SGW-58690
Revision 0

Remedial Process Optimization Work Plan for 100-HR-3 and 100-KR-4 Groundwater Operable Units Interim Action

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

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

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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APPROVED
By Julia Raymer at 8:28 am, Jun 06, 2016

Release Approval Date

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Terms

100AGWM	100 Area groundwater model
ALARA	as low as reasonably achievable
AWLN	automated water level network
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFM	capture frequency map
COC	contaminant of concern
CSM	conceptual site model
CTZ	composite target zone
CUL	cleanup level
CY	calendar year
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DWS	drinking water standard
E/I	extraction/injection
ECF	environmental calculation file
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESD	explanation of significant difference
EW/IW	extraction well/injection well
FEP	features, events, and processes
FY	fiscal year
FSB	fuel storage basin
GW	groundwater (used only in figures)
GWM	groundwater monitoring (used only in figures)
HHE	human health and the environment
IC	institutional control
ISRM	in situ redox manipulation

IX	ion exchange
LPF	layer-property flow
LRA	lead regulatory agency
MNW	multinode well
N/A	not applicable
O&M	operations and maintenance
OU	operable unit
P&T	pump-and-treat
POM	pumping optimization model
PVT	Plume Visualization Tool
QA	quality assurance
RAO	remedial action objective
RD/RAWP	remedial design/remedial action work plan
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RPO	remedial process optimization
RUM	Ringold Formation upper mud
S&GRP	Soil and Groundwater Remediation Project
SAP	sampling and analysis plan
SCADA	system control and data acquisition
SCAT	Specific Capacity Analysis Tool
SGW	soil and groundwater
SMR	Sample Management and Reporting
TM	technical memorandum
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
UMM	unit managers meeting
USGS	U.S. Geological Survey
WMP	well maintenance plan

1 Introduction

Remedial process optimization (RPO) is a dynamic process used to evaluate active remediation systems with the overall objective of identifying design or operational modifications to improve remedy performance while potentially reducing life cycle costs. The overarching goal of RPO is to accelerate the time to achieve remedial action objectives (RAOs) by improving the effectiveness and efficiency of the remedy while accelerating progress towards site closure (EPA 542-R-07-007, *Optimization Strategies for Long-Term Ground Water Remedies (with Particular Emphasis on Pump and Treat Systems*). This can translate into increased protectiveness while also reducing costs.

This document describes the approach for pump-and treat (P&T) system RPO. It describes the tools and processes that have been developed for use in optimizing the groundwater P&T systems operating at the Hanford Site 100-HR-3 and 100-KR-4 Groundwater Operable Units (OUs).

1.1 Purpose and Objectives

Successful RPO requires development of a series of related tasks that, when implemented, enable and promote the objective of remedy optimization. The purpose of this document is to describe tasks that are envisioned (as of its publication) to meet the objective, emphasizing the development of a set of processes and associated tools that facilitate systematic performance analysis and optimization. These tools and processes help guide current and future operations, such that the overall goals of protecting the Columbia River and restoring groundwater for potential beneficial use are achieved in a cost-effective and technically efficient manner.

The RPO approach provides an overall strategy for continuing optimization of groundwater remedies over the life of the remedial actions and guiding development of regular remediation activity and planning summaries. A description is provided for baseline activities and other activities to be performed on a routine or periodic basis. The timing of activities and associated documentation and reporting are also identified. The objective is to facilitate a more refined and systematic optimization process.

1.2 Background

The U.S. Department of Energy (DOE) currently operates and maintains five ion exchange (IX) P&T systems as part of ongoing efforts to remediate hexavalent chromium (Cr(VI))-contaminated groundwater at the Hanford Site 100-HR-3 and 100-KR-4 OUs. Descriptions of these OUs and remedial systems are provided in Hanford Site annual reports (e.g., DOE/RL-2015-05, *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation*, and DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*).

The following subsections provide background information on the basis for action, waste site remediation, conceptual site models (CSMs), and status of P&T system operations for both OUs. The baseline tasks were developed based on calendar year (CY) 2014 status.

1.2.1 Basis for Action

The 100-HR-3 and 100-KR-4 OUs are located in the Hanford Site River Corridor. The 100-HR-3 OU includes groundwater below the 100-D and 100-H Reactor areas and the area in between known as the Horn. Groundwater in this area was contaminated by planned and unplanned releases associated with past operations of the 105-D, 105-DR, and 105-H Reactors and associated support facilities. Descriptions of the features, events, and processes (FEPs) that resulted in groundwater contamination are presented 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*). The 100-KR-4 OU includes groundwater below the 100-K Area and contaminated groundwater from 100-KR-1 and 100-KR-2 Source OUs. Groundwater in this OU was contaminated by

planned and unplanned releases associated with past operations of the 105-KE and 105-KW Reactors and associated support facilities. Descriptions of FEPs that resulted in groundwater contamination are presented in the 100-K RI/FS report (DOE/RL-2010-97, Draft A, *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*).

Groundwater P&T technology was first implemented as an interim action in each OU in accordance with the 1996 interim action record of decision (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*), which states the following:

> *The interim action is expected to provide adequate protection of human health and ecological receptors in the Columbia River and will continue until implementation of the final remedy for the 100-HR-3 and 100-KR-4 groundwater operable units, or until such time that the DOE demonstrates to Ecology and the EPA that no further interim action is required. This interim action is expected to become part of the final remedial action for the 100-HR-3 and 100-KR-4 Operable Units.*

The following RAOs are established in the interim action ROD (EPA/ROD/R10-96/134):

- Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.
- Protect human health by preventing exposure to contaminants in the groundwater.
- Provide information that will lead to the final remedy.

The 1996 interim action ROD (EPA/ROD/R10-96/134) specified installation of a P&T system in the 100-HR-3 and 100-KR-4 OUs to intercept Cr(VI) plumes that affect the Columbia River in order to protect aquatic receptors from contaminants in groundwater. The interim action ROD (EPA/ROD/R10-96/134) also identified the application of institutional controls (ICs) to prevent removal of contaminated groundwater for consumptive purposes and restrict access to areas where exposure to groundwater (i.e., seeps and springs) may occur for protection of human health. Ongoing evaluations, including information from the tasks described in this document, will provide information to support the final remedy.

Final remedy development will be based on results of the 100-D/H and 100-K RI/FS reports (DOE/RL-2010-95 and DOE/RL-2010-97, respectively). RAOs specified in the final RODs for each groundwater OU will replace RAOs specified in the 1996 interim action ROD (EPA/ROD/R10-96/134). Final RAOs for both OUs are expected to be similar to those presented in the 100-D/H RI/FS (DOE/RL-2010-95) for 100-HR-3 OU groundwater, which 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 containing contaminant concentrations above federal and state standards and risk-based thresholds.
- **RAO 7:** Restore groundwater impacted by 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 releases to proposed cleanup levels (CULs), which include drinking water standards (DWSs), within a time frame that is reasonable, given the particular circumstances of the site.

These RAOs address the objective goals for the protection of human health and the environment (HHE) at the 100-HR-3 and 100-KR-4 Groundwater OUs.

RAO 1 is achieved through maintaining ICs that restrict groundwater use. The RPO approach describes the tasks to be implemented that will yield a set of tools and processes to guide current and future P&T system operations such that RAOs 2 and 7 are achieved as quickly and efficiently as possible. Existing P&T systems are interim actions, designed to protect aquatic receptors in the Columbia River from exposure to Cr(VI) and restore groundwater to potential beneficial use. Their design and implementation have been conducted such that they can be a component of the final remedy, and they are proposed as such in the remedial alternatives identified in the 100-D/H and 100-K RI/FS reports (DOE/RL-2010-95 and DOE/RL-2010-97, respectively). Therefore, the RPO recommendations and tasks presented herein are expected to translate to the operation of final groundwater remedies in the 100-HR-3 and 100-KR-4 OUs once they are identified.

1.2.2 Waste Site Remediation

An integral factor in implementing an effective P&T remedy is source control. Waste site remedial action began in the 100-D/H Area in 1995 under EPA/ROD/R10-95/126, *Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington*. In the 100-K Area, waste site cleanup was initiated in 2002 under EPA/ROD/R10-99/039, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington (100 Area Remaining Sites)*. These interim actions consisted primarily of removal, treatment, and disposal followed by backfill and revegetation. Waste site descriptions are provided in the 100-D/H and 100-K RI/FS reports (DOE/RL-2010-95 and DOE/RL-2010-97, respectively).

The status of waste site remediation for the 100-D/H Area was estimated at 87 percent complete at the end of CY 2014. For the 100-K Area, an estimated 59 percent of waste site remediation was complete at the end of CY 2014 (DOE/RL-2015-07).

1.2.3 Conceptual Site Models and Interim Remedies

Understanding the CSM at a groundwater OU is a fundamental element of overall RPO. Remedial actions must incorporate the key elements of the CSM to ensure timely completion of the remedy. The following subsections describe key elements of the CSMs at the 100-HR-3 and 100-KR-4 OUs and interim remedial actions implemented to date.

1.2.3.1 100-HR-3 OU CSM and Remedy Description

A detailed description of the 100-HR-3 OU CSM is presented in the 100-D/H RI/FS report (DOE/RL-2010-95). Essential elements of the CSM relevant to RPO activities are primary and secondary sources of contamination, release mechanisms, and potential exposure points. Existing plumes for contaminants of concern (COCs) identified in the 100-D/H RI/FS report (DOE/RL-2010-95) at the 100-HR-3 OU and related CSM elements are described in Table 1-1.

Groundwater remedial actions at the 100-HR-3 OU have been conducted under the following:

- 1996–interim action ROD (EPA/ROD/R10-96/134)
- 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*)
- 2003–EPA/ESD/R10-03/606, *Explanation of Significant Difference for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*

- 2009–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*

- 2010 – 11-AMCP-0002, "Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Washington, July 2010, Memo to File Regarding: Supplemental Actions for the In-Site Reduction/Oxidation Manipulation Barrier Performance for the 100-HR-3 Groundwater Operable Unit Interim Remedy"

Groundwater remediation by extraction and treatment was initiated in 1997 under the interim action ROD (EPA/ROD/R10-96/134) with startup of the first P&T system (HR-3). The objective of the groundwater remediation systems is to remove Cr(VI) contamination from groundwater and address immediate threats to the Columbia River. Installation of an in situ redox manipulation (ISRM) barrier as a new technology for treating Cr(VI)-contaminated groundwater in the 100-D Area was conducted under the 1999 interim action ROD amendment (EPA/AMD/R10-00/122) and 2003 explanation of significant difference (ESD) (EPA/ESD/R10-03/606). A second pump-and-treat system, DR-5, was installed to treat groundwater in the 100-D Area. The ISRM barrier did not achieve the required level of performance for treatment and resulted in a determination from the Washington State Department of Ecology (Ecology) and U.S. Environmental Protection Agency (EPA) that expansion of the P&T system would provide a better remedy for this area. The initial two P&T systems (DR-5 and HR-3) were replaced with expanded system (DX and HX) to include additional treatment capacity under the 2009 ESD (EPA et al., 2009). The 2010 memorandum (11-AMCP-0002) identifies the decision to discontinue maintaining the ISRM barrier. Table 1-2 identifies the P&T system operating history for the 100-HR-3 OU.

A summary of the P&T systems performance during 2014 is presented in Table 1-3. The annual P&T reports (e.g., DOE/RL-2015-05) provide detailed descriptions of current system operations.

1.2.3.2 100-KR-4 OU CSM and Remedy Description

A detailed description of the CSM for the 100-KR-4 OU is presented in the 100-K RI/FS report (DOE/RL-2010-97). Essential elements of the CSM relevant to RPO activities are primary and secondary sources of contamination, release mechanisms, and potential exposure points. Existing COC plumes identified in the 100-K RI/FS report (DOE/RL-2010-97) at the 100-KR-4 OU, and their related CSM elements, are described in Table 1-4.

Groundwater remedial actions at the 100-KR-4 OU have been conducted under the interim action ROD (EPA/ROD/R10-96/134) and ESD (EPA et al., 2009).

Groundwater remediation using extraction, treatment, and injection techniques was initiated in 1997 under the interim action ROD (EPA/ROD/R10-96/134) with installation of the 100-KR-4 system. The objective of the groundwater remediation system was to remove Cr(VI) contamination from groundwater and address immediate threats to the Columbia River. The 100-KR-4 system removes and treats groundwater downgradient of the 116-K-2 Trench site. Two additional P&T systems were added in 2007 (100-KW) and 2009 (100-KX). The KW system came online in 2007 to remove and treat the Cr(VI) plumes associated with the 105-KW Reactor. The KX system removes and treats the Cr(VI) plumes near the 105-KE Reactor and the extremities of the 116-K-2 Trench site. Table 1-5 identifies the P&T system operating history for the 100-KR-4 OU.

A summary of the P&T systems performance during 2014 is presented in Table 1-3. The annual P&T reports (e.g., DOE/RL-2015-05) provide detailed descriptions of current system operations.

Table 1-1. Elements of the CSM at the 100-HR-3 Operable Unit

Plume Segment	Source	Release Mechanism	Source Remedy Status	Remaining or Potential Source	Transport Mechanism
Cr(VI) at 100-D South Plume	Sodium dichromate solutions released at transfer line	Leaks, spills, and limited intentional release to ground	Remediation into the top of the aquifer sediment at 100-D-100	Potential Cr(VI)-contaminated aquifer material below the depth of remediation; potential for chromate-substituted calcite near RUM surface	Release from aquifer sediment into groundwater and groundwater migration
Cr(VI) at 100-D North Plume	120-D-1/100-D Ponds	Intended use as a percolation pond treating approximately 170,000 L (45,000 gal) per day	Closure of the ponds as a treatment, storage, and/or disposal facility was accepted in a letter from Ecology on August 27, 1999 (Soper, 1999).	Test pit 120-D-1-TP1 indicates chromium remains in the vadose zone. No known excavation was conducted.	Release from vadose zone into groundwater and groundwater migration
	100-D-31 underground pipelines transporting prereactor cooling water	Leaks to vadose zone	Pipelines have been remediated; no visible signs of leaking were observed during excavation (some sections of pipe were left in place).	Potential Cr(VI)-contaminated vadose zone	Release from vadose zone into groundwater and groundwater migration
Cr(VI) at 100-D, North Area	Contaminated cooling water discharged during 1967 infiltration test at 116-DR-1&2 Trench	Intentional release to ground	Groundwater remediation is ongoing; current P&T injection wells may be masking the full extent of contamination.	N/A	Groundwater migration
Cr(VI) in the Horn	Contaminated cooling water discharged during 1967 infiltration test at 116-DR-1&2 Trench	Intentional release to ground	Groundwater remediation is ongoing.	N/A	Groundwater migration
Cr(VI) and Tritium at Well 199-D4-20	118-D-2/100-D Burial Ground 2: potential contaminants include Cr(VI) and others not identified as COCs	Release to vadose zone from leakage at burial ground	The site has been remediated to a depth of 7.5 m (24.6 ft) bgs, with groundwater at 25.9 m (85 ft) bgs.	Potential Cr(VI) and other contaminants in the vadose zone	Release from vadose zone into groundwater and groundwater migration
		Application of large volumes of water, causing release from soil to groundwater	Large volumes of water were used to extinguish a fire in 1958 that potentially washed contaminants into the groundwater.	Potential Cr(VI) and other contaminants in the groundwater	Release from vadose zone into groundwater and groundwater migration
Cr(VI) at Well 199-D5-103	100-D-56 sodium dichromate supply lines	Leaks to vadose zone	The waste site has been remediated; the potential for incomplete remediation near the pipeline break is based on photographs and remaining groundwater contamination levels.	Cr(VI)-contaminated lower vadose zone and groundwater	Release from vadose zone into groundwater and groundwater migration
	100-D-30 sodium dichromate trench and sump, spill/100-D-104 sodium dichromate storage tank, French drain, and unplanned release	Leaks and spills to ground	Remediation into the aquifer sediment at 100-D-30/100-D-104	Potential Cr(VI) contamination in aquifer material below the depth of remediation; potential for chromate-substituted calcite	Release from aquifer sediment into groundwater and groundwater migration
			Potential for incomplete excavation to the south	Potential Cr(VI) in vadose zone and aquifer material to the south of the excavation boundary	Release from vadose zone into groundwater; release from aquifer sediment into groundwater and groundwater migration
Strontium-90 near 105-D Reactor	105-D Reactor and FSB	Leaks and spills to vadose zone	The reactor has been put into interim safe storage, and about 80% of the reactor area footprint has been remediated; potential releases from the FSB (however, none are documented) and other areas near the reactor, such as piping lines, had potential for leakage	Potential for strontium-90 to remain present in the lower vadose zone	Release from vadose zone into groundwater; release from aquifer sediment into groundwater and groundwater migration

