DOE/RL-97-36
Revision 3

200-UP-1 Groundwater Remedial Design/ Remedial Action Work Plan

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

U.S. DEPARTMENT OF ENERGY
Richland Operations Office

P.O. Box 550
Richland, Washington 99352

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Executive Summary

This remedial design/remedial action work plan (RD/RA WP) describes the plan for implementing interim remedial actions (IRAs) for groundwater contamination at specific locations within the 200-UP-1 Groundwater Operable Unit (OU) at the U.S. Department of Energy's (DOE) Hanford Site. The IRAs are being implemented under the auspices of the interim record of decision (ROD) for the 200-UP-1 Groundwater OU (EPA/541/R-97/048)[1] as amended by the Washington State Department of Ecology (Ecology). *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit Hanford Site Benton County, Washington* (Ecology, 2009)[2] was prepared by Ecology and approved by Ecology, DOE, and the U.S. Environmental Protection Agency (EPA) on February 24, 2009. The IRA implemented at 200-UP-1 OU under the interim ROD consists of a pump-and-treat system to remove uranium and technetium-99 (Tc-99) from groundwater in the vicinity of the 221-U Building (U Plant). The remedial action has been in operation since 1995 (initially as a pilot scale treatment and subsequently as an interim action) and includes operation of extraction wells, transfer of extracted groundwater to the 200 East Effluent Treatment Facility (ETF) for treatment with ultimate infiltration of the treated water at the State-Approved Land Disposal Site (SALDS) located immediately north of 200 West Area.

The IRA goals are targeted to reduce contaminant mass within the plumes and minimize migration of uranium and Tc-99 from the 200 West Area. The selected remedy removes and treats these two contaminants of concern, as well as the co-contaminants of nitrate and carbon tetrachloride.

Ecology, 2009 mandates the following changes to the 200-UP-1 Groundwater OU IRA:

1. The IRA goal for contamination in groundwater is to remediate the portion of the groundwater that exceeds 300 micrograms per liter (μg/L) total uranium and

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[1] EPA/541/R-97/048, *Record of Decision for the 200-UP-1 Interim Remedial Measure*, 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/r1097048.pdf.

[2] Ecology, 2009, *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit Hanford Site Benton County, Washington*, Washington State Department of Ecology, Olympia, Washington, February 24, 2009. Available at: http://yosemite.epa.gov/r10/cleanup.nsf/sites/hanford2/$FILE/200UP1-ESD-0209.pdf.

9,000 picocuries per liter (pCi/L) of technetium-99. The IRA goal is established in the interim ROD at 10 times the Federal drinking water maximum contaminant level (MCL). On December 7, 2000, the EPA published a final Radionuclide Rule in the Federal Register[3] that established a National Primary Drinking Water Regulation MCL of 30 µg/L for uranium. This revised rule took effect December 2003. The National Primary Drinking Water MCL of 30 µg/L (ppb) for uranium is more stringent and protective than the *Model Toxics Control Act* cleanup level of 48 ppb for uranium in the interim ROD. This RD/RA WP incorporates the new MCL for uranium as an applicable or relevant and appropriate requirement (ARAR) for treatment of extracted groundwater. In addition, the pumping of 200-UP-1 groundwater extraction wells must continue until concentrations of both uranium and Tc-99 are less than or equal to 10 times the MCL for four consecutive quarters.

2. Groundwater extraction in the vicinity of the U Plant and subsequent treatment of extracted water at the ETF will continue. The pumping rate for groundwater extraction wells is changed from the 189 L/min (50 gal/min) specified in the interim ROD to a pumping rate determined by the site-specific conditions (e.g., hydrogeologic formation features) and described in this RD/RA WP. This activity will continue until such time as the groundwater conditions meet the remedial action goals (i.e., less than 300 µg/L uranium and/or less than 9,000 pCi/L Tc-99), or the IRA is replaced by a final remedial action.

3. Sampling of monitoring well 299-W23-19, located in the southern portion of Waste Management Area (WMA) S-SX in the 200 West Area, on a quarterly basis will continue, followed by purging an additional 3,800 L (1,000 gal) of groundwater from the well after sampling. This activity will continue until such time as the groundwater conditions in this well meet the remedial action goals for four consecutive quarters, or this IRA element is replaced by final remedial action. A pump-and-treat IRA to treat technetium in the vicinity of WMA S-SX is also described in this work plan. The interim pump-and-treat system in the vicinity of WMA S-SX will consist of extraction wells and a water conveyance system to transport extracted groundwater to the planned 200 West Area treatment facility associated with the final remedial action

[3] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule," *Federal Register*, Vol. 65, No. 236, pp. 76708-76753, December 7, 2000.

he planned 200 West Area treatment facility associated with the final remedial action at 200-ZP-1 OU.

4. The institutional controls identified in the RD/RA WP will be modified to be consistent with the controls specified at other OUs. The institutional controls will be described in a revision of the site-wide institutional controls plan.

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Terms

AEA	*Atomic Energy Act of 1954*
ARAR	applicable or relevant and appropriate requirement
ALARA	as low as reasonably achievable
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ETF	Effluent Treatment Facility
EPA	United States Environmental Protection Agency
ESD	explanation of significant difference
FY	fiscal year
HASP	health and safety plan
IRA	interim remedial action
IRM	interim remedial measure
LERF	Liquid Effluent Retention Facility
MCL	maximum contaminant level
O&M	Operations and Maintenance
OU	operable unit
QA	quality assurance
RA	remedial action
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RD/RA WP	remedial design/remedial action work plan
REDOX	Reduction-Oxidation (Plant)
RL	DOE Richland Operations Office
ROD	record of decision
SALDS	State-Approved Land Disposal Site

SAP	sampling and analysis plan
Tc-99	technetium-99
TEDF	Treated Effluent Disposal Facility
U Plant	221-U Building
WAC	*Washington Administrative Code*
WBS	work breakdown structure
WMA	waste management area

1 Introduction

This 200-UP-1 Groundwater Operable Unit (OU) remedial design/remedial action work plan (RD/RA WP) presents the approach for design and implementation of selected interim remedial actions (IRAs) for the 200-UP-1 Groundwater OU, located in the 200 West Area of the Hanford Site. These actions are intended to capture and remediate areas of groundwater contamination that exceed the interim cleanup levels established in the interim record of decision (ROD).

The 200-UP-1 Groundwater OU is one of four groundwater OUs located within the Hanford Central Plateau and generally occupies the southern portion of the Hanford 200 West Area (see Figure 1-1). The 200-UP-1 Groundwater OU includes groundwater contamination identified in the following general plume areas:

- A mixed plume of contamination by uranium, technetium-99 (Tc-99), nitrate, and other constituents located in the vicinity of the 221-U Building (U Plant). This plume has been the subject of ongoing pump-and-treat activities conducted as an IRA. This plume is referred to in this work plan as the U Plant vicinity plume and is the subject of an IRA.
- Two discrete developing plumes of Tc-99 and other constituents located immediately downgradient of Waste Management Area (WMA) S-SX. These plumes are referred to in this work plan as the WMA S-SX vicinity plumes and are the subject of an IRA.
- One small plume of Tc-99 located immediately downgradient of WMA U. This plume is referred to as the WMA U vicinity plume, but is not the subject of an IRA under this work plan.
- A large mixed plume of tritium, nitrate, iodine-129, and other constituents located over a broad area generally downgradient of the S Plant, or Reduction-Oxidation (REDOX) Plant. This plume is referred to as the dispersed plume east of the S Plant (REDOX). This plume is not the subject of an IRA under this work plan.

1.1 Purpose

This revised RD/RA WP provides the bases for implementing an IRA within the 200-UP-1 Groundwater OU as described in EPA/541/R-97/048, *Record of Decision for the 200-UP-1 Interim Remedial Measure*. This revised RD/RA WP also addresses changes to the IRAs specified in an explanation of significant difference (ESD) prepared by the Washington State Department of Ecology (Ecology) and approved by the U.S. Department of Energy (DOE) and the United States Environmental Protection Agency (EPA) in February 2009.

1.2 Site Description and Background

An IRA was determined to be necessary to respond to groundwater contamination conditions identified in the vicinity of the U Plant located in the Hanford 200 West Area and associated with historical releases of plant-related contaminants from that facility. The contaminants of primary concern for the interim action were uranium and Tc-99. Concentrations of these contaminants in groundwater were observed to substantially exceed drinking water standards.

The IRA was chosen in accordance with the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA); as amended by the *Superfund Amendments and Reauthorization Act of 1986*; Ecology, et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement); and the Code of Federal Regulations (CFR) 40 CFR 300.430, "National Oil and Hazardous

Substance Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy." The IRA for this area is described in EPA/541/R-97/048.

Onsite pump-and-treat operations were initiated in April 1994 as a pilot-scale treatability test (57 L/min [15 gal/min]). The system was upgraded to 189 L/min (50 gal/min), and remediation of the groundwater plumes was initiated in September 1995.

Public comments were requested in August 1995 on DOE/RL-95-26, *Interim Remedial Measure Proposed Plan for the 200-UP-1 Operable Unit, Hanford, Washington*. As a result of public comments, an additional remediation alternative (pump-and-treat using the 200 East Area Effluent Treatment Facility [ETF]) was evaluated and ultimately selected for implementation. BHI-00187, *Engineering Evaluation/ Conceptual Plan for the 200-UP-1 Groundwater Operable Unit Interim Remedial Measure*, provides an overview and comparative analysis of the remedial measure alternatives. The preferred alternative (i.e., groundwater pump-and-treat using the ETF) was selected in the ROD on the following basis.

- The alternative reduces potential risk to human health and the environment by removing contaminant mass and minimizing migration of the high-concentration portion of the uranium and Tc-99 plumes (defined as greater than or equal to 10 times the cleanup level for uranium under the Washington Administrative Code [WAC] 173-340, "Model Toxics Control Act – Cleanup," and 10 times greater than the maximum contaminant level (MCL) for Tc-99).

- The alternative requires that groundwater would be treated at the state-of-the-art ETF located in the 200 East Area of the Hanford Site. Certain contaminants such as carbon tetrachloride will be destroyed in this process, which minimizes waste generation.

- The alternative would remove the contaminants of concern and specific co-contaminants (nitrate and carbon tetrachloride) that exist within the groundwater.

Additional 200-UP-1 Groundwater OU background information can be found in the following documents:

- EPA/541/R-97/048, *200-UP-1 Groundwater OU Interim Declaration of the Record of Decision*

- BHI-00951, *200-UP-1 Groundwater OU Groundwater Pump-and-Treat Phase I Annual Report, FY 1996*

- DOE/RL-92-76, *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Richland, Washington*

- DOE/RL-95-02, *Treatability Test Report for the 200-UP-1 Groundwater Operable Unit - Hanford Site*

Following issuance of the 200-UP-1 ROD in February 1997, the first version of DOE/RL-97-36, Rev. 0, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan*, was issued in March 1997 to implement the IRA specified in the ROD. Subsequent revisions to the RD/RA WP were issued in July 1997 (Rev. 1) and October 1997 (Rev. 2) to incorporate minor changes to the initial work plan.

In February 2009, the Tri-Party agencies signed an ESD (Ecology, 2009, *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit Hanford Site Benton County, Washington*) for the 200-UP-1 Groundwater OU IRA. Ecology, 2009 identified the following specific changes to the interim action requirements:

- The IRA cleanup level for uranium is reduced to 300 µg/L (10 times the current uranium MCL of 30 µg/L) from the previously specified 480 µg/L.
- Groundwater extraction in the vicinity of the U Plant (the site of the original 200-UP-1 Groundwater OU IRA) will continue at a pumping rate identified in this work plan and consistent with well configuration and aquifer characteristics. This is a change from the 189 L/min (50 gal/min) specified in the interim ROD. This extracted groundwater would continue to be treated at ETF.
- Quarterly sampling of monitoring well 299-W23-19 will be continued, including purging of an additional 3,800 L (1,000 gal) of groundwater from the well following each sampling event. This activity is intended to remove contaminant mass from this well location within WMA S-SX, which has exhibited persistently elevated Tc-99 concentrations. This activity has been routinely implemented, but was not previously specified as an IRA.
- Institutional controls consistent with those previously specified in other OUs are to be implemented for the 200-UP-1 Groundwater OU IRA.
- Ecology, 2009 identified estimated costs of about $500,000 per year that will be associated with implementation of the IRAs.

The remedial action objectives (RAOs) for this IRA are to hydraulically contain and treat the high-concentration portions of the uranium and Tc-99 groundwater plumes and provide data to support a final remedial action. The high-concentration portions of the plumes are defined as the 300 µg/L (10 times the MCL drinking water standard) contour for uranium and 9,000 pCi/L (10 times the MCL) contour for Tc-99. During the course of monitoring groundwater conditions within 200-UP-1 Groundwater OU, emerging contaminant plumes have been identified at WMA S-SX and, to a lesser degree, at WMA U.

The Tri-Party agencies recognized the need to more fully address the developing Tc-99 groundwater plumes downgradient of WMA S-SX by approving Tri-Party Agreement Milestone M-016-120:

> *DOE will have a groundwater treatment system (not to exceed 50 gpm pump-and-treat capacity) for the Tc-99 plume at the S/SX Tank Farm within the 200-UP-1 Operable Unit. This milestone may be met by utilizing treatment capacity at another location such as the new 200 West pump and treatment system or the ETF.*

As previously discussed in this section, the 200-UP-1 OU interim remedy selection was based on using a pump-and-treat process to remediate groundwater plumes that are part of the OU. During the issuance of the interim ROD, instead of building a new treatment system, a decision was made to use the existing ETF in the 200 East Area. Since the issuance of the interim ROD, several plumes of Tc-99 have emerged near the 241-S/SX Tank Farm (e.g., WMA S-SX), which is part of the 200-UP-1 OU. Also, a final ROD was issued in September 2008 for the adjacent 200-ZP-1 Groundwater OU that will install a pump-and-treat system to treat the groundwater. The new 200 West Area treatment facility being constructed for the 200-ZP-1 OU will be used for treatment of the Tc-99 plumes in the 241-S/SX Tank Farm vicinity, as documented in Tri-Party Agreement Milestone M-016-120. These emerging plumes are within the 200-UP-1 OU and the proposed interim remedy is within the intent and scope of the 200-UP-1 OU interim ROD.

The requirements of Ecology, 2009 and Tri-Party Agreement Milestone M-016-120 will be implemented through the IRAs as described in this RD/RA WP. New groundwater extraction wells will be installed in the WMA S-SX area and will be integrated with the 200 West Area treatment system currently in design. Contaminated groundwater extracted from the vicinity of WMA S-SX would be pumped to the new 200 West Area treatment facility, treated to meet injection requirements, and then injected back into the aquifer with other treated water from the 200-ZP-1 OU. The institutional controls will be implemented through a revision to the Hanford Sitewide institutional control plan. The IRAs are intended to operate until the observed groundwater contamination conditions meet the RAOs or the interim systems are replaced by final remedial action systems.

Table 1-1 provides a cross-walk between the previous version (Rev. 2) and the current version (Rev. 3) of the 200-UP-1 OU RD/RA WP and the new Ecology, 2009 requirements.

Table 1-1. Cross-Walk Between Previous Version and Current Version of the 200-UP-1 OU RD/RA WP

Item	Rev. 2 Chapter[a]	Rev. 3 Chapter (this document)
Work Plan Elements		
Executive Summary	-	Executive Summary
Introduction	1	1
Extraction System	2	3.1.2, 3.2.2, 3.3.2, Appendix B
Pipeline and Treatment System	3	3.1.3, 3.2.3, 3.3.3
Operations and Maintenance	4	4.4.2
Air Monitoring	5	5.1
Treatment System Monitoring	6	3.4.2
Compliance Monitoring	7	2.4, 6
Health and Safety	8	5.4
Regulatory Compliance	9	2, Appendix A
Reporting	10	6
Schedule	11	7.2
Cost	12	7.1
Remedial Action Implementation	-	4
ESD Elements		
MCL for uranium changed to 30 µg/L	-	Executive Summary, 1.2, Appendix A
Pump wells per RD/RA WP to achieve RAOs	-	Executive Summary, 1.2, 2.1.1
Quarterly sample and purge of Well 299-W23-19	-	Executive Summary, 1.2, 2.1.2
Updated costs for interim remedial action	-	1.2, 7.1

Table 1-1. Cross-Walk Between Previous Version and Current Version of the 200-UP-1 OU RD/RA WP

Item	Rev. 2 Chapter[a]	Rev. 3 Chapter (this document)
Institutional Controls	-	1.2, 2.1.4[b]

a. DOE/RL-97-36, Rev. 2, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan.*

b. DOE/RL-2001-41, Rev. 2, 2007, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*, will be revised to include the institutional control requirements in Ecology, 2009, *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit Hanford Site Benton County, Washington.*

ESD = explanation of significant difference

MCL = maximum contaminant level

µg/L = microgram per liter

RD/RA WP = Remedial Design/Remedial Action Work Plan

RAOs = remedial action objectives

1.3 Scope

The scope of this RD/RA WP includes the IRAs summarized in the following subsections and presented in detail in the remaining sections of this document.

1.3.1 Pump-and-Treat Action in the Vicinity of the U Plant

The interim pump-and-treat IRA in the vicinity of the U Plant will continue operation within the portions of the groundwater plume that exceed the interim cleanup levels established in the interim ROD. The current system includes operation of two groundwater extraction wells with subsequent treatment of groundwater at the 200 East Area ETF. The intent of this IRA continues to be remediation of the portion of the plume in the U Plant vicinity that exceeds the interim cleanup levels for uranium and Tc-99 established in the interim ROD.

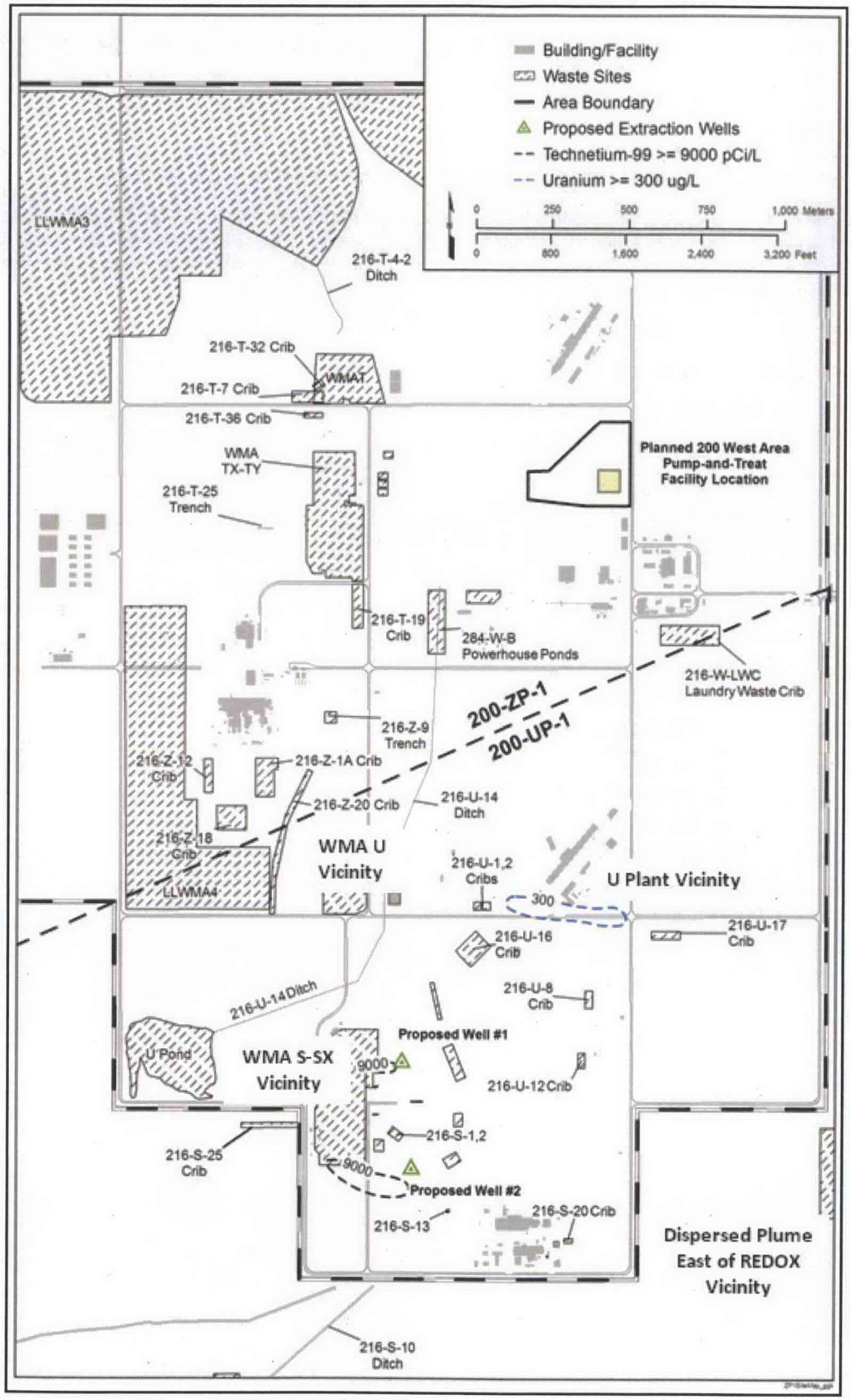

Figure 1-1. Location of Plume Areas Within 200-UP-1 Groundwater OU

1.3.2 New IRA Components Established through Ecology, 2009

The ESD to the 200-UP-1 Groundwater OU Interim ROD identifies additional IRA elements that will be established with the OU and are described in this RD/RA WP. The following IRA elements are defined in Ecology, 2009.

