U.S. Department of Energy
Hanford Site

May 12, 2022

22-SGD-001401
REISSUE

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Addressees:

REISSUE -TRANSMITTALS OF REBOUND STUDIES PARENT SAMPLING AND ANALYSIS PLAN FOR THE 100-HR-3 OPERABLE UNIT, HANFORD, DOE/RL-2021-23, REVISION 0, AND GROUNDWATER MONITORING PLAN FOR THE 100-H NORTH SUBAREA REBOUND STUDY (100-HR-3 OPERABLE UNIT), DOE/RL-2021-23-ADD1, REVISION 0

This letter is being reissued due to some attachment pages that were cut off.

This letter transmits two approved documents: Rebound Studies Parent Sampling and Analysis Plan for the 100-HR-3 Operable Unit, Hanford, DOE/RL-2021-23, Revision 0, and Groundwater Monitoring Plan for the 100-H North Subarea Rebound Study (100-HR-3 Operable Unit), DOE/RL-2021-23-ADD1, Revision 0, to the Washington State Department of Ecology and the U. S. Environmental Protection Agency.

If you have any questions please contact me, or you may contact Ellwood Glossbrenner, Project Lead, Soil and Groundwater Division, on (509) 376-5828.

Sincerely,

MICHAEL CLINE Digitally signed by MICHAEL CLINE
Date: 2022.05.25 06:17:44 -07'00'

Michael W. Cline, Director
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SGD:ETG

Attachments

cc w/attach:
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Administrative Record (100-HR-3)
Environmental Portal

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S. L. Brasher, HMIS
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Attachment 1
22-SGD-001401

Rebound Studies Parent Sampling and Analysis Plan for the 100-HR-3 Operable Unit, Hanford
(DOE/RL-2021-23 Revision 0)

(123 pages including Cover page)

DOE/RL-2021-23
Revision 0

Rebound Studies Parent Sampling and Analysis Plan for the 100-HR-3 Operable Unit, Hanford

Date Published
March 2022

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 Sarah Harrison at 2:38 pm, Mar 23, 2022

Release Approval   Date

Signature Sheet

Title: *Rebound Studies Parent Sampling and Analysis Plan for the 100-HR-3 Operable Unit*

MICHAEL CLINE Digitally signed by MICHAEL CLINE
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Washington State Department of
Ecology

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Contents

Appendix

Figures

Tables

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Terms

AWLN	automated water-level network
CN	change notice
DoD/DOE QSM	U.S. Department of Defense/U.S. Department of Energy Quality Services Manual
DOE	U.S. Department of Energy
DOE/CAP-AP	U.S. Department of Energy Consolidated Audit-Accreditation Program
DOE-RL	U.S. Department of Energy, Richland Operations Office
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
EB	equipment blank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operations
FTB	full trip blank
FWS	Field Work Supervisor
FY	fiscal year
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document*
HEIS	Hanford Environmental Information System
IATA	International Air Transportation Association
LCS	laboratory control sample
LRA	lead regulatory agency
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
NTU	nephelometric turbidity unit
OU	operable unit
P&T	pump and treat

PRZ	periodically rewetted zone
PSQ	principal study question
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RCT	radiological control technician
ROD	record of decision
RD/RAWP	remedial design/remedial action work plan
RI/FS	remedial investigation/feasibility study
RUM	Ringold Formation upper mud unit
Rwie	Ringold Formation member of Wooded Island – unit E
SAF	sample authorization form
SAP	sampling and analysis plan
SMR	Sample Management and Reporting
SPLIT	field split sample
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*

1 Introduction

This rebound studies parent sampling and analysis plan (SAP) outlines the overall requirements for groundwater sampling during implementation of hexavalent chromium (Cr(VI)) rebound studies within the 100-HR-3 Groundwater Operable Unit (OU). The intention is to perform rebound studies in discrete areas of the 100-HR-3 OU where trend analyses of Cr(VI) concentrations are favorable for post-pump and treat (P&T) evaluations. These rebound studies will help determine the progress of active remediation, evaluate any impact the periodically rewetted zone (PRZ) may have on contaminant concentrations, and determine if active remediation should end, or if P&T optimization is needed. Some rebound of the concentration is anticipated, and observed rebound will be compared to cleanup levels to evaluate if active remediation should recommence.

The approach of using a "parent" SAP with subarea-specific addenda adds flexibility to future document updates as work progresses. Subarea SAP addenda will be developed over time and provide more specific detail (i.e., sampling location, frequency, duration of rebound study).

The U.S. Department of Energy, Richland Operations Office (DOE-RL) has undertaken preparation of this rebound studies parent SAP because several areas within the 100-HR-3 OU are showing Cr(VI) concentrations below or near the groundwater remedial cleanup levels identified in EPA et al., 2018, *Record of Decision Hanford 100 Area Superfund Site 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units, Hanford Site* (hereinafter referred to as the 100-D/H Record of Decision [ROD]). The remedial cleanup levels for Cr(VI) were established in the 100-D/H ROD to ensure that groundwater concentrations remain below 48 µg/L at inland aquifer locations and that groundwater discharges to surface water remain below 10 µg/L.

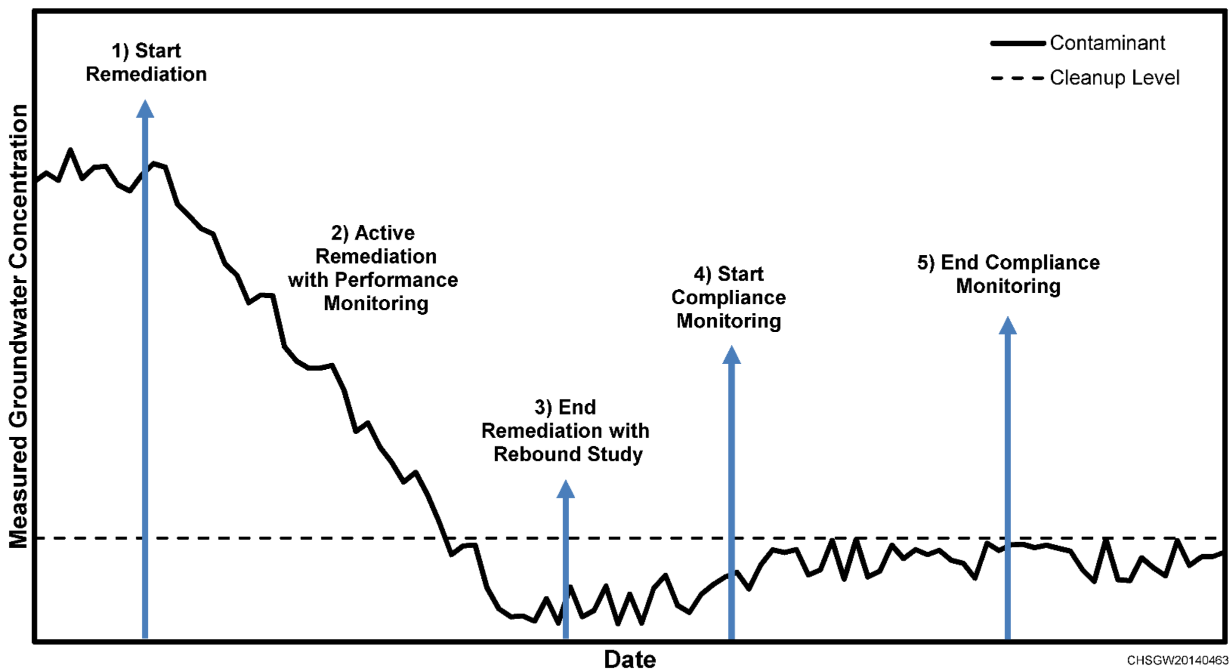
The groundwater sample collection and evaluations are focused on gathering data to assess the remedial action objectives (RAOs) for the 100-HR-3 OU groundwater. The RAOs are as follows:

- **RAO #1**: Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO #2**: Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO #7**: Restore groundwater in the 100-HR-3 OU to cleanup levels, which include drinking water standards, within a timeframe that is reasonable given the particular circumstances of the site.

DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (hereinafter referred to as the 100-D/H Remedial Design/Remedial Action Work Plan [RD/RAWP]), identifies that information needed to assess cleanup may be obtained through rebound studies. Rebound studies will evaluate whether contaminant concentrations will remain below cleanup levels when the aquifer is no longer under the influence of active remediation. If Cr(VI) concentrations remain below cleanup levels during shutdown of the P&T system, then the monitoring may extend into a compliance monitoring phase and, ultimately, lead to permanent termination of remediation in certain areas.

However, if results of the rebound study indicate the presence of continuing sources of groundwater contamination in the PRZ, deep vadose zone, or within the shallow unconfined aquifer, then the site may return to active remediation, and the potential continuing source should be evaluated for further action. The PRZ is the portion of the deep vadose zone between the seasonal high and low groundwater elevations. In areas of known or suspected deep vadose zone contamination, daily and seasonal fluctuations in the river stage can mobilize contaminants in the PRZ into groundwater. Under either scenario, the rebound study may lead to remedial process optimization (e.g., modification of pumping rates and extraction locations).

Details on the groundwater remediation strategy are summarized in Section 7.2. in the 100-D/H RD/RAWP (DOE/RL-2017-13). Figure 1-1 depicts the steps from a representative timeline for the progression of the P&T remedial action from start to finish, and shows when a rebound study may occur.



Source: EPA 230-R-92-014, *Methods for Evaluating the Attainment of Cleanup Standards, Volume 2: Ground Water*.

Figure 1-1. Steps in Groundwater Remediation

1.1 Project Scope and Objective

This rebound studies parent SAP was developed to detail the groundwater sampling and analysis requirements that are applicable to subarea SAP addenda for the 100-HR-3 OU. The subarea SAP addenda will provide site-specific field sampling plans (i.e., subarea location, wells, and sampling frequency). The objective of this SAP is to develop and document the principal study questions (PSQs) and the associated data needs to be addressed during unconfined aquifer rebound studies in the 100-HR-3 OU, as documented in Appendix A. Analysis of physical and chemical properties of the aquifer will be used to determine if conditions are representative of ambient post-P&T conditions. As rebound studies are developed, if additional data needs are identified within a given subarea they will be included in the specific subarea SAP addenda, and as appropriate, will be incorporated into this SAP through a *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a; Tri-Party Agreement) change notice (CN) or SAP revision.

The rebound studies are anticipated to last at least a full river stage cycle (i.e., 12 months) to ensure adequate understanding of contaminant migration due to river stage and seasonal transition periods in the absence of P&T. This duration may be extended if additional data are needed to establish concentration trends or support interpretation of unexpected sample results.

The data needs for rebound studies in the semiconfined aquifer have not been developed at this time. During the rebound studies, additional groundwater samples may be collected from groundwater wells completed within the uppermost RUM aquifer. These samples will be collected under Addendum 1 of the 100-D/H RD/RAWP (DOE/RL-2017-13). The purpose of performing rebound studies in the unconfined aquifer is to evaluate the effectiveness of P&T system operating in the unconfined aquifer. Quantifying the unconfined/RUM aquifer interaction is not an objective of this study. Laboratory and pumping tests results suggest that hydraulic conductivity of the RUM upper semi-confining layer range between 1E-7 and 1E-2 m/day (PNNL-30467, *Hydrologic Evaluation of the Ringold Upper Mud Aquifer in the 100-H Area of the Hanford Site*). Thus, it is not anticipated that unconfined/RUM aquifer interaction will impact the evaluation of the effectiveness of the P&T system operating in the unconfined aquifer and will be assessed per each subarea rebound SAP. More information will be obtained separately as part of a planned overall RUM evaluation.

To support continued Cr(VI) remediation in the semiconfined aquifer, RUM aquifer extraction wells will remain in operation during the unconfined aquifer rebound studies. Rebound studies in the RUM aquifer may be performed in the future but it is not the focus of this rebound studies parent SAP.

Performance monitoring will continue as described in Addendum 1 of the 100-D/H RD/RAWP (DOE/RL-2017-13). Any performance monitoring samples will be co-sampled with the rebound study samples and would not be duplicative. Performance monitoring will continue as per DOE/RL-2017-13-ADD1 outside of active rebound study areas.

1.2 Background

The 100-HR-3 OU (Figure 1-2) includes the groundwater in the 100-D/H Area. The groundwater was contaminated by releases from facilities and waste sites in the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs associated with past operations at the D, DR, and H Reactors. Operations at these reactors resulted in the contamination of soil and groundwater with various metals, radioactive materials, and other constituents. Reactor operations and descriptions of contaminant releases are provided in the 100-D/H remedial investigation/feasibility study (RI/FS) report (DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*) (hereinafter referred to as the 100-D/H RI/FS).

The most widespread contaminant in the 100-HR-3 OU is Cr(VI). During reactor operations sodium dichromate dihydrate containing Cr(VI) was added to the cooling water to inhibit corrosion within the reactors. After passing through the reactors, the majority of the Cr(VI)-contaminated cooling water was discharged to retention basins and subsequently released to the Columbia River. Large volumes of cooling water were also discharged to trenches for infiltration. Leakage of cooling water from the retention basins was common. The leakage from the retention basins and infiltration from the trenches resulted in groundwater mounds forming in the 100-D/H Area. As a result, the groundwater was contaminated with low-concentration Cr(VI) over a large area. In addition, the high-concentration sodium dichromate dihydrate solution entered the environment through spills and leaks from storage facilities and during transfers, causing further soil and groundwater contamination. Contamination from the releases migrated through the soil column to the groundwater and now underlies the 100-D/H Area, and the region between the 100-D and 100-H Areas known as the Horn.

Initial remedial actions began at the 100-HR-3 OU in 1997 with installation of a P&T system, HR3, under an interim action ROD (EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Interim Remedial Actions, Hanford Site, Benton County, Washington*) and in accordance with DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*. A second P&T system, DR5, was installed in 2004. In 2010 and 2011, the two original systems were replaced with the larger DX and HX P&T systems. The 1999 interim action ROD amendment (EPA/AMD/R10-00/122, *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*) approved installation of an in situ redox manipulation barrier, a new technology for treating Cr(VI) contaminated groundwater in the 100-D Area. The barrier did not achieve the required level of performance and resulted in a determination from the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) that expansion of the P&T system was to be used to provide a protective remedy for this area (EPA et al., 2009, *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington*).

The P&T systems have been expanded over the years and have been effective in reducing Cr(VI) concentrations in groundwater and improving hydraulic containment to protect the Columbia River from continuing releases of Cr(VI).

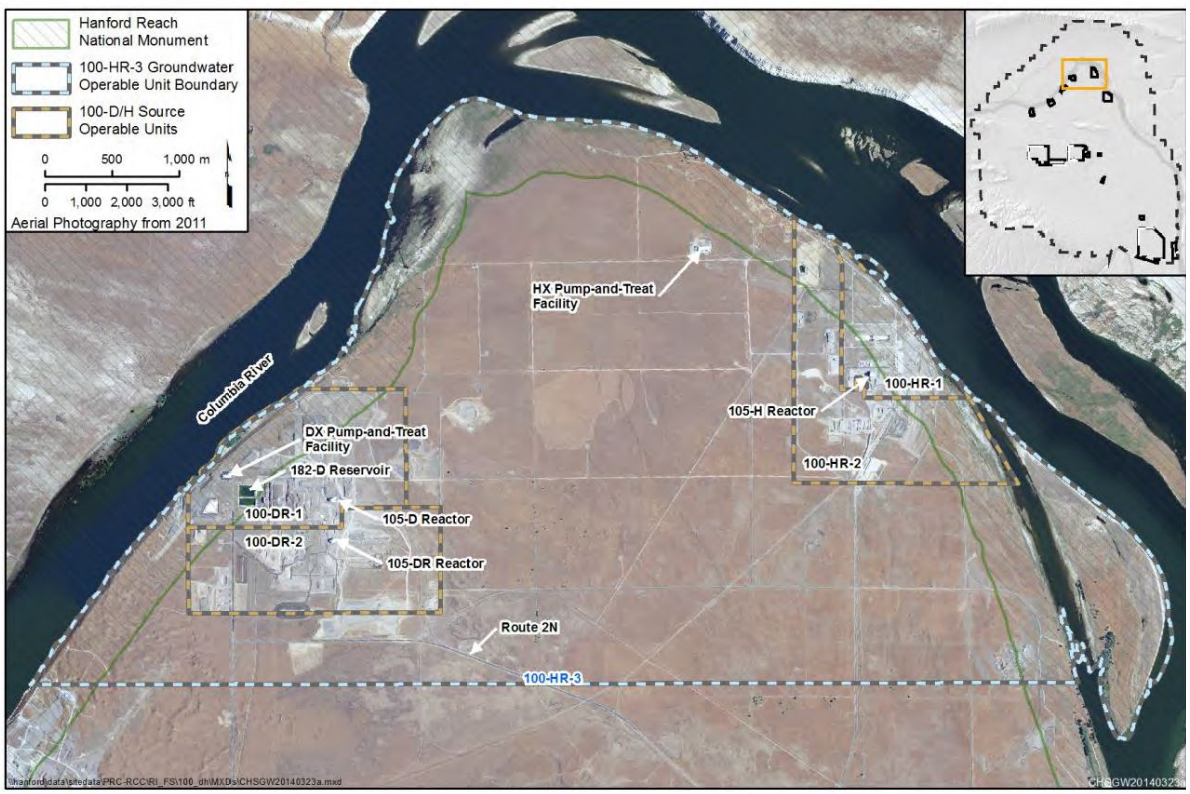


Figure 1-2. Hanford Site and the 100-HR-3 Operable Unit

In 2018 the 100-D/H ROD (EPA et al., 2018) selected expansion and optimization of the existing P&T systems for groundwater remediation of Cr(VI). Other groundwater contaminants of concern in the 100-HR-3 OU include nitrate, strontium-90, and total chromium. The 100-D/H ROD selected a final remedy of monitored natural attenuation for nitrate and strontium-90. Total chromium is collocated with

Cr(VI), and treatment of Cr(VI) groundwater contamination will result in attainment of cleanup levels for total chromium. Total chromium in groundwater is primarily present as Cr(VI). Treatment of Cr(VI) groundwater contamination will result in attaining cleanup levels for total chromium in less time than Cr(VI), since the total chromium cleanup levels are greater than the Cr(VI) cleanup levels.

1.2.1 Site Geology/Hydrology

A detailed description of the 100-D/H Area hydrogeologic conditions is included in the 100-D/H RI/FS. The generalized hydrogeology for the 100-D/H Area is provided in Figure 1-3.

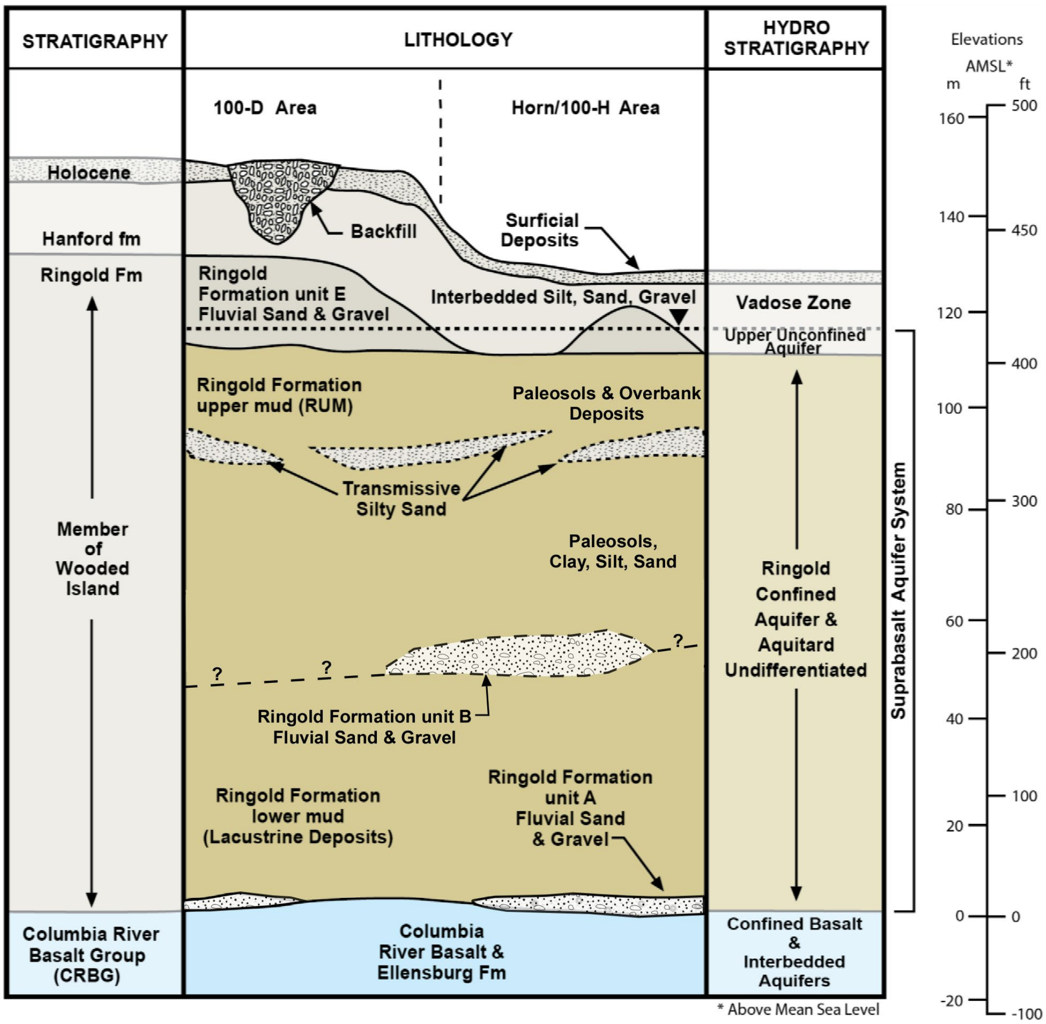


Figure 1-3. Conceptual Hydrogeologic Cross Section from West to East of the 100-D/H Area

The following primary stratigraphic units controlling groundwater flow in the unconfined aquifer in the 100-D/H Area are, from shallowest to deepest:

- Hanford formation
- Ringold Formation member of Wooded Island – unit E (Rwie)
- Ringold Formation upper mud unit (RUM)

The unconfined aquifer in the 100-D/H Area is within the Hanford formation and Rwie. The Hanford formation facies consists of moderately to very poorly sorted, large to very large, cobble-to boulder-sized clasts in open framework gravels that include discrete sand lenses, with little or no silt or clay-sized material. The unconfined aquifer is primarily within the Hanford formation in 100-H Area. The Rwie is a denser, compact and well-graded formation versus the looser, coarser-grained Hanford gravel-dominated facies. The Rwie is composed of fluvial matrix-supported gravels and sands with intercalated fine-to coarse-grained sand and silt layers. The unconfined aquifer is primarily within the Rwie in the 100-D Area. The thickness of the unconfined aquifer is determined by the difference between the water table elevation and the surface of the RUM, which forms the base of the unconfined aquifer.

The unconfined aquifer thickness in the 100-D/H Area generally thins from west to east, from the 100-D Area toward the 100-H Area, with the thinnest areas found in the northern area of the Horn. The thickness of the unconfined aquifer ranges from near 0 to 12 m (39 ft) across the area. The thickness of the unconfined aquifer mimics the topography of the RUM (DOE/RL-2008-42, *Hydrogeological Summary Report for 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit*). Further details on the unconfined aquifer are provided in Section 3.6 of the 100-D/H RI/FS.

The RUM is dominated by a fine-grained overbank paleosol facies that is up to 61 m (200 ft) thick (WHC-SD-EN-TI-132, *Geologic Setting of the 100-HR-3 Operable Unit, Hanford Site, South-Central Washington).* The silt- and clay-rich RUM has low hydraulic conductivity relative to that of the Hanford formation and the Rwie. Within the RUM, thin sand-to-gravel layers form zones with variable hydraulic conductivities that range from low to high and form confined or semiconfined aquifers. The uppermost confined or semiconfined aquifer is the first water-bearing unit of the RUM, bounded by the silt and clay of the RUM at the top, and by either a continuation of the RUM or the Ringold Formation member of Wooded Island – lower mud unit below.

Multiple water-bearing zones are known to be present within the RUM in the 100-D/H Area. These zones are present at different depths, and the number and connectivity of these various water-bearing zones are not known.

1.2.2 Groundwater Flow

In the 100-HR-3 OU, the natural groundwater gradient of the unconfined aquifer is toward the Columbia River. In the 100-H Area, the natural groundwater gradient is toward the east (Figure 1-4). Groundwater flow in the southern 100-D Area is toward the northwest (toward the river). In the remaining regions of the 100-D Area, groundwater flow is to the north and northwest, with groundwater flow inland being more eastward, moving across the Horn and toward the 100-H Area (Figure 1-5) (DOE/RL-2019-67, *Calendar Year 2019 Annual Summary Report for the 100-HR-3 And 100-KR-4 Pump and Treat Operations, and 100-NR-2 Groundwater Remediation*).

Pump and treat extractions wells remove groundwater from both the unconfined and the semiconfined aquifer whereas after treatment, the water is reinjected into the unconfined aquifer. Operation of P&T systems has created changes in groundwater flow direction and velocity in the 100-D/H Area. These changes are expressed as depressions and mounds in the water table, often very localized, affecting the local flow direction and hydraulic gradient. The effect of the P&T system is noticeable where groundwater depressions are present around some DX P&T system extraction wells.

In addition to changes due to remedial actions, daily and seasonal fluctuations in the river stage affect groundwater flow. Hydraulic gradients are generally flatter during the high river stage when compared to low river conditions. The flow directions and gradients experienced during low and high river stage have a greater effect on contaminant transport than during transitional periods. Longer term changes in the river stage produce more extensive and longer observed changes in the water levels, hydraulic gradients, and flow directions in the unconfined aquifer.

The high and low river stages, which typically last a few months, affect the groundwater flow near the river and the effects extend inland, the distance depending on hydrogeologic characteristics of the aquifer.

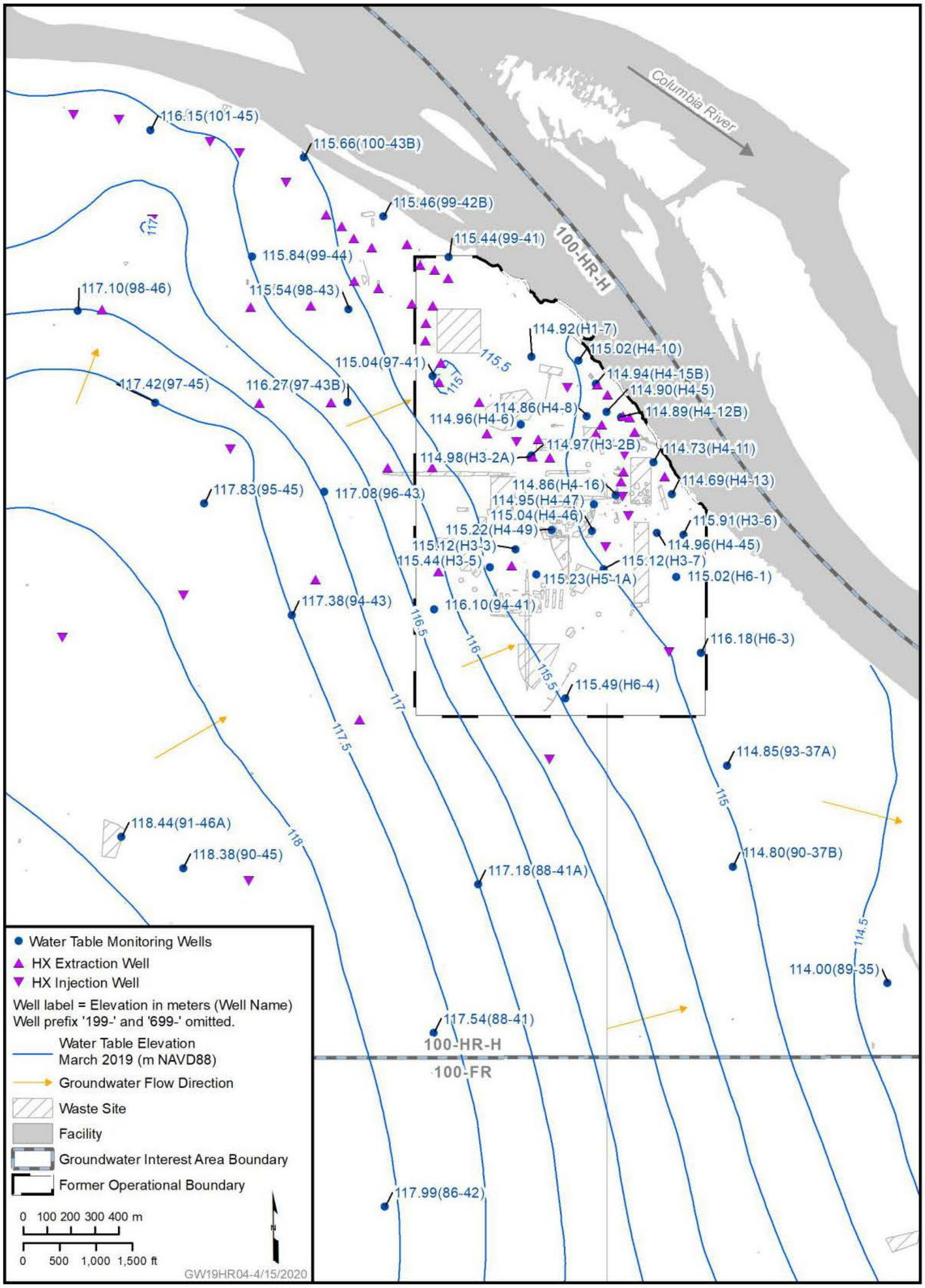


Figure 1-4. 100-H Area Overview and March 2019 Water Table Map with Flow Direction

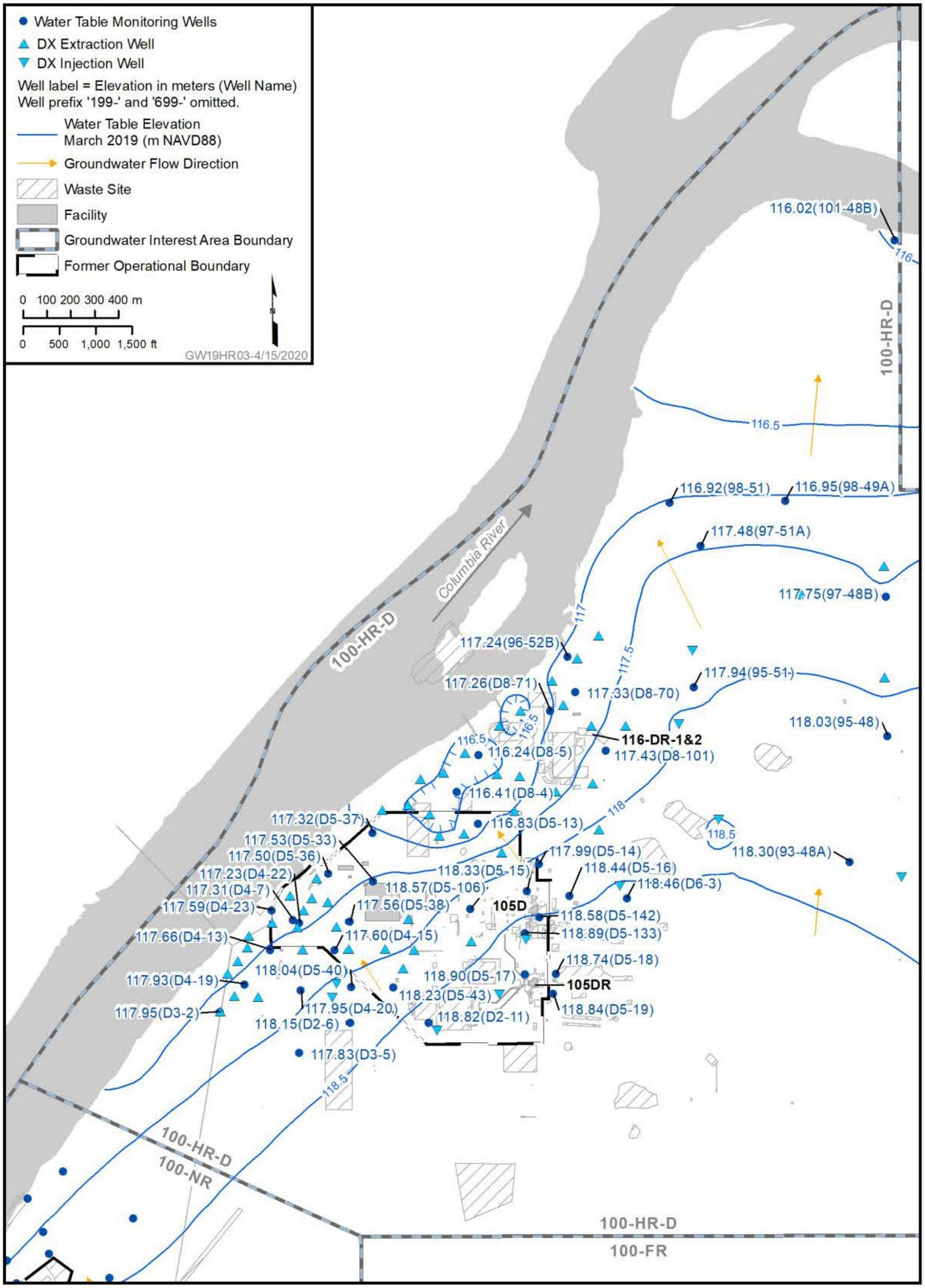


Figure 1-5. 100-D Area Overview and March 2019 Water Table Map with Flow Direction

During high river stage periods, the local groundwater gradient magnitude is reduced near the river; the vicinity near the river may exhibit a temporal flow direction reversal, with river water flowing into the aquifer (i.e., seasonal bank storage). In addition, this change (i.e., increased elevation) of the boundary condition causes the groundwater velocity inland of the river to decrease during high river stage, thus creating the seasonal rise in groundwater elevation typically observed inland of the river. As the river stage declines following the seasonal freshet, the boundary condition again adjusts, the groundwater gradient steepens toward the river, and velocity increases. This condition continues until the groundwater head again equilibrates with the low river stage condition. Seasonal groundwater elevation transients are observed up to several kilometers inland from the river as the water table and river stage equilibrate, but the magnitude of the transients attenuates with distance from the river.