Table 1-1. Elements of the CSM at the 100-HR-3 Operable Unit

Plume Segment	Source	Release Mechanism	Source Remedy Status	Remaining or Potential Source	Transport Mechanism
Strontium-90 at 116-H-1 Trench and 116-H-7 Retention Basin	Contaminated cooling water discharged to ground during reactor operations	Leaks and spills to ground; estimated rate of leakage from the retention basins as high as 19,000 to 38,000 lpm (5,000 to 10,000 gpm)	Excavation of contaminated soil to a depth of 4.6 m (15 ft) bgs	Strontium-90-contaminated soil remains below 4.6 m (15 ft) bgs.	Release from vadose zone into groundwater; release from aquifer sediment into groundwater and groundwater migration
Cr(VI) at 100-H-46	Dry and liquid sodium dichromate releases related to the 190-H Process Building	Leaks and spills to ground	Excavation of contaminated soil to the periodically rewetted zone	The excavation was completed during high river stage; residual material appears to be present in the periodic rewetted zone, based on groundwater contamination and response to seasonal fluctuations.	Release to groundwater from periodically rewetted zone and groundwater migration
Cr(VI), Nitrate, and Uranium at 183-H	Release from 183-H Solar Evaporation Basins during operations	Leaks from the basins	The site has been excavated to a depth of 4.6 m (15 ft) below Basin 1 (approximately 9 m [30 ft] bgs).	Based on groundwater contamination and the response to seasonal fluctuations, it appears that contaminated soil remains below the waste site from 9 m (30 ft) bgs at Basin 1 to groundwater at a depth of 13 m (42 ft) bgs	Release to groundwater from periodically rewetted zone and groundwater migration
Cr(VI) in the Horn – RUM	Contaminated cooling water discharged during 1967 infiltration test at 116-DR-1&2 Trench	Intentional release to ground	N/A	N/A	Increased hydraulic head from groundwater mound during operations and groundwater migration
Cr(VI) at 100-H – RUM	Contaminated cooling water discharged to ground during reactor operations	Leaks and spills to ground. Estimated rate of leakage from the retention basins as high as 19,000 to 38,000 lpm (5,000 to 10,000 gpm)	Ongoing groundwater remediation	N/A	Increased hydraulic head from groundwater mound during operations and groundwater migration

Reference: Soper, 1999, "100-D Ponds Closure (TSD # D-1-1)" (external letter to Keith A. Klein, U.S. Department of Energy, and Steven D. Leidle, Bechtel Hanford, Inc.).

bgs = below ground surface
COC = contaminant of concern
Cr(VI) = hexavalent chromium
CSM = conceptual site model
Ecology = Washington State Department of Ecology
FSB = fuel storage basin
N/A = not applicable
P&T = pump-and-treat
RUM = Ringold Formation upper mud

Table 1-2. 100-HR-3 OU P&T Operating History

P&T System	Operating Period	Volume Pumped (ML [Mgal])	Cr(VI) Removed (kg [lb])
HR-3	June 1997 until shutdown in May 2011	4,171 (1,102)	406 (895)
DR-5	July 2004 until shutdown in March 2011	386 (102)	338 (745)
DX	December 2010 through December 2014	4,296 (1,135)	1,403 (3,093)
HX	September 2011 through December 2014	4077 (1,077)	93 (205)

Cr(VI) = hexavalent chromium
OU = operable unit
P&T = pump-and-treat

Table 1-3. 2014 P&T Performance Summary

Groundwater OU	100-HR-3		100-KR-4		
P&T System	DX	HX	KW	KR4	KX
Design capacity (lpm [gpm])	2,273 (600)	3,030 (800)	758 (200)	1,136 (300)	2,273 (600)
Extraction wells	44	31	11	12	18
Injection wells	10	14	4	5	9
Average flow rate (lpm [gpm])	2,233 (589)	2,240 (591)	1,105 (292)	1,002 (265)	2,278 (601)
Volume treated (ML [Mgal])	1,174 (310)	1,178 (311)	580 (153)	527 (139)	1,199 (316)
Cr(VI) mass removed (kg)	178.7	22.8	19.4	5.0	25.8
Average Cr(VI) influent concentration (µg/L)	145	20.3	22.0	9.5	21.5
Average Cr(VI) effluent concentration (µg/L)	<2	<2	<2	<2	<2

Cr(VI) = hexavalent chromium
OU = operable unit
P&T = pump-and-treat

Table 1-4. Elements of the CSM at the 100-KR-4 OU

Plume Segment	Source	Release Mechanism	Source Remedy Status	Secondary Source	Transport Mechanism
Cr(VI) at 105-KW Reactor	Sodium dichromate solutions released at 100-KW Head House Tank Farm	Leaks, spills, and limited intentional release to ground and French drain	Shallow remediation; interim closed	Cr(VI)-contaminated vadose zone soil 183-KW Head House	Leaching to groundwater and groundwater migration
Cr(VI) at 105-KE Reactor	Sodium dichromate solutions released at KE Head House Tank Farm	Leaks, spills, and limited intentional release to ground and French drain	Not remediated	Cr(VI)-contaminated surface and subsurface soil 183-KE Head House	Leaching to groundwater and groundwater migration
Strontium-90 and Tritium at 105-KW Reactor	Contaminated FSB water	Engineered release of contaminated water to ground via crib/reverse well	Not remediated	Contaminated vadose zone soil 116-KW-1 Gas Condensate Crib	Leaching to groundwater and groundwater migration
Strontim-90 and Tritium at 105-KE Reactor	Contaminated FSB water	Leak in FSB and engineered release of contaminated water to ground via crib/reverse well	Shallow remediation; interim closed	Contaminated vadose zone soil 116-KE-3 105-KE FSB Crib/Reverse Well	Leaching to groundwater and groundwater migration
Carbon-14, Nitrate, and Tritium at 105-KW Reactor	Reactor gas dryer condensate	Engineered release of contaminated water to ground via crib	Shallow remediation; interim closed	Contaminated subsurface soil 116-KW-1 Gas Condensate Crib	Leaching to groundwater and groundwater migration
Carbon-14 and Tritium at 105-KE Reactor	Reactor gas dryer condensate	Engineered release of contaminated	Shallow remediation; interim closed	Contaminated subsurface soil	Leaching to groundwater and groundwater migration

Table 1-4. Elements of the CSM at the 100-KR-4 OU

Plume Segment	Source	Release Mechanism	Source Remedy Status	Secondary Source	Transport Mechanism
		water to ground via crib		116-KE-1 Gas Condensate Crib	
Tritium at 118-K-1 Burial Ground	Tritium in radiologically contaminated solid waste	Direct burial of solid waste in burial ground	Shallow remediation; interim closed; new waste site (100-K-132) created	Contaminated subsurface soil 118-K-1 Burial Ground/100-K-132	Leaching to groundwater and groundwater migration
Cr(VI) and Strontium-90 at 116-K-2 Trench	Spent reactor cooling water and aqueous chemical wastes	Engineered release to open trench	Shallow remediation; interim closed	Contaminated subsurface soil 116-K-2 Trench	Leaching to groundwater and groundwater migration

Cr(VI) = hexavalent chromium
CSM = conceptual site model
FSB = fuel storage basin
OU = operable unit

Table 1-5. 100-KR-4 OU P&T Operating History

Performance	KR4		KX		KW		Total	
	2014	1997–2014	2014	2009–2014	2014	2007–2014	2014	1997–2014
Groundwater processed (ML [Mgal])	527 (139)	7,280 (1,925)	1,198 (316)	5,773 (1,524)	579 (153)	2,916 (771)	2,304 (609)	15,969 (4,221)
Mass of Cr(VI) removed (kg [lb])	5 (11)	373 (833)	26 (57)	200 (497)	19 (43)	224 (537)	50 (111)	797 (1,868)
Wells	**2014**		**2014**		**2014**		**2014**	
Number of extraction wells	12		18		11		41	
Number of injection wells	5		9		4		18	

Cr(VI) = hexavalent chromium
OU = operable unit
P&T = pump-and-treat

1.3 Optimization Approach

Ongoing remedial activities currently incorporate the following elements in the optimization approach:

- Operation of existing groundwater P&T remedies hydraulically contain and capture groundwater contaminant plumes and remove contaminant mass from plume areas.
- Removal or elimination of sources prevents ongoing contaminant releases.
- Removal or stabilization of secondary sources of groundwater contamination minimizes migration of contaminants already in the environment to groundwater and other exposure points.
- Monitoring of groundwater conditions and remedial system operations provides the information necessary to assess remedy performance and progress.
- Routine data evaluation and reporting documents remedy progress and provides the basis for recommending changes.
- Preparation of annual RPO recommendations (plume containment and remediation utilization plan) is based on the evaluation of activities that occurred during the previous fiscal year (FY).

P&T enhancements at the 100-HR-3 and 100-KR-4 OUs from implementing this approach during past optimization evaluations resulted in the following RPO recommendations:

- Modifying the groundwater treatment process to use an alternate IX resin (SIR-700) that increased treatment effectiveness, extended resin life, and reduced waste disposal requirements
- Converting treatment trains from series to parallel configuration, increasing process throughput

- Repurposing existing wells to increase output
- Installing new wells to improve river protection and contaminant mass removal
- Adjusting groundwater extraction/injection (E/I) rates to improve attainment of short-and longer-term objectives
- Modifying influent pH to increase resin efficiency

P&T system efficiency at both OUs continues to improve as RPO recommendations are implemented. Figure 1-1 depicts a flow diagram of activities undertaken as part of ongoing RPO evaluations to provide a technical basis for making changes to the 100-HR-3 and 100-KR-4 P&T systems, including E/I well locations and flow rates, to improve the attainment of both short- and long-term remedy objectives.

The optimization approach presented in this document expands on recent RPO efforts by integrating year-over-year efforts into a systematic approach that includes the following elements:

1. **Evaluate and Refine the CSM.** A living CSM is maintained to reflect the current pumping strategy and understanding of site conditions while accounting for potential uncertainties or lack of knowledge regarding aquifer properties, contaminant extent, and continuing contributions from secondary sources. Ineffective or inefficient P&T system operations often result from an incomplete CSM understanding.
2. **Remedy Component Integration.** Each of the five P&T systems is composed of an array of hydraulically connected components consisting of E/I wells, conveyance systems, and treatment systems. A change in one P&T system component, such as extraction well pumping or injection rates, has the potential to affect other P&T system operations elsewhere. Analysis of one component independent of the other components can lead to sub-optimal operation and can inhibit efforts to accelerate remediation. Identifying where key dependencies exist and developing tools to integrate the analysis of the connected components when assessing the effect of system modifications is essential to maintaining an effective pumping strategy.
3. **Baseline and Periodic Optimization Tasks.** Optimization tasks are divided between baseline tasks and annual or periodic tasks. The baseline tasks are generally one-time activities used to develop the tools that will be used to conduct the annual/periodic tasks. The baseline tasks include overall review of the system and, upon completion, allow the annual/periodic tasks to focus on a smaller set of data, speeding up the evaluation process.
4. **Data Evaluation and Groundwater Modeling Tools.** Accelerating the cleanup rate is accomplished through “smart pumping,” which emphasizes dynamic operation of wells based on scheduled and real-time data analysis. For systems with a large number of extraction wells, groundwater flow and contaminant transport modeling is the primary tool for comparing the likely relative efficacy of alternate pumping strategies to accelerate remediation. Model simulations, supported by other data analysis tools, are used to help interpret P&T performance and determine decision points where strategic pumping or other remedy modifications may be needed. One critical optimization task is updating the groundwater modeling tools so that they reflect the current CSM and recent changes to P&T system components.
5. **Pre-Attainment Strategy.** Remedial goals for Cr(VI) and co-contaminants will be achieved in different areas of the aquifer at different times. The development and implementation of a technical approach that defines when and where active extraction, injection, and monitoring can be downsized or terminated is an important element of the overall remediation strategy for P&T systems.

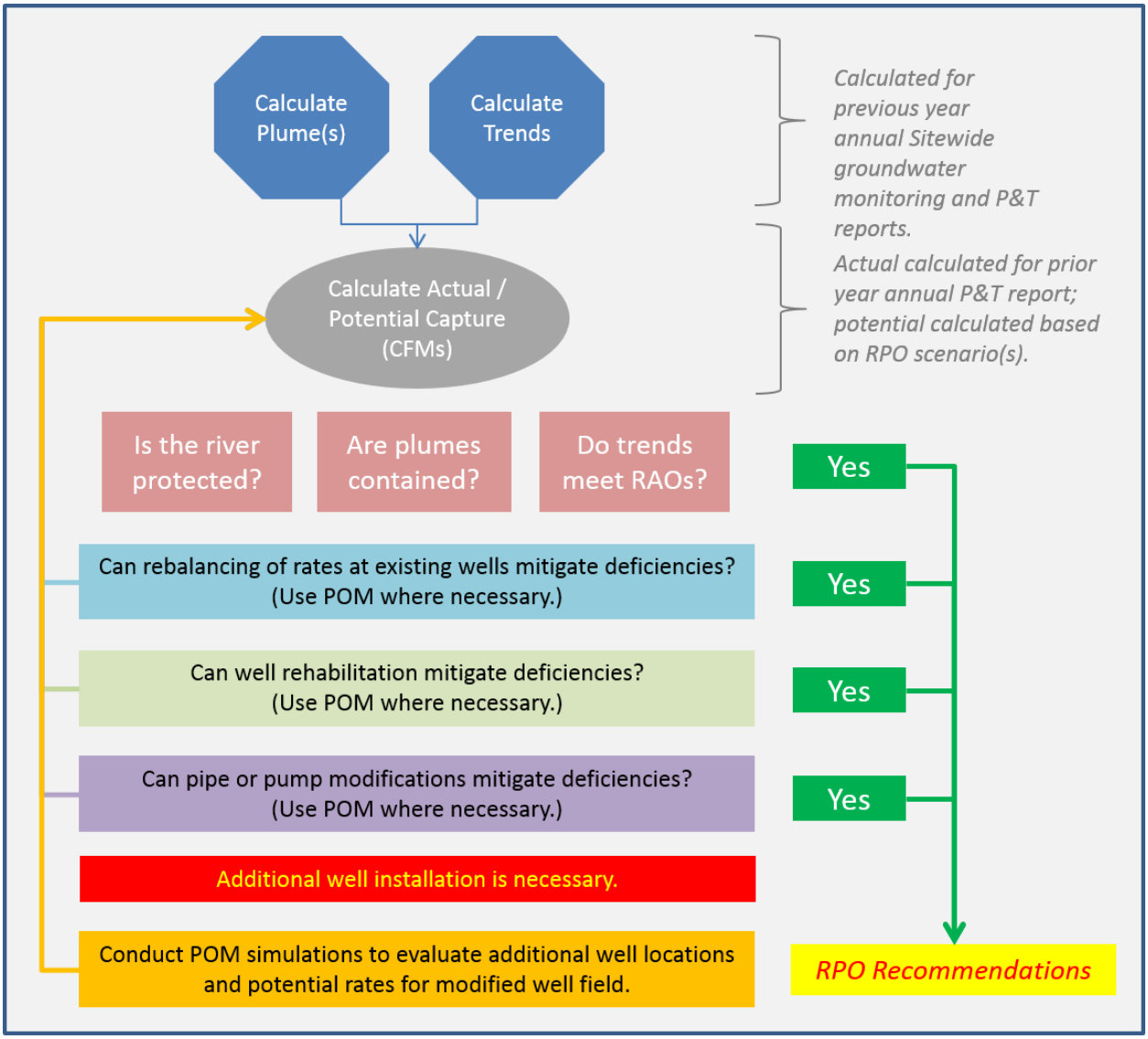

Figure 1-1. Illustration of Selected Current RPO Activities Undertaken to Provide a Technical Basis for Making Changes to the 100-HR-3 and 100-KR-4 OUs P&T Systems

Figure 1-2 presents a process work flow for the integration of tasks and tools in evaluating alternatives and generating recommendations under RPO.

