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Richland Operations Office
P.O. Box 550
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10-AMCP-0205

AUG 0 2 2010

Mr. D. A. Faulk, Program Manager
Office of Environmental Cleanup
Hanford Project Office
U.S. Environmental Protection Agency
309 Bradley Boulevard, Suite 115
Richland, Washington 99352

Dear Mr. Faulk:

200 WEST AREA GROUNDWATER PUMP-AND-TREAT REMEDIAL DESIGN REPORT, DOE/RL-2010-13, DRAFT A

This letter transmits the 200 West Area Groundwater Pump-and-Treat Remedial Design Report, DOE/RL-2010-13, Draft A to the U.S. Environmental Protection Agency (EPA) for review and comment.

The Remedial Design Report (RDR) describes how the remedy is being designed and installed to meet the remedial action objectives identified in the Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington. Further refinements to the design and the planned implementation will be finalized as the design and construction are completed.

Transmittal of the RDR satisfies the requirement to meet the Hanford Federal Facility Agreement and Consent Order Milestone M-016-124, Submit 200-ZP-1 Remedial Design Report to EPA by August 31, 2010.

Please provide your comments to the U.S. Department of Energy Richland Operations Office within 30 days of receipt. If you have any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

For

Richard A. Holten, Acting Assistant Manager
for the Central Plateau

AMCP:ACT

Attachment

cc: See Page 2

RECEIVED
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EDMC

M-016-124
200-ZP-1

cc w/attach:
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DOE/RL-2010-13
Draft A

200 West Area Groundwater Pump-and-Treat Remedial Design Report

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

U.S. DEPARTMENT OF ENERGY

Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
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DOE/RL-2010-13
Draft A

200 West Area Groundwater Pump-and-Treat Remedial Design Report

Date Published
June 2010

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 report (RDR) outlines the remedial design of the 200 West Area Groundwater Pump-and-Treat (P&T) system. The 200 West Area P&T system is a major component of the remedial action selected for cleanup of the 200-ZP-1 Groundwater Operable Unit (OU), located in the 200 West Area of the Hanford Site Central Plateau.

The remedy selected in the U.S. Environmental Protection Agency (EPA) et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*[1] (hereafter referred to as the Record of Decision [ROD]), combines installation of a groundwater P&T system, monitored natural attenuation, flow path control, and institutional controls. These remedy components combine to meet the objective of achieving established groundwater cleanup levels for all contaminants of concern (COCs) in the 200-ZP-1 OU within 125 years. The COCs identified for the 200-ZP-1 OU are carbon tetrachloride, total chromium (trivalent [III] and hexavalent [VI]), nitrate, trichloroethylene, iodine-129, technetium-99, and tritium.

The ROD also requires that a large fraction of the mass of contamination (i.e., 95 percent of the dissolved mass of COCs) be removed within the first 25 years. This mass removal will primarily be accomplished by the operation of the 200 West Area Groundwater P&T system, which is designed to capture and treat contaminated groundwater to reduce the mass of COCs throughout the 200-ZP-1 OU. Treated water will be re-injected into the aquifer to attain flow path control.

This RDR addresses the design of the 200 West Area Groundwater P&T system to ensure that these objectives are met. This RDR outlines the basis of design of the major components of the 200 West Area Groundwater P&T system and provides a summary of the anticipated construction cost and schedule.

[1] EPA, DOE, and Ecology, 2008, *Record of Decision Hanford 200 Area 200 ZP 1 Superfund Site Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r2008100003103.pdf.

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Terms

AEA	*Atomic Energy Act of 1954*
AFD	adjustable frequency drive
ALARA	as low as reasonably achievable
AMP	air monitoring plan
ASIL	acceptable source impact level
ATP	acceptance test procedure
ARAR	applicable or relevant and appropriate requirement
AWWA	American Waste Water Association
BOD	biochemical oxygen demand
BOP	balance of plant
CaO	calcium oxide or quicklime
CAT	construction acceptance test
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CHPRC	CH2M HILL Plateau Remediation Company
CLARC	Cleanup Levels and Risk Calculations
CM/SDC	construction managers/services during construction
COC	contaminant of concern
CPVC	chlorinated polyvinyl chloride
CTET	carbon tetrachloride
D&D	decontamination and decommissioning
DNAPL	dense non-aqueous phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EPC	engineer/procure/construct
ERDF	Environmental Restoration Disposal Facility

FBR	fluidized bed reactor
FFTF	Fast Flux Test Facility
FRP	fiber-reinforced plastic
FS	feasibility study
FY	fiscal year
G&A	General and Administrative
GAC	granular activated carbon
gpm	gallons per minute
HAB	Hanford Advisory Board
HASP	health and safety plan
HCP EIS	*Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
HDPE	high-density polyethylene
HMI	human machine interface
I&C	instrumentation and controls
IC	institutional control
IDW	investigation-derived waste
IRM	interim remedial measure
IX	ion exchange
HAB	Hanford Advisory Board
MCL	maximum contaminant level
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
NCP	National Contingency Plan
NEPA	*National Environmental Policy Act of 1969*
NPL	National Priorities List
NPSH	net positive suction head
NTU	nephelometric turbidity unit

O&M	operations and maintenance
OTP	operational test plan
OU	operable unit
P&T	pump-and-treat
PFP	Plutonium Finishing Plant
PLC	programmable logic controller
PMP	performance monitoring plan
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RA	remedial action
RAG	remedial action goal
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RD	remedial design
RD/RAWP	Remedial Design/Remedial Action Work Plan
RDR	remedial design report
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
ROD	record of decision
SCADA	supervisory control and data acquisition
SCFM	standard cubic feet per minute
SRT	sludge retention time
SVE	soil vapor extraction
TPA	Tri-Party Agreement, *Hanford Federal Facility Agreement and Consent Order*
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
TSS	total suspended solids
USGS	U.S. Geological Survey
VOC	volatile organic compounds

VPGAC	vapor phase granular activated carbon
WAC	*Washington Administrative Code*
WBS	work breakdown structure
WMA	waste management area

1 Introduction

The 200 West Area Groundwater Pump-and-Treat (P&T) system is a major component of the remedial action (RA) selected in U.S. Environmental Protection Agency (EPA) et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*. This remedial design report (RDR) provides a summary of the 200 West Area Groundwater P&T system design.

This RDR for the 200-ZP-1 Operable Unit 1 (OU) presents the selected design supporting the remedial alternative as established in the (ROD). The ROD selected remedy combines P&T, monitored natural attenuation (MNA), flow path control and institutional controls (ICs). This remedial alternative will address groundwater with concentrations of concern that pose a potential human health risk and will meet the remedial action objectives (RAOs) identified in the ROD. The RAOs are presented in Chapter 2.1.

Figure 1-1 shows the location of the 200-ZP-1 OU within the 200 West Area of the Hanford Site. The 200 West Area contains waste management facilities and former irradiated fuel reprocessing facilities. The major waste streams that contributed to groundwater and soil contamination were associated with the plutonium concentration and recovery operations at the Plutonium Finishing Plant (PFP) facilities and the plutonium-separation operations at the T Plant facilities, both in the 200 West Area. The liquid waste disposal in the trenches near these facilities resulted in several groundwater contamination plumes in the groundwater site, as well as contamination in the trench soil. More detailed information describing the Hanford Site, the 200 West Area, and the 200-ZP-1 OU is contained in the U.S. Department of Energy (DOE) reports *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24), the *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*, Rev. 0 (DOE/RL-2008-78), and the ROD (EPA et al., 2008).

This RDR was prepared by the DOE Richland Operations Office (RL) in accordance with the following documents:

- DOE/RL-2008-78, hereafter referred to as the RD/RAWP
- Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*, hereafter referred to as the Tri-Party Agreement
- Guidance provided in the *Code of Federal Regulations* (CFR) 40 CFR 300.435(f), "National Oil and Hazardous Substances Pollution Contingency Plan"

This RDR presents information that is based on the 90-percent design and, as such, portions of this document may be updated as substantive changes are made through final design.

This report is intended to transmit the design requirements from information collected during the remedial design and delineated in the ROD. The limited objective of this design report, the ongoing nature of the project, along with the evolving knowledge of site conditions and chemical effects on the environment and human health, must be considered when reviewing the design.

1.1 Purpose and Scope

The following subsection presents the purpose, scope, and content of the RDR.

1.1.1 Purpose of the Remedial Design Report

The RDR presents the site-specific data and considerations needed to successfully complete the remedial actions identified in the ROD. This RDR will be used in conjunction with the RD/RAWP. These design documents, as well as the other supporting documents will be used to identify tasks of the 200-ZP-1 OU remedial action, prepare a schedule with project milestones, assign the appropriate personnel and equipment for the accomplishment of each task, and submit the remedial action deliverables.

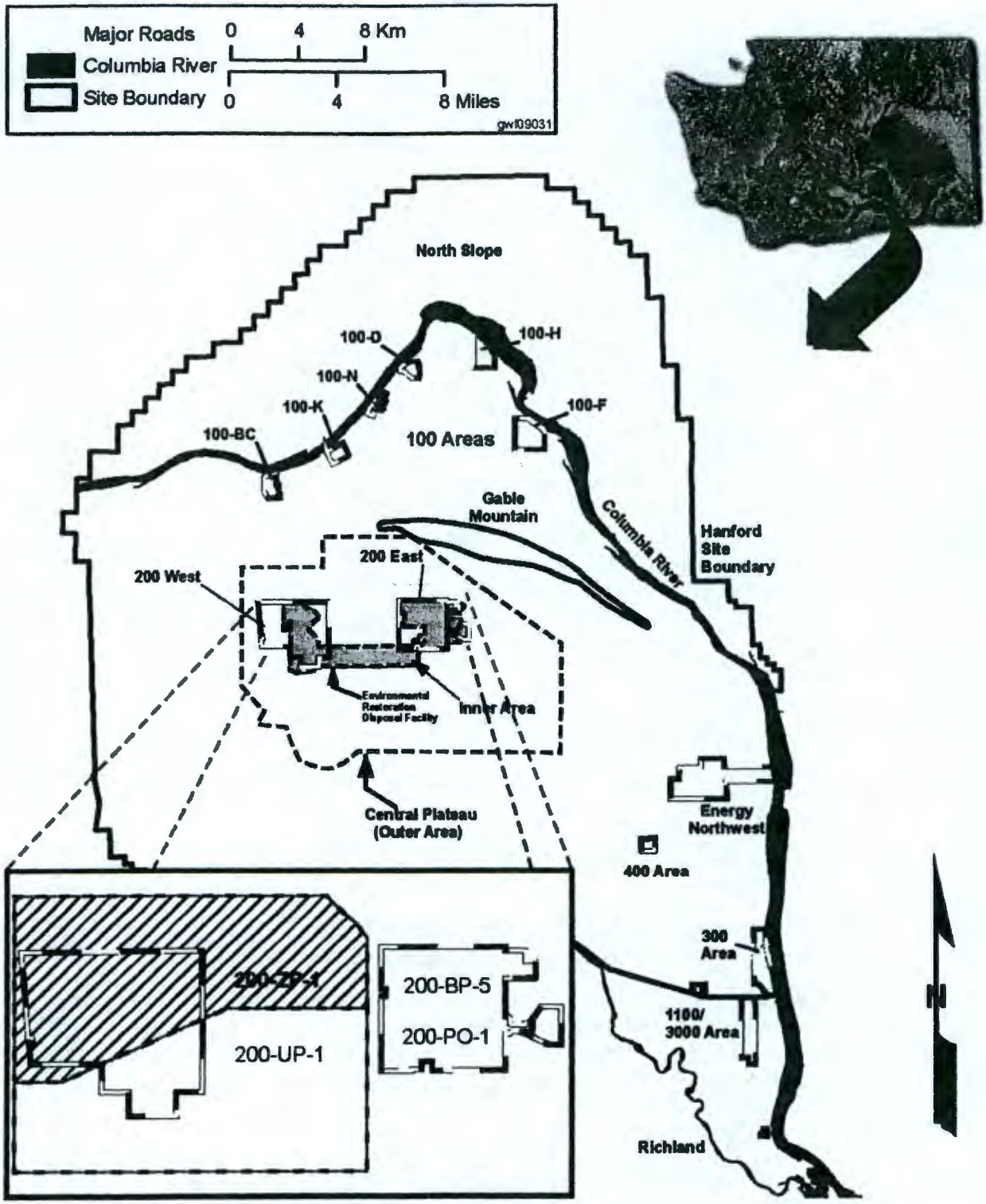

Figure 1-1. Hanford Site Map Showing Central Plateau Groundwater Operable Units

The overarching requirement in the ROD is to meet the groundwater cleanup levels within the 125-year IC period. The remedial actions in the ROD were 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* (SARA), the Tri-Party Agreement, and the 40 CFR 300.

This RDR describes how the site remedy is being designed and installed to meet the RAOs identified in the ROD. This document does not discuss information regarding operations. That information is presented in the *200 West Groundwater Pump-and-Treat Facility Operations and Maintenance Plan, DOE/RL-2009-124* (O&M Plan), and the to-be-prepared *200 West Area Groundwater Systems Operations and Maintenance Manual* (OMM). The selected remedy for the site includes a combination of P&T, MNA, flow-path control, and ICs to address the non-radiological and radionuclide contaminants of concern (COC).

1.1.2 Scope of the Remedial Design Report

This RDR is being submitted to EPA, the lead regulatory agency, in accordance with Section 7.3.9 of the Tri-Party Agreement Action Plan, as modified by Change Request P-11-06-01, which requires that "An RD report will be prepared that includes the designs and schedules for construction of any remediation facility and development of support facilities (lab services, etc.) The RD report shall contain at least a 90 percent design. If less than 90 percent design submission is required by the lead regulatory agency, it will be documented in the RD/RA work plan" (Ecology et al., 1989).

The design presented in this RDR is considered 90 percent complete. Further refinements to the design and the planned implementation will be finalized as the design and construction progress is completed. The project will be constructed within a design/build format. It will not be released as a typical construction project wherein the design is completed to 100 percent and then issued for bidding and construction. DOE is following an engineer /procure/construct (EPC) process and as such the various component drawings will be at different stages of completeness, at any time. When the drawings for specific component parts of the project are incrementally complete, those drawings will be released for construction to the general construction contractor. CHPRC is serving in the role of construction managers/services during construction (CM/SDC). Examples of this, for the initial parts of project are road crossing, pipe laying, and the transfer building drawings, which have been released for construction. The same will be done for the civil and architectural drawings. The structural, mechanical, and electrical drawings will follow. Key components that span across all disciplines are being evaluated for impact as the drawings are released.

Although a majority of this RDR addresses the design of the 200 West Area groundwater P&T system, other remedy components are also described briefly. Institutional controls for the Hanford Site are already in place as described in the *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41).

1.1.3 Contents of the Remedial Design Report

This RDR contains the following:

- Chapter 1, Introduction, presents the purpose and scope of the RDR, provides a summary of the site description and background, and an overview of the RDR document revision process.
- Chapter 2, Remedial Design, provides a summary of the selected remedy, overview of the treatment process description, basis of design, and materials for construction of major components and unit processes of the 200 West Area groundwater P&T system.

- Chapter 3, Construction Schedule, provides a summary of the major milestones for construction of the 200 West Area groundwater P&T system.
- Chapter 4, Cost Estimate, describes the major cost components that have been estimated for construction of the 200 West Area groundwater P&T system and provides an overview of the methods of estimating, basis of estimate, accuracy level, quality assurance, quality control, and limitations of use of the construction cost estimate.
- Chapter 5, References, lists the references cited in this document.

Key design documents constituting the detailed information needed for construction of the selected remedy were developed and presented to EPA in briefing presentations at design development stages of 30 percent, 60 percent and 90 percent. In association with the 90 percent design briefing conducted February 17, 2010, the 90 percent design documents were provided to EPA as follows:

- Volume 1: Basis of Design Report
- Volume 2: Specifications
- Volume 3: Specifications
- Volume 4: Facility Design Drawings
- Volume 5: Balance of Plant Design Drawings

The Basis of Design Report, provided in Volume 1, presents key design assumptions and criteria for each major unit process and system component (e.g., biological treatment system, radiological treatment system, air stripper) along with applicable design codes and standards. Volumes 2 and 3 provide the technical engineering specifications that dictate material, product, and equipment requirements, installer qualifications, submittal requirements, and execution requirements. Volume 4 provides design drawings (e.g., site plans, elevations, cross-sections, process flow diagrams, panel schedules) for the treatment facilities. Volume 5 provides similar design drawings for the Balance of Plant.

1.2 Site Description and Background

The 200-ZP-1 OU includes several groundwater contamination plumes that cover an area of approximately 10 km^2 (4 mi^2) beneath part of the 200 West Area. The 200 West Area is approximately 8 km^2 (3 mi^2) and is located near the middle of the Hanford Site. It is about 8 km (5 mi) south of the Columbia River and 4.5 km (2.8 mi) from the nearest Hanford Site boundary (SR 240). The 200 West Area is located on an elevated flat area that is often referred to as the Central Plateau, and there are no wetlands, perennial streams, or floodplains.

The following subsections briefly describe the site setting, nature, and extent of contamination within the 200-ZP-1 OU; ongoing 200 West Area interim remedial actions; and groundwater monitoring. More detailed information describing the Hanford Site, the 200 West Area, and the 200-ZP-1 OU is contained in the remedial investigation (RI) report (DOE/RL-2006-24), the *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-28), and the ROD (EPA et al., 2008).

1.2.1 Physical Setting

The Hanford Site lies in a sediment-filled basin on the Columbia Plateau in southeastern Washington (Figure 1-1). The Central Plateau is a relatively flat, prominent terrace near the center of the Site. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, which is on the western end of the Central Plateau.

Basalt of the Columbia River Basalt Group and a sequence of overlying sediments comprise the local geology. The overlying sediments are approximately 169 m (555 ft) thick and primarily consist of the Ringold Formation and Hanford Formation, which are composed of sand and gravel with some silt layers. Surface elevations range from approximately 200 to 217 m (660 to 712 ft).

The sediment thickness in the 200 West Area above the water table (the vadose zone) ranges from 40 to 75 m (132 to 246 ft). Sediments in the vadose zone are the Ringold Formation (the uppermost Ringold Unit E and the Upper Ringold Unit), the Cold Creek unit, and the Hanford Formation. Estimates of recharge from precipitation at the Hanford Site range from 0 to 10 cm/yr (0 to 4 in./yr); artificial recharge historically occurred when effluents (e.g., cooling water and process wastewater) were disposed to the ground during the 1940s through the 1990s. Artificial recharge that continues today in the Central Plateau consists of limited onsite sanitary sewage treatment and disposal systems; leaks from potable and raw water lines; two state-approved land disposal structures; and small-volume, uncontaminated, miscellaneous waste streams.

Groundwater beneath the Hanford Site is found in an upper primarily unconfined aquifer system and in deeper confined aquifers within the basalt. The Columbia River is the primary discharge area for both the unconfined and confined aquifer. The unconfined aquifer in the 200-ZP-1 OU of the Central Plateau occurs in the Ringold Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where it is lower (the Columbia River). In general, groundwater flow through the Central Plateau occurs in a predominantly easterly direction from the 200 West Area to the 200 East Area. Historical discharges to the ground greatly altered the groundwater flow regime, especially around the 216-U-10 Pond in the 200 West Area and the 216-B-3 Pond in the 200 East Area, which deflected the water flow to the north. As drainage from these discharges has ceased, the water flow direction is expected to again flow on a more easterly course through the Central Plateau.

The depth to the water table in the 200 West Area varies from about 50 m (164 ft) in the southwest corner near the former 216-U-10 Pond to greater than100 m (328 ft) in the north. The groundwater flow is primarily to the east, except in the northern portion of the 200 West Area where the flow is to the east-northeast. Groundwater flow is locally influenced by the 200-ZP-1 OU interim remedial measure (IRM) P&T system and permitted effluent discharges at the State-Approved Land Disposal Site.
The groundwater flow rates typically range from 0.0001 to 0.5 m/day (0.00033 to 1.64 ft/day) across the 200-ZP-1 OU; however, the water table continues to decline at a rate of approximately 0.21 m/yr (0.69 ft/yr) since the large influx of artificial recharge has ceased.

1.2.2 Nature and Extent of Contamination

In the 200-ZP-1 OU, the COCs identified are carbon tetrachloride, total chromium (trivalent [III] and hexavalent [VI]), nitrate, trichloroethylene, iodine-129, technetium-99 and tritium. The 200-ZP-1 OU has been well characterized over the years by well drilling and groundwater sampling. There are currently over 100 monitoring wells within the footprint of the 200-ZP-1 OU.

The primary cribs and trenches that contributed contaminants to the 200-ZP-1 OU groundwater through discharges from 1945 to the early 1970s included the 216-Z-1A Trench, 216-Z-9 Crib, 216-Z-18 Trench, 216-Z-19 Ditch, 216-Z-20 Crib, and 216-U-10 Crib. After effluents were discharged to these vadose zone disposal sites, more mobile contaminants migrated to the groundwater. Less mobile contaminants remain in the vadose zone and will be addressed in the source OU or other OU remedies. Data collected indicate that there is no carbon tetrachloride dense nonaqueous phase liquid (DNAPL) source term(s) in the 200-ZP-1 OU groundwater, which is documented in the *Carbon Tetrachloride Dense Non-Aqueous Phase*

Liquid (DNAPL) Source-Term Interim Characterization Report (DOE/RL-2006-58) and its addendum (DOE/RL-2007-22).

As stated in the 200-ZP-1 OU ROD, contaminant distributions within the 200-ZP-1 OU can be represented by three categories, as follows:

1. A high-concentration zone close to the ponds, cribs, and trenches that were used to dispose the liquid wastes. Data do not indicate the presence of significant DNAPL in groundwater acting as a continuing source.

2. A larger, dispersed or low-concentration zone that has migrated from the discharge locations or overlies the high-concentration zone. This less contaminated groundwater can occur above the high-concentration zone where large quantities of lower concentration effluent were discharged during or after the high-concentration waste discharges.

3. An area of technetium-99 contamination occurs near Waste Management Area (WMA) T and WMA TX/TY. The results from depth-discrete groundwater sampling in the newly installed wells in these areas show that the peak concentration of technetium-99 is typically found within the upper 15 m (50 ft) of the aquifer. These results will be considered in the final design and implementation of the remedy for the 200-ZP-1 OU groundwater.

Groundwater contamination is present from the top to the base of the unconfined aquifer, which is approximately 61 m (200 ft) thick. Distribution maps from data collected at the water table (2009 Annual Groundwater Report data set) that present the contaminants that exceed the maximum contaminant levels (MCLs) in the 200-West (ZP-1 OU and UP-1 OU) groundwater are presented Figures 1-2 through 1-8. The 200-ZP-1 Feasibility Study (DOE/RL-2007-28) includes depth specific maps presenting the vertical plume geometry contamination conditions. For scaling purposes, the extent of carbon tetrachloride contamination in the 200-ZP-1 OU encompasses an area of approximately 10 km^2 (4 mi^2).

