DOE/RL-2014-42-ADD2
Revision 0A

300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan Addendum 2 for Enhanced Groundwater Monitoring for the 618-11 Burial Ground

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

P.O. Box 550
Richland, Washington 99352

DOE/RL-2014-42-ADD2
Revision 0A

300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan Addendum 2 for Enhanced Groundwater Monitoring for the 618-11 Burial Ground

Date Published
September 2023

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
P.O. Box 550
Richland, Washington 99352

APPROVED
By Julia Raymer at 9:42 am, Sep 27, 2023

Release Approval | Date

TRADEMARK DISCLAIMER

Signature Sheet

Title: *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan Addendum 2 for Enhanced Groundwater Monitoring for the 618-11 Burial Ground*

NAOMI JASCHKE Digitally signed by NAOMI JASCHKE Date: 2023.09.27 20:52:32 -07'00'

Print Name
U.S. Department of Energy,
Richland Operations Office

Signature

Date

McCartney, Anne Digitally signed by McCartney, Anne Date: 2023.09.28 12:22:51 -07'00'

Print Name
U.S. Environmental Protection Agency

Signature

Date

Change History for DOE/RL-2014-42-ADD2, *300-FF-5Operable Unit Remedy Implementation Sampling and Analysis Plan Addendum 2 for Enhanced Groundwater Monitoring for the 618-11 Burial Ground*

TPA-CN	Modifications	Signature Date
TPA-CN-0973	• The document number has been updated to DOE/RL-2014-42-ADD2, Rev. 0A. • Change History table has been added. • Table 1-4: Removed "Redox Potential (Eh)" from the table. • Figure 2-1: Updated the figure. • Section 2.1: Updated the following text: o "TBD-4" to "699-13-E5" o "TBD-5A" to "699-13-3" o "TBD-5B" to "699-12-3A" o "two" to "three" • Section 2.1: o Updated the text from "This proposed location is within the boundary of the Energy Northwest operational area." to "The proposed location is on the northeast side of the Energy Northwest operational area, and just outside of the operational boundary." o Removed the following text "If this well cannot be installed within that boundary, an alternate location to the northeast of the original proposed location and just outside of the operational boundary will be established." o Added the following text "groundwater flow and …" o Added the following text "This location also improves plume delineation and serves as a potential alternate upgradient well." • Table 2-1: Updated the following text: o "TBD-4" to "699-13-E5" o "TBD-5A" to "699-13-3" o "TBD-5B" to "699-12-3A" o Updated the "Year Constructed" text for well 699-13-E5 to "2025". Updated the year constructed to "2024" for well 699-13-3, and 699-12-3A. o Removed superscript "c" from well "699-13-3" and "699-12-3A". • Section 2.2.3.1: Updated the following text: o "TBD-5A" to "699-13-3" o "TBD-5B" to "699-12-3A" • Section 2.2.3.2 and Section 2.2.8: Removed "Redox Potential" from the paragraph. • Table 2-2: Updated the following text: o "TBD-4" to "699-13-E5" o "TBD-5A" to "699-13-3" o "TBD-5B" to "699-12-3A" o Removed "TBD = to be determined" from the footnote.	07/03/2025

Contents

Appendix

Figures

Tables

Terms

bgs	below ground surface
COC	contaminant of concern
CCU	Cold Creek unit
DQO	data quality objective
DR	decision rule
DS	decision statement
MNA	monitored natural attenuation
OU	operable unit
PSQ	principal study question
QAPjP	quality assurance project plan
Rlm	Ringold Formation member of Wooded Island – lower mud unit
ROD	record of decision
RTD	remove, treat (as required), and dispose
Rwia	Ringold Formation member of Wooded Island – unit A
Rwie	Ringold Formation member of Wooded Island – unit E
SAP	sampling and analysis plan
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VPU	vertical pipe unit

This page intentionally left blank.

1 Introduction

This Addendum to DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan* (hereinafter referred to as the SAP), has been prepared to support the monitored natural attenuation (MNA) remedy for nitrate and tritium in groundwater downgradient of the 618-11 Burial Ground, identified as the groundwater contaminants of concern (COCs) for this area in the 300 Area Record of Decision (ROD) (EPA et al., 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*). This Addendum provides the well drilling and installation, aquifer tube installation, and soil and groundwater sampling and analysis requirements for enhanced groundwater monitoring downgradient of the 618-11 Burial Ground. This Addendum supplements information provided in the main text of the SAP as well as the following documents:

- DOE/RL-2014-13, *Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units)*
- DOE/RL-2014-13-ADD2, *Remedial Design Report/Remedial Action Work Plan for the 300 Area Groundwater*

The 618-11 Burial Ground is located approximately 11 km (6.8 mi) north-northwest of the 300 Area Industrial Complex and west of the Energy Northwest Columbia Generating Station (Energy Northwest) (Figure 1-1). The burial ground is part of the 300-FF-2 Operable Unit (OU). The groundwater beneath the burial ground is part of the 300-FF-5 OU. The burial ground contains nitrate and tritium that are believed to have contaminated the groundwater downgradient of the burial ground at concentrations greater than drinking water standards (EPA et al., 2013; DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*; DOE/RL-2021-51, *Hanford Site Groundwater Monitoring Report for 2021*). Figures 1-2 and 1-3 depict the tritium and nitrate plumes, respectively.

This Addendum supports implementation of the selected 300-FF-5 OU remedy for the 618-11 Burial Ground groundwater COCs, as described in the 300 Area ROD (EPA et al., 2013). The ROD established the selected remedy for the 300-FF-5 groundwater OU at the 618-11 Burial Ground as MNA. The cleanup levels are 20,000 pCi/L for tritium and 45 mg/L for nitrate (as NO_3). The ROD also established the selected remedy for the 618-11 Burial Ground in the 300-FF-2 OU as remove, treat (as required), and dispose (RTD). At the time the ROD was developed, RTD of the 618-11 Burial Ground was anticipated to be completed by 2021; however, the timeline to begin remediation of the 618-11 Burial Ground has been rescheduled to 2030 due to the continuing operations of the nearby Energy Northwest, with the completion of remediation to be determined in accordance with DOE/RL-2014-13-ADD1, *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils* (as documented in *Hanford Federal Facility Agreement and Consent Order* [Tri-Party Agreement] [Ecology et al., 1989] Change Control Form M-16-21-06).

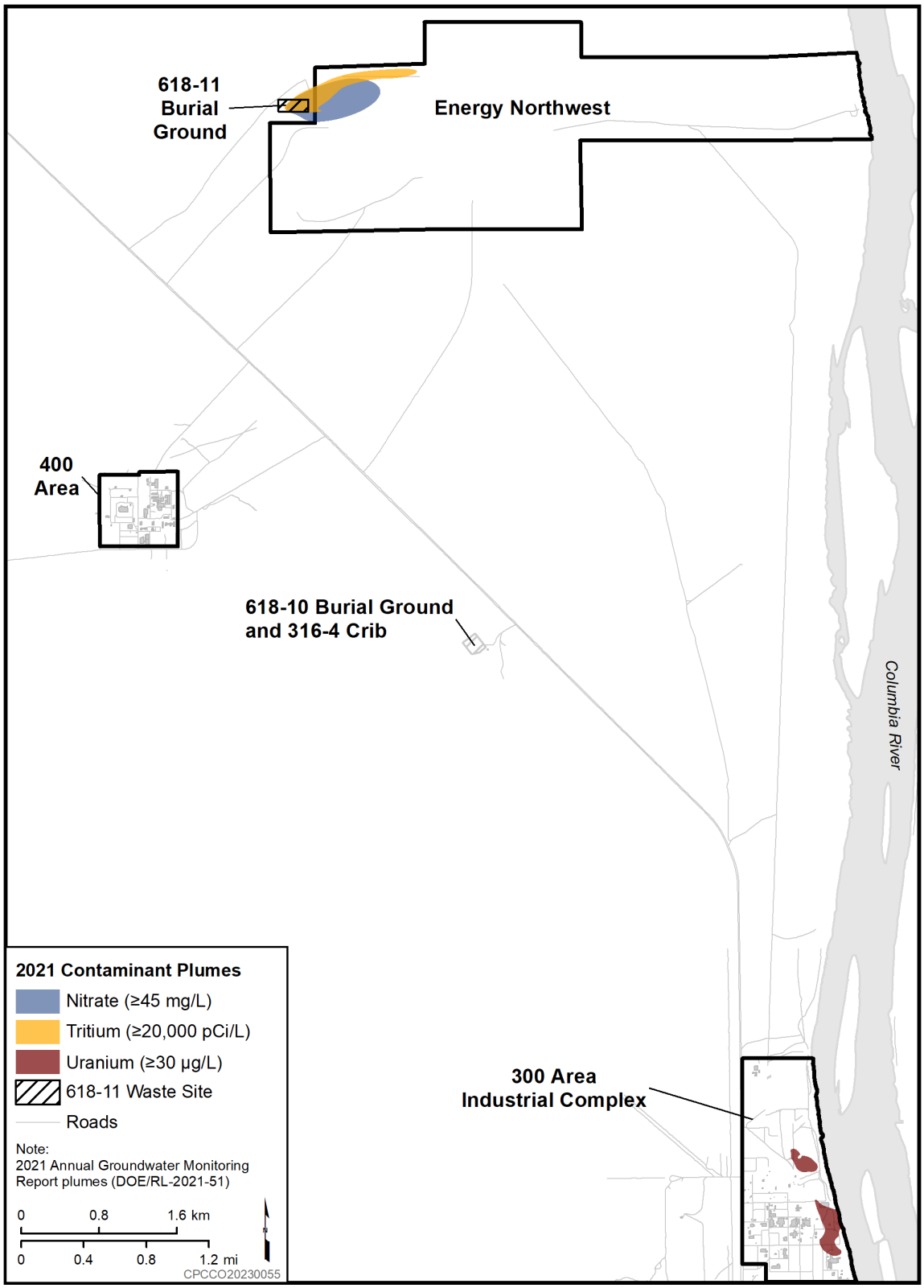
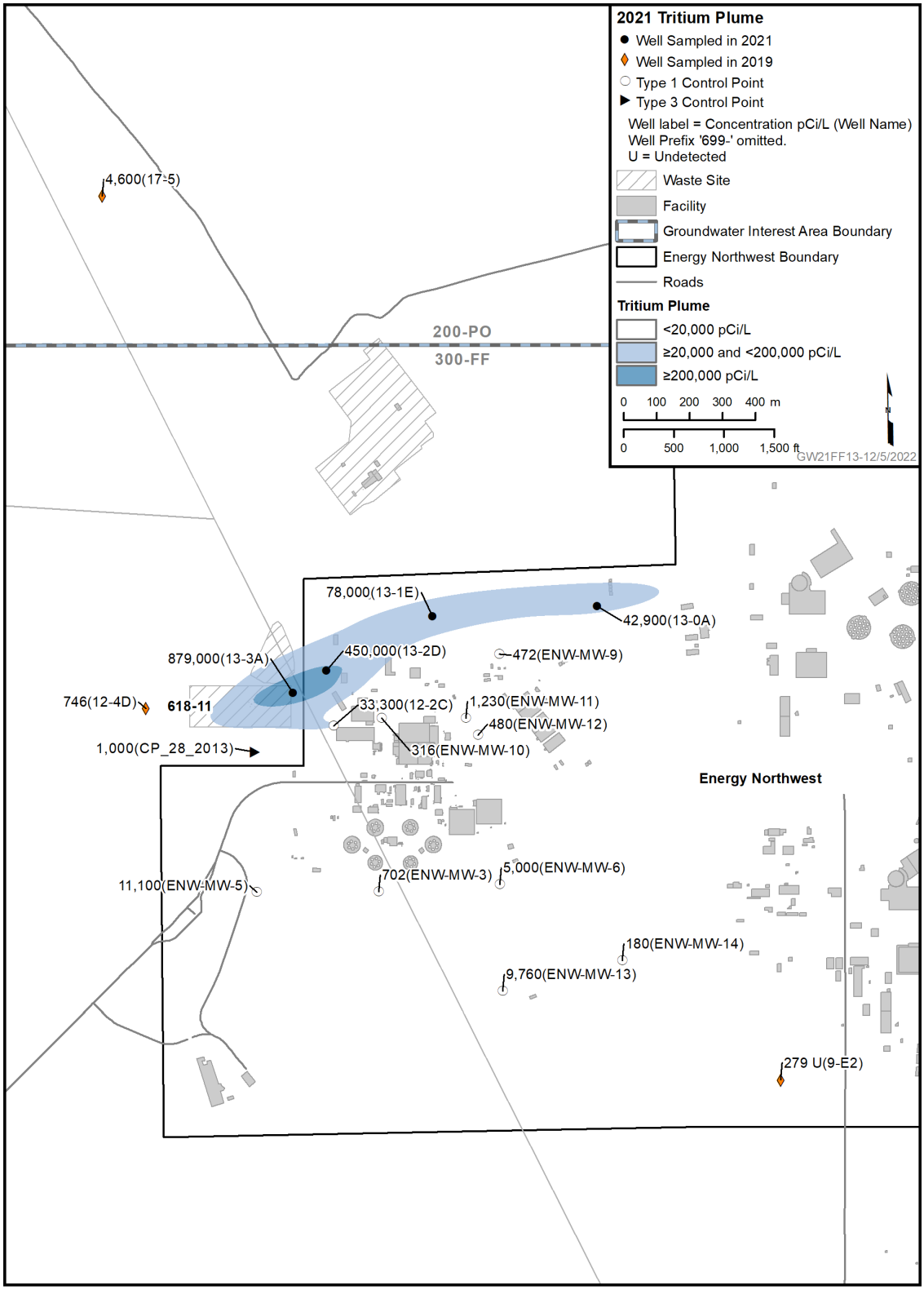
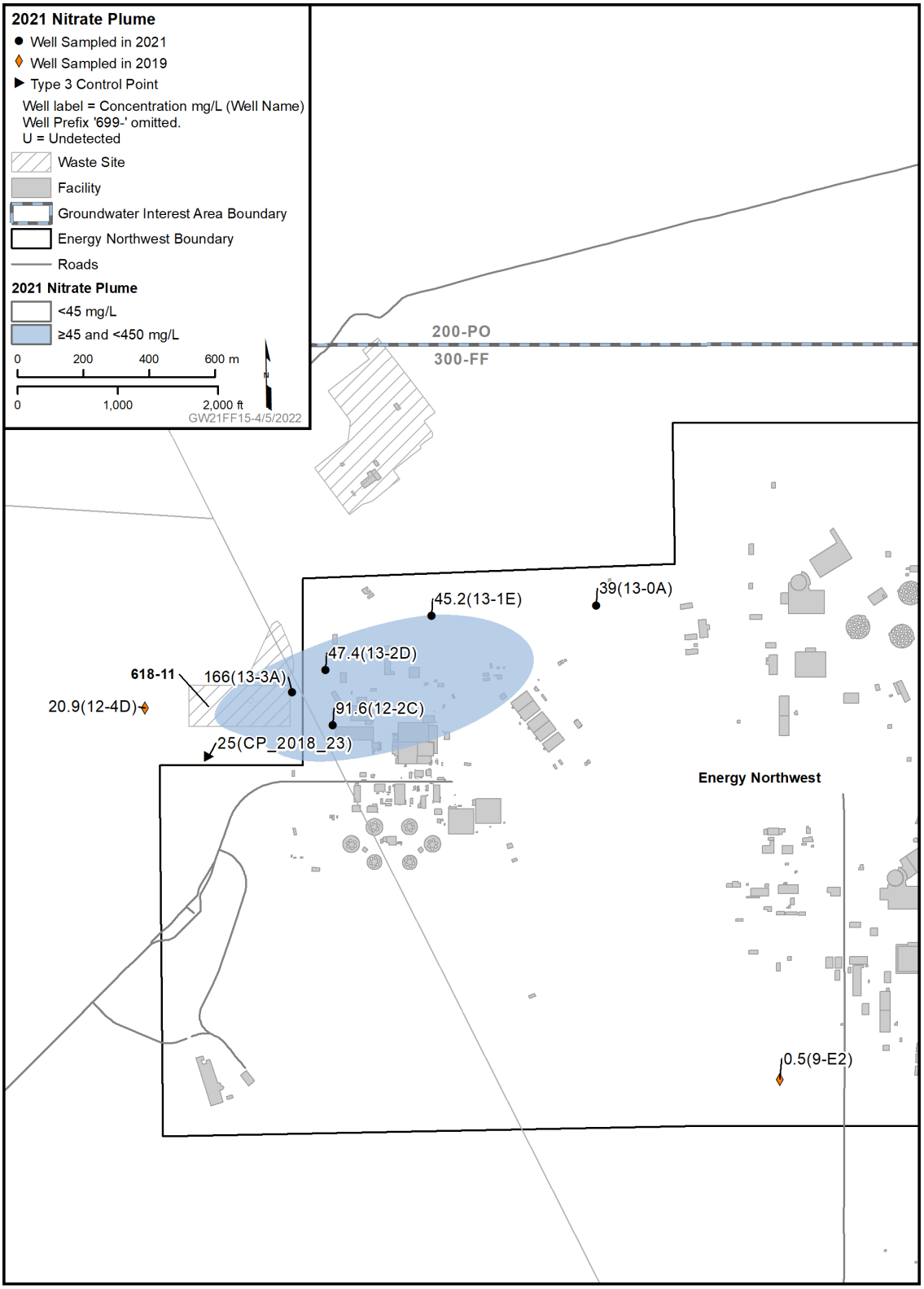


Figure 1-1. 300-FF-5 Groundwater Contaminant Plumes



Source: DOE/RL-2021-51, *Hanford Site Groundwater Monitoring Report for 2021.*

Figure 1-2. 300-FF-5 OU Tritium Plume Near the 618-11 Burial Ground, 2021



Source: DOE/RL-2021-51, *Hanford Site Groundwater Monitoring Report for 2021*.

Figure 1-3. 300-FF-5 OU Nitrate Plume Near the 618-11 Burial Ground, 2021

Between 2016 and 2017, an increase in nitrate concentrations was observed in monitoring well 699-13-3A, downgradient of the 618-11 Burial Ground (ECF-300FF5-21-0001, *618-11 Burial Ground Conceptual Model Update and Evaluation of Increasing Nitrate Concentrations in Groundwater, FY 2021*). The nitrate concentration increased from 58 mg/L (January 2016) to 186 mg/L (November 2017), an approximate three-fold increase. The highest concentration observed was 252 mg/L (November 2019). The increased concentration coincided with the relative stabilization of the water table elevation (in 2018), which had been declining since 1998 (ECF-300FF5-21-0001). The nitrate concentration decreased in 2020 to 164 mg/L (DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020*) and remained relatively stable in 2021 at 166 mg/L (DOE/RL-2021-51). Although the nitrate concentrations observed in monitoring well 699-13-3A have periodically fluctuated, the magnitude of this recent increase (two- to three-fold) and duration of the observed increase (approximately 5 years) are larger and longer than previously observed.

