Nitrate, Sr-90, metalsSr-90, RCRA	TU	N1983	A	A	--	A	A	--	--	--	--	--	--	--	--	A5	--	--	–	SA	SA	SA	--
A4681	199-N-32	Nitrate, Sr-90, metalsRCRA	TU	N1983	SA	SA	--	SA	SA	--	--	--	--	--	--	--	--	–A5	--	--	–	SA	SA	SA	--
A4683	199-N-34	Nitrate, Sr-90, metals, RCRA	TU	N1983	A	A	--	A	A	--	--	--	--	--	--	--	--	A5	--	--	–	SA	SA	SA	--
A4689	199-N-41	Nitrate, Sr-90, metals, RCRA	TU	N1984	A	A	--	A	A	--	--	--	--	--	--	--	--	A5	--	--	–	SA	SA	SA	--
A5833	199-N-46	Nitrate, Sr-90	TU	ND	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A4693	199-N-50	Nitrate, Sr-90	TU	N1985	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A4694	199-N-51	Sr-90	TU	N1985	--	--	--	--	--	--	--	--	--	--	--	--	--	A5	--	--	–	A5	A5	A5	--
A4699	199-N-56	BV, TPH, nitrate	TU	N1987	--	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	--	--	--	--	SA	SA	SA	SA	SA	SA
A4700	199-N-57	Sr-90, nitrate, metals, RCRA	TU	N1987	A	A	--	A	A	--	--	--	--	--	--	--	--	A5	--	--	–	SA	SA	SA	--
A4708	199-N-64	Nitrate, Sr-90, metals	TU	N1987	A	A	--	–A	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A4711	199-N-67	Nitrate, Sr-90, metals	TU	N1988	A	A	--	–A	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A4714	199-N-71	Nitrate, metalsRCRA	TU	C1991	A	A	--	A	A	--	--	--	--	--	--	--	--	--	--	--	–	SA	SA	SA	--
A4715	199-N-72	Nitrate, metals RCRA	TU	C1991	A	A	--	A	A	--	--	--	--	--	--	--	--	--	--	--	–	SA	SA	SA	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	~~TPH~~-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	~~Field Oxidation Reduction~~	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
A4716	199-N-73	Nitrate, metals ~~RCRA~~	TU	C1991	A	A	--	A	A	--	--	--	--	--		--	--	--	--	--	–	~~S~~A	~~S~~A	~~S~~A	--
A4717	199-N-74	Nitrate, Sr-90, metals ~~RCRA~~	TU	C1991	A	A	--	A	A	--	--	--	--	--	--	--	--	–A5	--	--	–	~~S~~A	~~S~~A	~~S~~A	--
A4718	199-N-75	Nitrate, Sr-90	TU	C1992	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A4719	199-N-76	Nitrate, Sr-90	TU	C1992	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A5442	199-N-77	Nitrate, metals, ~~RCRA~~	LU	C1992	A	A	--	A	A	--	--	--	--	--	--	--~~SA~~	--	--	--	--	–	~~S~~A	~~S~~A	~~S~~A	--
A4720	199-N-80	Hexavalent chromium, chromium, metals	Confined	C1992	A	A	A	--	--	--	--	--	--	--	--	--	--	--	--	--	–	A	A	A	--
A5443	199-N-81	Nitrate, Sr-90, metals, ~~RCRA~~	TU	C1993	A	A	--	A	A	--	--	--	--	--	--	--	--	A5	--	--	–	~~S~~A	~~S~~A	~~S~~A	--
A9878	199-N-92A[d]	PRB-E, Sr-90, nitrate, metals	TU	C1994	~~S~~A	~~S~~A	--	A–	~~S~~A	--	--	--	--	--	--	B~~SA~~	B~~SA~~	B~~SA~~	--	~~S~~A	~~SA~~	~~S~~A	~~S~~A	~~S~~A	--
A9882	199-N-96A	Nitrate, Sr-90, BV, TPH, PRB, metals, Cr+6	TU	C1994	SA–	SA	A	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	--	SA	~~SA~~	SA	SA	SA	SA
A9910	199-N-99A	Sr-90, nitrate	TU	C1994	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A9988	199-N-103A	Sr-90, nitrate	TU	C1995	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
A9989	199-N-104A	Sr-90, nitrate	TU	C1995	--	--	--	--	A–	--	--	--	--	--	--	--	--	A5	--	--	–	A~~5~~	A~~5~~	A~~5~~	--
B2408	199-N-105A	Sr-90, nitrate, metals, ~~RCRA~~	TU	C1995	A	A	--	A	A	--	--	--	--	--	--	--	--	A5	--	--	–	~~S~~A	~~S~~A	~~S~~A	--
C4954	199-N-122	PRB, Sr-90	TU	C2010	SA	SA	--	SA–	SA	--	--	--~~SA~~	--	--	--	SA	SA	SA	--	SA	~~SA~~	SA	SA	SA	--
C4955	199-N-123	PRB, Sr-90	TU	C2010	SA	SA	--	SA–	SA	--	--	--~~SA~~	--	--	--	SA	SA	SA	--	SA	~~SA~~	SA	SA	SA	--
C5042	199-N-136	PRB[c], Sr-90	TU	C2006	A5~~B~~	A5~~B~~	--	A5–	A5~~B~~	--	--	--~~B~~	--	--	--	--~~B~~	A5~~B~~	A5~~B~~	--	A5~~B~~	~~A5B~~	A5~~B~~	A5~~B~~	A5~~B~~	--
C5043	199-N-137	PRB[b]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	~~A5~~	A5	A5	A5	--
C5044	199-N-138	PRB[c]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	~~A5~~	A5	A5	A5	--
C5045	199-N-139	PRB[b]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	~~A5~~	A5	A5	A5	--
C5046	199-N-140	PRB[c]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	~~A5~~	A5	A5	A5	--
C5047	199-N-141	PRB[b]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	~~A5~~	A5	A5	A5	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
C5048	199-N-142	PRB[b]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C5049	199-N-143	PRB[b]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C5050	199-N-144	PRB[b]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C5051	199-N-145	PRB[b]	TU	C2006	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C5052	199-N-146	PRB, Sr-90, metals	TU	C2006	SA	SA	--	SA--	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	SA	SA	SA	SA	--
C5116	199-N-147	PRB, Sr-90	TU	C2006	SA	SA	--	SA--	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	SA	SA	SA	SA	--
C6177	199-N-159	PRB[g]	TU	C2008	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	A5B	A5B	A5B	A5B	--
C6178	199-N-160	PRB[c]	TU	C2008	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C6179	199-N-161	PRB[c]	TU	C2008	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C6180	199-N-162	PRB[c]	TU	C2008	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C6181	199-N-163	PRB[c]	TU	C2008	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C6182	199-N-164	PRB[c]	TU	C2008	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C6693	199-N-165	Nitrate, metalsRCRA	TU	C2008	A	A	--	A	A	--	--	--	--	--	--	SA	--	--	--	--	--	SA	SA	SA	--
C7032	199-N-167	BV, nitrate, TPH, metals	TU	C2009	A	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	--	--	--	--	SA	SA	SA	SA	SA	SA
C7034	199-N-169	BV, TPH	TU	C2009	--	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	--	--	--	--	SA	SA	SA	SA	SA	SA
C7036	199-N-171	BV, TPH	TU	C2009	--	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	--	--	--	--	SA	SA	SA	SA	SA	SA
C7037	199-N-172	BV	TU	C2009	--	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	--	--	--	--	SA	SA	SA	SA	SA	SA
C7038	199-N-173	BV, PRB-E, nitrate, TPH, Sr-90, metals	TU	C2009	SA	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	--	SA	SA	SA	SA	SA	SA
C8184	199-N-182	Nitrate, Sr-90, tritium	LU	C2011	--	--	--	--	A	--	--	--	--	--	--	--	--	A5--	A	--	--	A	A	A	--
C8185	199-N-183	BV, nitrate, TPH, Sr-90, metals, Cr+6	TU	C2011	--	SA	A	SA	SA	SA	SA	SA	SA	SA	SA	--	--	A5		SA	SA	SA	SA	SA	SA
C8186	199-N-184	Nitrate, tritium, Sr-90	TU	C2011	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	A	--	--	A	A	A	--
C8187	199-N-185	Nitrate, Sr-90	TU	C2011	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	--	A	A	A	--
C8188	199-N-186	Nitrate, Sr-90, tritium	TU	C2011	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	A	--	--	A	A	A	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
C8189	199-N-187	Nitrate, Sr-90	TU	C2011	--	--	--	--	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
C8190	199-N-188	Nitrate, Sr-90, metals	TU	C2011	A	A	--	A–	A	--	--	--	--	--	--	--	--	A5	--	--	–	A	A	A	--
C7327	199-N-200[bd]	PRB-E[b], TPH	TU	C2009	A5B	A5B	--–	A–	AB	--–	--–	AB	--–	--–	--–	--B	A5B	A5B	--–	AB	AB	AB	AB	AB	--–
C7326	199-N-201[bd]	PRB-E[c], TPH	TU	C2009	A5B	A5B	--–	A–	AB	--–	--–	AB	--–	--–	--–	--B	A5B	A5B	--–	AB	AB	AB	AB	AB	--–
C7317	199-N-210[bd]	PRB-E[b], TPH	TU	C2009	A5B	A5B	--–	A–	AB	--–	--–	AB	--–	--–	--–	--B	A5B	A5B	--–	AB	AB	AB	AB	AB	--–
C7316	199-N-211	PRB[c], TPH	TU	C2009	A5B	A5B	--–	A–	AB	--–	--–	AB	--–	--–	--–	--B	A5B	A5B	--–	AB	AB	AB	AB	AB	--–
C7315	199-N-212	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7314	199-N-213	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7313	199-N-214	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7312	199-N-215	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7311	199-N-216	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7310	199-N-217	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7309	199-N-218	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7308	199-N-219	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7307	199-N-220	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7306	199-N-221	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7305	199-N-222	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7304	199-N-223	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7303	199-N-224	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7302	199-N-225	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7301	199-N-226	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7300	199-N-227	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7299	199-N-228	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
C7298	199-N-229	PRB[c]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	A5B	A5B	A5B	A5B	--
C7297	199-N-230	PRB[b]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	A5B	A5B	A5B	A5B	--
C7296	199-N-231	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7295	199-N-232	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7294	199-N-233	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7293	199-N-234	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7328	199-N-235	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7329	199-N-236	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7330	199-N-237	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7331	199-N-238	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7332	199-N-239	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7333	199-N-240	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7334	199-N-241	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7335	199-N-242	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7336	199-N-243	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7337	199-N-244	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7338	199-N-245	PRB[b]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7339	199-N-246	PRB[c]	TU	C2009	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7340	199-N-247	PRB[b]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	A5B	A5B	A5B	A5B	--
C7341	199-N-248	PRB[c]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	A5B	A5B	A5B	A5B	--
C7342	199-N-249	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7343	199-N-250	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7344	199-N-251	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
C7345	199-N-252	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7346	199-N-253	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7347	199-N-254	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7348	199-N-255	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7349	199-N-256	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7350	199-N-257	PRB[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7351	199-N-258	PRB[c]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7352	199-N-259	PRB-E[b]	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7353	199-N-260	PRB-E[c], Sr-90	TU	C2010	A5	A5	--	A5	A5	--	--	--	--	--	--	--	A5	A5	--	A5	A5	A5	A5	A5	--
C7361	199-N-268	PRB-E[c]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7362	199-N-269	PRB-E[b]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7373	199-N-280	PRB-E[c]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7374	199-N-281	PRB-E[b]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7390	199-N-297	PRB-E[b], Sr-90	TU	C2010	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7391	199-N-298	PRB-E[c]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7408	199-N-315	PRB-E[b]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7409	199-N-316	PRB-E[c]	TU	C2009	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7425	199-N-332	PRB-E[c], Sr-90	TU	C2010	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7426	199-N-333	PRB-E[b]	TU	C2010	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7435	199-N-342	PRB-E[c]	TU	C2010	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7436	199-N-343	PRB-E[b]	TU	C2010	A5B	A5B	--	A5--	A5B	--	--	--B	--	--	--	--B	A5B	A5B	--	A5B	--B	A5B	A5B	A5B	--
C7436	199-N-346[b,d]	PRB-E, TPH	TU	C2010	SA	SA	--	A--	SA	--	--	SA	A	A	A	BSA	BSA	BSA	--	SA	SA	SA	SA	SA	--
C7441	199-N-347[b]	Sr-90, PRB-E, TPH, nitrate	TU	C2010	SA	SA	--	A--	SA	--	--	SA	A--	A--	A--	BSA	BSA	BSA	--	SA	SA	SA	SA	SA	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
C7440	199-N-348	PRB, Sr-90	TU	C2010	SA	SA	--	SA–	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	SA	SA	SA	SA	--
C7439	199-N-349	PRB, nitrate	TU	C2010	SA	SA	--	SA–	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	SA	SA	SA	SA	--
C7443	199-N-350	PRB	TU	C2009	SA	SA	--	SA–	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	SA	SA	SA	SA	--
C7444	199-N-351	PRB	TU	C2009	SA	SA	--	SA–	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	SA	SA	SA	SA	--
C7445	199-N-352	PRB, Sr-90	TU	C2010	SA	SA	--	SA–	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	SA	SA	SA	SA	--
C7446	199-N-353	PRB, Sr-90, nitrate, metals	TU	C2010	SA	SA	--	SA–	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	SA	SA	SA	SA	--
C7447	199-N-354[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7448	199-N-355[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7449	199-N-356[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7450	199-N-357[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7451	199-N-358[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7452	199-N-359[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7453	199-N-360[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7454	199-N-361[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7455	199-N-362[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7456	199-N-363[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7457	199-N-364[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7458	199-N-365[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7459	199-N-366[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7463	199-N-367[b,d]	PRB-E	TU	C2010	BSA	BSA	--	B–	BSA	--	--	--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C9400	199-N-371[d]	Sr-90, tritium, TPH	TU	NA	Q/A[e]	Q/A[e]	Q/A[e]	Q/A[e]	Q/A[e]	Q/A[e]	--	Q/A[e]	Q/A[e]	Q/A[e]	Q/A[e]	--	Q/A	Q/A5	Q/A	--	–	Q/A	Q/A	Q/A	--
C9401	199-N-372[d]	Nitrate, Sr-90, tritium	TU	NA	Q/A[e]	Q/A[e]	Q/A[e]	Q/A[e]	Q/A	Q/A[e]	--	--Q/A	--Q/A	--Q/A	--Q/A	--	Q/A	Q/A5	Q/A	--	–	Q/A	Q/A	Q/A	--
C9402	199-N-373[d]	Nitrate, Sr-90, TPH	TU	NA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	--	SA–	Q/A5[c]	-- Q/A[e]	--	–	Q/SA	Q/SA	Q/SA	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
C9403	199-N-374[d]	Sr-90, tritium	TU	NA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	--	--Q/A	--Q/A	--Q/A	--Q/A	--	Q/SA	Q/SA	Q/SA	--	–	Q/SA	Q/SA	Q/SA	--
C9425	199-N-376[d]	Nitrate	LU	NA	Q/A[c]	Q/A[c]	Q/A[c]	Q/A[c]	Q/A	Q/A[c]	--	--Q/A	--Q/A	--Q/A	--Q/A	--	--Q/A	-- Q/A5[e]	-- Q/A[e]	--	–	Q/A	Q/A	Q/A	--
C9429	199-N-377[d]	Nitrate, BV, TPH, Sr-90	TU	NA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	Q/SA	--	Q/SA	Q/A5	-- Q/A[e]	Q/SA –	Q/SA –	Q/SA	Q/SA	Q/SA	--
Aquifer Tubes[e]																									
C5269	APT1	PRB	TU	N2006	SA	SA	--	SA–	SA	--	--	SA	--	--	--	SA	SA	SA	--	SA	–SA	SA	SA	SA	--
C5386	APT5	PRB	TU	N2006	SA	SA	--	SA–	SA	--	--	SA	--	--	--	SA	SA	SA	--	SA	–SA	SA	SA	SA	--
C6132	C6132	PRB-E, BV	TU	N2007	SA	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	--	SA	–SA	SA	SA	SA	SA
C6136/C9586	C6136/C9586	PRB-E	TU	N2007/N2015	SA	SA	--	SA–	SA	--	--	SA	--	--	--	SA	SA	SA	--	SA	–SA	SA	SA	SA	--
C6135	C6135	PRB-E, BV	TU	N2007	SA–	SA	--	SA	SA	SA	SA	SA	SA	SA	SA	SA–	SA–	SA–	--	SA	–SA	SA	SA	SA	SA
C6317, C6318, C6319	C6317, C6318, C6319	Sr-90, tritium	TU	N2008	--	--	--	--	--	--	--	--	--	--	--	--	--	SA	SA	--	–	SA	SA	SA	--
C6320	C6320	Sr-90	TU	N2008	--	--	--	--	--	--	--	--	--	--	--	--	--	SA	--	--	–	SA	SA	SA	--
C6324	C6324[d]	PRB-E	TU	N2008	BSA	BSA	--	B–	BSA	--	--	SA--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C7934, C7935, C7936	C7934, C7935, C7936	Tritium, Sr-90	TU	N2010	--	--	--	--	--	--	--	--	--	--	--	--	--	SA	SA	--	–	SA	SA	SA	--
C7937, C7938 C7939	C7937, C7938 C7939	Tritium, Sr-90	TU	N2010	--	--	--	--	--	--	--	--	--	--	--	--	--	SA	SA	--	–	SA	SA	SA	--
C7881	N116m Array-7A[f]/ C7881	PRB	TU	N2010	SA	SA	--	SA–	SA	--	--	SA--	--	--	--	SA	SA	SA	--	SA	–SA	SA	SA	SA	--
C5514	N116m Array-0A[bd]	BV, PRB-E	TU	N2006	SA	SA	--	SA–	SA	SA	SA	SA	SA	SA	BSA	BSA	BSA	BSA	--	SA	SA	SA	BSA	BSA	BSA
C5255	N116m Array-1A	PRB	TU	N2005	SA	SA	--	SA	SA	--	--	--	--	--	--	SA	SA	SA	--	SA	–	SA	SA	SA	--
C5264	N116m Array-10A[bg]	PRB-E	TU	N2005	BSA	BSA	--	B–	BSA	--	--	SA--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C5265	N116m Array-11A[bd]	PRB-E	TU	N2005	BSA	BSA	--	B–	BSA	--	--	SA--	--	--	--	BSA	BSA	BSA	--	BSA	–SA	BSA	BSA	BSA	--
C9587	N116m Array-13A[f]/ C9587[d]	PRB-E	TU	N2015	B	B	--	B	B	--	--	--	--	--	--	B	B	B	--	B	–	B	B	B	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen
C9588	N116m Array-14A[f]/ C9588[d]	PRB-E	TU	N2015	B	B	--	B	B	--	--	--	--	--	--	B	B	B	--	B	=	B	B	B	--
C9589	N116m Array-12A[f]/ C9589[d]	PRB-E	TU	N2015	B	B	--	B	B	--	--	--	--	--	--	B	B	B	--	B	=	B	B	B	--
C5512	N116m Array-15A[bd]	PRB-E	TU	N2006	BSA	BSA	--	B--	BSA	--	--	SA--	--	--	--	BSA	BSA	BSA	--	BSA	--SA	BSA	BSA	BSA	--
C5256	N116m Array-2A	PRB	TU	N2005	SA	SA	--	SA--	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	--SA	SA	SA	SA	--
C5257	N116m Array-3A	PRB	TU	N2005	SA	SA	--	SA--	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	--SA	SA	SA	SA	--
C5258	N116m Array-4A	PRB	TU	N2005	SA	SA	--	SA--	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	--SA	SA	SA	SA	--
C5259	N116m Array-6A	PRB	TU	N2005	SA	SA	--	SA--	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	--SA	SA	SA	SA	--
C5261	N116m Array-8A[g]	PRB	TU	N2005	SA	SA	--	SA--	SA	--	--	SA--	--	--	--	SA	SA	SA	--	SA	--SA	SA	SA	SA	--
C5262/C9590	N116m Array-8.5A[g]/ C9590[d]	PRB-E	TU	N2005	BSA	BSA	--	B--	BSA	--	--	SA--	--	--	--	BSA	BSA	BSA	--	BSA	--SA	BSA	BSA	BSA	--
C5263	N116m Array-9A[d]	PRB-E	TU	N2005	BSA	BSA	--	B--	BSA	--	--	SA--	--	--	--	BSA	BSA	BSA	--	BSA	--SA	BSA	BSA	BSA	--
C5251	NVP2-116.0	PRB	TU	N2005	SA	SA	--	SA--	SA	--	--	--SA	--	--	--	SA	SA	SA	--	SA	--SA	SA	SA	SA	--