- Modifications to groundwater extraction operating parameters (e.g., pumping rates) at the existing interim pump-and-treat system located in the 221-U Building (U Plant) vicinity to reflect changes in hydrogeologic conditions (e.g., declining regional water table elevation) and continued operation of that system.
- Revision of the IRA goal for uranium in groundwater to be consistent with the current maximum contaminant level (MCL) for uranium (i.e., the new goal will be 300 μg/L, or 10 times the current MCL for uranium of 30 μg/L). The IRA goal for Tc-99 remains at 10 times the current MCL (i.e., 9,000 picocuries per liter [pCi/L], or 10 times the MCL of 900 pCi/L).
- Well 299-W23-19, located in the south end of WMA S-SX, will be sampled quarterly with a subsequent large-volume purge of 3,800 L (1,000 gal) of water as an IRA for observed Tc-99 contamination in groundwater at that well location. This well location exhibits the highest Tc-99 concentration in the WMA S-SX vicinity and this action is intended to remove contaminant mass from groundwater.
- Additional specific institutional controls for the 200-UP-1 Groundwater OU IRA will be implemented.
- Ecology, 2009 identifies estimated costs of about $500,000 per year that will be associated with implementation of the IRAs.

1.3.3 Pump-and-Treat Action in the Vicinity of WMA S-SX

Additional groundwater extraction wells will be installed in the vicinity of WMA S-SX to initiate capture and remediation of the Tc-99 contamination that exceeds the interim cleanup level (i.e., 9,000 pCi/L) observed in that area. The extracted groundwater will be pumped to the 200 West Area treatment system for treatment.

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2 Basis for Remedial Action

The National Contingency Plan establishes a national expectation for cleanup of groundwater at CERCLA sites: "EPA expects to return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (40 CFR 300.430). EPA generally defers to state agency definitions of useable groundwater provided under the various comprehensive state groundwater protection programs administered by the states across the U.S. Based on physical yield and natural water quality, Ecology, through its groundwater protection program, has determined that the aquifer setting for the 200-UP-1 Groundwater OU meets the WAC definition for potable groundwater and has been recognized by the state as a potential source of domestic drinking water.

The selected interim remedy protects human health and the environment through groundwater remediation and institutional controls. This action will reduce the highest concentration areas of the contaminated plumes of uranium and Tc-99, thereby reducing potential adverse impacts to downgradient areas. In addition, this interim action will provide site-specific performance information that can be used to evaluate alternative technologies, determine optimum process sizing, and estimate costs. This IRA is expected to be consistent with any planned future final remedial actions.

2.1 Selected Interim Remedy

The selected interim remedy consists of pumping the highest concentration zone of the contaminated groundwater plume at 200-UP-1 and treatment using the existing ETF located in the 200 East Area. The selected remedy is intended to reduce contaminant mass within the plume and minimize migration of uranium and Tc-99 from the 200 West Area. The selected remedy will remove and treat these two contaminants of concern, in addition to the specific co-contaminants of nitrate and carbon tetrachloride that exist within the groundwater. The high-concentration portion of the plume corresponds to that area having contaminants greater than or equal to levels 10 times the MCL for uranium and Tc-99.

The major components of the 200-UP- I OU IRA are further discussed in the following subsections.

2.1.1 U Plant Vicinity Groundwater Extraction and Treatment

The primary component of the 200-UP-1 Groundwater OU remedy is installation and operation of a groundwater pump-and-treat system designed to capture and treat contaminated groundwater to reduce uranium and Tc-99 concentrations during the interim action. Ecology, 2009 requires that pumping from existing and any new 200-UP-1 extraction wells be conducted in accordance with this RD/RA WP until concentrations of both uranium and Tc-99 are less than or equal to 10 times the MCL (i.e., less than or equal to 300 µg/L for uranium and less than or equal to 9,000 pCi/L for Tc-99) for four consecutive quarters.

The extracted groundwater will be transferred through an existing pipeline to the Liquid Effluent Retention Facility (LERF) for interim storage. Subsequently, the groundwater will be treated in the ETF. Both the LERF and ETF are permitted facilities and are currently treating aqueous wastes generated from Hanford Site restoration activities. The groundwater will be sampled and analyzed to determine if it contains a listed dangerous waste or displays a characteristic or criteria of dangerous waste in accordance with WAC 173-303-070 through 173-303-100. Any contaminated groundwater containing listed waste treated at the ETF must meet the de-listing criteria in 40 CFR 261, "Identification and Listing of Hazardous Waste," Appendix IX, Table 2 prior to disposal.

2.1.2 Well 299-W23-19

Ecology, 2009 added the requirement to sample well 299-W23-19 on a quarterly basis for Tc-99. After sampling, the well will be purged at a minimum of 3,800 L (1,000 gal) until concentrations of Tc-99, only at well 299-W23-19, are less than or equal to 10 times the MCL (i.e., less than or equal to 9,000 pCi/L) for four consecutive quarters. The contaminated groundwater will be subject to the same management, treatment, and disposal requirements as those for extracted groundwater described in Section 2.1.1.

2.1.3 WMA S-SX Vicinity Groundwater Extraction and Treatment

For the emerging Tc-99 groundwater plumes in the WMA S-SX vicinity, new groundwater extraction wells are proposed to capture the high concentration plumes (e.g., greater than 9,000 pCi/L) and pump that groundwater through a new pipeline constructed to the planned 200 West Area treatment facility (Section 3.3). After treatment, the effluent will be returned to the aquifer through injection wells being installed as part of the 200-ZP-1 Groundwater OU remedy.

The 200 West Area pump-and-treat system is being designed to implement the 200-ZP-1 Groundwater OU ROD (EPA, DOE, and Ecology, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*) in a phased approach and is scheduled to be operational by December 31, 2011 (DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*). In anticipation of future expansion, the 200 West Area groundwater treatment facility will also be capable of treating some of the contaminated groundwater from the 200-UP-1 Groundwater OU. Initially, the system will be able to treat up to 189 L/min (50 gal/min) of contaminated groundwater from the 200-UP-1 Groundwater OU. This initial groundwater is anticipated to come from planned new extraction wells in the WMA S-SX vicinity. Following initial operations, it is anticipated that the system will be expanded to provide the necessary treatment capabilities for the contaminated groundwater in the 200-UP-1 Groundwater OU following a final decision.

2.1.4 Institutional Controls

The 200-UP-1 Groundwater OU ROD and subsequent Ecology, 2009 require institutional controls during the interim action. Institutional controls are instruments (e.g., administrative and/or legal restrictions) that are designed to control or eliminate specific pathways of exposure to contaminants. For instance, for groundwater at Hanford, institutional controls are in place prohibiting the installation and use of groundwater wells for purposes other than monitoring, characterization, and cleanup. An existing source of potable water is provided to facilities on the Central Plateau and will continue to be available, so there is no demand for groundwater. Groundwater use would be restricted until cleanup levels are achieved. DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*, identifies the current institutional controls for the Hanford Site. It also describes how institutional controls are implemented and maintained, serving as a reference point for the selection of institutional controls for the future. The current plan provides a foundation from which to identify the long-term controls needed to prevent exposure during the restoration timeframe. DOE/RL-2001-41 will be updated to include the following institutional controls required to be met as part of the IRA selected in the 200-UP-1 Groundwater OU ROD and Ecology, 2009:

1. DOE shall control access to 200-UP-1 OU groundwater to prevent unacceptable exposure of humans to contaminants, except as otherwise authorized in Ecology-approved documents.

2. Visitors entering any site areas of the 200-UP-1 Groundwater OU will be required to be badged and escorted at all times.

3. No intrusive work shall be allowed in the 200-UP-1 Groundwater OU unless Ecology has approved the plan for such work and that plan is followed.

4. DOE shall prohibit well drilling in the 200-UP-1 Groundwater OU, except for monitoring, characterization, or remediation wells authorized in Ecology-approved documents.

5. Groundwater use in the 200-UP-1 Groundwater OU is prohibited, except for limited research purposes, monitoring, and treatment authorized in Ecology-approved documents.

6. DOE shall post and maintain warning signs along pipelines conveying untreated groundwater that caution site visitors and workers of potential hazards from the 200-UP-1 OU groundwater.

7. In the event of any unauthorized access (e.g., trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and evaluation of possible prosecution.

8. Activities that would disrupt or lessen the performance of the pump-and-treat component of the remedy are to be prohibited.

9. DOE shall prohibit activities that would damage the remedy components (e.g., extraction wells, piping, treatment plant, and monitoring wells).

10. DOE will prevent the development and use of property above the 200-UP-1 Groundwater OU for residential housing, elementary and secondary schools, childcare facilities, and playgrounds.

11. DOE shall report on the effectiveness of institutional controls for the 200-UP-1 Groundwater OU interim remedy in an annual report, or on an alternative reporting frequency specified by Ecology. Such reporting may be for the 200-UP-1 Groundwater OU alone or may be part of the Hanford Sitewide report.

12. Measures that are necessary to ensure continuation of institutional controls shall be taken before any lease or transfer of any land above the 200-UP-1 Groundwater OU. DOE will provide notice to Ecology and EPA at least six months prior to any transfer or sale of 200-UP-1 Groundwater OU or any land above the 200-UP-1 Groundwater OU so that Ecology can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective institutional controls. If it is not possible for DOE to notify Ecology and EPA at least six months prior to any transfer or sale, DOE will notify Ecology and EPA as soon as possible but no later than 60 days prior to the transfer or sale of any property subject to institutional controls. In addition to the land transfer notice and discussion provisions above, DOE further agrees to provide Ecology and EPA with similar notice, within the same time frames, as to federal-to-federal transfer of property. DOE shall provide a copy of executed deed or transfer assembly to Ecology and EPA.

The institutional controls specified above shall be maintained until the concentrations of hazardous substances in groundwater are at such levels to allow for unrestricted use and exposure and Ecology authorizes the removal of restrictions. DOE is responsible for implementing, maintaining, reporting on, and enforcing the institutional controls.

No later than 180 days after Ecology, 2009 is signed, DOE will update DOE/RL-2001-41 to include the institutional controls required by Ecology, 2009 and specify the implementation and maintenance actions that will be taken, including periodic inspections. The revised DOE/RL-2001-41 shall be submitted to EPA and Ecology for review and approval as a Tri-Party Agreement primary document. DOE shall comply with DOE/RL-2001-41 as updated and approved by EPA and Ecology.

2.2 Remedial Action Objectives

The 200-UP-1 Groundwater OU ROD and subsequent Ecology, 2009 have the following RAOs:

- Reducing contamination in the area of highest concentrations of uranium and Tc-99 to less than or equal to 10 times the MCL for four consecutive quarters.
- Reducing potential adverse human health risks through reduction of contaminant mass.
- Preventing further movement of these contaminants from the highest concentration area.
- Providing information that will lead to development and implementation of a final remedy that will be protective of human health and the environment.

2.3 Applicable or Relevant and Appropriate Requirement Compliance

The applicable or relevant and appropriate requirements (ARARs) implementation strategy for the 200-UP-1 Groundwater OU IRA is provided in Appendix A.

2.4 Remedy Monitoring

The remedy performance monitoring (treatment system, extraction wells, and monitoring wells) and progress toward achieving the RAOs and Interim Remedial Measure (IRM) requirements will be documented annually.

An integrated groundwater monitoring plan will be developed for all monitoring programs within the 200 West Area, including the 200-ZP-1 and 200-UP-1 Groundwater OUs, to address changing hydrologic and contaminant plume conditions due to the 200 West Area pump-and-treat systems. This monitoring plan will ensure monitoring activities meet the requirements of remediation performance monitoring under CERCLA, groundwater monitoring under *Resource Conservation and Recovery Act of 1976* (RCRA), and Sitewide surveillance monitoring under the *Atomic Energy Act of 1954* (AEA).

Consistent with the State's acceptance of the 200-ZP-1 Groundwater OU ROD and DOE/RL-2002-59, *Hanford Site Groundwater Strategy - Protection, Monitoring, and Remediation*, the objective of this effort is to develop a single, integrated monitoring plan that achieves the following:

- Satisfies regulatory requirements and integrates RCRA, CERCLA, and AEA requirements by using CERCLA monitoring wells to satisfy the treatment, storage, and/or disposal unit monitoring and post-closure monitoring required by RCRA and the environmental monitoring required by the AEA and implementing DOE Orders.
- Minimizes duplication and reduces inconsistencies for monitoring that arise from the multiple regulations.
- Supports groundwater cleanup decisions in a timely, effective, and efficient manner.

Ultimately, it is expected that a single monitoring plan will be developed that satisfies the monitoring requirements for all programs within the 200 West Area. The integrated monitoring plan will be referenced in the appropriate regulatory document while the active pump-and-treat remediation is in progress.

3 Remedial Design Approach

This chapter provides a description of the post-ROD activities necessary to support completion of the remedy design and provides remedy design details.

3.1 U Plant Vicinity Groundwater Contamination

The design basis, well network, and treatment system design for the groundwater contamination in the U Plant vicinity are described in this section.

3.1.1 Design Basis

The 200-UP-1 pump-and-treat operational history is detailed in DOE/RL-2008-77, *200-UP-1 and 200-ZP-1 Operable Units Pump-and-Treat System Annual Report for Fiscal Year 2008*, Appendix A.

The current fiscal year (FY) 2008 groundwater contamination extent and progress toward achieving the interim ROD RAOs are documented in DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008,* and DOE/RL-2008-77 and are summarized in this section. Figure 3-1 shows the locations of selected wells in the 200-UP-1 Groundwater OU. Figure 3-2 and Figure 3-3 show the average Tc-99 and uranium concentrations in the unconfined aquifer in the U Plant vicinity, respectively.

Average annual Tc-99 groundwater concentrations in FY 2008 were below the 9,000 pCi/L RAO at all wells. Tc-99 concentrations have remained level or showed a declining trend at most wells during FY 2008. The Tc-99 groundwater concentrations in FY 2008 were below the 9,000 pCi/L RAO for all of the monitoring wells (Figure 3-2), with the exception of the first quarter result of 11,000 pCi/L for extraction well 299-W19-36.

The FY 2008 uranium concentrations remained stable or decreased from FY 2007 and FY 2006 levels for most wells. The highest uranium concentrations occurred at wells 299-W19-37 (320 μg/L) and 299-W19-18 (390 μg/L). These were the only wells with concentrations that exceeded the 300 μg/L RAO. The portion of the plume in FY 2008 with a concentration greater than 300 μg/L is estimated to be approximately 2.1 ha (5.1 ac).

Groundwater elevation data collected during FY 2008 around the U Plant vicinity extraction wells indicated that the groundwater surface declined at an average rate of 0.19 m/yr (0.63 ft/yr), compared to 0.33 m/yr (1.1 ft/yr) in FY 2007 when the extraction wells were brought back online after being shut down for more than two years.

3.1.2 Well Network Design

During FY 2008 operations, extraction well 299-W19-36 had a pumping rate ranging from 14.8 to 25 L/min (3.9 to 6.6 gal/min) and a yearly average rate of 19.7 L/min (5.2 gal/min). Extraction well 299-W19-43 had a pumping rate of 12.2 to 30.3 L/min (3.2 to 8 gal/min) and a yearly average rate of 17.8 L/min (4.7 gal/min). The pumping rates of the two existing wells appear to have diminished in recent years, likely due to a combination of conditions. First, the water table elevation in this location has declined since the wells were constructed and currently only about one-half of the screened intervals in the wells are saturated. In addition, the wells may be exhibiting reduced production due to normal fouling of the screens that occurs over time. The wells will be inspected to assess their condition and necessary maintenance will be performed. The wells will be redeveloped to determine whether productivity can be increased.

In the event that redevelopment is not successful, replacement well(s) will be designed. Simulated extraction well capture zone for the U Plant vicinity is shown in Figure 3-4 for the extraction scenario in which the existing wells are restored to a combined capacity of about 76 L/min (20 gal/min). The capture zone estimates were prepared using the MODFLOW (Harbaugh et al., 2000) computer model for the Hanford Central Plateau described in Appendix B.

The assessment of groundwater extraction capacity in the U Plant vicinity includes the following maintenance activities that will be conducted under a task order:

- Inspect and redevelop the existing wells.
- Inspect the well head plumbing and assess the need to modify well head plumbing to reduce head loss.
- Reset the extraction pumps to deeper locations within the screened intervals.

Following these activities, the wells will be operated and the performance (e.g., water elevation drawdown and pumping rate) will be evaluated for continued operation. If sustained pumping rates are not substantially improved, a design for replacement well(s) will be prepared and the replacement(s) installed.