The December 2020 groundwater monitoring event showed increased tritium concentrations from the 2019 monitoring event in all five monitoring wells for the 618-11 Burial Ground. Monitoring well 699-13-3A exhibited the largest increase, from 209,000 pCi/L in 2019 to 1,050,000 pCi/L in 2020 (DOE/RL-2020-60). The tritium concentration in well 699-13-3A subsequently decreased in 2021 to 879,000 pCi/L but remained greater than concentrations in 2019.

An evaluation of the increasing nitrate and tritium groundwater concentrations was completed in the spring of 2021 (ECF-300FF5-21-0001). The evaluation considered the following six hypotheses:

- Laboratory analytical error
- Plume migration from upgradient of the 618-11 Burial Ground
- Waste source other than the 618-11 Burial Ground
- Decrease in groundwater flow rate
- Mud layer source
- Pulse release from the 618-11 Burial Ground

Previous modeling indicated either a continuous source and/or a pulse release behavior or a combination was probable when compared to 3 years of monitoring data (PNNL-15293, *Evaluation of the Fate and Transport of Tritium Contaminated Groundwater from the 618-11 Burial Ground*).

ECF-300FF5-21-001 contains details of the evaluation, including the rationale for ruling out hypotheses. Recommendations provided in ECF-300FF5-21-0001 led to a Tri-Party Agreement (Ecology et al., 1989) Change Notice to the SAP (TPA-CN-0917, *Tri-Party Agreement Change Notice Form: DOE/RL-2014-42, 300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan, Rev. 0*), which included enhanced groundwater monitoring around the 618-11 Burial Ground for fiscal years 2022 and 2023. This Addendum incorporates those changes and the outcomes of a data quality objective (DQO) process conducted to establish continued monitoring and investigation of groundwater downgradient of the 618-11 Burial Ground. The DQO was needed due to delays in RTD of the 618-11 Burial Ground, which allow continued groundwater contamination and potential source releases. The DQO supports investigation of contamination migration to inform remedial planning and design. The outcomes of the DQO process are summarized in Section 1.3.

An investigation of contaminant migration was described in ECF-HANFORD-22-0051, *Assessment of Potential Contaminant Release from 618-11 Burial Ground*, an evaluation of numerical modeling to assess the fate and transport of tritium and nitrate released from wastes disposed at the 618-11 Burial Ground. Assessment of future impacts of tritium and nitrate to groundwater were performed for two remedial scenarios: a no-action case assuming no change in infiltration rates from current conditions and

an interim action alternative case that results in reduced infiltration. The modeling results indicate small to negligible impact on future nitrate and tritium concentrations from emplacement of an interim surface barrier when compared to the no-action cases for the releases that occurred in the past. The modeling results further indicate that the impact of emplacement of a surface barrier on past releases of contaminants that have occurred over shorter durations (faster releases) is smaller when compared to the impact on the longer duration (slower) releases. These results would, however, vary based on the source strength and timing of the releases compared to the timing of the imposed changes in the recharge rates.

1.1 Project Scope and Objective

This Addendum addresses well drilling and installation, sample collection, and sample analysis activities to support the enhanced groundwater monitoring downgradient of the 618-11 Burial Ground. This Addendum adopts the analytical methods, quality control acceptance criteria, and preservation and holding time guidelines for laboratory analysis from the SAP (Chapter 4, "Quality Assurance Project Plan" [QAPjP]). The SAP also contains the waste management requirements and health and safety information for the activities in this Addendum.

1.2 Background

The 618-11 Burial Ground is located northwest of the 300 Area Industrial Complex and west of Energy Northwest (Figure 1-1). The fenced area of the burial ground has dimensions of 305 m (1,000 ft) (east-west) by 114 m (375 ft) (north-south).

The 618-11 Burial Ground began operating on March 9, 1962, and was permanently closed on December 31, 1967 (HNF-EP-0649, *Characterization of the 618-11 Solid Waste Burial Ground, Disposed Waste, and Description of the Waste-Generating Facilities*). The waste ranged from low-activity to high-activity radioactive materials from 300 Area facilities, including hot cells, and included some waste originating from the 1100 Area. With some exceptions, low- to moderate-activity waste was placed in the trenches while moderate- to high-activity waste was placed in vertical pipe units (VPUs) and caissons. Some of the hot cell waste was placed in the trenches within concrete-shielded drums. The burial ground is estimated to contain approximately 2,422 g of plutonium, and at the time of disposal, contained thousands of curies of mixed fission products (HNF-EP-0649). Information on inventory estimates is included in CP-67995, *Conceptual Site Model for the 618-11 Burial Ground*.

The results of an electromagnetic induction survey conducted at the 618-11 Burial Ground are presented in BHI-00291, *Geophysical Investigation of the 618-10 and 618-11 Burial Grounds, 300-FF-2 Operable Unit*. The disposal units within the burial ground are made up of VPUs, caissons, and trenches, which can generally be discerned in the survey images (Figure 13 of BHI-00291). The information available indicates there are 50 VPUs and up to 5 caissons in the northeast part of the burial ground and 3 "V"-shaped trenches oriented east-west in the remainder of the burial ground. The electromagnetic induction survey results suggest there are 53 VPUs (north of the N400 line and east of the E700 line) and 2 caissons (near N450, E650) (Figure 13 in BHI-00291). The VPUs consist of five 208 L (55 gal) drums welded together to form a 4.6 m (15 ft) long vertical pipe column that is bottomless and sits on concrete blocks. The caissons are constructed with 2.4 m (8 ft) diameter corrugated metal pipe and are open to the soil at the bottom. The tops of the caissons are approximately 4.6 m (15 ft) below grade and connected to the surface with an offset 0.9 m (3 ft) diameter pipe. The trenches are 274 m (900 ft) long, 15 m (50 ft) wide at the surface, and 7.6 m (25 ft) deep (in BHI-00291, Figure 13, the trenches are located between the N350 and N400 lines along the N250 line and between the N150 and N200 lines).

1.2.1 Site Geology/Hydrology

This section presents the geology/hydrogeology at the 618-11 Burial Ground, summarized from the following documents:

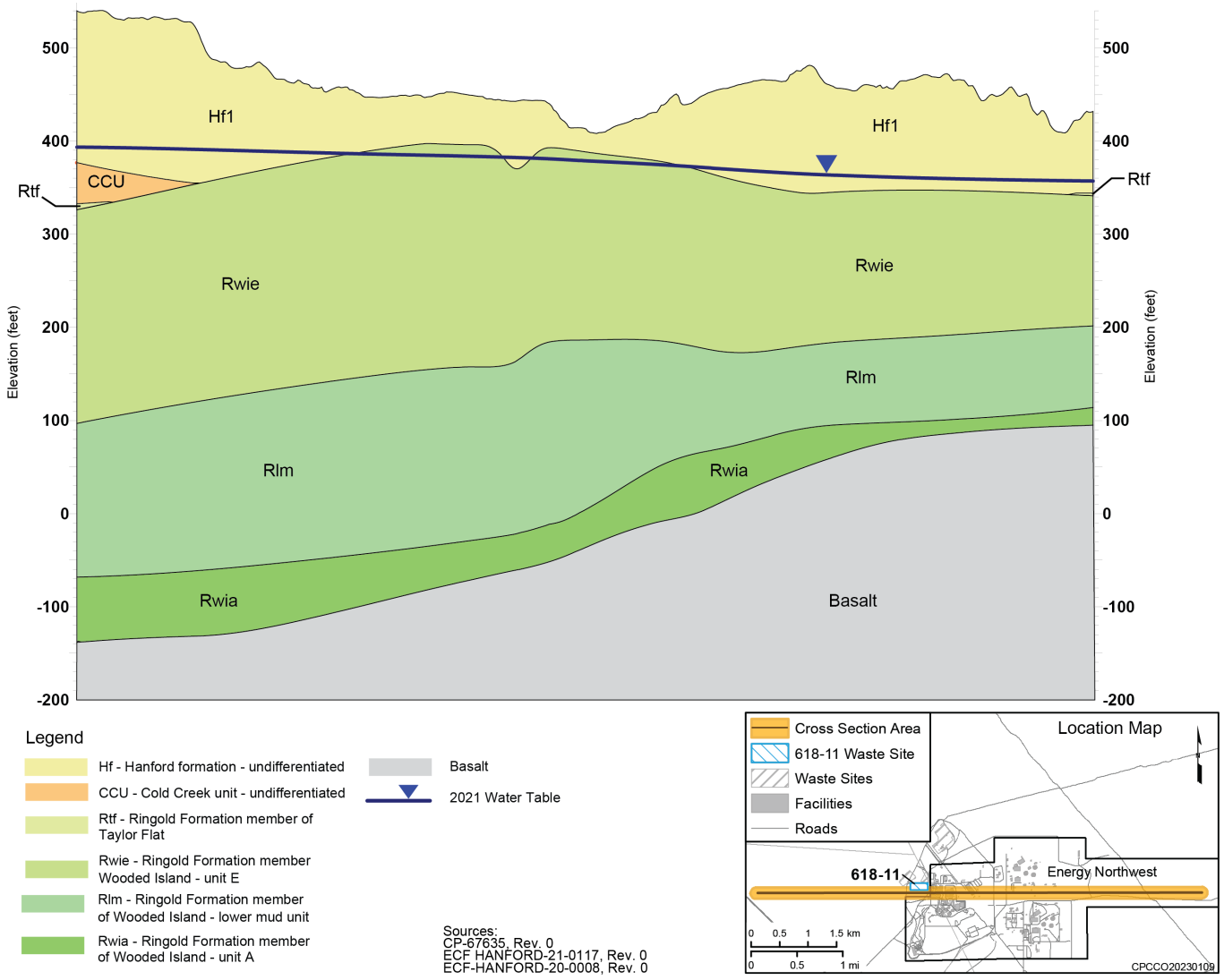
- CP-67635, *Development of the Hanford South Geoframework Model Version 6.0*
- ECF-HANFORD-20-0008, *Development of Hanford Site Top of Basalt Elevation Grid*
- ECF-HANFORD-21-0117, *Preparation of the March 2021 Hanford Site Water Table Map*

The geology/hydrogeology of the 618-11 Burial Ground and surrounding area is composed of the Holocene deposits, the Hanford formation, the Cold Creek unit (CCU), the Ringold Formation, and the Columbia River Basalt Group. The major suprabasalt formations present in the vicinity of the 618-11 Burial Ground are interpreted to be fluvial in nature. The formations and their respective sub-members present at and near the 618-11 Burial Ground are, in descending depth from surface:

- Holocene deposits – eolium, alluvium, colluvium, and anthropomorphic deposits
- Hanford formation – gravels, sands, and interbedded silts and sands
- CCU – undifferentiated – gravels and sands
- Ringold Formation
  - member of Taylor Flat – fine-grained sand and silts
  - member of Wooded Island – unit E (Rwie) – rounded gravel in sand and silt matrix, well cemented to poorly indurated
  - member of Wooded Island – local discontinuous mud unit
  - member of Wooded Island – lower mud unit (Rlm) – fine-grained sand, silt, and clay
  - member of Wooded Island – unit A (Rwia) – rounded gravel in sand and silt matrix generally well cemented
- Columbia River Basalt Group – flood-basalts

The vadose zone is composed primarily of backfilled materials and the Hanford formation, although there are local areas of the Rwie extending up to 4 m (12 ft) into the vadose zone. The thickness of the vadose zone at the 618-11 Burial Ground is approximately 19 m (63 ft) (CP-67635, ECF-HANFORD-21-0117).

The unconfined aquifer occurs primarily within the Ringold Formation, with localized areas of groundwater also found in the Hanford formation and the CCU. The CCU and the Ringold Formation member of Taylor Flat are found in the vicinity of the 618-11 Burial Ground but are not directly below the burial ground. The Rwie is the primary groundwater-bearing unit. The unconfined aquifer is confined at the base of the Rwie by the Rlm. Within the Rwie, there is a locally discontinuous mud unit that affects groundwater migration flow patterns (CP-67635, ECF-HANFORD-21-0117). Figure 1-4 presents a geologic cross section in the area of the 618-11 Burial Ground.



CPCCO20230109

Figure 1-4. Geologic Cross Section for the 618-11 Burial Ground

1.2.2 Groundwater Flow

The unconfined aquifer beneath the 618-11 Burial Ground occurs primarily within the gravel and sand of the Rwie, although the unconfined aquifer extends upward into the Hanford formation in isolated locations. The groundwater flow direction is east-northeast (Figure 1-5), and analyses of water-level measurements yield an average hydraulic gradient of approximately 1.6 x 10^{-3} m/m (ECF-300FF5-21-0001) from 2015 to 2019. A constant rate discharge test at well 699-17-5 (located approximately 1.5 km north of the 618-11 Burial Ground) yielded a hydraulic conductivity of 7.8 m/d (HW-60601, *Aquifer Characteristics and Ground-Water Movement at Hanford*; value of 190 gal/d/ft^2 in Table III converted to m/d). Using this value, and assuming an effective porosity of 0.15, a groundwater flow rate (average linear velocity) of approximately 30 m/yr is calculated (ECF-300FF5-21-0001). The migration pathway of the tritium plume appears to be closely related to the lateral variability in aquifer permeability (Section 3.6.3 of DOE/RL-2010-99). Wells at the 618-11 Burial Ground typically do not show a response to river stage changes.

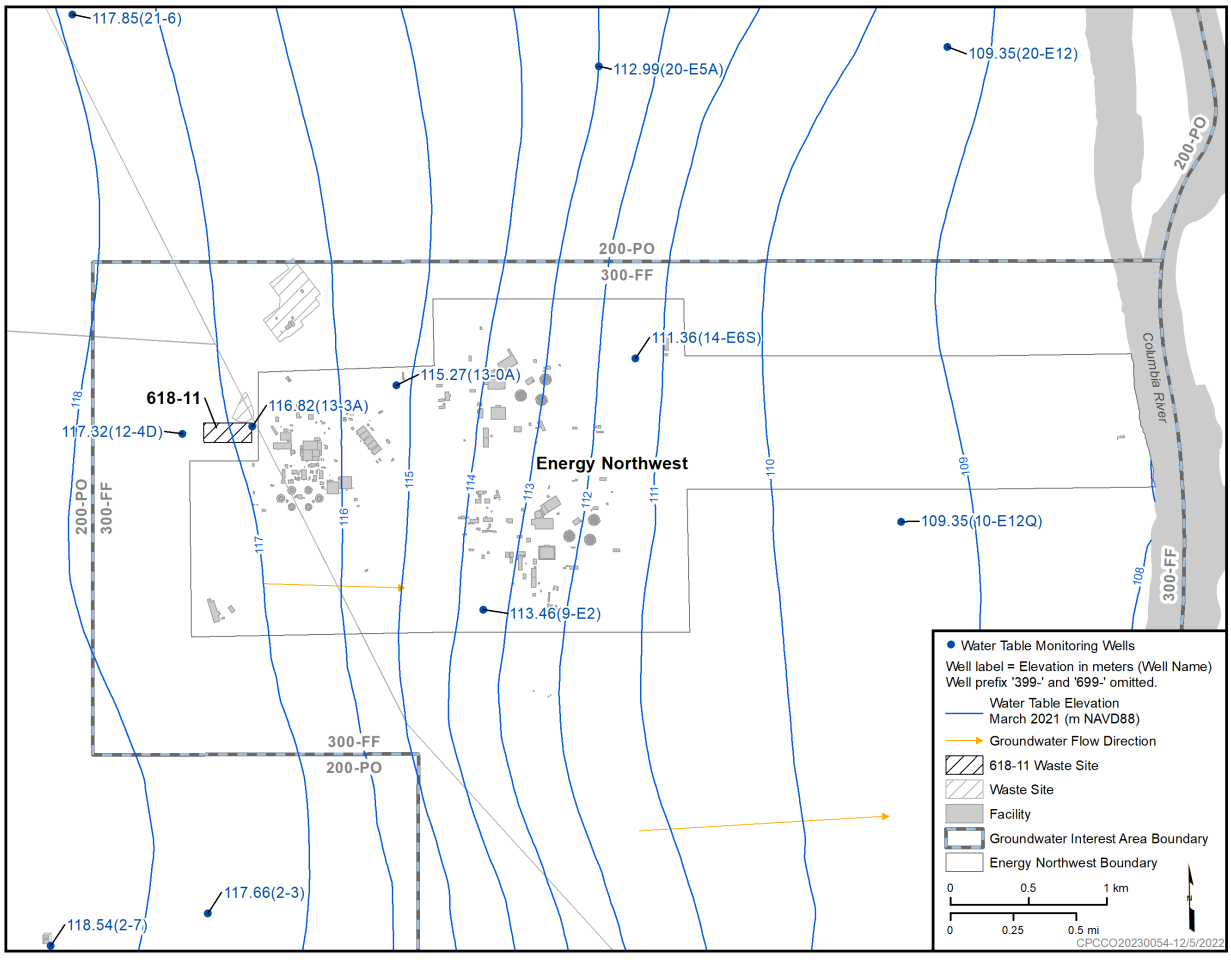


Figure 1-5. 300-FF Water Table, March 2021

1.2.3 Sources of Contamination

The 618-11 Burial Ground was the source of nitrate and tritium that interacted with vadose zone moisture and eventually entered and contaminated the underlying groundwater at concentrations greater than drinking water standards (DOE/RL-2010-99) downgradient of this waste site.

Tritium is detected in groundwater downgradient of the 618-11 Burial Ground at concentrations exceeding the 20,000 pCi/L cleanup level. The tritium plume source is presumed to be tritium released from buried radiological solid waste in a series of caissons located along the north side of the burial ground. The presence of tritium in the burial ground was confirmed by a soil gas survey (PNNL-13675, *Measurement of Helium-3/Helium-4 Ratios in Soil Gas at the 618-11 Burial Ground*).