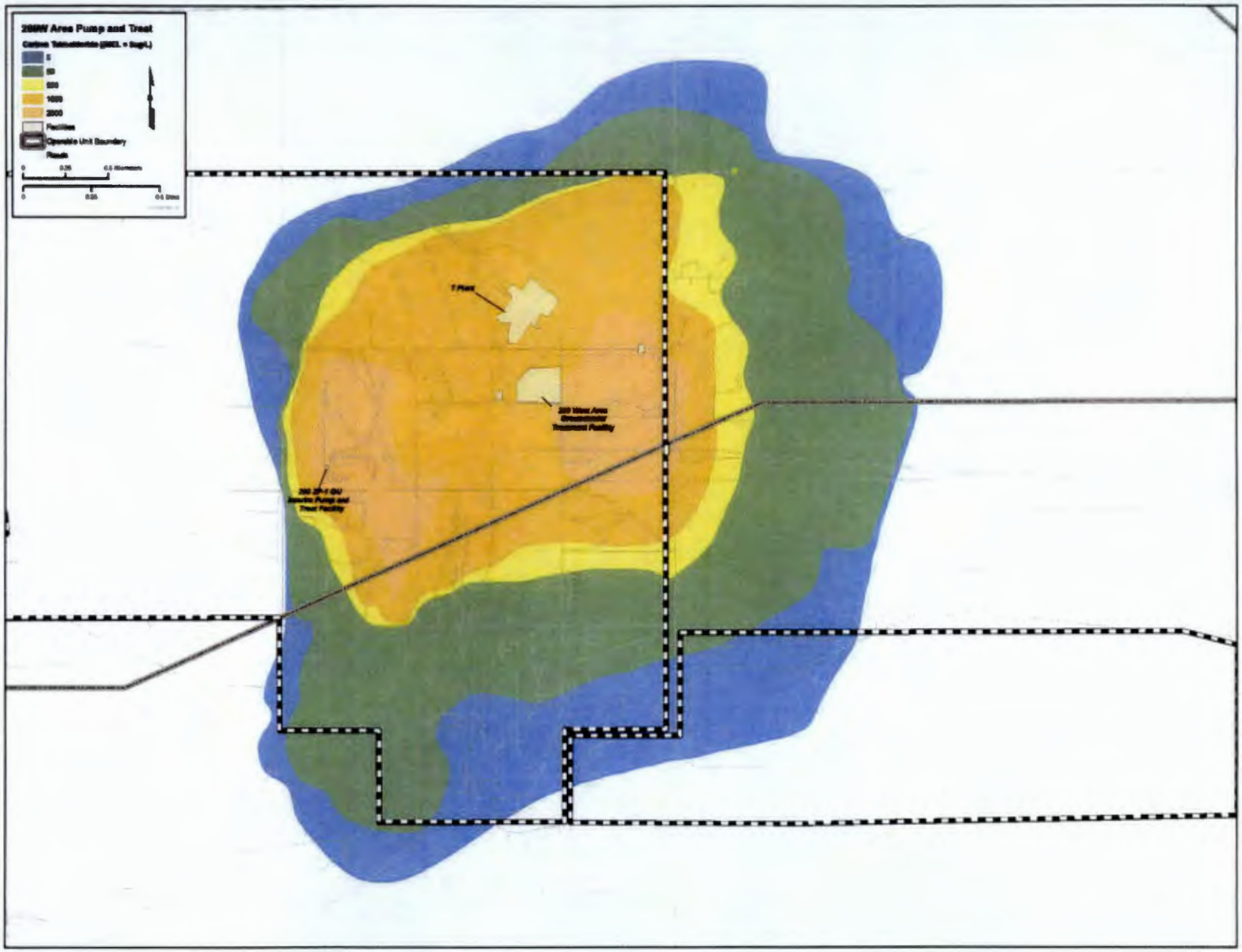

Figure 1-2. Estimated Lateral Extent of Carbon Tetrachloride

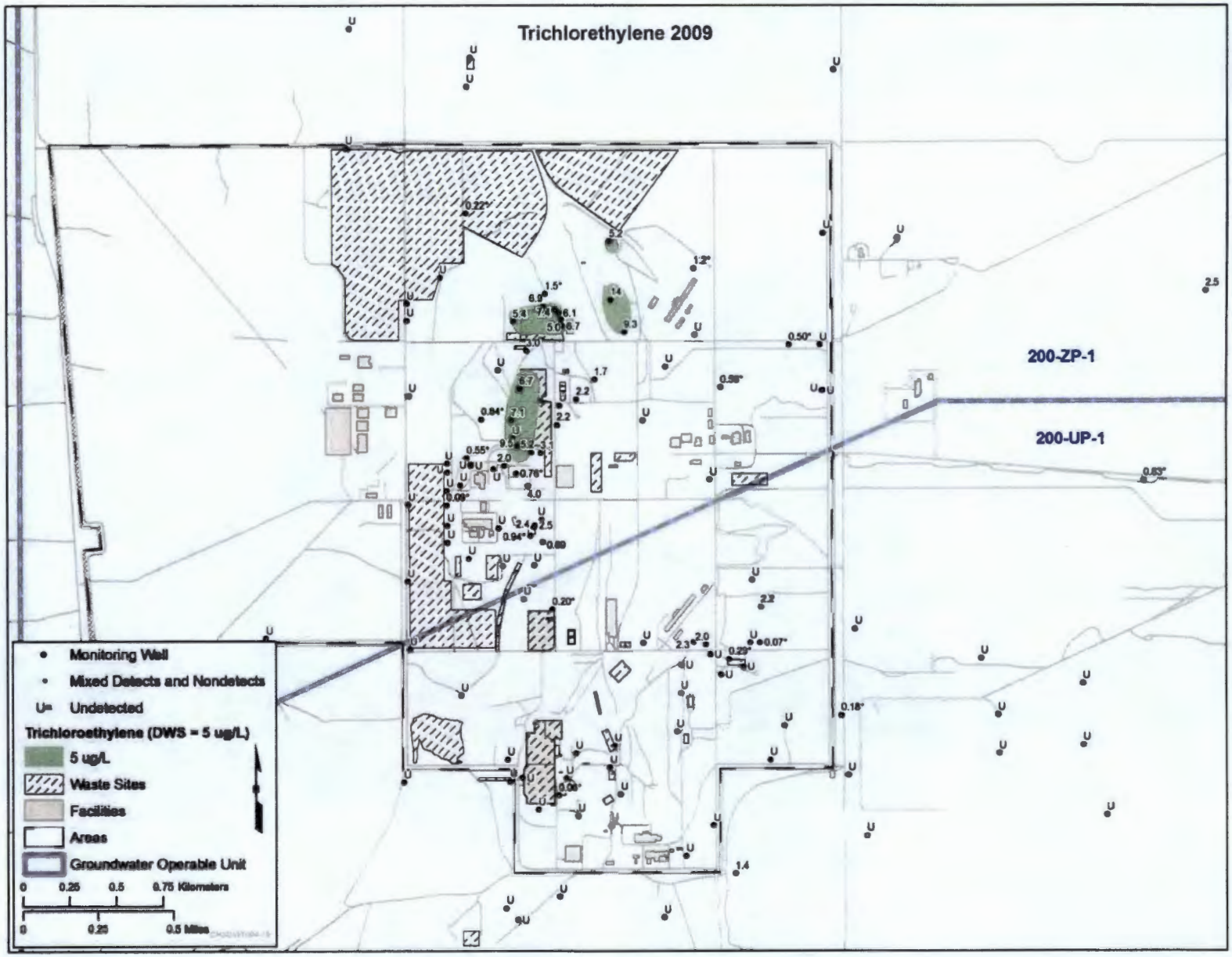

Figure 1-3. Estimated Lateral Extent of Trichloroethylene

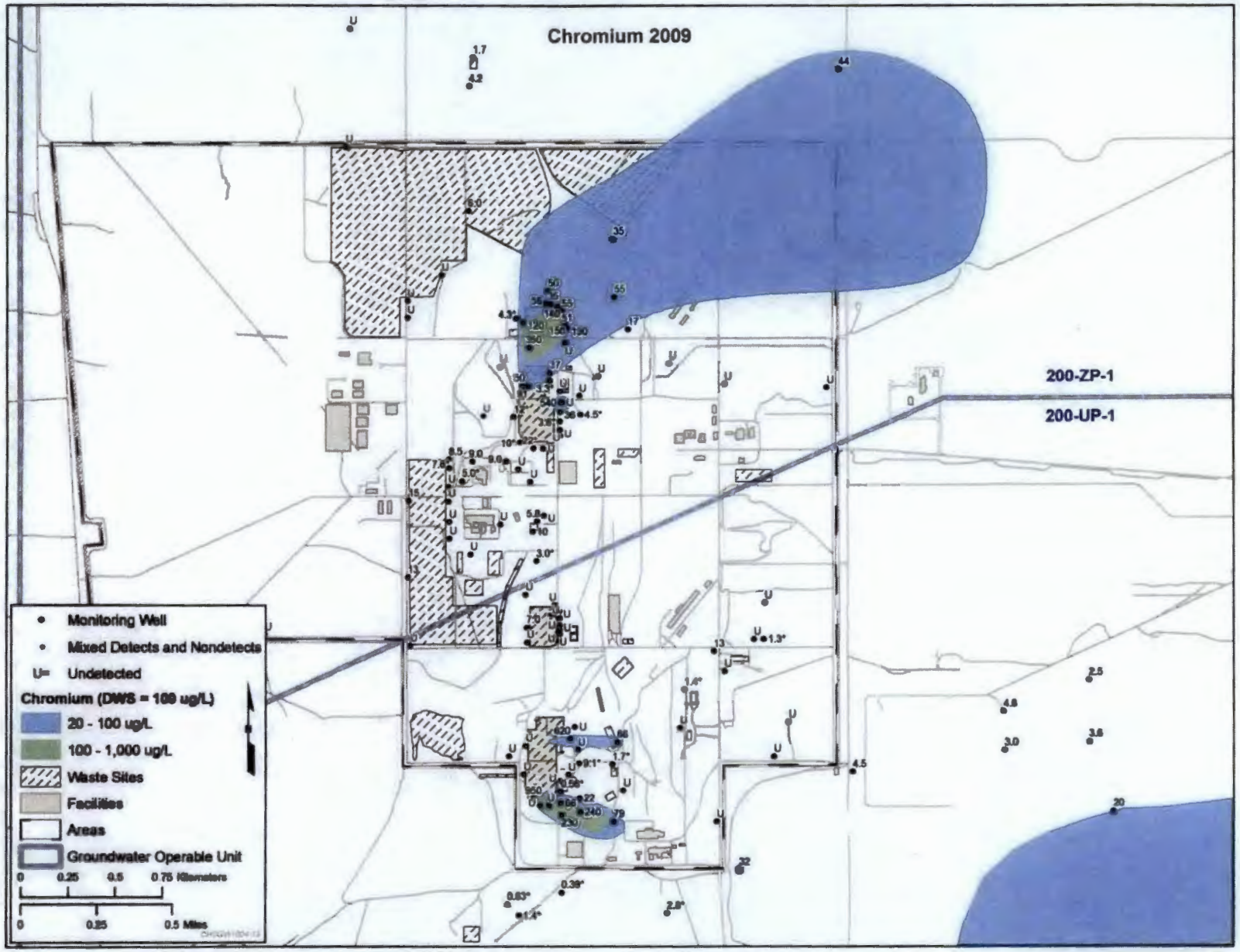

Figure 1-4. Estimated Lateral Extent of Chromium (Total) in Groundwater

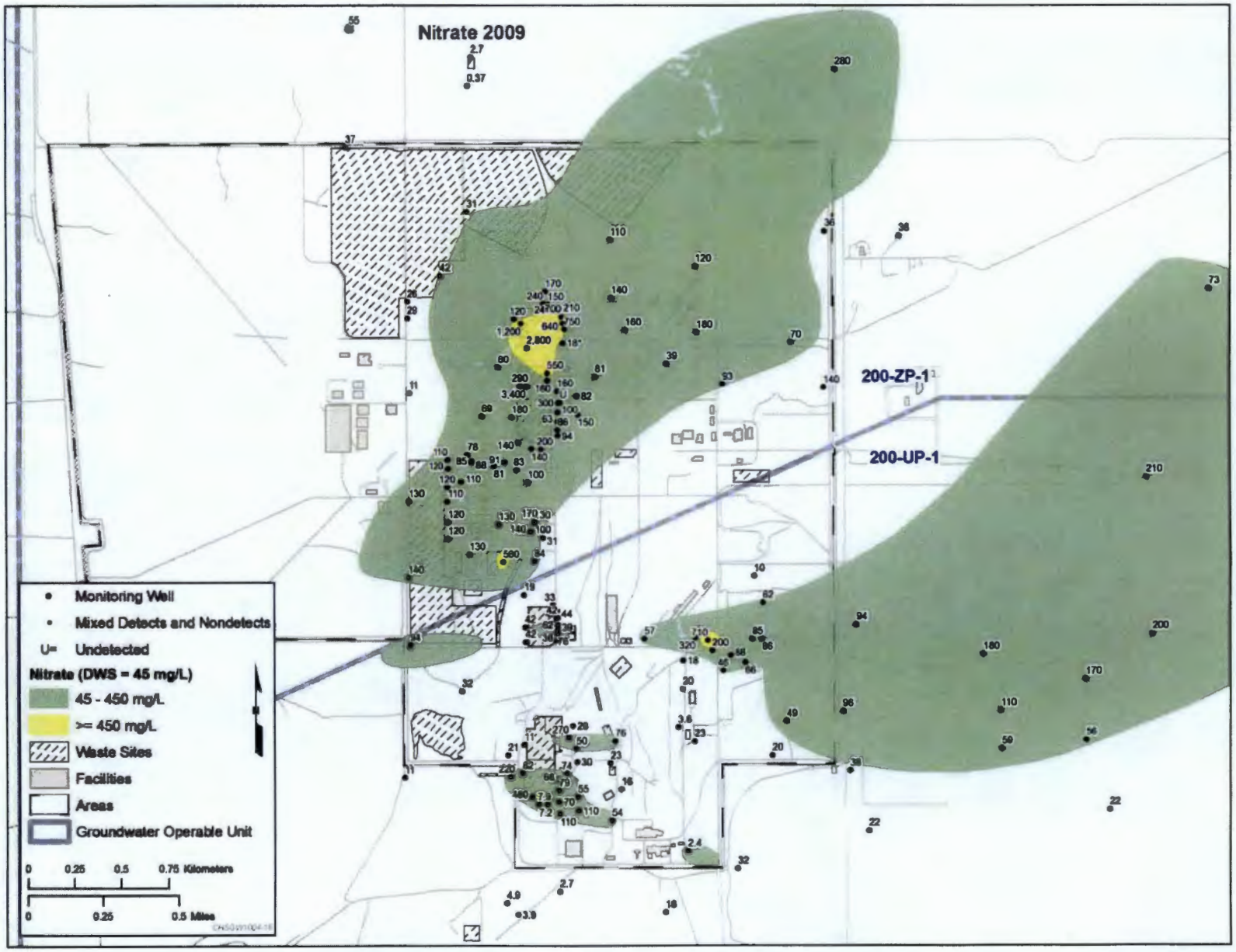

Figure 1-5. Estimated Lateral Extent of Nitrate in Groundwater

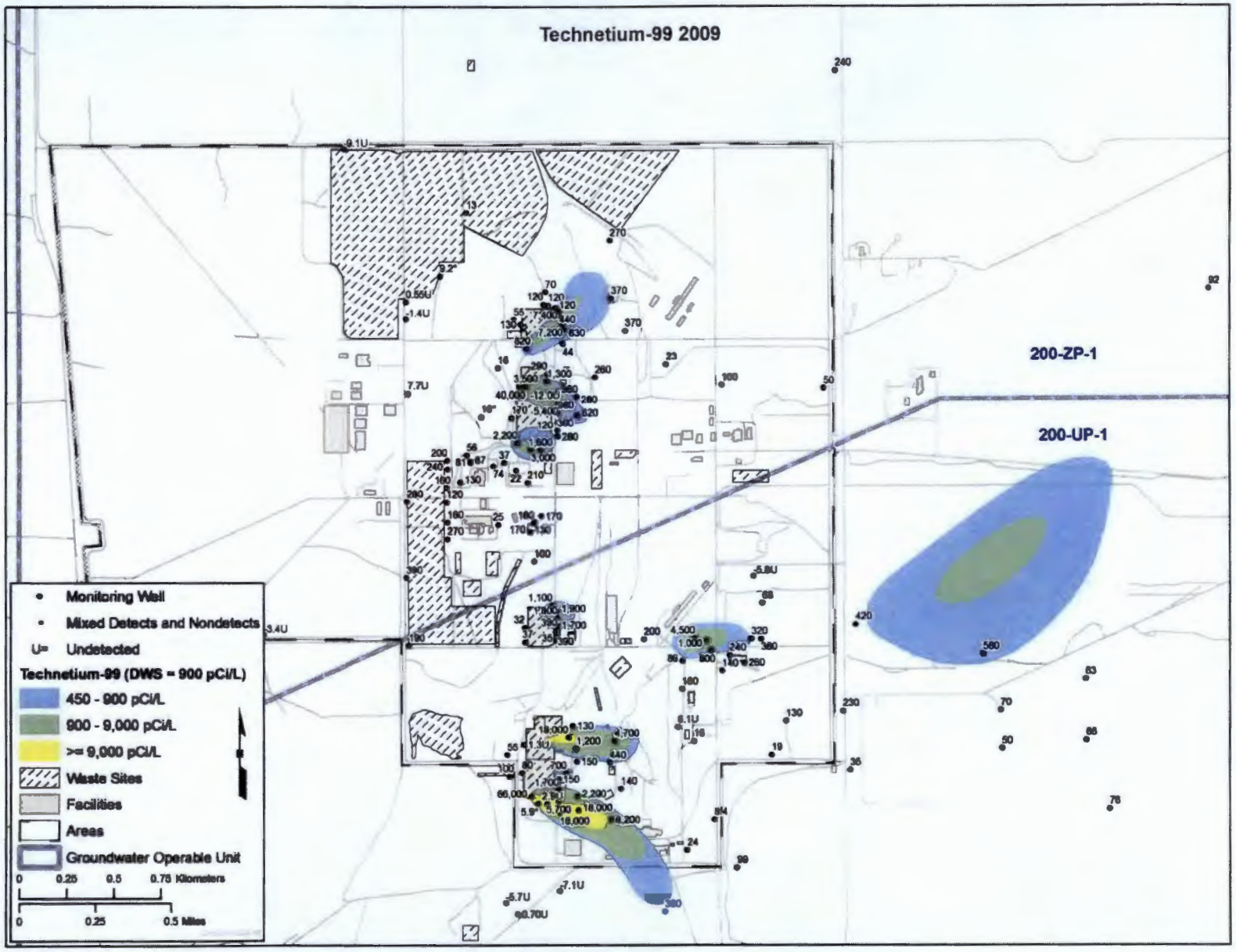

Figure 1-6. Estimated Lateral Extent of Technetium-99

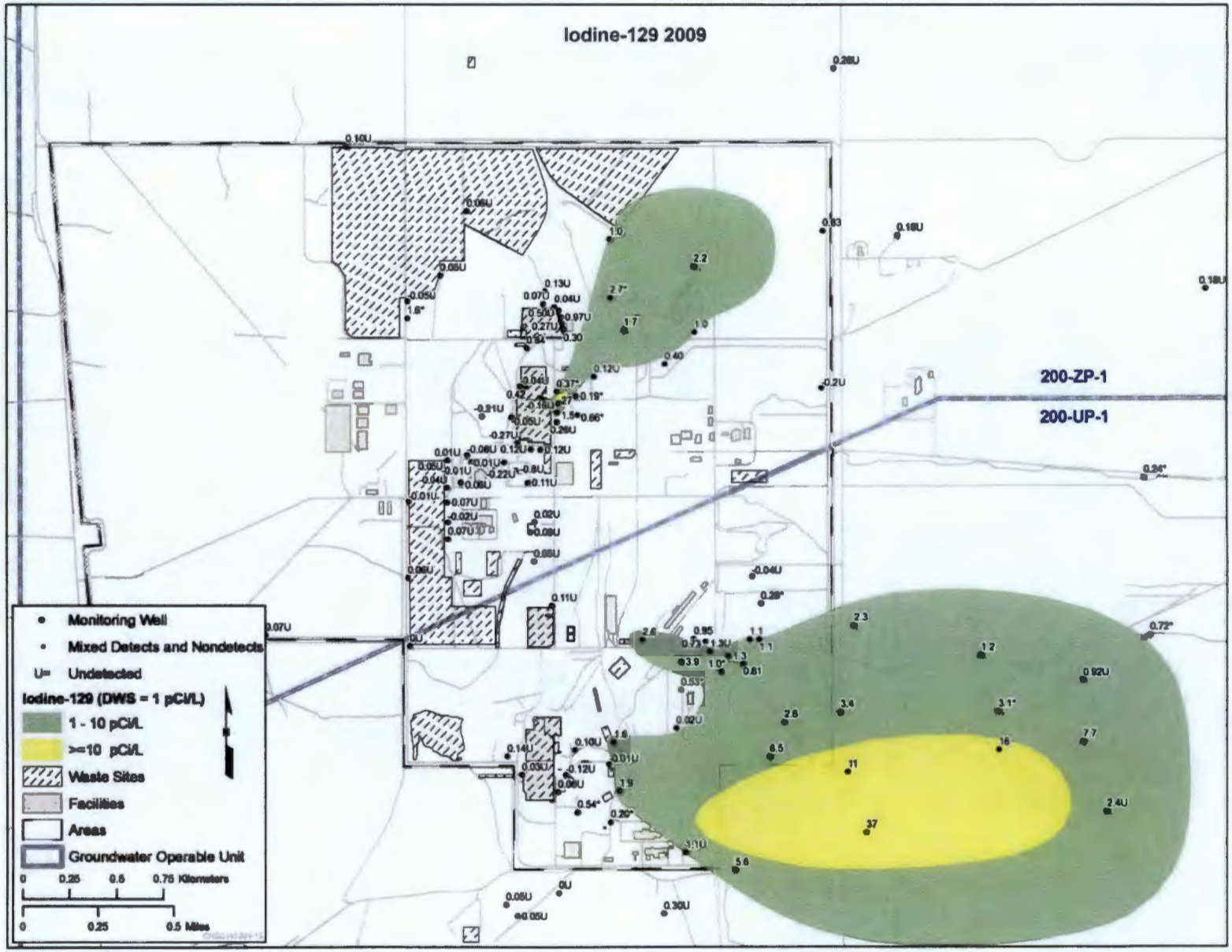

Figure 1-7. Estimated Lateral Extent of Iodine-129 in Groundwater

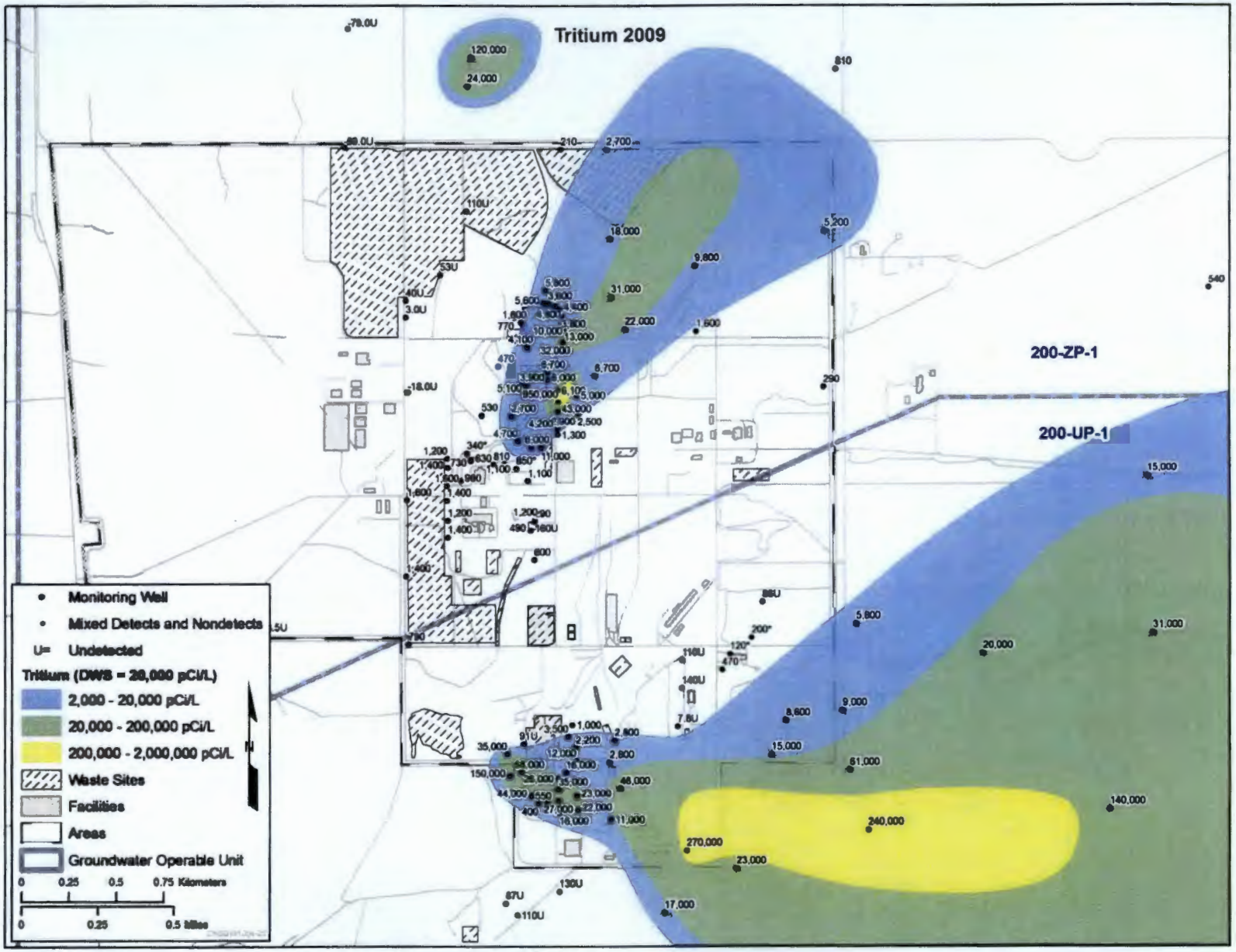

Figure 1-8. Estimated Lateral Extent of Tritium in Groundwater

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1.2.3 200-ZP-1 Operable Unit Interim Remedial Measure

The DOE currently operates an IRM P&T system to minimize further migration of carbon tetrachloride, chloroform, and trichloroethylene in the 200 West Area groundwater in accordance with the *Record of Decision for the USDOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure* (EPA/ROD/R10-95/114). This system has been in operation since 1994, extracting more than 4 billion liters (L) (1,057 million gal) of groundwater, removing greater than 11,415 kg (25,165 lb) of carbon tetrachloride. Additional information on the IRM is provided in the 200-ZP-1 proposed plan (DOE/RL-2007-33) and the Feasibility Study (DOE/RL-2007-28).

During IRM P&T system operations, carbon tetrachloride concentrations have decreased in the original target area (defined as the concentration within the 2,000 to 3,000 µg/L contour). The IRM P&T system was expanded by adding additional extraction wells between FY 2005 (FY05) and FY08. The IRM P&T system currently includes 14 extraction wells and 5 injection wells (Figure 1-9).

The response action addressed by the 200-ZP-1 OU ROD will implement the final components of the P&T RA for the 200-ZP-1 OU. The IRM will continue to operate until such time that the new P&T system is operational. Once the new system is operational, the IRM extraction and injection wells may be used to augment contaminant recovery and flow path control, respectively.

1.2.4 200-PW-1 Operable Unit Interim Remedial Measure

Soil vapor extraction (SVE) was initiated in 1992 as a CERCLA interim RA to remove carbon tetrachloride from the vadose zone in the 200 West Area. The objective of the IRM, as stated in the *Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume* (Smith and Stanley, 1992), is to mitigate the threat to site workers, public health, and the environment caused by the migration of carbon tetrachloride vapors through the soil column and into the groundwater.

The SVE system has been in operation at the three primary disposal sites that received liquid wastes containing carbon tetrachloride. The SVE system extracts contaminated soil vapor through wells that are screened in the vadose zone. The contaminated vapor is treated using aboveground canisters containing granular activated carbon (GAC), which adsorbs the carbon tetrachloride from the vapor. Between April 1991 (when the pilot test was conducted) and September 2008, the total mass of carbon tetrachloride removed from all sites was 79,400 kg (175,047 lb). Two new SVE units began operation in the spring of 2009.

1.2.5 Groundwater Monitoring at 200-ZP-1 Operable Unit

The CERCLA groundwater performance monitoring and interim remedial measures at the 200-ZP-1 OU, as required by regulatory agreement, are outlined in the interim Record of Decision (EPA/ROD/R10-95/114), and as implemented in *200-ZP-1 Interim Remedial Measure Remedial Design Report* (DOE/RL-96-07) and the *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE/RL-2002-17).

Groundwater monitoring is performed for two treatment, storage, or disposal units consisting of tank farm WMAs (T and TX-TY), Low-Level Waste Management Area 3 (LLWMA-3), and LLWMA-4. Groundwater at these facilities is monitored under the requirements of the *Resource Conservation and Recovery Act of 1976* (RCRA) for hazardous waste constituents and the requirements of the *Atomic Energy Act of 1954* (AEA) for radionuclides including source, special nuclear, and by-product materials. Data for facility-specific monitoring are also integrated into the CERCLA groundwater investigations.

