This document was too large to scan as a single document. It has been divided into smaller sections.

SECTION 1 OF 2

Document Information			
Document #	DOE/RL-2000-60	Revision	1
Title	URANIUM-RICH/GENERAL PROCESS CONDENSATE & PROCESS WASTE GROUP OU RI/FS WORK PLAN & RCRA TSD UNIT SAMPLING PLAN INCLUDES 200-PW-2 & 200-PW-4 OU		
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Uranium-Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan

Includes: 200-PW-2 and 200-PW-4 Operable Units

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

United States Department of Energy
P.O. Box 550
Richland, Washington 99352
Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Assistant Secretary for Environmental Management

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EXECUTIVE SUMMARY

This work plan supports the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study activities for the 200-PW-2 Uranium-Rich Process Waste Group and the 200-PW-4 General Process Condensate and Process Waste Group Operable Units (OU). This work plan also integrates the *Resource Conservation and Recovery Act of 1976* (RCRA) facility investigation / corrective measures study requirements for these OUs. The process outlined in the work plan follows the CERCLA format with modifications to concurrently satisfy RCRA requirements. The application of these processes in the 200 Areas is described in DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan).

As part of *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) (Tri-Party Agreement) change packages M-013-02-01, M-015-02-01, and M-020-02-01, approved in June 2002, the 200-PW-4 OU work plan was consolidated with the 200-PW-2 OU, an initial version of which was previously issued in May 2001. Data collected and remedial decisions made under the consolidated 200-PW-2 and 200-PW-4 OU remedial investigation/feasibility study process will be applied to the waste sites of analogous OUs within the waste category.

The 200-PW-2 and 200-PW-4 OUs are located near the center of the Hanford Site in south-central Washington State. The 200-PW-2 OU consists of 25 RCRA past-practice waste sites, 3 RCRA treatment, storage, and disposal (TSD) units, and 9 associated unplanned release sites. The 200-PW-4 OU consists of 13 RCRA past-practice waste sites, 2 RCRA TSD units, and 1 unplanned release site, as defined in the latest update to Appendix C of the Tri-Party Agreement (Ecology et al. 1989). The remedial investigation for the 200-PW-2 OU focuses characterization on four of the sites that are considered to be representative of the OU. Three of the four representative sites (i.e., the 216-A-19 Trench, 216-B-12 Crib, and 216-U-8 Crib) are RCRA past-practice sites, whereas the fourth site (i.e., the 216-U-12 Crib) also is a RCRA TSD unit. In addition, two RCRA TSD units (the 216-A-10 Crib and 216-A-36B Crib) will be characterized to support RCRA closure activities for this OU. As a result of the OU

consolidation process, the assessment of two additional RCRA TSD units (the 216-A-37-1 Crib and the 207-A South Retention Basin) from the 200-PW-4 OU has been integrated into the remedial investigation/feasibility study process. By adding the assessment of the 200-PW-4 General Process Condensate and Process Waste Group OU to the scope of the 200-PW-2 OU, it will be possible to accelerate the investigation of all process waste-type related RCRA TSD units.

As a result of negotiations with the U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology (Tri-Parties), the U Plant Closure concept has been formulated, which will address not only closure of the facilities associated with U Plant but also the waste sites in the vicinity of U Plant. Within the 200-PW-2 OU there are 10 waste sites and within the 200-PW-4 OU there are 2 waste sites that fall within the aerial extent of the U Plant Closure Area. If approved by the regulators, this geographic closure approach will result in remedial action decisions for these waste sites such that they will no longer need to be included in the Record of Decision for the 200-PW-2 and 200-PW-4 OUs. Until the U Plant Closure Area focused feasibility study and proposed plan documents and/or engineering evaluation/cost analysis and action memorandum are approved by the regulators, these 12 waste sites will be retained in this work plan. The focused feasibility study and proposed plan documents were provided to the regulators in the fall of 2003. A discussion will be added to the 200-PW-2 and 200-PW-4 OU remedial investigation or feasibility study reports to provide a current status. A footnote has been added to Table C-1 in Appendix C to identify which sites are affected.

This work plan documents OU-specific background information, defines OU-specific characterization and assessment activities and schedules based on the framework established in the Implementation Plan, and identifies the steps required to complete the remedial investigation/feasibility study and closure plan processes for the OUs. A data quality objectives (DQO) process was conducted for each of the 200-PW-2 (BHI-01411, *Remedial Investigation DQO Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit*) and the 200-PW-4 (CP-14176, *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-4 Operable Unit*) OUs. The DQOs were completed to define the radiological and nonradiological constituents to be characterized and to specify the number, type, and

location of samples to be collected at the representative sites and TSD units within the OUs. As a result of work plan consolidation efforts, all sections of this work plan were reviewed and updated to incorporate the 200-PW-4 OU-specific information.

The results of these DQO processes form the basis for remedial investigation characterization activities presented in the work plan and the associated sampling and analysis plan (Appendix B). The sampling and analysis plan includes an OU-specific quality assurance project plan and a field sampling plan for implementing the characterization activities in the field.

The 200-PW-2 OU waste sites received uranium-rich process condensate/process waste, primarily from waste streams generated at the 221/224-U Plant Uranium Recovery Project, the Reduction-Oxidation (REDOX) process facility, and the 224-U/UO_3 Program for the Plutonium/Uranium Extraction (PUREX) Plant, as well as at the 221-B (B Plant) and Hot Semiworks (C Plant) facilities in the 200 East and 200 West Areas. Most of the process waste sites (cribs and trenches) received uranium-rich solutions from both the cold runs that used nonirradiated uranium and the startup phases that used irradiated uranium, before the three main plants began operation. The process condensates were vapors collected from thermally hot process steps that were condensed and subsequently discharged to the ground.

The 200-PW-4 OU waste sites received mostly process drainage, process distillate discharge, and miscellaneous condensates from the U and T Plants, the REDOX Plant, the PUREX Plant, the Hot Semiworks Facility, and several contributing tank farm-related facilities such as the S and A Tank Farm condensates and the 242-A Evaporator.

Preliminary conceptual contaminant distribution models were developed for the 200-PW-2 and 200-PW-4 OUs in DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*. Based on these preliminary models and a range of existing site-specific environmental data, conceptual contaminant distribution models were developed for each representative site and TSD during the DQO processes.

The following statements are general conclusions regarding the conceptual contaminant distribution model for these waste groups.

- Effluent discharged to waste sites in the 200-PW-2 OU consisted of uranium-rich process condensate that contained high levels of fission products. Major radiological contaminants of potential concern include cesium, plutonium, strontium, technetium, and uranium. Nonradiological contaminants of potential concern include metals and some organic and inorganic chemical constituents. Effluent discharged to wastes sites in the 200-PW-4 OU consisted of mostly general process drainage, process distillate discharge, and miscellaneous condensates. In general, the majority of the waste generated by operations associated with the 200-PW-4 OU waste sites can be described as a variety of liquid effluents, all containing low inventories of radionuclides and mostly low-salt neutral/basic liquids. The waste contains various constituents that include radionuclides, metals, inorganic chemicals, and semivolatile and volatile organic chemicals.

- Waste sites in the 200-PW-2 OU waste group, with the exception of unplanned releases, generally received large quantities of effluent in comparison to vadose-zone soil pore volume (volume of pore space in a column of soil extending from directly beneath the waste to the groundwater table). Of the 37 RCRA past-practice waste sites and TSD units in the 200-PW-2 OU, effluent volumes exceeded soil pore volumes beneath 15 of the sites (i.e., a sufficient quantity of effluent was received to reach groundwater), including all 4 of the representative sites and 1 of the additional TSD units. Of the 16 RCRA past-practice waste sites and TSD units in the 200-PW-4 OU, it is estimated that effluent volumes exceeded soil pore volumes beneath 8 of the sites, including at least one of the TSD units.

- Effluent and mobile contaminant migration is predominantly vertical beneath the waste sites after release. Lateral spreading of liquids and contaminants may have occurred in

association with fine-grained lithofacies such as the sandy sequence of the Hanford formation, the Cold Creek unit (formerly the Hanford formation/Plio-Pleistocene unit), the Plio-Pleistocene unit/early Palouse soil, and the Ringold Formation lower mud unit.

- Contaminants with large distribution coefficients, such as cesium and plutonium, normally adsorb strongly onto Hanford Site sediments, rendering them relatively immobile. As a general rule then, these contaminants usually are detected in high concentrations near the area of release. Concentrations generally decrease with depth and distance from the source in the vadose zone; however, elevated concentrations may be detected where finer grained sediments are present, increasing the residence time of migrating contaminants.

- The specific forms of the cesium, uranium, and plutonium compounds affect their mobility. The distribution of cesium, uranium, and plutonium through the vadose zone to the groundwater typically shows significant local accumulations near the base of the structure (crib or trench), at the caliche interface, and along fine-grained lenses. The local accumulations are caused in part by sorption, porosity changes, and the presence of elements or mineral compounds that act as reductants for most uranium species.

Potential receptors (human and ecological) may be exposed to the affected media through several exposure pathways, including inhalation, ingestion, and direct exposure to external gamma radiation. Potential human receptors include current and future site workers. Potential ecological receptors include terrestrial plants and animals. Future impacts to humans are largely dependent on land-use designation. Future land use for the foreseeable future (approximately 50 years) is industrial (exclusive), based on DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, and the associated 64 FR 61615, "Hanford

Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS), Hanford Site, Richland, Washington; Record of Decision (ROD)." All of the sites within the 200-PW-2 and 200-PW-4 OUs are located within the area designated for industrial land use.

Characterization activities to collect the required data identified during the DQO process for the remedial investigation will include borehole drilling and soil sampling and geophysical logging using spectral gamma and neutron moisture tools. A laboratory (either on- or offsite) will complete soil sample analysis under a contract-required quality assurance program. The sampling strategy is designed to investigate potentially contaminated subsurface areas. Sample collection will be guided by field screening and a sampling scheme that identifies critical sampling depths.

The sampling and analysis plan (Appendix B) directs sampling and analysis activities that will be performed to characterize the vadose zone at the two representative waste sites and four TSD units. The data will be used to refine the contaminant distribution models, support an assessment of risk, and evaluate a range of alternatives for remediation of waste sites in these OUs. The scope of remedial investigation activities described in the work plan and the sampling and analysis plan involves soil sampling and geophysical logging of boreholes to obtain additional information on the distribution of contamination in the vadose zone. Boreholes will be drilled to groundwater at the 216-A-19 Trench, the 216-B-12 Crib, the 216-A-10 Crib, the 216-A-36B Crib, and the 216-A-37-1 Crib. The contamination present at the 207-A South Retention Basin is expected to decrease with added depth and extend to a maximum of 20 ft. Thus, the characterization for the 207-A South Retention Basin will be performed via the direct-push method, and soil samples will be collected. Boreholes/direct-push holes will be drilled/pushed through the waste sites; soil samples will be collected and analyzed for radiological and nonradiological contaminants of concern and selected physical properties. During the DQO process, an evaluation of existing data showed that no additional soil samples are required at the 216-U-8 Crib and the 216-U-12 Crib. However, existing boreholes in the vicinity of these two sites will be geophysically logged for comparison to historic records as a cost-efficient method of assessing potential changes in contaminant distribution. Table ES-1 summarizes the sample collection requirements for the representative waste sites and TSD units to be investigated.

In January 2004 the Washington State Department of Ecology (Ecology) sent a letter (Ecology 2004) to the U.S. Department of Energy, Richland Operations Office (RL), requesting additional revisions to the work plan beyond that which had been initially discussed when the 200-PW-4 OU was consolidated into the 200-PW-2 OU. More specifically, Ecology requested that the 216-S-7 Crib be characterized as an additional representative waste site for the 200-PW-2 OU. In a response letter (DOE/RL 2004) RL agreed to prepare a separate SAP to execute the additional sampling, this new SAP to become an additional appendix in the revision to the work plan. Data to be collected from the characterization borehole to be drilled at the 216-S-7 Crib will be included in the Feasibility Study which will be written to meet *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) Milestone M-15-43C. In this manner the schedule for submittal of the RI report due in June 2004 as part of Tri-Party Agreement Milestone M-15-43B can still be achieved. Details summarizing the anticipated number of samples for the 216-S-7 Crib have been added to Table ES-1.

Table ES-1. Summary of Projected Sample Collection Requirements for the 200-PW-2 and 200-PW-4 Operable Units.

Projected Sample Collection Requirement	216-A-19 Trench	216-B-12 Crib	216-A-10 Crib	216-A-36B Crib	207-A South Retention Basin[a]	216-A-37-1 Crib	216-S-7 Crib	Project Total
Chemical Parameters								
Projected maximum number of characterization samples	10	9	11	10	20	11	11	82
Detail of quality control samples								
Collocated duplicates	1	1	1	1	1	1	1	7
Equipment blanks	1	1	1	1	1	1	1	7
Approximate number of field quality control samples	2	2	2	2	2	2	2	14
Approximate total number of samples	12	11	13	12	22	13	13	96
Physical Properties								
Bulk density, moisture content, particle size distribution	4	2	3	3	4	3	4	23

[a]Based on the presumption of sampling from four shallow boreholes, including one concrete sample at each borehole.

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TERMS

amsl	above mean sea level
ANN	aluminum nitrate nonahydrate
ARAR	applicable or relevant and appropriate requirement
ASD	ammonia scrubber distillate
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CMS	corrective measures study
COC	contaminant of concern
COPC	contaminant of potential concern
DQO	data quality objective
Ecology	Washington State Department of Ecology
EHQ	environmental hazard quotient
EPA	U.S. Environmental Protection Agency
FY	fiscal year
HAB	Hanford Advisory Board
HASP	health and safety plan
HI	hazard index
HQ	hazard quotient
IAEA	International Atomic Energy Agency
ICR	incremental cancer risk
ICRP	International Commission on Radiological Protection
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28
LFI	limited field investigation
MCL	maximum contaminant level
MIBK	methyl isobutyl ketone (aka hexone)
NPH	normal paraffin hydrocarbon
OU	operable unit
PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction (Plant or process)
QRA	qualitative risk assessment
RAO	remedial action objective
RAWP	remedial action work plan
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR	remedial design report
REDOX	Reduction-Oxidation (Plant or process)
RESRAD	RESidual RADioactivity
RFI	RCRA field investigation
RFI/CMS	RCRA field investigation/corrective measures study
RI Report (future)	remedial investigation report
RI/FS	remedial investigation/feasibility study
RLS	Radionuclide Logging System

ROD	record of decision
RPP	RCRA past practice
SAP	sampling and analysis plan
TBP	tributyl phosphate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)
TRU	transuranic (waste materials contaminated with 100 nCi/g of transuranic materials having half-lives longer than 20 years)
TSD	treatment, storage, and/or disposal
UNH	uranyl nitrate hexahydrate
UPR	unplanned release
URP	uranium recovery process
WAC	*Washington Administrative Code*
WESF	Waste Encapsulation and Storage Facility
WIDS	*Waste Information Data System*

1.0 INTRODUCTION

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) identifies approximately 800+ soil waste sites (and associated structures) resulting from the discharge of liquids and solids from 200 Areas processing facilities to the ground. These 800+ sites have been arranged into 23 separate waste groups that contain *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) past-practice sites; *Resource Conservation and Recovery Act of 1976* (RCRA) past-practice (RPP) sites; and RCRA treatment, storage, and disposal (TSD) units.

This work plan supports CERCLA remedial investigation/feasibility study (RI/FS) activities for the 200-PW-2 Uranium-Rich Process Waste Group and the 200-PW-4 General Process Condensate and Process Waste Group Operable Units (OU). As part of Tri-Party Agreement change requests M-013-02-01, M-015-02-01, and M-020-02-01, approved in June 2002, the 200-PW-4 OU was consolidated with the 200-PW-2 OU. An initial version of the 200-PW-2 OU RI/FS work plan was previously issued in May 2001 to the Washington State Department of Ecology (Ecology). Data collected and remedial decisions made under the consolidated 200-PW-2 and 200-PW-4 OU RI/FS process will be applied to the analogous waste sites of the waste category. This consolidated work plan integrates both RCRA and CERCLA requirements for these OUs. The process outlined in the work plan follows the CERCLA format, with modifications to concurrently satisfy RCRA requirements as described in DOE/RL-98-28, *200-Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program*, (hereinafter referred to as the Implementation Plan). The Implementation Plan is summarized in Section 1.1 of this work plan.

The 200 Areas is one of three locations on the Hanford Site that remain on the U.S. Environmental Protection Agency's (EPA) National Priorities List (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List,") under CERCLA. The 200-PW-2 and 200-PW-4 OUs are located near the center of the Hanford Site in south-central Washington State. The 200-PW-2 OU consists of 26 waste sites and 8 associated unplanned release (UPR) sites as defined in the Implementation Plan (DOE/RL-98-28). The information in this plan subsequently was updated using information in the *Waste Information Data System* (WIDS), bringing the current total to 34 sites. In the spring of 2000, an effort was initiated to evaluate the waste sites identified in the 200-PW-2 OU following the waste site reclassification process, as described in *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)" (DOE-RL 1998). As a result of that process, waste site 200-W-23 has been rejected as a duplicate of 200-W-22, and site UPR-200-E-40 has been rejected through consolidation into a larger site, 200-E-103, which will be addressed under the 200-UR-1 OU. Thus, site numbers 200-W-23 and UPR-200-E-40 no longer will be considered in the 200-PW-2 planning. During the summer of 2002, three additional waste sites were transferred to the operable unit from other operable units. The total number of accepted sites remaining in the 200-PW-2 OU, therefore, is 35. The 200-PW-4 OU consists of 13 RCRA past-practice waste sites (consisting mostly of cribs and trenches), 2 RCRA TSD units, and 1 UPR site.

Of the 23 source OUs in the 200 Areas, the 200-PW-2 OU was assigned a higher priority, because waste sites within this OU have relatively high inventories of a mobile contaminant (i.e., uranium), and some waste sites are known contributors to uranium contamination in groundwater. In addition, the OU includes RCRA TSD unit waste sites that have Tri-Party Agreement-required closure plans scheduled in the year 2005.

The 200-PW-2 OU waste sites received uranium-rich process condensate/process waste, primarily from waste streams generated at the 221/224-U Plant Uranium Recovery Project (URP), the Reduction-Oxidation (REDOX) process facility, and the 224-U/UO_3 Program for the Plutonium/Uranium Extraction (PUREX) Plant, as well as at the 221-B (B Plant) and Hot Semiworks (C Plant) facilities in the 200 East and 200 West Areas. Most of the process waste sites (cribs and trenches) received uranium-rich solutions from both the cold runs (nonirradiated uranium) and the startup phases before the three main plants began operation. The process condensates were vapors collected from thermally hot process steps that were condensed and subsequently discharged to the ground. Waste sites in the 200-PW-4 OU received mostly process drainage, process distillate discharge, and miscellaneous condensates from the U Plant, the REDOX Plant, the PUREX Plant, the Hot Semiworks Facility, and several contributing tank farm operations. This work plan contains the requirements for characterization of the four waste sites from the 200-PW-2 OU that are considered to be representative of the remaining sites. Three of the four sites (i.e., the 216-A-19 Trench, the 216-B-12 Crib, and the 216-U-8 Crib) are RPP sites, whereas the fourth (the 216-U-12 Crib) also is a RCRA TSD unit. Two additional RCRA TSD units (the 216-A-10 Crib and the 216-A-36B Crib) also will be characterized as part of RCRA closure activities for the 200-PW-2 OU. The three TSD units are identified as interim status units under *Washington Administrative Code* (WAC) 173-303, "Dangerous Waste Regulations." The current Part A Permit applications for these units are contained in Appendix A. The logic for selecting sites from this OU to be characterized is contained in Section 2.2. All six sites are identified in the Implementation Plan (DOE/RL-98-28).

Characterization of two waste sites from the 200-PW-4 OU also is included in this work plan. The 207-A South Retention Basin and the 216-A-37-1 Crib are both RCRA TSD units that will be characterized as part of RCRA closure activities. These two TSD units also are identified as interim status units under WAC 173-303. The current Part A Permit applications for these units also are contained in Appendix A.

The characterization and remediation of waste sites at the Hanford Site are addressed in the Tri-Party Agreement (Ecology et al. 1989). The schedule of work at the Hanford Site is governed by the milestones in the Tri-Party Agreement. Ecology is the lead regulatory agency for both the 200-PW-2 and the 200-PW-4 OUs. The milestone controlling the schedule for characterization activities associated with the 200-PW-2/200-PW-4 OUs is M-015-43B, "Submit 200-PW-2 RI Report including the Past Practice Waste Sites in the 200-PW-4 General Process Waste Group." The RI Report is due to be submitted on June 30, 2004. Associated project milestones are discussed in Chapter 6.0. Other associated milestones include Milestone M-20-33, which requires submittal of the 216-A-10 Crib, 216-A-36B Crib, 216-A-37-1 Crib, and 216-A South Retention Basin closure/postclosure plans to Ecology in coordination with the FS for the 200-PW-2 Uranium Rich Process Waste Group Operable Unit by December 31, 2005. The schedule shown in Figure 6-1 reflects the alignment of these RCRA TSD milestones with completion of the FS/closure plan.

1.1 200 AREAS IMPLEMENTATION PLAN

The Implementation Plan (DOE/RL-98-28) outlines a strategy that is intended to streamline the characterization and remediation of waste sites in the 200 Areas, including CERCLA past-practice sites, RPP sites, and RCRA TSD units. The plan outlines the framework for implementing assessment activities and evaluation of remedial alternatives in the 200 Areas to ensure consistency in documentation, level of characterization, and decision making. A regulatory framework is established in the Implementation Plan to integrate the requirements of RCRA and CERCLA into one standard approach for cleanup activities in the 200 Areas. This approach, which primarily uses CERCLA terminology, is illustrated in Figure 1-1.

The Implementation Plan consolidates much of the information normally found in an OU-specific work plan to avoid duplication of this information in each of the 23 OU work plans for the 200 Areas. The Implementation Plan also lists potential applicable or relevant and appropriate requirements (ARAR) and preliminary remedial action objectives (RAO), and contains a discussion of potentially feasible remedial technologies that may be employed in the 200 Areas. This work plan references the Implementation Plan for further details on several topics, such as general information on the physical setting and operational history of 200 Areas facilities, ARARs, RAOs, and post-work plan activities.

The Implementation Plan (DOE/RL-98-28) addressed the more than 800 waste sites that were assigned to the 23 process-based OUs, which in turn were grouped into 9 major waste categories (e.g., process waste, landfills, cooling water). This categorization facilitates the use of the analogous site approach, which was a fundamental concept under the Implementation Plan. The 200-PW-2 and 200-PW-4 OUs fall within the process condensate/process waste category. This category is composed of waste sites that are typically ground-level disposal structures (e.g., cribs and ditches) that received process condensate and process waste streams.

- Process condensates were condensed liquids that became contaminated from direct contact with the process chemistry. The condensates formed from the heating of the process chemistry and were removed in the vapor space of a dissolver or concentrator vessel, condensed off-line in a cooling vessel, treated as necessary, and disposed to the ground.

- Process waste results from the treatment of process liquids to regenerate specific chemicals for reuse in the process. Process waste streams were derived from solvent recovery, ion-exchange regeneration, and ammonia scrubber distillation.

1.2 SCOPE AND OBJECTIVES

This work plan provides details for characterizing chemical, radiological, and physical conditions in the vadose zone soil at two RCRA TSD units and four other representative sites (one of which is also a RCRA TSD unit) in the 200-PW-2 OU and two RCRA TSD units in the 200-PW-4 OU. This work plan documents background information, defines characterization and assessment activities and schedule based on the framework established in the Implementation Plan, and identifies the steps required to complete the RI/FS process for the OUs. The general approach to characterization and evaluation of 200 Areas OUs is outlined in the Implementation

Plan. Details presented in this work plan include background information on the waste sites in these OUs and existing representative waste site characterization data, consistent with RI/FS scoping activities required by 40 CFR 300.430(b), "Remedial Investigation/Feasibility Study and Selection of Remedy," "Scoping." A substantial amount of this monitoring and investigation data were accumulated before the Tri-Party Agreement was executed in 1989. The relative limitations of these older data have been considered to identify the type, quality, and quantity of the data that will be collected during the RI/FS to support decisions regarding remedial response activities. Existing data on each waste site have been assembled and evaluated, to develop a conceptual understanding of the waste site based on the evaluation of that existing data. The approach that will be used to further investigate, characterize, and evaluate the sites is presented in this work plan. A discussion of the RI planning and execution process also is included, along with a schedule for the characterization work. Preliminary remedial action alternatives that are likely to be considered for these OUs are identified in the work plan. These preliminary remedial action alternatives will be further developed and agreed to in the FS/closure plan(s), in the proposed plan/proposed permit conditions to WA7890008967, *Hanford Facility RCRA Permit*, and in the eventual record of decision (ROD) and permit modification for these OUs.

A data quality objectives (DQO) process was conducted for the 200-PW-2 OU to define the radiological and nonradiological constituents to be characterized and to specify the number, type, and location of samples to be collected at the TSD units and representative sites within the 200-PW-2 OU. A second DQO process subsequently was conducted for the 200-PW-4 OU. The results of the DQO process for both OUs form the basis for the work plan and the associated sampling and analysis plan (SAP) included in Appendix B. The SAP includes a representative site-specific quality assurance project plan and a field sampling plan for implementing the characterization activities in the field.

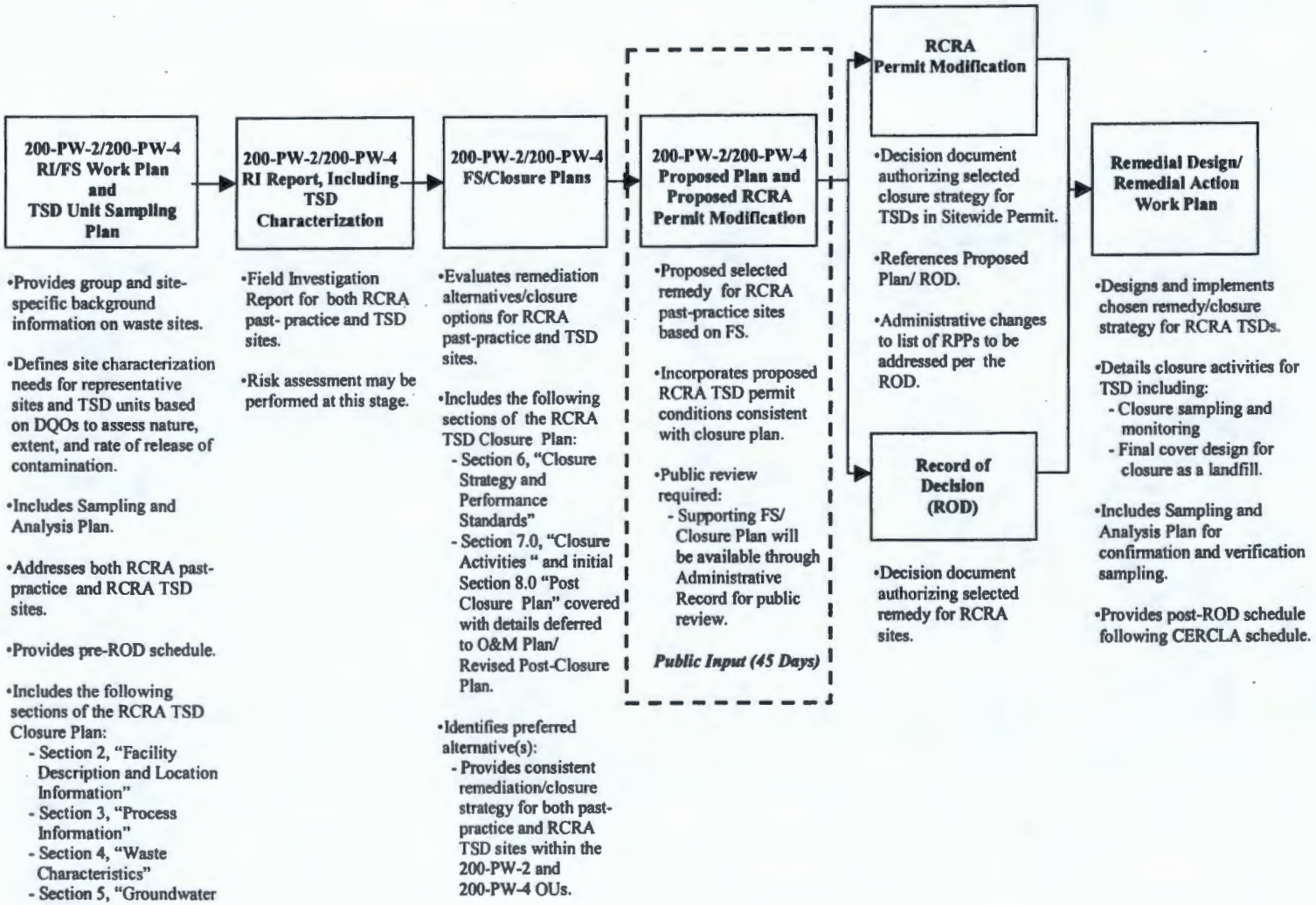
After characterization data have been collected, the results will be presented in an RI Report that includes the specific RCRA TSD unit characterization. The RI Report will contain an evaluation of the characterization data for the representative sites, including an assessment of the accuracy of the preliminary conceptual exposure model and refinement of the preliminary conceptual contaminant distribution model. The RI Report will support the evaluation of remedial alternatives and closure options that will be included in the FS/closure plan. Remedial alternatives may be applied to any or all of the waste sites in the OUs, and different alternatives may be applied to different waste sites depending on site characteristics. The schedule for assessment activities at the 200-PW-2 and 200-PW-4 OUs is presented in Chapter 6.0.

As a result of negotiations with the Tri-Parties, the U Plant Closure concept has been formulated that will address not only closure of the facilities associated with U Plant but also the waste sites in the vicinity of U Plant. Within the 200-PW-2 OU there are 10 waste sites and within the 200-PW-4 OU there are 2 waste sites that fall within the aerial extent of the U Plant Closure Area. If approved by the regulators, this geographic closure approach will result in remedial action decisions for these waste sites such that they will no longer need to be included in the Record of Decision for the 200-PW-2 and 200-PW-4 OUs. Until the U Plant Closure Area focused feasibility study and proposed plan documents and/or engineering evaluation/cost analysis and action memorandum are approved by the regulators, these 12 waste sites will be

retained in this work plan. The focused feasibility study and proposed plan documents were provided to the regulators in the fall of 2003. A discussion will be added to the 200-PW-2 and 200-PW-4 OU RI or FS reports to provide a current status. A footnote has been added to Table C-1 in Appendix C to identify which sites are affected.

In January 2004 the Washington State Department of Ecology (Ecology) sent a letter (Ecology 2004) to the U.S. Department of Energy, Richland Operations Office (RL), requesting additional revisions to the work plan beyond that which had been initially discussed when the 200-PW-4 OU was consolidated into the 200-PW-2 OU. More specifically, Ecology requested that the 216-S-7 Crib be characterized as an additional representative waste site for the 200-PW-2 OU. In a response letter (DOE/RL 2004) RL agreed to prepare a separate SAP to execute the additional sampling, this new SAP to become an additional appendix in the revision to the work plan. Data to be collected from the characterization borehole to be drilled at the 216-S-7 Crib will be included in the Feasibility Study which will be written to meet *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) Milestone M-15-43C. In this manner the schedule for submittal of the RI report due in June 2004 as part of Tri-Party Agreement Milestone M-15-43B can still be achieved.

Figure 1-1. Integrated Regulatory Process for CERCLA, RCRA Past-Practice, and RCRA Treatment, Storage, and Disposal Unit Closure (modified from DOE/RL-98-28, Figure 2-2).



2.0 BACKGROUND AND SETTING

This chapter describes the 200-PW-2 Uranium-Rich Process Waste and the 200-PW-4 General Process Waste Group OUs. Waste site information and the hydrogeologic framework associated with these OUs are described for the purpose of providing a fundamental understanding of the physical setting and potential impacts on the environment. Information is presented beginning with the physical setting, waste site description and history, and waste generating processes. The chapter ends with a detailed discussion of each representative site and RCRA TSD unit. The representative sites and TSD units will be characterized under this work plan and as guided by the analogous unit investigation strategy defined in the Implementation Plan (DOE/RL-98-28). Summary information is provided on analogous waste sites that will not be immediately characterized but rather will be addressed by future planning efforts. Information in this chapter is summarized from numerous reports. The following represents a few of the more significant documents:

- ARH-ST-156, *Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells*
- DOE/RL-91-52, *U Plant Source Aggregate Area Management Study Report*
- DOE/RL-91-60, *REDOX Plant Source Aggregate Area Management Study Report*
- DOE/RL-92-05, *B Plant Source Aggregate Area Management Study Report*
- DOE/RL-95-13, *Limited Field Investigation for the 200-UP-2 Operable Unit*
- DOE/RL-95-106, *Focused Feasibility Study for the 200-UP-2 Operable Unit*
- DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*
- DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*
- Duratek Federal Services Northwest Operations geophysical logging technical files
- Pacific Northwest National Laboratory geophysical logging technical files (http://boreholelogs.pnl.gov)
- Stoller-Grand Junction geophysical logging technical files (http://www.gjo.doe.gov/programs/hanf/HTFVZ.html).

Certain sections and subsections of this chapter contain information that will be used for portions of the FS/closure plan. Chapter 2.0, "Facility Description and Location Information," and Chapter 3.0, "Process Information," from closure plans is found in Sections 2.1 and 2.2 of this work plan. Chapter 4.0, "Waste Characteristics," and Chapter 5.0, "Groundwater Monitoring," from closure plans correspond to information found in Sections 2.2.3 and 3.4, respectively, of this document.

2.1 PHYSICAL SETTING

The following is a synopsis of the geology and hydrology associated with the 200 Areas inclusive of the 200-PW-2 and 200-PW-4 OUs. The 200-PW-2 and 200-PW-4 OUs are located on the 200 Areas Plateau, which is a relatively flat, prominent terrace (Cold Creek Bar) near the center of the Hanford Site. Cold Creek Bar trends generally east to west with elevations between 198 and 230 m (650 to 755 ft) above mean sea level (amsl). The plateau drops off rather steeply to the north and northwest and decreases more gently in elevation to the east toward the Columbia River. Plateau escarpments have elevation changes of between 15 to 30 m (50 to 100 ft) (DOE/RL-91-52). A north-to-south-trending flood channel bisects the Cold Creek Bar and separates the 200 East and 200 West Areas. More detail on the physical setting of the 200 Areas and vicinity is provided in the Implementation Plan (DOE/RL-98-28), Appendix F.

2.1.1 Topography

The 200 Areas, which contain the waste sites comprising the 200-PW-2 and 200-PW-4 OUs, are located in the Pasco Basin on the Columbia Plateau. The 200 Areas Plateau is the common reference used to describe the Cold Creek Bar, formed during the cataclysmic flooding events of the Missoula floods, which ended approximately 13,000 years ago. The cataclysmic floodwaters that deposited sediments of the Hanford formation also locally reshaped the topography of the Pasco Basin. The floodwaters deposited a thick sand and gravel bar that constitutes the higher southern portion of the 200 Areas Plateau. In the waning stages of the ice age, these floodwaters also eroded a channel north of the 200 Areas in the area currently occupied by Gable Mountain Pond. The northern half of the 200 East Area lies within this ancient flood channel.
The southern half of the 200 East Area and most of the 200 West Area are situated on the flood bar. A secondary flood channel running southerly from the main channel bisects the 200 West Area. The surface within the 200 West Area slopes gently to the west. The surface within the 200 East Area slopes gently to the northeast.

The 200-PW-2 and 200-PW-4 OU waste sites are located in or near the 200 East and 200 West Areas on the plateau. Waste sites in the 200 West Area are situated in a relatively flat area in a secondary flood channel. Surface elevations in the vicinity of the waste sites range from approximately 205 m (673 ft) to 217 m (712 ft) amsl. Waste site surface elevations in the 200 East Area range from approximately 200 m (656 ft) in the northern portion of the 200 Area to 220 m (722 ft) amsl at waste sites just south of the 200 East Area.

2.1.2 Geology

Basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments underlie the 200-PW-2 and 200-PW-4 OU waste group. From oldest to youngest, major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Plio-Pleistocene unit, the Hanford formation/Plio-Pleistocene unit (?), the Hanford formation, and the Holocene deposits. A generalized stratigraphic column for the 200 East and 200 West Areas is shown in Figure 2-1.

The youngest member of the Columbia River Basalt Group is the Elephant Mountain Member, a medium- to fine-grained tholeiitic basalt with abundant microphenocrysts of plagioclase (DOE/RW-0164, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*). The basalt is overlain by the Ringold Formation in the east, south, and central sections of the 200 East Area and all of the 200 West Area.

The fluvial-lacustrine Ringold Formation is informally divided into several units. This formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule-to-cobble gravel deposited by the ancestral Columbia River. These alluvial sediments consist of four major units (from oldest to youngest): the fluvial gravel and sand of unit A, the buried soil horizons and lake deposits of the lower mud sequence, the fluvial sand and gravel of unit E, and the lacustrine mud of the upper unit. The Ringold Formation is overlain by Plio-Pleistocene-aged units in the 200 West and 200 East Areas.

Overlying the Ringold Formation in the 200 West Area is the locally derived subunit of the Plio-Pleistocene unit, which consists of poorly sorted, interbedded, reworked loess, silt, sand, and basaltic gravel (WHC-SD-EN-TI-290, *Geologic Setting of the Low-Level Burial Grounds*). The subunit is interpreted to be a weathering surface developed on the top of the Ringold Formation (WHC-SD-EN-TI-290; PNL-7336, *Geohydrology of the 218-W-5 Burial Ground, 200 West Area, Hanford Site*) and consists of a lower carbonate-rich paleosol (caliche) and an upper eolian facies (Slate 1996, "Buried Carbonate Paleosols Developed in Pliocene-Pleistocene Deposits of the Pasco Basin, South Central Washington, USA"). The carbonate-rich section consists of interbedded carbonate-poor and carbonate-rich strata. The upper silty eolian facies was previously interpreted to be early Pleistocene loess and is referred to as the early Palouse soil (PNL-7336). Generally, it is well-sorted quartz-rich/basalt-poor silty sand to sandy silt (BHI-00270, *Preoperational Baseline and Site Characterization Report for the Environmental Restoration Disposal Facility*).

A recently identified unit of questionable origin, referred to as the Hanford formation/Plio-Pleistocene unit (?), is reported in the northwest corner of the 200 East Area. This unit may be equivalent or partially equivalent to the Plio-Pleistocene, or it may represent the earliest ice age flood deposits, overlain by a locally thick sequence of fine-grained nonflood deposits (HNF-5507, *Subsurface Condition Report for the B-BX-BY Waste Management Area*). The Hanford formation/Plio-Pleistocene unit (?) is made up of two facies and has been identified only in the 200 East Area near the B-BX-BY Tank Farms. The lower facies overlies basalt and is described in HNF-5507 as a loose, unconsolidated sandy gravel to gravelly sand. These gravels contain 50 percent to 70 percent basalt and are similar to and often indistinguishable from Hanford formation flood gravels, in the absence of the second facies. The second facies consists of an olive-brown to olive-gray well-sorted calcareous eolian/overbank silt with laminations and pedogenic structures. However, it also has been observed to be massive and void of any sedimentary or pedogenic structures. Where the Ringold Formation and Plio-Pleistocene unit are not present, the Hanford formation/Plio-Plestocene unit (?) and Hanford formation sediments overlie the basalt.

Glaciofluvial cataclysmic flood deposits of the Hanford formation are present in both the 200 East and 200 West Areas. The Hanford formation consists of unconsolidated gravel, sand, and silts deposited by cataclysmic floodwaters. These deposits consist of gravel-dominated and sand-dominated facies. The gravel-dominated facies are cross-stratified, coarse-grained sands

and granule-to-boulder gravel. The gravel is uncemented and matrix-poor. The sand facies are well-stratified fine- to coarse-grained sand and granule gravel. Silt in these facies is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common. The Hanford formation is locally overlain by veneers of Holocene deposits.

Holocene-aged deposits overlie the Hanford formation and are dominated by eolian sheets of sand that form a thin veneer across the site, except in localized areas where the deposits are absent. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand. Silty deposits less than 1 m (approximately 3 ft) thick also have been documented at waste sites where fine-grained, windblown material has settled out through standing water over many years.

2.1.3 Vadose Zone

The vadose zone is approximately 104 m (340 ft) thick in the southern section of the 200 East Area and thins to the north to 0.3 m (1 ft) near West Lake (Figure 2-2). Sediments in the vadose zone are dominated by the Ringold and Hanford Formations. The Hanford formation/Plio-Pleistocene unit (?) may be present in a small area immediately above the basalt beneath the B-BX-BY Tank Farm. Because erosion during cataclysmic flooding removed much of the Ringold Formation north of the central part of the 200 East Area, the vadose zone is dominantly composed of Hanford formation sediments between the northern part of the 200 Areas and Gable Mountain. Areas of basalt also project above the water table north of the 200 East Area. The lower mud sequence is the most important aquitard in the 200 East Area and may have been a significant perching horizon during discharge.

In the 200 West Area, the vadose zone thickness ranges from 79 m (261 ft) in the southeast corner to 102 m (337 ft) in the northwest corner. Sediments in the vadose zone are the Ringold Formation, the Plio-Pleistocene unit, and the Hanford formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and Plio-Pleistocene unit. Perched water historically has been documented above the Plio-Pleistocene unit at locations in the 200 West Area. Because discharge to the surface was ceased in the late 1980s, and the water table continues to decline at 0.36 m/yr, the perched water is infrequently encountered during drilling.

Recharge to the unconfined aquifer within the 200 Areas is from artificial and possibly natural sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation range from 0 to 10 cm/yr (0 to 4 in./yr) and are largely dependent on soil texture and the type and density of vegetation. For areas where the ground cover is assumed to remain undisturbed, a recharge rate of 0.35 cm/yr was assumed, which is within the range of values reported for shrub-steppe ground cover (PNL-10285, *Estimated Recharge Rates at the Hanford Site*). For the disturbed areas above the waste sites (i.e. stabilization cover), a recharge rate of 1.44 cm/yr has been assumed. Artificial recharge occurred when effluent such as cooling water was disposed to the ground. PNL-5506, *Hanford Site Water Table Changes 1950 through 1980, Data Observation and Evaluation*, reports that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes were discharged to the soil column.

Most sources of artificial recharge have been halted. According to HNF-EP-0527, Rev 12, *Environmental Releases for Calendar Year 2002*, "By August 1997, all 200 Area significant liquid effluent discharges to the ground were either discontinued or rerouted to the 200 Area

Treated Effluent Disposal Facility (TEDF). Significant wastewater streams from the Plutonium Finishing Plant, T Plant, PUREX Plant, B Plant, 242-A-81 Building, and 283-E and 283-W Water Treatment Plants were rerouted to the 200 Area TEDF. Other rerouted streams consist of steam condensate and cooling water from the 242-A Evaporator, 241-A Tank Farm, 244-AR Vault, and B Plant. Reporting on individual contributory liquid effluent streams is no longer required. Data are reported on the collective effluent discharged to the two 200 Area TEDF disposal basins. Beginning in November 1995, the Effluent Treatment Facility (ETF) began treating 242-A Evaporator process condensate, which previously had been discharged directly to the ground. The ETF also treats other radioactive liquids generated at the Hanford Site, such as groundwater from the 200-UP-1 OU and wastewater from the 222-S Laboratory retention basins when the effluent will not meet 200 Area TEDF acceptance criteria. The ETF treats liquid waste by filtration, ultraviolet oxidation, pH adjustment, and reverse osmosis before they are sampled, analyzed, and approved for discharge to the State Approved Land Disposal Site (SALDS)." Reporting on individual contributory liquid effluent streams is no longer required. Data are reported on the collective effluent discharged from the Effluent Treatment Facility in HNF-EP-0527 on a yearly basis.

While the liquid waste disposal facilities were operating, many localized areas of saturation or near saturation were created in the soil column. With the reduction of artificial recharge in the 200 Areas, these locally saturated soil columns are dewatering. The downward flux of moisture in the vadose zone beneath these waste sites has decreased. As the soil column dewaters, the moisture flux decreases, because unsaturated hydraulic conductivities decrease with decreasing moisture content. Residual moisture in the vadose zone, however, may remain for some time. In the absence of artificial recharge, the potential for recharge from precipitation becomes the primary driving force for any contaminant movement in the vadose zone.

2.1.4 Groundwater

The unconfined aquifer in the 200 Areas occurs within the Hanford formation/Plio-Pleistocene unit (?) and the Hanford and Ringold Formations. 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, toward the Columbia River (PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*). In general, groundwater flow through the 200 Areas 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 216-U-10 (U Pond) in the 200 West Area and 216-B-3 (B Pond) in the 200 East Area. Discharges to 216-U-10 Pond resulted in a groundwater mound developing in excess of 26 m (85 ft). Discharges to 216-B-3 Pond created a hydraulic barrier to groundwater flow coming from the 200 West Area, deflecting it either northward through the gap between Gable Mountain and Gable Butte or to the south of 216-B-3 Pond. As the hydraulic effects of these two discharge sites diminish, groundwater flow is expected to acquire a more easterly course through the 200 Areas, with some flow possibly continuing through Gable Gap (BHI-00469, *Hanford Sitewide Groundwater Remediation Strategy – Groundwater Contaminant Predictions*).

Groundwater in the 200 West Area occurs primarily in the Ringold Formation. The depth to the water table varies from about 50 m (164 ft) in the southwest corner near 216-U-10 Pond to

greater than 100 m (328 ft) in the north. Beneath the 216-U-8 and 216-U-12 Cribs, the only two representative sites located in the 200 West Area, depth to water measures approximately 78 m (255 ft), and groundwater flow is to the southeast. The surface of the water table beneath the 200 West Area currently is declining at a rate of less than 0.5 m/yr (1.6 ft/yr). A pump-and-treat system associated with Tc-99 and uranium contamination from the 216-U-1 and 216-U-2 Cribs has operated since 1994 as part of the remediation activities at the 200-UP-1 groundwater OU and has treated over 350,000,000 L of groundwater (DOE/RL-99-79, *Fiscal Year 1999 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units*).

In the northern half of the 200 East Area, the water table is present within the Hanford formation except in areas where basalt or the Ringold lower mud unit extends above the water table. Near the B-BX-BY waste management area, it occurs within the Hanford formation/Plio-Pleistocene unit (?). In the central and southern sections of the 200 East Area, the water table is located near the contact of the Ringold and Hanford Formations. The saturated thickness of the aquifer is predominantly within the Ringold Formation.

Depth to the water table in the vicinity of the 200 East Area ranges from about 54 m (177 ft) near B Pond to more than 100 m (328 ft) at the BC Cribs and Trenches Area. This entire area is within a region that is bound predominantly by the 124-m (407-ft) hydraulic contour interval to the west and east and the 122-m (400-ft) contour interval due east of the BC Cribs and Trenches Area (Figure 2-2). The water table surface in the 200 East Area is very flat. The difference in groundwater elevation in the 200 East Area is very small, and groundwater flow direction is difficult to determine. Groundwater flows primarily in two directions in this general area. Groundwater flow is to the northwest through Gable Gap (located between Gable Mountain and Gable Butte in Figure 2-2) and to the southeast. However, the location of the divide between the flow to the northwest and the flow to the southeast is not discernable because the water table is nearly flat (PNNL-13116). The very gently sloping water table corresponds to a high-transmissivity zone that extends through the 200 East Area (PNNL-13116). The surface of the water table beneath the 200 East Area currently is declining at a rate of less than 0.5 m/yr (1.6 ft/yr), based on water measurements collected between 1998 and 1999.

2.1.5 Summary of Hydrogeologic Conditions at Representative Sites

Lithology, stratigraphy, and general location information about each of the waste sites is presented in this section. More descriptive information on the waste sites, their history, and locations (including maps) is presented in the following subsections.

2.1.5.1 216-A-19 Trench

The 216-A-19 Trench is located just outside the eastern perimeter fence of the 200 East Area and is surrounded by other waste sites (clockwise, from the south: the 216-A-34 Ditch, 216-A-18 Trench, 216-A-24 Crib, and 216-A-20 Crib waste sites). The ground surface elevation is approximately 200 m (656 ft) and slopes to the north. The general stratigraphy in the vicinity of the 216-A-19 Trench includes, from the surface downward, the Hanford formation (gravel- and sand-dominated sequences) and the Ringold Formation (gravel unit A) (WHC-SD-EN-TI-019,

Hydrogeologic Model for the 200-East Groundwater Aggregate Area). The stratigraphy beneath the site is shown in Figure 2-3, based on data collected from borehole 299-E25-10. The quality of geologic data from this borehole is very poor.

Depth to water measures about 77 m (251 ft) and is approximately 124 m (407 ft) amsl. Flow direction is difficult to identify because the groundwater gradient is very small, but it appears to be to the northwest.

2.1.5.2 216-B-12 Crib

The 216-B-12 Crib is located near the western boundary of the 200 East Area. The ground surface slopes downward toward the north. Ground surface elevation is ~215 m (705 ft) at the southern edge of the crib and 212 m (697 ft) along the northern edge. The general stratigraphy in the vicinity of the 216-B-12 Crib includes, from the surface downward, the Hanford formation (sand and gravel sequences) and the Ringold Formation (gravel unit A) (WHC-SD-EN-TI-019). Ringold gravel unit E may occur in this area, but it is difficult to distinguish from the lower Hanford gravel sequence. BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*, showed it pinching out along the western edge of the 200 East Area, but no borehole geologic records were available to provide stratigraphic control. The Hanford formation consists predominantly of sand, but contains substantial percentages of gravel in the lowermost portion of the unit. The Ringold Formation contains thick layers of river gravel intercalated with sequences of overbank silts and fine-grained paleosols. The Ringold Formation includes coarse-grained fluvial unit A (and possibly unit E) (WHC-SD-EN-TI-012, *Geologic Setting of the 200 East Area: An Update*). The stratigraphy beneath the 216-B-12 Crib is shown in Figure 2-4.

The unconfined aquifer near the 216-B-12 Crib waste site occurs in the saturated portion of the Hanford gravel sequence, near the top of a silt unit or below the contact with the silt unit. The water table lies at approximately 123 m (403 ft) amsl and is approximately 91 m (297 ft) below ground surface (bgs). The base of the unconfined aquifer is at the top of the basalt. Below the silt unit, Ringold gravel unit A forms a locally confined aquifer that is approximately 24 m (79 ft) thick.

2.1.5.3 216-U-8 Crib and 216-U-12 Crib

The 216-U-8 Crib and the 216-U-12 Crib are located near U Plant and are near one another in the southeastern portion of the 200 West Area. Because the hydrogeologic conditions are similar at these two representative sites, they will be discussed together. The 216-U-12 Crib is located approximately 610 m (2,000 ft) south of U Plant in the 200 West Area, and the 216-U-8 Crib is located less than 200 m (656 ft) north of the 216-U-12 Crib.

The unsaturated sediments beneath the 216-U-12 and 216-U-8 Cribs are composed of unconsolidated sandy gravel and sand of the Hanford formation, sandy silt and silt of the Plio-Pleistocene unit, and upper Ringold silt and silty sandy gravel to gravelly sand of Ringold unit E. The unconfined aquifer is within the silty sandy gravels of Ringold unit E and is approximately 53 m (174 ft) thick. The depth to the water table is approximately 75 m (247 ft) and approximately 138 m (454 m) amsl. The top of the Ringold lower mud unit locally defines the base of the unconfined aquifer beneath the crib. The stratigraphy beneath the 216-U-8 and

216-U-12 Cribs is shown in Figures 2-5 and 2-6, respectively. Greater detail of the stratigraphy beneath the crib may be found in WHC-SD-EN-AP-108, *Interim-Status Groundwater Quality Assessment Plan for the 216-U-12 Crib.*

The water table beneath this crib indicates that the groundwater flow is still toward the east-southeast, but the average flow rate has been slowly decreasing as a result of a slight flattening of the water table in the vicinity of the crib. The flowrate estimate for June 1998 was 0.03 to 0.1 m/day.

2.1.5.4 216-A-10 Crib and 216-A-36B Crib

The 216-A-10 Crib and the 216-A-36B Crib are located near the PUREX Plant and are near one another in the southeastern portion of the 200 East Area. Because the hydrogeologic conditions are similar at these representative sites, they will be discussed together. The ground surface is relatively flat, but slopes gently toward the north. Elevation of the ground surface is approximately 220 m (722 ft). The general stratigraphy in the vicinity of these sites includes, from the surface downward, a discontinuous and thin veneer of Holocene-age eolian sand, the Hanford formation sand-dominated sequence, and the Ringold Formation. The Ringold Formation contains thick layers of river gravel intercalated with sequences of overbank silts and fine-grained paleosols. The Ringold Formation includes coarse-grained fluvial unit A (WHC-SD-EN-TI-012). The stratigraphy in the vicinity of the two cribs is shown in Figure 2-7.

The unconfined aquifer near the 216-A-10 Crib and 216-A-36B Crib waste sites is in the saturated portion of Ringold unit A below the lower mud unit. The water table lies at approximately 122 m (400 ft) amsl. The base of the unconfined aquifer is the top of the basalt at approximately 100 m (328 ft) amsl. The top of the basalt is uneven and irregular. It was encountered 102 m (335 ft) bgs at the south end of the 216-A-36B Crib but was not encountered in nearby boreholes drilled to similar and, in some cases, deeper depths. Groundwater flow beneath the 216-A-10 and 216-A-36B Cribs is towards the southeast at 0.003 to 0.48 m/day (PNNL-13116).

2.1.5.5 207-A South Retention Basin

The 207-A South Retention Basin is located in the 200 East Area near the east perimeter fence. The surface elevation is approximately 205.0 m (673 ft). The stratigraphy in the vicinity of the retention basin includes, from the surface downward, the Hanford formation (sand-dominated sequence), and the Ringold Formation. Depth to water is about 81.0 m (266 ft) bgs and occurs at approximately 124 m (407 ft) amsl within the Ringold Formation. Groundwater flow direction is difficult to identify because the groundwater gradient is very small. Groundwater flows either to the northwest, southeast, or both, as determined from depth-to-water measurements and the geometry of the groundwater plume. The stratigraphy beneath the site is shown in Figure 2-8.

2.1.5.6 216-A-37-1 Crib

The 216-A-37-1 Crib is located outside the southeast section of the 200 East Area and is approximately 52 m (170 ft) from the fence line at its closest approach. The surface elevation is approximately 207.5 m (681 ft). The stratigraphy in the vicinity of the 216-A-37-1 Crib includes, from the surface downward, the Hanford formation (sand-dominated sequences),

undifferentiated Hanford formation deposits, and the Ringold Formation. Depth to water is about 83.8 m (275 ft) bgs and occurs at approximately 124 m (407 ft) amsl within the Ringold Formation. Groundwater flow direction is difficult to identify because the groundwater gradient is very small. Groundwater flows either to the northwest, southeast, or both, as determined from depth-to-water measurements and the geometry of the groundwater plume. The stratigraphy beneath the site is shown in Figure 2-9 and is based on data collected from borehole 299-E25-17.

2.2 WASTE SITE DESCRIPTION AND HISTORY

Twenty-eight specific waste sites and UPRs within the 200-PW-2 OU are listed in the Implementation Plan (DOE/RL-98-28), Appendix G. This list subsequently was updated by WIDS, bringing the current total to 34 sites. In the spring of 2000, an effort was initiated to evaluate the waste sites identified in the 200-PW-2 OU following the waste site reclassification process, as described in DOE-RL 1998. As a result of that process, waste site 200-W-23 has been rejected as a duplicate of 200-W-22, and site UPR-200-E-40 has been rejected through consolidation into a larger site, 200-E-103, which will be addressed under the 200-UR-1 OU. Thus, site numbers 200-W-23 and UPR-200-E-40 no longer will be considered in the 200-PW-2 planning. During the summer of 2002, three additional waste sites were transferred to the operable unit from other operable units. The total number of accepted waste sites remaining in the 200-PW-2 OU, therefore, is 35.

Of the 35 200-PW-2 OU waste sites, 16 are located in the 200 West Area and 19 are located in the 200 East Area. All of the 200-PW-2 OU waste sites are located within the 200 Areas exclusive land-use boundary (as defined in DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*,) and the Central Plateau Core Zone (Figure 2-10). Figures 2-11, 2-12, 2-13, and 2-14 depict the locations of the waste sites. The 200-PW-2 OU contains 3 RCRA TSD units, 25 RPPs, and 7 UPR waste sites. Of these, 11 waste sites received waste from the U and UO_3 Plants, 14 waste sites received waste from PUREX (A Plant), 6 waste sites received waste from REDOX (S Plant), 3 waste sites received waste from the 221-B/Waste Encapsulation and Storage Facility (WESF) (part of B Plant), and one site received waste from the Hot Semiworks Plant (C Plant). The 216-B-12 Crib received waste from both the U/UO_3 Plants and 221-B/WESF operations. Summary information on 200-PW-2 OU waste sites is presented in Table 2-1.

The 200-PW-4 OU consists of 13 RCRA RPP waste sites, 2 RCRA TSD units, and 1 UPR site, as defined in the updated Tri-Party Agreement, Appendix C, package (Ecology et al. 1989). Of these 16 waste sites, 10 are located in the 200 East Area, and the remaining 6 are found in the 200 West Area. All of the 200-PW-4 waste sites are located within the 200 Areas exclusive land-use boundary (DOE/EIS-0222-F) (Figure 2-10). Figures 2-11, 2-12, and 2-14 depict the locations of the waste sites. Summary information on 200-PW-4 OU waste sites is presented in Table 2-2.

Most of the waste discharged to the soil column in these OUs was generated at the U, REDOX, PUREX, WESF/221-B, and Hot Semiworks Plants between 1952 and 1988. The locations of these plants are illustrated in Figure 2-15.

2.2.1 Plant History

2.2.1.1 U Plant

The U Plant was constructed in 1944 and included the 221-U Canyon Building and 224-U Building. The U Plant was based on the design of the T and B Plants and initially was used to train personnel for the bismuth/phosphate plutonium separation and purification operations conducted in the T and B Plants. During the training phase, only water was used in the plant systems and no waste streams were generated. However, in 1951, the U Plant was modified for the URP. From 1952 to 1958, the U Plant was used to recover uranium from bismuth/phosphate wastes stored in the single-shell tanks for reuse in the reactor plants and for waste volume reduction at the T and B Plants. A later operation conducted at the U Plant was the "scavenging" or precipitation of long-lived fission products from the settling process before residual wastes were discharged to the soil column.

The final operation of the U Plant was the conversion of uranyl nitrate hexahydrate (UNH) to UO_3. This operation was accomplished by calcinating the UNH in a batch process in the 224-U Building. In 1957, the batch conversion of UNH to UO_3 was renovated. The two calcinators previously used were removed and replaced with six newer ones. The operation was updated to a continuous flow and the 224-U Building became known as the UO_3 Plant (DOE/RL-91-52).

The UO_3 Plant operated from 1958 until 1972 when PUREX was put in "stand-down" status. During that time, the UO_3 Plant converted UNH received from the PUREX and REDOX Plants into UO_3 powder. It was packaged at UO_3, stored, and sent off-site to the Oak Ridge National Laboratory in Tennessee, and later to Fernald, Ohio, where the UO_3 powder was converted to uranium metal and returned to the Hanford Site's 300 Area for fuel extrusion rework. The UO_3 Plant resumed operations in 1984 to process UNH from the PUREX Plant. Because the feed lines from the REDOX Plant and the 221-U Building were no longer in use, they were disconnected and capped in the UO_3 Plant. Operations of the UO_3 Plant ceased in 1988 (DOE/RL-91-52).

2.2.1.2 S Plant

The REDOX Plant was the first continuous plutonium separation operation at the Hanford Site. Not only did the REDOX Plant separate weapons-grade plutonium from the irradiated fuel rods, but it also recovered unspent uranium. REDOX was a solvent extraction process that used hexone (methyl isobutyl ketone or MIBK) and aluminum nitrate nonahydrate (ANN) in nitric acid to complete these separations within anionic resin columns. Plant operations began in 1952 and continued until 1967 (DOE/RL-91-60).

2.2.1.3 A Plant

The PUREX Plant replaced the REDOX Plant separation process. The PUREX process used a recoverable salting agent (nitric acid) that proved to be economically more feasible, generated less waste, and operated more safely than did the REDOX process. The construction of the PUREX or A Plant was completed in late 1955. The PUREX Plant operated continuously from November 1955 until 1972, separating weapons-grade plutonium and depleted uranium products

from irradiated fuel. The PUREX Plant was put on standby from 1972 until 1983. The PUREX Plant was restarted in 1983 and continued operations until 1990 when it was deactivated. Since the PUREX Plant's initial operation, it has been modified to reprocess several types of fuel. These fuels included a zirconium alloy (Zircaloy) clad fuel with various enrichments ranging from 0.72 percent to 2.1 percent of U-235 exposed at various durations (300 to ~3,000 mW days per ton of uranium). The different types of fuels yielded various types of products that included fuel-grade plutonium, slightly enriched uranium and neptunium, uranium metals, uranium and plutonium oxides, and several thoria targets (DOE/RL-92-04, *PUREX Plant Source Aggregate Area Management Study Report*).