Nitrate concentrations are elevated at several wells downgradient of the 618-11 Burial Ground, with peak concentrations present at well 699-13-3A (closest to the eastern fenceline of the burial ground) compared to concentrations in the sitewide groundwater plume upgradient of the 618-11 Burial Ground. Historical concentrations at this well increased substantially between 1996 and 2000, corresponding to the period when a tritium release occurred. Several wells within the downgradient flow path of the tritium plume also show elevated nitrate concentrations relative to concentrations expected for the sitewide plume. For these reasons, the burial ground is assumed to be a local source for the excess nitrate (DOE/RL-2010-99).

Limited information is available for individual contaminant inventory for waste disposed to the 618-11 Burial Ground. DOE/RL-2008-27, *Sampling and Analysis Plan for 618-10 and 618-11 Nonintrusive Sampling*, lists the potential sources of nitrate from waste disposed to the 618-11 Burial Ground as sodium nitrite (a salting agent used during the cladding removal), nitric acid (used throughout the bismuth-phosphate process and uranium recovery process), and bismuth subnitrate (used to create the bismuth-phosphate/plutonium solid during the first and second decontamination cycles).

1.2.4 Contaminant Plumes

The narrow tritium plume extends for 1.2 km (0.7 mi) to the east of (downgradient from) the 618-11 Burial Ground and passes just to the north of Energy Northwest (Figure 1-2). The tritium plume appears to be contained within the saturated Rwie of the unconfined aquifer (CP-67635, ECF-HANFORD-21-0117).

Tritium concentrations near the 618-11 Burial Ground have generally declined from the maximum values observed in 1999 and 2000 (Figure 1-6). The tritium concentration trend in groundwater at well 699-13-3A (located adjacent to the eastern fenceline of the burial ground) suggests that an episodic event of unknown nature caused a tritium release from buried materials to contaminate groundwater. The tritium concentrations were relatively constant at well 699-13-3A from 2006 until 2016, declined significantly from 2017 to 2019, and then increased in 2020 and 2021. At wells farther downgradient from the 618-11 Burial Ground (e.g., 699-13-2D), trends reflect plume migration. The maximum concentration in 2021 was 879,000 pCi/L in well 699-13-3A, a decrease from the 2020 concentration of 1,050,000 pCi/L. Groundwater wells monitored by Energy Northwest do not show evidence of this plume above the cleanup level, and tritium is not detected in Energy Northwest water supply wells. However, the majority of Energy Northwest water supply wells are screened in the uncontaminated confined aquifer (i.e., do not produce water from the unconfined aquifer).

Nitrate concentrations near the 618-11 Burial Ground have fluctuated but generally remained steady except at well 699-13-3A until after January 2016 (Figure 1-7). Nitrate concentrations at well 699-13-3A quadrupled from a maximum concentration of 57.5 mg/L in 2016 to 252 mg/L in 2019, then decreased in 2020 and 2021 to 164 mg/L and 166 mg/L, respectively. The increased nitrate concentrations in 2019 and subsequent decrease may be associated with a mass release at least a decade ago and migration from the 618-11 Burial Ground rather than a change in vertical or horizontal groundwater flow direction (ECF-300FF5-21-0001). Nitrate concentrations also increased at well 699-12-2C in 2019. Well 699-12-2C then exhibited a slight decrease in nitrate in 2020 and a slight increase in 2021. Nitrate continued to increase at well 699-13-0A in 2021 and slightly increased at wells 699-13-1E and 699-13-2D. The locally elevated nitrate contamination is attributed to the 618-11 Burial Ground (Section 1.2.3).

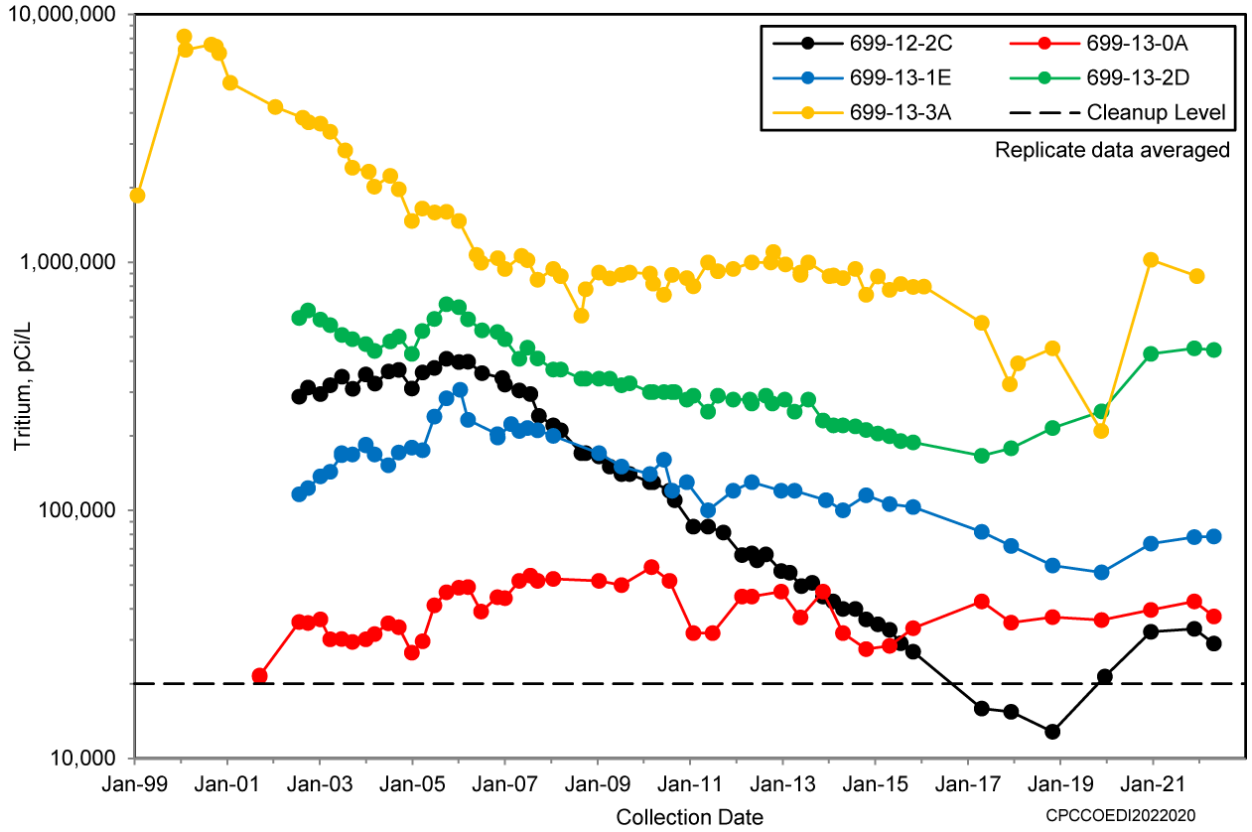


Figure 1-6. Tritium Data for Wells Downgradient of the 618-11 Burial Ground

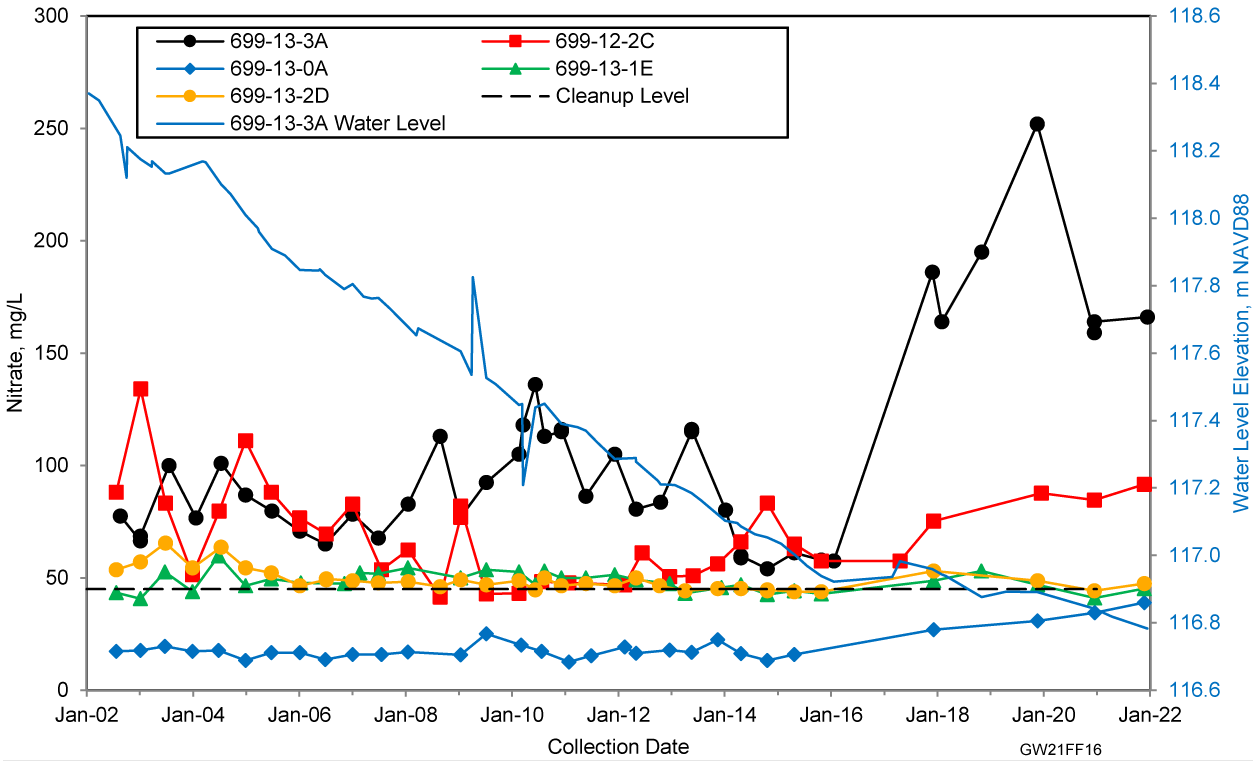


Figure 1-7. Nitrate Data for Wells Downgradient of the 618-11 Burial Ground

1.3 Data Quality Objective Summary

The DQO process is a strategic planning approach used to define the criteria that a data collection design should satisfy. This process is used to ensure that the type, quantity, and quality of the environmental data used in decision making will be appropriate for the intended application. The DQOs for this Addendum were developed in May 2022 through a collaborative effort among representatives from the U.S. Department of Energy, Richland Operations Office; U.S. Environmental Protection Agency; Washington State Department of Ecology, Central Plateau Cleanup Company, and INTERA in accordance with EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4), and Central Plateau Cleanup Company procedures. The DQO process involves a series of logical steps used to plan for the resource-effective acquisition of environmental data. The performance and acceptance criteria are determined through the DQO process, which serves as the basis for designing the plan to collect data of sufficient quality and quantity to support project goals. Appendix A of this Addendum presents summary information from the DQO process to support the sample design presented in this Addendum. The following sections discuss the key outputs resulting from the DQO process.

1.3.1 Statement of the Problem

Based on existing monitoring in the vicinity of the 618-11 Burial Ground, COCs are not attenuating according to expectations set forth in DOE/RL-2013-14-ADD2 and the ROD (EPA et al., 2013). Additionally, the RTD remedy for the 618-11 Burial Ground, which was expected to be completed by 2021, has not occurred. The magnitude of the difference between prior expectations and current conditions and the impact of that difference on remedy performance are uncertain.

1.3.2 Project Task and Problem Definition

The data gathered under this Addendum are intended to address data needs identified for enhanced groundwater monitoring around and downgradient of the 618-11 Burial Ground to further investigate and monitor the recent increases in tritium and nitrate concentrations downgradient of the waste site. The additional data are intended to support determining whether interim actions are warranted prior to initiating remediation of the burial ground to protect aquatic receptors. The principal study questions (PSQs) developed for this Addendum are as follows:

1. Will peak concentrations from the 618-11 Burial Ground nitrate groundwater plume exceed 45 mg/L (invertebrate surface water effect level) at the interface with the Columbia River?
2. Will peak concentrations from the 618-11 Burial Ground tritium groundwater plume exceed 2.65E+08 pCi/L (aquatic biota surface water effect value) at the interface with the Columbia River?
3. Has the timeline for MNA changed from the understanding established in the ROD (EPA et al., 2013)?
4. Are other 618-11 Burial Ground source constituent concentrations present in groundwater at levels that should be considered in an evaluation for potential remedial actions?
5. Is infiltration at the 618-11 Burial Ground driving the increasing concentrations of nitrate and tritium in groundwater?
6. Is the current monitoring network spatially adequate to answer PSQs 1 through 5?

Appendix A presents additional information regarding development of the PSQs and alternative actions to address the problem statement (Section 1.3.1).

1.3.3 Decision Statements

The DQO process identifies the key decisions and goals that must be addressed to achieve the final solution to the problem statement. This Addendum addresses data collection activities associated with enhanced groundwater monitoring around and downgradient of the 618-11 Burial Ground to solve the problem statement. The key questions that the data collection must address and the alternative actions that may result from the data analysis are presented in decision statements (DSs). Table 1-1 outlines the DSs.

Table 1-1. Decision Statements

No.	Decision Statement
1	Determine whether the peak concentration from the 618-11 Burial Ground nitrate groundwater plume will exceed 45 mg/L (invertebrate surface water effect level) at the interface with the Columbia River, then identify when the peak concentration is expected to arrive at the interface and if an update to the current remedy or its implementation and monitoring is needed; else, no change to the implementation and monitoring of the selected remedy is needed.
2	Determine whether the peak concentration from the 618-11 Burial Ground tritium groundwater plume will exceed 2.65E+08 pCi/L (aquatic biota surface water effect value) at the interface with the Columbia River, then identify when the peak concentration is expected to arrive at the interface and if an update to the current remedy or its implementation and monitoring is needed; else, no change to the implementation and monitoring of the selected remedy is needed.
3	Evaluate whether the timeline for MNA has changed from the understanding established in the ROD (EPA et al., 2013), then determine what the MNA timeline is and evaluate if an update to the current remedy or its implementation and monitoring is needed; else, no change is needed.
4	Determine whether concentrations of other 618-Burial Ground source constituents are present in groundwater at levels that should be considered in an evaluation for potential remedial action, then identify which constituents and at what values require an evaluation of changes to the current remedy or its implementation and monitoring; else, no change is needed.
5	Determine if infiltration at the 618-11 Burial Ground is driving the increasing concentrations of nitrate and tritium in groundwater, then evaluate whether infiltration reduction can achieve groundwater concentrations protective of the Columbia River and if an update to the current remedy or its implementation and monitoring is needed; else, no change is needed.
6	Evaluate whether the current well network is spatially adequate to answer PSQs 1 through 5, then continue the current monitoring of the selected remedy; else, determine the number and location of additional monitoring points needed to obtain the data necessary to address the PSQs and update the performance monitoring plan (the SAP [DOE/RL-2014-42]) accordingly.

References: DOE/RL-2014-42, 300-*FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan.*
EPA et al., 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*.

MNA = monitored natural attenuation
PSQ = principal study question
ROD = record of decision
SAP = sampling and analysis plan

1.3.4 Decision Rules

The decision rules (DRs) for each DS provide clear requirements that guide the decision-making process. The DRs are generated from the DSs. A DR is an "IF…THEN…ELSE…" statement incorporating the parameter of interest, unit of decision making, action level, and actions resulting from resolution of the decision. Table 1-2 presents the DR for each DS developed during the DQO process. Appendix A presents the information used to develop the DRs. Tables 1-1 and 1-2 present the DSs and DRs, respectively, as identified during the DQO process to be addressed in this Addendum. Appendix A presents the PSQs and alternative actions used to develop the DSs and DRs. Table 1-3 presents the data inputs to resolve the DSs. Chapter 2 presents the sampling plan (locations, frequencies, etc.). Appendix A includes additional information on the development of the sampling plan.

Table 1-2. Decision Rules

DR #	DS #	Decision Rules
1	1	If the peak concentration from the 618-11 Burial Ground nitrate plume will exceed 45 mg/L (invertebrate surface water effect level) at the interface with the Columbia River, then identify when that peak concentration is expected to arrive at the interface; else, no change to the implementation and monitoring of the selected remedy is needed.
2	2	If the peak concentration from the 618-11 Burial Ground tritium groundwater plume will exceed 2.65E+08 pCi/L (aquatic biota surface water effect value) at the interface with the Columbia River, then identify when that peak concentration is expected to arrive at the interface; else, no change to the implementation and monitoring of the selected remedy is needed.
3	3	If the timeline for MNA has changed from the understanding established in the ROD (EPA et al., 2013), then determine what the MNA timeline is and evaluate if an update to the current remedy or its implementation and monitoring is needed; else, no change is needed.
4	4	If concentrations of other 618-11 Burial Ground source constituents are present in groundwater at levels that should be considered in an evaluation for potential remedial action, then identify which constituents and at what values require an evaluation of changes to the current remedy or its implementation and monitoring; else, no change is needed.
5	5	If infiltration at the 618-11 Burial Ground is driving the increasing concentrations of nitrate and tritium in groundwater, then evaluate whether infiltration reduction can achieve groundwater concentrations protective of the Columbia River and if an update to the current remedy or its implementation and monitoring is needed; else no change is needed.
6	6	If the current well network is spatially adequate to answer PSQs 1 through 5, then continue the current monitoring of the selected remedy; else, determine the number and location of additional monitoring points needed to obtain the data necessary to address the PSQs and update the performance monitoring plan (the SAP [DOE/RL-2014-42]) accordingly.

References: DOE/RL-2014-42, 300-*FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan.*

EPA et al., 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*.