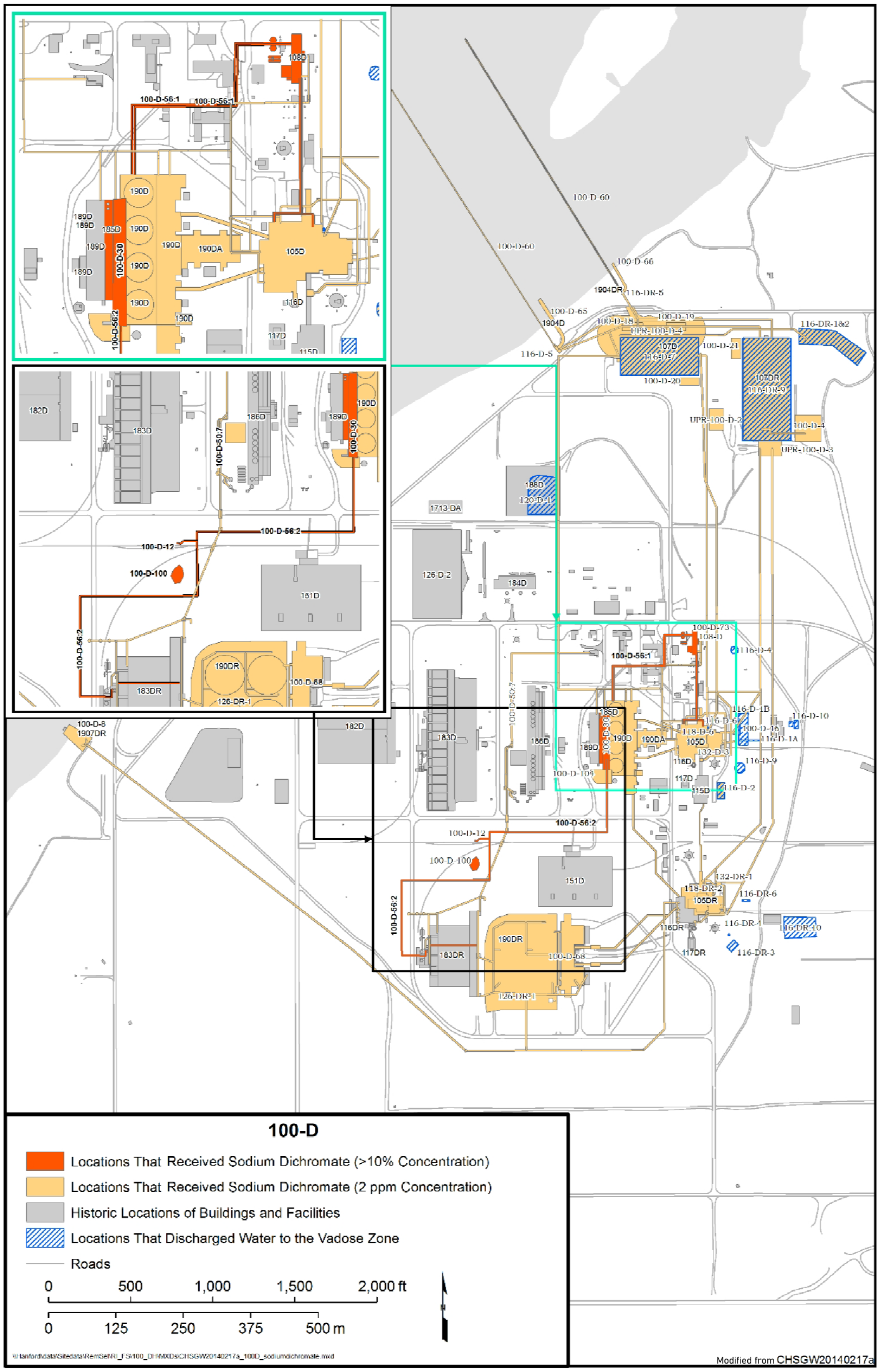
1.2.3 Sources of Contamination

The 100-D/H Area Reactors were supported by multiple facilities associated with services for water treatment, air filtration, nuclear fuel handling, and effluent disposal, with various other administrative buildings. Reactor operations and processes were the primary sources of contamination in 100-D/H Area.

Liquid wastes from reactor operations and associated facilities were released to the soil column and the Columbia River. Solid wastes were disposed in burial grounds associated with the facilities. Wastes released to or buried within the environment created secondary sources of contamination, such as liquid waste sites (ponds, trenches, cribs, and french drains), burial grounds, and small miscellaneous waste sites.

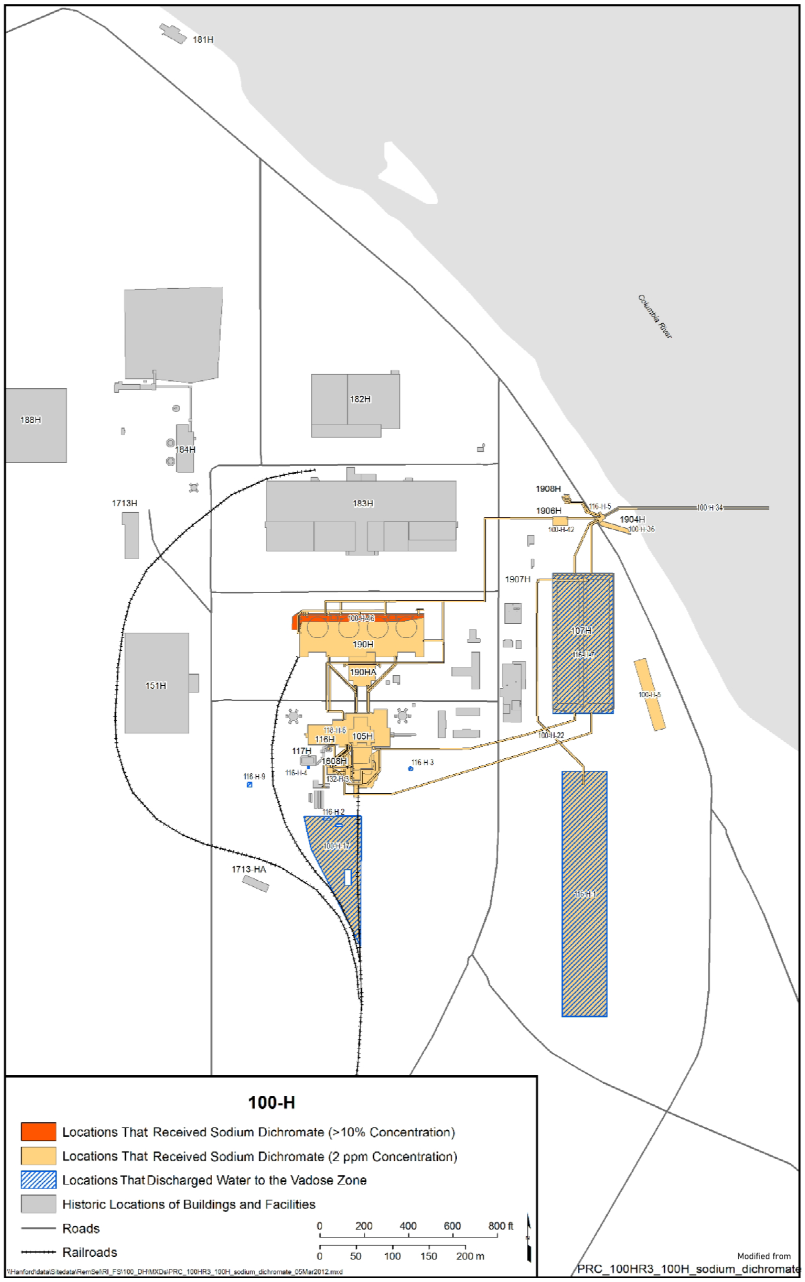
During operation of the D, DR, and H Reactors and associated facilities, numerous locations received highly concentrated sodium dichromate solutions, a source of Cr(VI). The stock solution was fed into the cooling water treatment system for mixing and dilution before entering the reactors. After passing through the reactor, low-concentration sodium dichromate solution was discharged to retention basins and selected trenches and cribs. Spills and leaks of concentrated liquid solutions of sodium dichromate materials occurred during receiving, handling, and processing activities near the 100-D-12 waste site, 108-D Building, 185-D Building, and the 100-D-56 pipeline are the most likely source of observed Cr(VI) groundwater contamination in the southern 100-D area and associated Cr(VI) plume. An area of suspect Cr(VI) soil staining near a former sodium dichromate railcar unloading station was first identified in 2008 and classified as the 100-D-100 waste site. The waste site was excavated in 2014. Excavation of the 100-D-100 waste site extended into the groundwater, which was encountered at a depth of 26 m (85 ft) below ground surface (SGW-58416, *Persistent Source Investigation at 100-D Area*). As a result of the excavation activities, groundwater contamination in that area decreased rapidly. However, two areas of elevated Cr(VI) remain in the groundwater near the 100-D-100 excavation footprint. Soil samples collected during the excavation of 100-D-100 had elevated Cr(VI). The sidewall area was not excavated due to the depth and size of the excavation and the proximity of nearby structures. The extent of the contamination is not known but is assumed to be limited based on the small area of elevated groundwater contamination in the area. The 100-D-30/104 waste site was remediated with a series of excavations to a depth of 24 m (78.7 ft) below ground surface (the approximate depth to groundwater). The excavations occurred between 2006 and 2014. Two soil grab samples from the 100-D-30/104 sidewall, located above the water table, indicated that leachable Cr(VI) was present in the excavation footprint. The conclusion was that leaching of Cr(VI) from the vadose zone soil in this area needs to be considered as a potential long-term source for groundwater contamination (SGW-58416).

Spills and leaks in the area near the 190H Pump House are the most likely source of observed Cr(VI) groundwater contamination in the 100-H area associated with the 100-H-46 waste site. Spills of sodium dichromate at cooling water support facilities had the greatest potential for environmental contamination (DOE/RL-2017-13). Decontamination wastes produced in the 100-D/H Area from operations were commingled with other liquids and were disposed in various trenches. Figures 1-6 and 1-7 show facilities and waste sites where sodium dichromate was handled in the 100-D Area and 100-H Area, respectively.



Modified from DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*.

Figure 1-6. 100-D Area Facilities and Waste Sites Where Sodium Dichromate was Handled



Modified from DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*.

Figure 1-7. 100-H Area Facilities and Waste Sites Where Sodium Dichromate was Handled

Cr(VI) contamination is present in the uppermost water-bearing unit in the RUM at the 100-H Area and in the Horn. The source of contamination is hypothesized to be Cr(VI)-contaminated groundwater in the overlying unconfined aquifer being forced into the lower aquifer by high hydraulic heads within the overlying shallow unconfined aquifer during reactor operations (HW-77170, *Status of the Ground Water Beneath Hanford Reactor Areas January, 1962 to January, 1963*), and during the 1967 infiltration test (BNWL-CC-1352, *Ground Disposal of Reactor Coolant Effluent*). The uppermost water-bearing unit in the RUM in the 100-H Area exhibits slightly higher head relative to the unconfined aquifer, indicating a small upward vertical gradient; however, this gradient has decreased through time (DOE/RL-2010-95).

In the Horn, well 699-97-60 is located between two pockets of Rwie located laterally to each side of the well. It is presumed that the elevated water table during operations would have been channeled into the zone between the two pockets, causing a high pressure head in the area where Cr(VI) contamination is noted at well 699-97-60 (SGW-54332, *Software for Support of Groundwater Contaminant Fate and Transport Analysis -13345*).

As discussed in SGW-64372, *100-D/H Continuing Hexavalent Chromium Source Evaluation*, there are several suspected areas where source material is known or suspected to remain in the lower vadose zone and PRZ. Soil remedial actions (excavations and removal) were performed at surface contaminated areas and at some locations, these soil removal actions extended to the water table. Soil contamination was excavated and removed at selected areas in the 100-HR-3 OU; however, several areas are suspected of having deeper source material in the lower vadose zone PRZ below the excavations. Three secondary source areas of residual Cr(VI) contamination are identified within the 100-D Area; the 100-D-100 Sidewall, the 100-D-56:2 Pipeline, and the 100-D North Area (which includes:116-DR-1&2; 107-DR Liquid Waste Disposal Trench #1; 107-DR Liquid Waste Disposal Trench #2; 116-DR-1; 116-DR-2; Emergency Crib Trench) (Figure 1-6). In the 100-H Area, three secondary source areas are identified; the 183-H Solar Evaporation Basins, the 100-H-46 waste site, and the 107H Retention Basin (Figure 1-7). Rebound studies are recommended to determine the progress of active remediation in the 100-D/H secondary source areas and to determine if P&T optimization is needed. Rebound studies throughout the 100-HR-3 OU may provide information to bound the magnitude and extent of secondary sources (including the PRZ) in order to select areas for further remediation where necessary. Subarea SAP addenda will include additional information pertinent to potential secondary sources within the subarea.

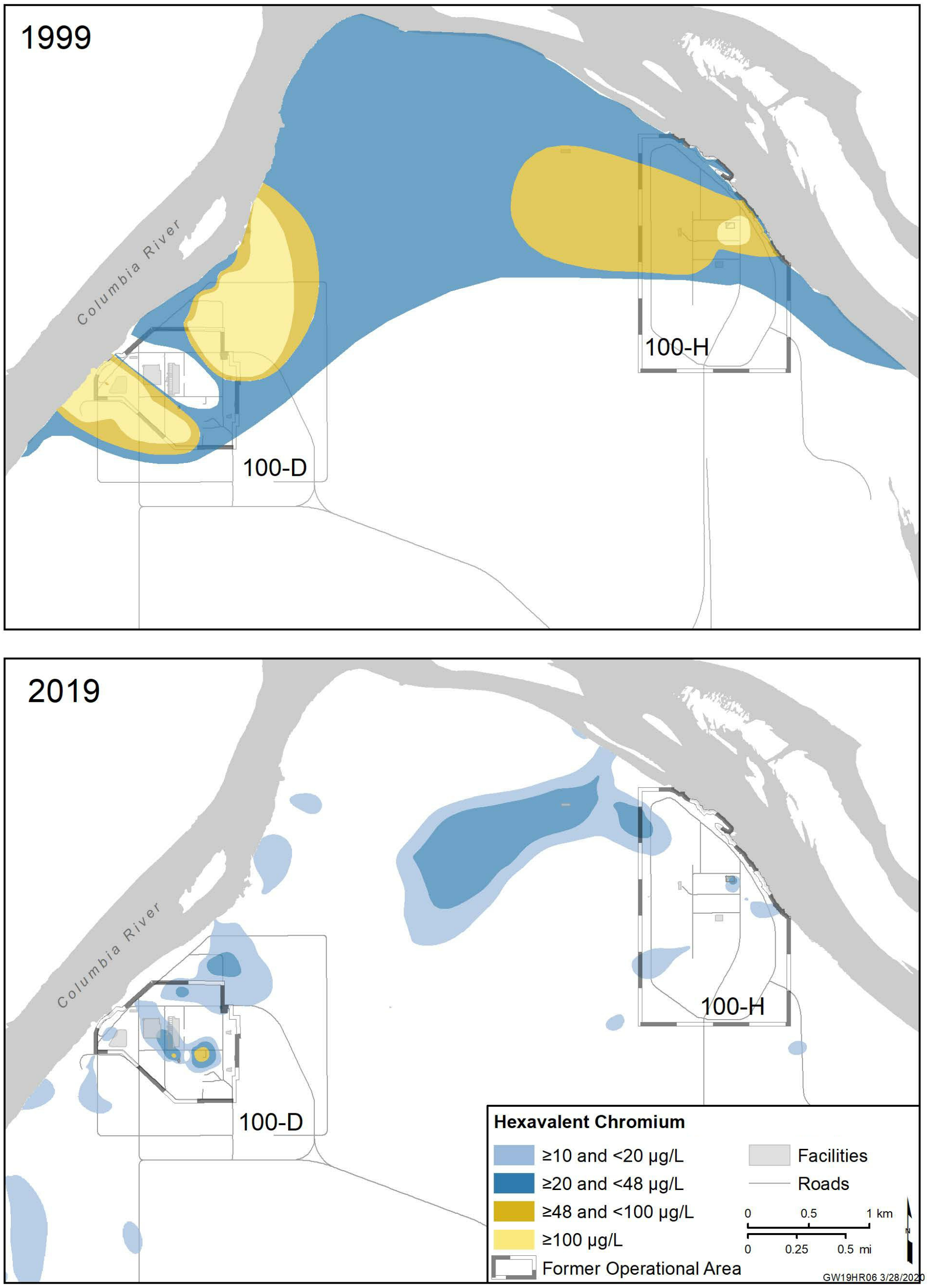
1.2.4 Contaminant Plumes

The current contaminant plume configurations result from both the behavior of the historical recharge mounds and from groundwater movement since the cessation of cooling water discharges. The most widely distributed contaminant is Cr(VI). Figure 1-8 shows the unconfined aquifer Cr(VI) plume in 1999 (2 years after the first P&T system began operating) and in 2019 (DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*). Plume size and areas with concentrations greater than 100 μg/L and 48 μg/L in the unconfined aquifer have been reduced due to continued P&T system operation. A few isolated areas with concentrations greater than 48 μg/L remain.

In some areas, the uppermost RUM aquifer is also contaminated with Cr(VI) and is the focus of ongoing characterization and remediation efforts. In 2019, water was extracted from the RUM aquifer from seven extraction wells for treatment at the 100-HR-3 OU P&T systems. New wells drilled during fiscal year (FY) 2020 and FY 2021 will allow for delineation of the RUM aquifer Cr(VI) plume in the Horn.

1.3 Data Quality Objectives Summary

Appendix A of this rebound studies parent SAP provides the details of the data quality objectives (DQO) process. This process was implemented to ensure that the data collected as part of this SAP through rebound studies in the 100-HR-3 OU can be used to support evaluation of post P&T Cr(VI) and unconfined aquifer conditions. The data needs were developed collaboratively between the U.S. Department of Energy (DOE) and Ecology and are based on lessons learned from rebound studies conducted at other OUs on the Hanford Site. Table 1-1 lists the PSQs that will be addressed through the collection of groundwater data associated with this rebound studies parent SAP and subarea addenda. As indicated in Section 1.1, if additional data needs are identified within a given subarea, they will be included in the subarea SAP addenda, and as appropriate, will be incorporated into this SAP through a Tri-Party Agreement CN or SAP revision.



Modified from DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019.*

Figure 1-8. 100-HR Cr(VI) Plume in 1999 (Early in Interim Action Period) and 2019 (During Remedial Action)

Table 1-1. Principal Study Questions

Principal Study Question		Data Need
PSQ 1	What is the magnitude and spatial extent of Cr(VI) concentration rebound in the absence of P&T?	Increased frequency of Cr(VI) concentration measurements in groundwater in the absence of P&T operations.
PSQ 2	In the absence of P&T operations, are Cr(VI) concentrations below OR anticipated to meet the 100-D/H ROD inland cleanup level of 48 µg/L and surface water cleanup level of 10 µg/L and expected to remain below cleanup levels?	Increased frequency of Cr(VI) concentration measurements in groundwater in the absence of P&T operations.
PSQ 3	In areas where the source of Cr(VI) contamination is known or suspected, what is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations?	Increased frequency of Cr(VI) concentration measurements in groundwater collected at discrete intervals vertically through the saturated screen interval in the absence of P&T operations.
PSQ 4	How is the aquifer within the rebound study areas affected hydraulically following shutdown of P&T?	Manual water level measurements collected during sampling, automated water level measurements from established AWLN wells, water level measurements from existing sensors in P&T extraction and injection wells.
PSQ 5	Has groundwater hydrochemistry reverted to ambient* conditions?	Increased frequency of measurements of major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance and other field parameters in groundwater in the absence of P&T operations. Manual water level measurements collected during sampling, AWLNs from established AWLN wells, water level measurements from existing sensors in P&T extraction and injection wells.
PSQ 6	What are the seasonal effects in groundwater Cr(VI) concentrations within the rebound study area due to river stage?	Increased frequency of Cr(VI) concentration measurements in groundwater, in the absence of P&T operations, during high, low, and intermediate river stages. Increased sampling frequency of major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance and other field parameters in groundwater in the absence of P&T operations. Measured water levels in the unconfined aquifer, in the absence of P&T operations, during high and low river stages.

Table 1-1. Principal Study Questions

Principal Study Question		Data Need
PSQ 7	Can the project use the data to supplement compliance monitoring?	Information collected to address previous PSQs. Data analysis and evaluation procedures used to demonstrate compliance with groundwater cleanup levels will be defined in a compliance monitoring plan prepared under WAC 173-340-410.

Reference: WAC 173-340-410, "Model Toxics Control Act—Cleanup," "Compliance Monitoring Requirements."

*Ambient conditions occur when the aquifer is able to flow along natural lines and resume a stable hydrochemical state in the absence of P&T.

AWLN	=	automated water-level network
P&T	=	pump and treat
PSQ	=	principal study question
ROD	=	record of decision

1.3.1 Evaluation of Rebound Study Data

The primary objective of rebound studies is to detect and quantify changes in Cr(VI) concentrations in groundwater that are attributed to shutdown of P&T systems in the unconfined aquifer in the 100-HR-3 OU. To this end, Cr(VI) data collected during the rebound test will be compared to pre-study values and 100-D/H ROD (EPA et al., 2018)-specified groundwater cleanup levels. This information will be used to interpret groundwater conditions in the rebound study area. Both well-by-well (time series or histograms) and spatially interpretive techniques will be employed including:

- **Hydrographs**: Graph water levels versus time to determine decreases and increases and seasonal or manmade fluctuations in groundwater levels.
- **Water table maps**: Use water table elevations from multiple wells to construct contour maps and estimate flow directions. Groundwater flow is assumed to be perpendicular to the equal potential lines on the maps.
- **Trend plots**: Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations in contaminant concentrations. These graphs may be used in tandem with hydrographs and water table maps to determine if observed changes in concentrations relate to changes in water level or groundwater flow directions.
- **Plume maps**: Map distributions of chemical constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of groundwater flow.

Plume maps and trend plots will be evaluated to determine whether Cr(VI) concentrations in the groundwater remain below and are expected to remain below the applicable cleanup levels of 48 µg/L inland or 10 µg/L at the river. If this is the case, transition from P&T operations to compliance monitoring will be considered. Otherwise, it may be necessary to terminate the rebound test and restart or optimize the P&T system.

If rebound of Cr(VI) concentrations above cleanup levels is observed in the vicinity of known or suspected source areas, this may indicate continuing sources and the need for continued operation of the P&T system and the initiation of vadose zone remediation efforts.

If the concentrations of Cr(VI) exhibit vertical stratification within the saturated zone, this depth discrete data may be utilized by source investigation studies and groundwater modeling investigations. In this case, continuing P&T operation may be required.

The decision rules are designed to require a full technical evaluation of the dataset as a whole and on a well-by-well basis. A condition for prematurely ending the rebound study is if hexavalent chromium concentrations at an aquifer tube exceeds 10 µg/L for three consecutive sampling events. In addition, a rebound study may prematurely end if hexavalent chromium concentrations in a groundwater well exceeds 20 µg/L for three consecutive sampling events. The hexavalent chromium concentration of 20 µg/L is lower than the 48 µg/L cleanup level for inland wells identified in the 100-D/H ROD (EPA et al., 2018). This value is used to minimize risk to surface water during the rebound study while still allowing the rebound study to evaluate the P&T effectiveness within the unconfined water.

At subareas with a known or suspected secondary source, hexavalent chromium concentrations may be or rebound to values greater than 20 µg/L. This is necessary to bound the magnitude and extent of secondary sources (including the PRZ) and will help inform additional remedial action, if necessary. Subarea SAP addenda will identify specific wells which may exceed the 20 µg/L hexavalent chromium concentration. An alternate concentration will be determined for affected areas and depend on current plume dynamics and where the well is located with respect to the river.

1.3.2 Role of the Sampling and Analysis Plan and Addenda

To avoid duplicating Chapters 2 through 5 of this rebound studies parent SAP, and to simplify the documentation process, this SAP will act as the main body of information that supports the creation of site-specific subarea SAP addenda. This SAP contains the overall sampling and analysis objectives to support groundwater monitoring activities associated with rebound studies performed in the 100-HR-3 OU. The subarea SAP addenda, which will be published as needed, include the well-specific sampling requirements. Future subarea SAP addenda will be developed using the DQOs as defined in Appendix A. Each addendum will include how the DQOs as defined in this parent rebound SAP are being addressed through the sampling scheme.

1.4 Contaminants of Concern/Target Analytes

Table 1-2 lists Cr(VI), field parameters, and general chemistry parameters that may be analyzed during a rebound study.

Table 1-2. Analytes for 100-HR-3 Operable Unit Rebound Study Sampling

Analyte	CAS Number or Constituent ID
General Chemical Parameters	
Alkalinity	ALKALINITY
Inorganics (Anions)	
Chloride	16887-00-6
Fluoride	16984-48-8

Table 1-2. Analytes for 100-HR-3 Operable Unit Rebound Study Sampling

Analyte	CAS Number or Constituent ID
Nitrate*	14797-55-8
Phosphate	14265-44-2
Sulfate	14808-79-8
Inorganics (Metals)	
Calcium	7440-70-2
Total chromium*	7440-47-3
Uranium (total)*	7440-61-1
Hexavalent chromium	18540-29-9
Magnesium	7439-95-4
Potassium	7440-09-7
Sodium	7440-23-5
Radionuclide	
Strontium-90*	10098-97-2
Field Measurements	
Dissolved oxygen	DO
pH Measurement	PH
Specific conductance	CONDUCT
Temperature	TEMPERATURE
Turbidity	TURBIDITY

*Analyte will be measured for informational purposes and will not be evaluated as part of the rebound study.

CAS = Chemical Abstracts Service
ID = identification

1.5 Project Schedule

The first SAP addendum is planned to be finalized in 2022 and will focus on a rebound study subarea within the 100-H Area. It is anticipated that one subarea rebound study will be planned and performed each year (consecutive studies) for the next three years. The first three rebound study subareas will target potential continuing source areas. Results of the rebound studies will be combined with the results of ongoing continuing source modeling. If the first two subarea rebound studies indicate modification of the schedule is needed to meet remediation goals, scheduling adjustments can be made. Subarea rebound study durations may overlap, depending upon outcomes of the subsequent rebound studies. In the event a subarea rebound study is extended, initiation of the next rebound study will not be impacted.

The subareas that are currently anticipated based on plume delineation and well networks are shown in Figure 1-9. As data collection and evaluation efforts continue, the boundaries of subareas may be adjusted, as appropriate. The first rebound study will be performed in the 100-H North subarea followed by rebound studies in the 100-D South, and 100-H South subareas respectively. Depending on the results of the first three rebound studies and on performance monitoring, additional rebound studies will be scheduled either sequentially or concurrently, as subareas achieve cleanup goals and become ready for rebound studies.

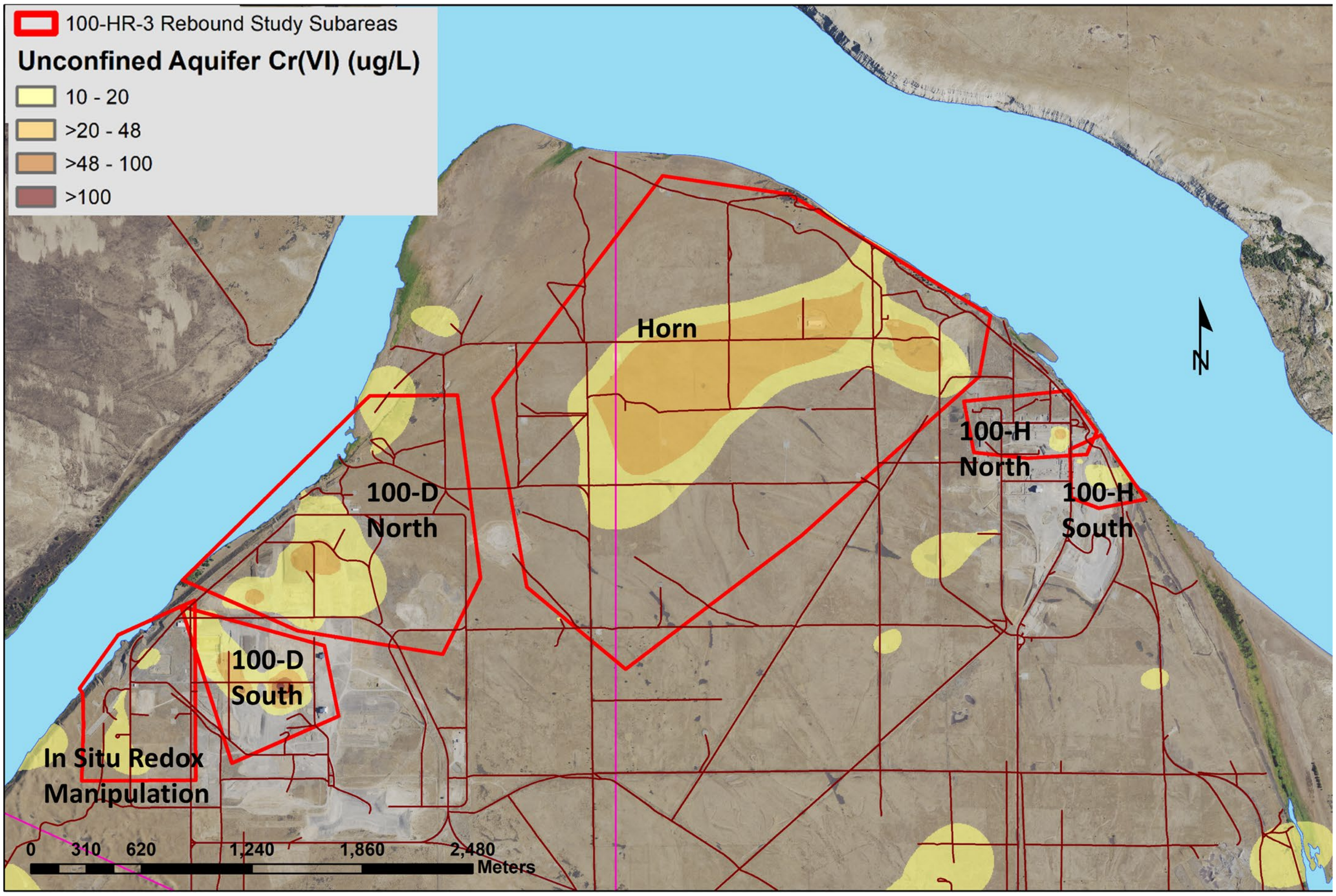


Figure 1-9. 100-HR-3 Rebound Study Subarea Boundaries

2 Quality Assurance Project Plan

A Quality Assurance Project Plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the quality assurance (QA) elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5), and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). DoD/DOE, 2019, *Department of Defense/Department of Energy Consolidated Quality System Manual for Environmental Laboratories* (DoD/DOE QSM), is also discussed. Section 7.8 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b; hereinafter called the Tri-Party Agreement Action Plan) requires the QA/quality control (QC) and sampling and analysis activities to specify the QA requirements for Past-Practice Processes. This QAPjP also describes applicable requirements and controls based on guidance in Ecology Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies,* and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP supplements the contractor's environmental QA program plan.

The QAPjP references are included in Chapter 6. The QAPjP includes the following sections, which describe the quality requirements and controls applicable to Hanford Site OU sampling activities:

- Section 2.1, "Project Management"
- Section 2.2, "Data Generation and Acquisition"
- Section 2.3, "Assessment and Oversight"
- Section 2.4, "Data Review and Usability"

2.1 Project Management

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

2.1.1 Project/Task Organization

The project organization is described in the following sections and illustrated in Figure 2-1.

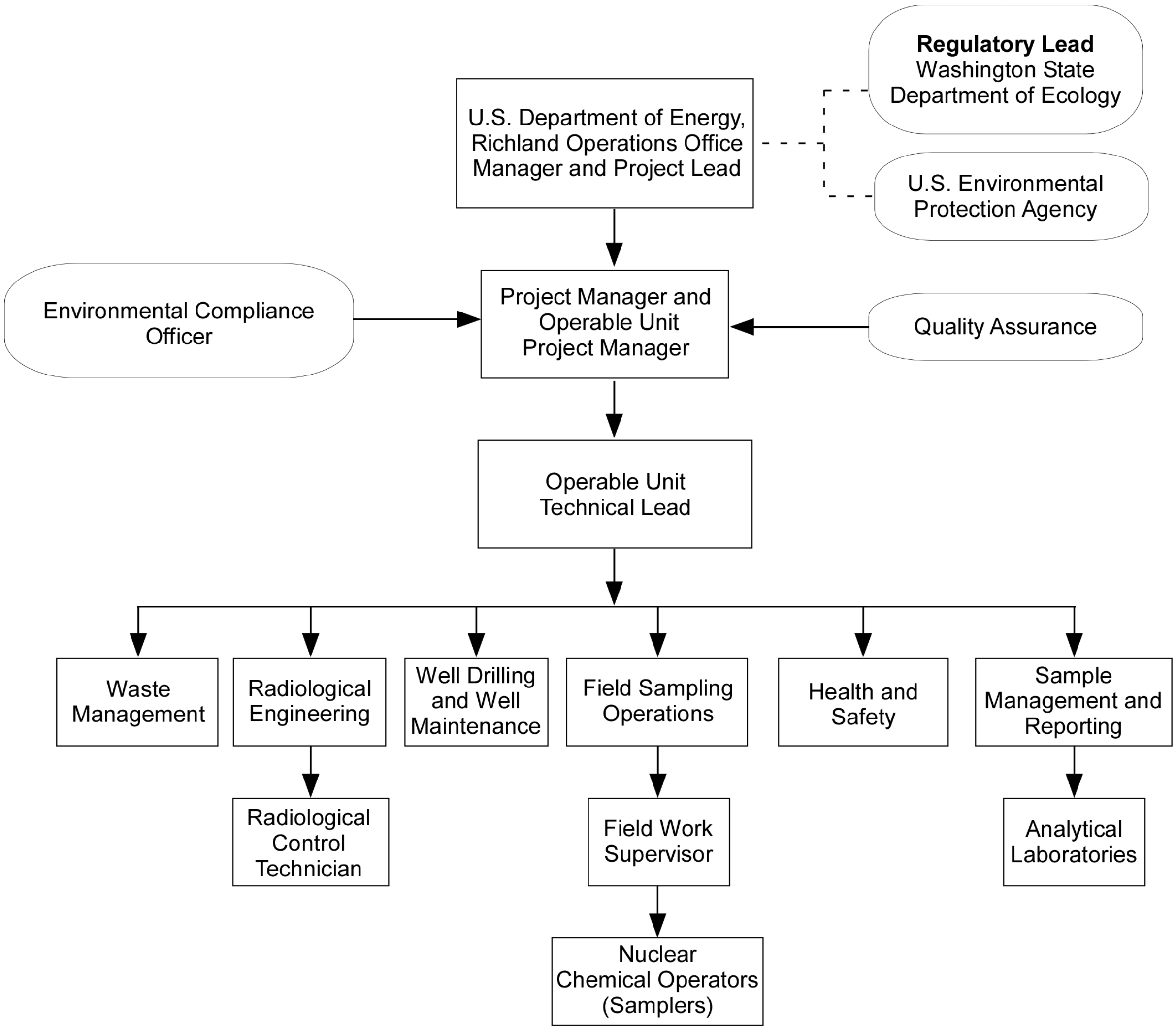


Figure 2-1. Project Organization

2.1.1.1 Regulatory Lead

The lead regulatory agency (LRA) for the 100-HR-3 OU is Ecology. Ecology is responsible for regulatory oversight of cleanup projects and activities. EPA retains approval authority for all SAPs. Ecology works with EPA and DOE-RL to resolve concerns over the work described in the rebound studies parent SAP or subarea SAP addenda in accordance with the Tri-Party Agreement (Ecology et al., 1989a).

2.1.1.2 DOE-RL Manager

Hanford Site cleanup in the 100-HR-3 OU is the responsibility of DOE-RL. The DOE-RL Manager is responsible for authorizing the contractor to perform activities described within this SAP at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; *Resource Conservation and Recovery Act of 1976*; *Atomic Energy Act of 1954*; and the Tri-Party Agreement (Ecology et al., 1989a).

2.1.1.3 DOE-RL Project Lead

The DOE-RL Project Lead is responsible for providing day-to-day oversight of the contractor's performance of the work scope, working with the contractor to identify and work through issues, and providing technical input to the DOE-RL management.

2.1.1.4 Regulatory Strategy and Integration Regulatory Document Delivery Manager

The Regulatory Strategy and Integration Regulatory Document Delivery Manager (Project Manager in Figure 2-1) provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The Regulatory Strategy and Integration Regulatory Document Delivery Manager also provides support to the 100-HR-3 OU Project Manager to ensure that work is performed safely and cost effectively.

2.1.1.5 100-HR-3 Operable Unit Project Manager

The 100-HR-3 OU Project Manager (or designee) is responsible and accountable for project-related activities including coordinating with DOE-RL, regulators, and contactor management in support of sampling activities to ensure work is performed safely, compliantly, and cost effectively. In addition, the 100-HR-3 OU Project Manager (or designee) is also responsible for managing sampling documents and requirements, field activities, subcontracted tasks, and for ensuring the project file is properly maintained.

2.1.1.6 Operable Unit Technical Lead

The 100-HR-3 OU Technical Lead is responsible for developing specific sampling design, analytical requirements, and QC requirements, either independently or as defined through a systematic planning process. The 100-HR-3 OU Technical Lead ensures that sampling and analysis activities as delegated by the 100-HR-3 OU Project Manager are carried out in accordance with the SAP, and works closely with the Environmental Compliance Officer, QA, Health and Safety, the Field Work Supervisor (FWS), and the Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope.