2.2.1.4 B Plant

The B Plant was constructed in 1944. From 1945 to 1952, B Plant operations consisted of a batch-wise, inorganic chemical separation of weapons-grade plutonium from irradiated uranium. This was known as the bismuth phosphate/lanthanum fluoride process. From 1952 to 1965, the B Plant was used for various waste treatment operations. In 1963, the 221-B Building began recovering strontium, cerium, and rare earths using an acid-side, oxalate-precipitation process as part of the first phase of processing for the 221-B Building Waste Fractionalization Project. This processing at the 221-B Building ended in June 1966 to accommodate additional construction. Waste fractionalization processing began again at the 221-B Building in 1968. This process separated the long-lived radionuclides Sr-90 and Cs-137 from high-level PUREX and REDOX process wastes, and stored a concentrated solution of Sr-90 and Cs-137 at the 221-B Building. In 1968, the B Plant underwent renovations and WESF was added. Waste fractionalization and encapsulation efforts continued until 1986 (DOE/RL-92-05).

2.2.1.5 C Plant

The Hot Semiworks Aggregate Area was composed of two primary facilities, the 201-C Process Building and the Critical Mass Laboratory (209-E Building). The 201-C Process Building was the main processing facility for the Hot Semiworks Aggregate Area. During its history, the 201-C Process Building went through three distinct operational modes. The 201-C Process Building was constructed in 1949 as a pilot plant for reprocessing reactor fuel using the REDOX (S Plant) chemical process, and later using the PUREX chemical process in 1954. In 1961, it was again converted to recover strontium from fission product waste. Cerium, technetium, and promethium, as well as minor amounts of americium and curium in the final production run, also were extracted. This facility operated until 1967. The facility remained in safe storage mode until decommissioning began in 1983 (DOE/RL-92-18, *Semiworks Plant Source Aggregate Area Management Study Report*).

The 209-E Critical Mass Laboratory operated in the 209-E Building from 1960 to 1983, conducting criticality experiments with plutonium nitrate and enriched uranium solutions. Criticality research also was conducted with solid special nuclear materials and fuels. The 209-E Critical Mass Laboratory averaged 15 such experiments per year with a maximum of 50 per year. Currently, the 209-E Critical Mass Laboratory is closed but not decommissioned. No research has occurred there since 1983.

2.2.1.6 242-A Evaporator

The 242-A Evaporator is the primary waste concentrator for Hanford Site mixed wastes that are stored and treated in the double-shell tank system. Treatment of the wastes removes water and most volatile organics. The 242-A Evaporator started operations in September 1977 and was originally designed for a useful life of 10 years. Subsequent upgrades have extended that service life and it still is in operation. Two waste streams leave the 242-A Evaporator following the treatment process. The first waste stream, the concentrated slurry, is pumped back into the double-shell tank system (the AN, AW, and/or AP Tank Farms). The second waste stream, process condensate, originally was routed through condensate filters for treatment before release to the 207-A Retention Basins and the 216-A-37-1 Crib. Following cessation of discharge to these facilities in April 1989 when it was determined that the effluent contained mixed waste regulated under WAC 173-303, the 242-A Evaporator facility was upgraded and discharges were rerouted to the Liquid Effluent Retention Facility, where the discharge receives final treatment at the Effluent Treatment Facility.

2.2.1.7 Liquid Waste

Liquid waste generated at the U, A (PUREX), S (REDOX), B (WESF/221-B), and C (Hot Semiworks) Plants was routed to underground storage tanks (i.e., U, A, S, B, and C Tank Farms) through an underground transfer system. The liquid waste was evaporated (concentrated) and often neutralized before it was routed to the tanks. The storage tanks were used to settle the heavier constituents out of the liquid effluents, forming a sludge. The liquid supernatants in the tanks, vaults, and pits were routed via pipelines, ditches, and retention basins, and ultimately discharged to the soil column via cribs, drains, trenches, and injection/reverse wells. Process distillate and drainages and various condensates from processing plants and evaporators also were sent to cribs and trenches via this underground network (see WIDS).

Tanks, vaults, and pits were constructed on the Hanford Site to handle and store high-level liquid wastes generated by uranium and plutonium processing activities. Several types of tanks were used at the Hanford Site, including catch tanks, single-shell tanks, double-shell tanks, vaults, and lift stations. The catch tanks generally are associated with diversion boxes and other transfer units and were designed to accept overflow and spills. The vaults are concrete structures housing several smaller tanks that serve a variety of functions. Single-shell tanks were used to collect and store large quantities of mixed wastes. Double-shell tanks are active tanks that currently are used to collect and store large quantities of mixed wastes.

High-level waste transfer lines (also referred to as process lines) connect the major processing facilities with each other and with the various waste disposal and storage facilities. Most high-level waste transfer lines are 7.6 cm (3 in.) diameter stainless steel pipes with welded joints. These lines generally are enclosed in steel-reinforced concrete encasements and are set below grade. Transfer lines to liquid effluent disposal facilities (e.g., cribs) were constructed of a variety of materials including vitreous clay and galvanized metal.

Diversion boxes house the switching facilities where waste can be routed from one process line to another. They are concrete boxes that were designed to contain any waste that leaked from the high-level waste transfer line connections. The diversion boxes generally drained by gravity to nearby catch tanks where any spilled waste was stored.

A ditch is a long, open, unlined excavation that was used to transfer low-level liquid wastes from process facilities to ponds or trenches. Ditches also were used as soil column disposal sites for low-level waste streams.

Retention basins were used for intermittent storage of liquid waste before it was transferred to ponds, ditches, and/or cribs. Retention basins usually were large "swimming pool" type structures that were lined with concrete. Liquid waste remained in the retention basins until a sufficient volume had accumulated and a collective sample had been retrieved and analyzed. Pending the analytical results, the liquid waste was routed via ditch to ponds or via pipelines to cribs for disposal.

Cribs and drains were designed to inject or percolate wastewater into the soil column. French drains generally were constructed of steel or concrete pipe. Cribs were shallow excavations that were either backfilled with permeable material or were voids created by wooden or concrete structures. Cribs and drains typically received low-level radioactive waste for disposal and most were designed to receive liquid until a specific soil-retention volume or radionuclide capacity was met (DOE/RL-92-05).

Trenches are shallow, long, narrow, unlined temporary (typically 1-3 months lifespan) excavations used for disposing of material from the process facilities by infiltration into the subsurface. Quantities of waste disposed to trenches usually were limited, compared to the quantities of waste disposed to cribs or ponds. Some of the trenches have been backfilled and marked as a single group of trenches, because trenches often were located adjacent to one other (DOE/RL-92-05).

2.2.2 Process Information

The processes at the U, UO_3, S (REDOX/241-S-101 and 241-S-104 single-shell tanks), A (PUREX), B (WESF), C (Hot Semiworks), and T (T Plant/241-TX-155 Diversion Box) Plants, and at the 242-A Evaporator that generated the primary waste streams into the 200-PW-2 and 200-PW-4 OU waste sites included the following.

- Uranium Recovery Process and Uranium Trioxide -- U Plant or Waste Generated in the 221-U, 224-UA, and 224-U Buildings. Waste streams included aqueous and organic solvent extraction wastes from uranium-recovery operations of original bismuth-phosphate/lanthanum fluoride separation-process wastes, process drainage, process distillate drainage, and miscellaneous off-gas condensates from the 291-U-1 Stack, waste treatment condensers, nitric acid and solvent recoveries, the 241 and 244 Vaults (waste treatment/storage), and 224-U storm drainage waste streams (see WIDS).

- REDOX or Waste Generated in the 202-S Building. Waste streams were mainly aqueous and organic solvent extraction wastes from several REDOX operations, including process drainage, process distillate drainage, and miscellaneous off-gas condensates from the silver reactor, air sparger, ruthenium tetraoxide scrubber, nitric acid recovery and radioiodine off-gas treatment, and waste treatment condensers, solvent recovery, and 240 and 241 Vault (waste treatment/storage) waste streams (DOE/RL-91-60).

- PUREX or Waste Generated in the 202-A, 203-A, 206-A, 293-A, 294-A, and 295-A Buildings. Waste streams were mainly aqueous and organic solvent extraction wastes from several PUREX process operations, including process drainage, process distillate drainage, and miscellaneous off-gas condensates from the acid absorbers, ammonia scrubber, nitric acid fractionalization, waste treatment condensers, solvent recoveries, nitric acid storage, and waste treatment/storage waste streams (DOE/RL-92-04).

- WESF/221-B. The waste fractionalization process included a thermal evaporation concentrator in WESF/221-B, cell 23, to concentrate process wastewaters before disposal. This system was used to concentrate low-level radioactive waste after the cesium and strontium waste fractionalization process was shut down in 1984. Double-shell tank waste was received at the 221-B Building, to be processed through the low-level waste concentrator, until 1986. The 221-B Building received no double-shell tank wastes after April 1986, and processing of these wastes was completed by late 1986. Other sources of the low-level waste included miscellaneous sumps and drains in WESF, which diverted decontamination waste solutions generated in the WESF process cells. Another contributor was a liquid collection system located beneath the 40 cells in the 221-B Building that collected cell drainage from decontamination work and water washdowns in the processing section of the 221-B Building. The concentrator also processed wastes produced by the cleanout of process vessels at the 221-B Building and WESF through 1986. The process condensate was disposed of in the 216-B-12 Crib beginning in May 1967 when disposal to this crib began again. In November 1973, the process condensate was diverted to the 216-B-62 Crib (DOE/RL-92-05).

- Hot Semiworks. The 201-C Building and ancillary facilities generated REDOX and PUREX high-salt waste, process condensates, and material described as "cold-run" waste from the REDOX and PUREX processes. Strontium, cerium, cesium, and promethium recovery experimental runs also were conducted in the 201-C Building.
  The 209-E Critical Mass Laboratory generated mostly acidic liquid waste (neutron reflector tank water) containing mainly Cs-137, Ru-106, Sr-90, plutonium, uranium, and some nitrates (DOE/RL-92-18). No high-level wastes were identified in available literature as having been generated at the 209-E Critical Mass Laboratory.

- Tanks 241-S-101 and 241-S-104. Tanks 241-S-101 and 241-S-104 received REDOX cladding wastes and high-level wastes from 1953 to 1956. This waste was often self-boiling. Vapors were collected and routed through condensers. The condensates then were routed to the 216-S-4 Crib.

- 242-A Evaporator Facility. Waste types from the A Tank Farms that were routed to Tank 241-AW-102, which fed the 242-A Evaporator, included dilute noncomplexed radioactive waste, PUREX dilute miscellaneous waste, PUREX cladding removal waste, and complexed radioactive waste. The 242-A Evaporator potentially may have received 204-AR Waste Unloading Facility (tank car) wastes, 300 and 400 Area laboratory wastes, 100 N, and Plutonium Finishing Plant wastes. Hazardous chemicals used include sodium nitrate used to regenerate the ion-exchange column, sodium hydroxide used for decontamination applications, and the antifoam agent used in the evaporator vessel.

- 241-TX-155 Diversion Box. The site received contaminated nitric acid from the 241-TX-155 Diversion Box Catch Tank. In 1952, the catch tank was used to transfer plant wastes to cribs and trenches. The T Plant was constructed in 1944. From 1945 to 1956, T Plant operations consisted of a batch-wise, inorganic chemical separation of weapons-grade plutonium from irradiated uranium. This was known as the bismuth phosphate/lanthanum fluoride process.

Figures 2-16 through 2-19 show graphical representations of the U, REDOX, PUREX, and 242-A Evaporator processes and the corresponding waste streams that were discharged to the 200-PW-2 and 200-PW-4 OU waste sites.

2.2.2.1 Uranium Recovery and Scavenging Processes/UO_3 Operations

From 1952 to 1958, the URP was implemented at the U Plant to recover the spent uranium from the metal waste and first-cycle waste streams generated in the T and B Plants for reuse in weapons-grade plutonium production. Figure 2-16 illustrates the URP process flow. The URP was performed in the following three phases (HW-19140, *Uranium Recovery Technical Manual*):

- Removal of bismuth/phosphate waste (metal waste, first-cycle supernatants, and cell 5 and 6 drainage) from underground storage tanks and preparation of the sludge/slurry solution
- Separation of the uranium from plutonium, fission products, and chemicals
- Conversion of the uranium into UO_3 powder.

The UO_3 Plant continued converting UNH from REDOX and PUREX to UO_3 from 1958 until 1972, when PUREX was put in "stand-down" status. The UO_3 Plant resumed operations in 1984 to process UNH from the PUREX Plant. Because the feed lines from the REDOX Plant and the 221-U Building were no longer in use, they were disconnected and capped in the UO_3 Plant. Operations of the UO_3 Plant ceased in 1988 (DOE/RL-91-52).

The metal waste and first-cycle wastes stored in the T and B Tank Farms were sent to the U Plant, via a network of underground pipes, tanks, and diversion boxes, where they were deposited into cascading underground storage tanks near the U Plant. The uranium-rich bismuth phosphate waste streams often turned into a sludge/supernatant combination because of the basic pH level of the waste solution. (The pH usually was adjusted and maintained at 10.5 because of the corrosiveness of the waste stored in the tanks.) The sludge was dissolved into a liquid solution to be pumped from the tanks into the 221-U Building. An aqueous solution was jetted at a high pressure into the sludge to dissolve it into a slurry solution. Water and/or sodium carbonate, ammonium bicarbonate, or sodium bicarbonate solutions were used as alternatives to enhance solubility. The supernatant was recycled and reused in the dissolution process of the sludge (HW-19140).

The sludge/supernatant slurry was pumped to an accumulation tank. The sludge settled and was transferred to an agitated dissolver tank, while the supernatant was recycled. To prepare the separation feed, a large quantity of nitric acid was added to the sludge. The nitric acid served

two purposes. First, it dissolved the uranium-rich sludge into an aqueous phase. Second, it acted as a "salting agent," reducing the solubility of the uranyl nitrate in the aqueous phase and increasing its solubility during the first separation via extraction column. The pH was adjusted in the resulting solution, which was concentrated by evaporation. This concentrated feed solution then was sent to the first-cycle extraction column. The off-gases were vented to the 291-U-1 Stack. The resulting condensate was collected, recondensed, sampled, and routed to the 241-WR Vault, where the condensate was neutralized before it was disposed of in cribs and trenches near the U Plant; these sites are the 216-U-1&2, 216-U-8, and 216-U-12 Cribs. The 216-U-5 and 216-U-6 Trenches received the same type of waste from earlier "start-up" and "cold runs" in which nonirradiated uranium was used (HW-19140).

The uranium-rich feed entered the extraction column at mid-point. A countercurrent flow of tributyl phosphate (TBP) dissolved in a hydrocarbon solution (usually kerosene or normal paraffin hydrocarbon [NPH]) extracted the uranium from the feed solution into the TBP/organic solution. The fission products, plutonium, and other inorganic chemicals from the bismuth-phosphate process remained in the aqueous feed solution. A "scrub solution" composed of nitric and sulfamic acids, along with ferrous ammonium sulfate, also was introduced at the top of the column. The scrub solution was used to scrub the fission products from the extraction column and ensure that the plutonium remained in solution as a 3^+ ion. The aqueous waste stream was sent to a waste treatment collection tank for further processing. This separation/extraction was a continuous flow process (HW-19140).

The TBP/organic solution, rich with uranium, left the first extraction column and continued to a second extraction column. At this column, the TBP/organic solution entered the bottom of the column and was met by a countercurrent flow of a slightly acidified stream of water. The slightly acidified stream of water stripped the uranium from the organic solution into an aqueous phase. The organic solution was sent to the solvent recovery operation in the 296-U Building while the uranium-rich aqueous solution (UNH) was sent to the UO_3 process in the U/UO_3 Plant (HW-19140) (see Figure 2-16).

The solvent recovery operation at the U Plant used a scrubber column and a sodium sulfate solution to remove any residual fission products, plutonium, and/or inorganic salts, including nitrates, from the organic solvent. The purified organic/TBP solvent was recycled, and the scrubber waste solution containing impurities was sent to the waste collection tank in the 241-WR Vault, scavenged, and sent to cribs and trenches in the 200-TW-1 OU. Figure 2-16 is an illustration of the URP process flow conducted at the U Plant (ARH-947, *200 Areas Disposal Sites for Radioactive Liquid Wastes*; WHC-MR-0132, *History of the 200 Area Tank Farms*).

The aqueous UNH from the URP was combined with UNH from the REDOX Plant and sent to the UO_3 plant for conversion of the uranyl nitrate solution into UO_3 powder. The feed solution passed through two evaporators that evaporated the water/nitric aqueous component and concentrated the UNH. Off-gases were collected and sent to a fractionalization operation in the U Plant, where the nitric acid was recovered and reused in the dissolver tank for feed preparation. Condensed off-gases (mainly water vapor from the nitric acid fractionation) also were routed to cribs, ditches, and trenches near the U Plant for disposal (ARH-947). The off-gases from the nitric acid fractionation and solvent recovery operations were vented to the 291-U-1 Stack. The resulting condensate was collected and routed to the 241-WR Vault, where the condensate was neutralized in the 270-W Tank and condensed again before it was disposed

of in cribs and trenches near the U Plant; these sites are the 216-U-1 and 216-U-2, 216-U-8, 216-U-12, and 216-B-12 Cribs. The 216-U-5 and 216-U-6 Trenches received the same type of waste from earlier "start-up" and "cold runs" in which nonirradiated uranium was used (see WIDS).

The concentrated UNH solution was sent to batch calcination vessels. These calciners were electrically heated and contained agitators or stirring mechanisms. The calciners were heated for 5 hours, allowing the UNH solution to reach a temperature of 400 °F and drive off nitrate, resulting in UO_3. The off-gases were collected and sent to a fractionation operation, where a dilute solution of nitric acid was recovered and reused in the dissolver tank for feed preparation and/or routed to the 216-U-10 Pond and later to the 216-U-16 and 216-U-17 Cribs via ditches and trenches near the U Plant for disposal. The UO_3 powder was removed from the vessels, packaged, and shipped off-site to Oak Ridge, Tennessee; converted to uranium metal; and sent back to the 300 Area at the Hanford Site to be reincorporated into the uranium fuel rod production (HW-19140).

The aqueous waste streams generated in this TBP/URP process from each of the extraction columns were sent to an aqueous waste collection tank within the 241-WR Vault. When the collected waste reached optimal volume (usually 45,425 L [12,000 gal]), it was sampled and then sent back to the feed accumulation tank (to be processed again), condensed, and/or routed to the neutralization tank, depending on the sample results. In the neutralization tank, the waste was combined with an equal volume of 50 percent caustic soda (sodium hydroxide) to obtain a pH of 9.5. Because a measurable quantity of ammonia was generated by neutralization, additional amounts of 50 percent caustic soda (sodium hydroxide) were added to raise the pH to 11.5. The caustic waste was condensed again and routed to cascading tanks including the 216-Z-361 Settling Tank, and the liquid effluent was sent to the 216-U-1&2 Cribs and other nearby cribs and trenches that are not part of this particular OU (HW-19140).

In 1953, tests to further treat URP aqueous and organic wastes and the metal waste and first-cycle waste streams generated at the T and B Plants during the bismuth/phosphate campaign proved successful. The "scavenging" process separated the long-lived fission products, including strontium and cesium, from the waste solutions by precipitation. This process served two purposes: (1) it reduced the volume of waste containing long-lived fission products previously stored within the tank farms, and (2) it allowed the remaining waste liquid effluents (no longer containing the long-lived fission products) to be discharged to the soil column. Waste liquid effluents from the test batches were sent to the 216-T-18 Crib (part of the 200-TW-1 OU) for disposal into the soil column (GE 1958, *Record of Scavenged TBP Waste (Logbook)*; ARH-947; LA-UR-96-3860, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*).

From 1954 to 1958, this scavenging process was conducted at the U Plant after URP operations. The order of operations often was modified throughout the duration of the scavenging process. Parameters such as pH, addition of other metals to enhance precipitation, and soil-retention properties also were continually changing. After URP processing, TBP column wastes were sent to a neutralization tank at the U Plant, where the pH was adjusted to 9 ± 1. Chemicals used to scavenge fission products included potassium and sodium derivatives of the metal/ferrocyanide complex ion. The most notable and widely used metals (used to assist precipitation) were iron, nickel, and cobalt. Calcium nitrate and/or strontium nitrate often were added to enhance the

precipitation of the radioactive Sr-90. Phosphate ions also were added to aid the soil retention of Sr-90. Once the TBP waste had been scavenged, the waste was returned to the B, BX, BY, T, TX, and TY Tank Farms to allow the solids (containing the fission products and scavenging chemicals) to settle for approximately 1 week. The waste liquid effluent was sampled and analyzed from the tanks at various depths. The waste liquid effluent was sent to cribs and/or trenches if the amounts of Cs-137 and Sr-90 were within cribbable limits; otherwise, the liquid waste was rerouted to other nearby tanks and settling continued. In extreme cases, rescavenging was conducted in-tank to further precipitate fission products out of solution. The cribs and trenches receiving the scavenged TBP wastes are found in the 200-TW-1 OU (HW-18700-DEL, *REDOX Technical Manual*; GE 1958; WIDS; WHC-SD-WM-ER-133, *An Assessment of the Inventories of the Ferrocyanide Watchlist Tanks*).

In 1955, in-tank or in-tank-farm scavenging operations also began. In-tank scavenging was conducted to process the TBP waste previously generated in the U Plant before the implementation of the scavenging operation that had been returned to the B, BX, BY, T, TX, and TY Tank Farms. The TBP wastes were transferred from the tanks to vaults, including the 244-CR Vault, near the PUREX Plant where the TBP waste was scavenged and sent back to the original tank farms. The same chemicals were used in the in-tank scavenging that were used in the U Plant operations. Often, rescavenging was performed in batches from tanks in the T, TX, TY, B, BX, and BY Tank Farms when the liquid effluents did not meet cribbing or trenching limits. The cribs and trenches that received in-tank or in-tank-farm scavenged and/or rescavenged TBP wastes are found in the 200-TW-1 OU (ARH-947). The in-tank scavenging operations ended in 1957, and the last of the liquid effluents were discharged in 1958 (HW-31442, *Recovery of Cesium-137 from Uranium Recovery Process Wastes*; HW-33591, *Summary of Liquid Radioactive Wastes Discharged to the Ground - 200 Areas (July 1952 Through June 1954*; HW-31000-DEL, *PUREX Technical Manual*; HW-42612, *Cobalt-60 in Groundwater and Separation Waste Streams*; GE 1958).

2.2.2.2 REDOX Process

Construction of the REDOX Plant began in 1950. In 1951, the REDOX process replaced the existing bismuth phosphate process, because the REDOX process had lower costs, improved output, and enhanced recovery of uranium and plutonium. The REDOX process, used until 1967, was a solvent-extraction process that extracted plutonium and uranium from dissolved fuel rods into an MIBK or hexone solvent. The solvent-extraction process was based on the preferential distribution of uranyl nitrate and the nitrates of plutonium between an aqueous phase and an immiscible organic phase (DOE/RL-91-60).

Most of the REDOX operations were conducted in the 202-S Building (commonly known as the S Processing Plant), resulting in numerous waste streams and relatively pure product streams. The REDOX process was designed to recover at least 98 percent of the uranium and plutonium from the irradiated fuel. With the exception of the feed preparation and dissolution processes, which operated in batch operation, the REDOX process was continuous. Figure 2-17 illustrates the REDOX process flow. The REDOX process included the following major components (DOE/RL-91-60):

- Fuel decladding, dissolution, oxidation, and preparation
- Separation cycles of the uranium from plutonium, fission products, and chemicals

- Further purification cycles of the uranium and plutonium
- Solvent recovery, treatment, and recycle.

Individual REDOX process operations, including their respective waste collection and treatments, are described in greater detail below.

The first step in the REDOX process involved preparing the irradiated fuel for processing. Irradiated uranium slugs, rich with plutonium, were transferred from the 100 Area to the 200 North Area via shielded rail car for a 45- to 60-day period of intermediate storage in large tanks containing water. After the necessary period of storage or "cooling," the slugs were sent via rail car to the REDOX Processing Plant. The uranium slugs were coated with an aluminum alloy jacket or cladding and later a zirconium alloy (containing small amounts of tin and iron) cladding (Zircaloy) for protection. A boiling sodium hydroxide/sodium nitrate solution was used to dissolve the aluminum alloy jackets while a boiling solution of ammonium fluoride/ ammonium nitrate was used to dissolve the Zircaloy cladding from fuels. Additional amounts of ammonium nitrate often were added to react with the ammonia and hydrogen that evolved during decladding operations. This operation produced an aqueous coating waste stream containing sodium, aluminum, and ammonium salts (nitrates). Small amounts of uranium, plutonium, and fission products also were found in these waste streams. The waste stream was sent directly to the 241-S Tank Farm (DOE/RL-91-60).

After decladding, the slugs were rinsed in a dilute nitric acid solution to remove residual alkalinity. The rinse water, containing small amounts of uranium and plutonium, also was directed to the S Tank Farm. The uranium slugs then were dissolved in concentrated nitric acid, creating a metal solution containing primarily uranyl nitrate, oxidized plutonium (III or IV) as soluble nitrates, and fission products. The dissolved metal solution then was transferred to a storage tank to await feed preparation operations (DOE/RL-91-60).

The dissolved metal solution in the storage tank was transferred to the "cross-over" oxidizer and treated simultaneously with potassium permanganate and sodium dichromate to oxidize all of the plutonium to the VI valence state. (The uranium already existed in this state as UNH.) Concurrently, Ru-106 (fission product) was oxidized by potassium permanganate to form the volatile ruthenium tetraoxide (DOE/RL-91-60).

Manganese dioxide also precipitated from the reduction of potassium permanganate. With the addition of chromic nitrate, the manganese dioxide scavenged zirconium and niobium out of the feed solution. A filter aid (an activated clay containing mostly silicon and aluminum oxides) carried away the adsorbed fission products of zirconium and niobium and was separated from solution by centrifugation. The centrifugation cake was dissolved with a ferrous sulfamate/nitric acid solution and was slurried and pumped to the S Tank Farm. This dissolved cake/slurry contained several ions including sulfates, nitrates, nitrites, iron, magnesium, and small quantities of uranium and plutonium (DOE/RL-91-60).

The metal solution (containing uranium, plutonium, nitric acid, and sodium and potassium dichromates) was adjusted to a basic pH (greater than 7) by the addition of sodium hydroxide. This ensured overall neutralization of the solution when it contacted acidified hexone (MIBK) in the subsequent process. The metal solution was completely prepared for extraction operations at this point and was transferred to the feed storage tank (DOE/RL-91-60).

Waste streams generated by the feed preparation process included both gaseous and liquid/solid wastes. Off-gases including ammonia, hydrogen, oxides of nitrogen (NO_X), and volatile radionuclides (including I-131 and I-129) were emitted during the decladding and dissolution operations. These gases were collected and routed through an off-gas treatment system that was composed of a condenser, an off-gas heater, a silver reactor, and fiberglass and sand filters before exiting out the 291-S Stack. Off-gases with lesser amounts of HNO_3 and water were put through a condenser, where the HNO_3 and water were condensed and returned to the dissolver tank. The returning condensate served to scrub NO_X from the exiting gaseous phase. The remaining off-gases that were not condensed were heated and sent through a silver reactor to capture radioiodine by a reaction with silver nitrate, forming silver iodide. Off-gases from the silver reactor passed through several fiberglass and sand filters that removed radioactive particulates (unless the ammonia content of the gas was too high). The resulting off-gases then were discharged to the atmosphere via the 291-S Stack complex (HW-18700-DEL).

Off-gases also were produced at the oxidizer. These gases, which contained radioactive ruthenium and traces of xenon and krypton, were sparged with air for 4 hours and sent through a sodium hydroxide scrubber to remove the Ru-106 as sodium ruthenium tetraoxide. The resulting off-gases then were routed through a condenser and filtered through the J-1 fiberglass and sand filter to remove particulates. The gaseous emissions then were discharged to the atmosphere through the 291-S Stack complex. These emissions discharged to the atmosphere contained substantially less radioactive particulate matter, ruthenium, and radioactive iodine than before filtering. Trace amounts of xenon and krypton were emitted (HW-18700-DEL).

Liquid waste generated by the off-gas treatment systems, including 291-S Stack drainage, various condensed process drainages, and liquid effluents from the silver reactor, condensers, and filters, were collected and routed to the condensate stripper (D-5). There the organics (primarily hexone and hexone impurities) were stripped (by steam) from the aqueous waste. The organic vapors were routed to the organic distillation column (G-3) for further treatment. The resulting aqueous waste stream was sent to the D-4 condensate evaporator. The aqueous waste from the stripper was added to the liquid effluent from the ruthenium scrubber. After redistillation, the aqueous waste was sampled to ensure that it met cribbing tolerances. If the waste was within cribbable limits, the waste was routed to the cell drainage receiver tank (D-1) and the condensate receiver tank (D-2) for storage or final disposal to the 216-S Cribs. However, if the aqueous waste was not within cribbing tolerances, it was rerouted to the waste header receiver tank and reprocessed in hopes of achieving tolerances or was sent directly to underground storage tanks for disposal. The 216-S Cribs include 200-PW-2 OU waste sites (216-S-1, 216-S-2, and 216-S-7 Cribs) and the 200-PW-4 OU waste site 216-S-23 Crib. The 216-S-8 Trench received the same type of waste from earlier start-up and cold runs in which nonirradiated uranium was used (HW-18700-DEL).

Additional liquid/solid and slurry wastes generated by the feed preparation process included the coating removal solution, the acid flush from the dissolvers, the dissolved or slurried centrifuge cake, and the ruthenium scrubber waste solution. All of these waste streams were considered to be high-level radioactive wastes and, with the exception of the ruthenium scrubber solution, all were sent to the S Tank Farm via the 240-S and 241-S Diversion Boxes. Tanks 241-S-101 and 241-S-104 received REDOX cladding wastes and high-level wastes from 1953 to 1956. This waste was often self-boiling. Vapors were collected and routed through condensers. The condensates then were routed to the 216-S-4 Crib.

The spent ruthenium scrubber solution (primarily a sodium hydroxide solution) was centrifuged. The liquid effluent was sent to the neutralizer one or two times a week, where it was used to help adjust the pH of the metals solution, while the scrubber bottoms (any resulting solids) were disposed of with other wastes in the S Tank Farm (Ru-106 was removed because it was the primary contaminant in purified plutonium and uranium streams) (HW-18700-DEL).

In 1967, the 293-S Building or Nitric Acid Recovery and Iodine Backup Facility was constructed. The 293-S Facility provided filter backup capabilities for radioactive iodine removal in combination with recovery of nitric acid vapors that developed when irradiated uranium rods were dissolved from 1958 to 1967. The facility was deactivated in 1969. Radioactive iodine was removed using a caustic scrubber system, and the acid fumes were captured in a nitric acid absorber. The recovered nitric acid was stored in an underground cylindrical, stainless steel, nitric acid storage tank (3 m high by 3 m in diameter [10 ft by 10 ft]), located directly west of the 293-S Building. Process condensates from this operation were routed to the 216-S-22 Crib.

The prepared feed (dissolved and oxidized metal solution) entered the first extraction cycle column at the midpoint. To increase the amount of separation, the column was packed and the aqueous and organic phases flowed counter-currently. The organic phase (acidified hexone [MIBK]) was fed to the bottom of the column and the aqueous phase (ANN scrub solution) was fed to the column from the top. The ANN, a salting agent, reduced the aqueous solubility of the uranium and plutonium nitrates by increasing the nitrate concentration in the aqueous phase. The uranium and plutonium were extracted into the organic phase and routed to the second extraction column while the fission products remained in the aqueous phase. Less than 0.2 percent of the plutonium and more than 99 percent of the fission products remained in the aqueous stream. This aqueous stream contained the wastes from the extraction cycle and was subjected to further processing before final disposal. Figure 2-17 illustrates the REDOX process flow (DOE/RL-91-60).

Uranium and plutonium (present in the organic phase) were chemically separated in the second extraction column. A ferrous sulfamate solution containing ANN reduced the plutonium to the III valence state. The plutonium (III) partitioned into the aqueous phase while the uranium remained in the organic phase. The organic phase then was directed to the third extraction column. The aqueous phase (containing plutonium) was scrubbed with additional acidified MIBK to remove residual uranium. The aqueous plutonium solution then was directed to the second and third plutonium cycles as necessary for further purification (DOE/RL-91-60).

In the third extraction column, the remaining organic phase (containing the uranium) was contacted with a new aqueous phase (ferrous sulfamate not containing ANN). The uranium partitioned from an organic phase to an aqueous phase of low salt content. The aqueous product stream was stripped to remove any dissolved hexone (MIBK) and adjusted to be acid deficient. The aqueous uranium solution was directed to the second and third uranium cycles as necessary for further purification (DOE/RL-91-60).

The primary waste streams generated by the first extraction cycle (extraction columns 1-3) were an aqueous stream containing fission products from the dissolved uranium fuel element stream and spent solvent. The aqueous stream containing fission products exited out the bottom of the first extraction column and was sent to the waste concentrator within the waste treatment system

for further treatment before disposal. Spent solvent from the separation process contained small amounts of uranium, plutonium, and fission products and was routed to the solvent treatment system for purification before it was recycled into the extraction process (DOE/RL-91-60).

If needed, the aqueous plutonium-rich stream from the first extraction was passed through additional cycles (similar to those described above) to achieve the desired purity. Before entering any additional plutonium purification cycles, the aqueous plutonium (III) again was oxidized with sodium dichromate to the IV or VI valence states to permit the solvent extraction process to proceed. The purified plutonium stream then was directed to a final isolation process in the 231-Z or 234-5Z Building. The final plutonium product was a plutonium nitrate solution containing approximately 10 g of plutonium and 400 to 600 g/L of free nitric acid. The uranium impurity in the plutonium product stream was estimated at 0.1 wt% of the plutonium metal. Other impurities in the plutonium stream were expected to be aluminum and iron at 30,000 and 10,000 p/M of plutonium, respectively (DOE/RL-91-60).

The primary waste streams generated by the second and third plutonium cycles were an aqueous stream containing impurities from the plutonium stream produced in the first extraction cycle and spent solvent, also containing trace impurities from the plutonium stream. The aqueous stream was directed to the waste concentrator within the waste treatment system, and the spent solvent was directed to the solvent recovery system. In addition, the plutonium product stream was concentrated before it was shipped to Z Plant for further purification and metal working. All of the waste streams generated during the second and third plutonium cycles received further treatment before disposal; therefore, no waste management units received wastes directly from this process. Figure 2-17 illustrates the REDOX process flow (DOE/RL-91-60).

If needed, the aqueous uranium-rich stream from the first extraction was passed through additional cycles (similar to those described above) to achieve the desired purity. The aqueous uranium stream produced by the first extraction cycle was steam stripped before final shipping to the Uranium Conversion Plant (224-UA Building) where the uranyl nitrate was calcinated to UO_3 for shipment off Site. The uranium production was designed for approximately 2,300 kg (2.5 short tons) per day, assuming an 80 percent operating efficiency. The uranium product stream was a solution containing approximately 1,004 g/L of UNH. The plutonium impurity in the uranium stream was expected to be approximately 10 p/B. Other impurities in the uranium stream were expected to be nitric acid, sodium, aluminum, and iron at 10,000, 400, 600, and 150 p/M, respectively (DOE/RL-91-60).

Waste streams generated by the second and third uranium cycles are very similar to those produced by the second and third plutonium cycles. Aqueous wastes were directed to the waste concentrator, and spent solvent was directed to the solvent recovery operations. In addition, the aqueous uranium product stream was steam stripped before final shipment. This produced a gaseous stream containing mainly water vapor and traces of hexone (MIBK). This waste stream was routed to the condensate stripper within the waste treatment system. The organics were condensed at 77 °F and routed to the solvent treatment system. The remaining aqueous stream then was concentrated, resulting in an air/water vapor stream with (potentially) small amounts of uranium. All of the waste streams generated during the second and third uranium cycles received further treatment before disposal; therefore, no waste management units received wastes directly from this process (HW-18700-DEL; DOE/RL-91-60).

Spent hexone solvent (MIBK) from the extraction cycles was directed to a solvent treatment system that included a scrubber where a sodium carbonate solution was used to remove the bulk of the fission products, residual plutonium, and uranium present in the solvent. The MIBK was then fed to a column where, by distillation and contact with caustic (sodium hydroxide), further removal of plutonium, uranium, and fission products was achieved. Organic impurities such as methyl isopropyl diketone or organic acids (from decomposition of MIBK) also were removed. Additional chemical treatments including washings with demineralized water, nitric acid, and dichromate solutions (similar to those conducted during solvent pretreatments) were performed to oxidize and remove various solvent impurities such as methyl isobutyl carbinol. Make-up MIBK and acid were added to the purified recycle stream for further use in the extractions (HW-18700-DEL; DOE/RL-91-60).

Waste streams generated by the solvent treatment process included an aqueous stream containing plutonium, uranium, and fission product impurities from the spent MIBK and an aqueous stream with trace impurities from the distillation of the cleaned MIBK. The first of these streams had higher concentrations of radioactive elements than the second stream and was directed to the waste concentrator within the waste treatment system for further treatment including evaporation and pH neutralization, before disposal. The second stream was very dilute and was disposed of in the 216-S Cribs, which are not a part of the 200-PW-2 OU. The waste organic effluent and waste organic solids were routed to collection tanks and disposed of by incineration or burial (HW-18700-DEL; DOE/RL-91-60).

Generally, the waste treatment system was intended to treat and segregate aqueous wastes according to their radioactivities and to recover MIBK. Liquid wastes that contained appreciable quantities of radioactive materials (such as aqueous fission product wastes from the extraction, zirconium and niobium scavenging, aluminum jacket removal, and solvent recovery cycles) were concentrated to the highest practicable aluminum nitrate content in a waste concentrator. Additional waste streams from the ruthenium scrubber and the 222-S Laboratory were blended with the remaining liquid/solids (bottoms) from the waste concentrator and were neutralized with caustic to convert the aluminum nitrate to sodium aluminate. (This conversion served to minimize corrosion problems during storage of the waste in the S Tank Farm.) Wastes were routed to the tanks via the 240-S and 241-S Diversion Boxes. The underground storage tanks operated as a cascade system, with successive overflow tanks containing less contaminated wastes than upstream tanks (HW-18700-DEL).

Condensate or condensed off-gases from the waste concentrator and condensate from the uranium and plutonium concentrators contained very low levels of radioactive wastes. These streams were combined and routed through a condensate stripper to remove residual MIBK (which was returned to the solvent recovery process). The aqueous product stream was evaporated to the extent possible, sampled, and, if proved to be within cribbable limits, was disposed as low radioactive waste in the 216-S Cribs, including 200-PW-2 OU waste sites 216-S-1, 216-S-2, and 216-S-7 Cribs. Residuals from the condensate stripper were returned to the waste concentrator, rerouted through the waste treatment system, and ultimately disposed of at the 216-S Cribs or via the 240-S/241-S Diversion Boxes to the S Tank Farms, depending on the nature of the waste. Other liquid wastes that contained only trace quantities of radioactive materials such as floor drain wastes also were disposed directly to cribs or routed through the waste treatment system and then disposed to cribs, depending on their radioactive contents as measured by sampling activities (HW-18700-DEL).

2.2.2.3 PUREX Process

The PUREX process was an advanced solvent extraction process that replaced the REDOX process. The PUREX process used a recyclable salting agent, nitric acid (which greatly lessened costs and the amount of waste generated), and TBP in an NPH solution as a solvent. TBP/NPH proved to be a much safer and more effective solvent than hexone (MIBK) (REDOX's solvent) for recovering uranium and plutonium from nitric acid solutions of irradiated uranium. The PUREX process was used between 1955 and 1972. After 11 years in standby, the facility resumed operations in November 1983. The 202-A Building (commonly known as the A Plant Complex) was the primary location for the PUREX processes. The 202-A Building ceased operating in 1990, and a decision to shut down the facility was announced in December 1992 (DOE/RL-92-04).

The main purpose of the PUREX facility was to extract, purify, and concentrate plutonium, uranium, and neptunium contained in irradiated uranium fuel rods discharged from Hanford Site reactors. The chemical separation processes were based on dissolving fuel rods in nitric acid and conducting multiple purification operations on the resulting aqueous nitrate solution. The driving forces for the separations consisted of concentration changes, temperature changes, and chemical additions (DOE/RL-92-04).

With the exception of the feed preparation and dissolution processes, which operated in batch operation, the PUREX process was continuous. Figure 2-18 illustrates the PUREX process. The process steps include the following (DOE/RL-92-04):

- Feed decladding, dissolution, and preparation
- Separation cycles of uranium, plutonium, neptunium, and fission products
- Further purification cycles of the uranium, plutonium, and neptunium
- Solvent recovery, treatment, and recycle
- Nitric acid recovery, fractionalization, and recycle
- Back-cycle waste treatment system and process condensate recycle.

Individual PUREX process operations, including their respective waste collection and treatments, are described in greater detail below.

The first step in the PUREX process involved preparing the uranium feed for processing. Irradiated uranium slugs, rich with plutonium, were transferred from the 100 Area to the 200 North Area via shielded rail car for a 45- to 60-day period of intermediate storage in large tanks containing water. After the necessary period of storage or cooling, the slugs were sent via rail car to the PUREX processing plant.

The uranium slugs initially were coated with an aluminum alloy jacket or cladding (early years) and later a zirconium alloy (containing small amounts of tin and iron) cladding (Zircaloy) for protection. A boiling sodium hydroxide/sodium nitrate solution was used to remove the aluminum alloy jackets, whereas a boiling solution of ammonium fluoride/ammonium nitrate was used to remove the Zircaloy cladding from fuels. Additional amounts of nitrate often were added to react with the ammonia and suppress the hydrogen that evolved during decladding operations (HW-31000-DEL; WHC-SP-0479, *PUREX Technical Manual*).

Between 1 percent and 10 percent of the uranium metal reacted with the fluoride of the decladding dissolution (ammonium fluoride/ammonium nitrate) solution to form insoluble uranium tetra- and hexafluoride compounds. To avoid losses of the uranium metal, water was added to dilute the decladding solution to the maximum dissolver tank volume at the end of the 6-hour digestion period. To recapture the 1 percent to 10 percent of uranium complexed with fluoride, a potassium hydroxide solution was added to metathesize the uranium fluoride compounds to uranium dioxides. The resulting supernatant was routed to the metathesis solution storage tank to be used again. The remaining solids (heel) were washed with water to remove any residual fluoride anions before the uranium fuel was dissolved (HW-31000-DEL; WHC-SP-0479).

These operations produced gaseous, liquid, and solid waste streams. Varying amounts of uranium, plutonium, and fission products were found in these waste streams. The dissolved off-gases were collected and routed to the off-gas treatment system. The liquid/solid waste generated by the feed preparation process included the coating removal waste, the acid wash from the dissolvers, and the dissolved or slurried centrifuge cake from the oxidizing operation. All of these waste streams were considered to be high-level radioactive wastes. The slurry (liquids/solids) waste stream was washed with water. A rare earth nitrate/lanthanum/neodymium nitrate mixture was added to coprecipitate the plutonium and uranium. Concentrated sodium hydroxide was added to the mixture to oxidize the uranium and plutonium residuals. The slurry mixture then was physically separated by centrifugation. The supernatant was sent to the waste treatment system while the solids either were dissolved with a nitric acid/ANN solution and routed to the metals feed tank or were slurried with water to the waste treatment system for metathesis with a spent potassium hydroxide solution and centrifuged. The supernatant of this separation was routed to the A Tank Farm, while the solids were dissolved in nitric acid, neutralized, and then routed directly to the A Tank Farm (HW-31000-DEL; WHC-SP-0479).

After the jackets/claddings were removed from the uranium slugs, the slugs were rinsed in a dilute nitric acid solution to remove residual alkalinity. The rinse water, containing small amounts of uranium and plutonium, also was directed to the A Tank Farm. ANN was added just before the dissolving solution to complex any remaining fluoride anions. The uranium slugs then were dissolved in concentrated nitric acid, creating a metal solution containing primarily UNH, oxidized plutonium (III or IV) as soluble nitrates, and fission products. The nitric acid served two purposes. First, it dissolved the uranium-rich sludge into an aqueous phase. Second, it acted as a salting agent, reducing the solubility of the UNH in the aqueous phase and increasing its solubility during the first separation via extraction column. The dissolved metal solution was jetted to the feed storage tank and sampled. Final adjustment included pH neutralization and concentration by evaporation of the resulting solution. This concentrated feed solution then was sent to the first-cycle extraction column. The dissolved off-gases were vented and routed to the off-gas waste treatment system (HW-31000-DEL; WHC-SP-0479).

Off-gases including ammonia, hydrogen, and nitrous oxides, containing various radionuclides including I-131 and I-129, were emitted during the decladding, metathesis, and dissolution operations. These gases were collected and routed through an off-gas treatment system that was composed of three dissolvers/condensers that recovered nitric acid, each in series with an ammonia scrubber, an off-gas heater, a silver reactor, filters, and a back-up treatment facility before exiting out the 291-A Stack (HW-31000-DEL; WHC-SP-0479).

The three dissolver towers were actually water-cooled condensers. Each tower also functioned as a first-stage off-gas scrubber, removing some ammonia and fission products. However, nitric acid was recovered mainly from the dissolver's condensate stream. The condensate from the dissolvers was routed to the ammonia scrubber catch tank. The off-gases continued from each of the dissolvers to respective ammonia scrubbers. Ammonia was removed by the condensate and also routed to the ammonia scrubber catch tank (HW-31000-DEL; WHC-SP-0479).

The remaining off-gases that were not condensed were heated and sent through a silver reactor to capture the radioiodine by a reaction with silver nitrate, forming silver iodide. Off-gases from the silver reactor passed through several fiberglass and sand filters that removed radioactive particulates. The resulting off-gases then were routed through the back-up facility. The back-up facility process was located in the 293-A Building. Off-gases were treated with hydrogen peroxide in two acid absorber towers (XA and XB) in series to remove additional amounts of nitrogen oxides. A portion of the returning condensate served as a scrubbing solution, while the remainder was recycled into the PUREX process via the 206-A Building (nitric acid recovery/recycle operations) as nitric acid. The gaseous emissions then were discharged to the atmosphere through the 291-A Stack. Volatile radioisotopes that may have been present in the gases discharged to the atmosphere include trace amounts of xenon and krypton (HW-31000-DEL; WHC-SP-0479).

The ammonia scrubber distillate (ASD) stream was the result of the first step in fuel dissolution, which produced large quantities of gaseous ammonia. The ammonia was scrubbed from the off-gas with water to prevent the ammonia from being released to the atmosphere.
Liquid condensate from the three dissolver towers, their respective ammonia scrubbers, and the back-up facility all were collected in the ammonia catch tank. The resulting ammonia solution was boiled to concentrate the ammonia and radionuclides for disposal to underground storage tanks. The condensed vapor became the ASD stream. The ASD stream was routed to a concentrator and then a condenser. The resulting off-gases were heated, routed through another silver reactor to remove radioactive iodine, mixed with the ventilation exhaust from the 202-A (Canyon) Building, routed through additional filters, and released to the atmosphere via the 291-A Stack. The condensate from the condenser was sampled for Sr-90 content. If the sample proved to be within discharge limits, it was routed to 200-PW-2 OU waste sites 216-A-36A and 216-A-36B (Cribs). If the liquid effluent was not within regulatory discharge limits, it was either reworked or neutralized with caustic (concentrated sodium hydroxide) and routed as ammonia scrub waste to the A Tank Farm underground storage tanks for final disposal (HW-31000-DEL; WHC-SP-0479).

Additional liquid waste generated by the off-gas treatment systems, including the 291-A Stack drainage, various condensed process drainages, and liquid effluents from the silver reactor, condensers, and filters, was collected and routed to the nitric acid recovery and/or back cycle waste treatment system (HW-31000-DEL; WHC-SP-0479).

The prepared feed (dissolved metal solution) entered the first extraction column or code contamination column at the midpoint. To increase the amount of separation, the packed column, essentially full of the organic phase, was pulsed from the bottom of the column.
The organic phase counter-currently passed the aqueous phase that descended from the top of the column. This first column had a dual purpose. First, the uranium, plutonium, and neptunium were extracted into the organic phase (TBP/NPH) in the bottom portion of the column.

Second, fresh aqueous (nitric acid) solution entered the column from the top and scrubbed impurities from the organic phase in the upper portion of the column. The nitric acid served as the salting agent and scrub solution in the first column. A stream of sodium nitrite also entered the bottom of the first extraction column. The sodium nitrite was used to convert the neptunium to a valence of VI, making it extractable into the organic phase. The organic phase, rich with product, exited from the top of the first column to a feed collection tank before entering the second extraction column. The first column extracted approximately 99.9 percent of the fission products. This aqueous waste stream was routed to the waste concentration/acid recovery operations and subjected to further processing before final disposal to the underground storage tanks. Figure 2-18 illustrates the PUREX process (HW-31000-DEL; WHC-SP-0479).

The TBP/NPH solution, rich with uranium, plutonium, and neptunium, left the first extraction column and continued to a feed collection tank before entering the second extraction column (column 1BX). In the collection tank (TK-J3) the organic product stream was mixed with recycled organic waste streams from the final (second and third) plutonium cycles, final neptunium purification cycles, and a uranium scrub solution (organic phase) from column 1BS. The second extraction column or partition column essentially was full of the aqueous phase. The organic phase entered the second column from the bottom portion, and the aqueous scrub solution containing dilute nitric acid, ferrous sulfamate, and sulfamic acid descended from the top of the column. The ferrous ion in the scrub solution reduced the valence of the plutonium from IV to III. The sulfamate/sulfamic acid served to neutralize the nitrite previously added in the first column. Thus, as the organic stream rose through the column, the plutonium was partitioned from the uranium and neptunium (in the organic phase) to an aqueous phase. The plutonium stream was mixed with recovered nitric acid and routed through another extraction column (column 1BS) to purify the plutonium. Small amounts of uranium and neptunium were removed from the aqueous plutonium stream and the recovered acid stream in the organic phase because of the addition of concentrated nitric acid in the 1BS column. The recovered uranium then was recycled to the TK-J3 feed collection tank, prepared, and rerouted through the 1BX or plutonium-partitioning column. The purified aqueous plutonium stream from the 1BS column continued to the final (second and third) plutonium cycles. The organic stream from the plutonium partition column (column 1BX), which contained neptunium and uranium, was routed to the third extraction column (column 1C) (HW-31000-DEL; WHC-SP-0479).

In the third extraction column (column 1C), the remaining organic phase (containing the uranium and neptunium) was contacted with a new aqueous phase (less than 2 percent nitric acid) of low-salt content. The uranium and neptunium were stripped from the organic phase (TBP/NPH) to an aqueous phase. No partitioning or valence changes occurred in this column. The aqueous uranium and neptunium solution was directed via steam jets to the 1CU concentrator. In the concentrator, the aqueous solution from column 1C was combined with the back-cycle condensate (product stream containing uranium) and together were steam stripped to remove the entrained organic phase. When the volume of the aqueous solution was condensed to one-seventh of the original, the aqueous solution was routed to the final uranium and neptunium cycles. The spent organic solvent was routed to the solvent system #1 feed tank for purification (HW-31000-DEL; WHC-SP-0479).

The primary waste stream generated by the first extraction cycle (extraction columns 1-3) was an aqueous stream containing fission products from the dissolved uranium fuel-element stream and

spent solvent. The aqueous stream containing fission products exited out the bottom of the first extraction column and was sent to the waste concentrator within the waste treatment system for further treatment before final disposal in the underground storage tanks. Spent solvent from the separation process contained small amounts of uranium, plutonium, and fission products and was routed to the first solvent treatment system for purification before being recycled into the extraction process (HW-31000-DEL; WHC-SP-0479).

The final (second and third) plutonium cycle extraction columns operated similarly to the original solvent-extraction columns. The purified plutonium stream from the partition extraction and purification columns (columns 1BX and 1BS) was routed to the second plutonium cycle for further plutonium purification. The aqueous plutonium (valence III) stream was routed into an evaporation/mixing tank (J-5) and oxidized by the addition of sodium nitrite and nitric acid. The oxidation of plutonium (III) converted it a valence of (IV). The plutonium solution then was routed into the first of four extraction columns. The plutonium feed entered column 2A at the midpoint. A nitric acid scrub solution and an organic TBP/NPH solution entered the column from the top and bottom, respectively. The plutonium was extracted to the organic phase and routed to the bottom of column 2B. In column 2B, plutonium was partitioned from uranium, neptunium, and fission products by converting the plutonium (IV) in the organic to phase to a (III) valence in an aqueous phase by the addition of hydroxylamine nitrate and hydrazine. Hydroxylamine nitrate served as a reductant that converted the plutonium (IV) to (III), while the hydrazine was used to chemically neutralize the oxidizing power of the previously added sodium nitrite and concentrated nitric acid. The resulting aqueous stream of plutonium was purified and concentrated by a factor of 10 by the second plutonium cycle. This stream was collected in feed makeup tank TK-L3. Additional amounts of concentrated nitric acid and/or sodium nitrite were added to oxidize the plutonium from the valence of (III) to (IV). Plutonium in the (IV) valence was readily extracted into the organic phase (TBP/NPH) and partitioned from any uranium, neptunium, and fission productions in column 3A or the first column in the third plutonium cycle. The organic product solution from column 3A then was directed to column 3B (last column of the final plutonium cycle). In column 3B, the plutonium was extracted from the organic phase back to an aqueous phase by the addition of dilute nitric acid. The aqueous plutonium then was sent to the 3BP plutonium stripper and concentrator units where the volume was reduced and, thus, the plutonium was concentrated. After final purification and concentration operations, the plutonium product was routed to Z Plant for final processing and shipment off-site (HW-31000-DEL; WHC-SP-0479).

The primary waste streams generated by the second and third plutonium cycles were aqueous streams containing impurities from the plutonium stream produced in the first extraction cycle, spent solvent also containing trace impurities from the plutonium stream, and off-gases from the stripper and concentrator. The aqueous streams were directed to the back-cycle waste treatment system for further treatment and were recycled back into the process. The spent solvent waste streams were recycled into the 1BX feed tank (TK-J3) and reincorporated into the feed entering the plutonium partition or column 1BX. In addition, the plutonium product stream was concentrated before shipping. All of the waste streams generated during the second and third plutonium cycles received further treatment before disposal; therefore, no waste management units received wastes directly from this process (HW-31000-DEL; WHC-SP-0479).

The aqueous uranium-rich stream from column 1C and the 1CU concentrator in the first extraction cycle was directed through the final uranium cycle or additional purification cycles

(similar to the first extraction cycle described above) to achieve the desired purity. Before the uranium entered the first extraction column, it was routed to a feed makeup tank (TK-K1), where concentrated nitric acid and hydrazine were added to neutralize any nitrite remaining in solution. The feed entered the first final cycle extraction column (column 2D) just above the mid-point, while hydroxylamine nitrate scrub solution used to separate plutonium from uranium was added from the top of the column. The column 2D extractant, recycled TBP/NPH solvent from the solvent treatment system 2, was pulsed into the bottom of the column. The partition of the uranium into the organic phase was accomplished by limiting the amount of organic phase present and scrubbing the solution with hydroxylamine nitrate, followed by demineralized water. The hydroxylamine nitrate reducing agent converted the plutonium remaining in the solution from (IV) valence to an inextractable (III) valence, ensuring that the plutonium remained in an aqueous solution while the uranium was extracted to an organic phase. The demineralized water reduced the acid content of the uranium product in the organic stream, which minimized corrosion of the final uranium cycle concentrator. The organic product stream then was directed to column 2E. Column 2E served the same purpose as did column 1C (to strip the uranium from an organic phase to an aqueous phase by adding dilute nitric acid of less than 2 percent). The aqueous uranium stream produced by the final uranium extraction cycle was routed to the 2EU concentrator, where it was steam stripped before final shipment. The purified uranium stream then was directed to the uranium conversion plant (224-UA Building), where the uranyl nitrate was calcinated to UO_3 for shipment off-site. Figure 2-18 illustrates the PUREX process flow (HW-31000-DEL; WHC-SP-0479).

Waste streams generated by the final uranium cycle were very similar to those produced by the second and third plutonium cycles. Aqueous wastes (containing neptunium) were directed to the back-cycle waste treatment system, and spent solvent was directed to the solvent recovery system 2 for treatment. In addition, the aqueous uranium product stream was steam stripped before final shipment. This produced a gaseous stream containing mainly water vapor and traces of uranium and spent solvent (TBP/NPH). All of the waste streams generated during the final uranium cycle received further treatment before disposal; therefore, no waste management units received wastes directly from this process (HW-31000-DEL; WHC-SP-0479).

The aqueous neptunium stream was sent to a collection tank and concentrated in concentrator E-F6 within the back-cycle waste treatment system. Approximately 57 percent of the concentrated waste was recycled to the first or HA column in the first extraction cycle. The rest of the concentrated waste (3WB) was directed to a feed tank within the neptunium recovery cycle. The neptunium recovery cycle or second neptunium cycle was a three-part transient process that was added to PUREX Plant operations in 1962. Phase I of the operation served to accumulate neptunium from the back-cycle waste streams. From the feed tank, the aqueous solution was pumped into column 2N, a dual-purpose extraction/scrub column containing a continuous organic phase. The neptunium (valence V) and plutonium (valence IV) were reduced by the ferrous sulfamate and hydrazine scrub solution to extractable (valence IV) and inextractable (valence III) forms. Uranium remained an extractable valence of VI. Thus neptunium and uranium were extracted into the organic (TBP/NPH) phase, and plutonium remained in the aqueous waste solution. Recycled solvent from solvent treatment system 1 entered below the extraction section of the column and scrubbed entrained aqueous-phase contaminants from the organic products. The organic phase was routed to the bottom of column 2P. Column 2P (continuous with an aqueous solution of dilute nitric acid) stripped the

neptunium from the uranium in the organic phase. The aqueous waste from column 2N containing plutonium was routed to a back-cycle waste collection tank, while the organic waste stream from column 2P was routed and recycled into the 1BX feed tank (HW-31000-DEL; WHC-SP-0479).

Phase II of the neptunium recovery operation was similar to phase I. The phases differed in that a solution of concentrated nitric acid was used as the feed into column 2N rather than the concentrated waste stream (3WB) that contained plutonium, uranium, neptunium, and fission products. Phase II purified and concentrated the neptunium by continually removing and reducing the amounts of uranium, plutonium, and fission products present. The resulting aqueous neptunium product from column 2P was sampled. When this stream reached a purity of 1 g of plutonium per 1,000 g of neptunium, the transition to phase III of the neptunium recovery operations began (HW-31000-DEL; WHC-SP-0479).

Phase III was the transfer of the concentrated neptunium from column 2P either to anion-exchange columns for purification or to tank TK-J2 for storage. The neptunium was transferred by air jet to either location. Once approximately 90 percent had been transferred, the neptunium recovery operations reverted to phase I (HW-31000-DEL; WHC-SP-0479).

The final step of neptunium treatment was purification. The aqueous neptunium solution was air jetted to a feed receiver tank and then to the 2PN stripper/concentrator tank. In this tank, recycled nitric acid was added. The tank also served as an interface between the continuous neptunium recovery operations and the batch-wise purification process. The neptunium/nitric acid solution was routed to the stripper/concentrator, which removed any entrained or dissolved organic from the 2PN stream and reduced the volume by a factor of approximately 4.5. This concentrated solution was then routed to the 3XF feed tank, where the neptunium was reduced to a valence of (IV) by the addition of hydrazine and use of the 3X anion exchange column. The anion exchange column contained Amberlite IRA-99 resin[1] that required pretreatment, including degassing and washing with nitric acid and hydrazine. The neptunium then was loaded onto the resin bed. The remaining solution was routed to a waste collection tank (TK-Q5). Plutonium was adsorbed onto the resin and would be carried through with the neptunium if not selectively removed. Thus, a scrub solution containing ferrous sulfamate and concentrated nitric acid was applied to the column to remove the plutonium, while hydrazine was added to keep the neptunium bonded to the anionic resin. To remove any remaining fission products, another scrub solution was applied to the column. This solution contained concentrated nitric acid and fluoride to remove the fission products, ANN to reduce the corrosivity of the fluoride, and hydrazine to maintain the resin/neptunium bond. A third scrub solution (concentrated nitric acid) was applied to the column to remove residual amounts of fluoride. All scrub effluents were collected in tank TK-Q5. Sodium nitrite was added to the waste collection tank to neutralize the hydrazine. This solution then was routed back to the waste collection tank in the back-cycle waste treatment system (HW-31000-DEL; WHC-SP-0479).

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[1] Amberlite is a registered trademark of Rohm and Haas Company, Philadelphia, Pennsylvania.

With repeated use, the organic solvent (TBP/NPH) used by the PUREX process degraded and became contaminated. Because of the high cost of fresh solvent and of disposing of used solvent, it was necessary to regenerate and reuse the spent TBP/NPH. Two solvent treatment systems were used to treat the spent solvent and minimize the contamination of the uranium product by impurities in the solvent or cross-contamination with the plutonium product. Thus, the organic waste streams from the initial extraction cycle columns, second and third plutonium extraction columns, and the back-cycle waste treatment systems were routed to solvent treatment system 1 because of their levels of contamination. The organic waste stream from the final uranium cycle was routed to solvent treatment system 2 because of its level of purity. The impurities removed from spent PUREX solvent included organic degradation products (dibutyl phosphate and monobutyl phosphate), entrained solids (nitrates/aqueous phase salts), fission products (I-131, I-129, Ru-106, and ZrNb-95), and uranium, neptunium, and plutonium contaminants from column processes (HW-31000-DEL; WHC-SP-0479).