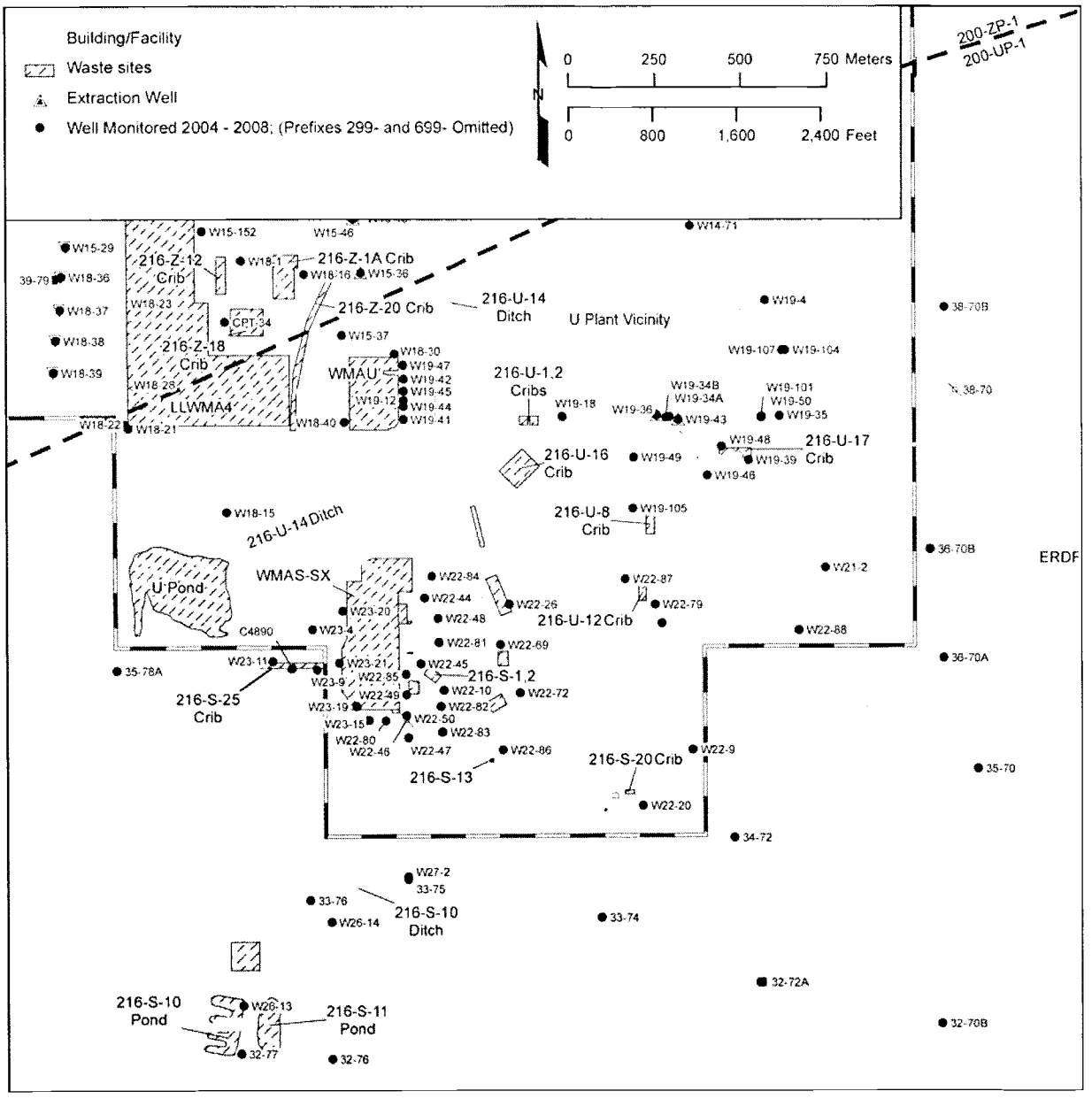


Figure 3-1. Selected Wells near Waste Sites in the 200-UP-1 Groundwater OU

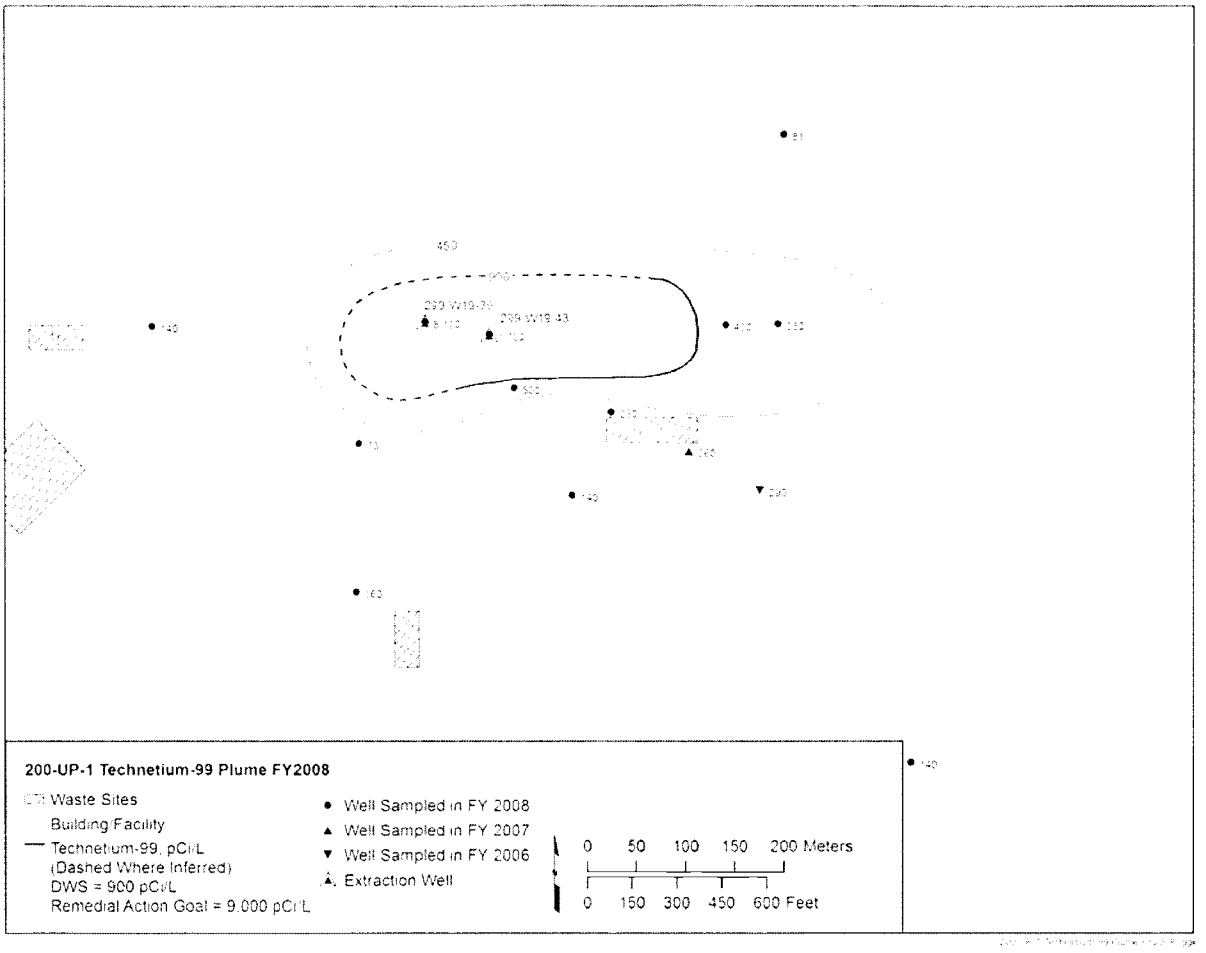


Figure 3-2. Average FY 2008 Tc-99 Concentrations in the U Plant Vicinity Groundwater

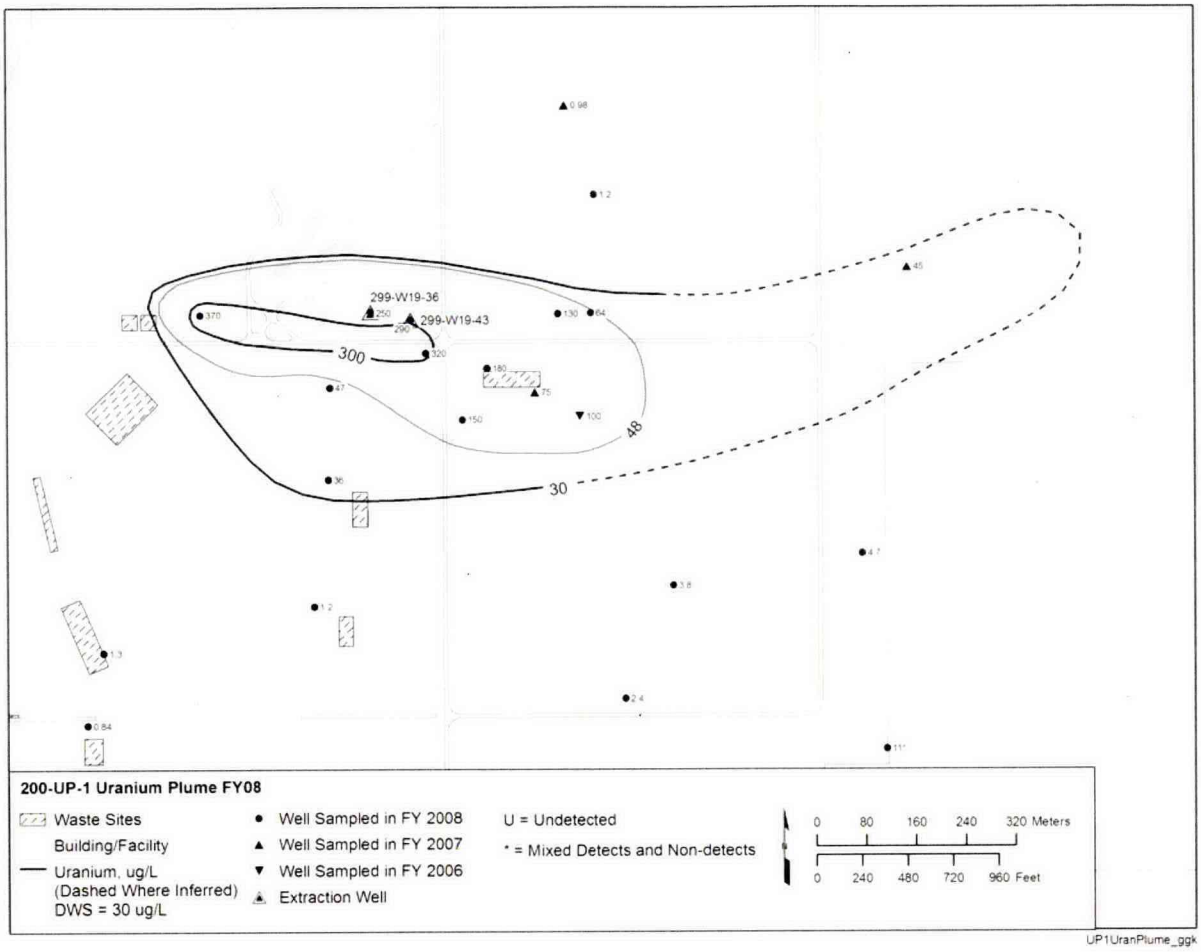
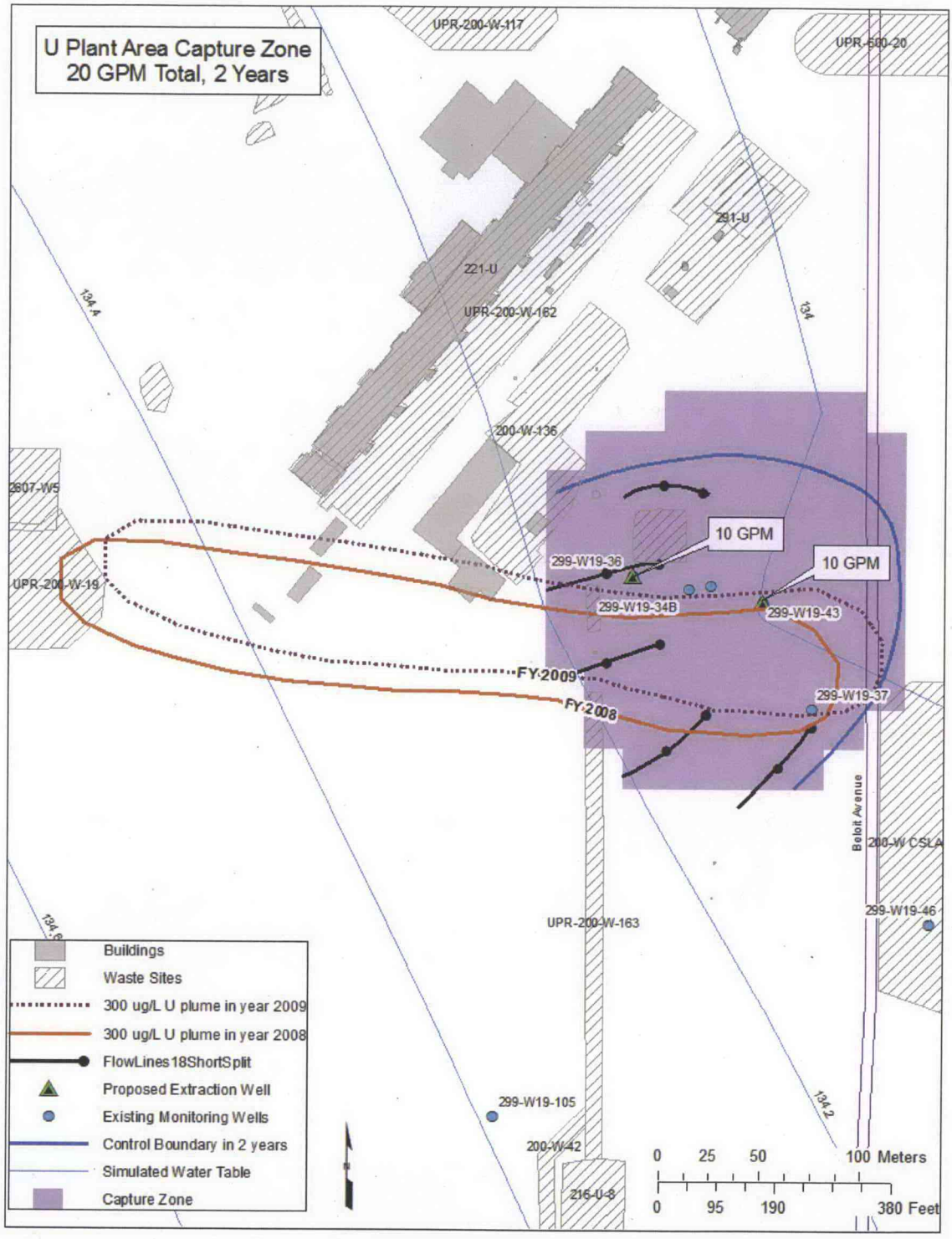


Figure 3-3. Average FY 2008 Uranium Concentrations in the U Plant Vicinity Groundwater



(Two-Year Hydraulic Control [Capture] Boundary indicated by blue line.)

Figure 3-4. Estimated Extraction Well Capture Zone in U Plant Vicinity for Existing Well Redevelopment and Pumping Rate Increased to 37.8 L/min (10 gal/min) per Well

3.1.3 Treatment System Design

This section provides a summary description of the treatment system. The system includes the transfer pipeline from the extraction wells to interim storage at LERF, the treatment system at the 200 Area ETF, and the discharge of the treated effluent to the State-Approved Land Disposal Site (SALDS).

3.1.3.1 Pipeline

The groundwater transfer pipeline consists of three main sections:

- The cross-site pipeline associated with the 200 Area Treated Effluent Disposal Facility (TEDF) system
- A transfer pipeline that was constructed to connect the 200-UP-1 groundwater extraction wells to the TEDF cross-site transfer line in the 200 West Area
- An additional transfer pipeline that was constructed to tie the existing cross-site transfer line to the LERF basins in the 200 East Area

These three pipeline sections together are approximately 12.2 km (7.6 mi) in length and are constructed of 15.2-cm (6-inch) polyvinyl chloride pipe. The majority of the pipeline is underground to provide freeze protection; any above-ground sections are heat traced. No additional pumps or tanks are used to transfer the groundwater.

Flowmeters are installed near the extraction wells in the 200 West Area and near LERF/ETF in the 200 East Area to measure flow rate and detect a pipeline system leak. The flowmeter in the 200 East Area is continuously monitored and alarms in the 200 ETF control room. The 200 West Area flowmeter has a local readout for flow rate and volume.

3.1.3.2 Liquid Effluent Retention Facility

Groundwater is transferred to LERF for interim storage through a pipeline from the 200 West Area. Sufficient storage capacity, primarily using basin 43, is available for continuous groundwater receipt.

The LERF consists of three double-lined surface impoundments with a nominal capacity of 29.5 million L (7.8 million gal) each. Each liner is constructed of high-density polyethylene. A cover made of low-density polyethylene ensures that the waste is not lost to the environment through evaporation.

A concrete catch basin at the northwest corner of each basin is equipped with risers that extend to the bottom of the basin. A submersible pump is used in one of these risers to pump the waste to the ETF for processing or pump a basin's contents to any other basin. Groundwater is pumped from the LERF to the ETF through a double-walled fiberglass pipeline. The pipeline is equipped with leak detection located in the annulus between the inner and outer pipes.

3.1.3.3 Effluent Treatment Facility

The ETF is composed of a series of process units that are located in primary and secondary treatment trains. Typically, an aqueous waste is processed in the primary treatment train first, which provides for the removal or destruction of contaminants. The secondary treatment train processes the waste byproducts from the primary treatment train. In the secondary treatment train, contaminants are concentrated and dried into a powder and the liquid fraction is routed back to the primary treatment train. The flexibility of the ETF allows for some aqueous wastes to be processed in the secondary treatment train first. The

preferred operating scenario will depend on the specific chemistry of the groundwater (and/or volume for other aqueous waste streams).

The primary treatment train consists of the following process units:

- Filtration - suspended solids removal
- Ultraviolet light oxidation - organic destruction
- Reverse osmosis - removal of dissolved solids and radionuclides
- Ion exchange - removal of dissolved solids and radionuclides

Three verification tanks receive the treated groundwater and laboratory analysis is performed on each tank to determine if the discharge limits are met. The verification tanks alternate between three operating modes:

- receiving treated wastewater
- holding treated wastewater during laboratory analysis
- verification, or discharging verified wastewater

Should the groundwater not meet Washington State Waste Discharge Permit ST-4500 (Ecology, 2000) or final delisting (40 CFR 261, Appendix IX, Table 2) requirements, it can be returned to the primary process for additional treatment.

Groundwater that meets release criteria is pumped through 20.3-cm (8-in.) polyvinyl chloride piping from the ETF to north of the 200 West Area where it is discharged to the SALDS.

The secondary treatment train provides the following process units:

- ETF evaporator - concentration of secondary waste streams
- Thin film dryer - dewatering of secondary waste streams

Containerized waste generated as a result of treating groundwater is temporarily stored at the ETF, designated, and disposed at the Environmental Restoration Disposal Facility or the Central Waste Complex, in accordance with the applicable acceptance criteria.

3.2 Well 299-W23-19

The design basis, well extraction, and treatment system design for the groundwater contamination in well 299-W23-19 are described in this section.

3.2.1 Design Basis

The Ecology, 2009 requirement to sample, purge, and treat the purgewater from well 299-W23-19 is described in Section 2.1.2. This well is located near the southwest corner of WMA S-SX (Figure 3-1).

Well 299-W23-19 has been sampled for Tc-99 since it was installed in 1999 (Figure 3-5) and since June 2003 a minimum of 3,800 L (1,000 gal) has been removed from the well each quarter after sampling (DOE/RL-2008-77). The Tc-99 concentrations in this well have ranged from 29,500 to 188,000 pCi/L and for FY 2008, concentrations ranged between 46,100 and 67,000 pCi/L (Figure 3-5).

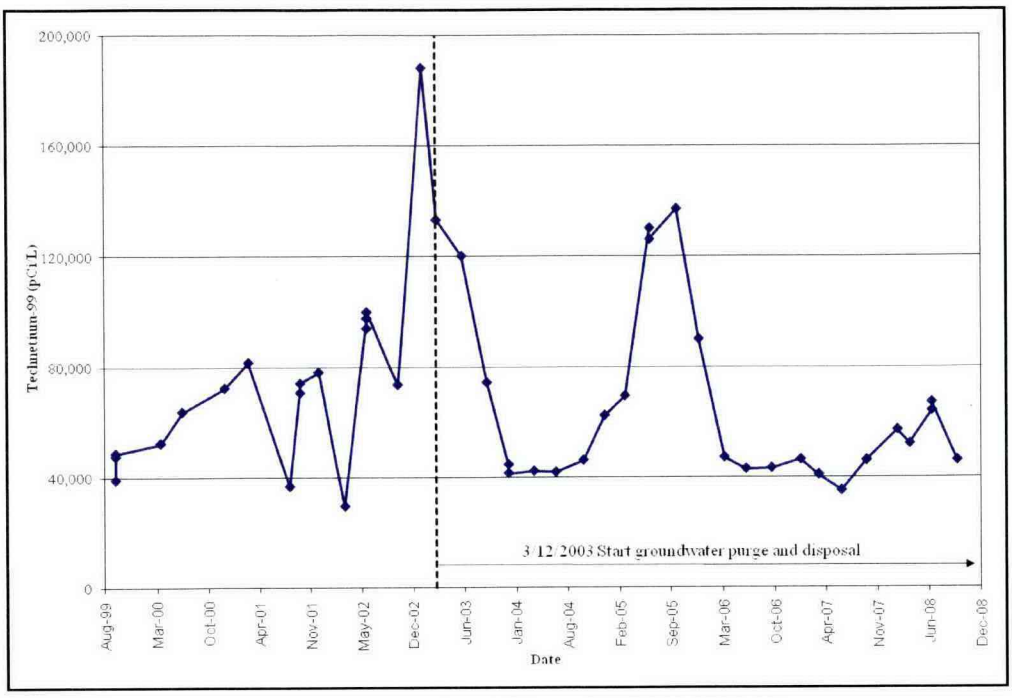


Figure 3-5. Tc-99 Trend Plot at Well 299-W23-19

3.2.2 Well Extraction Design

Well 299-W23-19 is an existing 10-cm (4-in) -diameter well with a nominal 9-m (30-ft) -long stainless steel screen constructed from approximately 64 to 73 m (210 to 241 ft) bgs. Based on the FY 2008 water table elevations near this well (DOE/RL-2008-77), the water level was about 67 m (220 ft) bgs.

The feasibility of using well 299-W23-19 as a pump-and-treat extraction well to remediate the southern Tc-99 plume in the WMA S-SX vicinity was investigated in 2001. After performing an aquifer test in this well, it was concluded that the production capacity was too small (11 to 13 L/min [3 to 3.5 gal/min]) for a pump-and-treat system (RPP-10757, *Tc-99 in Groundwater at Hanford Well 299-W23-19: Options, Analysis and Recommended Action Report*). To remove Tc-99 from the groundwater, the practice of extended purging during sampling at well 299-W23-19 was agreed to by DOE and Ecology and began in 2003. After samples are collected from this well each quarter, purging of the well is continued at a higher flow rate until a minimum of 3,800 L (1,000 gal) of water is removed from the aquifer. This extracted water is taken by tanker truck to the ETF for treatment and disposal.

3.2.3 Treatment System Design

The treatment system at ETF and subsequent disposal at SALDS are described in Section 3.1.3.3.

3.3 WMA S-SX Vicinity Groundwater Contamination

The design basis, well extraction, and treatment system design for the groundwater contamination in the WMA S-SX vicinity are described in this section.

3.3.1 Design Basis

The FY 2008 groundwater contamination extent in the WMA S-SX vicinity is documented in DOE/RL-2008-66 and DOE/RL-2008-77 and is summarized in this section. Figure 3-6 and Figure 3-7

show the average Tc-99 and uranium concentrations in the unconfined aquifer in the WMA S-SX vicinity, respectively.

Figure 3-7 shows that the highest FY 2008 uranium concentration in the WMA S-SX vicinity was 8.3 µg/L in well 299-W23-15, which is below the 300 µg/L RAO. Figure 3-6 shows that there are two discrete Tc-99 plumes in the WMA S-SX vicinity. The larger, more prominent, and long-lived of the two plumes was identified in 1999 and is located south and east of WMA SX. A smaller, isolated plume located east of WMA S emerged in FY 2007.