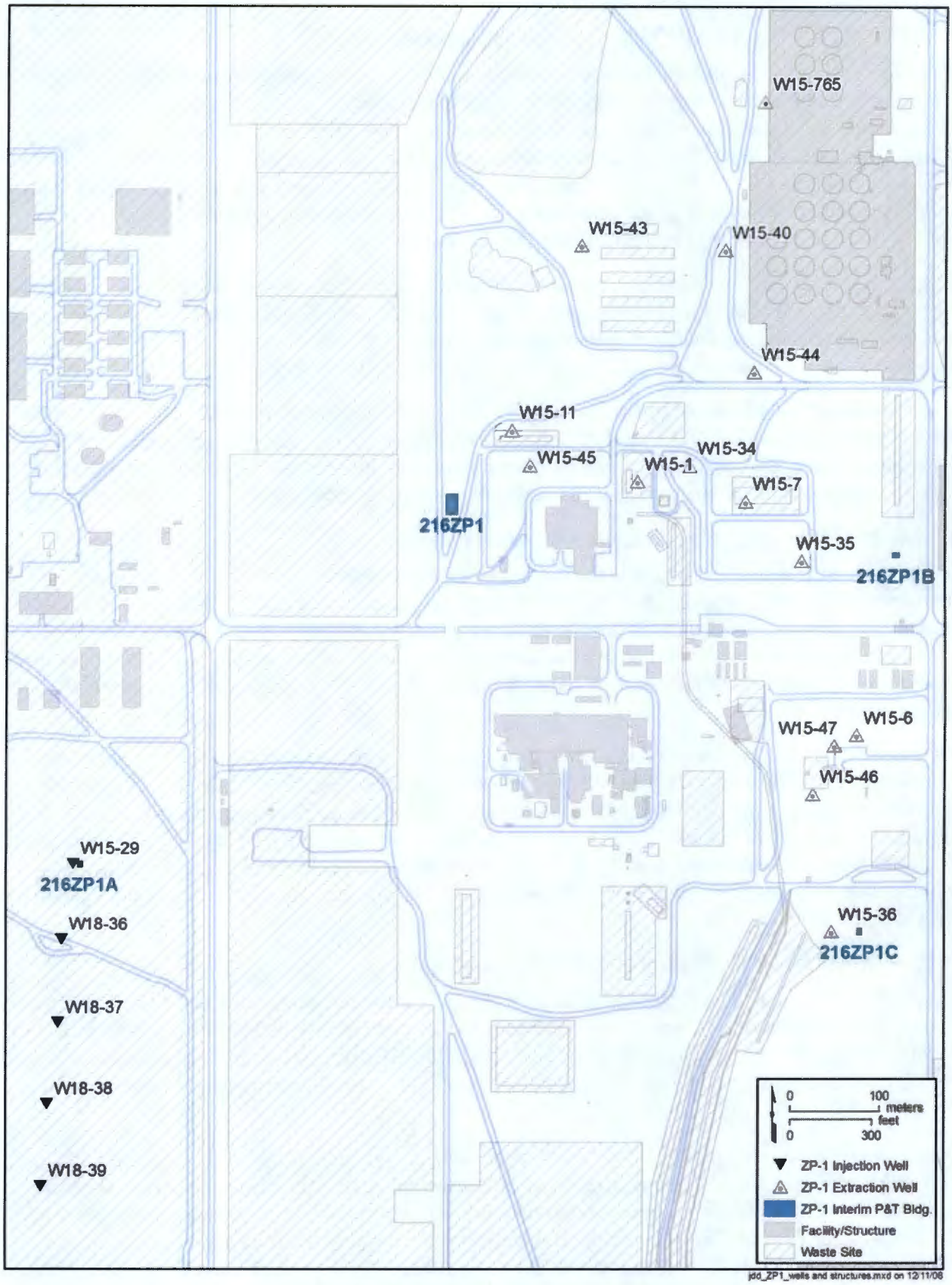

Figure 1-9. 200 West Area Interim P&T System

Groundwater at single-shell tank farm WMA T is monitored under RCRA interim status groundwater quality assessment requirements (40 CFR 265.93[d], "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response," as referenced by *Washington Administrative Code* [WAC] 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards"). The objective for groundwater quality assessment is to assess the extent and rate of movement of dangerous waste in groundwater that has a source from the WMA. Waste constituents found in groundwater near WMA T include chromium, fluoride, carbon tetrachloride and nitrate. Radioactive constituents include tritium and technetium-99.

Groundwater at single-shell tank farm WMA TX-TY is also monitored under interim status groundwater quality assessment requirements (40 CFR 265.93[d], as referenced by WAC 173-303-400). Waste constituents found in groundwater near WMA TX-TY are chromium, carbon tetrachloride and nitrate. Radioactive constituents include iodine-129, tritium, and technetium-99.

Groundwater at LLWMA-3 and LLWMA-4 is monitored under RCRA interim status indicator evaluation requirements (40 CFR 265.93[b], as referenced by WAC 173-303-400), and the radioactive waste management requirements of the AEA (DOE O 435.1, *Radioactive Waste Management*). Monitoring for RCRA is conducted to determine if the unit has impacted groundwater with dangerous constituents. Samples are collected for RCRA indicator and site-specific parameters. Monitoring for AEA is conducted to determine if the unit has impacted groundwater with radioactive constituents.

1.3 Document Revision Process

The RDR is based on information representing the 90 percent remedial design. As such, additional design development and changing site conditions discovered during construction may necessitate modifications to the information presented herein. Guidelines for revision of the RDR are presented below.

1.3.1 Project Team Roles, Expectations, and Limitations

The term "project team" includes the individuals working to accomplish the remedial action. Accordingly, the project team includes the U.S. Department of Energy, Richland Operations Office (RL); the lead regulatory agency (EPA); the remediation manager, and the site project manager, both contractors of DOE.

- **Lead Regulatory Agency (EPA)** – The EPA is the lead regulatory agency for the CERCLA remediation activities at the site, as described in the Tri-Party Agreement. 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 Tri-Party Agreement primary documents (e.g., this RDR, and the operations and maintenance [O&M] plan [DOE/RL-2009-124]).

- **Remedial Project Manager (DOE)** – The DOE is the government agency 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. A remedial project manager is responsible for managing the assigned activities, which include scope, budget, schedule, quality, personnel, communication, risk/safety, contracts, and regulatory interface.

- **Remediation Manager** – The CHPRC or RL remediation managers provide oversight for all activities and coordinates with RL, the regulators, and primary contractor management in support of remediation activities. Oversight and support is provided to the site project manager to ensure that work is performed safely and cost effectively.

- **Site Project Manager** – The CHPRC site 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 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 DOE, the regulators, and remediation and environmental managers on all remediation activities.

- **Environmental Manager** – The CHPRC environmental manager provides environmental oversight for document preparation as well as field activities. In addition, the environmental manager supports both the remediation manager and site project manager to ensure work is performed in accordance with environmental requirements. The environmental manager coordinates with DOE and the regulatory agencies in support of remediation activities.

1.3.2 Remedial Design Report Components

This RDR includes the following components, which were provided to EPA during the 90-percent design review briefing:

- A design analysis (basis of design), which delineates the criteria and standards for the project. These include horizontal and vertical extents of contamination, the area (*location*), and media (*soil, water, etc.*) containing constituents known to exceed cleanup standards

- A set of engineering specifications that describe the level of effort necessary to implement the design (not supplied at EPA request)

- Design drawings that show the areas of remediation and existing site features to be considered while implementing the remedial action (not supplied at EPA request)

- A general remedial action project schedule

- A construction cost estimate

The above remedial design elements will be revised and updated in accordance with the change management procedures outlined below.

1.3.3 Change Management

The following three types of changes in the remedial actions could affect compliance with the requirements in the ROD:

- A **fundamental change** is a change that does not meet the requirements set forth in the ROD or that incorporates remedial activities not defined in the scope of the ROD.

- A **significant change** generally involves a change to a component of a remedy that does not fundamentally alter the overall cleanup approach. Significant changes will be addressed in an explanation of significant difference.

- A **minor change** is one that will not have a significant impact on the scope, performance, or cost of the remedy. These minor changes should be documented in the appropriate post-decision project file (for example, through interoffice memoranda or logbooks). A minor (non-significant) change will not

impact the requirements of the ROD, nor will they impact the functional requirements and as such will not require modification to this document.

Determining the significance of the change is the responsibility of DOE and the lead regulatory agency. The remediation or environmental manager is responsible for tracking all changes and obtaining appropriate reviews by contractor staff who will discuss the change with DOE, and DOE will then discuss the type of change that is necessary with the lead regulatory agency up to and including the Tri-Party Agreement Action Plan, Section 9.3 and 12.0 changes. Appropriate documentation will follow, in accordance with the requirements for that type of change.

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2 Remedial Design

This chapter and subsections present a summary of the overall project, the regulatory basis and the designed groundwater P&T system being used for remedy implementation.

2.1 Summary of Selected Remedy

The 200-ZP-1 Groundwater OU is one of four groundwater OUs located on the Central Plateau. Each groundwater OU has its own plan of study and enforceable schedule and will eventually have its own ROD and cleanup action, as needed. The selected remedy for the 200-ZP-1 Groundwater OU combines groundwater P&T, MNA, flow path control, and ICs.

The following RAOs are specified in the ROD for the 200-ZP-1 Groundwater OU and are incorporated into the design of the P&T system:

- RAO No. 1: Return 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve domestic drinking water levels) by achieving the cleanup levels (provided in the ROD [EPA et al., 2008], Table 11). This objective is to be achieved within the entire 200-ZP-1 OU groundwater plumes. The estimated timeframe to achieve cleanup levels is within 150 years.[1]
- RAO No. 2: Apply ICs to prevent the use of groundwater until the cleanup levels (provided in the ROD, Table 11) have been achieved. Within the entire OU groundwater plumes, ICs must be maintained and enforced until the cleanup levels are achieved, which is estimated to be within 150 years.[1]
- RAO No. 3: Protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by contaminants originating from the 200-ZP-1 OU. This final objective is applicable to the entire 200-ZP-1 OU groundwater plume. Protection of the Columbia River from impacts caused by 200-ZP-1 OU contaminants must last until the cleanup levels are achieved, which is estimated to be within 150 years.[1]

The final cleanup levels for 200-ZP-1 OU groundwater COCs, following implementation of the selected remedy, are identified in the ROD and listed in Table 2-1 of this report. The cleanup levels were developed using federal drinking water MCLs; the criteria and equations provided in the WAC 173-340-720(4)(b)(iii)(A) and (B), "Model Toxics Control Act–Cleanup," "Ground Water Cleanup Standards," "Method B Cleanup Levels for Potable Ground Water," "Standard Method B Potable Ground Water Cleanup Levels," "Human Health Protection," "Noncarcinogens," and "Carcinogens," and WAC 173-340-720(7)(b), "Adjustments to Cleanup Levels," "Adjustments to Applicable State and Federal Laws," and the federal and drinking water standards for radionuclides.

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[1] The RAOs identify the estimated timeframe to achieve cleanup levels as 150 years. Further requirements in EPA et al., 2008 identify this timeframe as 125 years, which is more conservative than the RAO.

Table 2-1. Final Cleanup Levels for the 200-ZP-1 Groundwater Operable Unit

COC	Units	Final Cleanup Level	Cleanup Level Basis
Carbon tetrachloride	µg/L	3.4[c, d]	MTCA – Method B
Chromium (total)	µg/L	100	Federal/State MCL
Hexavalent chromium	µg/L	48[a]	MTCA – Method B
Nitrate-Nitrogen	µg/L	10,000[b]	Federal/State MCL
Trichloroethylene	µg/L	1[c, d]	MTCA – Method B
Iodine-129	pCi/L	1	Federal MCL
Technetium-99	pCi/L	900	Federal MCL
Tritium	pCi/L	20,000	Federal MCL

a. There is no MCL specific to hexavalent chromium.

b. Nitrate may be expressed as total nitrate (NO_3) or as nitrogen (N). The MCL for nitrate as NO_3 is 45,000 µg/L, and the same concentration expressed as Nitrate-N is 10,000 µg/L.

c. The Model Toxics Control Act Method B cleanup levels for carbon tetrachloride and trichloroethylene are from the Washington State Department of Ecology (Ecology) Cleanup Levels and Risk Calculations (CLARC) table current as of September 25, 2008 (Ecology, 2008).

d. The DOE will clean up COCs for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act--Cleanup" (carbon tetrachloride and trichloroethylene), so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

COC = contaminant of concern

MCL = maximum contaminant level

MTCA = Model Toxics Control Act

2.1.1 Remedy Description

The selected remedy for the 200-ZP-1 Groundwater OU is designed to meet the objective of achieving cleanup levels for COCs in the 200-ZP-1 OU in 125 years (Table 2-1). The effectiveness of the P&T system will diminish over time as COC concentrations are reduced, whereas the effectiveness of natural attenuation is relatively constant. As a result, natural attenuation will eventually become the dominant mechanism for continued reduction of COC concentrations. The effectiveness of the remedy is further enhanced by controlling the direction and rate of groundwater flow throughout the 200-ZP-1 OU using strategically placed extraction and injection wells for flow path control. The ICs provide protection from exposure to groundwater contamination for both site workers and potential future users of groundwater, at least through the 125 year period to achieve cleanup levels and potentially beyond (see Section 2.1.4.3).

2.1.2 Pump-and-Treat System Description

The new 200 West Area groundwater treatment facility will be located on Beloit Avenue between 22nd and 23rd Streets (south of T-Plant) in the 200 West Area (Figure 2-1). Prior to siting the facility at this location, a biological review of the proposed site was performed. The findings from the review were that no plant or animal species protected under the "Endangered Species Act" (16 USC 35), candidates for such protection, or species listed by the Washington State government as threatened or endangered were observed in the vicinity. The findings, along with some recommendations were documented in PNNL Letter 2009-200-004, *Biological Review of the 200 West Area Groundwater Treatment Facility's Proposed Site*, ECR#2009-200-004.

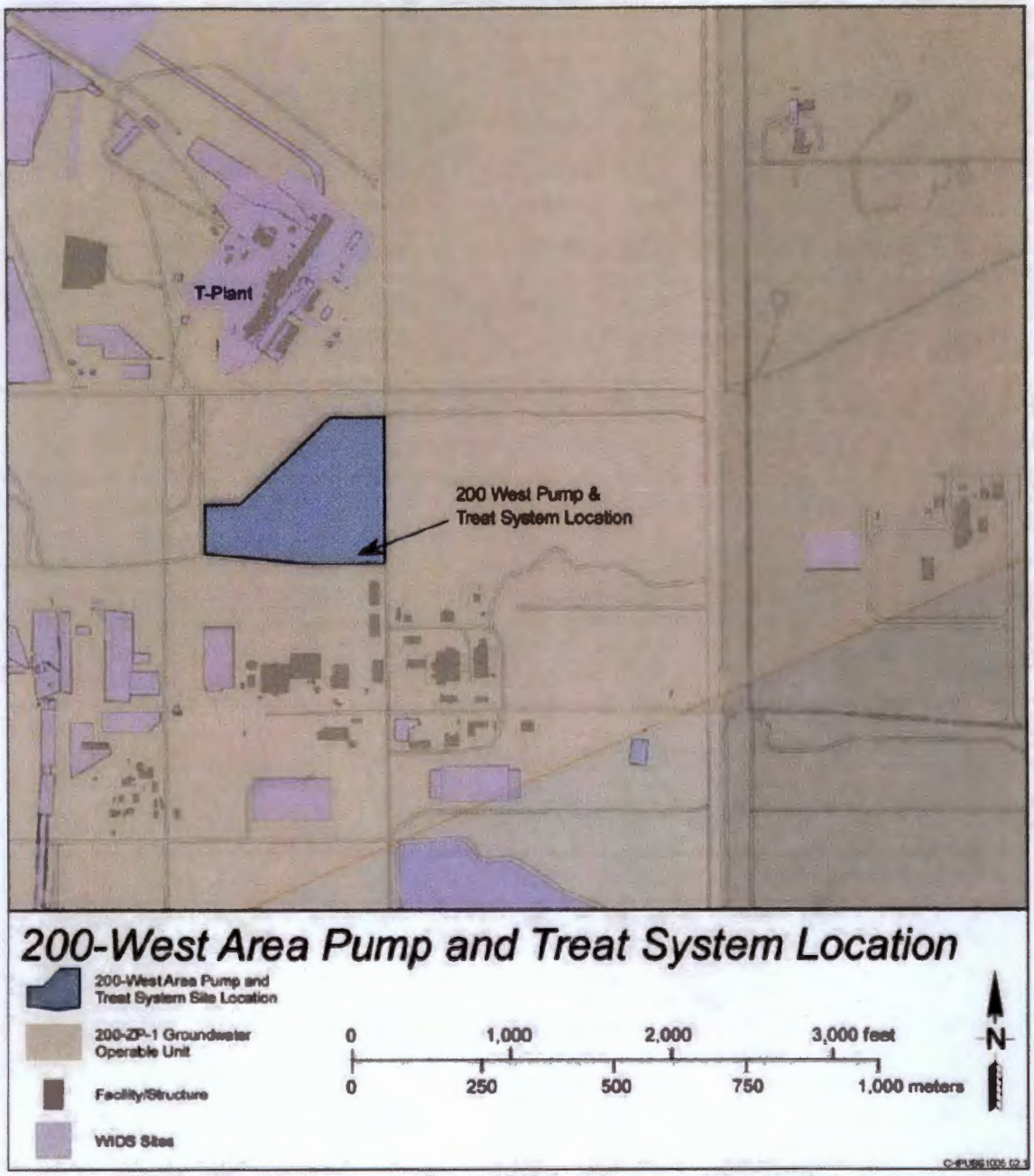

Figure 2-1. 200 West Area Groundwater P&T System Location

This system is designed to capture, treat, and/or manage contaminated groundwater to reduce the mass of COC (carbon tetrachloride, total chromium – trivalent (CrIII) and hexavalent (CrVI), nitrate, trichloroethylene, iodine-129, and technetium-99) throughout the 200-ZP-1 OU. Following treatment, the water is injected back into the aquifer to serve as a recharge source and to promote flow path control (Figure 2-2). The system design also includes provisions for future treatment of groundwater from the 200-UP-1 OU, including removal of uranium.

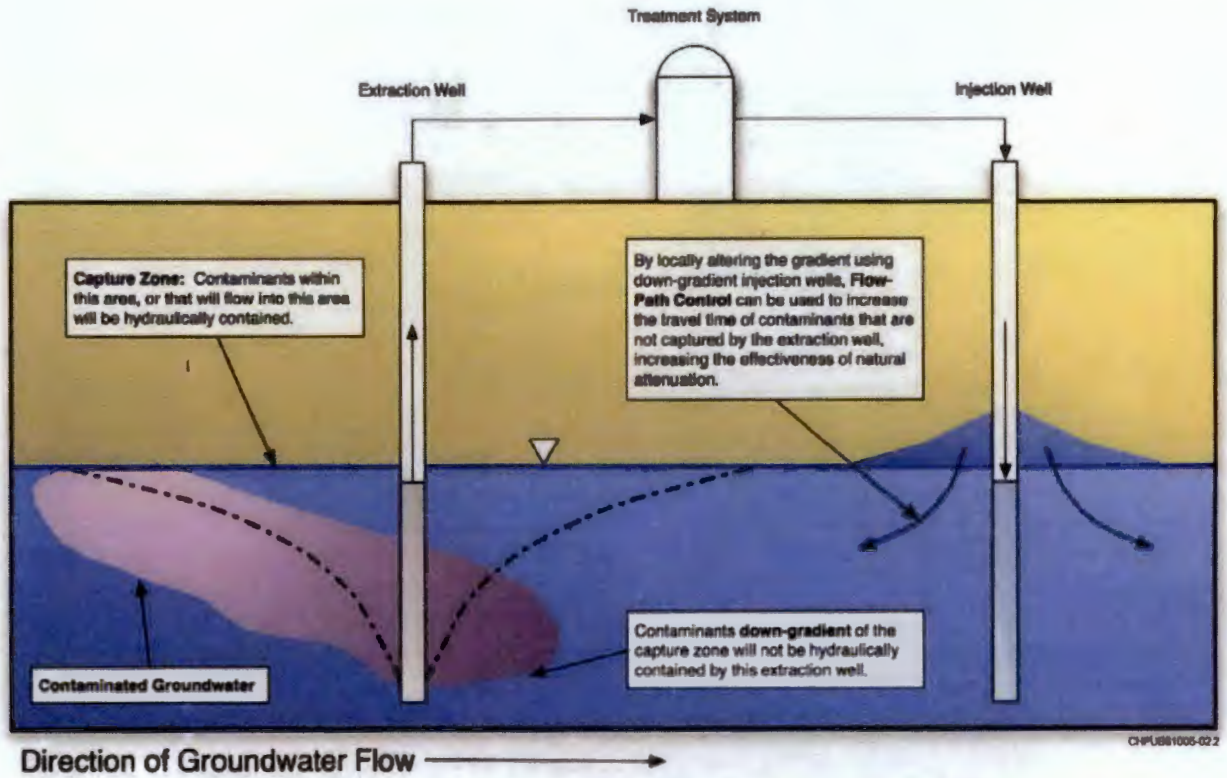

Figure 2-2. Conceptual Summary of the 200 West Area Groundwater P&T System

This RDR presents the overall system design of the 200 West Area groundwater P&T facility. The design is defined as 90 percent complete at this time, but varies in detail and specificity for some component parts of the system based on the EPC delivery model being used. Final decisions are being made and will continue to be made throughout the design/build process regarding the facility configuration. The system is scheduled to be constructed in calendar years 2009 through 2011 (see Chapter 3).

Construction of the treatment facility will provide an initial installed capacity to treat up to 2,500 gallons per minute (gpm) of extracted groundwater (2000 gpm nominal flow rate) utilizing two parallel treatment trains. The initial extraction and injection well network is projected to include 15 extraction wells and 5 injection wells. The number and location of these wells are being finalized and will depend on site-specific conditions.

After full system startup, operations at the existing IRM system may be idled, mothballed, or decommissioned. There are existing injection wells in the IRM system that may be used for injection of treated groundwater from the new 200 West Area groundwater treatment facility.

Upon completion of construction, facility commissioning, and initial startup, the system is projected to operate at approximately 1000 gpm, including an estimated 50 to 100 gpm of groundwater extracted from the 200-UP-1 OU Waste Management Area S-SX. Additional wells will be gradually brought on line over the next several years to utilize additional treatment capacity at the facility.

Design of the facility includes the ability to add a third treatment train (also in parallel) within the existing facility footprint and infrastructure and increasing the maximum design flow rate to 3,750 gpm. The need for additional treatment capacity will be based on the treatment capacity required for the 200-ZP-1 OU groundwater and groundwater that may be extracted as part of the final remedy for the 200-UP-1 OU.

2.1.3 Other Remedy Components

This section describes the additional components of the groundwater remedy that augment the P&T system, including MNA, flow path control and ICs.

2.1.3.1 Monitored Natural Attenuation

In addition to the P&T system, the remedy for the 200-ZP-1 OU includes natural attenuation processes for reducing COC concentrations to the cleanup levels. Natural attenuation will eventually become the dominant mechanism for continued reduction of COC concentrations in the 200-ZP-1 OU as the effectiveness of the P&T system decreases over time. Because there is no viable treatment technology for tritium from the groundwater and the short half-life of tritium will allow natural attenuation to reduce its concentration to meet the cleanup levels.

For the remaining portion of the carbon tetrachloride and nitrate (as well as tritium) not captured by the P&T component, natural attenuation processes will be used to reduce concentrations to the cleanup levels.

Natural attenuation processes, to be relied on as part of this component, includes biotic and abiotic degradation, dispersion, sorption, and (for tritium) natural radioactive decay. Monitoring conducted under the O&M Plan (DOE-RL-2009-124) and *The Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action* (DOE/RL-2009-115) will be used to evaluate the effectiveness of the P&T system and natural attenuation processes. Fate and transport analyses conducted as part of the Feasibility Study (DOE/RL-2007-28) and the *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2009-38) indicate that the timeframe necessary to reduce the remaining COC concentrations to acceptable levels through MNA will be approximately 100 years after the active pumping phase is complete.

2.1.3.2 Flow Path Control

The flow path control component of the 200-ZP-1 Groundwater OU RA consists of injecting treated groundwater into the aquifer to the west and east of the groundwater contaminant plume. Injecting water at these locations contains the contaminant plume and, as a result, keeps the higher concentration areas within the extraction well capture zone while also managing the flow path and related travel time for natural attenuation processes to reduce contaminant concentrations not captured by the extraction wells.

Flow path control is also used to minimize the potential for groundwater in the northern portion of the aquifer to flow northward through Gable Mountain Gap towards the Columbia River. The injection wells are located to redirect groundwater flow to the east, which provides the longest flow path to the river (about 26 km [16 mi]). Monitoring data conducted under the O&M Plan (DOE/RL-2009-124) will be assessed to determine the effectiveness of flow path control.

2.1.3.3 Institutional Controls

The 200-ZP-1 OU ROD requires ICs for 200-ZP-1 groundwater until cleanup levels are met. A description of these controls and their implementation is provided in the *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41). The following specific controls are required by the ROD for the 200-ZP-1 OU:

- No intrusive work shall be allowed in the 200-ZP-1 OU unless the EPA has approved the plan for such work and that plan is followed.
- The DOE shall prohibit well drilling in the 200-ZP-1 OU, except for monitoring, characterization, or remediation wells authorized in EPA-approved documents.

- Groundwater use in the 200-ZP-1 OU is prohibited, except for limited research purposes, monitoring, and treatment authorized in EPA-approved documents. The sitewide IC plan will contain the ICs and implementing details prohibiting well drilling and groundwater use in the 200-ZP-1 OU, as defined in the ROD.

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

- In the event of any unauthorized access to the site (e.g., trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and will consider administrative debarment of the trespasser as well as prosecution in state or federal court as deemed appropriate.

- Activities that would disrupt or lessen the performance of the P&T, MNA, and flow path control components of the remedy are to be prohibited.

- The DOE shall prohibit activities that would damage the P&T, MNA, and flow path control components (e.g., extraction wells, injection wells, piping, treatment plant, and monitoring wells).

- The DOE shall report on the effectiveness of ICs for the 200-ZP-1 OU remedy in an annual report, or on an alternative reporting frequency specified by EPA. Such reporting may be for this OU alone or may be part of a Hanford Site report.

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

- Land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances in groundwater are at such levels to allow for unrestricted use and exposure and EPA authorizes the removal of restrictions.

Most of the land within the 200-ZP-1 OU has been designated by DOE, through the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F), for industrial exclusive use for the foreseeable future. Because it contains facilities, which will have long-term responsibility for disposal or storage of hazardous substances, the possibility that this property could qualify for transfer of title out of the federal government is remote, especially in light of the exacting requirements of CERCLA Section 120(h) for transfers of contaminated federal land. Because the 200 Area was principally withdrawn from the public domain, if the land ever became surplus to the needs of DOE, federal law requires that it be turned over to the Bureau of Land Management. Nevertheless, as a general policy to ensure continuity of ICs that have been selected as part of the remedial actions at the Hanford Site, DOE has made the following commitments to EPA Region 10:

- DOE will provide notice to EPA at least six months prior to transfer or sale of the land within the 200-ZP-1 OU, so EPA can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs.

- If it is not possible for DOE to notify EPA at least six months prior to transfer or sale, then DOE will notify EPA as soon as possible but no later than 60 days prior to the transfer or sale of property subject to ICs.

- In addition to the land transfer notice and discussion provisions above, DOE further agrees to provide EPA with similar notice, within the same timeframes, as to federal-to-federal transfer of property. DOE shall provide a copy of executed deed or transfer assembly to EPA.