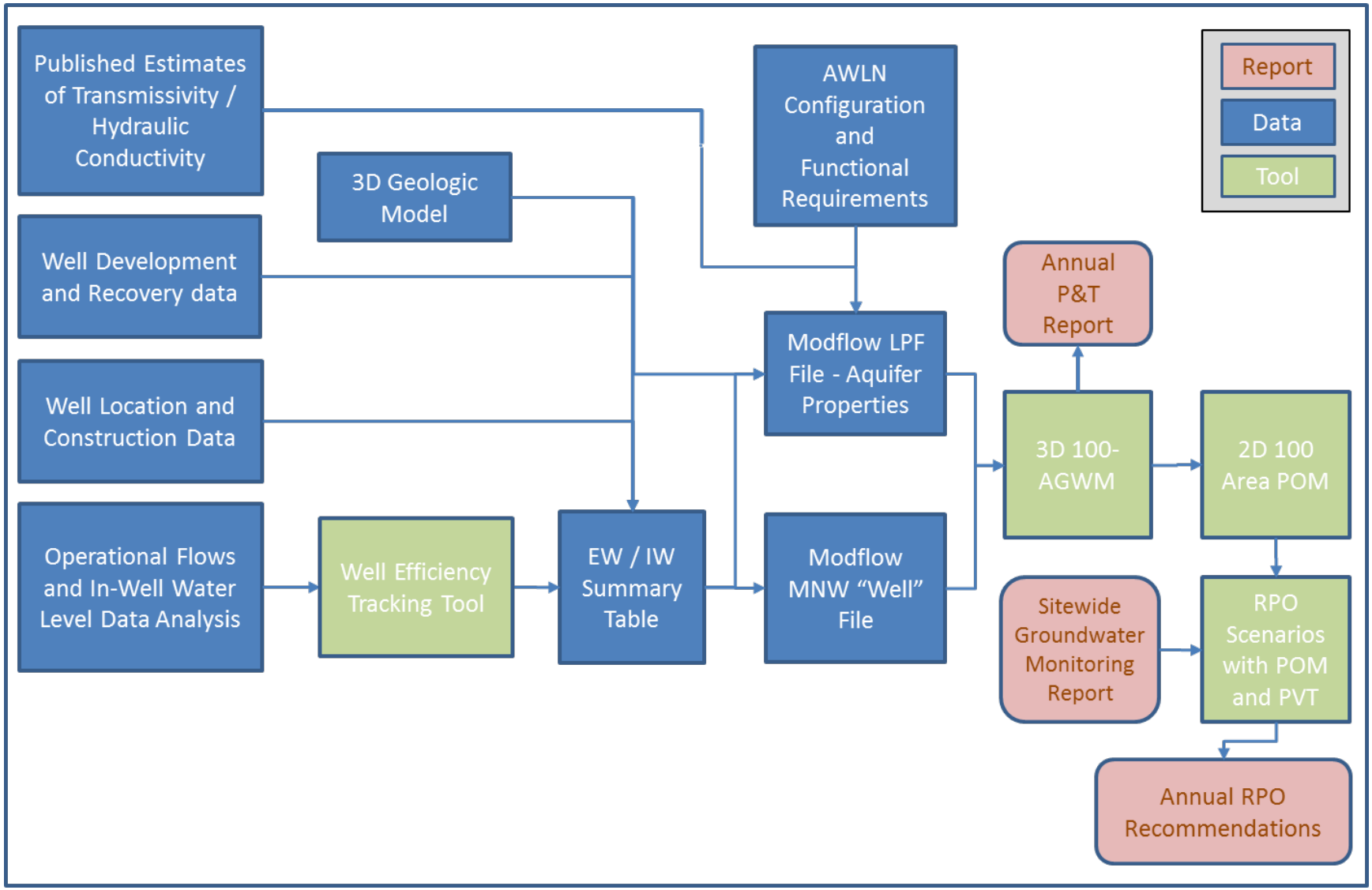

Figure 1-2. Integration of RPO Tasks and Tools

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2 Pump-and-Treat Optimization Strategy Overview

This chapter describes short- and long-term objectives of the interim P&T systems at the 100-HR-3 and 100-KR-4 OUs, the remedy implementation approach, and operational priorities for achieving these objectives.

2.1 Objectives of Remediation Activities

The objectives of the groundwater remedial actions that have been implemented at the 100-HR-3 and 100-KR-4 OUs are considered in two time frames:

- Short-term objectives are considered within the framework of the current interim remedial action and include integration of the interim remedial action into the final remedy.
- Long-term objectives are identified within the framework of the overall *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) response at the Hanford Site, and within these OUs specifically, and consider the effects of selected final remedial actions and site closure conditions.

2.1.1 Short-Term Objectives

Short-term objectives have been identified within the framework of the existing interim remedial actions and include the following:

- Maintain safe and compliant operations.
- Establish and maintain protection of the Columbia River from discharge of contaminated groundwater at concentrations that exceed the state surface water quality standard where groundwater discharges to surface water.
- Collect information from the interim remedial actions that will support the final remedial action selection and implementation.
- Maintain groundwater monitoring activities to support remedy performance evaluation.
- Perform regular evaluations of remedy performance.
- Identify and implement opportunities and activities that accelerate cleanup of contaminated groundwater and shorten the duration of P&T operations, which may include system modifications or use of alternative technologies.
- Continue to integrate activity planning and execution with other Hanford Site projects and contractors. Implement integration activities consistent with available funding and commensurate with out-year planning needs.

2.1.2 Long-Term Objectives

Final remedial action goals for the 100-HR-3 and 100-KR-4 OUs include the following general long-term objectives for the groundwater remedy:

- Prevent exposure of human receptors to conditions exceeding applicable promulgated standards or risk-based concentrations.
- Prevent exposure of aquatic receptors from discharges of contaminated groundwater to the Columbia River in excess of ambient water quality criteria.

- Restore groundwater to meet applicable promulgated standards, including DWSs, within a reasonable time frame.

2.2 Operational Priorities

Consistent with groundwater RAOs, the P&T system operational priorities of river protection and aquifer restoration have been established to guide current system operations, data evaluation, and design modification activities. These operational priorities are an integral component of the overall remedial strategy. Although river protection and aquifer restoration are the primary operational priorities for the P&T systems, consistency with final remedy, CSM refinements, and system operations and maintenance (O&M) are essential to achieving these priorities efficiently and effectively. The descriptions provided in the following subsections introduce the key considerations for RPO, together with strategies, tasks, and tools that will facilitate optimization of these operational priorities.

2.2.1 River Protection

The top priority for the five 100-HR-3 and 100-KR-4 OUs groundwater P&T systems under the interim remedial action ROD (EPA/ROD/R10-96/134) is river protection. As such, the P&T systems were designed to protect the Columbia River from further discharges of dissolved chromium at concentrations greater than 10 µg/L; this goal is typically referred to as the river protection objective. The overall strategy for achieving river protection is to use extraction wells along the river, near the shoreline, to provide hydraulic containment and prevent migration of contaminants toward the river.

2.2.2 Aquifer Restoration

The priority for aquifer restoration shares elements with the river protection priority by focusing on the extraction well field configuration and individual well extraction rate capacities. The aquifer restoration strategy focuses on maximizing contaminant mass removal, with the goal of reducing Cr(VI) concentrations and plume size. Aquifer restoration is usually accelerated by maximizing extraction rates from high-concentration areas that are typically associated with historical release points and contributions from secondary sources. However, when attempting to restore the aquifer as quickly possible, a second element of the strategy is to use re-injection to accelerate flushing of the aquifer with the treated water. As such, the configuration of both extraction and injection wells is critical to aquifer restoration. Properly placed injection wells (generally located inland of and away from core plume areas) maintain saturation of the unconfined aquifer, which enhances the capacity (sustainable yield) of the extraction wells, influences flow directions and rates by creating recharge mounds, flushes contaminants that may be sorbed onto or otherwise retained within aquifer sediments, and contributes to untreated co-contaminant attenuation through dispersion. Appropriately planning both extraction and injection well locations can control contaminant migration, produce more efficient contaminant removal, direct high-concentration plume regions toward extraction wells, and allow injection of effluent containing any untreated co-contaminants at locations where attenuation processes can reduce concentrations.

2.2.3 Consistency with Final Remedy

Final remedy decisions for the 100-HR-3 and 100-KR-4 OUs will be included in the final RODs for each OU, which have not been prepared as of the publication of this report. It is anticipated that the final remedial actions will address COCs to restore groundwater to its potential beneficial use and eliminate the discharge of contaminants to the Columbia River at concentrations above applicable standards. Operations and changes to the existing interim action remedies will continue to progress toward these goals while not exacerbating conditions that would inhibit attainment of RAOs.

2.2.4 CSM Refinement

The CSM is a dynamic model that evolves as system data are processed and reviewed and should be updated periodically to ensure that river protection and aquifer restoration goals are achieved as efficiently as possible. The CSM describes interactions between contaminants and the affected environment. The following CSM issues may need evaluation and potential refinement as additional information becomes available:

- Persistence of Cr(VI) concentrations in the northern plume in the 100-D Area suggests a continuing source.
- Persistence of Cr(VI) concentrations in the K-West and K-East Reactor areas suggests continuing sources near the former head houses.
- The distribution of Cr(VI) in the first water-bearing unit of the Ringold Formation upper mud (RUM) in the 100-H Area and the Horn is uncertain.
- Groundwater flow direction and velocity, and associated plume behavior in the area inland of the 100-K Area, exhibit some uncertainty with respect to potential effects on the 100-N Area and other groundwater to the east.
- Changes in plume boundaries caused by remedial pumping can affect the inference of plume relationships to apparent sources.

The 100 Area groundwater model (100AGWM) and 100 Areas pumping optimization model (POM), which are described in Section 2.3.4, are used to simulate groundwater flow and contaminant transport and to help optimize the locations and pumping rates of E/I wells with respect to Cr(VI) distribution. To provide accurate simulations, these models and the CSM are periodically updated as new data become available.

2.2.5 System Operations and Maintenance

Routine P&T system O&M are key RPO elements to ensure extraction well hydraulics and pipeline conveyance capacity, treatment system throughput, and injection conveyance and hydraulic capacity are balanced to achieve optimum performance. System components are maintained following established P&T procedures and manufacturers specifications to ensure that components achieve run time, hydraulic performance, and treatment goals.

Key considerations include the following:

- Production and conveyance capacity from extraction wells to treatment systems must meet or exceed extraction rates required to achieve the RAOs. Extraction well pumps and conveyance piping should be sized to overcome head losses resulting from long distances between wells, transfer stations, and treatment systems and routing along unprotected ground surfaces.
- Comparison of existing treatment capacity and flow rates to flow rates from E/I wells at each system, both existing and planned, should be conducted. Treatment system upgrades or realignments may be necessary to meet increasing planned flow rates, as well as future decreasing flow rates as plumes contract, and perimeter extraction wells are shut down.
- Ideally, the injection capacity for each system should be greater than the extraction capacity to reduce the potential for flow-limiting conditions. Additional injection wells or realignment of existing wells may be required for gradient control as the plume contracts over time. Considerations for placing injection wells include the acceptance capacity of the receiving aquifer, desired hydraulic gradients

and flow directions, plume containment to prevent expansion into remediated or uncontaminated areas, and/or dilution of contaminants in source areas.

2.3 RPO Data Sources and Tools

The following subsections describe the primary data sources and tools for the 100-HR-3 and 100-KR-4 OUs RPO analyses. Primary data sources include data derived from periodic measurements and observations (e.g., groundwater sampling and analysis measurements), as well as from automated systems (e.g., data recorded by plant system control and data acquisition [SCADA] and the automated water level network [AWLN] system). Primary tools include groundwater flow and contaminant transport models.

2.3.1 Automated Data Systems

Automated systems that provide information to the Hanford Site 100 Areas P&T system evaluation include the treatment plant SCADA systems, AWLN system, U.S. Geological Survey (USGS) automated river stage record, and local and regional weather recording systems. These systems and the data derived from them are described in the following subsections.

2.3.1.1 System Control and Data Acquisition

Each P&T system incorporates a SCADA system with a human-machine interface that enables programming, setting of controls, and determination of what data to collect on what frequency. The following data recorded by SCADA systems are used in the RPO evaluation process:

- Total discharge to or from individual E/I wells
- System run time
- Water level changes within E/I wells
- Process stream pH

2.3.1.2 Automated Water Level Network

Water levels are dynamic along the River Corridor because of changes in groundwater elevation in response to the stage of the Columbia River and the hydraulic response to E/I wells. As a result, conditions can change rapidly in the aquifer within a few hundred meters of the shoreline. Water level monitoring comprises a combination of manual (depth-to-water) measurements, obtained during routine sampling events or synoptic water level rounds, and automated recordings. AWLN consists of a number of monitoring wells, each equipped with a pressure transducer and data logger, which provide a continuous record of water levels at those wells. AWLN was first established during the 1990s with commencement of interim groundwater P&T remedies at the Hanford Site.

The AWLN provides continuous measurements from a network of wells that provide information that is not ascertainable using quarterly or annual manual water level measurements. The measurements are used for calculating hydraulic information, including the following:

- Plotting and analysis of time-weighted two- and three-point hydraulic gradients.
- Mapping of groundwater levels and assessment of fate and transport of contaminants.
- Response of the aquifer to periodic (scheduled and unscheduled) shutdown and startup of individual extraction or injection wells or entire P&T systems. These data can, under favorable conditions, enable estimation of aquifer properties.
- Assessment of the timing (lag) and size (amplitude) of effects to groundwater levels from changes in the stage of the Columbia River, including effects on hydraulic gradients.

- Calculation of capture frequency maps (CFMs) which depict the relative strength of hydraulic containment over widely varying conditions throughout the year.
- Processing for use as targets for calibration of groundwater models.

As of March 2015, the AWLN included 53 wells at the 100-HR-3 OU and 38 wells at the 100-KR-4 OU.

2.3.1.3 Other Continuous Data Records

Other data sources provide miscellaneous information used for a wide variety of purposes, including the following:

- USGS records of Columbia River stage height and discharge volume from the gauge station below Priest Rapids Dam. USGS river stage measurements are used to derive local river stage elevations at Hanford Site reactor areas.
- Site and public weather stations providing precipitation, barometric, and other data.

2.3.2 Periodic Data Measurements

Periodic measurements are made from monitoring wells, aquifer tubes, and other devices for a variety of characterization, performance monitoring, and reporting purposes and include the following types of information:

- Groundwater quality samples collected from wells and aquifer tubes and analyzed for selected constituents in accordance with current sampling and analysis plans (SAPs)
- Water level measurements collected from wells at the time of sample collection and during synoptic measurement rounds
- Treatment system influent and effluent samples collected from the process stream and analyzed for selected constituents
- Characterization samples, including samples of soil and groundwater, collected during drilling of wells and borings and analyzed for selected constituents

2.3.3 Other Information Sources

Other sources of information may be integrated into system performance evaluations, as appropriate, and may include the following:

- Design drawings
- Technical reports
- Field activity and characterization reports
- Work and publications from other contractors (e.g., excavation and research)

2.3.2 RPO Tools

Groundwater models are used to test the relative efficacy of alternative E/I well pumping configurations to improve hydraulic containment, prevent further discharges of contaminants to the Columbia River, and maximize contaminant mass recovery and aquifer restoration. The primary tools for optimizing well field configuration and flow rates are the 100AGWM and POM.