The highest concentration of Tc-99 in the southern plume occurs in the southwestern corner of WMA SX, at well 299-W23-19 (average 54,000 pCi/L in Figure 3-6). Downgradient wells 299-W22-47 and 299-W22-83 also had Tc-99 concentrations greater than 9,000 pCi/L. Wells 299-W22-80 and 299-W23-15 exhibited Tc-99 concentrations at or just above laboratory detection concentrations. These low results from wells located in the central portion of the greater than 9,000 pCi/L plume are an anomaly.

The Tc-99 plume east of WMA S is more limited in extent. Well 299-W22-44 (average 13,000 pCi/L in Figure 3-6), which defines the core of this plume, has been sampled since 1995. In February 2004, the concentration at this well exceeded the MCL of 900 pCi/L for the first time. Concentrations have increased rapidly since June 2006, from about 1,000 pCi/L to a maximum concentration of 14,000 pCi/L in March 2008. The source of the sharply increased Tc-99 concentrations at well 299-W22-44 is undetermined, but it is likely associated with the nearby WMA S.

3.3.2 Well Network Conceptual Design

Numerical modeling was performed to simulate hypothetical groundwater flow conditions in the vicinity of WMA S-SX to assess preliminary well locations and pumping rates to meet the RAO for Tc-99. The goal is to capture the target plume during the interim action operating period beginning in FY 2012. The results of the capture zone analysis modeling are presented in Appendix B of this work plan.

The target groundwater plume areas were identified using the Tc-99 plume distribution presented in DOE/RL-2008-66 (Figure 3-6). The area bounded by the 9,000 pCi/L Tc-99 concentration contour defined the target area for interim action. In addition, the results of depth-discrete sampling and analysis of groundwater from selected wells indicated that the apparent vertical distribution of target contaminants was limited to the upper portion of the unconfined aquifer (DOE/RL-2008-77). The depth-discrete data include measurements of Tc-99 in wells 299-W22-50 (Tc-99 at the water table), 299-W22-86 (Tc-99 detected from the water table to about 20 m (65 ft) below the water table), 299-W22-72 (Tc-99 not detected in the samples), and 299-W22-69 (Tc-99 detected from the water table to about 5 m (16 ft) below the water table) (depth-discrete Tc-99 measurements per Hanford Environmental Information System). These wells are shown in Figure 3-1. The conceptual well design includes a well screen extending from the water table to 30 m (98 ft) below the water table, which would provide capture of the Tc-99 within the target areas.

Based on evaluation of the simulation scenario results for the WMA S-SX vicinity groundwater extraction, the recommended approach is to install two extraction wells located as shown in Figure 3-8 and operate the wells at pumping rates of 132 to 170 L/min (35 to 45 gal/min) for the southern well and 57 L/min (15 gal/min) for the northern well. This would result in short-term capture of the downgradient portion of the target plume segments and provide hydraulic control of the same plume segments. This would provide effective IRA response in the short term until the final remedial action for 200-UP-1 Groundwater OU is identified. The exact well locations and final design pumping rates will be defined during the remedial design activity.

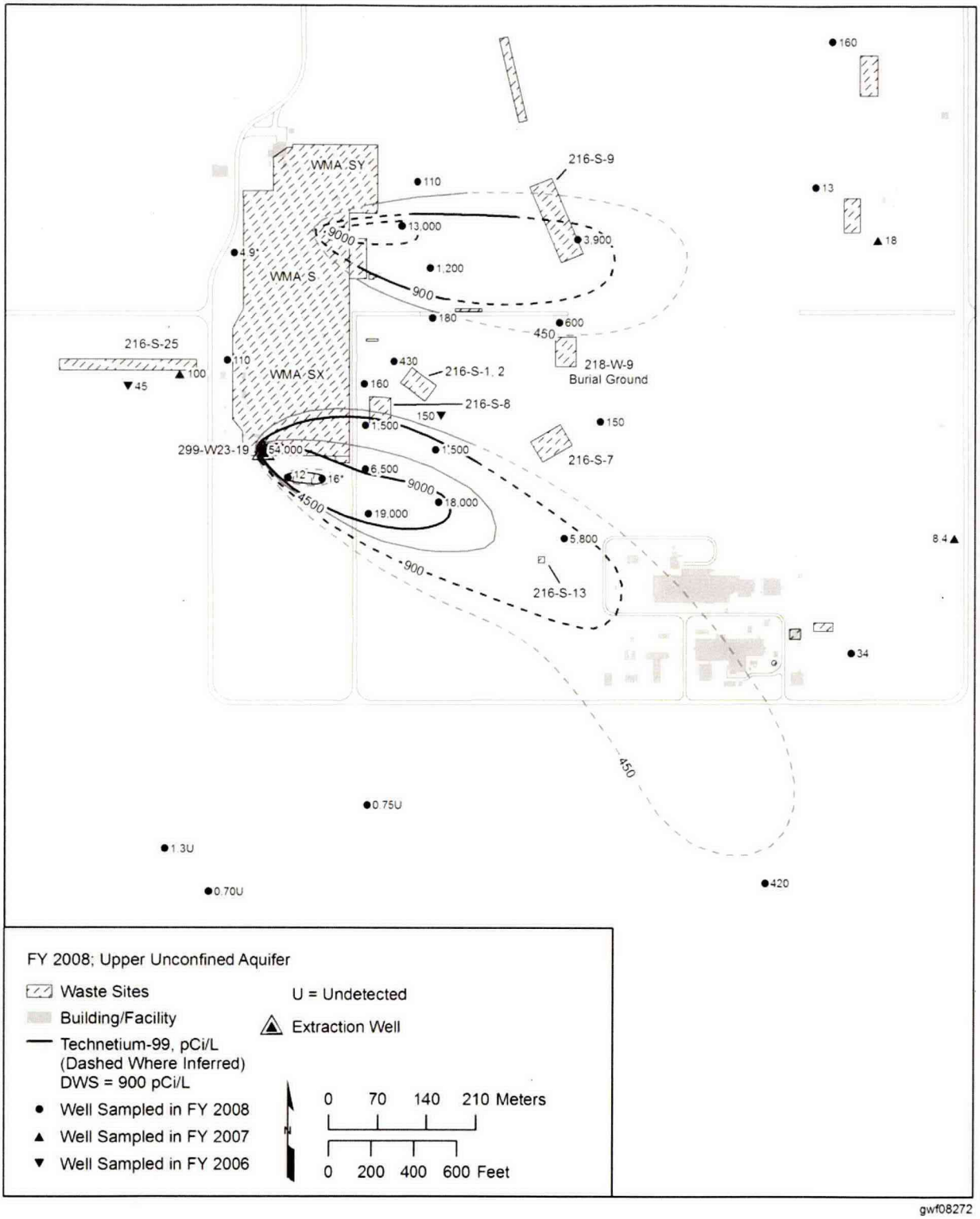


Figure 3-6. Average FY 2008 Tc-99 Concentrations in the WMA S-SX Vicinity Groundwater

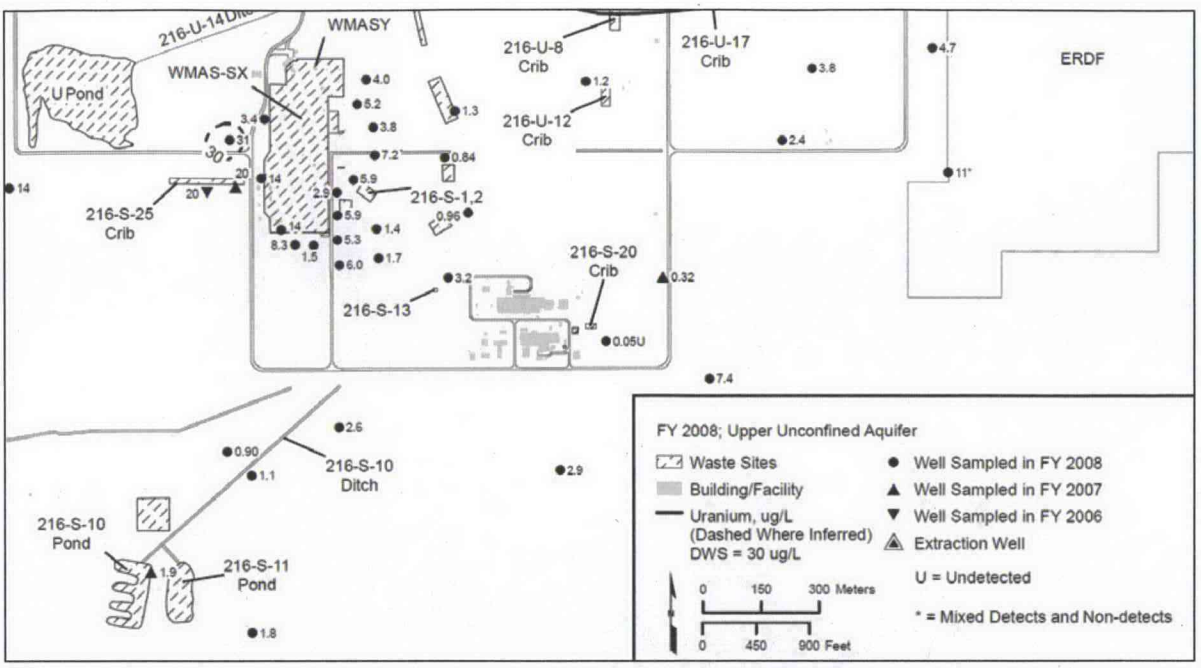
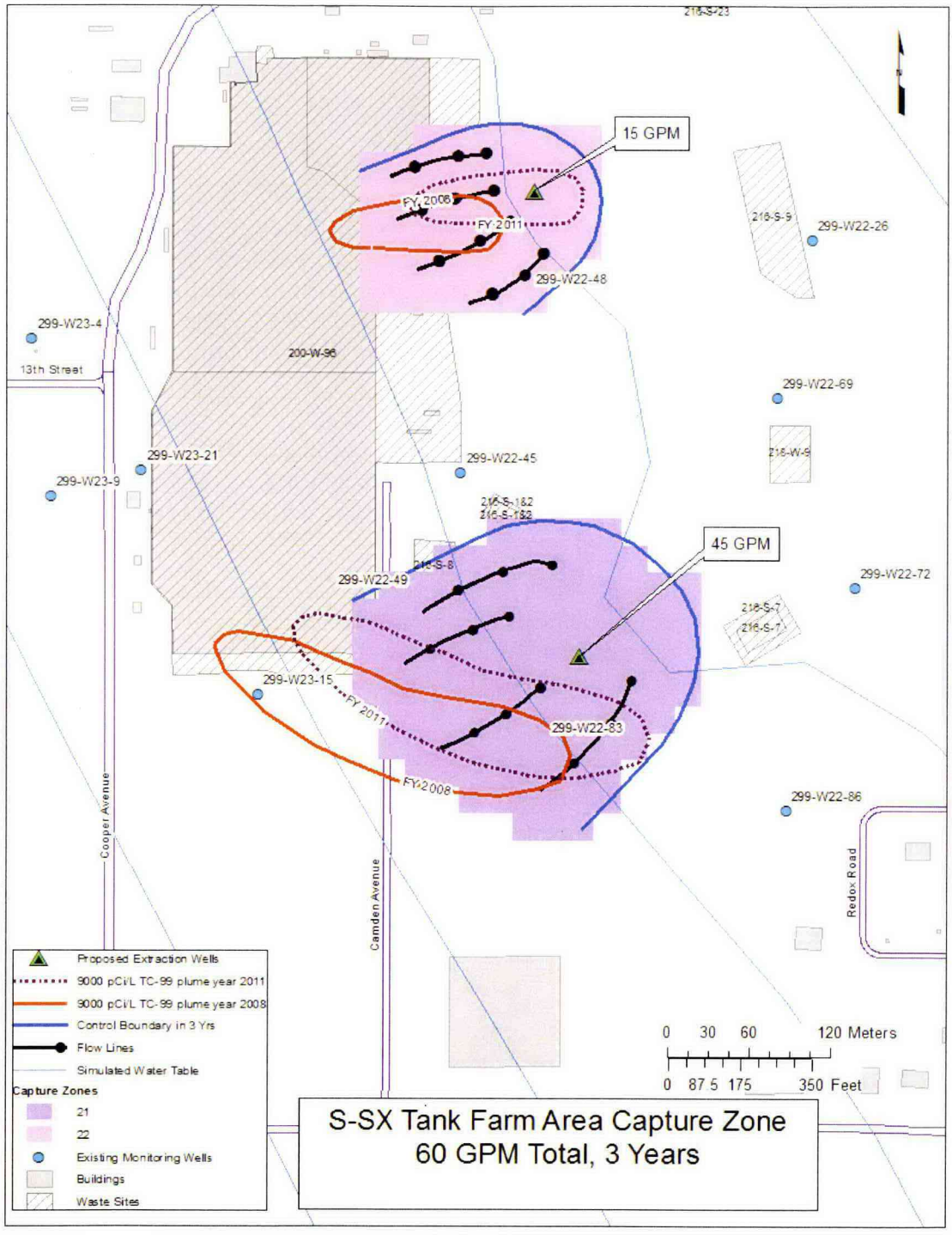


Figure 3-7. Average FY 2008 Uranium Concentrations in the WMA S-SX Vicinity Groundwater



(The Hydraulic Control Boundary [Capture Zone] at the end of the 3-year simulation period is indicated by the blue line.)

Figure 3-8. WMA S-SX Vicinity Groundwater Extraction Analysis Utilizing Two Extraction Wells with Combined 227 L/min (60 gal/min) Target Pumping Rate

3.3.3 Treatment System Conceptual Design

This section summarizes the 200 West Area groundwater treatment system from the conceptual design provided in DOE/RL-2008-78. The 200 West Area treatment facility is planned to be located near the center of the 200-ZP-1 OU in a previously disturbed area with the necessary utilities located nearby (Figure 1-1).

3.3.3.1 Transfer Pipeline

The groundwater from the two new extraction wells in the WMA S-SX vicinity will be pumped to the 200 West Area treatment facility. A conceptual layout of the transfer pipeline is shown in Figure 3-9. Transfer piping is expected to be single-wall, high-density polyethylene installed above grade to the maximum extent possible. Leak detection for dangerous waste in the above-grade piping will be provided either through daily inspections or an equally protective measure that is identified during remedial design.

3.3.3.2 200 West Area Treatment Facility

A preliminary process flow diagram illustrating the conceptual radiological treatment process is provided in Figure 3-10. Conceptually, the treatment process includes filtration to remove suspended solids and then ion exchange to reduce Tc-99 concentrations. The ion exchange effluent will then be pumped to the centralized treatment system for further treatment.

In anticipation of the future use of the 200 West Area pump-and-treat system, the 200-ZP-1 Groundwater OU remedial design is also addressing treatment of groundwater contaminated with uranium that may be captured by the extraction wells being installed for the 200-ZP-1 remedy. This evaluation includes: (1) the estimated influent concentrations, (2) recommended treatment technology (or technologies), and (3) design considerations.

A preliminary process flow diagram illustrating the central treatment process is provided in Figure 3-11. Conceptually the central treatment process includes the following units:

- Fluidized bed reactor for nitrate treatment and potentially carbon tetrachloride removal
- Aeration tank to remove the residual carbon substrate, total suspended solids, and biomass
- Air stripper to remove the remaining carbon tetrachloride and other volatile organic compounds

The treated water will either be pumped to an effluent tank or directly to the injection well field being installed for the 200-ZP-1 remedy.

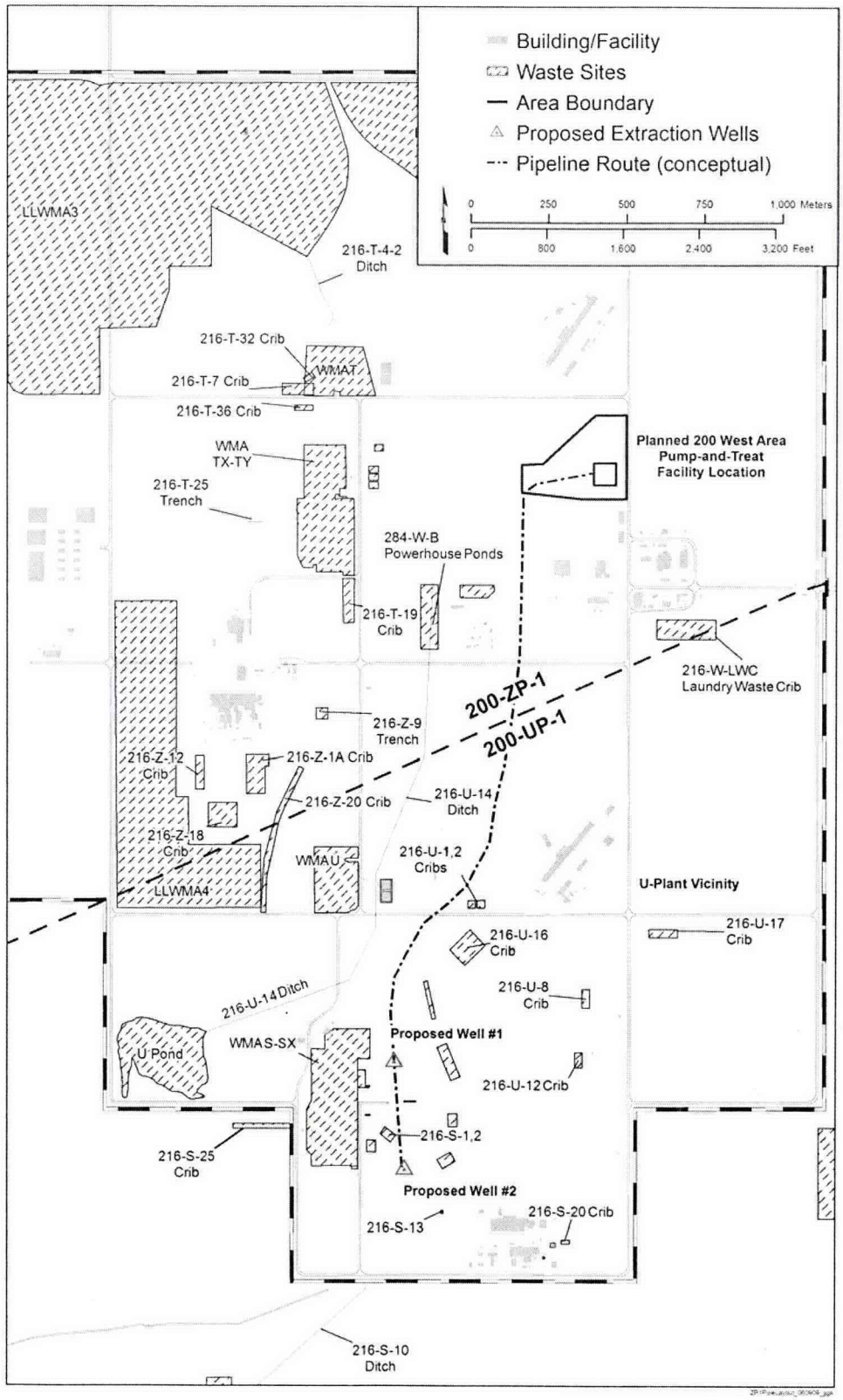
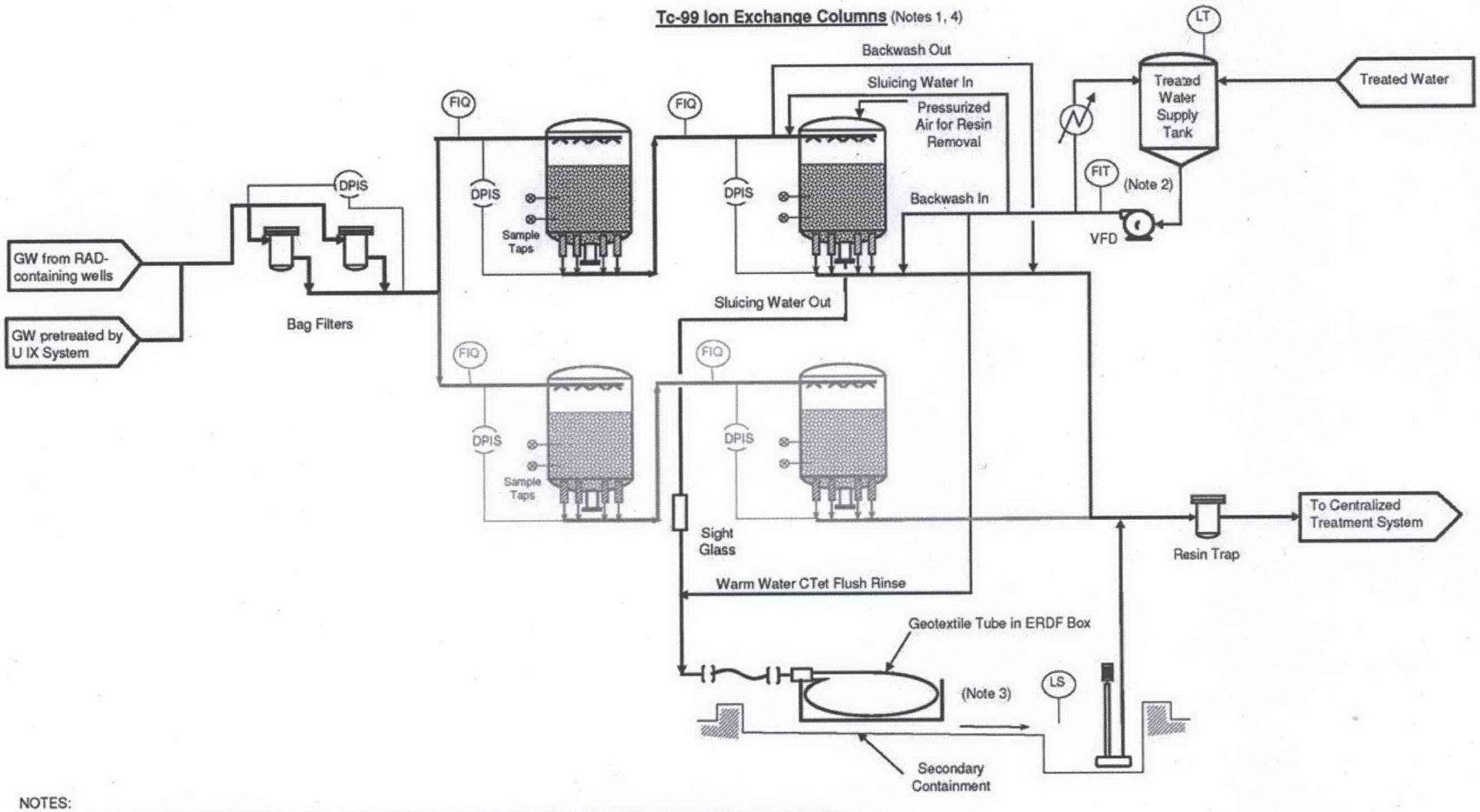


Figure 3-9. Conceptual Layout of Transfer Pipeline from Extraction Wells in the WMA S-SX Vicinity to 200 West Area Treatment Facility



NOTES:
1. Phase 1 system shall be two columns in series and an additional two columns (parallel pairs of 2 in series) for Phase II construction.
2. Common treated water supply for backwashing, resin removal sluicing, and warm water CTet rinsing of spent resin. Piping only shown for one column for clarity.
3. ERDF box to allow Geotextile Tube draining. Use same box for final ERDF disposal of spent resin.
4. Resin loading shall be via Supersacks using overhead hoist into top manway.