DR = decision rule
DS = decision statement
MNA = monitored natural attenuation
PSQ = principal study question
ROD = record of decision
SAP = sampling and analysis plan

Table 1-3. Summary of Data Inputs to Resolve Decision Statements

Data Input	DS #
Groundwater monitoring data in the vicinity and downgradient of the 618-11 Burial Ground are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6

Table 1-3. Summary of Data Inputs to Resolve Decision Statements

Data Input	DS #
Groundwater elevation/water-level data in the vicinity and downgradient of the 618-11 Burial Ground are needed to update the vadose zone model to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6
Hydrostratigraphic data from monitoring wells in the vicinity and downgradient of the 618-11 Burial Ground are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, and determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6
Hydraulic property data from monitoring wells in the vicinity and downgradient of the 618-11 Burial Ground are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6
Existing and new soil/sediment results collected from boreholes and monitoring wells in the vicinity and downgradient of the 618-11 Burial Ground are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, and determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6
Historical records regarding operations/waste disposed to the 618-11 Burial Ground are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6

Table 1-3. Summary of Data Inputs to Resolve Decision Statements

Data Input	DS #
Estimates of hydraulic and chemical transport values are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6
Precipitation data are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6
River stage and flow data are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the direction and rate of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	1, 2, 3, 5, and 6
Groundwater monitoring data in the vicinity and downgradient of the 618-11 Burial Ground are needed to determine whether other 618-11 Burial Ground source constituents are present in groundwater at levels that should be considered in an evaluation for potential remedial action.	4
Existing soil/sediment results collected from boreholes and monitoring wells and new soil/sediment results collected during the installation of new monitoring wells in the vicinity of the 618-11 Burial Ground are needed to determine whether other 618-11 Burial Ground source constituents are present in groundwater at levels that should be considered in an evaluation for potential remedial action.	4

DS = decision statement
MNA = monitored natural attenuation

1.4 Target Analytes

Target analytes to address the DSs (Table 1-1) and specific data inputs (Table 1-3) were selected through the DQO process. Table 1-4 lists the target analytes and the purpose for inclusion. Table 2-1 of this Addendum lists the sampling schedule and notes location-specific analytes. Chapter 4 of the SAP (DOE/RL-2014-42) contains the QAPjP for the work described in this Addendum.

Table 1-4. Analytes for Enhanced 300-FF-5 OU Sampling Downgradient of the 618-11 Burial Ground

Analyte	CAS No.	Purpose
General Chemistry and Anions		
Alkalinity (bicarbonate)	71-52-3	Indicator of contaminant migration; better understand likely inventory and potential mass within/from the 618-11 Burial Ground
Chloride	16887-00-6	
Nitrate (as NO_3)*	14797-55-8	
Nitrite	14797-65-0	
Sulfate	14808-79-8	
Metals		
Arsenic	7440-38-2	Indicator of contaminant migration; better understand likely inventory and potential mass within/from the 618-11 Burial Ground
Calcium	7440-70-2	
Iron	7439-89-6	
Magnesium	7439-95-4	
Manganese	7439-96-5	
Potassium	7440-09-7	
Sodium	7440-23-5	
Phosphorus	7723-14-0	
Uranium	7440-61-1	
Radiochemical Parameters		
Plutonium-239/240	PU-239/240	Better understand likely inventory and potential mass within/from the 618-11 Burial Ground
Technetium-99	14133-76-7	Indicator of contaminant migration; better understand likely inventory and potential mass within/from the 618-11 Burial Ground
Tritium*	10028-17-8	
Field Measurements		
Specific conductance	N/A	General water chemistry to support data review and interpretation
Temperature	N/A	
pH	N/A	
Dissolved oxygen	N/A	
Turbidity	N/A	

*Constituent is listed as a contaminant of concern in the ROD (EPA et al., 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*).

CAS = Chemical Abstracts Service

N/A = not applicable

ROD = record of decision

Nitrate and tritium are listed as COCs in the ROD for groundwater at the 618-11 Burial Ground (EPA et al., 2013). Section 1.2.4 of this Addendum presented summary information regarding these COCs and their recent increase in groundwater concentrations in the vicinity of the 618-11 Burial Ground, providing the basis for the enhanced monitoring need.

Uranium, technetium-99, and plutonium-239/240 were identified as target analytes during the DQO process based on their likely presence as source constituents in the 618-11 Burial Ground. Figures 1-8 and 1-9 show groundwater concentrations for uranium and technetium-99, respectively, in the groundwater monitoring wells downgradient of the burial ground. Concentrations for both uranium and technetium-99 remain below cleanup levels. Concentrations for uranium in these monitoring wells measured after 2017 (when the nitrate spike appeared) are generally within ±20% (the analytical acceptance range for the method) and are considered to have remained consistent with concentrations prior to 2017. Technetium-99 concentrations were measured in each well two or three times since 2016; therefore, concentration trends could not be confidently discerned based on these sparse data.

Plutonium-239/240 concentrations were measured once in each well (699-12-2C, 699-13-0A, 699-13-1E, 699-13-2D, and 699-13-3A). However, records indicate the possibility that small amounts of plutonium-contaminated liquid waste were sealed in concrete 208 L (55 gal) drums and disposed in the 618-11 Burial Ground. The calculated total mass of plutonium in the burial ground based on historical records and process knowledge is approximately 2,422 g (Appendix A of DOE/RL-2014-13-ADD1).

Concentrations of additional analytes of interest including alkalinity, select anions (chloride, sulfate, and nitrite), and metals (arsenic, calcium, iron, magnesium, manganese, potassium, sodium, and phosphorus) will be measured as indicators of contaminant migration.

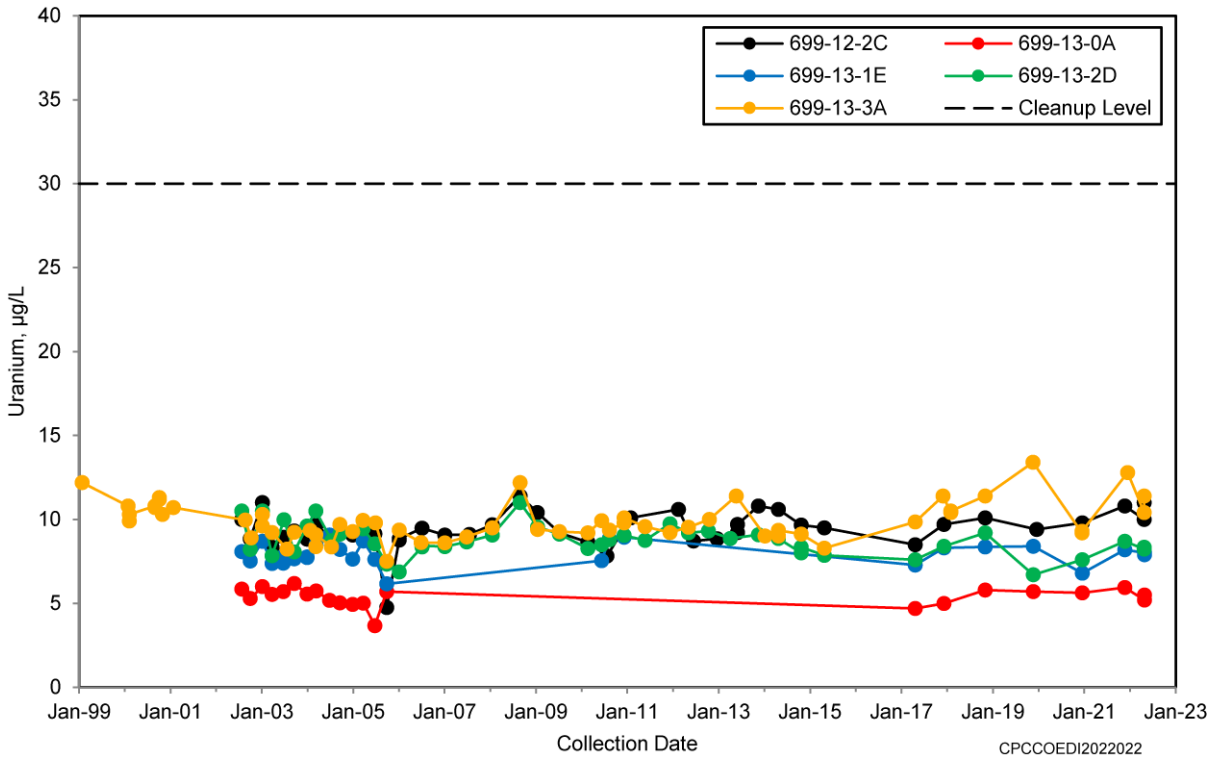


Figure 1-8. Uranium Data for Wells Downgradient of the 618-11 Burial Ground

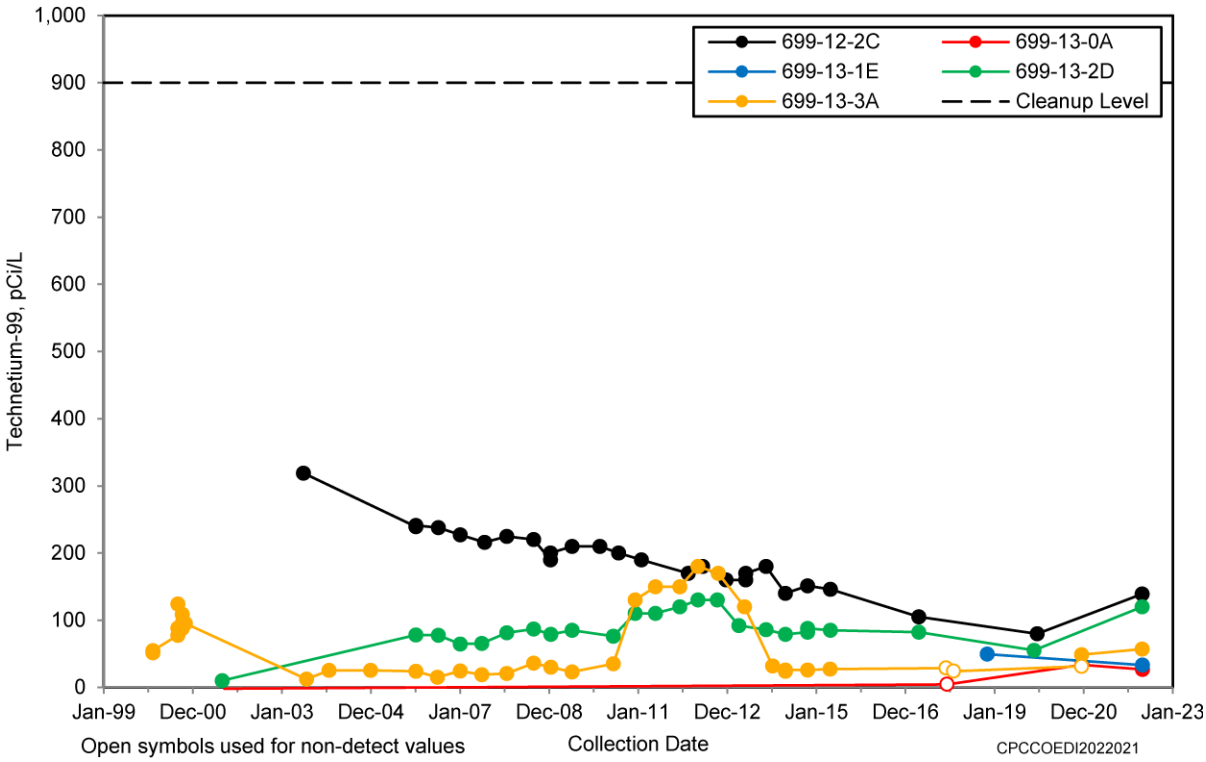


Figure 1-9. Technetium-99 Data for Wells Downgradient of the 618-11 Burial Ground

This page intentionally left blank.

2 Field Sampling Plan

The objective of the field sampling plan is to clearly identify project sampling and analysis activities. The field sampling plan uses the sampling design identified through the DQO process and identifies sampling locations, the total number of samples to be collected, the sampling procedures to be implemented, and the analyses to be performed. This chapter provides the sample locations and collection frequencies determined through the DQO process for the enhanced groundwater monitoring at and downgradient of the 618-11 Burial Ground. Chapter 5 of the SAP (DOE/RL-2014-42) contains the groundwater sampling methods, documentation of field activities, calibration of field equipment, sample handling, and operations and maintenance requirements for the groundwater sampling activities in this Addendum. Appendix A of this Addendum contains a summary of the outcomes of the DQO process.

Chapter 4 of the SAP (DOE/RL-2014-42) contains the QAPjP for the data collection activities in this Addendum. The QAPjP establishes the quality requirements for environmental data collection, including planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review.

Waste management and health and safety requirements for the activities in this Addendum are contained in Chapters 6 and 7 of the SAP (DOE/RL-2014-42), respectively.

2.1 Sampling Objectives and Design

The sampling design is judgmental. In judgmental sampling, the selection of sampling units (i.e., the number and location and/or timing of collecting samples) is based on knowledge of the feature or condition under investigation and on professional judgment. Judgmental sampling is distinguished from probability-based sampling in that inferences are based on professional judgment, not statistical scientific theory. Therefore, conclusions about the target population are limited and depend entirely on the validity and accuracy of professional judgment. Probabilistic statements about parameters are not possible.

The design for obtaining the data necessary to address the DSs developed through the DQO process includes groundwater contaminant concentration monitoring, hydraulic monitoring, and flow rate monitoring. This information is needed to support the following:

- Predicting peak nitrate and tritium concentrations between the unconfined aquifer and the interface with the Columbia River
- Confirming MNA is occurring with a stable and shrinking plume
- Estimating the MNA timelines for nitrate and tritium concentrations in groundwater
- Running different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions
- Developing detailed mapping of the contaminant concentration distribution in three dimensions and updating the plume maps and flow directions
- Evaluating the distribution and inventory of tritium existing within the vadose zone
- Identifying whether other 618-11 Burial Ground source constituents may be present in groundwater at concentrations that should be considered in an evaluation for potential remedial actions
- Determining the role of infiltration in increasing nitrate and tritium concentrations in groundwater

- Determining the direction of groundwater flow and the influence of river stage on groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River

As determined during the DQO process, new groundwater monitoring points are needed to enhance the existing monitoring network to address the DSs (Table 1-1). Existing data (e.g., groundwater contaminant concentrations from existing monitoring wells and aquifer tubes, groundwater flow directions, spatial distribution of the existing monitoring points) were used to determine the locations of the new monitoring points.

Initially, six aquifer tubes are needed to monitor the concentrations of nitrate and tritium at the interface of the aquifer and the Columbia River (DSs 1, 2, and 3) (Table 1-1). Figure 2-1 shows the locations of these six aquifer tubes (three existing and three proposed). The initial locations of the aquifer tubes for the enhanced groundwater monitoring network at the 618-11 Burial Ground include the following:

- Existing aquifer tube C6368 is located east-southeast of the 618-11 Burial Ground. The screened interval is 1.96 to 2.11 m (6.43 to 6.93 ft) below ground surface (bgs). This aquifer tube has been monitored since 2008 for the 200-PO-1 OU.
- Existing aquifer tube C6362 is located northeast of the 618-11 Burial Ground. The screened interval is 2.01 to 2.16 m (6.58 to 7.08 ft) bgs. This aquifer tube has been monitored since 2008 for the 200-PO-1 OU.
- Existing aquifer tube C6359 is located northeast of the 618-11 Burial Ground. The screened interval is 1.31 to 1.46 m (4.28 to 4.78 ft) bgs. This aquifer tube has been monitored since 2008 for the 200-PO-1 OU.
- New aquifer tube TBD-1, planned east-northeast of the 618-11 Burial Ground, is intended to replace aquifer tube C6365, which cannot be located and has been decommissioned.
- New aquifer tube TBD-2 is proposed east of the 618-11 Burial Ground, midway between aquifer tubes C6368 and TBD-1.
- New aquifer tube TBD-3 is proposed northeast of the 618-11 Burial Ground, midway between aquifer tubes C6362 and TBD-1.

The three proposed new aquifer tubes will be located following field reconnaissance and cultural resources review of the proposed general locations. New aquifer tubes will be installed by driving a steel tube approximately 5 to 7.5 m (15 to 25 ft) deep using a hand-operated air-driven and/or hydraulic-driven ram (post driver). Once the desired depth is reached, the aquifer tube is installed and the outer casing is removed leaving the sample tube in place. Installation typically occurs during a low water period, so all work is done above the wetted perimeter of the shoreline.

The location and need for additional new aquifer tubes will be determined based on review of new and existing monitoring data collected from these six aquifer tubes and the enhanced groundwater monitoring for the 618-11 Burial Ground.

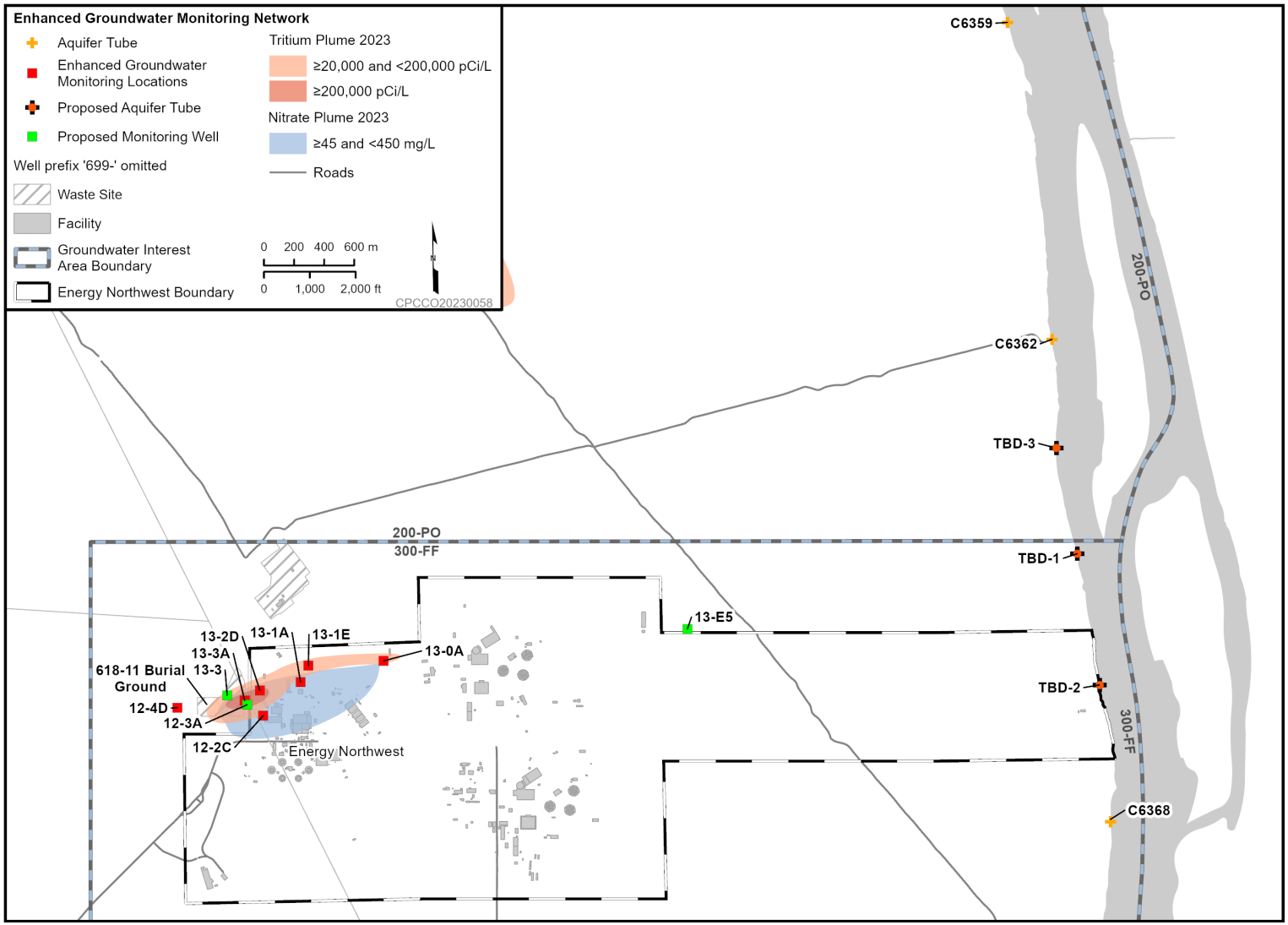


Figure 2-1. Enhanced 300-FF-5 OU Groundwater Monitoring Network for the 618-11 Burial Ground

Seven existing and three new groundwater monitoring wells are needed to evaluate groundwater contaminant concentrations and trends (DSs 3, 4, 5, and 6). Figure 2-1 shows the locations (existing and proposed) for these monitoring wells. The seven existing groundwater wells in the 618-11 Burial Ground enhanced monitoring network include downgradient wells 699-12-2C, 699-13-0A, 699-13-1E, 699-13-2D, 699-13-1A, and 699-13-3A, and upgradient well 699-12-4D. It should be noted that there are other wells located within the Energy Northwest boundary not shown in Figure 2-1. Data from Energy Northwest annual reports are used to define control points in plume maps for the Hanford Site annual groundwater report. However, for the purpose of this SAP Addendum, Figure 2-1 focuses on the current 618-11 Burial Ground enhanced monitoring network. The location and rationale for the three proposed groundwater monitoring wells follow:

- New groundwater well 699-13-E5 (D0417) is proposed downgradient of the 618-11 Burial Ground and east of well 699-13-0A to address DSs 1, 2, 4, and 5. This location provides enhanced detail of groundwater concentrations downgradient of the plumes defined using the existing well network. Soil samples will be collected and analyzed as needed to support fate and transport modeling. The proposed location is on the northeast side of the Energy Northwest operational area, and just outside of the operational boundary. The expected depth to water is approximately 38.1 m (100 ft) bgs.