2.2 Extraction and Injection Well Field

The following sections provide an overview of the basis of design, groundwater modeling, well installation, and materials of construction for the extraction and injection well field components of the remedy. Figure 2-3 shows the planned layout of the extraction wells, injection wells, and conveyance piping in the 200 West Area. Groundwater conveyance piping and transfer buildings are included as part of the balance of plant design described in Section 2.4.

2.2.1 Basis of Design

Initial extraction and injection well locations were sited using a groundwater flow and contaminant transport model to maximize carbon tetrachloride mass removal by extracting groundwater from portions of the aquifer with the highest concentrations while providing plume containment. Final well locations will be determined based on further optimization of the groundwater flow and contaminant transport modeling during the well installation process and a field walk-down survey of current site conditions.

Wells will be sited to avoid Hanford Site National Historic restrictions, roads, waste sites and other obstructions. Based on initial estimates of aquifer hydraulic properties and anticipated well screen lengths, it is estimated that each of the 20 extraction wells (initially 15 wells for startup) have a pumping capacity of 567 L/min (150 gpm) and are expected to provide a nominal pumping rate of about 108 gpm at design conditions, for a total well field nominal operating rate of about 8,165 L/min (2,160 gpm); however, to meet the ROD specified restoration timeline, actual extraction well yields are expected to be different and will vary depending on the final well screen length and aquifer characteristics at each location.

To reduce future costs, the system has capacity to extract and treat the plumes in and around WMA S-SX and U Plant in the 200-UP-1 OU. To that end, the ability to add additional wells in the future has been included in the design. .Final well yields will be evaluated following well installation.

Injection well locations were selected to optimize the flow-path control component of the selected remedy. The planned injection well array includes 16 injection wells (5 initial injection wells are planned to be installed for startup) that will be divided into two well groups; an upgradient group and downgradient group, both consisting of 8 wells each. The alignment of each well group forms a sweeping curve to cover the depicted contaminant footprint and to produce convergent groundwater flow that directs the contaminated groundwater toward the extraction wellfield capture zone. Based on the aquifer hydraulic properties and anticipated well screen lengths, it is estimated that each injection well will have a minimum injection capacity of 475 L/min (125 gpm). Actual injection well capacities are expected to be different and will vary depending on the final well screen length and aquifer and vadose zone characteristics at each location. Final capacities will be estimated following well installation.

2.2.2 Groundwater Modeling

As indicated in Section 2.2.1, extraction and injection well locations were selected with the aid of a groundwater flow and contaminant transport model. As described in the *200 West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses* (DOE/RL-2008-56), the initial modeling effort consisted of constructing a three-dimensional modular groundwater flow model based on the U.S. Geological Survey MODFLOW (Harbaugh and McDonald, 1988) platform. The MODFLOW-2000 release version of this widely used desktop software was selected because it possesses the necessary simulation capabilities, is public domain software, and has been thoroughly reviewed. The model domain spans the Central Plateau area and contains five different layers that correspond to the principal hydrostratigraphic units present beneath the Central Plateau. Once the model grid, layers and boundary

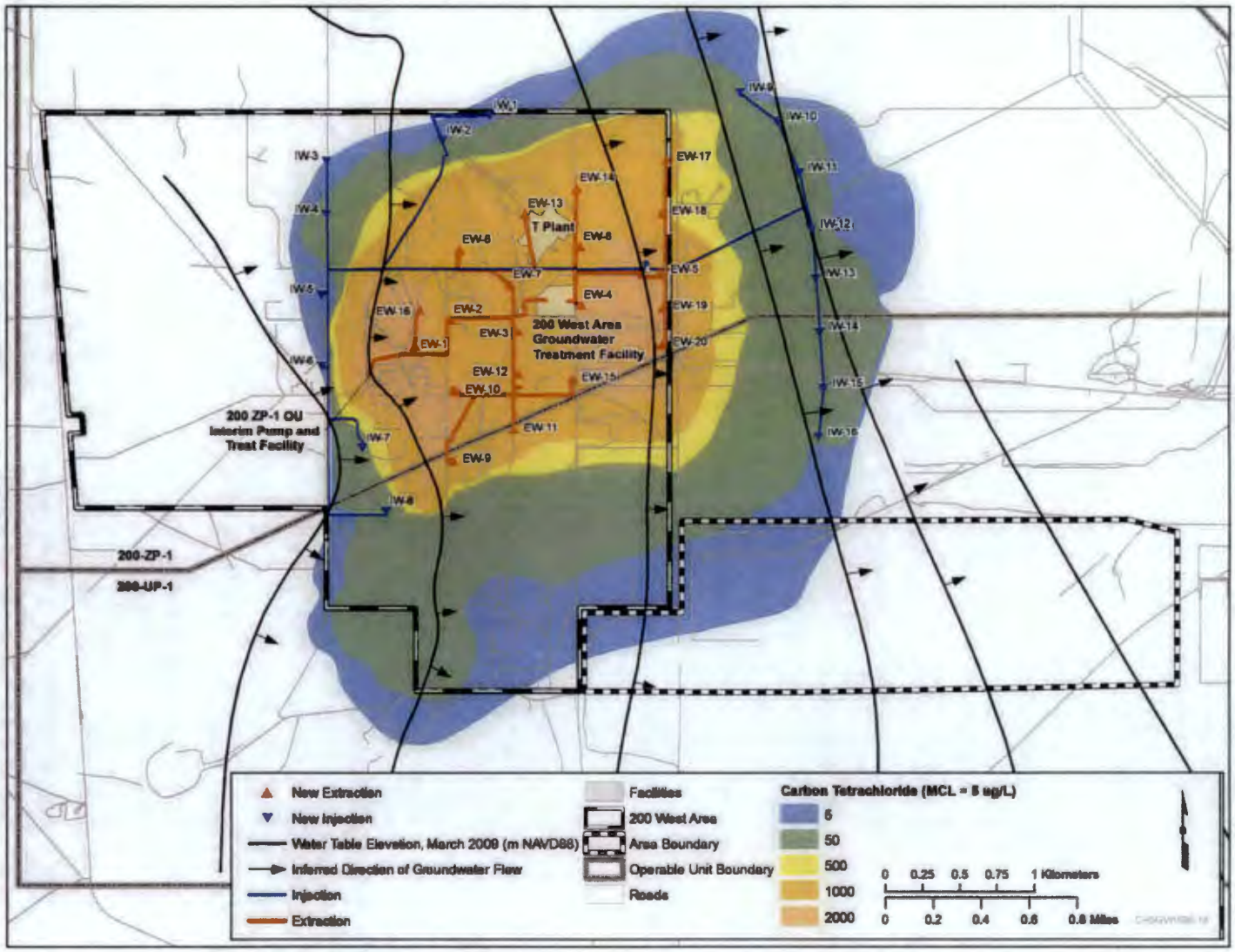

Figure 2-3. Proposed Extraction and Injection Well Locations and Conveyance Pipe Routing for the 200 West Area Groundwater P&T System

conditions were defined, the model was run and calibrated to historic groundwater elevations recorded at monitor wells throughout the 200-ZP-1 Groundwater OU. The calibration step was performed by adjusting selected model input parameters, using both manual and automated parameter estimation techniques, until a relatively good correspondence between the simulated and measured changes in groundwater elevations at monitoring wells; contoured, simulated and measured groundwater elevations; and hydraulic gradients were obtained. No formal statistical methods were used to assess calibration; rather, calibration was interpreted qualitatively by comparing simulated and observed groundwater elevation hydrographs at monitor wells located throughout the 200-ZP-1 Groundwater OU.

Following development and calibration of the groundwater flow model, contaminant plume shells were developed using the Modular 3-D Transport Multi-Species (MT3DMS) as described in the Description of Modeling Analyses (DOE/RL-2009-38). Plume shells were developed for each of the 200-ZP-1 Groundwater OU COCs (i.e., carbon tetrachloride, technetium-99, iodine-129, nitrate, trichloroethylene, chromium, tritium, and uranium). Contaminant transport terms represented in the simulation included advection, dispersion, and instantaneous sorption/desorption. The degradation of carbon tetrachloride and decay of radionuclides was not simulated in the contaminant model.

Based on the integrated groundwater flow and contaminant transport model simulations, it is estimated that 20 extraction wells and 16 injection wells operating at approximately 7,570 L/min (2,160 gpm) for 25 years would achieve the 95 percent carbon tetrachloride mass reduction requirement identified in the ROD. The contaminant transport simulations were also used to estimate initial extraction well influent concentrations for each of the contaminants of concern. The influent concentration simulation results were used in the design of the P&T system.

Depth-discrete groundwater samples will be collected while the wells are being installed and the samples tested in the laboratory for the COCs. Based on the laboratory analysis results the contaminant plume shells will be updated. Aquifer testing conducting at extraction well EW-1, and any other locations where testing is warranted, will be used to measure the aquifer's hydraulic conductivity. The results from this testing will be compared with the hydraulic conductivity values determined through the model calibration process. If there are large differences (order of magnitude or greater) between the measured and modeled values, additional refinement of the model will be performed and new simulations run. The results of these simulations will be presented annually in addendum to the modeling reports.

2.2.3 Well Installation

As described in the *Sampling and Analysis Plan for the First Set of Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2008-57) and the *Sampling Analysis Plan for Eleven ARRA Wells to Support the 200 West Groundwater Treatment System in FY 2010* (DOE/RL-2009-95), the extraction and injection wells are being installed in campaigns. Nine wells were installed during the first campaign as part of the FY09 drilling campaign. Six extraction wells and five injection wells are being installed in the second campaign as part of the FY10 drilling campaign. Two additional drilling campaigns (#3 and #4) are planned for installation of the remaining five extraction and 11 injection wells.

2.2.3.1 Well Installation Methods

Well drilling will be performed in accordance with the "Minimum Standards for Construction and Maintenance of Wells" (WAC 173-160). The drilling method employed to date uses an air rotary and telescoped casing advancement method to drill the boreholes to the total depth. The drilling method for sequence #3 and #4 is expected to use a similar method.

2.2.3.2 Test Well Installation and Aquifer Test

Aquifer testing was conducted at the first extraction well location, identified as 299-W15-225 (EW-1), to obtain detailed hydrologic data to support this 200 West P&T system remedial design report. The aquifer testing includes the following hydrologic test methods:

- Depth discrete interval slug testing
- A dynamic electromagnetic flowmeter survey
- A step-drawdown test A constant-rate pump test

The aquifer test results were used to measure the lateral and vertical distribution of aquifer hydraulic properties and to estimate the lateral extent of the well's capture zone under pumping conditions. The results from this testing was used to validate the initial extraction well spacing intervals determined from the groundwater flow and contaminant transport modeling.

Additional aquifer testing may be conducted after extraction well EW-1 is connected to the IRM P&T system.

2.2.3.3 Extraction Well Installations

The extraction well will be drilled to the Ringold Lower Mud Unit or basalt based on rapid turn-around laboratory results for samples collected during drilling. Specific well information including estimated borehole depths for the first two sets of wells is provided in Table 2-2. The shaded rows in the table represent wells that have been installed (to total depth) or are planned to be installed in DOE fiscal year 2010. Actual depths will likely vary and will be determined in the field based on geologic logging information. Estimated borehole depths for the remaining wells will be determined in the sampling and analysis plans prepared for the third and fourth well group sequences.

The extraction wells will be constructed using 20.3 cm (8 in.) diameter casing. The extraction well screens are constructed of Schedule 10, Type 304 or Type 316, stainless-steel, V-slot continuous wire wrap screen equipped with an approximate 1.5 m (5 ft) long, stainless-steel bottom sump and end cap. The blank riser casing will extend from the top of the screen interval to approximately 0.61 m (2 ft) above the ground surface.

Extraction well screen intervals will generally be placed such that the aquifer zones with carbon tetrachloride concentrations greater than100 µg/L are open to the well. Each of the extraction wells may have a long screen, possibly greater than 45.7 m (150 ft) in length, potentially extending from the water table to the lowermost portion of the 100 µg/L carbon tetrachloride concentration isopach. Final well screen lengths and screen depths will be determined in the field using the depth-discrete groundwater sample analytical results for carbon tetrachloride, technetium-99, and nitrate, contaminant concentrations present in nearby monitoring wells, and the extraction well's location within the carbon tetrachloride plume. A conceptual illustration of a typical extraction well is provided in Figure 2-4. Blank casing sections may be placed between screen intervals in areas of low permeability or low contaminant concentration to optimize groundwater and contaminant mass removal efficiency.

Table 2-2. Estimated Location and Total Depth of Proposed Extraction Wells

Well Name	Extraction Well	Well No.	Northing	Easting	Ground Elev. (m)	Total Depth (ft)	TD (m)
299-W15-225	EW-1	C7017	136108.88	566657.25	204.44	410.5	125
299-W14-20	EW-2	C7018	136284.62	566909.21	204.16	409.0	125
299-W14-73	EW-3	C7021	136204.21	567359.14	216.41	507.5	155
299-W14-74	EW-4	C7024	136383.00	567780.91	221.06	508.0	155
299-W12-2	EW-5	C7027	136609.97	568312.99	223.05	505.0	154
299-W11-50	EW-6	C7020	136756.64	566966.26	211.93		
299-W11-90	EW-7	C7022	136519.63	567306.69	217.76	520	158
299-W11-96	EW-8	C7754	136777.95	567776.40	220.49	480.5	146
299-W17-3	EW-9	C7577	135324.9	566925.96	205.75	440	134
299-W17-2	EW-10	C7576	135806.14	566951.59	204.38	405	123
	EW-11						
299-W11-49	EW-12	C7019	135924.61	567361.68	215.93	431	131
	EW-13						
	EW-14						
299-W14-21	EW-15	C7494	135886.84	567721.42	218.94	525.0	160
299-W11-92	EW-16	C7025	136351.76	566692.79	204.40	405	123
	EW-17						
299-W12-3	EW-18	C7028	137000.00	568324.77	223.94	496.0	151
299-W12-4	EW-19	C7029	136363.44	568328.96	223.13	525.8	160
299-W14-22	EW-20	C7030	136116.03	568330.14	223.39		

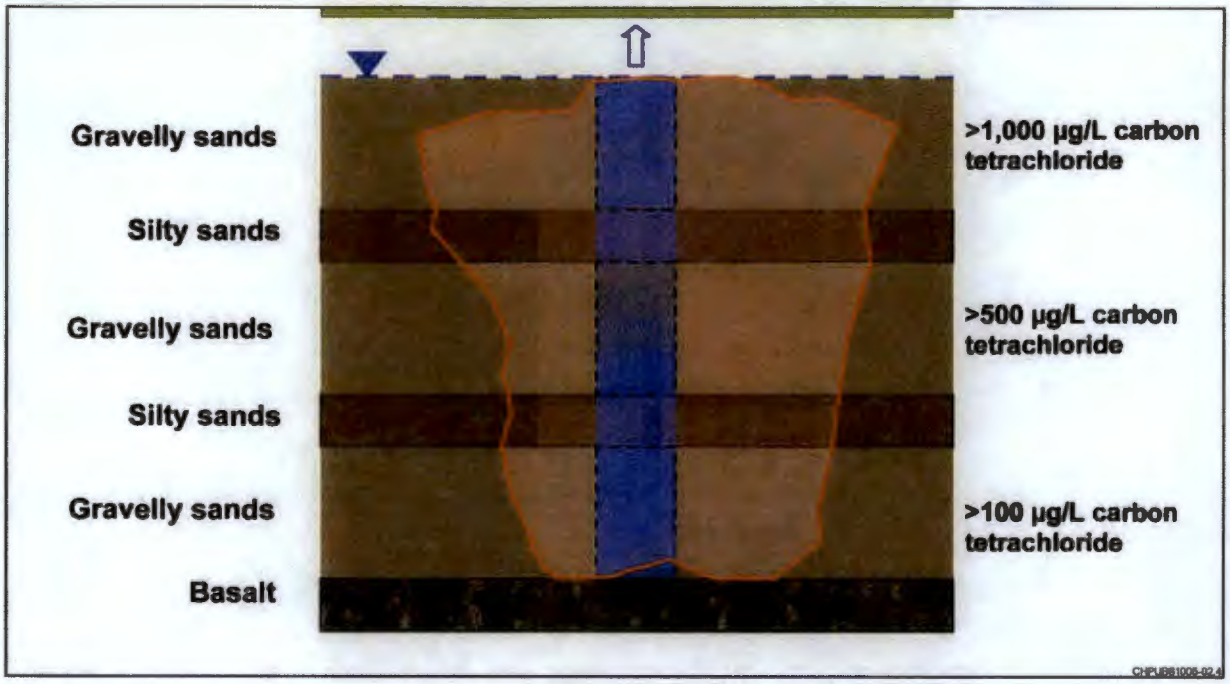

Figure 2-4. Conceptual Illustration of Extraction Well Screen Design

Well screen slot size and filter pack gradation will be determined in the field following evaluation of grain size (sieve analysis) results obtained from testing of samples collected at approximate 6.1 m (20 ft) intervals. Colorado silica sand (unless otherwise determined by the drilling contract) will be used for the sand pack. Sodium bentonite pellets and/or natural sodium bentonite chunks, crumbles, or powdered bentonite will be used for bentonite sealing material. Type I/II Portland cement will be used for cement grout. A bentonite seal will be emplaced between the well screens, as required by the design. Granular bentonite shall not be poured down the long annulus.

The surface completion will include a protective casing, protective guard posts, and a cement pad. The protective is a minimum 5.1 cm (2 in.) larger in diameter than the permanent casing and rises approximately 0.9 m (3 ft) above the ground surface, and 0.3 m (1 ft) above the top of the well casing. The protective casing includes a lockable well cap. If variances from this proposed construction and WAC 173-160 are required based on actual conditions encountered in the field or updated modeling simulations, a variance request will be obtained from Ecology.

Following installation, each extraction well will be developed to remove drilling induced turbidity sources and to restore the natural hydraulic conductivity around the well screen interval. Well development and aquifer testing (as applicable) will generally follow the same approach as described in the *Description of Work for Aquifer Testing at Well 299-W15-225* (SGW-40266), unless it is determined that other well development methods or variations are more appropriate. Airburst Technology™[2] is currently being evaluated as a means to improve well efficiency. Each extraction well has a pump and motor assembly designed for a capacity of up to 568 L/min (150 gpm), but will operate at various flow ranges depending on the given well production capability. Extraction well pump motors are powered from Adjustable Frequency Drives (AFDs) to match aquifer conditions. Each AFD can be controlled manually at its local

[2] Airburst Technology™ is a trademark of Frazier Industries, Inc., Muskego, Wisconsin.

panel or remotely by the programmable logic controller (PLC). Electric supply power is routed above grade from the power distribution system to the local well head electrical rack. Extracted well water is piped to a tank in each of the transfer buildings with a few wells piped directly from the well field to the process building influent equalization tank. The 200 West P&T control system will automatically react to balance the system if the respective transfer tank level reaches the high level set point. Pump operation will be controlled until the tank level drops to the reset point. The control system will also respond when the flow signal comparison results in a difference greater than 5 percent of the readings (possible line break), or the extraction well level is too low.

2.2.3.4 Injection Well Installations

The planned injection well locations and depths are presented below in Table 2-3. The shaded rows in the table represent wells that are planned to be installed in DOE fiscal year 2010. The well capacities are dependent on the length of the screen, aquifer thickness, and aquifer hydraulic properties at each location. Injection well screens will be installed generally at a depth of approximately 82.3 m (270 ft) and have a screen length of approximately 45.7 m (150 ft), as illustrated in Figure 2-5. The current assumption for each well's capacity is 18.6 L/min/m (1.5 gpm/ft) of well screen. An injection well with 45.7 m (150 ft) of well screen is expected to be capable of injecting 851.7 L/min (225 gpm). Given the heterogeneity known to be present (particularly the mixed sedimentary sequences and the variability of cementing in the Ringold Formation), it is not possible to assure that each well will accept between 475 L/min (125 gpm) and 852 L/min (225 gpm). It is assumed that some wells may accept water at the upper end of this estimate, while others may be closer to the lower end of performance, at least initially. Sieve analyses will be used to size the filter pack and well screen slot size as described for the extraction wells. A typical injection well installation is shown in Figure 2-5.

Table 2-3. Estimated Location and Total Depth of Proposed Injection Wells

Well Name	Injection Well	Well No.	Northing	Easting	Ground Elev. (m)	Total Depth	TD (m)
	IW-1						
	IW-2						
	IW-3						
299-W10-35	IW-4	C7573	136987.06	566067.33	210.31	432	131.71
299-W15-226	IW-5	C7574	136450.13	566033.26	212.06	456	139.02
299-W15-227	IW-6	C7575	135966.32	566034.41	213.36	470	143.60
	IW-7						
	IW-8						
	IW-9						
	IW-10		137600.00	569110.00	216.86		
699-45-67	IW-11	C7578	137263.00	569257.00	219.52	307	93.60
	IW-12		136894.00	569338.00	224.03		
699-43-67	IW-13	C7579	136560.00	569370.00	227.06	351	107.01
	IW-14		136200.00	569390.00	227.98		
	IW-15		135816.00	569420.00	228.30		
	IW-16						

Notes:
Horizontal Coordinate System: WCS83S/91 (Meters)
Vertical Datum: NAVD88 (meters)
Equipment used: Trimble GPS 5800 RTK

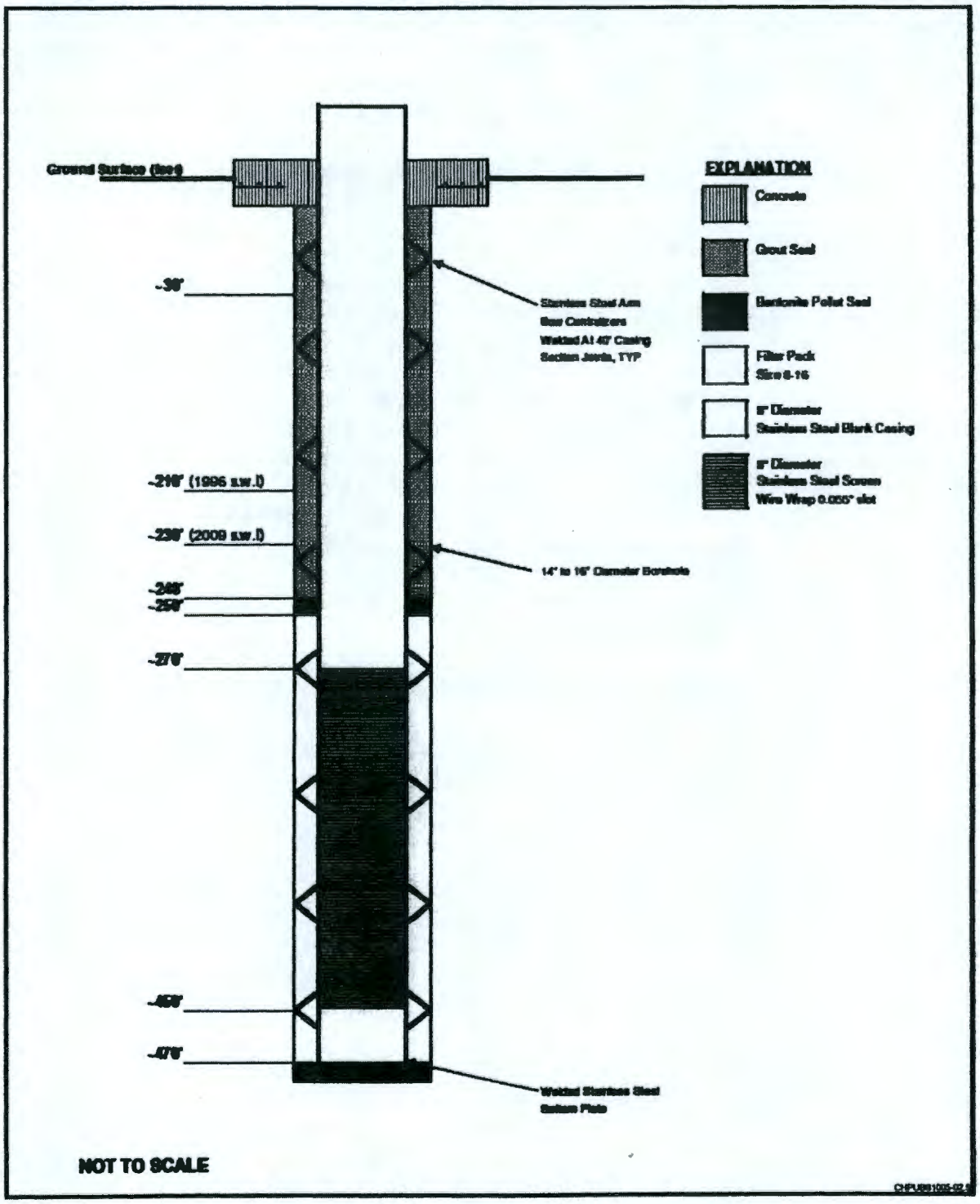

Figure 2-5. Conceptual Illustration of Injection Well Screen Design

2.3 Groundwater Treatment System

This section summarizes the unit processes included in the 200 West Area groundwater treatment facilities, the basis of design of the treatment system, and specification of construction materials.

2.3.1 200 West Area Groundwater Treatment System Process Summary

The 200 West Area groundwater treatment system includes seven primary system components: (1) radiological pre-treatment, (2) biological groundwater treatment, (3) sludge handling, (4) sludge stabilization, (5) chemical feed system, (6) air stripping, and (7) off-gas treatment. The major components for each part of the system are presented below:

The radiological pre-treatment system components include:

- Technetium-99 Ion Exchange (IX)
- Uranium IX

The primary biological system groundwater treatment components include:

- Anoxic/Anaerobic Biodegradation in a fluidized bed reactor (FBR)
- Aerobic Biodegradation/membrane filtration

The sludge system primary components include:

- Sludge thickening in rotary drum thickeners
- Sludge aeration in aerated sludge holding tanks
- Sludge dewatering in centrifuges
- Centrate return system

The sludge stabilization system primary components include:

- Lime silos
- Pug Mills
- Conveyors
- Screw conveyors

The chemical treatment systems primary components include finished water chemistry adjustment through chemical addition.

The air stripping systems primary components include:

- Packed tower air stripper
- Demisters

The off-gas treatment system's primary components include capture of air stripper and tank-off gas emissions through vapor-phase granular activated carbon (VPGAC).

The groundwater treatment approach involves multiple treatment steps to remove the various COCs (Table 2-1). The relationship between each unit process and the targeted COCs is presented in Table 2-4. Additional information on each treatment step is provided in the following subsections.

The instrumentation and control (I&C) components of the 200 West Area groundwater P&T system provide the physical link with the operators and the plant processes for monitoring and control functions with process equipment, instrumentation, and computer system components. The process control system

designed to monitor and control the treatment processes used at the facility are referred to as the supervisory control and data acquisition (SCADA) system.