2.1.1.7 Sample Management and Reporting

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. The SMR group generates field sampling documents, labels, and instructions for field sampling personnel and develops the sample authorization form (SAF), which provides information and instruction to the analytical laboratories. The SMR group ensures that field sampling documents are revised to reflect approved changes. The SMR group receives analytical data from the laboratories, ensures the data are appropriately reviewed, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. The SMR group is responsible for informing the 100-HR-3 OU Project Manager of any issues reported by the analytical laboratories.

2.1.1.8 Field Sampling Operations

FSO is responsible for planning and coordinating field sampling resources. The FWS directs the nuclear chemical operators (samplers), who collect samples in accordance with this sampling plan and corresponding standard methods and work packages. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). The FWS ensures that samplers are appropriately trained and available. Samplers collect samples in accordance with sampling requirements. Samplers also complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and enable delivery of the samples to the analytical laboratory.

Pre-job briefings are conducted by FSO, in accordance with work management and work release requirements, to evaluate activities and associated hazards by considering the following factors:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required

2.1.1.9 Quality Assurance

The QA point of contact provides independent oversight and is responsible for addressing QA issues on the project, overseeing implementation of the project QA requirements. Responsibilities include reviewing project documents including the QAPjP, and participating in QA assessments on sample collection and analysis activities, as appropriate.

2.1.1.10 Environmental Compliance Officer

The Environmental Compliance Officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work and also develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

2.1.1.11 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulation or internal primary contractor work requirements.

2.1.1.12 Radiological Engineering

Radiological Engineering is responsible for the following:

- Radiological engineering and project health physics support
- Conducting as low as reasonably achievable reviews, exposure and release modeling, and radiological controls optimization
- Identifying radiological hazards and ensuring appropriate controls are implemented to maintain worker exposures to hazards at as reasonably achievable levels
- Interfacing with the project Health and Safety representative and other appropriate personnel, as needed, to plan and direct project radiological control technician (RCT) support

2.1.1.13 Waste Management

Waste Management is responsible for identifying waste management sampling/characterization requirements to ensure regulatory compliance and for interpreting data to determine waste designations and profiles. Waste Management communicates policies and practices and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

2.1.1.14 Analytical Laboratories

The analytical laboratories accept, manage, prepare, and analyze samples in accordance with established methods and the requirements of their subcontract, and provide necessary data packages containing analytical and QC results. Laboratories provide explanations of results to support data review and in response to resolution of analytical issues. Laboratory quality requirements are consistent with HASQARD (DOE/RL-96-68). The laboratories are evaluated under the U.S. Department of Energy Consolidated Audit-Accreditation Program (DOE/CAP-AP) or its successor programs to the DoD/DOE QSM requirements. HASQARD requirements, beyond those within the DoD/DOE QSM, are also evaluated under the DOE/CAP-AP. Laboratories are accredited by Ecology for the analyses performed under this rebound studies parent SAP and subarea SAP addenda.

2.1.1.15 Well Drilling and Well Maintenance

The well drilling and maintenance and well coordination and planning managers are responsible for the following:

- Planning, coordinating, and executing drilling construction
- Well maintenance activities
- Coordinating with the 100-HR-3 OU Technical Lead about field constraints that could affect sampling design
- Coordinating well decommissioning with DOE-RL in accordance with the substantive standards of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

2.1.2 Quality Objectives and Criteria

The QA objective of this plan is to ensure the generation of analytical data of known and appropriate quality is acceptable and useful in order to meet the evaluation requirements stated in the sampling plan. Data descriptors known as data quality indicators (DQIs) help determine the acceptability and usefulness of data to the user. The principal DQIs (precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity) are defined for the purposes of this document in Table 2-1.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated during a process to assess data usability (Section 2.4.3).

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or remeasurement. • Qualify the data before use.
Accuracy (laboratory control samples, matrix spikes, surrogates, carriers, and tracers)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use. • Request reanalysis or remeasurement.

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Representativeness (field duplicates)	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring that the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one dataset can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and QA protocols.	If data are not comparable to other datasets: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Completeness (no QC element; addressed in data usability assessment)	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (DQO or performance/acceptance criteria).	If datasets do not meet the completeness objective: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.
Bias (equipment blanks, full trip blanks, laboratory control samples, matrix spikes, and method blanks)	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).	For sampling bias: • Properly select and use sampling tools. • Institute correct sampling and subsampling practices to limit preferential selection or loss of sample media. • Use sample handling practices, including proper sample preservation, that limit the loss or gain of constituents to the sample media. • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. • Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation[b] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

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

a. Acceptance criteria for QC elements are provided in Table 2-5.

b. For purposes of this sampling plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

DQO = data quality objective

QA = quality assurance

QC = quality control

2.1.3 Methods-Based Analysis

Laboratory testing for analytes described in Sections 1.4 and 2.2.1 may include non-target analytes that are part of the analytical method (i.e., methods-based reporting). The additional constituents that are part of the method and reported by the laboratory are for informational purposes. Analytical performance requirements will be applicable only to the analytes specific to this SAP. Poor QC related to non-target analyte results would not result in any required corrective action by the laboratory, except for the application of proper result qualification flags.

If a non-target analyte exceeds an MCL, the results would be reported in the Hanford Site annual groundwater report and regulatory limit exceedances would be handled according to performance monitoring guidelines established for 100-HR-3.

2.1.4 Analytical Priority

If sample volume is insufficient to analyze for all analytes listed for a given well, the sampling priority will be determined by the 100-HR-3 OU Technical Lead. In general, the highest priority analytes critical for supporting groundwater decisions are required to be analyzed. While insufficient sample volume is not expected to be a concern, priority is first given to Cr(VI) and analytes linked to a continuing source of groundwater contamination, second to other 100-HR-3 OU contaminants of interest, and finally analytes typically associated with groundwater geochemistry. Sample priority may be included in the individual addenda to this SAP.

2.1.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting samples and compliant with applicable DOE orders and government regulations. The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Training has been instituted by the contractor management team to meet training and qualification programs that satisfy multiple training drivers imposed by applicable DOE, *Code of Federal Regulations*, and *Washington Administrative Code* requirements.

Training records are maintained for each employee in an electronic training record database. The contractor's training organization maintains the training records system. Line management confirms that an employee's training is appropriate and up to date prior to performing work under this SAP.

2.1.6 Documents and Records

The 100-HR-3 OU Project Manager (or designee) is responsible for ensuring the current version of the parent rebound SAP and subarea SAP addenda is being used and providing any updates to field personnel. Version control is maintained by the administrative document control process. Table 2-2 defines the types of changes that may impact the sampling and the associated approvals, notifications, and documentation requirements.

Table 2-2. Change Control for Sampling Projects

Type of Change[a]	Action	Documentation
Minor Field Change. Changes that have no adverse effect on the technical adequacy of the sampling activity or the work schedule.	The field personnel recognizing the need for a field change will consult with the 100-HR-3 OU Project Manager (or designee) prior to implementing the field change.	Minor field changes will be documented in the field logbook. The logbook entry will include the field change, the reason for the field change, and the names and titles of those approving the field change.
Minor Change. Changes to approved plans that do not affect the overall intent of the plan or schedule.	The 100-HR-3 OU Project Manager will inform DOE-RL and the Regulatory Lead of the change. Ecology determines there is no need to revise the document.	Documentation of this change approval would be in the Unit Manager's Meeting minutes or comparable Tri-Party Agreement CN[b].
Revision Necessary. The LRA determines changes to approved plans require revision to document.	If it is anticipated that a revision is necessary, the 100-HR-3 OU Project Manager will inform DOE-RL and the Regulatory Lead. Ecology determines the change requires a revision to the document.	Formal revision of the sampling document.

References: DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents.*

Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order.*

Ecology et al, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan.*

a. Consistent with DOE/RL-96-68 and Sections 9.3 and 12.4 of Ecology et al., 1989b.

b. The Tri-Party Agreement Action Plan, Section 9.3, defines the minimum elements of a CN.

CN	=	change notice
DOE-RL	=	U.S. Department of Energy, Richland Operations Office
Ecology	=	Washington State Department of Ecology
LRA	=	Lead Regulatory Agency
OU	=	operable unit
Tri-Party Agreement	=	*Hanford Federal Facility Agreement and Consent Order*

Regarding minor field changes, the 100-HR-3 OU Technical Lead will approve deviations from the rebound studies parent SAP and subarea SAP addenda that do not have an adverse effect on the technical integrity or adequacy of the sampling activity. Examples of minor field changes are as follows:

- During groundwater sampling, most groundwater samples will be pumped, although use of another method may be authorized by the 100-HR-3 OU Technical Lead.
- The sample depths provided in the subarea SAP addenda are based on well specific construction information. In the event that a groundwater sample cannot be completed due to excessive buildup of fine material in the sump of the well, the sample depth may be altered during sampling in consultation with the 100-HR-3 OU Technical Lead. In the event this occurs, wells will be submitted to the well drilling and well maintenance organization for inspection and cleaning.

Regarding minor changes, the 100-HR-3 OU Technical Lead (in coordination with the appropriate Central Plateau Cleanup Company subject matter expert for any given issue that may arise) will consult with DOE-RL and Ecology when deviations from the rebound studies parent SAP or subarea SAP addenda do not affect the overall intent of the plan. Examples of minor changes are as follows:

- The addition of monitoring wells to the sampling program
- The modification of groundwater sampling frequency

The 100-HR-3 OU Technical Lead (in coordination with the appropriate Central Plateau Cleanup Company subject matter expert for any given issue that may arise) will inform DOE-RL and Ecology of deviations from the rebound studies parent SAP or subarea SAP addenda that affect the overall intent and schedule may require revision to the approved plan.

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Only authorized individuals may make entries into the logbooks. The logbooks and data forms will be controlled in accordance with internal work requirements and processes.

The FWS and SMR are responsible for ensuring that the field instructions are maintained and aligned with any revisions or approved changes to the rebound studies parent SAP or subarea SAP addenda. The SMR will ensure that any deviations from the SAP are reflected in revised field sampling documents for the samplers and the analytical laboratory. The FWS will ensure that deviations from the rebound studies parent SAP or subarea SAP addenda or problems encountered in the field are documented appropriately (e.g., in the field logbook).

The 100-HR-3 OU Project Manager, FWS, or designee, is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities. The 100-HR-3 OU Project Manager is also responsible for ensuring that project files are appropriately set up and maintained. The project files will contain project records or references to their storage locations. Project files may include the following information:

- Operational records and logbooks
- Data forms
- Global positioning system data (a copy will be provided to SMR)
- Inspection or assessment reports and corrective action reports
- Field summary reports
- Interim progress reports
- Final reports
- Photographs

The following records are managed and maintained by SMR personnel:

- Completed field sampling logbooks
- Field drilling and analytical data
- Groundwater sample reports
- Completed chain-of-custody forms
- Sample receipt records

- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by the offsite analytical laboratories

Convenience copies of laboratory analytical results are maintained in the HEIS database. Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed per Tri-Party Agreement requirements.

2.2 Data Generation and Acquisition

This section addresses data generation and acquisition to ensure that the project's methods for sampling measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented. Requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

2.2.1 Analytical Methods Requirements

Table 2-3 provides information regarding analytical method requirements for samples collected as part of rebound studies. Updated EPA methods and nationally recognized standard methods may be substituted for the analytical methods identified in Table 2-3 in order to follow changed requirements in the method update. The new method shall achieve project DQOs as well or better than the replaced method.

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC[b]	Analytical Method[c]	Required PQL for Water[d]
General Chemical Parameters (µg/L)				
Alkalinity	ALKALINITY	N/A	310.1, 2320	5,250
Inorganics – Anions (µg/L)				
Chloride	16887-00-6	250,000	300, 9056	400
Fluoride	16984-48-8	4,000	300, 9056	525
Nitrate	14797-55-8	45,000 [e]	300, 9056	525
Phosphate	14265-44-2	N/A	300, 9056	787.5
Sulfate	14808-79-8	250,000	300, 9056	1,050
Inorganics - Metals (µg/L)				
Calcium	7440-70-2	N/A	6010	1,050
Total chromium	7440-47-3	100	6020	10.5
Hexavalent chromium	18540-29-9	48/10	7196 (low level)	5
Magnesium	7439-95-4	N/A	6010	1,050
Potassium	7440-09-7	N/A	6010	5,250

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC[b]	Analytical Method[c]	Required PQL for Water[d]
Sodium	7440-23-5	N/A	6010	1,050
Uranium (total)	7440-61-1	30	6020	1.05
Radionuclide (pCi/L)				
Strontium-90	10098-97-2	8	Gas proportional counting	2
Field Measurements				
Dissolved oxygen	DO	N/A	Field measurement instrument/meter	N/A
pH measurement	PH			
Specific conductance	CONDUCT			
Temperature	TEMPERATURE			
Turbidity	TURBIDITY			

a. Value identified is either the CAS number or the constituent identifier if no CAS number exists.

b. WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards" Method B; or WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington"; or 40 CFR 141, "National Primary Drinking Water Regulations."

c. For EPA Method 310.1 see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Compendium*. Equivalent methods may be substituted.

d. Required PQLs are specified in contracts with analytical laboratories. Actual practical quantitation limits vary by laboratory and may be lower. Method detection limits are three to five times lower than quantitation limits. For radionuclides, values in this column are the required minimum detectable concentrations in pCi/L for water and pCi/g for soil/other media.

e. The federal drinking water standard for nitrate is 10 mg/L, expressed as nitrogen. This equates to 45,000 µg/L when expressed as NO_3.

CAS = Chemical Abstracts Service

EPA = U.S. Environmental Protection Agency

MCL = maximum contaminant level

N/A = not applicable

PQL = practical quantitation limit

2.2.2 Field Analytical Methods

Field screening and survey data will be measured consistent with HASQARD (DOE/RL-96-68). Field analytical methods are performed in accordance with the manufacturers' manuals. Table 2-3 provides the parameters (if any) for field measurements. Section 3.3 further discusses field measurements.

2.2.3 Quality Control

The QC requirements specified in the rebound studies parent SAP and subarea addenda, must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to sampling variability.

Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC samples are summarized in Table 2-4.

Acceptance criteria for field and laboratory QC are shown in Table 2-5. Data will be qualified and flagged in HEIS, as appropriate.

Table 2-4. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field Quality Control		
Equipment blank	Contamination from nondedicated sampling equipment	As needed[a,b]
Full trip blank	Contamination from containers, preservative reagents, storage, or transportation	1 per 20 sampling events (well trips[c] or other media samples)
Field duplicate samples	Reproducibility/sampling precision	1 in 20 sampling events (well trips or other media samples[c])
Field split samples	Inter-laboratory comparability	As needed
Laboratory Batch Quality Control[d]		
Carrier	Recovery/yield for radioanalytes	Added to each sample and quality control sample[e]
Method blanks	Laboratory contamination	1 per analytical batch[e]
Laboratory sample duplicate	Laboratory reproducibility and precision	1 per analytical batch[e]
Matrix spikes	Matrix effect/laboratory accuracy	1 per analytical batch[e]
Matrix spike duplicate	Laboratory reproducibility, and method accuracy and precision	1 per analytical batch[e]
Tracers	Recovery/yield for radioanalytes	1 per analytical batch[e]
Laboratory control	Method accuracy	1 per analytical batch[e]

Note: The information in this table does not represent U.S. Environmental Protection Agency or Washington State Department of Ecology requirements; it is intended solely as guidance.

a. For portable Grundfos® pumps, equipment blanks are collected 1 per 20 well trips. Whenever a new type of nondedicated equipment is used, an equipment blank shall be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the nondedicated equipment.

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

c. A "well trip" is defined as any time a well is accessed for sampling. For groundwater monitoring, field duplicates and full trip blanks are run at a frequency of 1 in 20 well trips (i.e., 5% of the well trips) for all groundwater monitoring wells sampled within any given month (not just those restricted to a single treatment, storage, and storage unit). For example, if a month has 181 wells scheduled, then 10 field duplicates will be collected.

d. Batching across projects is allowed for similar matrices (e.g., Hanford Site groundwater).

e. Unless not required by, or different frequency is called out, in laboratory analysis method.

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Table 2-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte	Quality Control Element	Acceptance Criteria (Water)	Corrective Action
General Chemical Parameters			
Alkalinity	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80%-120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75%-125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field Duplicate[b]	≤20% RPD	Review data[d]
Inorganics – Anions			
Anions by IC	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80%-120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤ 20% RPD	Review data[d]
	MS/MSD[c]	75%-125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field Duplicate[b]	≤20% RPD	Review data[d]
Inorganics – Metals			
Hexavalent chromium	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80%-120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75%-125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field Duplicate[b]	≤20% RPD	Review data[d]
ICP-AES metals	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80%-120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]

Table 2-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte	Quality Control Element	Acceptance Criteria (Water)	Corrective Action
	MS/MSD[c]	75%-125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field Duplicate[b]	≤20% RPD	Review data[d]
ICP-MS metals	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80%-120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD	Review data[d]
	MS/MSD[c]	75%-125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field Duplicate[b]	≤20% RPD	Review data[d]
Radionuclide			
Strontium-90	MB	<MDC <5% sample activity concentration	Flag with "B"
	LCS	80% to 120% recovery or statistically derived limits[e]	Flag with "o"[a]
	DUP[b]	≤20% RPD	Review data[d]
	Tracer	30% to 105% recovery	Review data[d]
	Carrier	40% to 110% recovery	Review data[d]
	EB, FTB	<MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]

Notes: The information in this table does not represent U.S. Environmental Protection Agency requirements but is intended solely as guidance. The table is consistent with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods,* and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document*.

This table only applies to laboratory analyses. Depth to groundwater, dissolved oxygen, pH, specific conductance, temperature, and turbidity are not listed because they are measured in the field.

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

b. Applies when at least one result is greater than the laboratory practical quantitation limit (chemical analyses).

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

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

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

Table 2-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Analyte	Quality Control Element	Acceptance Criteria (Water)	Corrective Action

DUP = laboratory sample duplicate
EB = equipment blank
FTB = full trip blank
IC = ion chromatography
ICP-AES = inductively coupled plasma – atomic emission spectroscopy
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference
SMR = Sample Management and Reporting

Data flags:

B, C = possible laboratory contamination: analyte was detected in the associated method blank
o = result may be biased: associated laboratory control sample result was outside the acceptance limits – laboratory applied
N = result may be biased: associated matrix spike result was outside the acceptance limits
Q = problem with associated field QC blank: results were out of limits

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation studies. Audit results are used to improve performance.

Samples are analyzed within the holding time guidelines specified in Table 2-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilization, decomposition, or by other chemical changes. Data from samples analyzed outside of the holding times are flagged in the HEIS database with an “H.”

Table 2-6. Holding Time Guidelines for Laboratory Analytes

Constituent/ Parameter	Preservation[a]	Holding Time[b]
General Chemistry Parameters		
Alkalinity	Cool ≤6°C	14 days
Inorganics – Anions		
Chloride, fluoride, sulfate	Cool ≤6°C	28 days
Nitrate, phosphate	Cool ≤6°C	48 hours
Inorganics – Metals		
Hexavalent chromium	Cool ≤6°C	24 hours
ICP-AES metals/ ICP-MS metals	HNO3 to pH <2	6 months

Table 2-6. Holding Time Guidelines for Laboratory Analytes

Constituent/ Parameter	Preservation[a]	Holding Time[b]

Notes: Holding times and preservation methods are dependent on the constituent and are consistent with U.S. Environmental Protection Agency guidance and approved analytical methods.

Container types and volumes will be identified on the chain of custody form.

This table only applies to laboratory analyses. Depth to groundwater, dissolved oxygen, pH, specific conductance, temperature, and turbidity are not listed because they are measured in the field.

a. For preservation identified as stored at <6°C, the sample should be protected against freezing unless it is known that freezing will not impact the sample integrity.

b. Additional information regarding holding times can be found in the current version of CPCC-00172, *Central Plateau Cleanup Company (CPCCo) Environmental Quality Assurance Program Plan*, Rev. 1, Appendix B.

ICP-AES = inductively coupled plasma – atomic emission spectroscopy

2.2.3.1 Field Quality Control Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure reliable data are obtained. Field QC samples include field duplicates, field split (SPLIT) samples, and two types of field blanks (equipment blanks [EBs] and full trip blanks [FTBs]). Field blanks are typically prepared using high-purity reagent water.[1] QC sample definitions and their required frequency for collection are described below. Required frequencies are provided in Table 2-4.

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

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

Equipment blanks (EBs): high-purity water passed through or poured over decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. EB sample bottles are placed in the storage containers with samples from the associated sampling event and are analyzed for the same constituents as samples from the sampling event. EBs are used to evaluate decontamination process effectiveness; these samples are not required for disposable sampling equipment.

[1] Reagent water is high-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques (HASQARD; DOE/RL-96-68).

Full trip blanks (FTBs): bottles prepared by the sampling team before travel to the sampling site. The preserved bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. It is filled with high-purity water and the bottles are sealed and transported (unopened) to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential sample contamination from the sample bottles, preservative, handling, storage, and transportation.

2.2.3.2 Laboratory QC Samples

Internal QA/QC programs are maintained by laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of carriers, laboratory control samples (LCSs), laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), carriers, tracers, and method blanks (MBs). These QC analyses are required by EPA methods (e.g., those in the SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Compendium*), and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during data usability assessments, if performed. Laboratory QC checks and their typical frequencies are listed in Table 2-4. Acceptance criteria are shown in Table 2-5. Following are descriptions of the various types of laboratory QC samples.

Carrier: a known quantity of nonradioactive isotope that is expected to behave similarly and is added to an aliquot of sample. Sample results are generally corrected based on carrier recovery.

Laboratory control sample (LCS): a control matrix (e.g., reagent water) spiked with analytes representing the target analytes or certified reference material used to evaluate laboratory accuracy.

Laboratory sample duplicate (DUP): an intra-laboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

Matrix spike (MS): an aliquot of a sample spiked with a known concentration of target analyte(s). The MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.

Matrix spike duplicate (MSD): a replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.

Method blank (MB): an analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the sample preparations and analytical procedure and is used to quantify contamination resulting from the analytical process.

Tracer: a known quantity of a radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is generally added to an aliquot of sample prior to the sample preparation step. A tracer does not chemically interfere with the target radioisotope during radiochemical preparation, separation, and counting. Sample results are generally corrected based on tracer recovery.

2.2.4 Measurement Equipment

Each measuring equipment user is responsible to ensure the equipment is functioning as expected, properly handled, and properly calibrated at required frequencies per methods governing control of the equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance will be recorded in accordance with approved methods. Field screening instruments will be used, maintained, and calibrated in accordance with the manufacturer's specifications and other approved methods.

2.2.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or have been evaluated as acceptable and valid in accordance with instrument-specific methods, requirements, and specifications. Software applications will be acceptance tested prior to use in the field.

Measurement and testing equipment used in the field or in the laboratory will be subject to preventive maintenance measures to ensure minimization of downtime. Laboratories must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and onsite organization's QA plan or operating protocols, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with HASQARD (DOE/RL-96-68) requirements.

2.2.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Section 3.5. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

2.2.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with applicable analytical test method (Table 2-3) requirements and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

2.2.8 Nondirect Measurements

Data obtained from sources such as computer databases, programs, literature files, and historical databases will be technically reviewed to the same extent as data generated as part of any sampling and analysis QA/QC effort. Data used in evaluations will be identified by source.

2.2.9 Data Management

The SMR group, in coordination with the 100-HR-3 OU Project Manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements governing data management methods.

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to the SMR group through an established process. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and to establish their resolution with the 100-HR-3 OU Project Manager. The sample issue resolution forms become a permanent part of the analytical data package for future reference and for records management.

2.3 Assessment and Oversight

Assessment and oversight activities address the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

2.3.1 Assessments and Response Actions

Assessments may be performed to verify compliance with the requirements outlined in this SAP and supporting SAP addenda, project field instructions, the QAPjP, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project line management chain coordinates the corrective actions/deficiency resolutions in accordance with the QA program, the corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the 100-HR-3 OU Project Manager (or designee). A data usability assessment will be performed for the identified rebound studies parent SAP and subarea SAP addenda activities. The data usability assessment results will be provided to the 100-HR-3 OU Project Manager. No other planned assessments have been identified. If circumstances arise in the field dictating the need for additional assessments, then additional assessments will be performed.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratories' QA plans. The laboratories are evaluated under the DOE/CAP-AP or its successor programs to the DoD/DOE QSM requirements. HASQARD requirements, beyond those within the DoD/DOE QSM, are also evaluated under the DOE/CAP-AP.

2.3.2 Reports to Management

Program and project management (as appropriate) will be made aware of deficiencies identified by assessments and oversight. Issues reported by the laboratories are communicated to SMR, which then initiates a sample issue resolution form. The process is used to document analytical or sample issues and to establish resolution with the 100-HR-3 OU Project Manager. If an assessment finding results in sampling issues that affect a regulatory requirement, DOE would be informed and the matter discussed with the regulatory agencies.

2.4 Data Review and Usability

This section addresses QA activities that occur after data collection. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

2.4.1 Data Review and Verification

Data review and verification are performed to confirm that sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, and reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times, if any, have been met. Furthermore, review of QC data is used to determine whether analyses have met the data quality requirements specified in the rebound studies parent SAP.

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Field QA/QC results will be reviewed to ensure they are usable.

The 100-HR-3 OU Technical Lead performs data reviews to help determine if observed changes reflect potential data errors, which may result in submitting a request for data review on questionable data. The laboratory may be asked to check calculations or reanalyze the sample. In extreme cases, another sample may be collected. Results of the request for the data review process are used to flag the data appropriately in the HEIS database and/or to add comments.

2.4.2 Data Validation

Data validation is an independent assessment to ensure the reliability of the data. Analytical data validation provides a level of assurance that an analyte is present or absent. Validation may also include:

- Verification of instrument calibrations
- Evaluation of analytical results based on MBs
- Recovery of various internal standards
- Correctness of uncertainty calculations
- Correctness of identification and quantification of analytes
- The effect of quality deficiencies on data reliability

The contractor follows the data validation process described in EPA-540-R-2017-001*, National Functional Guidelines for Inorganic Superfund Methods Data Review*; and EPA-540-R-2017-002, *National Functional Guidelines for Organic Superfund Methods Data Review*, adjusted for use with SW-846, HASQARD (DOE/RL-96-68), and radiochemistry methods. The criteria for data validation are based on a graded approach, using five levels of validation: Levels A through E. Level A is the lowest level and is the same as verification. Level E is a 100% review of all data (e.g., calibration data and calculations of representative samples from the dataset). Data validation may be performed to Level C, which is a review of the QC data. Level C validation consists of a review of the QC data and specifically requires verification of deliverables; requested versus reported analytes; and qualification of the results based on evaluation of analytical holding times, MB results, MS/MSD results, surrogate recoveries, and duplicate sample results. Level C data validation is generally equivalent to Level 2A in EPA 540-R-08-005, *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*. Level C data validation will be performed on at least 5% of the data by matrix and analyte group under the direction of SMR. Analyte group refers to categories such as radionuclides, volatile chemicals, semivolatiles, metals, and anions. The goal is to include each of the various analyte groups and matrices during the data validation process. The DOE-RL Project Lead or 100-HR-3 OU Project Manager may specify a higher percentage of data to be validated or that data validation be performed at higher levels.

2.4.3 Reconciliation with User Requirements

The purpose of reconciliation with user requirements is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. The data quality assessment (DQA) process is the scientific and statistical evaluation of previously verified and validated data to determine if information obtained from environmental data operations are of the right type, quality, and quantity to support their intended use (usability). The DQA process uses the entirety of the collected data to determine usability for decision making. If a statistical sampling design was utilized during field sampling activities, then the DQA will be performed following guidance in EPA/240/B-06/003, *Data*

Quality Assessment Statistical Methods for Practitioners (EPA QA/G-9S). When judgmental (focused) sampling designs are implemented in the field, DQIs such as precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity for the specific datasets (individual data packages) will be evaluated in accordance with EPA/240/R-02/004, *Guidance on Environmental Data Verification and Data Validation* (EPA QA/G-8). Data verification and data validation are integral to both the statistical DQA data evaluation process and the DQI evaluation process. Results of the DQA or DQI processes will be used by the contractor 100-HR-3 OU Project Manager to interpret the data and determine if the DQOs for this activity have been met.

3 Field Sampling Plan

This field sampling plan identifies activities associated with groundwater sampling and analysis for rebound studies performed in the 100-HR-3 OU. This field sampling plan provides the general overview and requirements to support groundwater sampling activities, while the specific wells and sampling frequency will be included in subsequent subarea SAP addenda.

3.1 Sampling Objectives/Design

As discussed in Appendix A, the objectives for collecting groundwater samples during a rebound study in the 100-HR-3 OU are to assess remedial action completion, confirm or identify areas that may require additional action to remediate a secondary source, and/or identify opportunities for P&T optimization. In general, a judgement sampling approach will be used and documented in the subarea SAP addenda.

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. The locations, sample type, and frequencies are partially based on the current locations and expected migration pathways of contaminant plumes. Judgmental sampling is distinguished from probability-based sampling in that inferences are based on professional judgment, not statistical scientific theory.

3.2 Sample Location, Frequency, and Constituents to be Monitored

As previously stated, the purpose of this rebound studies parent SAP is to compile the necessary requirements to implement rebound studies at locations within the 100-D/H Area. Appendix A contains the selection criteria that should be used to evaluate potential sampling locations. The subarea SAP addenda will specify the specific sampling locations, frequency, duration of rebound study, subset of applicable PSQs for the subarea, and constituents to be monitored to meet the data needs summarized in Table 3-1.

Table 3-1. Summary of Principal Study Questions, Measurements, and Applied Frequency

PSQ	Measurement	Filtered or Unfiltered	Frequency
PSQ 1	Cr(VI)	Filtered	Per subarea SAP addenda
PSQ 2	Cr(VI)	Filtered	Per subarea SAP addenda
PSQ 3	Cr(VI)	Filtered	Per subarea SAP addenda
PSQ 4	Water levels	--	Water levels to be measured manually during sampling events, and from the AWLN or existing sensors in P&T extraction and injection wells (frequency per subarea SAP addenda).
PSQ 5	Water levels Major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate) Alkalinity	Metals – filtered and unfiltered Anions – unfiltered Alkalinity – unfiltered	Water levels to be measured manually during sampling events, from the AWLN or existing sensors in P&T extraction and injection wells (frequency per subarea SAP addenda). Groundwater samples will be collected per subarea SAP addenda.

Table 3-1. Summary of Principal Study Questions, Measurements, and Applied Frequency

PSQ	Measurement	Filtered or Unfiltered	Frequency
	Field parameters (i.e., specific conductance, dissolved oxygen, pH)		
PSQ 6	Cr(VI) Water levels Major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate) Alkalinity Field parameters (i.e., specific conductance, dissolved oxygen, pH)	Cr(VI) – filtered Metals – filtered and unfiltered Anions – unfiltered Alkalinity – unfiltered	Groundwater samples will be collected per subarea SAP addenda. Water levels to be measured manually during sampling events, from the AWLN or existing sensors in P&T extraction and injection wells (frequency per subarea SAP addenda).
PSQ 7	Information collected to address previous PSQs Data analysis and evaluation procedures used to demonstrate compliance with groundwater cleanup levels will be defined in a compliance monitoring plan prepared under WAC 173-340-410.	--	Collected as part of previous PSQs.
Informational purposes*	Strontium-90, nitrate, total chromium, total uranium	Strontium-90 – unfiltered Nitrate – unfiltered Metals – filtered and unfiltered	Per subarea SAP addenda

* Analyte will be measured for informational purposes and will not be evaluated as part of the rebound study.

Reference: WAC 173-340-410, “Model Toxics Control Act—Cleanup,” “Compliance Monitoring Requirements.”

AWLN = automated water level network

P&T = pump and treat

PSQ = principal study question

SAP = sampling and analysis plan

As discussed in Appendix A, PSQ 3 identified a need to evaluate the vertical distribution of groundwater contamination in the absence of P&T operations. Wells will be evaluated based on the criteria in Appendix A to determine the number of samples needed to evaluate the vertical distribution of groundwater contamination within the available saturated screen length. The sample depths will be included in the subarea SAP addenda. During the subarea SAP addenda DQO workshops, low-flow and other sampling techniques will be evaluated to determine the most appropriate groundwater sampling technique based upon well-specific conditions. Vertical groundwater samples will be collected in addition to the groundwater samples collected for the purpose of evaluating the other PSQs.

3.3 Sampling Methods

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

- Field screening measurements
- Radiological screening
- Groundwater sampling
- Aquifer tube sampling
- Water level measurements

Groundwater samples will be collected in accordance with the current revision of applicable operating methods. Groundwater samples are collected after field measurements of purged groundwater have stabilized:

- 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 – less than 5 nephelometric turbidity units (NTUs) prior to sampling (or 100-HR-3 OU Technical Lead's recommendation)

Dissolved oxygen will also be measured in the field under this SAP and subarea SAP addenda but is not required to be stable prior to sample collection.

Field measurements (except for turbidity) are obtained using a flow-through cell. Groundwater is pumped directly from the well to the flow-through cell. At the beginning of the sample event, field crews attach a clean, stainless-steel sampling manifold to the riser discharge. The manifold has two valves and two ports: one port is used only for purgewater and the other port is used to supply water to the flow-through cell. Probes are inserted into the flow-through cell to measure pH, temperature, conductivity, and dissolved oxygen. Turbidity is measured by inserting a sample vial into a turbidimeter. The purgewater is then discharged to the purgewater truck.

Once field measurements have stabilized, the hose supplying water to the flow-through cell is disconnected and a clean, stainless-steel drop leg is attached for sampling. The flow rate is reduced during sampling to minimize loss of volatiles (if any) and prevent over filling the bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles (if any). Filtered samples are collected after collection of the unfiltered samples. For some constituents (e.g., metals), both filtered and unfiltered samples are collected to help differentiate particulates from groundwater contamination. If additional samples require filtration (e.g., at turbidity greater than 5 NTUs), an inline, disposable 0.45 µm filter is used.

Typically, three traditional types (i.e., Grundfos®, Hydrostar®, and submersible electrical pumps) of environmental-grade sampling pumps are used for groundwater sampling at Hanford Site monitoring

® Grundfos is a registered trademark of Grundfos Holding A/S Corporation, Bjerringbro, Denmark.

® Hydrostar is a registered trademark of KYB Corporation, Tokyo, Japan.

wells. In addition, low-purge-volume, adjustable-rate bladder pumps may be used. Individual pumps are selected based on the unique characteristics of the well and the sampling requirements.

A small number of wells will not support sample collection via pumping because of low yield or the physical characteristics of the well. In these cases, a grab sample may be obtained. In cases where there is not sufficient yield, purgewater activities are not performed.

Low-purge-volume sampling methodology for the collection of groundwater samples is also being implemented at the Hanford Site. Low-flow purging and sampling uses a low-purge-volume, adjustable-rate bladder pump with flow rates typically on the order of 0.1 to 0.5 L/min (0.26 to 0.13 gal/min). This methodology is intended to minimize excessive movement of water from the soil formation into the well. The objective is to pump in a manner that minimizes stress (drawdown) to the system. Purge volumes for wells using low-purge bladder pumps are determined on a well-specific basis based on drawdown, pumping rate, pump and sample line volume, and volume required to obtain stable field conditions prior to collecting samples.

Collecting groundwater samples vertically throughout the aquifer may also be performed using low-flow sampling or other applicable techniques. Due to uncertainties with vertical flow within completed monitoring wells, depth-discrete samples provide a limited interpretation of the vertical distribution of contamination. To meet PSQ 3, groundwater samples will be collected at specified depths as identified in the subarea SAP addenda.

For certain types of samples, preservatives are required. Preservatives, based on the media type and analytical methods, are added to the collection bottles before their use in the field. Groundwater or surface water samples may require filtering in the field, as noted on the chain-of-custody form.

To ensure sample and data usability, the sampling associated with this SAP and subarea SAP addenda will be performed in accordance with HASQARD (DOE/RL-96-68) requirements for sample collection, collection equipment, sample handling, and sample shipment to the laboratory.

Sample preservation and holding time requirements are specified for groundwater samples in Table 2-6. These requirements are in accordance with the analytical method specified in Table 2-3. The container types, preservatives, and volumes will be identified on the SAF and chain-of-custody form. This SAP defines a “sample” as a set of filled sample bottles for the purpose of beginning holding-time restrictions.