2.3.2.1 100 Area Groundwater Model

The 100AGWM was initially developed in 2008 to evaluate and optimize the 100-HR-3 and 100-KR-4 OUs interim groundwater P&T remedies, as they existed at that time and with a view to future expansions of the P&T remedies. The initial version of the 100AGWM encompassed the 100-D, 100-H, 100-K, and 100-N Areas, comprised a single model layer, simulated steady-state (time-averaged) groundwater flow, and depicted the movement of water and contaminants over time using path lines only (particle tracking). Since its initial release, the 100AGWM has undergone several updates to improve the simulation capabilities of the model, including the following enhancements:

- An increase from one layer (i.e., 2-D) to four layers (i.e., 3-D)
- Transient flow simulations, using monthly stress periods to represent variations over time
- Reactive transport of contaminants and other indicator compounds
- Recirculation of contaminants and indicator compounds through the P&T system, with user-specified treatment efficiency and blending (mixing)
- 3-D, time-varying geometry for the Columbia River boundary condition
- Simulation of E/I using the multinode well (MNW) package to account for both aquifer and system (pump-and-pipe) head losses

Including these features enables the 100AGWM to provide realistic simulation of FEPs that determine the transport and fate of contaminants in the 100 Areas. However, this additional capability and complexity increases computational demand and simulation time. As a result, simple flow and path line simulations undertaken with the initial version of the 100AGWM, which required a matter of seconds to minutes to execute, have been superseded by comprehensive reactive transport simulations that require hours to execute. While the increased simulation capabilities are necessary for final remedy design and optimization activities, the computational demands are excessive when undertaking a large number of comparative “what if” evaluations. While the 100AGWM is ideally suited for making detailed predictive simulations of contaminant transport and fate, it is not suited for undertaking a large number of comparative type simulations, which are commonly used in RPO to test the relative efficacy of alternative pumping configurations. For these reasons, POM was developed in 2014.

2.3.2.2 Pumping Optimization Model and Plume Visualization Tool

POM (an equivalent-property 2-D version of the fully 3-D 100AGWM) was developed to simulate flow path lines (for hydraulic capture) and reactive contaminant transport. POM has been verified to provide results similar to those obtained using the 100AGWM when calculating the approximate extent of hydraulic capture developed by a P&T system and comparing the likely relative time required to achieve aquifer restoration under different pumping configurations (SGW-46279, Rev. 3, *Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*). Comparison with the results obtained using the 100AGWM shows that although there are small differences, the computational expediency renders POM an expeditious approximation to the full multilayered 100AGWM. The native model files that comprise POM are developed directly from the native model files that comprise 100AGWM by executing a series of programs that develop single-layer property analogies equivalent to the multilayer package input files of the 100AGWM.

POM is typically preprocessed (i.e., POM inputs prepared), executed, and post-processed (mainly visualized) via an interactive graphical user interface, referred to as the Plume Visualization Tool (PVT). PVT has two primary output products: a dynamic visual representation of contaminant plume

extent in time and space in relationship to one or more base maps and a visual representation of dynamic pumping rates and direction (injection or extraction). Thus, PVT facilitates the following actions:

- Reconfiguration of E/I well locations and rates
- Execution of the underlying POM groundwater flow, path line (particle tracking), and reactive transport models
- Post-processing of model runs into visual (primarily map-based) depictions for assessment

Because POM was developed to evaluate the relative efficacy of alternate pumping configurations (i.e., rates and locations over time), usually the only file required to be changed for each scenario is the file that specifies locations and rates of E/I. Numerous POM simulations can be completed to compare and contrast multiple alternate pumping configurations. In order to ensure that conclusions drawn from POM calculations are reliable and provide design basis simulations (where needed), candidate configurations developed using POM are executed by running 100AGWM with the same files.

2.3.2.3 River Protection Assessment

Hydraulic capture of Cr(VI) contamination is evaluated annually and reported in the annual P&T report. The method used to evaluate progress toward attaining the river protection objective, which focuses on the performance of P&T (and other remedies) in protecting the Columbia River from further discharges of dissolved chromium from inland plumes at concentrations greater than 10 µg/L, is described in SGW-54209, *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River Shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)*. Environmental calculation file (ECF) ECF-Hanford-14-0035, *Description of Groundwater Calculations and Assessments for the Calendar Year 2013 (CY2013) 100 Areas Pump and Treat Report*, demonstrates the methods described in SGW-54209 for evaluating the progress toward attaining the river protection objective. The status of river protection is determined by systematically processing several data types and preparing an ensemble graphical depiction that exhibits lengths of shoreline (in increments of 100 m [328 ft]) that are or are not protected from Cr(VI) discharges. Colored circles are used to indicate the relative river protection objective status (i.e., green = protected; yellow = protected, but action may be required to ensure long-term protectiveness; and red = not protected). The RPO strategy for protecting the river and eliminating nonprotected areas (red) and, ultimately, the areas where action may be required (yellow) primarily involves the evaluation of hydraulic capture and plume maps and the performance of E/I wells under current and potential (changed) configuration. Figure 2-1 provides an example graphic depicting the status of the river protection objective.

Over time, as hydraulic containment at the shoreline is successful, and the river protection objective is fully met, the balance of the groundwater E/I well system can be modified to accelerate attainment of other goals while maintaining river protection. For example, the balance of extraction can shift steadily inland, and nearshore wells can be used as monitoring locations to demonstrate successful containment of the plume. Injection wells can be used strategically inland, upgradient of the plume, to return treated water to the aquifer while increasing groundwater flows toward extraction wells, thereby accelerating aquifer restoration, as detailed in the following section.

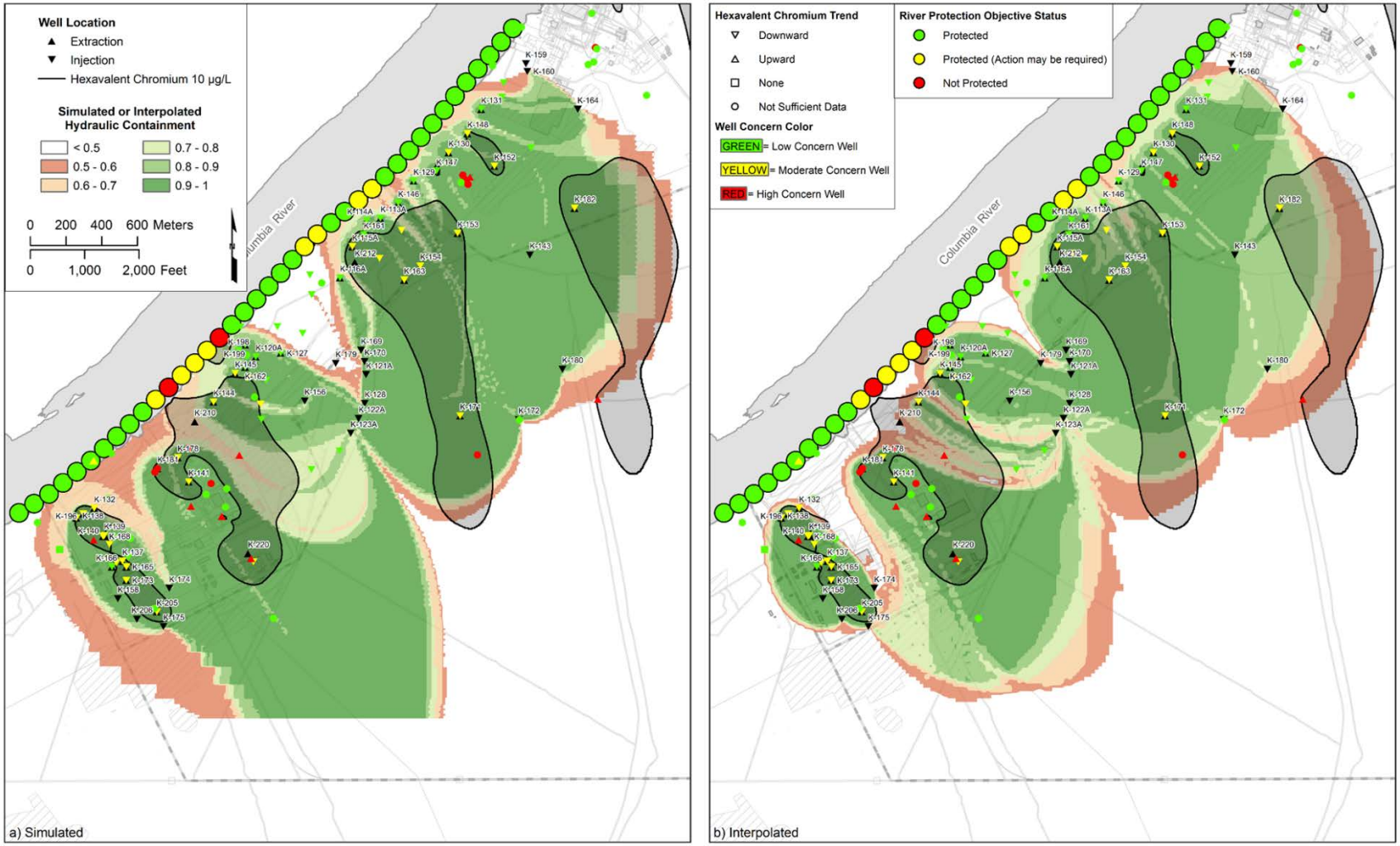

Figure 2-1. River Protection Status for the 100-K Area in CY 2014 Showing the Simulated and Interpolated Capture Frequency Maps and Extent of Cr(VI) in Groundwater at Concentrations Greater Than 10 µg/L

3 Baseline Optimization Tasks

Optimization tasks in this approach are divided between baseline tasks and periodic tasks. Baseline tasks are generally one-time activities that are used to develop the tools that will be maintained, updated, and used during periodic tasks. Baseline tasks include overall review of the system and allow the periodic tasks to focus on targeted sets of data, speeding up the evaluation process. Baseline tasks include conducting an overall evaluation of the P&T system capabilities as built, updating the 100AGWM, and creating desktop tools to test "what if" scenarios.

The 100-HR-3 and 100-KR-4 RI/FS reports (DOE/RL-2010-95 and DOE/RL-2010-97, respectively) present detailed discussions that form the baseline CSM. As new information becomes available, the CSM will be refined/updated to incorporate this data into the overall understanding of the site. CSM refinements/updates are presented in the annual P&T and sitewide groundwater monitoring reports.

Updated SAPs under development as of the publication of this report for both the 100-HR-3 and 100-KR-4 OUs (DOE/RL-2013-30, *Sampling and Analysis Plan for 100-HR-3 Groundwater Operable Unit Monitoring*, and DOE/RL-2013-29, S*ampling and Analysis Plan for 100-KR-4 Groundwater Operable Unit Monitoring*, respectively) identify monitoring needs to collect data for plume tracking, P&T system performance evaluation, and CSM refinement.

Both the 100-HR-3 and 100-KR-4 OUs AWLN system networks have recently undergone review as part of a sitewide evaluation of their role in support of remedial decision making and performance assessment to identify three levels of monitoring that can provide varying levels of data to support RPO objectives (SGW-53543, *Automated Water-Level Network Functional Requirements Document*). Based on this review, AWLN upgrades were implemented to achieve a near-optimal configuration to evaluate plume hydraulic capture effectiveness. Baseline tasks are described in the following subsections, while periodic tasks are presented in Chapter 4.

Methods to evaluate well performance and prescribe necessary technologies and techniques to recondition and rehabilitate wells are identified in the well maintenance plan (WMP) SGW-58236, *Well Maintenance Plan for the 100-HR-3 and 100-KR-4 Groundwater Treatment Facilities*. Rehabilitation may include well redevelopment, chemical addition to eliminate biofouling, or surge and purge to reduce scaling or other well casing encrustations. The maintenance plan also establishes performance monitoring strategies, well baseline performance characteristics, and action levels for key well performance parameters. Triggers can be established in the P&T electronic control system to identify developing problems and initiate well maintenance. The triggers can be set for performance characteristics such as decreasing well production (as indicated by specific capacity), pressure differential across the influent filter assembly, or parameters indicating changing conditions that affect well performance. The focus of the evaluation is on wells in higher plume concentration areas and critical injection wells.

3.1 Remedy Component Integration

Each of the five P&T systems at the 100-HR-3 and 100-KR-4 OUs is composed of an array of hydraulically linked components, beginning at the extraction wells, extending through the treatment systems, and ending at the injection wells. There are dependencies throughout these systems. Changes in one component of the system, such as an extraction well pumping rate, have the potential to affect the system elsewhere and result in unintended consequences. RPO baseline activities include analysis of the components of these systems to help identify where the key dependencies occur and to support the calculation of "what if" scenarios that enable the development and implementation of dynamic pumping strategies. This task involves analysis, documentation, and optimization of three major elements: E/I wells, conveyance, and treatment system processes.

3.1.1 Extraction/Injection Wells

E/I wells are used in the P&T systems at the 100-HR-3 and 100-KR-4 OUs to remove contaminated groundwater from the aquifer and return treated water to the aquifer.

3.1.1.1 Overview

Performance of E/I wells is an important factor influencing the duration of P&T operations. Extraction wells that are not suitably placed to intercept contamination, are not maintained, or are unable to withdraw water at sufficient rates to achieve capture will result in ineffective or inefficient remedy operation. Similarly, injection wells that are not suitably located, maintained, or capable of accepting treated water at sufficient rates will result in ineffective or inefficient remedy operation. This element includes evaluation of individual well performance and function relative to the current plume configuration and P&T system capacities. Well pump sizing, placement, performance, and configuration of other in-well components are assessed as part of this element. Three elements critical to E/I well performance are well placement, well design, and well efficiency:

- **Well Placement:** Appropriate well placement requires suitably located E/I wells in each P&T system to meet both short- and long-term RAOs (i.e., protect the Columbia River from contaminant discharges while hydraulically containing and recovering groundwater contaminants to achieve groundwater CULs). Well locations and placement are evaluated yearly under the RPO and as part of the annual P&T reports. Although the existing P&T systems were installed to meet interim remedial action requirements, their design and implementation have been conducted such that they will likely be a significant component of the final remedy for the OUs. New well placement and usage evaluations occur throughout the year, and recommendations for future year improvements/changes are included in the annual plume containment and remediation utilization plan.

- **Well Design:** Proper well design ensures that each E/I well is suitable for its intended use and range of desired operational flow rates to or from targeted aquifer zones. This element considers well construction (diameter, screen slot size and length of open interval, filter pack, and screen type), vertical placement relative to contamination, and other factors. The current E/I well networks at the 100-KR-4 and 100-HR-3 OUs comprise a combination of newer wells designed and installed with fully penetrating screened intervals and older wells that were converted from shorter-screened monitoring wells or designed with small screen slot sizes. Converting older monitoring wells to extraction wells is often limited because the wells are generally completed at the water table with short-screened intervals and small screen openings. These features tend to limit the rate of withdrawal that is possible. Extraction flow rates may also be affected by seasonal variations in groundwater elevation: wells with short-screened intervals and small screen openings may exhibit relatively low specific capacity and become seasonally inoperable or highly limited. In recognition of these limitations, recently constructed wells have screened intervals extending from above the water table to the bottom of the unconfined aquifer and use larger screen openings based upon analysis of the particle size distribution of the targeted formation. This has resulted in new wells being more productive than converted wells and, therefore, capable of extracting groundwater at higher rates. The same design strategy is being applied to new monitoring wells placed near contaminant plumes: these wells serve as monitoring wells but can be readily converted to extraction (or injection) use if needed.

- **Well Efficiency:** The ability of a well to produce or inject water without regard to other limitations (i.e., pumps and pipes) is measured by the well specific capacity, which can be determined from recorded pumping rates and in-well water levels. The WMP (SGW-58236) outlines the activities necessary to operate, maintain, and monitor performance of the 100-HR-3 and 100-KR-4 OUs P&T wells. The WMP (SGW-58236) provides guidance for well maintenance and restoration to sustain

well functionality. SCADA systems in the P&T facility control rooms manage E/I wells and record operations data, including flow rates, in-well water levels, pressure heads, and other factors. There is also capability for customized local control and operation of some subsystems based upon custom controls. As part of the RPO, well performance is evaluated by calculating the well-specific capacity as part of both the baseline and ongoing periodic activities. These RPO activities will be undertaken in accordance with the WMP (SGW-58236) and will take advantage of the capabilities of SCADA systems and the data recorded there. ECF-Hanford-15-0062 *Estimation and Tracking of Well Efficiency with Application to the 100 Areas Pump-and-Treat (P&T) Systems* presents and demonstrates these calculations.