- New groundwater well 699-13-3 (D0418) is proposed north of the 618-11 Burial Ground in the general vicinity of the burial ground to address DSs 1 through 5. This location provides enhanced detail of groundwater flow and groundwater concentrations near the burial ground, which is the source of the contamination. This location also improves plume delineation and serves as a potential alternate upgradient well. The expected depth to water is approximately 19.5 m (64 ft) bgs. Soil samples targeting specific depths and analyzed for chemical and radiological contaminants will be used to evaluate the vertical profile of concentrations in the vadose zone and support fate and transport modeling. Vadose zone sampling data may be used in soil water balance calculations to estimate deep drainage percolation as a method to investigate enhanced recharge from natural precipitation (ECF-300FF5-21-0001).

- New groundwater well 699-12-3A (D0419) is proposed east of the 618-11 Burial Ground in the general vicinity of the burial ground to address DSs 1 through 5. This location provides enhanced detail of groundwater concentrations near the trench area of the burial ground, which is a source of the contamination. The expected depth to water is approximately 19.5 m (64 ft) bgs. Soil samples targeting specific depths and analyzed for chemical and radiological contaminants will be used to evaluate the vertical profile of concentrations in the vadose zone and support fate and transport modeling. Vadose zone sampling data may be used in soil water balance calculations to estimate deep drainage percolation as a method to investigate enhanced recharge from natural precipitation (ECF-300FF5-21-0001).

New groundwater wells will be geologically and geophysically logged to refine the hydrogeologic model used in fate and transport modeling.

The final locations for the new proposed groundwater wells will be selected based on results of continued monitoring of the existing well network, the updated conceptual site model, and site reconnaissance and cultural resources review. Well specifications and installation requirements (e.g., sampling during drilling, well design) for the new groundwater monitoring wells are provided in Section 2.2.

2.2 Sample Locations and Frequency

This section presents the groundwater sampling locations and frequencies and the general types and locations of soil/sediment samples to be collected during drilling.

2.2.1 Groundwater Monitoring

Figure 2-1 shows the wells and aquifer tubes that comprise the enhanced groundwater monitoring network for the 618-11 Burial Ground. Table 2-1 lists the sample collection frequency for each monitoring location. Groundwater samples will be analyzed for the constituents listed in Table 1-4, except as footnoted in Table 2-1. In addition, water-level measurements will be recorded as part of sample collection activities. Groundwater sampling methods and requirements are located in Chapter 5 of the SAP (DOE/RL-2014-42).

Following acceptance of each new groundwater well, a groundwater sample will be collected for laboratory analysis of potential contaminants, as identified in Table 1-4. Field parameters will be measured during sampling. Continued groundwater monitoring sampling for the new wells will occur in accordance with Table 2-1.

Table 2-1. Sample Locations and Frequencies for the Enhanced Groundwater Monitoring at the 618-11 Burial Ground

Location	Screened Unit	Year Constructed	Sampling Frequency
Groundwater Wells			
699-12-2C	TU	2001	SA
699-12-4D	TU	1982	A
699-13-0A	TU	2001	SA
699-13-1E[a]	TU	2001	SA
699-13-2D	TU	2001	SA
699-13-1A[b]	TU, MU	1973	SA
699-13-3A	TU	1995	SA
699-13-E5 [c]	TU	2025	SA
699-13-3	TU	2024	SA
699-12-3A	TU	2024	SA
Aquifer Tubes[d]			
TBD-1[a,c]	TBD	TBD	A
TBD-2[a,c]	TBD	TBD	A
TBD-3[a,c]	TBD	TBD	A
C6362 [a,c]	2.16[e]	2008	A

Table 2-1. Sample Locations and Frequencies for the Enhanced Groundwater Monitoring at the 618-11 Burial Ground

Location	Screened Unit	Year Constructed	Sampling Frequency
C6359[a,c]	1.46[e]	2008	A
C6368 [a,c]	2.11[e]	2008	A

Note: Groundwater samples will be analyzed for the constituents in Table 1-4, except as listed in the footnotes below.

a. Plutonium-239/240 analysis is not required at this location.

b. Portable pump intake will be set at the uppermost screened interval during sampling.

c. The location name and coordinates for new groundwater wells and aquifer tubes will be determined after field reconnaissance and cultural resource review of the proposed location.

d. Aquifer tubes are to be sampled during low river stage.

e. Screen depth (meters below ground surface).

A = annual
MU = middle unconfined
SA = semiannual (twice yearly)
TBD = to be determined
TU = top unconfined. Screen is across or within 1.5 m (5 ft) of the water table with <10.7 m (35 ft) of the open interval extending below the water table.

2.2.2 Helium-3 Soil Gas Survey

A helium-3 soil gas survey will be performed over the 618-11 Burial Ground to assess the distribution of tritium. The results of the survey will lead to better understanding of the distribution of tritium existing within the vadose zone and help estimate the inventory and distribution of tritium in the subsurface.

2.2.3 Sampling During Well Installation

Soil and groundwater samples will be collected during drilling in accordance with the sample designs listed in Table 2-2 and will be analyzed for the radiological and chemical constituents listed in Table 1-4.

2.2.3.1 Soil/Aquifer Sediment Sampling

Soil samples for analytical testing, including vadose zone soil and/or aquifer sediment, will be collected during drilling of wells 699-13-3 and 699-12-3A to support refinements to the fate and transport model. Sample collection will begin at approximately 3 m (10 ft) bgs and continue at 3 m (10 ft) intervals thereafter to total borehole depth and at depths just above, at, and just below the top of the unconfined aquifer.

Soil samples for laboratory analysis will be collected in Lexan™ liners using a decontaminated split-spoon sampler or sonic core barrel (depending on the drilling method) and sealed in the field. Each liner typically has a diameter of 10 cm (4 in.), and a length of 15 cm (6 in.). Other methods for collecting representative soil samples for laboratory analysis may also be used during drilling.

™ Lexan is a trademark of Sabic Global Technologies, Riyadh, Saudi Arabia.

2.2.3.2 Groundwater Sampling During Drilling

Groundwater samples will be collected during drilling of new groundwater wells to confirm ambient water chemistry, determine baseline contaminant concentrations within the aquifer in the vicinity of the new well, and determine whether a vertical distribution of contaminants is present. Sample collection will begin approximately 1.5 m (5 ft) into the unconfined aquifer and continue at 3 m (10 ft) intervals throughout the thickness of the unconfined aquifer. If field conditions preclude collection of the first groundwater sample (e.g., insufficient groundwater available, borehole collapse), advance the borehole to approximately 3 m (10 ft) into the aquifer and continue collecting groundwater samples at 3 m (10 ft) intervals. The estimated depths for groundwater sample collection are listed in Table 2-2. Groundwater samples collected during drilling will be analyzed for the constituents in Table 1-4.

Each groundwater sample will be screened in the field for pH, temperature, conductivity, dissolved oxygen, and turbidity (Table 1-4). Groundwater samples will be collected after field measurements stabilize as follows:

- **pH:** Two consecutive measurements agree within 0.2 pH units
- **Temperature:** Two consecutive measurements agree within 0.2°C (0.4°F)
- **Conductivity:** Two consecutive measurements agree within 10% of each other
- **Turbidity:** <5 nephelometric turbidity units (NTUs) prior to sampling[1]

The OU technical lead will be contacted if screening levels cannot be achieved prior to sampling.

Groundwater samples collected during drilling will be obtained using an environmental-grade pump supplied by the drilling contractor at the approximate depths shown in Table 2-2. Bailed samples can be collected if purging is not practicable, as determined by the OU technical lead. Prior to sample collection, purging of the sampling interval will be performed at flow rates of <38 L/min (10 gal/min) until field parameters stabilize (as defined above). Samples will be collected from the aquifer at flow rates of <3.8 L/min (1 gal/min).

Table 2-2. Sample Collection During Drilling

Location	Estimated Sampling Depth During Drilling (ft bgs)[a]		Geologic Archive Grab Sampling	Sieve Analysis Grab Sampling	Post-Acceptance Groundwater Sampling
	Soil[b]	Groundwater[c]			
699-13-E5 (D0417)	NA	100 110 120	Every 5 ft or where lithologic changes occur from ground surface to total depth. Collect geologic archive samples in pint jar and a chip tray from drill cuttings.	Grab samples will be collected at 5 ft intervals from 0 to 25 ft below the water table for sieve analysis. Adjacent grab samples with similar texture may be composited. Sieve analysis results will be used to select the well screen slot size and filter pack material.	Baseline sample after well completion and acceptance

[1] For groundwater samples collected during drilling, turbidity values <5 NTUs may not be achievable. Samples may be collected at the discretion of the field geologist or sampler once the other field parameters stabilize as indicated.

Table 2-2. Sample Collection During Drilling

Location	Estimated Sampling Depth During Drilling (ft bgs)[a]		Geologic Archive Grab Sampling	Sieve Analysis Grab Sampling	Post-Acceptance Groundwater Sampling
	Soil[b]	Groundwater[c]			
699-13-3 (D0418)	10 to 12.5 20 to 22.5 30 to 32.5 40 to 42.5 50 to 52.5 60 to 62.5 65 to 67.5 70 to 72.5 75 to 77.5 80 to 82.5	70 80 90	Every 5 ft or where lithologic changes occur from ground surface to total depth. Collect geologic archive samples in pint jar and a chip tray from drill cuttings.	Grab samples will be collected at 5 ft intervals from 0 to 25 ft below the water table for sieve analysis. Adjacent grab samples with similar texture may be composited. Sieve analysis results will be used to select the well screen slot size and filter pack material.	Baseline sample after well completion and acceptance
699-12-3A (D0419)	10 to 12.5 20 to 22.5 30 to 32.5 40 to 42.5 50 to 52.5 60 to 62.5 65 to 67.5 70 to 72.5 75 to 77.5 80 to 82.5	70 80 90	Every 5 ft or where lithologic changes occur from ground surface to total depth. Collect geologic archive samples in pint jar and a chip tray from drill cuttings.	Grab samples will be collected at 5 ft intervals from 0 to 25 ft below the water table for sieve analysis. Adjacent grab samples with similar texture may be composited. Sieve analysis results will be used to select the well screen slot size and filter pack material.	Baseline sample after well completion and acceptance

Note: Sample depths may be adjusted based on field conditions and the depth to water table. All depths are in feet bgs. At the discretion of the operable unit technical lead, field geologist, or sampler, additional samples may be collected based on field screening results and observations.

a. Samples will be analyzed for Table 1-4 constituents, unless otherwise noted.

b. Soil sampling is to begin at ~10 ft (3 m) bgs and continue at 10 ft (3 m) intervals thereafter until the total borehole depth is reached. In addition, soil/aquifer sediment samples are to be collected at depths just above, at, and just below the top of the unconfined aquifer.

c. Groundwater sampling is to begin at ~5 ft (1.5 m) into the unconfined aquifer and continue at 10 ft (3 m) intervals throughout the thickness of the unconfined aquifer. If field conditions preclude collection of the first groundwater sample at this depth (e.g., insufficient groundwater available, borehole collapse), advance the borehole to ~10 ft (3 m) into the aquifer and begin collecting groundwater samples at 10 ft (3 m) intervals throughout the thickness of the unconfined aquifer.

bgs = below ground surface
NA = not applicable

2.2.4 Well Drilling and Completion

The drilling method will be determined by the drilling lead and drilling contractor. The method must be compatible with data needs. All reasonable efforts will be made to minimize or eliminate the addition of water to the borehole. If water addition is necessary, the volume added should be kept to the smallest volume required.

Well drilling and completion will be performed in accordance with the substantive requirements of WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells.” If the completion

differs from the WAC 173-160 minimum standards, a variance will be obtained from the Washington State Department of Ecology and a comparable alternative specification that will provide equal or greater human health and resource protection will be used.

2.2.5 Geological Logging and Waste Characterization

Geologic logging is a system of documenting the stratigraphic relationships of geologic materials encountered during borehole drilling. Soil samples from drill cuttings, split-spoon samplers, or sonic cores (depending on drilling method) will be logged throughout the borehole, and changes in drilling rate will be documented by the field geologist in accordance with contractor procedures. The field geologist will collect drill cuttings every 1.5 m (5 ft) and at changes in stratigraphy from the surface to the total drilling depth, and the samples will be archived. Archive samples will be collected in pint-sized glass jars, and representative interval samples will be collected in chip trays and photographed. The log will be reviewed and approved by a geologist who did not complete the log. If representative samples cannot be collected, notes describing the condition of the samples will be entered into the field geologist's log. Archive samples will not be collected if contamination is encountered. Archived samples will be transported to the geologic sample library and stored. Records generated during geologic logging will be managed in accordance with contractor procedures. A soil sample may be collected for analytical testing in such cases.

Soil "grab" samples may be collected during borehole drilling for waste characterization requirements. If needed, additional waste characterization samples may be collected from archived samples, if an unanticipated analyte is identified in the waste characterization sample, creating the need for additional characterization data at a specific location. It should be noted that grab samples are not stored in a temperature-controlled environment and that any data obtained from them will likely have laboratory and/or review qualifiers applied.

2.2.6 Sieve Analyses

Sieve analyses will be performed on samples collected across the wells' planned submerged screen length (e.g., from 0 to 7.6 m [0 to 25 ft] below the water table), and adjacent samples with similar texture may be composited. The sieve analysis results will be used to select the screen slot sizes and filter pack material for the wells.

2.2.7 Geophysical Logging

Geophysical logging will be performed through each single string of casing to produce a geophysical log of the entire length of the borehole. The borehole will be logged before downsizing each temporary casing string or once the total drill depth is reached. A spectral gamma logging system will be run from ground surface to the total depth of the borehole to determine the vertical distribution and concentration of gamma-emitting radionuclides. A neutron-moisture logging system will also be run from ground surface to the top of the water table to determine soil moisture. Geophysical logging will not be performed in open boreholes or after well construction.

2.2.8 Well Installation and Development

Figure 2-2 depicts the conceptual well design for the new monitoring wells. Well drilling and completion will be performed in accordance with the substantive requirements of WAC 173-160. If the completion differs from the WAC 173-160 minimum standards, then a comparable alternative specification that will provide equal or greater human health and resource protection will be used.

The wells will be constructed generally (as shown in Figure 2-2) using 10.16 cm (4 in.) diameter casing. The wells will be constructed using Schedule 10, Type 304 or 316, stainless-steel, V-slot, continuous wire-wrap screen with an end cap. The screened interval for the three wells is anticipated to be 7.62 m (25 ft) in length and will be set at the interval with the highest groundwater contamination. The depth of the screens will be selected based on an evaluation of groundwater samples collected during drilling. A Schedule 10 stainless-steel casing will extend from the top of the well screen to the ground surface. Colorado silica sand or an approved equivalent will be used for the sand pack; sodium bentonite pellets and/or natural sodium bentonite chunks, crumbles, or powdered bentonite will be used for bentonite sealing material; and Type I/II Portland cement will be used for cement grout. Any changes in well construction materials will be approved by the drilling lead or designee prior to use.

Surface construction will consist of a protective casing, protective guard posts, and cement pad. The protective casing shall be a minimum of 5.1 cm (2 in.) larger in diameter than the permanent casing. The protective casing shall rise approximately 0.9 m (3 ft) above the ground surface. Permanent casing shall rise to approximately 0.3 m (1 ft) below the top of the protective casing. The protective casing shall have a lockable well cap extending approximately 38 cm (15 in.) above the top.

The functionality of wells is dependent on the well design and development of the well during completion activities. Surging and pumping the well will assist in obtaining maximum flow rates. Well surging will continue until there is <3 cm (0.1 ft) of screen infill (sediment entering the well screen and settling in the end cap) per 15 minutes of surge time. Surging will continue until the well ceases to exceed this rate of settling and turbidity has decreased to less than or equal to 5 NTUs. Material settled in the bottom of the well will be removed prior to well acceptance and use.