Holding times are the maximum periods allowed between sample collection and lab analysis summarized in Table 2-6. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the constituent and are listed in analytical method compilations such as APHA/AWWA/WEF, 2012, *Standard Methods for the Examination of Water and Wastewater*; and SW-846. Recommended holding times are also provided in HASQARD (DOE/RL-96-68).

3.3.1 Decontamination of Sampling Equipment

Sampling equipment will be decontaminated in accordance with sampling equipment decontamination methods. To prevent potential contamination of the samples, care should be taken to use decontaminated equipment for each specific sampling activity.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

Decontamination of sampling equipment is performed using high-purity water in each step. In general, three rinse cycles are performed to decontaminate sampling equipment: a detergent rinse, an acid rinse, and a water rinse. During the detergent rinse, the equipment is washed in a phosphate-free detergent solution, followed by rinsing with high-purity water in three sequential containers. After the third high-purity water rinse, equipment that is stainless-steel or glass is rinsed in a 1M nitric acid solution (pH less than 2). Equipment is then rinsed with high-purity water in three sequential containers (the high-purity water rinses following the acid rinse are conducted in separate water containers that are not used for detergent rinse). Following the final high-purity water rinse, equipment is rinsed in hexane and then placed on a rack to dry. Dry equipment is loaded into a drying oven. The oven is set at 50°C (122°F) for items that are not metal or glass, or at 100°C (212°F) for metal or glass. Once reaching temperature, equipment is baked for 20 minutes and then cooled. The equipment is then removed from the oven, and the equipment is wrapped in clean, unused aluminum foil using surgeon's gloves. The wrapped equipment is stored in a custody-locked, controlled-access area.

To decontaminate sampling pumps that are not permanently installed, the pump cowling is first removed, washed (if needed) in phosphate-free detergent solution, and then reinstalled on the pump. The pump is then submerged in phosphate-free detergent solution, and 11.4 L (3 gal) of solution is pumped through the unit and disposed. Detergent solution is then circulated through the submerged pump for 5 minutes. The pump is removed from solution and rinsed with high-purity water. The pump is submerged in high-purity water and 30.3 L (8 gal) of high-purity water is pumped through the unit and disposed. The pump is removed from the high-purity water and the intake and housing are covered with plastic sleeving. The cleaning is documented on a tag affixed to the pump, which includes the following information:

- Date pump cleaned
- Pump identification
- Comments
- Signature of person performing decontamination

3.3.2 Radiological Field Data

Alpha and beta/gamma data collection in the field will be used as needed to support sampling and analysis efforts. Radiological screening will be performed by the RCT or other qualified personnel. The RCT will record field measurements, noting the depth of the sample and the elevated instrument reading.

The following information will be provided to field personnel performing work in support of this SAP:

- Instructions to RCTs on the methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate.

- Information regarding the portable radiological field instrumentation including: a physical description of the instruments, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. These instruments are commonly used on the Hanford Site to obtain measurements of removable surface contamination measurements and direct measurements of the total surface contamination.
- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, "Occupational Radiation Protection."
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of radiological information.
- The minimum standards and practices necessary for preparing, performing, and retaining radiological-related information.
- The requirements associated with preparing and transporting regulated material.
- Daily reports of radiological surveys and measurements collected during conduct of field investigation activities. Data will be cross-referenced between laboratory analytical data and radiation measurements to facilitate interpreting the investigation results.

3.3.3 Water Levels

Using a calibrated depth measurement tape, the depth to water is also recorded in each well prior to sampling. When two consecutive measurements are taken that agree within 6 mm (0.24 in.), the final determined measurement is recorded, along with the date and time for the specific event. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of the casing) to obtain the water level elevation. The top of the casing is a known elevation reference point because it has been surveyed to local reference data.

The automated water-level network (AWLN) is an array of remote monitoring stations connected by a telemetry network to a central base station (SGW-53543, *Automated Water Level Network Functional Requirements Document*). Each monitoring station consists of a pressure transducer connected to a data collection telemetry unit. Hourly pressure data from the AWLN are used to calculate water levels, which are used to estimate the level of hydraulic containment achieved by P&T systems, determine hydraulic gradients in areas with variable conditions, and measure changes in the stage of the Columbia River. Applicable AWLN station will be identified in the subarea SAP addenda. Unless otherwise stated in the specific addendum, hourly measurements are sufficient.

3.4 Documentation of Field Activities

Logbooks and data forms are required for field sampling activities and will be used in accordance with HASQARD (DOE/RL-96-68) requirements. A logbook must be identified with a unique project name and number. Only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the FWS, cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

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

A summary of information to be recorded in logbooks or on the data forms is as follows:

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task.
- Purpose of visit to the task area.
- Site activities in specific detail (e.g., maps and drawings) or the forms used to record such information (e.g., soil boring log or well completion log). Also, details of any field tests that were conducted; reference to any forms that were used, other data records, and methods followed in conducting the activity.
- Details of any field calibrations and surveys that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the calibrations and surveys.
- Details of any samples collected and the preparation (if any) of SPLITs, MSD, MSs, or MBs. Reference the methods followed in sample collection or preparation; list location of sample collected, sample type, each label or tag numbers, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and analytical request form number pertinent to each sample or sample set; and note the time and the name of the individual to whom custody of samples was transferred.
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed. Reference the page number(s) of any logbook where detailed information is recorded.
- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

3.4.1 Corrective Actions and Deviations for Sampling Activities

The 100-HR-3 OU Project Manager, FWS, appropriate field crew supervisors, and SMR personnel must document deviations from protocols, issues pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected due to field conditions.

As appropriate, such deviations or issues will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The 100-HR-3 OU Project Manager, FWS, field crew supervisors, or SMR personnel will be responsible for communicating field corrective action requirements and for ensuring corrective actions are applied to field activities as soon as practical.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Table 2-2.

3.5 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Calibration records shall include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst's name or initials. The results from all instrument calibration activities are recorded in accordance with HASQARD (DOE/RL-96-68) requirements.

Field instrumentation calibration and QA checks will be performed as follows:

- Prior to initial use of a field analytical measurement system.
- At the frequency recommended by the manufacturer or methods, or as required by regulations.
- Upon failure to meet specified QC criteria.
- Calibration of radiological field instruments on the Hanford Site is performed by the Hanford Mission Integrated Solutions prime contractor, as specified by their calibration program.
- Daily calibration checks will be performed and documented for each instrument used. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.
- Using standards for calibration that are traceable to a nationally recognized standard agency source or measurement system. Manufacturer's recommendations for storage and handling of standards (if any) will be followed. Expired standards will not be used for calibration.

3.6 Sample Handling

Sample handling and transfer will be in accordance with established methods to preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape will be used to verify that sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date. If during the chain-of-custody process it is discovered that the custody tape has been tampered with or broken on the sample bottle, the sample will be analyzed but the results will include an "A" data qualifier flag to indicate that custody was broken. If the custody tape has been tampered with or broken on the cooler, the sample custodian shall note this on the sample receiving documentation.

A sampling and analytical database is used to track samples from the point of collection through the laboratory analysis process.

3.6.1 Containers

Samples shall be collected, where and when appropriate, in break-resistant containers. The field sample collection record shall indicate the lot number of the bottles used in sample collection. When commercially precleaned containers are used in the field, lot identification shall be retained for documentation.

Containers shall be capped and stored in an environment that minimizes the possibility of sample container contamination. If contamination of the stored sample containers occurs, corrective actions shall be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified on the chain-of-custody form.

If required, the Radiological Control organization will measure both the contamination levels and dose rates associated with the filled sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's radioactivity acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the FWS (in consultation with the SMR organization), can send smaller sample volumes to the laboratory.

3.6.2 Container Labeling

Each sample is identified by affixing a standardized label or tag to the container. This label or tag shall contain the sample identification number. The label shall identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis required, and collector's name or initials. Sample labels may be either preprinted or handwritten in indelible or waterproof ink.

3.6.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure that sample integrity is maintained throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each sample or set of samples shipped to any laboratory.

Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility for the custody of the sample changes, new and previous custodians will sign the record and note the date and time. The field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group.

The following minimum information is required on a completed chain-of-custody form:

- Project name
- Collectors' names
- Unique sample number
- Date, time, and location (or traceable reference thereto) of sample collection
- Matrix
- Preservatives
- Chain-of-possession information (i.e., signatures and printed names of each individual involved in the transfer of sample custody and storage locations, and dates/times of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Number of sample containers per unique sample identification number
- Shipped-to information (i.e., analytical laboratory performing the analysis)

Samplers should note any anomalies with the samples. If anomalies are found, samplers should inform the SMR group so special direction for analysis can be provided to the laboratory if deemed necessary.

3.6.4 Sample Transportation

Packaging and transportation instructions shall comply with applicable transportation regulations and DOE requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, "Transportation," "General Information, Regulations, and Definitions," through 177, "Carriage by Public Highway."[2] Carrier-specific requirements defined in the current edition of International Air Transportation Association (IATA) *Dangerous Goods Regulations* (IATA, 2013) shall also be used when preparing sample shipments conveyed by airfreight providers.

Samples containing hazardous constituents above regulated amounts shall be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be packaged, marked, labeled, and shipped according to the specific instructions for that material. Appropriate laboratory notifications will be made, if necessary, through the SMR project coordinator.

Materials are classified by DOT/IATA as radioactive when the isotope specific activity concentration and the exempt consignment limits described in 49 CFR 173, "Shippers—General Requirements for Shipments and Packagings," are exceeded. Samples shall be screened, or relevant historical data will be used, to determine if these values are exceeded. When screening or historical data indicate samples are radioactive, they shall be properly classified, described, packaged, marked, labeled, and transported according to DOT/IATA requirements.

Prior to shipping radioactive samples to the laboratory, the organization responsible for shipping shall notify the laboratory of the approximate number of and radiological levels of the samples. The laboratory is responsible for ensuring that the applicable license limits are not exceeded. Prior to sample receipt, the laboratory shall provide SMR with written acceptance for samples with elevated radioactive contamination or dose.

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[2] Transportation regulations 49 CFR 174, "Carriage by Rail," and 49 CFR 176, "Carriage by Vessel," are not applicable, as these two transportation methods are not used.

4 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with the 100-D/H RD/RAWP (DOE/RL-2017-13). For waste designation purposes, wells identified in subsequent subarea SAP addenda may be surveyed in HEIS, and the maximum concentration for each analyte within the most recent 5 years will be evaluated for use in creating a waste profile, if required.

Miscellaneous solid waste that has contacted suspect dangerous waste will be managed as dangerous waste. Purgewater and decontamination fluids will be collected and managed in accordance with Section 6.3 in the 100-D/H RD/RAWP (DOE/RL-2017-13). A nonsignificant change for the 100-D/H ROD was approved and authorizes purgewater disposal at the Modular Storage Units (DOE et al., 2021, "Non-Significant Change for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-HR-3 Operable Units Record of Decision, Hanford Site, July 2018, Memo to File Regarding: Clarification of the Modular Storage Units as On-Site for the Purpose of Purgewater Management for Final Remedial Actions"). Packaging and labeling during waste storage and transportation will meet the applicable substantive federal and/or state requirements. Waste materials requiring collection will be placed in containers appropriate for the material and the receiving facility in accordance with the applicable waste management or waste control plan and applicable substantive federal and/or state requirements.

Offsite analytical laboratories are responsible for the disposal of unused sample quantities and wastes from analytical processes.

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5 Health and Safety

DOE established the hazardous waste operations safety and health program pursuant to the *Price-Anderson Amendments Act of 1988* to ensure the safety and health of workers involved in mixed-waste site activities. The program was developed to comply with the requirements of 10 CFR 851, “Worker Safety and Health Program,” which incorporates the standards of 29 CFR 1910.120, “Occupational Safety and Health Standards,” “Hazardous Waste Operations and Emergency Response”; 10 CFR 830, “Nuclear Safety Management”; and 10 CFR 835. The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for daily work activities on the overall Hanford Site. Personnel training; control of industrial safety and radiological hazards; personal protective equipment; site control and general emergency response to spills, fire, accidents, injury, and site visitors; and incident reporting are governed by the health and safety program. Hanford Site-specific health and safety plans will be used to supplement the general health and safety program.

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6 References

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10 CFR 851, "Worker Safety and Health Program," *Code of Federal Regulations*. Available at: https://www.govinfo.gov/content/pkg/CFR-2019-title10-vol4/pdf/CFR-2019-title10-vol4-part851.pdf.

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Appendix A

Data Quality Objectives Process for the Rebound Studies Parent Sampling and Analysis Plan

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Contents

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Terms

DQO	data quality objective
MTCA	"Model Toxics Control Act—Cleanup"
OU	operable unit
P&T	pump and treat
PSQ	principal study question
RAO	remedial action objective
RD/RAWP	remedial design/remedial action work plan
ROD	record of decision
RUM	Ringold Formation upper mud unit
SAP	sampling and analysis plan
UCL	upper confidence limit
UCL-95	95% upper confidence limit

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A1 Introduction

These 100-HR-3 Groundwater Operable Unit (OU) data quality objectives (DQOs) were developed to support groundwater monitoring associated with the implementation of rebound studies within the OU. The intention is to perform rebound studies in discrete areas of the 100-HR-3 OU where trend analysis of hexavalent chromium (Cr[VI]) concentrations are favorable for post pump and treat (P&T) evaluations or in areas with a suspected secondary source of Cr(VI) contamination. These rebound studies will help to determine the progress of active remediation, evaluate any impact the periodically rewetted zone may have on contaminant concentrations, and determine if active remediation should end or if P&T optimization is needed. Some rebound of the concentration is anticipated and observed rebound will be compared to cleanup levels to evaluate if active remediation should recommence. The rebound studies will also help to identify areas in which continuing sources potentially impact groundwater and risk timely conclusion of active P&T remediation.

The monitoring is focused on gathering data to assess the remedial action identified in EPA et al., 2018, *Record of Decision Hanford 100 Area Superfund Site 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units, Hanford Site* (hereinafter referred to as the 100-D/H Record of Decision [ROD]), to determine if the remedial action objectives (RAOs) will be met in the timeline identified in the 100-D/H ROD. The RAOs for the 100-HR-3 OU are as follows:

- **RAO #1**: Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO #2**: Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO #7**: Restore groundwater in the 100-HR-3 OU to cleanup levels, which include drinking water standards, within a timeframe that is reasonable given the particular circumstances of the site.

In response to Cr(VI) contamination, groundwater remediation activities were initiated in 1997 with installation of a P&T system, HR3, under an interim action ROD (EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Interim Remedial Actions, Hanford Site Benton County, Washington*) and in accordance DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*. A second P&T system, DR5, was installed in 2004. In 2010 and 2011, the two original systems were replaced with the larger DX and HX P&T systems. The two P&T systems treat contaminated groundwater with an ion-exchange resin. The P&T systems have been expanded since inception and have been effective in reducing Cr(VI) concentrations in groundwater and improving hydraulic containment to protect the Columbia River from continuing releases of Cr(VI). The potential for continuing contributions of Cr(VI) to groundwater from secondary sources can negatively affect remedy completion timeframes.

The selected final remedy in the 100-D/H ROD (EPA et al., 2018) authorized continued use of the DX and HX P&T systems for groundwater treatment. The 100-D/H ROD established a cleanup level of 10 µg/L for Cr(VI) where groundwater discharges to surface water and 48 µg/L inland (Table 6 in the 100-D/H ROD). The cleanup levels for total chromium are 65 µg/L where groundwater discharges to surface water and 100 µg/L inland. Other groundwater contaminants were identified as nitrate and strontium-90, with a selected final remedy of monitored natural attenuation for both. With the issuance of the 100-D/H ROD, a new remedial design/remedial action work plan (RD/RAWP) was prepared.

The new RD/RAWP (DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*) was developed to ensure that the P&T systems are operated with the goal of meeting the RAOs described in the 100-D/H ROD.

Data collected under this sampling and analysis plan (SAP) will guide optimization of the P&T system and potentially support implementation of additional remedial actions for waste sites that continue to feed groundwater contamination above cleanup standards. The purpose of the rebound studies parent SAP is to provide a framework for identifying rebound study data needs across the 100-HR-3 OU, while allowing flexibility to perform subarea-specific rebound tests. Information collected under the subsequent subarea SAP addenda will support decisions needed to determine if and when (all or part of) the P&T operations should be turned off. Subarea P&T rebound studies and/or cyclic P&T operations (optimization/enhancement) may be applied based on plume responses. This rebound studies parent SAP will also act as the main body of information with subsequent subarea SAP addenda to identify wells, sampling frequency, and other information needed to address subarea-specific objectives and answer the principal study questions (PSQs) developed in Chapter A2.

The DQO process was conducted to support identification of sampling requirements. This document follows the DQO guidance identified in EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4). The following steps are used for DQO development:

1. State the problem.
2. Identify the goal of the study.
3. Identify information inputs.
4. Define the boundaries of the study.
5. Develop the analytical approach.
6. Specify performance or acceptance criteria.
7. Develop the detailed plan for obtaining data.

The complete Systematic Planning Record for the rebound studies parent SAP is included in Exhibit A1.

A2 Evaluation of the Data Needs

Evaluation of data needs involves review and compilation of information from sampling and analysis activities and computational modeling. The updated understanding of contaminant levels and plume extent is provided in the annual groundwater monitoring reports (e.g., DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*; DOE/RL-2019-67, *Calendar Year 2019 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations, and 100-NR-2 Groundwater Remediation*).

Representatives from the U.S. Department of Energy, the primary groundwater contractor, and the Washington State Department of Ecology participated in a facilitated workshop to support the DQO process. During this workshop, which was held on December 3, 2020, the participants discussed the types of data required to assess progress toward the attainment of groundwater RAOs. Exhibit A2 includes the meeting notes, the workshop agenda, and a copy of the presentation discussed during the workshop (SGW-65691-VA, *Data Quality Objectives for the 100-HR-3 Rebound Study Sampling and Analysis Plan*). The meeting notes include a list of individuals who represent the planning team members for this DQO. SGW-65691-VA contains the agreed to DQO elements which are incorporated into this DQO.

Problem Statement: Information are needed to determine whether active remediation can be discontinued or modified to enhance Cr(VI) recovery within specific areas of 100-HR-3 OU. If rebound data indicate active remediation can be discontinued, determine if the data can be used to support transition to compliance monitoring.

Groundwater data are needed to support the following evaluations:

- Changes in the Cr(VI) plume during rebound
- Changes in unconfined aquifer conditions (hydraulically and chemically) during rebound
- If Cr(VI) concentration levels have met or are on track to meet cleanup goals and timeline identified in the ROD
- If rebound data can be used to supplement compliance monitoring

The goal of this study is addressed through PSQs identified for the problem statement. Data needs identified for each PSQ identify the information inputs necessary to address each PSQ. The PSQs and data needs for each PSQ, as well as the measurement or observations needed and data uses are captured in Table A-1. The alternative outcomes, which will determine actions to be completed based on the information collected, are also included in Table A-1.

The purpose of PSQ 1 is to determine how the Cr(VI) plume changes (i.e., concentrations and spatial extent) when P&T system is turned off. Information of interest include the following:

- The degree of increase or decrease of concentrations during the period of rebound
- The spatial extent of the plume, in particular, locations where concentrations increase
- Migration patterns of Cr(VI) plumes
- Candidate locations of continuing sources that may need additional remediation
- Natural attenuation of plume concentrations as related to groundwater flow conditions during the period of rebound

The purpose of PSQ 2 is to assess whether remediation is approaching achievement of the RAOs. It is necessary to determine if an area has achieved the RAOs under active remediation, and in the future, after remediation is completed. Above all, information obtained under PSQ 2 will help determine whether compliance monitoring may be appropriate. In particular, the data will be used for fate and transport modeling (prediction of natural attenuation) and statistical evaluations of concentration levels. It is important to understand trends over time and quantification of natural attenuation to show Cr(VI) concentrations remain at/below cleanup levels. It is also important to determine if additional remediation is needed in areas with continuing sources or if there is any indication of Cr(VI) plume breakthrough to the shoreline that could impact the Columbia River. Decision Rules 2A and 2B, identified in Table A-1, do not lead to a recommendation for compliance monitoring if there are unknowns such as the movement of groundwater and contamination over time. The decision rules state that if the outcome of the rebound study is favorable, then evaluate transition to compliance monitoring. An outcome of the evaluation could be that the site is not ready for compliance monitoring even though the cleanup levels (e.g., 48 µg/L inland or 10 µg/L at the river) have been achieved. There should be an understanding of how the groundwater is expected to move under ambient conditions because the cleanup standard of 10 µg/L must be achieved and maintained at the river interface. An understanding of how far inland must achieve 48 µg/L to maintain 10 µg/L at the river interface will be evaluated as part of these decision rules in addition to information and data collected under the other PSQs.

Future fate and transport modeling will be used to gain an understanding of how far inland must achieve 48 µg/L to maintain 10 µg/L at the river interface.

PSQ 3 is targeted to help characterize the vertical distribution of Cr(VI) in the alluvial system to support identification of potential source locations and may not be applicable to all subareas. In particular, PSQ 3 helps determine if contaminant transport/pathways will change in the absence of P&T operations. Sampling and analysis is more appropriate to subareas with persistently high Cr(VI) concentrations and thicker saturated thicknesses. Monitoring wells with long screened intervals facilitate depth discrete sampling (e.g., low-flow sampling or other applicable methods).

PSQ 4 addresses groundwater flow conditions of the aquifer. The principal quantities to be estimated are the magnitude and direction of horizontal hydraulic gradient in the unconfined aquifer groundwater under ambient conditions. There is uncertainty in how changes in unconfined aquifer hydraulics and their effect on Cr(VI) concentrations observed in wells when pumping at extraction and injection wells is terminated within a subarea. Data are needed to determine if the groundwater monitoring network is still adequate to address any impacts to change in groundwater flow directions. Data needs are to include water levels for flow and transport models. This may require additional automated water level network stations.

The purpose of PSQ 5 is to estimate reestablished inland groundwater hydrochemistry and determine if conditions have returned to ambient conditions following shutdown of P&T operations. The data will be used to determine if groundwater parameters, as compared to other wells in the subarea, indicate an unexpected hydraulic or hydrochemical condition in the absence of P&T operations. If concentrations of major ions or other hydrochemical data during assessment of rebound conditions are correlated via trend analysis to an increase in Cr(VI) concentration, then groundwater hydrochemistry will be examined to determine whether additional continuing sources are present. Primary interest is focused upon the geochemistry of the system as related to the mobility of the individual chromium species in the contaminant plume within the saturated system and the periodically rewetted zone.

PSQ 6 involves primarily Cr(IV) concentrations with the remediation system shut down and is inherently related to PSQ 1. The principal quantity to be estimated is the concentration of Cr(VI) contamination in the unconfined aquifer and along the Columbia River. Data will be used to determine the seasonal fluctuations of Cr(VI) contamination under rebound conditions at various river stages. Temporal trends, natural attenuation, and dilution effects from the river will be evaluated and used to update the conceptual site model.

The purpose of PSQ 7 is to determine if the data collected under the rebound studies parent SAP and subarea SAP addenda could support the transition to compliance monitoring (if appropriate). Information from aquifer tubes could not be used for this purpose but groundwater samples from monitoring, extraction and injection wells could be used. If data collected meet anticipated minimum data quality and frequency requirements and Cr(VI) concentration data help to support transition to compliance monitoring, then data may be used in part to supplement the compliance monitoring dataset, else data will not be used to support compliance monitoring. The decision of if and when a subarea can transition to compliance monitoring will not be made under this SAP.

Since total chromium, strontium-90, and nitrate are identified as groundwater contaminants in the 100-D/H ROD (EPA et al., 2018), concentration data for total chromium, strontium-90, and nitrate will be collected for informational purposes. Groundwater samples for total uranium analysis will also be collected for select wells due to an increasing concentration trend noted during recent sampling events. Concentration data for total chromium, strontium-90, nitrate, and total uranium will not be evaluated as part of the rebound study.

Table A-1. Compilation of Data Needs and Alternative Outcomes

Principal Study Question		Data Need	Measurements or Observations and Data Use	Sample/Measurement Type and Frequency	Decision Rules
PSQ 1	What is the magnitude and spatial extent of Cr(VI) concentration rebound in the absence of P&T?	Increased frequency of Cr(VI) concentration measurements in groundwater in the absence of P&T operations.	Measurements taken from existing unconfined aquifer wells and aquifer tubes within a to-be specified subarea(s) in the 100-HR-3 OU. Data will be used to determine magnitude and extent of Cr(VI) concentrations and spatial changes during a period of rebound to assess continuation of active remediation.	Analysis of representative groundwater samples on filtered aliquots at locations to be determined in subarea SAP addenda. The recommended sampling frequency is every other month. The final frequency will be agreed upon during the subarea SAP addenda DQO workshops.	If the magnitude or spatial extent of the Cr(VI)concentration plume increases in the absence of P&T, then assess impact of observed rebound and evaluate the need for restarting the P&T system, update groundwater models and reevaluate the monitoring network, else evaluate whether active remediation can be discontinued within the subarea.
PSQ 2	In the absence of P&T operations, are Cr(VI) concentrations below OR anticipated to meet the 100-D/H ROD inland cleanup level of 48 µg/L and surface water cleanup level of 10 µg/L and expected to remain below cleanup levels?	Increased frequency of Cr(VI) concentration measurements in groundwater in the absence of P&T operations.	Measurements taken from existing unconfined aquifer wells and aquifer tubes within a to-be specified subarea(s) in the 100-HR-3 OU to determine if Cr(VI) concentration will remain below the applicable cleanup levels.	Analysis of representative groundwater samples on filtered aliquots at locations to be determined in subarea SAP addenda. The recommended sampling frequency is every other month. The final frequency will be agreed upon during the subarea SAP addenda DQO workshops.	(1) If Cr(VI) concentrations in groundwater remains below applicable cleanup levels of 48 µg/L inland or 10 µg/L at the river, then evaluate transition from P&T operations to compliance monitoring, else evaluate the need for restarting the P&T system. (2) If rebound of Cr(VI) concentrations in groundwater exceed the applicable cleanup levels of 48 µg/L inland or 10 µg/L at the river, then evaluate the need for restarting the P&T system or consider P&T optimization, else evaluate whether active remediation can be discontinued within the subarea. (3) If rebound of Cr(VI) concentrations in groundwater above applicable cleanup levels is observed coming from known or suspected sources in the vicinity of historical releases, and may indicate the need for additional remedial actions, then evaluate continuing the P&T system or consider P&T optimization, else evaluate the need for alternate remediation strategy.
PSQ 3	In areas where the source of Cr(VI) contamination is known or suspected, what is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations.	Increased frequency of Cr(VI) concentration measurements in groundwater collected at discrete intervals vertically through the saturated screen interval in the absence of P&T operations.	Depth discrete measurements taken from existing unconfined aquifer wells within a to-be specified subarea(s) in the 100-HR-3 OU. Data will be used to assess the vertical distribution of Cr(VI) contamination and determine adequacy of existing monitoring wells and sampling scheme. The data may also be used to modify the P&T infrastructure to enhance groundwater extraction to increase remediation efficiency.	Analysis of representative groundwater samples on filtered aliquots, collected vertically through available well screens and aquifer thickness at locations to be determined in subarea SAP addenda. For wells located at or immediately downgradient of known or suspected secondary sources, vertical sampling is recommended every other month. For other wells, vertical sampling is recommended to occur during seasonal high and seasonal low river stage. The final frequency will be agreed upon during the subarea SAP addenda DQO workshops.	If the concentrations of Cr(VI) exhibit a stratification within the saturated zone of the screened interval, then utilize vertical distribution data to support source investigation studies, consider P&T optimization, *else* utilize vertical distribution data solely to update groundwater models.
PSQ 4	How is the aquifer within the rebound study areas affected hydraulically following shutdown of P&T?	Manual water level measurements collected during sampling, automated water level measurements from established AWLN wells, water level measurements from existing sensors in P&T extraction and injection wells.	Manual water level measurements taken during sampling, automated water level measurements from established AWLN wells. Additional AWLN stations may need to be installed. Data will be used to determine the change in magnitude, gradient, and flow direction of groundwater in the absence of P&T operations. The data will also be used to evaluate adequacy of monitoring both upgradient and downgradient of any remaining Cr(VI) plume following active P&T remediation.	Water level measurements will be taken from locations to be determined in subarea SAP addenda over a relatively short time frame during groundwater sampling activities. AWLN measurements collected hourly from existing stations. If needed, additional wells may be added to the network. Locations to be added to the AWLN will be identified in subarea SAP addenda.	If the hydraulic gradient observed in the absence of P&T operations establishes an unexpected direction or unexpected apparent velocity, then assess the need to modify P&T and groundwater monitoring network and frequency of water level measurements, *else* continue monitoring under ambient conditions.

Table A-1. Compilation of Data Needs and Alternative Outcomes

Principal Study Question		Data Need	Measurements or Observations and Data Use	Sample/Measurement Type and Frequency	Decision Rules
PSQ 5	Has groundwater hydrochemistry reverted to ambient conditions?	Increased frequency of measurements of major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance and other field parameters in groundwater in the absence of P&T operations. Manual water level measurements collected during sampling, automated water level measurements from established AWLN wells, water level measurements from existing sensors in P&T extraction and injection wells.	Measurements taken from existing unconfined aquifer wells and aquifer tubes within a to-be specified subarea(s) in the 100-HR-3 OU to determine if the groundwater has return to ambient conditions and flow directions following active P&T remediation. Data will be used to perform comparative trend analysis of general groundwater chemistry.	Analysis of representative groundwater samples on unfiltered aliquots of major anions, cations, alkalinity, specific conductance, and other field parameters, at locations to be determined in subarea SAP addenda. Samples collected for metals analysis will also be performed on filtered aliquots. The recommended sampling frequency is every other month for a minimum 6 months. The final frequency will be agreed upon during the subarea SAP addenda DQO workshops. Water level measurements taken during sampling events as well as automatically from the AWLN and existing sensors in P&T extraction and injection wells. Automatic measurements should be taken, at a minimum, hourly.	(1) If groundwater parameters, as compared to other wells in the subarea, indicate an unexpected hydraulic or hydrochemical condition in the absence of P&T operations, then assess the need to modify P&T and groundwater monitoring network and frequency of water level measurements, *else* continue monitoring under ambient conditions. (2) If concentrations of major ions or other hydrochemical data during assessment of rebound conditions are correlated via trend analysis to an increase in Cr(VI) concentration, then examine groundwater hydrochemistry to determine whether additional continuing sources are present, *else* hydrochemical data will be collected solely for assessing aquifer and rebound conditions.
PSQ 6	What are the seasonal effects in groundwater Cr(VI) concentrations within the rebound study area due to river stage?	Increased frequency of Cr(VI) concentration measurements in groundwater, in the absence of P&T operations, during high, low, and intermediate river stages. Increased sampling frequency of major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance and other field parameters in groundwater in the absence of P&T operations, during high, low, and intermediate river stages. Measured water levels in the unconfined aquifer, in the absence of P&T operations, during high, low, and intermediate river stages.	Cr(VI) concentration measurements taken under PSQ 2. Water level measurements taken under PSQ 4. Hydrochemical measurements taken under PSQ 5.	Analysis of representative groundwater samples on filtered or unfiltered aliquots, collected at locations to be determined in subarea SAP addenda for a full river stage cycle (e.g., 12 months). The recommended sample frequency is every other month. The final frequency will be agreed upon during the subarea SAP addenda DQO workshops. Water level measurements taken during sampling events as well as automatically from the AWLN and existing sensors in P&T extraction and injection wells. Automatic measurements should be taken, at a minimum, hourly.	If Cr(VI) concentrations rebound seasonally to greater than cleanup levels, then assess magnitude of the observed rebound and evaluate restarting or optimizing and restarting P&T operations to address seasonal increases in Cr(VI) contamination, *else* evaluate transitioning to compliance monitoring.
PSQ 7	Can the project use the data to supplement compliance monitoring?	Cr(VI) concentrations in the unconfined aquifer wells and comparison to data needs required for compliance.	Information collected to address previous PSQs. Data analysis and evaluation procedures used to demonstrate compliance with groundwater cleanup levels will be defined in a compliance monitoring plan prepared under WAC 173-340-410.	Data for Cr(VI) collected as part of previous PSQs. Analysis of representative groundwater samples on filtered aliquots at locations to be determined in subarea SAP addenda. The recommended sampling frequency is every other month. The final frequency will be agreed upon during the subarea SAP addenda DQO workshops.	If data collected meet anticipated minimum data quality and frequency requirements and Cr(VI) concentration data help to support transition to compliance monitoring, then data may be used, in part, to supplement the compliance monitoring dataset, *else* data will not be used to support compliance monitoring.

Reference: WAC 173-340-410, "Model Toxics Control Act—Cleanup," "Compliance Monitoring Requirements."

AWLN = automatic water-level network
DQO = data quality objective
OU = operable unit
P&T = pump and treat
PSQ = principal study question
ROD = record of decision
SAP = sampling and analysis plan

A3 Defining the Boundaries of the Study

The DQO process identifies the target population(s) of interest and the spatial and temporal features pertinent for decision making. Specific spatial and temporal boundaries are identified for groundwater monitoring at the 100-HR-3 OU and were discussed during the DQO workshop meeting. However, the specific areas in which future rebound studies will be performed will be defined in subarea SAP addenda.

A3.1 Spatial Boundaries of the Study

The monitoring program physical boundaries constrain the data collection in three dimensions. The areal extent includes those areas affected by the 100-HR-3 OU P&T systems, as shown in Figure A-1. The overall boundary of the study area is constrained by the areal and vertical extent of groundwater contamination associated with the 100-HR-3 OU. The data needs for the rebound studies parent SAP were developed for the unconfined aquifer, which is constrained by the Ringold Formation upper mud unit (RUM), and groundwater within the hyporheic zone at the groundwater discharge boundary with the Columbia River. Study area(s) may evaluate the extent of contamination within the RUM aquifer. Additional PSQs specifically for characterizing the RUM aquifer will be included in subarea-specific addenda.

Groundwater from the 100-HR-3 OU discharges to the Columbia River through the hyporheic zone. The interface of the groundwater and surface water represents a boundary of the study area based on regulatory levels for groundwater discharge to surface water.

A3.2 Temporal Boundaries of the Study

Temporal boundaries are related to timing, frequency, and duration of measurements and observations. Timing is driven by river stage seasonal variation and the associated changes in groundwater flow direction and flow velocity. Frequency is the number of times per year a sample is collected from a monitoring location.

The Columbia River functions as a discharge boundary for the shallow unconfined aquifer beneath the 100-HR-3 OU. During periods of low river stage, groundwater in the unconfined aquifer flows toward the river and discharges into the river along the shore. During periods of rising level and high river stage, the magnitude of the groundwater gradient is reduced, and in portions of the shallow aquifer near the river, gradient may actually reverse and river water may enter the aquifer. As the river stage remains elevated, groundwater from inland continues to flow toward the river and backs up against the boundary head provided by the elevated river stage; groundwater elevation inland of the river shore rises accordingly. As the river stage declines after the freshet, groundwater again flows toward the river, typically under greater-than-average gradient. Because of the hydraulic lag that occurs between high river stage and maximum groundwater elevation inland, high river stage does not directly coincide with high groundwater elevation. Data generally indicate that the river stage begins to climb in April, while May through July have historically remained above the annual mean river stage. Periods of high and low river stage change from year to year. However, the period of high river stage is generally from April through August, and low river stage is generally observed from September through December.