Figure 3-10. Preliminary Process Flow Diagram for the Radiological Treatment System in the 200 West Area Treatment Facility

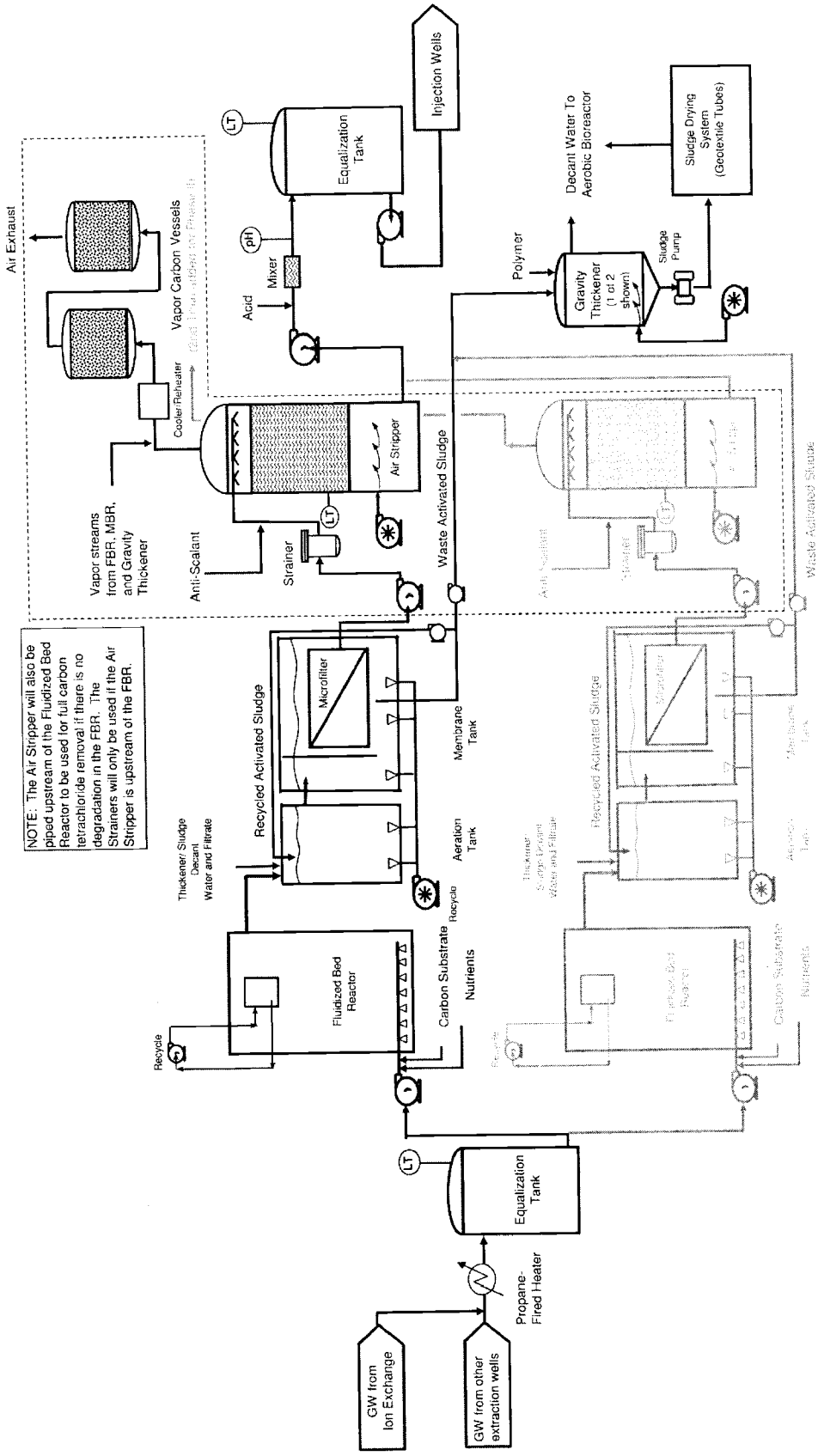


Figure 3-11. Preliminary Process Flow Diagram for the Central Treatment System in the 200 West Area Treatment Facility

3.4 Design Approach

Remedial design of several work elements is needed so that the IRA implements Ecology, 2009 to the 200-UP-1 OU ROD and the Tri-Party Agreement milestone for the Tc-99 contamination in the WMA S-SX vicinity. These work elements are remedial design of new extraction wells and transfer piping in the WMA S-SX vicinity, as described below. The 200 West Area treatment facility is being designed and constructed under a separate work plan (DOE/RL-2008-78).

The remedial design process will address the refined numerical modeling to determine the locations and pumping rates of two new extraction wells in the WMA S-SX vicinity, and hydraulic analysis and design of a new transfer pipeline from these extraction wells to the 200 West Area treatment facility. The design process will be performed in a phased approach (e.g., 30 percent design, 60 percent design, 90 percent design, and final design). The lead regulatory agency will be briefed as the design progresses. A remedial design report will not be prepared.

The final remedial design will include the following items:

- Design drawings
- Construction specifications
- Construction cost estimate
- Construction schedule

4 Remedial Action Work Plan

This section describes implementation of the remedial action (RA) to accomplish the goals set forth in the 200-UP-1 Groundwater OU ROD, as amended by Ecology, 2009. It includes a discussion of the management team, facility procurement and construction approach, and the operational approach. A description of the actual operation of the 200 West Area pump-and-treat system will be prepared concurrently with the design and included in the Operations and Maintenance (O&M) plan.

4.1 Project Team

The term "project team" includes the individuals working to accomplish the 200-UP-1 Groundwater OU RA. Accordingly, the project team includes the lead regulatory agency; the DOE-RL; and the remediation contractor.

4.1.1 Lead Agency

DOE is the lead agency under CERCLA, delegated by Executive Order 12580, the primary authority under Section 104 and 121, to conduct removal and remedial actions on DOE facilities. DOE is responsible for the RAs throughout the Hanford Site and, as such, has assigned remedial project managers to each main area and task involved with remediation activities. The lead agency is responsible for managing the assigned activities, which include scope, budget, schedule, quality, personnel, communication, risk/safety, contracts, and regulatory interface, and works under the lead regulatory agency oversight in accordance with CERCLA Section 120, as implemented through the Hanford Tri-Party Agreement. It obtains congressional funding for these functions.

4.1.2 Lead Regulatory Agency

Ecology is the lead regulatory agency for the CERCLA remediation activities at the 200-UP-1 Groundwater OU. The lead regulatory agency is responsible for overseeing activities to verify that applicable regulatory requirements are met. Lead regulatory agency approval will be required on all sampling and analysis plans (SAPs) and Tri-Party Agreement primary documents (e.g., this RD/RA WP).

4.1.3 Remediation Contractor

On October 1, 2008, CH2M HILL Plateau Remediation Company assumed the contract with the DOE to perform remedial actions at the 200-UP-1 Groundwater OU. CH2M HILL Plateau Remediation Company performs work under direction of the DOE Remedial Project Manager, assisted by other DOE personnel, as outlined in the following descriptions and Figure 4-1.

4.1.3.1 Groundwater Remediation Manager

The groundwater remediation manager provides oversight for all activities and coordinates with the DOE Richland Operations Office (RL), the regulators, and primary contractor management in support of remediation activities. In addition, support is provided to the 200-UP-1 Groundwater OU project manager to ensure work is performed safely and cost effectively.

4.1.3.2 Project Manager

The 200-UP-1 Groundwater OU project manager is responsible for direct management of sampling documents and requirements, field activities, and subcontracted tasks. The project manager ensures that the field construction manager, environmental compliance officer, sampling coordinator, and others responsible for implementation of regulatory documents are provided with current copies of these

documents and any revisions thereto. The project manager also works closely with the Quality Assurance (QA) organization, the Health and Safety organization, and the field construction manager to integrate these and the other lead disciplines in planning and implementing the work scope. The project manager also coordinates with and reports to RL, the regulators, and remediation contractor management on all remediation activities.

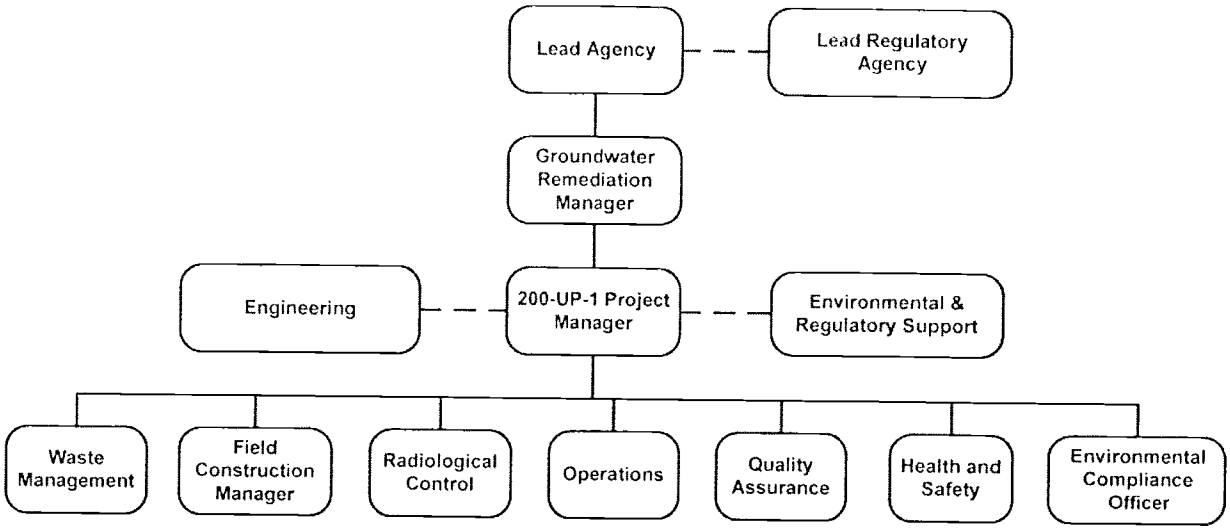


Figure 4-1. Project Organization

4.1.3.3 Engineering

All engineering and design work will be performed by qualified engineering staff in accordance with remediation contractor engineering procedures (or equivalent standards) using a graded approach.

4.1.3.4 Operations

Operations include the operating personnel, field engineering, procurement, and maintenance. Operations ensure that the facility and systems are operated and maintained in accordance with applicable requirements and procedures while safely meeting production goals. Responsibilities include the pump-and-treat system operations, process control, sampling, configuration and work control, modification to systems/facilities, corrective and preventive maintenance, waste management, and support to new system/facility construction, testing, and startup.

4.1.3.5 Quality Assurance

The QA lead is matrixed to the 200-UP-1 Groundwater OU project manager and is responsible for QA issues on the project. Responsibilities include overseeing implementation of the project QA requirements; reviewing project documents, including data quality objective summary reports, SAPs, and the QA project plan; and participating in QA assessments on sample collection and analysis and other remediation activities, as appropriate.

4.1.3.6 Health and Safety

The Health and Safety organization's responsibilities include coordinating industrial health and safety support within the project as carried out through health and safety plans (HASPs), job hazard analyses, and other pertinent safety documents required by federal regulations or by remediation primary contractor work requirements. In addition, assistance is provided to project personnel in complying with applicable

health and safety standards and requirements. Personnel protective clothing requirements are coordinated with the Radiological Controls lead.

4.1.3.7 Field Construction Manager

The field construction manager has the overall responsibility for supporting the safety, environmental, QA, sampling, waste management, and radiological control staff in the planning, coordination, and execution of field remediation activities. Responsibilities also include directing training, mock ups, and practice sessions with field personnel to ensure that the field actions are understood and can be performed as specified. The field construction manager communicates with the 200-UP-1 Groundwater OU project manager to identify field constraints that could affect the remediation activities.

4.1.3.8 Environmental and Regulatory Support

The Environmental and Regulatory Support lead is responsible for developing required regulatory documents. Responsibilities include developing and documenting the sampling data quality objectives, SAPs, and RD/RA WPs. The Environmental and Regulatory Support lead also supports the data quality assessment process and develops the final verification plan or RA report at the conclusion of the remediation activity.

4.1.3.9 Environmental Compliance Officer

The environmental compliance officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work and also develops appropriate mitigation measures, with a goal of minimizing adverse environmental impacts. The environmental compliance officer also reviews plans, procedures, and technical documents to ensure that all environmental requirements have been addressed, identifies environmental issues that affect operations and develops cost-effective solutions, and responds to environmental/regulatory issues or concerns raised by RL and/or regulatory agency staff.

4.1.3.10 Radiological Control

The Radiological Control lead is responsible for the radiological/health physics 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. In addition, radiological hazards are identified and appropriate controls are implemented to maintain worker exposures to hazards at ALARA levels (e.g., personal protective equipment). Radiological Controls interfaces with the project health and safety representative and plans and directs the radiological control technician support for all activities.

4.1.3.11 Waste Management

The Waste Management lead 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 identifying waste management sampling/characterization requirements to ensure regulatory compliance and interpreting the characterization data to generate waste designations, profiles, and other documents that confirm compliance with waste acceptance criteria.

4.2 Change Management

The three types of changes in the 200-UP 1 OU RA that could affect compliance with the requirements in the 200-UP 1 OU ROD include: (1) a non-significant or minor change, (2) a significant change to a component of the remedy, and (3) a fundamental change to the overall remedy.

A non-significant or minor change does not impact the remedy identified in the 200-UP-1 Groundwater OU ROD. Examples of non-significant changes may include adding additional groundwater plumes for remediation by the remedial action, adding an additional contaminant for cleanup, or modifications to the remedial action schedule that do not impact an agreed-upon milestone. These minor changes should be documented in the appropriate post-decision project file (e.g., through interoffice memoranda or logbooks).

It may be determined that a significant change to the selected remedy as described in the 200-UP 1 OU ROD is necessary. Significant changes are defined as changes that significantly modify the scope, performance, or component cost for the remedy as presented in the ROD. All significant changes will be addressed in an ESD. Examples of significant changes may include, but are not limited to, the following:

- A significant increase (greater than 50 percent) or decrease (greater than 30 percent) in the total cost of site remediation
- A significant delay in the point in time when the remedial action or objectives are met

A fundamental change is a change that does not meet the requirements set forth in the 200-UP 1 OU ROD or that incorporates remedial activities not defined in the scope of the ROD. Should the situation arise, the ROD must be amended.

Determining whether a change is significant or fundamental is the lead agency's responsibility. The project manager is responsible for tracking all changes and obtaining appropriate reviews by staff. The project manager will discuss the changes with the lead agency, followed by discussions with the lead regulatory agency.

4.3 Procurement and Construction

4.3.1 Procurement Approach

The final remedial design package is used to support the procurement of construction service and/or materials. The scope of work will be accomplished using the most efficient combination of onsite resources and/or procurements to outside vendors and subcontractors.

4.3.2 Construction

The new extraction wells in the WMA S-SX vicinity and transfer pipeline construction to the 200 West Area treatment facility will be performed in accordance with the drawings and specifications developed by the final remedial design. Remediation contractor oversight will be onsite during all construction activities to ensure compliance with the drawings/specifications and to address field questions from the driller, vendor, or subcontractor. Following construction, compliance with the design requirements will be performed as part of the construction acceptance testing. Changes to the final remedial design will be documented using construction change control, and significant changes will be discussed with the lead agency and lead regulatory agency during regular status meetings.

4.3.3 Construction Acceptance Testing

A construction acceptance testing plan will be developed and finalized during the remedial design phase. This plan will be executed after construction is complete and will provide documentation that the new extraction wells in the WMA S-SX vicinity and transfer pipeline have performed as intended. Upon successful construction acceptance testing, the new extraction well system will be turned over to operations.

4.4 Operational Approach

4.4.1 System Startup

Upon completion of the construction acceptance testing of new extraction wells in the WMA S-SX vicinity and the transfer pipeline to the 200 West Area treatment facility, the system will be formally turned over to groundwater remediation operations. Operational testing will be coordinated between the WMA S-SX system and the 200 West Area treatment system. The first activity during initial operations will be to complete the actions identified in the operational testing plan. These actions will include final operability testing and system interface with facility operators. During this phase, all facets of the system will be cyclically started, operated, and shut down for training purposes. Procedures that were drafted prior to turnover will be used and refined. Preventive maintenance procedures (also developed prior to turnover), including equipment and instrument calibrations, will be performed where necessary and procedures refined as needed.

System operators and maintenance personnel will spend time familiarizing themselves with the equipment, systems, procedures, and interfaces. It is expected that minor modifications and maintenance will be necessary, as the equipment and systems are run-in. Safety, radiation control, and waste management programs will be implemented and verified as operational. Upon completion of operational testing, the system will transition to long-term operations.

4.4.2 Operations

Operation of the pump-and-treat systems in the U Plant vicinity and in the WMA S-SX vicinity includes the O&M, engineering, and support functions that will continue until the RAOs have been achieved or a final remedy is in place. Operations activities include the operation and control of extraction systems, the training and qualification of operators to ensure depth of trained personnel, sample collection, emergency response, continuous improvement through lessons learned, and control of access. Preventive, corrective, and modification maintenance will continue throughout this phase. Engineering evaluations and plant/system optimization will be an ongoing activity to continuously improve efficiency, reliability, and maintainability. Radiation control, industrial safety and hygiene, and waste management programs for long-term surveillance, oversight, and stewardship of the facility will be implemented and continuously updated as conditions change or new activities warrant. Continuous feedback using tools such as management assessments, independent assessments, QA, and RL oversight will be in place throughout the life cycle of the project. Treatment of extracted groundwater will occur at the ETF or 200 West Area treatment facility and will follow associated facility operational procedures and plans.

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5 Environmental Management and Controls

This section describes the environmental management and controls associated with the 200-UP-1 Groundwater OU pump-and-treat system.

5.1 Air Emissions

Listed below are descriptions of the management and controls associated with both radiological and nonradiological air emissions.

5.1.1 Radiological Air Emissions

The proposed remedial activity will be evaluated with respect to determining the potential-to-emit radionuclides from any point source or diffuse/fugitive source. To accomplish this, the total unabated potential release (in curies) will be determined and the annual dose to the maximally exposed individual will be calculated using DOE/RL-2006-29, *Calculating Potential-to-Emit Radiological Releases and Doses*, or modeled using the CAP 88PC computer model. Control and monitoring requirements for potential radiological air emissions will be based on the calculated/modeled value of the potential-to-emit.

5.1.2 Nonradiological Air Emissions

To demonstrate compliance with the ARARs of WAC 173-400, "General Regulations for Air Pollution Sources," and WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," an acceptable source impact analysis will be completed. The analysis will demonstrate that, after application of toxic best available control technology, the new source's maximum incremental ambient air impact levels do not exceed the WAC 173-460 Class A or Class B acceptable source impact levels; or, if applicable, the new source toxic air pollutant emission rates do not exceed the small quantity emission rates specified in WAC 173-460.