The objectives of well development are to settle the filter pack, prevent uncontrolled infiltration of fines, and improve communication of the well with the surrounding formation. Well development will be conducted during well construction and after well completion. Initial development will be performed during well construction in conjunction with placement of the filter pack using a dual surge block. The purpose of the dual surge block method is to settle the filter pack, remove loose particulates generated during construction activities, and develop communication across the borehole wall. Fine-grained sediment and filter pack sand drawn into the well during surging are typically removed with a bailer (nondart bailer recommended) or sand pump.

After well completion, final well development will be performed using the mechanical pumping (over-pumping) method. Final well development with a submersible pump will occur after the fines are removed. Fines that settle to the bottom of the well are typically removed with a bailer or sand pump. If the saturated screened interval is >6.1 m (20 ft) in length, the development pump intake will be placed at two equally spaced intervals along the length of the screen to adequately develop the screened interval. The OU technical lead will be consulted for pumping rates to target during well development.

Water samples will be collected for analysis of turbidity, temperature, pH, and specific conductance using field instruments. Development will continue until the well produces clear water (<5 NTUs) and the temperature, pH, and conductivity have stabilized (in accordance with site procedures) with 20% to 50% drawdown with a stabilized pumping rate. The field buyer's technical representative, with information from the field geologist, will determine when development is complete.

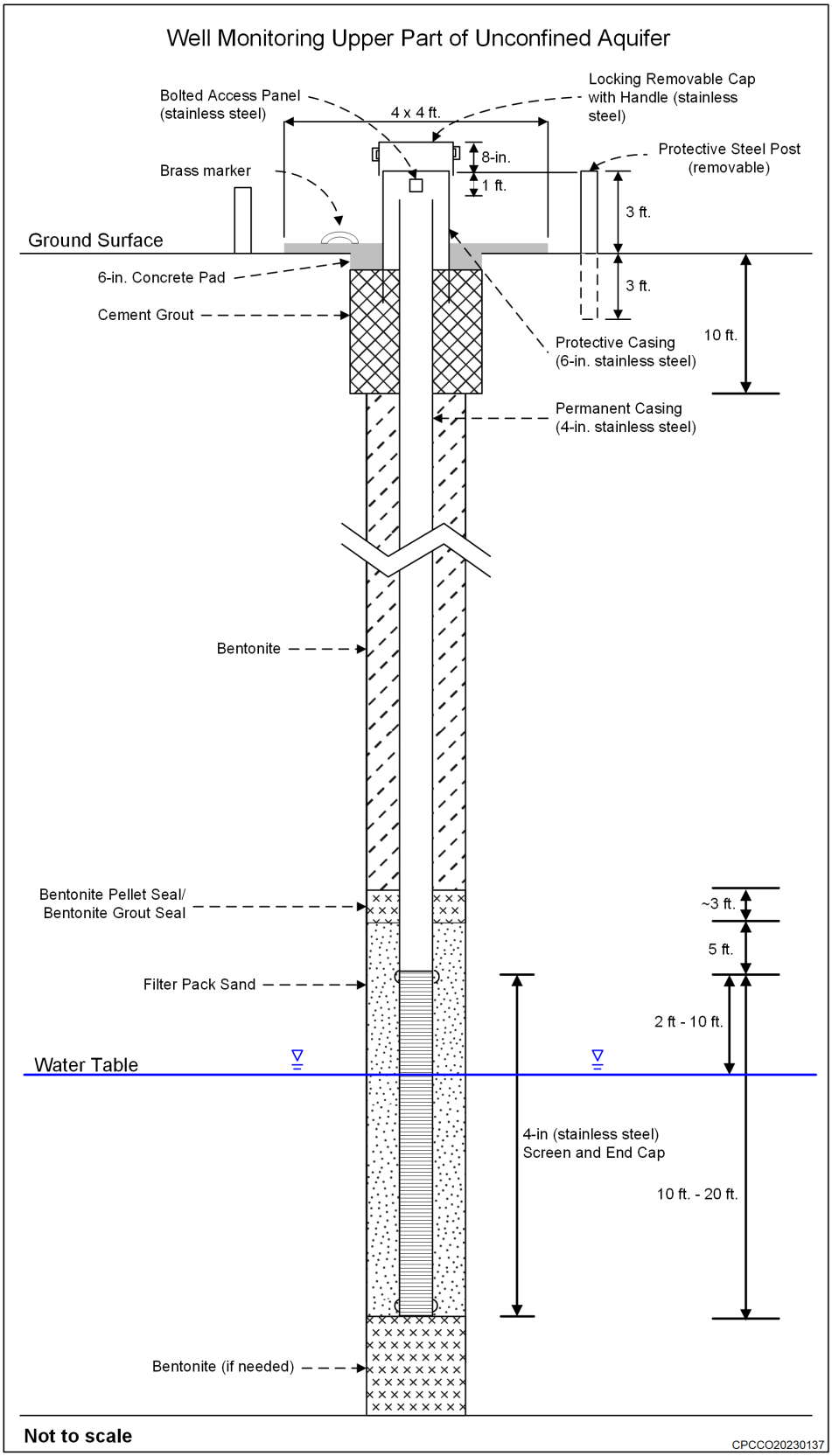


Figure 2-2. Conceptual Groundwater Monitoring Well Design

This page intentionally left blank.

3 References

BHI-00291, 1997, *Geophysical Investigation of the 618-10 and 618-11 Burial Grounds, 300-FF-2 Operable Unit*, Rev. 1, Bechtel Hanford Inc., Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-13332.

CP-67635, 2022, *Development of the Hanford South Geoframework Model Version 6.0*, Rev. 0, Central Plateau Cleanup Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-21578.

CP-67995, 2023, *Conceptual Site Model for the 618-11 Burial Ground*, Rev. 0, Central Plateau Cleanup Company, Richland, Washington. Available at: http://pdw.hanford/gov/document/AR-.

DOE/RL-2008-27, 2009, *Sampling and Analysis Plan for 618-10 and 618-11 Nonintrusive Sampling*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0906110868.

DOE/RL-2010-99, 2013, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/document/0088359.
http://pdw.hanford.gov/document/0088307.
http://pdw.hanford.gov/document/0088306.
http://pdw.hanford.gov/document/ 0088305.

DOE/RL-2014-13, 2015, *Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units)*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/document/ 0081153H.

DOE/RL-2014-13-ADD1, 2016, *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0076809H.

DOE/RL-2014-13-ADD2, 2015, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0081151H.

DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0079669H.

Modified by:

TPA-CN-0917, 2021, *Tri-Party Agreement Change Notice Form: DOE/RL-2014-42, 300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, *Rev. 0*, dated September 14, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-16451.

DOE/RL-2020-60, 2021, *Hanford Site Groundwater Monitoring Report for 2020,* Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-16952.

DOE/RL-2021-51, *Hanford Site Groundwater Monitoring Report for 2021,* Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-22712.

ECF-300FF5-21-0001, 2021, *618-11 Burial Ground Conceptual Model Update and Evaluation of Increasing Nitrate Concentrations in Groundwater, FY 2021,* Rev. 0, Central Plateau Cleanup Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-13531.

ECF-HANFORD-20-0008, 2021, *Development of Hanford Site Top of Basalt Elevation Grid*, Rev. 0, Central Plateau Cleanup Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-17448.

ECF-HANFORD-21-0117, 2021, *Preparation of the March 2021 Hanford Site Water Table Map*, Rev. 0, Central Plateau Cleanup Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-18164.

ECF-HANFORD-22-0051, 2023, *Assessment of Potential Contaminant Release from 618-11 Burial Ground*, Rev. 0, Central Plateau Cleanup Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-.

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

EPA, Ecology, and DOE, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*, U.S. Environmental Protection Agency and U.S. Department of Energy, Richland, Washington. Available at: https://pdw.hanford.gov/document/0087180.

EPA/240/B-06/001, 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/default/files/2015-06/documents/g4-final.pdf.

HNF-EP-0649, 1997, *Characterization of the 618-11 Solid Waste Burial Ground, Disposed Waste, and Description of the Waste-Generating Facilities*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0091165.

HW-60601, 1959, *Aquifer Characteristics and Ground-Water Movement at Hanford*, General Electric Company, Hanford Atomic Products Operation, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196029475.

M-16-21-06, 2022, *Federal Facility Agreement and Consent Order Change Control Form: Milestone M-016-86 Enhanced Monitoring and Revised Completion Schedule in TPA Appendix D*, dated February 10, U.S. Department of Energy, Richland Operations Office, and U.S. Environmental Protection Agency, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-18688.

PNNL-13675, 2001, *Measurement of Helium-3/Helium-4 Ratios in Soil Gas at the 618-11 Burial Ground*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/pnnl-13675.pdf.

PNNL-15293, 2005, *Evaluation of the Fate and Transport of Tritium Contaminated Groundwater from the 618-11 Burial Ground* , Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0084083.

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

This page intentionally left blank.

Appendix A

Data Quality Objectives Summary

This page intentionally left blank.

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Project Summary

Project Name:	618-11 Burial Ground Enhanced Groundwater Monitoring	Date:	06/07/2022
Name of Person Completing Record:	Anna Radloff	Position:	Scientist
Name of Responsible Manager:	Emily Macdonald		

Project Background:

The 618-11 Burial Ground is located in the northwest portion of the 300 Area and west of the Energy Northwest Columbia Generating Station (Figure 1). The burial ground is part of the 300-FF-2 Operable Unit (OU). The groundwater beneath the burial ground is part of the 300-FF-5 Groundwater OU. The burial ground was the source of nitrate and tritium that contaminated the groundwater (Figures 2 and 3) at concentrations greater than drinking water standards (DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*; DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020*).

In November 2013, a Record of Decision (ROD) was signed that established the selected remedy for the 300-FF-5 OU as monitored natural attenuation (MNA), enhanced attenuation of uranium at the top of the aquifer, and institutional controls (ICs) (EPA and DOE, *Hanford Site 300 Area Record of Decision for 300-FF2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*). The cleanup levels are 20,000 pCi/L for tritium and 45 mg/L for nitrate. The ROD also established the selected remedy for 300-FF-2, including 618-11, as remove, treat (as required), and dispose (RTD). At the time the ROD was developed, RTD of 618-11 was scheduled to be completed by 2021; however, that timeline has been pushed back at least 10 years due to the continuing operations of Energy Northwest Columbia Generating Station nearby.

Beginning in 2017, a rapid increase in nitrate concentrations was observed in monitoring well 699-13-3A, which is downgradient from the 618-11 Burial Ground (Figure 1-1 of ECF-300FF5-21-0001, *618-11 Burial Ground Conceptual Site Model Update and Evaluation of Increasing Nitrate Concentrations in Groundwater, FY 2021*). The nitrate concentration increased from 58 mg/L in January 2016 to 186 mg/L in November 2017. The largest concentration observed was 252 mg/L in November 2019. The increase in concentration coincided with the relative stabilization of the water table elevation which had been declining (Figure 1-1 of ECF-300FF5-21-0001). The nitrate concentration decreased in 2020 to 164 mg/L (DOE/RL-2020-60).

The December 2020 monitoring event for the 618-11 Burial Ground showed that tritium concentrations in all five monitoring wells increased from the 2019 monitoring event. Monitoring well 699-13-3A exhibited the largest increase, going from 209,000 pCi/L in 2019 to 1,050,000pCi/L in 2020. An evaluation of the increasing nitrate and tritium groundwater concentrations was completed in Spring 2021 (ECF-300FF5-21-0001). The evaluation yielded several hypotheses, with the pulse release hypothesis being the most likely based on data currently available. Recommendations in ECF-300FF5-21-0001 led to Tri-Party Agreement (TPA) Change Notice (CN) 0917 to DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, for the enhanced groundwater monitoring around 618-11.

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Planning Type:

(If systematic planning is not required, state the reason)

This systematic planning record (i.e., DQO) describes the characterization and sampling efforts planned for the enhanced groundwater monitoring in the vicinity of the 618-11 Burial Ground. The additional data are intended to support determining whether interim actions are warranted prior to initiating remediation of the burial ground.

In fall of 2021 and early 2022, the technical groundwater team discussed the increasing concentrations with RL-41 representatives, TPA-CN-0917 to address the lack of cohesive data among all seven wells surrounding the 618-11 Burial Ground, the amount of groundwater sampling events needed to have a substantive data set (four semiannual sampling events starting in April 2022), and recommended needs for vadose zone modeling. These discussions, in part, informed the tasks identified in Milestone Package M-16-21-06, *Federal Facility Agreement and Consent Order Change Control Form: Milestone M-016-86 Enhanced Monitoring and Revised Completion Schedule in TPA Appendix D*.

Four new milestones were created under M-16-21-06. This DQO was developed, with the assistance of the U.S. Environmental Protection Agency (EPA), to fulfill the U.S. Department of Energy's (DOE) commitment to "Submit to EPA the DQO for enhanced monitoring around 618-11" under M-016-87-T01 (created through M-16-21-06).

Organization, Schedule, and Goal

(State the problem, requirements, schedule, PSQs, and outcomes)

State the Problem

(Describe the reason/need for data collection and project goals/objectives)

Based on existing monitoring in the vicinity of the 618-11 Burial Ground (618-11), contaminants of concern (COCs) are not attenuating according to expectations set forth in the Remedial Investigation (RI)/Feasibility Study (FS) report and ROD. Additionally, the RTD remedy for waste in 618-11, which was expected to be completed by 2021, has not occurred. The magnitude of the difference between prior expectations and current conditions and the impact of that difference on remedy performance are uncertain.

Principal Study Questions *(What questions are data needed to answer?)*	**PSQ 1**	Will peak concentrations from the 618-11 nitrate groundwater plume exceed 45 mg/L at the interface with Columbia River?	**PSQ 6**	Is the current monitoring network spatially adequate to answer PSQs 1 through 5?
	PSQ 2	Will peak concentrations from the 618-11 tritium groundwater plume exceed 2.65E+08 pCi/L at the interface with Columbia River?	**PSQ 7**	
	PSQ 3	Is the timeline for MNA changed from the understanding established in the ROD?	**PSQ 8**	
	PSQ 4	Are other 618-11 source constituent concentrations present in groundwater at levels that should be considered in an evaluation for potential remedial actions?	**PSQ 9**	

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

	PSQ 5	Is infiltration at 618-11 driving the increasing concentrations of nitrate and tritium in groundwater?	**PSQ 10**	
Define alternative outcomes or actions that can occur upon answering PSQs.	**AA 1A**	Yes. Identify the peak nitrate concentration and when it will arrive at the interface with the Columbia River and evaluate if an update to the current remedy or its implementation and monitoring is needed.	**AA 6A**	Yes. No change needed.
	AA 1B	No. No change needed.	**AA 6B**	No. Determine the number and location of additional monitoring points needed to obtain the data necessary to address PSQs 1 through 5 and update the performance monitoring plan (DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*)accordingly.
	AA 2A	Yes. Identify the peak tritium concentration and when it will arrive at the interface with the Columbia River and evaluate if an update to the current remedy or its implementation and monitoring is needed.	**AA 7A**	
	AA 2B	No. No change needed.	**AA 7B**	
	AA 3A	Yes. Determine what the MNA timeline is and evaluate if an update to the current remedy or its implementation and monitoring is needed.	**AA 8A**	
	AA 3B	No. No change needed.	**AA 8B**	
	AA 4A	Yes. Identify which constituents and values require an evaluation of changes to the current remedy or its implementation and monitoring.	**AA 9A**	
	AA 4B	No. No change needed.	**AA 9B**	
	AA 5A	Yes. Determine if infiltration reduction can achieve groundwater concentrations protective of the Columbia	**AA 10A**	

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

		River and if an update to the current remedy or its implementation and monitoring is needed.		
	AA 5B	No. No change needed.	**AA 10B**	

Identify the decision statements or estimation statements needed to address the PSQs.	1. Determine whether the peak concentration from the 618-11 nitrate groundwater plume will exceed 45 mg/L at the interface with Columbia River, then identify when that peak concentration is expected to arrive at the interface and if an update to the current remedy or its implementation and monitoring is needed; else, no change to the implementation and monitoring of the selected remedy is needed.
	2. Determine whether the peak concentration from the 618-11 tritium groundwater plume will exceed 2.65E+08 pCi/L at the interface with Columbia River, then identify when that peak concentration is expected to arrive at the interface and evaluate if an update to the current remedy or its implementation and monitoring is needed; else, no change to the implementation and monitoring of the selected remedy is needed.
	3. Evaluate whether the timeline for MNA has changed from the understanding established in the ROD, then determine what the MNA timeline is and evaluate if an update to the current remedy or its implementation and monitoring is needed; else, no change is needed.
	4. Determine whether concentrations of other 618-11 source constituents are present in groundwater at levels that should be considered in an evaluation for potential remedial action, then identify which constituents and values require an evaluation of changes to the current remedy or its implementation and monitoring; else, no change is needed.
	5. Determine if infiltration at 618-11 is driving the increasing concentrations of nitrate and tritium in groundwater, then evaluate whether infiltration reduction can achieve groundwater concentrations protective of the Columbia River and if an update to the current remedy or it implementation and monitoring is needed; else no change is needed.
	6. Evaluate whether the current well network is spatially adequate to answer PSQs 1 through 5, then continue the current monitoring of the selected remedy; else, determine the number and location of additional monitoring points needed to obtain the data necessary to address the PSQs and update the performance monitoring plan (DOE/RL-2014-42) accordingly.
	7.
	8.
	9.
	10.

Data Needs
(Define the spatial and temporal boundaries of the study)

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Define what constitutes a sampling unit:

The sampling unit consists of groundwater collected from monitoring points in the vicinity and downgradient of the 618-11 Burial Ground and soil collected during installation of new groundwater monitoring wells in support of this effort.

What is the smallest unit upon which decisions or estimates will be made?

The smallest unit for decision making/estimation for soil sampling is equal to the length of a split-spoon liner (6 in. [0.5 m]). The depth at which a groundwater sample is collected (the smallest unit for decision making/estimation is taken at the measured depth to the pump intake (rounded to the nearest foot) for collection of that sample.

Data Needs Summary

(Information inputs to answer PSQs: target population, characteristics of interest, spatial and temporal limits, scale of inference)

PSQ	Data Need	Media of Interest	Location	Sampling Method	Action Level	Frequency	Practical Constraints	Analytical Method	Potential Source of Data
See Attachment 1									

Performance or Acceptance Criteria

(Determine the quality of data needed and analytical approach)

Specify the population parameter *(e.g., mean, median, or percentile)*, appropriate for making decisions or estimates:

See attachment 2 for Performance/Acceptance Criteria.