To remove these contaminants, an alkaline (sodium carbonate-potassium permanganate) wash was performed batch-wise in a wash tank of each solvent treatment system. To enhance separation of the aqueous and organic phases, these tanks were packed with Raschig rings[2], which allowed more contact between the phases. The aqueous waste stream from the solvent treatment system 1 wash tank was routed to a waste collection tank before disposal in underground tanks. The aqueous waste solution from the solvent treatment system 2 wash tank either was rerouted to be used in the solvent treatment system 1 operations or was sent to a waste collection tank before final disposal in underground storage tanks. The organic stream from the wash tanks was directed to columns 1O and 2O, where a dilute solution of nitric acid was used, recirculated, and reused to scrub entrained impurities. The nitric acid scrub stream was recirculated/reused for approximately 24 hours. After the 24-hour period, the scrub solution from column 1O was routed to a waste collection tank for ultimate disposal in underground storage tanks, and the scrub solution from column 2O was routed to column 1O to be used as scrub solution. The purified organic solvent from column 1O was sent to a solvent receiver tank and routed to columns HA, 1BS, 2A, 3A, or 2N pending process solvent requirements. The purified solvent from column 2O was sent to a different solvent receiver tank and routed to column 2D pending process solvent requirements (HW-31000-DEL; WHC-SP-0479).

The PUREX Plant was provided with facilities for the recovery of the salting agent (nitric acid). More than 80 percent of the nitric acid present in the aqueous waste streams from the solvent extraction operations was reclaimed in a reusable form. By recovering the nitric acid instead of neutralizing it and routing it to storage in underground storage tanks, large amounts of caustic, nitric acid, and waste storage space were achieved. Recovered acid streams were received by the 206-A Building (nitric acid recovery/recycle operations) from three main sources within the PUREX Plant. Nitric acid was recovered from off-gases generated during metal dissolution at each of the three dissolver towers (water-cooled condensers) that functioned as first-stage off-gas scrubbers, ammonia scrubber catch tanks, and the back-up facility located in the 293-A Building. (There the off-gases were treated with hydrogen peroxide in two acid absorber towers [XA and XB] in series.) The second main source of nitric acid recycled from the PUREX Plant occurred when acid was driven off during process waste concentration and denitration operations

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[2] Raschig is a trademark of Raschig GmbH, Ludwigshafen, Germany.

conducted within the back-cycle waste treatment system. The third main source of recovered nitric acid was that recovered in the UO_3 Plant and transferred back to the nitric acid recovery system (206-A Building) via railroad tank cars (HW-31000-DEL; WHC-SP-0479).

Nitric acid fractionation operations concentrated the acid from the main sources for reuse in the PUREX Plant. It also destroyed residual ammonium nitrate from the absorption of ammonia in the back-up facility. The acid solutions from the various absorbers were routed to collection tank TK-F3 and then sent to tank TK-U5, where blending with the nitric acid recovered in the UO_3 Plant occurred before the solutions were directed to the T-U6 tower. The fractionator was a 14-tray bubble-cap tower, operated under vacuum to reduce corrosion rates. The dilute acid feed was pumped into the column above the midpoint. The reboiler section operated with a constant boiling mixture of 50 percent nitric acid. Acid vapors from the reboiler passed upward through the bubble caps and were absorbed by the descending solution. The resulting overhead vapor (99.5 percent steam) exited the top of the tower and was condensed in the E-U6-1 condenser and directed to the back-cycle waste system feed tank. The bottom of the acid fractionation tower was routed to the sample gallery for temporary storage before it was reused in the PUREX Plant (HW-31000-DEL; WHC-SP-0479).

The back-cycle waste treatment system collected and treated all of the aqueous PUREX waste before it was released to the atmosphere after the PUREX Plant resumed operations in November 1983. Before 1983, some of the low-level process distillates and condensates were released without being recycled or treated. Three distinct groups of liquid process waste resulted from PUREX Plant operations, and different handling and disposal procedures were employed for each of these waste groups (HW-31000-DEL; WHC-SP-0479).

High-activity waste resulted from the cladding dissolution, metal dissolution, and first extraction column (HA) waste. This waste was sent to high-level waste collection tank TK-F7, concentrated in E-F6, and sampled. Sugar was used to denitrate the waste, and dilution water (recycled from condensate from the E-F5 condenser) was added to improve nitric acid recovery from the high-level wastes and suppress ruthenium volatilization in the form of ruthenium tetraoxide. If recoverable levels of plutonium and/or uranium were present, the waste was routed to the waste rework handling tank TK-F8 and boiled/refluxed for at least 21 days in the E-F9 condenser. The rework waste then was transferred batch-wise to tank TK-E6 for blending with the feed and was recycled though the PUREX extraction operations. However, if the waste contained only fission products, it was routed from the E-F6 concentrator to the underground storage tanks for final disposal. The off-gases from the high-level waste concentrators passed upwards through the two mist eliminators located in the deentrainment tower and finally to the nitric acid recovery equipment. The condensate formed in the upper mist eliminators was returned to the solution section of the concentrator (HW-31000-DEL; WHC-SP-0479).

The acid and water vapors that exited the waste concentrator via the concentrator tower and deentrainer were routed to the back-cycle waste acid absorber (T-F5), where nitric acid was recovered. The acid absorber was a 15-tray bubble-cap tower that ran at atmospheric pressure. The nitric acid was recovered by a counter-current flow of vapors and a water reflux stream. The off-gases (99.5 percent steam) of the adsorption tower passed to a condenser where the condensate was recycled as dilution water back into the waste feed tank. The bottoms of the adsorption tower (concentrated nitric acid) were directed to the absorber receiver tank (TK-F3) and combined with the acid product from the XA and XB acid absorbers of the dissolved off-gas

treatment system. This acid product then was routed to the nitric acid recovery operation in the 206-A Building for further purification (HW-31000-DEL; WHC-SP-0479).

The second type of aqueous waste generated by PUREX operations consisted of cooling water, used sanitary water including laundry, kitchen, and bathroom facilities, and chemical sewers. This stream was routed to various ditches and ponds for disposal.

The third type of aqueous waste generated by PUREX operations was low-level waste. Low-level wastes included the 291-A Stack drainage, various condensed process drainages, and liquid effluents from the silver reactor, condensers, and filters. Additional low-level liquid wastes were generated by nitric acid recovery/storage, uranium pretreatment and storage, the back-cycle waste treatment system, process condensates (the concentration stages of the PUREX process), and process drainages from all other operations conducted within the PUREX facility. In the last years of operation, these wastes were reworked, neutralized, and routed to underground storage tanks for disposal. However, from 1955 until 1988, the low-level wastes were combined and treated, usually by redistillation or concentration. After redistillation, the aqueous waste was sampled to ensure that it met cribbing tolerances. If the low-level waste was within tolerances, the waste was routed to a drainage receiver tank or a condensate receiver tank (200-E-58) for storage and neutralization or final disposal to the 216-A Cribs. However, if the aqueous waste was not within cribbing tolerances, it was rerouted to a collection/feed tank within the waste handling-rework operation and reprocessed in hopes of achieving cribbable tolerances or was sent directly to underground storage tanks for disposal. The 216-A Cribs that received process discharge from the PUREX Plant include 200-PW-2 OU waste sites 216-A-10, 216-A-5, 216-A-3, 216-A-22, 216-A-28, and 216-A-45 (Cribs). The 216-A-1 Crib and 216-A-18, 216-A-19, and 216-A-20 Trenches received the same type of waste from earlier start-up and cold runs in which nonirradiated uranium was used. The 216-A-19 and 216-A-20 Trenches and the 216-A-34 Ditch also received condensate waste from the A Tank Farm, which was condensed in the 241-A-431 Tank Farm Ventilation House (HW-31000-DEL; WHC-SP-0479).

2.2.2.4 Waste Encapsulation and Storage Facility/221-B Operations

The 221-B Building is one of the primary B Plant facilities. It began operation in 1945, separating plutonium using bismuth phosphate chemical methods. It ceased operation in 1952, then began various waste treatment operations in 1965. In 1968, it was used to recover cesium and strontium. Since 1968, several new structures have been added to the 221-B Building, such as the 225-B WESF and the 212-B Cask Transfer Facility.

In 1963, the 221-B Building began recovering strontium, cerium, and rare-earth metals using an acid-side, oxalate-precipitation process as part of the phase I processing for the 221-B Building Waste Fractionalization Project. A centrifuge was used to separate the phases. The lead, cerium, and rare-earth fractions were dissolved in nitric acid and stored. The strontium fraction was thermally concentrated and stored. Portions of the strontium and rare earths produced in phase I were pumped by underground transfer line to the Hot Semiworks Facility for purification of the SR-90 fraction and separation of the rare-earth fraction in Ce-144 and a rare-earth fraction including Pm-147. Phase I processing at the 221-B Building ended in June 1966 to accommodate phase II construction (DOE/RL-91-52).

The objective of the phase I processing was to restore services to the 221-B Building after its extended shutdown and to accumulate an inventory of fission products. The phase II portion of the project was the installation of facilities necessary to demonstrate a process system for packaging the long-lived fission products as a small-volume concentrated waste (phase III). The purpose of phase III was to provide waste fractionalization facilities in the 221-B Building for processing high-level wastes from the PUREX Plant and the B Plant tank farms into fractions that could be immobilized and contained more safely (DOE/RL-91-52).

The phase III waste fractionalization processing began at the 221-B Building in 1968. This process separated the long-lived radionuclides, Sr-90 and Cs-137, from high-level PUREX and REDOX wastes, and the process stored a concentrated solution of Sr-90 and Cs-137 at the 221-B Building. Individual tanks at the B Plant contained up to 35 MCi of Sr-90 and Cs-137 at concentrations up to 10,000 Ci/gal. The combined storage capacity of the tanks was estimated to be 85 MCi of Sr-90 and 25 MCi of Cs-137 (DOE/RL-91-52).

Three processes were used for the waste fractionalization. The first process was the feed preparation and solvent extraction of current acid wastes generated by the 202-A Building and stored at the PUREX Plant and REDOX Plant tank farms. The solids in these wastes contained about 55 percent of the strontium and 70 percent of the rare earths. The solids, consisting mostly of silicates, phosphates, and sulfates, were treated by a carbonate-hydroxide metathesis solution to convert the sulfates to carbonate-hydroxide solids. These solids then were separated from the solution by centrifuge and dissolved in nitric acid to recover the fission products. The dissolved fission products were combined with original acid waste supernate after it had been treated to form feed for the solvent extraction columns by adding a metal-ion complexing agent, a pH buffer, and a pH adjustment solution (DOE/RL-91-52).

The feed went through a series of solvent extraction columns. The solvent used was a mixture of di(2-ethylhexyl) phosphoric acid extractant and TBP modifier in an NPH diluent. The strontium, and other rare earths (including cerium) were extracted from the aqueous phase into the solvent. The aqueous fraction contained cesium and was routed to the A or AX Tank Farm underground storage tanks near the PUREX Plant for temporary storage to allow the decay of short-lived activity (DOE/RL-91-52).

The strontium fraction was stripped from the solvent with dilute nitric acid and was thermally concentrated with the cell 5 concentrator for storage in tanks in 221-B Building cells 6-8. The cerium and rare-earth fraction was stripped from its solvent with nitric acid, combined with organic wash wastes, and sent to single-shell tank storage. The solvent was washed and recycled for reuse (DOE/RL-91-52).

The second process used was a feed preparation and solvent extraction process for processing stored sludge wastes from the A, AX, and SX Tank Farms. The sludge was sluiced with supernate and water and pumped out of the tanks to the 244-AR Vault. At this vault, the sluicing water was decanted for storage to await treatment for cesium removal. The sludge, containing the bulk of the fission products, was dissolved in nitric acid and transferred to the 221-B Building for treatment (DOE/RL-91-52).

At the 221-B Building, the rare earths and strontium were precipitated as sulfates using lead sulfate as a carrier to separate them from iron and aluminum. A sodium hydroxide-sodium

carbonate metathesis was performed to convert the sulfates to hydroxides and carbonates and to eliminate the bulk of the lead. The product cake was centrifuged, dissolved with nitric acid, and accumulated for solvent extraction treatment. The solvent extraction was similar to the solvent extraction for the current acid waste. However, the aqueous waste fraction from the initial solvent extraction (containing the rare earths and the solvent wash) wastes were thermally concentrated at the 221-B Building using the cell 20 concentrator and were transferred to immobilization processing (in-tank solidification) (DOE/RL-91-52).

The third waste fractionation process was the ion exchange of stored cesium supernates and sluicing solutions. High-level tank farm supernates and sluicing water containing Cs-137 were passed through an ion-exchange column at the 221-B Building. The cesium and a small fraction of sodium were adsorbed on a synthetic alumino-silicate zeolite resin. About 97 percent of the adsorbed sodium and 0.5 percent of the loaded cesium were designed to be removed from the column with a dilute ammonium and carbonate-ammonium hydroxide scrub solution. Following this, the remaining cesium was removed with a concentrated mixture of ammonium carbonate and ammonium hydroxide. The cesium was thermally concentrated in the cell 20 concentrator and stored in tanks in 221-B Building cells 14 and 17. The waste from the adsorption step was routed directly to in-tank solidification. The column wash wastes and scrubs were thermally concentrated in the cell 23 concentrator before being transferred to in-tank solidification.
In 1974, the 221-B Building began using cell 38 to perform final purification of the cesium before being processed at the WESF. The strontium solvent extraction process operated until 1978. Cesium final purification was ended in 1983, and strontium purification was ended in 1984 (DOE/RL-91-52).

The waste fractionalization process included a thermal evaporation concentrator in cell 23 to concentrate process wastewaters before disposal. This system was used to concentrate low-level radioactive waste after the cesium and strontium waste fractionalization process was shut down in 1984. Double-shell tank waste was received at the 221-B Building to be processed through the low-level waste concentrator until 1986. The 221-B Building received no double-shell tank wastes after April 1986, and processing of these wastes was completed by late 1986.
Other sources of the low-level waste included miscellaneous sumps and drains in the WESF, which diverted decontamination waste solutions generated in the WESF process cells.
Another contributor was a liquid collection system located beneath the 40 cells in the 221-B Building, which collected cell drainage from decontamination work and water washdowns in the processing section of the 221-B Building. A portion of the collected cell drainage from water washdowns was disposed of in the 200-PW-2 OU waste site, the 216-B-60 Crib.
The concentrator also processed wastes produced by the cleanout of various process vessels at the 221-B Building and WESF through 1986 (DOE/RL-91-52).

The concentrator process consisted of a vertical, single-pass, shell-and-tube thermal-recirculated and steam-heated evaporator. The evaporator had two bundles of tubes that contained low-pressure steam to heat the process feed. The tube bundles heated the feed to the boiling point and vaporized it. The evaporated liquid passed through a high-efficiency deentrainer to remove entrained liquid droplets and was condensed as process condensate. The process condensate was disposed of in the 216-B-12 Crib beginning in May 1967, when the 216-B-12 Crib was reactivated. In November 1973, the process condensate was diverted to the 216-B-62 Crib. Disposal continued to this crib until the concentrator was shut down. The process condensate is known as the B Plant process condensate stream (DOE/RL-91-52).

2.2.2.5 Hot Semiworks Operations

The 201-C Process Building was constructed in 1949. During its history, the 201-C Process Building went through three distinct operational modes. These operations include the following:

- Pilot plant for REDOX chemical processing
- Pilot plant for PUREX chemical processing
- Strontium (and other fission products) recovery operations.

Limited information was obtained regarding the nature of cold-run wastes derived from startup trials for the various Hot Semiworks Pilot Plant chemical processing. Historical cold-run wastes likely were characterized by high salt content, low organics, and as neutral to basic. Unspecified wastes also were derived from the 201-C Process Building systems decontamination activities, which were conducted before the building was converted for new processes. Information regarding the waste management units receiving other waste streams is limited (DOE/RL-92-18).

Wastes generated during the REDOX process included coating wastes from decladding of aluminum fuels in a boiling sodium nitrate/sodium hydroxide solution. The waste stream was composed primarily of uranium, plutonium, sodium hydroxide, sodium aluminate, sodium nitrate and nitrite, and sodium silicate. The waste solution was transferred to a tank separate from the high-level waste. During the REDOX processes, Zircaloy-clad fuels were declad in an ammonium nitrate-ammonium fluoride mixture. The REDOX process waste stream was composed of large volumes of aluminum nitrate, and zirconium oxide, sodium fluoride, sodium nitrate, potassium fluoride, uranium, and plutonium. Other wastes associated with the REDOX process included chromate, sodium sulfate, and ferric hydroxide compounds in addition to the many other compounds listed. Waste streams from the REDOX process were slightly acidic and contained fission products including Cs-137, Ru-106, Sr-90, Pu-239, and uranium, based on information in WIDS. The presence of additional radionuclides including tritium, Co-60, and U-238 were reported in the waste stream. The coating wastes from the aluminum and Zircaloy-clad fuels decladding were neutralized with caustic soda. Wastes generated during the REDOX process were sent to several waste sites, including the 216-C-1 and 216-C-3 Cribs, which received acidic radioactive waste between 1953 and 1954 (DOE/RL-92-18).

The PUREX process generated wastes from decladding the aluminum and Zircaloy fuels that reportedly were identical to those generated from REDOX decladding. Tributyl phosphate in kerosene solvent was used to extract plutonium and uranium from acid solutions of irradiated uranium. During the PUREX process, a potassium permanganate, sodium carbonate, and nitric acid wash were used to separate organic compounds from a process extraction solvent before the solvent was reused. The PUREX organic wash wastes primarily included sodium nitrate, sodium carbonate, manganese oxide, and uranium. Process condensate from the PUREX Plant was generated as a waste stream. This process condensate consisted of water that had been in intimate contact with process organics, TBP, and NPH. Because these chemicals were of technical grade, they contained a variety of trace impurities: butanol, butyraldehyde, acetone, methyl ethyl ketone, and others. In addition, degradation products also are expected from the breakdown of unstable compounds, such as TBP. Wastes generated during the PUREX process were sent to several waste management units, including the 216-C-1 and the 216-C-5 Cribs,

which received neutral-to-basic process condensate and cold oven wastes between 1954 and 1956 (DOE/RL-92-18).

The strontium recovery process was performed using an organic complexant di-2-ethyl-hexyl phosphoric acid to extract strontium from acid solutions of waste fuels. However, no information regarding specific characteristics of wastes derived from cerium, technetium, and promethium recovery were found. In general, high-level wastes were stored in underground tanks in the 200 East Area tank farms, and low-level wastes were routed to cribs in the Hot Semiworks area for disposal. Wastes from the 201-C Process Building were sent to several waste sites, including the 241-CX-71 Storage Tank, which received acidic wastes from the 201-C Process Building before they were discharge to the 216-C-1 and the 216-C-10 Cribs, and unspecified wastes from the 201-C Process Building hot-shop sink (DOE/RL-92-18).

The Critical Mass Laboratory (209-E Building) conducted criticality experiments with plutonium nitrate and enriched uranium solutions from 1960 to 1983 using plutonium nitrate and enriched uranium solutions. Criticality research also was conducted with solid nuclear materials and fuels such as plutonium blocks, uranium blocks and slabs, and fuel assemblies from the Fast Flux Test Facility and other reactors (DOE/RL-92-04). The laboratory generated mostly acidic liquid waste (neutron reflector tank water) containing mainly Cs-137, Ru-106, Sr-90, plutonium, uranium, and some nitrates. Process wastes were routed to the 209-E-WS-3 Valve Pit/Hold Tank, where they were collectively sampled and ultimately routed to the 216-C-7 Crib.

2.2.2.6 242-A Evaporator

The 242-A Evaporator is the primary waste concentrator for Hanford Site mixed wastes that are stored and treated in the double-shell tank system. The 242-A Evaporator began operation in 1977. Extensive modifications to the process have been implemented to maintain regulatory compliance of the facility's operation. The purpose of the facility is to reduce the volume of radioactive liquid (aqueous and organic) waste by evaporating water from the feed solution to produce a concentrated salt solution. The solution separates upon cooling to form salt cake and residual liquor. This process reduces the number of double-shell tanks required to store this type of waste by 35 to 60 percent.

The 242-A Evaporator building contains the evaporator vessel, supporting process equipment, and the principal process components of the evaporator-crystallizer system. The building comprises two adjoining, structurally independent structures, designated A and B. Structure A houses the processing and service areas, while structure B houses operating and personnel support areas.

Evaporator feed entered the system through double-shell Tank 241-AW-102. The feed consisted of unprocessed and processed waste from various sources:

- PUREX (decladding, ammonia scrubber, 204-AR tank car, etc. wastes)
- B Plant (complexed or Sr-90/Cs-137 recovery wastes and aging wastes)
- Double-shell tank farms (recycled slurry and salt-well pumping wastes)
- Miscellaneous wastes (Plutonium Finishing Plant, laboratory, 100-N phosphate and sulfate wastes).

The feed is pumped into a recirculation line upstream of the reboiler, where it is joined and blended with the main process slurry stream. Once in the reboiler, the mixture is heated by

steam to approximately 100-170 °F. The mixture is discharged to the vapor-liquid separator, which is maintained at a reduced pressure, causing a portion of the stream to "flash" from liquid to steam. The steam is drawn though mesh deentrainer pads to a larger vapor line and finally to the primary condenser. The slurry becomes super-saturated as it evaporates and crystals (salt cake) form in liquor. After approximately 2 minutes, the slurry is recirculated and the process repeats. Once the desired volume reduction parameters are reached, the liquid effluents are separated into two waste streams (WHC-EP-0342, *242-A Evaporator Process Condensate Stream-Specific Report*, Addendum 15).

The first waste stream, the concentrated slurry, is pumped back into the double-shell tank system (AN, AW, and/or AP Tank Farms). The second waste stream, process condensates and wastes from the 242-A Evaporator, flowed into one of the three cells at the 207-A South Retention Basin until the cell had reached operational capacity (before 1989). At this time, the stream condensate flow was diverted to one of the two remaining cells. The cell that had reached capacity was sampled and analyzed at the 222-S Laboratory for radionuclides, as an indication of process control. The steam condensate from the full diversion basin then was discharged to the 216-A-37-1 Crib if the analytical results were within applicable regulatory limits. Figure 2-19 illustrates the past process flow and wastewater routing of the 242-A Evaporator.

Following cessation of discharge to these facilities in April 1989 when it was determined that the effluent contained mixed waste regulated under WAC 173-303, the 242-A Evaporator facility was upgraded and discharges were rerouted to the Liquid Effluent Retention Facility, where the discharge receives final treatment at the Effluent Treatment Facility.

2.2.2.7 Bismuth/Phosphate and Lanthanum/Fluoride Processes

The bismuth/phosphate process was an inorganic, step-wise, precipitation process that separated plutonium from uranium and fission products. This process occurred in the 221-B/T Canyon Buildings and used sodium hydroxide to remove aluminum cladding and concentrated nitric acid to dissolve the fuel rods. Bismuth phosphate and bismuth oxynitrate were used to support the precipitation of plutonium, while hydrogen peroxide, sodium dichromate, ferrous hydroxide, and ferrous ammonium sulfates were used to change the plutonium valence during the oxidation reactions. Phosphoric, sulfuric, and nitric acids were added to dissolve the precipitants formed. The bismuth/phosphate process preferentially attracted plutonium from the solution and, as a precipitate, was physically separated by centrifuging.

The lanthanum/fluoride process was performed in the 224-B/T Concentration Facilities and further purified the dilute plutonium solution created in the last step of the bismuth/phosphate process. The dilute plutonium nitrate supernatant was oxidized with sodium metabismuthate. Phosphoric acid was added to precipitate impurities, and the resulting solution was treated with oxalic and hydrofluoric acids and lanthanum salt. As a result, lanthanum fluoride and plutonium fluorides were co-precipitated. The lanthanum and plutonium fluoride solids then were converted to hydroxides by the addition of a hot potassium-hydroxide solution. The hydroxides were washed with water, dissolved in nitric acid, and heated to form a concentrated plutonium nitrate solution. This solution was sent to the isolation building (231-Z Materials Engineering Laboratory) for further purification treatments and evaporation. A concentrated plutonium nitrate paste was the final product. For every batch (760 L [200 gal]) of dilute, unpurified plutonium solution entering the 224-B/T Concentration Facilities, an estimated 30 L (8 gal) of

purified concentrated weapons-grade plutonium was produced (HW-10475, *Hanford Engineer Technical Manual (T/B Plants)*, Parts A, B, C).

The 216-T-20 Trench received contaminated nitric acid from the 241-TX-155 Diversion Box Catch Tank in November 1952. In 1952, the catch tank was used to transfer plant process wastes to various tank farm facilities, cribs, and trenches via underground transfer lines.

2.2.3 Representative Sites and Treatment, Storage, and Disposal Units

The concept and rationale for using analogous sites to reduce the amount of site characterization and evaluation required to support remedial action decision making is discussed in the Implementation Plan (DOE/RL-98-28). The use of this approach relies on, first, grouping sites with similar location, geology, waste site history, and contaminants, and then choosing one or more representative sites for comprehensive field investigations, including sampling. Findings from site investigations at representative sites are extended to apply to other sites in the waste group that were not characterized. Sites for which field data have not been collected are assumed to have chemical characteristics similar to those of the sites that were characterized. Confirmatory investigations can be performed after the remedy selection at the sites not selected as representative sites, rather than pre-remedial characterization efforts.

Data from representative sites are used to evaluate remedial alternatives and to select one (or more) to apply for the entire waste group. Confirmatory sampling of the analogous sites after remedy selection may be required and is built into the remedial design planning to demonstrate that analogous conditions exist. Although a degree of uncertainty exists in employing the analogous site concept, substantial benefit is realized in the early selection of a remedy that allows early cleanup action to be performed. As defined in the Implementation Plan (DOE/RL-98-28), four representative sites were identified for the 200-PW-2 OU. The representative sites include three RPP sites (216-A-19 Trench, 216-B-12 Crib, and 216-U-8 Crib) and one RCRA TSD unit (216-U-12 Crib). In addition, two more RCRA TSD units (216-A-10 Crib and 216-A-36B Crib) will be characterized as part of RCRA closure activities for this OU.

The 216-U-8 Crib was chosen as a worst-case site because of its high inventory and the current level of characterization. The 216-A-19 Trench was chosen as the second worst-case site because of its high contaminant inventory (and the highest uranium inventory) from a process waste stream. The 216-B-12 and 216-U-12 Cribs are typical waste sites for the OU. The 216-B-12 Crib was selected for its contaminant inventory and the fact that it received a second process condensate that added high inventories of fission products. The 216-U-12 Crib was selected for its typical uranium inventory and current level of characterization. It is also a RCRA TSD unit. The remaining two sites (216-A-10 and 216-A-36B Cribs) also are RCRA TSD units and will be characterized as part of the closure/postclosure activities.

In the 200-PW-4 OU one representative waste site (216-C-3 Crib) was identified, along with the two RCRA TSD units (207-A South Retention Basin and 216-A-37-1 Crib). The consolidation of the 200-PW-4 OU waste sites into the 200-PW-2 OU work plan resulted in an assessment of the 200-PW-4 OU waste sites against the 200-PW-2 OU conceptual contaminant distribution

models. Consequently, the 216-B-12 Crib waste site was identified as an appropriate conceptual contaminant distribution model for the 216-C-3 Crib, based on waste site physical configuration, liquid effluent volumes, soil pore volumes, and contaminant concentrations. Therefore, the 216-C-3 Crib will not be retained as a representative waste site for the 200-PW-4 OU. Instead, the information obtained from the investigation of the 216-B-12 Crib waste site and the two 200-PW-4 TSD units, as well as other information from the 200-PW-2 OU investigation, will serve as the characterization data for the 200-PW-4 OU.

The following sections describe the representative sites in detail. Information was obtained from the WIDS database and WIDS historical files unless otherwise noted.

2.2.3.1 216-A-19 Trench

The 216-A-19 Trench is located in the 200 East Area about 800 m (2,625 ft) northwest of the 202-A (PUREX Plant) Building (Figure 2-20). It has dimensions of approximately 7.6 by 7.6 by 4.6 m (25 by 25 by 15 ft) deep (WIDS). When in operation, the trench had a surface elevation of 199 m (652 ft). It began operation in November 1955 and operated until January 1956. During that period it received cold (nonirradiated uranium) and PUREX startup wastes (containing fission products) and condenser cooling water from the 241-A-431 Ventilation Building.

Waste from PUREX entered the trench from above-ground piping that emptied into the trench. Condenser cooling water from the 241-A-431 Ventilation Building may have reached the trench via the 216-A-34 Ditch that lies adjacent to the 216-A-19 Trench. An estimated 38,700 kg (85,317 lb) of uranium in about 1,100,000 L (291,000 gal) of waste was routed to the trench (DOE/RL-96-81; PNL-6456, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*).

Nitrate salts were disposed of at the site. The radionuclide inventory included Co-60, Sr-90, Cs-137, Pu-239/240, and U-238 (PNL-6456). The 216-A-19 Trench and 216-A-34 Ditch were backfilled following use and later were covered with several feet of fill (HW-43121, *Tabulation of Radioactive Liquid Waste Disposal Facilities*; HW-41535, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas*; HW-57830, *Isolation of Abandoned or Depleted Waste Disposal Sites*). The site was surface stabilized again in 1990 with additional fill material (WIDS).

2.2.3.2 216-B-12 Crib

The 216-B-12 Crib is located in the 200 East Area about 305 m (1,000 ft) northwest of the 221-B Building. The bottom surface area of the crib is 49 by 15 m (160 by 50 ft); the crib is approximately 8 m (26 ft) deep on one end and 9 m (30 ft) deep on the downgradient end (Figure 2-21) (HW-43121; RHO-CD-673, *Handbook 200 Area Waste Sites*, Vol. I and II; PNL-6456).

The unit consists of a series of three cascading, 5- by 5- by 3-m (16- by 16- by 10-ft)-high wooden boxes made from 6- by 8-in. Douglas-fir in a 9-m (30-ft)-deep excavation. The bottom 4 m (12 ft) contains 1.3-cm (0.5-in.) gravel backfill, 1.2 m (4 ft) of which underlie the cribs. The excavation has side slopes of 1:1. It is unclear if the gravel backfill merely surrounds the

boxes or also fills them. The unit is considered to have cave-in potential (WHC-IP-0809, *B Plant Aggregate Area Management Study Technical Baseline Report*).

During its service history, the 216-B-12 Crib received process condensate from the 221-U and 224-U Buildings and the 221-B Building from November 1952 until December 1957. The cribs were inactive from December 1957 until May 1967. From May 1967 until November 1967, the crib received liquid waste from the 221-B Building. From November 1967 to November 1973, it received additional process condensate via a 15-cm (6-in.) vitrified clay pipe from the 221-B Building, including limestone that was used for neutralization of the waste stream. The site was retired in November 1973. Radiation Occurrence Report 73-82 (discussed in RHO-CD-673) suggests that the 216-B-12 Crib was abandoned in November 1973 when the ground above the crib started to subside, resulting in flow restrictions in the piping. The subsidence was backfilled and the fill line was blanked in 1973. In 1974, the crib was stabilized with layers of sand and gravel, with a plastic liner to deter vegetation growth. An additional 0.6 m (2 ft) of clean soil was added in 1993 (RHO-CD-673; WIDS).

The waste is low salt and neutral/basic. Records indicate that 180,000 kg (396,832 lb) of ammonium nitrate was disposed of at the site. The radionuclide inventory of the site includes Co-60, Sr-90, Cs-137, Pu-239/240, and U-238 (PNL-6456; DOE/RL-88-19, *B Plant Aggregate Area Management Study Technical Baseline Report*). An estimated 21,000 kg (46,300 lb) of uranium, 374 g (1 lb) of plutonium, 716 Ci of Cs-137, and 79.3 Ci of Sr-90 may have been discharged to this site. The total volume of effluent discharged is estimated to be 520,000,000 L (140,000,000 gal) (PNL-6456; DOE/RL-96-81).

2.2.3.3 216-U-8 Crib

The 216-U-8 Crib is located in the 200 West Area about 137 m (450 ft) west of Beloit Avenue and 229 m (750 ft) south of 16th Street.

The crib consists of three timbered cascading crib structures, referred to as a stack drain, with a bottom surface area that is 48 by 15 m (160 by 50 ft); the crib is 9 m (31 ft) deep (Figure 2-22) (HW-57830; PNL-6456). Surface elevation was 211 m (692 ft) and the bottom of the crib was at 202 m (662 ft) (HW-33305, *Radioactive Liquid Waste Disposal Facilities*). Each box-style crib measures 5 by 5 by 3 m (16 by 16 by 10 ft) high and was constructed of fir timbers resting on a 0.9-m (3-ft)-thick gravel bed about 9 m (31 ft) below grade. It is unclear if the gravel backfill merely surrounds the boxes or also fills them. The cribs are 18 m (60 ft) apart and connected in a series by a 15-cm (6-in.) schedule 40 pipe. Each crib was vented by two 4-in. schedule 40 steel pipes that were capped below grade. A 15-cm (6-in.)-diameter vitrified clay waste transfer line entered the crib and was partially protected by a concrete encasement (WHC-EP-0400, *200-UP-2 Operable Unit Technical Baseline Report*).

The crib operated from June 1952 to March 1960. The crib received process condensate via a 15-cm (6-in.) vitrified clay pipe from the 221-U and 224-U Tanks and 291-U-1 Stack drainage (HW-41535; DOE/RL-88-19; DOE/RL-95-106). By July 1954, the crib had received 14,544 kg (32,064 lb) of uranium, 185 g (0.4 lb) of plutonium, and an estimated 1.54×10^8 L (4.1×10^7 gal) of liquid materials (HW-33591). By the end of 1956, the crib had received 3.34×10^8 L (8.8×10^7 gal) of liquid, 23,800 kg (6,173 lb) of uranium, and 365 g (0.8 lb) of plutonium (HW-48518, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations*

Facilities Through December 1956). By 1958, it had received 3.63 x10^8 L (9.6 x 10^7 gal) of liquid materials and 367 g (0.8 lb) of plutonium (HW-59359, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through December 1958*). In 1959, the crib received an additional 9.08 x 10^6 L (2.4 x 10^6 gal) of waste (HW-63121, *Laboratory Studies of Hanford Waste Cribs*). During its operational use, the crib received a total of 3.79 x 10^8 L (1.0 x 10^8 gal) of waste (DOE/RL-91-52; DOE/RL-95-106).

In 1960, the crib was deactivated when it began to subside. Sinkholes were backfilled around the three cribs and the risers were cut off and capped below grade (RHO-CD-673). The incoming waste transfer line was blanked about 18 m (60 ft) north of the crib, and waste materials were diverted to the 216-U-12 Crib. In 1994, the area over the crib and the portion of the vitrified clay pipe from 16th Street south to the crib were stabilized with about 0.6 m (2 ft) of soil (DOE/RL-95-13).

The site was characterized in 1995 as part of 200-UP-2 OU characterization activities (DOE/RL-95-13). This included installation of a borehole through the crib, collection of soil and vegetation samples, and an in-line camera survey of a portion of the pipeline that led to the waste site. Waste in the site is acidic. Chemicals disposed of at the site include nitric acid. The radionuclide inventory includes Co-60, Sr-90, Cs-137, Pu-239/240, and U-238 (PNL-6456). This included an estimated 2.39 x 10^4 kg (52,700 lb) of uranium and 370 g (0.8 lb) of plutonium (DOE/RL-96-81).

2.2.3.4 216-U-12 Crib

The 216-U-12 Crib is the first of three RCRA TSD units in the 200-PW-2 OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1987 (DOE/RL-88-21, *Hanford Site Dangerous Waste Part A Permit Application*, "216-U-12 Crib Supplemental Information to the Hanford Facility Contingency Plan [DOE/RL-93-75]").

The 216-U-12 Crib replaced the 216-U-8 Crib when it began to subside. The 216-U-12 Crib is located in the 200 West Area about 650 m (2,130 ft) south of the 221-U Building and 140 m (460 ft) north of Beloit Avenue. The crib was constructed in 1960. It was designed to receive mixed waste (corrosive, D002) from U Plant, via a 15-cm (6-in.) vitrified clay pipe, for approximately 5 minutes every hour, at the rate of 378 L/min (100 gal/min), and to dispose of the process condensate by percolation into the soil column (DOE/RL-95-13). The 46-m (150-ft)-long gravel-filled crib has bottom dimensions of 30 by 3 m (100 by 10 ft) with natural earth sides, a 2:1 slope, and no constructed internal structure (Figure 2-23). The crib is about 5 m (15 ft) below grade. The lower 2.1 m (7 ft) is filled with graduated layers of sand and gravels and covered with a polyethylene barrier. A 305-mm (12-in.) vitrified clay pipe extends the length of the crib 3 m (10 ft) below the surface. A vent riser, about 4 m (14 ft) long, extends from 3 m (10 ft) below the surface to 0.9 m (3 ft) above grade. Two 5.2-m (17-ft)-long vitrified clay liquid-level gage wells also extend 0.9 m (3 ft) above grade. A 15-cm (6-in.) diameter vitrified clay pipe delivered water to the crib from the point where the 216-U-8 Crib feed line was blanked off (WHC-EP-0400).

During its operational period beginning in April 1960 and continuing for 28 years, the crib received 150,000,000 L (40,000,000 gal) of liquid waste. From 1960 to 1967 it received 291-U-1 Stack drainage, 244-WR Vault waste, storm drain waste from the 224-U Building, and

waste from tanks C-5 and C-7 in the 224-B Building. In October 1965, the crib received 31.4 kg (69 lb) of thorium from contaminated water and 3.1 kg (6 lb) of thorium from the 244-WR Vault (DOE/RL-91-52). From May 1967 to September 1972, the crib received occasional waste via tank C-7 in the 244-U Building. From September 1972 to November 1981, the crib was out of service. From November 1981 to June 1988, the crib received corrosive (pH of 0.5 to 1.5) process condensate and miscellaneous storm drain runoff from the 224-U Building (RHO-CD-673; WHC-EP-0400; BHI-00123, *216-U-12 Crib Supplemental Information to the Hanford Facility Contingency Plan [DOE/RL-93-75]*). The crib received process condensate until January 1988, when it was replaced by the 216-U-17 Crib. That same year, the 216-U-12 Crib pipeline was cut and permanently capped. Approximately 6,440,000 L (1,701,268 gal) of process condensate was disposed to the crib annually (DOE/RL-88-21).

The site was characterized in 1995 as part of 200-UP-2 OU characterization activities (DOE/RL-95-13). This included installation of a borehole adjacent to the crib, collection of soil and vegetation samples, and an in-line camera survey of a portion of the pipeline that led to the waste site. The radionuclide inventory includes tritium, Sr-90, Am-241, Cs-137, Pu-239, and U-238 (DOE/RL-88-19). This included an estimated 2.01×10^3 kg (4,400 lb) of uranium (DOE/RL-96-81). The crib was stabilized with at least 0.6 m (2 ft) of soil.

2.2.3.5 216-A-10 Crib

The 216-A-10 Crib is the second of three RCRA units in the 200-PW-2 OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1987 (DOE/RL-88-21).

The 216-A-10 Crib is located in the 200 East Area approximately 82 m (270 ft) south of the southwest corner of the 202-A (PUREX Plant) Building. The crib is rock filled with dimensions of 84 by 14 by 14 m (275 by 45 by 45 ft) deep. Elevation at the surface was 218 m (714 ft) (Figure 2-24) (HW-43121). A 203-mm (8-in.) vitrified clay distribution pipe was placed horizontally 9 m (30 ft) below grade 8 m (27 ft) east of the centerline. The crib was designed as a percolation unit for the disposal of liquid wastes and was capable of receiving 272,550 L (72,000 gal) per day. Initially, it was a spare crib for the 216-A-5 Crib and received only water (HW-55176, *Index of CPD Crib Building Numbers Designs of CPD Radioactive Liquid Waste Disposal Sites*; HW-57830). From 1956 to 1959, the crib received 2.34×10^8 L of water (HW-44784, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through June 1956*; HW-48518; HW-55593, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through December 1957*; HW-57649, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through June 1958*; HW-64375, *Radioactive Contamination in Liquid Wastes Discharged to Ground at the Separations Facilities Through December 1959*). The 216-A-10 Crib replaced the 216-A-5 Crib in 1961, which was the year that contaminated liquid waste began being discharged into the crib (WIDS). Liquid waste included an acidic waste stream (D002) from the process distillate discharge from PUREX and corrosive/mixed waste (D002) process distillate (RHO-CD-673).

In 1962, the original 203-mm (8-in.) vitrified clay pipe was replaced with a 203-mm (8-in.) stainless steel effluent pipeline, because the acidic waste destroyed the integrity of the original vitrified clay pipe. The replacement pipe was placed on the east side of the crib. In 1967 some

portions of the stainless steel pipe also were replaced. The crib was inactive from 1978 to 1981. From 1981 to 1986, it received acidic process condensate from the 202-A Building. The crib operated until 1987. Following operational use the crib was backfilled (BHI-00121, *216-A-36B Crib Supplemental Information to the Hanford Facility Contingency Plan (DOE/RL-93-75)*).

The total volume of liquid effluent discharged to the crib was 3.2 x 10^9 L (8.5 x 10^8 gal) (DOE/RL-96-81). The crib received tritium, Sr-90 (82.5 Ci), I-129, Am-241 (0.7 Ci), Cs-137 (80.5 Ci), Pm-147, Pu-238, Pu-239, and Pu-241 (350 g total plutonium), and 241 kg (530 lb) of uranium (DOE/RL-88-19; DOE/RL-96-81).

2.2.3.6 216-A-36B Crib

The 216-A-36B Crib is the last of three RCRA TSD units in the 200-PW-2 OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1987 (DOE/RL-88-21).

The 216-A-36B Crib is located in the 200 East Area about 366 m (1,200 ft) south of the 202-A (PUREX Plant) Building. The surface elevation is about 217 m (712 ft), and the subsurface elevation of the crib is about 211 m (691 ft). The gravel-filled crib has bottom dimensions of 152 m (500 ft) and a width that varies from 2 to 3.4 m (7 to 11 ft) (Figure 2-25). The first 7.6 m (25 ft) of the crib is 2 m (7 ft) wide, and the remainder is 3.4 m (11 ft) wide. The bottom of the crib is 7.3 m (24 ft) below grade (WHC-EP-0100, *Properties and Environmental Impact of Ammonia Scrubber Discharge Waste to the 216-A-36B Crib*). A 15-cm (6-in.) perforated pipe was placed horizontally 7 m (23 ft) below grade (DOE/RL-88-19).

The 216-A-36B Crib is the southern 152 m (500 ft) of a longer crib, originally known as the 216-A-36 Crib. The original crib received liquid effluent from September 1965 to March 1966. Over this time period a substantial inventory of radionuclides was disposed to the crib and is assumed to have infiltrated sediments near the inlet to the crib. To eliminate the potential to drive these contaminants deeper into the vadose zone and to continue discharge to the crib, it was reconfigured into two sections: 216-A-36A and 216-A-36B. Grout was injected into the gravel layer of the crib to form a barrier between the two sections. The 216-A-36B Crib was extended southward from 216-A-36A by inserting a smaller diameter pipeline inside the original pipeline, effectively moving the discharge point farther south into the 216-A-36B Crib. Discharge to the 216-A-36B Crib resumed in March 1966 and continued until October 1972, when the crib was temporarily removed from service. During that time period (in May 1970), about 14,000 Ci was discharged to the crib because of a leaking valve in the scrubber drain to the catch tank (SD-HS-SAR-001, *PUREX Plant Final Safety Analysis Report*, Rev. 3, 4, and 5). The crib was placed back in service in November 1982 for the restart of the PUREX Plant and remained active until the spring of 1988.

During its operational use, the 216-A-36 Crib received ammonia scrubber distillate waste, a state-only toxic dangerous waste (WT02) from the 202-A Building (RHO-CD-673). This resulted in the crib's designation as a RCRA TSD unit in the fall of 1987. A RCRA interim status indicator parameter evaluation program has been in operation at the crib since May 1988.

The ammonia scrubber distillate waste contained Am-241 (0.2 Ci), Co-60, Pu-239 (258 g), Sr-90 (1,310 Ci), tritium, S-113, I-129, Cs-137 (1,200 Ci), Pm-147, and U-238 (262 kg).

Chemical contaminants included ammonium fluoride, ammonium nitrate, and sodium dichromate (WHC-EP-0100; DOE/RL-88-19). Use of the crib was discontinued in the spring of 1988 and the facility was backfilled (BHI-00121). No stabilization actions have taken place at the waste site.

2.2.3.7 207-A South Retention Basin

The 207-A South Retention Basin is one of two RCRA TSD units in the 200-PW-4 OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1990 (DOE/RL-88-21). The retention basin is located in the 200 East Area directly east of the 242-A Evaporator.

The 207-A South Retention Basin, which also was known as Process Condensate Basins 1, 2, and 3 (i.e., PC-1, PC-2, and PC-3), began operations in March of 1977. The 207-A South Retention Basin consists of three concrete cells, each with a 264,979-L (70,000 g) design capacity for a total capacity of 794,937 L (210,000 g). The bottom dimension of each cell is 16.8 m (55 ft) long, 3.0 m (10 ft) wide at the bottom, and 2.1 m (7 ft) deep (Figure 2-26). All three cells were coated to prevent constituents from penetrating the concrete. The 207-A South Retention Basin was used for the interim storage of the 242-A Evaporator process condenate to allow for sampling and analysis before the condensate was discharged to the 216-A-37-1 Crib for final disposition. Discharge of 242-A Evaporator process condensate to the 207-A South Retention Basin was terminated on April 12, 1989, when it was determined that the 242-A Evaporator process condensate contained mixed waste regulated under WAC 173-303. The basin was cleaned out and emptied in September 1989 and no longer is used to receive or store mixed waste.

The 242-A Evaporator process condensate was regulated as mixed waste, because the waste was derived from a waste containing spent halogenated and nonhalogenated solvents (F001, F002, F003, F004, and F005), and due to the toxicity of ammonia (WT02, state-only, toxic, dangerous waste). The estimated annual quantity of dangerous waste of 793,469 kg (1,749,300 lb) represented the maximum operating capacity of the 207-A South Retention Basin, and a specific gravity for the waste of 1.0, when the basin was operational.

2.2.3.8 216-A-37-1 Crib

The 216-A-37-1 Crib is the second of two RCRA TSD units in the 200-PW-4 OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1987 (DOE/RL-88-21). This TSD unit is located outside the 200 East Area perimeter fence, about 610 m (2,000 ft) east of the 202-A Building. The gravel-filled crib has bottom dimensions of 213 m (700 ft) long and 3 m (10 ft) wide. A 254 mm (10-in.) galvanized steel distribution pipe was placed 2 m (7 ft) below grade along the centerline of the crib (Figure 2-27). The pipe was covered with a gravel and sand cover before backfill was used to fill the crib to the surface elevation. A valve station is at the south end of the crib, and a vent is located at the north end. The valve station is inside the crib perimeter fence and has surface radiation warning signs and a light chain barricade.

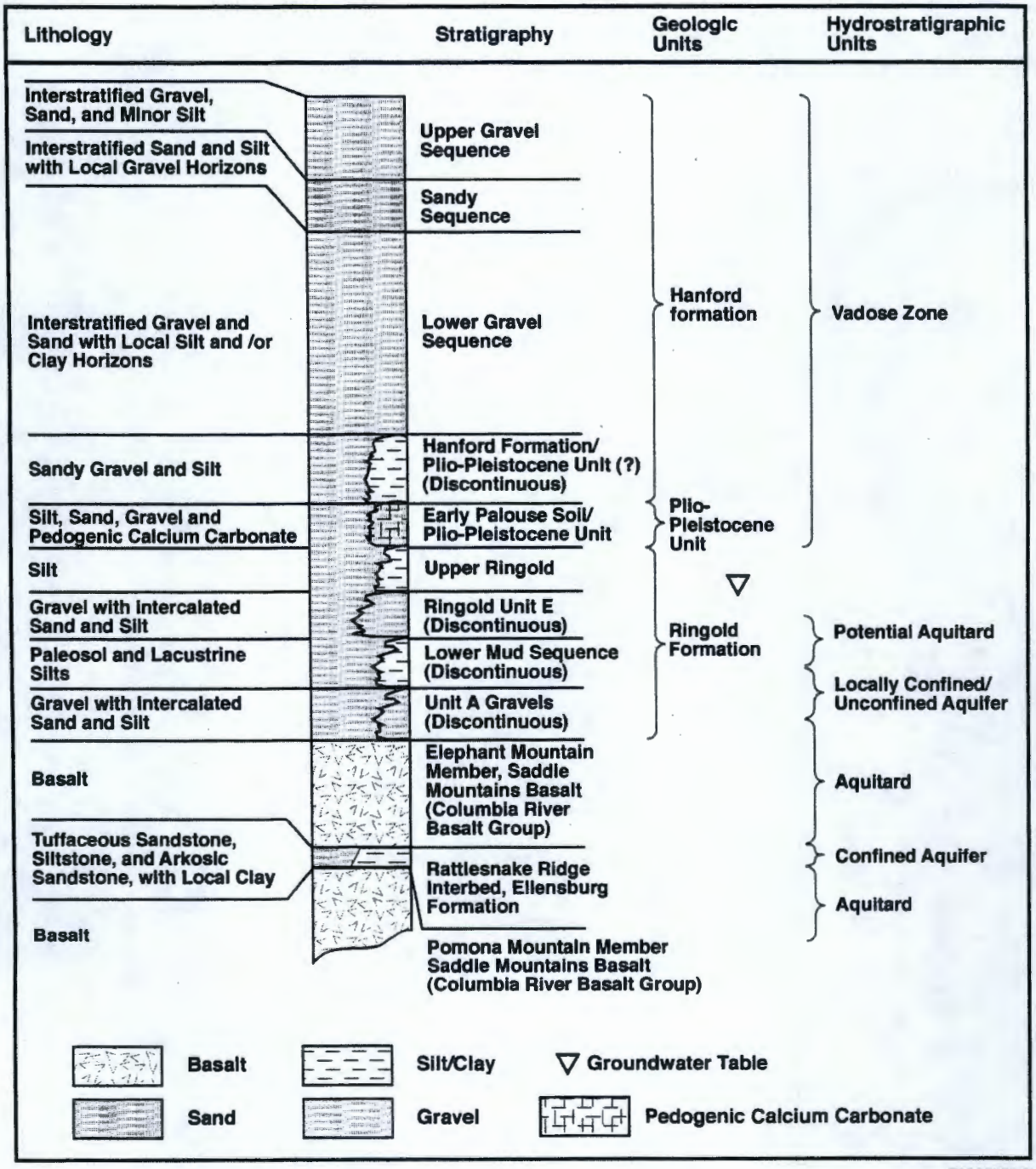
The 216-A-37-1 Crib began operation in March 1977 and was used for the percolation of the 242-A Evaporator process condensate to the soil column. The process design capacity of

86,400 g (327,000 L) per day was based on the daily output of the 242-A Evaporator process condensate discharged to the crib. Discharge of the evaporator process condensate to the crib was terminated on April 12, 1989, when it was determined that the evaporator process condensate contained or could have contained mixed waste regulated under WAC 173-303. The crib is out of service and will be closed under interim status.

The 242-A Evaporator process condensate later was confirmed to be regulated as a mixed waste because of the presence of spent halogenated and nonhalogenated solvents (F001, F002, F003, F004, and F005), and due to the toxicity of ammonia (WT02, toxic state-only). The estimated annual quantity of dangerous waste of 108,290,000 lb (4,912,000 kg) represented the maximum annual output of 242-A Evaporator process condensate during operating campaigns. The site received 377,000,000 L of process condensate, thought to contain Am-241, Cs-137, tritium, I-129, Pm-147, Pu-239, Ru-106, Sn-113, and Sr-90 from the 242-A Evaporator (DOE/RL-88-30, *Hanford Site Waste Management Units Report*; WHC-EP-0141-2, *Westinghouse Hanford Company Effluent Discharges and Solid Waste Management Report for 1989: 200/600 Areas*).

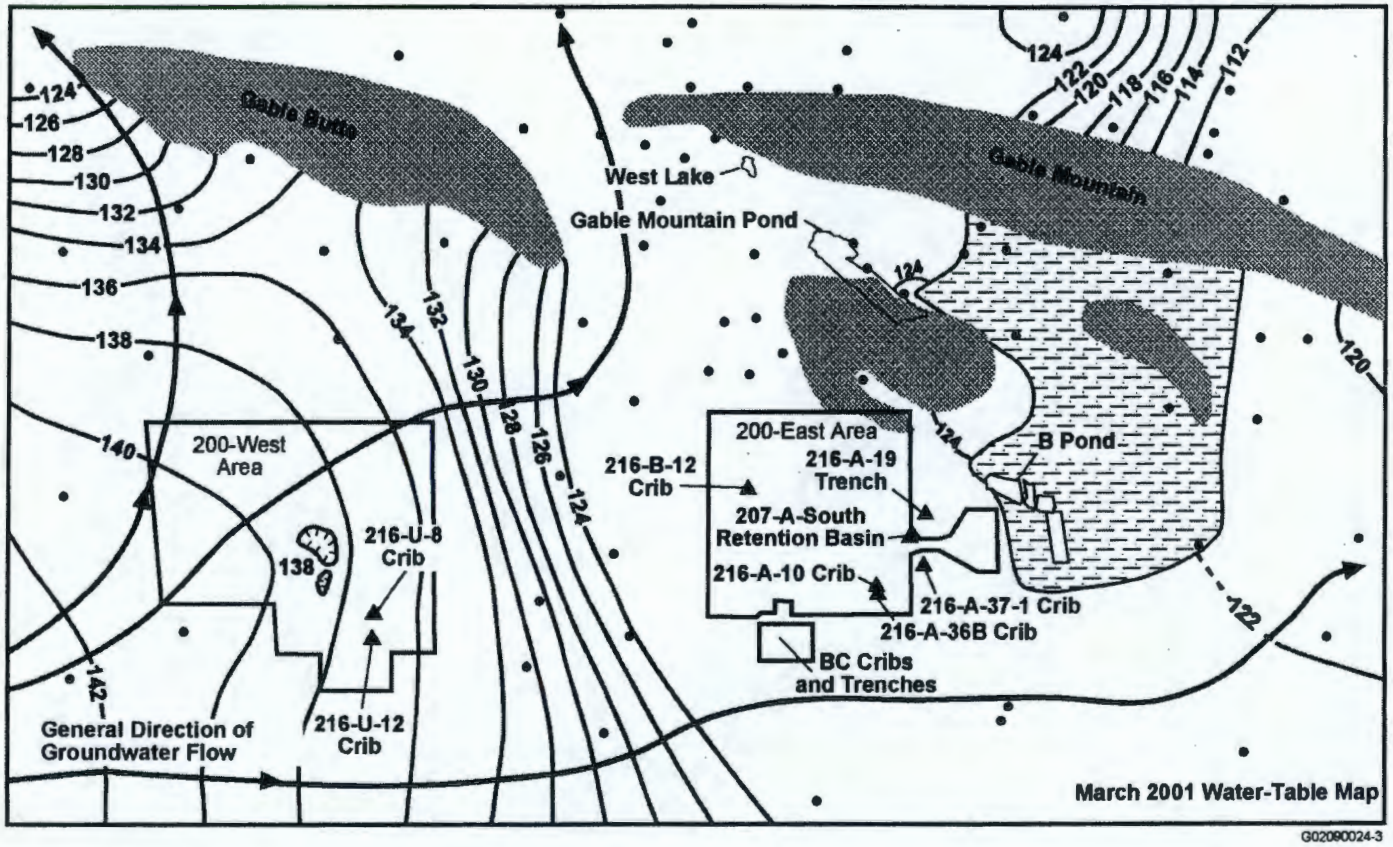
Wells 299-E25-19 and 299-E25-20 monitor this site and indicate an increasing and decreasing tritium activity, respectively. The NO_3 concentration remains at two to five times the drinking water standards. A surface radiation survey, performed in 1991, did not detect contamination (BHI-00033, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit*).

Figure 2-1. Generalized Stratigraphic Column for the 200 Areas.



E0005009.9b

Figure 2-2. Groundwater Table Around the 200 East and 200 West Areas, March 2001.



Estimated Basalt Outcrop Above Water Table

100 Water-Table Contour, m above mean sea level; Dashed Where Inferred

Ringold Formation Lower Mud Above Water Table

● Monitoring Well ▲ Representative Sites

Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Figure 2-3. Stratigraphy Near the 216-A-19 Trench.

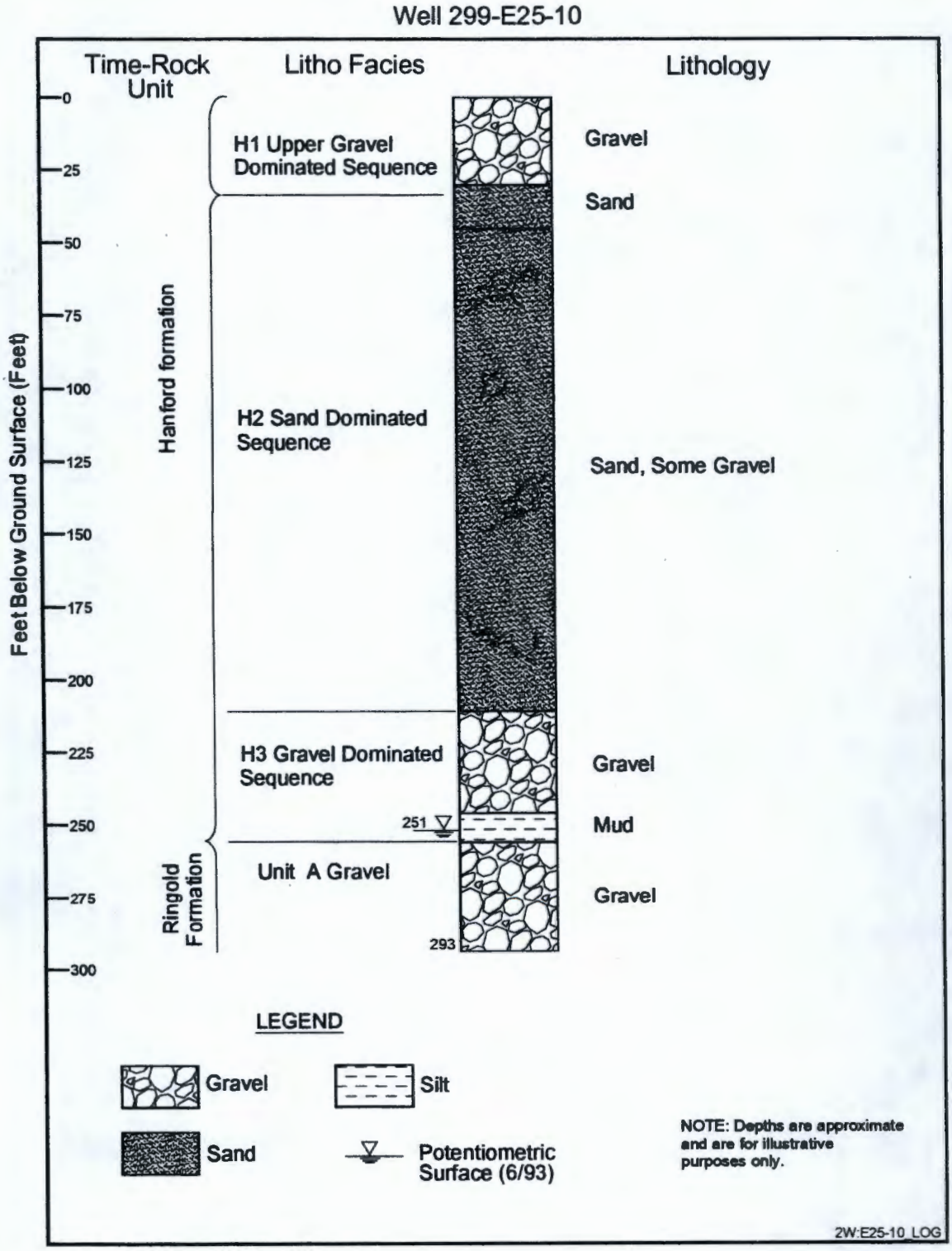


Figure 2-4. Stratigraphy in the Vicinity of the 216-B-12 Crib.

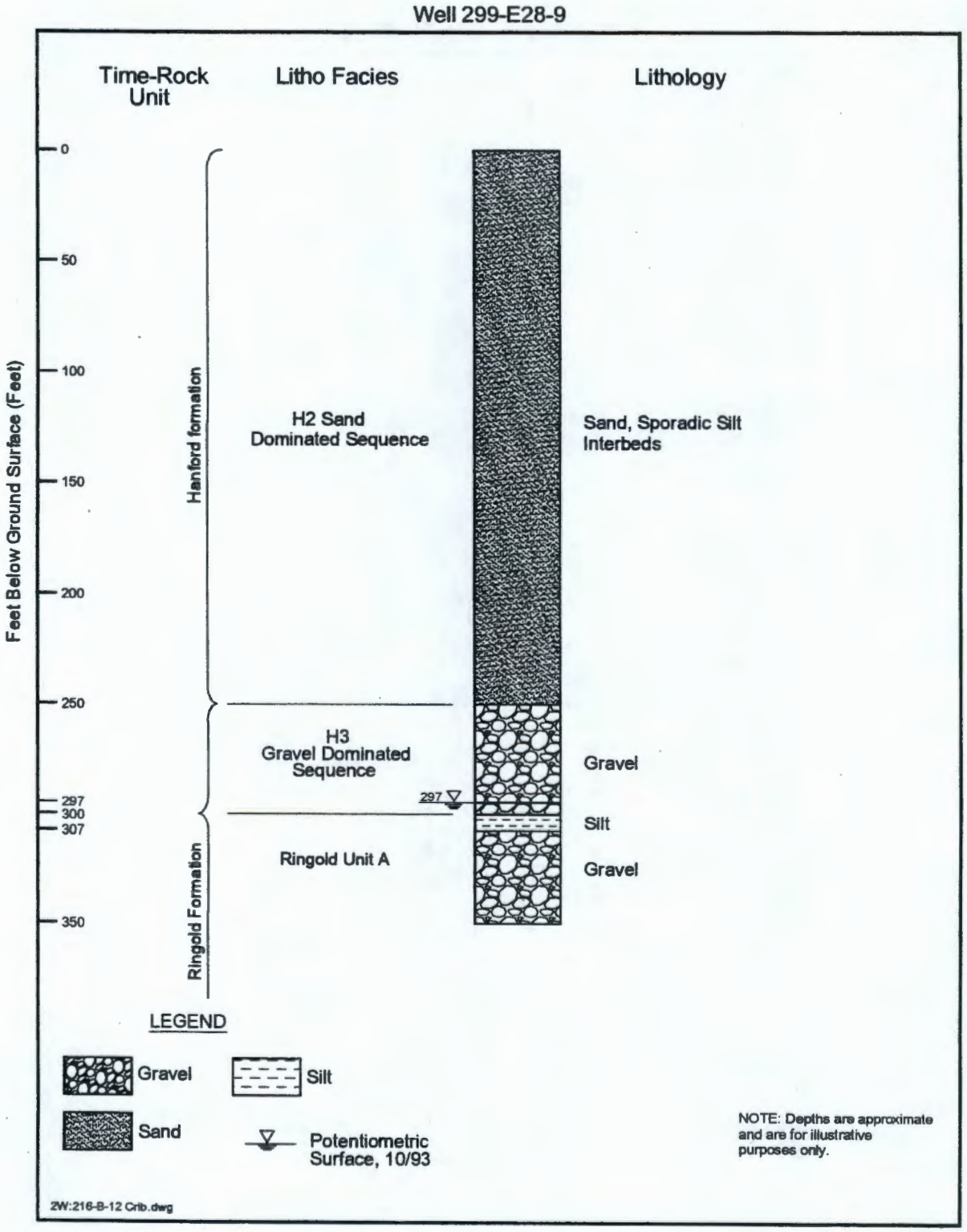


Figure 2-5. Stratigraphy in the Vicinity of the 216-U-8 Crib.