5.2 Waste Management

A minimal amount of waste will be generated during routine operations of the extraction wells and transport of groundwater to ETF. The specific requirements for waste identification, characterization, segregation, packaging, labeling, storage, and inspections for generation activities associated with the 200-UP-1 Groundwater OU pump-and-treat will be managed under DOE/RL-2000-51, *Interim Action Waste Management Plan for the 200-UP-1 Operable Unit.*

5.3 Cultural/Ecological

Protection of cultural resources is addressed in the *Archeological and Historic Preservation Act of 1974*, the *National Historic Preservation Act of 1966*, and the *Native American Graves Protection and Repatriation Act of 1990.* These federal acts mandate the identification and protection of archeological objects and historic data including human remains, funerary objects, sacred objects, and objects of cultural significance. Prior to disturbing the earth (e.g., drilling, surface grubbing, and excavating), a survey will identify culturally significant items and will document those with respect to the areas included in this IRA where there would be disturbance of the earth. Any restrictions regarding disturbance of the earth or otherwise will be identified in a letter report.

5.4 Safety and Health Program

The remediation contractor's hazardous waste operations health and safety program was developed for employees involved in hazardous waste site activities. The program was developed to comply with the requirements of 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response;" and 10 CFR 835, "Occupational Radiation Protection," to ensure the safety and health of workers during hazardous waste operations.

A site-specific HASP will be revised or a new HASP developed in accordance with the health and safety program to define the chemical, radiological, and physical hazards and specify the controls and requirements for work activities. Access and work activities will be controlled in accordance with approved work packages, as required by established internal work requirements and processes. The HASP will address the health and safety hazards of each phase of site operation and includes the requirements for hazardous waste operations and/or construction activities, as specified in 29 CFR 1910.120.

Project field staff must comply with the HASP at all times. Unescorted site visitors are required to read and sign the HASP before entering the construction area and must have completed the required training outlined in the HASP. Escorted visitors are briefed on health and safety concerns and must be escorted by the site superintendent (or designee) at all times when they are in the construction area.

5.5 Emergency Response

During operations, emergency response for the 200 West Area pump-and-treat activities will be covered by the site-specific HASP. The HASP contains primary emergency response actions for site personnel, area alarms, implementation of the emergency action plan, and emergency equipment at the task site, emergency coordinators, emergency response procedures, and spill containment. A copy of the HASP will be kept in the ETF and 200 West Area control room. Emergency actions are primarily governed by the HASP.

5.6 Quality Assurance Program

Overall QA for the RD/RA WP will be planned and implemented in accordance with 10 CFR 830, Subpart A, "Quality Assurance Requirements;" (EPA QA/R-5) EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*; and SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. The QA activities will use a graded approach based on the potential impact on the environment, safety, health, reliability, and continuity of operations. The LERF and ETF are permitted final status treatment, storage, and/or disposal units and the existing documentation for these facilities meets these QA requirements.

All prepared SAPs that support the 200-UP-1 Groundwater OU IRA will contain a QA project plan, which will be used to support the sampling and characterization activities. Other specific activities will include QA implementation, responsibilities and authority, document control, QA records, and audits.

6 Interim Remedial Action Reporting and Completion

This chapter describes how IRM progress toward achieving the RAOs and complying with requirements in Ecology, 2009 will be evaluated and documented. The interim action will continue until RAOs have been achieved or a final action is in place.

6.1 U Plant Vicinity Groundwater Contamination

Ecology, 2009 requires that existing and any new 200-UP-1 Groundwater OU extraction wells be pumped in accordance with this RD/RA WP until concentrations of both uranium and Tc-99 are less than or equal to 10 times the MCL for four consecutive quarters. The groundwater extraction well locations are discussed in Section 3.1.2. The interim ROD management and treatment requirements for the extracted groundwater are unchanged.

Groundwater extraction will continue at wells 299-W19-36 and 299-W19-43 until the concentrations of uranium and Tc-99 in the U Plant vicinity groundwater are less than or equal to 10 times the MCL for each of these contaminants (e.g., less than or equal to 300 µg/L for uranium and less than or equal to 9,000 pCi/L for Tc-99) for four consecutive quarters. The extracted groundwater will be pumped through existing pipelines from the wells to LERF and then to ETF for treatment. The treated effluent from ETF will comply with Ecology, 2000 and final delisting (40 CFR 261, Appendix IX, Table 2) requirements. No additional sampling and analysis of the treated effluent will be performed for the purpose of implementing Ecology, 2009. The progress toward achieving the RAOs will be documented annually.

6.2 Well 299-W23-19

Ecology, 2009 added the requirement to sample well 299-W23-19 on a quarterly basis for Tc-99. After sampling, the well will be purged at a minimum of 3,800 L (1,000 gal) until concentrations of Tc-99, only at well 299-W23-19, are less than or equal to 10 times the MCL (i.e., less than or equal to 9,000 pCi/L) for four consecutive quarters. Purging of well 299-W23-19 will continue until replacement by WMA S-SX pump-and-treat operations. The contaminated groundwater will be subject to the same management, treatment, and disposal requirements as those for extracted groundwater described in Section 6.1. The progress toward achieving this RAO will be documented annually.

6.3 Waste Management Area S-SX Vicinity Groundwater Contamination

The two emerging Tc-99 groundwater plumes in the WMA S-SX vicinity will be addressed by installing two new extraction wells as described in Section 3.3. The extracted groundwater will be pumped through a new pipeline from the wells to the 200 West Area treatment facility that is being designed to implement the 200-ZP-1 Groundwater OU remedy. The conceptual groundwater extraction well locations are discussed in Section 3.3.2 and the new extraction well locations will be refined as discussed in Section 3.4.

Groundwater extraction will continue at the new extraction wells until the concentrations of uranium and Tc-99 measured in the WMA S-SX vicinity groundwater are less than or equal to 10 times the MCL for each of these contaminants (e.g., less than or equal to 300 µg/L for uranium and less than or equal to 9,000 pCi/L for Tc-99) for four consecutive quarters. The progress toward achieving the RAOs will be documented annually.

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7 Cost and Schedule

This chapter provides the cost estimate and project schedule broken down into major phases or components.

7.1 Cost Summary

A cost estimate for elements of the 200-UP-1 Groundwater OU IRMs for the next four years is provided in Table 7-1. This timeframe includes the upfront planning and design, well drilling and pipeline construction, startup, and initial operations for the new pump-and-treat system at WMA S-SX, in addition to continued operation of the existing pump-and-treat system at the U Plant and the quarterly 3,800 L (1,000-gal) purge of well 299-W23-19. A detailed cost estimate for the entire RA will be prepared once the design is finalized.

Table 7-1. 200-UP-1 Groundwater OU IRM Cost Estimate

WBS Title	FY 2009 ($ in thousands)	FY 2010 ($ in thousands)	FY 2011 ($ in thousands)	FY 2012 ($ in thousands)	Total ($ in thousands)
Remedial Action Design – WMA S-SX Vicinity Extraction Wells and Conveyance[a]	$0	$170	$0	$0	$170
Procure and Construct WMA S-SX Vicinity Extraction Wells and Conveyance[b]	$0	$0	$1,700	$0	$1,700
Start-up and Operational Testing WMA S-SX Vicinity Extraction System	$0	$0	$5	$45	$50
WMA S-SX Vicinity Pump-and-Treat System Operations	$0	$0	$0	$100	$100
U Plant Vicinity Pump-and-Treat Operations[c]	$93	$93	$93	$93	$372
200-UP-1 Groundwater OU Annual Pump-and-Treat Performance Report	$100	$100	$100	$100	$400
Well 299-W23-19 Quarterly (3,800 L (1,000-gal) Purge	$10	$10	$10	$10	$40
Grand Total[d]	**$203**	**$373**	**$1,908**	**$348**	**$2,832**

Table 7-1. 200-UP-1 Groundwater OU IRM Cost Estimate

WBS Title	FY 2009 ($ in thousands)	FY 2010 ($ in thousands)	FY 2011 ($ in thousands)	FY 2012 ($ in thousands)	Total ($ in thousands)

a. The estimate for design of the WMA S-SX vicinity is assumed to include design support during construction.

b. The estimate for WMA S-SX vicinity extraction wells and conveyance assumes drilling and construction of two extraction wells with associated mechanical, electrical, and transfer piping from the WMA S-SX vicinity to the 200 West Area treatment facility (assumes 4,270 m [14,000 ft] of utilities). Site support and construction oversight are included in the estimate. The need for a unit-specific transfer station has not been determined and transfer station costs are not included in this estimate.

c. U Plant vicinity pump-and-treat operations include the cost of redeveloping the existing wells to improve pumping rate. The cost for replacement wells has not been determined and is not included in this cost estimate.

d. This cost estimate is a scoping level cost estimate and is not based on detailed design requirements. Scope and bid contingencies are not included in the cost estimate. The estimate has an expected accuracy of -30%/+50%.

WBS = Work Breakdown Structure

7.2 Schedule

Figure 7-1 illustrates the overall IRM project schedule for the 200-UP-1 Groundwater OU activities described in this RD/RA WP. Operational testing and operation of the WMA S-SX extraction system will be coordinated with operational testing and operation of the 200 West Area treatment facility and may require schedule adjustments.

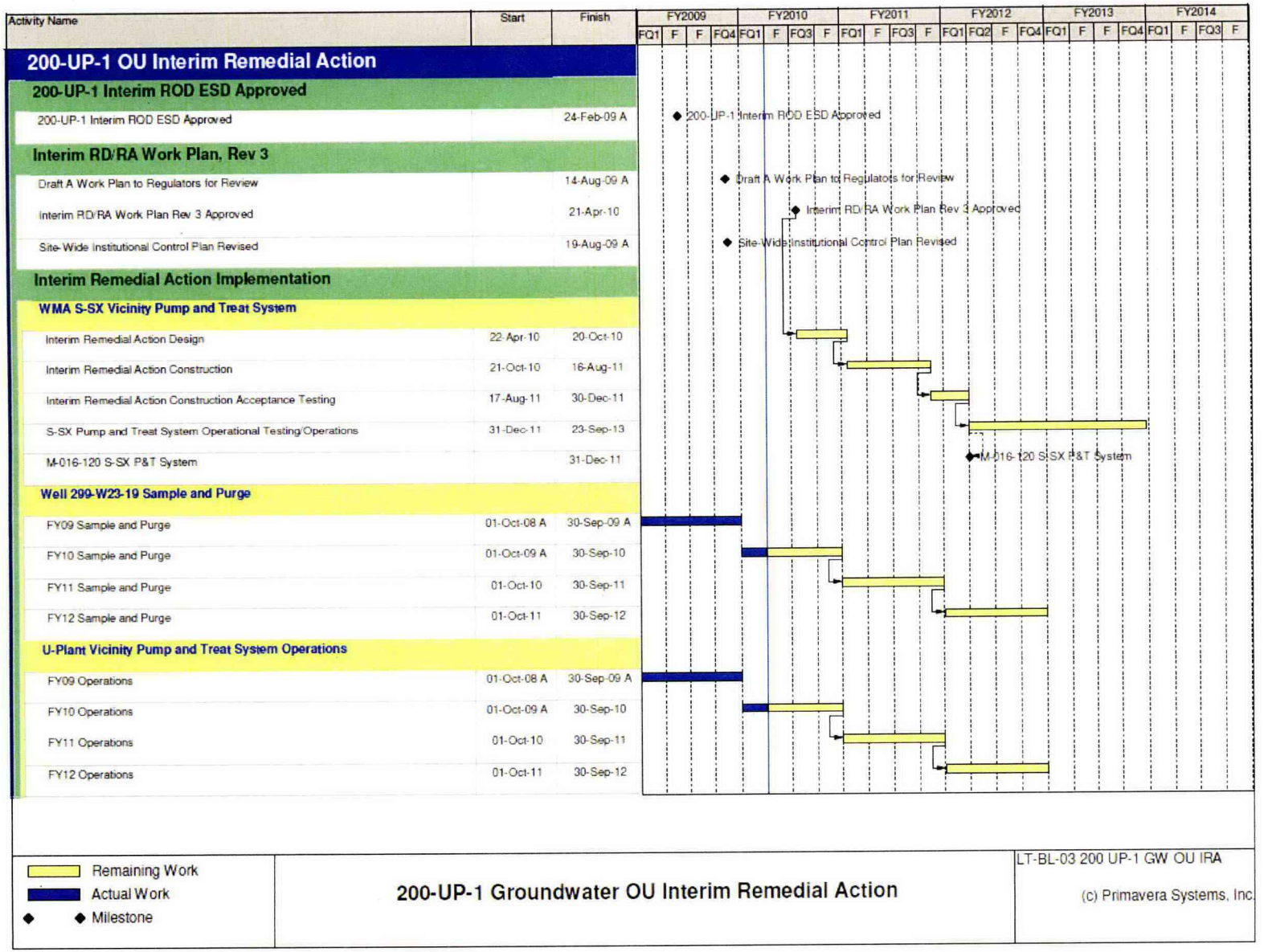

Figure 7-1. 200-UP-1 Groundwater OU Overall IRA Schedule

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Appendix A

Applicable or Relevant and Appropriate Requirements Compliance

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A1 Introduction

Table A-1 summarizes the implementation strategy for applicable and appropriate requirements for the 200-UP-1 Groundwater Operable Unit.

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
Groundwater			
40 CFR 141.61, "Maximum Contaminant Levels," "Maximum Contaminant Levels for Organics." 40 CFR 141.62, "Maximum Contaminant Levels for Inorganics." 40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides." WAC 173-340-720(4)(b)(iii)(A), "Model Toxics Control Act—Cleanup," "Ground Water Cleanup Standards," "Standard Method B Potable Groundwater Cleanup Levels," "Human Health Protection," "Noncarcinogens," and (B), "Carcinogens." WAC 173-340-720(7)(b), "Adjustments to Cleanup Levels."	Chemical-specific	*Safe Drinking Water Act of 1974*, 40 CFR 141 for public drinking water supplies is relevant and appropriate for setting groundwater treatment levels. The treatment train will meet MCLs for carbon tetrachloride, technetium-99, nitrate, and the MCL for uranium (30 µg/L). Regulation WAC 173-340 is applicable for setting groundwater treatment levels for uranium. The groundwater removed will be treated to achieve these levels (or the final cleanup levels for the 200-ZP-1 OU) before discharge. However, the underlying groundwater will not be treated to achieve these levels. This interim action is only part of a total remedial action and is cost effective. Therefore, these ARAR requirements at this time are being waived pursuant to Section 121(d)(4)(A) of CERCLA. **COC** / **MCL** / **Interim Cleanup Level (10x MCL)** Uranium / 30 µg/L / 300 µg/L Technetium-99 / 900 pCi/L / 9,000 pCi/L	Groundwater sampling of monitoring wells will be performed to collect data to monitor the progress of cleaning contaminated groundwater to achieve interim cleanup levels. Following extraction, the COCs in groundwater (except tritium) will be treated to achieve the MCLs.
Groundwater - Minimum Standards for Construction and Maintenance of Wells			
WAC 173-160-161, "Minimum Standards for Construction and Maintenance of Wells," "How Shall Each Water Well Be Planned and Constructed?"	Action-specific	Identifies well planning and construction requirements.	All monitoring and extractions wells completed for the 200-UP-1 Groundwater OU remediation activities will meet the substantive requirements of these regulations.

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
WAC 173-160-171, "What Are the Requirements for the Location of the Well Site and Access to the Well?"		Identifies the requirements for locating a well.	
WAC 173-160-181, "What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?"		Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	
WAC 173-160-400, "What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?"		Identifies the minimum standards for resource protection wells and geotechnical soil borings.	
WAC 173-160-420, "What Are the General Construction Requirements for Resource Protection Wells?"		Identifies the general construction requirements for resource protection wells.	
WAC 173-160-430, "What Are the Minimum Casing Standards?"		Identifies the minimum casing standards.	
WAC 173-160-440, "What Are the Equipment Cleaning Standards?"		Identifies the equipment cleaning standards.	
WAC 173-160-450, "What Are the Well Sealing Requirements?"		Identifies the well sealing requirements.	
WAC 173-160-460, "What Is the Decommissioning Process for Resource Protection Wells?"		Identifies the decommissioning process for resource protection wells.	

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
Air - Radiation/Radionuclides			
WAC 246-247-035(1)(a)(ii), "Radiation Protection—Air Emissions," "National Standards Adopted by Reference for Sources of Radionuclide Emissions," "40 CFR Part 61, Subpart H – National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities."	Action-specific	Incorporates requirements of 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants" Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," by reference. Requires that emissions of radionuclides to the ambient air from DOE facilities shall not exceed amounts that would cause any member of the public to receive in any year an effective dose equivalent of >10 mrem/yr.	This is a risk-based standard for the purposes of protecting human health and the environment. The regulations require a comparison of potential emissions from remedial point sources to the emission threshold. The 200-UP-1 remediation will be evaluated with respect to determining its PTE radionuclides from any point source or diffuse/fugitive source. To accomplish this, the total unabated potential release (in curies) will be determined and the annual dose to the maximally exposed individual calculated using the DOE guide, DOE/RL-2006-29, *Calculating Potential-to-Emit Radiological Releases and Doses*, or modeled using the CAP-88PC computer model. Control and monitoring requirements for potential radiological air emissions will be based on the calculated/modeled value of the PTE.
WAC 246-247-040, "General Standards." WAC 246-247-040(3). WAC 246-247-040(4). WAC 246-247-075(1), (2), (3), (4), (8), "Monitoring, Testing and Quality Assurance."		Requires that emissions be controlled to ensure radiation emission standards are not exceeded. New construction and significant modifications of emission units. Existing emission units and non-significant modifications. Establishes the monitoring, testing, and QA requirements for radioactive air emissions.	These regulations require an evaluation of potential radiation emissions from new remedial sources using best available radionuclide control technology or from existing sources using ALARA control technology. Emissions from non-point and fugitive sources of airborne radioactive material will be measured. The total unabated potential release (in curies) will be determined, and the annual dose to the maximally exposed individual calculated using the DOE guide, DOE/RL-2006-29, or modeled using the CAP-88PC computer model. Control and monitoring requirements for potential radiological air emissions will be based on the calculated/modeled value of the PTE. The PTE calculation, emissions controls, and monitoring will be described in the air emissions section of the RD/RA WP.

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
WAC 173-480-050(1), "Ambient Air Quality Standards and Emission Limits for Radionuclides," "General Standards for Maximum Permissible Emissions." WAC 173-480-070, "Emission Monitoring and Compliance Procedures."	Action-specific	Determine compliance with the public dose standard by calculating exposure at the point of maximum annual air concentration in an unrestricted area where any member of the public may be. This State regulation is as (or more) stringent than the equivalent Federal program requirement.	The total unabated potential release (in curies) will be determined, and the annual dose to the maximally exposed individual calculated using the DOE guide DOE/RL-2006-29, or modeled using the CAP-88PC computer model. Control and monitoring requirements for potential radiological air emissions will be based on the calculated/modeled value of the PTE. The PTE calculation, emissions controls, and monitoring will be described in the air emissions section of the RD/RA WP.
Air - General Regulations for Air Pollution Sources			
WAC 173-400-040, "General Regulations for Air Pollution Sources," "General Standards for Maximum Emissions." WAC 173-400-113, "Requirements for New Sources in Attainment or Unclassifiable Areas."	Action-specific	Requires all sources of air contaminants to meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions. Requires use of reasonably available control technology. This State regulation is as (or more) stringent than the equivalent Federal program requirement.	If remedial actions in the 200-UP-1 Groundwater OU result in visible, particulate, fugitive, and hazardous air emissions and odors, applicable control technology is required. This will be described in the air emissions section of the RD/RA WP.
Air - Controls for New Sources of Toxic Air Pollutants			
WAC 173-460, "Controls for New Sources of Toxic Air Pollutants." Specific subsections: WAC 173-460-030, "Applicability." WAC 173-460-060, "Control Technology Requirements." WAC 173-460-070, "Ambient Impact Requirement."	Action-specific	Requires that new sources of air emissions meet emission requirements identified in this regulation. This State regulation is as (or more) stringent than the equivalent Federal program requirement. The owner/operator of a new toxic air pollutant source that is likely to increase toxic air pollutant emissions shall demonstrate that emissions from the source are sufficiently low to protect human health and safety from potential carcinogenic and/or other toxic effects. This State regulation is as (or more) stringent than the equivalent Federal program requirement.	If there is the potential for toxic air pollutants to become airborne as a result of remedial activities, the applicable emission standards must be met. To demonstrate compliance with ARARs of WAC 173-400 and WAC 173-460, an acceptable source impact analysis will be completed. The analysis will demonstrate that, after application of T-BACT, the new source's maximum incremental ambient air impact levels do not exceed the WAC 173-460 Class A or Class B acceptable source impact levels at the nearest site boundary; or, if applicable, that the new source toxic air pollutant emission rates specified in WAC 173-460 at the stack, or do not exceed de minimis values established in WAC 173-460, as revised.