Normal plant control and monitoring functions will be performed through the SCADA system. Normal automatic and manual controls for most equipment will be implemented in the system. Exceptions will be controls that are part of standard package control systems furnished with specific equipment, although provisions will be made in the SCADA system to monitor and provide necessary operator interface with the package system automatic controls.

The SCADA system monitors the following items:

- Process conditions (flows, levels, pressures, turbidity, pH, etc.)
- Equipment status and control mode status (on/off, open/close, local/remote, etc.)
- Equipment and process alarms (fail, high, low, tripped, etc.)
- Chemical storage tanks and hopper inventory (level and/or weight)
- Equipment run times (based on on/off status)
- Electrical power at motor control centers

The SCADA system uses programmable logic controllers (PLCs) and human machine interface (HMI) control system software for operator control and monitoring of the facility. The HMI software will run on standard PC's. Software to support the SCADA system is under development as part of the engineering design.

Table 2-4. 200 West Area Groundwater P&T System Unit Process Descriptions

Unit Process	Process Benefit	Targeted Parameter
Ion exchange (IX)	Removal of technetium-99, uranium, and iodine-129	Technetium-99 Iodine-129 Uranium*
Anoxic/Anaerobic Biodegradation (fluidized bed reactor or FBR)	Removal of nitrate and carbon tetrachloride and conversion of hexavalent chromium to trivalent form	Nitrate Carbon tetrachloride Hexavalent chromium Trichloroethylene
Aerobic biodegradation	Degradation/removal of residual organic carbon substrate	Biochemical Oxygen Demand (BOD)
	Removal of carbon tetrachloride and trichloroethylene	Carbon tetrachloride Trichloroethylene
Membrane filtration	Removal of particles, biomass, and precipitated trivalent chromium	Trivalent Chromium Turbidity and BOD
Air stripping	Removal of volatile organic compounds(VOCs) – carbon tetrachloride and trichloroethylene	Carbon Tetrachloride Trichloroethylene
Sludge thickening	Thicken biological solids for dewatering process	Solids Content

Table 2-4. 200 West Area Groundwater P&T System Unit Process Descriptions

Unit Process	Process Benefit	Targeted Parameter
Sludge dewatering	Reduce water content to allow for landfill disposal	Water content
Lime treatment of dewatered sludge	Lyse microorganism cells and kill biomass	Stabilized sludge for disposal
Treated water chemistry adjustment	Provide treated water stability	pH and alkalinity

* Uranium treatment is only required for groundwater from the 200-UP-1 OU.

FBR = fluidized bed reactor

pH = acidity or alkalinity of an aqueous solution

2.3.1.1 Radiological Pre-Treatment System

Groundwater from selected wells in the 200-ZP-1 OU and 200-UP-1 (after separate pre-treatment for uranium, as required) is pre-treated to reduce technetium-99, to less than 900 pCi/L (see Figure 2-6) prior to conveyance to the main treatment process building. Influent groundwater is first filtered to remove fine particulate matter, and then flows to the technetium-99 IX vessels before passing through a final set of filters and transfer to the main process building.

Prior to the IX resin reaching its loading limit, it will be removed from the vessel by sluicing it with treated water into a carbon tetrachloride stripping tank (Figure 2-7) where the resin will be submerged with treated water. The tank will be heated with air bubbled through the resin bed to mix the bed and strip off carbon tetrachloride. The water will be routed back to the IX system (radiological building) inlet feed tank (Figure 2-6) for treatment. The vapor emissions will be treated with VPGAC.

The resin in the strip tank will be sluiced with treated water to a plastic lined Environmental Restoration Disposal Facility (ERDF) burial box or geotextile tube placed in a container to allow drainage (Figure 2-8). The filtrate from the waste container will be collected and pumped back into the feed tank (Figure 2-6). The dewatered resin will be transported for placement at the ERDF. The spent resin will be profiled to verify that the ERDF limits for technetium-99, iodine-129, uranium, and carbon tetrachloride are met. If these limits cannot be met, stabilization of the resin may be required.

The design also considers, as necessary, the need for treatment of other constituents (such as uranium) that may be captured by the 200-ZP-1 OU extraction wells. While they are not COCs for the 200-ZP-1 OU, these constituents may be encountered during restoration from sources related to the other adjacent groundwater OUs (200-UP-1 OU). Additionally, in anticipation of future expansion, the treatment system will also be capable of treating some contaminated groundwater (including uranium) from the 200-UP-1 OU. Following initial operations, it is anticipated that the 200 West Area groundwater P&T system will be expanded to provide the necessary treatment capabilities for additional contaminated groundwater from the 200-UP-1 OU following issuance of a final ROD for that OU.

Based on the need to address uranium concentrations, groundwater from these sources will be pretreated to remove uranium using IX resin vessels prior to conveyance to the technetium-99 IX pretreatment system. The uranium IX pretreatment system will be similar to the technetium-99 IX system described above. Ongoing resin testing is being conducted to further optimize resin utilization for both Technetium-99 and uranium removal.

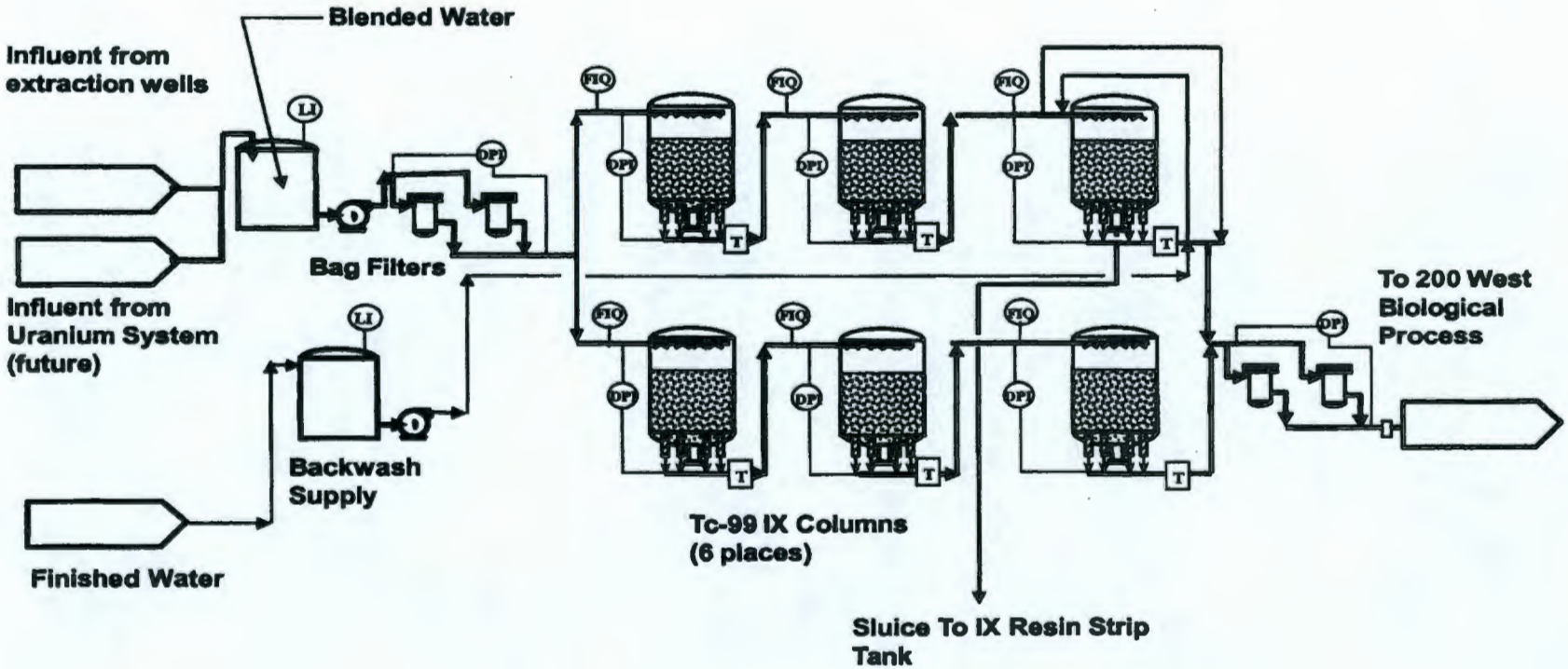

Figure 2-6. Radiological Pre-Treatment System (Technetium-99) IX Process Schematic

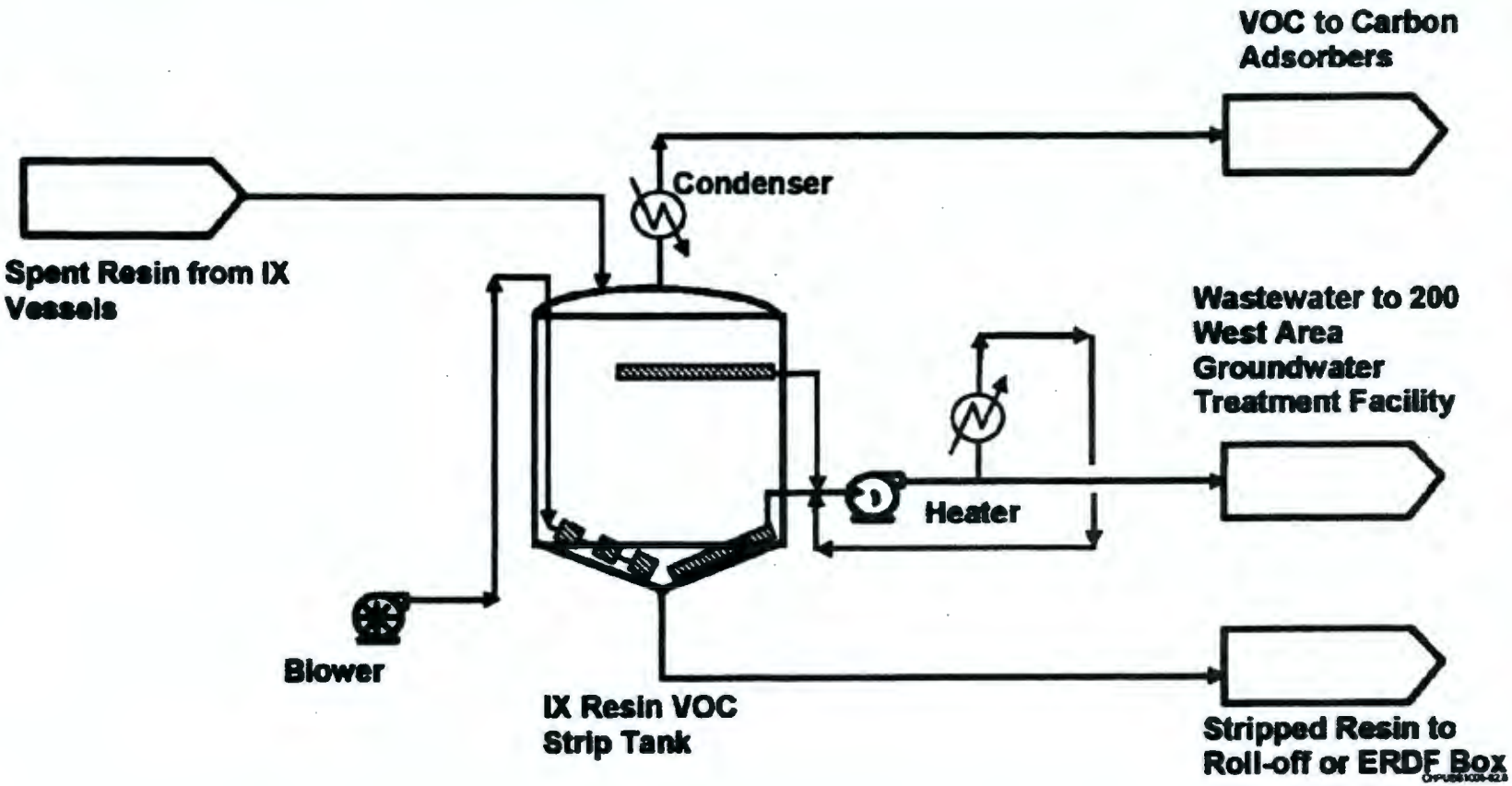

Figure 2-7. Radiological Pre-Treatment System (Technetium-99) IX Resin Strip Tank Schematic

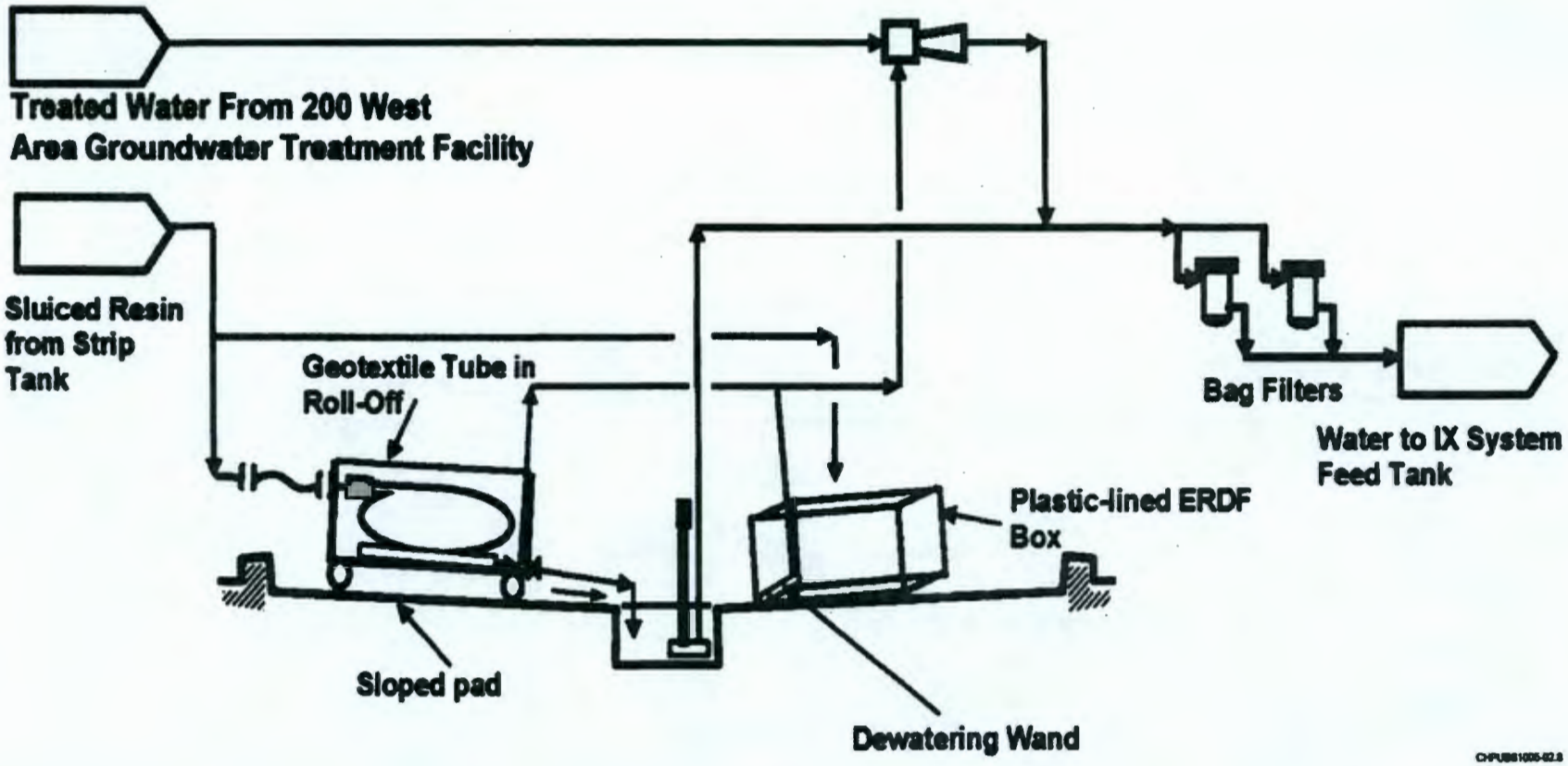

Figure 2-8. Radiological Pre-Treatment System (Technetium-99) IX Resin Dewatering Schematic

2.3.1.2 200 West Area Groundwater Treatment Facility

The treatment processes for carbon tetrachloride and nitrate removal are configured in two parallel 1,250 gpm treatment trains to accommodate increasing flow ranges up to 2,500 gpm. The treatment facility infrastructure is designed to accommodate a third treatment train, if required, to increase the total installed treatment capacity to 3,750 gpm.

Water from the technetium-99 IX system flows to the main process building, where it is blended in an equalization tank (Figure 2-9) with the extracted groundwater and then conveyed through the extraction transfer building serving several extraction wells or directly to the facility from individual extraction wells.

Biological Groundwater Treatment

Water is pumped from the equalization tank to a recycle tank and then to a FBR, where nitrate is converted to nitrogen gas. Carbon tetrachloride is also treated in the FBR, which operates under anoxic conditions (i.e., in the absence of dissolved oxygen).

Water is pumped into the bottom of the FBR creating upflow to suspend the granular activated carbon (GAC) bed media to which microorganisms attach and grow anoxically and anaerobically. The FBR will be seeded with microbes that are suited for nitrate/nitrogen removal (denitrification) and carbon tetrachloride degradation under anoxic and anaerobic conditions. An organic carbon substrate and phosphorus will be added into the FBR to serve as the electron donor and nutrient to promote microbial growth. As the microbes grow on the GAC, the fluidized bed height will excess biomass removed with a biomass separator.

The effluent from the FBR flows by gravity to the aerated splitter box and aerobic membrane tanks (also called MBRs) (Figure 2-10) for removal of residual carbon substrate through aerobic biodegradation and removal of total suspended solids (TSS), including biomass generated in the FBR. The membrane tanks have aeration capacity to provide sufficient oxygen for maintaining the aerobic biological process to reduce the residual carbon substrate. The membrane tanks have submerged membranes for filtration. The aeration is maintained by a blower that diffuses air into the tank and provides air scouring to remove accumulated organic debris from the membrane surface to maintain its water permeability. The aeration and air scouring processes will strip off carbon tetrachloride. Vapor emissions will be collected for treatment with VPGAC.

In the membrane zone, there are multiple modules of vertically or horizontally strung membrane fibers. Water is filtered by applying a slight vacuum to the end of each fiber which draws the water through the tiny pores into the fibers. The filters reject solids, which are retained in the tank concentrate. A portion of the concentrate is recycled to the aerated splitter box to maintain the biomass concentration necessary to reduce BOD.

Sludge Handling

Solids from the membrane tanks are pumped to rotary drum thickeners (Figure 2-11). Thickened sludge leaving the rotary drum thickeners is sent to aerated sludge storage tanks. A bypass line is used to maintain the solids content in the aerated sludge storage tanks within an optimum range. As the solids concentration in the aeration tanks decreases, less flow is bypassed around the thickeners; conversely, as the solids concentration in the tank increases, more flow is bypassed around the thickening process. Polymer is added upstream of the rotary drum thickeners, as necessary, to thicken the solids. The aerated sludge storage tanks also provide further digestion of biomass and maintain aerobic conditions for odor control.

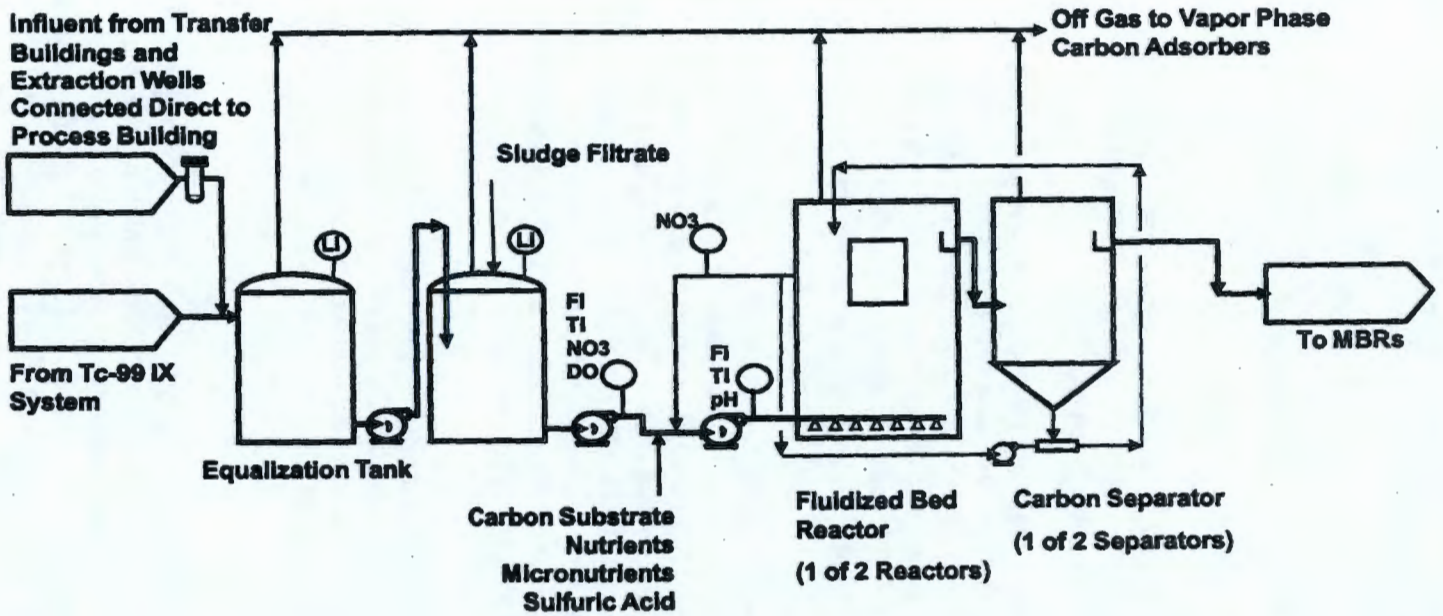

Figure 2-9. Biological Process – Anoxic FBR Schematic

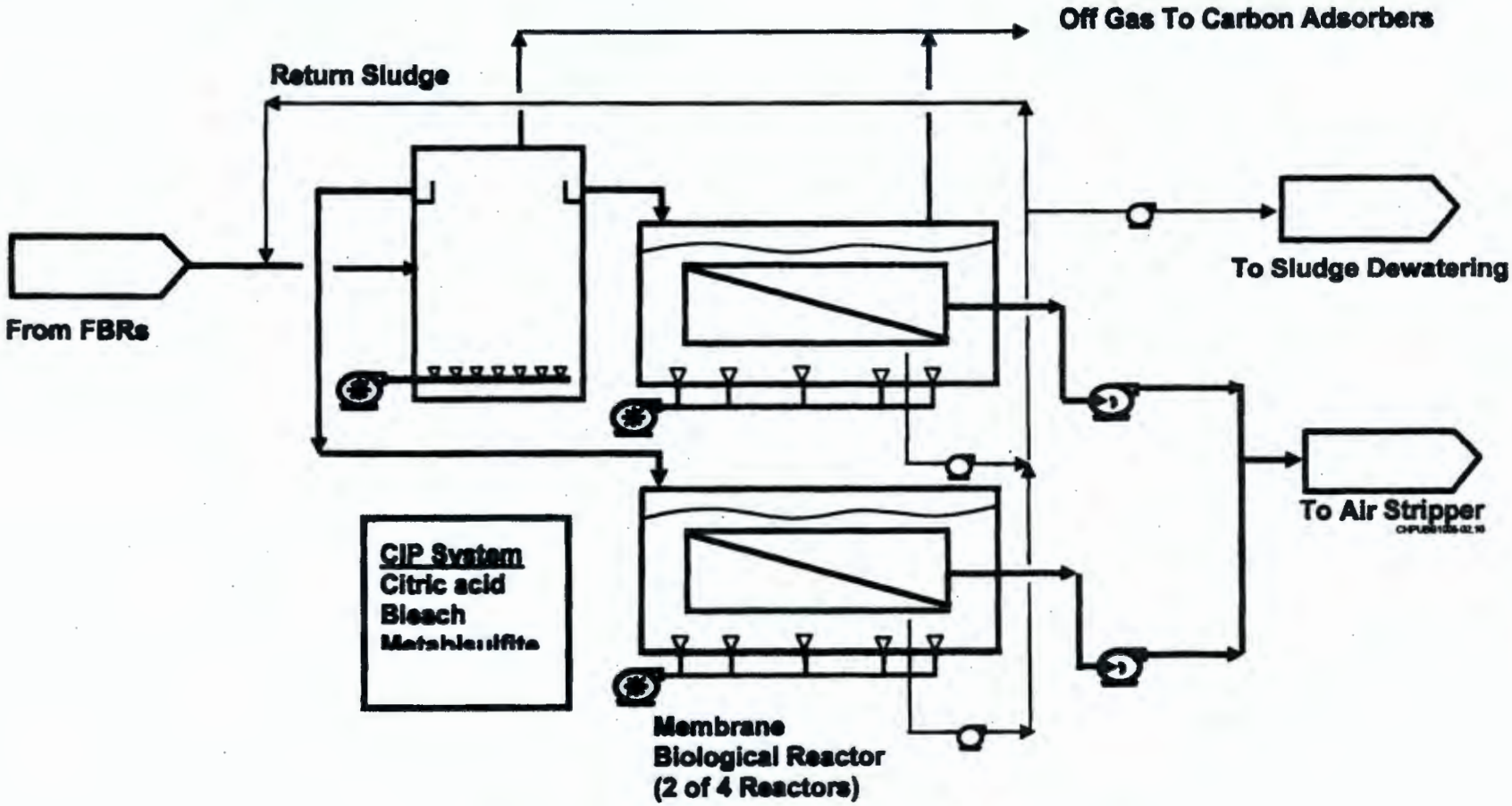

Figure 2-10. Biological Process – Aerobic MBR Schematic

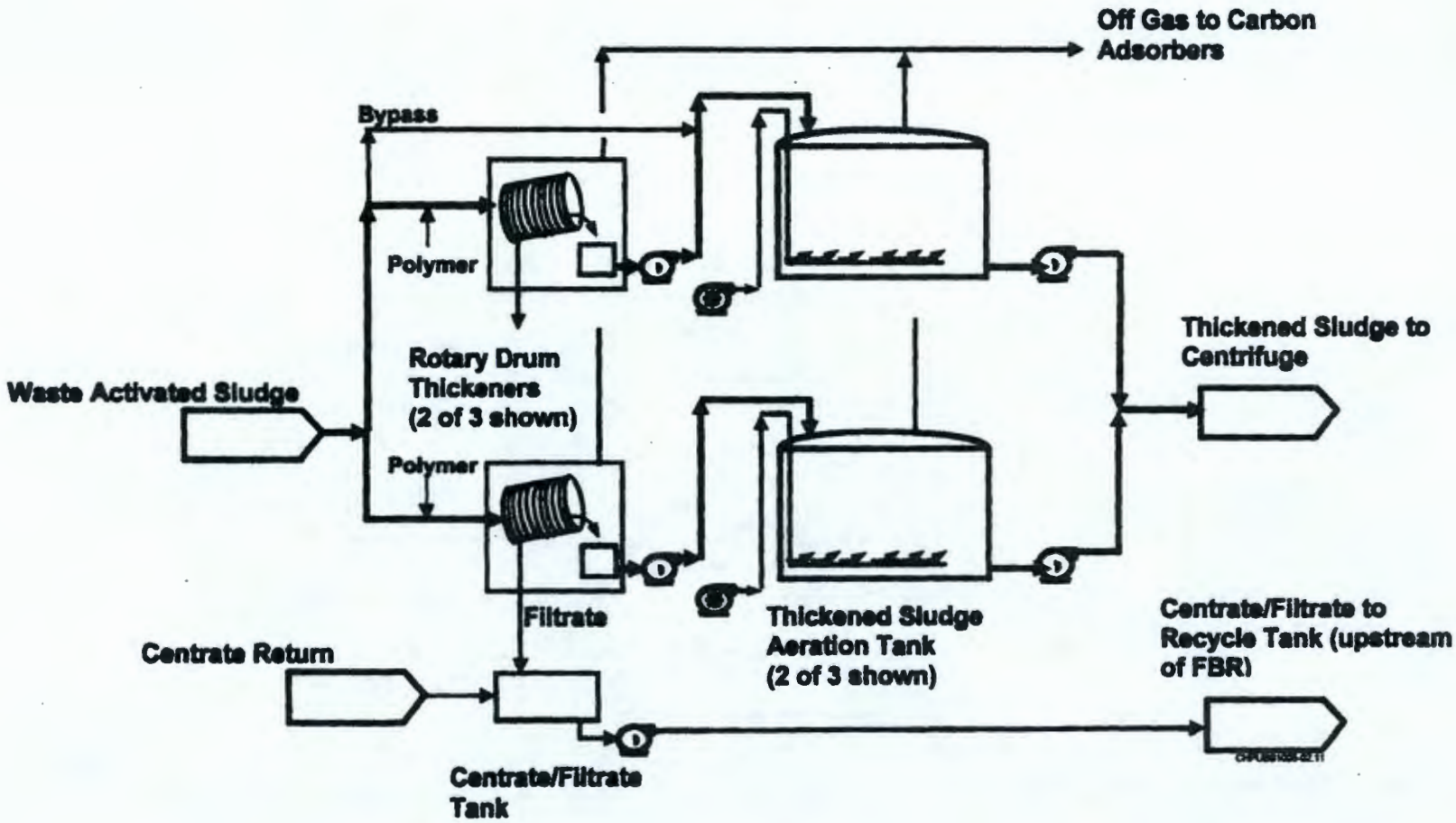

Figure 2-11. Solids Handling System – Thickeners and Thickened Sludge Aeration Tank Schematic

The thickened solids are then pumped from the aerated sludge storage tanks to centrifuges for dewatering (Figure 2-12). Polymer is added upstream of the centrifuges to aid in solids dewatering. The filtrate from the rotary drum thickeners and centrate from the centrifuges are piped to a collection sump and then pumped to aerated centrate storage tanks and then bled to the recycle tank located upstream of the FBR.