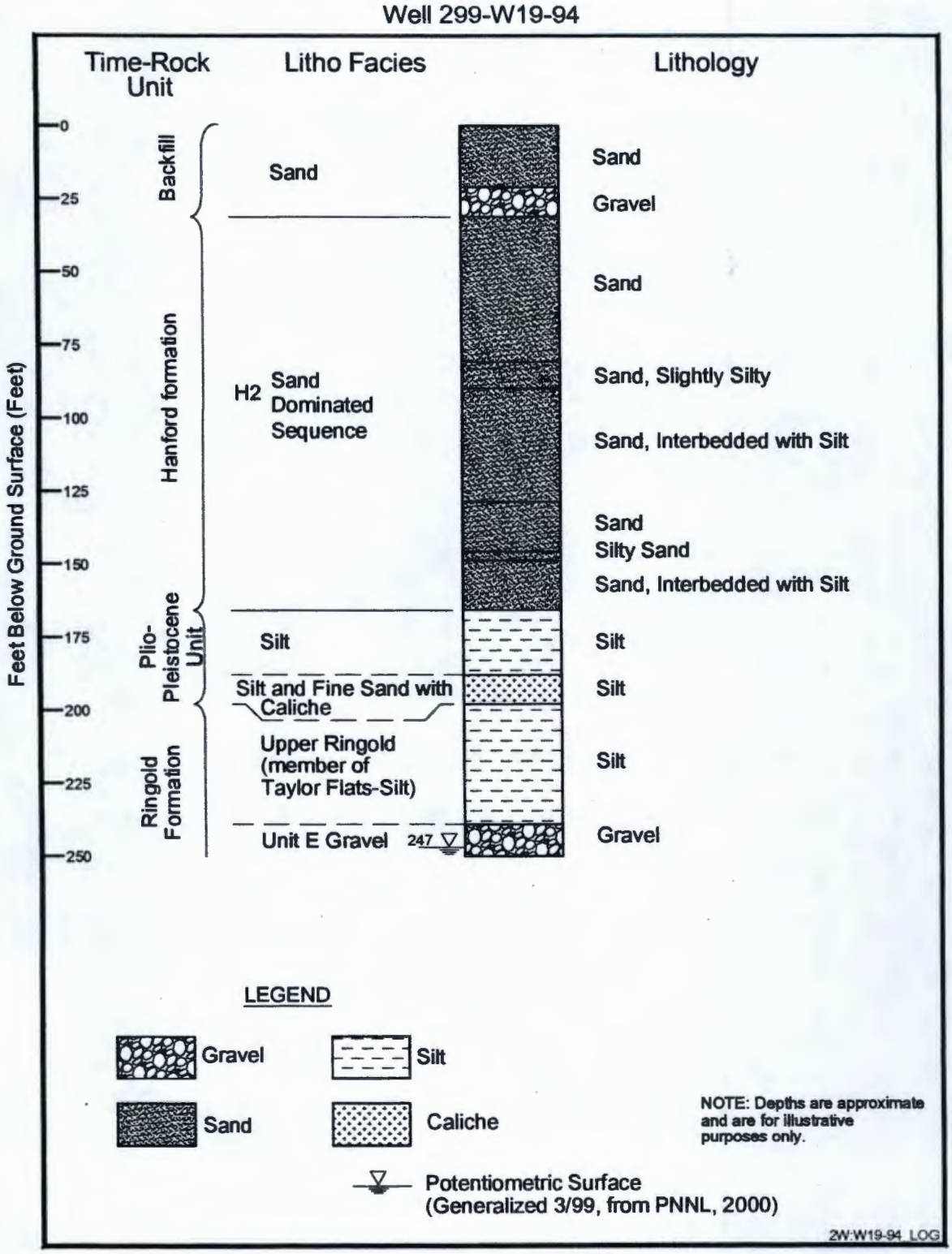


Figure 2-6. Stratigraphy Near the 216-U-12 Crib.

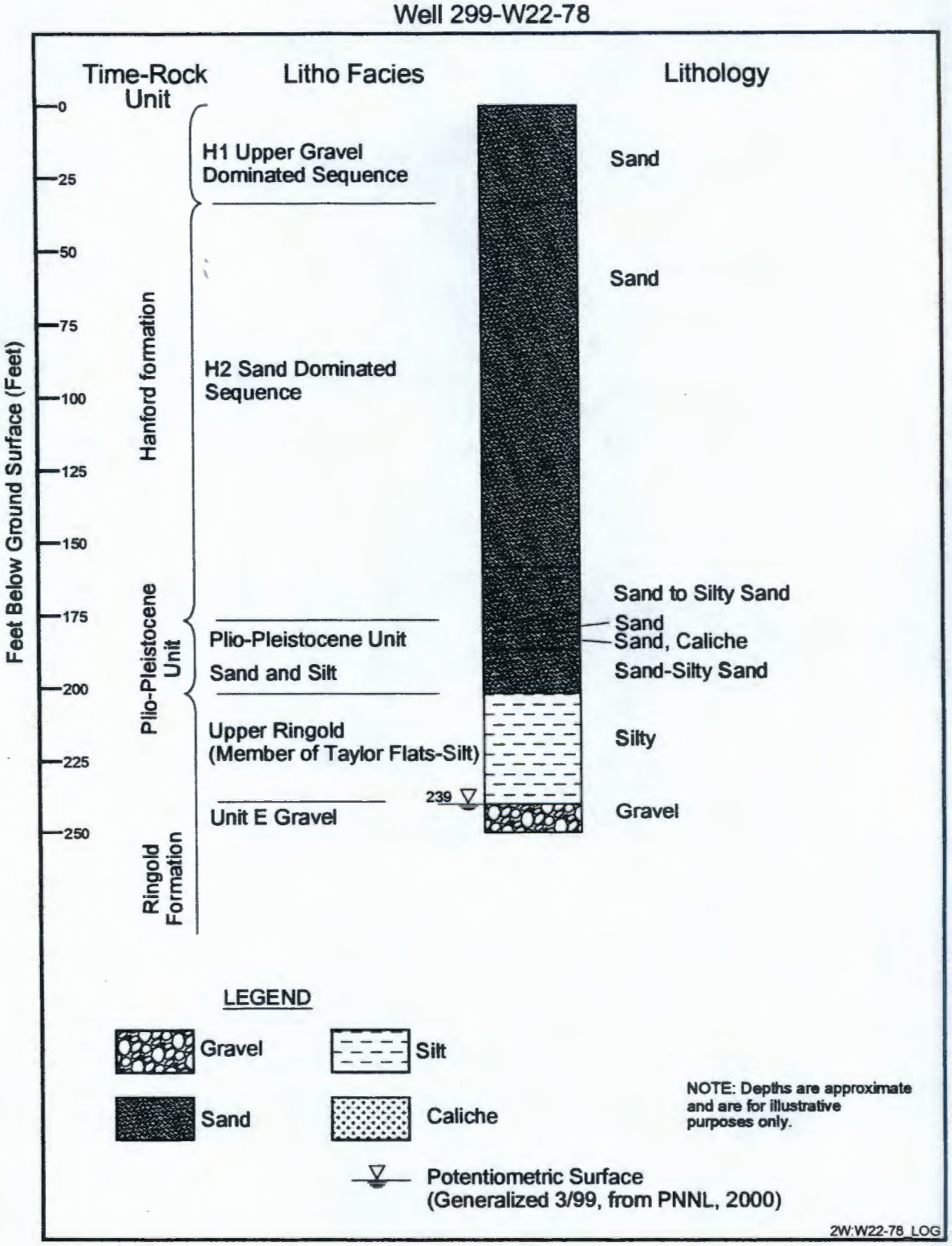


Figure 2-7. Stratigraphy in the Vicinity of the 216-A-10 Crib and the 216-A-36B Crib.

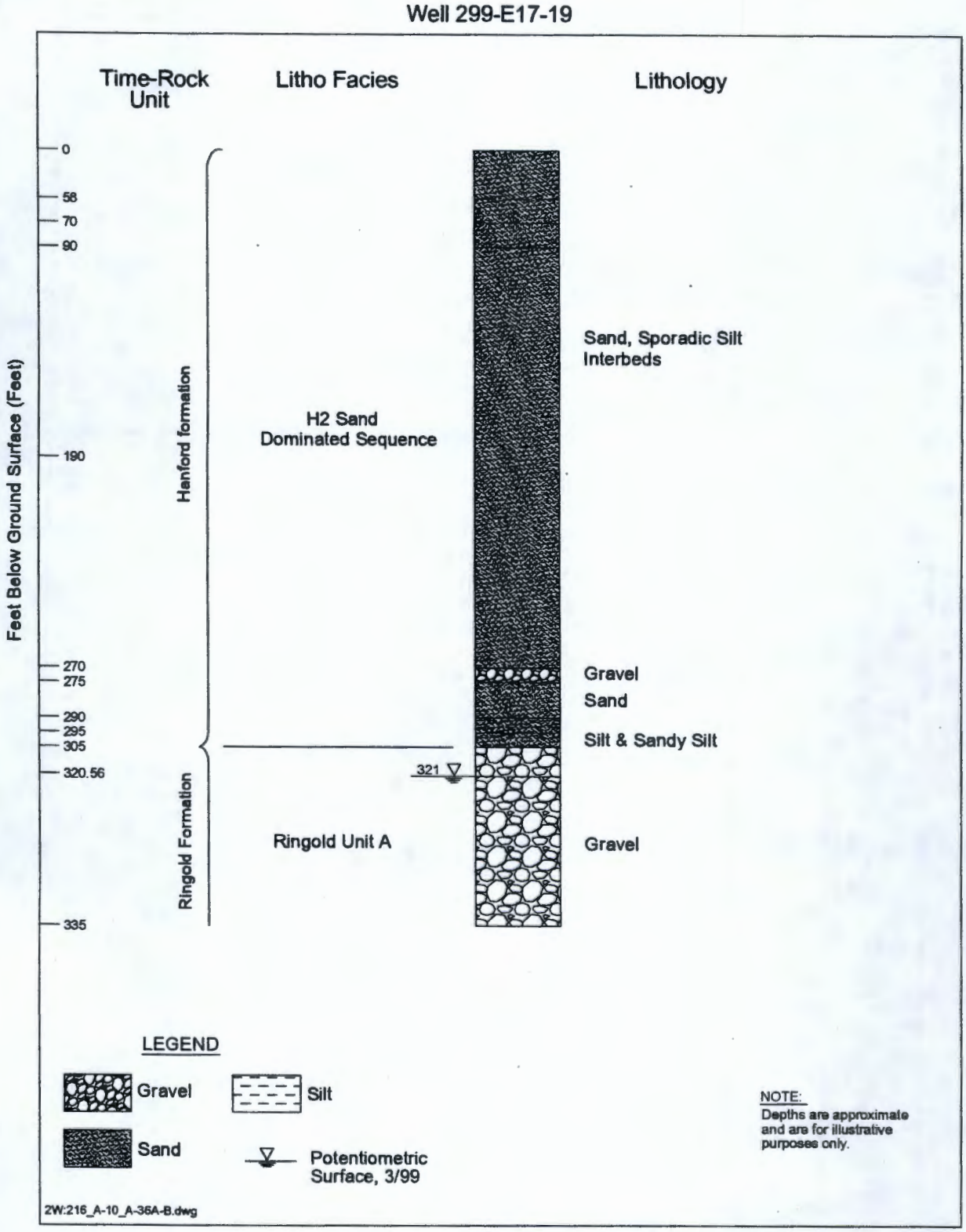


Figure 2-8. Stratigraphy in the Vicinity of the 207-A South Retention Basin.

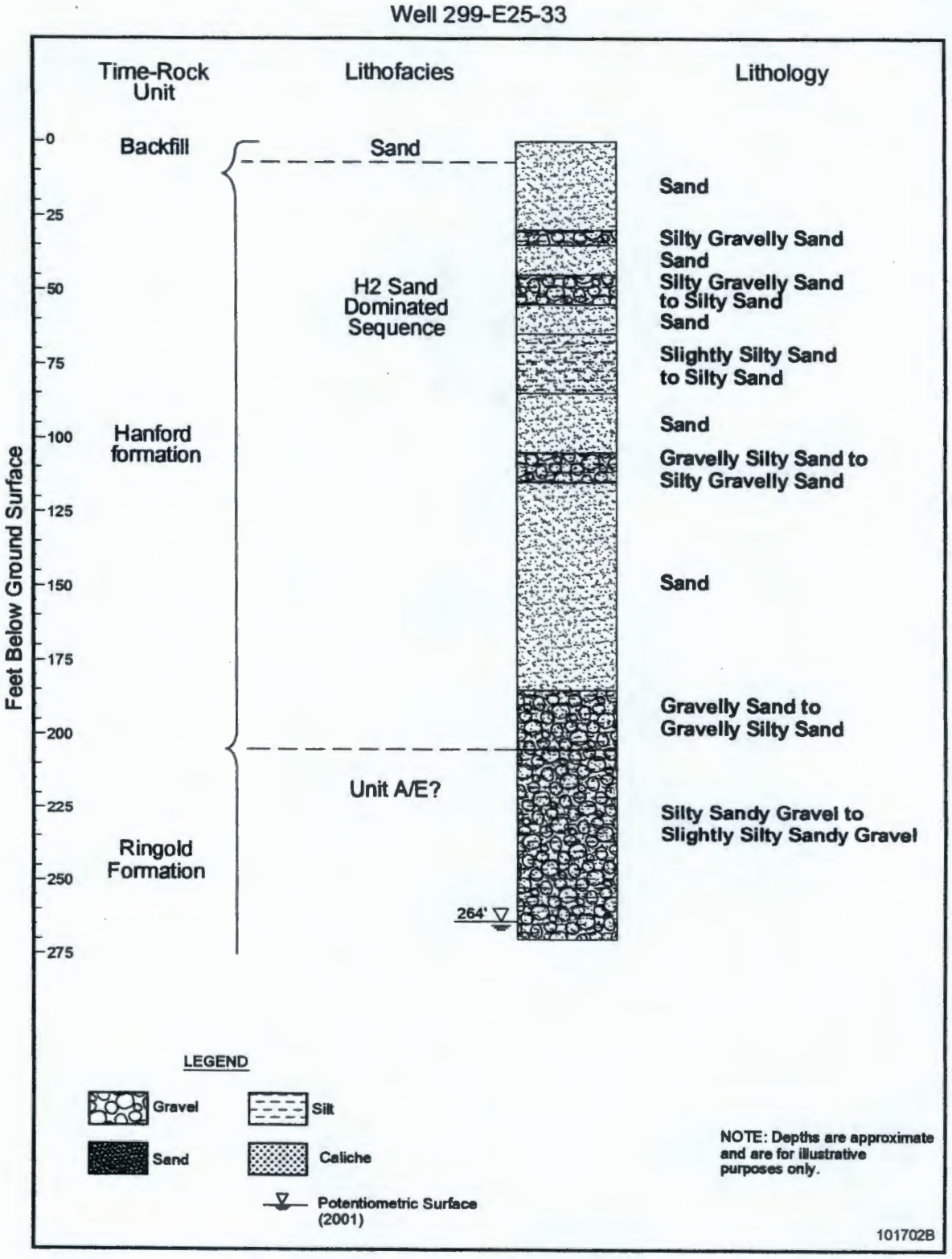


Figure 2-9. Stratigraphy in the Vicinity of the 216-A-37-1 Crib.

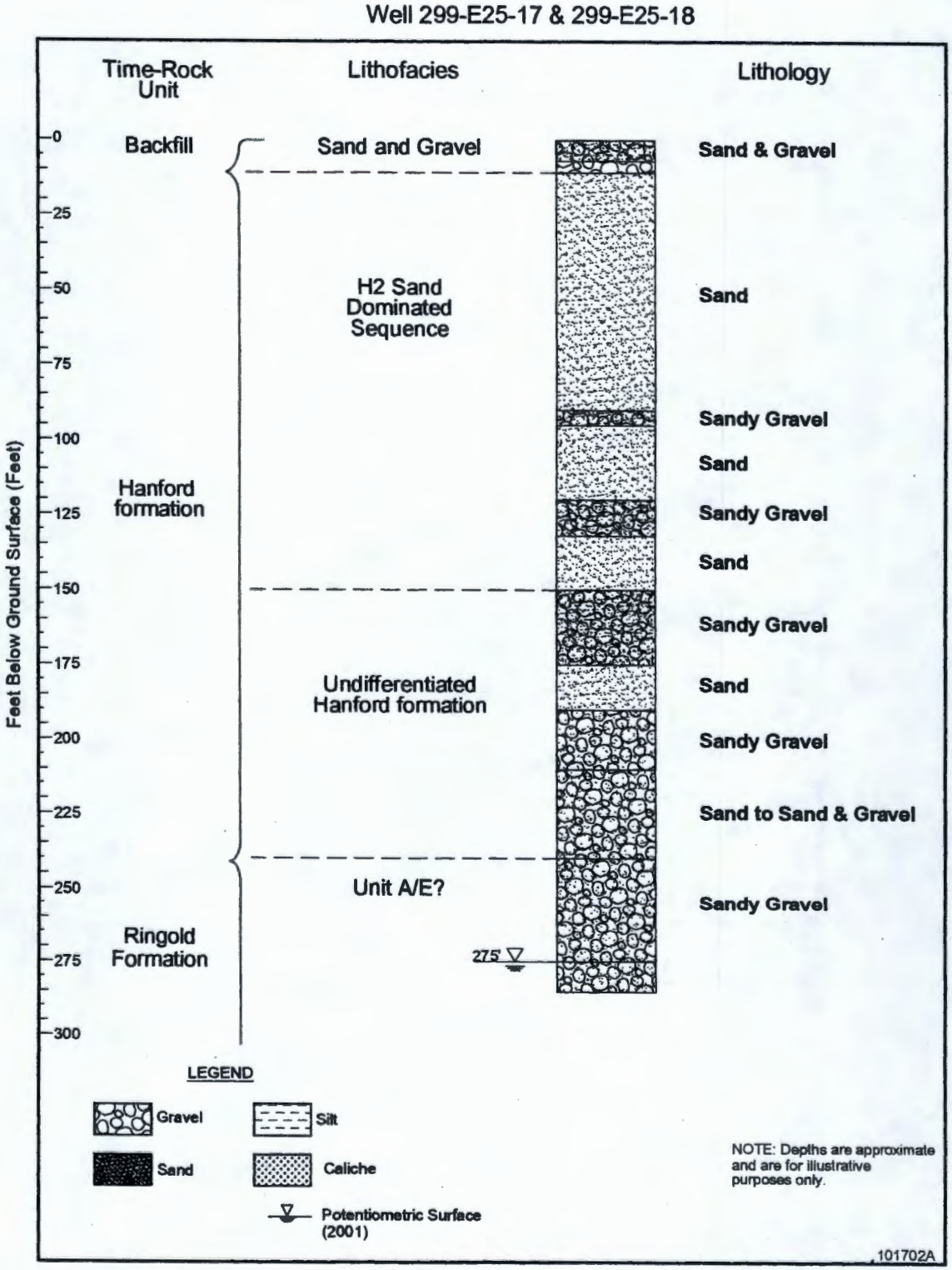


Figure 2-10. Location of the Hanford Site and the 200-PW-2 and 200-PW-4 Operable Unit Waste Sites.

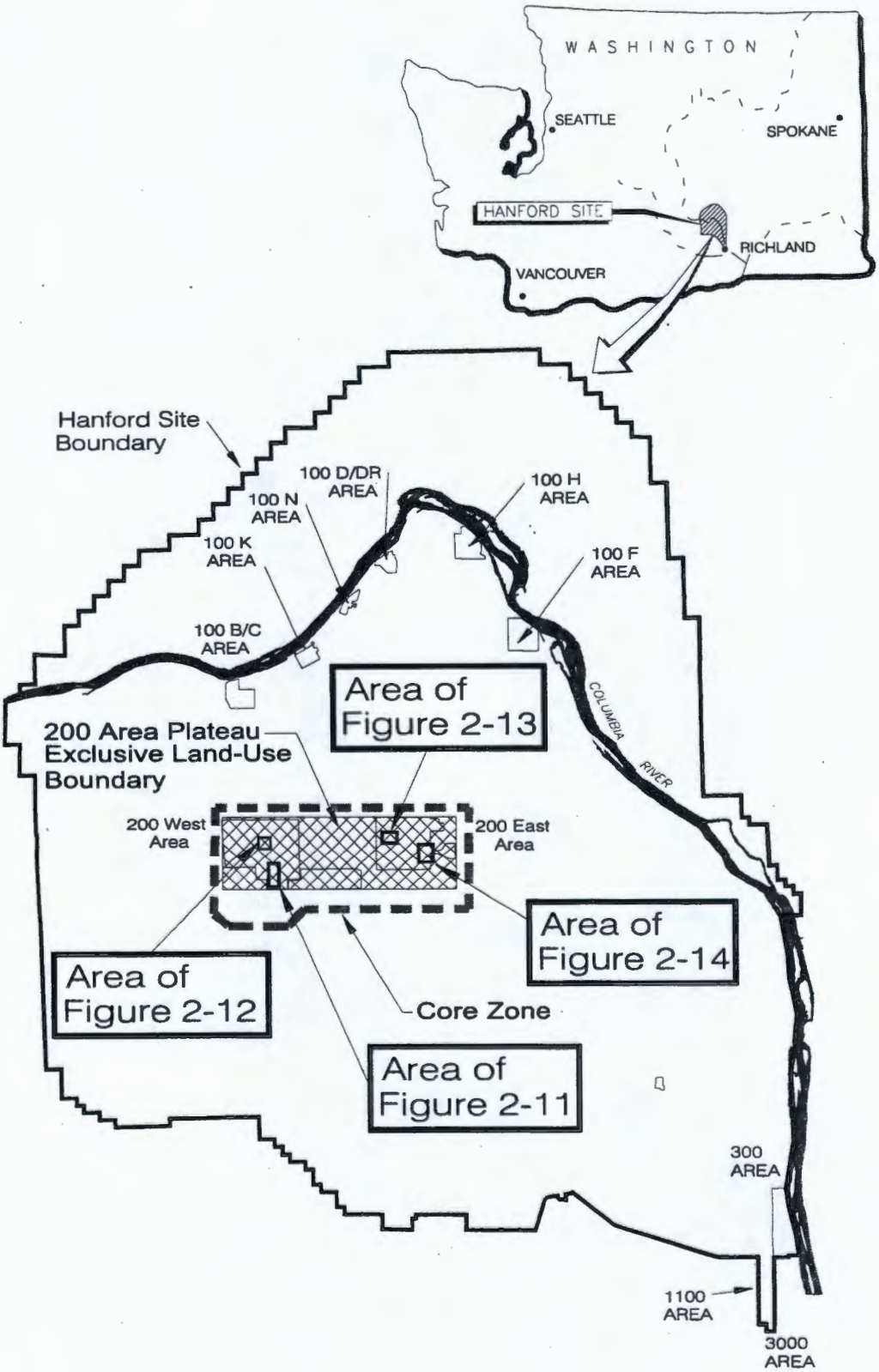


Figure 2-11. Location of the 200-PW-2 and 200-PW-4 Waste Sites Inside the 200 West Area.

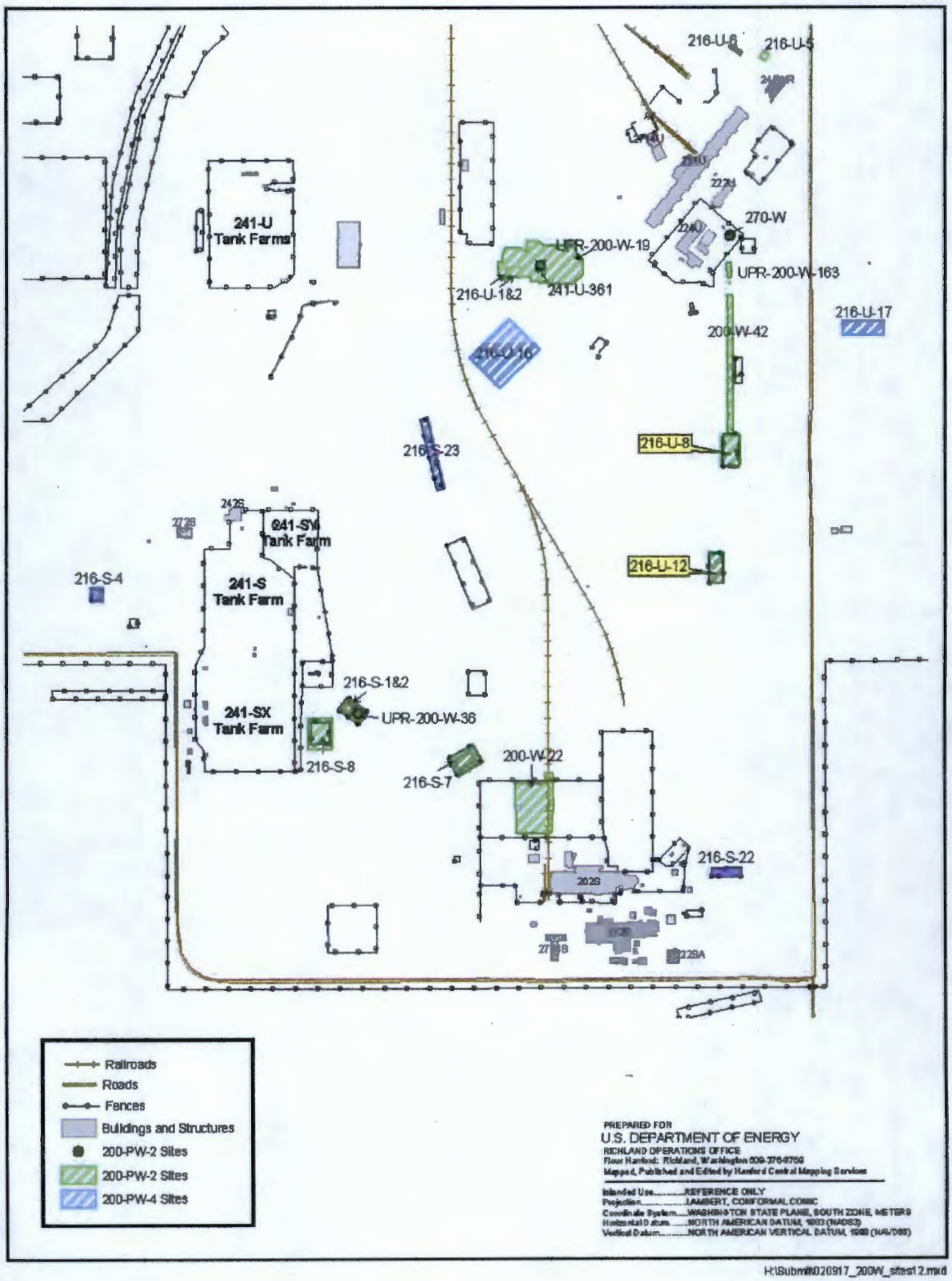


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Figure 2-12. Location of Additional 200-PW-2 and 200-PW-4 Waste Sites Inside the 200 West Area.

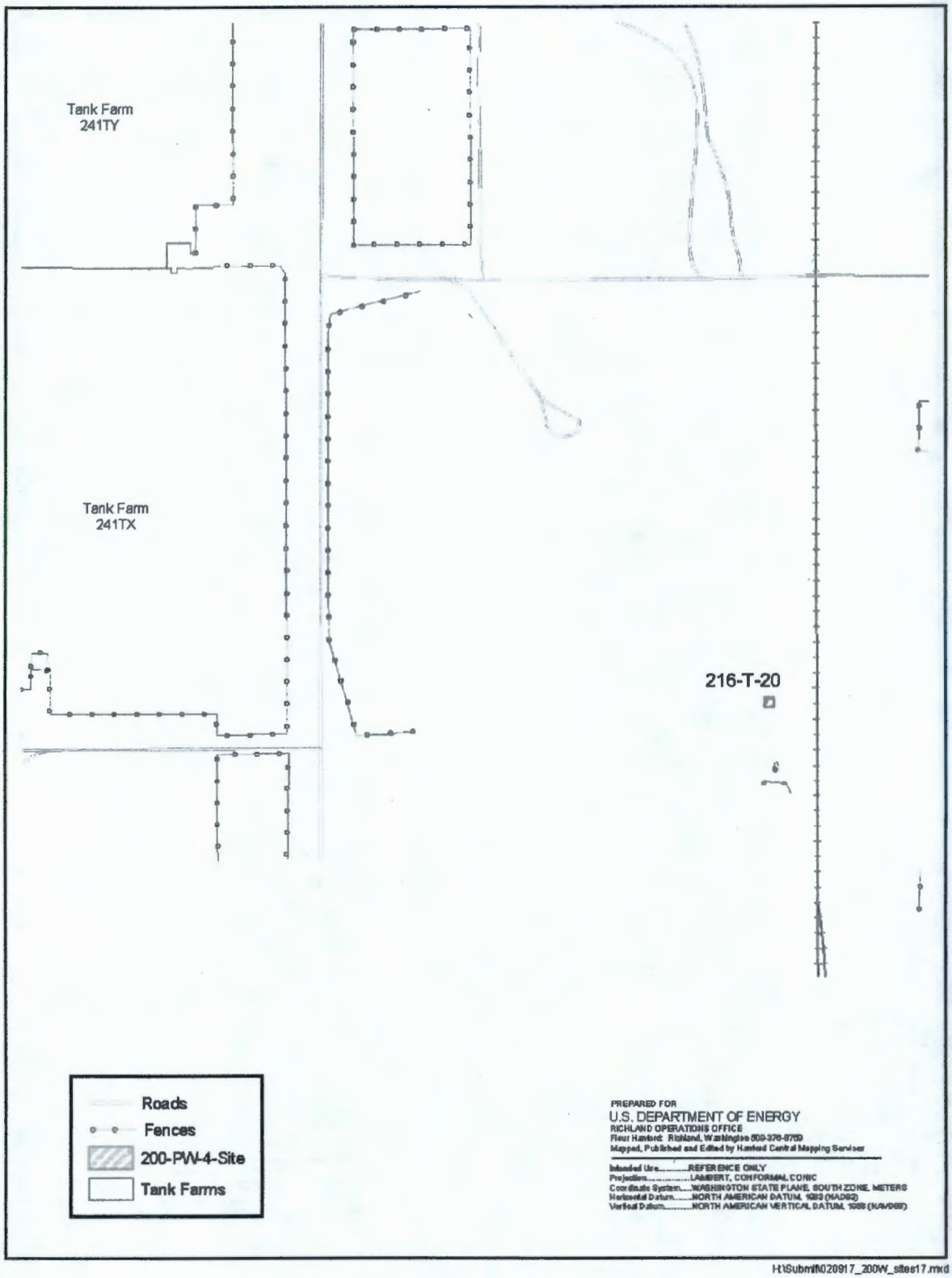

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Figure 2-13. Location of 200-PW-2 and 200-PW-4 Waste Sites on the West Side of the 200 East Area.

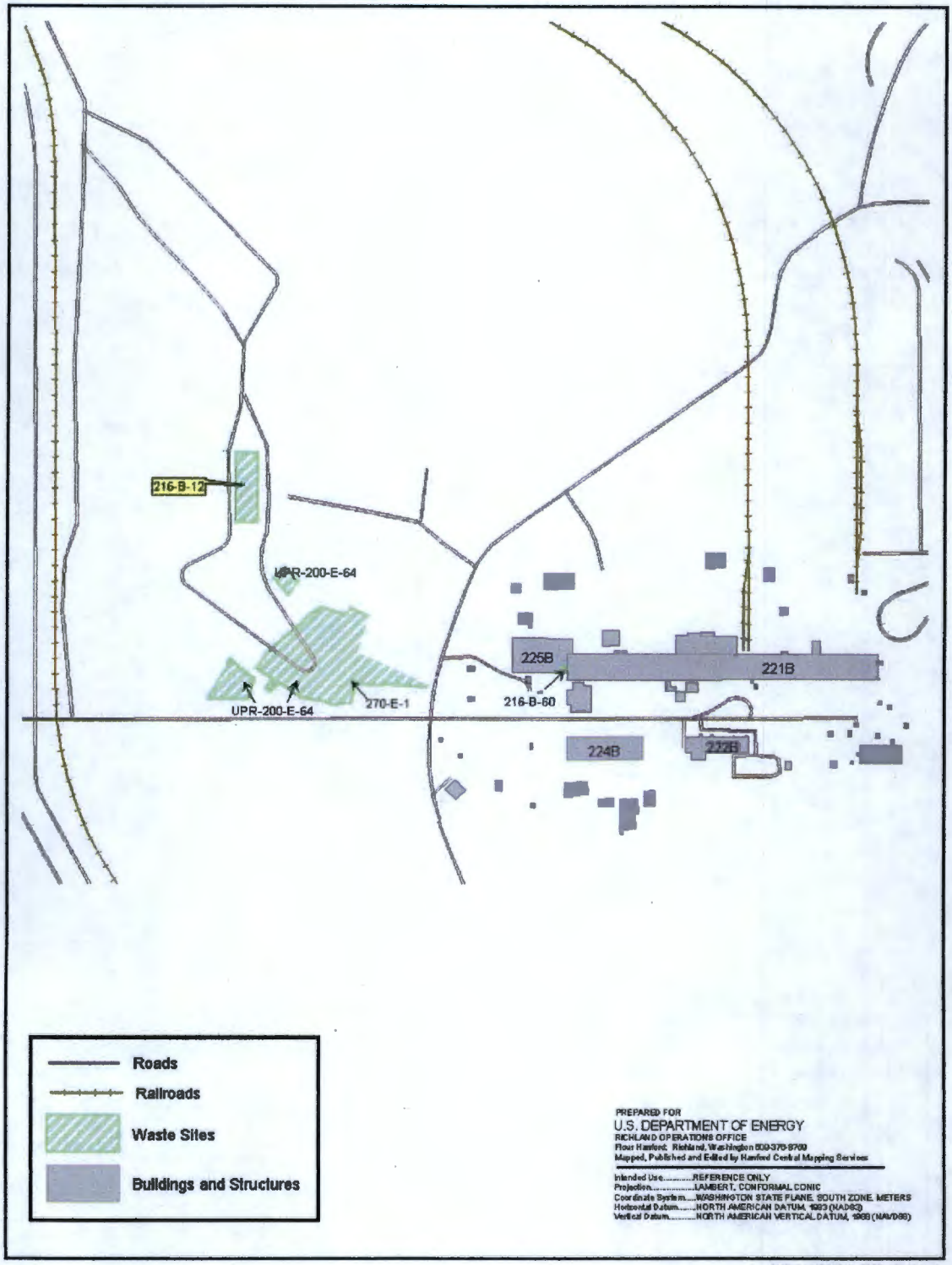

Figure 2-14. Location of 200-PW-2 and 200-PW-4 Waste Sites on the East Side of the 200 East Area.

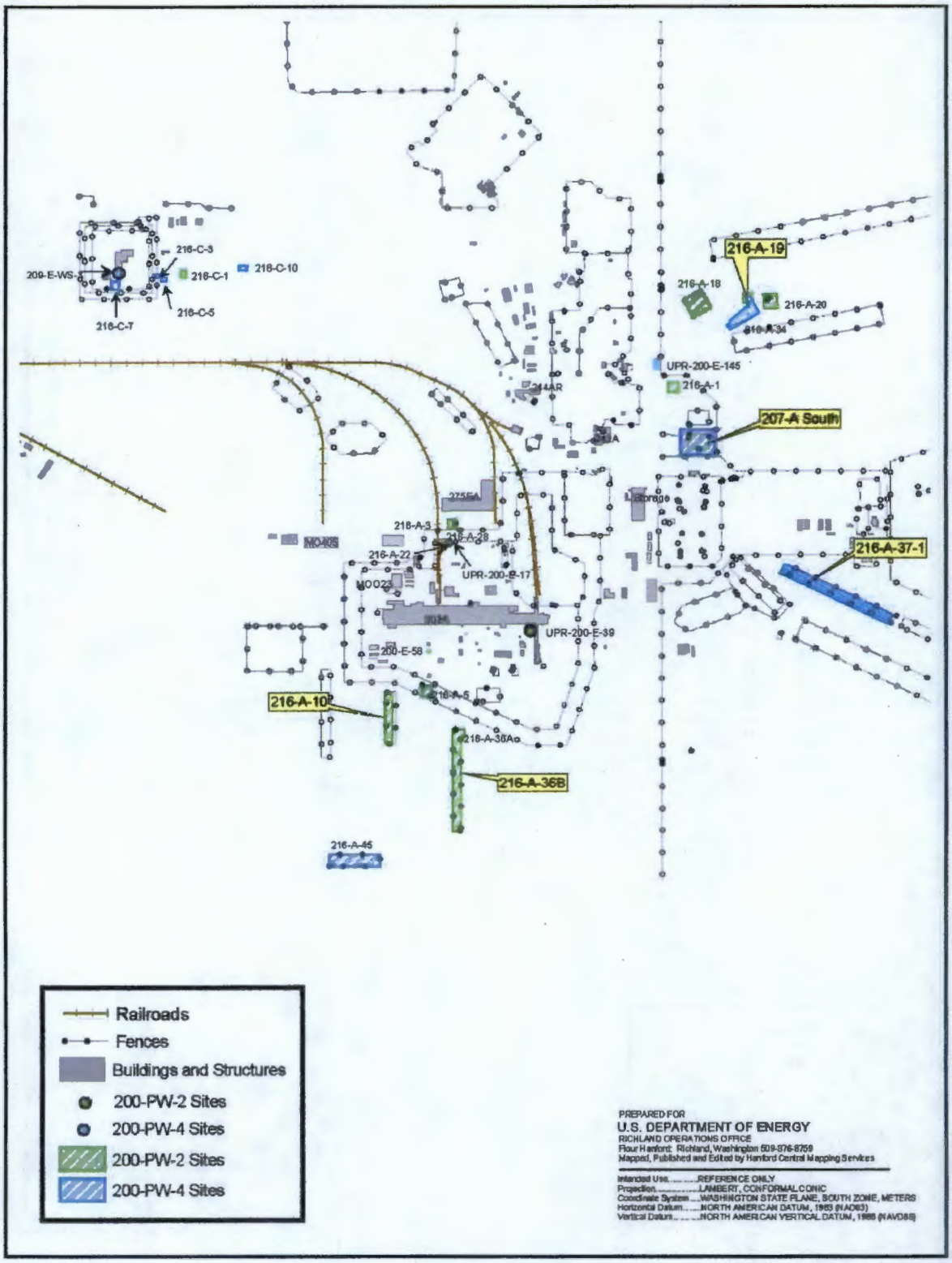

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Figure 2-15. Source Facilities Associated with 200-PW-2 and 200-PW-4 Operable Unit Representative Waste Sites and Treatment, Storage, and Disposal Units.

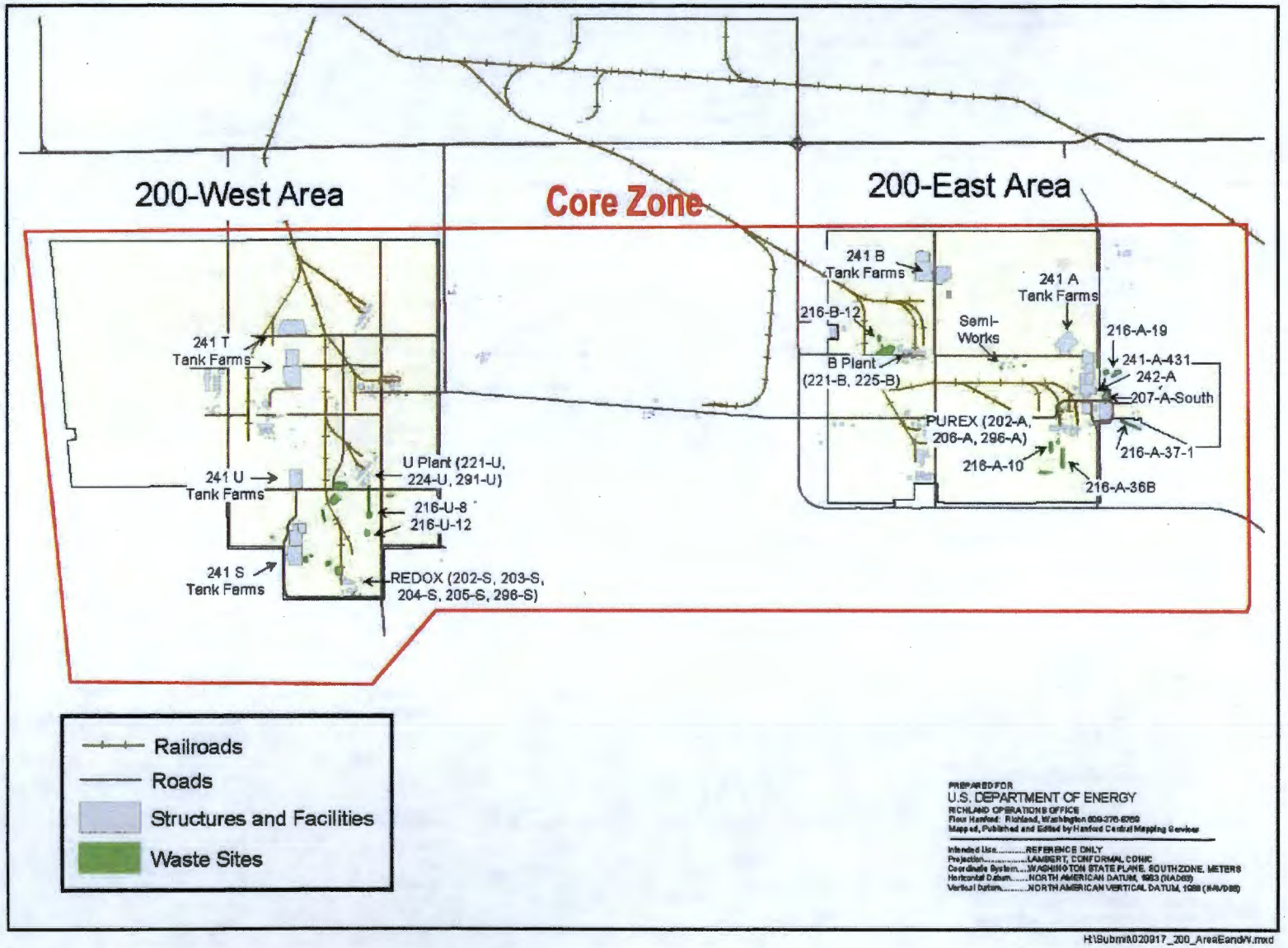


Figure 2-16. Plant Processes and Waste Streams at U Plant.

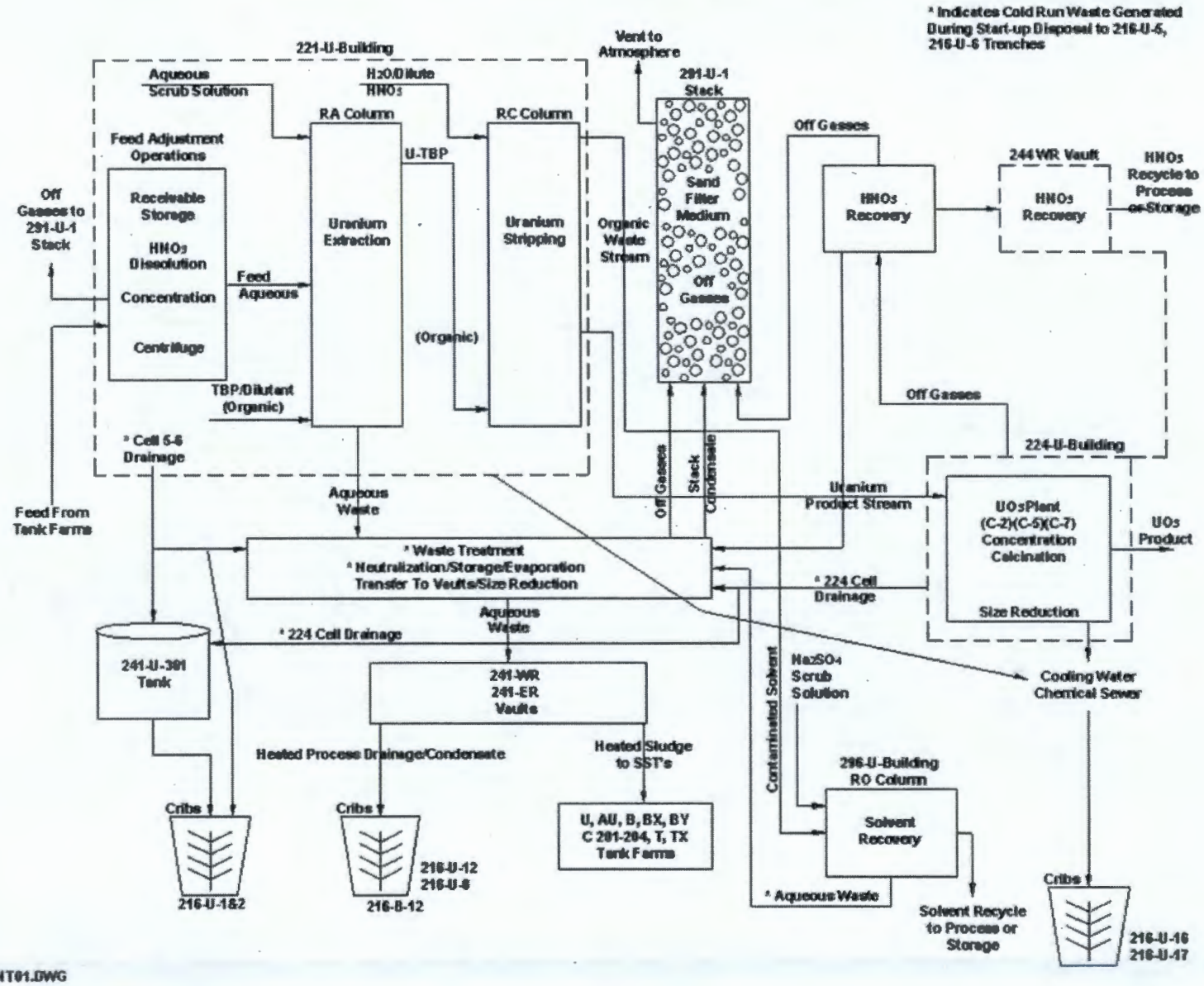


Figure 2-17. Plant Processes and Waste Streams at the REDOX Plant.

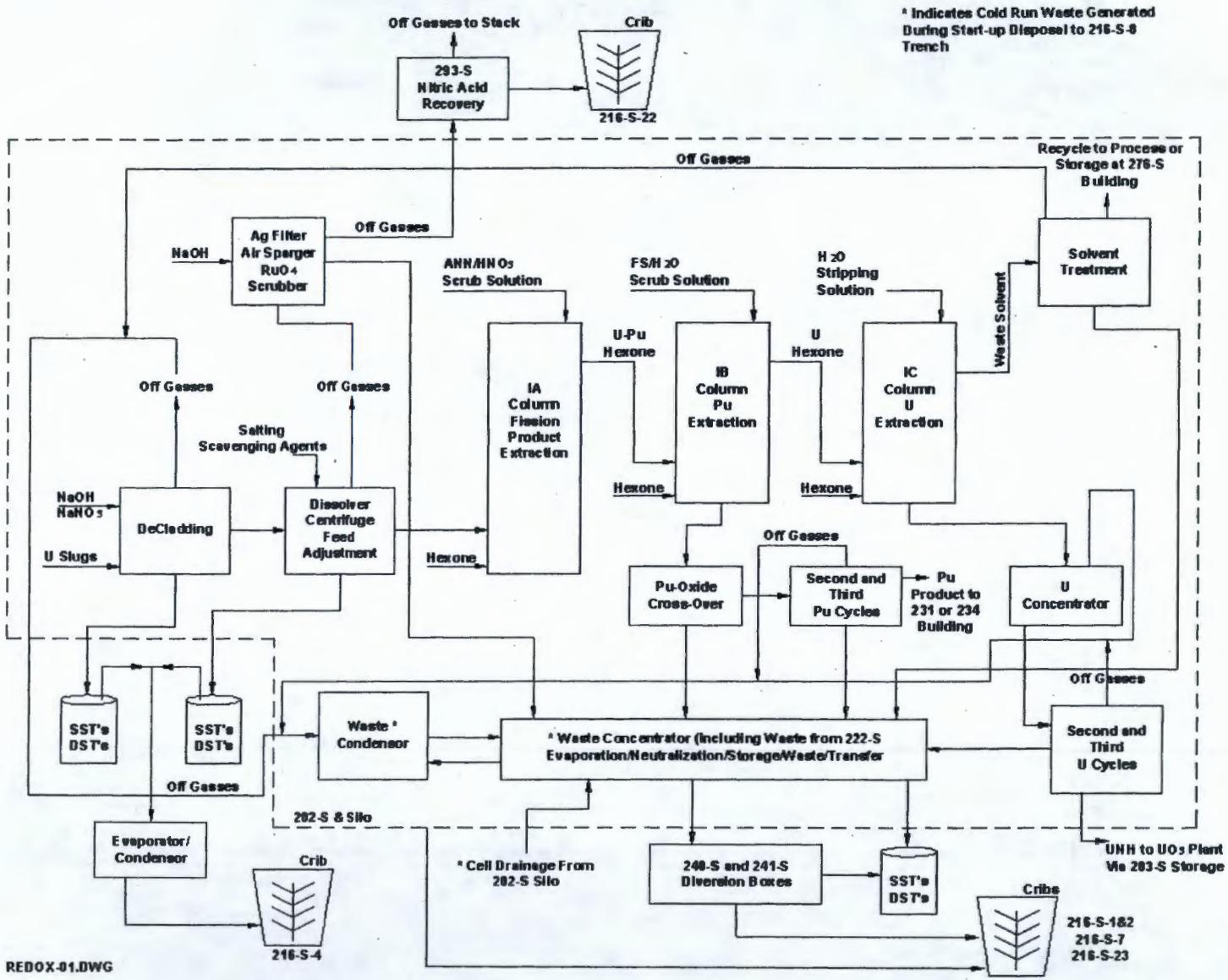


Figure 2-18. Plant Processes and Waste Streams at the PUREX Plant.

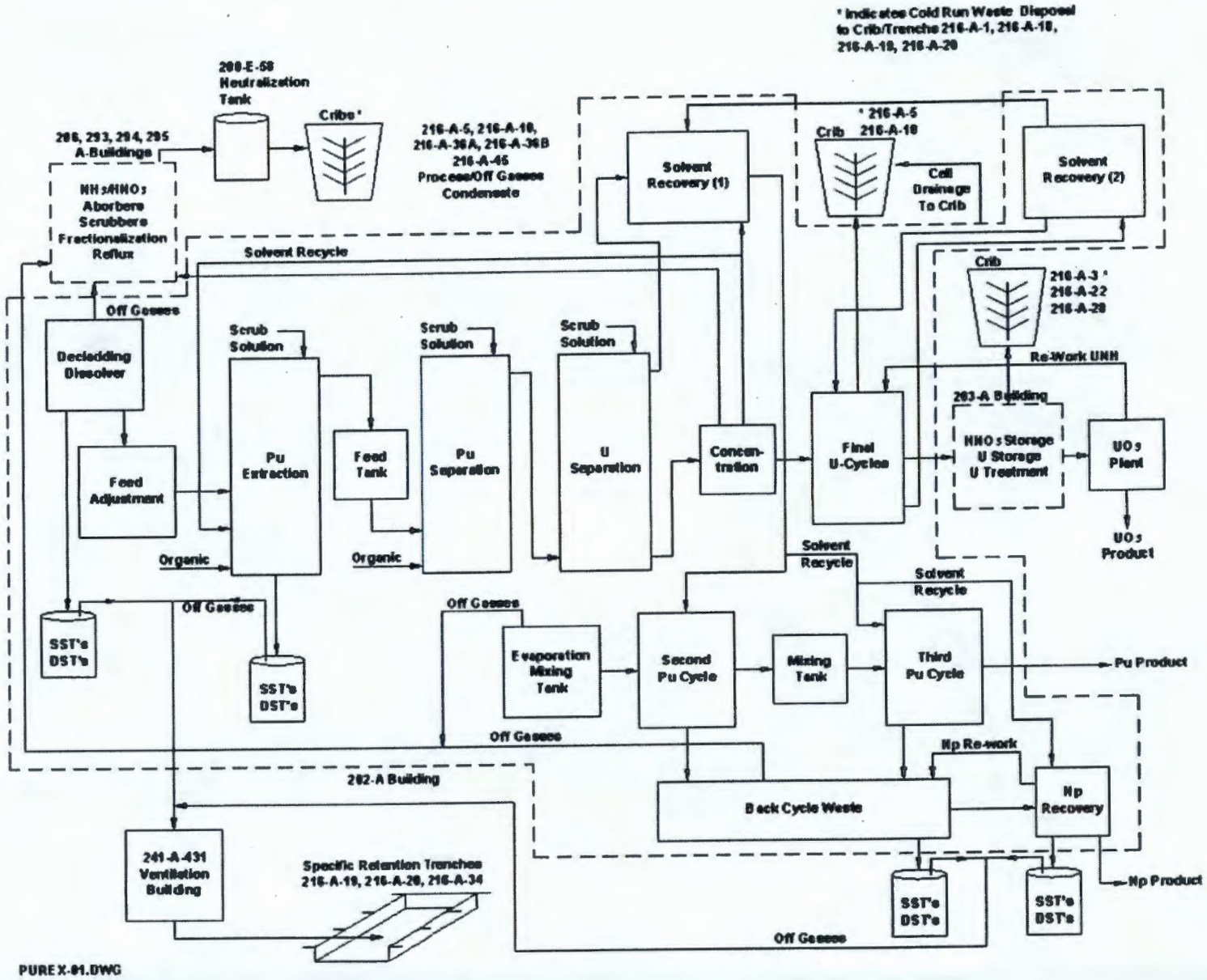


Figure 2-19. Plant Processes and Waste Streams at the 242-A Evaporator.

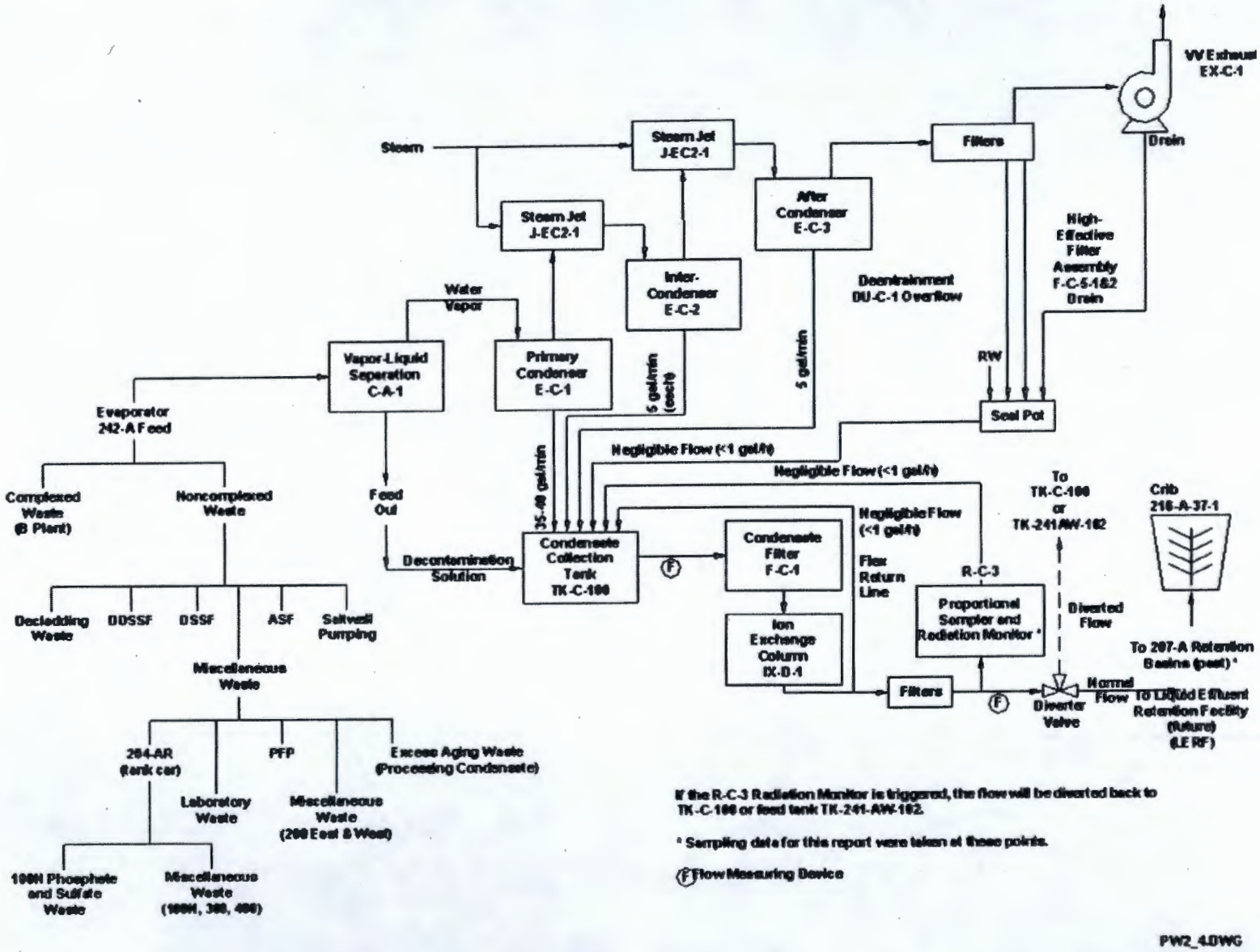


Figure 2-20. 216-A-19 Trench Construction Diagram.

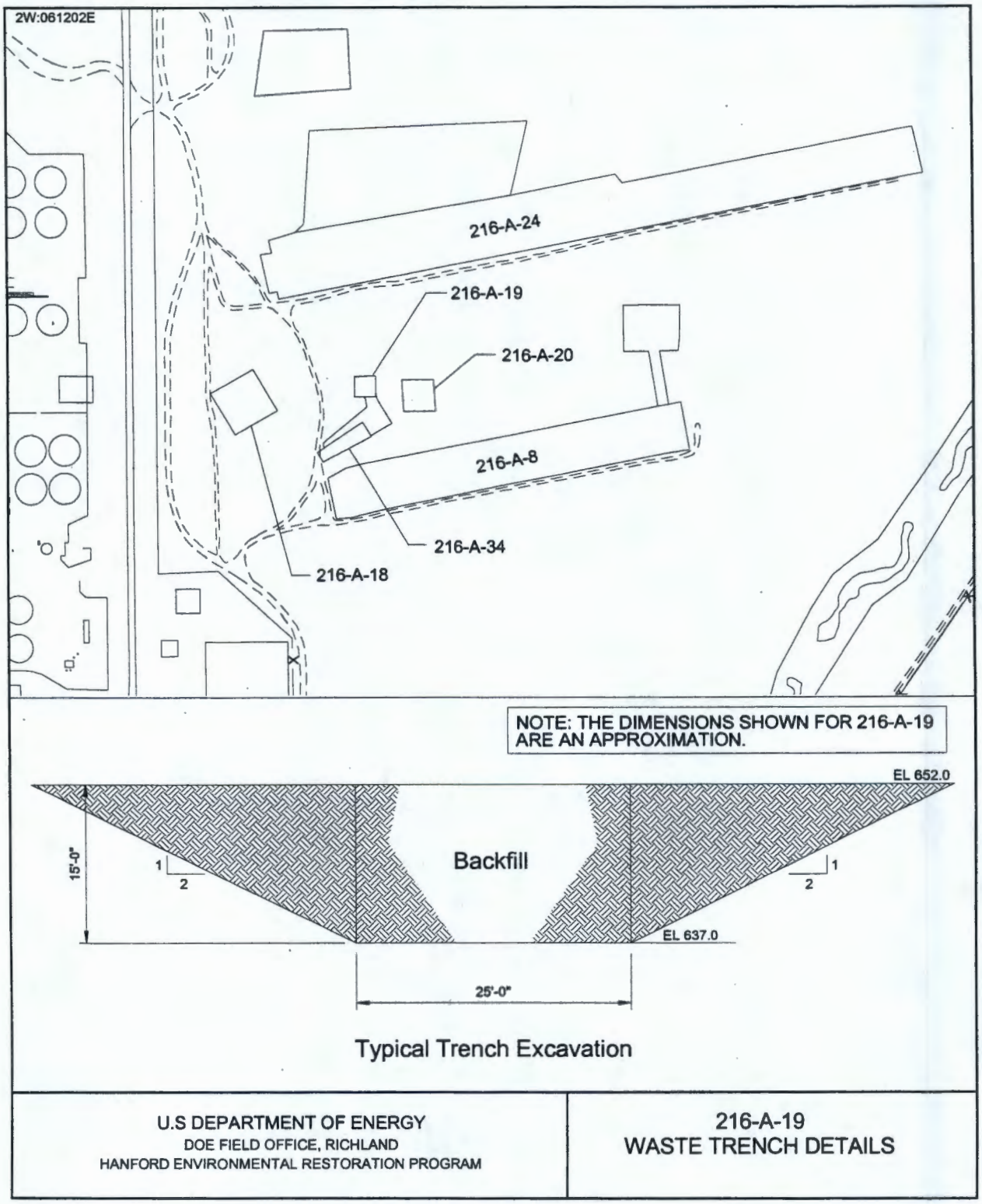


Figure 2-21. 216-B-12 Crib Construction Diagram.