Table A-10. Sampling and Analysis Schedule for the 100-NR-2 Groundwater OU Program

Well ID	Well Number	Co-Sampled Networks	Aquifer Interval	WAC Compliant[a]	Filtered ICP Metals	Unfiltered ICP Metals	Filtered Hexavalent Chromium	Alkalinity	Anions	VOAs (BTEX)	PAH	TPH-Diesel	TPH-Gas	TPH-Motor Oil	TPH-Oil and Grease	Gross Alpha	Gross Beta	Strontium-90	Tritium	Field Dissolved Oxygen	Field Oxidation Reduction	Field Temperature	Field pH and Turbidity	Specific Conductance	Odor and Sheen

A = Annual. Sample in 2015 at low river stage (mid-September through mid-November timeframe) unless otherwise noted in footnotes b and c and annually thereafter. The low river stage sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

A5 = Annually every 5 years. Sample in 2015 at low river stage (mid-September through mid-November timeframe) unless otherwise noted in footnotes b and c and every 5 years thereafter. The low river stage sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

B = Biennial; biennial sampling targets high river state (mid-May through mid-July timeframe) andwill be during low river stage (mid-September through mid-November timeframe) every other yearunless otherwise noted in footnotes b and c. Groundwater wells sampled biennially should be sampled during the same year. The 100-NR-2 Operable Unit sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, metals) should not exceed 4 weeks.

Q/A = As a general rule, new long-term groundwater monitoring wells shall be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four quarters of sampling. Otherwise, the well will be sampled as defined by A. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

Q/A5 = As a general rule, new long-term groundwater monitoring wells shall be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four quarters of sampling. Otherwise, the well will be sampled as defined by A5. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

SA = Semiannual; biennial and semiannual targets high river stage (mid-May through mid-July timeframe) and low river stage (mid-September through mid-November timeframe). The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

a. Includes year of construction, if available.

b. The screen interval for this well targets the high river stage periods and may be dry during low river periods; sampling at this well will be at high river stage (May through July timeframe).

c. The screen interval for this well targets the low river stage periods; sampling at this well will be at low river stage (September through November timeframe).

bd. Sample frequency at Monitoring in this PRB monitoring network well, or aquifer tube, will beginincrease to semi-annually after upgradient wells have been treated with apatite-forming chemicals.

ce. Aquifer tubes are subject to breakage, and can only be repaired during periods of low river flow. If an aquifer tube is found to be broken when sampling is attempted, another aquifer tube (either a different depth in the same cluster, or a nearby aquifer tube) may be sampled instead and Ecology will be informed of the change. If no nearby aquifer tube is available, the sample will be skipped. DOE will consult with Ecology to determine if aquifer tube repair or replacement is required at a later dateContinued monitoring for COPCs following first year of quarterly sampling will be conducted at the specified frequencies only if quarterly sample results indicate COPCs are above cleanup level.

f. Records indicate aquifer tube is missing or broken and has been replaced with new aquifer tube at same location. Original aquifer tube name designation is shown with replacement aquifer tube name for cross reference (i.e., [original aquifer tube name/replacement aquifer tube name]).

gd. Aquifer tube is missing and will be assessed if replacement is needed after upgradient wells have been treated with apatite-forming chemicalsAwaiting drilling.

--	= not required
BTEX	= benzene, ethylbenzene, toluene, and xylenes
BV	= bioventing
C	= well construction is compliant with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"
ICP	= inductively coupled plasma
ID	= identification
LU	= lower unconfined aquifer
N	= well construction is not compliant with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"
NA	= not applicable
ND	= no data
PAH	= polycyclic aromatic hydrocarbon
PRB	= permeable reactive barrier
PRB-E	= planned extension of permeable reactive barrier
TBD	= to be determined
TPH	= total petroleum hydrocarbons
TU	= top of unconfined aquifer
VOA	= volatile organic analysis
WAC	= WAC = *Washington Administrative Code*

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters [c]
199-N-122	~~Barrier~~ PRB monitoring	SA	SA	SA	— ~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-123	~~Barrier~~ PRB monitoring	SA	SA	SA	— ~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-146	~~Barrier~~ PRB monitoring	SA	SA	SA	— ~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-147	~~Barrier~~ PRB monitoring	SA	SA	SA	— ~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-173	~~Barrier~~ PRB monitoring	SA	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA
199-N-136	~~Barrier~~ PRB monitoring[f]	A5~~B~~	A5	A5~~B~~	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-137	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-138	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-139	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-140	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-141	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-142	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-143	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-144	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-145	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-159	~~Barrier~~ PRB monitoring[e]	A5~~B~~	A5	A5~~B~~	— ~~B~~	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-160	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-161	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-162	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters[c]
199-N-163	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-164	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-200	~~Barrier~~ PRB monitoring[d,f]	A5~~B~~	A	A~~B~~	A~~B~~	—~~B~~	A5~~B~~	A5~~B~~	A~~B~~	~~AB~~	A~~B~~
199-N-201	~~Barrier~~ PRB monitoring[de,f]	A5~~B~~	A	A~~B~~	A~~B~~	—~~B~~	A5~~B~~	A5~~B~~	A~~B~~	~~AB~~	A~~B~~
199-N-210	~~Barrier~~ PRB monitoring[d,f]	A5~~B~~	A	A~~B~~	A~~B~~	—~~B~~	A5~~B~~	A5~~B~~	A~~B~~	~~AB~~	A~~B~~
199-N-211	~~Barrier~~ PRB monitoring[e]	A5~~B~~	A	A~~B~~	A~~B~~	—~~B~~	A5~~B~~	A5~~B~~	A~~B~~	~~AB~~	A~~B~~
199-N-212	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-213	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-214	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-215	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-216	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-217	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-218	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-219	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-220	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-221	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-222	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-223	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-224	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-225	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters [c]
199-N-226	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-227	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-228	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-229	~~Barrier~~ PRB monitoring[e]	A5~~B~~	A5	A5~~B~~	—~~B~~	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-230	~~Barrier~~ PRB monitoring[d]	A5~~B~~	A5	A5~~B~~	—~~B~~	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-231	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-232	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-233	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-234	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-235	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-236	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-237	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-238	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-239	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-240	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-241	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-242	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-243	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-244	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-245	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-246	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters[c]
199-N-247	~~Barrier~~ PRB monitoring[d]	A5~~B~~	A5	A5~~B~~	— ~~B~~	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-248	~~Barrier~~ PRB monitoring[e]	A5~~B~~	A5	A5~~B~~	— ~~B~~	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-249	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-250	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-251	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-252	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-253	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-254	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-255	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-256	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-257	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-258	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-259	PRB monitoring[d]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-260	PRB monitoring[e]	A5	A5	A5	—	—	A5	A5	A5	~~A5~~	A5
199-N-268	~~Barrier~~ PRB monitoring[d]	A5~~B~~	A5	A5~~B~~	—	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-269	~~Barrier~~ PRB monitoring[d][e]	A5~~B~~	A5	A5~~B~~	—	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-280	~~Barrier~~ PRB monitoring[d]	A5~~B~~	A5	A5~~B~~	—	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-281	~~Barrier~~ PRB monitoring[d][e]	A5~~B~~	A5	A5~~B~~	—	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-297	~~Barrier~~ PRB monitoring[d]	A5~~B~~	A5	A5~~B~~	—	— ~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters [c]
199-N-298	~~Barrier~~ PRB monitoring[~~d~~e]	A5~~B~~	A5	A5~~B~~	—	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-315	~~Barrier~~ PRB monitoring[d]	A5~~B~~	A5	A5~~B~~	—	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-316	~~Barrier~~ PRB monitoring[~~d~~e]	A5~~B~~	A5	A5~~B~~	—	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-332	~~Barrier~~ PRB monitoring[~~d~~e]	A5~~B~~	A5	A5~~B~~	—	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-333	~~Barrier~~ PRB monitoring[d]	A5~~B~~	A5	A5~~B~~	—	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-342	~~Barrier~~ PRB monitoring[d,e]	A5~~B~~	A5	A5~~B~~	—	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-343	~~Barrier~~ PRB monitoring[d]	A5~~B~~	A5	A5~~B~~	—	—~~B~~	A5~~B~~	A5~~B~~	A5~~B~~	~~A5B~~	A5~~B~~
199-N-346	~~Barrier~~ PRB monitoring[~~d~~f]	~~S~~A	A	~~S~~A	~~S~~A	B~~SA~~	B~~SA~~	B~~SA~~	~~S~~A	~~S~~A	~~S~~A
199-N-347	~~Barrier~~ PRB monitoring	~~S~~A	A	~~S~~A	~~S~~A	B~~SA~~	B~~SA~~	B~~SA~~	~~S~~A	~~S~~A	~~S~~A
199-N-348	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-349	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-350	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-351	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-352	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	~~SA~~	SA

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters [c]
199-N-353	~~Barrier~~ PRB monitoring	SA	SA	SA	— ~~SA~~	SA	SA	SA	SA	~~SA~~	SA
199-N-354	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-355	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-356	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-357	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-358	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-359	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-360	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-361	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-362	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-363	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-364	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-365	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~
199-N-366	~~Barrier~~ PRB monitoring~~[d]~~[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters[c]
199-N-367	~~Barrier~~ PRB monitoring[~~d~~f]	B~~SA~~	B	B~~SA~~	—~~—~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	~~BSA~~	B~~SA~~
199-N-92A	~~Barrier~~ PRB monitoring[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	~~BSA~~	B~~SA~~
199-N-96A	~~Barrier~~ PRB monitoring	SA	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA
APT1	~~Barrier~~ PRB monitoring	SA	SA	SA	SA	SA	SA	SA	SA	—~~SA~~	SA
APT5	~~Barrier~~ PRB monitoring	SA	SA	SA	SA	SA	SA	SA	SA	—~~SA~~	SA
C6132	~~Barrier~~ PRB monitoring	SA	SA	SA	SA	SA	SA	SA	SA	—~~SA~~	SA
C6135	~~Barrier~~ PRB monitoring	SA	SA	SA	SA	SA	SA	SA	SA	—~~SA~~	SA
C6136/C9586	~~Barrier~~ PRB monitoring	SA	SA	SA	SA	SA	SA	SA	SA	—~~SA~~	SA
C6324	~~Barrier~~ PRB monitoring[f]	B~~SA~~	B	B~~SA~~	—~~—~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
N116m Array-7A[g]/ C7881	~~Barrier~~ PRB monitoring	SA	SA	SA	—	SA	SA	SA	SA	—~~SA~~	SA
N116m Array-0A	~~Barrier~~ PRB monitoring[~~d~~f]	B~~SA~~	B	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
N116m Array-1A	PRB monitoring	SA	SA	SA	—	SA	SA	SA	SA	—	SA
N116m Array-10A	~~Barrier~~ PRB monitoring[~~d~~h]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
N116m Array-11A	~~Barrier~~ PRB monitoring[~~d~~f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
N116m Array-13A[g]/ C9587	~~Barrier~~ PRB monitoring[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters[c]
N116m Array-14A[g]/ C9588	~~Barrier~~ PRB monitoring[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
N116m Array-12A[g]/ C9589	~~Barrier~~ PRB monitoring[f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
N116m Array-15A	~~Barrier~~ PRB monitoring[~~d~~f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
N116m Array-2A	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	—~~SA~~	SA
N116m Array-3A	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	—~~SA~~	SA
N116m Array-4A	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	—~~SA~~	SA
N116m Array-6A	~~Barrier~~ PRB monitoring	SA	SA	SA	—~~SA~~	SA	SA	SA	SA	—~~SA~~	SA
N116m Array-8A	~~Barrier~~ PRB monitoring[h]	SA	SA	SA	—	SA	SA	SA	SA	—~~SA~~	SA
N116m Array-8.5A[g]/ C9590	~~Barrier~~ PRB monitoring[~~d~~f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
N116m Array-9A	~~Barrier~~ PRB monitoring[~~d~~f]	B~~SA~~	B	B~~SA~~	—	B~~SA~~	B~~SA~~	B~~SA~~	B~~SA~~	—~~SA~~	B~~SA~~
NVP2-116.0	~~Barrier~~ PRB monitoring	SA	SA	SA	—	SA	SA	SA	SA	—~~SA~~	SA

Table A-11. Apatite Barrier Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes ~~(69)~~	Purpose	Filtered and Unfiltered ICP Metals[a]	Alkalinity	Anions[b]	TPH-Diesel	Gross Alpha	Gross Beta	Strontium-90	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Other Field Parameters [c]

A5 = Annually every 5 years. Sample at low river stage (September through November timeframe) unless otherwise noted in footnotes d and e. The sample event duration should not exceed 4 weeks.