3.1.1.2 Baseline Tasks and Deliverables

The following baseline tasks are being completed during CY 2015 to provide a foundation for the RPO, with specific emphasis on optimization of the performance of both E/I wells:

- Compilation of E/I rates and in-well water levels (absolute levels or relative changes) over a suitable time period of the available record
- Compilation of well design specifics (as built), including well diameter, screen length and placement, sand pack type and placement, and screen size and type, in a well construction table for all existing wells
- Compilation and analysis of well development data obtained during drilling and well installation/construction
- Evaluation of individual well-specific capacities based on operational data (water levels and pumping rates) and well development data, and development of a baseline-specific capacity value for each E/I well (possibly including a low- and high-stage capacity for some wells)

The outcome of these baseline tasks is the development of an E/I well database (or comprehensive worksheets) that defines the baseline E/I well construction and operation, design specifications, water levels, pumping rates, aquifer test results, and well development data, where available. Figure 1-2 presents the integration of these tasks. Having compiled this database (or series of worksheets), the following tools have been developed to assess well performance and future changes in well performance, and provide the basis for specifying future (ranges of) rates at each well that are required in order to achieve RAOs:

1. **Tabulation of Aquifer Parameter Estimates:** An analysis of the available well development data has been completed and documented in *Analysis of Well Development Data in the 100 Areas* (ECF-Hanford-15-0040). *Compilation of Information Regarding Extraction and Injection Wells of the 100 Areas Pump-and-Treat (P&T) Systems* (CHPRC-02625) is a technical memorandum (TM) describing the composite table that presents the data from ECF-Hanford-15-0040 (well development data) combined with an initial assessment of operational in-well water levels and pumping rates.
2. **Specific Capacity Estimation Tool:** A convolution-based analysis tool for estimating the specific capacity of wells over time has been developed in Microsoft[1] Excel, as documented in *Estimation and Tracking of Well Efficiency with Application to the 100 Areas Pump-and-Treat (P&T) Systems* (ECF-Hanford-15-0062). This Specific Capacity Analysis Tool (SCAT) facilitates periodic evaluation and reporting of individual well-specific capacity that can be trended and compared against performance benchmarks. Wells that do not meet performance benchmarks will be targeted for further evaluation.

[1] Microsoft® Excel is a registered trademark of Microsoft Corporation in the United States and/or in other countries.

3.2 Update of the 100AGWM and POM

Modeling tools have been developed to support analysis of alternative pumping strategies in the 100-HR-3 and 100-KR-4 OUs. These tools will be maintained and used in support of RPO activities.

3.2.1 Overview

As previously described, 100AGWM, POM, and PVT are integral to RPO activities. As of the publication of this report, a large volume of data and information has been gathered in relation to the 100-D/H and 100-K RI/FS reports (DOE/RL-2010-95 and DOE/RL-2010-97, respectively) and other activities in the 100 Areas that were incorporated into 100AGWM and, correspondingly, POM. Each time a significant 100AGWM update is made, POM is updated accordingly to reflect current conditions before it is deployed to make predictive simulations as part of RPO. This update and deployment cycle has occurred annually, in a stepwise manner, as depicted in Figure 3-1.

POM was initially developed using a version of 100AGWM that is documented in SGW-46279, Rev. 3. 100AGWM was updated during 2014 and 2015 to incorporate additional geologic, well performance, and bathymetric data, and both the 100AGWM and POM were updated in 2015 to help improve upon evaluating the river protection objective and evaluate alternatives. Since POM is a screening level tool, candidate configurations developed with POM will be simulated, using 100AGWM together with the corresponding MNW files, and these runs of record will be documented in an ECF at the conclusion of the RPO process for that CY, providing the recommended rates and locations of E/I for subsequent years of operation. Where appropriate, these recommendations will consider the role of river stage/seasonal factors on well operations. This may include providing river stage/season-dependent pumping rate recommendations for wells that are influenced by river stage/season in their capacity to produce water and contaminants and maintain hydraulic control.

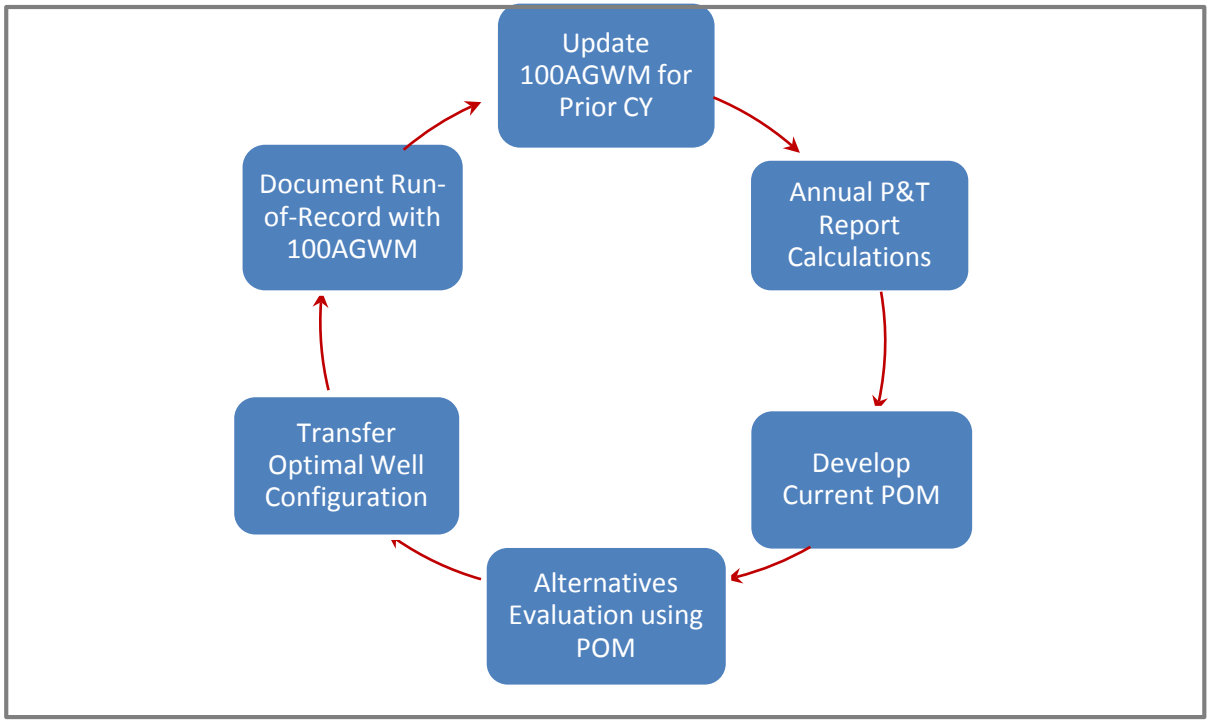

Figure 3-1. Process for Updating the 100AGWM and POM

3.2.2 Baseline Tasks and Deliverables

100AGWM was updated in 2015 with data and information resulting from characterization, remediation, and other activities completed throughout the 100 Areas in the prior 3 years. This 100AGWM update incorporated relevant information from the following baseline RPO activities:

- Refined understanding of the CSM, including the following:
  - Updated geological characterization obtained from installation and testing of new monitoring and E/I wells
  - Groundwater flow dynamics between 100-K, 100-N, 100-D, and 100-H
  - Seasonal effects of river/groundwater interaction
  - Fate and transport characteristics of co-contaminants
  - Contaminant plume geometry
  - Continuing sources of contamination
- E/I well database, including well-specific capacities to support reliable estimates of well yields

The updated version of POM was created from the 100AGWM version that was completed in spring of 2015, as documented in SGW-46279, Rev. 3. The updated POM is used, together with the PVT, to assess alternate pumping configurations, including locations and rates of E/I wells that are considered plausible, in order to evaluate remedy performance and develop and prioritize recommendations for operation of the P&T systems. A subset of the well configurations referred to as candidate configurations, each of which comprises a tabulation of pumping rates and locations over time until (simulated) CULs are achieved, has been provided within associated MODFLOW MNW well files, as used with POM. These candidate configurations are documented in a TM. The run of record is executed using 100AGWM and documented in an ECF. Implementation of these recommendations will initiate the next succession of data collection, analysis, groundwater model updates, and evaluation and recommendations for optimal pumping and well configurations.

3.3 Summary of Baseline Tasks

Table 3-1 presents a summary of the baseline activity tasks, including subtasks, reporting, action items, and implementing personnel.

Table 3-1. Summary of Baseline Activities

Activity	Subtasks	Schedule	Reporting	Additional Actions	Implementing Personnel
Integrate multiple sources of E/I well information into single compilation: include as-built well specifications, typical water levels and saturated thickness, typical pumping rates, aquifer test / well development results, estimated specific capacities, 100-AGWM stratigraphy.	--	2015	*Compilation of Information Regarding Extraction and Injection Wells of the 100 Areas Pump-and-Treat (P&T) Systems* (CHPRC-02625) EXCEL File: *Compilation of Information Regarding Extraction and Injection Wells of the 100 Areas Pump-and-Treat (P&T) Systems*		Project scientists, groundwater modelers, and operations
Categorize E/I wells based on focus (mass recovery and river protection).	Include well ranking.	2015	Separate TMs for 100-KR-4 and 100-HR-3		Project scientists
Develop method to estimate recent specific capacities (well efficiency) and track changes while accounting for river stage influence and well interference. Use with triggers of well maintenance.	Analyze E/I rates, in-well water levels, as-built well specifications, aquifer test data, and well development data.	2015	*Analysis of Well Development Data in the 100 Areas* (ECF-Hanford-15-0040) *Estimation and Tracking of Well Efficiency with Application to the 100 Areas Pump-and-Treat (P&T) Systems* (ECF-Hanford-15-0062) EXCEL File: *Template Worksheet to Estimate and Track Extraction and Injection Well Efficiency*		Project scientists and groundwater modelers

Table 3-1. Summary of Baseline Activities

Activity	Subtasks	Schedule	Reporting	Additional Actions	Implementing Personnel
Identify wells in need of maintenance, rehabilitation, or replacement and E/I wells for potential realignment. Identify locations to install additional wells.	Perform cost/benefit analysis. Update 100AGWM and POM.	2015	Annual plume containment and remediation utilization plan	Well maintenance, rehabilitation, replacement, or realignment	Project scientists and operations
Integrate specific capacity, CSM updates, data from E/I well database, and results from hydraulic model into 100AGWM and POM; integrate changes to wells, conveyance, and treatment system into 100AGWM and corresponding POM.			*Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model* (SGW 46279 Rev. 3)		Groundwater modelers

100AGWM = 100 Area groundwater model
CSM = conceptual site model
E/I = extraction/injection
ECF = environmental calculation file
P&T = pump-and-treat
POM = pumping optimization model
RPO = remedial process optimization
TM = technical memorandum

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4 Periodic Optimization Tasks

For each remedy component, this chapter describes periodic optimization activities, followed by the methods and tools used to evaluate the resulting data.

4.1 Refining the Conceptual Site Model

The 100-HR-3 and 100-KR-4 RI/FS reports (DOE/RL-2010-95 and DOE/RL-2010-97, respectively) present detailed CSM discussions. As new information becomes available, the CSM will be refined and updated to incorporate this data into the overall understanding of the site. The following information-and data-generating tasks will be completed periodically to update understanding of site conditions and to assess and optimize remedial performance:

- Update seasonal groundwater flow maps.
- Update 3-D geological structure model as new data are developed.
- Update groundwater contaminant maps (i.e., plume maps).
- Update time series data plots and trends.
- Integrate results of source area remediation actions.
- Collect baseline data from all new wells.

These refinements will be documented periodically by updating the annual P&T and sitewide groundwater monitoring reports for the 100-KR-4 and 100-HR-3 OUs.

4.2 Remedy Component Integration

Remedy component integration examines the treatment system and evaluates operational data to enhance remedy effectiveness. Periodic tasks related to each of the remedy components are described in the following subsections.

4.2.1 Extraction/Injection Wells

The following periodic tasks address well placement optimization and include updating results annually:

- Ongoing monitoring and assessment of specific capacities
- Aquifer testing of new or replacement wells
- Aquifer testing of existing wells, as needed
- Review and update triggers for well maintenance
- Well maintenance

These updates will be documented periodically by updating (i.e., formally revising and issuing new revisions) the documents initially developed under the baseline RPO activities.

4.2.1.1 Well Placement Optimization

The appropriateness of well locations will be evaluated via qualitative (graphical) and quantitative (statistical) means. The qualitative assessment involves overlaying current groundwater flow, hydraulic containment (“capture” or CFMs), and contaminant plume maps. Statistical analysis of the intrawell longitudinal (time series) sample results may include the following:

- Use of regression analysis to identify patterns in concentrations over time for each contaminant including but not limited to increasing or decreasing trends over time in response to Columbia River stage and trends resulting from remedial actions (i.e., pre-remedy versus post-remedy trends).

- Evaluation of plots qualitatively (visual inspection) and interpreted quantitatively using trend tests (such as using the Mann-Kendall trend test) and slope calculations (such as using Sens Test). Where trends are identified, slopes may be calculated before and after the onset of remedial actions, such as commencement of a P&T remedy, to determine the effectiveness of those actions.
- Use of calculated trend slopes to assess the rate of progress empirically toward the attainment of targeted CULs, in particular, identifying areas where cleanup is not progressing as expected and may require remedial enhancement.

Results from these analyses will be interpreted to identify the following areas:

- Ongoing effect or breakthrough of contamination to the Columbia River
- High-concentration (e.g., 10 times the CULs) plume areas that are not being sufficiently addressed
- Persistent concentration that might indicate secondary sources or poor local system performance
- Effluent injection that may be masking contaminant sources

Based on these results, well placement optimization will include evaluating the potential for adjusting groundwater E/I rates to mitigate any identified deficiencies and determining if new wells are necessary to supplement the existing well field to achieve the RAOs. Recommendations may include installation of the following wells:

- Additional extraction wells to contain and capture plume segments that exceed RAOs and that are migrating, or have potential to migrate, to the Columbia River (river protection)
- Source area extraction wells in or near high-concentration plume segments associated with historical release points that exhibit potential effects of continuing secondary sources (source control and enhanced mass recovery)
- Mid-plume extraction wells to provide additional plume containment and capture, minimize the contaminant mass approaching the river, and increase the rate of flushing in the body of the plume(s) (accelerate attainment of RAOs)
- Injection wells to provide replacement water, support contaminant flushing, or enhance plume capture

These updates will be documented periodically in corresponding TMs, ECFs, and Soil and Groundwater Remediation Project (S&GRP) soil and groundwater (SGW)-numbered documents.

4.2.1.2 Well Design and Well Efficiency

The following tasks will be completed on a periodic basis to update the E/I well database:

- Use the recorded flow rates in E/I wells and wellheads (water levels) to conduct ongoing monitoring, assessing, and reporting of well-specific capacities.
- Use compiled extraction well influent concentrations and combined influent concentrations to (1) evaluate extraction well influent data for wells recovering contaminants at levels below CULs, and (2) identify those extraction wells that are primarily recovering mass, developing containment, and protecting the river from contaminant discharges.
- Implement well design recommendations in well designs and bid documents for new wells.

- Conduct aquifer tests in new and existing wells to assess aquifer properties and likely or expected well performance, including the following (in order of preference):
  - Multiwell pumping tests
  - Single-well pumping tests
  - Extended-duration constant rate tests

After assessing well locations, design, and well efficiency, recommendations will be made to identify the following:

- System limitations due to well design, maintenance needs, or location
- Wells for potential realignment
- Wells in need of maintenance based on declining specific capacity
- Wells with significant design limitations

The recommendations will be used to develop a graded approach for prioritizing well maintenance, rehabilitation, replacement, or reconfiguration. These updates will be documented periodically by updating (i.e., formally revising and issuing new revisions to) the master well tables and corresponding TMs, ECFs, and SGW-numbered documents developed under the baseline RPO activities.

4.2.1.3 Conveyance

The design authority evaluates the conveyance systems on an ongoing basis to identify limitations to the system. Pipe and pump limiting conditions are identified and integrated to recommendations for improvements. Results from the periodic review of the E/I wells and conveyance system will be integrated to update the consolidated documentation of each P&T system (format: Microsoft Excel), and to define new inputs for the 100AGWM (and derivative POM) model based on the updated well performance, so that the rate limitations (yields) of wells are represented accurately in model predictions/scenarios.

Recommended pumping rates for the upcoming year are derived from a pumping rate analysis based on system performance of the prior year and planned system modifications. Determining whether these rates are achievable is essential to identifying component deficiencies or areas for maintenance or modification. Whichever is the lower value of the desired E/I rate or currently achievable E/I rates will be input as the current operational parameters until the next system performance analysis and reconfiguration is completed. This process is outlined in Figure 4-1.