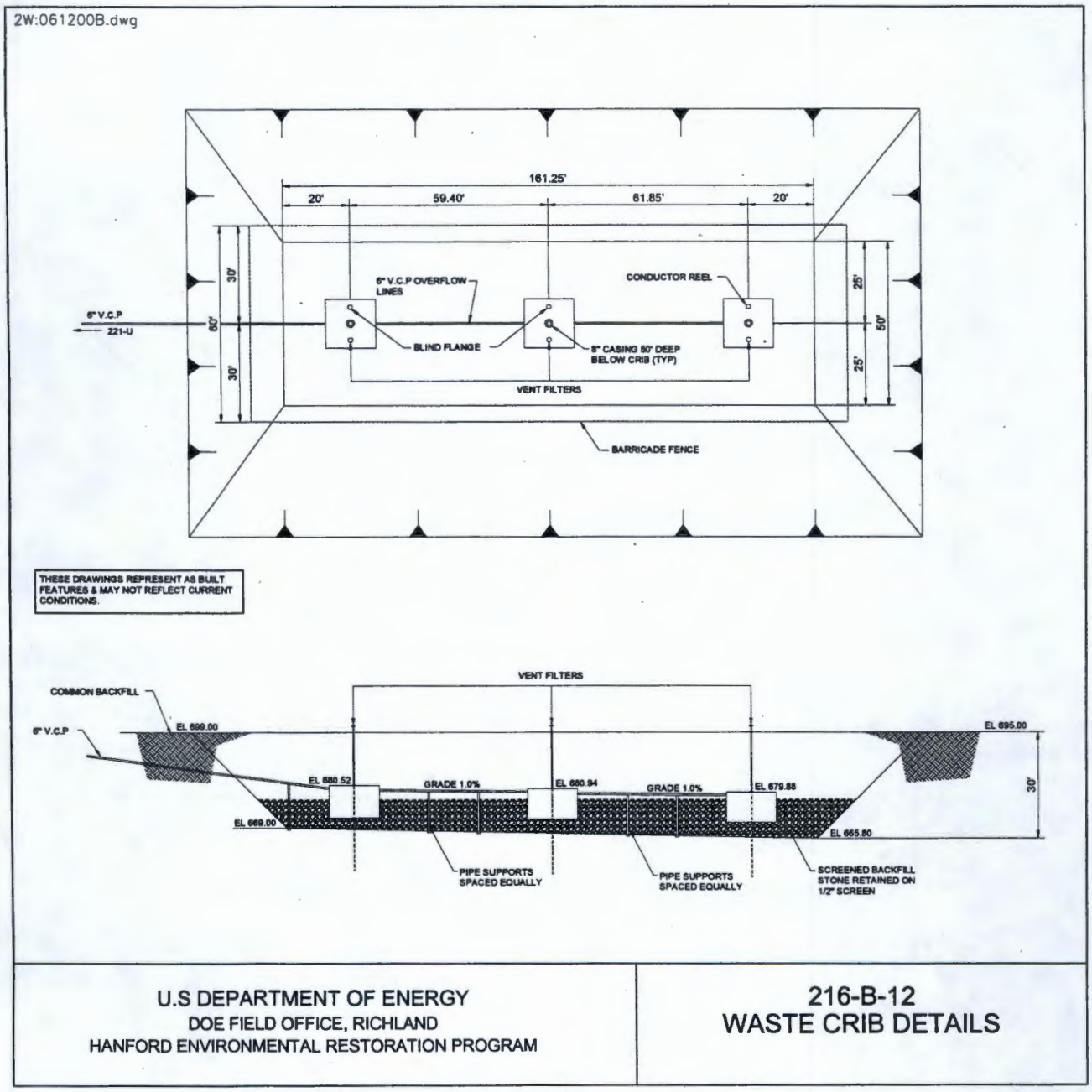


Figure 2-22. 216-U-8 Crib Construction Diagram.

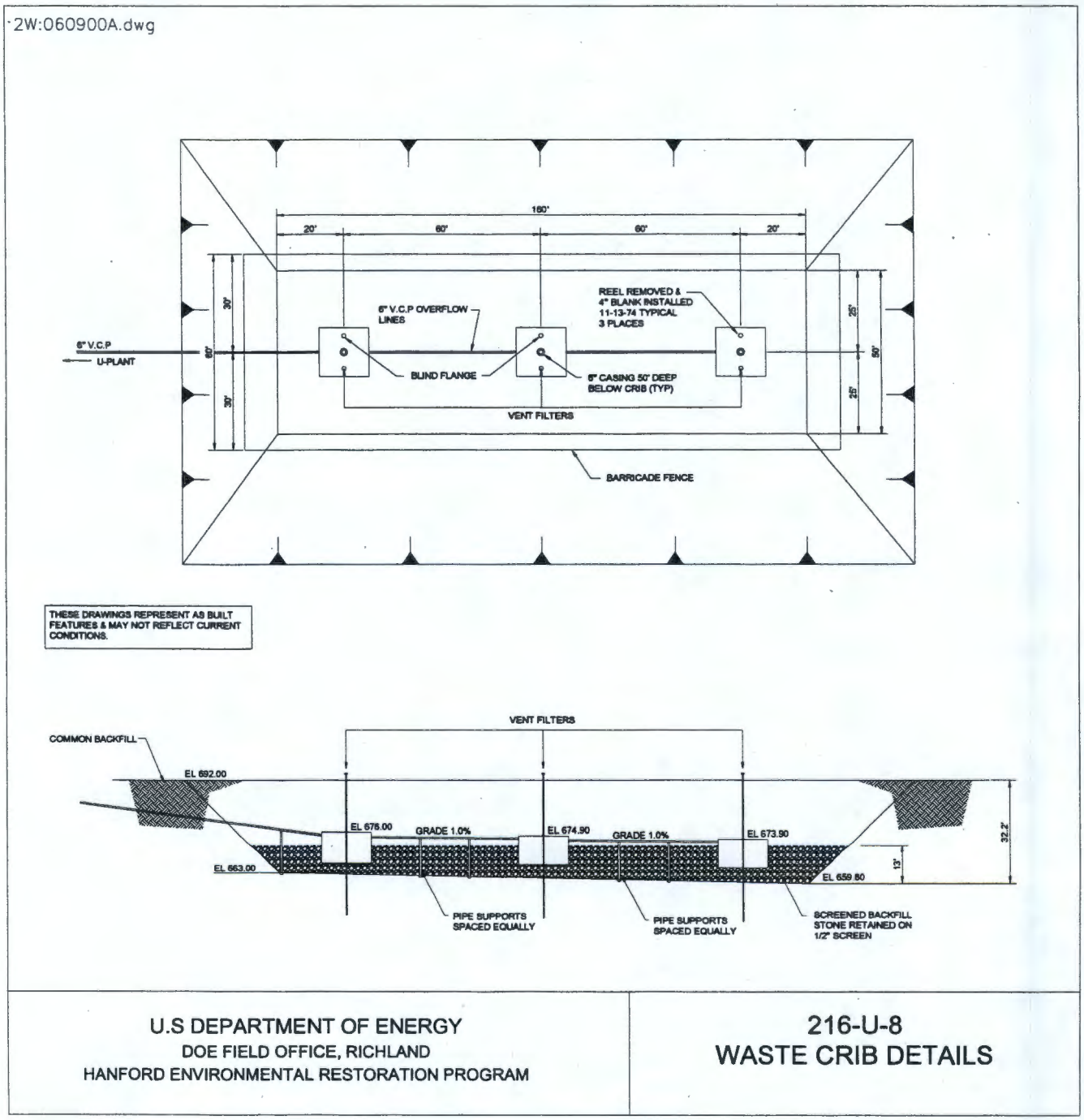


Figure 2-23. 216-U-12 Crib Construction Diagram.

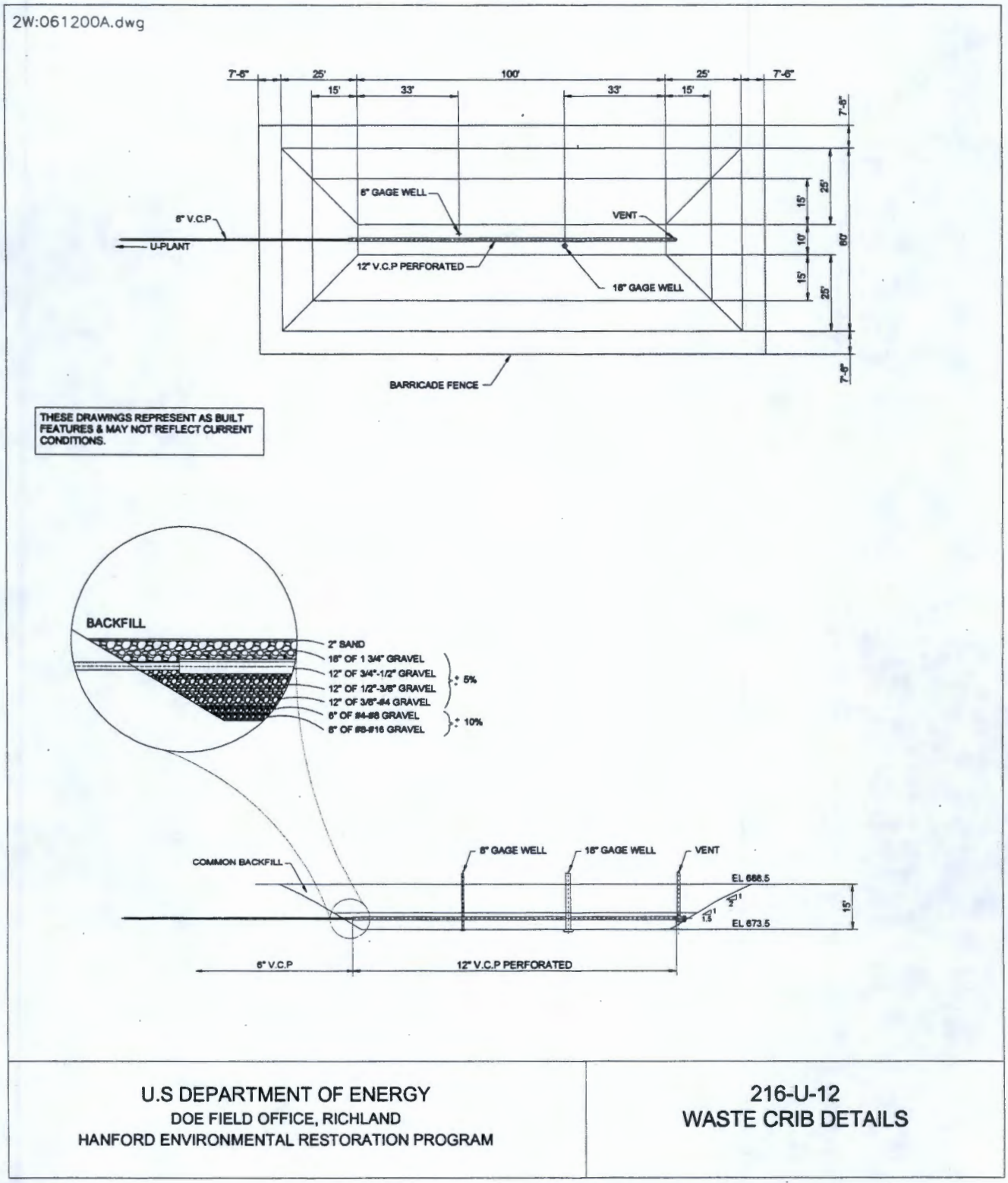


Figure 2-24. 216-A-10 Crib Construction Diagram.

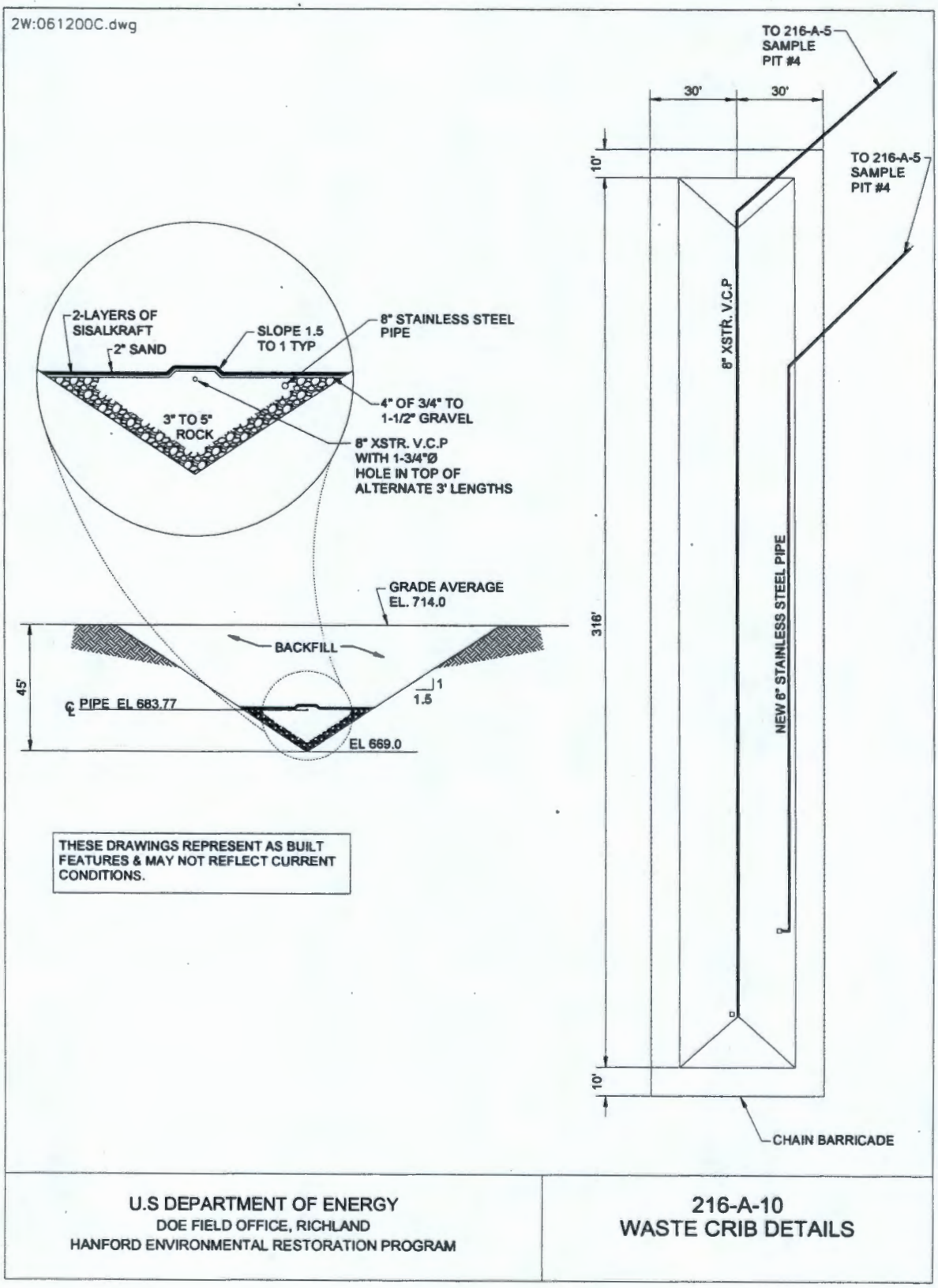


Figure 2-25. 216-A-36B Crib Construction Diagram.

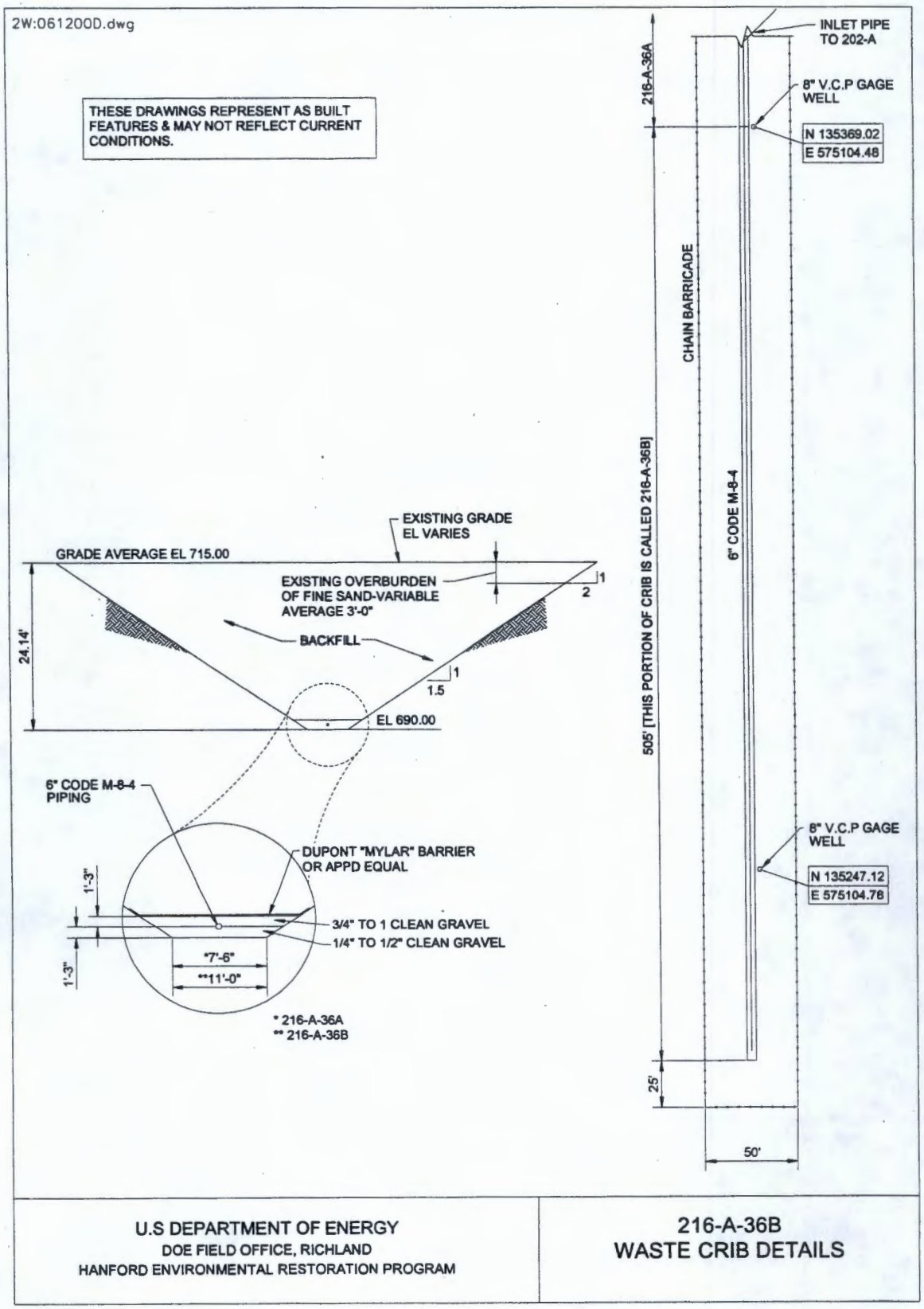
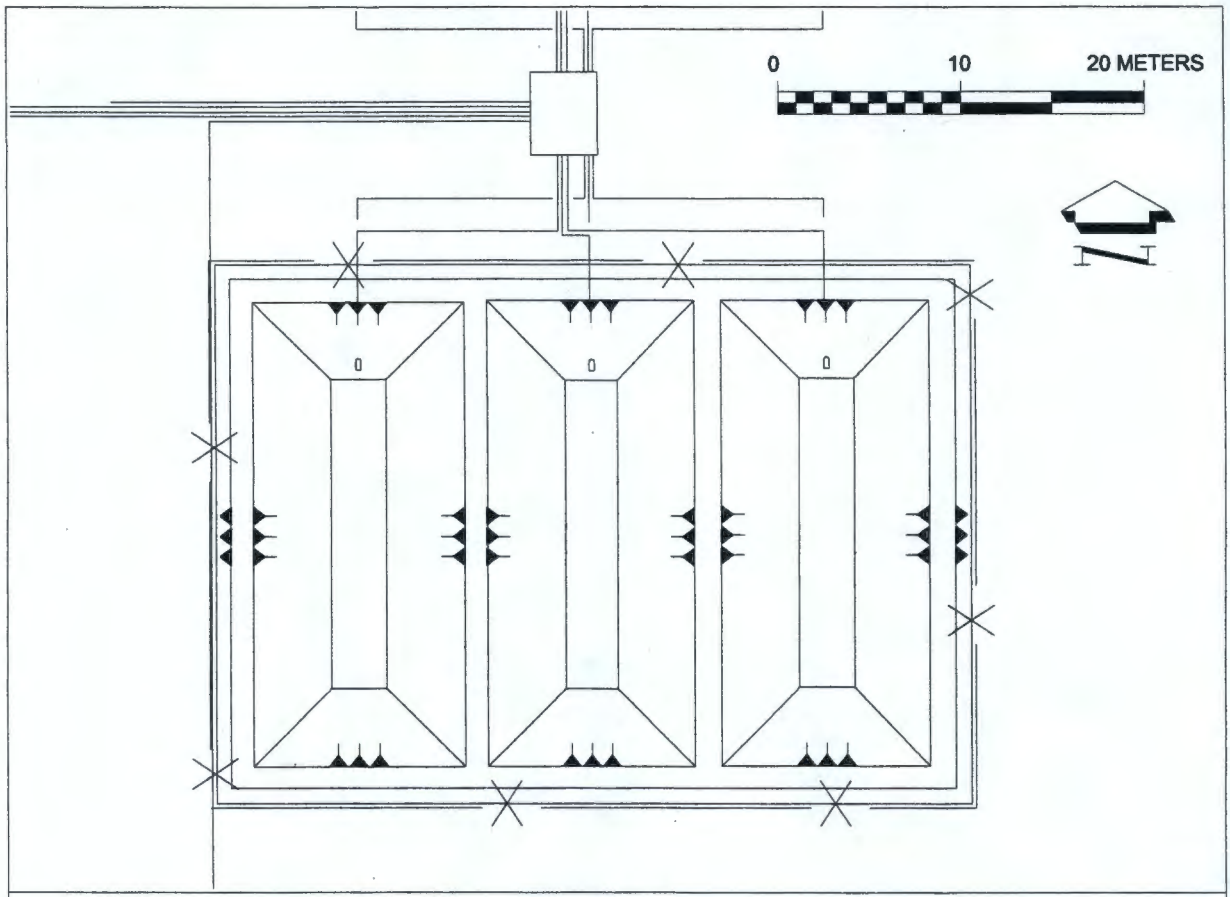
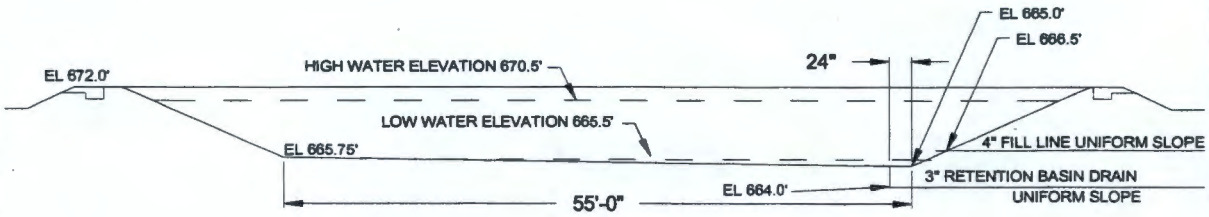


Figure 2-26. 207-A South Retention Basin Construction Diagram.



207-A SOUTH
PLAN VIEW



207-A SOUTH
SECTION

Note: These drawings represent as-built features and may not reflect current conditions.

U.S DEPARTMENT OF ENERGY DOE FIELD OFFICE, RICHLAND HANFORD ENVIRONMENTAL RESTORATION PROGRAM 082802A	207-A South Retention Basin Plan View and Longitudinal Section

Figure 2-27. 216-A-37-1 Crib Construction Diagram.

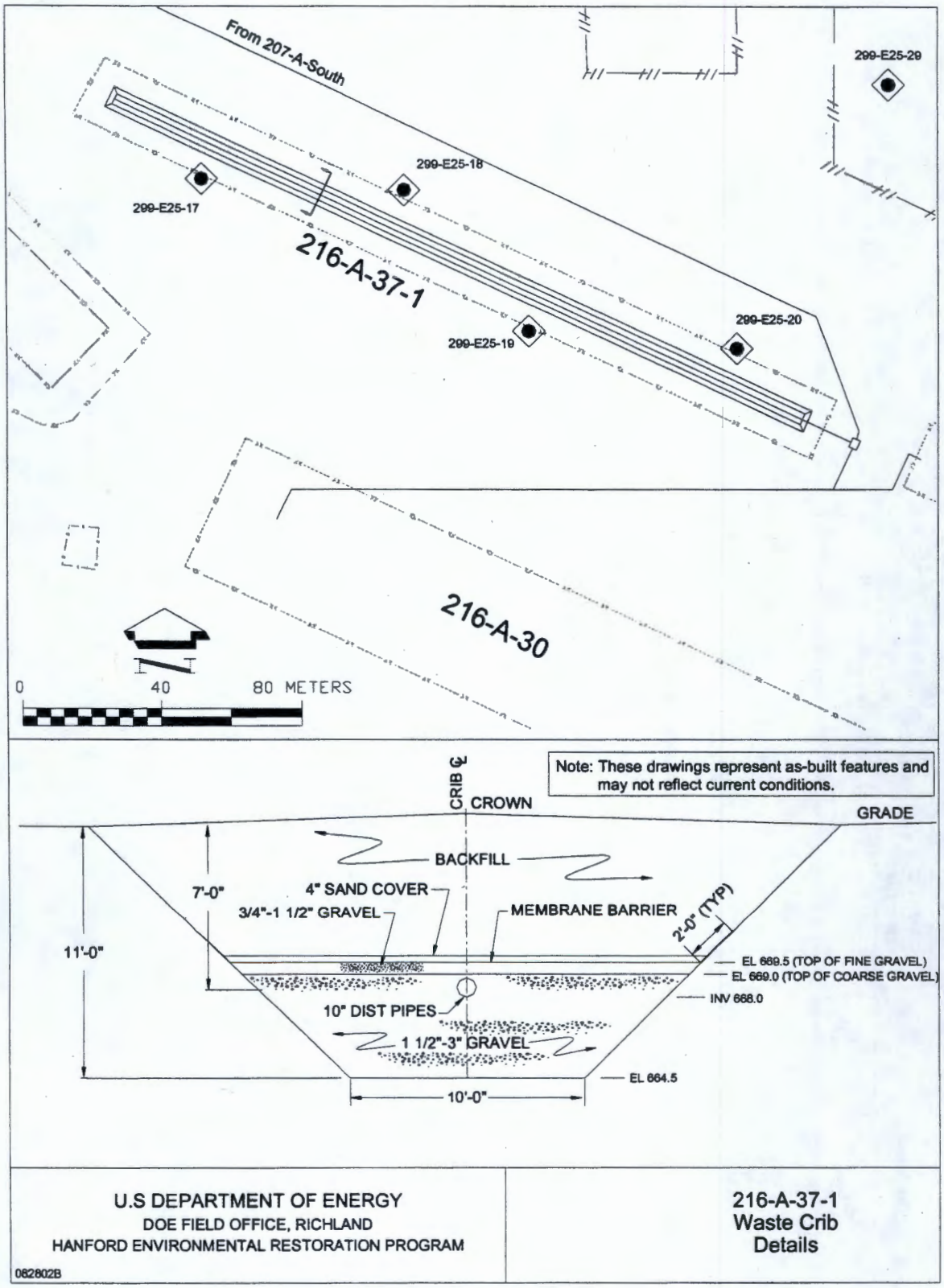


Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
200-E-58	200-E-58, 216-A-5 Neutralization Tank, Tank A5	South of PUREX, inside security fence, south of 295-AB Building, north of 216-A-5 Crib, northwest of 216-A-10 Crib	1955 to 1987	202-A (PUREX)	Tank capacity of 28,390 L (7,500 gal); acidic liquid waste containing high levels of uranium and nitrate; volume released is unknown	4.9 m (16 ft)	3.5-m (11.3-ft) diameter tank	The stainless steel tank contained a bed of limestone and was used to neutralize acid waste from PUREX prior to discharged to the 216-A-5 and 216-A-10 Cribs. The tank stands vertically on a concrete pad. A 20-m (8-in.) pipe enters the base of the tank, connects to discharge piping, and exits near the top.
200-W-22	200-W-22, 203-S/ 204-S/205-S Stabilized Area	Northwest of 202-S Building	1952 to 1983	203-S and 205-S UNH processing facilities, and REDOX UNH processing facility	Contaminated UNH from REDOX and PUREX, thorium nitrate from PUREX, N Reactor decon waste and 300 Area lab waste; volume released is unknown	Not reported	84 m x 68 m (276 ft x 223 ft)	A two-story above-ground chemical makeup building was used to process and store UNH produced by REDOX and PUREX operations before transfer to 224-U. The site has various UPRs associated with it due to different activities performed. The above-ground features associated with this site were removed in 1983.
200-W-23	200-W-23, 203-S, 205-S, Underground Contaminated Zone	Duplicate of 200-W-22	--	--	--	--	--	Rejected by WIDS in January 2000.
200-W-42	200-W-42, U Plant Radioactive Process Sewer from 221-U to 216-U-8 and 216-U-12 Cribs	VCP Pipeline from 221-U Building to 216-U-8 and 216-U-12 Cribs; west of Beloit Avenue; a portion is north of 16th Street but most is south of 16th Street.	1952 to 1958	221-U (U Plant) and 224-U (UO_3) Buildings and 291-U stack	Sr-90, Am-241, Cs-137, Pu-238, -239, -240, uranium, acidic process condensate; volume released is unknown	2.1 - 3.7 m (7 - 12 ft)	Pipeline is 646 m (2,120 ft) in length	An underground pipeline that extends from the 221-U Building to the 216-U-8 Crib in 1952. In 1960, a "Y" joint was made and waste was sent directly to the 216-U-12 Crib. The 200-UP-2 LFI performed in 1995. Surface and subsurface soil samples, vegetation samples, and a camera survey of the pipeline was completed. An end of the VCP near U-12 was broken, placed within the pipe, and sealed with grout in 1996.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
203-S & 205-S	203-S & 205-S, 203-S/204-S/205-S Stabilized Area, 203-S Uranyl Nitrate Hexahydrate Tank Farm, 204-S Tank Farm & Pumphouse, 205-S Process Vault & Chemical Makeup Building, 205-S Uranyl Nitrate Hexahydrate Processing Facility	Northwest of the 202-S (REDOX) facility	1953 to 1965	203-S and 205-S UNH processing facilities, and REDOX UNH processing facility	Contaminated UNH from REDOX and PUREX, thorium nitrate from PUREX, N Reactor decon waste and 300 Area lab waste; volume released is unknown	Not reported	84 m x 68 m (276 ft by 223 ft) – calculated dimensions of the surface stabilized area	See 200-W-22
216-A-1	216-A-1, 216-A-1 Cavern, 216-A-1 Trench	Inside 200 East Area perimeter fence extension; east of 241-A Tank Farm along Canton Avenue. Next to the 216-A-7 Crib	1955 to 1955	Startup waste from PUREX	98,400 L (26,000 gal) of depleted uranium waste, some Cs-137, Co-60, and Sr-90	4.6 m (15 ft)	9.1 m x 9.1 m (30 ft by 30 ft)	The crib is composed of three 15-cm (6-in.) perforated pipes, 9 m (30 ft) long, running horizontally at 3 m (9 ft) below grade in an H pattern. The crib has two layers of sisalkraft paper separating the gravel fill from the backfill. The site was backfilled with about 0.6 m (2 ft) of material in 1992. Sisalkraft is not a trademark; it is sisal fibre sandwiched between two laminated bituminized papers.
216-A-3	216-A-3, 216-A-3 Cavern, 216-A-3 Crib	South of 275-EA Building; west of Canton Avenue and north of 202-A Building	1956 to 1981	Silica-gel waste regeneration, pump house drainage from 203-A, and drainage from UNH storage pit	3,050,000 L (806,000 gal) including uranium, Cs-137, Sr-90, Ru-106	4.6 m (15 ft)	6.1 m x 6.1 m (20 ft x 20 ft)	The crib has three perforated pipes 2.4 m (8 ft) below grade placed horizontally forming an H pattern. The unit has about 2.4 m (8 ft) (280 m^3 [10,000 ft^3]) of gravel backfilled into the crib.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-A-5	216-A-5, 216-A-5 Cavern	South of 202-A Building between the inner and outer PUREX exclusion fences	1955 to 1966	Acidic process condensate from 202-A (PUREX)	1,630,000,000 L (431 Mgal) containing nitric acid, uranium, and other fission products	9.1 m (30 ft)	10. 7 m x 10. 7 m (35 ft x 35 ft)	The crib contains three 20-cm (8-in.) pipes placed horizontally 7.3 m (24 ft) below grade in an H pattern, an inlet pipe, a strainer and vent, two layers of sisalkraft paper, and a concrete pad to support the strainer. The crib was deactivated by closing the valve from the effluent piping to the unit and then rerouting the waste to the 216-A-10 Crib. The crib is backfilled with about 2.4 m (8 ft) (600 m^3 [21,000 ft^3]) of coarse rock.
216-A-10	216-A-10, 216-A-10 Crib	South of 202-A Building	1956 to 1987	202-A (PUREX) acidic process condensate (PDD)	3,210,000,000 L (848 Mgal) of acidic waste containing uranium and nitrate	13.7 m (45 ft)	83.8 m x 13.7 m (275 ft x 45 ft)	The excavation is a wedge-shaped cross section. The unit has a 20-cm (8-in.) pipe placed horizontally 9 m (30 ft) below grade. It also has the original distribution pipe, two layers of vinyl plastic separating the gravel from the backfill, two vent structures, a vent box on a concrete pad, and three 15-cm (6-in.) risers extending from the bottom to the vent structure. The site was later backfilled. The site is a RCRA TSD unit.
216-A-18	216-A-18, 216-A-18 Excavation, 216-A-18 Grave, 216-A-18 Sump, 216-A-18 Crib	Outside 200 East Area perimeter fence, east of 241-AX Tank Farm, along Canton Avenue	1955 to 1955	Startup waste from PUREX	488,000 L (129,000 gal) of depleted uranium waste from the cold startup run at the 202-A Building	4.6 m (15 ft)	24.4 m x 24.4 m (80 ft x 80 ft)	The site received depleted uranium waste from the cold startup run at the 202-A Building. Later it received contact condenser cooling water from the 241-A-431 Building via the 216-A-34 Ditch. The site was deactivated by removing the above-ground piping and backfilling the excavation after the specific retention capacity was reached. The site was surface stabilized in 1990.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-A-19	216-A-19, 216-A-19 Test Hole, 216-A-19 Grave, 216-A-19 Sump, 216-A-19 Crib	East of the 200 East Area perimeter fence; north of 216-A-8 Crib	1955 to 1956	Startup waste and contact condenser cooling water from PUREX	1,100,000 L (291,000 gal) of start-up waste containing uranium and nitric acid.	4.6 m (15 ft)	7.6 m x 7.6 m (25 ft x 25 ft)	The site received depleted uranium waste from the cold startup run at the 202-A Building. Later it received contact condenser cooling water from the 241-A-431 Building via the 216-A-34 Ditch. The site was deactivated by removing the above-ground piping and backfilling the excavation after the specific retention capacity was reached. The site was surface stabilized in 1990.
216-A-20	216-A-20, 216-A-20 Test Hole, 216-A-20 Grave, 216-A-20 Sump, 216-A-20 Crib	East of the 200 East Area perimeter fence; north of 216-A-8 Crib	1955 to 1955	Startup waste from PUREX; cooling water from 241-A-431 Building contact condenser	961,000 L (254,000 gal) of start-up waste containing uranium and nitric acid	4.6 m (15 ft)	7.6 m x 7.6 m (25 ft x 25 ft)	
216-A-22	216-A-22, 216-A-22 French Drain, 216-A-22 Crib	Along the north wall of the 203-A Building, north of PUREX.	1955 to 1958	Drainage from the 203-A building load out apron, 203-A sump waste, and heating coil condensate from the UNH tanks	10,000 L (2,600 gal) of liquid that was low in salt and neutral to basic containing uranium	3 m (10 ft)	Circular area of 4.9 m (16 ft) in diameter at surface	The site received the drainage from the 203-A Building truck loadout apron, the sump waste from the 203-A Building enclosure, and the heating coil condensate from the P-1 through P-4 uranyl nitrate hexahydrate (UNH) tanks. The excavation is 4.9 m in diameter at grade and 1.8 meters in diameter at the bottom, with a side slope of 3:1 (V:H). Approximately 3 m (10 ft) of gravel fills the excavation bottom, and the site is backfilled. The 216-A-28 Crib replaced this crib.
216-A-28	216-A-28, 216-A-28 French Drain, 216-A-28 Crib	Near the northwest corner of 203-A Building, north of PUREX The site is not currently marked or posted	1958 to 1967	Liquid waste from 203-A sumps and heating coil condensate from the UNH tanks	30,000 L (7,900 gal) of liquid that was low in salt and neutral to basic containing uranium	3.4 m (11 ft)	Circular area of 6.1 m (20 ft) in diameter at surface	The crib was constructed in a truncated cone shape. The excavation has about 3 m (31 m^3 [1,100 ft^3]) of gravel fill and is backfilled to grade. The crib also contains a 10-cm (4-in.) perforated pipe 5.2 m (17 ft) long extending horizontally 1.2 m (4 ft) below grade. In 1981, the center of the unit was excavated and disposed of prior to installation of a PUREX Plant aggregate area security system. After the security system was installed it was backfilled to grade.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site_Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-A-36A	216-A-36A, 216-A-36 Crib	South of 202-A Building, west of Canton Avenue outside the security fence	1965 to 1966	Ammonia scrubber waste (ASD) from PUREX; fission product release	1,070,000 L (283,000 gal); low in salt and neutral to basic; 400,000 Ci of fission products including 1,600 Ci of Cs-137; also 625 Ci of Sr-90	7.6 m (25 ft)	30.5 m x 3.4 m (100 ft x 11 ft)	The 216-A-36A Crib was the original crib used until high contamination resulted in the abandonment and creation of its replacement, the 216-A-36B Crib. The discharge pipe was extended and a concrete dam was installed between the two cribs.
216-A-36B	216-A-36B, 216-A-36 Crib, PUREX Ammonia Scrubber Distillate (ASD) Crib	South of 202-A Building, west of Canton Avenue outside the security fence	1966 to 1987	Ammonia scrubber waste (ASD) from PUREX	317,000,000 L (84 Mgal); low in salt and neutral to basic containing large amounts of uranium	7.3 m (24 ft)	152.4 m x 3.4 m (500 ft x 11 ft) (bottom)	The crib is a gravel structure separated from the 216-A-36A Crib by a concrete dam. The 216-A-36B Crib contains a 10-cm (4-in.) perforated pipe placed horizontally 7 m (23 ft) below grade inside a 15-cm (6-in.) pipe from the 216-A-36A segment. The crib includes a 20-cm (8-in.) gage well, a plastic barrier between gravel and backfill, and a 20-cm (8-in.) vent with a 5-cm (2-in.) drain. The site is a RCRA TSD unit.
216-B-12	216-B-12, 216-ER Crib, 216-ER-1,2,3 Cribs	Northwest of 221-B Building and north of 7th Street	1952 to 1973	Condensate waste from 221-U (U Plant), 224-U (UO_3), and 221-B Plant (B Plant)	520,000,000 L (137 Mgal) of low in salt, neutral to basic liquid containing larger amounts of uranium, fission products, and TBP	9m (30 ft)	48.8 m x 15.2 m (160 ft x 50 ft)	The unit consists of a series of three cascading 5- x 5- x 3-m (16- x 16- x 10-ft) wooden boxes. The bottom 4 m (12 ft) contains 1.3 cm (0.5 in.) gravel backfill, 1.2 m (4 ft) of which underlie the cribs. The cribs have subsided gradually to a final depression of 1.5 m (5 ft) in the past. The cribs were immediately backfilled and discharged ceased. The site was surface stabilized in 1993. The cribs continue to have a possible cave-in potential.
216-B-60	216-B-60, 216-B-60 Crib	West end of 221-B Building under a portion of 225-B Building	1967 to 1967	221-B (B Plant) cell drain header	18,900 L (5,000 gal); low in salt, neutral to basic liquid containing uranium, plutonium, Ce-144, Cs-137, Eu-154	12 m (40 ft)	2.4 m (8 ft) in diameter, 4.3 m (14 ft) long	The crib was specifically constructed for solid and liquid wastes generated from the cleanout of the 221-B Building cell drain header that took place in November 1967. The crib consists of two steel vertical cascading caissons positioned side by side covered by 46-cm (18-in.)-thick concrete tops.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-C-1	216-C-1, 216-C-1 Crib, 216-C Crib	South of 7th Street and east of 209E Building	1953 to 1957	Cold run waste and process condensate from 201-C	23,400,000 L (6 Mgal) high salt waste, cold-run waste, process condensate of experimental REDOX and PUREX operations conducted at C Plant	4 m (13 ft)	8.2 m x 3.7 m (27 ft x 12 ft)	The crib was constructed of concrete ties, spacer blocks, roof slabs, and gravel fill. The crib was later surface stabilized with 10 cm (4 in.) of gravel (leaving 1.5 m [5 ft] of excavation unfilled). In 1979, the surfaces of the 216-C-1, C-3, C-4, and C-5 Cribs were scraped and placed within the depression of the C-1 Crib. The crib was then covered with a 10-cm (4-in.) sand pad, a layer of plastic, 0.3 m (1 ft) of sand, and 10 cm (4 in.) of pit run gravel.
216-S-1&2	216-S-1&2, 216-S-5 Crib, 216-S-1 & 2	East of 241-SX Tank Farm, southwest of 241-S-151 Diversion Box	1952 to 1956	Cell drainage and process condensate from REDOX (202-S)	160,000,000 L (42 Mgal); acidic liquid containing nitrate, aluminum nitrate, nitric acid, sodium; Sr-90, Cs-137, plutonium, and uranium	10.7 m (35 ft)	27.4 m x 12.2 m (90 ft x 40 ft)	The site contains two open-bottomed, square wooden crib boxes, placed 1.8 m (5.9 ft) into a gravel layer. The bottom 3 m (10 ft) was filled with screened, crushed stone. The crib boxes were constructed with 15- x 15-cm (6- x 6-in.) timbers and cross braces. The two crib boxes were connected in series, with overflow from the 216-S-1 Crib flowing into the 216-S-2 Crib via a pipe. Waste was discharged to the crib in batches of about 19,000 L (5,000 gal) at an average rate of 10 batches per day. In 1955, process vapors and high dose rates were noted at a monitoring well. A well casing was corroded and waste traveled through a nearby well to impact groundwater (UPR-200-W-36).
216-S-7	216-S-7, 216-S-7 Crib, 216-S-15	North of 10th Street and northwest of 202-S Building	1956 to 1965	Cell drainage and process condensate from REDOX (202-S)	390,000,000 L (103 Mgal); acidic liquid waste containing nitrate, aluminum nitrate, nitric acid, sodium, plutonium, and uranium	6.6 m (21.8 ft)	30.5 m x 15.2 m) (100 ft x 50 ft)	The 216-S-7 Crib replaced the S-1&2 Cribs. The crib consists of two 4.9- x 4.9- x 1.5-m (16- x 16- x 5-ft) wooden structures 10 m (34 ft) apart in one excavation. The wooden structures are surrounded by gravel fill and covered with 4.6 m (15 ft) of dirt. In 1991, the surface was stabilized with approximately 0.6 m (2 ft) of sand and gravel.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-S-8	216-S-8, Cold Aqueous Trench, Cold Aqueous Crib, 216-S-3, Unirradiated Uranium Waste Trench, Cold Aqueous Grave	East side of 241-SX Tank Farm and southwest of 216-S-1&2 Cribs	1951 to 1952	Startup waste from 202-S Building (REDOX)	10,000,000 L (3 Mgal); acidic liquid containing uranium and nonirradiated uranium from startup and test runs	7.6 m (25 ft)	30. 5 m x 18.3 m (100 ft x 60 ft)	The crib is in the general area of the 216-S-1 and -2 Cribs as well as Unplanned Release UN-200-W-114. The crib was retired when the discharge of startup waste to the unit was completed. The crib was de-activated by removing the above-ground piping and backfilling the unit. In 1994, the crib surface was interim stabilized.
216-U-1&2	216-U-1&2, 361-WR (Crib 2), 216-U-3, 216-UR #1&2 Cribs, 216-U-1 & 2	North of 16th Street, west of 221-U Building, east of 207-U Retention Basin	1951 to 1967	Overflow from 241-U-361 Settling Tank; cell drainage from 221-U, waste from 224-U (UO_3)	46,200,000 L (12 Mgal); acidic liquid containing uranium, nitrate, and TPB	6 m (20 ft)	23.8 m x 8.5 m (78 ft x 28 ft)	The cribs consist of two wood structures each 3.7 m (12 ft) square designed to operate in a series. Timbers 15 x 15 x 3.7 m (6 x 6 in. x 12 ft) long were used to construct each crib. Liquid waste materials entered the crib through a 8.9-cm (3.5-in.) stainless steel pipe via the 241-U-361 settling tank. A 20-cm (8-in.) black iron casing extended 21 m (70 ft) below finished grade through the crib. In 1992, the crib was surface stabilized with soil and marked as a cave-in potential. In 1995, as part of the 200-UP-2 LFI, three boreholes were drilled and soil samples characterized.
216-U-5	216-U-5, 216-U-4, 221-U Cold U Trench #2	Northwest of 221-U Building	1952 to 1952	Cold startup run at 221-U (U Plant)	2,250,000 L (600,000 gal); unirradiated uranium, nitrate	3 m (10 ft)	12 m x 3 m (40 ft x 10 ft)	The trenches were excavated to receive nonirradiated uranium waste from the cold startup run at U Plant by way of above-ground pipes. The pipes were removed when waste transfer operations were concluded and the trenches backfilled. The site was interim stabilized with about 0.6 m (2 ft) of soil in 1994.
216-U-6	216-U-6, U Facility Unirradiated Uranium Waste Trench, 221-U Cold U Trench, 216-U Cold U Trench #1, 216-U-5, 221-U Cold U Grave #1	Northwest of 221-U Building	1952 to 1952	Cold startup run at 221-U (U Plant)	2,250,000 L (600,000 gal); unirradiated uranium, nitrate	3 m (10 ft)	22.9 m x 3 m (75 ft x 10 ft)	The trenches were excavated to receive nonirradiated uranium waste from the cold startup run at U Plant by way of above-ground pipes. The pipes were removed when waste transfer operations were concluded and the trenches backfilled. The trench was interim stabilized with about 0.6 m (2 ft) of backfill in 1994.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site_Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-U-8	216-U-8, 216-WR-1,2,3 Cribs, 216-U-9	West of Beloit Avenue and south of 16th Street	1952 to 1960	Acidic process condensate from 221-U (U Plant) and 224-U (UO_3) Buildings and 291-U stack	379,000,000 L (100 Mgal); acidic waste, Cs-137, Eu-154, U-235, U-238, Sr-90	9.8 m (32 ft)	48.8 m x 15.2 m (160 ft x 50 ft)	The crib consists of three timbered structures (each 4.9 x 4.9 x 3 m [16 x 16 x 10 ft]) that received process waste. In 1960, the crib was deactivated when it began to subside. Sinkholes were backfilled around the three cribs and the risers were cut off and capped below grade. In 1994, the crib and the portion of the vitrified clay pipe from 16th Street south to the crib were stabilized with about 0.6 m (2 ft) of soil. The site was characterized in 1995 as part of the 200-UP-2 LFI. One borehole was drilled through the crib. Surface and near-surface soil samples, vegetation samples, and a pipeline camera survey were completed for characterization. Groundwater has been impacted at this site.
216-U-12	216-U-12, 216-U-12 Crib	South of 16th Street, west of Beloit Avenue, south of 216-U-8 Crib	1960 to 1988	291-U-1 stack drainage, 244-WR vault waste, 224-U process condensate	150,000,000 L (40 Mgal); acidic liquid containing thorium, uranium, Sr-90, Cs-137, nitrate, and TBP	4.6 m (15 ft)	30.5 m x 3 m (100 ft x 10 ft)	The 216-U-12 Crib was constructed when the 216-U-8 Crib began to subside. The pipe that delivered liquid materials to the U-8 Crib was blanked off, and a 15-cm (6-in.) vitrified clay pipe transported liquid waste to the U-12 Crib. A 30-cm (12-in.) perforated vitrified clay pipe extends horizontally the length of the crib. The crib contains a vent pipe and two gage wells. The vent pipe is 30-cm (12-in.) vitrified clay vent pipe. Gauge wells were 45-cm (18 in.) and 20 cm (8 in.) diameter and believed to be vitrified clay pipe. The bottom 167 cm (66 in.) of the crib contains gravel. In 1995, one borehole was characterized as part of the 200-UP-2 LFI. In 1996, a section of the VCP was removed, and sealed within the pipeline with grout. This site is a RCRA TSD.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
241-U-361	241-U-361, 241-U-361 Settling Tank, 361-U-TANK	Southwest of 221-U Building	1951 to 1967	Cell drainage from 221-U (U Plant), waste from 224-U (UO_3)	104,100 L (28,000 gal) tank capacity; plutonium, Sr-90, Cs-137, uranium, nitrate, and TBP; volume released is unknown	7.6 m (25 ft)	6.1-m (20-ft) diameter tank	The site contained an underground concrete settling tank. A 8.9-cm (3.5-in.) stainless steel pipe entered the tank from the 224-U Building. A 8.9-cm (3.5-in.) stainless pipe extended from the tank to the 216-U-1 Crib. The tank was interim stabilized in 1985 with 0.6 m (2 ft) of clean fill. This tank is included on the list of Inactive Miscellaneous Underground Storage Tanks (IMUST).
270-E-1	270-E-1, 270-E CNT, 270-E Condensate Neutralization Tank, 216-ER-1	West of 221-B Building, near southwest corner of 216-B-64 Basin	1952 to 1957	Acidic process condensate from 221-B (B Plant) and 224-B Buildings	15,840-L (4,200-gal) tank capacity; acidic process condensate precipitates, salt, uranium, minor plutonium, TBP, and other beta emitters; volume released is unknown	2.7 m (9 ft)	2.7-m (9-ft) diameter tank	The site contained an underground steel tank. Acidic condensate entered the base of the tank and flowed upward to an outlet pipe. The tank contained a limestone bed that allowed condensate to percolate, react, and overflow to the 216-B-12 Crib.
270-W	270-W, 270-W Tank, 270-W Neutralization Tank	Under the northeast end of 2715-UA Building, inside 224-U facility fence	1952 to 1960	Acidic process condensate from 224-U (UO_3) Building	Phosphoric acid, potassium hydroxide, trace amounts of hydrogen fluoride, mercury, beta emitters, uranium, plutonium; volume released is unknown	2.7 m (9 ft)	2.7-m (9-ft) diameter tank	The site contains an underground stainless steel tank with a 54,132-L (14,300-gal) capacity. The tank was filled with limestone used to neutralize acidic process condensate. This tank is included on the list of Inactive Miscellaneous Underground Storage Tanks (IMUST).
UPR-200-E-17	UPR-200-E-17, Overflow at 216-A-22, UN-200-E-17	Affected the ground on top of the 216-A-22 Crib, located north of PUREX, north of the 203-A facility, near the 216-A-28 Crib.	1958	Splashing occurred when the 216-A-22 Crib inlet failed, causing the ground on top of the crib to become yellow with uranium.	Uranium from uranyl nitrate hexahydrate (UNH) storage; volume released is unknown	NA	unknown	Sufficient splashing occurred when the 216-A-22 Crib inlet failed, causing the ground on top of the crib to become yellow with uranium. In 1959, the area was covered with dirt. The site is located within the 203-A tank chained radiation zone.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
UPR-200-E-39	UPR-200-E-39, Release from 216-A-36B Crib Sampler (295-A) Building, UN-200-E-39	Ground and blacktop area outside the 216-A-36B Crib Sampler Shack inside the PUREX fence, south of 202-A	1968	In February 1968 a release from the vent filter at the 216-A-36B Crib Sampler Shack occurred.	Ammonia scrubber waste containing fission products; volume released is unknown	NA	7.9 m x 7.9 m (26 ft x 26 ft)	An unplanned release on the ground and blacktop outside the 216-A-36B Crib Sampler Shack. The blacktop and ground surfaces were hosed down with water.
UPR-200-E-40	UPR-200-E-40, Release from the 216-A-36B Crib Sampler, UN-200-E-40	Ground and blacktop area outside the 216-A-36B Crib Sampler Shack inside the PUREX fence, south of 202-A	1968	In August 1968 a release from the vent filter at the 216-A-36B Crib Sampler Shack occurred.	Ammonia scrubber waste containing fission products; volume released is unknown	NA	4.7 m^2 (50 ft^2)	An unplanned release on the ground and blacktop outside the 216-A-36B Crib Sampler Shack. Contaminated blacktop was removed in 1968. In 1999, the area was covered with clean gravel. Because of its location, the site was consolidated with 200-E-103 and is shown in the WIDS database as a rejected site as of January 2000.
UPR-200-E-64	UPR-200-E-64, UN-216-E-64, Radioactive Soil and Ant Hills, UN-200-E-64, UN-216-E-36	North of 7th Street, adjacent to the west side of 216-B-64 Basin	1984	Insect transported soil contamination near a swab riser for an underground pipeline.	Cs-137, Sr-90; volume released is unknown	NA	8,100 m^2 (2 acres) in 1995	Ants burrowed into contaminated soil originating from a swab riser pipe that is associated with an underground pipeline in the vicinity of the 270-E-1 Neutralization Tank and the 216-B-64 Basin. Windblown contamination has resulted in a posted soil contamination area.
UPR-200-W-19	UPR-200-W-19, 361-U Overflow, UN-200-W-19	North of 16th Street, near the 361-U Settling Tank and 216-U-1&2 Cribs	1953	In spring of 1953 TBP process in 221-U (U Plant) and waste from 224-U (UO_3) overflowed to the ground from the tank and crib vents	Organic wastes and cell drainage from TBP and UO_3 plants; volume released is unknown	NA	Originally only 4.7 m^2; now much larger as a URM area	An unplanned release that consisted of drainage overflow from U Plant (tributyl phosphate) and UO_3 Plant. Organic waste and cell drainage with readings to 11.5 R/h at 7.6-cm (3-in.) distance. Site area is approximately 5.0 m^2. In 1953, decontamination was attempted and the site was backfilled and posted. In 1992, contaminated soil near the 216-U-1 and -2 Cribs was scraped and consolidated near the 241-U-361 Tank. The surface near the tank was surface stabilized with shotcrete.

Table 2-1. Uranium-Rich Process Waste Group, 200-PW-2 Operable Unit. (11 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
UPR-200-W-36	UPR-200-W-36, Groundwater Contamination at 216-S-1 and 216-S-2	At well 299-W22-3 near the east end of 216-S-1&2 Cribs, east of 241-SX Tank Farm	1955	In August 1955 release to groundwater via a failed well casing	Aluminum, nitrate, nitric acid, sodium, Co-60, Am-241, Cs-137, uranium, plutonium; volume released is unknown	NA	30 m x 15 m (98.4 ft x 49.2 ft)	An unplanned release that consisted of a ruptured test well that caused a release from the 216-S-1 and -2 Cribs. No data concerning contamination detailed.
UPR-200-W-163	UPR-200-W-163, Contaminated Vegetation at the 216-U-8 Pipeline, UN-216-W-33	In soil above pipeline from 224-U Building to 216-U-8 Crib; south of 16th Street and west of Beloit Avenue	1952 to 1960	224-U Building (UO_3)	Acidic waste, Cs-137, Eu-154, U-235, U-238, Sr-90; volume released is unknown	NA	4,047 m^2 (1 acre)	An unplanned release that consisted of radiologically contaminated vegetation growing above the buried pipeline to the 216-U-8 Crib. The contaminated area was interim stabilized in 1995.

Table 2-2. General Process Waste Group, 200-PW-4 Operable Unit. (5 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
207-A-SOUTH	207-A-SOUTH, 207-A, 207-A Retention Basin, 207-A-SOUTH Retention Basin, 207-A South	East of the 242-A Evaporator Building, adjacent to the 207-A-NORTH Retention Basin.	1977 to 1989	242-A Evaporator	Total capacity of 790,000 L (210,000 gal); process condensate waste containing mixed waste from spent halogenated and nonhalogenated solvents, and ammonia; estimated annual quantity of dangerous waste was 793,469 kg (1,749,300 lb) when operational.	2.1 m (7 ft)	3 concrete cells, each cell is 16.8 m (55 ft) long, 3.0 m (10 ft) wide at the bottom, and 2.1 m (7 ft) deep	All three cells were coated to prevent constituents from penetrating the concrete. The 207-A Basin was used for the interim storage of the 242-A Evaporator process condensate to allow for sampling and analysis before the condensate was discharged to the 216-A-37-1 Crib for final disposition. The site is a RCRA TSD unit.
209-E-WS-3	209-E-WS-3, Critical Mass Laboratory Valve Pit and Hold Up Tank (209-E-TK-111), IMUST, Inactive Miscellaneous Underground Storage Tank	Underground, near the south end of the 209-E building	1960 to 1989	209-E Critical Mass Laboratory Building	Tank capacity of 189 L (150 gal); condensate drained from 209-E facility into the holding tank underneath the valve pit. Contaminated with plutonium and nitric acid.	1.2 m (4 ft) to base of valve pit	2.1 m x 1.5 m x 2.1 m high (7 ft x 5 ft x 7 ft high) with 0.9 m (3 ft) above grade	The unit is concrete valve pit structure with a cadmium lined tank under the valve pit. The north edge of the tank is 0.9 m (3 ft) south of the south wall of the 209-E Critical Assembly Room. After confirmation, contents were discharged to the 216-C-7 Crib. Remaining liquids are residual condensate collection with low levels of plutonium. It is covered by a steel pit cover and posted as a RCA.
216-A-34	216-A-34, 216-A-34 Ditch, 216-A-34 Crib	East of the 200 East Area perimeter fence and north of the 216-A-8 crib.	1955 to 1957	241-A-431 Building contact condenser	Approximately 2,100,000 L (555,000 gal) if summed from 216-A-19 and 216-A-20; cooling water from the contact condenser. Contains less than 1 Ci total beta activity.	1.8 m (6 ft)	85 m (280 ft) x 9 m (30 ft)	Consists of a headwall structure tapering off into an open ditch which terminated at the 216-A-20 trench. The ditch has been backfilled and was stabilized in 1990.