B = Biennial; biennial sampling ~~targets high river state (mid-May through mid-July timeframe) and~~ will be during low river stage (~~mid-~~September through ~~mid-~~November timeframe) every other year. ~~Groundwater wells sampled biennially should be sampled during the same year.~~ The ~~100-NR-2 Operable Unit~~ sample event duration ~~for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH metals)~~ should not exceed 4 weeks.

SA = Semiannual; biennial and semiannual targets high river stage (~~mid-~~May through ~~mid-~~July timeframe) and low river stage (~~mid-~~September through ~~mid-~~November timeframe). The sample event duration ~~for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals)~~ should not exceed 4 weeks.

a. Metals include, but are not limited to, cadmium, calcium, chromium, magnesium, manganese, and sodium.

b. Anions include, but are not limited to, chloride, nitrate, and sulfate.

c. Field parameters include pH, specific conductance, temperature, and turbidity.

d. The screen interval for this well targets the high river stage periods and may be dry during low river periods; sampling at this well will be at high river stage (May through July timeframe).

e. The screen interval for this well targets the low river stage periods; sampling at this well will be at low river stage (~~mid-~~September through ~~mid-~~November timeframe).

~~d~~f. Sample frequency at this PRB monitoring network well, or aquifer tube, will increase to semi-annually after upgradient wells have been treated with apatite-forming chemicals~~Monitoring at these wells/aquifer tubes will begin after the upgradient PRB wells have been treated with apatite-forming chemicals for the PRB~~.

g. Records indicate aquifer tube is missing or broken and has been replaced with new aquifer tube at same location. Original aquifer tube name designation is shown with replacement aquifer tube name for cross reference (i.e., [original aquifer tube name/replacement aquifer tube name]).

h. Aquifer tube is missing and will be assessed if replacement is needed after upgradient wells have been treated with apatite-forming chemicals.

ICP = inductively coupled plasma

PRB = permeable reactive barrier

TPH = total petroleum hydrocarbons

Table A-12. Bioventing Performance Monitoring Sampling and Analysis Schedule

Wells and Aquifer Tubes (14)	Purpose	Unfiltered ICP Metals	Anions	TPH-Diesel, TPH-Gas, TPH Motor Oil, and ~~TPH~~ Oil and Grease	PAH	VOA (BTEX)	Alkalinity	Field Dissolved Oxygen	~~Field Oxidation-Reduction Potential~~	Odor and Sheen[a]	Other Field Parameters [b]
199-N-3	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-19	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-56	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-96A	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-167	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-169	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-171	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-172	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-173	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-183	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
199-N-377	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
C6132	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
C6135	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA
N116mArray-0A	Bioventing	SA	SA	SA	SA	SA	SA	SA	~~SA~~	SA	SA

SA = semiannual; semiannual targets high river stage (~~mid-~~May through ~~mid-~~July timeframe) and low river stage (~~mid-~~September through ~~mid-~~November timeframe). The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

a. Prior to purging the well, a transparent bailer will be used to collect a grab sample to evaluate the presence of sheen.

b. Temperature, pH, specific conductivity, and turbidity.

BTEX = benzene, ethylbenzene, toluene, and xylenes

ICP = inductively coupled plasma

PAH = polycyclic aromatic hydrocarbons

TPH = total petroleum hydrocarbons

VOA = volatile organics analysis

Table A-13. Sr-90 Sampling and Analysis Schedule

Wells and Aquifer Tubes (53)	Purpose	Sr-90	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-2	Sr-90 network	A5	A5	A5	A5	A5
199-N-3	Sr-90 network	A5	A5	A5	A5	A5
199-N-14	Sr-90 network	A5	A5	A5	A5	A5
199-N-21	Sr-90 network	A5	A5	A5	A5	A5
199-N-27	Sr-90 network	A5	A5	A5	A5	A5
199-N-28	Sr-90 network	A5	A5	A5	A5	A5
199-N-32	Sr-90 network	A5	A5	A5	A5	A5
199-N-34	Sr-90 network	A5	A5	A5	A5	A5
199-N-41	Sr-90 network	A5	A5	A5	A5	A5
199-N-46	Sr-90 network	A5	A5	A5	A5	A5
199-N-50	Sr-90 network	A5	A5	A5	A5	A5
199-N-51	Sr-90 network	A5	A5	A5	A5	A5
199-N-57	Sr-90 network	A5	A5	A5	A5	A5
199-N-64	Sr-90 network	A5	A5	A5	A5	A5
199-N-67	Sr-90 network	A5	A5	A5	A5	A5
199-N-74	Sr-90 network	A5	A5	A5	A5	A5
199-N-75	Sr-90 network	A5	A5	A5	A5	A5
199-N-76	Sr-90 network	A5	A5	A5	A5	A5
199-N-81	Sr-90 network	A5	A5	A5	A5	A5
199-N-92A	Sr-90 network	A5	A5	A5	A5	A5
199-N-96A	Sr-90 network	A5	A5	A5	A5	A5
199-N-99A	Sr-90 network	A5	A5	A5	A5	A5
199-N-103A	Sr-90 network	A5	A5	A5	A5	A5

Table A-13. Sr-90 Sampling and Analysis Schedule

Wells and Aquifer Tubes (53)	Purpose	Sr-90	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-104A	Sr-90 network	A5	A5	A5	A5	A5
199-N-105A	Sr-90 network	A5	A5	A5	A5	A5
199-N-122	Sr-90 network	A5	A5	A5	A5	A5
199-N-123	Sr-90 network	A5	A5	A5	A5	A5
199-N-136	Sr-90 network	A5	A5	A5	A5	A5
199-N-146	Sr-90 network	A5	A5	A5	A5	A5
199-N-147	Sr-90 network	A5	A5	A5	A5	A5
199-N-173	Sr-90 network	A5	A5	A5	A5	A5
199-N-182	Sr-90 network	A5	A5	A5	A5	A5
199-N-183	Sr-90 network	A5	A5	A5	A5	A5
199-N-184	Sr-90 network	A5	A5	A5	A5	A5
199-N-185	Sr-90 network	A5	A5	A5	A5	A5
199-N-186	Sr-90 network	A5	A5	A5	A5	A5
199-N-187	Sr-90 network	A5	A5	A5	A5	A5
199-N-188	Sr-90 network	A5	A5	A5	A5	A5
199-N-297	Sr-90 network	A5	A5	A5	A5	A5
199-N-332	Sr-90 network	A5	A5	A5	A5	A5
199-N-347	Sr-90 network	A5	A5	A5	A5	A5
199-N-348	Sr-90 network	A5	A5	A5	A5	A5
199-N-352	Sr-90 network	A5	A5	A5	A5	A5
199-N-353	Sr-90 network	A5	A5	A5	A5	A5
199-N-371	Sr-90 network	~~Q/A5~~A	~~Q/A5~~A	~~Q/A5~~A	~~Q/A5~~A	~~Q/A5~~A
199-N-372	Sr-90 network	A~~Q/A5~~	A~~Q/A5~~	A~~Q/A5~~	A~~Q/A5~~	A~~Q/A5~~

Table A-13. Sr-90 Sampling and Analysis Schedule

Wells and Aquifer Tubes (53)	Purpose	Sr-90	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-373	Sr-90 network	A5	A5	A5	A5	A5
199-N-374	Sr-90 network	~~Q/A5~~SA	SA~~Q/A5~~	SA~~Q/A5~~	SA~~Q/A5~~	SA~~Q/A5~~
199-N-377	Sr-90 network	~~Q/~~A5	~~Q/~~A5	~~Q/~~A5	~~Q/~~A5	~~Q/~~A5
C6317, C6318, C6319*	Sr-90 network	SA	SA	SA	SA	SA
C6320*	Sr-90 network	SA	SA	SA	SA	SA
C7934, C7935, C7936*	Sr-90 network	SA	SA	SA	SA	SA
C7937, C7938, C7939*	Sr-90 network	SA	SA	SA	SA	SA

A = Annual. Sample at low river stage (September through November timeframe). The sample event duration should not exceed 4 weeks.

A5 = Annually every 5 years. Sample ~~in 2015~~ at low river stage (~~mid~~ September through ~~mid~~ November timeframe) ~~and every 5 years thereafter~~. The low river stage sample event duration ~~for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals)~~ should not exceed 4 weeks.

~~Q/A5 = As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and every 5 years thereafter. If, after the first year, contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four consecutive quarters of sampling. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter). Then, the well will be sampled as defined by A5.~~

SA = Semiannual; semiannual targets high river stage (~~mid~~ May through ~~mid~~ July timeframe) and low river stage (~~mid~~ September through ~~mid~~ November timeframe). The sample event duration ~~for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals)~~ should not exceed 4 weeks.

* Sr-90 detected at these locations suggests there may be a continuing source associated with the 1908-N Outfall that is not a part of the larger stable plume. As such, these locations are sampled semiannually.

Table A-14. Nitrate Sampling and Analysis Schedule

Wells (39)	Purpose	Anions	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-2	Nitrate network	A	A	A	A	A
199-N-3	Nitrate network	A	A	A	A	A
199-N-14	Nitrate network	A	A	A	A	A
199-N-19	Nitrate network	A	A	A	A	A
199-N-27	Nitrate network	A	A	A	A	A
199-N-28	Nitrate network	A	A	A	A	A
199-N-32	Nitrate network	A	A	A	A	A
199-N-34	Nitrate network	A	A	A	A	A
199-N-41	Nitrate network	A	A	A	A	A
199-N-46	Nitrate network	A	A	A	A	A
199-N-50	Nitrate network	A	A	A	A	A
199-N-56	Nitrate network	A	A	A	A	A
199-N-57	Nitrate network	A	A	A	A	A
199-N-64	Nitrate network	A	A	A	A	A
199-N-67	Nitrate network	A	A	A	A	A
199-N-71	Nitrate network	A	A	A	A	A
199-N-72	Nitrate network	A	A	A	A	A
199-N-73	Nitrate network	A	A	A	A	A
199-N-74	Nitrate network	A	A	A	A	A
199-N-75	Nitrate network	A	A	A	A	A
199-N-76	Nitrate network	A	A	A	A	A
199-N-77	Nitrate network	A	A	A	A	A
199-N-81	Nitrate network	A	A	A	A	A
199-N-92A	Nitrate network	A	A	A	A	A
199-N-96A	Nitrate network	A	A	A	A	A
199-N-99A	Nitrate network	A	A	A	A	A
199-N-103A	Nitrate network	A	A	A	A	A
199-N-104A	Nitrate network, metals	A	A	A	A	A
199-N-105A	Nitrate network	A	A	A	A	A
199-N-165	Nitrate network	A	A	A	A	A
199-N-167	Nitrate network	A	A	A	A	A
199-N-173	Nitrate network	A	A	A	A	A
199-N-182	Nitrate network	A	A	A	A	A

Table A-14. Nitrate Sampling and Analysis Schedule

Wells (39)	Purpose	Anions	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-183	Nitrate network	A	A	A	A	A
199-N-184	Nitrate network	A	A	A	A	A
199-N-185	Nitrate network	A	A	A	A	A
199-N-186	Nitrate network	A	A	A	A	A
199-N-187	Nitrate network	A	A	A	A	A
199-N-188	Nitrate network	A	A	A	A	A
199-N-347	Nitrate network	A	A	A	A	A
199-N-349	Nitrate network	A	A	A	A	A
199-N-353	Nitrate network	A	A	A	A	A
199-N-372	Nitrate network	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A
199-N-373	Nitrate network	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A
199-N-376	Nitrate network	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A
199-N-377	Nitrate network	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A

A = Annual. Sample in 2015 at low river stage (~~mid-~~September through ~~mid-~~November timeframe) and annually thereafter. The low river stage sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

Q/A = As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four consecutive quarters of sampling. Otherwise, the well will be sampled as defined by A. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

Table A-15. TPH Sampling and Analysis Schedule

Wells (10)	Purpose	TPH-Diesel	TPH-Gas	TPH-Motor Oil	~~TPH-~~Oil and Grease	PAH	VOA (BTEX)	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-3	TPH network	A	A	A	A	A	A	A	A	A	A
199-N-19	TPH network	A	A	A	A	A	A	A	A	A	A
199-N-56	TPH network	A	A	A	A	A	A	A	A	A	A

Table A-15. TPH Sampling and Analysis Schedule

Wells (10)	Purpose	TPH-Diesel	TPH-Gas	TPH-Motor Oil	~~TPH-~~Oil and Grease	PAH	VOA (BTEX)	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-96A	TPH network	A	A	A	A	A	A	A	A	A	A
199-N-167	TPH network	A	A	A	A	A	A	A	A	A	A
199-N-169	TPH network	A	A	A	A	A	A	A	A	A	A
199-N-171	TPH network	A	A	A	A	A	A	A	A	A	A
199-N-173	TPH network	A	A	A	A	A	A	A	A	A	A
199-N-183	TPH network	A	A	A	A	A	A	A	A	A	A
199-N-200	TPH network	A	—	—	—	—	—	A	A	A	A
199-N-201	TPH network	A	—	—	—	—	—	A	A	A	A
199-N-210	TPH network	A	—	—	—	—	—	A	A	A	A
199-N-211	TPH network	A	—	—	—	—	—	A	A	A	A
199-N-346	TPH network	A	A	A	A	— ~~A~~	— ~~A~~	A	A	A	A
199-N-347	TPH network	A	A	A	A	—	—	A	A	A	A
199-N-371	TPH network	A	A	A	A	—	A	A	A	A	A
199-N-373	TPH network	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA
199-N-377	TPH network	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA

A = Annual. Sample ~~in 2015~~ at low river stage (~~mid-~~September through ~~mid-~~November) ~~and annually thereafter~~. The ~~low river stage~~ sample event duration ~~for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals)~~ should not exceed 4 weeks.

~~Q/~~SA = Semiannual; targets high river stage (~~mid-~~May through ~~mid-~~July timeframe) and low river stage (September through November timeframe). The sample event duration should not exceed 4 weeks. ~~As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four consecutive quarters of sampling. Otherwise, the well will be sampled as defined by A. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).~~

PAH = polycyclic aromatic hydrocarbon

TPH = total petroleum hydrocarbons

VOA = volatile organics analysis

Table A-16. Tritium Sampling and Analysis Schedule

Wells and Aquifer Tubes (15)	Purpose	Tritium	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-182	Tritium network	A	A	A	A	A
199-N-184	Tritium network	A	A	A	A	A
199-N-186	Tritium network	A	A	A	A	A
199-N-371	Tritium network	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A
199-N-372	Tritium network	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A	~~Q/~~A
199-N-374	Tritium network	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA	~~Q/~~SA
C6317, C6318, C6319~~[a]~~[*]	Tritium network	SA	SA	SA	SA	SA
C7934, C7935, C7936~~[a]~~[*]	Tritium network	SA	SA	SA	SA	SA
C7937, C7938, C7939~~[a]~~[*]	Tritium network	SA	SA	SA	SA	SA

A = Annual. Sample ~~in 2015~~ at low river stage (~~mid-~~September through ~~mid-~~November timeframe) ~~and annually thereafter~~. The low river stage sample event duration ~~for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals)~~ should not exceed 4 weeks.