Decision Problem	Provide a decision rule related to the Action Level identified above that includes a clear "if…then…else" statement:
	What are the consequences of making an incorrect decision and what is the tolerance for an incorrect decision?
Estimation Problem	Develop the specification of the estimator by combining the true value of the selected population parameter with the scale of estimation and other boundaries:
	What are the acceptable limits on uncertainty?

Plan for Obtaining the Data

(Specify the general plan of obtaining the needed data and explain where and how the information in this Planning Record will be formalized in a data collection plan)

The design for obtaining the data necessary to address the Decision Statements (DSs) developed in this DQO includes groundwater contaminant concentration monitoring, hydraulic monitoring, and flow rate monitoring. The design is summarized as follows:

- Monitoring point locations and groundwater sample analysis for nitrate and tritium needed to support the following:
  - Predicting peak nitrate and tritium concentrations between the unconfined aquifer and the interface with the Columbia River
  - Estimating the MNA timelines for nitrate and tritium concentrations in groundwater

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

Plan for Obtaining the Data

(Specify the general plan of obtaining the needed data and explain where and how the information in this Planning Record will be formalized in a data collection plan)

- Determining the role of infiltration in increasing nitrate and tritium concentrations in groundwater
- Determining the direction of groundwater flow from the vicinity of the 618-11 Burial Ground to the Columbia River
- Determining the influence of river stage on groundwater flow

- Monitoring will typically include nitrate and tritium for all locations; and may include uranium, technetium-99, and/or plutonium-239/240, depending on location.
- Monitoring groundwater elevation/water level measurements for the area from the 618-11 Burial Ground to the Columbia River.
- Review and use of
  - Existing hydrostratigraphic information for the area from vicinity of 618-11 Burial Ground and the Columbia River.
  - Precipitation records and estimates of natural recharge in the vicinity of the 618-11 Burial Ground
  - River stage and flow rate information for the Columbia River.
  - Existing groundwater contaminant concentration data, groundwater elevation/water-level measurements, and other data/information.

New groundwater monitoring points are needed to enhance the enhance the existing monitoring network to address the DSs. Existing data and information (groundwater contaminant concentrations from existing monitoring wells and aquifer tubes, groundwater flow, etc.) will be used to determine locations of the new monitoring points. It is anticipated that new aquifer tubes and/or up to two new monitoring wells may be needed. If new groundwater monitoring wells are installed as part of this study, soil samples or split-spoon samples targeting specific depths may be collected for chemical and radiological analysis. In addition, geologic and geophysical logging would be done; and aquifer testing (e.g., slug tests, constant-rate tests) also may be performed.

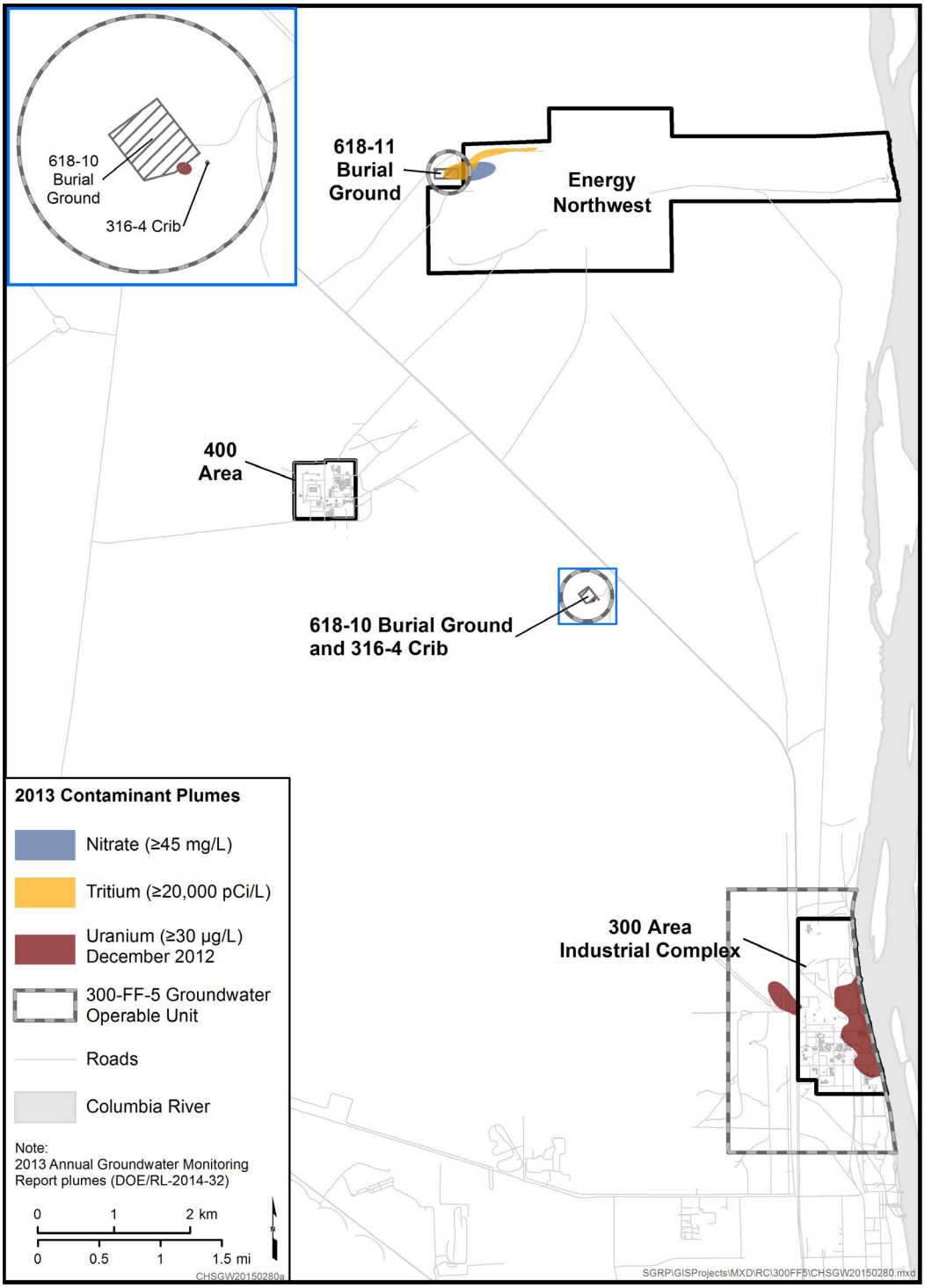
All characterization, drilling, well construction, and associated activities (e.g., decontamination and sample custody) will be conducted and controlled in accordance with contractor procedures. Radiological control and industrial hygiene coverage will be provided during these efforts. Practical considerations to be accounted for during the planning of sample collection include cultural and ecological site restrictions.

Practical considerations to be accounted for during the planning of sample collection include operational, cultural, and ecological site restrictions.

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.



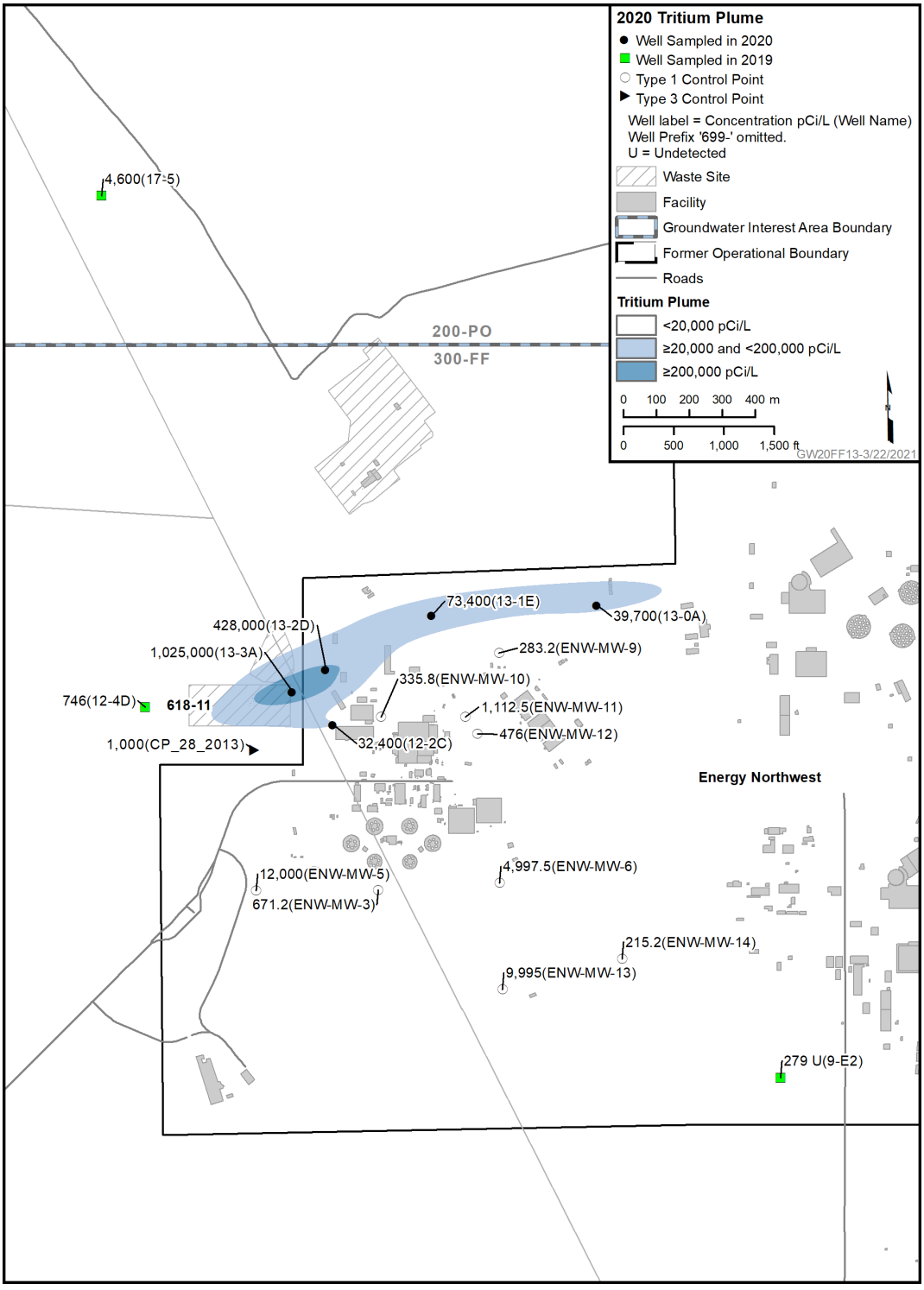
Source: DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, for the enhanced groundwater monitoring around 618-11.

Figure 1 300-FF-5 Operable Unit

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.



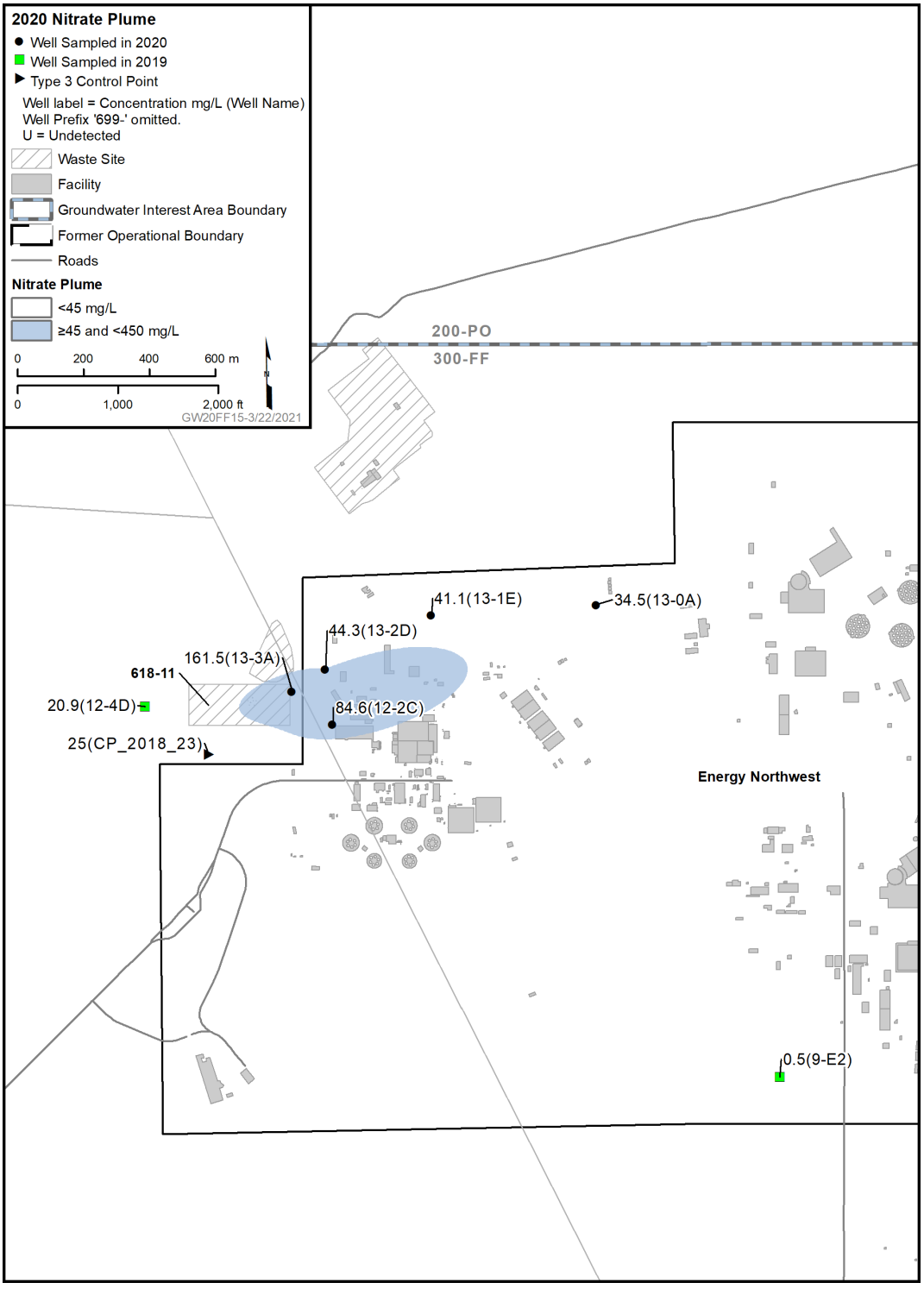
Source: DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020.*

Figure 2. 300-FF Tritium Plume Near the 618-11 Burial Ground, 2020

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.



Source: DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020.*

Figure 3. 300-FF Nitrate Plume Near the 618-11 Burial Ground, 2020

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

NOTE: In cases where the requested information is not applicable, state that, and explain why it is not applicable so that it is clear that a required field has not been forgotten.

References:

DOE/RL-2010-99, 2013, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0085352 https://pdw.hanford.gov/document/0085335 https://pdw.hanford.gov/document/0088305

DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, Rev 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0079669H.

Modified by

TPA-CN-0917, 2021, *Tri-Party Agreement Change Notice Form: DOE/RL-2014-42, 300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan, Rev. 0*, dated September 14, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-16451.

DOE/RL-2020-60, 2021, *Hanford Site Groundwater Monitoring Report for 2020*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-16952.

ECF-300FF5-21-0001, *618-11 Burial Ground Conceptual Site Model Update and Evaluation of Increasing Nitrate Concentrations in Groundwater, FY 2021*, Rev. 0, Central Plateau Cleanup Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-13531.

EPA and DOE, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*, U.S. Environmental Protection Agency, Region 10, and U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0087180.

M-16-21-06, 2022, *Federal Facility Agreement and Consent Order Change Control Form: Milestone M-016-86 Enhanced Monitoring and Revised Completion Schedule in TPA Appendix D*, dated February 10, U.S. Department of Energy, Richland Operations Office, and U.S. Environmental Protection Agency, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-18688.

Attachment 1 – Data Needs Summary

Spatial and Temporal Limits of the Study

Spatially, data collected will cover an area from the vicinity of the 618-11 Burial Ground to the Columbia River. Elevations range from ground surface to the bottom of the unconfined aquifer.

Temporally, data collection is expected to start in early 2023 and be fully implemented (i.e., well installation complete) in July 2023.

Regional and location flow and transport modeling will consider the full hydrogeologic system and contaminant transport, spatially and temporally.

This page intentionally left blank.

Data Needs Summary Table

PSQ	Data Need	Media of Interest	Location	Sampling Method	Action Level	Frequency	Practical Constraints	Analytical Method	Potential Source of Data:
1, 2,3, 5, and 6	Groundwater monitoring data in the vicinity and downgradient of 618-11 are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Groundwater	Select wells and aquifer tubes in the vicinity of and downgradient from 618-11	Pump	N/A	Periodic	Sampling pump malfunction, cannot access sampling location (monitoring well, etc.).	COCs: • Nitrate by EPA 300 or SW-846 9056 • Tritium by LSC Technetium-99 by LSC Plutonium by alpha energy analysis Uranium by alpha energy analysis	Site-specific sampling historical data
1, 2,3, 5,and 6	Groundwater elevation/water level data in the vicinity and downgradient of 618-11 are needed to update the vadose zone model to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow from the vicinity of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Groundwater	Select wells in the vicinity of and downgradient from 618-11	Pressure transducer, manual measurement	N/A	Periodic	Transducer malfunction, cannot access monitoring well, etc.	N/A	Site-specific sampling historical data
1, 2,3, 5, and 6	Hydrostratigraphic data from monitoring wells in the vicinity and downgradient of 618-11 are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Soil/sediment	Wells and boreholes in the vicinity of and downgradient from 618-11	Split spoon, sonic cores, or grab	N/A	Periodic	Available data may be limited.	N/A	Site-specific testing historical data
1, 2,3, 5, and 6	Hydraulic property data from monitoring wells in the vicinity and downgradient of 618-11 are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Soil/sediment	Wells and boreholes in the vicinity of and downgradient from 618-11	Pressure transducer, manual measurement	N/A	Periodic	Available data may be limited.	N/A	Site-specific testing historical data

PSQ	Data Need	Media of Interest	Location	Sampling Method	Action Level	Frequency	Practical Constraints	Analytical Method	Potential Source of Data:
1, 2,3, 5, and 6	Existing and new soil/sediment results collected from boreholes and monitoring wells in the vicinity and downgradient of 618-11 are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Soil/sediment	Wells and boreholes in the vicinity of and downgradient from 618-11	Split spoon or sonic cores	N/A	Periodic	Insufficient/poor sample recovery, etc.	N/A	Site-specific sampling historical data
1, 2,3, 5, and 6	Historical records regarding operations/waste disposed to 618-11 are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Waste	618-11	N/A	N/A	N/A	Incomplete or incorrect records, etc.	N/A	Historical data and information
1, 2,3, 5, and 6	Estimates of hydraulic and chemical transport values are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Groundwater	Vicinity of 618-11 to the Columbia River	N/A	N/A	N/A	Lack of chemical inventory information, etc.	N/A	Simulations calibrated to field data
1, 2,3, 5, and 6	Precipitation data are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the potential role of infiltration in increasing nitrate and tritium concentrations, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Water	Vicinity of 618-11	N/A	N/A	N/A	Infrequency large precipitation events, estimating timing of snowmelt (delayed entry to soil column of precipitation previously measured), etc.	N/A	Historical precipitation data. Historical and site-specific groundwater elevation/level measurements.