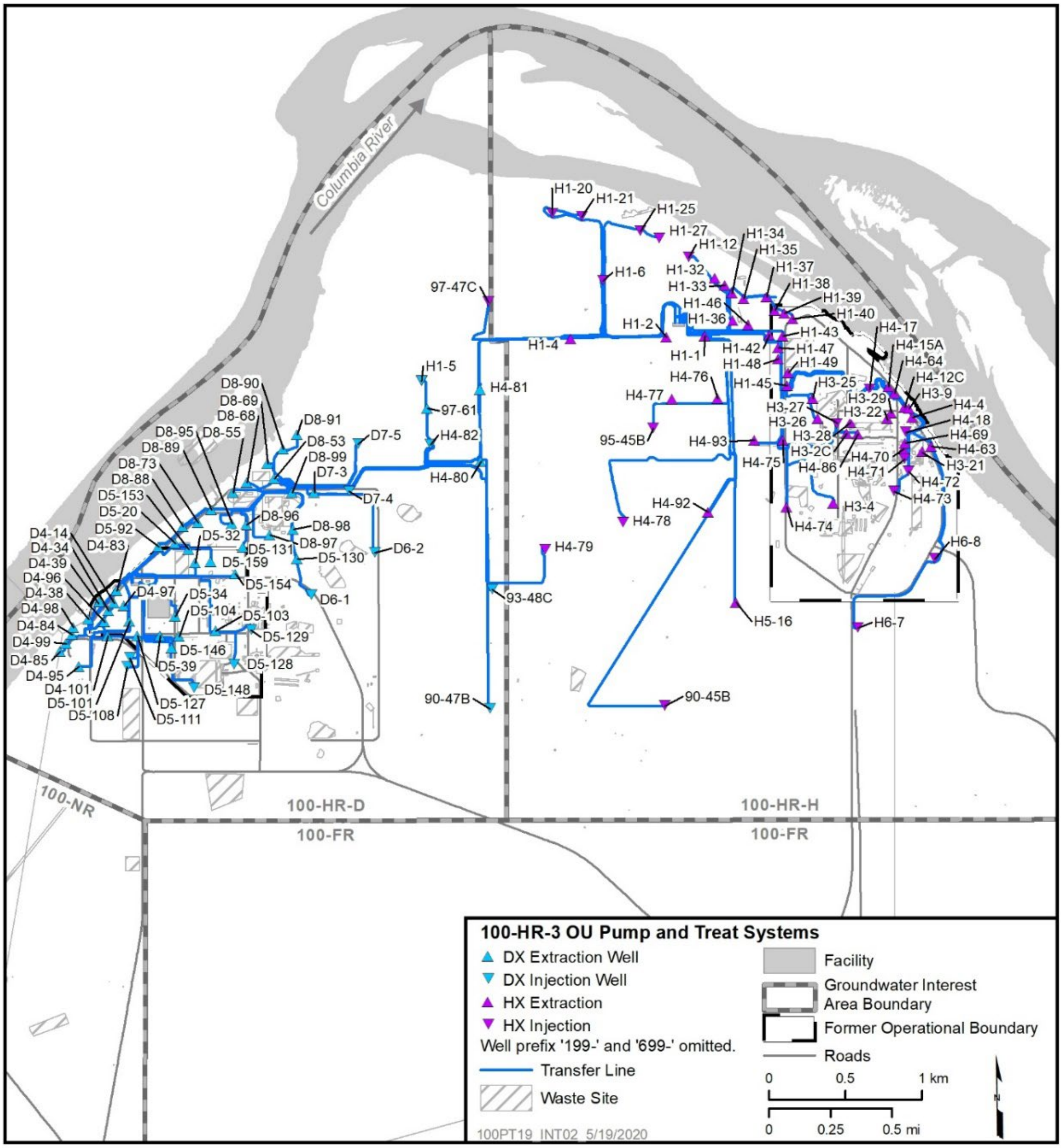

Figure A-1. 100-HR-3 Groundwater Operable Unit Pump and Treat System

Response of the Cr(VI) plume in the unconfined aquifer at 100-HR-3 OU to the change in river stage has been tracked and is reported as part of the Hanford Site annual groundwater report (e.g., DOE/RL-2019-66). The dimensions and changes in plume geometry in the unconfined aquifer with changes in river stage are well understood under pumping conditions. The plume boundaries are generally further inland from the river during high river stage in comparison to low river stage. The greatest flux of contaminants to the river occurs as the river transitions from seasonal high to seasonal low.

The subarea SAP addenda will document the specific timeframe for the rebound studies. Each rebound study is projected to last a full river stage cycle (i.e., 12 months) to ensure adequate understanding of contaminant migration effects during high and low river stage as well as during seasonal transition periods, however, this duration may vary to be longer or shorter depending on the specific study objectives and subarea-specific needs. Recommended sampling frequency is based on a judgmental sampling design. The recommended sampling frequency is identified in Table A-1 but may be modified in the subarea SAP addenda, if necessary.

A3.3 Resource Limitations and Constraints

A number of known and potential constraints may interfere with implementation of the groundwater rebound studies. The following constraints are identified at this time:

- Limitations due to DOE baseline budget priorities and available funding.
- Extent of testing to be conducted at new and existing wells, which is limited by funding, priorities, and identified needs at a point in time.
- Project and field operation personnel availability.
- Groundwater sampling of current P&T wells assumes that all downhole equipment from operating extraction and injection wells has been removed.
  - An evaluation will be performed to determine if sampling can be performed with P&T equipment installed.
- Rebound studies may impact yearly treatment goals for gallons treated and mass removed. This needs to be discussed and documented with the DOE as part of the yearly remedial process optimization.
- The vertical flow within completed monitoring wells remains uncertain. The vertical samples collected under this rebound studies parent SAP provide a limited interpretation of the vertical distribution of contamination. Further hydraulic testing could be performed on wells that indicated full thickness contamination to confirm the results.
- Further remedial actions (i.e., waste site excavation) near wells that may result in removal of a well included in the monitoring plan.
- Aquifer tubes may be damaged or otherwise inaccessible during desired sampling timeline.
- Unforeseen circumstances such as extended site closures.

A4 Specification of Performance or Acceptance Criteria

This step in the evaluation is intended to specify performance criteria expressed as probability limits on potential errors in decision making. The probability limits specify the level of confidence desired for conclusions drawn from site data.

Primary decisions for monitoring DQOs involve the adequacy of spatial and temporal coverage of the monitoring network. In general, the spatial coverage will be defined in the subarea SAP addenda, but will include monitoring wells that adequately describe a given rebound area with consideration to the contaminant distribution (i.e., upgradient, downgradient, and bounding) and hydraulic flow in the absence of P&T operations.

Analytical data and field measurements can only estimate the true condition of the site under investigation, and decisions that are made based on measurement data could potentially be in error (i.e., decision error).

Based on the PSQs established in Table A-1, Tables 2-3 and 2-5 in the main text of this document, include the applicable method, practical quantitation limits, and acceptable analytical performance ranges to ensure data collected are of sufficient quality for their intended purpose.

A4.1 Statistical Versus Nonstatistical Sampling Design

Resolving the PSQs is dependent on evaluating different datasets, including historical and current analytical data and field measurements. These data will be used for scientific calculations and statistical analyses. The limits on analytical data are specified within the analytical method quality assurance/quality control criteria, as identified in Chapter 2 of the main document.

Traditional statistical sampling designs were not identified for the groundwater monitoring for PSQs. OSWER Directive 9283.1-44, *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*, identifies nonstatistical or visual review that may be appropriate when groundwater data are all nondetected, or data are a combination of nondetected, and all detected contaminant of concern concentrations are less than the cleanup level. For groundwater data that are not appropriate for nonstatistical review, a mean test or trend test, using the upper confidence limit (UCL) for comparison to the cleanup level, is recommended. Data may be expressed and reported as individual measurements for each analyte as a 95% UCL (UCL-95), using the well monitoring dataset. Using UCL-95 to determine whether an area can be declared clean is suggested in both the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* and WAC 173-340, "Model Toxics Control Act—Cleanup" (MTCA) guidance. A comparison to the action level may be performed using UCL-95 for each analyte. The UCL-95 calculation will be completed using the recommended methodologies found in U.S. Environmental Protection Agency guidance (EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance* and WAC 173-340-720(9)(d)(i), "Groundwater Cleanup Standards").

The data collected will be used to optimize the remedial action and evaluate RAOs. Consequences of inadequate sampling design may impact the period to achieve cleanup or the ability to achieve RAOs. All monitoring locations are accessible for resampling, though the time of collection will differ and may introduce variability in the dataset.

A5 Development of the Detailed Plan for Obtaining Data

A resource effective design will be developed for the collection of data to address the identified problems. Monitoring locations and frequencies will be selected to address subarea-specific data needs within each rebound SAP addendum. The following sections provide the methodology to select groundwater monitoring locations and sampling frequencies that adequately meet the data needs associated with the PSQs.

A5.1 Identification of Available Monitoring Locations

When subarea within the 100-HR-3 OU has been identified for a rebound study, all available monitoring locations (e.g., extraction, injection, and monitoring wells, and aquifer tubes) should be identified and reviewed. Figure A-2 shows the 100-HR-3 OU well network at the end of fiscal year 2020, as well as the groundwater plumes from the 2019 Hanford Annual Groundwater Report (DOE/RL-2019-66).

A5.2 Evaluation of Available Locations Against the Data Needs

Each existing and potential location will be evaluated against the data needs for each PSQ to identify locations that potentially fulfill the data need. The available monitoring locations that can be used to fulfill each PSQ will be plotted on maps and provided in specific subarea SAP addenda.

The following rationale should be used for identifying potential locations:

- Location – understanding of contaminant plumes (both current and historic) and proximity to known or suspect sources
- Screened interval for monitoring wells
- Historical sample results – contaminant detections at existing monitoring locations

Well locations and construction information will be extracted from the Environmental Dashboard Application at https://ehs.hanford.gov/eda. This provides physical information for the monitoring locations (e.g., relative position of screened intervals). Historical measurements and observations recorded in the Hanford Environmental Information System will also be used to identify historical sample results, including detection of contaminants of interest, contaminant concentration time series, and water level measurements.

A5.3 Monitoring Location Retained/Excluded

Each available monitoring location should be systematically evaluated to determine the suitability in fulfilling the data needs identified in Table A-1. This evaluation will include criteria for retaining and excluding specific monitoring locations. The following criteria should be considered in the evaluation (criteria for retention included locations that meet the following requirements):

- Defined contaminant groundwater plumes
- Proximity to known or suspected continuing sources of Cr(VI) contamination (SGW-64372, *100-D/H Continuing Hexavalent Chromium Source Evaluation*)
- Recent and historic temporal trends
- Historic vertical distribution of contaminants within the unconfined aquifer
- Apparent migration pathway of defined contaminant plumes
- Recent and historic hydraulic head conditions
- Monitor performance and aquifer impact of ongoing operation of remedial action systems (e.g., P&T extraction wells and specifically identified performance monitoring wells)

Criteria for exclusion included locations that meet the following requirements:

- Redundant (i.e., are located within approximately 10 m [30 ft] of another monitoring location) and does not provide supplemental or definitive input to a data need
- Does not provide useful bounding condition measurements (i.e., not located in a downgradient area where the plume may be migrating)

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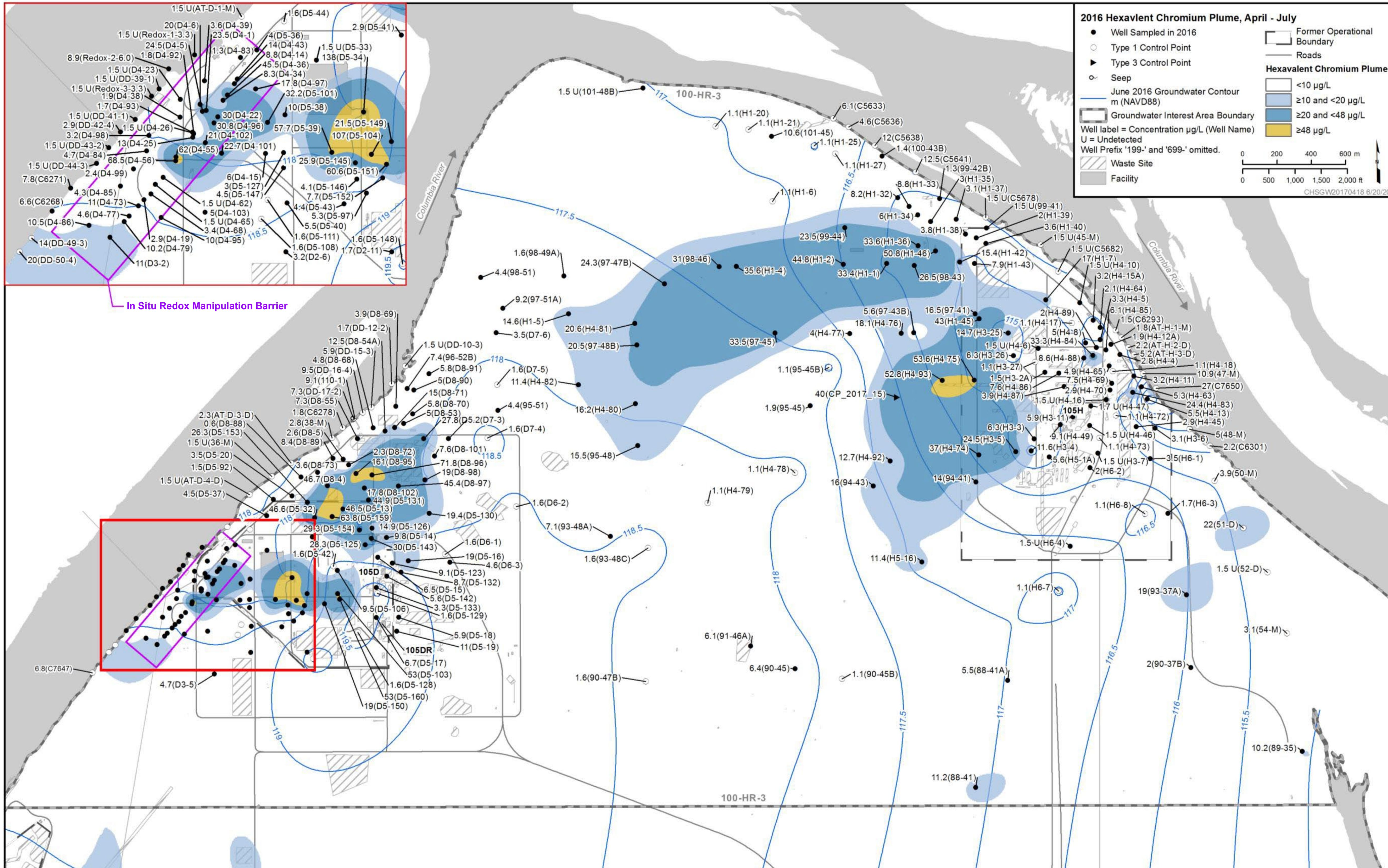

Figure A-2. 100-HR-3 Well Network and Cr(VI) Plumes (High River Stage 2016)

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The result of this evaluation will be sampling locations that meet the identified data needs for each PSQ in Table A-1.

As part of the sampling activities associated with this rebound studies parent SAP and addenda, groundwater samples will be collected from wells to determine the vertical distribution of groundwater contamination in the absence of P&T operations. Wells should be evaluated based on the following:

- Proximity to known or suspected continuing sources of contamination
- Screen design
- Saturated thickness
- Stratigraphy
- Previously collected vertical groundwater characterization samples and/or soil samples collected during drilling

A5.4 Data Collection Frequency

Groundwater samples will be collected on a schedule based on the relative proximity of monitoring locations to the apparent secondary source areas, with the monitoring locations within the source areas being sampled most frequently (e.g., monthly) and locations more distant from the source areas sampled less frequently (e.g., bi-monthly, quarterly). Groundwater elevation will be measured manually during each groundwater sampling event; existing automated water level network stations will remain in service and will record hourly groundwater elevation measurements. Each rebound study is anticipated to last a minimum of 12 months to fully evaluate seasonal river stage effects on a given area. A rebound study may be shortened if Cr(VI) concentration increase to a concentration greater than 48 µg/L at an extraction well in proximity of the river.

If a site-specific rebound study concludes that additional active treatment is required, then groundwater sampling will revert to the 100-HR-3 OU groundwater monitoring identified in DOE/RL-2017-13-ADD1, *Groundwater Monitoring Sampling and Analysis Plan for the 100-HR-3 Groundwater Operable Unit*. If a site-specific rebound study concludes that the area has met cleanup levels, the groundwater monitoring will transition to either an approved compliance monitoring SAP or back to DOE/RL-2017-13-ADD1 with an optimized P&T well network until a compliance monitoring SAP is approved.

A6 Final Sample Design

The final sampling design will be included in the subarea SAP addenda and will include wells identified to meet each PSQ and the recommended frequency for data collection for each data type identified for those locations. Table A-2 summarizes PSQs, measurements to be collected, and the identified frequency that will be applied based on the identified PSQs.

Table A-2. Summary of Principal Study Questions, Measurements, and Applied Frequency

PSQ	Measurement	Filtered or Unfiltered	Frequency
PSQ 1	Cr(VI)	Filtered	Per subarea SAP addenda
PSQ 2	Cr(VI)	Filtered	Per subarea SAP addenda
PSQ 3	Cr(VI)	Filtered	Per subarea SAP addenda

Table A-2. Summary of Principal Study Questions, Measurements, and Applied Frequency

PSQ	Measurement	Filtered or Unfiltered	Frequency
PSQ 4	Water Levels	--	To be collected during sampling events AWLN
PSQ 5	Water Levels Major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate) Alkalinity Field parameters (i.e., specific conductance, dissolved oxygen, pH)	Metals – filtered and unfiltered Anions – unfiltered Alkalinity – unfiltered	Water levels to be measured during sampling events and from the AWLN or existing sensors in P&T extraction and injection wells Groundwater samples will be collected per subarea SAP addenda.
PSQ 6	Cr(VI) Water Levels Major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate) Alkalinity Field parameters (i.e., specific conductance, dissolved oxygen, pH)	Cr(VI) filtered Metals – filtered and unfiltered Anions – unfiltered Alkalinity – unfiltered	Groundwater samples will be collected per subarea SAP addenda. Water levels to be measured during sampling events and from the AWLN or existing sensors in P&T extraction and injection wells
PSQ 7	Information collected to address previous PSQs	--	Collected as part of previous PSQs and per subarea SAP addenda
Informational purposes*	Strontium-90, nitrate, total chromium, total uranium	Strontium-90 – unfiltered Nitrate – unfiltered Metals – filtered and unfiltered	Per subarea SAP addenda

* Analyte will be measured for informational purposes and will not be evaluated as part of the rebound study.

AWLN = automatic water-level network

PSQ = principal study question

SAP = sampling and analysis plan

A7 References

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Exhibit A1

Systematic Planning Record for the Rebound Studies Parent Sampling and Analysis Plan

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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:	Date:
Name of Person Completing Record:	Position:
Name of Responsible Manager:	

Project Background:

The purpose of the "Parent" Rebound Study sampling and analysis plan (SAP) is to capture analytical requirements for groundwater samples and water level measurements collected at monitoring locations in 100-HR-3 operable unit (OU) for the purpose of rebound studies. This form will be incorporated within Addendum 3 to DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (RD/RAWP). Information collected under this "Parent" Rebound Study SAP and subarea-specific addenda, will support decisions needed to determine if and when (all or part of) the P&T operations should be suspended and enter a cold-standby phase in which P&T could be restarted, if needed, after the rebound study and evaluations have concluded. The rebound studies may also focus on continuing sources identified in *100-D/H Continuing Hexavalent Chromium Source Evaluation* (SGW-64372).

Project location and operational history are discussed in the RD/RAWP (DOE/RL-2017-13).

Planning Type:

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

Systematic planning in support of groundwater Rebound Studies in the 100-HR-3 OU.

Organization, Schedule, and Goal

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

State the Problem

Information is needed to determine whether active remediation can be discontinued or modified to enhance Cr(VI) recovery within specific areas of 100-HR-3 OU. If rebound data indicate active remediation can be discontinued, determine if the data can be used to support transition to compliance monitoring.

- Determine if and how Cr(VI) concentrations change during a period of rebound.
- Determine how the unconfined aquifer changes (hydraulically and chemically) during a period of rebound.
- Determine if Cr(VI) concentrations have met or are on track to meet cleanup goals and timeline identified in the ROD (DOE et al., 2018, *Record of Decision Hanford 100 Area Superfund Site 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units, Hanford Site*).
- Determine if rebound data can be used, in part, to supplement compliance monitoring data needs.

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.				
Principal Study Questions *(What questions are data needed to answer?)*	**PSQ 1**	What is the magnitude and spatial extent of Cr(VI) concentration rebound in the absence of P&T?	**PSQ 5**	Has groundwater hydrochemistry reverted to ambient conditions?
	PSQ 2	In the absence of P&T operations, are Cr(VI) concentrations below OR anticipated to meet the ROD inland cleanup level of 48 µg/L and surface water cleanup level of 10 µg/L and expected to remain below cleanup levels?	**PSQ 6**	What are the seasonal effects in groundwater Cr(VI) concentrations and the rebound study area due to river stage?
	PSQ 3	In areas where the source of Cr(VI) contamination is known or suspected, what is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations?	**PSQ 7**	Can the project use the data to supplement compliance monitoring?
	PSQ 4	How is the aquifer within the rebound study areas affected hydraulically following shutdown of P&T?	**-**	-
Define alternative outcomes or actions that can occur upon answering PSQs.	**AA 1A**	Update groundwater models and reevaluate the monitoring network.	**AA 4A**	Assess the need to modify P&T and groundwater monitoring network and frequency of water level measurements
	AA 1B	Assess impact of observed rebound	**AA 4B**	Continue monitoring under ambient conditions
	AA 1C	Evaluate the need for restarting the P&T system	**AA 5A**	Continue monitoring under ambient conditions
	AA 1D	Evaluate whether active remediation can be discontinued within the subarea.	**AA 5B**	Assess need to modify P&T and groundwater monitoring network and frequency of water level measurements

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.

	AA 2A	Evaluate transition from P&T operations to compliance monitoring	**AA 5C**	Examine groundwater hydrochemistry to determine whether additional continuing sources are present
	AA 2B	Evaluate the need for restarting the P&T system	**AA 5D**	Hydrochemical data will be collected solely for assessing aquifer and rebound conditions
	AA 2C	Evaluate whether active remediation can be discontinued within the subarea	**AA 6A**	Evaluate restarting or optimizing and restarting P&T operations to address seasonal increases in Cr(VI) contamination
	AA 2D	Consider P&T optimization	**AA 6B**	Assess magnitude of the observed rebound
	AA 2E	Evaluate the need for alternate remediation strategy	**AA 6C**	Evaluate transition from P&T operations to compliance monitoring
	AA 3A	Utilize vertical distribution data to support source investigation studies		
	AA 3B	Consider P&T optimization		
	AA 3C	Update groundwater models		
Identify the decision statements or estimation statements needed to address the PSQs.	**DS 1**	Determine if the magnitude and spatial extent of the Cr(VI) plume increases during the rebound study.		
	DS 2A	Determine whether rebound of Cr(VI) concentrations in groundwater will remain below applicable cleanup levels of 48 µg/L inland or 10 µg/L at the river.		
	DS 2B	Determine whether rebound of Cr(VI) concentrations in groundwater are exceeding the applicable cleanup levels of 48 µg/L inland or 10 µg/L at the river is observed.		
	DS 2C	Determine if rebound of Cr(VI) concentrations in groundwater above applicable cleanup levels is observed coming from known or suspected sources in the vicinity of historical releases, and may indicate the need for additional remedial actions.		

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.

	DS 3	Determine if Cr(VI) concentrations exhibit a stratification within the saturated zone of the screened interval.
	DS 4	Determine if the hydraulic gradient observed in the absence of P&T operations established in an unexpected direction or unexpected apparent velocity.
	DS 5A	Determine if groundwater parameters, as compared to other wells in the subarea, indicate an unexpected hydraulic or hydrochemical condition in the absence of P&T operations.
	DS 5B	Determine if concentrations of major ions or other hydrochemical data during assessment of rebound conditions are correlated via trend analysis to an increase in Cr(VI) concentration.
	DS 6	Determine if Cr(VI) concentrations rebound seasonally to greater than cleanup levels.
	DS 7	Determine whether data collected meet anticipated minimum data quality and frequency requirements to be defined in the Compliance Monitoring SAP.

Data Needs

(Define the spatial and temporal boundaries of the study)

Define what constitutes a sampling unit:

Samples collected from an individual well as described in separate addenda to the "Parent" Rebound Study SAP.

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

One groundwater sample.

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

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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
PSQ 1	Cr(VI) concentrations in groundwater in the absence of P&T operations	Ground-water	Wells and aquifer tubes within subareas of interest.	To be determined in subarea SAP addenda.	Cr(VI) concentrations greater than 48 µg/L inland.	To be determined in subarea SAP addenda.	Well access. Inaccessible/damages aquifer tubes.	7196	Site-Specific Sampling
PSQ 2	Cr(VI) concentrations in groundwater in the absence of P&T operations	Ground-water	Wells and aquifer tubes within subareas of interest.	To be determined in subarea SAP addenda.	Cr(VI) concentrations greater than 48 µg/L inland or 10 µg/L at the river.	To be determined in subarea SAP addenda.	Well access. Inaccessible/damages aquifer tubes.	7196	Site-Specific Sampling
PSQ 3	Cr(VI) concentrations in groundwater collected vertically through the saturated screen interval in the absence of P&T operations	Ground-water	Wells within subareas of interest.	To be determined in subarea SAP addenda.	Cr(VI) concentrations greater than 48 µg/L inland.	To be determined in subarea SAP addenda.	Well access	7196	Site-Specific Sampling
PSQ 4	Manual water level, continuous water level measurements from existing sensors and AWLN measurements collected in the absence of P&T operations	Ground-water	Wells within subareas of interest.	Submersible pressure sensors installed in wells as part of the AWLN.	N/A	Determined in subarea SAP addenda.	Existing wells may need to have sensors installed and added to the AWLN.	N/A	Site-Specific Measurements

Appendix A – Systematic Planning Record

Characterization Data Collection Planning Record

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PSQ 5	Concentrations of major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance and other field parameters in groundwater in the absence of P&T operations. Manual water level measurements collected during sampling, continuous water level measurements from existing sensors and automated water level measurements from AWLN wells.	Ground-water	Wells and aquifer tubes within subareas of interest.	To be determined in subarea SAP addenda.	Ion concentrations greater than laboratory practical quantitation limits (PQL).	To be determined in subarea SAP addenda.	Well access. Inaccessible/ damages aquifer tubes.	IC 9056 and 300, 6010,6020,7196, 2320, Field instruments used during sampling	Site-Specific Sampling

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 6	Cr(VI) concentrations in groundwater, in the absence of P&T operations, during high, low, and intermediate river stages. Increased frequency of major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance and other field parameters in groundwater in the absence of P&T operations. Measured water levels in the unconfined aquifer, in the absence of P&T operations, during high and low river stages.	Ground-water	Wells and aquifer tubes within subareas of interest.	Groundwater sampling methods to be determined in subarea SAP addenda. Submersible pressure sensors installed in wells as part of the AWLN.	Cr(VI) concentrations greater than 48 µg/L inland or 10 µg/L at the river. Action Level not applicable to groundwater level measurements.	To be determined in subarea SAP addenda.	Well access. Inaccessible/damages aquifer tubes.	7196, IC 9056 and 300, 6010,6020,7196, 2320, Field instruments used during sampling	Site-Specific Measurements and Sampling

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 7	Cr(VI) concentrations in groundwater in the absence of P&T operations and comparison to data needs required for compliance.	Ground-water	Wells within subareas of interest	To be determined in subarea SAP addenda	N/A	To be determined in subarea SAP addenda.	Same as previous PSQs.	7196	Results and information generated as a result of the subarea SAP addenda.

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:

Decisions may be made on an individual result for Cr(VI) or other hydrochemical indicator or field parameter datum.

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.

Decision Problem	Provide a decision rule related to the Action Level identified above that includes a clear "if…then…else" statement: **(DR 1)** If the magnitude or spatial extent of the Cr(VI)concentration plume increases in the absence of P&T, then assess impact of observed rebound and evaluate the need for restarting the P&T system, update groundwater models and reevaluate the monitoring network, else evaluate whether active remediation can be discontinued within the subarea. **(DR 2A)** If Cr(VI) concentrations in groundwater remains below applicable cleanup levels of 48 µg/L inland or 10 µg/L at the river, then evaluate transition from P&T operations to compliance monitoring, *else* evaluate the need for restarting the P&T system. **(DR 2B)** If rebound of Cr(VI) concentrations in groundwater exceed the applicable cleanup levels of 48 µg/L inland or 10 µg/L at the river, then evaluate the need for restarting the P&T system or consider P&T optimization, *else* evaluate whether active remediation can be discontinued within the subarea. **(DR 2C)** If rebound of Cr(VI) concentrations in groundwater above applicable cleanup levels is observed coming from known or suspected sources in the vicinity of historical releases, and may indicate the need for additional remedial actions, then evaluate continuing the P&T system or consider P&T optimization, *else* evaluate the need for alternate remediation strategy. **(DR 3)** If the concentrations of Cr(VI) exhibit a stratification within the saturated zone of the screened interval, then utilize vertical distribution data to support source investigation studies, consider P&T optimization, else utilize vertical distribution data solely to update groundwater models. **(DR 4)** If the hydraulic gradient observed in the absence of P&T operations establishes an unexpected direction or unexpected apparent velocity, then assess the need to modify P&T and groundwater monitoring network and frequency of water level measurements, else continue monitoring under ambient conditions. **(DR 5A)** If groundwater parameters, as compared to other wells in the subarea, indicate an unexpected hydraulic or hydrochemical condition in the absence of P&T operations, then assess the need to modify P&T and groundwater monitoring network and frequency of water level measurements, else continue monitoring under ambient conditions.

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.*	
	(DR 5B) If concentrations of major ions or other hydrochemical data during assessment of rebound conditions are correlated via trend analysis to an increase in Cr(VI) concentration, then examine groundwater hydrochemistry to determine whether additional continuing sources are present, else hydrochemical data will be collected solely for assessing aquifer and rebound conditions. **(DR 6)** If Cr(VI) concentrations rebound seasonally to greater than cleanup levels, then assess magnitude of the observed rebound and evaluate restarting or optimizing and restarting P&T operations to address seasonal increases in Cr(VI) contamination, else evaluate transitioning to compliance monitoring. **(DR 7)** If data collected meet anticipated minimum data quality and frequency requirements and Cr(VI) concentration data help to support transition to compliance monitoring, then data may be used, in part, to supplement the compliance monitoring dataset, *else* data will not be used to support compliance monitoring. Note: Decision rules may be modified during subarea DQO workshops with regulators based on project-specific objectives identified for subarea DQOs to addresses site-specific PSQs.
	What are the consequences of making an incorrect decision and what is the tolerance for an incorrect decision? 1) Moving into compliance when concentrations cannot be expected to remain below cleanup levels, thereby wasting months or years when P&T system could have been operating, 2) failing to recognize a stratified level of high concentrations and being able to optimize best for the conditions, 3) for DR7: money wasted on duplicative sampling in the same wells because some sampling requirements for compliance were ignored and otherwise usable sample results from the end of the rebound study could be used in compliance.
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: N/A, as this sampling effort does not involve an estimation problem.
	What are the acceptable limits on uncertainty? N/A, as this sampling effort does not involve an estimation problem.
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 main "Parent" Rebound Study SAP DQO process included in this form will be incorporated as Addendum 3 to DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units.* Generally, additional Cr(VI) and hydrochemical indicator data as well as water level measurements will be obtained, possibly at an increased frequency, at monitoring locations within these OUs. The detailed plan for obtaining data will be addressed in separate subarea "Parent" Rebound Study SAP addenda to be included as part of DOE/RL-2017-13. Each subarea specific SAP addendum will go through a separate DQO process based upon the data needs identified during formal workshops with U.S. Department of Ecology and the EPA.	

Exhibit A2

Data Quality Objective Workshop Meeting Notes, Agenda, and Presentation

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Meeting Notes

100-HR-3 Rebound Studies Sampling and Analysis Plan Data Quality Objectives Workshop

Meeting Date: December 3, 2020

Background

On December 3, 2020, the individuals identified in Table 1 met to discuss the overall approach for creating a sampling and analysis plan (SAP) for rebound studies in the 100-HR-3 Operable unit (OU) (hereinafter referred to as the "Parent" Rebound Study SAP), with study-area specific details being provided in "Parent" Rebound Study SAP addenda. Handout 1 provides the agenda and Handout 2 includes the PowerPoint slides presented during the 100-HR-3 Rebound Studies Sampling and Analysis Plan Data Quality Objectives (DQO) Workshop.

The meeting objectives included:

- Agreeing on the overall approach of creating a "Parent" Rebound Study SAP with study-area specific addenda
- Agreeing on general principal study questions (PSQs), data needs and uses, and a monitoring approach applicable to all areas of the 100-HR-3 OU.

The following is intended to capture the general nature of discussions that took place and to document agreements made during the DQO workshop. The DQO elements were discussed in detail and information in some of the PowerPoint slides were revised as an outcome of the workshop. Any text changes made to the original PowerPoint slides are discussed in these meeting notes. The final PowerPoint presentation is included in Handout 2.

Table 1. List of Attendees

First	Last	Representing
Alaa	Aly	Intera
Steve	Balone	DOE-RL
Alicia	Boyd	Ecology
Garrett	Day	Ecology
Joe	Devary	Freestone
Marty	Doornbos	Intera
Bob	Evans	CHPRC
Scot	Fitzgerald	CHPRC
Zack	McGuire	Freestone
Travis	Hammond	CHPRC
Jason	Hulstrom	CHPRC
Kris	Ivarson	CHPRC
Brian	Johnson	Ecology
Rob	Mackley	PNNL
Heather	Medley	CHPRC
Darrell	Newcomer	CHPRC
Greg	Ruskauff	Intera
John	Sands	DOE-RL
Kim	Schuyler	Freestone
Sean	Sexton	CHPRC
Noe'l	Smith-Jackson	Ecology

Table 1. List of Attendees

First	Last	Representing
Alex	Spiliotopoulos	SSPA
Sarah	Springer	CHPRC
John	Virgin	DOE-RL

CHPRC = CH2M HILL Plateau Remediation Company
DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
PNNL = Pacific Northwest National Laboratory
SSPA = S.S. Papadopulos & Associates, Inc.

Introduction to the Workshop

Bob Evans welcomed all to the meeting and introductions were made. He identified that the plan is to develop a "parent" or primary SAP for rebound studies to be performed in the 100-HR-3 OU. He stated that the intention is to perform rebound studies in discrete areas of the 100-HR-3 OU where trend analysis of hexavalent chromium (Cr[VI]) concentrations are favorable for post-pump and treat (P&T) evaluations. He explained that rebound studies will help to determine the progress of active remediation, and determine if active remediation should end and go into compliance monitoring or if P&T optimization is needed. He stated that the plan is to initiate the first rebound study during the fall of 2021.

The working session was then turned over to Travis Hammond (Technical Lead and Project Scientist) who walked through the workshop agenda (Handout 1), meeting objectives, background information for the 100-HR-3 OU. He stressed that this workshop will not define or discuss the sub-areas proposed for rebound studies. Each sub-area will have its own DQO workshop in which the rebound study and sample design (e.g., rebound study duration, sample locations and frequency) will be discussed in detail. He also stated that data needs discussed during this workshop are focused on the unconfined aquifer. Principal study questions for the confined to semiconfined aquifer within the Ringold Formation upper mud unit (hereinafter referred to as the RUM aquifer) will be identified in "Parent" Rebound Study SAP addenda, as needed.

Background Information in 100-HR-3 OU

Travis Hammond introduced the 100-HR-3 OU and identified key features such as the location of the DX and HX P&T systems and the 100-D/H source operable units. He stated that the study boundary for the "Parent" Rebound Study SAP includes any area within the 100-HR-3 OU boundary.

Travis Hammond states Cr(VI) and total chromium were identified as a groundwater contaminants of concern in the 100-HR-3 OU (EPA et al., 2018, *Record of Decision Hanford 100 Area Superfund Site 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*, Hanford Site, Benton County, Washington, (hereinafter referred to as the record of decision [ROD]). The ROD selected P&T as the final remedy for Cr(VI) and total chromium.