~~Q/A = As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four consecutive quarters of sampling. Otherwise, the well will be sampled as defined by A. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).~~

SA = Semiannual; semiannual targets high river stage (~~mid-~~May through ~~mid-~~July timeframe) and low river stage (~~mid-~~September through ~~mid-~~November timeframe). The sample event duration ~~for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals)~~ should not exceed 4 weeks. ~~[a]~~

*. Tritium detected at these locations may be indicative of a continuing source associated with the 1908-N Outfall. As such, these locations are sampled semiannually.

Table A-17. Hexavalent Chromium and Metals Sampling and Analysis Schedule

Wells	Purpose	Filtered and Unfiltered ICP Metals	Filtered Hexavalent Chromium	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-2	Metals network	A	--	A	A	A	A
199-N-3	Metals network	A	--	A	A	A	A
199-N-14	Metals network	A	--	A	A	A	A

Table A-17. Hexavalent Chromium and Metals Sampling and Analysis Schedule

Wells	Purpose	Filtered and Unfiltered ICP Metals	Filtered Hexavalent Chromium	Field pH	Field Temperature	Field Specific Conductance	Field Turbidity
199-N-28	Metals network	A	--	A	A	A	A
199-N-32	Metals network	A	--	A	A	A	A
199-N-34	Metals network	A	--	A	A	A	A
199-N-41	Metals network	A	--	A	A	A	A
199-N-57	Metals network	A	--	A	A	A	A
199-N-64	Metals network	A	--	A	A	A	A
199-N-67	Metals network	A	--	A	A	A	A
199-N-71	Metals network	A	A	A	A	A	A
199-N-72	Metals network	A	--	A	A	A	A
199-N-73	Metals network	A	A	A	A	A	A
199-N-74	Metals network	A	--	A	A	A	A
199-N-77	Metals network	A	--	A	A	A	A
199-N-80	Metals network	A	A	A	A	A	A
199-N-81	Metals network	A	--	A	A	A	A
199-N-92A	Metals network	A	--	A	A	A	A
199-N-96A	Metals network	A	A	A	A	A	A
199-N-105A	Metals network	A	--	A	A	A	A
199-N-146	Metals network	A	--	A	A	A	A
199-N-165	Metals network	A	--	A	A	A	A
199-N-167	Metals network	A	--	A	A	A	A
199-N-173	Metals network	A	--	A	A	A	A
199-N-183	Metals network	A	A	A	A	A	A
199-N-188	Metals network	A	--	A	A	A	A
199-N-353	Metals network	A	--	A	A	A	A

A = Annual. Sample ~~in 2015~~ at low river stage (~~mid-~~September through ~~mid-~~November timeframe)~~, and annually thereafter~~. The low river stage sample event duration ~~for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals)~~ should not exceed 4 weeks.

-- = not required

ICP = inductively coupled plasma

Table A-18. 100-N RCRA Sites Sampling and Analysis Schedule

Wells	Purpose	Chloride	Iron	Manganese	Sodium	Sulfate	Alkalinity	Gross Alpha	Total Organic Carbon	Total Organic Halides	Field pH	Field Specific	Field Turbidity
1324-N/NA (120-N-1, 120-N-2)													
199-N-71	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-72	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-73	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-77	RCRA Monitoring	A	A	A	A	A	A	SA	SA	SA	SA	SA	SA
199-N-165	RCRA Monitoring	A	A	A	A	A	A	SA	S4	S4	S4	S4	SA
1301-N (116-N-1)													
199-N-2	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-3	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-34	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-57	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-105A	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
1325-N (116-N-3)													
199-N-28	RCRA Monitoring	A	A	A	A	A	A	–	SA	SA	SA	SA	SA
199-N-32	RCRA Monitoring	SA	SA	SA	SA	SA	SA	–	S4	S4	S4	S4	SA
199-N-41	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-74	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA
199-N-81	RCRA Monitoring	A	A	A	A	A	A	–	S4	S4	S4	S4	SA

A = Annual, SA = Semi-annual, S4 = Semi-annual with quadruplicate samples. Sampling frequency as summarized from PNNL-13914, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities.*

– = not required

Monitoring locations for PSQ 1 (Figure A-12) were selected based on a judgmental sampling design. The main goal of the monitoring is to determine if the PRB is effective in reducing concentrations of Sr-90 in groundwater downgradient of the barrier and reducing the flux into the Columbia River. Selection of the wells in the apatite barrier well network was based on the extent of Sr-90 contamination, location of the PRB and Columbia River, potential exposure areas near the river shore, and the physical characteristics and behavior of Sr-90 within the aquifer. As such, sample locations were selected within and downgradient of the PRB. Because Sr-90 extends into the river above the drinking water standard of 8 pCi/L, aquifer tubes are also positioned to collect samples along the Columbia River. A semiannual to biannual sample frequency was selected to monitor Sr-90 associated with the PRB (Table A-11). The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

A3.2.1.1.1 Performance Monitoring Objective

The objective of performance monitoring is to determine if the PRB is effective in reducing concentrations of Sr-90. This is determined by comparing Sr-90 or gross beta concentrations from downgradient wells to baseline (pre-injection) values (FH, 2008, "100/300 Area Unit Managers Meeting Minutes"). The performance of the vadose zone PRB will be monitored indirectly by the monitoring network in place for the saturated zone PRB. Sediment cores samples collected in accordance with Insert A2 will determine apatite loading in the vadose zone PRB for sequestration of Sr-90 that would be mobilized in the periodically rewetted vadose zone sediments from seasonal variation in river water elevation. Sequestration of mobilized Sr-90 by the vadose zone PRB would be reflected in further flux reduction of Sr-90 to the river, as measured in the PRB monitoring wells compared to pre-vadose zone jet injections.

The monitoring network may be adjusted and the frequency of sampling may be reduced after 2 years following injection treatments. Any special monitoring for additional barrier emplacement activities (e.g., infiltration) not currently included in the RD/RAWP is beyond the scope of this SAP and will require a revision to this SAP.

Radiological decay is not factored into the baseline concentrations at this time in order to maintain a comparison to monitoring well concentrations for PRB performance. Future modifications to this SAP should consider evaluation of radiological decay with barrier performance monitoring.

Performance monitoring is conducted to compare Sr-90 concentrations downgradient of the barrier to baseline values. Only limited pre-injection data were available from many of the wells in the original segment of the barrier. A geostatistically based approach was implemented to estimate baseline conditions at the injection well locations based on the observed range of concentrations in nearby aquifer tubes. The statistical method is described in PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low Concentration Calcium Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*. Table A-1~~9~~8 lists results for previously treated portions of the PRB up to the year 2008.

Based on previous monitoring data, the PRB is expected to achieve a 90 percent reduction in Sr-90 concentrations in the monitoring wells. Reinjections may be deemed necessary for sections of the groundwater PRB based on the decision flow diagram presented in Figure A-13. The decision flow diagram considers monitoring data collected for the following:

- **Volume of high-concentration Ca-citrate-PO_4 solution injected into each multipurpose well:** Wells that received less than 80 percent of the target volume equivalent to 1.7 mg apatite/g sediment (227,125 L [60,000 gal]) will be considered for potential reinjection.

Table A-1~~9~~8. Mean and 95 Percent Confidence Interval of Pretreatment Sr-90 Concentrations at Injection Wells

Statistic	N-138	N-139	N-140	N-141	N-142	N-143	N-144	N-145	N-136	N-137
Mean	417.09	573.77	627.05	972.25	1,590.10	1,944.96	2,814.61	1,886.27	951.24	1,056.80
95% Confidence Interval Upper	706.51	1,115.39	812.41	1,077.59	1,866.73	2,597.18	3,235.32	2,621.08	1,483.42	2,825.77
95% Confidence Interval Lower	127.66	32.14	441.69	866.91	1,313.48	1,292.74	2,393.89	1,151.47	419.06	-712.16

Reference: PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization* (Table 8).

Note: Well prefixes are "199-" for the wells listed in this table.

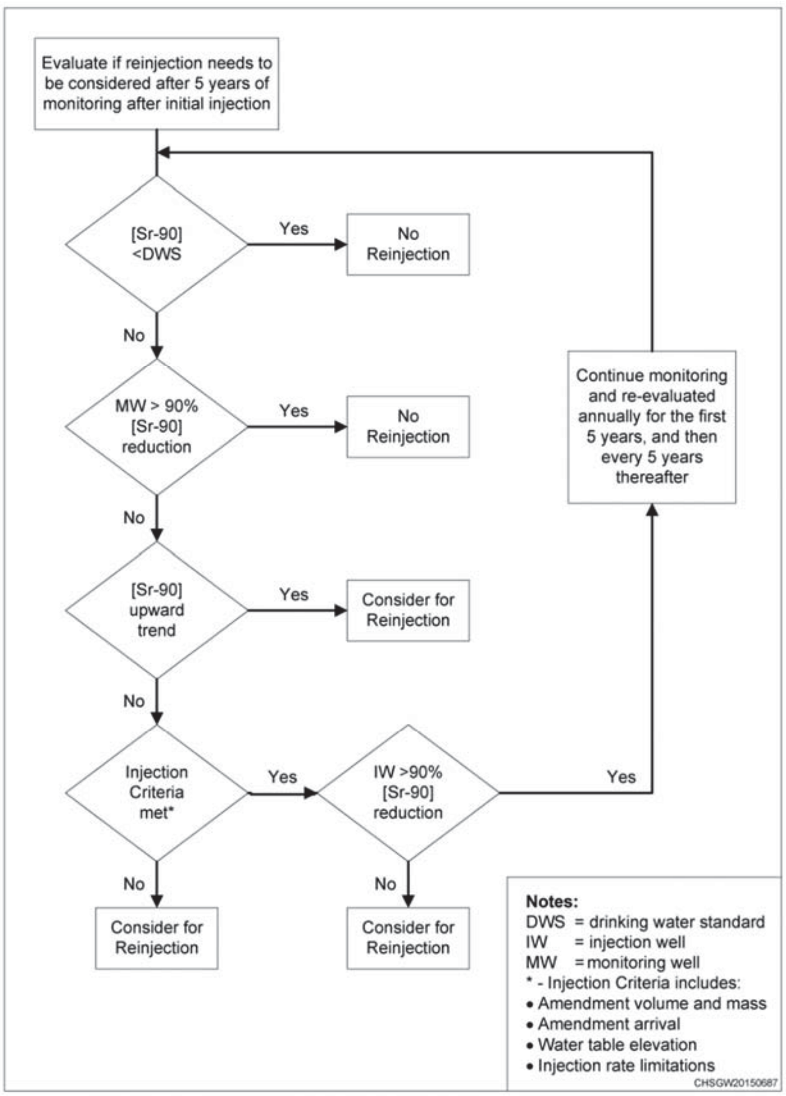


Figure A-13. Reinjection Decision Flow Diagram

~~Monitoring locations for the RCRA sites 1324-N/NA (120-N-1 and 120-N-2), 1301-N (116-N-1), and 1325-N (116-N-3) are shown in Figures A-20, A-21, and A-22, respectively, as defined in the RCRA groundwater monitoring plans (WHC-SD-EN-AP-038 and PNNL-13914). The sample event duration for RCRA groundwater monitoring should not exceed 1 week for each RCRA TSD unit. If the duration of a sampling interval for all monitoring wells for a TSD unit is more than 1 week, RL and Ecology will evaluate if the sample duration is acceptable or if the wells need to resampled. This determination will be based on the information being collected from the samples and potential effect the sampling duration has on the temporal variability of sample results.~~

New long-term groundwater monitoring wells will be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four quarters of sampling. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

Tables A-13, A-14, A-15, A-16, A-17, and A-18 identify the wells and aquifer tubes applicable to PSQ 4. Furthermore, PSQ-1 and PSQ 4 are applicable to Sr-90 sampling in the OU. Differences associated with sampling the apatite barrier (PSQ-1) and Sr-90 (PSQ-4) groundwater monitoring networks can be ascertained from the information provided in Figures A-12 and A-15 and Tables A-11 and A-13. Information from each of these networks will collectively be used to assess the nature and extent of Sr-90 contamination in the 100-NR-2 OU.

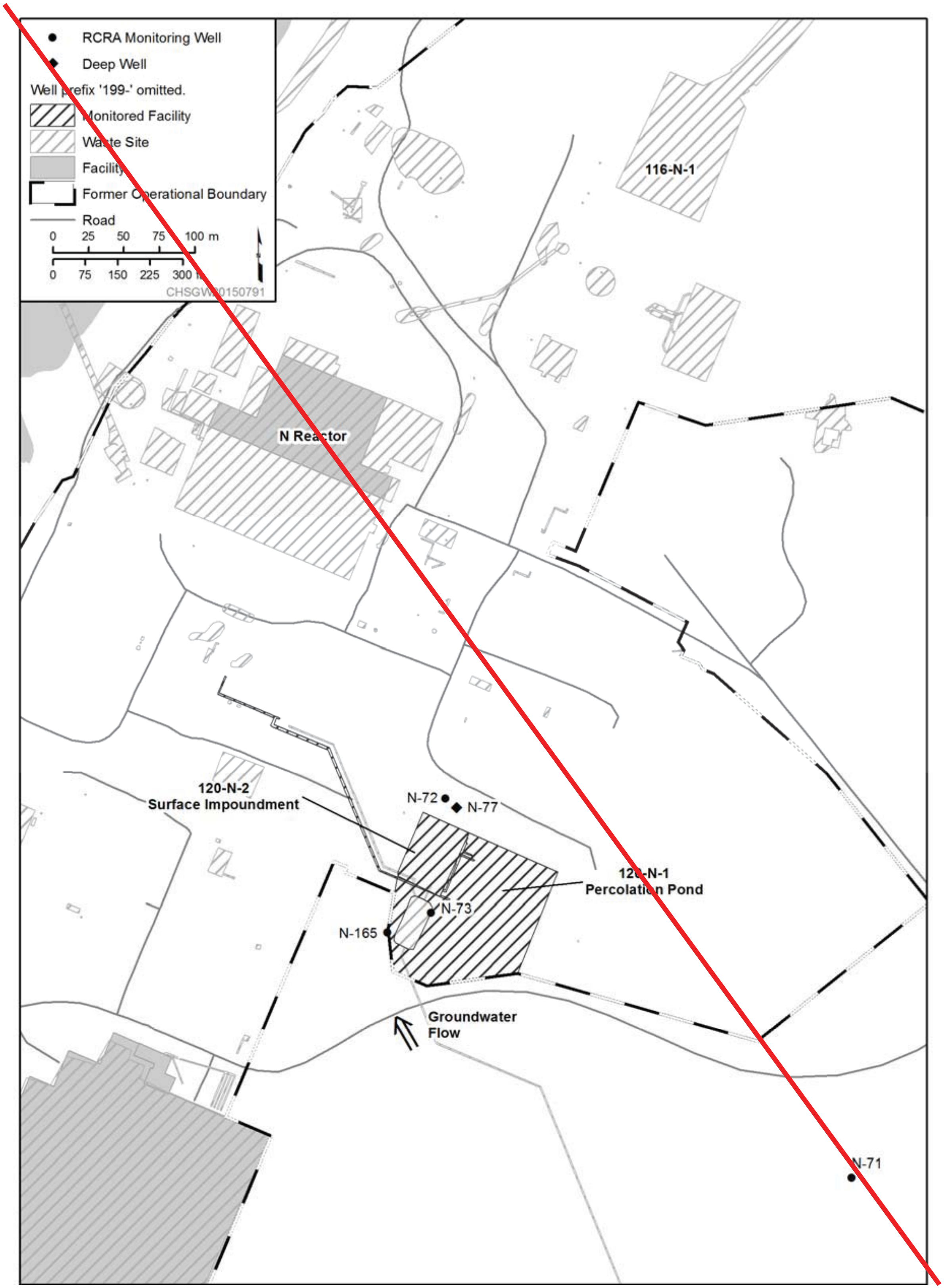
A3.2.1.5 PSQ 5: Is there evidence that Columbia River water quality is being protected?