Table 2-2. General Process Waste Group, 200-PW-4 Operable Unit. (5 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-A-37-1	216-A-37-1, 216-A-37 Crib	Outside of the 200 East Area perimeter fence, east of the 202-A Building.	1977 to 1989	242-A Evaporator	377,000,000 L (99.6 Mgal) of process condensate waste containing mixed waste from spent halogenated and nonhalogenated solvents, and ammonia; estimated annual quantity of dangerous waste was 793,469 kg (1,749,300 lb) when operational.	2.4 – 4.3 m (8 - 14 ft)	213 (700 ft) x 3 m (10 ft)	The crib received process condensate waste from the 242-A Evaporator facility. The unit is a gravel structure with a 25 cm (10-in.) corrugated, galvanized, perforated pipe located horizontally, 2.1 m (7 ft) below grade. The excavation contains 1.5 m (5 ft) of gravel fill with a volume of 150 m^3 (5,300 ft^3) and has been backfilled over. The site is a RCRA TSD unit.
216-A-45	216-A-45, 216-A-45 Crib	South of the PUREX facility, southwest of the 216-A-10 Crib.	1987 to 1991	Process condensate from 202-A (PUREX)	103,000,000 L (27.2 Mgal) of acidic waste containing uranium and nitrate.	13.7 m (45 ft)	94.5 m x 18.3 m (310 ft by 60 ft)	The unit has an associated drain field consisting of five 10 cm- (4 in.-) diameter perforated, fiberglass-reinforced pipes evenly spaced across the width. At the bottom is 1.7 m (5.5 ft) of clean rock, 8 to 13 cm (3 to 5 in.) in diameter. A layered cover consisting of a 15 cm (6-in.) layer of 8 to 13 cm (3 to 5-in.) diameter clean rock, a 15 cm (6-in.) layer of 1.9 cm (3/4-in.) gravel, a sheet of 10-mil polyethylene, and a 10 cm (4-in.) layer of sand was placed over the unit. This crib replaced the 216-A-10 Crib.
216-C-3	216-C-3, 201-C Leaching Pit, 216-C-3 Crib	South of 7th Street, within the larger posted URM area known as the Strontium Semiworks Stabilized Area (200-E-41).	1953 to 1954	Acidic process condensate from 201-C, 215-C and 217-C buildings	5,000,000 L (1.3 Mgal) containing nitric acid, uranium, and other fission products due to experimental REDOX runs.	3 m (10 ft)	15.2 m x 3 m (50 ft x 10 ft)	The crib consists of 10 cm (4-in.) pipes resting on a gravel bed that created a drain field type crib. The crib was deactivated by blanking the inlet pipeline and backfilling the excavation with sand and gravel. In 1979, the area containing this crib and several others was stabilized. More stabilization work was done in the area in 1992 and 1999, the latter related to the development of the 200-E-41 waste site.

Table 2-2. General Process Waste Group, 200-PW-4 Operable Unit. (5 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-C-5	216-C-5, 216-C-5 Crib	South of 7th Street, within the Hot Semiworks stabilized area (200-E-41)	1955 to 1955	201-C (Semiworks) high salt waste from startup tests	37,900 L (10,000 gal) of high salt waste containing nitric acid, uranium, and other fission products due to experimental PUREX runs.	4.9 m (16 ft)	6.1 m x 3 m (20 ft x 10 ft)	The excavation is a wedge-shaped cross section. The crib received waste via a 15 cm- (6-in.-) diameter galvanized, corrugated, perforated piping placed horizontally at 3.4 m (11 ft) below grade. Two 6.1 m (20-ft) lengths were placed perpendicularly to the inlet pipe, forming an H pattern. The site contains approximately 1.8 m (6 ft) or 74 m^3 (2,600 ft^3) of gravel fill and has been backfilled. The waste release point is 1.5 m (5 ft) from the site bottom. The surface area was later stabilized in 1979 and is now known as 200-E-41.
216-C-7	216-C-7, 216-C-7 Crib	Southwest of the 209-E Building, inside the 209-E exclusion area fence.	1961 to 1983	Liquid waste from the 209-E Critical Mass Laboratory	60,100 L (15,900 gal) of liquid waste containing uranium, plutonium, and limited amounts of Cs-137, Sr-90, Ru-106 due to critical mass experiments.	3.7 m (12 ft)	6.1 m x 6.1 m (20 ft x 20 ft)	The crib received waste via a 0.15 m- (6-in.-) diameter, perforated vitrified clay pipe, placed horizontally 3 m (9 ft) below grade. Two lengths of clay pipe were placed perpendicularly to the first, forming an H pattern. The site contains 123 m^3 (4,100 ft^3) of gravel fill and has been backfilled.
216-C-10	216-C-10, 216-C-10 Crib	South of 7th Street and southeast of the 201-C Building	1964 to 1969	Process condensate and acidic liquid waste from the 201-C Building	897,000 L (237,000 gal) including strontium, cerium, cesium, and promethium due to strontium and rare earth metal recovery experiments.	2.1 m (7 ft)	9.8 m x 1.5 m (32 ft x 5 ft)	The crib received process condensate from 201-C via a 7.6 cm (3-in.) diameter stainless steel pipe, located horizontally, 1.2 m (4 ft) below grade. The site slope is 1:1.5. The site contains 48 m^3 (1,700 ft^3) of gravel fill and has been backfilled with dirt. The crib was surface stabilized in 1989. In July 2000, the vent risers were sealed as a preventative measure for potential passive radioactive emissions.
216-S-4	216-S-4, 216-S-7, 216-S-4 Sump or Crib, UN-216-W-1	East of the 216-U-10 Pond and northwest of the 216-S-21 Crib	1953 to 1956	Condensate and cooling water from condensers on the 241-S-101 and 241-S-104 tanks in the 241-S Tank Farm.	1,000,000 L (264,000 gal) of liquid that contained nitrate and fission products.	6.1 m (20 ft)	Two 0.8 m (2.5 ft) diameter culvert pipes placed vertically side by side	The French drain was constructed of two rock-filled metal culverts fed by an aboveground pipe. The site was deactivated by removing the aboveground piping. The site was surface stabilized in 1991 with clean backfill.

Table 2-2. General Process Waste Group, 200-PW-4 Operable Unit. (5 Pages)

Site_Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-S-22	216-S-22, 216-S-22 Crib	East of 202-S Building and northeast of 216-S-20 Crib.	1957 to 1967	Liquid waste from the acid recovery facility in the 293-S building.	98,400 L (26,200 gal) of liquid waste containing nitrate, sodium, and fission products.	3.0 m (10 ft)	30.5 m x 1 m (100 ft x 3.5 ft)	The crib is a gravel structure with a side slope of 1:1.5. A pipe enters the unit below grade, branches out at right angles downwards to the bottom, and runs along the bottom for the length of the unit. The section of pipe along the crib bottom has open joints. The rest of structure is filled with backfill. The site was retired when production operations were shut down at REDOX.
216-S-23	216-S-23, 216-S-23 Crib	Northeast of the 241-SY Tank Farm and north of the 216-S-9 Crib	1969 to 1972	REDOX process condensate from the D-2 Receiver Tank in the 202-S building.	34,000,000 L (9 Mgal) of low-salt process condensate containing uranium, plutonium, fission products, and nitric acid.	8.5 m (28 ft)	110 m x 3 m (360 ft x 10 ft)	The crib consists of a perforated pipe set in a gravel layer, running the length of the crib. At one end of the crib a filter and gage well riser connects to the pipe. The rest of the crib contains backfill. The site was interim stabilized with 0.6 m (2 ft) of clean fill in 1995 after soils from UPR-200-W-165 were scraped up and placed on the surface of the crib. This crib was the replacement for 216-S-9.
216-T-20	216-T-20, 216-TX-2, 216-T-20 Crib, 241-TX-155 Contaminated Acid Grave	East of Camden Avenue, adjacent to the north end of the 200 West Area Power House Pond.	1952 to 1952	Contaminated nitric acid from the 241-TX-155 diversion box catch tank.	18,900 L (5,000 gal) containing contaminated nitric acid and fission products.	1.2 m (4 ft) of overburden	3 m x 3 m (10 ft x 10 ft)	The site is a single use pit dug to receive the acid. Presently there is a concrete block structure with a metal lid situated on the surface of the site. During deactivation the aboveground piping was removed and the site was backfilled.

Table 2-2. General Process Waste Group, 200-PW-4 Operable Unit. (5 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
216-U-16	216-U-16, UO_3 Crib	South of 16th Street, between Beloit and Cooper Avenues, southwest of the 224-U Building.	1984 to 1987	224-U steam condensate, chemical sewer waste, and process condensate; 271-U compressor cooling water, and 221-U chemical sewer waste.	409,000,000 L (108 Mgal); containing large amounts of uranium.	5.2 m (17 ft)	80.0 m x 58 m (262 ft x 191 ft)	The crib is constructed of two header pipes, 20 cm (8 in) reducing to 15 cm (6 in.) that are located 0.9 m (3 ft) above the crib bottom, running the length of the unit, one on each side. At each end of the pipe is a 15 cm (6 in) vent pipe. Connecting the two header pipes were twenty-two 10 cm (4 in) perforated pipes running the width of the unit, equally spaced, 0.9 m (3 ft) above the bottom. Each header pipe has a 10 cm (4 in) vent riser. In July 2000, the vent risers were sealed and cut off below grade. There are three gage wells, one near the north and south ends and one near the center. The bottom is filled with 1.5 m (5 ft) of gravel. Covering the gravel is a reinforced polyethylene liner extending 2.4 m (8 ft) up the sides of the excavation. The crib structure has been backfilled over to grade. A 15 cm (6 in) subdrainage pipe runs the width of the unit at the west side.
216-U-17	216-U-17, 216-U-17 Crib	South of 16th Street and east of Beloit Ave. inside the 200 West Area. It is southeast of the 221-U facility.	1988 to 1994	Process Condensate waste from the 224-U (UO_3) facility.	2,110,000 L (557,000 gal) of acidic, neutral, or basic liquid containing larger amounts of uranium, fission products, and limited amounts of TBP.	5.5 m (18 ft)	45.7 m x 3 m (150 ft x 10 ft) (bottom) 70 m x 26 m (230 ft x 86 ft) (top)	The unit consists of a distribution line lying in an aggregate field with a PVC vapor barrier. The 224-U Facility was permanently isolated from the crib by cutting and capping the crib pipeline on 11/9/1994. In July 2000, the vent risers were sealed as a preventative measure for potential passive radioactive emissions.
UPR-200-E-145	UPR-200-E-145, W049H Green Soil, VCP Pipeline Leak	East of the 241-A Tank Farm entrance, northeast of the 242-A Evaporator Building, and east of Canton Avenue.	1993	Pipeline from the 216-A-8 Proportional Sample Pit #2 to the 216-A-34 Crib.	unknown; soil contained uranium oxide.	.1 m (3 ft) minimum	12 m (40 ft) x 1.8 m (6 ft)	Contaminated soil reading 300,000 d/min of beta/gamma was found in an excavation, above a buried vitrified clay pipeline. Sample results indicate the contamination was primarily due to uranium oxide from past practices on the Hanford Site.

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3.0 INITIAL EVALUATION OF REPRESENTATIVE AND TREATMENT, STORAGE, AND DISPOSAL SITES

The purpose of this section is to present the results of previous characterization efforts at the representative and TSD unit waste sites in the 200-PW-2 and 200-PW-4 OUs, to provide a background for understanding the waste sites in these OUs. The contaminant inventory effluent volumes, available soil data, and current understanding of the distribution of contamination also are discussed for each of the representative sites.

3.1 KNOWN AND SUSPECTED CONTAMINATION

As discussed in Chapter 2.0, waste sites in these OUs received radionuclides, organics, and inorganic chemicals from process drainage, process distillate discharge, and miscellaneous condensates from the U Plant, REDOX (S Plant), PUREX (A Plant), B Plant (WESF), Hot Semiworks (C Plant), and several other contributing tank farm-related facilities such as the 242-A Evaporator. The waste was disposed to the vadose zone through cribs and trenches. The estimated inventory of the primary radionuclides and chemicals that were discharged to waste sites in the 200-PW-2 and 200-PW-4 OUs was obtained from the following sources:

- WIDS
- The aggregate area management study reports for the 200 Areas (e.g., DOE/RL-92-05)
- Implementation Plan (DOE/RL-98-28)
- *Waste Site Grouping for 200 Areas Soil Investigations* (DOE/RL-96-81)
- PUREX and REDOX Plant technical operating manuals (WHC-SP-0479; HW-18700-DEL)
- *Uranium Recovery Technical Manual* (U Plant) (HW-19140)
- *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE/RL-95-13)
- *Hanford Facility Dangerous Waste Part A Permit Application* (DOE/RL-88-21).

The estimated inventory for the waste sites in these OUs is presented in Table 3-1.

In general, the majority of the waste generated by operations associated with the 200-PW-2 OU can be described as a variety of liquid effluents, all containing large amounts of uranium. The waste ranges from acidic to neutral and basic pHs. It contains various constituents that include radionuclides, metals, inorganic chemicals, semivolatiles, and volatile organic compounds. Waste sites associated with the 200-PW-4 OU primarily received process condensate wastes and process wastes. In general, these sites have low inventories of all radionuclides and have received mostly low salt, neutral/basic liquids. Inorganic content is not reported with the

exception of several streams that received low levels of nitrates. The presence of organic constituents in some of the waste streams was noted.

3.2 ENVIRONMENTAL MONITORING

Currently, environmental monitoring at the Hanford Site consists of effluent monitoring, environmental surveillance, groundwater monitoring, investigative sampling, and select characterization within the vadose zone. The environmental surveillance is performed for the following:

- Air
- Surface water and sediment
- Drinking water
- Farm and farm product
- Soil and vegetation
- External radiation.

Air, external radiation, soil, and vegetation are routinely evaluated in the 200 Areas as part of the Hanford Site near-facility and environmental monitoring programs. The most recent of these annual reports are PNNL-13910, Appendix 2, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 2001*, and PNNL-13910, *Hanford Site Environmental Monitoring Report for Calendar Year 2001*. The near-facility document focuses on monitoring activities near facilities that have the potential to or have discharged, stored, or disposed of radioactive or hazardous materials, including facilities in the 200 East and 200 West Areas. PNNL-13910 covers the entire Hanford Site, including those areas not associated with operations (such as the 600 Area). This document examines the resources associated with the Hanford Site, including those media listed above, as well as groundwater. The results of these monitoring efforts for the 200-PW-2 and 200-PW-4 OU waste sites and vicinity are presented in Section 3.3. The potential impacts of contamination in these waste sites on human health and the environment are discussed in Section 3.3.2.

Groundwater also is routinely monitored sitewide. More than 600 monitoring wells are sampled annually to characterize groundwater flow; groundwater contamination by metals, radionuclides, and chemical constituents; and the area of contamination. Groundwater remediation, ingestion risk, and dose also are assessed. Results of groundwater monitoring and remediation are presented in an annual report, the most recent of which is PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*. This document also summarizes vadose zone characterization activities conducted on the Site through other projects.

Investigative sampling of soil and biota is conducted as part of the Hanford Site environmental monitoring program to confirm the absence or presence of radioactive and/or hazardous contaminants where known or suspected contaminants are present, or to verify radiological conditions at specific project sites. Media sampled include soil, vegetation, nests (bird, wasp, ant), mammal feces (rabbit, coyote), mammals (mice, bats), and insects (fruit flies). Investigative wildlife samples are used to monitor and track the effectiveness of measures designed to deter animal intrusion. Wildlife-related materials, including nests, carcasses, and feces, are collected as part of the integrated pest management program or when encountered

during a radiological survey. Samples are analyzed for radionuclides and/or other hazardous substances, with disposal contingent on the level of contamination present. Results of investigative sampling are reported in the annual *Hanford Site Environmental Monitoring Report* (PNNL-13910). Three waste sites in the 200-PW-2 OU, the 216-A-36B Crib, the 216-A-10 Crib, and the 216-U-12 Crib, are part of a 200 Areas Liquid Effluent Disposal Facility assessment monitoring program and are discussed in PNNL-13230-SUM, *Hanford Site Environmental Monitoring Report for Calendar Year 1999*. The 216-A-36B (inactive) Crib is monitored with the 216-A-10 and 216-A-37-1 Cribs (a 200-PW-4 OU waste site) in a single waste management area, based on similar hydrology and waste constituents. The cribs contributed to the large nitrate, I-129, and tritium plumes downgradient of the 200 East Area (PNNL-13230-SUM).

The 216-U-12 Crib, also part of the 200 Areas Liquid Effluent Disposal Facility assessment monitoring program, received wastewater containing chemical wastes and radionuclides. Iodine-129, nitrate, Tc-99, and tritium are detected consistently in the groundwater underlying the site. The findings of the first two phases of the assessment monitoring program indicate that the 216-U-12 Crib is a source of the nitrate and Tc-99 detected in the downgradient wells (PNNL-11574, *Results of RCRA Groundwater Quality Assessment Program at the 216-U-12 Crib*).

3.3 NATURE AND EXTENT OF CONTAMINATION

The following sections describe the nature and extent of contamination at representative waste sites and TSD units. The information in Section 3.3.1 then is combined with geological information (Section 2.1.5) and other contaminant distribution factors to formulate the conceptual contaminant distribution models that are presented in Section 3.3.2. Section 3.3.3 provides an overview of ecological data that have been collected over the years that pertain to the 200-PW-2 and 200-PW-4 OUs.

3.3.1 Representative Sites and Treatment, Storage, and Disposal Units

3.3.1.1 216-A-19 Trench

There are no boreholes in the immediate vicinity of the 216-A-19 Trench. The closest borehole (299-E25-10) is located approximately 18 m (60 ft) north of the crib. Therefore, soil data are not available to evaluate the nature and extent of contamination at this site. Borehole 299-E25-10 was logged with the Radionuclide Logging System (RLS) in 1999 to a depth of 87 m (286 ft). No man-made radionuclides were detected in the borehole with the RLS. The locations of boreholes in the vicinity of the 216-A-19 Trench are shown in Figure 3-1.

The effluent volume (1,100 m^3) discharged at this site is approximately 90 percent of the soil pore volume (1,232 m^3), as indicated in Table 3-1. These data suggest that groundwater may not have been impacted by waste disposal practices during operation of the trench as severely as at those sites where greater volumes of discharge occurred. The current status of groundwater

contamination in the vicinity of the 216-A-19 Trench is described in PNNL-13788. The report indicates that I-129 and tritium exceed groundwater protection standards/guidelines in the vicinity of the trench but does not specifically imply that this site is the source. Major groundwater plumes in the vicinity of the 200 East Area and the 216-A-19 Trench are shown in Figures 3-2 and 3-3.

3.3.1.2 216-B-12 Crib

Borehole geophysics (scintillation gamma logs in ARH-ST-156) were used to assess the nature and extent of contamination at the 216-B-12 Crib. No other data (i.e., soil sample analyses, RLS) are available to evaluate contamination at this site. Log data were collected from three boreholes (299-E28-64, 299-E28-65, 299-E28-66) within the crib and two boreholes (299-E28-9, 299-E28-16) located adjacent to the crib. The locations of boreholes in the vicinity of the crib are shown in Figure 3-4. The maximum extent of the investigation in and adjacent to the crib is 24 and 107 m (79 and 350 ft), respectively.

Elevated levels of contamination were detected beneath the crib in boreholes drilled through the structure. Contamination was detected near the base of the crib to a maximum depth of approximately 23 m (76 ft). Maximum contaminant levels (>1,000,000 c/min) were detected about 9 to 15 m (30 to 49 ft) bgs in the three subject boreholes within the crib. Background levels of radioactivity in these boreholes are less than 10,000 c/min.

Contamination was not detected in borehole 299-E28-9, which is located about 18 m (59 ft) west of the crib. Background levels of radioactivity in this borehole range between 2,000 and 9,000 c/min. Elevated levels of radioactivity appear to extend at least 8 m (26 ft) south of the crib to borehole 299-E28-16. Elevated activity was detected 14 to 18 m (46 to 59 ft) below the bottom of the crib. Maximum activity exceeded 1,100,000 c/min. Background levels (2,000 to 8,500 c/min) of radioactivity were detected approximately 18 m (59 ft) below the bottom of the crib to a total depth of 96 m (315 ft) in borehole 299-E28-16.

The effluent volume (520,000 m^3) discharged at this site is 28 times greater than the soil pore volume (18,300 m^3), as indicated in Table 3-1. These data indicate that there may have been impact to the groundwater at this site. The current status of groundwater contamination at the 216-B-12 Crib is described in PNNL-13788. The report indicates that the I-129 and nitrate (nitrogen in nitrate) plumes extend northwesterly from B Plant and may exist beneath the 216-B-12 Crib, but does not specifically imply that this site is the source. These major groundwater plumes in the vicinity of the 200 East Area and the 216-B-12 Crib are shown in Figures 3-2 and 3-3.

3.3.1.3 216-U-8 Crib

The current understanding of the nature and extent of contamination at the 216-U-8 Crib is summarized from DOE/RL-95-13; BHI-00034, *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area*; and DOE/RL-95-106. As described in these reports, contamination beneath the 216-U-8 Crib was assessed by collecting soil samples from borehole 299-W19-94. Boreholes in the vicinity of the crib also were logged with the RLS. Borehole 299-W19-94 was drilled halfway between two of three equally spaced underground timber structures on the northern half of the waste site. Soil samples were collected and analyzed for

volatile organic compounds; semivolatile organic compounds; inorganics; cyanide; fluoride; chloride; nitrate; nitrite; sulfate; gross alpha and gross beta; total uranium; radioisotopes including Cs-137, Co-60, and Sr-90; dry density; moisture content; specific gravity; calcium carbonate; and porosity. Borehole 299-W19-94, as well as others in the vicinity of the crib, was logged with the RLS to determine the presence of manmade and naturally occurring gamma-emitting radionuclides. The maximum depth of the investigation was 61 m (199 ft). RLS logs are available for boreholes 299-W19-70, 299-W19-71, and 299-W19-2. The locations of boreholes in the vicinity of the 216-U-8 Crib are shown in Figure 3-5.

Of the nineteen contaminants of potential concern identified for the 216-U-8 Crib, all are radiological with the exception of arsenic, chromium, and nickel. As reported in BHI-00034 soil samples from borehole 299-W19-94 exceeded the sitewide background for arsenic (8.9 p/m) in two samples at a depth of 4.6 and 9.1 m (15 and 30 ft) bgs. The concentrations were 9.1 and 9.14 p/m, respectively. Chromium was detected below the background level of 28 p/m with one exception: at a depth of 60 m (197 ft), it was found at a concentration of 28.4 p/m. Nickel was not detected above background in any of the soil samples taken from borehole 299-W19-94.

Radiological contamination was detected throughout the vadose zone beneath the 216-U-8 Crib to the maximum depth of the investigation. The highest levels of contamination, with the exception of Sr-90, which was present throughout the soil column, were detected at the bottom of the crib at a depth of approximately 9 m (31 ft). Elevated levels of contamination extend to a depth of approximately 13 m (42 ft) and generally decrease with depth to the bottom of the borehole. For example, Cs-137 activities ranged from 91,190 to 1,700 pCi/g between the crib-soil interface (at 8 m [32 ft]) and 13 m (42 ft). From this point to approximately 30 m (100 ft), Cs-137 activities ranged between 3.4 and 56 pCi/g. Cesium-137 was not detected below 30 m (100 ft). Contaminants with large contaminant distribution coefficients such as plutonium and americium were distributed similarly to Cs-137. However, the vertical extent of contamination was less than 15 m (50 ft) and concentrations were typically less than 1 pCi/g.

RLS data from other boreholes (299-W19-70 and 299-W19-71) correlate well with soil data collected from borehole 299-W19-94. The log data indicate that the highest contaminant concentrations were associated with the bottom of the crib at about 9 m (30 ft) bgs. Concentrations decreased with depth to the bottom of each borehole at about 25 m (80 ft) bgs. Less than 10 pCi/g of Cs-137 was detected above the bottom of the crib. A detailed discussion of the distribution of contamination based on RLS data is presented in BHI-00033.

The distribution of uranium isotopes in the subsurface beneath the crib indicates that this contaminant can be mobile and immobile in the subsurface. The highest concentrations of uranium were detected at the bottom of the crib and approximately 57 m (188 ft) bgs, associated with a caliche layer within the Plio-Pleistocene unit. Near the base of the crib, U-238 concentrations ranged between 29 and 94 pCi/g. Beneath this zone of higher contamination and to a depth of approximately 50 m (165 ft), U-238 concentrations ranged between 4.3 and 19 pCi/g. The maximum concentration of U-238 (150 pCi/g) was detected at the caliche layer at 57 m (188 ft) bgs. At the maximum extent, 61 m (199 ft) of the investigation, the U-238 concentration was less than 1 pCi/g.

Uranium-233/234 and U-235 were distributed similarly to U-238. However, contaminant concentrations were not as high. Near the bottom of the crib, concentrations ranged between

1.1 and 28 pCi/g. Beneath this upper zone of contamination to a depth of approximately 50 m (165 ft), concentrations ranged between the detection limit and 20 pCi/g. Similar to U-238, elevated levels of U-233/234 and U-235 were detected associated with the caliche layer. Concentrations of these isotopes at the caliche layer were 140 pCi/g and 6.7 pCi/g. At the maximum extent of the investigation, concentrations were less than 1 pCi/g. These data indicate that the wetting front and mobile contaminants have migrated deep within the vadose zone, and uranium mobility varies greatly.

Strontium-90, a moderately mobile contaminant, was present throughout the soil column beneath the 216-U-8 Crib. Concentrations ranged between 36 pCi/g and 130 pCi/g from the bottom of the crib to about 27 m (90 ft). Below 27 m (90 ft) bgs, concentrations generally increased with depth to 50 m (165 ft) and ranged between 370 pCi/g and 520 pCi/g. A maximum concentration of 520 pCi/g was detected at 34 m (110 ft) and 50 m (165 ft) bgs within the sand-dominated sequence of the Hanford formation. Concentrations decreased to 270 pCi/g at a depth of 60 m (197 ft) bgs.

In addition to the contaminants described above, arsenic, chromium, Am-241, Eu-154, Np-237, Pu-238, Pu-239/240, Ra-226, Ra-228, and Th-234 were detected during the limited field investigation (LFI). The distribution and presence of these potential contaminants of concern in the soil column are slightly above background, single detects, and sporadic detection. A summary of all contaminants detected during the LFI is presented in BHI-00034.

The effluent volume (379,000 m^3) discharged at this site is 34 times greater than the soil pore volume (11,100 m^3), as indicated in Table 3-1. These data indicate that there has been impact to the groundwater at this site. The current status of groundwater contamination in the vicinity of the 216-U-8 Crib is described in PNNL-13788 and indicates that this site in the past was one of several contributing sources. The report indicates that nitrate (nitrogen in nitrate), carbon tetrachloride, I-129, tritium, and uranium exceed groundwater protection standards/guidelines in the vicinity of the crib. Uranium is a major groundwater contaminant at the 216-U-8 Crib and was monitored in groundwater at borehole 299-W19-2. The 216-U-8 Crib is the only representative site in the 200-PW-2 OU that has been confirmed to have contributed uranium to the groundwater. No groundwater data are available to evaluate impact on the aquifer at the crib during the periods of effluent discharge (1952 to 1960). Monitoring at the crib began in 1974, was stopped in the spring of 1990, was resumed again in the summer of 1994, and finally was discontinued in 1995 because well 299-W19-2 did not produce enough water for sampling, because of the decline in the elevation of the water table across the 200 West Area. The well was decommissioned in March 1998. Trend analysis indicates that uranium has been detected in the aquifer since monitoring began. Between 1974 and 1984, uranium concentrations were decreasing over time and ranged between 1 and 71 μg/L. After 1986, concentrations increased sharply to approximately 150 μg/L, exceeding the proposed maximum contaminant level of 20 μg/L. A general decrease in the level of contamination was observed after 1989; however, sampling was halted. Samples collected in 1994 and 1995 typically ranged between 14.5 and 79 pCi/L. A trend plot of uranium concentrations in well 299-W19-2 is shown in Figure 3-6. Major groundwater plumes in the vicinity of the 200 West Area and the 216-U-8 Crib are shown in Figures 3-7 and 3-8.

As part of the LFI at the 216-U-8 Crib, an integrity investigation also was conducted on the pipeline that discharged to the crib. The objective of the investigation was to determine the

potential of this schedule 40 stainless steel/vitrified clay pipeline to leak and cause soil contamination. Sections of pipeline were surveyed with an in-line video camera, and 23 surface and near-surface soil samples were collected to depths of 2 to 4 m (7 to 12 ft). These depths represent the approximate location of the pipeline in the subsurface. Activities and results are described in greater detail in BHI-00033 and DOE/RL-95-13.

The pipeline integrity investigation yielded a number of observations. In the vitrified clay section of the pipeline, many of the joints were dislodged; the degree of dislodgment varied from very minor to very serious, and silty sandy material was observed. The stainless steel section of the pipe was in excellent condition and the joints were sound. However, silty material also was observed in the pipe.

Surface soil samples collected during the pipeline investigation typically showed background levels of activity for analyzed constituents. The highest levels of contamination were detected in the subsurface near the vitrified clay pipe. However, many constituents were distributed throughout the 4-m (12-ft) depth of the investigation. The data also suggested that minor lateral spreading (no more than 1 to 2 m [3 to 5 ft]) was apparent. The maximum concentrations of Am-241, Cs-137, Pu-239/240, and Sr-90 detected during the pipeline investigation were 426 pCi/g, 49,100 pCi/g, 70.6 pCi/g, and 1,380 pCi/g, respectively. Note that the highest strontium activity was detected in a vegetation sample. Soil sampling results for constituents are presented graphically in BHI-00033.

3.3.1.4 216-U-12 Crib

The nature and extent of contamination at the 216-U-12 Crib was evaluated using the RLS and soil data. RLS data from borehole 299-W22-75 provide the only data available to evaluate contamination directly through the 216-U-12 Crib. Data were obtained from this borehole over a log interval of 57 m (175 ft) in 1991. The RLS and analytical chemistry data from borehole 299-W22-78 provide information to assess contamination immediately adjacent to the crib. Data were collected from this borehole to a depth of 71 m (233 ft) in 1994 to support the 200 UP-2 OU LFI (DOE/RL-95-13). Although soil chemistry data are not available to evaluate contamination directly beneath the 216-U-12 Crib, DOE/RL-95-13 and DOE/RL-95-106 suggest that the site is highly analogous to the 216-U-8 Crib. These sites received the same type of waste and are located relatively close together. Boreholes near the 216-U-12 Crib are shown in Figure 3-5.

Three man-made radionuclides (Cs-137, U-235, and U-238) were identified beneath the 216-U-12 Crib with the RLS. Cesium-137 was detected to a maximum depth of 8 m (59 ft). Concentrations greater than 5,000 pCi/g were detected at 6 to 8 m (20 to 25 ft) bgs. The maximum activity was estimated at 16,100 pCi/g at 7 m (23 ft) bgs. Cesium-137 detected with the RLS adjacent to the crib in borehole 299-W22-78 was less than 1 pCi/g at less than 0.3 m (1 ft) bgs. Cesium-137 was not detected in soil samples collected in the adjacent borehole. Cesium-137 concentrations generally decreased with depth at the crib and were not detected at depths greater than 8 m (59 ft) bgs.

Uranium-235 was detected within a 2-m (7-ft) zone beneath the crib at a depth between 22 and 24 m (73 and 80 ft) with the RLS. The maximum activity of U-235 in this zone is approximately 20 pCi/g and also corresponds to maximum U-238 concentrations detected with the RLS. The maximum concentration (500 pCi/g) of U-238 was detected 23 m (77 ft) bgs and

indicates that higher concentrations were detected with depth. Uranium-238 initially was detected at a depth of 5 m (17 ft) (approximate depth of inlet pipe) to a maximum depth of 24 m (80 ft). Its distribution above the hot spot is sporadic. Uranium was detected in soil samples throughout the vadose zone adjacent to the crib to a depth of 70 m (230 ft). Activities were typically less than 1 pCi/g, except as noted.

Uranium isotopes were detected 4 to 7 m (13 to 23 ft) bgs adjacent to the crib in borehole 299-W22-78. A maximum of 66 pCi/g was detected with the RLS at the bottom of the crib, 6 m (19 ft) bgs. Isotopic uranium detected in soil chemistry samples adjacent to the crib was less than 1.1 pCi/g.

Soil sampling efforts from borehole 299-W22-78 near the 216-U-12 Crib indicate that the constituents were not detected above background levels (DOE/RL-95-13). Higher levels of contaminants likely were not detected because soil samples were collected outside of the crib. These data suggest that the lateral spread of contaminants at the crib may be limited to the immediate area of the crib.

The effluent volume (150,000 m^3) discharged at this site is 107 times greater than the soil pore volume (1,400 m^3), as indicated in Table 3-1. These data indicate that there has been impact to groundwater at this site. The current status of groundwater contamination in the vicinity of the 216-U-12 Crib is described in PNNL-13788 and indicates that the site in the past was one of several contributing sources. The report indicates that nitrate (nitrogen in nitrate), carbon tetrachloride, I-129, tritium, and uranium exceed groundwater protection standards/guidelines in the vicinity of the crib. Major groundwater plumes in the vicinity of the 200 West Area and the 216-U-12 Crib are shown in Figures 3-7 and 3-8.

3.3.1.5 216-A-10 Crib

The nature and extent of contamination at the 216-A-10 Crib was assessed by evaluating the spectral gamma data for boreholes 299-E24-2, 299-E24-59, 299-E24-60, and 299-E24-160. There are no soil chemistry data available. Boreholes near the 216-A-10 Crib are shown in Figure 3-9.

Cesium-137, Co-60, and Eu-154 were detected beneath the crib through RLS logging. No uranium species were identified, but may be present near the bottom of the crib and masked by the activity of the Cs-137. The bottom of the crib is situated at 14 m (45 ft) below the ground surface, and the discharge points are 9 m (30 ft) bgs in the 216-A-10 Crib. Logging data from borehole 299-E24-2 at the north end of the crib revealed Cs-137 to be located from 13 to 28 m (43 to 90 ft), with the highest concentrations of greater than 200 pCi/g in two distinct zones at 17 to 24 and 26 to 27 m (56 to 78 and 85 to 88 ft) bgs. Two vadose borings were RLS logged at the east and west sides of the crib, to a depth of 45 m (147 ft). Borehole 299-E24-59, on the east side of the crib, had Cs-137 activity from 15 to 32 m (50 to 105 ft) bgs, with the maximum activity of approximately 10,000 pCi/g at 17.8 to 18.6 m and 19.3 to 23 m (58 to 61 and 63 to 76 ft) bgs. Borehole 299-E24-60, on the west side of the crib, revealed activity from 16 to 27 m (52 to 88 ft), with a maximum of 700 pCi/g at a depth of 17 m (56 ft) bgs. The Cs-137 in borehole 299-E24-160, located on the northeast side of the crib, extends from 14 to 49 m (45 to 160 ft) with another interval recorded at the depth of 58 to 61 m (192 to 199 ft) bgs; the maximum activity of 1,050 pCi/g is at 20 m (67 ft) bgs.

Cobalt-60 was not found in the 299-E24-160 boring, and only a trace at the top of the water table was discovered in 299-E24-2. The Co-60 in boring 299-E24-59 extends from 26 to 38 m (85 to 125 ft) bgs and has a maximum activity of 0.4 pCi/g. The other borehole, 299-E24-60, has the same general distribution of the cobalt-60, with the highest concentration of 0.2 pCi/g at a depth of 28 m (92 ft).

Europium-154 was found at a depth of 26 to 33 m (86 to 109 ft) bgs in borehole 299-E24-160, and the same isotope occurs in borehole 299-E24-2 at a depth of 26 to 28 m (85 to 91 ft) bgs; in both wells the activity is less than 3 pCi/g. The Eu-154 activity in the two midline borings is similar in both holes. The total Eu-154 activity extends from approximately 24 to 40 m (79 to 130 ft) bgs. In borehole 299-E24-59 the maximum concentration reaches 4 pCi/g, but in borehole 299-E24-60 the maximum is 12 pCi/g at a depth of 18 to 19 m (60 to 63 ft) bgs.

The effluent volume (3,210,096 m^3) discharged at this site is 104 times greater than the soil pore volume (28,072 m^3), as indicated in Table 3-1. These data indicate that there has been impact to the groundwater at this site. The current status of the groundwater contamination in the vicinity of the 216-A-10 Crib is analogous to the 216-A-36B Crib. The cribs are close to each other and have the same general source for the wastewater. Groundwater contamination in the area of these cribs is described in PNNL-13788 and is partially attributed to these two waste sites. The report indicates that tritium, nitrate (nitrogen in nitrate), I-129, Sr-90, and gross beta exceed the groundwater protection standards/guidelines in the vicinity of the crib. Major groundwater plumes in the vicinity of the 216-A-10 Crib are shown in Figures 3-2 and 3-3.

3.3.1.6 216-A-36B Crib

The nature and extent of contamination at the 216-A-36B Crib was assessed by evaluating soil and borehole geophysical log data. Characterization of the crib began in late 1965. Scintillation log data and soil samples were collected to assess the distribution of Cs-137 and Sr-90 contamination. Data were collected from six boreholes (299-E17-4, 299-E17-5, 299-E17-7, 299-E17-9, 299-E17-11, and 299-E17-51) adjacent to the crib. In this investigation, larger concentrations of Cs-137 and Sr-90 were reported to have been retained in the upper 18 m (59 ft) of the soil column. Data from wells 299-E17-5, 299-E17-11, and 299-E17-51 indicate that Sr-90 is highest (up to 100,000 pCi/g) at approximately 10 to 12 m (33 to 39 ft) bgs. Concentrations decrease with depth to approximately 1,000 pCi/g from 25 to 28 m (82 to 92 ft). Cesium-137 concentrations are not documented in the report. However, the vertical profile of gamma activity suggests that contamination may extend to 73 m (240 ft) in the 216-A-36A section of the crib. Enhanced mobility of gamma contamination (perhaps Cs-137) may be the result of the presence of ammonium discharged to the crib or migrated via unsealed boreholes. Results and contaminant profiles of Sr-90 and gamma activity are presented in RHO-HS-EV-18, *Serviceability of Crib Affected by PUREX Startup*.

Soil samples next were collected and analyzed in 1988 from borehole 299-E17-55, which is located in the crib, and five boreholes (299-E17-14, 299-E17-15, 299-E17-16, 299-E17-17, and 299-E17-18) located adjacent to the crib. Soil samples from borehole 299-E17-55 were analyzed for Am-241, U-235, Cs-137, Co-60, ammonia, ammonia-potassium chloride, nitrate (as nitrate), fluoride, and hydrogen ion concentration (pH). Samples collected from boreholes adjacent to the crib were analyzed only for nonradiological constituents. Sediment samples gathered within the crib were collected to a maximum depth of 19 m (61 ft). Samples adjacent to the crib were

collected to a maximum depth of 70 m (230 ft). Additionally, spectral gamma data were generated from borehole 299-E17-9, which is located within the 216-A-36A segment of the crib. Boreholes near the 216-A-36B Crib are shown in Figure 3-9.

Cesium-137, Co-60, Am-241, and U-235 were detected in soil samples collected from borehole 299-E17-55. Americium-241 and U-235 were detected in a single sample at 9 m (30 ft) bgs. Their concentrations were 48,100 and 1,225 pCi/g, respectively. This elevated zone of contamination also corresponds to the depth of maximum Cs-137 (3,280,000 pCi/g) and Co-60 (1,025 pCi/g) activity. Trend analysis indicates that Cs-137 activity generally increased with depth to 9 m (30 ft); however, most results were typically less than 4 pCi/g. Activities decreased from 9 m (30 ft) bgs to total depth (19 m [61 ft]) and ranged between 1.38 and 153 pCi/g. The distribution of Co-60 is similar to that of Cs-137. Cobalt activities, with exception of the 9 m (30-ft) sample, ranged between 0.32 and 11.5 pCi/g.

Soil samples collected in the vicinity of the crib indicate that ammonia concentrations ranged between 0.15 and 400 p/m. Within the crib, concentrations ranged between 0.15 and 105.7 p/m and increased with depth to the bottom of the borehole at 19 m (61 ft). Higher concentrations were detected adjacent to the east side of the crib in boreholes 299-E17-14, 299-E17-15, and 299-E17-16. Maximum concentrations of 126.1 to 400 p/m in these three adjacent boreholes occurred approximately at 32 m (105 ft) bgs. Ammonia was not detected from the surface to a depth of 18 m (60 ft) in wells adjacent to the crib. Ammonia was not detected in boreholes 299-E17-17 and 299-E17-18, which are located south of the crib.

Fluoride concentrations were typically less than 1.2 p/m in boreholes in the vicinity of the crib. Only one sample exceeded this threshold. A maximum concentration of 6.08 p/m was detected in borehole 299-E17-15 at a depth of 27 m (90 ft).

Nitrate concentrations in the soil column (as nitrate) ranged between 1.3 and 582.8 p/m in the vicinity of the crib. Higher concentrations of nitrate typically were detected in the upper section of the soil column approximately 18 to 20 m (60 to 65 ft) bgs. Concentrations generally decreased with depth. Samples collected within the crib ranged between 1.38 and 44 p/m. The pH in all samples ranged between 7.76 and 10.11.

The spectral gamma logging system identified three man-made radionuclides (Cs-137, Co-60, and Sb-125) beneath the 216-A-36B Crib in borehole 299-E17-9. Uranium isotopes were not detected.

Cesium-137 was detected from 9 to 19 m (29 to 61 ft) bgs. Concentrations greater than 5,000 pCi/g (instrument saturation point) were detected from 9 to 12 m (31 to 39 ft) bgs. Cesium-137 concentrations generally decreased with depth. The Cs-137 contamination also corresponds to higher levels of gamma energy detected with the natural gamma tool in borehole 299-E17-11. This borehole is located approximately 33 m (100 ft) south of borehole 299-E17-9.

Cobalt-60 was detected in two zones beneath the crib. The upper zone is from 14 to 28 m (46 to 92 ft), and the lower zone is from 51 to 92 m (167 to 300 ft) bgs. The maximum concentration within either zone was less than 3 pCi/g.

The distribution of Sb-125 is similar to that of Co-60. This contaminant was detected in the same upper zone as was Co-60 contamination, at 14 to 28 m (46 to 92 ft) beneath the 216-A-36B Crib. The concentration of antimony is less than 7 pCi/g throughout the zone.

The effluent volume (318,080 m^3) discharged at this site is greater than 20 times the soil pore volume (16,327 m^3), as indicated in Table 3-1. These data indicate that there has been impact to groundwater at this site. The current status of groundwater contamination in the vicinity of the 216-A-36B Crib is described in PNNL-13788, which attributes some of the contamination to the discharges to this crib. The report indicates that tritium, nitrate (nitrogen in nitrate), I-129, Sr-90, and gross beta exceed the groundwater protection standards/guidelines in the vicinity of the crib. Major groundwater plumes in the vicinity of the 216-A-36B Crib are shown in Figures 3-2 and 3-3.

3.3.1.7 207-A South Retention Basin

There are no boreholes in the vicinity of the 207-A South Retention Basin, and characterization has not been performed. Therefore, little or no data are available to evaluate the nature and extent of contamination in the vadose zone beneath the 207-A South Retention Basin. In addition, the contaminant inventory and effluent volume specific to this site are not documented, because the basin was designed to hold liquids rather than percolate liquids through the vadose zone. The 207-A South Retention Basin discharged to the 216-A-37-1 Crib, which received 377,000,000 L (99,528,000 gal). An assessment of contamination beneath the basin is drawn from the structural layout and process history of the retention basin and the inventory and effluent volume associated with the 216-A-37-1 Crib. The location of the basin relative to the 216-A-37-1 Crib is shown in Figure 3-10.

Little or no contamination is expected beneath this site, because the retention basin is a concrete structure that was designed to hold liquids. Any contamination present may be located near cracks and drains within the structure. The maximum vertical extent of contamination is expected to be less than 4.5 m (15 ft) bgs.

3.3.1.8 216-A-37-1 Crib

Four groundwater monitoring wells (299-E25-17, 299-E25-18, 299-E25-19, and 299-E25-20) are located adjacent to the 216-A-37-1 Crib (Figure 3-10). The wells were logged with natural gamma and neutron tools in 1982. The available data from these wells provide little information with which to assess the vertical extent of contamination in the vadose zone beneath the 216-A-37-1 Crib. The low count rate (~500 c/s), as indicated by gamma logs in the wells, suggest limited lateral spreading adjacent to the crib.

The effluent volume discharged (377,011 m^3) at this site is greater than 24 times the soil column pore volume (15,879 m^3) beneath the crib. These data indicate that there may have been impact to the groundwater at this site. The current status of groundwater contamination at the crib is described in PNNL-13788. The report indicates that there are two plumes (I-129 and tritium) near the crib. Groundwater plumes near the crib are shown in Figures 3-2 and 3-3.

3.3.2 Conceptual Contaminant Distribution Models

Preliminary conceptual contaminant distribution models first were developed for the 200-PW-2 and 200-PW-4 OUs in the waste site grouping report (DOE/RL-96-81), which provided generalized models at the OU scale. Using waste site-specific information (Sections 2.1.5, 2.2.3, and 3.3) and the OU models as a baseline, site-specific conceptual contaminant distribution models were developed for each of the representative sites and TSD units. These site-specific models represent our current understanding of the physical conditions and the nature and extent of contamination and provide the basis for the RIs proposed for each of the representative sites and TSD units. Conceptual contaminant distribution models are shown in Figures 3-11 through 3-18.

Information pertaining to contaminant sources, release mechanisms, transport media, exposure route, and receptors has been incorporated into the discussion of the conceptual contaminant distribution models in this section. The conceptual exposure model is included to develop an understanding of potential risks and exposure pathways. This information forms the basis for an evaluation of potential human health and environmental risk.

Waste streams associated with 200-PW-2 OU waste sites consisted of uranium-rich process condensate and can range in pH from acidic to neutral, and to basic. The waste streams are characterized by significant concentrations of both radionuclides and inorganic chemicals (DOE/RL-98-28). The primary sources of contamination at waste sites in these groups were generated at chemical processing plants (i.e., PUREX, REDOX, B [WESF], and U Plants) in the 200 Areas. Effluent from these contaminant sources was discharged to the soil column in trenches and cribs.

Waste streams associated with 200-PW-4 OU waste sites consisted of general process condensate wastes and process wastes. In general, these sites have low inventories of all radionuclides and have received mostly low-salt, neutral/basic liquids. Inorganic content is not reported with the exception of several streams that received low levels of nitrates. The primary sources of contamination at waste sites in these groups were generated at chemical processing plants (i.e., PUREX, REDOX, Hot Semiworks, U Plant), and several other contributing tank farm-related facilities such as the 242-A Evaporator in the 200 Areas. Effluent from these contaminant sources was discharged to the soil column in trenches and cribs.

Releases to the environment from primary sources have produced secondary contaminant sources. These secondary sources can consist of contaminated surface soils, subsurface soils, and groundwater beneath waste sites. Releases from secondary sources also can impact the environment by infiltration, resuspension of contaminated soil, volatilization, biotic uptake, leaching, and external radiation. When waste sites were receiving effluent, the dominant mechanism of contaminant transport was vertical infiltration. After this practice ceased, liquids continued to move through the soil column by gravity drainage for an undetermined period of time. Currently, the dominant mechanism of contaminant transport is assumed to be residual moisture from the effluents and limited natural recharge from precipitation.

The following statements are general conclusions regarding the conceptual contaminant distribution model for this waste group.

- Effluent discharged to waste sites in the 200-PW-2 OU consisted of uranium-rich process condensate that contained high levels of fission products. Effluent discharged to waste sites in the 200-PW-4 OU consisted of mostly general process drainage, process distillate discharge, and miscellaneous condensates, all containing low inventories of radionuclides. Primary radiological contaminants of potential concern (COPC) include cesium, plutonium, strontium, technetium, and uranium.

- Waste sites in this waste group, with the exception of unplanned releases, generally received large quantities of effluent compared to soil pore volume. Therefore, the wetting front and mobile contaminants at most sites likely impacted groundwater when these sites were actively receiving effluent. DOE/RL-96-81 suggests that discharge volumes met or exceeded soil pore volumes beneath representative sites and TSD units in this waste group.

- Effluent and mobile contaminant migration is predominantly vertical beneath the waste site after release. Lateral spreading of effluents and contaminants may have occurred in association with fine-grained lithofacies such as the sandy sequence of the Hanford formation and the Plio-Pleistocene unit/early Palouse soil.

- Contaminants such as cesium and plutonium that have large distribution coefficients (K_d >2,000 mL/g) normally adsorb strongly onto Hanford Site sediments. As a general rule, these normally immobile contaminants are detected in high concentrations near points of release. Their concentrations generally decrease with depth in the vadose zone. Contaminant impact in the lower half of the vadose zone or to groundwater should not be significant. Contaminants with K_ds equal to 0 mL/g, such as nitrite and tritium, are not readily adsorbed on soil particles and migrate throughout the vadose zone to groundwater. These very mobile contaminants may be present in residual concentrations in the vadose zone. Moderately mobile contaminants, such as Sr-90 (K_d = 0.4 to 50 mL/g), also are present throughout the vadose zone, and their concentrations may increase in the lower half of the soil column. In the 200 Areas, the distribution of Sr-90 in groundwater above the maximum contaminant level (MCL) of 8 pCi/L is limited.

- Uranium mobility is affected by the specific form of the uranium compound. The distribution of uranium through the vadose zone to groundwater typically shows local significant accumulations near the base of the structure (crib or trench), at the caliche interface, and along some fine-grained lenses in between. The elevated levels are the result, in part, of sorption, porosity changes, and the presence of elements, molecules, or compounds that act as reductants for most uranium species.

Uranium generally is considered to be poorly sorbed by sandy sediments; estimates of uranium K_d range from 0 to 25 mL/g or higher (DOE/RL-99-40, *Focused Feasibility Study for the 300-FF-2 Operable Unit*). Several different scenarios may help to explain the transport of uranium in the vadose zone and to groundwater: (1) uranium is immobilized by the formation of insoluble carbonate-phosphate compounds such as autunite, a hydrated calcium uranyl phosphate; (2) uranium compounds formed in the subsurface may be dissolved and mobilized by nitric acid typical of the discharges to the 200-PW-2 OU waste sites; and (3) once dissolved, the uranium is transported through the vadose zone to different horizons or to groundwater, depending on the volume of discharge and the presence of zones such as the caliche layer

documented at the 216-U-8 Crib. These situations, in concert with the pH, porosity, and other preexisting conditions found in the subsurface soils, can contribute to the variable uranium concentrations found at some of the waste sites.

Waste sites in the 200-PW-2 and 200-PW-4 OUs no longer receive effluent. Sites in these OUs have been surface stabilized (i.e., covered with clean soil to prevent the spread of contaminants) or were covered with clean soil during construction. With the cessation of artificial recharge, the downward flux of moisture through the vadose zone has decreased. Residual moisture should continue to decrease in the vadose zone over time and should equilibrate with the natural recharge rate, thus reducing the potential for future impacts to groundwater.

3.3.3 Environmental Information

The section introduces DOE/RL-2001-54, *Central Plateau Ecological Evaluation Report*, which serves as the basis for ecological evaluation activities in the Central Plateau. (The Central Plateau includes the 200 East Area, 200 West Area, and 200 North industrial area and portions of the largely undisturbed 600 Area.) This section also summarizes existing OU-specific environmental information.

3.3.3.1 Central Plateau Ecological Evaluation Report

DOE/RL-2001-54 has been prepared to support ecological evaluations under the RI/FS process for Central Plateau waste sites. DOE/RL-2001-54 completes a screening-level ecological risk assessment for the Central Plateau in accordance with the eight-step EPA ecological risk assessment process presented in EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. The first two steps of the process, the screening-level assessment, are presented in the document (DOE/RL-2001-54, Figure 1-1).

The document contains a compilation and evaluation of ecological sampling data that have been collected over many years from undisturbed and disturbed habitats in the Central Plateau. The ecological evaluation document helps answer questions about the ecological resources in the Central Plateau that are important to preserve and protect. The document also identifies ecological data needs that can be addressed in future ecological sampling activities on the Central Plateau.

The document includes descriptions of the habitats in the Central Plateau, including sensitive habitats, and the plants and animals that inhabit them. The document identifies potential species of concern, including threatened and endangered species and new-to-science species. The Ecological Compliance Assessment Project conducted a detailed survey of the Central Plateau in 2000 and 2001, and it is incorporated into the ecological evaluation document. The information from the survey provides a detailed description of the ecological setting of the Central Plateau and augments the ecological information presented in this work plan.

3.3.3.2 200-PW-2 and 200-PW-4 Operable Unit-Specific Environmental Information

A summary of ecological resources for the 200 Areas is provided in the Implementation Plan (DOE/RL-98-28), Appendix F, Chapters 8.0 and 9.0. Available information pertaining to sampling of vegetation and biota within the 200-PW-2 and 200-PW-4 OU waste sites is presented in this section to summarize existing ecological data, and as input to Section 3.5 on potential impacts to human health and the environment. Several other sources of information, while not pertinent to a specific representative site, provide useful data in the vicinity of the sites.

Eighty-five environmental monitoring records of wildlife and vegetation at the 200 East and 200 West Areas taken since 1965 were reviewed and summarized in WHC-MR-0418, *Historical Records of Radioactive Contamination in Biota at the 200 Areas of the Hanford Site*. The report indicates that areas in the vicinity of the 200-PW-2 OU and three waste sites within the 200-PW-4 OU were sampled between 1965 and 1993. About 4,500 individual cases of monitoring for radionuclide uptake or transport in biota in the 200 Areas environs were included in the documents reviewed in WHC-MR-0418. Approximately 2,400 samples were collected from near the operations areas, and only about 120 samples (i.e., approximately 5 percent) exceeded radionuclide concentrations of 10 pCi/g. Roughly 2,100 biotic samples were collected during special investigations at known or suspected contaminated sites, and about 1,800 (i.e., approximately 86 percent) exceeded concentrations of 10 pCi/g, indicating that radionuclide contamination has remained relatively localized even though it has spread beyond intended waste site boundaries. WHC-MR-0418 further states that the routine monitoring is targeted to detect potential radioactive contamination at nuclear facilities and waste sites, and the special investigative samples usually are targeted at known incidents of biotic uptake and transport. Therefore, both results are biased toward detection of radioactivity. These radionuclide transport or uptake cases were distributed among 45 species of animals (mostly small mammals), feces, and 30 species of vegetation.

Wildlife species most commonly associated with uptake of radioactive contamination in the 200 Areas historically have been house mice and deer mice, but other animals such as birds (including waterfowl), coyotes, cottontail rabbits, mule deer, and elk have been sampled (WHC-MR-0418; PNNL-12088, Appendix 2, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998*). Deer or elk and rabbits are routinely monitored outside the fence in the vicinity of the 200 East and 200 West Areas as part of the Surface Environmental Surveillance program identified in DOE/RL-91-50, Rev. 3, *Environmental Monitoring Plan United States Department of Energy Richland Operations Office*.

Plant species potentially may be exposed to contaminated soils and/or groundwater present in the vadose zone soil. Radionuclide uptake by plants within the 200 Areas was demonstrated in WHC-MR-0418. Plants live in direct contact with the soil and can take up contaminants through physical and biological processes. Exposure is a function of the plant species, root depth, physical nature of the contamination, and the contaminant concentrations and distributions in the soil. Plants generally are tolerant of ionizing radiation (IAEA 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*), but potentially present a contaminant pathway to wildlife through the consumption of contaminated seeds, leaves, roots, or stalks. The vegetative species most commonly associated with the contamination was the Russian thistle. As described in WHC-MR-0418, vegetation samples

were collected at three waste sites within the 200-PW-4 OU, including the 216-A-37-1, 216-C-5, and 216-C-10 Cribs. Unspecified levels of radionuclide contamination were detected in Russian thistle at the 216-A-37-1 Crib. Field screening revealed activities of 10,000 and 40,000 c/min in Russian thistle at the 216-C-5 and 216-C-10 Cribs, respectively (WHC-MR-0418). The largest numbers and levels of radionuclide uptake or transport occurred at several sites unrelated to the 200-PW-2 or 200-PW-4 OUs, including the 216-Z Ditches, 216-B-3 Ditches, 216-BC Cribs, B Tank Farm, and the BX/BY Tank Farms. Much of this information was collected before stabilization activities began at the individual waste sites. Noticeable improvements in reducing the uptake and transport of radionuclide contaminants by biota were observed in areas where interim stabilization activities have taken place (WHC-MR-0418).

A 1994 field investigation of the 200-UP-2 OU (BHI-00033), which was conducted in conjunction with the 200-UP-2 OU LFI (DOE/RL-95-13), examined surface soil contamination and uptake of radionuclides and metals by vegetation at the 216-U-8 Crib, the 216-U-8 Vitrified Clay Pipeline (216-U-8 VCP, now officially known as waste site 200-W-42 in the WIDS), the 216-U-1 and 216-U-2 Cribs, and the 216-U-10 Pond.

Vegetation samples were taken at three sites: the 216-U-8 VCP, the 216-U-8 Crib, and the 216-U-10 Pond. Samples were analyzed for a series of metals and radionuclides. Sampling results for each site are listed in Tables 3-2 and 3-3 and also can be found in BHI-00033, Appendix B. Metal and radionuclide contaminants of concern (COC) for the 200-PW-2 OU were identified at each site. Four surface soil samples and four vegetation samples were collected at the 216-U-8 Crib site. Three metal COCs, including barium, chromium, and copper, and eight radionuclide COCs, including Am-241, Cs-137, Pu-239/240, Tc-99, Th-232, total strontium, U-234, and U-238, were detected in vegetation samples from the 216-U-8 Crib. Vegetation samples at the 216-U-8 Crib showed high activity levels for Cs-137 and Sr-90. Both constituents were also found in the surface soil (DOE/RL-95-13). An additional 14 surface and subsurface samples, as well as 4 vegetation samples, were collected at the 216-U-8 VCP site. Four metal COCs, including antimony, barium, copper, and lead, and seven radionuclide COCs, including Cs-137, Pu-239/240, Tc-99, Th-232, total strontium, U-234, and U-238, were detected in vegetation samples near the 216-U-8 VCP site. Three metal COCs and six radionuclide COCs (including barium, copper, lead, Cs-137, Tc-99, Th-232, total strontium, U-234, and U-238) were detected in vegetation near the 216-U-10 Pond.

In 1993 and 1994, a sampling effort to collect ecological samples at four sites within the 200 Areas was summarized (BHI-00032, *Ecological Sampling at Four Waste Sites in the 200 Areas*). The basis of the sampling strategy was to select some worst case sites for sampling, to focus future biota sampling activities. One site sampled, the 216-A-24 Crib, which is part of the 200-PW-3 OU, was located near several 200-PW-2 OU sites (216-A-18 and 216-A-19 Trenches and the 216-A-20 Crib). The other three sampling locations shown in BHI-00032 are unrelated or distant to the 200-PW-2 OU sites. Control samples were collected from a site on the Saddle Mountain Wildlife Refuge. Soil, vegetation, small mammal, and insect samples were collected and analyzed for the EPA's Target Analyte List (SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*) constituents, Sr-90, total uranium, and gamma-emitting radionuclides using gamma spectroscopy. Soil and vegetation samples were also analyzed for Tc-99.

Vegetation analysis included one cheatgrass, one cheatgrass/wheatgrass, and two Russian thistle samples at the 216-A-24 Crib. Radionuclides detected in vegetation included Sr-90 (in both Russian thistle samples and both grass samples), Cs-137 (in one Russian thistle sample and both grass samples), and total uranium in one grass sample. Chromium and cobalt were detected in one grass sample, but both analytes also were present in the associated sample blanks. Copper was detected in one Russian thistle sample and both grass samples. However, copper was also present in the associated sample blanks for those samples, and the concentration of copper present in one grass sample was estimated. Zinc was detected in two Russian thistle samples and in one of the grass samples.

Four small mammal samples were taken at the 216-A-24 Crib. Analytes detected in small mammal (pocket mouse) samples included Sr-90 (three out of four samples), Cs-137 (two out of four samples, both values estimated), arsenic (one out of four samples, with an estimated concentration), lead (three out of four samples, with all concentrations estimated, and lead present in two of the sample blanks), and selenium (four out of four samples, with two concentrations estimated, and selenium present in all sample blanks). Strontium-90 was the only analyte detected in the composite insect sample. The following constituents were undetected in all samples: Tc-99, Co-60, cadmium, cyanide, lead, mercury, nickel, and silver (BHI-00032).

BHI-00032 concludes that Russian thistle is the preferred vegetative indicator for radionuclide and metal uptake, and pocket mice are the preferred mammalian indicators of contaminant uptake at terrestrial sites. Of the four sites sampled and described in BHI-00032, the 216-A-24 Crib had the highest reported vegetation concentrations of Sr-90, Cs-137, chromium, zinc, and copper.

In a 2001 sampling effort described in PNNL-13910, 57 soil samples and 49 vegetation samples were collected in the 200/600 Areas. Soil samples consisted of a composite of five plugs of soil, each 2.5 cm (1 in) deep, and 10 cm (4 in) in diameter, from each sampling location. Eleven sites in the 200-PW-2 and 200-PW-4 OUs were sampled for soil contamination in 2000 and 2001. Perennial vegetation samples consisted of the current year's growth of leaves, stems, and new branches collected from sagebrush and rabbitbrush. Vegetation from nine locations in the 200-PW-2 and 200-PW-4 OUs were sampled in 2000 and 2001. Surveillance of perennial vegetation in 1998 generally confirmed observations of past sampling efforts. Radionuclide analysis indicated that Co-60, Sr-90, Cs-137, Pu-239/240, and uranium consistently were detectable in both soil and vegetation. Fission products were most common in the 200 Areas. Thirty-one site-wide investigative vegetation samples were analyzed for radionuclides in 2001. Of the samples analyzed, 27 showed measurable levels of activity. Eight tumbleweed fragments showed elevated field readings, with 5 of these 8 samples originating from the 218-E-12B Burial Ground (part of the 200-SW-2 OU) in the 200 East Area (PNNL-13910).

As reported in PNNL-12088, Appendix 2; PNNL-13230, Appendix 2, *Hanford Site Near-Facility Environmental Monitoring Data report for Calendar Year 1999*; PNNL-13487, Appendix 2, *Hanford Site Near-Facility Environmental Monitoring Data report for Calendar Year 2000*; and PNNL-13910, Appendix 2, for calendar years 1998 through 2001, soil and vegetation samples were collected near a number of 200-PW-2 OU waste sites and were collected directly from two 200-PW-4 OU waste sites. Results for radionuclide analyses conducted on eleven soil samples in the 200-PW-2 and 200-PW-4 OUs, are indicated in

Table 3-4. Seven vegetation samples also were collected near five 200-PW-2 OU waste sites, and two samples were collected directly from 200-PW-4 OU waste sites. Radionuclide analysis results for these samples are presented in Table 3-5. The exact locations of these samples are shown in the referenced documents. Surface surveys are conducted annually at the waste sites and include vegetation, animal burrows, and feces. Surveys are conducted with vehicles equipped with radiation detection instruments or hand-held field instruments. Special surveys also are conducted at these waste sites if conditions warrant (i.e., growth of deep-rooted vegetation is observed). A more detailed discussion of the annual monitoring can be found in DOE/RL-91-50, Rev. 3.