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
Solid Waste - Dangerous Waste Regulations			
WAC 173-303-016, "Dangerous Waste Regulations," "Identifying Solid Waste."	Action-specific	Identifies criteria for determining if materials are solid wastes.	Waste materials generated during the 200-UP-1 Groundwater OU remedial action will be compared to these criteria. Those that are determined to be solid waste and that are also dangerous waste will be subject to applicable and substantive waste management requirements of WAC 173-303.
WAC 173-303-017, "Recycling Process Involving Solid Waste."	Action-specific	Identifies materials that are and are not solid wastes when recycled.	Waste materials generated during the 200-UP-1 Groundwater OU remedial action will be compared to these criteria. Those categories of wastes that are not solid wastes are not subject to these requirements. If any meet this requirement and are also solid wastes, they are subject to requirements of WAC 173-303.
WAC 173-303-070(3), "Designation of Dangerous Waste," "Designation Procedures."	Action-specific	Establishes whether a solid waste is, or is not, a dangerous waste or an extremely hazardous waste.	The designation procedures to determine if a solid waste meets any dangerous waste criteria applies to remediation wastes generated from 200-UP-1 Groundwater OU remediation activities. Remediation wastes, including media and treatment residuals generated from the 200-UP-1 Groundwater OU, will be designated according to the procedures identified in WAC 173-303. The generator will determine if waste is a characteristic or listed dangerous waste by applying knowledge or by testing material.
WAC 173-303-071, "Excluded Categories of Waste."	Action-specific	Describes those categories of wastes that are excluded from the requirements of WAC 173-303 (excluding WAC 173-303-050), because they are generally not dangerous or are regulated under other State and Federal programs or are recycled in ways that do not threaten public health or the environment.	Wastes generated from the 200-UP-1 Groundwater OU remedial action (e.g., laboratory and treatability samples) will be reviewed against the categories identified in WAC 173-303-071.

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
WAC 173-303-073, "Conditional Exclusion of Special Wastes."	Action-specific	Establishes the conditional exclusions and the management requirements of special wastes, as defined in WAC 173-303-040.	Wastes generated during the remedial action (i.e., wastes that are State-only dangerous waste and that are solid [nonliquid, nonaqueous, nongaseous]) will be reviewed against these exclusions. For example, wastes that are corrosive waste or toxic waste with Category D toxicity may be eligible for this conditional exclusion.
WAC 173-303-077, "Requirements for Universal Waste."	Action-specific	Identifies those wastes exempted from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9906 (excluding WAC 173-303-960). These wastes are subject to regulation under WAC 173-303-573.	Wastes generated from the 200-UP-1 Groundwater OU remedial action will be reviewed against universal waste criteria. For example, if batteries, thermostats, fluorescent lamps, and mercury-containing equipment are generated, their handling, accumulation, labeling, shipping, and management will comply with the requirements provided in WAC 173-303-573.
WAC 173-303-120, "Recycled, Reclaimed, and Recovered Wastes." Specific subsections: WAC 173-303-120(3). WAC 173-303-120(5).	Action-specific	These regulations define the requirements for recycling materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials.	Wastes generated from the 200-UP-1 Groundwater OU remedial action will be reviewed against the requirements for recyclable materials. If recyclable materials (e.g., spent refrigerants, antifreeze, lead-acid batteries, and used oil) are generated, they will managed according to the requirements of WAC 173-303-120(3). Eligible recyclable materials can be recycled and/or conditionally excluded from certain dangerous waste requirements.

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
WAC 173-303-140(4), "Land Disposal Restrictions," "Land Disposal Restrictions and Prohibitions." (Implements 40 CFR 268, "Land Disposal Restrictions.")	Action-specific	This regulation establishes State standards for land disposal of dangerous waste and incorporates, by reference, the Federal restrictions of 40 CFR 268 that are relevant and appropriate to solid waste that is designated as dangerous or mixed waste. The requirements prohibit the placement of restricted RCRA hazardous waste in land-based units such as landfill surface impoundments, and waste piles until treated to standards considered protective for disposal. Specific treatment standards are included in requirements.	200-UP-1 remediation dangerous waste destined for onsite land disposal will be managed in accordance with these restrictions. Cuttings generated as a result of well installation will be tested for indicator COCs. If soil characterizes as dangerous waste for RCRA-listed and/or characteristic criteria, it will be compared to corresponding LDRs/UTS. Soil (e.g., from borings) that designate as listed dangerous waste must be treated to meet UTS or alternative treatment standards for RCRA hazardous soils. Generator certification is required verifying that the treatment standard has been achieved and the waste has not been diluted. Media with concentrations below health-based standards (i.e., Model Toxics Control Act Method B cleanup levels as described in WAC 173-340-720(4)(b)(iii)(A) and (B)) may be eligible for a contained-out determination subject to Ecology approval.
WAC 173-303-170, "Requirements for Generators of Dangerous Waste."	Action-specific	Establishes the requirements for dangerous waste generators. For purposes of this remedial action, WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200, "Accumulating Dangerous Waste On-Site," by reference.	These requirements will be followed if dangerous waste is generated by the 200-UP-1 remedial activity.

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
Special Historic and Ecological Resources			
Endangered Species Act of 1973, 16 USC 1531, et seq. 16 USC 1536(c), "Interagency Cooperation," "Biological Assessment."	Location-specific	Prohibits actions by Federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. Mitigation measures must be applied to actions that occur within critical habitats or surrounding buffer zones of listed species in order to protect the resource.	There are no plant species on the Federal list of endangered or threatened species; some State-listed plant species occur on or near the Central Plateau. There are also no wildlife species of concern found on the land overlying the 200-UP-1 Groundwater OU. Siting of the extraction wells and aboveground piping shall be coordinated with available ecological site data and surveys to ensure that adverse impacts to critical habitats will not occur. Prior to disturbing the earth (e.g., drilling, surface grubbing, and excavating), a survey will be completed and documented by Pacific Northwest National Laboratory (PNNL). The survey will identify threatened or endangered species and critical habitat and document such with respect to the areas included in this remedial action where there would be disturbance of the earth. Any restrictions regarding disturbance of the earth or otherwise will be identified in a letter report from PNNL to CHPRC.
Archaeological and Historic Preservation Act, 16 USC 469aa-mm, et seq.	Location-specific	Requires that remedial actions at the 200-UP-1 Groundwater OU do not cause the loss of any archaeological or historic data. This act mandated preservation of data and does not require protection of the actual historical sites.	In 1987 and 1988, a comprehensive archaeological resources review of the Central Plateau was conducted that included an examination of samples collected from undisturbed portions of the 200 West Area. The inventory reported no significant surface archaeological sites were encountered. Remedial actions shall be coordinated with available site data and surveys and consultants to ensure adverse impacts do not occur. Prior to disturbing the earth (e.g., drilling, surface grubbing, and excavating), a survey will be completed and documented by PNNL. The survey will identify culturally significant items and document such with respect to the areas included in this remedial action where there would be disturbance of the earth. Any restrictions regarding disturbance of the earth or otherwise will be identified in a letter report from PNNL to CHPRC.

Table A-1. Implementation Strategy for Applicable and Appropriate Requirements for the 200-UP-1 Groundwater Operable Unit

Regulation	Type	Regulatory Requirements	Implementation/Action Strategy
National Historic Preservation Act of 1966 16 USC 470, Section 106, et seq.	Location-specific	Requires Federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, and mitigation processes.	In 1987 and 1988, a comprehensive archaeological resources review of the Central Plateau was conducted that included an examination of samples collected from undisturbed portions of the 200 West Area. The inventory reported no significant surface archaeological sites were encountered. Remedial actions shall be coordinated with available site data, surveys, and consultants to ensure adverse impacts do not occur. Prior to disturbing the earth (e.g., drilling, surface grubbing, and excavating), a survey will be completed and documented by PNNL. The survey will identify culturally significant items and document such with respect to the areas included in this remedial action where there would be disturbance of the earth. Any restrictions regarding disturbance of the earth or otherwise will be identified in a letter report from PNNL to CHPRC.

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR = Code of Federal Regulations
CHPRC = CH2M HILL Plateau Remediation Company
COC = contaminant of concern
DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
LDR = land disposal restriction
MCL = maximum contaminant level
MNA = monitored natural attenuation
OU = operable unit
PNNL = Pacific Northwest National Laboratory
PTE = potential to emit
RCRA = Resource Conservation and Recovery Act of 1976
RD/RA WP = remedial design/remedial action work plan
ROD = record of decision
TCLP = toxicity characteristic leaching procedure
Tri-Party Agreement = Hanford Federal Facility Agreement and Consent Order (Ecology et al.,1989)
UTS = universal treatment standard
WAC = Washington Administrative Code

A2 References

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173-160-181, "What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?"

173-160-400, "What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?"

173-160-420, "What Are the General Construction Requirements for Resource Protection Wells?"

173-160-430, "What Are the Minimum Casing Standards?"

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Appendix B

Groundwater Pumping Capture Zone Analysis to Support Preliminary Well Locations and Pumping Rate Selection

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B1 Introduction

This appendix describes the application of a numerical computer model to estimate groundwater extraction well capture zones as discussed in the Interim Remedial Design/Remedial Action Work Plan for the 200-UP-1 Groundwater Operable Unit (OU). The capture zone analysis was performed to support preliminary selection of well locations and identify possible extraction well pumping rates. The model used for this analysis was originally developed for use in optimization of groundwater extraction and injection wells in the 200-ZP-1 Groundwater OU, located immediately adjacent to the 200-UP-1 Groundwater OU. This model was selected because it already existed at the time and had been demonstrated to provide useful illustrations of groundwater extraction well capture zones.

B2 Purpose

The purpose of this appendix is to present the methodology, inputs, and results of numerical simulations to estimate the extent of groundwater capture zones for groundwater extraction wells under consideration for interim remedial actions (IRAs) at two locations within the 200-UP-1 Groundwater OU. The specific locations are in the vicinity of the U Plant, where an IRA is currently in operation to remediate plumes of uranium and technetium-99, and the vicinity of Waste Management Area (WMA) S-SX, where plumes of technetium-99 exceed action levels identified for interim action.

B3 Methodology

The computer codes MODFLOW (Harbaugh et al., 2000) and MODPATH (Pollack, 1994) were used to simulate the capture zones of proposed extraction wells. Previous modeling using MODFLOW conducted for the simulation of the pump-and-treat system for the 200-ZP-1 Groundwater OU simulated groundwater movement in the Central Plateau region and the same computational approach was also used to simulate the proposed extraction wells. The 200-ZP-1 Groundwater OU model incorporates the unconsolidated units of the Hanford formation and Ringold Formation as the permeable domain with the underlying basalt treated as an impermeable boundary. The model extends from the basalt areas above the water table on the north, west, and south to a boundary with an Easting coordinate of approximately 581200 (Figure B-1). This eastern boundary is some 10,000 m (32,800 ft) from the eastern edge of the 200-UP-1 Groundwater OU area and thus is quite distant from the 200-UP-1 OU IRA target areas (i.e., U Plant Vicinity and WMA S-SX vicinity). A generalized head boundary condition is applied along this eastern edge, simulating the hydraulic connection of this boundary to the Columbia River farther to the east. The southeast boundary from the eastern edge to the intersection of the basalt area south of the 200-UP-1 Groundwater OU is treated as a no-flow boundary. Along the northern edge, the two gaps in the basalt areas are treated as specified head boundary conditions. The locations within the 200-UP-1 Groundwater OU that were simulated for this preliminary design are sufficiently distant from the model domain boundaries as to not be affected by boundary conditions.

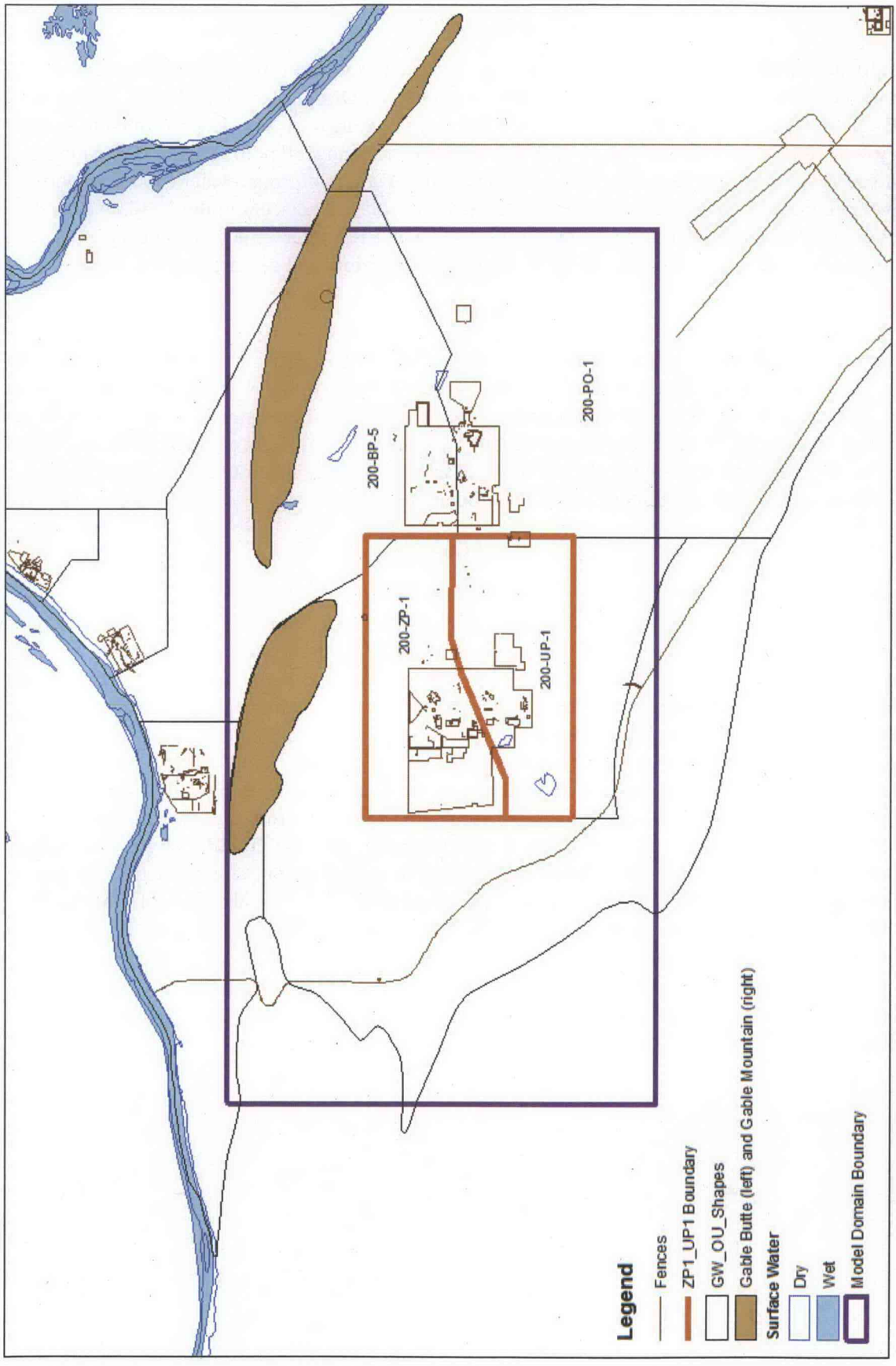


Figure B-1. Boundaries of the Numerical Model Used to Simulate Groundwater Extraction in the 200-UP-1 Groundwater OU

The hydrostratigraphy of the Central Plateau is simulated with six units in the 200-ZP-1 Groundwater OU model. These are the highly permeable Hanford formation, Ringold Formation units E and C, fine-grained Ringold Formation unit B, coarse-grained Ringold Formation units B and D, the Ringold Formation lower mud unit, and Ringold Formation unit A. Only the Ringold Formation units E and C, the lower mud, and unit A appear in the model in the northern portion of the 200-UP-1 Groundwater OU that contains the U Plant and WMA S-SX. In this area, the Ringold Formation units E and C are approximately 60 m (196 ft) thick and, with respect to the relatively shallow groundwater plumes, constitute an aquifer separated from the permeable Ringold Formation unit A by the relatively low-permeability Ringold Formation lower mud unit. Inspection of well logs from wells 299-W22-86 and 299-W22-72 indicate the lower 40 m (131 ft) of the Ringold Formation units E and C is cemented or partly cemented, further isolating these upper units from the Ringold Formation unit A. This cemented region is not widespread in the 200-ZP-1 Groundwater OU and separate treatment of this feature is below the level of detail represented in this model.

Because the 200-ZP-1 Groundwater OU pump-and-treat remedy will influence the hydrology in the WMA S-SX vicinity, the simulations conducted for the conceptual design of the interim action extraction wells in the WMA S-SX vicinity assume the current net 1,325 L/min (350-gal/min) pumping of the 200-ZP-1 Groundwater OU IRA continues for 3 years. Afterward, the 200-ZP-1 Groundwater OU remedy is assumed to expand to the planned 3,800-L/min (1,000-gal/min) net pumping. Startup of the interim action extraction wells for the WMA S-SX vicinity is assumed to be concurrent with startup of the 3,800-L/min (1,000-gal/min) operation of the 200-ZP-1 Groundwater OU remedy.

The methodology used to estimate groundwater extraction well capture zones applied the following steps:

1. The existing 200-ZP-1 Groundwater OU model was selected for this analysis because it had been previously constructed using hydrogeologic information that includes the 200-UP-1 Groundwater OU area. The model allows for examination of varying well locations, well configurations, and extraction rates.

2. The areal extent of target plume areas were identified in plan view using groundwater contaminant plume maps prepared for the Hanford annual groundwater monitoring report. The target plume areas are those portions of the identified groundwater plumes where the concentration of selected contaminants (i.e., total uranium and technetium-99 for the U Plant Vicinity, and technetium-99 for the WMA S-SX vicinity) exceed the IRA goals of 10 times the established Maximum Contaminant Level (MCL) for the individual contaminants. These concentration goals are 300 μg/L and 9,000 pCi/L for uranium and technetium-99, respectively.

3. Preliminary extraction well locations were selected for each of the target plume areas. Preliminary locations were generally near the downgradient extent of the target plume areas.

4. The plumes were simulated to migrate downgradient from their present locations at the same rate as groundwater movement in the area. This plume migration was estimated to provide additional basis for identifying extraction well locations.

5. Preliminary extraction well pumping rates were selected for hypothetical wells. The preliminary pumping rates ranged from 37.8 L/min (10 gal/min) to 189 L/min (50 gal/min). The duration of pumping operation was also selected for each scenario.

6. The model was operated for each selected set of well locations and pumping rates. The model generated resultant series of groundwater particle tracks and calculated extent of capture for the duration of pumping for each well. The U Plant Vicinity analysis was performed separately from the

WMA S-SX Vicinity analysis. Following completion of the numerical simulation, the results were post-processed to prepare graphic illustrations of the simulation results.

7. The graphic illustrations were subsequently visually inspected to evaluate the apparent capture efficacy for individual wells. For illustration purposes, the capture zones and hypothetical well locations were located to indicate the extent of capture relative to the plume(s).

B4 Assumptions and Inputs

The assumptions and inputs used for the extraction well capture zone analysis are described in this section. Generally assumptions were made at the level of detail of the model domain, and at no smaller level of detail than the OU level. Inputs were identified for each model scenario run.

B4.1 Assumptions

Simplifying and facilitating assumptions were made to allow application of the existing model to the 200-UP-1 Groundwater OU interim action target areas. The following assumptions were applied:

- The hydrogeologic basis of the existing 200-ZP-1 OU model is sufficiently representative of conditions within the target areas of the 200-UP-1 OU. This assumption is valid, based on the use of overall 200 West Area hydrogeology to develop the 200-ZP-1 OU model.
- The pumping rates identified for groundwater extraction wells are within realistically achievable values for actual well performance. This assumption is valid, based on historical groundwater pumping operations at the 200-ZP-1 Groundwater OU IRA, as well as historical pumping at the 200-UP-1 Groundwater OU IRA in the U Plant vicinity. Although the IRA extraction wells currently in operation at the U Plant vicinity are producing relatively small quantities of water (e.g., on the order of 18 L/min [5 gal/min]), this appears to be the result of a combination of declining water table and corresponding decrease in available well screen length, non-optimal pump placement within the screened interval, and fouling of the well screen associated with long-term pumping operation.
- The aquifer system is currently affected by groundwater extraction in the 200-ZP-1 Groundwater OU and this effect will become more pronounced as the ZP-1 remedial action is implemented in phases to increase the overall groundwater extraction rate.
- Existing groundwater plumes were assumed to migrate coincidental with groundwater within the time frame of the capture zone simulation.
- The results of capture zone analysis calculations are sufficiently accurate to provide a technical basis for preliminary well location. This assumption is valid, based on the demonstrated performance of the model in the 200-ZP-1 OU capture zone analysis.
- As water enters the model grid node containing the extraction well(s), it is assumed to have been captured.
- No continuing vadose zone source term contributions are assumed.