Monitoring locations to address PSQ 5 were selected based on a judgmental sampling design and shown in Figures A-12, A-142, A-15, A-16, A-17, A-18, and A-19. Wells and aquifer tubes in these networks will be sampled semiannually, annually, and biannually. The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

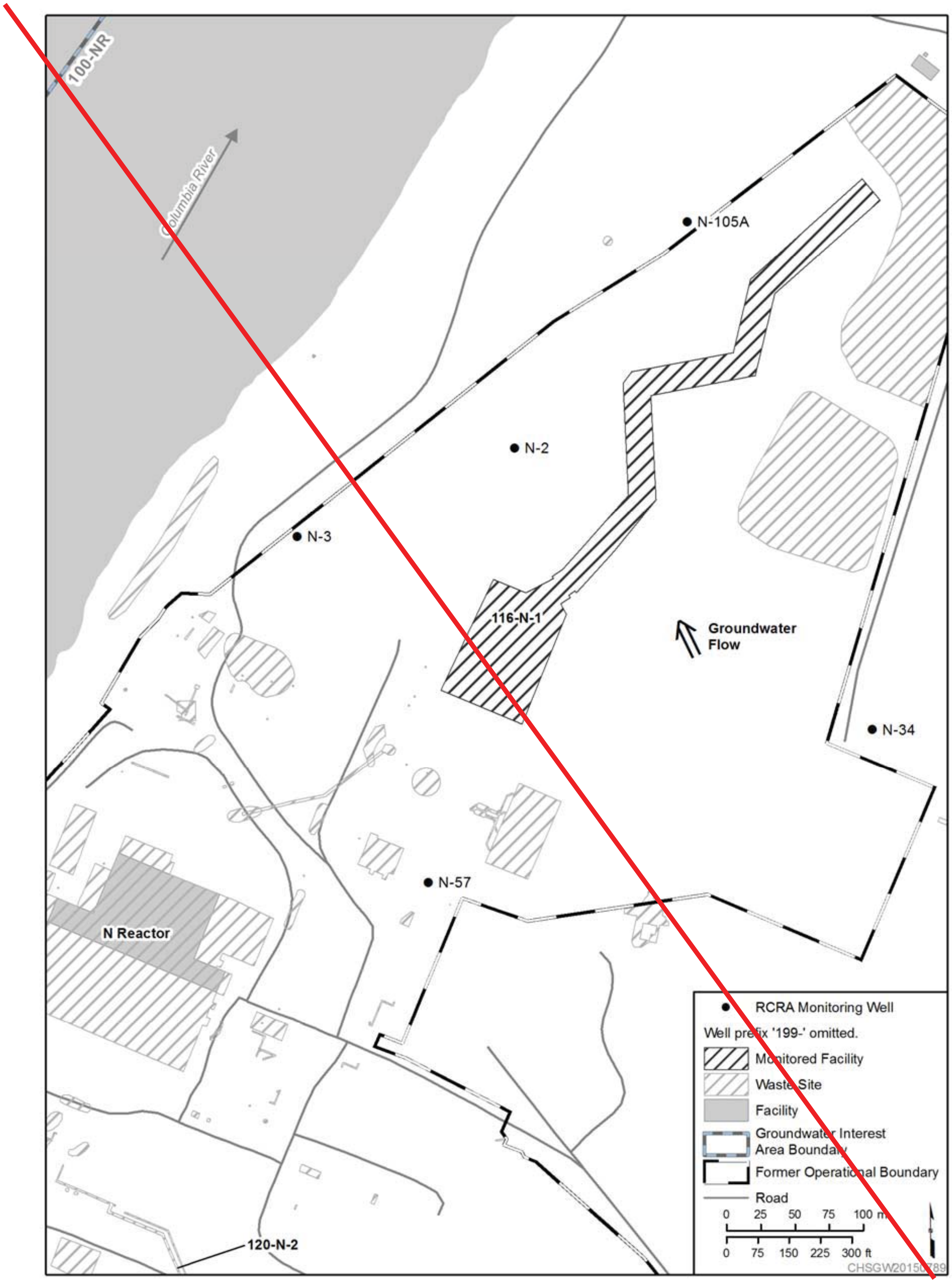
Groundwater wells and aquifer tubes identified in this SAP are positioned along and in the Columbia River. Data from these locations will provide evidence on Columbia River water quality. Inland monitoring wells were also selected away from the Columbia River to track and monitor groundwater plumes on approach to this major discharge area. The goal of the sample design is to collect data on the nature and extent of groundwater contamination as well as releases to the river. As such, wells and aquifer tubes were selected to determine concentrations in areas of known contamination and areas adjacent to contamination. Tables A-11, A-12, A-13, A-14, A-15, A-16, and A-17 identify the wells and aquifer tubes applicable to PSQ 5.

A3.2.1.6 PSQ 6: How do adjacent operable units influence 100-NR-2 remedies?

Groundwater within the 100-NR-2 OU will be monitored for contaminant and hydrologic impacts from the adjacent OUs within the 100-K Area. The sources of these impacts are located upgradient and southwest of the 100-NR-2 Groundwater OU. Contaminant impacts are due to hexavalent chromium that extends across OU boundaries. Hydrogen ion concentrations (pH) associated with 100-KR-2 OU pump and treat operation may also influence 100-NR-2 OU water quality and remedies. The subject areas of hexavalent chromium contamination are shown in Figure A-19 as seven inland hexavalent chromium plumes. Hydrologic impacts are mainly the results of pumping and treating 100-KR-4 groundwater. Impacts to the water table are expressed mainly as radial flow in the vicinity of groundwater Well 199-K-148 (see Figure A-3).



~~Figure A-20. 1324-N/A (120-N-1, 120-N-2) Monitoring Locations for PSQ 4~~



~~Figure A-21. 1301-N (116-N-1) Monitoring Locations for PSQ 4~~

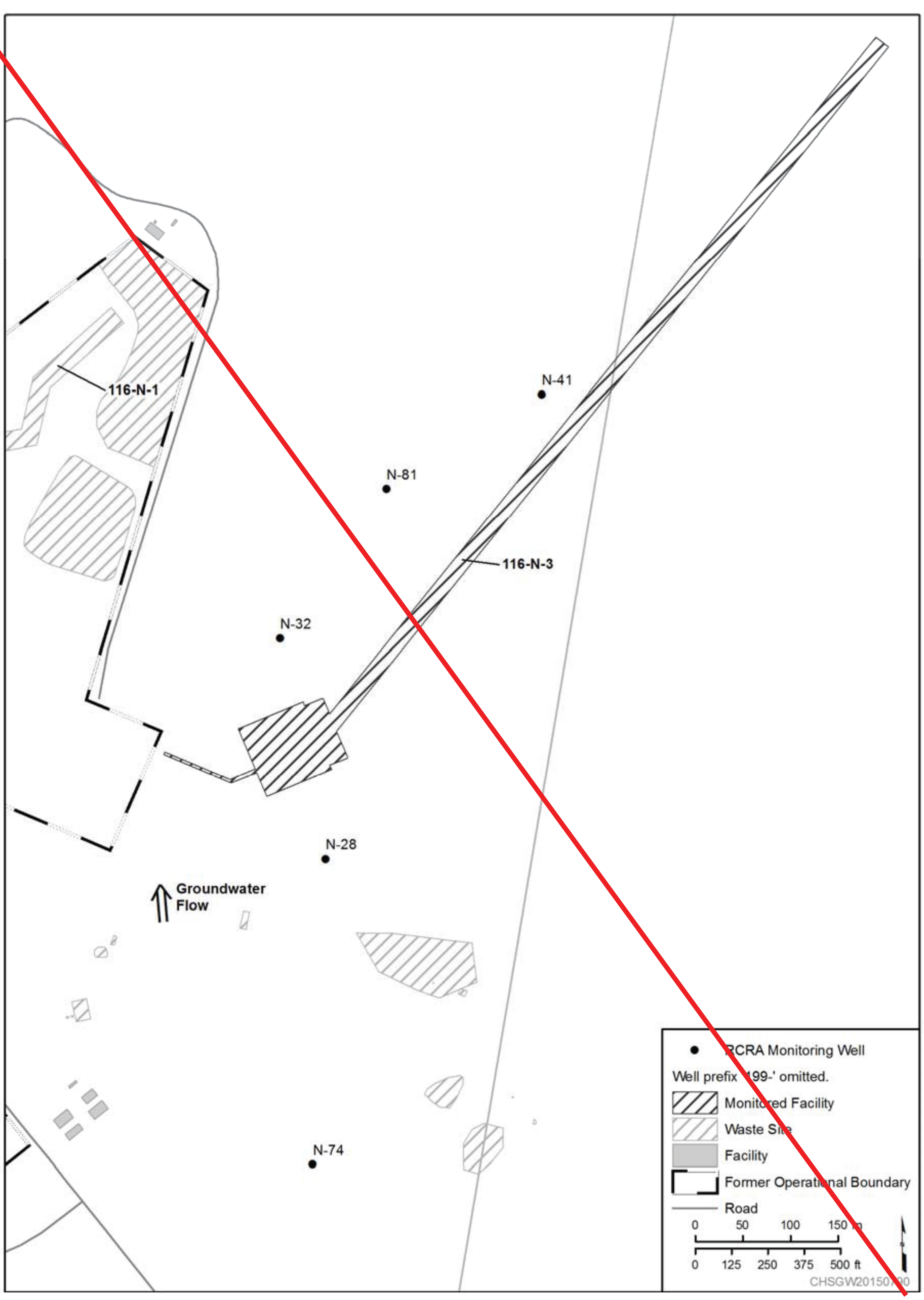


Figure A-22. 1325-N (116-N-3) Monitoring Locations for PSQ 4

Hexavalent chromium; general water quality measurements for pH, temperature, and specific conductivity; and water level monitoring within the boundary of the 100-NR-2 OU (i.e., inland plumes) that is associated with the 100-K Area are addressed in DOE/RL-2013-29. Contaminant migration, geochemical changes (e.g., pH), and groundwater flow will be evaluated in the wells identified in DOE/RL-2013-29 and this SAP to evaluate potential impacts from the 100-K Area on 100-NR-2 OU water quality and remedies. Monitoring locations for PSQ 6 were selected based on a judgmental sampling design and shown in Figures A-15, A-16, A-17, A-18, and A-19. Tables A-13, A-14, A-15, A-16, A-17, and A-1~~9~~8 identify the wells and aquifer tubes applicable to PSQ 6.

A3.2.1.7 PSQ 7: Is there additional information needed for a final ROD?

Characterization of the 100-NR-2 OU will require collection of contaminant and hydrologic data. The data collected will support regulatory decision making and preparation of a ROD. The monitoring networks shown in Figures A-12, A-14, A-15, A-16, A-17, A-18, and A-19 will provide data to address the nature and extent of contamination, elevation changes at the water table (in part), and PSQs identified in this SAP. The DQO summary report (Insert A1) identifies four potential information needs in PSQ 7 that might be required in the final ROD:

- What TPH fractions are present in groundwater?
- Is there evidence to support groundwater contaminant priority changes based on the draft RI/FS?
- Are concentrations of antimony, arsenic, cadmium, chromium (total), cobalt, copper, and manganese below action levels or standards?
- To what extent do seasonal variations in elevation of the water table influence the magnitude and direction of hydraulic gradient in the unconfined aquifer?

The data collected to support the PSQs identified in this SAP will support these potential ROD needs. This is performed by collecting and analyzing samples for the following:

- TPH fractions (TPH-diesel, TPH-gasoline, TPH-motor oil, and ~~TPH-~~oil and grease) as defined in Tables A-12 and A-15.
- The nature and extent of contamination based on contaminants identified in the draft RI/FS (see Table A-1).
- Metal concentrations using inductively coupled plasma analysis. This method will identify more than 20 metals, including arsenic, cadmium, chromium (total), cobalt, and manganese as shown in Table A-6. More than 80 groundwater wells/aquifer will be sampled for metals (see Table A-10).
- Seasonal changes in the elevation of the water table (as described in Section A3.3.4).

Tables A-11, A-12, A-13, A-14, A-15, A-16, and A-17 identify the wells and aquifer tubes applicable to PSQ 7.

A3.3 Sampling Methods

Sampling may include, but is not limited to, the following methods:

- Field screening measurements
- Groundwater sampling
- Water level measurements

A measurement of depth to water is also recorded in each well prior to sampling, using calibrated depth measurement tapes. When two consecutive measurements are taken that agree within 6 mm (0.02 ft), the final determined measurement is recorded along with the date and time for the specific event (e.g., sampling or annual water level measurements). The depth to groundwater is subtracted from the elevation of a reference point (usually the top of casing) to obtain the water level elevation. Tops of casings are known elevation reference points because they have been surveyed to local reference data.

Manual water level measurements will be performed in the wells identified in Tables A-10 through A-~~18~~ 17 during each sampling event. Data will also be collected from the automated water level network wells throughout the year (typically hourly), and manual water level measurements will be performed in the wells in March of each year (Table A-~~20~~19). The proposed automated water level network well locations are identified in Figure A-~~23~~20.

Table A-~~20~~19. 100-NR-2 OU Water Level Monitoring Wells

199-N-2*	199-N-92A*
199-N-3**	199-N-96A
199-N-14**	199-N-99A*
199-N-18	199-N-105A
199-N-19	199-N-106A***
199-N-21***	199-N-119
199-N-27***	199-N-184~~9~~***
199-N-28	699-81-58
199-N-32	699-87-55
199-N-34*	~~199-K-129~~
199-N-41	~~199-K-130~~
199-N-49*	199-K-131*
199-N-50*	199-N-146*
199-N-51***	199-N-147**
199-N-52***	~~199-K-148~~
199-N-56***	~~199-K-149*~~
199-N-57	~~199-K-151~~
199-N-62	~~199-K-152~~
199-N-64***	~~199-K-153~~
199-N-67***	199-K-159
199-N-71*	199-K-160
199-N-72*	~~199-K-164~~

Table A-~~20~~19. 100-NR-2 OU Water Level Monitoring Wells

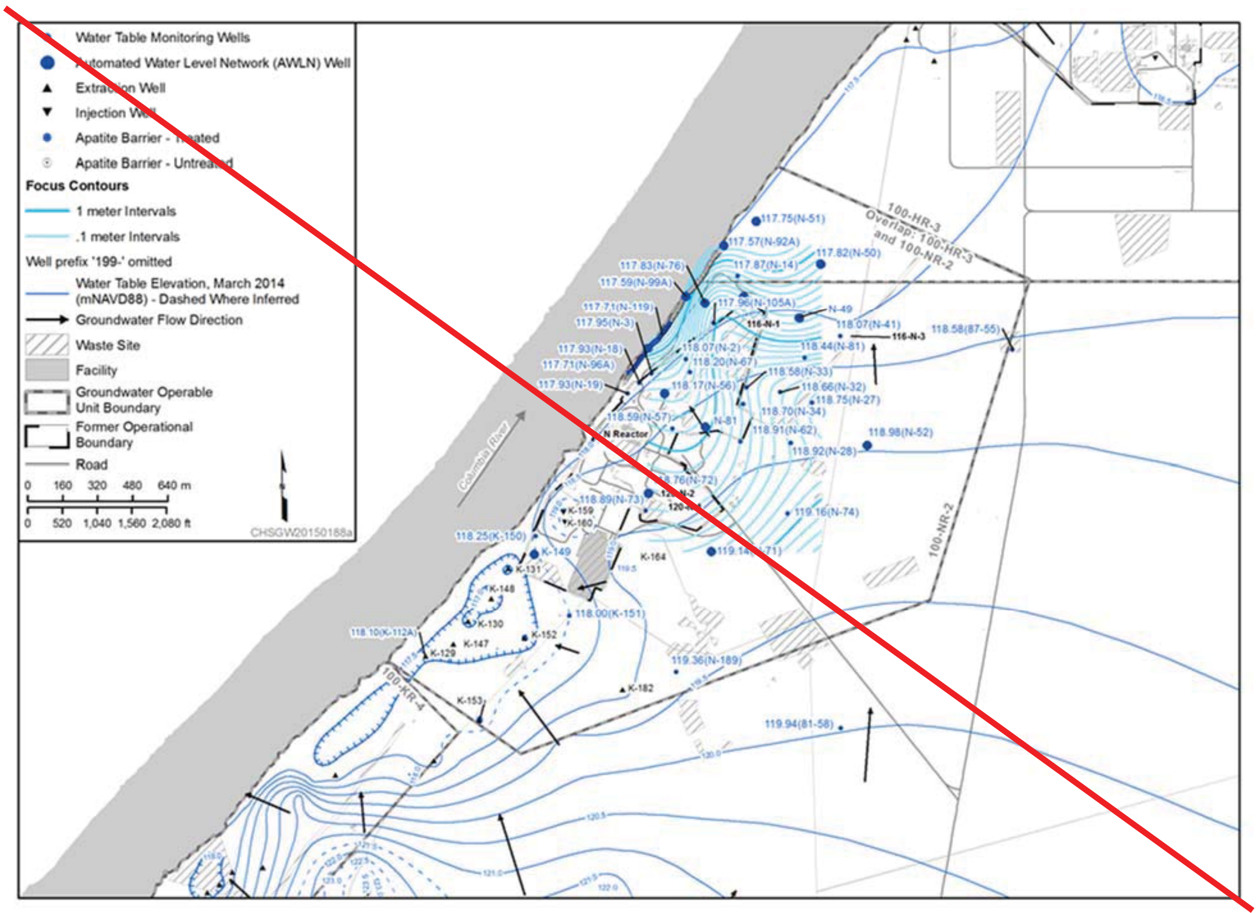
199-N-73	~~199-K-182~~
199-N-76*	~~199-K-189~~
199-N-81***	199-N-77*

* Current AWLN well.