4.3 Annual Update of 100AGWM and POM

100AGWM will be updated annually, with data and information resulting from the completion of the periodic optimization activities conducted over the prior year, to simulate operation of the 100 Area P&T systems, including all E/I wells, during that year. The following updates are included:

- Adjustments to the E/I wells that affect performance (e.g., well additions, subtractions, limitations, specific capacity, and pumping rates)
- Treatment system influent/effluent pH and co-contaminant concentrations

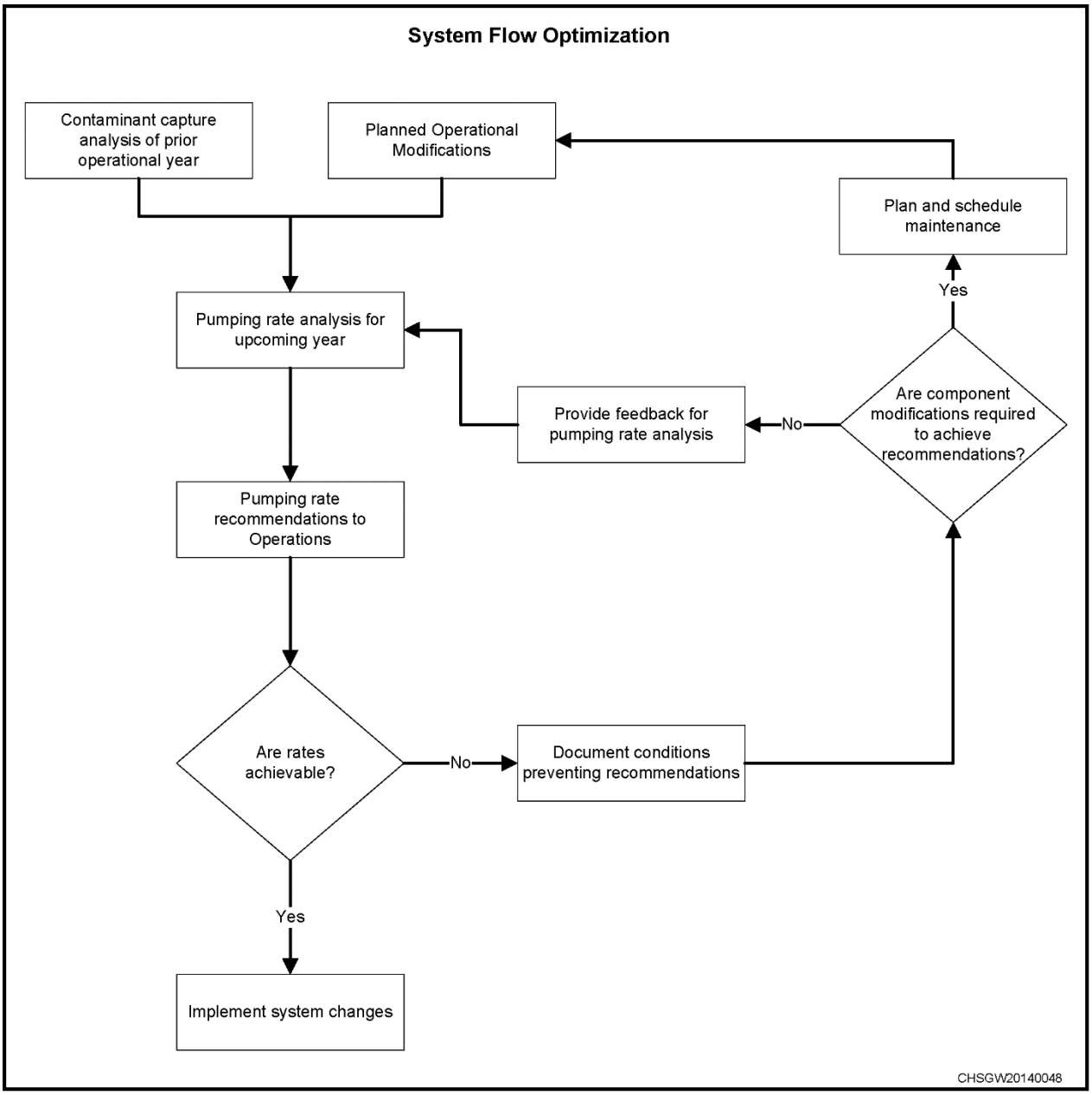

Figure 4-1. System Flow Optimization

As described in Section 3.3, once updated, 100AGWM model files will be used to generate a revised version of the 2-D POM model files. The 2-D POM will be used, together with the PVT, to evaluate alternate pumping configurations to determine remedy performance and to develop and prioritize recommendations for the operation of the P&T systems for the following year.

100AGWM updates will be documented in a formal revision to the previously published report (SGW-46279, Rev. 3). Once updated, the 100AGWM model files and all corresponding updated data sets will be used to generate a current version of the POM model files, for use in RPO calculations, which will be documented as an appendix to the corresponding revision of the 100AGWM documentation report.

4.4 Performance Monitoring and Assessment

The analysis of remedy performance will be conducted based on the updated maps and data sets resulting from the periodic optimization tasks. Although the current interim remedial actions are focused on (and limited to) remediation of Cr(VI), consideration of effects on the identified co-contaminants will support assessment of the final remedy for the 100-KR-4 and 100-HR-3 OUs. Performance monitoring and assessment includes the following tasks:

- Use the Cr(VI) plume maps, Cr(VI) time series data (trend results), and hydraulic containment maps (interpolated CFM/simulated CFM) to evaluate the river protection objective by completing the systematic determination calculation, with attendant visual outputs (maps and time series).
- Prepare composite target zones (CTZs) for each groundwater OU (a single map that depicts the extent of Cr(VI) and any co-contaminants above their respective CULs).
- Use the overlay of the CTZ maps with the P&T well field and hydraulic capture maps to complete the following tasks:
  - Identify areas of low capture (capture frequency) where concentrations exceed CULs.
  - Develop initial interpretations of areas where there may be insufficient groundwater extraction or injection that may require increased rates or additional wells.

4.5 Summary of Periodic Tasks

Table 4-1 presents a summary of the periodic tasks, including subtasks, reporting, action items, and implementing personnel.

4.6 Managing and Communicating Uncertainties

Groundwater remediation activities are subject to a range of uncertainties that fall into three major categories: incomplete CSM, system O&M that does not achieve quantitative benchmarks, or resource limitations. The following subsections describe how uncertainties in any one of these elements could affect interim action P&T system operations and what strategies are needed to minimize these effects. These mitigation strategies are incorporated into the optimization tasks described in Chapter 3.

4.6.1 Conceptual Site Model

Groundwater remediation at the Hanford Site involves integration of engineered systems constructed in the subsurface environment up to depths of several hundred feet. Imperfect knowledge of subsurface conditions represents a large portion of the overall remedial action uncertainty. The following uncertainties are typically encountered during P&T activities with potential mitigation strategies:

- Groundwater contaminant plume geometry and magnitude are not clearly defined in all areas. Actions that can be used to reduce this area of uncertainty may include installation of additional monitoring wells at selected locations to provide bounding measurements (vertical and horizontal distribution) of contaminant concentrations and collect additional measurement and observations of local hydrogeologic conditions and stratigraphy.
- Potential continuing contributions to groundwater from secondary sources in the vadose zone, the periodically rewetted zone, or within the aquifer are not well defined in some areas. Actions that can be used to reduce this area of uncertainty include performing additional characterization of the soil column in historical release areas and installing monitoring wells to measure groundwater quality changes at known or suspected release locations.

Table 4-1. Summary of Periodic Tasks

Activity	Subtasks	Frequency/ Schedule	Reporting	Action Needed	Implementing Personnel
CSM					
Update seasonal groundwater flow maps (especially low river stage), hydrogeologic cross sections, plume maps (especially low river stage), and time series data plots and trends.	Groundwater flow maps Plume maps and capture frequency maps Time series plots and trends Geologic sections	Semiannual low and high river Annual Annual Annual	Annual P&T and sitewide groundwater monitoring reports	Complete current updates.	Project scientists and groundwater modelers
E/I Wells					
Well placement optimization: realign, replace, or install new wells.	Update 100AGWM and POM. Develop graded approach for prioritizing well replacement or reconfiguration.	Annual	Annual plume containment and remediation utilization plan	Install or realign wells as prescribed.	Project scientists and groundwater modelers Operations
Monitor and assess specific capacities (ongoing).	Run analysis on well performance.	Periodic recommendations for well maintenance		Record specific capacities. Develop tool for project scientists.	Project scientists and groundwater modelers
Conduct aquifer tests to assess aquifer properties.	Test existing and new/replacement wells.	As needed	Stand-alone pump test report Summarized in an annual sitewide groundwater monitoring report	Schedule and undertake first series of tests.	Test plan to be developed by project scientists
Recommendations for improved well configurations: prepare RPO recommendations.	Define individual well function and requirements (e.g., monitoring, extraction, and injection).	Annual	Annual plume containment and remediation utilization plan	None	Project scientists

Table 4-1. Summary of Periodic Tasks

Activity	Subtasks	Frequency/ Schedule	Reporting	Action Needed	Implementing Personnel
Data Evaluation					
Maintain 100AGWM and POM with current data (e.g., changes to E/I wells, hydraulic model, and treatment systems).	Complete updates and measurement inputs.	Annual	Annual P&T report with updated data applications ECF		Project scientists and groundwater modelers
Complete river protection determination.	Update plume maps, time series data, and hydraulic containment maps.	Annual	Annual P&T report	None	Project scientists and groundwater modelers
Hydraulic capture: identify areas of low capture for expanded containment and recovery.	Update plume maps, time series data, and hydraulic containment maps.	Annual	Annual P&T report Annual plume containment and remediation utilization plan	Prepare RPO recommendations.	Project scientists and groundwater modelers
Prepare composite plume map(s) for each groundwater OU.	Conduct annual groundwater monitoring and data review.	Annual	Annual P&T and sitewide groundwater monitoring reports		Project scientists and groundwater modelers

100AGWM = 100 Area groundwater model
CSM = conceptual site model
E/I = extraction/injection
ECF = environmental calculation file
OU = operable unit
P&T = pump-and-treat
POM = pumping optimization model
RPO = remedial process optimization

4.6.2 Remedial System Performance

Remedial systems may not perform as expected during operations due to variations in component functionality or system design. The following types of performance uncertainty may be experienced:

- Exact performance of E/I wells may vary from design expectations. The following actions can be used to reduce uncertainty from this element:
  - Monitor system element performance and establish corrective action limits for selected metrics.
  - Continue preventive and corrective maintenance on remedial systems.
  - Ensure that remedial systems have adequate levels of excess capacity or redundancy to maintain operations.
- Aquifer hydraulic parameters may vary from average or typical values. The following actions can be used to reduce uncertainty from this element:
  - Collect samples for aquifer hydraulic parameter measurements during drilling and construction of new and replacement wells to enhance understanding of site conditions.
  - Perform aquifer pumping tests at new and replacement wells.
  - Design system components, particularly E/I wells, to perform as intended.
  - Ensure adequate development of new and reconditioned wells.

4.6.3 Resource Allocation

Groundwater remediation activities at the Hanford Site include complex mechanical systems that are expected to operate over many years to achieve cleanup goals. Specific areas of uncertainties that may affect project performance and potential actions to reduce or mitigate effects of funding uncertainty include the following:

- Unforeseen project needs are identified during operations:
  - Maintain prioritization of project activities that allow redirection of specific project resources.
- A requested resource is not provided:
  - Provide an adequately defined technical basis for project activities.
  - Maintain prioritization of project activities that allow redirection of specific project resources.
- Selection of final remedies for OUs under interim remedial action is delayed:
  - Maintain robust operation of interim remedial systems where those systems are expected to form the basis of final actions.
- Hanford Site shutdown occurs:
  - Implement safe-store activities to protect systems from deterioration during nonoperational periods.

Instituting these mitigating strategies should minimize potential affects to P&T operations resulting from resource uncertainty.

4.6.4 Cleanup Levels

The current remediation goal under the interim action ROD (EPA/ROD/R10-96/134) is to achieve a concentration of less than 20 µg/L Cr(VI) in groundwater in compliance wells. This current remediation goal is based on the state Cr(VI) surface water standard of 10 µg/L, in the area where groundwater discharges to surface water, and assumption of a 1:1 dilution factor. A compliance point along the river has not been established. Uncertainty regarding CULs affects the completion strategy. A higher CUL at the river allows for reallocation of resources from river protection to aquifer restoration within a shorter time frame. Alternately, a lower CUL for inland areas may prolong cleanup time.

CULs have not been established in a ROD for other contaminants identified in the 100-HR-3 and 100-KR-4 OUs. COCs identified in the 100-D/H and 100-K RI/FS reports (DOE/RL-2010-95 and DOE/RL-2010-97, respectively) and preliminary remediation goals are listed in Table 4-2.

Table 4-2. Preliminary Remediation Goals for the 100-HR-3 and 100-KR-4 Groundwater OUs

COC	Units	Preliminary Remediation Goal	Basis for Preliminary Remediation Goals
Cr(VI)[a]	µg/L	10/48	WAC 173-201A/WAC 173-340-720
Total Chromium	µg/L	65/100	40 CFR 131/DWS
Nitrate[b]	µg/L	10,000	DWS
Strontium-90[c]	pCi/L	8	DWS
Carbon-14[c]	pCi/L	2,000	DWS
Trichloroethene	µg/L	5	DWS
Tritium[c]	pCi/L	20,000	DWS

Sources: DWS from 40 CFR 141, "National Primary Drinking Water Regulations."

40 CFR 131, "Water Quality Standards

WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington."

WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards."

a. Preliminary remediation goals for Cr(VI) are 10 µg/L where groundwater discharges to surface water and 48 µg/L in the upland groundwater.

b. Nitrate may be expressed as nitrate-nitrogen (NO_3-N) or as nitrate (NO_3). The DWS for nitrate measured as NO_3-N is 10,000 µg/L. The mathematical equivalent, when nitrate is measured as NO_3, is 45,000 µg/L.

c. The DWS for beta/photon emitters is 4 mrem/yr. This requires a sum of fractions calculation when more than one isotope is present.

COC = contaminant of concern

Cr(VI)= hexavalent chromium

DWS = drinking water standard

OU = operable unit

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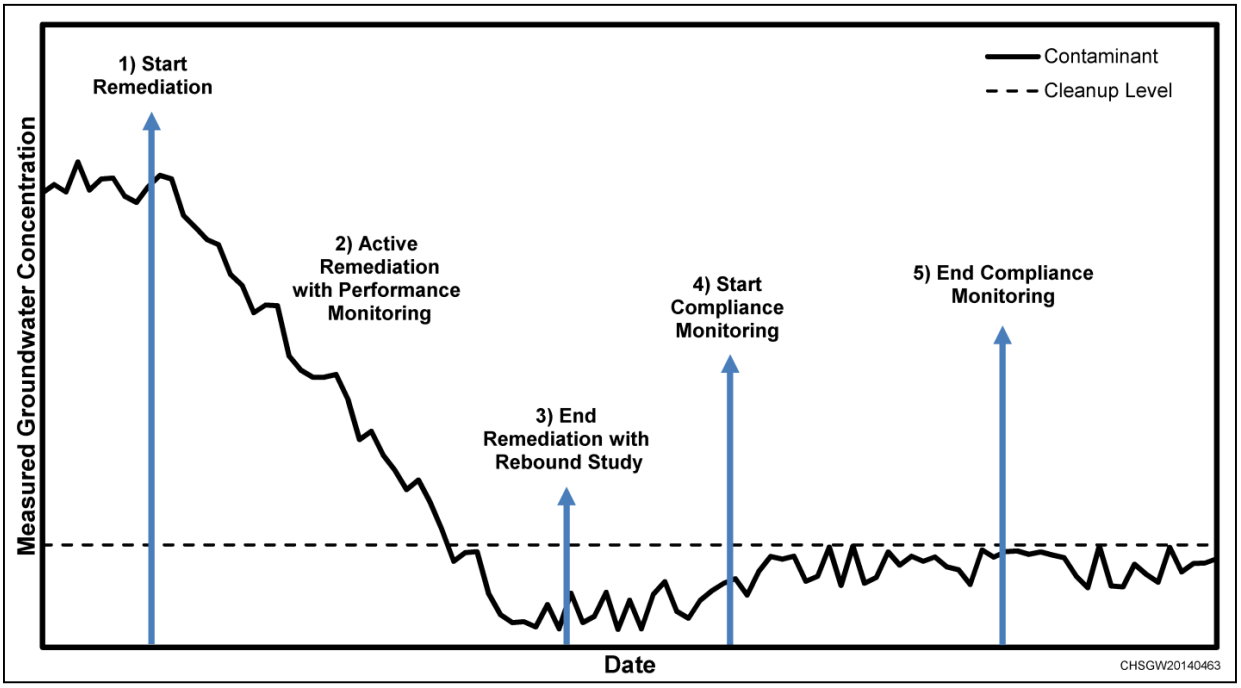
5 Pre-Attainment Strategies

Groundwater P&T remedial actions typically move through a series of recognized phases beginning with the start of remediation and ending with the completion of the compliance monitoring phase (Figure 5-1). In general, when P&T is used for aquifer restoration, different areas of the plume clean up in different time frames. The cleanup rate is influenced by contaminant velocities, hydraulic flushing efficiency, contaminant mass transfer limitations, and groundwater velocity/travel time variations. Where P&T technology is employed for aquifer remediation, it is often necessary to employ dynamic pumping strategies, especially in the latter stages of active remediation, to account for variable aquifer and contaminant plume response.