Relevant documents that were reviewed in preparation for this workshop include:

- The ROD;
- DOE/RL-2017-13, 2020, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units;*
- DOE/RL-2010-95, 2014, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units; and*
- SGW-64372, 2020, *100-D/H Continuing Hexavalent Chromium Source Evaluation.*

Travis Hammond provided a brief history of the 100-HR-3 OU remedial action and displayed Cr(VI) plume maps comparing concentrations from 1999 and 2019. He explained that the P&T remedial action has been successful and Cr(VI) concentrations are low enough that an evaluation of remedy completion through rebound studies is appropriate. Information collected during the sub-area rebound studies will support decisions needed to determine if and when (all or part of) the P&T operations should be turned off. Sub-area P&T rebound studies and/or cyclic P&T operations (optimization/enhancement) may be applied based on plume responses.

Rebound Study DQOs

Travis Hammond stated that the next step is to plan and perform rebound studies at different sub-areas in 100-HR-3 OU to evaluate the aquifer condition and Cr(VI) concentrations in the absence of the P&T system. The information discussed and agreed upon will be incorporated into a "Parent" Rebound Study SAP. Area-specific data needs will be incorporated into separate addenda within the "Parent" Rebound Study SAP. Travis Hammond said this approach is similar to the 100-KR-4 OU "Parent" Rebound Study SAP. The rebound studies may also focus on continuing sources identified in *100-D/H Continuing Hexavalent Chromium Source Evaluation* document (SGW-64372).

Travis Hammond stated that to support future groundwater sampling activities, agreement needs to be made on the types of groundwater data necessary to evaluate the following:

- Aquifer rebound
- Cr(VI) rebound
- P&T optimization
- Identify areas that require additional action to remediate

Statement of the Problem

Travis Hammond identified that there are three lines of inquiry to the Statement of the Problem:

- Determine if and how Cr(VI) concentrations change during a period of rebound;
- Determine how the unconfined aquifer changes (hydraulically and chemically) during a period of rebound; and
- Determine if Cr(VI) concentration levels have met or are on track to meet cleanup goals and timeline identified in the ROD.

PSQs, Data needs, Monitoring Approach

The working session was then turned over to Kim Schuyler (Primary Author of the "Parent" Rebound Study SAP) who presented the PSQs, general data needs and uses, and monitoring approach. She explained that these PSQs are for the "Parent" Rebound Study SAP and will be used to guide development of the rebound study design (e.g., rebound study duration, sample locations and frequency) for each sub-area addendum. Kim Schuyler explained that these initial PSQs were developed to facilitate discussion. The PSQs are written to be broadly applicable to the entire 100-HR-3 OU unconfined aquifer. This workshop is a solicitation of input on the proposed DQO elements to ensure the approach is appropriate and will provide adequate data to assess progress toward the attainment of the 100-HR-3 OU groundwater remedial action objectives. Kim Schuyler identified that five main PSQs were developed with two sub-PSQs for PSQ4. Handout 2 identifies additional details on the data needs, data uses and monitoring approach for each specific PSQs.

<u>PSQ1: What is the magnitude and spatial extent of Cr(VI) concentration rebound in the absence of P&T?</u>

Kim Schuyler explained that this is a relative straightforward PSQ: How do Cr(VI) concentrations change when P&T system is turned off? Information of interest include:

- Do concentrations increase (rebound)?
- If so, how much do they increase?
- Where are concentrations increasing?
- Do the Cr(VI) plumes migrate?
- Are there areas of continuing source that may need additional remediation?
- How does attenuation change?

Darrell Newcomer asked if trend analysis would be performed after a period of rebound, before the P&T in a sub-area is turned off, or both. Kim Schuyler responded trend analysis and evaluations will occur before and during the period of rebound.

Noe'l Smith-Jackson asked if total chromium will be included for analysis. Kim Schuyler said "no" because the ROD states that since the cleanup level for Cr(VI) is more protective than the cleanup level for total chromium, treatment of Cr(VI) groundwater contamination will result in attaining cleanup levels for total chromium. Noe'l Smith-Jackson noted that groundwater samples should be unfiltered for total chromium, however samples for Cr(VI) should be filtered per Interagency Management Integration Team (IAMIT) agreement number 2019-002.

Garrett Day asked if there would need to be some monitoring of the RUM aquifer as rebound continues in a sub-area. Travis Hammond said that is something to consider as we initiate the rebound test planning. Garrett Day stated it may be worth taking additional samples before and after in the RUM aquifer when rebound is occurring in adjacent (overlying) areas. Travis Hammond said we will also need to look at how active P&T operations in the RUM aquifer could impact rebound study.

Rob Mackley asked if extraction wells and injection wells would be considered for groundwater sample collection. Kim Schuyler said "yes", groundwater samples could be collected from extraction wells, injection wells and aquifer tubes in addition to monitoring wells.

Alaa Aly asked if there was any thought of looking at other indicators like specific conductance, pH. Kim Schuyler responded "yes", that information is covered in PSQ5 which we have not yet discussed.

There were no requested changes to any of the information on PSQ1.

PSQ2: In the absence of P&T operations, are Cr(VI) concentrations below OR anticipated to meet the ROD inland cleanup level of 48 µg/L and surface water cleanup level of 10 µg/L and expected to remain below cleanup levels?

Kim Schuyler explained that the purpose of this PSQ is to assess how close an area is to achieving the remedial action objectives. She elaborated that PSQ2 may be more modeling and evaluation-intensive, and include forward modeling, attenuation estimation, 3D modeling, and statistical evaluation. Alex Spiliotopoulos explained how understanding of trends over time, breakthrough areas, and attenuation may show Cr(VI) concentrations remain at/below cleanup levels. Kim Schuyler stated that we want to determine if an area has achieved the RAOs under P&T conditions, will it remain that way. It is also important to determine if additional remediation is needed in areas with continuing sources or if there is any indication of Cr(VI) breakthrough area that could impact the Columbia River.

Jason Hulstrom asked if vertical contaminant distribution is a part of this PSQ or a different PSQ? Kim responded that PSQ3 will address vertical distribution of Cr(VI).

Garrett Day stated that you would have to shut down the P&T system to get the appropriate information needed to run a model for this assessment. It is essential to capture what is happening in a dynamic system. Alex Spiliotopoulos says it is very important that we have a better understanding of the dynamics of the system to inform the model. This is essential information to have in the areas near the river, it is a very dynamic system.

A small change was requested to one of the bullets under the data needs and data uses list. The change will be described in a subsequent PSQ discussion. There were no requested changes to any other information on PSQ2.

PSQ3: In areas where the source of Cr(VI) contamination is known or suspected, what is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations?

Kim Schuyler explained that this is a targeted PSQ for more dynamic systems and may not be applicable to all sub-areas. The purpose of this PSQ is to determine if contaminant transport/pathways will change in the absence of P&T operations. Kim Schuyler said that this PSQ would be important in areas with a persistent high concentration Cr(VI) plume and a thicker aquifer. Information such as screened intervals could be used when designing the sampling design. This may impact sampling frequency. Additional sampling techniques like low-flow may be incorporated and will need to incorporate well design.

Alicia Boyd said that she thought it was a very good idea to use the well designs to guide the sampling approach. She asked if samples will only be collected in the top 3 to 5 ft of aquifer as stated in Slide 16. Kim Schuyler acknowledged that is an error and the presentation (Handout 2) will be revised to state "Groundwater sample collection methods appropriate to address specific objectives in each area-specific Rebound Study SAP Addenda."

Noe'l Smith-Jackson asked if there is any history of well casing corrosion. Travis Hammond said there isn't an issue with well corrosion in 100-HR-3. He wasn't sure about the other areas along the river corridor. He thought that was a greater issue with caustic materials on the Central Plateau.

Steve Balone asked Jason Hulstrom if he knew of any study on well corrosion at 100-KR-4 OU. Jason Hulstrom stated that they did do a corrosion study. They did see some well degradation but it was due to bio-fouling rather than corrosion. Kris Ivarson said some wells had high sulfur content associated with injection and reducing conditions.

Rob Mackley said that for this PSQ, we're talking about source of investigation as well as vertical distribution within the aquifer. On the monitoring approach, low-flow is useful for identifying the upper part of the aquifer. Other sampling approaches may need to be incorporated. He suggested that low-flow sampling may be appropriate and that multiple sampling methods may also be appropriate for sub-objectives for monitoring approach. Kim Schuyler agreed to add the language “and other appropriate techniques” to Slide 21 (Handout 2). Garrett Day agreed and said leave yourself open about low flow sampling methods due to potential issues regarding vertical flow gradients within long screened wells.

Rob Mackley also stated that we need to be clear about source in vadose or source in the aquifer or periodic rewetted zone (PRZ). The conceptual model is that there are areas with “continuing source” rather than source. The type of data from continuing source vs high concentration may be different. Kris Ivarson stated that she thinks we need to consider both.

Rob Mackley asked if there are areas with continuing sources, and second and not necessarily related, is there a zone in the aquifer of high concentration. Jason Hulstrom asked if we had a PSQs for the continuing sources, stating 100-KR-4 OU rebound study only had a single PSQ, similar to what is shown here. The 100-KR-4 OU team broke out how they would use this information in the sample design and monitoring approach (measurement type and frequency). Travis Hammond stated 100-HR-3 OU can address this issue in the sub-area addenda.

A small change was requested to one of the bullets under Monitoring Approach. There were no requested changes to any other information on PSQ3.

<u>PSQ4 How is the aquifer within the rebound study areas affected following shutdown of P&T?</u>

Kim Schuyler stated that for this PSQ, we want to determine how gradients change, and identify small scale heterogeneity. Data is needed to determine if the groundwater monitoring network is still adequate to address any impacts to change in groundwater dynamics. Data needs include water levels for flow and transport models. This may require additional Automated Water Level Network (AWLN) stations.

Darrell Newcomer asked if, in regard to flow direction and gradient, how do we differentiate between river stage effects and rebound effects? With modeling? Are we going to be removing river stage effects to determine the gradients? Travis Hammond said “yes,” we will be looking at trend analysis and account for river effects. There are a few ECFs for this and lag-time studies for river effects that will be accounted for. Darrell asked Alex if he had worked on this before. Alex Spiliotopoulos said “yes,” and explained that there will be an analysis on the trends and modeling and multiple lines of evidence.

Rob Mackley asked if the sub-addenda would be the point in time that the analyses and frequencies would be identified. Kim Schuyler responded “yes.” Alex Spiliotopoulos said there should be some flexibility to that depending on what the data are showing. Kim Schuyler agreed to add language that the data needs or frequency can be modified.

The attendees discussed the use of extraction wells in the AWLN. It was identified that pumps may need to be removed and this should be evaluated when designing the rebound study. This work may take time to plan and could impact the initiation of the rebound study if the work isn’t included in the planning. Having pumps in the wells will also make vertical distribution evaluations difficult.

Alicia Boyd asked how vertical profiling will be compare to the historical data. Travis Hammond responded it is valuable for optimization and enhancement of PSQs, modeling, and informing future placement of screens and pumps. Alicia Boyd said we still need to be able to compare operations to post-operations. Rob Mackley said if we see rebound after stopping pumping, vertical profiling can help to explain why this is occurring. He stated that we need to acknowledge that these methods and concentrations will be different.

Sarah Springer recommended adding "Concentrations of major ions (calcium, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance and other field parameters in groundwater in the absence of P&T operations. Nitrate will be sampled in areas where it is known to exist in groundwater." to data needs and use in PSQ4. Kim Schuyler agreed to add these parameters to PSQ4.

There were no additional requested changes to any other information on PSQ4.

<u>PSQ4a: Has groundwater reverted to ambient conditions?</u>

Kim Schuyler stated that the purpose of this PSQ is to determine what "ambient" means. How do we determine what parameter represent ambient conditions? We would look at historical water table data. This may include things like alkalinity or ions and may include modeling.

No one had questions or comments on PSQ4a. There were no additional requested changes to any other information on PSQ4a.

<u>PSQ4b: What are the seasonal effects in groundwater Cr(VI) concentrations and the rebound study area due to river stage?</u>

Kim Schuyler stated that this PSQ builds on information from PSQ1. This will include water levels and may increase sample frequency near the Columbia River. Is there any modeling detail here and assumptions that need to be worked through? We will be using trend analysis, looking at attenuation and dilution from the river, and we will be using the data to inform the conceptual site model.

There was a discussion on extending the aquifer tubes that are inaccessible during high river stages. This is another activity that should be considered when planning the rebound study. When designing the sub-area addenda, the team should identify the aquifer tubes that are damaged or inaccessible so the repair work can be scheduled. The work is only possible when the Columbia River is low so coordinate and plan ahead of initiation of the actual rebound study.

The duration of rebound studies were discussed. Travis Hammond thought 1 year at a minimum, but we will add flexibility for duration for special circumstances (e.g., the Columbia River floods or an extreme drought is occurring). Darrell Newcomer said a 1 year rebound study should be extended a bit more than a year so data is collected during the entire season in which the rebound test was initiated. Alicia Boyd asked that if we would have rebound studies that last longer than a year that we should see if we can use the same sample trips for the rebound and attainment phase of remediation. We need to make sure that this sampling can be also used for compliance monitoring if appropriate.

There were no requested changes to any other information on PSQ4b.

<u>PSQ5: How are hydrochemical indicators affected within the rebound study area?</u>

Kim Schuyler stated that this PSQ deals with hydrochemical indicators and field parameters. Sarah Springer stated that it looks like we have identified all pertinent parameters. Do we need to capture the frequency of collection for these parameters? Kim Schuyler stated that this would be analyzed whenever a groundwater samples for Cr(VI). We would need a logical tie between PSQ4 and PSQ5.

There were no requested changes to any other information on PSQ5.

<u>PSQ6: Can the project use the data to supplement compliance monitoring?</u>

PSQ6 was not included in the original presentation and was added after a discussion on compliance monitoring and how it relates to the rebound studies. Alicia Boyd asked if the data collected under the "Parent" Rebound Study SAP could be used for attainment monitoring for compliance. She clarified that aquifer tube data could not be used for that purpose but groundwater samples from monitoring, extraction and injection wells could be used.

Jason Hulstrom stated that we need to make sure data are of the appropriate quality but wondered if that was really a PSQ. If so, does it belong in the "Parent" Rebound Study SAP or in the compliance monitoring SAP. Kim Schuyler asked the attendees whether they can all agree that the "Parent" Rebound Study SAP is an appropriate place for this type of PSQ? Travis Hammond responded that for this "Parent" Rebound Study SAP, we are looking to see if we are at the stage where we can begin compliance monitoring. Alicia Boyd said PSQ6 belongs in this SAP but also in the compliance monitoring SAP. Noe'l Smith-Jackson also concurred that the PSQ is appropriate for the "Parent" Rebound Study SAP.

Alicia Boyd said that determining the data are good at the sub-area level may be rescinded if/when we have plume migration. She stated that it would be her preference to be able to qualify the data for compliance if we see that in our analysis. Let's keep in mind we need to complete the analysis across the areas. We need to know if the data can be used, but not complete the compliance monitoring data.

Alex Spiliotopoulos clarified that this is the attainment phase we're talking about. He explained that this is an indication we can move to the next phase of the remediation. He said it really goes back to PSQ2, and attainment. If PSQ2 happens, that is where we need to be to consider compliance. Alex Spiliotopoulos asked if a separate PSQ was needed or if PSQ2 could be amended. Alicia Boyd said the trend analysis in PSQ2 is qualitative. She added that the "Parent" Rebound Study SAP needs to acknowledge that the sub-area addenda will have different timeframes. We know that different data needs will be needed for different sources areas. Alicia Boyd recommended an acknowledgment that each "Parent" Rebound Study SAP addenda will have different details. Alex Spiliotopoulos recommended modifying the PSQ2 data needs by adding "qualitative" and "Perform a statistical trend evaluation if time frame and sampling frequency is appropriate" to Slide 20 (Handout 2). He added that additional information about attainment vs compliance will need to go in the "Parent" Rebound Study SAP addenda.

Kim Schuyler asked if we still need PSQ6? Alicia Boyd said "yes," we need to consider that the data we are collecting is appropriate for the first portion of compliance monitoring. She said that it is important that you are able to use data and combine with compliance monitoring and that the data are compatible with compliance monitoring. PSQ6 needs to say that if data are favorable, is the data compatible and usable to supplement compliance monitoring based on the quality of the data. Kim Schuyler recommended the following language for PSQ6: "Can we use the data to supplement compliance monitoring?" Meeting attendees concur with this language.

Kim Schuyler stated the "Parent" Rebound Study SAP will contain other general information that will be applicable to all sub-area addenda including a quality assurance project plan, generalized field sampling plan, analytical requirements, waste management plan, and health and safety requirements.

Travis Hammond stated that the decisional draft of the "Parent" Rebound Study SAP will be transmitted to DOE-RL in March of 2021. Ecology and EPA review would occur tentatively for May 2021.

Actions

- Kim Schuyler will update the presentation per the comments received during the workshop. The presentation will be finalized and provided to the meeting attendees.
    - After the December 3, 2020 meeting, the workshop presentation was updated. The Revision 0 presentation is included in Handout 2.
- Kim Schuyler will also prepare meeting notes summarizing the discussions that took place during the workshop.
- Travis Hammond will follow-up on the question about whether or not the "Parent" Rebound

Study SAP and addenda should be a stand-alone document or as an appendix to the 100-HR-3 OU Work Plan (DOE/RL-2017-13).

- After the December 3, 2020 meeting, Travis Hammond identified that the "Parent" Rebound Study SAP and addenda will become addenda to the RD/RAWP.

Agreements

- The overall approach of creating a "Parent" Rebound Study SAP with study-area specific addenda is acceptable to the workshop attendees.
- All five preliminary PSQs and two sub-PSQs discussed during the workshop were adequate as written.
- An additional PSQ is needed (PSQ6: Can the project use the data to supplement compliance monitoring?

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Handout 1, Agenda

100-HR-3 OU Rebound Studies Sampling and Analysis Plan
Data Quality Objectives Workshop

December 3, 2020

- Meeting objectives
  - Reach an agreement on the overall approach for creating a sampling and analysis plan (SAP) for rebound studies in the 100-HR-3 operable unit (OU), with study-specific details to be provided in SAP addenda.
  - Identify principal study questions and data needs for rebound studies in the 100-HR-3 OU.
  - This workshop will not specifically define or discuss the regions proposed for rebound studies.
  - This workshop is limited to the unconfined aquifer.

- Background information
  - Brief history of 100-HR-3 OU groundwater remedial action
  - Purpose of Parent Rebound Studies SAP
  - Remediation Steps

- Rebound study data quality objectives
  - Plan and perform rebound studies at different sub-areas in 100-HR-3 OU to evaluate the aquifer condition and Cr(VI) concentrations in the absence of the P&T system.
  - Information discussed and agreed upon will be incorporated into a "Parent" Rebound Study SAP. Subarea-specific data needs will be incorporated into separate addenda within the "Parent" Rebound Study SAP.
  - To support upcoming and future groundwater sampling activities, agreements need to be made on the types of groundwater data necessary to evaluate the following:
    - Aquifer rebound
    - Cr(VI) rebound
    - P&T optimization
    - Assess remedy completion and identify areas that require additional action to remediate.

- Statement of the problem
  - Need to determine if and how Cr(VI) concentrations change during a rebound period.
  - Need to determine how the unconfined aquifer changes (hydraulically and chemically) during a period of rebound.
  - Need to determine if Cr(VI) concentration levels have met or are on track to meet cleanup goals and timeline identified in the ROD.

- PSQs, data needs, monitoring approach
  - Preliminary PSQs were developed for this DQO discussion.
  - The focus of PSQs is to help determine what data are needed to assess aquifer and Cr(VI) rebound conditions in the absence of the P&T system.
  - For each PSQ, the following are included to aid discussion:
    - Data needs and use
    - Monitoring/sampling approach

- Summary of actions and agreements
  - Follow-up actions
  - Meeting notes will be developed and distributed
  - The decisional draft of the SAP will be transmitted to RL in March 2021

Attachment 2
22-SGD-001401

Groundwater Monitoring Plan for the 100-H North Subarea Rebound Study (100-HR-3 Operable Unit)
DOE/RL-2021-23-ADD1 Rev 0

(41 pages including cover sheet)

DOE/RL-2021-23-ADD1
Revision 0

Groundwater Monitoring Plan for the 100-H North Subarea Rebound Study (100-HR-3 Operable Unit)

Date Published
May 2022

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 Sarah Harrison at 7:17 am, May 09, 2022

Release Approval Date

Signature Sheet

Title: *Groundwater Monitoring Plan for the 100-H North Subarea Rebound Study (100-HR-3 Operable Unit)*

MICHAEL CLINE Digitally signed by MICHAEL CLINE
Date: 2022.05.10 06:11:23 -07'00'

Print Name	Signature	Date

U.S. Department of Energy,
Richland Operations Office

LAURA BUELOW Digitally signed by LAURA BUELOW
Date: 2022.05.10 08:24:30 -07'00'

Print Name	Signature	Date

U.S. Environmental Protection Agency

Digitally signed by
Welsch, Kim (ECY)
Date: 2022.05.10
07:46:28 -07'00'

Print Name	Signature	Date

Washington State Department of Ecology

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Contents

Appendix

Figures

Tables

Terms

AWLN	automated water-level network
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
Ecology	Washington State Department of Ecology
Hf	Hanford formation
OU	operable unit
P&T	pump and treat
PRZ	periodically rewetted zone
PSQ	principal study question
RD/RAWP	remedial design/remedial action work plan
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RUM	Ringold Formation upper mud
Rwie	Ringold Formation member of Wooded Island – unit E
SAP	sampling and analysis plan

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1 Introduction

This sampling and analysis plan (SAP) addendum presents the groundwater monitoring plan and test design for an area-specific hexavalent chromium (Cr(VI)) rebound study within the 100-H North Subarea in the 100-HR-3 Operable Unit (OU). As discussed in DOE/RL-2021-23, *Rebound Studies Parent Sampling and Analysis Plan for the 100-HR-3 Operable Unit, Hanford* (hereinafter referred to as the rebound studies parent SAP), the parent document will act as the main body of information, while this SAP addendum provides the area-specific detail associated with implementing a rebound study within the unconfined aquifer. This addendum will implement the guidance of the quality assurance (QA) documents which are specifically referenced in Chapter 2 of the rebound studies parent SAP (DOE/RL-2021-23).

A rebound study involves the evaluation of contaminant concentrations under ambient aquifer conditions (no active pump and treat [P&T] remediation) for a duration of time. In DOE/RL-2017-13, *Remedial Design/Remedial Action Work Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2 and 100-HR-3 Operable Units* (hereinafter referred to as the 100-D/H Remedial Design/Remedial Action Work Plan [RD/RAWP]), Section 4.2 identifies rebound studies as part of the Phase 2 P&T shutdown evaluations. The monitoring will be focused on gathering data to assess the remedial action identified in EPA et al., 2018, *Record of Decision Hanford 100 Area Superfund Site 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units, Hanford Site* (hereinafter referred to as the 100-D/H Record of Decision [ROD]) specifically to determine if the remedial action objectives identified in the 100-D/H ROD will be met. The rebound study at the 100-H North Subarea will occur within the boundary shown in Figure 1. As identified in SGW-64372, *100-D/H Continuing Hexavalent Chromium Source Evaluation*, confirmed (183-H Solar Evaporation Basins) and potential (100-H-46 contaminated soil waste site) secondary sources are located within the 100-H North Subarea. In SGW-64372, rebound studies were recommended to be conducted at both of these sites.

1.1 Project Scope and Objectives

This rebound study SAP addendum uses the principal study questions (PSQs) and the associated data needs developed in the rebound studies parent SAP (DOE/RL-2021-23) as they apply to the 100-H North Subarea. Performance monitoring will continue as described in Addendum 1 of the 100-D/H RD/RAWP (DOE/RL-2017-13-ADD1, *Groundwater Monitoring Sampling and Analysis Plan for the 100-HR-3 Groundwater Operable Unit*). Any performance monitoring samples will be co-sampled with the rebound study samples and would not be duplicative. Performance monitoring will continue as per DOE/RL-2017-13-ADD1 outside of active rebound study areas. The 100-H North Subarea rebound study objectives include:

- Evaluation of Cr(VI) concentrations in the unconfined aquifer to determine if groundwater remediation activities have met or are on track to meet cleanup goals identified in the 100-D/H ROD (EPA et al., 2018).
- Determine how the unconfined aquifer changes (hydraulically and hydrochemically) during shutdown.
- Evaluate any impact secondary sources in the periodically rewetted zone (PRZ) may have on contaminant concentrations.
- Provide additional information to help confirm the 100-H-46 contaminated soil waste site as a secondary source and identify a potential treatment area if additional remediation is needed (SGW-64372).

- Evaluate the need for additional extraction downgradient from the 183-H Solar Evaporation Basins as recommended in SGW-64372. The pump and treat network configuration for 100-HR-3 (including the 100-H North subarea) can be seen in Figure 1-2 of DOE/RL-2020-61, *Calendar Year 2020 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations, and 100-NR-2 Groundwater Remediation*.

- Observe uranium and nitrate concentrations near the 183-H Solar Evaporation Basin to evaluate a possible secondary source. Data will be collected for informational purposes and will not be evaluated as part of this rebound study.

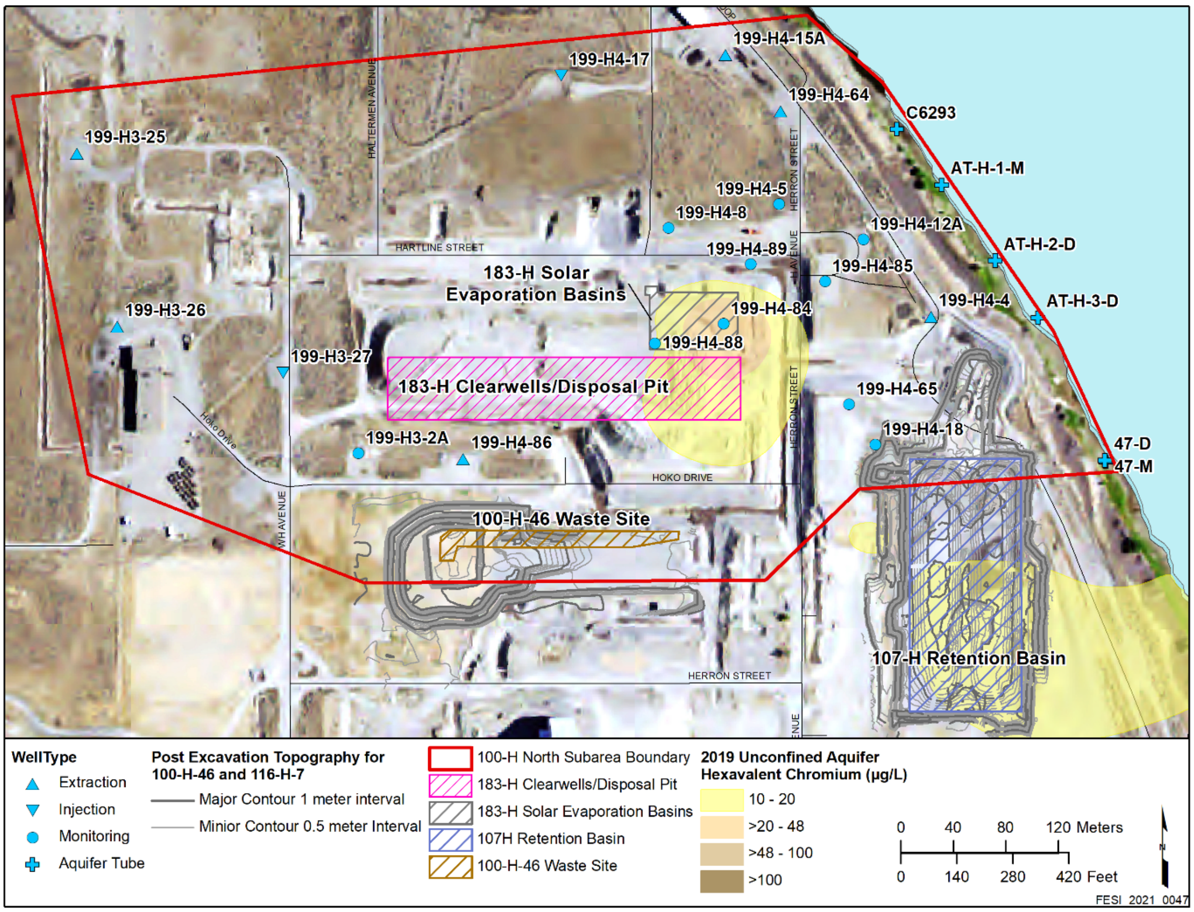


Figure 1. 100-H North Subarea Boundary with Unconfined Aquifer Monitoring Locations

The 100-D/H RD/RAWP (DOE/RL-2017-13) identifies that data will be evaluated to quantify how the remedy is affecting the plume dynamics and local conditions at individual wells. Conditions and trends can be interpreted to support remedial process optimization and to assess the potential for continuing sources, as appropriate.

The duration and timing of this subarea rebound study will adhere to the rebound timing regime discussed in Section 1.1, "Project Scope and Objectives," of DOE/RL-2021-23.

2 Site Background

The 100-HR-3 OU includes the groundwater in the 100-D/H Area. The groundwater was contaminated by releases from facilities and waste sites in the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 OUs associated with past operations at the D, DR, and H Reactors. Operations at these reactors resulted in soil and groundwater contamination. Reactor operations and descriptions of contaminant releases are provided in the 100-D/H remedial investigation/feasibility study (RI/FS) report (DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*) (hereinafter referred to as the 100-D/H RI/FS).

2.1 183-H Solar Evaporation Basins and the 100-H-46 Waste Site

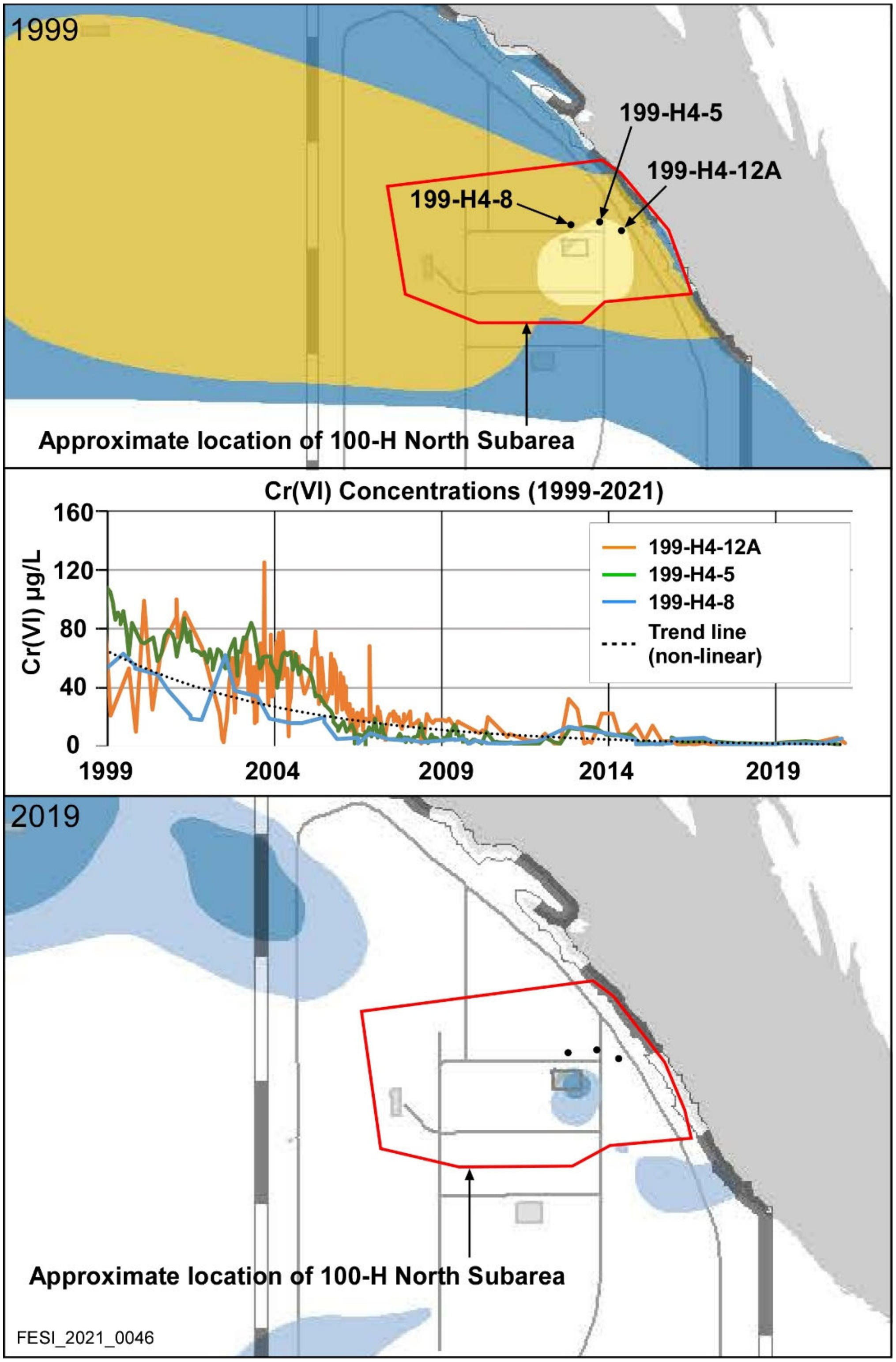
The 183-H Solar Evaporation Basins consisted of four repurposed concrete flocculation and sedimentation basins that were constructed in 1949 and used for water treatment until the mid-1960s. From 1973 to 1985, the basins accepted radioactive and mixed waste from the 300 Area fuel fabrication facilities. Routine waste included spent acid etch solutions (primarily nitric, sulfuric, hydrofluoric, and chromic acids). Metal constituents—including chromium, manganese, and uranium (among others)—were in the form of precipitates (Section 4.6 in BHI-00127, *100-H Area Technical Baseline Report*). Based on DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*, the concrete floor of the basins was removed; however, a portion of the footings likely remain.

The 100-H-46 waste site consists of a portion of the former 190H Pump House footprint associated with concentrated sodium dichromate handling. The concentrated solution was injected into treated water supplied by the 183H Water Treatment Facility, which was then held in four large water tanks within the 190H Pump House. Above grade portions of the 190H Pump House were demolished in 1977, leaving the slab in place. Confirmatory sampling identified 66.6 mg/kg of Cr(VI) in stained concrete at the former unloading dock area. The site was excavated between February and July 2013, removing structural debris and soil up to 12.5 m (41 ft) below ground surface. The site was reclassified as “interim closed out” based on verification sampling results and was then backfilled (SGW-64372).

2.2 Unconfined Aquifer Hexavalent Chromium Plumes

The Cr(VI) groundwater plumes within the 100-HR-3 OU in 1999 (2 years after the first P&T system began operating) and 2019 are shown in Figure 2. The Cr(VI) contamination within the 100-H Area has been reduced to several discontinuous plumes due to removal of source material and ongoing P&T groundwater remediation. The spatial extent and concentrations have been reduced (generally less than 48 µg/L) in the 100-H North Subarea. Figure 1 shows a more detailed view of the 2019 Cr(VI) plumes located within the 100-H North Subarea.

Two Cr(VI) plumes remain in the 100-H Operational Area: a plume near the 183-H Solar Evaporation Basins (within the study area) and a plume near the 107H Retention Basin (Figure 1). Plumes, defined for the purposes of this study, are areas of Cr(VI) concentration exceeding 10 µg/L. The 100-H North Subarea includes the plume associated with the 183-H Solar Evaporation Basins, which are located downgradient of the excavation area for the 100-H-46 contaminated soil waste site (another potential continuing source). Both the 183-H Solar Evaporation Basins and the 100-H-46 waste site are identified in SGW-64372 as secondary sources for Cr(VI). Both will be evaluated as potential continuing sources during the 100-H North Subarea rebound study. The secondary sources and plume associated with the 116-H-7 Retention Basin (referred to as the “107H Retention Basin” in SGW-64372) are located southeast of the 100-H North Subarea and are not the subject of or anticipated to impact this rebound study.



Note: Modified from Figure 4-5 of DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*.