** Current AWLN well but proposed to be removed fromAWLN.

*** Proposed addition to AWLN~~automated water level network wells~~.

AWLN = automated water level network



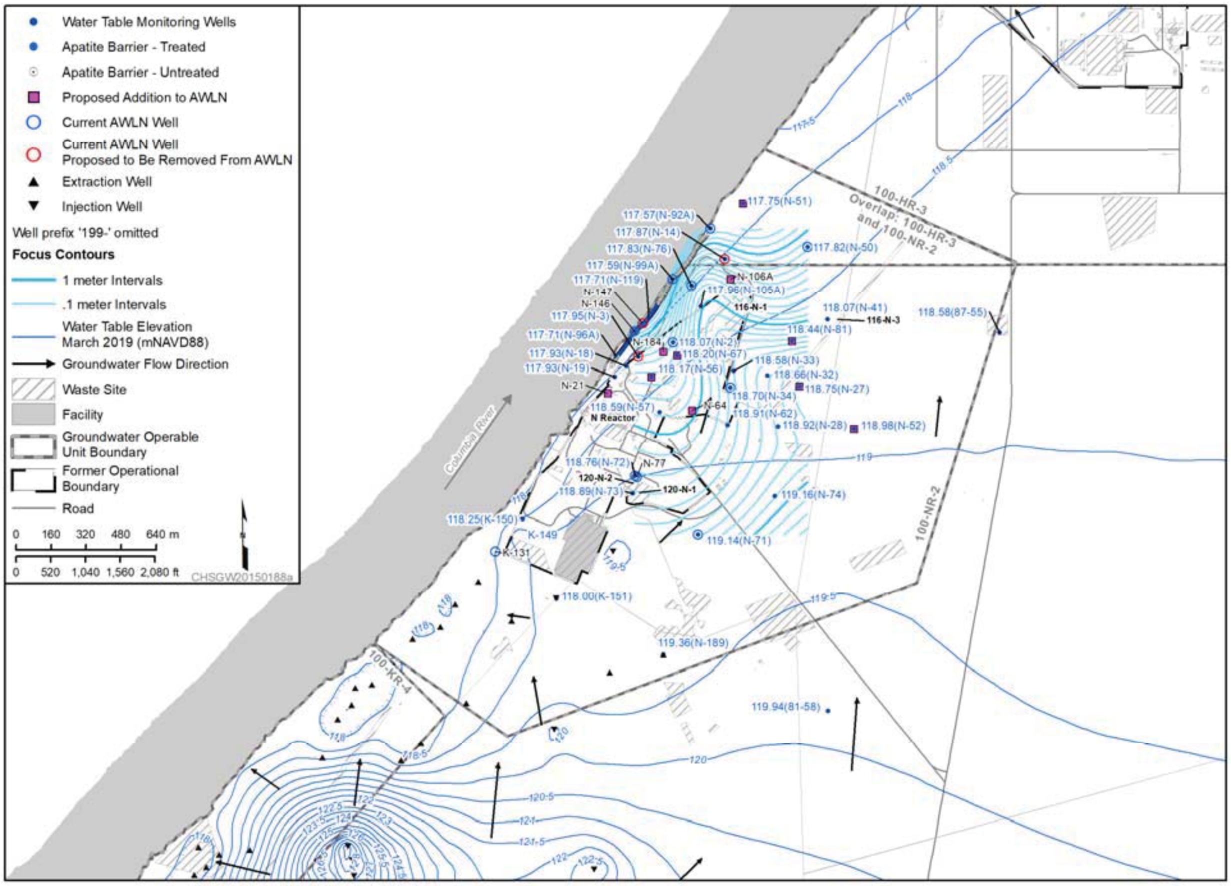


Figure A-~~23~~20. 100-NR-2 Proposed Automated Water Level Network

A3.4 Documentation of Field Activities

Logbooks or data forms are required for field activities. A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the FWS, cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms may be used to collect field information; however, the information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

A summary of information to be recorded in logbooks is as follows:

- Purpose of activity
- Day, date, time, and weather conditions
- Names, titles, and organizations of personnel present

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Table A1-7. 100-NR-2 OU Apatite Barrier Wells

Well Type	Monitoring Location (69)	Network*	Northing	Easting	PRB Network Addresses PSQs	Sample Frequency for PRB	WAC Compliant? (Yes or No)
Aquifer tube	N116mArray-10A	PRB	150158.65	571452.00	1, 3, 4, 5, and 7	SA	No
Aquifer tube	N116mArray-11A	PRB-E	150184.45	571482.06	1, 3, 4, 5, and 7	SA after installation of PRB	No
Aquifer tube	N116mArray-13A	PRB	150264.01	571540.68	1, 3, 4, 5, and 7	SA	No
Aquifer tube	N116mArray-15A	PRB-E	150391.00	571632.00	1, 3, 4, 5, and 7	SA after installation of PRB	No
Aquifer tube	NVP2-116.0	PRB	149944.56	571313.31	1, 3, 4, 5, and 7	SA	No

* The bioventing, Sr-90, nitrate, TPH, tritium, and metals groundwater monitoring networks are shown in Tables A1-8 through A1-13.

Principal study questions (PSQs):

PSQ 1. Is the Sr-90 permeable reactive (apatite) barrier performing as intended?

PSQ 3. Is there evidence of Interim Action Record of Decision contaminant of concern plume, concentration, area, or location changes?

PSQ 4. Are there continuing sources of contamination to groundwater (e.g., Sr-90 and tritium near the 1908-N Outfall)?

PSQ 5. Is there evidence that Columbia River water quality is being protected?

PSQ 7. Is additional information needed for a final record of decision?

A = Annual. Annual sampling targets low river stage (mid-September through mid-November timeframe). The low river stage sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

B = Biennial. Biennial sampling targets high river stage (mid-May through mid-July timeframe) and low river stage (mid-September through mid-November timeframe) every other year. Groundwater wells sampled biennially should be sample during the same year. The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

BV = Bioventing. This network will be sampled and analyzed for alkalinity, anions, unfiltered metals, TPH-D, TPH-G, TPH motor oil, oil and grease, PAH, and VOA (BTEX). Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, turbidity, sheen, and odor. Prior to purging the well, a transparent bailer will be used to collect a grab sample to evaluate the presence of sheen.

Nitrate = Equivalent to anions.

PRB = Existing permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Exception: Wells 199-N-268, 199-N-269, 199-N-280, 199-N-281, 199-N-297, 199-N-298, 199-N-315, 199-N-316, 199-N-332, 199-N-333, 199-N-342, and 199-N-343 are not sampled for TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

PRB-E = Planned extension of permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

Q/A = As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four quarters of sampling. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

SA = Semiannual. Semiannual sampling targets high river stage (mid-May through mid-July timeframe) and low river stage (mid-September through mid-November timeframe) every year. The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

Table A1-8. 100-NR-2 OU Bioventing Groundwater Monitoring Network

Well Type	Monitoring Location (14)	Network	Northing	Easting	BV Network Addresses PSQs	Sample Frequency for BV	WAC Compliant? (Yes or No)
Aquifer Tube	N116mArray-0A	BV, PRB-E	149776.00	571169.00	2, 3, 4, 5, and 7	SA	No

Principal study questions (PSQs):

PSQ 1. Is the Sr-90 permeable reactive (apatite) barrier performing as intended?

PSQ 2. Is there evidence of Interim Action Record of Decision contaminant of concern plume, concentration, area, or location changes?

PSQ 3. Is there evidence of Interim Action Record of Decision contaminant of concern plume, concentration, area, or location changes?

PSQ 4. Are there continuing sources of contamination to groundwater (e.g., Sr-90 and tritium near the 1908-N Outfall)?

PSQ 5. Is there evidence that Columbia River water quality is being protected?

PSQ 7. Is additional information needed for a final record of decision?

BV = Bioventing. This network will be sampled and analyzed for alkalinity, anions, unfiltered metals, TPH-D, TPH-G, TPH motor oil, oil and grease, PAH, and VOA (BTEX). Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, turbidity, sheen, and odor. Prior to purging the well, a transparent bailer and/or electronic oil water interface probe will be used to collect a grab sample to evaluate the presence of sheen.

Nitrate = Equivalent to anions

PRB = Existing permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Exception: Wells 199-N-268, 199-N-269, 199-N-280, 199-N-281, 199-N-297, 199-N-298, 199-N-315, 199-N-316, 199-N-332, 199-N-333, 199-N-342, and 199-N-343 are not sampled for TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

PRB-E = Planned extension of permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

SA = Semiannual. Semiannual sampling targets high river stage (mid-May through mid-July timeframe) and low river stage (mid-September through mid-November timeframe) every year. The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

BTEX = benzene, toluene, ethylbenzene, and xylene

PAH = polycyclic aromatic hydrocarbons

TPH-D = total petroleum hydrocarbons-diesel

TPH-G = total petroleum hydrocarbons-gasoline

VOA = volatile organic analysis

WAC = *Washington Administrative Code*

Table A1-9. 100-NR-2 Strontium-90 Groundwater Monitoring Network

Well Type	Monitoring Location (53)	Network	Northing	Easting	Sr-90 Network Addresses PSQs	Sample Frequency for Sr-90	WAC Compliant? (Yes or No)

PSQ 2. Is there evidence of Interim Action Record of Decision contaminant of concern plume, concentration, area, or location changes?

PSQ 4. Are there continuing sources of contamination to groundwater (e.g., Sr-90 and tritium near the 1908-N Outfall)?

PSQ 5. Is there evidence that Columbia River water quality is being protected?

PSQ 7. Is additional information needed for a final record of decision?

A5 = Annually every 5 years. Sample in 2015 at low river stage (mid-September through mid-November timeframe) and every 5 years thereafter. The low river stage sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

BV = Bioventing. This network will be sampled and analyzed for alkalinity, anions, unfiltered metals, TPH-D, TPH-G, TPH motor oil, oil and grease, PAH, and VOA (BTEX). Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, turbidity, sheen, and odor. Prior to purging the well, a transparent bailer and/or electronic oil water interface probe will be used to collect a grab sample to evaluate the presence of sheen.

PRB = Existing permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Exception: Wells 199-N-268, 199-N-269, 199-N-280, 199-N-281, 199-N-297, 199-N-298, 199-N-315, 199-N-316, 199-N-332, 199-N-333, 199-N-342, and 199-N-343 are not sampled for TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

PRB-E = Planned extension of permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

Q/A5 = As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four quarters of sampling. Otherwise, the well will be sample as defined by A5. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

SA = Semiannual. Semiannual sampling targets high river stage (mid-May through mid-July timeframe) and low river stage (mid-September through mid-November timeframe) every year. The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

BTEX = benzene, toluene, ethylbenzene, and xylene

PAH = polycyclic aromatic hydrocarbons

PAH = polycyclic aromatic hydrocarbons

TPH-D = total petroleum hydrocarbons-diesel

TPH-G = total petroleum hydrocarbons-gasoline

WAC = *Washington Administrative Code*

Table A1-10. 100-NR-2 Nitrate Groundwater Monitoring Network

Well Type	Monitoring Location (39)	Network	Northing	Easting	Nitrate Network Addresses PSQs	Sample Frequency for Nitrate	WAC Compliant? (Yes or No)
Unconfined	199-N-353	Nitrate, PRB, Sr-90, metals	150031.62	571403.29	3, 4, 5, and 7	A	Yes
Planned unconfined	199-N-372	Nitrate, Sr-90, tritium	149502.95	571100.16	3, 4, 5, and 7	Q/A	Yes
Planned unconfined	199-N-373	Nitrate, TPH	149442.00	571276.00	3, 4, 5, and 7	Q/A	Yes
Planned deep unconfined	199-N-376	Nitrate	149338.62	571141.08	3, 4, 5, and 7	Q/A	Yes
Planned unconfined	199-N-377	Nitrate, BV, TPH, Sr-90	149678.00	571278.00	3, 4, 5, and 7	Q/A	Yes

Principal study questions (PSQs):

PSQ 3. Is there evidence of Interim Action Record of Decision contaminant of concern plume, concentration, area, or location changes?

PSQ 4. Are there increasing concentrations in groundwater indicating newly identified or continuing sources of contamination to groundwater (e.g., Sr-90 and tritium near the 1908-N Outfall)?

PSQ 5. Is there evidence that Columbia River water quality is being protected?

PSQ 7. Is additional information needed for a final record of decision?

A= Sample in 2015 at low river stage (mid-September through mid-November timeframe) and annually thereafter. The low river stage sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

BV = Bioventing. This network will be sampled and analyzed for alkalinity, anions, unfiltered metals, TPH-D, TPH-G, TPH motor oil, oil and grease, PAH, and VOA (BTEX). Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, turbidity, sheen, and odor. Prior to purging the well, a transparent bailer and/or electronic oil water interface probe will be used to collect a grab sample to evaluate the presence of sheen.

PRB = Existing permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Exception: Wells 199-N-268, 199-N-269, 199-N-280, 199-N-281, 199-N-297, 199-N-298, 199-N-315, 199-N-316, 199-N-332, 199-N-333, 199-N-342, and 199-N-343 are not sampled for TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

PRB-E = Planned extension of permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

Q/A = As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four quarters of sampling. Otherwise, the well will be sample as defined by A. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

BTEX = benzene, toluene, ethylbenzene, and xylene
PAH = polycyclic aromatic hydrocarbons
PAH = polycyclic aromatic hydrocarbons
TPH-D = total petroleum hydrocarbons-diesel
TPH-G = total petroleum hydrocarbons-gasoline
WAC = *Washington Administrative Code*

Table A1-11. 100-NR-2 TPH Groundwater Monitoring Network

Well Type	Monitoring Location (10)	Network	Northing	Easting	TPH Network Addresses PSQs	Sample Frequency for TPH	WAC Compliant? (Yes or No)
Unconfined	199-N-183	TPH, Sr-90, BV, nitrate, metals, Cr+6	149756.01	571269.69	3, 4, 5, and 7	A	Yes
Unconfined	199-N-346	TPH, PRB-E	149780.23	571203.32	3, 4, 5, and 7	A	Yes
Planned unconfined	199-N-373	TPH, nitrate	149442.00	571276.00	3, 4, 5, and 7	Q/A	Yes*
Planned unconfined	199-N-377	TPH, BV, nitrate, Sr-90	149678.00	571278.00	3, 4, 5, and 7	Q/A	Yes

* If TPH is not detected during the initial sampling event, sampling for TPH will be discontinued.

Principal study questions (PSQs):

PSQ 3. Is there evidence of Interim Action Record of Decision contaminant of concern plume, concentration, area, or location changes?

PSQ 4. Are there increasing concentrations in groundwater indicating newly identified or continuing sources of contamination to groundwater (e.g., Sr-90 and tritium near the 1908-N Outfall)?

PSQ 5. Is there evidence that Columbia River water quality is being protected?