Investigative wildlife sampling was used to monitor and track the effectiveness of measures designed to deter animal intrusion. Wildlife-related materials, including nests, carcasses, and feces, were collected as part of the integrated pest management program or when encountered during a radiological survey. Samples were analyzed for radionuclides and/or other hazardous substances, with disposal contingent on the level of contamination present. In 2001, five wildlife samples were submitted for analysis. The maximum radionuclide activities in 2001 were in mouse feces collected near the 241-TX-155 Diversion Box (part of the 200-IS-1 OU) in the 200 East Area. Contaminants included Sr-89/90, Cs-137, Eu-154, Pu-238, and Pu-239/240 (PNNL-13910). The number of animals found to be contaminated with radioactivity, their radioactivity levels, and the range of radionuclide activities were within historical levels (PNNL-13910).

Biological transport of contamination by ants is a source of concern on the Hanford Site. Harvester ants, which are present on the disturbed soils associated with waste sites, have shown extreme resistance to radioactive sources (Gano 1980, "Mortality of the Harvester Ant (*Pogonomyrmex owyheei*) After Exposure to 137Cs Gamma Radiation"). In a contamination area, ants are capable of bringing radioactive materials to the surface, where they potentially could become available to other means of transport by wind, plant uptake, birds, or mammals. The biological transport of contamination by harvester ants was noted during an annual radiological survey at the UPR-200-E-64 site in 1985. The source of contamination was assumed to be a small-diameter pipe visible on the west side of the 216-B-64 Basin, near the 270-E-1 tank. In 1985, the pipe had a dose rate of 30 mrad/h. Surrounding contamination was transported to the surface by harvester ants and further spread by wind. The size of the area of contamination in 1995 was approximately 8,100 m^2 (2 acres), and it currently is posted as a soil contamination area. Additional contaminated soil and ant hills were identified both north and south of 7th Street and around the 241-ER-151 Diversion Box in September 1998.

3.4 RCRA TREATMENT, STORAGE, AND DISPOSAL UNIT GROUNDWATER MONITORING

This section presents current groundwater monitoring information for the 216-U-12 Crib, 216-A-10 Crib, 216-A-36B Crib, and 216-A-37-1 Crib TSD units. This information will be referenced or inserted into the FS/closure/postclosure plan that will form the basis for a modification to the Hanford Facility (HF) RCRA Permit. Documentation meeting groundwater monitoring requirements for the HF RCRA Permit will be provided in the future in concert with the FS/closure/postclosure plan.

The current groundwater monitoring plans are contained in two separate documents: PNNL-11523, *Combined RCRA Groundwater Monitoring Plan for the 216-A-10, 216-A-36B, and 216-A-37-1 PUREX Cribs*, and WHC-SD-EN-AP-108, *Interim-Status Groundwater Quality Assurance Plan for the 216-U-8 Crib*. These documents contain further details regarding the geology, hydrology, and current groundwater monitoring programs for these RCRA TSD units. Excerpts from PNNL-13788 are presented in the following sections for the current monitoring network and groundwater conditions.

Quarterly RCRA groundwater compliance monitoring reports first were published in 1986 on the Hanford Site. Annual reports commenced in 1988. RCRA-compliant groundwater monitoring networks were implemented at different times for the various units, as defined under Tri-Party Agreement (Ecology et al. 1989) Milestone M-24-00. Sample collection and analyses for the RCRA groundwater monitoring program were halted on June 1, 1990, when Pacific Northwest Laboratory cancelled the United States Testing, Inc., analytical support services contract. The sampling program was reinstated on June 6, 1991, under an interim contract with International Technology Corporation (DOE/RL-92-03, *Annual Report for RCRA Groundwater Monitoring Projects for Hanford Site Facilities for 1991*). Annual reports for the RCRA groundwater monitoring program have been included in the Hanford Site groundwater monitoring report since 1997 (e.g., PNNL-11470, *Hanford Site Groundwater Monitoring for Fiscal Year 1996*; PNNL-11793, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*).

3.4.1 216-U-12 Crib Groundwater Monitoring

3.4.1.1 History of RCRA Groundwater Monitoring

A detection-level monitoring program has been in operation at the 216-U-12 Crib since September 1991. The crib was sampled for contaminant indicator parameters, groundwater quality parameters, drinking water parameters, and site-specific parameters. The specific conductance in two downgradient wells exceeded the background critical mean (WHC-SD-EN-AP-108). The Groundwater Quality Assessment Program at the 216-U-12 Crib (PNNL-11574) concluded that the crib was the source of the elevated specific conductance. The crib also was identified as a source of nitrate, calcium, and Tc-99 in the groundwater and the program was changed from detection-level monitoring to assessment monitoring. The objective of assessment monitoring is to evaluate the flux of constituents into the groundwater beneath the crib and to monitor the known constituents until a corrective action is defined or the unit (crib, etc.) is closed. DOE will propose an appropriate monitoring program for the TSD unit when the documentation is submitted to Ecology for incorporation into the HF RCRA Permit. Changes to the 216-U-12 Crib groundwater monitoring program will be reflected as necessary in a modification of the HF RCRA Permit.

3.4.1.2 Aquifer Identification

The unconfined aquifer occurs primarily within the Ringold gravel unit E, with the Ringold lower mud unit forming the base of the aquifer. The Ringold lower mud unit also serves as a confining unit for the aquifer located in Ringold gravel unit A. Groundwater in the 200 West Area has been greatly impacted by discharges to U Pond, which created a hydraulic mound of more than 26 m (85 ft) before being deactivated in 1984. Depth-to-water in the vicinity of the

216-U-12 Crib measures approximately 75 m (247 ft), but increases as the surface of the water table declines. The saturated thickness of the unconfined aquifer measures approximately 100 m (328 ft), but similarly decreases as the water table declines. Groundwater flow is to the southeast. The surface of the water table beneath the 200 West Area currently is declining less than 0.5 m/yr (1.6 ft/yr) (DOE/RL-99-79). A pump-and-treat system located approximately 500 m (1,640 ft) northeast of the crib has operated since 1994 and has treated over 350,000,000 L of groundwater.

3.4.1.3 Well Location and Design

The historic monitoring plan (WHC-SD-EN-AP-108) included five wells: 299-W22-40, 299-W22-41, 299-W22-42, 299-W22-43, and 699-36-70A; however, wells 299-W22-40 through 299-W22-43 have since gone dry or cannot be sampled. Well 299-W22-40 was not replaced because analysis of groundwater chemistry data indicated that it was adjacent to but not downgradient of the crib. Well 299-W22-79 (located at the existing point of compliance) replaced wells 299-W22-41 and 299-W22-42 in 1999. Therefore, the current groundwater monitoring network includes just two downgradient wells: one new well (299-W22-79) and well 699-36-70A. WHC-SD-EN-AP-108 contains as-built drawings of wells 299-W22-40, 299-W22-41, 299-W22-42, and 299-W22-43, and wells 299-W22-22 and 299-W22-23, which were included in the RCRA Phase I and II assessments. The current and past groundwater monitoring wells and boreholes in the vicinity of the 216-U-12 Crib are shown in Figure 3-5.

3.4.1.4 RCRA Groundwater Monitoring Results

The216-U-12 Crib wells are sampled quarterly for gross alpha and beta, tritium, Tc-99, total dissolved solids, alkalinity, and anions, and annually for inductively coupled plasma metals and I-129. Upon its completion, the new well initially was sampled for the RCRA Appendix IX constituents. The crib is a source of elevated nitrate and Tc-99 detected in downgradient wells 299-W22-41, 299-W22-42, 299-W22-79, and 699-36-70A. The nitrate and Tc-99 plumes are actually a series of smaller plumes with sources from several cribs (216-U-1, 216-U-2, 216-U-8, and 216-U-12) in the U Plant area. Technetium-99 activities in fiscal year (FY) 2001 ranged from 20 to 92 pCi/L in downgradient wells, well below the 900 pCi/L drinking water standard. Nitrate (nitrogen in nitrate) continued to be detected at levels greater than the 45 mg/L MCL in all the downgradient wells. However, the concentration trend in the nitrate has been downward. Technetium-99 concentrations follow a trend similar to nitrate in the downgradient monitoring wells. Technetium-99 concentration trends are declining in wells near the crib but increasing farther downgradient in well 699-36-70A. This suggests that the plume is moving downgradient farther east, away from the crib. Also, the decline of contaminant concentration may be caused by the change in groundwater flow.

Iodine-129 and tritium were detected repeatedly in several 216-U-12 Crib downgradient monitoring wells, but the sources appear to be the REDOX Plant effluent disposal cribs that are upgradient of the 216-U-12 Crib. Iodine-129 is elevated above the 1 pCi/L drinking water standard in wells 299-W22-79 and 699-36-70A. Iodine-129 in these wells measured 1.9 and 7.37 pCi/L, respectively, in FY 2001. During FY 2001, the center of the tritium plume appears to have moved farther east, away from the crib. Tritium concentrations remained above the 20,000 pCi/L drinking water standard in downgradient well 699-36-70A. The most recently

reported concentrations are 8,540 and 69,000 pCi/L in wells 299-W22-79 and 699-36-70A, respectively.

3.4.2 216-A-10, 216-A-36B, and 216-A-37-1 Cribs Groundwater Monitoring

3.4.2.1 History of RCRA Groundwater Monitoring

Groundwater monitoring is conducted near the PUREX Plant for several Hanford Site programs. The 216-A-10, 216-A-36B, and 216-A-37-1 Cribs (i.e., PUREX cribs) are at least partially responsible for significant groundwater contamination over a large area of the site, and were monitored in FY 2001 in accordance with ongoing RCRA monitoring requirements.
The PUREX cribs received similar constituents in their respective waste streams, so identifying the contributions of the individual cribs to the groundwater plumes is very difficult. Therefore, monitoring requirements and results for the 216-A-10 and 216-A-36B Cribs are included together with the other two cribs.

A groundwater monitoring program has been in operation at the 216-A-36B Crib since May 1988 and at the 216-A-10 Crib since November 1988. The cribs have been sampled for contaminant indicator parameters, groundwater quality parameters, drinking water parameters, and site-specific parameters to satisfy RCRA groundwater monitoring program requirements.
Although semiannual statistical evaluations have not shown that groundwater quality has been impacted from waste discharged into the 216-A-10 and 216-A-36B Cribs, individual constituents known to have originated from the PUREX cribs have been detected in groundwater above the MCL or drinking water standards. DOE will propose an appropriate monitoring program for the TSD unit when the documentation is submitted to Ecology for incorporation into the HF RCRA Permit.

3.4.2.2 Aquifer Identification

The uppermost or unconfined aquifer in the vicinity of the PUREX cribs occurs within Ringold Formation unit A. Depth to water is approximately 100 m (328 ft), and the aquifer is approximately 22 m (72 ft) thick. Flow direction of the unconfined aquifer near the PUREX cribs occurs primarily toward the southeast. However, to the west and northwest, the water table is essentially flat. Groundwater flow velocities beneath the cribs range between 0.003 and 0.48 m/day (PNNL-13788).

3.4.2.3 Well Location and Design

The current monitoring plan (PNNL-11523) proposed monitoring 11 near-field wells, located near PUREX, and 57 far-field wells, most located between the 200 East Area and the Columbia River. The plan identified wells 299-E17-1, 299-E24-16, and 299-E17-19 as the near-field downgradient monitoring wells for the 216-A-10 Crib, wells 299-E17-14, 299-E17-18, and 299-E17-9 as the near-field downgradient monitoring wells for the 216-A-36B Crib, and wells 299-E25-9, 299-E25-17, and 699-37-47A as the near-field downgradient monitoring wells for the 216-A-37-1 Crib. Wells 299-E17-1, 299-E17-19, 299-E17-18, 299-E25-17, 299-E37-47A, and 299-E17-9 are sampled semiannually; wells 299-E24-16, and 299-E17-14, and

299-E25-19 are sampled quarterly (well 299-E17-9 is going dry and may be replaced by 299-E17-16 in the near future). Likewise, since FY 2000, well 299-E25-17, near the 216-A-37-1 Crib, has been difficult to sample. It may be replaced by well 299-E25-18 in the near future. Well 299-E24-18 serves as the upgradient monitoring well for the 216-A-10 Crib, whereas well 299-E25-31 serves this purpose for the 216-A-37-1 Crib. Both are sampled semiannually. Fifty-seven other wells are identified for far-field monitoring. PNNL-11523 contains as-built drawings of the 11 near-field wells and schematic diagrams of the 57 far-field wells. Groundwater monitoring wells and boreholes in the vicinity of the 216-A-10, 216-A-36B, and 216-A-37-1 Cribs are shown in Figures 3-9 and 3-10.

3.4.2.4 RCRA/CERCLA/Atomic Energy Act Groundwater Monitoring Results

The RCRA indicator parameters in the far-field wells are pH, specific conductivity, temperature, turbidity, and anions (including nitrate), along with site-specific parameters tritium and I-129. The near-field parameters include all of the far-field parameters plus phenols, inductively coupled plasma metals, gross alpha, gross beta, alkalinity, ammonium ion, arsenic, and Sr-90. The most extensive and significant contaminants are tritium, I-129, and nitrate. Monitoring results (including process knowledge and discharge records) indicate that the impact to groundwater also originates from other facilities as well as from the216-A-10, 216-A-36B, and 216-A-37-1 Cribs, but that the three cribs probably contributed the greatest share of contaminants to the groundwater.

The highest tritium concentrations in the 200 East Area continued to be found in wells near cribs that received effluent from the PUREX Plant. The maximum concentration detected was 4.3 million pCi/L in well 299-E17-9 next to the 216-A-36B Crib (PNNL-13788). Tritium concentrations that exceeded the 20,000 pCi/L drinking water standard continued to be found in many wells affected by cribs near the PUREX Plant. Tritium levels appear to be increasing in well 699-37-47A, near the southeastern corner of the 200 East Area, but the rise in tritium in this well probably is caused by the reduction in wastewater volume discharged in the vicinity of the 216-B-3 Pond. As the effects of the 216-B-3 Pond continue to diminish, groundwater near well 699-37-47A becomes more dominated by groundwater from the northwest, which has higher tritium concentrations. During 1999 and 2000, the concentration of tritium decreased temporarily to as low as 21,000 pCi/L, but in April 2001, it was back up to 30,100 pCi/L.

The widespread tritium plume extending from the southeastern portion of the 200 East Area to the Columbia River results primarily from two periods of PUREX Plant operations. Tritium contained in discharges from 1956 to 1972 and traveling at the average groundwater velocity has been observed near the Columbia River since the early 1970s. Tritium contained in discharges between 1983 and 1988 appears immediately downgradient from the 200 East Area. The concentrations are greater than 200,000 pCi/L, but are decreasing. The decrease is primarily attributed to radioactive decay and dispersion of the plume. Comparing the maximum concentrations of the two plumes observed at well 699-24-33 shows that the first plume contained concentrations three times the value of the second plume. Overall, the concentration of tritium in the groundwater is decreasing, but it is still above the 20,000 pCi/L drinking water standard.

The highest I-129 (drinking water standard of 1.0 pCi/L) concentrations observed in the 200 East Area in FY 2001 were near the PUREX Plant cribs. Concentrations of I-129 in groundwater

near the PUREX cribs generally are declining slowly or are stable. The maximum concentration of I-129, 9.8 pCi/L, was measured in a monitoring well associated with the 216-A-10 Crib (well 299-E24-16). The I-129 plume extends southeast into the 600 Area and appears to coincide with the tritium and nitrate plumes.

High nitrate (nitrogen in nitrate) concentrations continue to be found near the 216-A-36B Crib. The maximum nitrate concentration detected was 184 mg/L in well 299-E17-9. The extent of the nitrate plume that emanates from the 200 East Area is nearly identical to that of the tritium plume. However, the area with nitrate greater than 45 mg/L (the MCL) is considerably more restricted than the area with tritium above the drinking water standard (20,000 pCi/L).

One monitoring well near the 216-A-36B Crib (299-E17-14) had a concentration above the drinking water standard (8.0 pCi/L) for Sr-90 (a beta emitter) in FY 2001. The Sr-90 concentration measured 17.7 pCi/L. The impact is very localized because of the lower mobility of Sr-90 compared to I-129, nitrate, and tritium. Strontium-90 was detected at levels below the drinking water standard at five other wells near the 216-A-10 and 216-A-36B Cribs during FY 2001. The concentrations have remained stable since 1994, with the exception of well 299-E24-16 (near the 216-A-10 Crib), where it has been increasing since 1997.

3.5 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT

This section presents and discusses the conceptual exposure model developed to identify potential impacts to human health and the environment from waste sites in the 200-PW-2 and 200-PW-4 OUs. Existing information pertaining to contaminant sources, release mechanisms, transport media, exposure routes, and receptors is discussed to develop a preliminary conceptual understanding of potential risks and exposure pathways. This information will be used to support further evaluation of potential human health and environmental risk based on the RI results as part of the RI and FS documents for the 200-PW-2 and 200-PW-4 OUs (discussed in more detail in Chapter 5.0).

3.5.1 Contaminant Sources and Release Mechanisms

The primary sources of contamination at waste sites in these OUs were major facilities (e.g., U Plant, REDOX, PUREX, B Plant, Hot Semiworks Facility) in the 200 East and 200 West Areas. Effluents related to the plutonium production, uranium recovery, and encapsulation processes in these facilities were routinely discharged to cribs and trenches where the wastewater infiltrated into the soil. Unplanned releases of contaminants also occurred.

Releases to the environment from primary sources have resulted in secondary contaminant sources such as the contaminated soils beneath the stabilized waste sites and unplanned release sites in this OU. Secondary releases can occur through infiltration (continued movement of wastewater through the soil), resuspension of contaminated soil (erosion or mechanical disturbances), volatilization (movement of organic chemicals through the soil and into the air), biotic uptake (plant uptake or animal ingestion), leaching (contaminant release from rain or snowmelt exposure), and external radiation (gamma). The dominant mechanism of 200-PW-2

and 200-PW-4 OU contaminant transport is from infiltration and leaching, with rainwater or snowmelt as driving forces. Residual effluent contamination at the waste sites has the potential to impact groundwater.

3.5.2 Potential Receptors

Potential receptors (i.e., human and ecological) may be exposed to the affected media through several exposure pathways, including the following:

- Ingestion of contaminated soils, sediments, or biota
- Inhalation of contaminant dusts, vapors, or gases
- Dermal contact with contaminated soils or sediments
- Direct exposure to external gamma radiation in site soils and sediments.

Potential human receptors include site workers (current and future) and site visitors (occasional users). Site worker and visitor exposure pathways primarily would involve incidental soil/sediment ingestion, inhalation of contaminants, dermal contact with contaminated soils/sediments, and external gamma radiation. Potential ecological receptors include terrestrial plants and animals using the sites. More details on these specific receptors are presented in Section 3.5.3. Site biota exposures primarily would involve incidental soil/sediment ingestion, biota ingestion (e.g., coyotes eating prey that live on the site or deer consuming plants growing on the site), dermal contact with contaminated soils/sediments, and external gamma radiation. The conceptual exposure model for the 200-PW-2 and 200-PW-4 OUs is shown in Figure 3-19.

3.5.3 Potential Impacts

This section discusses potential impacts to human and ecological receptors based on existing information. Potential contaminant exposures and health impacts to humans are largely dependent on land use. The land use for the 200 Areas selected by DOE through the *National Environmental Policy Act of 1969* process (DOE/EIS-0222-F) and documented in a record of decision (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS),") is industrial (exclusive). Outside the 200 Areas boundary, the selected land use is conservation (mining). The 200-PW-2 and 200-PW-4 OU waste sites are located within the 200 Areas industrial (exclusive) land-use boundary. Therefore, based on the land-use decision for the 200 Areas, potential impacts from the waste site contaminants within the 200 Areas would be to current and future site workers and to terrestrial biota using the sites.

Identification of ecological receptors and potential impacts to those receptors have been evaluated previously at waste sites within the 200 Areas (PNNL-13910, Appendix 2; PNL-2253, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*; WHC-SD-EN-TI-216, *Vegetation Communities Associated with the 100 Area and the 200 Area Facilities on the Hanford Site*). The vegetation cover within the 200 Areas Plateau is dominantly a rabbitbrush/ cheatgrass and sagebrush/cheatgrass association with incidence of herbaceous and annual species. Many areas are disturbed and nonvegetated or sparsely vegetated with annuals and weedy species such as Russian thistle. The contamination pathway to ecological exposures for the waste sites are minimized because of stabilization activities that have been conducted.

DOE/RL-2001-54 presents a more recent evaluation of habitats on the Central Plateau and provides a screening-level risk assessment, including an evaluation of threatened and endangered and new-to-science species that may be associated with the Central Plateau.

3.5.3.1 Human Health Risk

A qualitative risk assessment (QRA) was performed as part of the 200-UP-2 OU LFI (216-U-8 and 216-U-12 Cribs) to evaluate potential human health risks to workers under an industrial scenario. The QRA followed the methodology in DOE/RL-91-45, Rev. 3, *Hanford Site Risk Assessment Methodology*. Maximum concentrations of COCs were used to evaluate worker risk associated with contaminated soils from 0 to 4.6 m (0 to 15 ft) bgs. This zone provided a reasonable estimate of the depth of soil that could be excavated and distributed at the ground surface as a result of site development activities (i.e., laying a pipeline). Contaminants initially were screened against natural background, then against risk-based screening concentrations identified as described in DOE/RL-91-45, Rev. 3). Contaminants that were not screened out in this process were evaluated in the exposure assessment, toxicity assessment, and risk characterization elements of the QRA. Uncertainties also were evaluated. The relatively high uncertainties generally biased the evaluation to overestimate the risks. The results of the risk evaluation are presented in Table 3-6.

3.5.3.2 Ecological Risk

In addition to the human health risk evaluation, an ecological risk evaluation was conducted during the 200-UP-2 OU LFI (DOE/RL-95-13). The objective of the ecological risk evaluation was to assess potential risk to ecological receptors by (1) estimating potential risks to the Great Basin pocket mouse from exposure to waste site contaminants through the use of exposure models and (2) evaluating biological monitoring data collected in the 200-UP-2 OU area. Uptake of contaminants from soil by vegetation was considered the primary source of contaminant entry to the food chain. Contaminants of potential ecological concern were identified for zones from 0 to 2 m (0 to 6 ft) and from 2 to 4.6 m (6 to 15 ft). Exposure pathways included ingestion of contaminated plant material, inhalation, and direct exposure to radioactive contaminants.

The evaluation was conducted based on biological monitoring data (WHC-MR-0418) and modeling results, using relative risks to evaluate the sites. Plants collected from the 216-U-8 Crib during the 200-UP-2 OU LFI were analyzed for both radionuclides and metals. Modeling concentrations of metals as measured in plants inside a mouse resulted in an environmental hazard quotient (EHQ) >1 for aluminum (EHQ = 5,030), antimony (EHQ = 52.3), barium (EHQ = 7.66), copper (EHQ = 18.7), manganese (EHQ = 21.7), and vanadium (EHQ = 5.96). Estimating the radiation dose to the mouse following ingestion of plant matter revealed that exposure to the maximum activity concentration in plants from the site resulted in a total dose rate of 1.57 rad/day. Strontium-90 alone contributed approximately 99 percent of the total dose rate. Exposure of the mouse to radionuclides in the soil resulted in an estimated total dose at the 0- to 2.0-m (0- to 6-ft) interval and at the greater than 2- to 4.5-m (6- to 15-ft) interval to be less than 1 rad/day. Modeling results indicated that no chemicals of potential ecological concern were detected in soils from this site as having an EHQ >1. The ecological risk associated with the 216-U-8 Crib and the 216-U-8 VCP was considered medium to high.

The area around the 216-U-8 Crib and along the 216-U-8 VCP was surface stabilized following completion of the LFI activities, to minimize future risk at the surface.

In a similar manner, modeling the radiation dose to the mouse following ingestion of plant matter from the 216-U-12 Crib revealed that exposure to the maximum activity concentration in plants from the site resulted in a total internal dose rate of less than 1 rad/day. No nonradioactive chemicals were found to be contaminants of ecological concern in soil at this site. The mouse is therefore not expected to be exposed to hazardous concentrations of nonradioactive chemicals at this site, as determined through the evaluation of soil concentrations. Exposure of the mouse to radionuclides of potential ecological concern at this site did not result in a radiation dose greater than 1 rad/day. The ecological risk associated with the 216-U-12 Crib was estimated to be low.

Although not part of the 200-PW-2 or 200-PW-4 OUs, data obtained during the 200-UP-2 OU LFI for the 216-U-10 Pond and the 216-U-11 Ditch also can be considered indicative of conditions in the area. At these two sites, chemicals and radionuclides were modeled from soil to the ecological receptors to estimate potential impacts on biota at these locations.
No chemicals at a soil depth of 0 to 1.9 m (0 to 6 ft) were predicted to be potentially hazardous to the mouse. Barium, copper, and zinc were found to have EHQs >1 for soil depths from 2 to 4.5 m (6 to 15 ft). No radionuclides were found to result in a dose of greater than 1 rad/day to the mouse.

Modeling maximum concentrations measured in plants resulted in an EHQ >1 for barium, copper, and vanadium. A total internal dose rate less than 1 rad/day to the mouse was estimated from ingestion of the maximum activity measured in plant matter. Data collected from mice living adjacent to the 216-U-10 Pond from 1975 to 1977 (during operation) showed the highest exposure rate of 1.47 roentgens (R)/week or 0.21 R/day to the pocket mouse (PNL-2479, *Analysis of Small Mammal Populations Inhabiting the Environs of a Low-Level Radioactive Waste Pond*). Soil data also were collected along the same sampling transects for the mice. Results showed the highest gamma exposure of 37 mrad/yr or 0.1 mrad/day and neutron exposure of 75 R/yr or 0.2 R/day from soils 0 to 1 dm below the surface. Based on the risk modeling conducted for the 200-UP-2 OU LFI, the ecological risk associated with the 216-U-10 Pond and the 216-U-11 Ditch was considered medium, the neighboring 216-Z-11 Ditch was considered low to medium, and the 216-U-14 Ditch was considered low.

3.5.3.3 Summary

Soil characterization data previously collected, and information to be obtained from the proposed borehole sampling to be conducted at representative waste sites as part of this work plan, will be sufficient to address potential impacts to human health.

Based on the ecological data collected from previous investigations (e.g., 200-UP-2 LFI) and surveys (e.g., annual near-facility environmental surveys), no additional OU-specific ecological data are considered necessary to address potential impacts to the environment at this time.
A screening-level ecological risk assessment for the Central Plateau waste sites was completed in 2002. Based on the results of the screening-level ecological risk assessment, the full EPA 8-step ecological risk assessment process was initiated in 2003. DOE expects to complete the ecological risk assessment in conjunction with the ongoing RI/FS processes for the 200 Areas. The ecological risk assessment process may identify additional needs. Those needs could

include soil sampling and analysis, biological studies (including sampling and analysis), or other studies. Any data needs may apply to one or more OUs. If they apply to this OU, they will be integrated with the RI/FS.

3.6 DEVELOPMENT OF CONTAMINANTS OF CONCERN

The development of the list of COPCs and refinement to the list of COCs for these OUs were main objectives of the DQO processes conducted. The preliminary list of COPCs for these OUs included the complete set of contaminants that were potentially discharged to this waste group from facilities discussed in Section 2.2. This master list of COPCs was generated by process information gathered and evaluated against a set of exclusion criteria and past sampling/characterization events to enable the development of a final COC list. Chemical characteristics such as toxicity, persistence, and chemical behavior in the environment were considered. The criteria for exclusion of certain constituents, as detailed in the DQO reports (BHI-01411, *Remedial Investigation DQO Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit*; CP-14176, *Remedial Investigation DQO Summary Report for the 200-PW-4 General Process Condensate and Process Waste Group Operable Unit*) are as follows:

- Short-lived radionuclides with half-lives less than 3 years
- Radionuclides that constitute less than 1 percent of the fission product inventory and for which historical sampling indicates nondetection
- Naturally occurring isotopes that were not created as a result of Hanford Site operations
- Constituents with atomic mass numbers greater than 242 that represent less than 1 percent of the actinide activities
- Progeny radionuclides that build insignificant activities within 50 years and/or for which parent/progeny relationships exist that permit progeny estimation
- Constituents that would be neutralized and/or decomposed by facility processes
- Chemicals in a gaseous state that cannot accumulate in soil media
- Chemicals used in minor quantities relative to the bulk production chemicals consumed in the normal processes; these chemicals are not likely to be present in toxic or high concentrations
- Chemicals that are not persistent in the environment because of volatilization, biological degradation, or other natural mitigating features
- Chemicals that are not persistent in the vadose zone because of high mobility and previous confirmatory sampling/analysis activities

- Chemical substances that are not found on the Ecology 94-145, *Model Toxics Control Act Cleanup Levels & Risk Calculations (CLARC Version 3.1)*, tables (November 2001) and that therefore are not regulated by WAC 173-340, "Model Toxics Control Act - Cleanup."

The exclusion process resulted in a final list of COCs for each the 200-PW-2 and the 200-PW-4 OUs. The COC final listings for each OU are presented in Tables 3-7 and 3-8, respectively. The preliminary list of COPCs, the excluded analytes, and the rationale for exclusion for the 200-PW-2 and 200-PW-4 OUs are presented in the RI DQO summary reports, BHI-01411 and CP-14176, respectively. The exclusion rationale for the investigation-derived waste DQO (CP-14682, *Data Quality Objectives Summary Report for the Designation of the 200-PW-2 and 200-PW-4 Investigation Derived Wastes*) differed somewhat from those used in the RI DQOs, resulting in a different list of COCs for waste designation purposes. Additional information regarding the COPCs is presented in the RI and investigation-derived waste DQO summary reports (BHI-01411, CP-14176, and CP-14682) and Chapter 4.0 of this document.

Figure 3-1. 216-A-19 Trench Borehole Location Map.

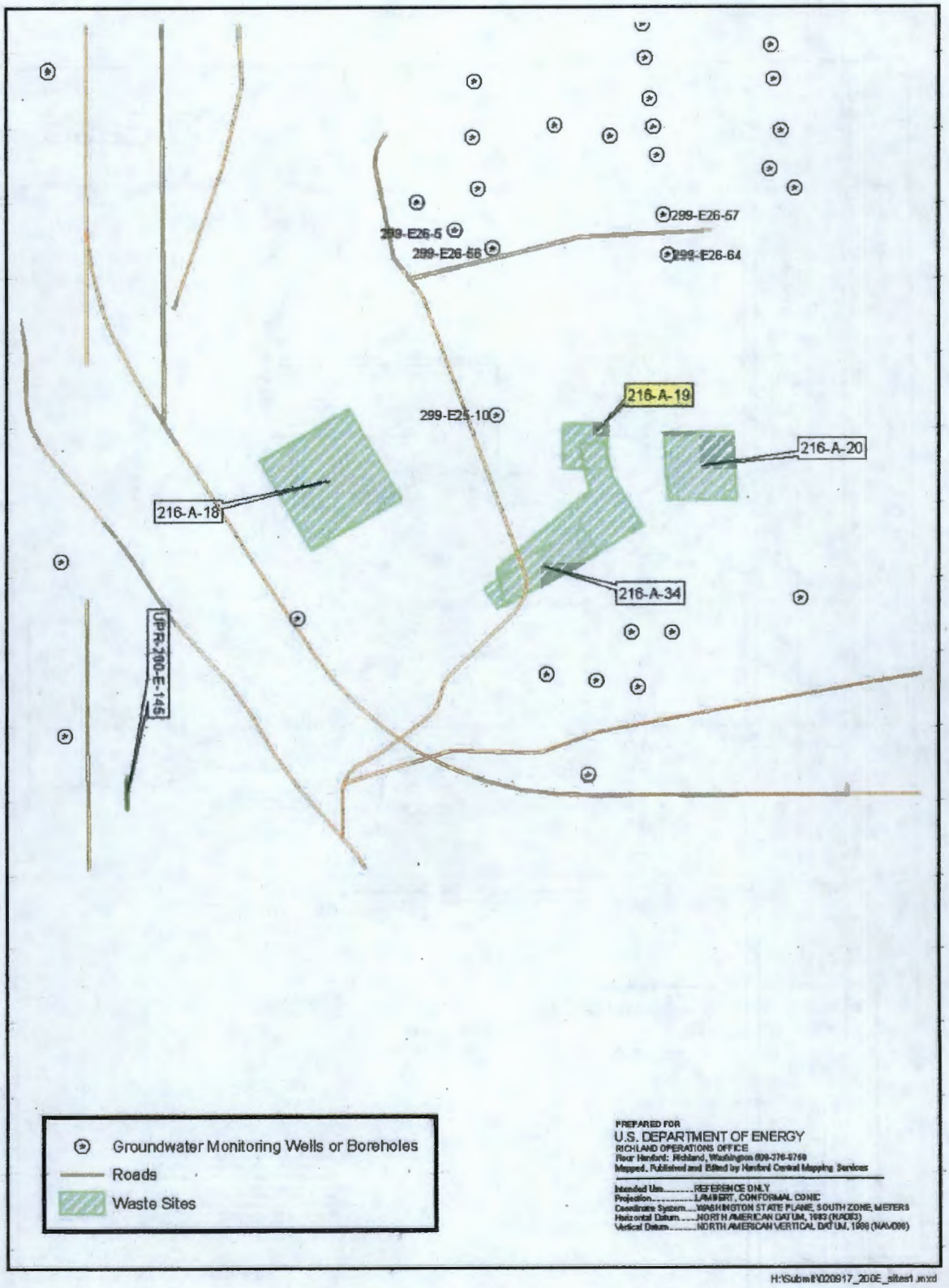

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Figure 3-2. Major Nonradiological Groundwater Plumes in the Vicinity of the 200 East Area (Modified from PNNL-13788).

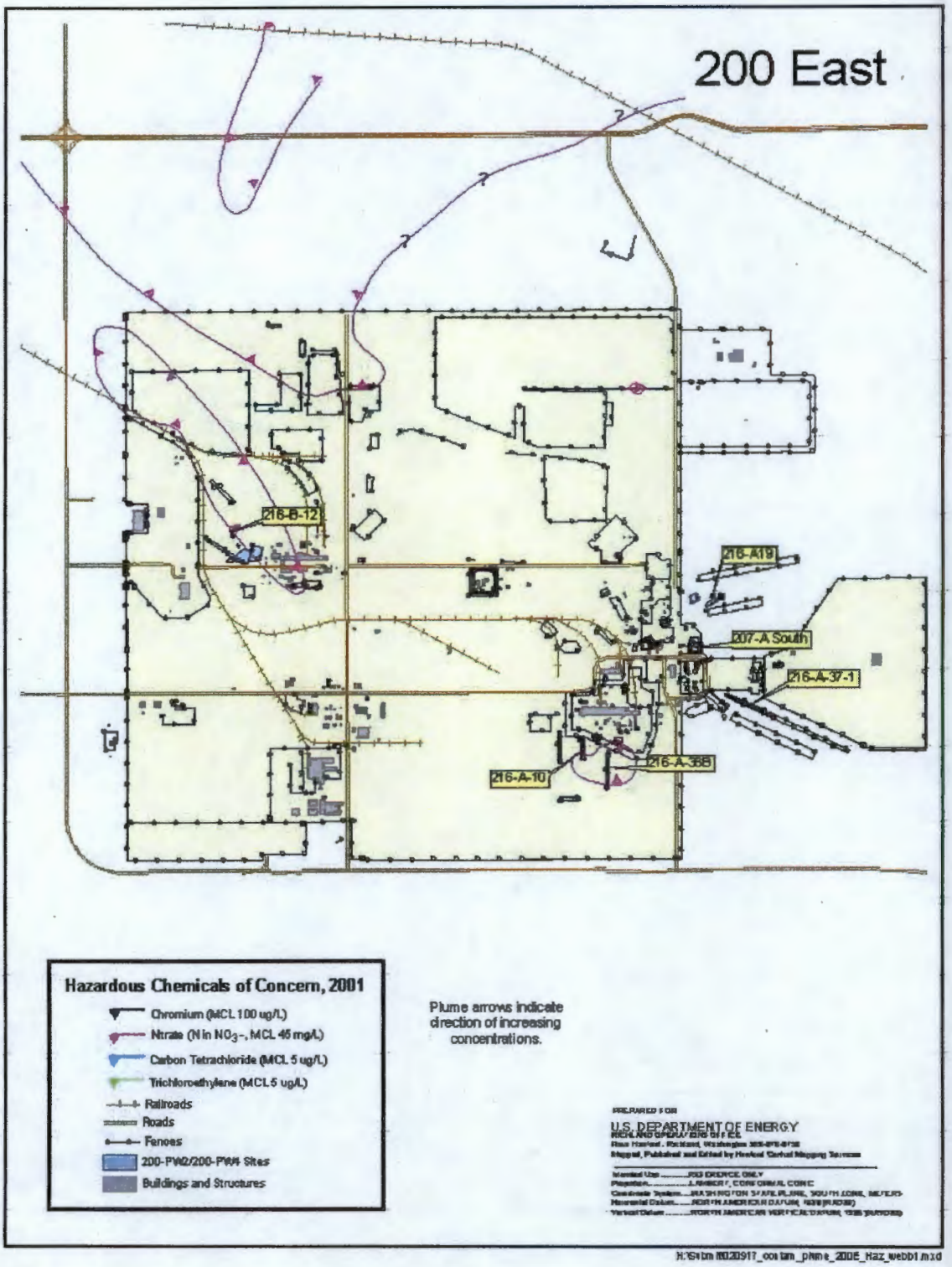

Figure 3-3. Major Radiological Groundwater Plumes in the Vicinity of the 200 East Area (Modified from PNNL-13788).

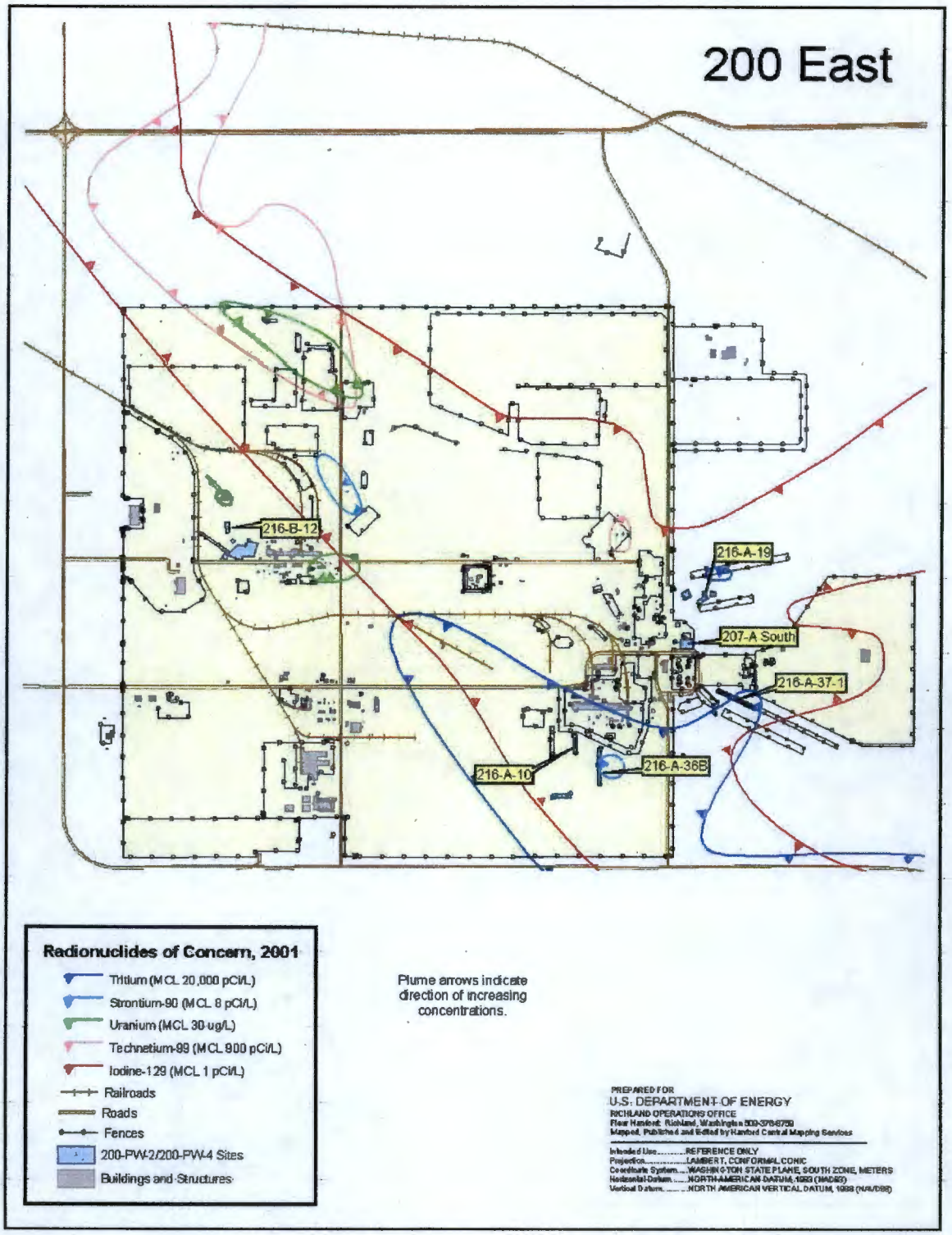

Figure 3-4. 216-B-12 Crib Borehole Location Map.

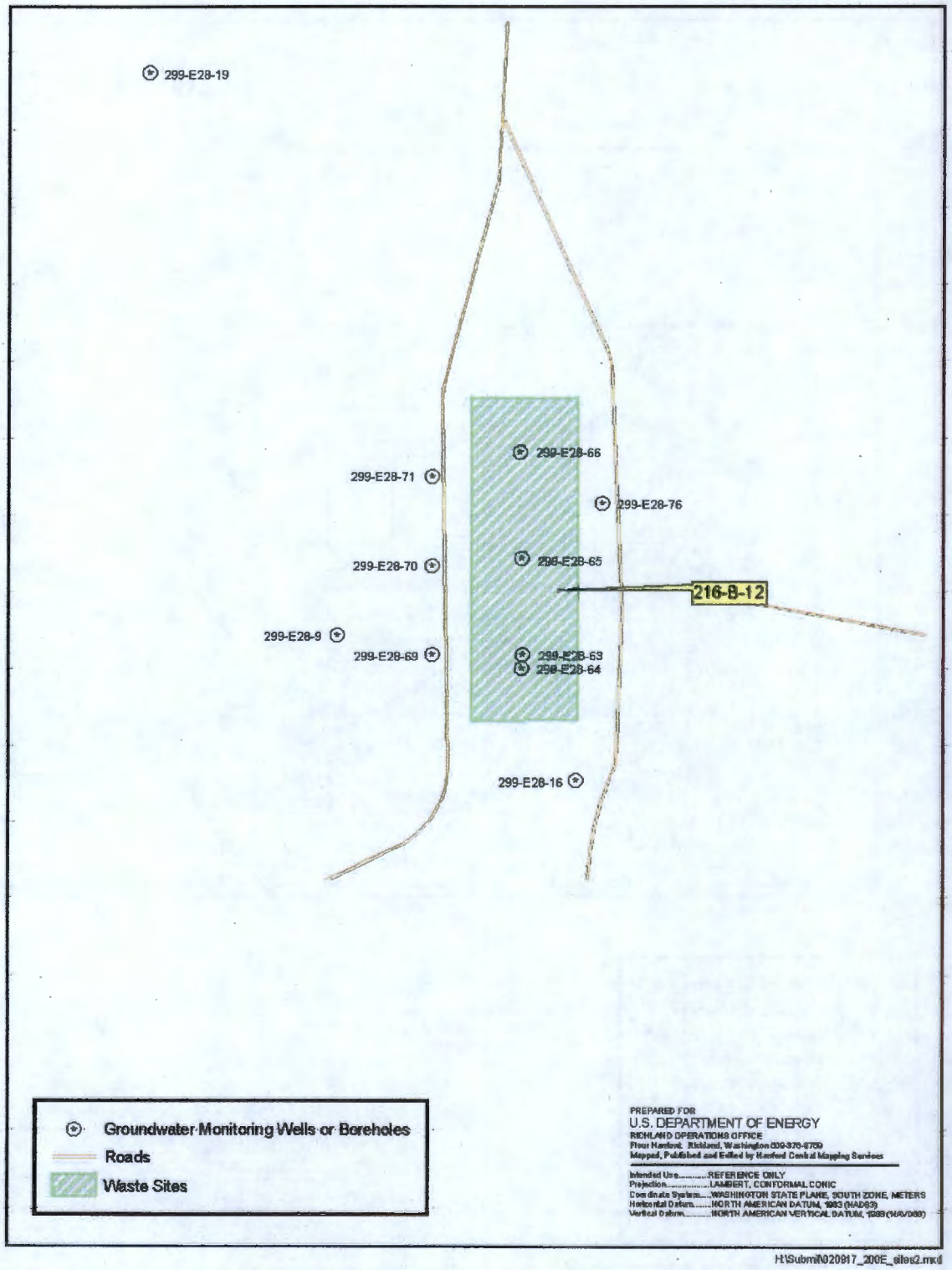

Figure 3-5. 216-U-8 Crib and 216-U-12 Crib Borehole Location Map.

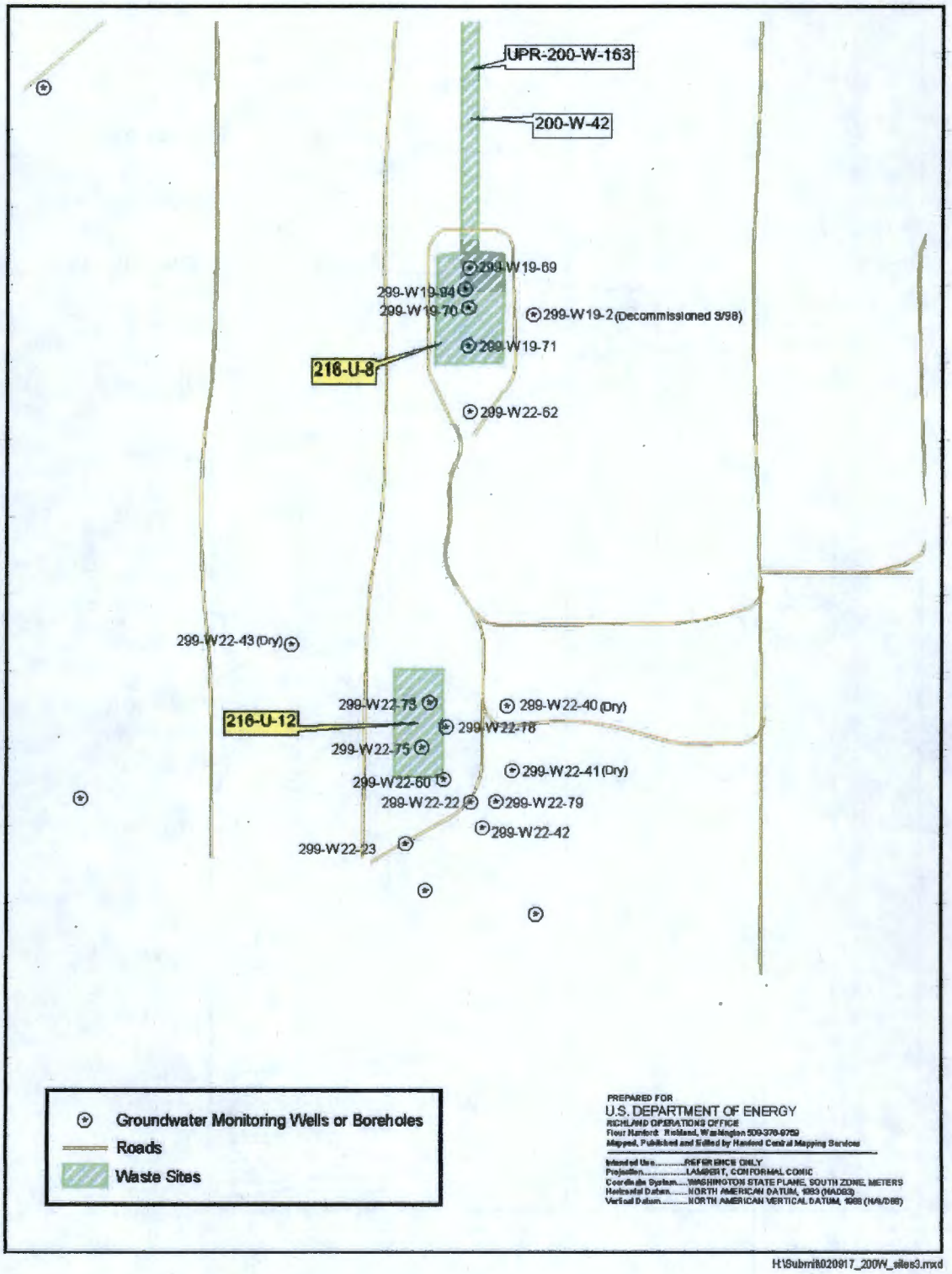

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Figure 3-6. Uranium Concentrations in Groundwater at Well 299-W19-2.

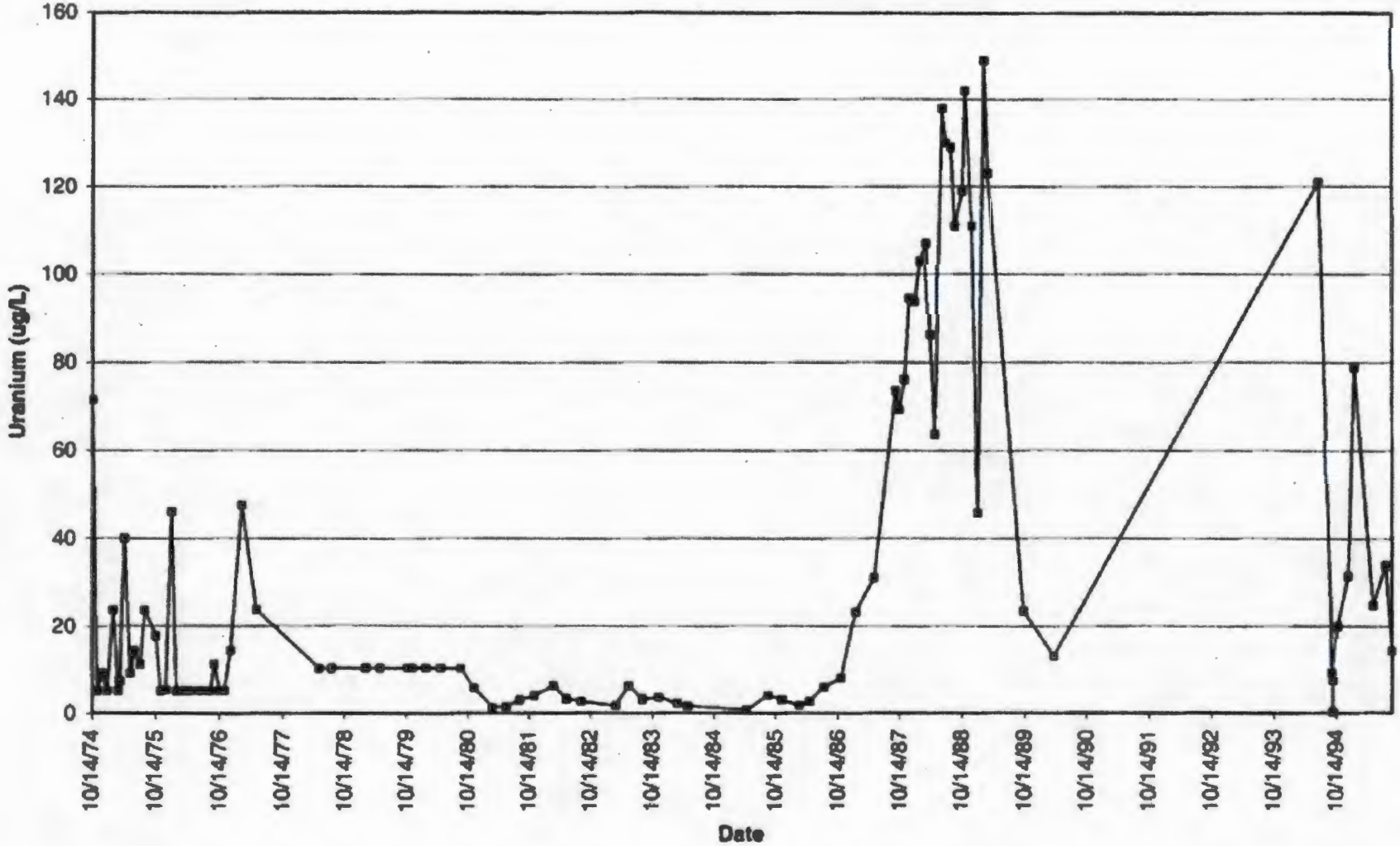


Figure 3-7. Major Nonradiological Groundwater Plumes in the Vicinity of the 200 West Area (Modified from PNNL-13788).

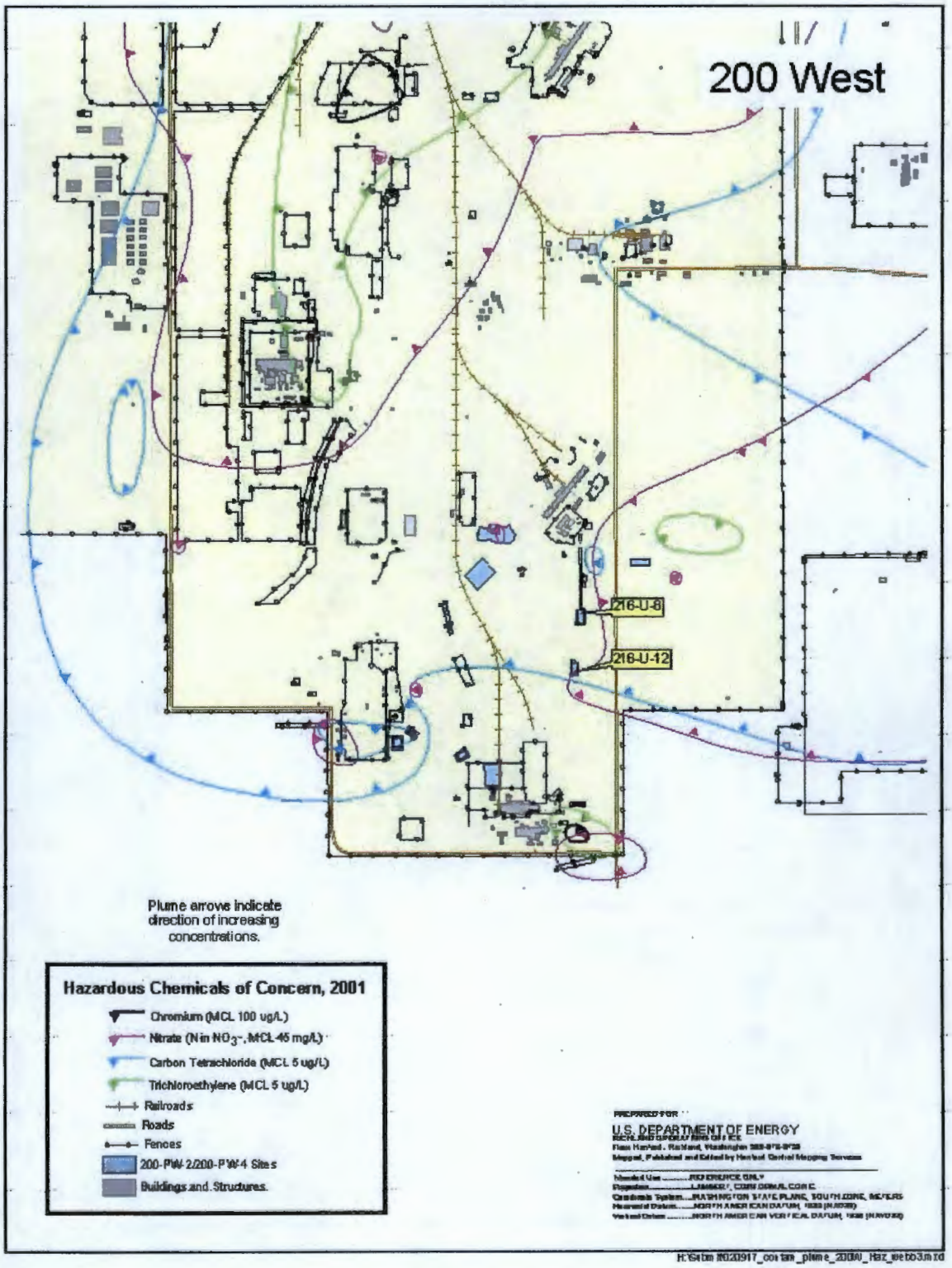


Figure 3-8. Major Radiological Groundwater Plumes in the 200 West Area (Modified from PNNL-13788).

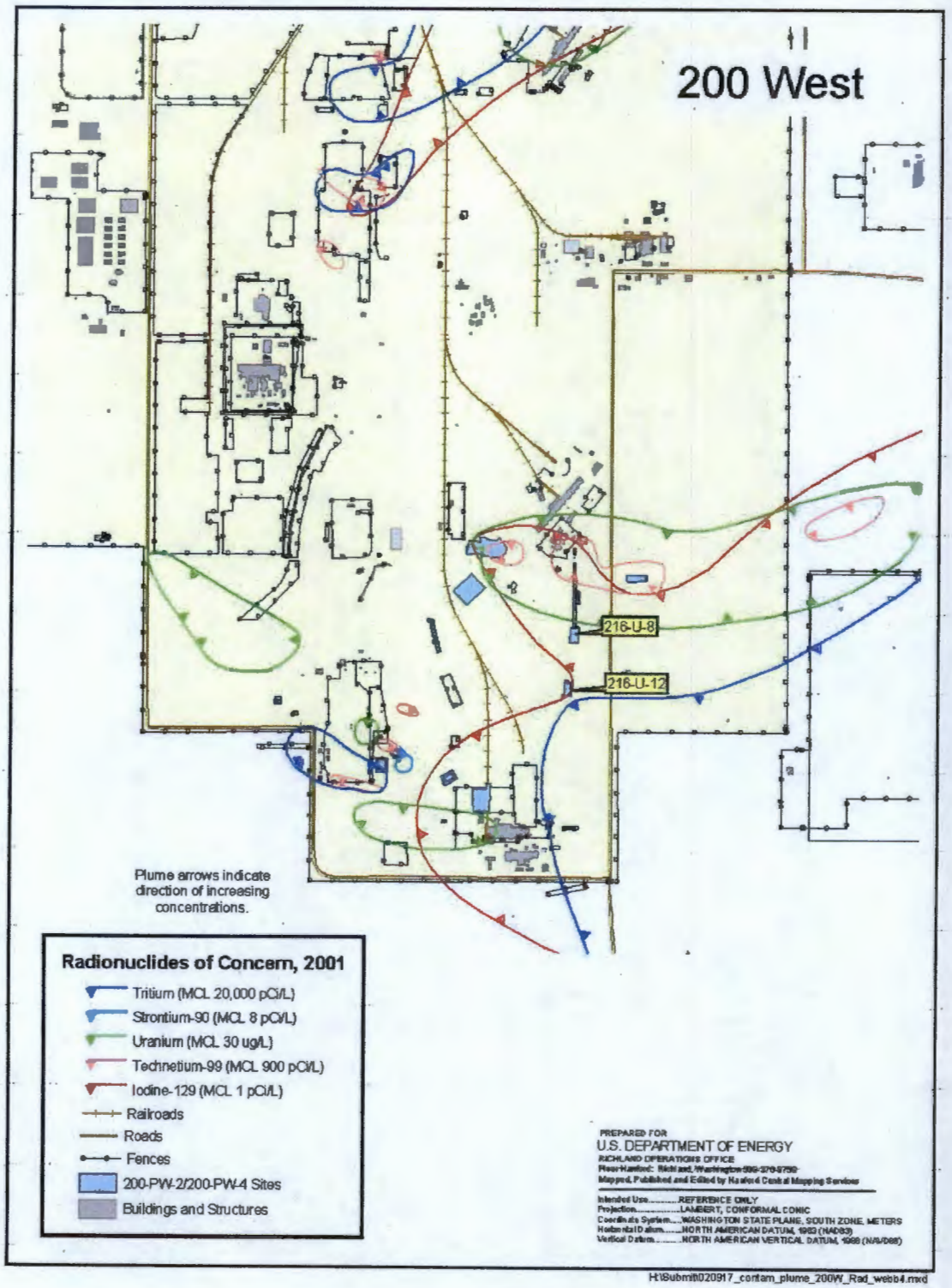


Figure 3-9. 216-A-10 Crib and 216-A-36B Crib Borehole Location Map.