Figure 2. Comparison of the Cr(VI) Groundwater Plumes in 1999 (Early in Interim Action Period) and 2019 (During Remedial Action)

The 100-H North Subarea is the subject of this rebound study for the following reasons:

- Cr(VI) concentrations in the unconfined aquifer are generally less than the 48 μg/L inland cleanup level.
- Cr(VI) concentrations near the shoreline are currently less than the 10 μg/L surface water protection cleanup level.
- Cr(VI) concentrations have shown generally decreasing trends.
- The 100-H North Subarea is located away from areas of scheduled P&T realignment activities.
- An extensive network of wells is in place for monitoring the rebound effect.
- An adequate extraction and injection well network is available for contingent protection of the Columbia River.

Data from monitoring wells throughout the 100-H North Subarea are generally below the 100-D/H ROD inland cleanup level of 48 μg/L (Figures 3 and 4). The highest Cr(VI) concentrations in the 100-H North Subarea are observed at the 199-H4-84 and 199-H4-88 (well locations are shown on Figure 1) groundwater monitoring wells, both within the Cr(VI) plume located at the183-H Solar Evaporation Basins. Concentrations increase during periods of higher water levels, which is typical for areas with a contaminant source (DOE/RL-2020-60, *Hanford Site Groundwater Monitoring Report for 2020*). These observations led to the conclusion that a continuing source of Cr(VI) contamination exists in the portion of the vadose zone that is dry during low river stage and wet during high river stage (known as the PRZ), mobilizing residual Cr(VI) to groundwater during high river stage. Well 199-H4-84, located at the center of the 100-H North Subarea Cr(VI) plume, is the only groundwater monitoring well to exceed the 48 μg/L inland cleanup level in the last 5 years, with a peak concentration of 130 μg/L in 2017 (Figure 4). Well 199-H4-88 is located upgradient of well 199-H4-84 and has had Cr(VI) concentrations up to 40 μg/L in the last 5 years; however, concentrations of Cr(VI) have declined since 2017 (Figure 4) and are generally below 10 μg/L.

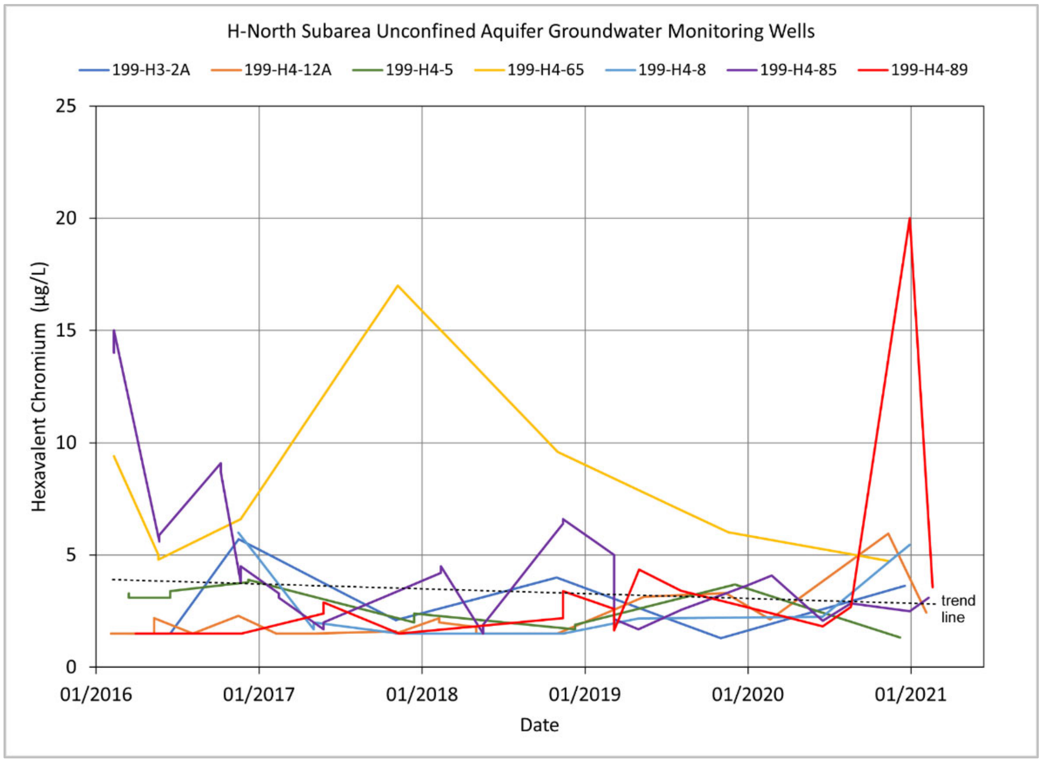


Figure 3. Five-Year Hexavalent Chromium Concentration Trends for Monitoring Wells Within the 100-H North Subarea (Excluding 199-H4-84 and 199-H4-88)

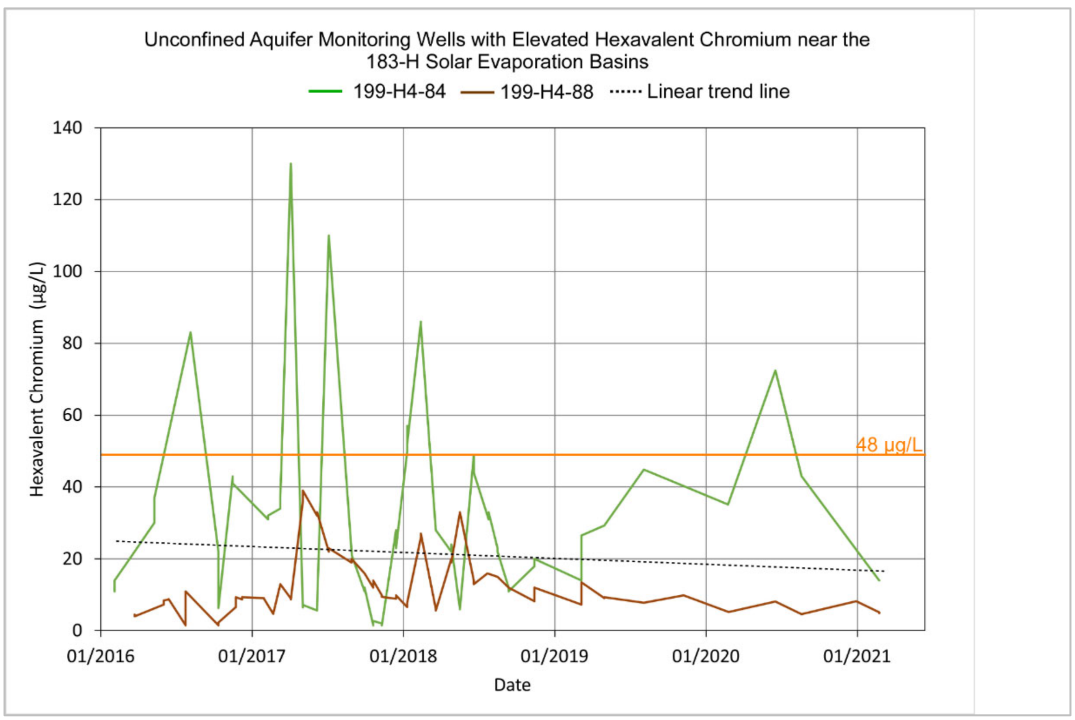


Figure 4. Five-Year Hexavalent Chromium Concentration Trends for Wells 199-H4-84 and 199-H4-88

2.3 Unconfined Aquifer Uranium and Nitrate

SGW-64372 also indicates uranium and nitrate as contaminants associated with the 183-H Solar Evaporation Basins. From 1973 to 1985, the basins accepted radioactive and mixed waste from the 300 Area fuel fabrication facilities. Routine waste included spent acid etch solutions (primarily nitric, sulfuric, hydrofluoric, and chromic acids). Metal constituents, including chromium, manganese, and uranium (among others), were in the form of precipitates (Section 4.6 in BHI-00127). Concentrations of Cr(VI), nitrate, and uranium in groundwater at well 199-H4-88 responded to groundwater fluctuations. Increased concentrations are noted when the water table is high (Figure 5). These observations also indicate the presence of a continuing uranium and nitrate source in the PRZ like for Cr(VI).

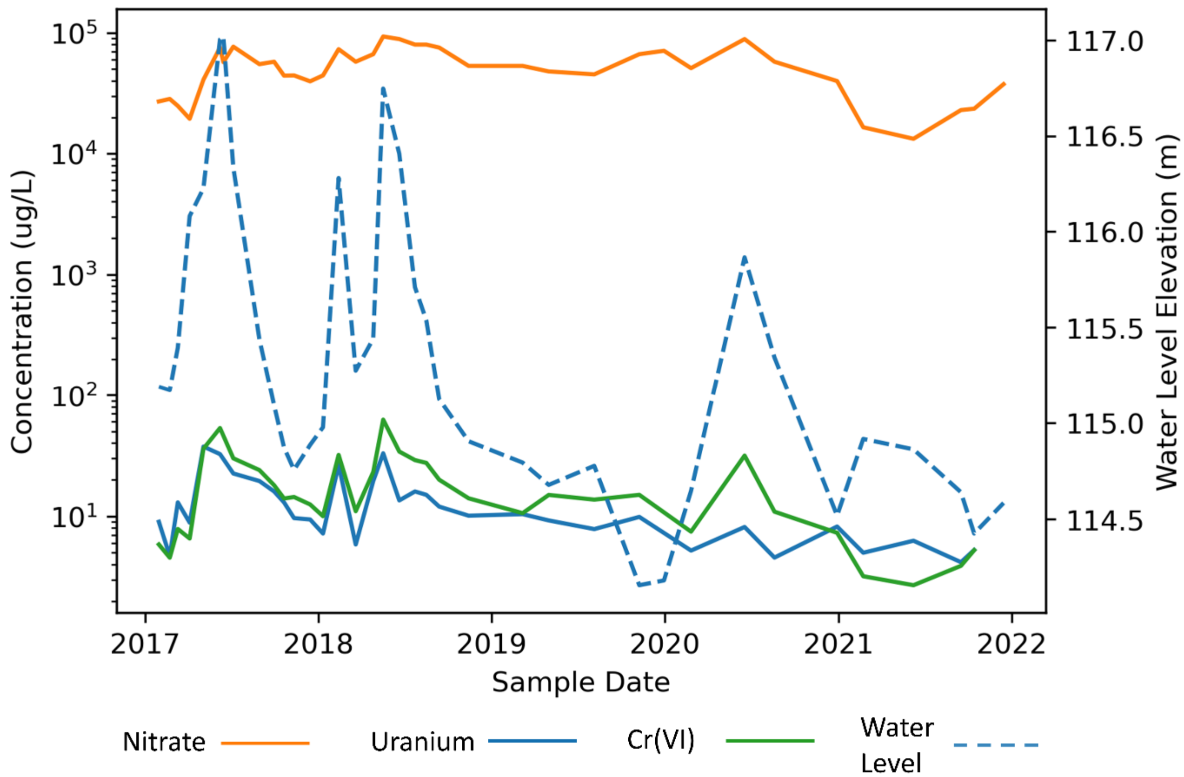


Figure 5. Contaminant Response to Groundwater Fluctuation at Well 199-H4-88

2.4 Groundwater Remediation Activities

In response to Cr(VI) contamination, groundwater remediation activities were initiated in 1997 with installation of a small P&T system—HR3 —under an interim action ROD (EPA/ROD/R10-96/134, *Declaration of the Record of Decision for 100HR3 and 100KR4 Operable Units US DOE Hanford 100 Area*) and in accordance DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*. The P&T systems have been expanded since inception and have been effective in reducing Cr(VI) concentrations in groundwater and improving hydraulic containment to protect the Columbia River from continuing releases of Cr(VI).

The final remedy in the 100-D/H ROD (EPA et al., 2018) selected continued use, expansion, and optimization of the DX and HX P&T systems for groundwater treatment. The 100-D/H ROD established a cleanup level of 10 µg/L for Cr(VI) where groundwater discharges to surface water and 48 µg/L inland. With the issuance of the 100-D/H ROD, a new 100-D/H RD/RAWP (DOE/RL-2017-13) was prepared.

The 100-D/H RD/RAWP was developed to ensure that the P&T systems are operated with the goal of meeting the remedial action objectives described in the 100-D/H ROD.

2.5 Site Geology/Hydrogeology

A detailed description of the 100-D/H Area hydrogeologic conditions is included in the 100-D/H RI/FS (DOE/RL-2010-95) and the rebound studies parent SAP (DOE/RL-2021-23). The primary stratigraphic units controlling groundwater flow in the unconfined aquifer in the 100-H North Subarea, from shallowest to deepest, are as follows:

- Hanford formation (Hf)
- Ringold Formation member of Wooded Island – unit E (Rwie)
- Ringold Formation upper mud unit (RUM)

The unconfined aquifer in the 100-H North Subarea is primarily within the gravel-dominated Hf, although there are localized areas where the Rwie is present and underlies the Hf (DOE/RL-2010-95). The Hf facies consists predominantly of unconsolidated sediments that cover a wide range of grain sizes, from boulder-sized gravel to sand, silty sand, and silt. The Hf ranges in thickness from 35 to 57 ft (10.1 to 17.4 m) in the 100-H North Subarea (ECF-100NPP-11-0070, *100 Area Stratigraphic Database Development*). The Rwie unit consists of fluvial matrix supported by gravels and sands with intercalated fine- to coarse-grained sand and silt layers and is relatively less transmissive than the overlying Hf (SGW-60571, *Aquifer Testing of the First Water-Bearing Unit in the RUM at 100-H*). Where present, the Rwie ranges in thickness from 3.8 to 5.2 m (12.5 to 17 ft) in the 100-H North Subarea (ECF-100NPP-11-0070). The thickness of the unconfined aquifer is determined by the difference between the water table elevation and the surface of the RUM, which forms the base of the unconfined aquifer in the 100-H North Subarea. The unconfined aquifer ranges in thickness from <0.3 to 6.4 m (1 ft to 21.1 ft) in the 100-H North Subarea and varies due to seasonal fluctuations in the Columbia River stage.

The RUM is dominated by fine-grained overbank paleosol facies consisting of the silt- and clay-rich sediment with a lower hydraulic conductivity relative to the Hf and Rwie. The top of the RUM forms a semi-confining layer or aquitard between the overlying unconfined aquifer and the uppermost RUM aquifer and varies in thickness from about 3 to 13 m (9.8 to 42.7 ft) in the 100-H North Subarea (PNNL-30467, *Hydrologic Evaluation of the Ringold Upper Mud Aquifer in the 100-H Area of the Hanford Site*).

2.5.1 Groundwater Flow and Seasonal Impacts to Hexavalent Chromium Concentrations

Groundwater in the 100-H North Subarea unconfined aquifer typically flows to the northeast, towards the Columbia River (Figure 6). The Columbia River functions as a discharge boundary for the shallow unconfined aquifer beneath the 100-H North Subarea. Hydraulic gradients are generally flatter during the high river stage when compared to low river conditions. The flow directions and gradients experienced during the low and high river stages have a greater effect on contaminant transport than during transitional periods. The high and low river stages, which typically last a few months, affect the groundwater flow near the Columbia River and the effects extend inland, the distance depending on hydrogeologic characteristics of the aquifer. The period of high river stage is generally from April through August, and low river stage is generally observed from September through December.

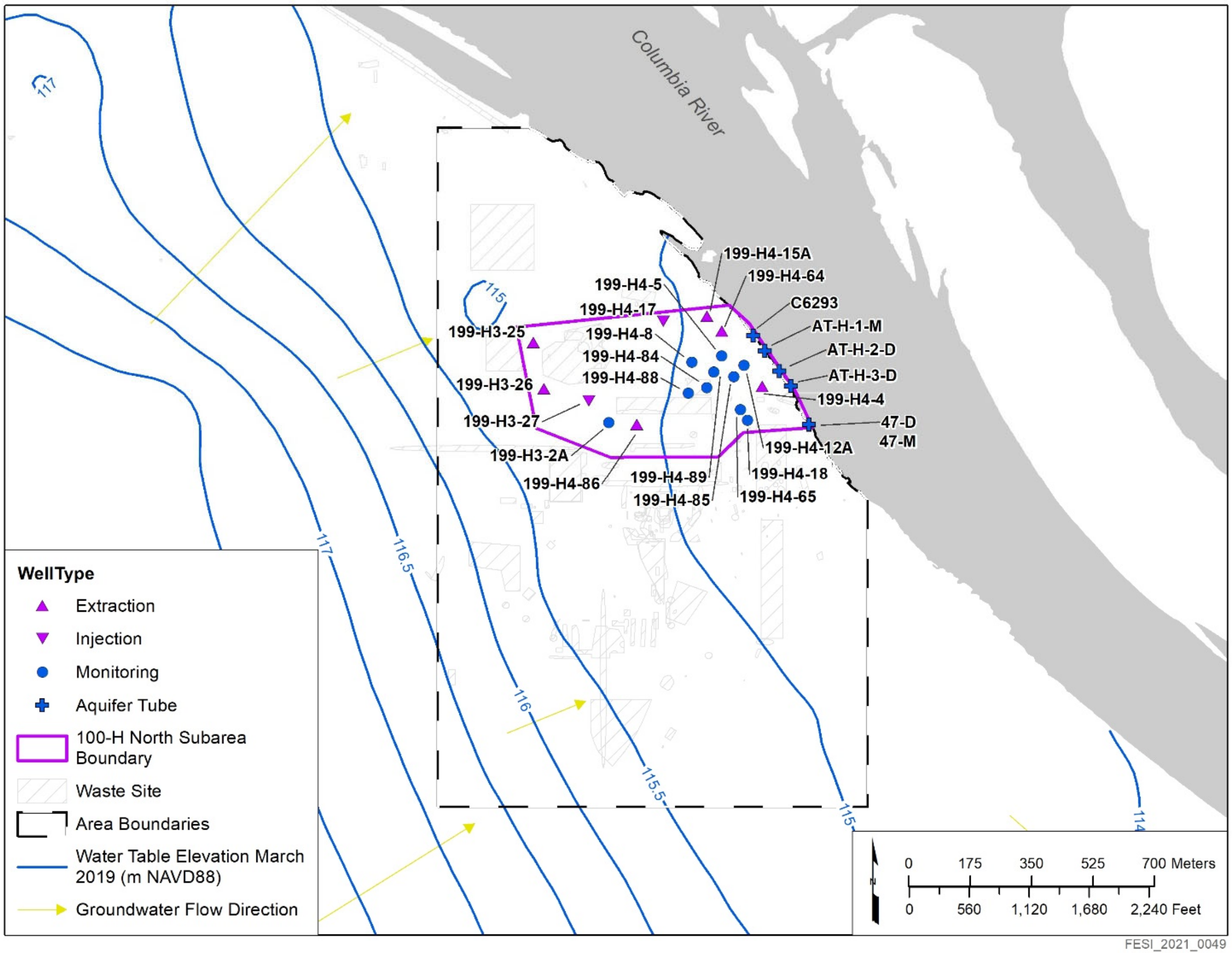


Figure 6. 100-H North Subarea Water Table, March 2019

Response of the Cr(VI) plume in the unconfined aquifer within the 100-H North Subarea to the change in river stage has been tracked and is reported as part of the Hanford Site annual groundwater report (e.g., DOE/RL-2020-60). The dimensions and changes in plume geometry in the unconfined aquifer with changes in river stage are well understood under pumping conditions. The effect of the river stage on plume configuration (e.g., extent) has lessened over time. Plume changes in the unconfined aquifer near the 100-H North Subarea are now primarily controlled by modifications to the P&T system during the year, with the natural gradient dominating in those areas with few or no extraction or injection wells (DOE/RL-2020-60). The plume boundaries are generally farther inland from the Columbia River during high river stage in comparison to low river stage. The greatest flux of contaminants to the river occurs as the river transitions from seasonal high to seasonal low river levels but do not show much variation within the 100-H North Subarea. Cr (VI) plumes and water levels measured in 2016 are shown under high- and low river stage conditions (Figure 7). DOE/RL-2020-60 indicates that these trends persisted into 2020. Additional detail on the seasonal impacts to Cr(VI) concentrations at the 100-H Area is included in the 100-D/H RD/RAWP (DOE/RL-2017-13).

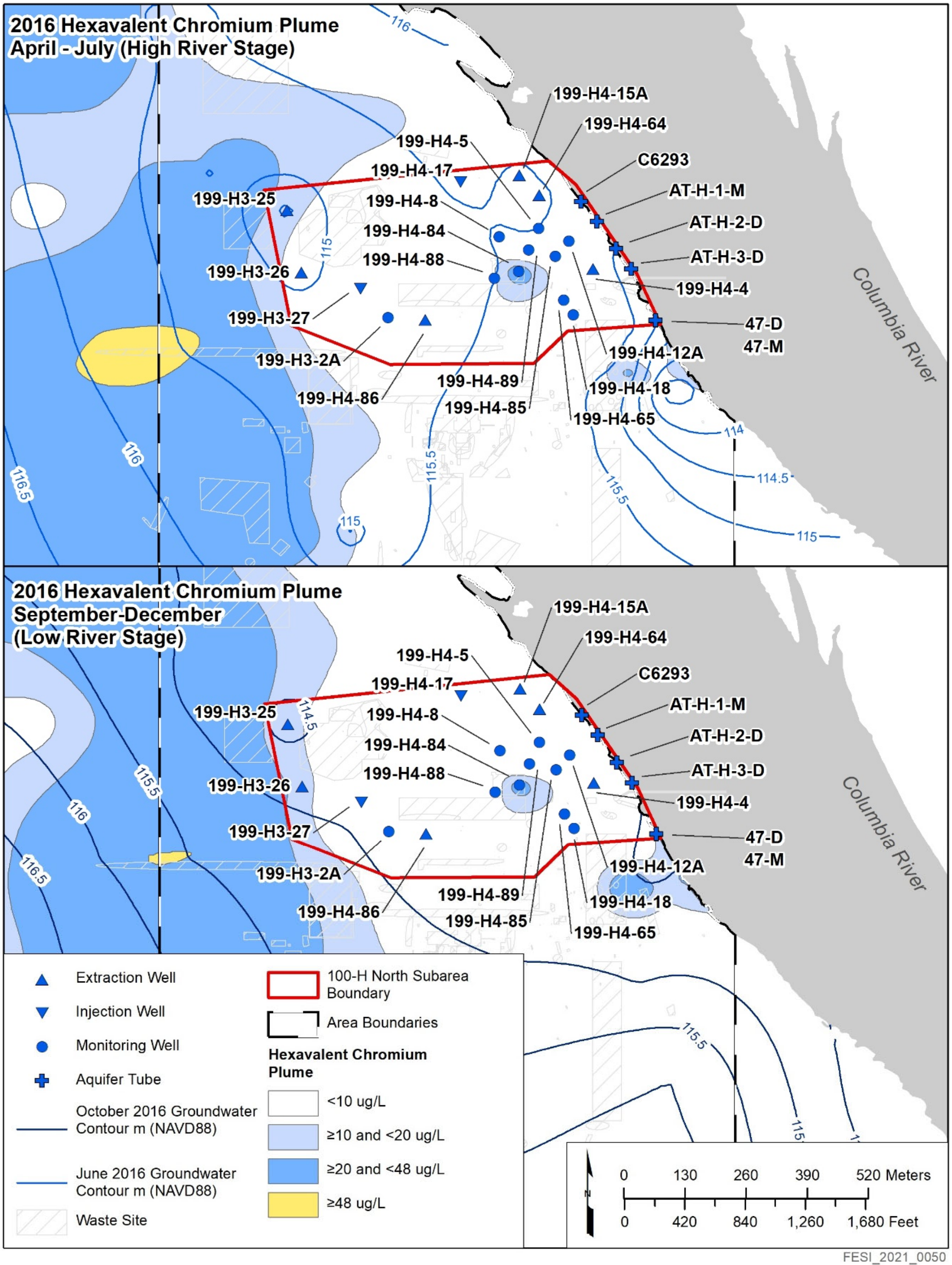


Figure 7. 2016 Hexavalent Chromium Concentrations near 100-H North Subarea at High and Low River Stage

Temporal parameters of the 100-H North Subarea rebound study involve the timing, frequency, and duration of measurements and observations. Timing is affected by Columbia River stage seasonal variation and the associated changes in groundwater flow direction and flow velocity. Frequency is primarily dependent on the proximity to the Columbia River. Locations closer to the river are expected to have a more dynamic range of concentrations so an increased frequency is needed to capture these localized changes. This rebound study is anticipated to last at least a full river stage cycle (i.e., 12 months) to ensure adequate understanding of contaminant migration due to river stage and seasonal transition periods in the absence of P&T. This duration may be extended if additional data are needed to establish concentration trends or support interpretation of unexpected sample results.

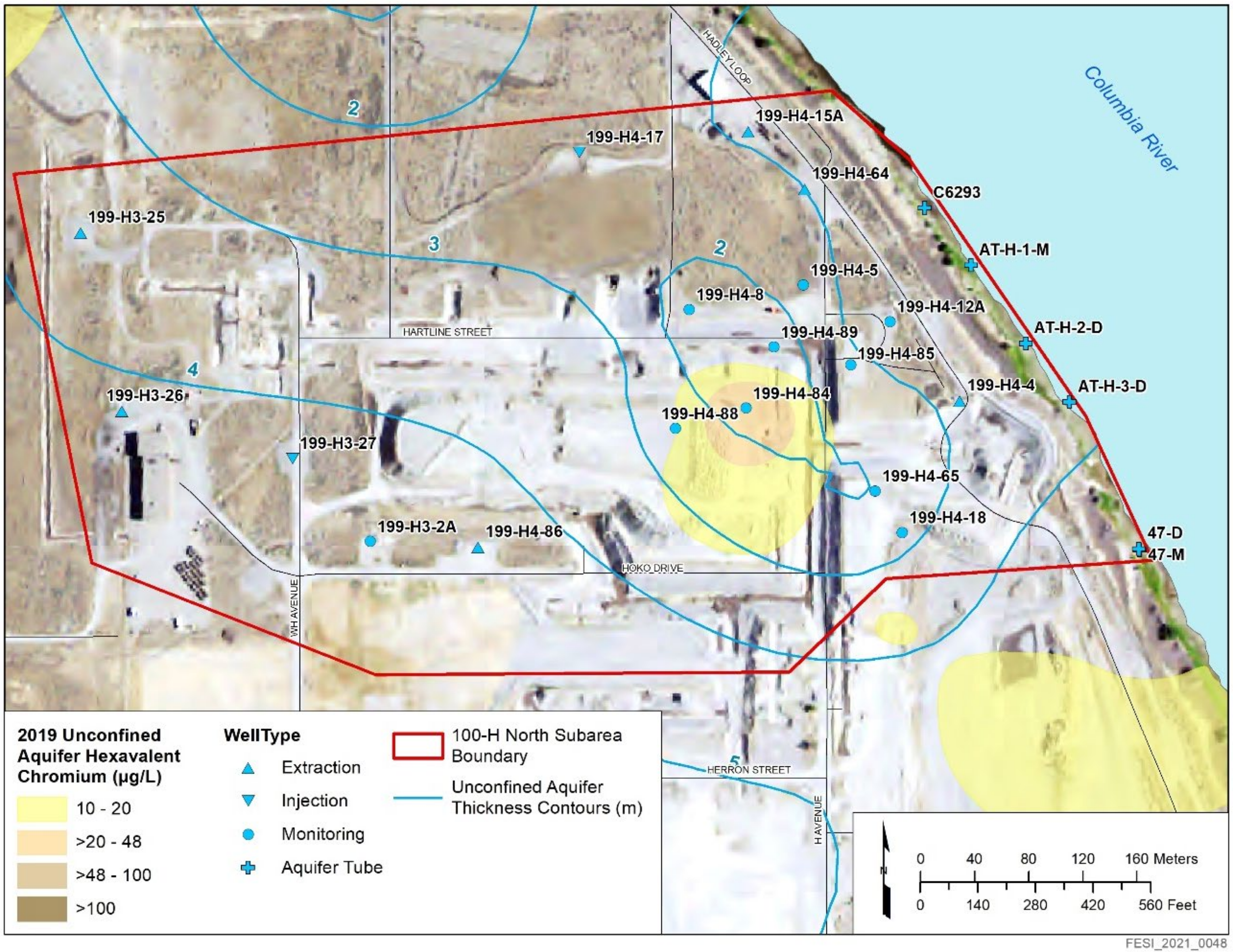
2.5.2 RUM Aquifer

In 2019, a constant-rate pumping test and three P&T shutdown events were performed in the 100-H Area to analyze for aquifer hydraulic properties and address areas of uncertainty regarding the lateral continuity of the RUM aquifer. The results indicated that the RUM aquifer is a semiconfined or leaky-confined aquifer and lateral hydraulic connectivity extends distances of 0.5 km (0.3 mi) or more within the high-concentration portion of the RUM aquifer Cr(VI) plume beneath the 100-H North Subarea (PNNL-30467). Results from previous RUM aquifer investigations have provided a range of hydraulic and storage properties for the uppermost RUM aquifer in several locations within the 100-H Area. However, there are notable areas of uncertainty. The flux of Cr(VI) and interactions between the RUM and the Columbia River and the RUM and the unconfined aquifer have not yet been quantitatively assessed (SGW-60571). Aquifer hydraulic properties have not yet been determined for new RUM aquifer wells and additional aquifer testing is needed to fill this information gap. These data serve as inputs for groundwater flow and contaminant transport models that are used, in part, to quantify Cr(VI) flux from the RUM aquifer.

This addendum does not include collecting data for the purpose of RUM aquifer characterization; however, the project will ensure coordination and sharing of information with other projects as new information becomes available (e.g., initiation of the rebound study, notification of when RUM extraction wells are turned on/off). Pumping effects in the RUM aquifer on the unconfined aquifer during the 100-H North Subarea rebound study are not anticipated. However, water level monitoring and results from groundwater chemistry sampling performed as part of the100-H North Subarea rebound study will be observed for changes or trends that may be attributed to contributions from the RUM aquifer to the unconfined aquifer (i.e., changes in water level or groundwater chemistry not attributed to known effects on the unconfined aquifer due to influx or outflux of recharge from the river). If it is found that pumping in the RUM aquifer is affecting the 100-H North Subarea rebound study, numerical model simulations will be performed to estimate the magnitude, confirm the effects, and to optimize pumping to mitigate the effects. Dependent on the modeling findings, the rebound study may be extended to ensure adequate data collection.

2.5.3 Saturated Thickness at the 100-H North Subarea

Extraction pumps require a minimum of 0.6 m (2 ft) of water above the pump intake to operate. The aquifer is less than 1 m (3 ft) thick in some northern 100-H Area locations during low river stage. During low river-stage periods, the amount of water available in the aquifer for pumping is minimal. Even when pumps are set low into well sumps, insufficient water is available for the pumps to operate. The reduced operational period during low river stage adversely affects hydraulic containment of the contaminant plume. The saturated thickness of the unconfined aquifer is shown in Figure 8, which also depicts the 100-H North Subarea during low river stage as measured in September to December 2012 (DOE/RL-2010-95).



Note: Modified from Figure 3-8 of DOE-RL-2010-95, *Remedial Investigation Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*.

Figure 8. Saturated Thickness Within the 100-H North Subarea

In particular, the unconfined aquifer is very thin below the former 183-H Solar Evaporation Basins, and most of the wells are screened across the entire aquifer. In a typical year, the saturated aquifer thickness varies from less than 1 m (3 ft) in the fall during low river stage to 3 m (10 ft) in the spring and early summer during high river stage.

Due to the narrow range of accessible water column within the aquifer in this subarea, all of the wells within the study area have 4.6 m (15 ft) of screened water column or less, and only five wells have more than 3 m (10 ft) of water column (Table 1). At several wells within the 100-H North Subarea, seasonal fluctuations in water level can make sample collection difficult due to the reduced water column. As discussed in Section 3.3 of the rebound studies parent SAP (DOE/RL-2021-23, Draft A), pumps can be removed and manual bailers or other low-flow sampling techniques may be used, as needed.

Table 1. Sampling Locations in the 100-H North Subarea

Well Name	Well ID	Well Type	Screened Water Column Length (m [ft])
199-H3-25	C7110	Extraction	3.4 (11.2)
199-H3-26[a]	C7115	Extraction	Information not available
199-H3-27	C7114	Injection	Information not available
199-H3-2A	A4611	Monitoring	2.4 (7.8)
199-H4-17	A4627	Injection	3.0 (10.0)
199-H4-18	A4628	Monitoring/formerly injection	3.0 (10.0)
199-H4-65	B8759	Monitoring	0.3 (1.0)
199-H4-8[a]	A4639	Monitoring	Intermittently dry
199-H4-84[a]	C7860	Monitoring	Intermittently dry
199-H4-85[a]	C8723	Monitoring	0.4 (1.4)
199-H4-86[a]	C8724	Extraction	4.4 (14.4)
199-H4-88	C8734	Monitoring	Intermittently dry
199-H4-89[a]	C9735	Monitoring	Intermittently dry
199-H4-12A	A4616	Monitoring	3.5 (11.4)
199-H4-15A	A4621	Extraction	3.3 (10.7)
199-H4-4[a]	A4630	Extraction	1.3 (4.3)
199-H4-5	A4630	Monitoring	4.7 (15.4)
199-H4-64	B2777	Extraction	2.6 (8.4)
47-D	--	Aquifer tube	--
47-M	--	Aquifer tube	--
AT-H-1-M	--	Aquifer tube	--
AT-H-2-D	--	Aquifer tube	--
AT-H-3-D[b]	--	Aquifer tube	--
C6293[c]	--	Aquifer tube	--

a. Low river stage may impact the ability to collect a groundwater sample. A sample will be collected as soon as water levels increase such that a pumped sample is possible.

b. During the 2020 sampling campaign, this aquifer tube could not be sampled because the tubing was either underwater or the tube was missing. An attempt will be made to locate and repair or extend the tubing so it can be sampled during high river stage.

c. During the 2019 sampling campaign, it was discovered that the aquifer tube may be broken (unable to collect groundwater samples). An attempt will be made to repair this aquifer tube but it may not be possible.

ID = identification

3 Data Quality Objectives

Representatives from the U.S. Department of Energy (DOE), the prime groundwater contractor, and the Washington State Department of Ecology (Ecology) participated in a workshop to support development of the 100-H North Subarea rebound study and monitoring plan. During this workshop, held on March 29, 2021, the participants discussed the types of data required to assess progress toward the attainment of groundwater remedial action objectives. Appendix A includes the March 29, 2021, workshop meeting notes. The presentation discussed during the workshop was SGW-66242-VA, *FY2022 Rebound Study for the 100-H North Subarea of the HR-3 Operable Unit*.

Problem Statement: Information is needed to determine whether active remediation of groundwater can be discontinued or modified to enhance Cr(VI) recovery within the 100-H North Subarea unconfined aquifer. If rebound data indicate active remediation can be discontinued, determine if the data can be used to support transition to compliance monitoring.

Key issues to be addressed include the following:

- Determining progress/status towards 100-D/H Area ROD cleanup levels.
- Measuring time equivalent water levels for estimating changes in groundwater hydraulic gradient and flow paths.
- Determining how the unconfined aquifer changes (hydraulically and hydrochemically) during shutdown.
- Collecting groundwater hydrochemistry data (ionic strengths, etc.) to help determine river stage effects on plume migration and Cr(VI) concentrations.
- If Cr(VI) concentrations do rebound, determining if action is needed to address continuing sources in the PRZ.

Table 2 identifies the PSQs from the rebound studies parent SAP (DOE/RL-2021-23) that were evaluated and used to develop the monitoring data needs for the 100-H North Subarea. All PSQs are applicable to this subarea except for PSQ 3, which was not included because depth-discrete sampling is not practical and would not provide useful information for the thin unconfined aquifer in the 100-H North Subarea. Additional information about aquifer thickness is discussed in Section 1.2.1 of the parent SAP. Table 1 identifies the screened water column length at each sampling location.

Table 2. Principal Study Questions

Principal Study Question		Data Need
PSQ 1	What is the magnitude and spatial extent of Cr(VI) concentration rebound in the absence of P&T?	Increased frequency of Cr(VI) concentration measurements in groundwater in the absence of P&T operations.
PSQ 2	In the absence of P&T operations, are Cr(VI) concentrations below OR anticipated to meet the 100-D/H ROD (EPA et al., 2018) inland cleanup level of 48 µg/L and surface water cleanup level of 10 µg/L and expected to remain below cleanup levels?	Increased frequency of Cr(VI) concentration measurements in groundwater in the absence of P&T operations.