PSQ 7. Is additional information needed for a final record of decision?

A = Annual. Annual sampling targets low river stage (mid-September through mid-November timeframe). The low river stage sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

BV = Bioventing. This network will be sampled and analyzed for alkalinity, anions, unfiltered metals, TPH-D, TPH-G, TPH motor oil, oil and grease, PAH, and VOA (BTEX). Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, turbidity, sheen, and odor. Prior to purging the well, a transparent bailer and/or electronic oil water interface probe will be used to collect a grab sample to evaluate the presence of sheen.

Q/A = As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four quarters of sampling. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

PRB = Existing permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Exception: Wells 199-N-268, 199-N-269, 199-N-280, 199-N-281, 199-N-297, 199-N-298, 199-N-315, 199-N-316, 199-N-332, 199-N-333, 199-N-342, and 199-N-343 are not sampled for TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

PRB-E = Planned extension of permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

BTEX = benzene, toluene, ethylbenzene, and xylene

PAH = polycyclic aromatic hydrocarbons

TPH-D = total petroleum hydrocarbons-diesel

TPH-G = total petroleum hydrocarbons-gasoline

WAC = *Washington Administrative Code*

Table A1-13. 100-NR-2 Hexavalent Chromium and Metals Groundwater Monitoring Network of 12 Wells

Well Type	Monitoring Location	Network	Northing	Easting	Cr(VI)/Metals Network Addresses PSQs	Sample Frequency for Metals	WAC Compliant? (Yes or No)
Unconfined	199-N-173	Metals, PRB, BV, nitrate, TPH, Sr-90	149759.67	571193.02	3, 4, 5, 6, and 7	A	Yes
Unconfined	199-N-183	Cr(VI), metals, BV, nitrate, TPH, Sr-90	149756.01	571269.69	3, 4, 5, 6, and 7	A	Yes
Unconfined	199-N-188	Metals, nitrate, Sr-90	149581.53	571906.94	3, 4, 5, 6, and 7	A	Yes
Unconfined	199-N-353	Metals, PRB, Sr-90, nitrate	150031.62	571403.29	3, 4, 5, 6, and 7	A	Yes

Principal study questions (PSQs):

PSQ 3. Is there evidence of Interim Action Record of Decision contaminant of concern plume, concentration, area, or location changes?

PSQ 4. Are there increasing concentrations in groundwater indicating newly identified or continuing sources of contamination to groundwater (e.g., Sr-90 and tritium near the 1908-N Outfall)?

PSQ 5. Is there evidence that Columbia River water quality is being protected?

PSQ 6. How do adjacent operable units influence 100-NR-2 Operable Unit remedies?

PSQ 7. Is additional information needed for a final record of decision?

A = Annual. Annual sampling targets low river stage (mid-September through mid-November timeframe). The low river stage sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

BV = Bioventing. This network will be sampled and analyzed for alkalinity, anions, unfiltered metals, TPH-D, TPH-G, TPH motor oil, oil and grease, PAH, and VOA (BTEX). Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, turbidity, sheen, and odor. Prior to purging the well, a transparent bailer and/or electronic oil water interface probe will be used to collect a grab sample to evaluate the presence of sheen.

PRB = Existing permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Exception: Wells 199-N-268, 199-N-269, 199-N-280, 199-N-281, 199-N-297, 199-N-298, 199-N-315, 199-N-316, 199-N-332, 199-N-333, 199-N-342, and 199-N-343 are not sampled for TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

BTEX = benzene, toluene, ethylbenzene, and xylene

PAH = polycyclic aromatic hydrocarbons

PRB = permeable reactive barrier

TPH-D = total petroleum hydrocarbons-diesel

TPH-G = total petroleum hydrocarbons-gasoline

WAC = *Washington Administrative Code*

A1.8.3.3.8 Water Level Monitoring

- Assumptions
  - Automated water level, river gauge and manual measurements will be collected within the 100-NR-2 OU.
  - Water level monitoring will be performed in the wells identified in Table A1-6.
  - Water level monitoring will also be performed during the sampling event at each monitoring well.
  - Monitoring will be performed once in March for certain wells identified in SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project.*

A1.8.3.4 Additional Data from New Wells

- Geologic samples
- Sediment (soil) samples for analytical evaluation of COPCs
- Aquifer properties (slug tests)
- Other data as defined by new well drilling sampling plan.

A1.8.3.5 Use of Old Wells

- Evaluate pre-WAC wells for suitability (e.g., review documentation where available, perform camera surveys, borehole geophysics, field inspections) as needed.

Rehabilitate wells as appropriate (e.g., routine maintenance)

A1.8.3.6 Analytes (include in matrix summaries above)

- COCs specific to each location (see Tables A1-7 through A1-13)
- COPCs in wells that had detections in the past (information in the Groundwater Annual Report)
- Field parameters (specific conductance, pH, turbidity, temperature, dissolved oxygen, ~~oxidation-reduction potential,~~ sheen/odor)

A1.8.3.7 Sampling Frequency

Sample frequency defines the number of sampling events planned over a given time period. The sample frequencies identified for the 100-NR-2 OU are as follows: annual (once a year), semiannual (two times per year), quarterly (four times a year), and annually every 5 years (once every 5 years). On the Hanford Site, the groundwater sampling frequency has historically been defined as semiannual along the river to account for seasonal changes in the water table due to Columbia River stage.

Determination of sample frequency is guided by the goals of the monitoring program, quality and quantity of the available data, the hydrology of the aquifer system, and the CSM. These considerations are discussed briefly in this section. Justification for the selected sample frequency is also provided at the end of this section for the 100-NR-2 OU groundwater monitoring networks.

The basic goals of the 100-NR-2 OU groundwater monitoring program are threefold:

1. Determine the effectiveness of two remedial alternatives (i.e., performance monitoring systems) to reduce Sr-90 and TPH concentrations.

2. Collect data to monitor changes relative to the documented concentrations and the extent of Sr-90, tritium, nitrate, TPH, and hexavalent chromium contamination.

3. Collect data to reduce uncertainty about concentrations of antimony, cadmium, and cobalt in groundwater

Table A1-16. Groundwater Monitoring Wells and Aquifer Tubes in the 100-NR-2 Network

Well Type	123 Monitoring Locations	Network	Northing	Easting	Sample Frequency	WAC Compliant? (Yes or No)	Justification

B = Biennial. Biennial sampling targets high river stage (mid-May through mid-July timeframe) and low river stage (mid-September through mid-November timeframe) every other year. Groundwater wells sampled biennially should be sampled during the same year. The 100-NR-2 OU sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

BV = Bioventing. This network will be sampled and analyzed for alkalinity, anions, unfiltered metals, TPH-D, TPH-G, TPH motor oil, oil and grease, PAH, and VOA (BTEX). Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, turbidity, and sheen and odor. Prior to purging the well, a transparent bailer will be used to collect a grab sample to evaluate the presence of sheen.

PRB = Existing permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH-D. Exception: 199-N-268, 199-N-269, 199-N-280, 199-N-281, 199-N-297, 199-N-298, 199-N-315, 199-N-316, 199-N-332, 199-N-333, 199-N-342 and 199-N-343 are not sampled for TPH-D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

PRB-E = Planned extension of permeable reactive barrier. This network is sampled and analyzed for anions, gross alpha, gross beta, unfiltered and filtered metals, Sr-90, and TPH D. Field methods include dissolved oxygen, ~~oxidation-reduction potential,~~ pH, conductivity, temperature, and turbidity.

Q/A = As a general rule, new long-term groundwater monitoring wells should be sampled quarterly for the first year and annually thereafter. If after the first year contaminant trends indicate concentrations are increasing, quarterly sampling will continue until the contaminant trends remain steady or decrease over four quarters of sampling. Quarterly sampling should also be performed during the same timeframe as other sampling events (low-high river stage) as applicable, but should not be performed back to back (i.e., last day of the first quarter and first day of the second quarter).

SA= Semiannual. Semiannual sampling targets high river stage (mid-May through mid-July timeframe) and low river stage (mid-September through mid-November timeframe) every year. The sample event duration for all networks (apatite barrier, bioventing, Sr-90, nitrate, TPH, tritium, metals) should not exceed 4 weeks.

Metal analysis should be performed on unfiltered and filtered samples.

BTEX = benzene, toluene, ethylbenzene, and xylene
DWS = drinking water standard
Nitrate = equivalent to anions
PAH = polycyclic aromatic hydrocarbons
PSQ = principal study question
TPH-D = total petroleum hydrocarbons-diesel
TPH-G = total petroleum hydrocarbons-gasoline
VOA = volatile organic analysis
WAC = *Washington Administrative Code*

1

Table A2-2. Saturated Zone Injection Monitoring Points

Well Name	Well Type	Well Name	Well Type
199-N-96A	MW	199-N-281	IW[a]
199-N-99A	MW	199-N-282	IW[a]
199-N-185	MW	199-N-283	IW[a]
199-N-354	MW	199-N-284	IW[a]
199-N-355	MW	199-N-287	IW[a]
199-N-356	MW	199-N-288	IW[a]
199-N-357	MW	199-N-289	IW[a]
199-N-358	MW	199-N-290	IW[a]
199-N-359	MW	199-N-293	IW[a]
199-N-360	MW	199-N-294	IW[a]
199-N-361	MW	199-N-295	IW[a]
199-N-362	MW	199-N-296	IW[a]
199-N-363	MW	199-N-299	IW[a]
199-N-364	MW	199-N-300	IW[a]
199-N-365	MW	199-N-301	IW[a]
199-N-366	MW	199-N-302	IW[a]
199-N-367	MW	199-N-305	IW[a]
199-N-200	IW[a]	199-N-306	IW[a]
199-N-201	IW[a]	199-N-307	IW[a]
199-N-202	IW[a]	199-N-308	IW[a]
199-N-203	IW[a]	199-N-311	IW[a]
199-N-208	IW[a]	199-N-312	IW[a]
199-N-209	IW[a]	199-N-313	IW[a]
199-N-210	IW[a]	199-N-314	IW[a]
199-N-211	IW[a]	199-N-317	IW[a]
199-N-212	IW[a]	199-N-318	IW[a]
199-N-257	IW[a]	N116mArray-0A	AT
199-N-258	IW[a]	N116mArray-8.5A[b]/C9590	AT
199-N-263	IW[a]	N116mArray-9A	AT
199-N-264	IW[a]	N116mArray-10A	AT

Table A2-2. Saturated Zone Injection Monitoring Points

Well Name	Well Type	Well Name	Well Type
199-N-265	IW[a]	N116mArray-11A	AT
199-N-266	IW[a]	N116mArray-12A[b]/C9589	AT
199-N-269	IW[a]	N116mArray-13A[b]/C9587	AT
199-N-270	IW[a]	C6324	AT
199-N-271	IW[a]	N116mArray-15A	AT
199-N-272	IW[a]	N116mArray-16A	AT
199-N-275	IW[a]	N116mArray-16A	AT
199-N-276	IW[a]	N116mArray-16A	AT
C6135	AT	N116mArray-14A[b]/C9588	AT
C6136[b]/C9586	AT		

a. Identified IW for monitoring may be adjusted based on injection sequence to ensure that IWs adjacent to wells being injected are monitored.

b. Records indicate ~~these~~ aquifer tubes ~~may be~~is missing or broken and has been replaced with new aquifer tube at same location. ~~Replacements, if available, may need to be identified or repairs may need to be completed~~ Original aquifer tube name designation is shown with replacement aquifer tube name for cross reference (i.e., [original aquifer tube name/replacement aquifer tube name]).

AT = aquifer tube

IW = injection well

MW = monitoring well

Table A2-3. Approximate Saturated Zone Injection Sampling Locations and Frequency

Sample Purpose	Sampling Locations	Approximate Sampling Frequency	Analytes
Baseline sampling	Monitoring wells and aquifer tubes downgradient of wells to be injected	One time prior to injections. Available sample results may be used if well/aquifer tube has previously been sampled as part of PRB monitoring.	Cations, anions, Sr-90, gross beta, TPH-diesel,[b] and field parameters[c]
Injection monitoring	Injection stream from injection skid	Field parameters every 4 hours, aqueous samples daily.	Cations, anions, and field parameters[c]
Injection arrival monitoring[a]	Downgradient monitoring wells/ aquifer tubes	Field parameters continuously in situ from wells, aqueous samples at the end of each injection series from both wells and aquifer tubes (upriver and downriver).	Cations, anions, Sr-90, gross beta, TPH-diesel,[b] and field parameters[c]
Short-term performance monitoring	Nearby monitoring wells/aquifer tubes	Two and 4 weeks after the end of each injection series (upriver and downriver) and then quarterly for the first year after injections.	Cations, anions, Sr-90, gross beta, TPH-diesel,[b] and field parameters[c]

Table A2-4. Apatite Barrier Pre-Injection, Injection, and First Year Post-Injection Sampling Schedule and Constituents

Well	Purpose	ICP Metals[a]			Anions[b]			TPH-Diesel			Gross Alpha			Gross Beta			Sr-90			Field DO			Field ORP			Other Field Parameters[c]		
		Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]
199-N-122	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-~~O~~	-~~SA~~	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-123	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-~~O~~	-~~SA~~	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-146	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-~~O~~	-~~SA~~	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-147	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-~~O~~	-~~SA~~	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-173	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	O	SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-136	Injection well[d]	-	-	SA~~B~~	-	-	SA~~B~~	-	-	-~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~
199-N-159	Injection well[d]	-	-	SA~~B~~	-	-	SA~~B~~	-	-	-~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~
199-N-200	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	O[f]	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	O	SA~~B~~
199-N-201	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	O[f]	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	O	SA~~B~~
199-N-202	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-203	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-208	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-209	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-210	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	O[f]	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	O	SA~~B~~
199-N-211	Injection well[d]	-	-	SA~~B~~	-	O[f]	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	O	SA~~B~~
199-N-212	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-229	Injection well[d]	-	-	SA~~B~~	-	-	SA~~B~~	-	-	-~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~

Table A2-4. Apatite Barrier Pre-Injection, Injection, and First Year Post-Injection Sampling Schedule and Constituents

Well	Purpose	ICP Metals[a]			Anions[b]			TPH-Diesel			Gross Alpha			Gross Beta			Sr-90			Field DO			Field ORP			Other Field Parameters[c]		
		Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]
199-N-230	Injection well[d]	-	-	SA~~B~~	-	-	SA~~B~~	-	-	-~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~
199-N-247	Injection well[d]	-	-	SA~~B~~	-	-	SA~~B~~	-	-	-~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~
199-N-248	Injection well[d]	-	-	SA~~B~~	-	-	SA~~B~~	-	-	-~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~	-	-	SA~~B~~
199-N-257	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-258	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-263	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-264	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-265	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-266	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-268	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~
199-N-269	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	O[f]	SA~~B~~	A5~~B~~	-	-~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	O	SA~~B~~
199-N-270	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-271	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-272	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-275	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-276	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-277	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-

Table A2-4. Apatite Barrier Pre-Injection, Injection, and First Year Post-Injection Sampling Schedule and Constituents

Well	Purpose	ICP Metals[a]			Anions[b]			TPH-Diesel			Gross Alpha			Gross Beta			Sr-90			Field DO			Field ORP			Other Field Parameters[c]		
		Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]
199-N-278	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-280	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~
199-N-281	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	O[f]	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	O	SA~~B~~
199-N-282	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-283	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-284	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-287	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-288	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-289	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-290	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-293	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-294	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-295	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-296	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-297	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~
199-N-298	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~
199-N-299	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-

Table A2-4. Apatite Barrier Pre-Injection, Injection, and First Year Post-Injection Sampling Schedule and Constituents

Well	Purpose	ICP Metals[a]			Anions[b]			TPH-Diesel			Gross Alpha			Gross Beta			Sr-90			Field DO			Field ORP			Other Field Parameters[c]		
		Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]
199-N-300	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-301	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-302	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-305	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-306	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-307	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-308	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-311	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-312	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-313	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-314	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-315	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~
199-N-316	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~
199-N-317	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-318	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-332	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~
199-N-333	Injection well	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-	-	-	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~	-~~B~~	-	SA~~B~~	A5~~B~~	-	SA~~B~~