Lime Stabilization of Sludge

The treatment system will produce a biological sludge as a residual from the treatment of nitrate in the groundwater. This sludge will be disposed at ERDF. The sludge material must be absent of free liquids and pass the paint filter test to meet the ERDF disposal criteria. It must also be stabilized to minimize biological breakdown and control odor prior to disposal at ERDF. A screw conveyor is used to move the dewatered sludge from the centrifuge to a lime sludge stabilization system where a mechanical mixer (e.g., pug mill) mixes lime with the thickened sludge (Figure 2-12) to control free water to meet ERDF disposal criteria and kill the biomass to prevent further decomposition and generation of objectionable gasses and odors. Once the lime is added, the conditioned sludge will be transferred into ERDF containers for disposal.

Air Stripper

The treated water from the membranes is pumped to an air stripper (Figure 2-13) for removal of the remaining carbon tetrachloride and other volatile organic compounds (VOCs). The air stripper effluent is then pumped to an effluent tank. Acid is added upstream of the effluent tank through an inline static mixer to adjust pH.

The air stripper tower is piped so that this treatment step can occur before the FBR in the event degradation of the carbon tetrachloride in the FBR is less than anticipated. For the latter scenario, the water from the influent equalization tank is pumped through strainers to remove larger particles before entering the air strippers. Process monitoring conducted during initial operations will be used to determine the optimum configuration of the air stripper.

Off Gas Treatment

Off gas from the air stripper, influent equalization tank, radiological building strip tanks (technetium-99 and uranium), FBRs, membrane tanks, sludge holding tanks, rotary drum thickeners, and centrifuges is combined and treated by VPGAC. To avoid build-up of radionuclides in the VPGAC, air streams to the VPGAC system will be pretreated by a demister to minimize liquid carryover.

Chemical Feed Systems

Various chemicals are added during the treatment processes to adjust water chemistry (including pH and alkalinity). The P&T system will utilize numerous chemical feeds. Table 2-5 provides a list of these chemical feeds and the primary use of each.

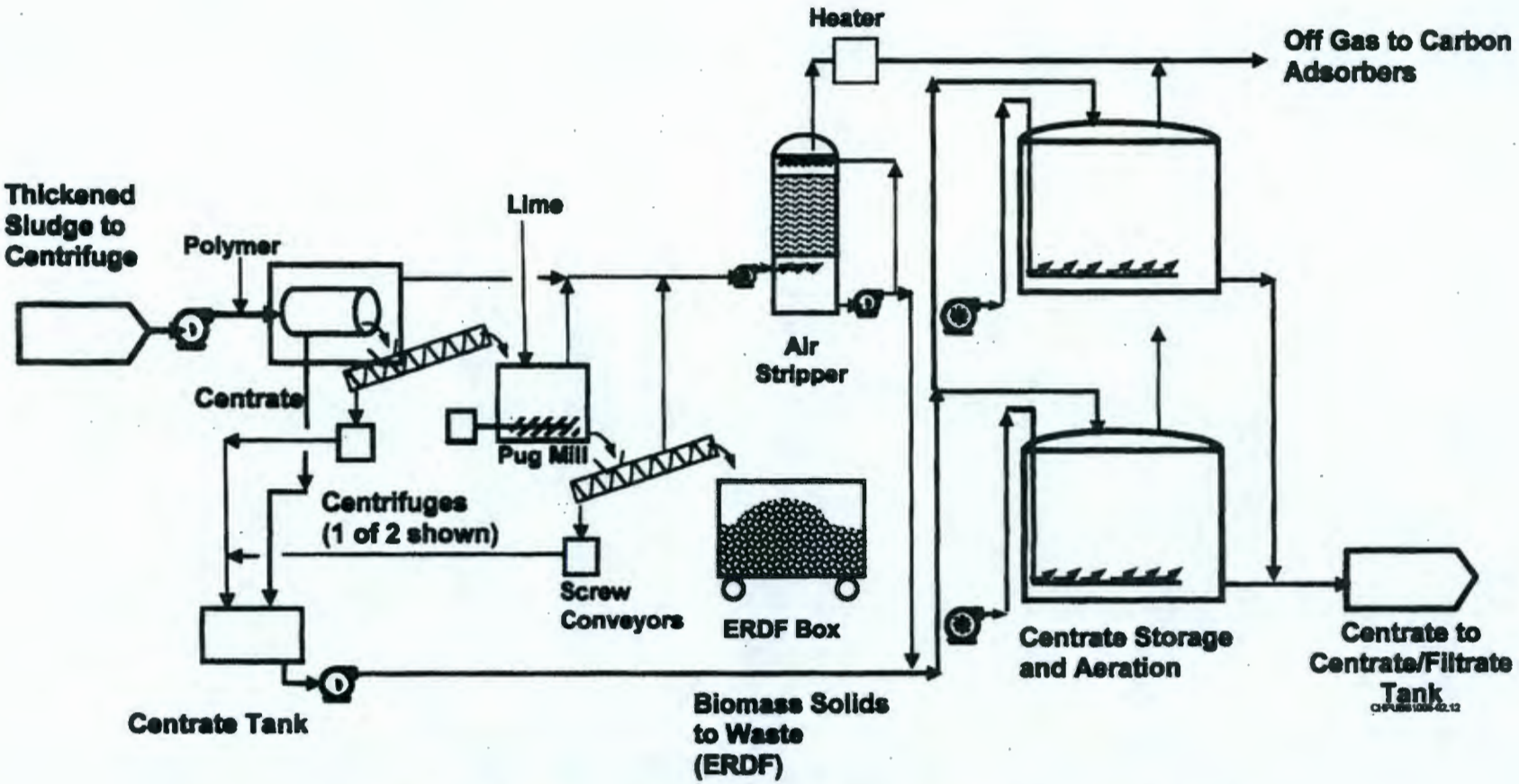

Figure 2-12. Solids Handling System – Centrifuge Dewatering and Lime Treatment Schematic

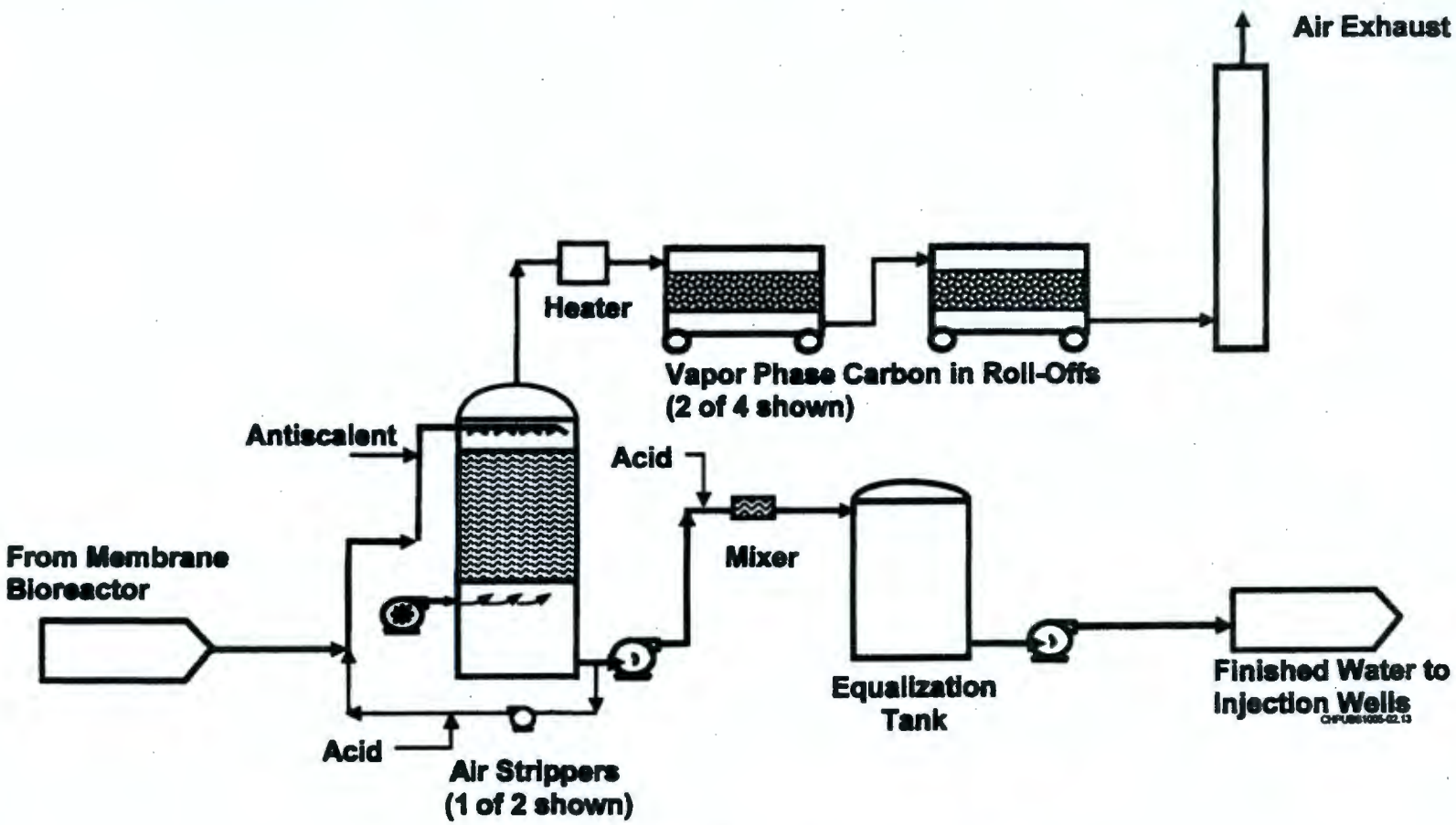

Figure 2-13. Air Stripper System Schematic

Table 2-5. Summary of Expected Chemical Feeds

Chemical	Primary Use
Anti-scalant (Nalco CL-50 or equivalent)	Air stripper anti-scalant
Calcium oxide (Quicklime)	Sludge stabilization
Carbon substrate	Biological fluidized bed reactor carbon substrate
Citric acid	Membrane in-place cleaning
Ferric chloride	Coagulant upstream of membranes
Hydrochloric acid	Air stripper cleaning
Micronutrient	Biological fluidized bed reactor micronutrient feed
Phosphoric acid	Biological fluidized bed reactor phosphorus nutrient feed
Polymer	Solids thickening and dewatering aids
Sodium bisulfite	Dechlorinate membrane cleaning wastewater
Sodium hydroxide	Neutralize citric acid membrane cleaning wastewater and odor control chemical scrubber
Sodium hypochlorite	Membrane in-place cleaning and odor control chemical scrubber
Sodium nitrate	Biological FBR nitrate feed for start-up and interim plant shutdowns only
Sulfuric Acid	pH adjustment and odor control chemical scrubber

FBR = fluidized bed reactor
pH = acidity or alkalinity of an aqueous solution

2.3.2 Groundwater Treatment System Basis of Design

The finished water quality requirements for the 200 West Area groundwater treatment facility are stated in the ROD. The final groundwater cleanup levels are federal and state drinking water MCLs and state groundwater cleanup standards (where more stringent than the MCLs) that are the applicable or relevant and appropriate requirements (ARARs) for the selected remedy (EPA et al., 2008). However, the design treatment goal is for the finished water quality to be less than the target finished water quality standard. These goals are presented in Table 2-6.

For three of the primary COCs requiring active treatment to meet the cleanup levels (carbon tetrachloride, technetium-99, and uranium), the above-ground treatment system will be designed to achieve a nominal operating treated effluent target of 60 percent of the final cleanup level under normal operations (thus, 2 μg/L for carbon tetrachloride, 540 pCi/l for technetium-99, and 18 pCi/L for uranium). This will provide an allowance for a slight upward trend during stressed operating periods. The upward trend will be acted on by the operations staff to bring the system back to normal operations. Nitrate, which also must be treated to meet the cleanup levels, will be designed to achieve a nominal operating treated effluent target of 20 percent of the cleanup level (thus, 2000 μg/L as nitrogen). This lower level is being selected because biological treatment systems can be less stable and an extra operating margin is desired. The system will not be specifically designed to treat to 60 percent of the final cleanup levels for the other COCs (chromium [hexavalent and total], trichloroethylene, and I-129) because the blended influent will

Table 2-6. Finished Water Quality Requirements and Goals

Parameter	Point of Compliance	Finished Water Quality Standard		Acceptance Standard Description	Design Treatment Goal
		Value	Units		
Carbon tetrachloride[a]	Pipeline to injection wells	3.4	ug/L	Specified by ROD	2 ug/L
Chromium (total)	Pipeline to injection wells	100	ug/L	Federal MCL	60 to 100 ug/L
Hexavalent chromium	Pipeline to injection wells	48	ug/L	Specified by ROD	29 to 48 ug/L
Nitrate as nitrogen	Pipeline to injection wells	10,000	ug/L	Federal MCL	2,000 ug/L
Trichloroethylene[a]	Pipeline to injection wells	1	ug/L	Specified by ROD	0.6 to 1 ug/L
Iodine-129	Pipeline to injection wells	1	pCi/L	Federal MCL	0.3 to 1 pCi/L
Technetium-99	Pipeline to injection wells	900	pCi/L	Federal MCL	540 pCi/L
Tritium	Pipeline to injection wells	20,000	pCi/L	Federal MCL	12,000 to 20,000 pCi/L
Uranium	Pipeline to injection wells	30	pCi/L	Federal MCL	18 to 30 pCi/L

a. The DOE will clean up COCs for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act–Cleanup," which includes carbon tetrachloride and trichloroethylene, so that the excess lifetime cancer risk does not exceed 1 x 10 -5 at the conclusion of the remedy.

MCL = maximum contaminant level

ROD = record of decision

be below or close to the cleanup levels, and/or they will be removed concurrently with the primary COCs. For example, trichloroethylene will be removed with the carbon tetrachloride and hexavalent chromium will be removed with the nitrate.

The nominal design life for the groundwater P&T system is estimated to be 25 years, based on ROD Part 1, Section 4.3.1. Replacement of equipment and piping during this period is allowed to meet this goal if life-cycle cost analysis shows it is the lowest cost option of meeting this criterion.

Key design criteria for each of the major process steps described above are summarized in the following sections.

2.3.2.1 Reliability and Redundancy Provisions

To achieve the cleanup goals, reliability and redundancy provisions have been included in the design of the 200 West Area groundwater treatment facility. These provisions are in place to ensure that the system has operational flexibility to continue operations during routine and preventative maintenance procedures, as well as backup provisions in case of unscheduled maintenance or equipment failure. Table 2-7 presents the reliability and redundancy provisions.

Table 2-7. Reliability and Redundancy Provisions

Unit Process or System	Reliability and Redundancy Provisions
Uranium ion exchange	(Future) One – 50 gpm system (three vessels in series per system)
Tc-99 ion exchange	Two – 335 gpm systems (three vessels in series per system)
Anoxic/anaerobic biodegradation	Two – 1,250 gpm systems
Membrane filtration system	Four – 625 gpm systems
Air stripping	Two – 1,250 gpm system Four – VPGAC roll-off units (2 pairs in series operation)
VOC off-gas (other sources)	Four – VPGAC roll-off units (2 pair in series operation)
Sludge thickening	Three – rotary drum thickeners Three – aerated sludge holding tanks
Sludge dewatering	Two – centrifuges/conveyors Three – aerated centrate holding tanks
Chemical storage	Spare totes each for phosphoric acid, micronutrients, citric acid, sodium hypochlorite, sodium hexametaphosphate, and sludge dewatering polymer (one tote in use and one tote as supply to first tote) Four storage tanks for carbon substrate for a minimum of 14 days storage at average flow and dose Two storage tanks for sulfuric acid for a minimum of 14 days storage at average flow and dose
Chemical feeds	One duty pump and one standby pump of largest capacity for each main chemical application point

VOC = volatile organic compounds
VPGAC = vapor phase granular activated carbon

2.3.2.2 Radiological Treatment Basis of Design

The objective of the technetium-99 IX system is to reduce the concentration of technetium-99 to less than 900 pCi/L prior to conveyance to the main treatment building. Table 2-8 summarizes the anticipated influent water quality to the technetium-99 IX system and Table 2-9 provides a summary of the anticipated and estimated effluent treated water quality discharged from the technetium-99 IX system to the main treatment building. Table 2-10 provides a summary of the estimated design criteria for the technetium-99 IX system. These are presented for reference and comparative purposes and may vary.

Table 2-8. Estimated Technetium-99 IX Influent Water Quality Values

Parameter	Average Value	
Influent water temperature (raw well water)	65° F	
Estimated influent water temperature	Recommended design range: minimum 40° f, maximum 90° F	
pH	Average: 7.7	
COCs	**Average Value**	**Units**
Carbon tetrachloride	491	µg/L
Nitrate as nitrogen	69	mg/L
Hexavalent chromium	161	µg/L
Chromium (total)	161	µg/L
Trichloroethylene	3.2	µg/L
Iodine-129	0.9	pCi/L
Technetium-99	14,700	pCi/L
Tritium	23,800	pCi/L
Uranium	5.9	pCi/L
Non-COCs	**Average Value**	**Units**
Alkalinity as (CaCO3)	103	mg/L
Calcium	75	mg/L
Chloride	18	mg/L
Chloroform	0.025	mg/L
Fluoride	0.37	mg/L
Iron (dissolved)	0.19	mg/L
Magnesium	24	mg/L
Manganese (dissolved)	0.049	mg/L
Potassium	7	mg/L
Sodium	24	mMg/L
Sulfate	34	mg/L
TOC	1.3	mg/L
TSS	3.0	mg/L
TDS	614	mg/L

CACO3 = calcium carbonate
COC = contaminant of concern
TDS = total dissolved solids
TOC = total organic carbon
TSS = total suspended solids

Table 2-9. Approximate Radiological IX Finished Water Quality Requirements and Goals

Parameter	Point of Compliance	Finished Water Quality Standard		Acceptance Standard Description	Design Treatment Goal
		Value	Units		
Iodine-129	Pipeline to injection wells	1	pCi/L	Federal MCL	0.6 to 1 pCi/L
Technetium-99	Pipeline to injection wells	900	pCi/L	Federal MCL	540 pCi/L
Tritium	Pipeline to injection wells	20,000	pCi/L	Federal MCL	12,000 to 20,000 pCi/L
Uranium	Pipeline to injection wells	30	pCi/L	Federal MCL	18 to 30 pCi/L

Table 2-10. Generalized Technetium-99 IX Design Criteria

Parameter	Value	Units
Number of trains	2	#
Nominal flow rate (per train)	350	gpm
Maximum sustained flow rate (per train)	400	gpm
IX Vessels		
Number per train	3	#
Number of trains (Skids)	2	#
Resin volume per vessel	300	ft^3
Hydraulic loading rate (maximum)	7 to 8	gpm/ft^2
Resin loading rate (maximum)	1 to 1.5	gpm/ft^3
Pumps		
Number	2 (1 standby)	#
Capacity	700 to 1,200 (needs verified)	gpm
Filters		
Inlet cartridge filters	3	#
Cartridges (number per filter)	52	#
Particle size rating	5	micron
Effluent bag filters	3	#
Filter bags (number per filter)	4	#
Particle size rating	50	micron
Resin Holding Tank		

Table 2-10. Generalized Technetium-99 IX Design Criteria

Parameter	Value	Units
Material	FRP	--
Diameter	11	ft
Height (w//cone)	13' 9"	--
Maximum working capacity	8,886	Gal

2.3.2.3 Biological Groundwater Treatment Facilities Basis of Design

Groundwater from the technetium-99 ion exchange system will flow to the biological treatment system equalization tank where it will be blended with the extracted groundwater from the remainder of the well field. The treatment process for carbon tetrachloride and nitrate removal will have two treatment trains initially to accommodate flow ranges up to 2,500 gpm, with space within the facility reserved for a third parallel train that can be added in the future to accommodate a higher flow rate of 3,750 gpm.

The biological groundwater treatment facilities include an anoxic FBR and an aeration/membrane filtration system. The objective of this system is to remove nitrate and carbon tetrachloride from the groundwater prior to re-injection. The FBR uses micro-organisms that use nitrate as an electron acceptor (like an oxygen source) for biological growth. The addition of external carbon and phosphorus sources is required to provide food and nutrient sources for growth of the organisms.

Table 2-11 provides a summary of the anticipated influent water quality to the biological treatment system for the 2,500 gpm capacity operation and Table 2-12 summarizes the anticipated influent water quality for the 3,750 gpm capacity operation. Table 2-13 provides finished water quality requirements and goals for the biological groundwater treatment systems.

The primary components of the biological groundwater treatment system include:

- Anoxic/anaerobic biodegradation in a FBR
- Aerobic biodegradation/membrane filtration

Table 2-14 summarizes key design criteria for the FBR and Table 2-15 summarizes key design criteria for the aeration/membrane filtration units.

Table 2-11. Estimated Biological Treatment System Influent Water Quality with Technetium-99 Pretreatment—2,500 gpm Capacity[a]

Parameter	Estimated Raw Water Quality	Units
Influent water temperature[b]	65	Degrees F
Estimated influent water temperature[c]	Design range: 47 to 78	Degrees F
pH	Average 7.7	Standard units
COCs	**Average**	**Units**
Carbon tetrachloride	650 to 750	ug/L
Nitrate as nitrogen[e,g]	35 to 45	mg/L
Hexavalent chromium[e]	27	ug/L
Trichloroethylene[e]	3.7	ug/L
Iodine-129[e]	0.15	pCi/L
Technetium-99[d,e]	227	pCi/L
Tritium[e]	8,180	pCi/L
Uranium[e]	3.6	pCi/L
Non-COCs	**Value**	**Units**
Chromium (total)[f]	26	ug/L
Alkalinity as (CaCO3)[f]	112	mg/L
Calcium[f]	67	mg/L
Chloride[f]	20	mg/L
Chloroform[f]	0.044	mg/L
Fluoride[f]	0.35	mg/L
Iron (dissolved)[f]	0.26	mg/L
Magnesium[f]	20	mg/L
Manganese (dissolved)[f]	0.089	mg/L
Potassium[f]	5	mg/L
Sodium[f]	20	mg/L
Sulfate[f]	38	mg/L
TOC[f]	1.7	mg/L
TSS[f]	1.6	mg/L
TDS[f]	465	mg/L

a. Influent chemistry based on blended concentrations of Wells EW-1 to -8, -12, -15, -16, -18, -19, and -20; S wells 26, 44, and 48; SX well 19; existing ZP-1 well 765; refer to 382519-CALC-020 and 382519-CALC-021.

b. Native groundwater temperature data based on site data; refer to 382519-CALC-001.

c. Estimate influent temperature based on planned pipe layouts and pumping rates; refer to 382519-CALC-001 for low temperature and 382519-CALC-0032 for high temperature.

Table 2-11. Estimated Biological Treatment System Influent Water Quality with Technetium-99 Pretreatment—2,500 gpm Capacity[a]

Parameter	Estimated Raw Water Quality	Units

d. Estimate assumes groundwater from two extraction wells (EW-6 and -7) in 200 West area, wells in S/SX Tank Farm, and existing ZP-1 well 765 are treated by the ion exchange system to less than or equal to 900 pCi/L Tc-99.

e. Maximum credible value based on hydrogeologic modeling and limited well data (M. Tonkin email, Jan 12, 2009 and S Simmons emails, Feb 4 and 17, 2009). Additional, more precise references pending update for 30 percent design.

f. Average value based on limited well data (S Simmons emails, Jan and Feb, 2009).

g. Average values used for nitrate loading per agreement with client.