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

Figure 5-1. Phases in Groundwater Remediation

Relative to the 100-HR-3 and 100-KR-4 OUs interim P&T remedial actions, mass transfer limiting conditions that are likely to be encountered include Cr(VI) desorption from aquifer solids, Cr(VI) mineral precipitate dissolution (e.g., secondary sources), and dissolved Cr(VI) diffusion from low- to high-permeability aquifer zones (e.g., back diffusion). The presence of mass transfer limiting conditions is generally indicated in the middle to latter stages of the active remediation period by a flattening in the Cr(VI) concentration versus time curve. Because mass transfer limitations slow remediation progress, monitoring strategies that provide for timely detection of these conditions can be an important component of the performance monitoring program.

Due to the scale of P&T interim remedial actions underway in the 100-HR-3 and 100-KR-4 OUs, groundwater velocity and travel time variations may also affect cleanup rates and time to completion. Travel times reflect the flow path length that contaminants must travel from their place of origin in the aquifer to an extraction point. Pumping strategies that shorten these pathways are an important component of the active remediation phase.

As different areas within the plume approach CULs, it may be advantageous to modify a continuously running pumping strategy by transitioning low-concentration extraction wells to a pulsed operations schedule or by turning them off altogether. These modifications make system hydraulic capacity, as well as technical and financial resources, available for use elsewhere within the plume. Shutting down extraction wells, temporarily or permanently, also changes groundwater flow paths within the aquifer to break up velocity stagnation zones or potentially shorten flow path lengths.

The purpose of this section is to describe a pre-attainment strategy that can be implemented such that active remediation within subareas of the plume can transition from continuous to pulsed operations or be suspended altogether until the start of the compliance monitoring phase.

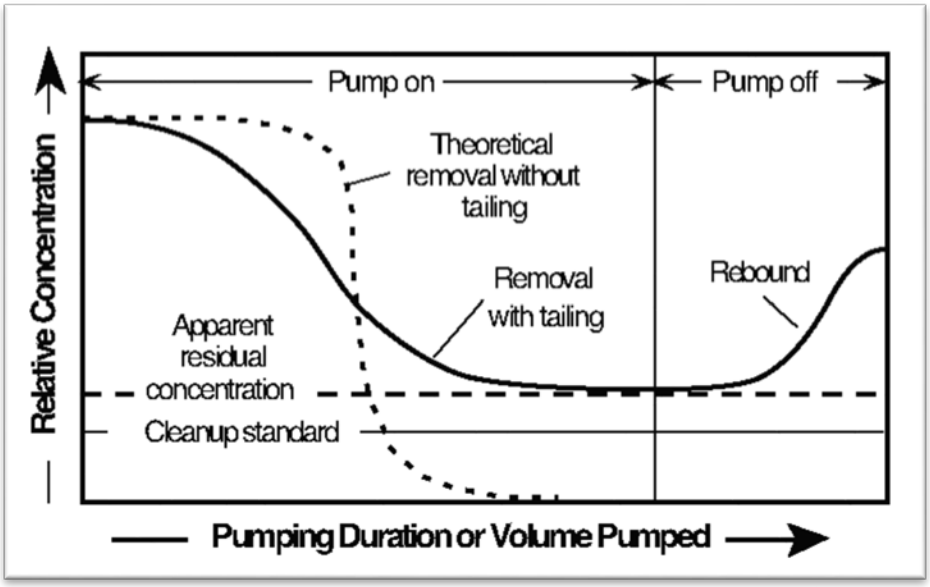
For purposes of discussion, tailing is the progressively slower rate of decline in dissolved contaminant concentration with continued operation of a P&T system. Tailing may be caused by dissolution of a solid-phase COC precipitate, desorption or matrix diffusion of COCs from fine-grained materials, and/or variations in groundwater flow velocities. Rebound is the rapid increase in contaminant concentration that can occur after pumping has been discontinued. This increase may be followed by stabilization of the COC concentration at a somewhat higher level than was achieved initially by the P&T system.

5.1 Extraction Well Pumping Modifications

As described in Chapter 6 of the 100-HR-3 and 100-KR-4 remedial design/remedial action work plans (RD/RAWPs) (DOE/RL-2013-31, *Remedial Design/Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit*, and DOE/RL-2013-33, *Remedial Design/Remedial Action Work Plan for the 100-KR-4 Groundwater Operable Unit*, respectively), the remediation performance monitoring phase includes evaluation of extraction and monitoring well Cr(VI) concentration measurements using simple and advanced performance analysis tools. For the purposes of making decisions about ongoing extraction well operation schedules, a pre-attainment data evaluation approach using simple performance analysis is presented in this subsection for use with routine extraction well and monitoring well Cr(VI) or other COC analysis results. The pre-attainment data evaluation is designed to guide decisions on the need to continue pumping at a specific location or subarea within the plume, proceed with a rebound test (as described in the 100-HR-3 and 100-KR-4 RD/RAWPs (DOE/RL-2013-31 and DOE/RL-2013-33, respectively]), or suspend pumping until P&T operations across the OU are terminated.

5.1.1 Contaminant Concentration Behavior

During routine P&T system operations, contaminant concentrations generally decrease linearly, reaching an asymptotic or “tailing” concentration that may lie above or below the CUL. Figure 5-2 presents a graphical depiction of tailing during P&T remediation. Ideally, tailing occurs below the CUL, but experience with P&T systems at sites with heterogeneous aquifers, such as the Hanford formation and Ringold unit E, indicates there is a reasonable expectation that tailing may occur above the CUL at one or more extraction/monitoring well groups within the 100-HR-3 and 100-KR-4 Groundwater OUs. This tailing will most likely occur due to some form of mass transfer limitation.



Source: EPA/540/4-89/005, *Performance Evaluation of Pump-and-Treat Remediations*.

Figure 5-2. Tailing in P&T Remediation

5.1.2 Proposed Approach and Decision Criteria

A determination on whether to modify extraction well pumping at a specific location or within an area of the Cr(VI) plume may be made based on evaluation of routine performance monitoring results as shown in Figure 5-1. Based on evaluation of the performance monitoring results, possible outcomes include the following:

1. **Continue pumping.** If Cr(VI) concentrations are present above the CUL at the extraction well and its companion monitoring wells and continue to indicate a downward trend, then continuous pumping may be maintained. A Mann Kendall statistical test with a Decreasing determination may also be used.

2. **Suspend pumping.** Pumping may be suspended at an extraction well when Cr(VI) concentrations at monitoring wells located within its zone of capture (e.g., companion monitoring wells) have declined and remain below the CUL for two consecutive sampling events. A rebound test may be performed by collecting groundwater samples from the extraction well and companion monitor wells to confirm that Cr(VI) concentrations will remain below the CUL. The sampling frequencies, location, and duration of the rebound test are unique to each well and, therefore, will be presented in a future TM. If the rebound test demonstrates that Cr(VI) concentrations have remained below the CUL, then the extraction well will remain off. Groundwater sampling at monitoring wells will continue in accordance with the SAPs.

3. **Implement pulsed-off operations.** If Cr(VI) concentrations at an extraction well and/or its companion monitoring wells exhibit tailing above the CUL, the extraction well may be shifted to pulsed-off operations. Tailing is defined as four consecutive sampling events where there is less than a 10 percent decrease in the Cr(VI) concentration, or a No Trend determination is made using a larger data set and applying the Mann-Kendall Test. Extraction wells that operate for river protection are not candidates for pulsed operation. The duration of the pulsed-off operations schedule is unique to each location within the aquifer and will be determined based on the results of a rebound test. It is expected

that once rebound tests have been conducted at 6 to 10 extraction/companion monitoring well pairs, there will be a sufficient data set available to develop a pulsed operations schedule for use at other extraction well locations.

4. **Resume pulsed-on operations.** An extraction well that has been placed in pulsed-off mode will be returned to pulsed-on operations based on (a) a schedule determined from a previously conducted rebound study, or (b) Cr(VI) concentrations in groundwater samples from the extraction well and/or companion monitoring wells that rise above the CUL for two consecutive events.

5.1.3 Pulsed Pumping Description

Pulsed pumping is sometimes implemented in response to tailing and relies on the COC concentration rebound phenomenon to increase overall mass removal efficiency. Pulsed pumping, which consists of intermittent operation of an extraction well, has the potential to increase the ratio of contaminant mass removed to groundwater volume pumped. Pulsed pumping can also be used to maintain a desired flow path or horizontal gradient when such controls may be required at specified times of the year (e.g., low river stage).

During the temporary shutdown or pulsed-off phase, COC concentrations in groundwater increase due to mass transfer. Once the P&T system is restarted (e.g., pulsed on), higher COC concentrations are removed, resulting in increased mass removal efficiency. Pulsed pumping may include progressively longer periods of pulsed-off operations, followed by regular periods of pulsed-on operations, as the effects of mass transfer limitations decrease.

6 RPO Schedule and Reporting

This chapter presents a schedule template for the execution of RPO activities and implementation of recommendations that are developed from those activities, including intermediate performance goals that will form the basis for key remedy modification decisions. This is followed by a summary of the types and contents of the reporting that will be used.

6.1 Schedule

Figure 6-1 depicts the annual RPO cycle, showing the general timeline for RPO activities and reporting. Not shown are the tasks that run continuously throughout the year, including P&T system periodic tasks, O&M, groundwater monitoring, and unit managers meetings (UMMs).

The following narrative summarizes the principal activities that are conducted by each quarter of each CY:

- **First Quarter CY.** The annual kickoff meeting in late December/early January begins the process of collating and evaluating prior CY groundwater sampling, water level, and operations data for preparation of the annual P&T and sitewide groundwater monitoring reports:
  - Contaminant plumes are developed based on data obtained through the prior CY, and these (together with any changes to the CSM, well field, flow rates, or hydrological conditions) are used to update 100AGWM and POM.
  - Hydraulic capture maps are developed from 100AGWM and through groundwater elevation mapping.
  - P&T system data are analyzed.
  - Contaminant trend analyses are completed.
- **Second Quarter CY.** P&T and sitewide groundwater monitoring reports are completed and submitted, and formal RPO calculations are undertaken to develop RPO recommendations (plume containment and remediation utilization plan) for the next FY:
  - P&T and groundwater monitoring reports are produced.
  - POM is used to predict the cleanup time frame based on the previous CY and on plume, hydraulic capture analysis, and concentration trends; project scientists consider changes to flow rates and well fields for the next FY, using POM/PVT to simulate alternatives.
  - Proposed alternatives are validated via 100AGWM, and a run of record is generated.
  - The plume containment and remediation utilization plan is submitted.
- **Third Quarter CY**. Identify scope of activities for upcoming physical year and identify recommendations.
- **Fourth Quarter CY**. Implementation of RPO recommendations begins:
  - Planning activities commence to implement RPO activities.

- Infrastructure planning activities commence, such as the siting, cultural reviews, contracting, and other activities associated with new well drilling.
- Actual drilling or well realignment commences:
  - Flow rate changes at existing wells commence following documentation and communication to Engineering of the recommendation(s).
  - Pump or pipe changes commence following documentation and communication to Engineering of the recommendation(s), assuming no cultural review is required for the piping.
  - Contracts are issued for new drilling, and drilling commences.

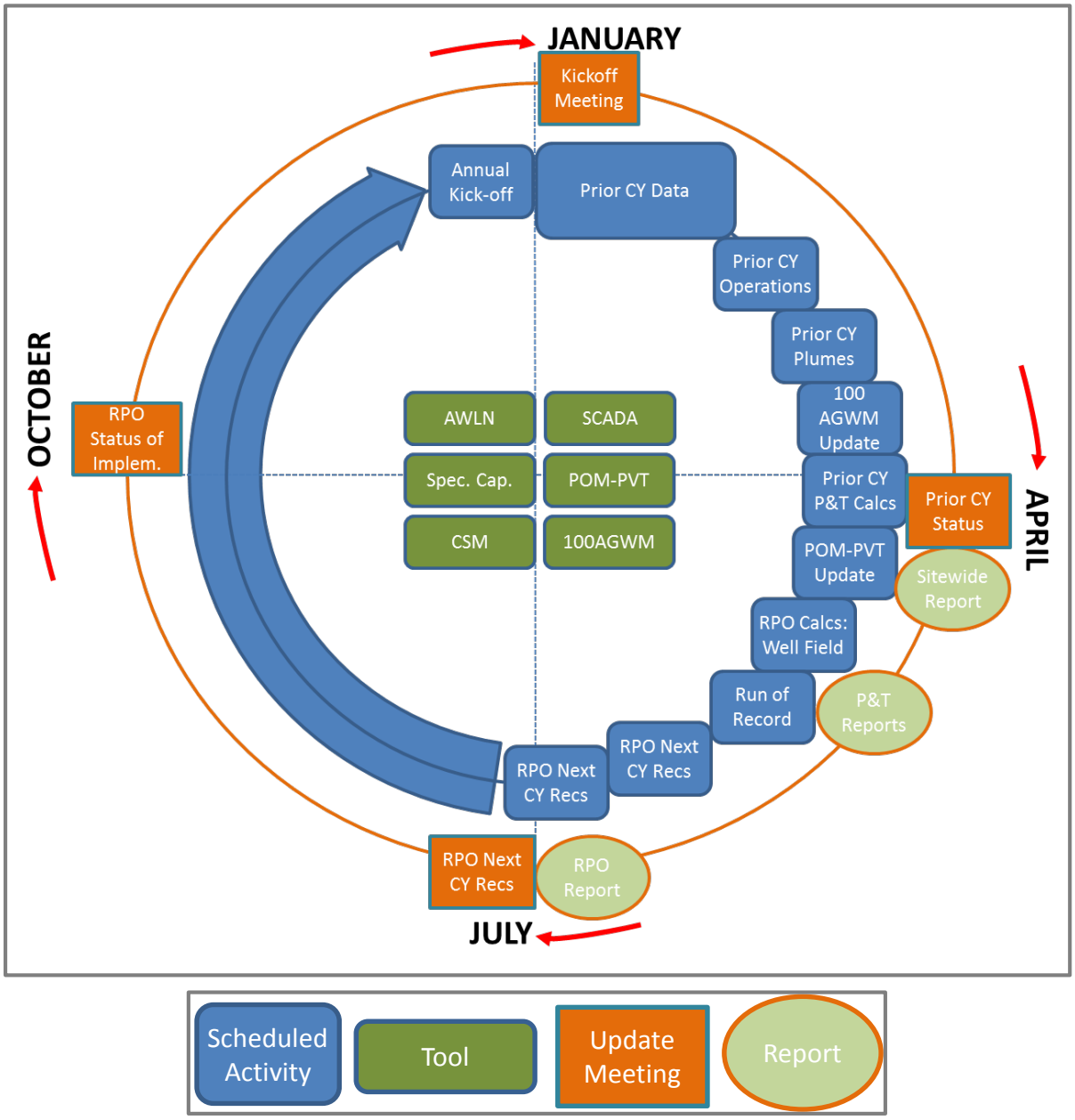


Figure 6-1. Draft Annual Schedule Showing Tasks and Reporting To Be Completed Each Year

6.2 Reporting

Reporting of periodic RPO activities includes the following:

- Annual submittals:
  - P&T report
  - Sitewide groundwater monitoring report
  - Plume containment and remediation utilization plan
- Periodic updates:
  - Monthly UMM/presentations
  - Quarterly progress/status presentation
  - Periodic TMs and ECFs presenting the results of RPO analyses that form the basis of the annual recommendations

Preparation of the annual sitewide groundwater monitoring report and 100 Area P&T report includes compilation, review, quality assurance (QA), and interpretation from the prior CY of the majority of data streams that will underpin RPO activities, including the following:

- Compilation of groundwater sample results and preparation of the following:
  - Intrawell time series plots
  - Groundwater contaminant plume maps
- Compilation of groundwater elevation and river stage data and preparation of the following:
  - Intrawell time series hydrographs
  - Groundwater elevation maps
- Compilation of P&T system data, including the following:
  - E/I rates
  - Well-specific and combined influent concentrations

Results, findings, conclusions, and recommendations from analysis of the prior years' P&T operations data are also summarized in the annual P&T report. Underlying calculations, emphasizing the application of the 100AGWM together with groundwater level mapping and other calculations, are detailed in an accompanying ECF.