PSQ	Data Need	Media of Interest	Location	Sampling Method	Action Level	Frequency	Practical Constraints	Analytical Method	Potential Source of Data:
1, 2,3, 5, and 6	River stage and flow data are needed to predict peak nitrate and tritium groundwater concentrations at the interface with the Columbia River, estimate the MNA timelines for nitrate and tritium, confirm MNA is occurring with a stable and shrinking plume, determine the direction and rate of groundwater flow from the vicinity of 618-11 to the Columbia River, determine the influence of river stage on groundwater flow, and support different source-release models along with uncertainty analysis of flow and transport parameters to further quantify the range of uncertainty in model predictions.	Surface and Groundwater	Vicinity of 618-11, Columbia River	N/A	N/A	N/A	Infrequency large precipitation events, estimating timing of snowmelt (delayed entry to soil column of precipitation previously measured), etc.	N/A	Historical river stage and flow data. Historical and site-specific groundwater elevation/level measurements.
4	Groundwater monitoring data in the vicinity and downgradient of the 618-11 Burial Ground are needed to determine whether other 618-11 Burial Ground source constituents are present in groundwater at levels that should be considered in an evaluation for potential remedial action.	Groundwater	Vicinity and downgradient of 618-11	Pump	N/A	Periodic	Sampling pump malfunction, cannot access sampling location (monitoring well, etc.)	COCs: • Nitrate by EPA 300 or SW-846 9056 • Tritium by LSC Technetium-99 by LSC Plutonium by alpha energy analysis Uranium by alpha energy analysis	Site-specific sampling historical data
4	Existing soil/sediment results collected from boreholes and monitoring wells and new soil/sediment results collected during the installation of new monitoring wells in the vicinity of the 618-11 Burial Ground are needed to determine whether other 618-11 Burial Ground source constituents are present in groundwater at levels that should be considered in an evaluation for potential remedial action.	Soil/sediment	Wells and boreholes in the vicinity of and downgradient from 618-11	Split spoon or sonic cores	N/A	Periodic	Insufficient/poor sample recovery, etc.	N/A	Site-specific sampling historical data

Reference: SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods Compendium.*

Note: For EPA Method 300, see EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes.*

COC = contaminant of concern
EPA = U.S. Environmental Protection Agency
LSC = liquid scintillation counting
MNA = monitored natural attenuation
N/A = not applicable

This page intentionally left blank.

Constraints/Limitations on the Data

The general approach to resolve DSs and manage the remedy uses a combination of several types of primary data and associated data analysis, as well as a comparison of data to flow and transport (F&T) model predictions. The approach uses these multiple lines of evidence (not a single metric) in an integrated remedy performance evaluation. Each primary and derived element of the approach provides essential information to be used in the decision-making process, but limitations of each element exist and must be considered. The fundamental components are defined as follows:

- **Information:** Compiled, reduced, and summarized data collected through measurement and observation, then processed through specified data-reduction techniques to provide the desired input to the analysis. Information is always based on measurement and observation.
- **Limitation:** The analysis of information and the resulting knowledge and understanding contain inherent uncertainties and limitations. These limitations may constrain the ability to extrapolate the knowledge or understanding beyond identified spatial or temporal boundaries. Specific uncertainties will be identified that bound the ability to extrapolate from current conditions.

Derived data and simulation elements of the approach are listed below, as well as a description of the information provided by the element and its limitations.

- Monitoring well concentration trends:
  - **Information:** Time series of COC concentration in groundwater at monitoring locations based on measurement and observation.
  - **Limitation:** Limitations are driven by measurement data quality indicators (i.e., precision, accuracy, representativeness, completeness, and comparability) for individual location measurements.
- Plume volume changes over time (including plume contour depictions):
  - **Information:** Changes in time over three-dimensional spatial distribution of the concentration of COCs in groundwater at monitoring locations based on measurement and observation and extrapolated through computational approaches to the overall plume.
  - **Limitation:** The most substantial limitation is in interpolation over distance (horizontal and vertical) between points of measurement and extrapolation beyond points of measurement where necessary. In addition, the monitoring location densities decrease with depth in the target aquifer, which adds uncertainty to the extrapolation calculations. Individual measurements are subject to limitations driven by measurement data quality indicators (DQIs) (i.e., precision, accuracy, representativeness, completeness, and comparability).
- Hydraulic heads:
  - **Information:** This requires information describing the hydraulic conditions within the aquifer based on measurement and observation, as well as an understanding of aquifer properties to extrapolate groundwater movement.
  - **Limitation:** Hydraulic head analysis is subject to limitations in data collection (e.g., accuracy, precision, and representativeness of water-level measurement) and computational capability (e.g., representativeness of selected aquifer hydraulic properties with respect to

actual site conditions). Extrapolations of individual dynamic well conditions to the aquifer are frequently uncertain.

- Model predictions of plume behavior and remedy performance:
  - **Information:** Modeling activities require integrating all of the inputs described above to refine the model performance and enhance the predictability of the model output. Models must be assembled to represent the system as accurately as reasonable and refined routinely with inputs based on measurement and observation. As additional information describing aquifer physical and hydraulic properties becomes available, the model basis must be refined to incorporate the new information so the model remains representative and comparable to the system.
  - **Limitations:** Models are inherently subject to uncertainties in inputs and definition of computational parameters. Modeling tools allow calculation of predicted conditions over wide physical areas and over long periods of time into the future. The level of uncertainty in model outputs generally increases with the area (and volume) of the aquifer described and with the simulation time period. A well-performing model should produce a description of aquifer conditions over relatively short time periods (e.g., years). Short-period descriptive runs should be performed regularly to ensure continued model representativeness. If short-term results are comparable, the level of confidence can increase in the longer-term analyses.

During the enhanced groundwater monitoring period for the 618-11 Burial Ground, trend analyses will be conducted annually, although the new data will be plotted and compared to trend confidence and prediction intervals following receipt of the data. Significant deviations from confidence or prediction intervals will be used to initiate consideration of more frequent evaluation or data collection. Similarly, model prediction updates would occur at the same frequency. The approach will also consider three-dimensional aspects of the plume, especially when evaluating plume configuration and mass changes over time and determining whether the monitoring network needs to be updated.

Attachment 2 – Performance/Acceptance Criteria

The Decision Rules (DRs) developed for the study are presented in the following table.

DS #	DR #	Decision Rule
1	1	If the peak concentration from the 618-11 nitrate groundwater plume will exceed 45 mg/L at the interface with Columbia River, then identify when that peak concentration is expected to arrive at the interface; else, no change to the implementation and monitoring of the selected remedy is needed.
2	2	If the peak concentration from the 618-11 tritium groundwater plume will exceed 2.65E+08 pCi/L at the interface with Columbia River, then identify when that peak concentration is expected to arrive at the interface; else, no change to the implementation and monitoring of the selected remedy is needed.
3	3	If the timeline for MNA has changed from the understanding established in the ROD, then determine what the MNA timeline is and evaluate if an update to the current remedy or its implementation and monitoring is needed; else, no change is needed.
4	4	If concentrations of other 618-11 source constituents are present in groundwater at levels that should be considered in an evaluation for potential remedial action, then identify which constituents and values require an evaluation of changes to the current remedy or its implementation and monitoring; else, no change is needed.
5	5	If infiltration at 618-11 is driving the increasing concentrations of nitrate and tritium in groundwater, then evaluate whether infiltration reduction can achieve groundwater concentrations protective of the Columbia River and if an update to the current remedy or it implementation and monitoring is needed; else no change is needed.
6	6	If the current well network is spatially adequate to answer PSQs 1 through 5, then continue the current monitoring of the selected remedy; else, determine the number and location of additional monitoring points needed to obtain the data necessary to address the PSQs and update the performance monitoring plan (DOE/RL-2014-42) accordingly.

Reference: DOE/RL-2014-42, 2015, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*.

MNA = monitored natural attenuation
PSQ = principal study question
ROD = record of decision

Approach for Determining Data Adequacy

The overall goal of the analytical approach is to obtain additional data to provide for reliable and predictive F&T modeling to support evaluation of MNA remedy performance. The general approach to resolve the DSs in this study is to adopt and expand upon previous work using methods similar to those used in past studies to complete integrated data analyses, set within an uncertainty management framework that considers the value added by new data and information. This uncertainty management framework will be developed to establish the process for determining what is “adequately defined” for use in resolving the DSs. “Adequately defined” will be determined in the context of the ability to reasonably predict the likely future performance of the remedy in attaining the RAOs specified in the 300-FF-5 ROD (EPA et al., 2013), recognizing that although data may be sufficient to make a prediction, the data may not necessarily be adequate to make a reliable prediction.

Some uncertainties may not be meaningfully reduced by further data collection efforts and are, therefore, irreducible uncertainties. These uncertainties have to be managed in the decision-making process. To support the need for establishing what is considered to be adequately defined, the uncertainty

management framework will be developed to propose a strategy incorporating the following three elements and associated specifications:

- **Data collection procedures and methods:** Data collection will be guided by integrated analyses of existing available data. The planning process is founded on formalized and documented DQOs. Peer review will be conducted of the planning stages. State-of-the-art field techniques will be implemented. Data obtained will be subject to thorough quality assurance and quality control procedures.
- **Spatial distribution and variability:** Sample data and geological characteristics will be evaluated using geostatistical methods that facilitate evaluation of spatial (and temporal) variability and uncertainty.
- **Statistical and modeling analysis methods:** The sequential analysis process will be focused on empirical data evaluations, historical modeling to calibrate flow fields and aspects of contaminant transport, and predictive modeling. The data gap analysis combines geostatistical descriptions of spatial variability with predictive modeling to estimate future migration to prioritize new data acquisition and improve knowledge.

Data collection methods are implemented to provide representative data values over space and time. Using these data, methods are available to characterize and quantify spatial and temporal variability. In addition, some aspects of associated uncertainties can also be quantified, although this also relies upon the judgment of subject matter experts.

Groundwater flow and contaminant F&T modeling have been used at the Hanford Site to guide remedy decisions and make predictions of likely future performance. Although imperfect, F&T modeling is the most suitable mechanism to combine available data and information to make predictions of future behavior and performance. When available data are combined with F&T modeling, predictions can be made, and some aspects of the uncertainty associated with those predictions can be quantified. For the purpose of this study, the reduction in the uncertainty associated with model predictions of future groundwater flow conditions, contaminant migration patterns and rates, and remedy performance will be used to evaluate the adequacy of the available data and information.

The uncertainty management framework developed will be documented in an internal document. The approach used and the outcome will be summarized and presented in the characterization report.

Limits on Uncertainty / Tolerance for an Incorrect Decision:

Groundwater levels

Groundwater-level data consist of several components:

- Depth-to-water measurement from top of casing
- Surveyed elevation of the top of casing
- Surveyed northing and easting coordinates of the well
- Elevation interval in the aquifer at which the depth to water is representative (well screen top and bottom elevations)

The most critical components of groundwater-level data are the depth-to-water measurement and the top-of-casing elevation. Elevations for the top of casing are typically specified to the nearest 0.3 cm (0.01 ft), and depth-to-water measurements are typically specified to the nearest 0.61 cm (0.02 ft). Errors on the

order of a couple of hundredths of a foot can be significant in situations where small horizontal hydraulic gradients are expected or when calculating vertical hydraulic gradients.

Groundwater elevation errors can be detected by preparing a two-dimensional water table map and looking for irregularities in the elevation contours or conducting more formal cross-validation analyses of the groundwater elevation data incorporating suitable trending and regression-based methods. These methods comprise spatial evaluations of data consistency. Newly obtained groundwater elevation data can also be compared to previously collected data through visual hydrograph analysis and more formal temporal cross-validation analyses. These methods comprise temporal evaluations of data consistency.

Ground surface elevations are typically provided to the nearest 0.03 m (0.10 ft) and are used along with the top and bottom screen depths to calculate the top and bottom screen elevations. Errors in top and bottom screen elevations may have significant impact on the use of groundwater elevation data in areas with a thin saturated zone. Historical well construction data for older monitoring wells may have the potential for significant uncertainty of screened interval data. However, well screen elevation errors are likely not a significant concern for groundwater elevation data since the vertical spatial position of groundwater elevation measurement is typically interpreted as the potentiometric groundwater elevation at the mid-screen elevation in the well. These mid-screen elevation data points can be used in the groundwater flow model by comparing them to simulated heads taken from model grid cell center elevations.

Surveyed northing and easting coordinates are typically provided to the nearest 0.03 m (0.10 ft). However, errors of up to 1.5 m (5 ft) in well coordinates should have little impact on any processes or significant decisions. Well coordinates are relatively easy to verify in the field; thus, well coordinate errors are likely not a concern.

Contaminant concentrations

Contaminant concentration data consist of several components, including the actual groundwater and sediment samples, subsequent laboratory analysis, and the three-dimensional spatial location from which the sample originated in the aquifer. Contaminant concentrations from analytical laboratory analyses are needed to construct three-dimensional contaminant plume depictions. To meet this goal, the required practical quantitation limits (PQLs) should be equal to, or ideally less than, required groundwater cleanup levels.

Failure to set required PQLs equal to or less than the cleanup levels could result in groundwater contaminant monitoring data of insufficient quality. Because three-dimensional contaminant plume depictions are usually constructed with the lowest concentration isosurface depicting the estimated extent at the cleanup level, using the required PQLs above the cleanup levels will result in a lack of data to establish plume outer boundaries. This will result in errors in the reported mass and volume statistics, errors in extraction well capture analyses, and errors in simulated contaminant transport.

Other types of errors (e.g., random nonrepresentative samples and/or laboratory analyses) should have limited impact on any significant decisions regarding remedy performance. Typically, if a sample result seems erroneous and the result is critical (i.e., the result significantly changes the conceptual site model, indicates loss of capture, or falsely indicates plume cleanup), sampling is repeated at that location to verify the result. Significant decisions are generally not based on one sample result. An erroneous sample result could impact the kriged concentrations in a limited area of a contaminant plume. However, the plume depictions are usually regenerated annually, so the impact of such an error should be relatively short-lived.

Horizontal spatial position errors are usually of small magnitude and would have little impact on any processes or significant decisions. Surveyed northing and easting coordinates are typically provided to the nearest 0.03 m (0.10 ft). Errors of up to 1.5 m (5 ft) in well coordinates would usually have little impact. In addition, well coordinates are relatively easy to verify in the field; thus, well coordinate errors are likely not a concern.

Ground surface elevations are typically provided to the nearest 0.03 m (0.10 ft), which is usually used along with the top and bottom screen depths to calculate the top and bottom screen elevations. Errors in top and bottom screen elevations of a couple of feet would likely have little impact on the use of concentration data. However, contaminant concentrations tend to be highly vertically heterogeneous, and an error of 3.0 m (10 ft) or more in a screened interval could introduce significant errors in the three-dimensional contaminant plume depictions. If much of the well construction data are historical for monitoring wells, the potential exists for significant errors in the reported well screened intervals. These errors could lead to errors in the three-dimensional contaminant plume depictions.

Vertical spatial position errors in contaminant concentration sampling data are relatively difficult to detect and manage. Well construction information for a particular monitoring well should be reviewed if samples collected from the well are questionable in relation to other upgradient and downgradient samples. However, the relatively low density of samples usually makes it difficult to detect these types of errors. In general, the uncertainty in three-dimensional contaminant plume delineation caused by the sparse sampling network is much greater than all of the other sources of contaminant concentration uncertainty. This uncertainty is furthered by the relative coarseness of the contaminant transport model grid and the uncertainty in the model transport parameters. These errors are most often managed by using professional judgment when evaluating the three-dimensional plume depictions and resulting model simulations for consistency with the conceptual site model and hydrologic principles, as well as by questioning any discrepancies.

Model Predictions

The groundwater flow and transport model is an important tool for predicting whether RAOs will be achieved. However, there are uncertainties associated with the use of groundwater flow and F&T modeling that can lead to misunderstanding of model prediction reliability. The potential impact of such uncertainties on the decision process can be minimized by using multiple lines of evidence to increase the confidence in model predictions by ensuring that all available data are used. Examples of available methods are described below; however, the protocol outlined determining adequacy will ultimately be used to identify and incorporate suitable methods in the workflow process.

The ability of the groundwater transport model to accurately simulate plume migration depends, in part, on the accuracy of the starting concentration distribution (three-dimensional plume depiction) and the contaminant transport parameters used in the model. Additionally, the processes and parameters represented in the model are approximations of the “real” transport processes and parameters. The three-dimensional plume for each contaminant will adequately represent the available sampling data at the sampling locations based on the construction method (kriging). The uncertainty involves the areas in between the sampling locations and the outer boundaries of the plume depictions. The accuracy of each three-dimensional plume depiction can be increased by providing additional sampling locations. However, increasing the number of monitoring wells is costly and over time suffers from reduced benefit (in terms of reduction in uncertainty).

Contaminant transport parameters used in the model can be evaluated by simulating the forward (in time) migration of plume depictions prepared using historical data and comparing the simulated contaminant concentrations to more recently measured contaminant concentrations and concentration trends at

monitoring wells. This evaluation can reduce the uncertainty in the transport parameters controlling the physical, chemical, and biological processes that influence contaminant F&T, and it may result in changes to the model parameters that control dispersion, retardation, and biodegradation. The use of such methods ensures that multiple lines of evidence are used to reduce the uncertainty associated with model predictions.

This page intentionally left blank.