Table 2-12. Estimated Biological Treatment System Influent Water Quality with Technetium-99 and U Pretreatment—3,750 gpm Capacity[a]

Parameter	Estimated Raw Water Quality	Units
Influent water temperature[b]	65	Degrees F
Estimated influent water temperature[c]	Design range: 47 to 78	Degrees F
pH	Average: 7.7	
COCs	**Average**	**Units**
Carbon tetrachloride[e]	661	ug/L
Nitrate as nitrogen[e,g]	40	mg/L
Hexavalent chromium[e]	47	ug/L
Trichloroethylene[e]	4.1	ug/L
Iodine-129[e]	0.27	pCi/L
Technetium-99[d,e]	273	pCi/L
Tritium[e]	9250	pCi/L
Uranium[e]	3.6	pCi/L
Non-COCs	**Value**	**Units**
Chromium (total)[f]	47	ug/L
Alkalinity as (CaCO3)[f]	110	mg/L
Calcium[f]	69	mg/L
Chloride[f]	20	mg/L
Chloroform[f]	0.041	mg/L
Fluoride[f]	0.35	mg/L
Iron (dissolved)[f]	0.25	mg/L
Magnesium[f]	21	mg/L
Manganese (dissolved)[f]	0.084	mg/L

Table 2-12. Estimated Biological Treatment System Influent Water Quality with Technetium-99 and U Pretreatment—3,750 gpm Capacity[a]

Parameter	Estimated Raw Water Quality	Units
Potassium[f]	5	mg/L
Sodium[f]	21	mg/L
Sulfate[f]	37	mg/L
TOC[f]	1.6	mg/L
TSS[f]	1.9	mg/L
TDS[f]	484	mg/L
Dissolved oxygen	11.3	mg/L

a. Influent chemistry based on blended concentrations of Wells EW-1 to -20; UP-1 wells 36, 39, and 43; S wells 26, 44, and 48; SX well 19; existing ZP-1 well 765; refer to 382519-CALC-020 and 382519-CALC-021.

b. Native groundwater temperature data based on site data; refer to 382519-CALC-001.

c. Estimate influent temperature based on planned pipe layouts and pumping rates; refer to 382519-CALC-001 for low temperature and 382519-CALC-0032 for high temperature.

d. Estimate assumes groundwater from three new extraction wells (EW-6, EW -7, and EW-13), existing wells in S/SX Tank Farm, an existing well in UP-1, and ZP-765 well are treated by the Tc-99 ion exchange system to less than or equal to 900 pCi/L Tc-99.

e. Estimate assumes groundwater from one extraction well in the UP-1 area is treated by the uranium ion exchange system to less than or equal to 30 ug/L uranium.

f. Maximum credible value based on hydrogeologic modeling and limited well data (M. Tonkin email, Jan 12, 2009 and S Simmons emails, Feb 4 and 17, 2009).

g. Average value based on limited well data (S Simmons emails, Jan and Feb, 2009). Additional, more precise references pending update for 30 percent design.

h. Average value used for nitrate loading per agreement with client.

Table 2-13. Finished Water Quality Requirements and Goals for the Biological Groundwater Treatment System

Parameter	Point of Compliance	Finished Water Quality Standard		Acceptance Standard Description	Design Treatment Goal
		Value	Units		
Carbon tetrachloride[a]	Pipeline to injection wells	3.4	ug/L	Specified by ROD	2 ug/L[b]
Chromium (total)	Pipeline to injection wells	100	ug/L	Federal MCL	60 to 100 ug/L
Hexavalent chromium	Pipeline to injection wells	48	ug/L	Specified by ROD	29 to 48 ug/L
Nitrate as nitrogen	Pipeline to injection wells	10,000	ug/L	Federal MCL	2,000 ug/L

a. The DOE will clean up COCs for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act–Cleanup," which includes carbon tetrachloride and trichloroethylene, so that the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

b. The design treatment goal for carbon tetrachloride is met by the air stripping system and is not a design parameter for the biological treatment system; although some degradation may occur.

Table 2-14. Fluidized Bed Reactor Design Criteria

Parameter	Value	Units
Hydraulic flux	20	gpm/ft^2
Hydraulic residence time, minimum	1100	seconds
Maximum tank diameter	14	feet
Minimum tank height	20	feet
Media type	Granular activated carbon	
Media volume per reactor, minimum	1850	ft^3
Nitrate loading per 1,000 ft^3 media, maximum	300	lb NO3-N
Design discharge nitrate concentration	0.5	mg/L NO3-N
Maximum allowable discharge nitrate concentration	6.0	mg/L NO3-N
Maximum external carbon dosing ratio agriculturally derived carbon source glycerin-based carbon source	 6.0:1 6.5:1	
Average discharge soluble BOD5 concentration	8.0	mg/L
Maximum discharge soluble BOD5 concentration	14.0	mg/L

Table 2-15. Aeration/Membrane Filtration Units Design Criteria

Parameter	Value	Units
Influent TSS concentration[a]	153	mg/L
Influent BOD5 concentration[a]	98	mg/L
Average soluble	5 to 8	mg/L
Maximum soluble	8 to 14	mg/L
Influent solubility TKN + Nitrate		
Average	1.0	mg/L
Maximum	4.0	mg/L
Influent alkalinity concentration (as $caco_3$)	100-220	mg/L
Minimum hydraulic retention time	30	minutes
Splitter structure mixed liquor suspended solids range	1000 to 5000	mg/L
Design discharge nitrate concentration	2.0	mg/L NO3-N
Maximum discharge nitrate concentration	8.0	mg/L NO3-N
Effluent BOD5, maximum	7.0	mg/L
Effluent TSS, maximum	1.0	mg/L
Effluent turbidity, maximum	0.5	NTU
Number of systems for 2,500 gpm capacity	2 active 0 standby	#
Number of systems for 3,750 gpm capacity	3 active 0 standby	#
Number of units 2,500 gpm capacity 3,750 gpm capacity	 4 6	 # #
Membrane Design Configuration		
Number of cassettes per train 2,500 gpm capacity 3,750 gpm capacity	 5 5	 # #
Maximum number of cassette spaces per unit	6	#
Maximum transmembrane pressure	12	psi
Membrane System Recovery without Backwash Recovery with Backwash Recovery	 91 96	 % %

a. Safety factor has been added to FBR effluent values to provide aeration/membrane filtration influent values.

2.3.2.4 Sludge Handling Basis of Design

The purpose of the biological sludge handling facilities is to process the biological solids removed by the biological treatment systems. The sludge handling facilities include waste activated sludge storage, sludge

thickening and sludge dewatering systems. Tables 2-16, 2-17, and 2-18 provide a summary of the anticipated sludge quantities generated at groundwater treatment flow rates of 1000 gpm, 2,500 gpm, and 3,750 gpm, respectively.

The primary process equipment for the sludge handling system includes:

- Aerated sludge holding tank
- Rotary drum thickeners
- Dewatering centrifuges
- Centrate sump
- Centrate aeration tank

Tables 2-19 through 2-22 provide summaries of the key design criteria for each of these components of the sludge handling system.

Table 2-16. Estimated Sludge Quantities for Startup—1,000 gpm Operation

Parameter	Out of Membrane Tank[a]	Out of Aerated Sludge Storage[b,c]	Dewatered Sludge[c]
Expected average solids volume			
Dry solids (ton/yr)	500	364	346
Expected case solids (% solids)	0.3 to 0.5	2.5 to 3.0	18 to 20
Volume (ft^3/week)			700 to 1,100
Worst case solids volume			
Dry solids (ton/yr)	508	396	376
Worst case solids (% solids)	0.4	2.5	20
Volume (ft^3/week)			1300

a. Assumes 1.2 days solids retention time in aeration/membrane tanks.

b. Assumes 20-25% solids reduction in aerated holding tank.

c. Assumes 97% capture of solids during thickening process and 95% capture during the dewatering process.

Table 2-17. Estimated Sludge Quantities for 2,500 gpm Plant Capacity

Parameter	Out of Membrane Tank[a]	Out of Aerated Sludge Storage[b,c]	Dewatered Sludge[c]
Expected average solids volume			
Dry solids (ton/yr)	719	523	429
Expected case solids (% solids)	0.3 to 0.5	2.5 to 3.0	18 to 20
Volume (ft^3/week)			1550 to 1770
Worst case solids volume			
Dry solids (ton/yr)	754	588	559
Worst case solids (% solids)	0.4	2.5	18
Volume (ft^3/week)			1940

a. Assumes 1.2 days solids retention time in aeration/membrane tanks.

b. Assumes 20-25% solids reduction in aerated holding tank.

c. Assumes 97% capture of solids during thickening process and 95% capture during the dewatering process.

Table 2-18. Estimated Sludge Quantities for 3,750 gpm Plant Capacity

Parameter	Out of Membrane Tank[a]	Out of Aerated Sludge Storage[b,c]	Dewatered Sludge[c]
Expected average solids volume			
Dry solids (ton/yr)	1,080	784	745
Expected case solids (% solids)	0.5	3.0	20
Volume (ft^3/week)	134,000	16,300	2,320
Worst case solids volume			
Dry solids (ton/yr)	1,130	882	838
Worst case solids (% solids)	0.4	3.0	18
Volume (ft^3/week)	176,000	22,000	2,900

a. Assumes 1.2 days solids retention time in aeration/membrane tanks.

b. Assumes 20-25% solids reduction in aerated holding tank.

c. Assumes 97% capture of solids during thickening process and 95% capture during the dewatering process.

Table 2-19. Aerated Sludge Holding Tank Design Criteria

Parameter	Value	Units
Type	Heated and Insulated FRP	
Tank volume	32,225	gal
Diameter	14	ft
Height	28	ft
Air requirements	600/tank	scfm
Diffuser type	Course Bubble	

scfm = standard cubic feet per minute

Table 2-20. Rotary Drum Thickener Design Criteria

Parameter	Value	Units
Type	Wedge wire or screen fabric	
Sludge flow applied to thickener	25 to 50	gpm
Influent sludge percent dry solids	0.2 to 0.5	%
Solids concentration out of thickener	3.5 to 5.0	%
Percent recovery of suspended solids	95 to 98	%
Polymer dosage to influent sludge	12 to 20	lbs/dry ton solids
Power	3	Hp

Table 2-21. Dewatering Centrifuge Design Criteria

Parameter	Value	Units
Type of centrifuge	High solids horizontal	NA
Sludge flow applied to centrifuges	130	gpm
Influent sludge percent dry solids	2.0 to 3.0	%
Dewatered solids concentration out of centrifuges	15 to 20	%
Maximum solids loading rate, each	1,780	lbs/hr
Percent recovery of suspended solids	95 to 98	%
Polymer dosage to influent sludge	12 to 20	lbs/dry ton solids
Expected hours of operation for 2,500 gpm capacity	6	hours/week
Expected hours of operation 3,750 gpm capacity	12	hours/week

Table 2-22. Aerated Centrate Tank Design Criteria

Parameter	Value	Units
Type	Heated and Insulated FRP	
Tank volume	32,225	gal
Diameter	14	ft
Height	28	ft
Air requirements	60/tank	scfm
Diffuser type	Course Bubble	

2.3.2.5 Sludge Stabilization System Basis of Design

Dewatered sludge from the centrifuges will be stabilized with lime to control free water and kill the biomass to prevent further decomposition and generation of objectionable gasses and odors. Dewatered sludge screw conveyors will transfer dewatered sludge from the centrifuges to the pug mill where lime will be added and mixed with the sludge. Screw conveyors will transport the stabilized sludge to containers for disposal. The system also includes two lime silos and lime transfer screw conveyors.

The lime/sludge stabilization system is designed to meet the following system objectives:

1. Remove additional moisture to ensure no free liquids.
2. Stabilize the sludge to minimize odor generation for a period up to three weeks as the sludge sits in the tarped ERDF roll-offs awaiting transport and disposal.
3. Maintain a sludge consistency adequate to facilitate loading and unloading the ERDF roll-offs.
4. Size the stabilization system to allow 1-day/week operation during the first phase of operation (up to 2500 gpm groundwater treatment capacity), and 2-day/week operation if after system is expanded to full design capacity (groundwater treatment up to 3750 gpm).
5. Provide sufficient system redundancy and flexibility commensurate with the balance of the treatment system.
6. Provide a degree of maintenance and operability consistent with the balance of the treatment system.
7. Use 22-cy ERDF roll-offs and already established procedures for tarping the roll-offs, loading them onto the trucks, and unloading new roll-offs.
8. Contain the sludge to minimize spillage and odor release.
9. Provide a system design life of 25 years.

The selected sludge stabilization process is quicklime stabilization. Quicklime stabilization consists of mixing enough quicklime (calcium oxide, or CaO) with the centrifuge cake to absorb residual moisture and minimize biological odor-causing activity due to the high pH. The system will be configured to achieve Class B stabilization requirements. Class B stabilization requirements are defined in 40 CFR Part 503 "Standards for the Use or Disposal of Sewage Sludge." The pH will be elevated to greater than 12.0 for 2 hours and remain at a pH greater than 11.5 for an additional 22 hours to meet the Class B vector attraction reduction requirements.

Quicklime stabilization is recommended because it is a highly effective process and relatively simple, robust, and flexible process. The process of mixing sufficient lime with the sludge can be volumetrically controlled, it is readily started and stopped, and it can be quickly adjusted to meet varying sludge cake production rates. These traits are desirable given the need to operate the system once or twice per week, or on an as needed basis.

Table 2-23 provides a summary of key design criteria for sizing the lime stabilization system.

2.3.2.6 Chemical Feed Systems Basis of Design

The maximum design flow of 3750 gpm was used to determine chemical storage and equipment space requirements for each of the chemicals used in the treatment processes. Table 2-24 provides key design criteria for the major process equipment, vessels, and containment areas that make up the chemical feed systems.

2.3.2.7 Air Stripping System Basis of Design

The air stripping system is designed to remove carbon tetrachloride and other VOCs from the groundwater and to control VOC emissions within the treatment area to acceptable work place levels. The air stripping system is designed to remove carbon tetrachloride that is not removed in the biological treatment processes.

Because the air stripper tower will be piped so that the treatment can occur before or after the biological treatment process, the tower must be designed for a dual set of operating parameters for each phase of treatment. Table 2-25 presents the estimated water quality analysis for the influent to the air stripper for all four treatment options (startup and full capacity both before and after biological process). Table 2-26 provides a summary of key design criteria for the air stripping system.

The 200 West Area groundwater treatment facility will be capable of meeting the requirements of the ROD. The finished water quality requirements and goals for the air stripper facility are presented in Table 2-27. The final cleanup levels for the groundwater VOCs are based on groundwater cleanup standards. However, the design treatment goal is for the finished water quality to be less than the target finished water quality standard to allow for an operational factor. The nominal operating treated effluent target will be 60 percent of the final cleanup level under normal operations.

2.3.2.8 Off-Gas Treatment System Basis of Design

The 200 West Area groundwater treatment facility requires emission controls for off-gases of the equalization tank, air stripper(s), FBR(s), membrane tanks, sludge holding tank(s), recycle tank, rotary drum thickeners, and centrifuges. Preliminary estimates of air emissions toxicity values indicated that the off-gas treatment system would require a minimum capture rate of 96 percent to meet the proposed local air emission limit for carbon tetrachloride.

Off-gas treatment will be accomplished with VPGAC vessels. Air stripper, tank and process vessel off-gas will be treated to remove VOCs prior to discharge to the atmosphere. Table 2-28 presents the influent data, model results, current emission limits, and proposed emission limit for carbon tetrachloride the design is intended to meet.

Table 2-29 provides a summary of key design criteria for the VPGAC vessels.

Table 2-24. Chemical Feed Systems Design Criteria

Item	Value	Units	Comments
Minimum containment volume freeboard	6	In	
Number of secondary containment areas	1	Ea	Separate containment for each chemical.
Secondary containment area sump pump criteria	15	gpm	Provided for carbon substrate and sulfuric acid containment areas. Also provided for common chemical room trench drain. Pump capacity of 15 gpm at 10 psi.
Motor Driven Metering Pumps			
Speed adjustment ratio	10:1	Ratio	Speed adjustment will be from 0 to 100 percent with a guaranteed accuracy of ±0.5 percent steady state on set point over a 10:1 flow turndown range.
Electronic stroke length ratio	10:1	Ratio	Adjusted through pump controls.
Overall turndown ratio	100:1	Ratio	Resulting overall turndown based on speed and stroke length adjustments.
Net positive suction head	3	psia	Suction hydraulics to provide proper net positive suction head.

Table 2-23. Sludge Stabilization Sizing Basis

Parameter	Units	2500 gpm Plant Capacity		3750 gpm Plant Capacity	
		Average Annual	Maximum Month	Average Annual	Maximum Month
Total dry solids from both centrifuges (at 365 day/yr operation)	dry lb/day	2,350 to 2,800	3,105	4,140	4,657
% Solids by weight from centrifuge	wt%	18	18	18	18
Wet centrifuge cake density	wet lb/cf	52	52	52	52
Days per week system operates	day/wk	1	1	2	2
Hours per day system operates	hr/day	6	6	6	6
Total dry solids from both centrifuges (per day of operation)	dry lb/day	19,332	21,732	14,491	16,299
Total cake volume from both centrifuges (per day of operation)	cy/day	76	86	57	65

Table 2-24. Chemical Feed Systems Design Criteria

Item	Value	Units	Comments
Storage Vessels			
Quantity at maximum flow and maximum dose	14	days	
Maximum vessel height	16	feet	Reserve a minimum 4-foot clearance from vessel top to roof framing structure for access.
Maximum vessel diameter	14	feet	Larger-diameter tanks would require field fabrication.
Chemical Truck Containment Area and Unloading Panels			
Chemical truck unloading area	–	–	A concrete chemical unloading pad will be provided along the south side of the Bioprocess facility by the Chemical Storage room. A sump pump will be provided with a capacity of 15 gpm at 10 psi.
Chemical unloading panel	–	–	The carbon substrate system will have a chemical unloading panel along the exterior wall face adjacent to the carbon substrate tank location. The sulfuric acid system will have a chemical unloading panel adjacent to the sulfuric acid tanks.
Secondary Containment			
Minimum chemical spill volume	120 30	% %	Greater of 120 percent of largest vessel volume or 30 percent of total vessel volume per chemical.
Minimum fire sprinkler water volume	0.15	gpm/sf	30 minute duration.

Table 2-25. Estimated Air Stripper Influent Water Quality

	Average Value Before Bioprocess[a]		Average Value After Bioprocess[a]		
Parameter	Startup[b]	2,500 gpm Capacity[b]	Startup[b]	2,500 gpm Capacity[b]	Units
Carbon Tetrachloride	738	660 to 670	738	20 to 30	ug/L
Nitrate as Nitrogen (average)	35	40 to 50	2	2	mg/L
Hexavalent Chromium	27	47	nil	20 to 50	ug/L
Trichloroethylene	3.7	4.1	3.7	<1	ug/L
Iodine-129	0.15	0.20 to 0.30	0.15	0.2 to 0.3	pCi/L
Technetium-99	227	83	227	<10	pCi/L
Tritium	8,200	9,315	8,200	9,315	pCi/L
Uranium	3.6	3.2	3.6	3.2	ug/L
Chromium (total)	26	47	<26	<47	ug/L
Alkalinity (as $CaCO_3$)	112	110	150	217	mg/L
Calcium as Ca	67	69	67	69	mg/L
Chloride	20	20	20	20	mg/L
Chloroform	0.044	0.041	0.044	<0.5	mg/L
Fluoride	0.35	0.035	0.35	0.035	mg/L
Iron (dissolved)[c]	0.26	0.025	nil	nil	mg/L
Magnesium	20	21	20	21	mg/L
Manganese (dissolved)[c]	0.089	0.084	<0.089	<0.084	mg/L
Potassium	5	5	5	5	mg/L
Sodium	20	21	20	21	mg/L
Sulfate	38	37	38	37	mg/L
Total Organic Carbon	1.7	1.6	1.7	1.6	mg/L
Total Suspended Solids[c]	1.6	1.9	nil	nil	mg/L
Total Dissolved Solids	305	484	305	484	mg/L

a. The analyses indicated are estimated analyses for two potential operating scenarios that affect specified process influent conditions, treatment before biological treatment and treatment after the biological treatment.

b. Startup incoming groundwater flow rate is 1250 gpm maximum and full operational flow rate is 2500 gpm maximum.

c. Indicated contaminants may deviate up to twice the indicated value. Information concerning the recommended antiscalent and dosage, as well as the maximum allowable concentration of the specified parameters when using the antiscalent, will be requested from the air stripper manufacturer.

Table 2-26. Air Stripper Design Criteria

Parameter	Value	Units
Type	Forced-draft, counter-current	
Capacity	600-1,250	gpm
Design flux	15-25	gpm/ft^2
Air-to-water ratio	15:1 minimum 42:1 maximum	
Housing		
Material	Heated and Insulated FRP	
Diameter	12	ft
Height	70	ft
Packing		
Type	Polypropylene	
Number of beds	2	#
Bed depth, minimum	20	feet
Packing size, maximum	2.3	inch
Allowable headloss (clean packing material at maximum air and water flow rates)	0.02	in. WC/ft
Packed bed safety factor	25	%
Minimum free area of packing supports (percentage of cross-sectional area)	90	
Inlet water distributor		
Type	V-notch distribution and parting boxes	
Distribution points	6	#/ft^2
Water redistributor		
Type	Orifice-riser	
Minimum water level above orifice	2	inches
Distribution points	6	#/ft^2
Inlet air distributor		
Allowable air face velocity distribution gradient	5	%
Mist eliminator		
Type	Mesh-type	
Thickness	6	inch
Water droplet removal	Adjustable speed	
> 10 microns in diameter	99.5	%

Table 2-27. Air Stripper Finished Water Quality Requirements and Goals

Parameter	Point of Compliance	Finished Water Quality Standard		Acceptance Standard Description	Design Treatment Goal
		Value	Units		
Carbon tetrachloride[a]	Pipeline to injection wells	3.4	ug/L	Specified by ROD	2 ug/L
Trichloroethylene[a]	Pipeline to injection wells	1	ug/L	Specified by ROD	0.6 to 1 ug/L

a. The DOE will clean up COCs for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act–Cleanup," which includes carbon tetrachloride and trichloroethylene, so that the excess lifetime cancer risk does not exceed 1×10^{-6} at the conclusion of the remedy.

Table 2-28. Finished Air Quality Requirements and Goals

Pollutant	Maximum 1-Hour Concentration (µg/m³)	Annual Average Concentration (µg/m³)	Annual ASIL(µg/m³)
Carbon tetrachloride	0.0149	0.0012	0.0238
Chloroform	0.1120	0.0090	0.0435
Vinyl chloride	0.0035	0.0003	0.0128

See Air Emissions Calculation (CALC-053, Rev. 1) for modeling inputs and results.

Table 2-29. Vapor Phase Granular Activated Carbon Vessel Design Criteria

Parameter	Value	Units
Type	Horizontal roll-off	
Bed capacity	20,000	lb
Design velocity	0.5 to 1.2	ft/s
Humidity (percent relative)	40 to 60	%
Bed depth	5 to 6	feet
Configuration	Series operation	
VOC removal		
at Start-up of Vessel	99	%
at Exhaustion of Vessel	90	%
Number of active units per phase	2.0	#

2.3.3 Specification of Construction Materials

A brief narrative of the materials of construction that will be used for the 200 West Area groundwater P&T system is provided in the sections that follow. This narrative is intended as a summary of the construction materials related to the treatment process, not as a comprehensive listing of all material types for every piece of equipment or structure in each respective unit process or structure. Details of the materials selection is provided in the design drawings and specifications (provided under separate cover).

The discussion below focuses on the following exposures that warrant special consideration for material selection:

- Buried exposure
- Atmospheric exposure
- Technetium-99 exposure
- Chemical exposure

2.3.3.1 Buried Exposure

The majority of buried process piping will be high-density polyethylene (HDPE), which will require no special corrosion mitigation. It is not anticipated that there will be much buried metallic piping. Any buried ductile iron pipe should be protected with polyethylene encasement in accordance with American Waste Water Association (AWWA) C105. Galvanized pipe should not be used for underground service. Copper pipe may be used underground. However, it should be electrically isolated from ferrous structures to eliminate galvanic (2-metal) corrosion.

2.3.3.2 Atmospheric Exposure

The use of aluminum, stainless steel, FRP and other nonmetallic materials can be used in addition to coated carbon steel for most plant atmospheres. The application of high performance coating systems to carbon steel surfaces is recommended throughout the facility. High performance coating systems are defined further in the design documentation provided under separate cover.

2.3.3.3 Technetium Exposure

Technetium-99 bonds with ferrous metals. Uncoated carbon steel, ductile iron, and other ferrous metals will not be used in immersion service with technetium-99 exposure. Stainless steel (Type 304), polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC) or fiber-reinforced plastic (FRP) wetted parts and piping are specified for these services.

2.3.3.4 Chemical Exposure

The majority of these chemicals will be delivered and stored in chemical resistant Totes. Table 2-30 provides recommendations apply to the storage tanks and associated pumps and piping and Table 2-31 provides pipe material guidelines for chemical feeds.

Table 2-30. Chemical Exposure Material Specifications

Chemical	Tanks	Pump	Piping	Valves
Alum	PE totes, FRP	Nonmetallic wetted parts	PVC or CPVC	PVC or CPVC
Antiscalant	PE totes, FRP	Nonmetallic wetted parts	PVC or CPVC	PVC or CPVC
Calcium oxide	PE totes, FRP	Nonmetallic, steel	PVC, steel	PVC, steel
Carbon substrate	FRP	Nonmetallic wetted parts	PVC, CPVC, FRP	Nonmetallic
Citric acid	PE totes, FRP	Nonmetallic wetted parts	PVC, CPVC, FRP	Nonmetallic
Hydrochloric acid	PE totes, FRP	Nonmetallic wetted parts	PVC, CPVC	PVC, CPVC
Micronutrient	PE totes	Nonmetallic wetted parts	PVC, CPVC	PVC, CPVC
Phosphoric acid	PE totes, FRP	Nonmetallic wetted parts	CPVC, FRP	PVC, CPVC
Polymer	FRP, PE	Nonmetallic wetted parts	PVC, CPVC, FRP	Nonmetallic
Sodium bisulfite	PE totes, FRP	Nonmetallic wetted parts	PVC, CPVC	Nonmetallic
Sodium hydroxide	PE totes, FRP	Cast steel	PVC, CPVC	PVC, CPVC
Sodium hypochlorite	PE totes, FRP	Nonmetallic wetted parts	FRP, CPVC, PVC	Nonmetallic
Sodium nitrate	PE totes, FRP	Nonmetallic wetted parts	PVC, CPVC, FRP	Nonmetallic
Sulfuric acid	PE totes	Alloy 20	Type 304 or 316 stainless steel (6 fps max velocity)	CF-8 or CF-8M for shut-off; Alloy 20 for throttling

Notes:

When two materials are listed, the first is preferred.