Each year, an annual plume containment and remediation utilization plan outlining specific RPO activities planned or recommended for the following FY is submitted for approval. Generally, this plan is developed after completion of the P&T and annual sitewide groundwater monitoring reports. Compiled data and work products are incorporated into the assessments and tools associated with the baseline activities (updated 100AGWM and E/I well database) to provide justification for RPO recommendations, incorporating features of remedial operations described in this document.

The annual RPO recommendations developed from the baseline and periodic data analyses may include the following:

- Well configuration (well locations and E/I rates) to accelerate attainment of CULs while maintaining or improving upon the current extent of hydraulic containment (where appropriate) and the current status of river protection
- Maintenance and modifications to the water conveyance infrastructure such as pumps and pipes, the treatment train, and individual wells
- Modifications to performance monitoring
- Modifications to the workflow processes and methods of analyses

The work flow for the analyses and reporting required to develop recommendations for the rates and locations of groundwater E/I for each P&T system in the 100-HR-3 and 100-KR-4 OUs will follow the general process depicted in Figure 6-1.

7 Roles and Responsibilities

This chapter presents the organizations responsible for identifying and implementing RPO activities. Figure 7-1 provides an organizational chart.

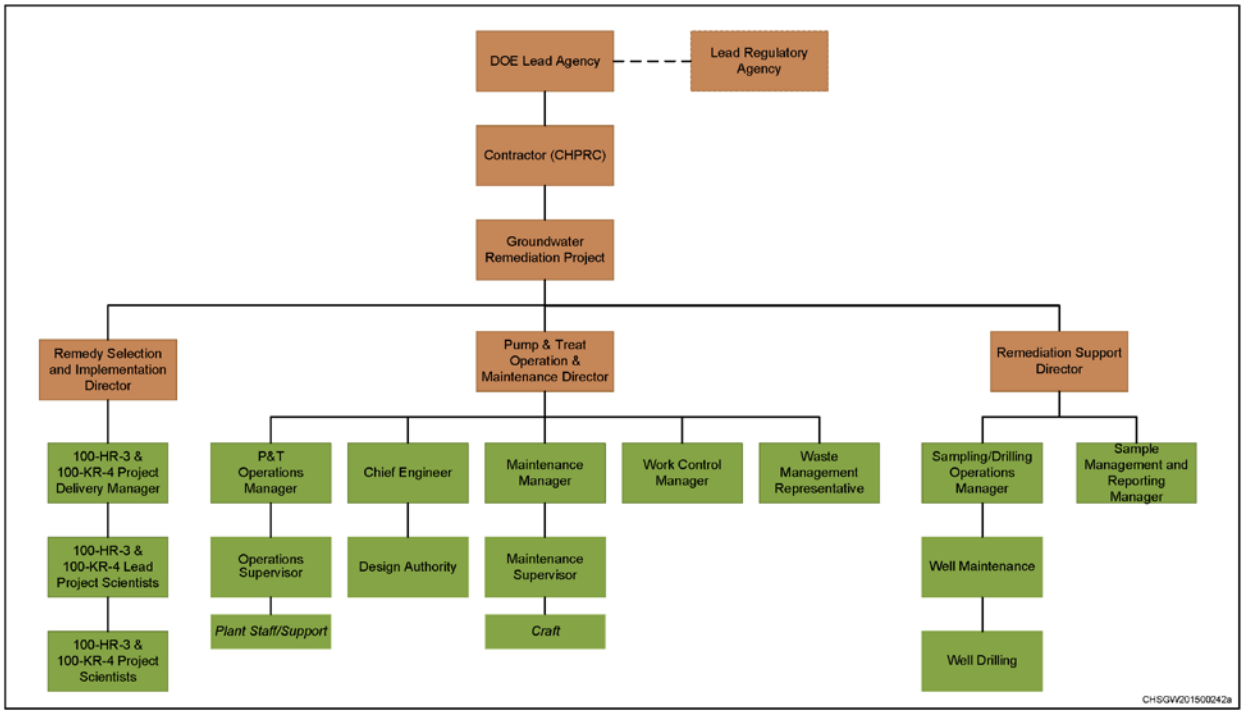


Figure 7-1. Organizational Chart for RPO Activities

7.1 Organizational Responsibilities

The following subsections describe the RPO organizational responsibilities detailed in Figure 7-1.

7.1.1 Lead Agency

DOE is the government agency responsible for the remedial actions throughout the Hanford Site. As such, DOE has assigned remedial project managers to each main area and task involved with remediation activities. A remedial project manager is responsible for managing the assigned activities, which include scope, budget, schedule, quality, personnel, communication, risk/safety, contracts, and regulatory interface.

7.1.2 Lead Regulatory Agency

Ecology is the lead regulatory agency (LRA) for CERCLA remediation activities at the 100-HR-3 OU, and EPA is the LRA for the 100-KR-4 OU, as described in the Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*). The LRA is responsible for overseeing activities to verify that applicable regulatory requirements are met.

7.1.3 Contractor

The prime contractor is responsible for the safe environmental cleanup of the groundwater OUs at the DOE Hanford Site. The prime contractor implements the remedy at the direction of DOE.

7.1.4 Groundwater Remediation Project

The groundwater remediation project provides oversight for activities and coordinates with the DOE Richland Operations Office (DOE-RL), EPA, and Ecology.

7.1.5 Remedy Selection and Implementation Director

The remedy selection and implementation director maintains contractor responsibility for activities and interfaces with DOE-RL for program implementation.

7.1.6 100-HR-3 and 100-KR-4 OUs P&T Project Delivery Manager

The 100-HR-3 and 100-KR-4 OUs P&T project delivery manager is responsible for budget and schedule for the management of documents, requirements, and RPO activities. Performance toward achieving RAOs and associated process optimization is also the responsibility of the 100-HR-3 and 100-KR-4 OUs P&T project delivery manager, who coordinates with and reports to DOE-RL on 100-HR-3 and 100-KR-4 OUs P&T activities.

7.1.7 P&T Operations and Maintenance Director

The O&M director is responsible and accountable for budget and schedule related to O&M of the P&T system. Responsibilities include ensuring that appropriate operations support functions (e.g., radiological protection and safety) are available to support operational activities and verifying that O&M procedures have been prepared, approved, and implemented.

7.1.8 P&T Operations Manager

The 100-HR-3 and 100-KR-4 OUs P&T operations manager assists with startup, developing operational guides, and evaluating training and performance for the P&T facilities. Additional responsibilities include the following:

- Implement operator and operations management training programs.
- Evaluate and direct the process of the treatment plant,
- Analyze operational process control procedures and make recommendations to the project manager.
- Maintain accurate operational records.
- Prepare reports as required by the project manager.
- Monitoring records
- Review all plant operating records

7.1.9 Operations Supervisors

Operations supervisors are responsible for planning and coordinating field resources and ensuring that workers are appropriately trained and available. They are responsible for day-to-day safe configuration and continued operations of the facility, issue identification, and reaction to system maintenance needs. Operations supervisors participate in continuing training to help maintain system/process-related knowledge of the 100-HR-3 and 100-KR-4 OUs P&T systems.

7.1.10 Chief Engineer

The chief engineer has overall management responsibility for the engineering within the Remediation Contractor’s S&GRP. The chief engineer is responsible for assigning and approving qualifications for the design authorities.

7.1.11 Design Authority

The design authority is responsible and accountable for reviewing and approving the functional design criteria and for the final acceptability of a structure, system, or component. The design authority also identifies applicable regulatory and safety requirements. Design authority responsibilities related to operations include the following:

- Review and approve functional design criteria, design changes, construction submittals, and requests for information.
- Perform engineering inspections for design compliance.
- Review and approve procedures.

7.1.12 Maintenance Manager

The maintenance manager is responsible for the following:

- Supervise all preventive and corrective maintenance of the 100-HR-3 and 100-KR-4 OUs P&T facilities.
- Plan, schedule, and direct maintenance of a variety of specialized mechanical and electrical equipment including buildings, structures, and grounds.
- Assign, coordinate, and supervise personnel and materials required for the maintenance and repair of facilities.
- Estimate cost and time for all aspects of maintenance, repair, and construction work.

7.1.13 Maintenance Supervisors

Maintenance supervisors are responsible for preparing and executing facility maintenance-related work activities:

- Conduct prework reviews, automated job hazard analyses, and walkdowns with the work team.
- Ensure all work documents are technically accurate and current, and have been approved and released for work performance.
- Coordinate with other organizations to provide full support of fieldwork activities and ensure that craft personnel are adequately trained and qualified.
- Implement planned and unplanned maintenance in accordance with facility operational priorities.
- Conduct post-job reviews and technical work document closure upon completion of the field activities.

7.1.14 Work Control Manager

The work control manager is responsible for ensuring that work is planned and performed in accordance with approved work management procedures:

- Implement Integrated Safety Management Systems core functions and guiding principles and Environmental Management Systems core elements throughout the work management process.
- Integrate activity-based job hazards analyses into all fieldwork documents per established job hazard analysis procedures.

- Oversee development of work documents, work instructions, and work packages.
- Ensure that all work documents are developed by qualified and trained work planners.

7.1.15 Waste Management Representative

The waste management representative communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner. Other responsibilities include receiving data from the field team lead to initiate waste designations, profiles, and other documents to confirm compliance with waste acceptance criteria.

7.2 Other Support Staff

The following subsections describe the responsibilities of other support staff.

7.2.1.1 Environmental Compliance Officer

The environmental compliance officer is responsible for the following:

- Review plans, procedures, and technical documents to ensure that environmental requirements have been addressed.
- Identify environmental issues that affect operations, and develop cost-effective solutions.
- Respond to environmental/regulatory issues or concerns raised by DOE-RL and/or the LRA.
- Oversees project implementation for compliance with applicable internal and external environmental requirements.

7.2.1.2 Quality Assurance Engineer

The QA engineer is matrixed to the 100-HR-3 and 100-KR-4 OUs P&T project manager and is responsible for QA issues on the project. Responsibilities include overseeing project QA requirements, reviewing project documents (including SAPs and the QA project plan), and participating in QA assessments.

7.2.1.3 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project, as carried out through hazards analysis, job hazard analyses, and other pertinent safety documents required by federal regulations or internal primary contractor work requirements. The Health and Safety organization also assists project personnel in complying with applicable health and safety standards and requirements. The Health and Safety organization coordinates with the Radiological Control organization to determine personal protective equipment requirements.

7.2.1.4 Radiological Control Organization

The Radiological Control organization is responsible for radiological support within the project. Specific responsibilities include conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for all work planning. The Radiological Control organization also identifies radiological hazards and implements appropriate controls to maintain worker exposures ALARA (e.g., requiring personal protective equipment). The Radiological Control organization plans and directs radiological control technician support for all activities.

7.2.1.5 Sample Management and Reporting

Sample Management and Reporting (SMR) coordinates laboratory analytical work and ensures that laboratories conform to Hanford Site internal laboratory QA requirements (or their equivalent), as approved by DOE and the regulatory agencies. SMR receives analytical data from the laboratories, enters the data into the Hanford Environmental Information System database, and arranges for data validation. SMR is responsible for informing the project manager of any issues reported by the analytical laboratories.

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8 References

11-AMCP-0002, 2010, "Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Washington July 2010, Memo to File Regarding: Supplemental Actions for the In-Site Reduction/Oxidation Manipulation Barrier Performance for the 100-HR-3 Groundwater Operable Unit Interim Remedy" (letter to J.A. Hedges, Washington State Department of Ecology, and D.A. Faulk, U.S. Environmental Protection Agency from R.A. Holten), U.S. Department of Energy, Richland Operations Office, Richland, Washington, October 26. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1011290677.

40 CFR 131, "Water Quality Standards," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol21/xml/CFR-2010-title40-vol21-part131.xml.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol22/xml/CFR-2010-title40-vol22-part141.xml.

CHPRC-02625, 2015, *Compilation of Information Regarding Extraction and Injection Wells of the 100 Areas Pump-and-Treat (P&T) Systems*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

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*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083383H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083382H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083381H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083380H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083379H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083378H.
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http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083331H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083330H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083329H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083328H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083327H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083326H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083325H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083324H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083323H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083322H.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083321H.

DOE/RL-2010-97, 2011, *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093615.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093613.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093612.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093611.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093610.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093609.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093608.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093607.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093606.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093605.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093604.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093603.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093602.

DOE/RL-2013-29, 2015, *Sampling and Analysis Plan for 100-KR-4 Groundwater Operable Unit Monitoring*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2013-30, 2014, *Sampling and Analysis Plan for 100-HR-3 Groundwater Operable Unit Monitoring*, Draft B, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082922H.

DOE/RL-2013-31, 2014, *Remedial Design/Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082921H.

DOE/RL-2013-33, 2015, *Remedial Design/Remedial Action Work Plan for the 100-KR-4 Groundwater Operable Unit*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2015-05, 2015, *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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

ECF-Hanford-14-0035, 2014, *Description of Groundwater Calculations and Assessments for the Calendar Year 2013 (CY2013) 100 Areas Pump-and-Treat Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082016H.

ECF-Hanford-15-0062, 2015, *Estimation and Tracking of Well Efficiency with Application to the 100 Areas Pump-and-Treat (P&T) Systems*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-Hanford-15-0040, 2015, *Analysis of Well Development Data in the 100 Areas*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

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

EPA, Ecology, and DOE, 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*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0096029.

EPA 230-R-92-014, 1992, *Methods for Evaluating The Attainment Of Cleanup Standards Volume 2: Ground Water*, Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/policy/remedy/pdfs/230r-92014-s.pdf.

EPA/540/4-89/005, 1989, *Performance Evaluation of Pump-and-Treat Remediations*, Office of Research and Development, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Ada, Oklahoma. Available at: http://www.epa.gov/superfund/remedytech/tsp/download/pereva.pdf.

EPA 542-R-07-007, 2007, *Optimization Strategies for Long-Term Ground Water Remedies (with Particular Emphasis on Pump and Treat Systems)*, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/cleanup/postconstruction/OptimizationStrategies.pdf.

EPA/ROD/R10-95/126, 1995, *Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1095126.pdf.

EPA/ROD/R10-96/134, 1996, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1096134.pdf.

EPA/ROD/R10-99/039, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington (100 Area Remaining Sites)*, U.S. Environmental Protection Agency, Region 10, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1099039.pdf.

EPA/AMD/R10-00/122, 2000, *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Washington State Department of Ecology, and U.S. Department of Energy, Seattle, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/a1000122.pdf.

EPA/ESD/R10-03/606, 2003, *Explanation of Significant Difference for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Washington State Department of Ecology, and U.S. Department of Energy, Seattle, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/e1003606.pdf.

SGW-46279, 2012, *Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*, Rev. 2, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087245.

SGW-46279, 2015, *Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-53543, 2012, *Automated Water-Level Network Functional Requirements Document*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081288H.

SGW-54209, 2013, *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River Shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087569.

SGW-58236, 2014, *Well Maintenance Plan for the 100-HR-3 and 100-KR-4 Groundwater Treatment Facilities*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082017H.

Soper, Wayne, 1999, "100-D Ponds Closure (TSD # D-1-1)" (letter to K.A. Klein, U.S. Department of Energy, and S.D. Leidle, Bechtel Hanford, Inc.). Washington State Department of Ecology, Richland, Washington, August 27. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199157864.

WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A.

WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-720.