The assumptions made to support this computational effort are not believed to contribute to substantial uncertainty in the results.

B4.2 Inputs

The variable inputs that were modified for each scenario were as follows:

- Number of extraction well(s) operated
- Location of extraction well(s)
- Extraction well pumping rate(s)
- Extraction well operating period

Well screen length for extraction wells was 30 m (98 ft) below the water table in all scenarios. The values for specific input variables used in the model scenarios for each scenario at each plume area are summarized in Table B4-1.

Well pumping rates of 57 L/min (15 gal/min) to 189 L/min (50 gal/min) for wells located in the vicinity of the WMA SX technetium-99 plume were selected for the simulation. These pumping rates exceed the pumping rate observed for well 299-W23-19, however, that well was not designed and constructed as a groundwater extraction well and is not expected to produce substantial amounts of water. Pumping activities at other locations nearby (e.g., the IRA extraction wells near the U Plant) have exhibited substantially higher pumping rates.

Table B4-1. Simulation Variable Values for Groundwater Extraction Well Capture Zone Analysis for 200-UP-1 Groundwater OU Interim Remedial Actions

Scenario	Number of Wells	Well Locations	Pumping Rates	Operating Period
U Plant Vicinity	2	Existing Wells 299-W19-36 and 299-W19-43	37.8 L/min (10 gal/min)	2 years
WMA S-SX Vicinity Scenario 1	2	1 well near downgradient end of SX Tc-99 Plume 1 well near downgradient end of S Tc-99 Plume	132 L/min (35 gal/min) 57 L/min (15 gal/min)	3 years
WMA S-SX Vicinity Scenario 1	2	1 well near downgradient end of SX Tc-99 Plume 1 well near downgradient end of S Tc-99 Plume	170 L/min (45 gal/min) 57 L/min (15 gal/min)	3 years

B5 Software Applications

The computer codes MODFLOW (Harbaugh et al., 2000) and MODPATH (Pollack, 1994) were used to simulate the capture zones of proposed extraction wells. These are both commercial off-the-shelf computer codes that are currently undergoing qualification for entry into the Hanford Information System Inventory (HISI).

B6 Results and Conclusions

The capture zone simulation results are presented graphically in Figure B-2 through Figure B-4 and are discussed in the following subsections. The simulation scenario results were screened to identify those that resulted in desirable capture of target plume segments. The model is constructed using 100-m-square (320.8-ft square) computational grid nodes. This results in some uncertainty regarding capture behavior

within about 50 m (164 ft) of any particular pumping well location. In addition, this model grid configuration does not yield readily detectable capture results from pumping rates less than about 57 L/min (15 gal/min). Historical pumping activities in this area, however, indicate that pumping rates of 57 L/min (15 gal/min) or greater will be required to provide acceptable capture.

B6.1 U Plant Vicinity Extraction Well Capture Zone Analysis Results

Analysis of extraction well capture in the U Plant vicinity assumes the performance of the existing extraction wells can be restored to increased pumping rates. The time period for the simulations in the U Plant vicinity was identified as two years, assuming the pumping was commenced in 2009 and continued through 2011. For the U Plant vicinity, the target plume segment is identified as that portion of the inferred uranium groundwater plume where the total uranium concentration exceeds 300 µg/L. No monitoring wells in the U Plant vicinity currently exceed the IRA objective of 9,000 pCi/L technetium-99. The results of the scenario simulation are described as follows.

U Plant Vicinity Scenario assumes the two existing groundwater extraction wells (i.e., wells 299-W19-36 and 299-W19-43) are redeveloped and pumps reset such that pumping rates in those wells can be increased to 37.8 L/min (10 gal/min) for each well for a total of 75.7 L/min (20 gal/min). The results of this scenario simulation are shown in Figure B-2. This extraction scenario provides capture of the east (i.e., downgradient) portion of the target plume. Some uncertainty exists regarding capture of the upgradient portion of the target plume; however, this scenario provides hydraulic containment of the plume and remediation of the downgradient portion of the plume until a final remedy for 200-UP-1 Groundwater OU is defined and implemented.

Based on evaluation of the simulation scenario results for the U Plant vicinity groundwater extraction, the recommended approach is to redevelop the existing extraction wells, reset the pumps, and attempt to increase the combined pumping rate from those two wells to 75.7 to 132 L/min (20 to 35 gal/min). This would result in short-term capture of the downgradient portion of the target plume and provide hydraulic control of the same plume segment. This would provide effective IRA response in the short term until the final remedial action for 200-UP-1 Groundwater OU is identified. Use of the existing groundwater extraction wells would be the most cost-effective alternative for this location. In the event the existing wells cannot be restored to at least 37.8 L/min (10 gal/min) from each well, installation of a new well should be evaluated in greater detail.

B6.2 WMA S-SX Vicinity Extraction Well Capture Zone Analysis Results

Analysis of extraction well capture in the WMA S-SX vicinity utilized assumptions of installing new groundwater extraction wells to capture the discrete plumes of elevated technetium-99 concentration in the vicinity of the S and SX tank farms. The time period for the simulations in the WMA S-SX vicinity was 3 years for all scenarios, assuming the pumping started in 2011 and continued through 2013. For the WMA S-SX vicinity, the target plume segment is identified as that portion of the inferred technetium-99 groundwater plume where the concentration exceeds 9,000 pCi/L. No monitoring wells in the U Plant vicinity currently exceed the IRA objective of 300 µg/L uranium. In both of these simulations, the time period for operation coincides with expansion of the 200-ZP-1 Groundwater OU final remedial action. This causes noticeable inflection in the groundwater flow direction toward the north-northeast. The results of these scenario simulations are described below.

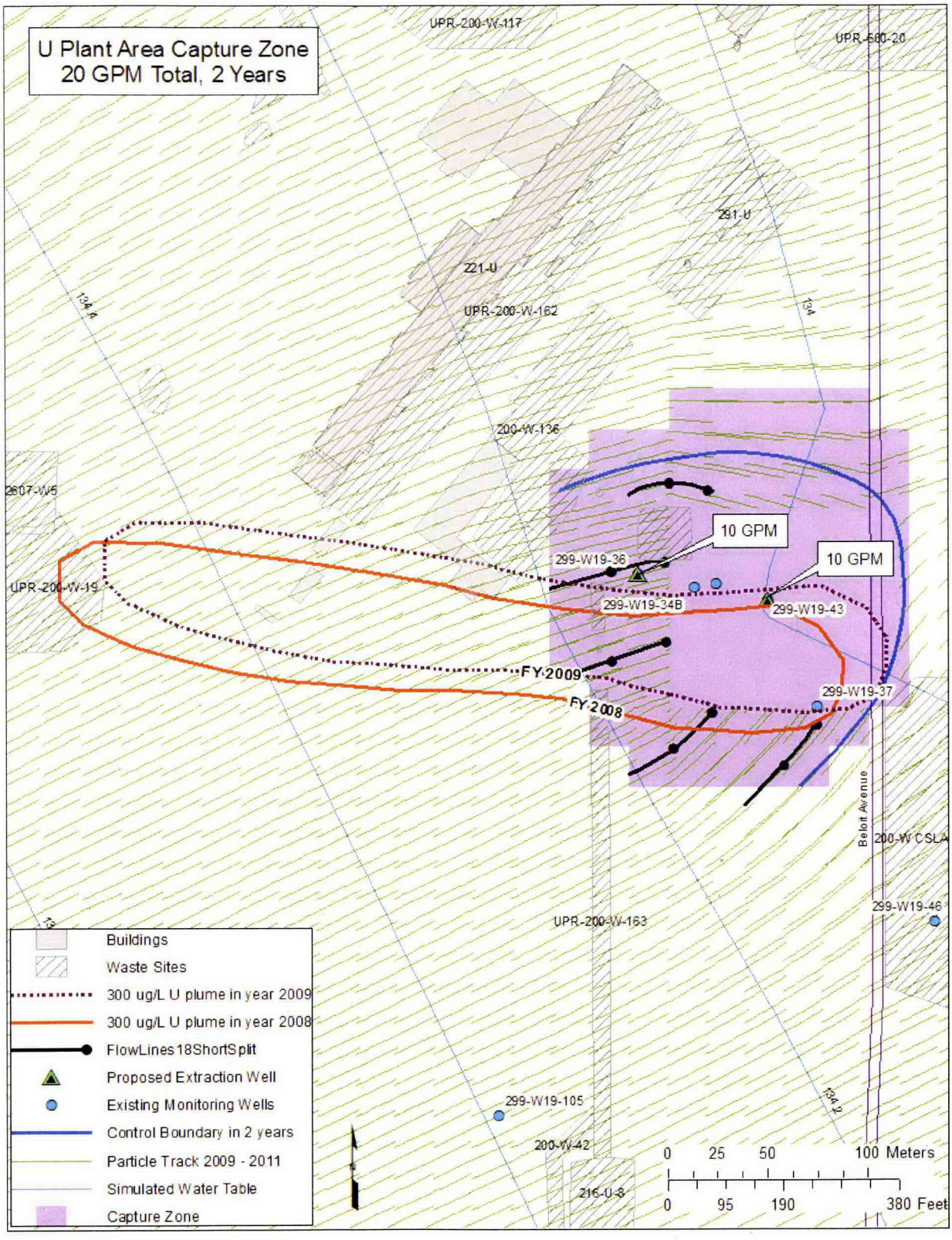


Figure B-2. U Plant Vicinity Groundwater Extraction Scenario 1

WMA S-SX Vicinity Scenario 1 assumes two new groundwater extraction wells are constructed, one located to the east side of the SX tank farm portion of WMA S-SX and one to the east side of the S tank farm portion of WMA S-SX. These wells were assumed to be operated at pumping rates of 132 L/min (35 gal/min) and 57 L/min (15 gal/min) for the southern and northern wells, respectively. This scenario provides a total extraction rate of 189 L/min (50 gal/min). The results of this scenario simulation are shown in Figure B-3. This extraction scenario provides capture of the northern plume segment in the short term and provides interception of the downgradient portion of the southern plume segment. Some uncertainty exists regarding capture of the upgradient portion of the target plume over a longer period of time.

WMA S-SX Vicinity Scenario 2 assumes two new groundwater extraction wells are constructed, one located to the east side of the SX tank farm portion of WMA S-SX and one to the east side of the S tank farm portion of WMA S-SX. These wells were assumed to be operated at pumping rates of 170 L/min (45 gal/min) and 57 L/min (15 gal/min) for the southern and northern wells, respectively. This scenario provides a total extraction rate of 227 L/min (60 gal/min). The results of this scenario simulation are shown in Figure B-4. This extraction scenario provides capture of the northern plume segment in the short term and provides interception of the downgradient portion of the southern plume segment. This scenario also provides increased confidence in capture of the upgradient portion of the target plume over a longer period of time. This extraction scenario provides capture of the northern plume segment in the short term and also intercepts the southern plume segment in the simulation time period and would capture the southern plume segment over a longer period of operation.

Based on evaluation of the simulation scenario results for the WMA S-SX vicinity groundwater extraction, the recommended approach is to install two extraction wells as described in the simulation scenarios and operate the wells at pumping rates between 132 and 170 L/min (35 gal/min to 45 gal/min) in the southern plume segment and 57 L/min (15 gal/min) in the northern plume segment. This would result in short-term capture of the downgradient portion of the target plume segments and provide hydraulic control of the same plume segments. This would provide effective IRA response in the short term until the final remedial action for 200-UP-1 Groundwater OU is identified. The target combined pumping rate would range from 189 to 227 L/min (50 to 60 gal/min).

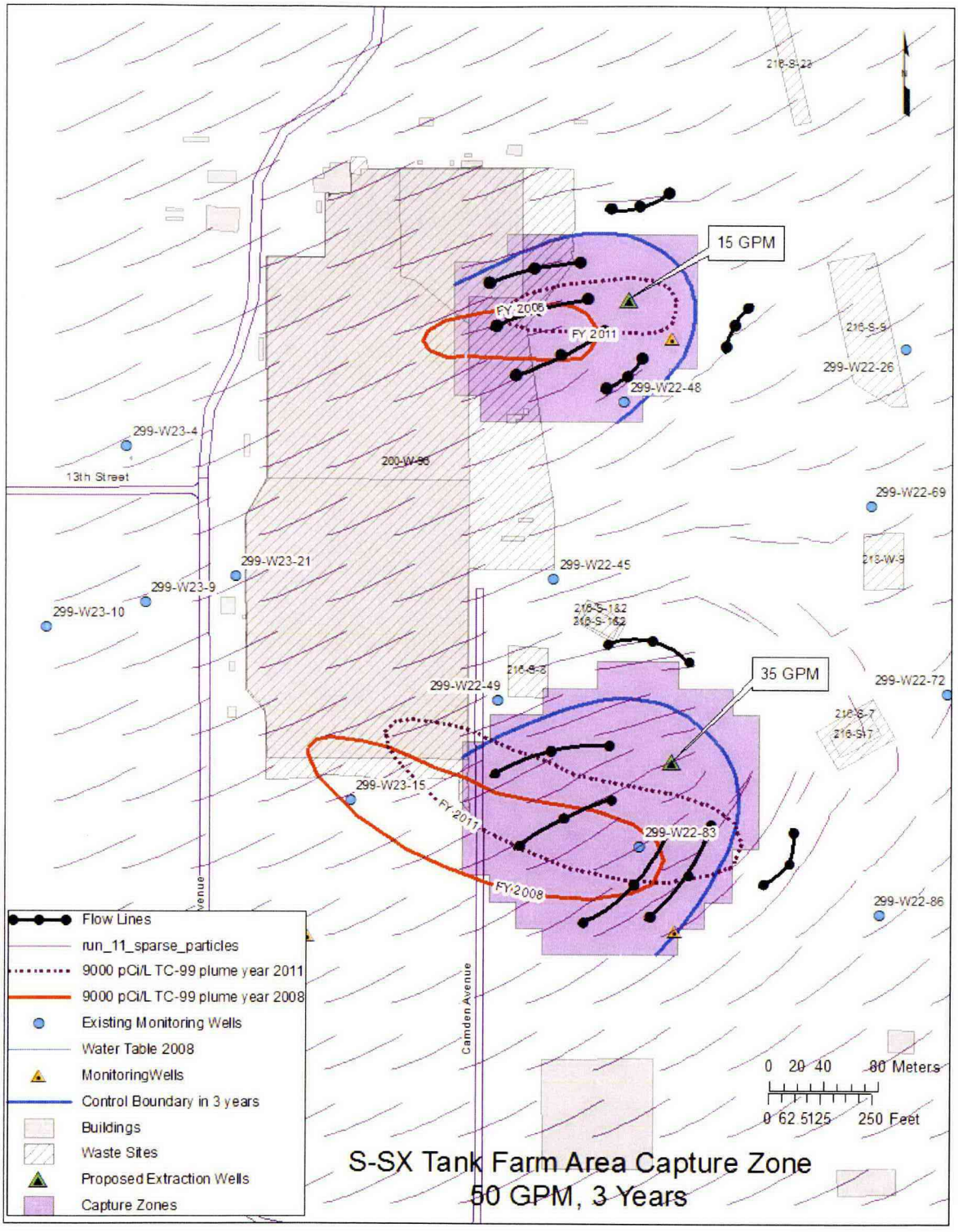
B6.3 Uncertainties in Simulation Results

The simulations described in the preceding sections are subject to some uncertainty related to the following conditions:

1. The model grid cell size (i.e., 100-m square [328-ft square]) is relatively large compared to the size of the target plume areas, so there is low resolution in the exact location of the hypothetical extraction wells relative to the target plume areas.

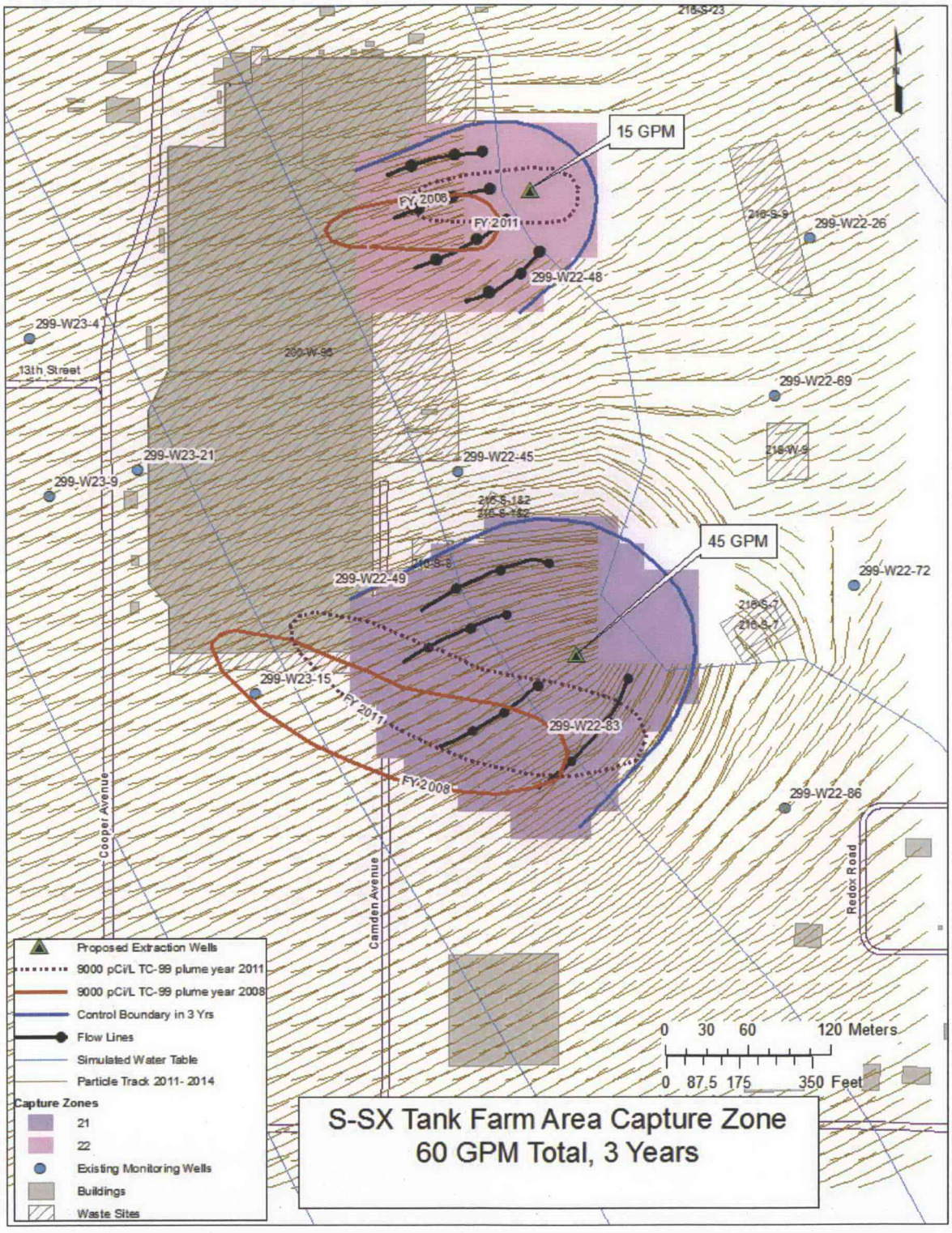
2. The conceptual extraction well performance does not address the differences between the local hydrostratigraphy in the WMA S-SX vicinity and the 200-ZP-1 Groundwater OU model, specifically related to the apparent cementation of deeper Ringold Formation sediments that are present in the WMA S-SX vicinity. Cementation would reduce the hydraulic conductivity in a portion of the formation that will be expected to increase the radius of apparent capture for a given well configuration and pumping rate. The impact of this uncertainty is expected to be relatively small because the target contamination in the areas addressed under this IRA is found in the upper portion of the aquifer.

The conceptual extraction well locations should be refined during the remedial design by using a numerical model with a finer grid resolution in the target plume area. This refined numerical model will allow better representation of the local hydrostratigraphy, optimal pumping locations, and reduce the uncertainty in the conceptual well results that arise from the 100-m square (328-ft square) grid dimensions.



(The Hydraulic Control Boundary [Capture Zone] at the end of the three-year simulation period is indicated by the blue line.)

Figure B-3. WMA S-SX Vicinity Groundwater Extraction Scenario Utilizing Two Extraction Wells with Combined 189 L/min (50 gal/min) Target Pumping Rate



(The Hydraulic Control Boundary [Capture Zone] at the end of the three-year simulation period is indicated by the blue line.)

Figure B-4. WMA S-SX Vicinity Groundwater Extraction Scenario Utilizing Two Extraction Wells with Combined 227 L/min (60 gal/min) Target Pumping Rate

B7 References

Harbaugh, A.W., E.R. Banta, M.C. Hill, and M.G. McDonald, 2000, *MODFLOW-2000, the U.S. Geological Survey Modular Ground-Water Model -- User Guide to Modularization Concepts and the Ground-Water Flow Process*, U.S. Geological Survey, Open-File Report 00-92. Available at: http://pubs.er.usgs.gov/usgspubs/ofr/ofr200092.

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