PE = polyethylene

Table 2-31. Chemical Feed Pipe Material Specifications

Chemical	Pipe material
Anti-scalant	PVC
Calcium oxide carbon substrate	STL w/ Hammertek Lining
Citric acid	PVC
Ferric chloride	PVC
Hydrochloric acid	PVC
Micronutrient	PVC
Phosphoric acid	CPVC
Polymer	PVC
Cationic (RDT) polymer	PVC
Cationic (centrifuge) sodium bisulfite	PVC
Sodium hydroxide	PVC
Sodium hypochlorite	PVC
Sodium nitrate	PVC
Sulfuric acid	SST

2.4 Balance of Plant

The balance of plant (BOP) design includes conveyance piping, transfer pumps and transfer buildings necessary to pump the extracted groundwater to the 200 West Area groundwater treatment facility, and from the treatment facility to the injection wells. BOP also includes any administrative, maintenance, or other infrastructure (e.g., site grading and access roads) and utilities designed to support the treatment facilities. The balance of plant design includes:

- Utilities
- Access roads and road crossings
- Grading and drainage
- Yard piping
- Groundwater conveyance (piping, transfer pumps and transfer buildings)

2.4.1 Basis of Design

The basis of design for key elements of the BOP design is discussed below.

Major Site Features

The plant facility contains a radiological building and a biological process building. A biological process equipment pad is provided on the north side of the biological process building. Unloading areas are provided for GAC canisters and chemical deliveries. A paved asphalt apron surrounds the buildings and equipment pad to provide facility access and act as a fire buffer zone.

Access Roads

Two access points are provided to the 200 West Area groundwater treatment facility. A paved driveway is provided on the west side of Beloit Avenue between 22nd Street and 23rd Street. A second paved driveway is provided on the north side of 22nd Street between Beloit Avenue and Bridgeport Ave. Beloit Avenue is paved road and 22nd Street is a gravel road.

Grading and Drainage

The existing topography of the 200 West Area groundwater treatment facility site is generally flat terrain sloping to the northwest. Native vegetation currently exists on site with an area that appears to have been previously cleared. The site will be graded away from the buildings to the exterior of the apron and onto the existing ground surface and allowed to infiltrate. Existing drainage flow paths will be preserved.

Yard Piping

A 12-inch diameter sanitary water line is provided in a loop around the 200 West Area groundwater treatment facility site to provide building fire and service water, and supply the fire hydrants. This line ties into an existing 12-inch diameter sanitary water line that runs along the northwest corner of the site.

A sewage line will exit the building and be stored in a sewage holding tank. Piping to/from the transfer buildings and wells will exit the site through open trenches with grating through the asphalt apron.

Groundwater Conveyance Piping

Above-ground HDPE pipelines convey the contaminated groundwater from the extraction wells to the transfer buildings and from the treatment facility to the injection wells. The HDPE pipelines are essentially an unrestrained piping system, since changes in the piping temperature result in dimensional changes. Decrease in temperature results in shortening of the piping, while temperature increase results in lengthening of the piping. End-point anchors are provided at the transfer buildings.

Insulation and heat trace are provided at each well head for freeze protection in winter conditions as required. The minimum expected temperature is -25 degree F. Heat tracing is adjusted to operate at 40 degree F and below.

Transfer Buildings

Each of the four transfer buildings include a transfer tank made from fiber-reinforced plastic. Extraction building No. 2 (289TC) includes two transfer tanks, one for technetium-99 contaminated groundwater and one for non-technetium-99 contaminated groundwater. Each tank is approximately 122 inches in height with varying diameters. The storage tanks receive water from the extraction wells and function as the supply reservoirs for the transfer pumps. Each tank includes a level transmitter indicator, a "high-high" level float switch, a low level float switch, temperature indicator, vent, and a discharge pipeline. The "high-high" level float switch prevents the tank from overflowing. The low-level switch prevents the transfer pumps from running below the minimum net positive suction head (NPSH) of the pumps, which would damage the equipment.

A leak detection system in each transfer building uses optical-type liquid level probes mounted below finished floor grade in strategic locations. The probes are connected in series to the PLC. The system is designed to enable the pump AFDs in each building; otherwise, it will alarm when any one of the probes detects the presence of leaking process water. Leak detection in the HDPE well piping and transfer building conveyance piping will be electronically monitored using the differential flow rates between inline flow meters as well as operations personal inspecting /walking the lines, at defined periods.

Each transfer building contains pumps used to pump water from the transfer building storage tanks to the treatment buildings or to the injection wells. Table 2-32 summarizes the pump locations, capacities and design head criteria.

Table 2-32. Transfer Building Pumps

Equipment Name	Location	Capacity	Units	Design Head (ft)
Extraction Transfer Pump A	Extraction Transfer Bldg. 1 (289TB)	650	gpm	81.5
Extraction Transfer Pump B	Extraction Transfer Bldg. 1 (289TB)	650	gpm	81.5
Extraction Transfer Pump A	Extraction Transfer Bldg. 2 (289TC)	455	gpm	86.5
Extraction Transfer Pump B	Extraction Transfer Bldg. 2 (289TC)	455	gpm	86.5
Extraction Transfer Pump C	Extraction Transfer Bldg. 2 (289TC)	455	gpm	86.5
Extraction Transfer Pump A	Extraction Transfer Bldg. 2 (289TC)	700	gpm	72.5
Extraction Transfer Pump B	Extraction Transfer Bldg. 2 (289TC)	700	gpm	72.5
Injection Booster Pump A	Injection Transfer Bldg. 1 (289TD)	960	gpm	100
Injection Booster Pump B	Injection Transfer Bldg. 1 (289TD)	960	gpm	100
Injection Booster Pump C	Injection Transfer Bldg. 1 (289TD)	720	gpm	180
Injection Booster Pump D	Injection Transfer Bldg. 1 (289TD)	720	gpm	180
Injection Booster Pump A	Injection Transfer Bldg. 2 (289TE)	1200	gpm	160
Injection Booster Pump B	Injection Transfer Bldg. 2 (289TE)	1200	gpm	160
Injection Booster Pump C	Injection Transfer Bldg. 2 (289TE)	960	gpm	285
Injection Booster Pump D	Injection Transfer Bldg. 2 (289TE)	960	gpm	285

2.4.2 Specification of Construction Materials

The final piping materials will be defined in the final design package, but as of now, piping from the extraction well pump to the top of the well would be constructed of stainless steel. Galvanized steel would transition from the stainless steel extraction pipe to HDPE piping that serves as the conveyance system from each well head to the transfer building.

The pipelines used to transport groundwater from each of the extraction wells are constructed of HDPE piping conforming to AWWA C906. The HDPE piping is specified for a pressure rating of 200 psi at 73 degrees F. At a service temperature of 110°F, the piping has a pressure rating of 150 psi.

2.5 200 West Area Groundwater P&T System Related Primary Documents

Two primary documents support this RDR. These include an operation and maintenance (O&M) plan, and a performance monitoring plan (PMP). These two documents are described below.

2.5.1 Operations and Maintenance Plan

The O&M Plan (DOE-RL-2009-124) outlines the activities necessary to operate, maintain, and monitor the operation of the 200 West Area groundwater P&T systems, from the completion of construction through decommissioning of the system.

The O&M plan serves as a regulatory/administrative document that describes how O&M of the remedy will be conducted. An adequate and functioning O&M program throughout a remedy's lifecycle is critical for successful implementation and ultimate achievement of the RAOs. The measures described in the O&M Plan are designed to provide guidance on implementation of the requirements necessary for maintaining the remedy to ensure protection of human health and the environment. Specifically, the plan presents discussion on process controls/instrumentation, response to off-normal events, data reporting requirements, the operating transition from the existing interim remedy to the final remedy, QA/QC and health and safety.

The appendix sections of the O&M Plan present a compliance matrix discussing the ARARs and how the facility will address each requirement, waste management requirements and handling/disposal requirements, sampling and analysis procedures for the well field and the process treatment system, and the air emission monitoring/sampling requirements.

2.5.2 Performance Monitoring Plan

The 200 West Area Groundwater Pump and Treat System Performance Monitoring Plan (DOE-RL-2009-115) has been prepared to guide groundwater monitoring data collection activities associated with implementation of the 200-ZP-1 OU remedial action. The PMP was prepared in a data quality objective (DQO) type format and presents recommendations for the types of data that should be collected, the well networks that should be monitored, the frequency data should be collected, and the analysis of the data to satisfy the requirements of the ROD.

Each of these is a DOE-designated primary document and has been submitted for review under separate cover and are on separate review and approval paths.

3 Construction Schedule

Construction of the 200 West Area Groundwater P&T systems will be completed in several separate efforts. The initial construction effort will provide an installed capacity to treat up to 2,500 gpm of extracted groundwater utilizing two parallel treatment trains.

The sections below provide a description of the Tri-Party Agreement (TPA) milestones and the key schedule elements (Figure 3-1) for construction of the 200 West Area Groundwater P&T systems.

3.1 TPA Milestones

The TPA milestones associated with the construction of the 200 West Area Groundwater P&T system are summarized in Table 3-1. Each of these milestones is discussed further within the schedule summary presented below.

Table 3-1. Summary TPA Milestones for 200 West Area Groundwater P&T System Construction

Milestone	Description	Date
M-16-124	Submittal of Remedial Design Report, Draft A (reflecting 90% design).	August 31, 2010
M-16-122	Begin Phase 1 operation of the new 200 West pump and treat system per the RD/RAWP and the 200-ZP-1 ROD. This action will provide the initial portion of the overall pump and treat capacity expected to be required by the 200-ZP-1 and 200-UP-1 RODs. This initial operation can provide treatment of the Tc-99 plume at the S/SX Tank Farm within the 200-UP-1 Operable Unit.	December 31, 2011

3.2 Schedule Summary

The 200 West Area Groundwater P&T system construction schedule is provided in Figure 3-1. Key schedule elements are summarized below.

- Remedial Design Report Preparation
- Well installation
- Construct Balance of Plant
- Construct Radiological Treatment Facility
- Construct Biological Process Facility
- Commissioning and Startup
- System expansion and optimization

TPA Milestone M-16-124 requires that Draft A of the RDR (presenting the 90 percent design) be submitted by August 31, 2010. Construction of selected elements started under the design/build delivery model in November 2009 with the installation of access road crossings, HDPE piping, and the extraction wells. Construction of transfer buildings will commence prior to completion of design activities. These early activities have been started in advance of completion of the remedial design to accelerate the construction schedule. Completion of construction activities for the initial efforts of construction (achieving an installed capacity to treat 2,500 gpm) is anticipated by September 30, 2011.

Construction acceptance testing (CAT) will be conducted to ensure equipment is installed as designed and that individual components operate as expected. CAT requirements are defined in the construction specifications. The end state of CAT is the systematic demonstration that the systems were installed per the design and the system is ready for functional testing during implementation of the acceptance testing procedure (ATP).

After completion of construction, commissioning and startup (acceptance and operational testing) will be performed to ensure that the system is operational and functional. This testing will be accomplished through the aforementioned ATP and the operational test procedure (OTP). The ATP demonstrates that fabrication, assembly, installation, and construction requirements meet design requirements and verifies that final systems and sub-systems are installed successfully per the functional design criteria. The OTP facilitates validation of operating procedures and completion of operator training. Calibration and necessary preventative maintenance will be conducted prior to the ATP/OTP. The ATP and OTP documents are prepared during the final design period and will be completed in time to support commissioning and startup of the system. The TPA milestone M-16-122 requires that the Phase 1 operation of the 200 West P&T begin by December 31, 2011. Additional phases of ATP/OTP will be conducted as additional capacity and/or wells are brought on line.

Upon completion of construction, facility commissioning, and initial startup, the system is projected to operate at approximately 1,000 gpm utilizing approximately 15 extraction wells, 5 injection wells, and associated conveyance infrastructure. By December 31, 2012, additional extraction and injection wells will be brought on line (optimization phase), based on aquifer performance, to further utilize the designed 2500 gpm treatment capacity of the facility. Currently a total of 20 extraction wells and 16 injection wells are projected for installation.

Design of the facility includes the ability to add a third treatment train (also in parallel) within the existing facility footprint and infrastructure, increasing the design flow rate to 3,750 gpm. This expansion phase (if necessary) is anticipated to occur after 2012.

Activity Name	Start	Finish
RDR - Primary Document Preparation and Support		
Prepare ZP-1 Remedial Design Report	Dec-2009	Aug-2010
TPA Milestone M-16-124: Submit Draft A, ZP-1 Remedial Design		Aug-2010
Well Installation		
Drill and Develop 15 Extraction Wells and 5 Injection Wells Supporting 1000 gpm Process Flow	Jun-2009	Jan-2011
Drill and Develop 5 Extraction Wells and 11 Injection Wells Supporting 2500 gpm Process Flow	Jan-2011	Sep-2012
Construct Balance of Plant		
Install Road Crossings and Transfer Piping for 15 Extraction Wells & 5 Injection Wells	Oct-2009	Nov-2010
Install Well Power for 15 Extraction Wells & 5 Injection Wells	Jun-2010	Dec-2010
Construct 2 Injection Transfer Buildings	Mar-2010	Jan-2011
Construct 2 Extraction Transfer Buildings	Mar-2010	Jan-2011
Perform Well Tie in Activities for 15 Extraction Wells & 5 Injection Wells	Aug-2010	May-2011
Install Road Crossings and Transfer Piping for 5 Extraction Wells & 11 Injection Wells	Jan-2012	Nov-2012
Install Well Power for 5 Extraction Wells & 11 Injection Wells	Jun-2012	Dec-2012
Perform Well Tie in Activities for 5 Extraction Wells & 11 Injection Wells	Aug-2012	May-2013
Construct Rad Building		
Construct Rad Building - Civil & Infrastructure	Jun-2010	Sep-2010
Construct Rad Building - Concrete & Building	Aug-2010	Dec-2010
Construct Rad Building - Install Process Equipment	Oct-2010	Jul-2011
Construct Rad Building - Perform Construction Acceptance Testing	Jun-2011	Sep-2011
Construct Bio Process Facility		
Construct Bio Process Facility - Civil & Infrastructure	Jun-2010	Sep-2010
Construct Bio Process Facility - Concrete & Building	Aug-2010	Feb-2011
Construct Bio Process Facility - Install Process Equipment	Jan-2011	Aug-2011
Construct Bio Process Facility - Perform Construction Acceptance Testing	Jun-2011	Sep-2011
200W Pump & Treat Facility Construction Substantially Complete		Sep-2011
Commissioning and Startup		
Perform ATP/OTP	Aug-2011	Jun-2012
TPA Milestone M-16-122: Begin Phase 1 Operations	Dec-2011	
Expansion & Optimization		
Expansion/Optimization	Jun-2012	Sep-2014

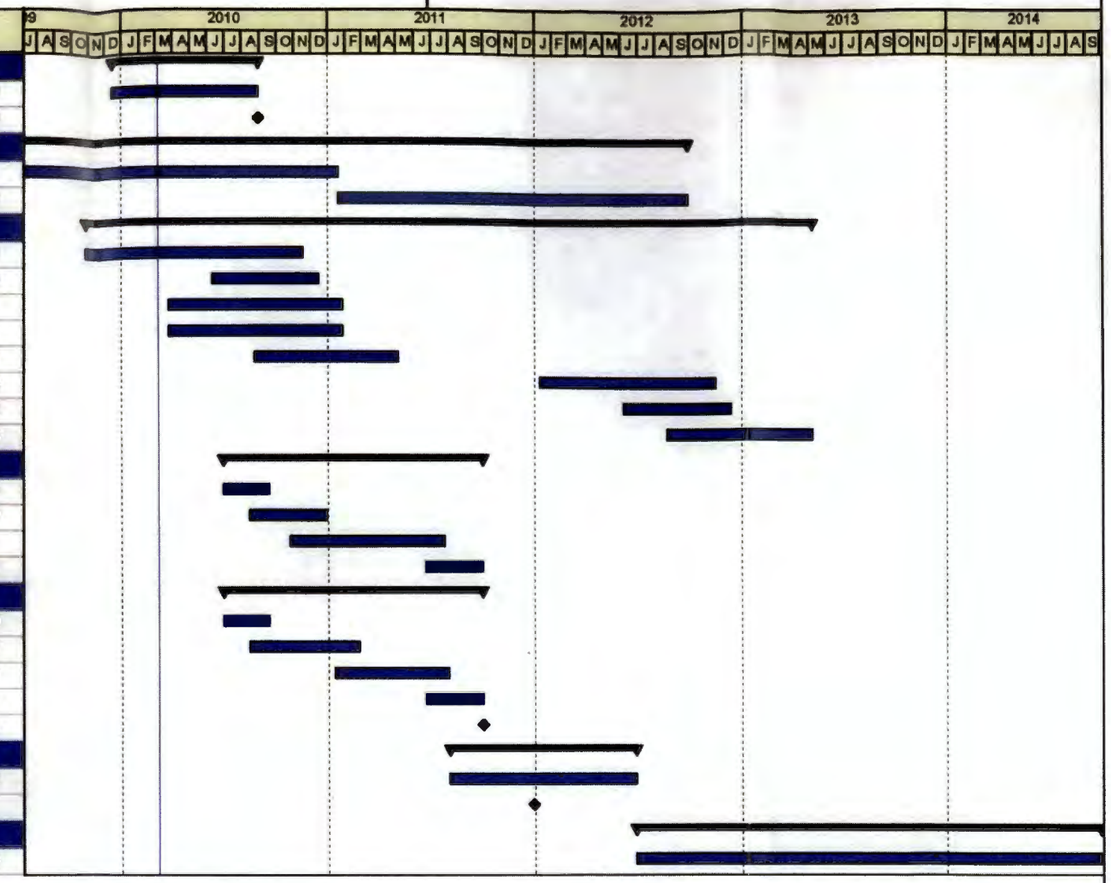

Figure 3-1. 200 West Area Groundwater P&T Construction Schedule

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4 Cost Estimate

The 200 West Area Groundwater P&T systems construction cost estimate has been prepared in coordination with the 90 percent design submittal. This estimate reflects the *current design* development, and, as such, is subject to change based on completion of the final design.

4.1 Basis of Estimate

The major elements of the cost estimate for constructing the 200 West Groundwater P&T systems is presented in the following sections.

The basis of estimate establishes the conditions and certain key assumptions (often not stated in the project scope) that provide a firm foundation for the development and presentation of costs for a given construction project. The cost items presented herein are designed to closely match the elements of the schedule, for comparative purposes.

4.1.1 Scope of Estimate

The scope of the estimate includes the engineering, design, construction, testing startup, and commissioning of the 200 West Area groundwater P&T systems, with an initial installed treatment capacity of 2,500 gpm. Initial construction activities include; groundwater extraction and injection wells that will have been installed at the time the treatment facility construction is complete (expected to be 15 extraction and 5 injection wells at startup). These wells are expected to extract groundwater at a combined rate of approximately 1,000 gpm to support initial operations, and will include wells from the vicinity of T-Tank Farm and S-SX Tank Farm. The treatment facility will be capable of treating the contaminants of concern (carbon tetrachloride, trichloroethylene, total chromium, hexavalent chromium, nitrate, iodine-129 and technetium-99), as specified in the RD/RAWP. Tritium is a COC, but will be managed through monitored flow path control and natural attenuation. The P&T system will also be able to treat uranium once the 200-UP-1 OU extraction and treatment systems are added (in the optimization and expansion effort) after initial startup.

After initial construction and operation of the system at 1,000 gpm, the remaining extraction wells (~5 total), remaining injection wells (~11), and associated transfer piping will be installed and hooked up to approach the 2,500 gpm pumping rates. This will bring the total number of wells to approximately 20 extraction wells and 16 injection wells. The estimate also reflects treatment of technetium-99 from the 200-UP-1 OU S-SX WMA, as well as adding the uranium IX treatment train (up to 350 gpm). Uranium treatment will be added to the system (as required by the 200-UP-1 OU ROD) once the remedial design is complete. This is expected to occur in the optimization and expansion effort.

4.1.2 Exclusions

The cost estimate does not include costs to drill and install the 200-UP-1 (S-SX and U-Plant) groundwater wells, laying transfer lines or installing pump stations to get 200-UP-1 groundwater to the 200-West Area Groundwater Treatment Facility. Those costs will be covered by the final remedy selected for 200-UP-1 OU. Also, the estimate does not include any capital equipment or other balance of plant costs to provide, deliver, or install a third biological process treatment train to increase the current designed process flow from 2,500 gpm to 3,750 gpm.

The cost estimate does not include contingencies for the defined scope of responsibility.

4.1.3 Cost Basis

The cost estimates include costs and capital expenditures associated with the engineering, design, construction, services, and fees to deliver the system as intended and necessary to meet defined objectives. These costs include but are not limited to the following:

- Engineering costs
- Design costs
- General and Administrative (G&A) costs
- Capital costs for procurement and delivery of equipment
- Taxes and fees
- Field mobilization and demobilization costs, insurance, and bonds
- Direct field construction costs
- Engineering services during construction
- Construction management services
- O&M manuals and startup plans
- Startup costs and commissioning
- Escalation costs during construction
- Other defined or determined costs as necessary

The estimate was prepared in accordance with CHPRC cost-estimating procedures and guidance documents, which establish the process and tools used in the development of CHPRC cost estimates. These documents control the development, review, documentation, and archiving of CHPRC cost estimates. The cost estimate was developed using Timberline cost estimating software, unit cost data from RS Means 2010 Facilities Construction Cost Data, other available cost and catalog data, and the estimator's professional judgment.

Engineering, design, and construction of the P&T Facility have already commenced. A minor portion of the estimate is based on actual cost and performance available at the time of estimation, and an extrapolation of that data has been applied to the work remaining where applicable.

The majority of the estimate is based upon current engineering and design documents as developed through current design development. Capital equipment pricing is based on developed process equipment lists and competitive cost quotations as received from manufacturers through an approved solicitation and procurement process. Where applicable, costs for pricing of "long lead" items included in this estimate were provided by CHPRC procurement.

Current cost information pertains to buildings and other structures, site utilities, and balance of plant systems, etc., was derived from the current design drawings (including equipment installation, mechanical systems, and process system interconnections). Other costs for mechanical systems, electrical systems, and instrumentation and control systems (as provided) are factored from the single line diagrams and process and instrument diagrams to determine the remaining balance of process costs to derive the estimated capital cost for the facility.

4.1.4 Accuracy of Estimate

This cost estimate is based on multiple methods and approaches for the development of the capital and construction costs for this facility. CHPRC has solicited and obtained price quotations for most of the capital equipment as well as representative quotations for the other cost components including buildings

and other structures. Other costs are developed by the utilization of process flow diagrams, process and instrument diagrams, single line diagrams, and applied factors to determine costs that are most probable for this type of water treatment facility.

The final costs of the project will depend on actual labor and material cost, competitive market conditions, final project scope, implementation schedule, and other variable conditions. As a result, the final project costs will vary from the estimate as developed and presented.

The classification of the construction cost estimate provided herein is considered to be Class 2 (Title II) with engineering and design less than 80 percent complete overall. As stated earlier, the project is using a design/build approach and therefore portions of the design are further defined than others (ranging from 60 to 90 percent overall). The accuracy of the estimate ranges between -10 percent to -20 percent and +10 percent to +30 percent. A Title II design estimate is defined as an estimate that uses the detailed design drawings and specifications to develop the costs for construction projects. These estimates are (1) produced at the completion of definitive design, (2) based on approved or "issued for approval" design documents, and (3) used as the basis for establishing the project construction budget.

4.2 Summary of Estimate

The 200 West Area Groundwater P&T system construction cost estimate is summarized in Table 4-1. Key elements of the construction cost estimate are broken down into the following categories:

- Well Installation
- Balance of Plant
- Radiological Process Facility
- Biological Treatment Facility
- Commissioning and Startup

4.2.1 Well Installation

The cost estimate for well installation includes a total of 20 groundwater extraction and 16 groundwater injection wells. Cost activities related to well installation include but are not limited to the following:

- Providing management support, labor support, and associated documentation (e.g., borehole compliance reports, and close-out activities)
- Drilling, installation, and development of groundwater wells
- Preparing well pads
- Sampling groundwater
- Conducting civil surveys of well locations

4.2.2 Balance of Plant

The BOP cost estimate includes but is not limited to the following:

- Conveyance piping installation (including road crossings)
- Well hookup to conveyance piping
- Power hookup for wells
- Construction of extraction transfer Buildings 1 and 2
- Construction of injection transfer Buildings 1 and 2

4.2.3 Radiological Process Facility

The cost estimate for the radiological process facility includes but is not limited to the following:

- Civil and infrastructure (e.g., site preparation, clearing, grading, yard piping, and utilities)
- Concrete and building (e.g., building foundation, equipment pads, and secondary containment structures)
- Process equipment installation (e.g., purchase/install equipment, piping, valves, mechanical and electrical hookups, and instrumentation and controls)

4.2.4 Biological Treatment Facility

The cost estimate for construction of the biological treatment facility to a capacity of 2500 gpm includes but is not limited to the following:

- Civil and infrastructure (e.g., site preparation, clearing, grading, yard piping, and utilities)
- Concrete and building (e.g., building foundation, equipment pads, and secondary containment structures)
- Process equipment installation (e.g., purchase/install equipment, piping, valves, mechanical and electrical hookups, and instrumentation and controls)

4.2.5 Commissioning and Startup

The cost estimate for commissioning and startup (acceptance and operational testing) includes costs associated with performance of ATP and OTP. ATP includes development of the acceptance test plan by operations staff with technical support from design staff, training, performance of acceptance testing with design staff support, and documentation of test results. OTP includes development of the operational test plan and performance of operational testing by operations staff with technical support from design staff, and documentation of test results.

Table 4-1. 200 West Area Groundwater P&T System Construction Costs

Description		Cost
Wells		
Drill and develop 20 extraction wells and 16 injection wells supporting a 2,500-gpm process flow		$31,571,961
	Subtotal	$31,571,961
Balance of Plant		
Install road crossings and transfer piping for 20 extraction wells and 16 injection wells		$18,642,655
Install power to 20 extraction wells and 16 injection wells		$ 2,474,883
Perform well tie in activities for 15 extraction wells and 5 injection wells		$ 3,841,758
Construct extraction transfer Buildings 1 and 2		$ 7,967,990
Construct injection transfer Buildings 1 and 2		$ 5,822,795
	Subtotal	$ 38,750,081
Radiological Process Facility		
Construct Rad Process Facility - civil and infrastructure		$ 1,130,535
Construct Rad Process Facility - concrete and building		$ 9,428,730
Construct Rad Process Facility - process equipment and installation		$ 19,808,726
	Subtotal	$ 30,367,991
Biological Treatment Facility		
Construct Bio Treatment Facility - civil and infrastructure		$ 7,391,785
Construct Bio Treatment Facility - concrete and building		$ 28,496,084
Construct Bio Treatment Facility - process equipment and installation		$ 73,185,171
	Subtotal	$ 109,073,040
Commissioning and Startup		
Commissioning (ATP/OTP)		$ 5,759,594
	Total	**$ 215,522,667**

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