Table A2-4. Apatite Barrier Pre-Injection, Injection, and First Year Post-Injection Sampling Schedule and Constituents

Well	Purpose	ICP Metals[a]			Anions[b]			TPH-Diesel			Gross Alpha			Gross Beta			Sr-90			Field DO			Field ORP			Other Field Parameters[c]		
		Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]
199-N-342	Injection well	A5B	-	SAB	A5B	-	SAB	-	-	-	A5B	-	SAB	A5B	-	SAB	A5B	-	SAB	A5B	-	SAB	-B	-	SAB	A5B	-	SAB
199-N-343	Injection well	A5B	-	SAB	A5B	-	SAB	-	-	-	A5B	-	SAB	A5B	-	SAB	A5B	-	SAB	A5B	-	SAB	-B	-	SAB	A5B	-	SAB
199-N-344	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-345	Injection well[g]	-	-	-	-	O[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-
199-N-346	Monitoring well	BA	O	Q	BA	O[f]	Q	BA	O	SA	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-347	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	O	SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-348	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	O	-SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-349	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	O	-SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-350	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-351	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-352	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-353	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-354	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-355	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-356	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-357	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-358	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q

Table A2-4. Apatite Barrier Pre-Injection, Injection, and First Year Post-Injection Sampling Schedule and Constituents

Well	Purpose	ICP Metals[a]			Anions[b]			TPH-Diesel			Gross Alpha			Gross Beta			Sr-90			Field DO			Field ORP			Other Field Parameters[c]		
		Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]
199-N-359	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-360	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-361	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-362	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-363	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-364	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-365	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-366	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-367	Monitoring well	BA	O	Q	BA	O[f]	Q	-	-	-	BA	O	SA	BSA	O	Q	BSA	O	SA	BSA	O	Q	-SA	O	Q	BSA	O	Q
199-N-92A	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
199-N-96A	Monitoring well[d]	-	O	Q	-	O[f]	Q	-	O	SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
APT1	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	O	SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
APT5	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	O	SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
C6132	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	O	SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
C6135	Aquifer tube	-	O	Q	-	O[f]	Q	-	O	SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
C6136[h]/-C9586	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	O	SA	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
C6324	Aquifer tube[d]	B-	O	Q	B-	O[f]	Q	B-	-	-	B-	O	SA	B-	O	Q	B-	O	SA	B-	O	Q	-	O	Q	B-	O	Q

Table A2-4. Apatite Barrier Pre-Injection, Injection, and First Year Post-Injection Sampling Schedule and Constituents

Well	Purpose	ICP Metals[a]			Anions[b]			TPH-Diesel			Gross Alpha			Gross Beta			Sr-90			Field DO			Field ORP			Other Field Parameters[c]		
		Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]
N116m Array-7A[h]/ C7881	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
N116m Array-0A	Aquifer tube	B~~A~~	O	Q	B~~A~~	O[f]	Q	B~~A~~	O	SA	B~~A~~	O	SA	B~~SA~~	O	Q	B~~SA~~	O	SA	B~~SA~~	O	Q	-~~SA~~	O	Q	B~~SA~~	O	Q
N116m Array-10A	Aquifer tube	B~~A~~	O	Q	B~~A~~	O[f]	Q	-	-	-	B~~A~~	O	SA	B~~SA~~	O	Q	B~~SA~~	O	SA	B~~SA~~	O	Q	-~~SA~~	O	Q	B~~SA~~	O	Q
N116m Array-11A	Aquifer tube	B~~A~~	O	Q	B~~A~~	O[f]	Q	-	-	-	B~~A~~	O	SA	B~~SA~~	O	Q	B~~SA~~	O	SA	B~~SA~~	O	Q	-~~SA~~	O	Q	B~~SA~~	O	Q
N116mArray-12A[h]/ C9589	Aquifer tube	A	O	Q	A	O[f]	Q	-	-	-	A	O	SA	SA	O	Q	SA	O	SA	SA	O	Q	-	O	Q	SA	O	Q
N116mArray-13A[h]/ C9587	Aquifer tube	A	O	Q	A	O[f]	Q	-	-	-	A	O	SA	SA	O	Q	SA	O	SA	SA	O	Q	-	O	Q	SA	O	Q
N116mArray-14A[h]/ C9588	Aquifer tube	A	O	Q	A	O[f]	Q	-	-	-	A	O	SA	SA	O	Q	SA	O	SA	SA	O	Q	-	O	Q	SA	O	Q
N116m Array-15A	Aquifer tube	B~~A~~	O	Q	B~~A~~	O[f]	Q	-	-	-	B~~A~~	O	SA	B~~SA~~	O	Q	B~~SA~~	O	SA	B~~SA~~	O	Q	-~~SA~~	O	Q	B~~SA~~	O	Q
N116m Array-2A	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
N116m Array-3A	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
N116m Array-4A	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
N116m Array-6A	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
N116m Array-8A	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q
N116mArray-8.5A[h]/ C9590	Aquifer tube	B	O	Q	B	O[f]	Q	-	-	-	B	O	SA	B	O	Q	B	O	SA	B	O	Q	-	O	Q	B	O	Q

Table A2-4. Apatite Barrier Pre-Injection, Injection, and First Year Post-Injection Sampling Schedule and Constituents

Well	Purpose	ICP Metals[a]			Anions[b]			TPH-Diesel			Gross Alpha			Gross Beta			Sr-90			Field DO			Field ORP			Other Field Parameters[c]		
		Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]	Pre-Injection	Injection	First Year Post-Injection[e]
N116m Array-9A	Aquifer tube	B~~A~~	O	Q	B~~A~~	O[f]	Q	-	-	-	B~~A~~	O	SA	B~~SA~~	O	Q	B~~SA~~	O	SA	B~~SA~~	O	Q	-~~SA~~	O	Q	B~~SA~~	O	Q
NVP2-116.0	Aquifer tube[d]	-	O	Q	-	O[f]	Q	-	-	-	-	O	SA	-	O	Q	-	O	SA	-	O	Q	-	O	Q	-	O	Q

Note: A5 = annually every 5 years, B = biennial, O = once only after chemical injections, Q = quarterly, SA = semiannual; ~~biennial and~~ semiannual targets high river stage (~~mid~~ May through ~~mid~~ July ~~June~~ timeframe) and low river stage (~~mid~~ September through ~~mid~~ November ~~September~~ timeframe).

a. Metals include, but are not limited to, cadmium, calcium, chromium, magnesium, manganese, and sodium. Both filtered and unfiltered samples are collected for metals analyses.

b. Anions include, but are not limited to, chloride, nitrate, and sulfate.

c. Field parameters include pH, specific conductance, temperature, and turbidity.

d. Currently under routine performance monitoring for treated portion of the PRB. Sampling identified in this table only applies to the treated portion of the PRB.

e. The frequency shown only applies to the first year after injection. Sampling frequency after 1 year will be as described for routine performance monitoring in the SAP (Appendix A).

f. Include phosphate analysis in sample collected after injection.

g. Injection well used only for injection arrival monitoring during apatite chemical injections. Samples analyzed only for phosphate and field parameters.

h. Records indicate aquifer tube is missing or broken and has been replaced with new aquifer tube at same location. Original aquifer tube name designation is shown with replacement aquifer tube name for cross reference (i.e., [original aquifer tube name/replacement aquifer tube name]).

DO	=	dissolved oxygen	PRB	=	permeable reactive barrier
ORP	=	oxidation-reduction potential	TPH	=	total petroleum hydrocarbons

Table A2-6. Vadose Zone Jet Injection Monitoring Points

Well Name/Identification	Well Type	Well Name/Identification	Well Type
199-N-173/C7038	MW	N116mArray-4A/C5258	AT
199-N-346/C7442	MW	199-N-122/C4954	MW
199-N-96A/A9882	MW	NVP2-116.0m/C5251	AT
C6136-*/C9586	AT	N116mArray-6A/C5259	AT
199-N-347/C7441	MW	199-N-147/C5116	MW
N116mArray-1A/C5255	AT	APT-5/C5386	AT
199-N-348/C7440	MW	199-N-350/C7443	MW
N116mArray-2A/C5256	AT	C7881	AT
199-N-349/C7439	MW	199-N-351/C7444	MW
199-N-123/C4955	MW	199-N-352/C7445	MW
APT-1/C5269	AT	199-N-353/C7446	MW
N116mArray-3A/C5257	AT	N116mArray 8A/C5261	AT
199-N-146/C5052	MW		

* Records indicate aquifer tube is missing or broken and has been replaced with new aquifer tube at same location. Original aquifer tube name designation is shown with replacement aquifer tube name for cross reference (i.e., [original aquifer tube name/replacement aquifer tube name]).

AT = aquifer tube

MW = monitoring well

The objectives of the vadose zone jet injection monitoring are to determine the following information:

- Pre-jet injection baseline concentrations of Sr-90 for evaluating overall combined saturated zone and vadose zone PRB performance
- Mass and extent of apatite emplacement within the aquifer and vadose zone to evaluate effective PRB installation
- Reduction in Sr-90 concentrations in response to the PRB installation

Sampling protocols are designed to determine these conditions.

A2.6.1 Injection Flow Rate and Volume

Flow rates during drilling and jet injection will be monitored and any necessary flow adjustments will be made accordingly. Flow rates will be determined by conditions encountered during jet injection and the capacity of the formation to accept the material.

A data recorder system will be used to record important parameters continuously through the drilling and injection of each borehole. Table A2-7 summarizes the types, information and frequency that data will be recorded on the data sheets. At the completion of borehole jet injection, logs will be prepared (similar to Figure A2-3, showing a jet injection log report from SGW-47062 for the jet injection pilot test). All field activities will be overseen by qualified staff, as described in Section A2.1.1 of the SAP (Appendix A).

Table A3-1. Sampling Interval Information for Wells and Aquifer Tubes
Within the 100-NR-2 Groundwater Operable Unit

Well or Aquifer Tube Name	Hydrogeologic Unit Monitored	Elevation		Open Interval Length (m)	Water Level Elevation (m NAVD88)	Screen Open to Aquifer (m)	Water Level Date
		Top of Open Interval (m NAVD88)	Bottom of Open Interval (m NAVD88)				
199-N-343	TU	119.21	117.68	1.52	No data	NA	No data
199-N-346	TU	118.31	116.17	2.13	No data	NA	No data
199-N-347	TU	117.84	115.71	2.13	117.43	1.72	9/10/2014
199-N-348	TU	117.86	115.72	2.13	119.88	2.13	6/5/2014
199-N-349	TU	117.83	115.70	2.13	119.81	2.13	6/5/2014
199-N-350	TU	116.92	114.79	2.13	119.80	2.13	6/5/2014
199-N-351	TU	116.99	114.87	2.12	119.78	2.13	6/5/2014
199-N-352	TU	116.76.	114.63	2.13	119.70	2.13	6/5/2014
199-N-353	TU	116.51	114.38	2.13	119.77	2.13	6/5/2014
199-N-354	TU	116.48	114.35	2.13	No data	No data	No data
199-N-355	TU	116.51	114.37	2.13	No data	No data	No data
199-N-356	TU	116.77	114.64	2.13	No data	No data	No data
199-N-357	TU	116.37	114.23	2.13	No data	No data	No data
199-N-358	TU	116.30	114.17	2.13	No data	No data	No data
199-N-359	TU	116.59.	114.46	2.13	No data	No data	No data
199-N-360	TU	116.68	114.55	2.13	No data	No data	No data
199-N-361	TU	116.60	114.46	2.13	No data	No data	No data
199-N-362	TU	116.65	114.51	2.13	No data	No data	No data
199-N-363	TU	116.57	114.44	2.13	No data	No data	No data
199-N-364	TU	116.48	114.35	2.13	No data	No data	No data
199-N-365	TU	116.68	114.55	2.13	No data	No data	No data
199-N-366	TU	116.88	114.75	2.13	No data	No data	No data
199-N-367	TU	116.96	114.83	2.13	No data	No data	No data
199-N-371	TU	121.42~~NA~~	111.03~~NA~~	10.4~~NA~~	119.27~~NA~~	8.24~~NA~~	6/6/2016~~NA~~
199-N-372	TU	121.10~~NA~~	108.89~~NA~~	12.2~~NA~~	119.16~~NA~~	10.27~~NA~~	6/16/2016 ~~NA~~
199-N-373	TU	120.93~~NA~~	113.41~~NA~~	7.5~~NA~~	119.31~~NA~~	5.90~~NA~~	6/27/2016 ~~NA~~

Table A3-1. Sampling Interval Information for Wells and Aquifer Tubes Within the 100-NR-2 Groundwater Operable Unit

Well or Aquifer Tube Name	Hydrogeologic Unit Monitored	Elevation		Open Interval Length (m)	Water Level Elevation (m NAVD88)	Screen Open to Aquifer (m)	Water Level Date
		Top of Open Interval (m NAVD88)	Bottom of Open Interval (m NAVD88)				
199-N-374	TU	120.84~~NA~~	110.16~~NA~~	10.7~~NA~~	118.57~~NA~~	8.42~~NA~~	7/11/2016 ~~NA~~
199-N-376	~~LU~~ TU	119.41~~NA~~	108.73~~NA~~	10.7~~NA~~	118.76~~NA~~	10.03~~NA~~	8/2/2016~~NA~~
199-N-377	TU	118.63~~NA~~	112.52~~NA~~	6.1~~NA~~	118.65~~NA~~	6.13~~NA~~	8/3/2016~~NA~~
APT1	TU	NA data	No data	0.15	No data	No data	No data
APT5	TU	No data	No data	0.15	No data	No data	No data
C6132	TU	No data	No data	0.15	No data	No data	No data
C6135	TU	No data	No data	0.15	No data	No data	No data
C6136/C9586	TU	No data	No data	0.15	No data	No data	No data
C6317	TU	No data	No data	0.15	No data	No data	No data
C6318	TU	No data	No data	0.15	No data	No data	No data
C6319	TU	No data	No data	0.15	No data	No data	No data
C6320	TU	No data	No data	0.15	No data	No data	No data
C6324	TU	No data	No data	0.15	No data	No data	No data
C7934	TU	No data	No data	0.15	No data	No data	No data
C7935	TU	No data	No data	0.15	No data	No data	No data
C7936	TU	No data	No data	0.15	No data	No data	No data
C7937	TU	No data	No data	0.15	No data	No data	No data
C7938	TU	No data	No data	0.15	No data	No data	No data
C7939	TU	No data	No data	0.15	No data	No data	No data
N116mArray-7A C7881	TU	No data	No data	0.15	No data	No data	No data
N116mArray-0A	TU	No data	No data	0.15	No data	No data	No data
N116mArray-2A	TU	No data	No data	0.15	No data	No data	No data
N116mArray-3A	TU	No data	No data	0.15	No data	No data	No data
N116mArray-4A	TU	No data	No data	0.15	No data	No data	No data
N116mArray-6A	TU	No data	No data	0.15	No data	No data	No data

Table A3-1. Sampling Interval Information for Wells and Aquifer Tubes Within the 100-NR-2 Groundwater Operable Unit

Well or Aquifer Tube Name	Hydrogeologic Unit Monitored	Elevation		Open Interval Length (m)	Water Level Elevation (m NAVD88)	Screen Open to Aquifer (m)	Water Level Date
		Top of Open Interval (m NAVD88)	Bottom of Open Interval (m NAVD88)				
N116mArray-8A	TU	No data	No data	0.15	No data	No data	No data
N116mArray-8.5A/ C9590	TU	No data	No data	0.15	No data	No data	No data
N116mArray-9A	TU	No data	No data	0.15	No data	No data	No data
N116mArray-10A	TU	No data	No data	0.15	No data	No data	No data
N116mArray-11A	TU	No data	No data	0.15	No data	No data	No data
N116mArray-12A/ C9589	TU	No data	No data	0.15	No data	No data	No data
N116mArray-13A/ C9587	TU	No data	No data	0.15	No data	No data	No data
N116mArray-14A/ C9588	TU	No data	No data	0.15	No data	No data	No data
N116mArray-15A	TU	No data	No data	0.15	No data	No data	No data
NVP2-116.0	TU	No data	No data	0.15	No data	No data	No data

LU = lower unconfined
~~NA = not available (planned well or aquifer tube)~~
TU = top of unconfined

A3.2 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/.