Table 2. Principal Study Questions

Principal Study Question		Data Need
PSQ 3	In areas where the source of Cr(VI) contamination is known or suspected, what is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations?	Increased frequency of Cr(VI) concentration measurements in groundwater collected at discrete intervals vertically through the saturated screen interval in the absence of P&T operations.
PSQ 4	How is the aquifer within the rebound study areas affected hydraulically following shutdown of P&T?	Manual water level measurements collected during sampling, automated water level measurements from established AWLN wells, and water level measurements from existing sensors in P&T extraction and injection wells.
PSQ 5	Has groundwater hydrochemistry reverted to ambient conditions?*	Increased frequency of measurements of major ions (calcium, nitrate, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance, and other field parameters in groundwater in the absence of P&T operations. Manual water level measurements collected during sampling, AWLNs from established AWLN wells, and water level measurements from existing sensors in P&T extraction and injection wells.
PSQ 6	What are the seasonal effects in groundwater Cr(VI) concentrations within the rebound study area due to river stage?	Increased frequency of Cr(VI) concentration measurements in groundwater, in the absence of P&T operations, and during high-, low-, and intermediate river stages. Increased sampling frequency of major ions (calcium, nitrate, chloride, magnesium, potassium, sodium, and sulfate), alkalinity, specific conductance, and other field parameters in groundwater in the absence of P&T operations. Measured water levels in the unconfined aquifer, in the absence of P&T operations, during high and low river stages.
PSQ 7	Can the project use the data to supplement compliance monitoring?	Information collected will be used to address previous PSQs. Increased frequency of total chromium, nitrate, and Sr-90 concentration measurements in groundwater in the absence of P&T operations. Data analysis and evaluation procedures used to demonstrate compliance with groundwater cleanup levels will be defined in a compliance monitoring plan prepared under WAC 173-340-410.

References: EPA et al., 2018, *Record of Decision Hanford 100 Area Superfund Site 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units, Hanford Site*.

WAC 173-340-410, “Model Toxics Control Act—Cleanup,” “Compliance Monitoring Requirements.”

*Ambient conditions occur when the aquifer is able to flow along natural lines and resume a stable hydrochemical state in the absence of P&T.

AWLN = automated water-level network

P&T = pump and treat

PSQ = principal study question

ROD = record of decision

The purpose of PSQ 7 is to determine if the data collected under the 100-H North Subarea addendum could support the transition to compliance monitoring (if appropriate). The decision of if and when a subarea can transition to compliance monitoring will not be made under this rebound studies parent SAP (DOE/RL-2021-23). It is the intention of the 100-H North subarea rebound study to produce information to be used in determining if the subarea can transition to compliance monitoring, but it is not the study's intention to make that determination. Because total chromium and nitrate are identified as a contaminants of concern in the 100-D/H ROD (EPA et al., 2018), total chromium and nitrate will be collected under PSQ 7 for informational purposes. Strontium-90 is another contaminant of concern identified in the 100-D/H ROD. Strontium-90 is not known to be present in this subarea and is excluded from the list of analytes at the 100-H North Subarea.

All wells identified in Table 1 are applicable to PSQ 1, PSQ 2, and PSQs 4 through 7. The alternative outcomes, which will determine actions to be completed based on the information collected, are included in Table A-1 of the rebound studies parent SAP (DOE/RL-2021-23).

Three types of data are required to effectively monitor the progress of the rebound study.

- Water-level measurements: manual measurement, automated water-level network (AWLN), and other pressure sensors.
- Analytical data: Cr(VI), total chromium, and major ion hydrochemistry (calcium, chloride, magnesium, nitrate, potassium, sodium, and sulfate) concentration measurements.
- Field parameters: specific conductance, pH, turbidity, dissolved oxygen, temperature.

4 Rebound Study Design

Information to be obtained during the rebound study includes water-level measurements, Cr(VI) and total chromium concentration measurements, major ion hydrochemistry, and field parameters (e.g., turbidity and dissolved oxygen). A 1-year study is planned to be initiated in 2022. Rebound study evaluations will be ongoing during the first year, and then a decision will be made to determine if sufficient data were collected to answer the PSQs applicable to the 100-H North Subarea. If data gaps or uncertainties are identified at the end of the first year, the U.S. Department of Energy, Richland Operations Office (DOE-RL) and Ecology Project Leads will make a collaborative decision on whether or not extending the rebound study would address the data gaps and resolve the applicable PSQs.

Uranium was not identified as a constituent of interest in the rebound studies parent SAP (DOE/RL-2021-23) and will be measured for informational purposes at a subset of wells in the 100-H North Subarea. The subset of wells, identified in Table 3, were selected based on a history of uranium detected at those locations. Requirements for sample analysis of total uranium is included in Table 2-3 of DOE/RL-2021-23. Laboratory quality control elements and acceptance criteria for total uranium is included in Table 2-5 of the rebound studies parent SAP (DOE/RL-2021-23).

4.1 Monitoring Well Network

For this rebound study, groundwater monitoring frequency will vary based upon the location of wells with respect to the Columbia River. Groundwater wells are identified as "inland" or "near-river" (Figure 9) based on proximity to the river and the presence or absence of downgradient wells. The "near-river" wells and aquifer tubes will be sampled monthly and the "inland" wells will be sampled every other month. Sampling frequencies may be increased at any time to address any unexpected conditions (e.g., unusually high river stages). The 100-HR-3 OU Lead, in consultation with DOE-RL and Ecology Project Leads, will determine if additional sampling is needed.

Table 3. Summary of Sample Design and Availability of Water-Level Sensors in the 100-H North Subarea

Well Name	Well ID	Well Type	Designation	Status of Water Level Sensor	Groundwater Constituents and Properties[a]																		
					Hexavalent Chromium (F)	Chloride (UF)	Fluoride (UF)	Nitrate (UF)	Phosphate (UF)	Sulfate (UF)	Calcium (F)	Magnesium (F)	Potassium (F)	Sodium (F)	Total chromium (F)	Alkalinity (UF)	Dissolved Oxygen	pH	Specific Conductance	Temperature	Turbidity	Water Level	Uranium (Total) (UF and F)
199-H3-25	C7110	Extraction	Inland	Sensor data available[b]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	--
199-H3-26	C7115	Extraction	Inland	Sensor data available[b]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	--
199-H3-27	C7114	Injection	Inland	Sensor data available[b]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	--
199-H3-2A	A4611	Monitoring	Inland	To be added to AWLN	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	--
199-H4-17	A4627	Injection	Inland	Sensor data available[b]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	--
199-H4-18	A4628	Monitoring/formerly injection	Inland	No sensor data[c]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	--
199-H4-65	B8759	Monitoring	Inland	No sensor data[c]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	--
199-H4-8	A4639	Monitoring	Inland	Currently in AWLN[d]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	BM
199-H4-84	C7860	Monitoring	Inland	Currently in AWLN[d]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	BM
199-H4-85	C8723	Monitoring	Inland	No sensor data[c]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	BM
199-H4-86	C8724	Extraction	Inland	Sensor data available[b]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	--
199-H4-88	C8734	Monitoring	Inland	To be added to AWLN	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	BM
199-H4-89	C9735	Monitoring	Inland	No sensor data[c]	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	BM	DS	DS	DS	DS	DS	DS	BM
199-H4-12A	A4616	Monitoring	Near-river	No sensor data[c]	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	DS	--
199-H4-15A	A4621	Extraction	Near-river	Sensor data available[b]	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	DS	--
199-H4-4	A4630	Extraction	Near-river	Sensor data available[b]	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	DS	--
199-H4-5	A4630	Monitoring	Near-river	Currently in AWLN[d]	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	DS	--
199-H4-64	B2777	Extraction	Near-river	Sensor data available[b]	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	DS	--
47-D	--	Aquifer tube	Near-river	--	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	--	--
47-M	--	Aquifer tube	Near-river	--	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	--	--
AT-H-1-M	--	Aquifer tube	Near-river	--	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	--	--
AT-H-2-D	--	Aquifer tube	Near-river	--	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	--	--
AT-H-3-D	--	Aquifer tube	Near-river	--	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	--	--
C6293	--	Aquifer tube	Near-river	--	M	M	M	M	M	M	M	M	M	M	M	M	DS	DS	DS	DS	DS	--	--

Table 3. Summary of Sample Design and Availability of Water-Level Sensors in the 100-H North Subarea

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					Hexavalent Chromium (F)	Chloride (UF)	Fluoride (UF)	Nitrate (UF)	Phosphate (UF)	Sulfate (UF)	Calcium (F)	Magnesium (F)	Potassium (F)	Sodium (F)	Total chromium (F)	Alkalinity (UF)	Dissolved Oxygen	pH	Specific Conductance	Temperature	Turbidity	Water Level	Uranium (Total) (UF and F)

Notes: Based on Section A3.2 of the rebound studies parent SAP (DOE/RL-2021-23, *Rebound Studies Parent Sampling and Analysis Plan for the 100-HR-3 Operable Unit, Hanford*), this rebound study is assumed to last up to a full river stage cycle (i.e., 12 months) to ensure adequate understanding of contaminant migration as a result of river stage.

Both filtered and unfiltered samples are collected for metals to help differentiate particulates from groundwater contamination. If additional samples require filtration (e.g., at turbidity greater than 5 NTUs), an inline, disposable 0.45 µm filter is used.

a. Identified constituents will be analyzed using the methods specified in Table 2-3 in the rebound studies parent SAP (DOE/RL-2021-23).

b. Water level data from sensors used to monitor groundwater levels during active P&T operations will be left in place during the rebound study. Water level data from these sensors can be used to supplement the monitoring network where AWLN stations are not already installed.

c. The well is not in the AWLN nor does it have a sensor installed. Only manual water level measurements will be available at this location.

d. Identified wells are equipped with AWLN transducers that will continue to operate during the rebound study at an hourly frequency.

-- = no data available or not applicable

AWLN = automated water-level network

BM = bimonthly; constituent will be sampled every other month

DS = during sampling

F = filtered

ID = identification

M = monthly; constituent will be sampled on a monthly basis

NTU = nephelometric turbidity unit

SAP = sampling and analysis plan

UF = unfiltered

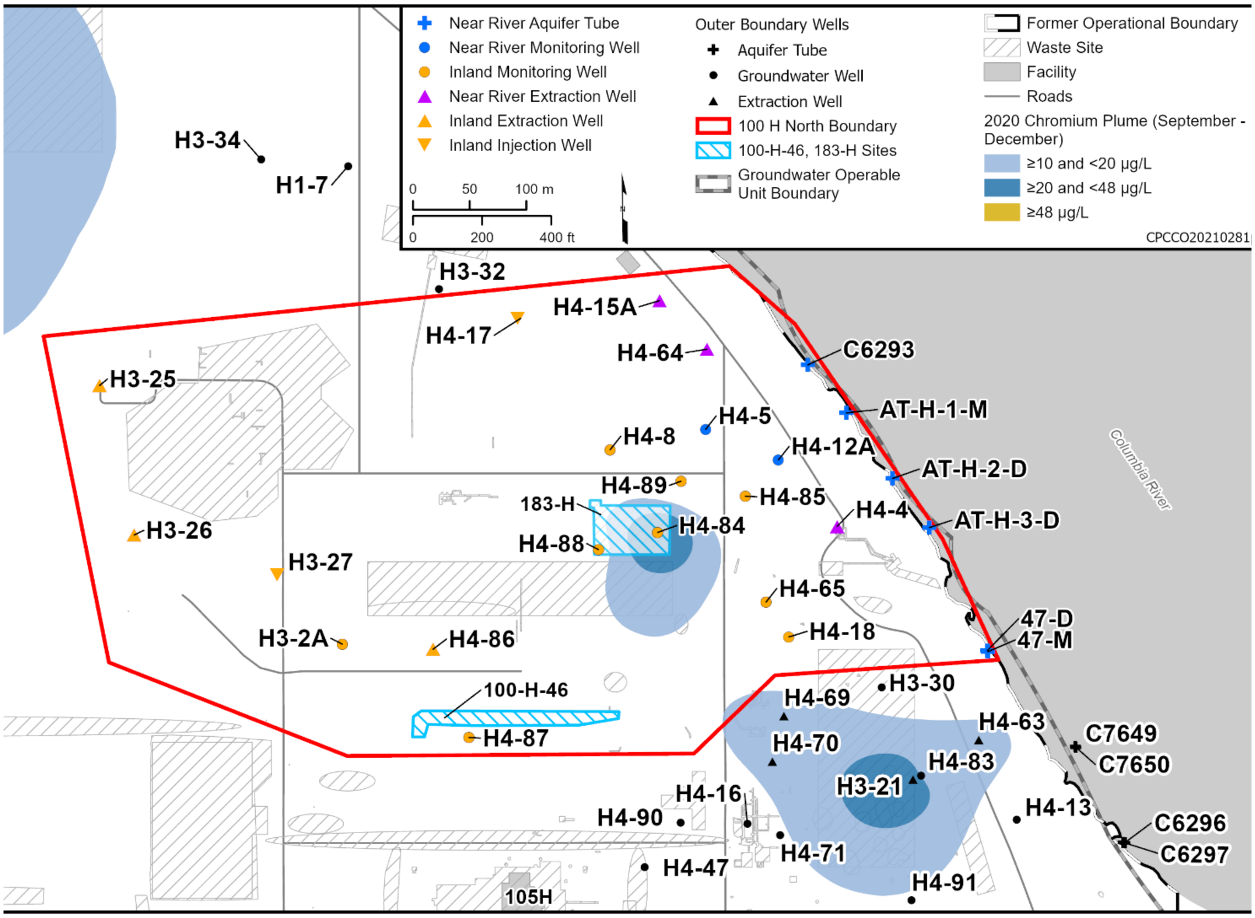

Figure 9. Near-River and Inland 100-H North Subarea Monitoring Locations

Table 1 provides the sampling locations during the 100-H North Subarea rebound study. The saturated screened intervals identified in Table 1 correspond to the saturated thicknesses shown in Figure 8. Six unconfined aquifer extraction and two injection wells identified in Table 1 will be turned off for the duration of the study. RUM extraction will remain in operation. If the 100-H North Subarea rebound study is successful with Cr(VI) levels below and expected to remain below ROD cleanup levels, the subarea may transition to compliance monitoring with the P&T system continued to be shut down.

4.2 Synchronous Water-Level Measurements

Time equivalent water-level measurements are essential for accurate hydraulic gradient and groundwater flow path estimation. Use of the AWLN ensures synchronous measurements. In addition, pressure sensors in the 100-H North Subarea injection and extraction wells will be queried to be synchronized to AWLN water-level measurements.

The locations of current and planned AWLN wells and P&T wells with pressure sensors are shown in Figure 10 and listed in Table 3.

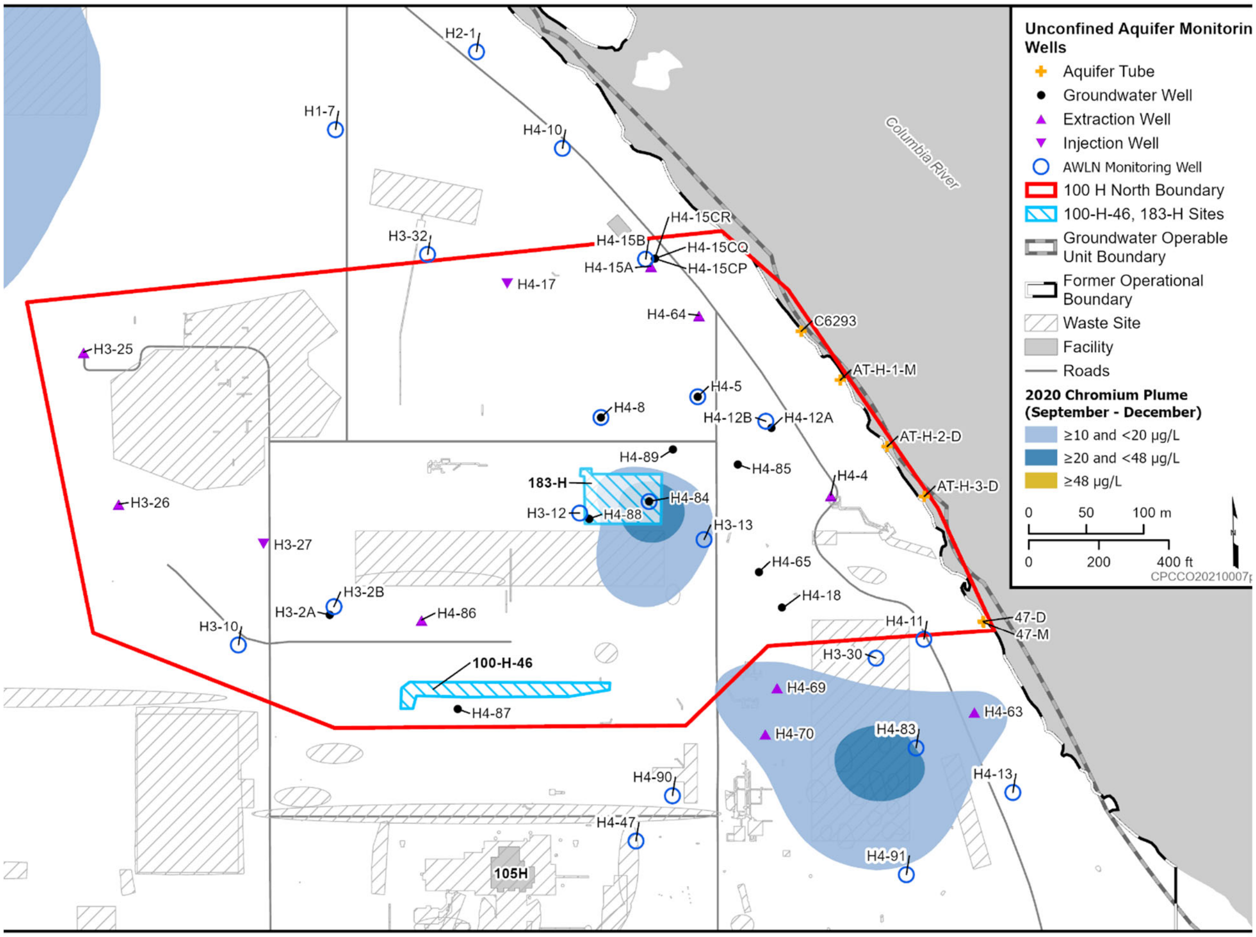

Figure 10. Current and Planned AWLN Wells and P&T Wells with Pressure Sensors

4.3 Groundwater Sampling

Table 3 summarizes the measurements to be collected and the frequencies that will be applied based on the identified PSQs. QA and quality control standards for sampling and analysis will be followed per the rebound studies parent SAP (DOE/RL-2021-23).

5 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data and reporting the results.

5.1 Data Review

Data review and verification are discussed in the QA project plan or Section 2.4.1 of the rebound studies parent SAP (DOE/RL-2021-23). In general, measurement data will be reviewed as they are received and will be verified through assessment against data quality objectives identified in Appendix A of the rebound studies parent SAP (DOE/RL-2021-23). Corrective actions and alternative outcomes will be reviewed and implemented as indicated based on the data review.

5.2 Statistical Evaluation

The primary objective of this area-specific rebound study is to detect and quantify changes in Cr(VI) concentrations in groundwater that are attributed to shutdown of P&T systems in the unconfined aquifer in the 100-H North Subarea to assess remedy completion. To this end, collected Cr(VI) data will be compared to pre-study concentrations and the ROD-specified groundwater cleanup levels. Those measurements will be evaluated using standard statistical techniques (e.g., hypothesis testing, trend analyses). For hypothesis testing, analysis of variance (ANOVA) will be used to compare the 100-H North subarea rebound data for Cr(VI), total uranium, or nitrate to pre-rebound data from the same wells. A statistically significant result from the ANOVA would indicate that the rebound could have resulted in a change in concentration. Trend analysis using tests such as Mann-Kendall would be performed to determine concentration trend presence in the pre-rebound and rebound data to examine for further influence of the rebound testing on contaminant concentrations.

5.3 Interpretation

Data from measurements and observations will be used to interpret groundwater conditions in the rebound study area. Interpretive techniques include the following:

- **Hydrographs**: Graph water levels versus time to determine decreases and increases and seasonal or manmade fluctuations in groundwater levels.
- **Water table maps**: Use water table elevations from multiple wells to construct contour maps and estimate flow directions. Groundwater flow is assumed to be perpendicular to the equal potential lines on the maps.
- **Trend plots**: Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations in contaminant concentrations. These graphs may be used in tandem with hydrographs and water table maps to determine if observed changes in concentrations relate to changes in water level or groundwater flow directions.
- **Plume maps**: Map distributions of chemical constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of groundwater flow.

5.4 Reporting and Notification

Results of the rebound studies will be discussed with DOE-RL and Ecology at least monthly, with a particular focus on any sample results with increasing Cr(VI) trends over 20 μg/L. Monitoring location concentrations will be evaluated during these discussions, and a collaborative decision will be made regarding any potential need to modify the rebound study. Specifically, plume maps, water level maps, and concentration trend plots will be prepared and presented to DOE-RL and Ecology as the basis for these discussions.

Following the 100-H North rebound study, a technical report will be prepared that describes the study and test conditions, summarizes measurements and observations, and includes recommendations for the remedial action.

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6 References

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Appendix A

100-D/H Rebound Study Planning Meeting Notes (March 29, 2021)

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100-D/H Rebound Study Planning Meeting

Meeting Date: March 29, 2021

On March 29, 2021, the individuals identified in Table 1 met to discuss a proposed sampling plan for a rebound study within a subarea of the 100-D/H Area. This sampling plan will be documented as Addendum 1 to the "Parent" Rebound Study sampling and analysis plan (SAP) (DOE/RL-2021-23, Decisional Draft, *Rebound Studies Parent Sampling and Analysis Plan for the 100-HR-3 Operable Unit, Hanford*).

Table 1. List of Attendees

First	Last	Representing
Steve	Balone	DOE-RL
Alicia	Boyd	Ecology
Garrett	Day	Ecology
Joe	Devary	Freestone
Zack	McGuire	Freestone
Travis	Hammond	CPCCo
Brian	Johnson	Ecology
Emily	Macdonald	CPCCo
Darrell	Newcomer	CPCCo
John	Sands	DOE-RL
Kim	Schuyler	Freestone
Sean	Sexton	CPCCo
Noe'l	Smith-Jackson	Ecology
John	Virgin	DOE-RL

CPCCo = Central Plateau Cleanup Company
DOE-RL = U.S. Department of Energy, Richland Operations Office
Ecology = Washington State Department of Ecology

The meeting objectives include agreement upon:

- The spatial extent of the first subarea rebound study
- Sample location and frequency
- Rebound study duration
- Permissible rebound levels and conditions upon which the rebound study would be terminated early
- Post-rebound study monitoring

The following is intended to capture the general nature of discussions that took place and to document agreements made during this meeting.

Introduction and Background

Emily Macdonald welcomed all to the meeting and introductions were made. She stated that the purpose of the meeting is to discuss the groundwater rebound study design for the first subarea in the 100-D/H Area. She identified that this meeting was meant to be collaborative and any feedback on the sample design is welcome and encouraged. The working session was then turned over to Travis Hammond (Technical Lead and Project Scientist) who walked through the meeting objectives and background information used to determine the location and size of the rebound study in the 100-H North subarea (as shown in slide 6 of SGW-66242-VA, *FY2022 Rebound Study for the 100-H North Subarea of the HR-3 Operable Unit*). He explained that information collected during the 100-H North subarea rebound study will support decisions needed to determine if and when (all or part of) the pump and treat (P&T) operations should be turned off.

Subarea Principal Study Questions, Data Needs, Monitoring Approach

The working session was then turned over to Kim Schuyler (primary author of the 100-H North subarea rebound SAP addendum) who presented the principal study questions (PSQs), data needs and uses, and monitoring approach. She explained that the PSQs were originally from the "Parent" Rebound Study SAP data quality objectives (DQO) workshop but were slightly modified during the planning process for the 100-H North subarea. It was noted that these changes were made to clarify the purpose of each PSQ and will not impact how the rebound studies are designed. She stated that the decisional draft of the "Parent" Rebound Study SAP has not yet been transmitted to U.S. Department of Energy, Richland Office (DOE-RL) and will include these updated PSQs. Alicia Boyd requested a red-line copy of the revised PSQs either in an email or attached to these meeting notes. (The red-line changes have been added to these meeting notes after the list of agreements.)

Kim said all of the revised PSQs from the "Parent" Rebound Study SAP (see slides 11 and 12 in SGW 66242-VA) are applicable to the 100-H North subarea with the exception of PSQ 3: <u>In areas where the source of Cr(VI) contamination is known or suspected, what is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations?</u> A vertical profile of contaminant distribution using depth discrete sampling is not practical due to the thinness of the unconfined aquifer and screened intervals within 100-H North subarea groundwater wells. The saturated screen thickness is such that seasonal fluctuations in water levels can make pumped groundwater sample collection impossible.

Emily clarified that PSQ 7 (<u>Can the project use the data to supplement compliance monitoring?</u>) in the 100-H North subarea addendum will not include specific language about compliance monitoring requirements because a compliance monitoring SAP has not yet been developed.

Kim discussed the data needs which includes water level measurements, Cr(VI) concentration measurements, major ion hydrochemistry, and field parameters (e.g., turbidity and dissolved oxygen). She stated that the proposed rebound study duration at the 100-H North subarea is one year, beginning in October 2021 within the area identified on slide 14 of SGW-66242-VA. She said the groundwater monitoring frequency will vary based upon the location of wells with respect to the Columbia River. For the purpose of this rebound study, groundwater wells were arbitrarily identified as "inland" or "near-river" (as seen on slide 14 of SGW-66242-VA). The wells identified as "near-river" are the closest to the Columbia River but it was noted that this does not mean those wells will be used as the points of compliance for cleanup. The designations were used solely to define the sample frequency. The "near-river" wells and aquifer tubes will be sampled monthly, and the "inland" wells will be sampled every other month.

Garrett Day asked if uranium concentrations will be measured around the 183-H Solar Evaporation Basin. Kim responded yes, and that it will be monitored under the 100-HR-3 OU monitoring SAP (DOE/RL-2017-13-ADD1, Draft A, *Groundwater Monitoring Sampling and Analysis Plan for the 100-HR-3 Groundwater Operable Unit*).

Kim asked the meeting attendees if there was a Cr(VI) concentration level at the "inland" wells that would necessitate samples to be collected more often than every other month. Alicia suggested that rather than having a specific concentration threshold for the "inland" wells, consider increasing the frequency to monthly if there is an increasing Cr(VI) concentration trend, regardless of concentration with respect to the cleanup levels. She recommended that the sample results be discussed with Ecology during the 100-HR-3 OU status meetings with DOE-RL. Kim clarified that language should be added to the 100-H North subarea addendum that states Ecology will be notified and sampling frequency at "inland" wells may be increased to monthly if <u>three consecutive Cr(VI) concentration measurements indicate an increasing trend</u>. The meeting attendees agreed. Emily clarified that this would not be a condition in which the rebound study would be ended prematurely, but rather a condition in which to discuss sampling frequency with an upward trend. Kim stated that adding this language to the 100-H North subarea addendum would eliminate the need for a Tri-Party Agreement change notice.

The meeting attendees agreed that sampling the "near-river" wells and aquifer tubes monthly was acceptable and contingent language on increasing the sampling frequency was not needed.

Kim then discussed the proposed water level monitoring network which includes wells already in the Automated Water Level Network (AWLN), wells that should be added to the AWLN, and extraction/injection wells that already have sensors installed but are not connected to the AWLN. Joe Devary stated the project needs time equivalent water level measurements to help with data interpretation. John Virgin inquired if the 100H Columbia River gage was still functional. Alicia asked where it was located with respect to the 100-H North subarea. Travis indicated the gage is still working and located at the northern most point of the 100H Operation Boundary which is outside of the 100-H North subarea. The meeting attendees agreed upon the water level monitoring network as identified on slide 16 of SGW-66242-VA.

Garrett asked if there were any extraction wells in the uppermost water-bearing unit in the Ringold Formation upper-mud unit (RUM) in the subarea and if they would be turned off. Kim responded that the RUM extraction wells would continue to operate but acknowledged that additional data may be collected by the team performing RUM aquifer characterization. She explained that the project recognizes that there is some interconnection between the unconfined aquifer and the uppermost water-bearing unit in the RUM but the rebound study does not include RUM aquifer characterization at this time so it would be inappropriate to collect that data under the 100-H North subarea rebound study. Alicia agreed that we don't want to characterize the RUM in this study, but we want to know what is going on in these wells, and that the RUM wells be stable, note whether any went off or came online during the study. Kim agreed and said the rebound study team will work closely with the RUM characterization team (through the OU Technical Lead) to ensure coordination and sharing of information (e.g., initiation of the rebound study, notification of when RUM extraction wells are turned on/off). Darrell Newcomer said Pacific Northwest National Lab (PNNL) just released a study on the hydrologic evaluation of the Ringold upper mud aquifer in the 100-H Area. Garrett requested a copy of the report or a document number.

Early Termination and Post-Rebound Study Monitoring

Kim said that since the study area is adjacent to the Columbia River, we need to be cognizant of Cr(VI) concentrations at monitoring locations near the shoreline. She proposed an evaluation of concentration data if any of the "near-river" wells have three consecutive concentration measurements ≥ 48 µg/L or three consecutive concentration measurements ≥ 10 µg/L at the aquifer tubes. We would notify Ecology and discuss the possibility of terminating the rebound study before the end of the 12 month study duration. She asked Ecology if that seemed reasonable. Alicia thought 48 µg/L was too high and that it's an arbitrary number pertaining to human health specified in the ROD. She would be more comfortable with a lower concentration. Emily noted that we would need some technical justification for a different value and asked Ecology if they had a recommendation. Alicia recommended 2 times the compliance number from the interim action record of decision (ROD) (EPA/ROD/R10-96/134), which would be 20 µg/L. Emily said we may need to look for precedent for using a concentration value that isn't in the final ROD. Alicia noted that these are likely to become "compliance wells", and we will likely need to evaluate these wells at 10 µg/L. Emily said that until we have a compliance monitoring SAP, we will not have an answer to whether these are compliance monitoring wells for 10 µg/L. Kim agreed that in theory, these wells could be used for that 10 µg/L point of compliance level, but we are concerned that we may not decide on that level soon enough, and if that level isn't decided on soon it could jeopardize the initiation of the rebound study. Noe'l Smith-Jackson recommended using the PQL of 10.5 µg/L. John Virgin recommended that we move on from the compliance level for now so DOE-RL can regroup and decide what they are prepared to present.

Kim moved on to the discussion of PSQ 7 (Can the project use the data to supplement compliance monitoring?) in terms of what happens at the end of the 12-month rebound period. She noted that there will be a time lag between the end of the rebound study and when a decision is made on whether or not to restart P&T at the 100-H North subarea. Do we need to continue monitoring Cr(VI) during that period? Since we don't have a compliance monitoring SAP yet, we have no way to evaluate the data quality for that purpose. The only thing we can really surmise is that compliance monitoring will likely require more frequent sampling than what is prescribed in the 100-HR-3 OU performance monitoring SAP (DOE/RL-2017-13-ADD1). Alicia said that isn't quite the problem she had in mind. She wasn't concerned with a "bridge" (monitoring frequency requirements post-rebound study). Her concern was if the data collected during the last 3 months of the rebound study would be of the appropriate quality to use perhaps for compliance monitoring. Kim said we don't have a compliance monitoring SAP, so we can't know that for sure. Alicia said the only thing that needs to be nailed down is the data quality and appropriate sampling methods and detection levels for compliance monitoring. Kim asked where those requirements come from (the WAC?). The current Comprehensive Environmental Response, Compensation, and Liability Act SAP requirements for a quality assurance project plan (QAPjP) are standardized across the Hanford Site. What aspect of the Hanford Site QAPjP wouldn't meet compliance monitoring QC requirements? Noe'l said Ecology would evaluate the QAPjP in the "Parent" Rebound Study SAP once it is transmitted to Ecology for review.

Kim stated that we still need to address what happens after the 12 month study: do we leave all the pumps off or change monitoring approach? Emily said we should hold off on this question. If the question is whether the data are of the appropriate quality, we will be looking at the appropriate levels for the compliance monitoring SAP. John Virgin said it comes down to what frequency we will propose. The methods will be appropriate, it's a question of frequency depending on the concentrations.

Alicia said that part of what we are considering was depth discrete sampling which cannot be used for compliance monitoring. Garrett noted that 100-K was looking at one sample near top of screen and one near bottom. He said he is a proponent of consistency across an area. He agrees that there should be a cutoff for a screened interval for depth discrete sampling.

Kim discussed outcomes and expectations of the 100-H North subarea rebound study and summarized the list of agreements made during the meeting which included spatial extent and area of study, duration of rebound study, data needs, monitoring network, and sample collection frequency. She said initial field planning tasks can begin but the 100-H North subarea rebound SAP addendum may not be ready to submit to Ecology for review by early July 2021. Alicia asked if it matters when the study begins. Kim said the project made a goal to initiate the study in October 2021 but if the study covers a full 12 months, it doesn't matter when it begins.

Emily asked if there were any more questions. Alicia said DOE-RL should look at having a DQO/SAP process in place by October 2022 so that the decision about transitioning to compliance monitoring can be made rather than needing some alternate sampling plan/frequency. John Virgin and John Sands agreed. Emily said if there weren't any other questions, we'll work to incorporate Ecology's input and if needed, we will consider scheduling a follow-up after we can come up with a proposal internally.

Actions

- Provide to Alicia Boyd the red-line changes made to the original PSQs developed during the "Parent" Rebound Study SAP DQO session. (Red-line changes to the PSQs are included at the end of the meeting notes.
- Darrell Newcomer will provide to Garrett Day the 2020 PNNL report on RUM characterization (PNNL-30467, *Hydrologic Evaluation of the Ringold Upper Mud Aquifer in the 100-H Area of the Hanford Site*).
- DOE-RL and CPCCo will internally discuss the use of a lower Cr(VI) concentration action level at which the rebound study may be prematurely ended.
- DOE-RL and CPCCo will internally discuss the post-rebound study monitoring needs and the schedule for preparing a compliance monitoring SAP.
- DOE-RL and CPCCo will internally discuss scheduling and development of a compliance monitoring SAP.

Agreements

- The spatial extent and monitoring network of the 100-H North subarea will be as shown on slide 6 of SGW-66242-VA.
- The rebound study duration will be one year with the option to extend, if needed.
- Minor revisions to the original PSQs identified during the December 3, 2020 DQO workshop were acceptable.
- The data needed to address PSQs 1, 2, 4, 5, and 6 as identified on slides 11 and 12 of SGW-66242-VA. Specific data needs are identified on slide 13 of SGW-66242-VA.
- Frequency of groundwater sample collection at locations identified as either "inland" or "near-river" as shown on slide 15 of SGW-66242-VA.

- Language will be added to the addendum stating that Ecology will be notified and sampling frequency at "inland" wells may be increased to monthly if three consecutive Cr(VI) concentration measurements indicate an increasing trend.
- The locations at which groundwater levels could be measured continuously as identified on slide 16 of SGW-66242-VA.

Red-line changes to PSQs from the "Parent" Rebound Study SAP DQO workshop:

- PSQ1: What is the magnitude and spatial extent of Cr(VI) concentration rebound in the absence of P&T?
- PSQ2: In the absence of P&T operations, are Cr(VI) concentrations below OR anticipated to meet the ROD inland cleanup level of 48 µg/L and surface water cleanup level of 10 µg/L and expected to remain below cleanup levels?
- PSQ3: In areas where the source of Cr(VI) contamination is known or suspected, what is the vertical distribution of Cr(VI) within the unconfined aquifer in the absence of P&T operations?
- PSQ4: How is the aquifer within the rebound study areas affected hydraulically following shutdown of P&T?
- PSQ5: Has groundwater hydrochemistry reverted to ambient conditions?
- PSQ6: What are the seasonal effects in groundwater Cr(VI) concentrations within the rebound study area due to river stage?
- PSQ7: Can the project use the data to supplement compliance monitoring?