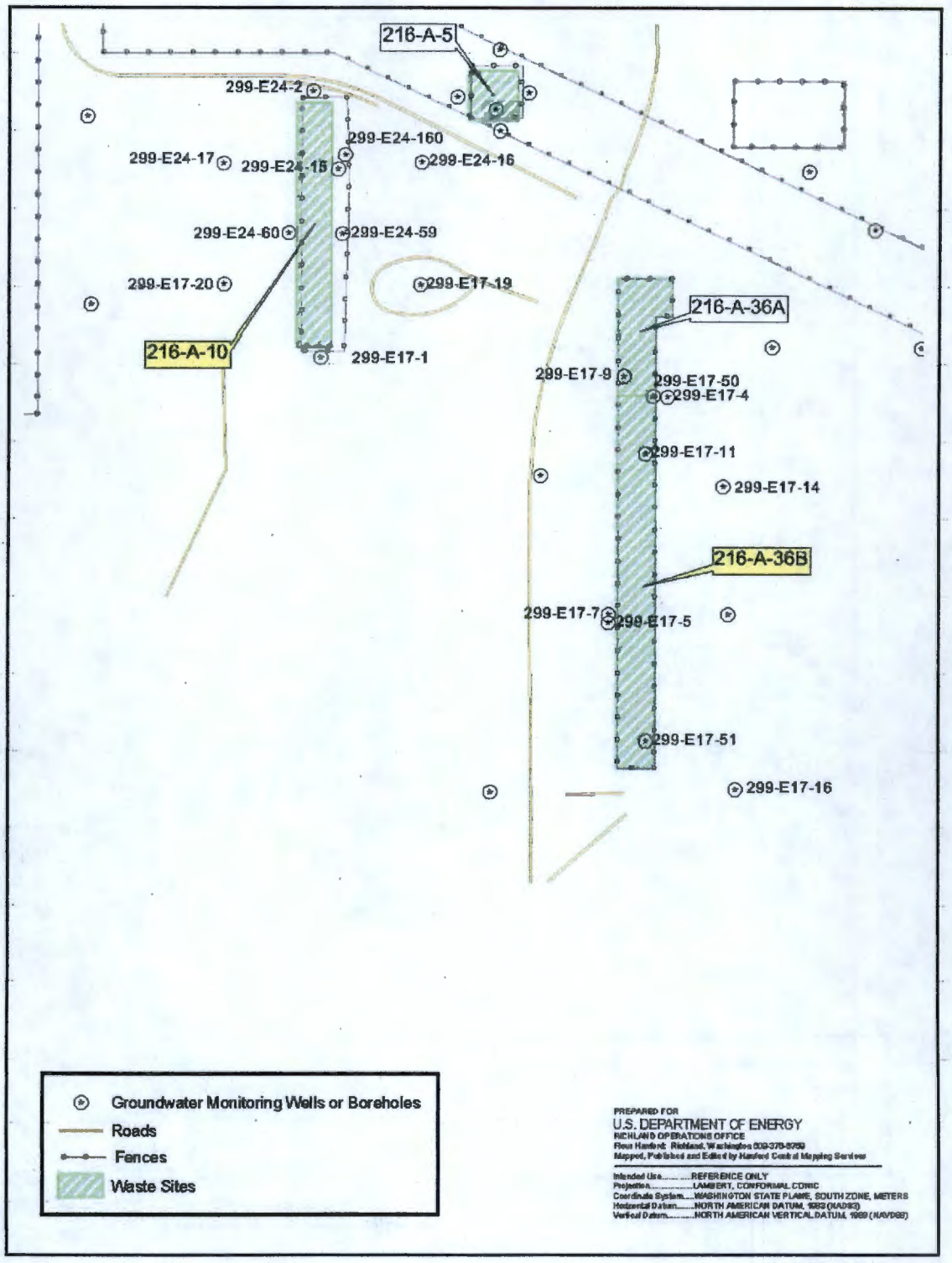


Figure 3-10. 207-A South Retention Basin and 216-A-37-1 Crib Borehole Location Map.

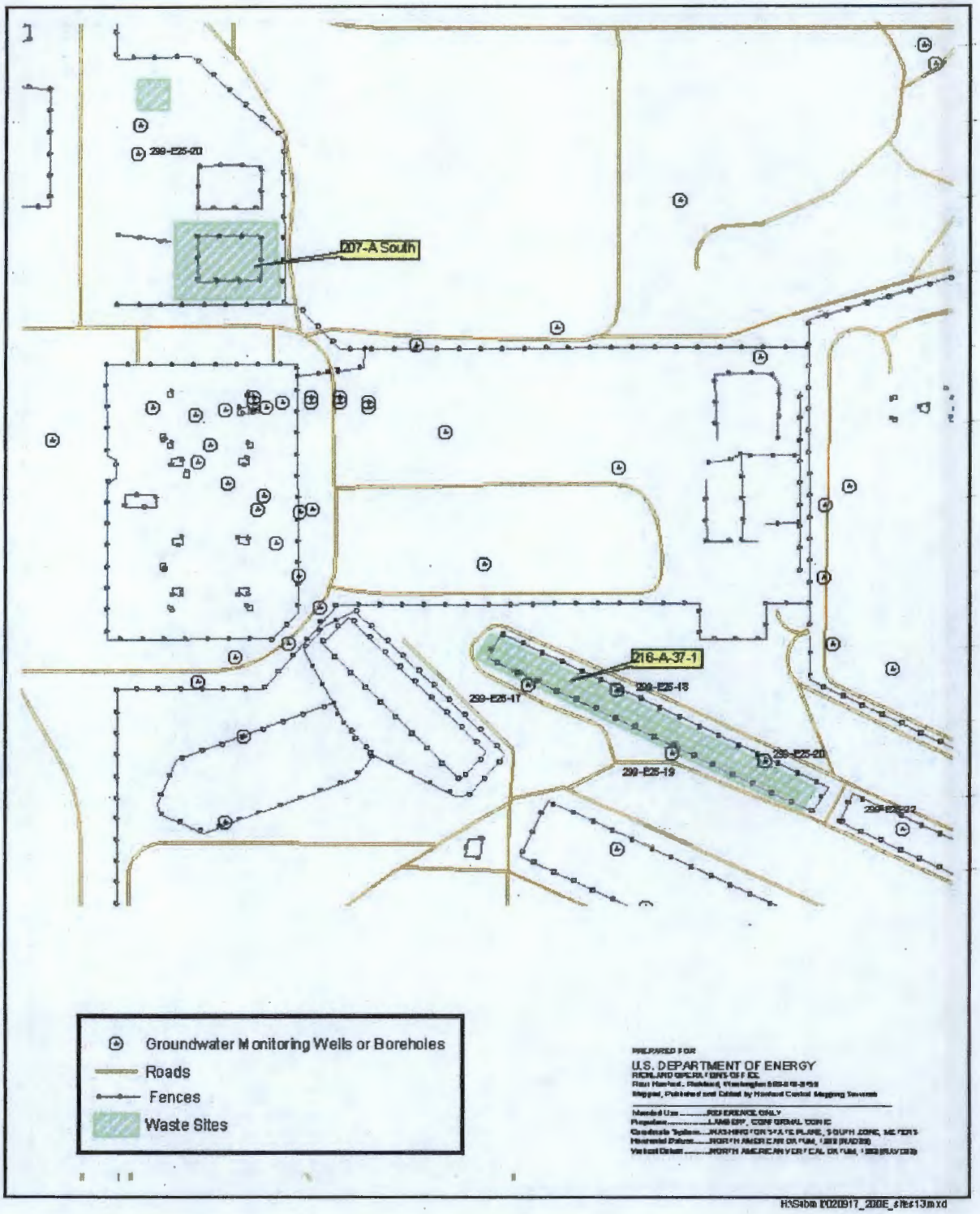
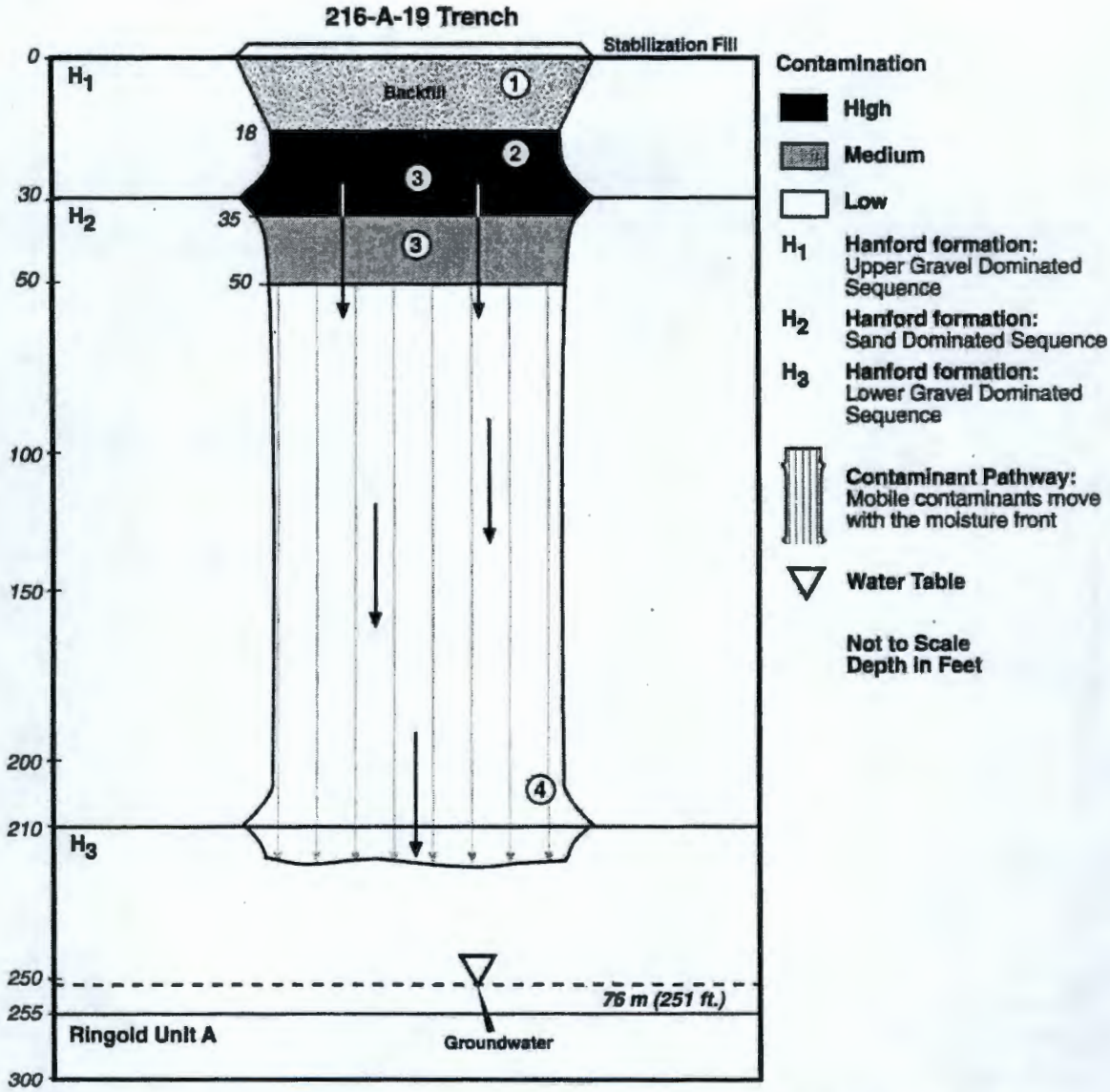


Figure 3-11. 216-A-19 Trench Conceptual Contaminant Distribution Model.



① Uranium rich process wastes were discharged to the 216-A-19 Trench between November 1955 and January 1956. The open trench received a total volume of 1.1×10^6 liters (291,000 gallons) of wastewater via a temporary overland pipe. The effluent contained uranium, cesium-137, plutonium, strontium-90, and nitrate. The trench was backfilled with native material after operations ceased. The site was stabilized with an additional 0.6 m (2 ft) of clean fill in 1990.

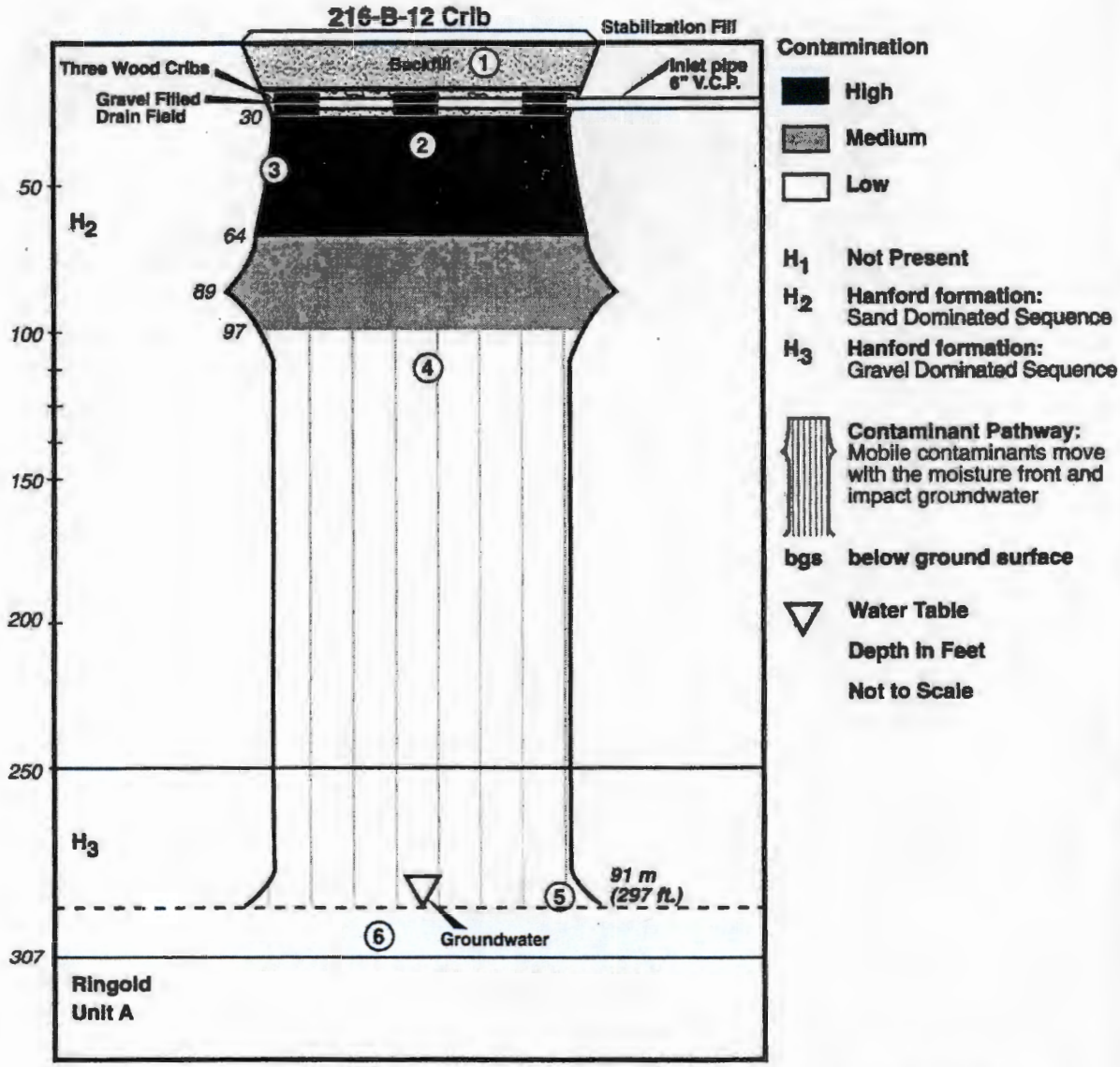
② Effluent and contaminants were released into H1. The wetting front and contaminants moved vertically down beneath the crib. There is little or no lateral spreading as evidenced by the lack of contamination in borehole 299-E25-10 which is located 18 m (60 ft) west of the trench.

③ Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the trench. The highest concentrations are expected near the bottom of the trench. Contaminants that are moderately mobile, such as strontium-90 and uranium, are present deeper in the vadose zone. The most mobile contaminants, such as nitrate, move with the moisture front. Contaminant data have not been collected within the waste site boundary.

④ Wastewater and contaminants may not have significantly impacted groundwater as the effluent volume discharged to the soil column (1,100 m^3) does not exceed the soil pore volume (1,232 m^3).

E0006137.2

Figure 3-12. 216-B-12 Crib Conceptual Contaminant Distribution Model.



① Uranium rich process wastes were discharged to the 216-B-12 Crib between 1952 and 1973. The crib received a total volume of 5.2×10^8 L (1.4×10^8 gal) of waste water.

② Effluent and contaminants were released to the environment at the bottom of the wooden structures into the H_2.

③ The wetting front and contaminants moved vertically down beneath the crib. There is little or no lateral spreading.

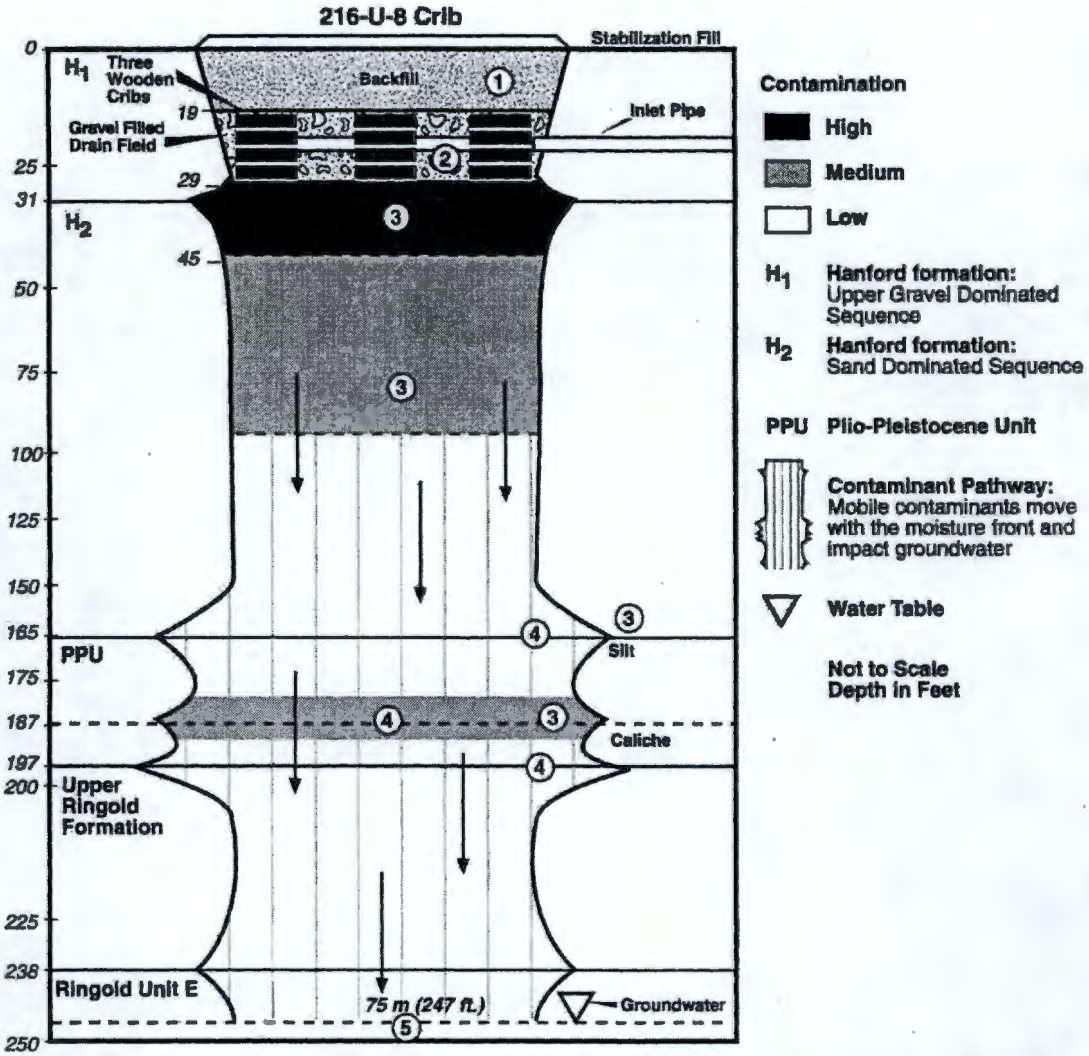
④ Contaminants with large contaminant distribution coefficients, such as cesium-137, sorb to soils with the highest concentrations within 34 ft. of the crib bottom. Contaminant concentration generally decreases with depth. Contaminants with moderate contaminant distribution coefficients, such as cobalt-60, are present throughout the vadose zone. Contaminants with contaminant distribution coefficients of 0 move with the moisture front and are present in trace amounts throughout the vadose zone.

⑤ If lateral spreading occurs within the vadose zone, it is associated with fine grained lenses within the H_2 and H_3.

⑥ Waste water and contaminants with moderate to very low distribution coefficients impacted groundwater since the effluent volume discharged to the soil column (520,000 m^3) is greater than the soil pore volume (18,300 m^3).

E0007007.1

Figure 3-13. 216-U-8 Crib Conceptual Contaminant Distribution Model.



(1) Uranium rich process wastes were discharged to the 216-U-8 Crib between 1952 and 1960. The wooden crib structures received a total volume of 3.7×10^8 liters (1.0×10^8 gallons) of wastewater. The effluent contained uranium, cesium-137, plutonium, strontium-90, and nitric acid. The crib was stabilized with 0.3-0.6 m (1-2 ft) of clean fill in 1994. The pipeline leading to the crib was known to have leaked contamination into near-surface soils.

(2) Effluent and contaminants were released to the environment at the bottom of the wooden structure near the contact between H1 and H2. The wetting front and contaminants moved vertically down beneath the crib. There is little or no lateral spreading. (Low levels (<1 pCi/g) of cesium-137 contamination were intermittently detected in borehole 299-W19-2 approximately 15.2 m (50 ft) east of the waste site).

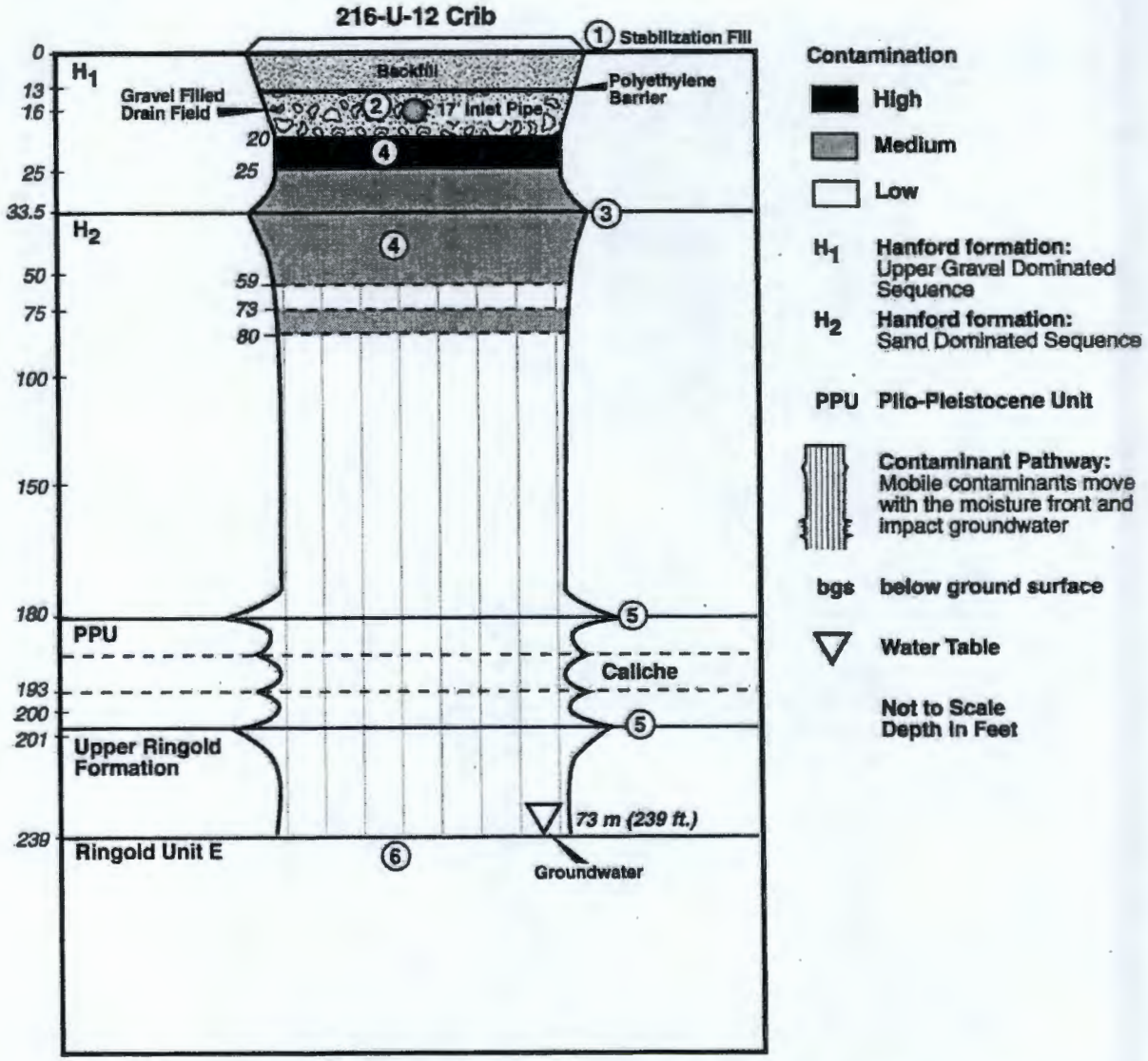
(3) The zone of greatest contamination is detected from the bottom of the crib to a depth of 12.8 m (42 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the trench. Cesium-137 concentrations are highest at depths less than 12.8 (42 ft); they decreased with depth to 30.5 m (100 ft) where they become undetectable. Contaminants that are moderately mobile, such as strontium-90 and uranium, are present deeper in the vadose zone. Uranium-238 concentrations were highest at the base of the crib and at a depth of 56.4 m (185 ft). Strontium-90 was detected in the vadose zone to a depth of at least 61 m (199 ft). The maximum concentration was detected at the interface between H2 and the PPU at 50.3 m (165 ft). The most mobile contaminants, such as nitrate, move with the moisture front and are present in trace amounts in the vadose zone.

(4) If significant lateral spreading occurs within the vadose zone, it is associated with the upper Ringold Formation and the Plio-Pleistocene Unit.

(5) Wastewater and mobile contaminants impacted groundwater since the effluent volume discharged to the soil column (380,000 m^3) is greater than the soil pore volume (11,100 m^3) as evidenced by the uranium, tritium, and nitrate in downgradient well 299-W19-2.

E0006137.3

Figure 3-14. 216-U-12 Crib Conceptual Contaminant Distribution Model.



1. Uranium rich process wastes (pH≤1) were discharged to the 216-U-12 Crib between 1960 and 1988. The crib received a total of 1.5×10^6 liters (4.0×10^7 gal) of waste water.

2. Effluent and contaminants were released to the environment from a vitrified clay pipe approximately 17' bgs within a gravel filled drain field.

3. The wetting front and contaminants moved vertically down beneath the crib. There is little or no lateral spreading.

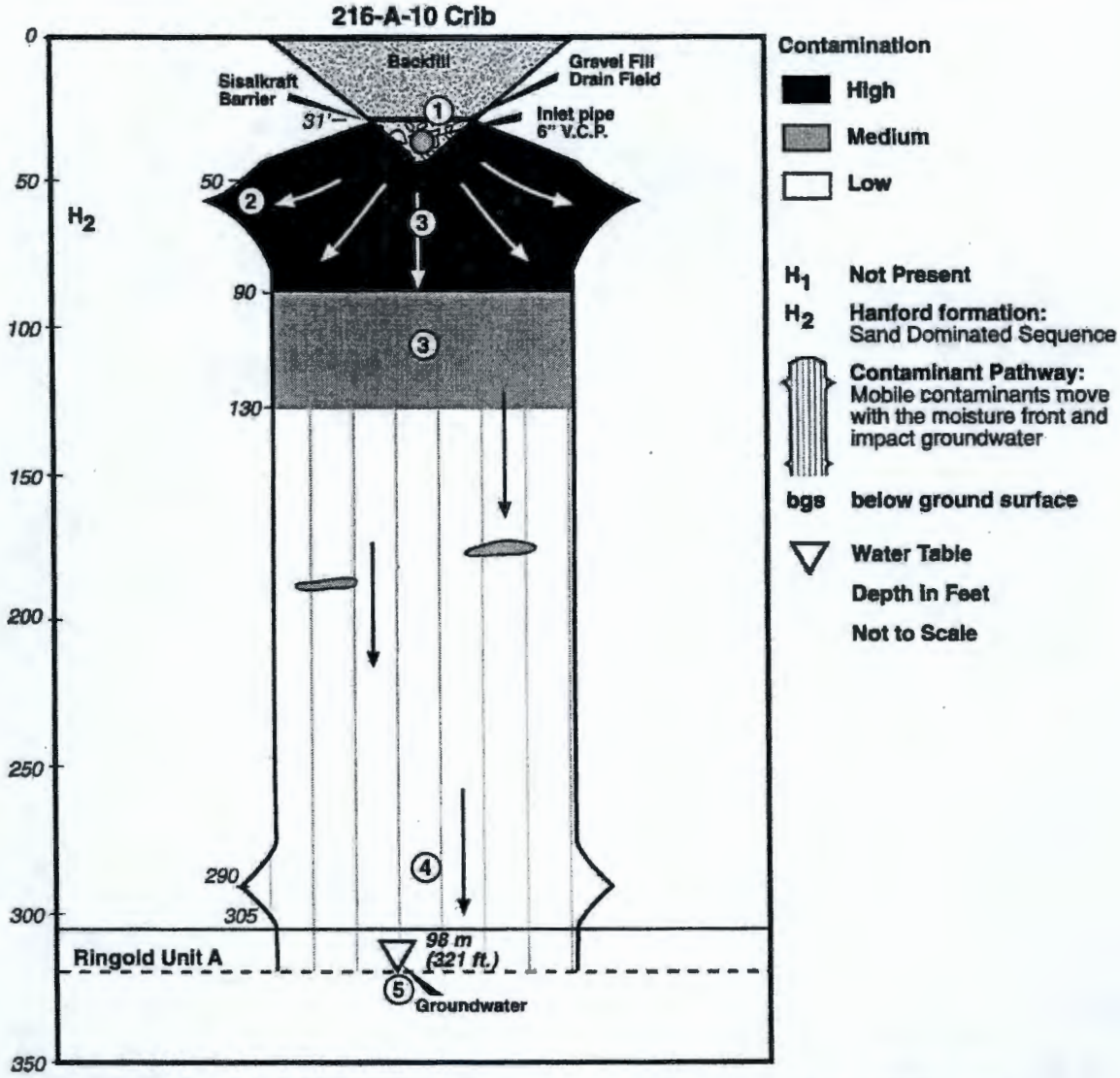
4. Contaminants such as cesium-137 have large contaminant distribution coefficients and sorb to soils with higher concentrations within 5 feet of the bottom of the crib. Cesium-137 concentrations generally decrease with depth and were not detected greater than 59 ft bgs. Uranium, which can have small to moderate contaminant distribution coefficients was the only other contaminant detected beneath the crib. It is present to a depth of 80 ft and contaminant concentration generally increase with depth. The 216-U-12 crib is considered analogous to the 216-U-8 Crib, and therefore uranium may be present associated with the Plio-Pleistocene Unit (caliche layer) and may be distributed throughout the vadose zone with strontium-90, a moderately mobile contaminant. Contaminants with distribution coefficients of zero move with the moisture front and may be present in trace amounts throughout the vadose zone.

5. If spreading occurs within the vadose zone, it is associated with the Plio-Pleistocene Unit and the upper Ringold Formation.

6. Wastewater and contaminants with moderate to very low contaminant distribution coefficients impact groundwater. The effluent volume discharged to the soil column (150,000 m^3) is greater than the soil pore volume (1,400 m^3) as evidenced by the tritium, and nitrate in the groundwater in the vicinity of the crib.

E0006137.1

Figure 3-15. 216-A-10 Crib Conceptual Contaminant Distribution Model.



① Uranium rich process wastes (pH 1 to 2.5) were discharged to the 216-A-10 Crib between 1961 and 1986. The crib received a total volume of 3.21×10^9 L (8.5×10^8 gal) of wastewater. The effluent contained uranium, cesium-137, plutonium, strontium-90, tritium, americium-241, iodine-129, and nitric acid.

② Effluent and contaminants were released to the environment from a buried vitrified clay pipe approximately 9.4 m (31 ft) bgs within a gravel filled drain field in H2. The wetting front and contaminants moved vertically down beneath the crib. There is moderate lateral spreading as evidenced by contamination in borehole 299-E24-60 which is located 6.1 m (20 ft) west of the crib.

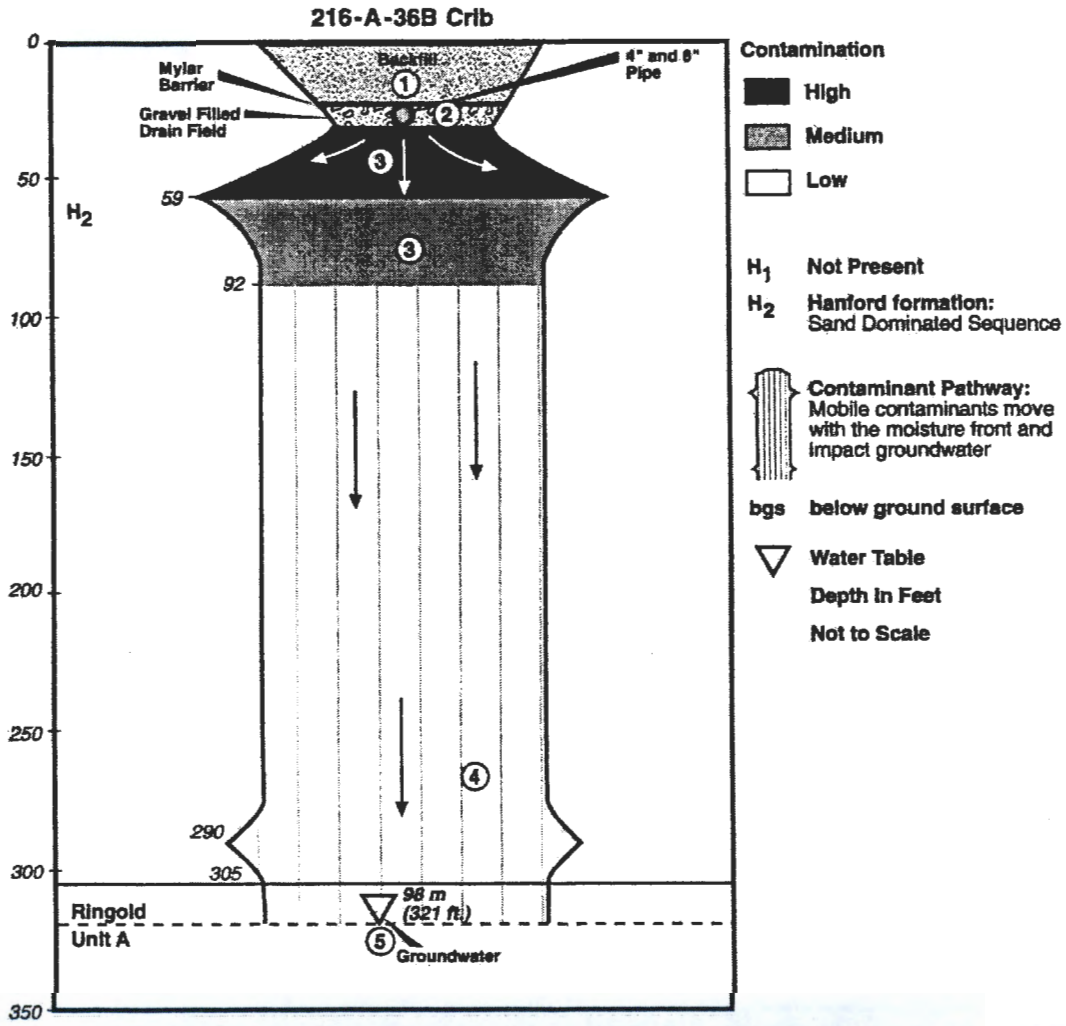
③ The zone of greatest contamination is detected near the discharge pipe to a depth 27.4 m (90 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the crib. Cesium-137 concentrations are highest (10,000 pCi/g) 18 to 23 m (59 to 76 ft) bgs. Contaminants that are moderately mobile, such as europium-154 and cobalt-60, are present deeper in the vadose zone at low concentrations. The most mobile contaminants, such as nitrate, moved with the moisture front and are present in trace amounts throughout the vadose zone.

④ If additional lateral spreading occurs within the vadose zone, it is likely to be associated with the fine grained lenses within the H_2.

⑤ Wastewater and mobile contaminants impact groundwater as the effluent volume discharged to the soil column (3,210,096 m^3) is greater than the soil pore volume (28,072 m^3) as evidenced by the tritium, iodine-129, and nitrate in the groundwater.

E0007007.2

Figure 3-16. 216-A-36B Crib Conceptual Contaminant Distribution Model.



① Uranium rich process and ammonia scrubber wastes were discharged to the 216-A-36A/B Cribs between 1966 and 1987. The gravel filled drain field received a total volume of $3.17X10^8$ liters ($8.37x10^7$ gallons) of wastewater through a 15 cm (6 in. pipe) buried 7.0m (23 ft.) bgs. The low salt, neutral to basic effluent contained uranium, cesium-137, plutonium, strontium-90, iodine-129, tritium, tributyl phosphate, normal paraffin hydrocarbon, nitrate, sodium dichromate, and ammonia. Due to the high inventory of short lived beta emitters (147,000 Ci) discharged to 216-A-36A, the crib was isolated by grouting a 10 cm (4 in.) pipe inside of the original 15 cm (6 in.) pipe. The 10 cm (4 in.) pipe was extended to 216-A-36B and perforated. Contamination from 216-A-36A may impact soils on the northern end of the 216-A-36B crib.

② Effluent and contaminants were released to the environment at the bottom of the crib within H_2. The wetting front and contaminants moved vertically down beneath the crib. There may be significant lateral spreading as indicated by the elevated hydrogen ion (pH 9-10) and ammonium concentrations (max 353 ppm) 30.5m (100 ft) bgs in boreholes 299-E17-14, 299-E17-15 and 299-E17-16 which are located approximately 30.5 m (100 ft) east of the waste site.

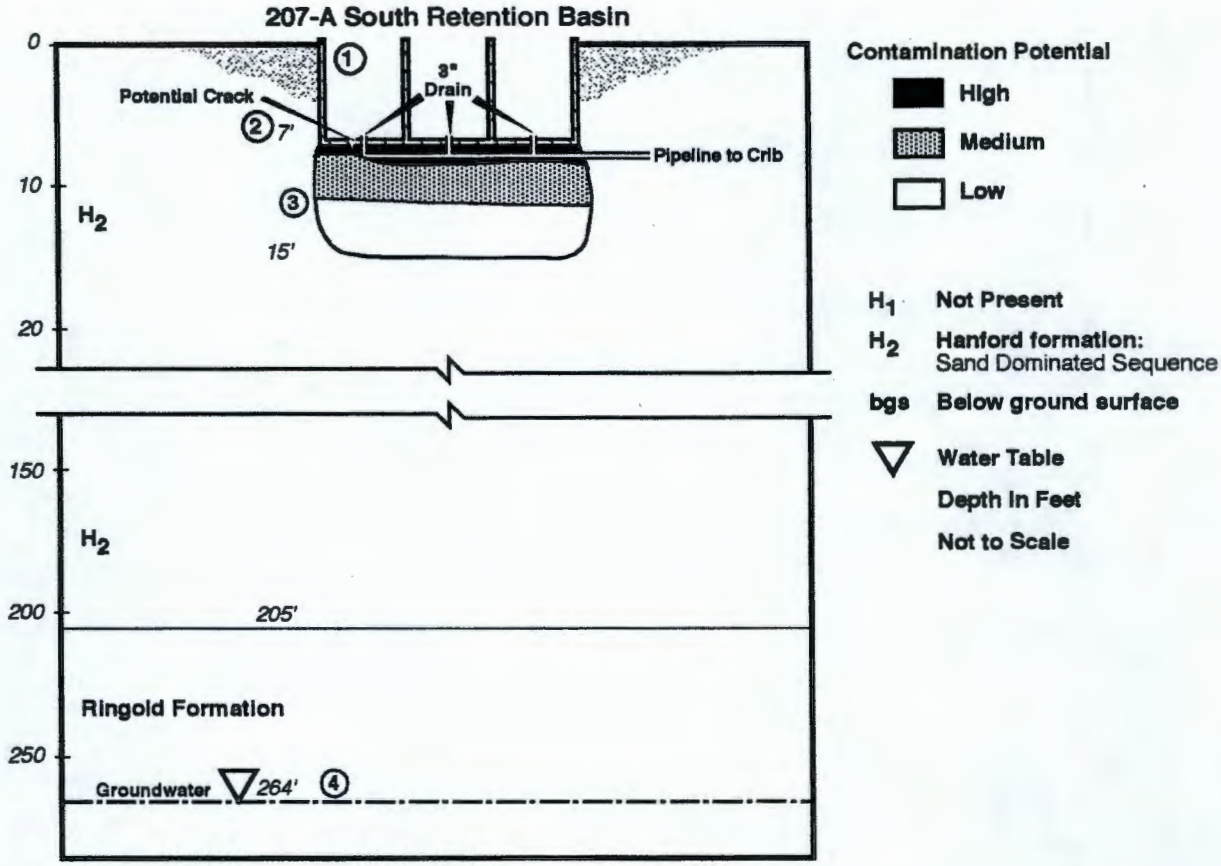
③ The zone of greatest contamination is detected from the bottom of the crib to a depth of 18.0 m (59 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the trench. Cesium-137 concentrations are highest ($1.6x10^6$ pCi/g) at a depth of 11 m (36 ft); concentrations decrease with depth to 18.6 m (61 ft). Maximum concentrations of americum-241 (18,200 pCi/g) and cobalt-60 (1,025 pCi/g) were also detected in this zone. Contaminants that are moderately mobile, and uranium are present deeper in the vadose zone. Strontium-90 is detected to a depth of 28 m (92 ft). The maximum concentration is about 100,000 pCi/g at a depth of 10 - 12 m (33 - 39 ft). Uranium-235 concentrations were highest (1,225 pCi/g) at the base of the crib. The most mobile contaminants such as nitrate move with the moisture front and are present in trace amounts in the vadose zone.

④ Lateral spreading may also occur within the vadose zone associated with the fine grained lenses in the H_2.

⑤ Wastewater and mobile contaminants impact groundwater as the effluent volume discharged to the soil column (318,080 m^3) is greater than the soil pore volume (16,327 m^3) as evident by iodine-29, tritium, and nitrate in the groundwater.

E0007007.3

Figure 3-17. 207-A South Retention Basin Conceptual Contaminant Distribution Model.



① The retention basin is a concrete structure that received effluent from 1977 to 1989. It was used for the interim storage of 242-A Evaporator process condensate to allow for sampling and analysis prior to being discharged to the 216-A-37-1 Crib. The process liquid contained cesium, plutonium, strontium, uranium, acetone, and butanol. The amount of liquid passing through the basin is likely equivalent to the volume discharged [377,000,000 liters (99,528,000 gal)] to the 216-A-37-1 Crib.

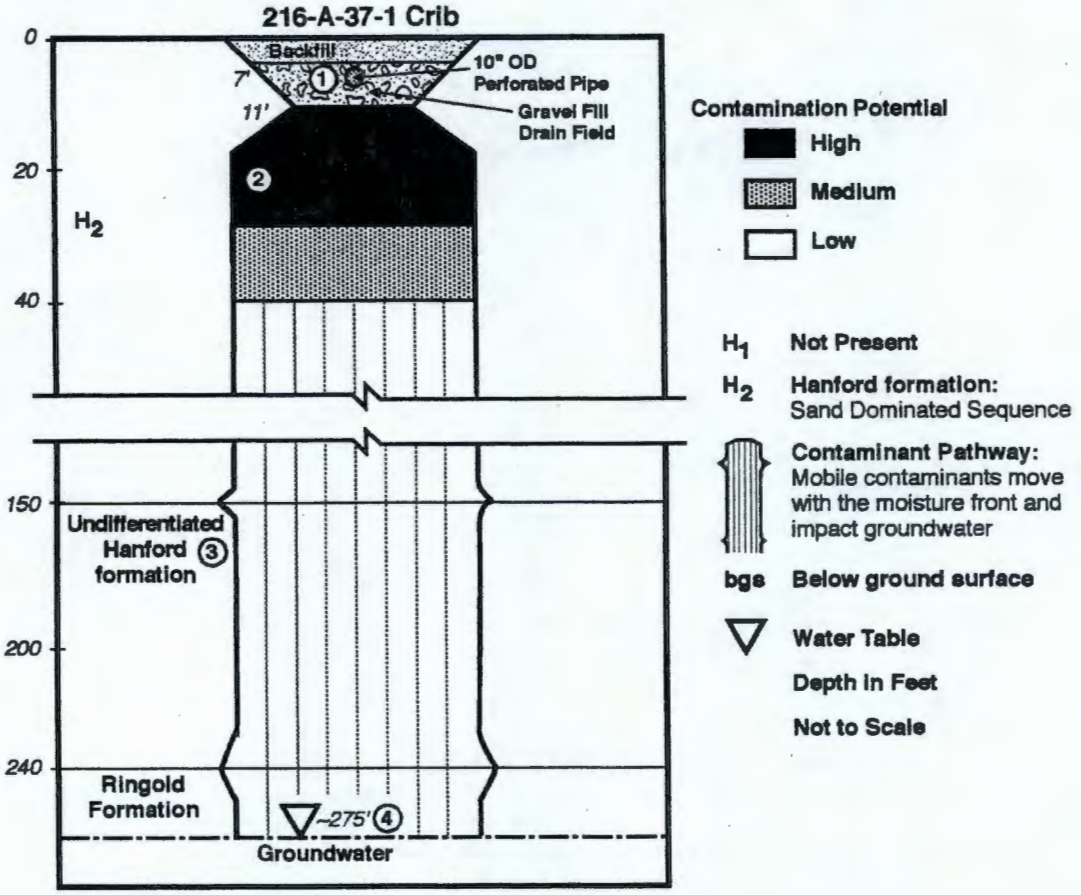
② The basin was designed to hold liquids. There has been no evidence of leaks. Little or no contamination is expected beneath the concrete structure. Any contamination present may be located near cracks in, and drains within, the structure. No structural failures have been documented associated with the basin. Low mobility and moderately mobile contaminants such as cesium and strontium, respectively, will sorb near the bottom of the basin. Contaminant concentrations decrease with depth. Releases would impact H2.

③ High mobility contaminants migrate with the moisture front and may be detected in low concentrations to a depth of about 4.6 m (15 ft). Halogenated and non-halogenated solvents might be detected in the vicinity of the crib in low concentrations.

④ The low potential for the release of effluent to the subsurface suggest that this site has not impacted groundwater. There are no boreholes in the vicinity of the basin and no characterization has been performed.

G02090024-2

Figure 3-18. 216-A-37-1 Crib Conceptual Contaminant Distribution Model.



① The 216-A-37-1 Crib received effluent from 1977 to 1989. It received process liquid waste from the 242-A Evaporator containing cesium, plutonium, strontium, uranium, acetone, and butanol. Effluent was distributed through a 25.4 cm (10 in.) diameter perforated pipe that runs the length of the crib. The pipe is buried about 2.1 m (7 ft) below the surface. Approximately 377,000,000 liters (99,528,000 gal) of effluent were released to the crib.

② Once discharged, the effluent and contaminants migrate vertically down beneath the crib, within H2. Low mobility contaminants such as cesium will sorb near the point of release. Contaminant concentrations decrease with depth. Moderately mobile contaminants may be present to a depth of 12.2 m (40 ft).

③ High mobility contaminants migrate with the moisture front and may be detected in low concentrations throughout the vadose zone. The available data (natural gamma logs) from four groundwater monitoring wells adjacent to the crib suggest that little or no lateral spreading has occurred. Halogenated and non-halogenated solvents may be detected in the vicinity of the crib in low concentrations throughout the vadose zone.

④ The volume of effluent discharged (377,011 m^3) to the crib is greater than the soil column pore volume (15,879 m^3). This data suggest that groundwater has been impacted beneath the crib. Tritium and iodine-129 exceed groundwater protection standards near the crib.

G02090024-4

Figure 3-19. Conceptual Exposure Model for the 200-PW-2 and 200-PW-4 Operable Units.

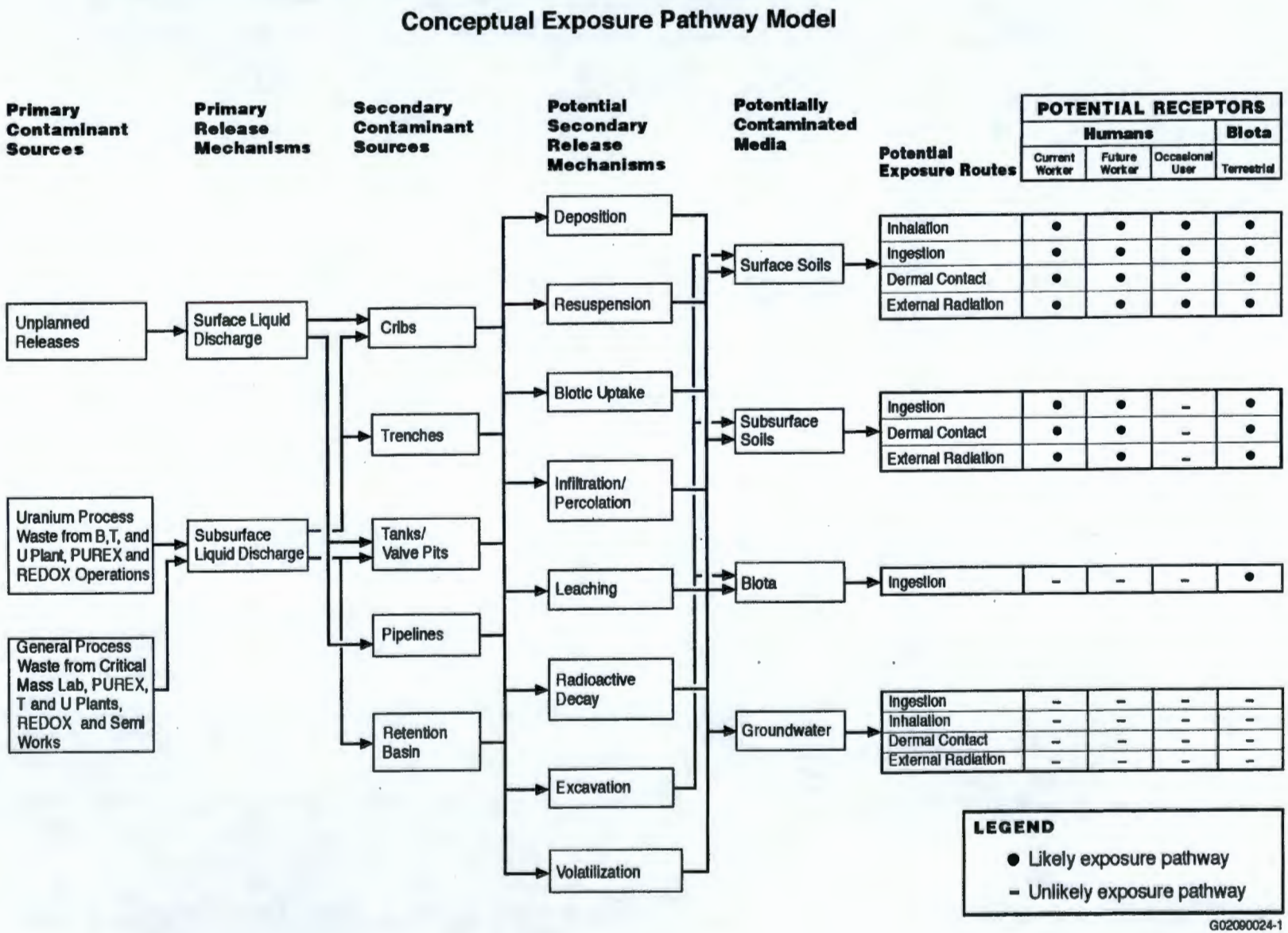


Table 3-1. 200-PW-2 and 200-PW-4 Operable Unit – Estimated Contaminant Inventory. (3 Pages)

Site	Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	CCl_4 (kg)	Ferro-cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Pore Volume (m^3)	Effluent Volume/Pore Volume
200-PW-2 Uranium-Rich Process Condensate/Process Waste Group Operable Unit															
216-A-1	1.53E+02	1.00E-01	-	4.44E-02	4.22E-02	-	-	-	80	-	-	-	98	1980	0.05
216-A-3	1.66E+03	2.00E-01	-	4.55E-02	4.31E-02	-	-	-	-	-	-	-	3050	952	3.2
216-A-5	2.61E+02	6.50E+01	-	1.21E+01	4.16E+01	-	-	-	1000000	-	-	-	1630049	2925	557.3
216-A-10	**2.41E+02**	**3.50E+02**	**7.73E-01**	**8.05E+01**	**8.25E+01**	-	-	-	-	-	-	-	**3210096**	**28072**	114.4
216-A-18	1.39E+03	1.00E-01	-	4.44E-02	4.20E-02	-	-	-	730	-	-	-	488	13050	0.04
216-A-19	**3.87E+04**	**1.00E-01**	-	**4.44E-02**	**4.20E-02**	-	-	-	**20000**	-	-	-	**1100**	**1232**	0.89
216-A-20	4.01E+02	1.00E-01	-	4.44E-02	4.20E-02	-	-	-	210	-	-	-	961	1274	0.75
216-A-22	-	-	-	-	-	-	-	-	-	-	-	-	10	68	0.15
216-A-28	6.27E+02	-	-	-	-	-	-	-	300	-	-	-	30	191	0.16
216-A-36A/B	**2.62E+02**	**2.58E+02**	**2.17E-01**	**1.20E+03**	**1.31E+03**	-	-	-	-	**350**	**178**	**0.0569**	**318080**	**16327**	19.5
216-B-12	**2.10E+04**	**3.74E+02**	-	**7.16E+02**	**7.93E+01**	-	-	-	-	-	-	-	**520000**	**18300**	28.4
216-B-60	7.20E+02	-	-	-	-	-	-	-	-	-	-	-	18.9	438	0.04
216-C-1	3.00E+02	8.00E+00	-	4.55E-02	8.55E+01	-	-	-	-	-	-	-	23400	785	29.8
216-S-1&2	2.25E+03	1.20E+03	-	1.10E+03	1.25E+03	-	-	-	60000	-	-	-	160000	6020	26.6
216-S-7	2.56E+03	4.40E+02	-	7.03E+02	1.39E+03	-	-	-	110000	-	-	-	390000	8361	46.6
216-S-8	1.93E+02	2.00E+00	-	4.92E+00	3.86E-01	-	-	-	100	-	-	-	10000	10033	0.99
216-U-1&2	4.00E+03	4.26E+01	-	4.36E+00	2.11E+00	-	-	-	1200000	-	-	-	46200	400	115.5
216-U-5	3.63E+02	-	-	-	-	-	-	-	200	-	-	-	4500	3300	1.4
216-U-6	3.63E+02	-	-	-	-	-	-	-	200	-	-	-	4500	3300	1.4
216-U-8	**2.39E+04**	**3.70E+02**	-	**4.55E-02**	**4.31E-02**	-	-	-	-	-	-	-	**379000**	**11100**	34.1
216-U-12	**2.01E+03**	**1.00E+00**	**6.45E-03**	**5.66E-02**	**5.59E+01**	-	-	-	-	-	-	-	**150000**	**1400**	107.1
241-U-361	4.00E+03	-	-	-	-	-	-	-	-	-	-	-	-	-	
270-E CNT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
270-W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-E-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-E-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-E-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-E-64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-PW-2 Uranium-Rich Process Condensate/Process Waste Group Operable Unit															
UPR-200-W-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Table 3-1. 200-PW-2 and 200-PW-4 Operable Unit – Estimated Contaminant Inventory. (3 Pages)

Site	Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	CCl_4 (kg)	Ferro-cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Pore Volume (m^3)	Effluent Volume/Pore Volume
UPR-200-W-36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-W-163	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-E-58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-W-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-W-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-W-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
203S&205S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-PW-4 General Process Condensate/Process Waste Group Operable Unit															
207-A-SOUTH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
209-E-WS-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
216-A-34	-	-	-	-	-	-	-	-	-	-	-	-	-	11990	
216-A-37-1	**3.24E+01**	**2.83E-02**	**3.69E-04**	**9.47E-02**	**5.42E-02**	-	-	-	**600**	-	-	-	**377011**	**15879**	**23.7**
216-A-45	6.69E+00	-	1.10E-01	9.70E-03	8.34E-03	-	-	-	-	-	-	-	103003	58074	1.8
216-C-3	4.50E+01	1.00E+00	-	4.24E-02	8.04E+00	-	-	-	-	-	-	-	5000	1211	4.1
216-C-5	5.40E+01	1.00E+00	-	4.44E-02	4.20E+00	-	-	-	-	-	-	-	38	484	0.08
216-C-7	1.00E-02	1.10E+00	-	5.34E-02	5.12E-02	-	-	-	-	-	-	-	60	967	0.06
216-C-10	5.00E-02	1.50E-01	-	8.55E-02	3.45E+00	-	-	-	-	-	-	-	897	387	2.3
216-S-4	-	-	-	-	-	-	-	-	1	-	-	-	1000	150	6.7
216-S-22	5.00E-02	1.01E-01	-	4.78E-01	4.55E-01	-	-	-	7000	-	-	-	98	585	0.17
216-S-23	2.90E-01	9.94E-01	-	3.47E+00	1.14E+00	-	-	-	0	-	-	-	34100	6020	5.7
216-T-20	5.00E+00	-	-	4.40E-01	3.88E-01	-	-	-	15000	-	-	-	18.9	66	0.29
216-U-16	1.76E+01	-	-	1.65E-02	9.20E-03	-	-	-	-	-	-	-	409000	16500	24.8
216-U-17	1.42E+00	-	5.30E-05	-	-	-	-	-	-	-	-	-	2110	2100	1.0
UPR-200-E-145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Table 3-1. 200-PW-2 and 200-PW-4 Operable Unit – Estimated Contaminant Inventory. (3 Pages)

Site	Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	CCl_4 (kg)	Ferro-cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Pore Volume (m^3)	Effluent Volume/Pore Volume

Notes: All inventories taken from the 200 Area Source Aggregate Area Management Study Reports, Table 2-2, Radionuclide Waste Inventory Summary, or Table 2-3, Chemical Waste Inventory Summary (i.e., DOE/RL-91-52, *U Plant Source Aggregate Area Management Study Report*; DOE/RL-91-60, *REDOX Plant Source Aggregate Area Management Study Report*; DOE/RL-92-04, *PUREX Plant Source Aggregate Area Management Study Report*; DOE/RL-92-05, *B Plant Source Aggregate Area Management Study Report*; DOE/RL-92-18, *Semiworks Plant Source Aggregate Area Management Study Report* .

All radionuclide inventories decayed through 1989 unless otherwise noted in the aggregate area management study report. Sites shown in **bold** were selected as representative sites and/or are treatment, storage, and disposal units in the Implementation Plan (DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*) and the Waste Site Grouping Report (DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*).

"-" indicates data not available.
NPH = normal paraffin hydrocarbon.
TBP = tributyl phosphate.

Table 3-2. Detectable Metal Concentrations in Vegetation at the 216-U-8 Vitrified Clay Pipeline, 216-U-8 Crib, and 216-U-10 Pond (BHI-00033).

		Metals (mg/kg)													
	Sample ID	Al	Sb[a]	Ba[a]	Ca	Cu[a]	Fe	Pb[a]	Mg	Mn	K	Na	Ti	V	Zn
216-U-8 Vitrified Clay Pipeline	BOBFL8	192	11.6 B	27.3 B	21400	6.2	278	0.47 B	5990	25.7	4140	U	19.1	U	U
	BOBFL9	U	U	33.9 B	28900	7.6	298	U	8160	41.6	4740	U	19.7	U	U
	BOBFM0	419	15.8	18.9 B	19900	6.9	830	0.75	4510	59.5	1740	U	57.4	U	34
	BOBFM1	578	U	27.7 B	20800	4.1 B	1110	0.7	3470	48.2	1130	U	80.9	2.9 B	U
	BOBFM2	226	U	22.3	15400	12.2	433	1	4530	37.1	8390	161 B	32.3	U	20.4
	BOBFM3	274	12.3 B	19.9 B	15600	7.9	534	0.55 B	5850	41.3	5360	U	40.2	U	U
	Max	578	15.8	33.9	28900	12.2	1110	1	8160	59.5	8390	161	80.9	2.9	34
	Min	192	11.6	18.9	15400	4.1	278	0.47	3470	25.7	1130	161	19.1	2.9	20.4
	Avg. Detectable Concentration	337.8	13.2	25	20333.3	7.48	580.5	0.694	5418.3	42.2	4250	161	41.6	2.9	27.2

		Metals (mg/kg)												
	Sample ID	Al	Ba[a]	Ca	Cr[a]	Co	Cu[a]	Fe	Mg	Mn	K	Ti	V	Zn
216-U-8 Crib	BOBKN1	110	7.2 B	2630	U	U	5.6	226	1600	11.5	5930	16.8	U	U
	BOBKN2	1280	25 B	7800	U	U	9.7	2730	2220	72.1	4840	191	6.2 B	16.2
	BOBKN3	96.6	4.4 B	2710	U	U	6	182	1020	18	5410	12.8	U	10.1
	BOBKN4	1870	34.4 B	10100	2.5	2 B	11.7	4150	2260	154	2950	292	9.2 B	33.3
	Max	1870	34.4	10100	2.5	2	11.7	4150	2260	154	5930	292	6.2	33.3
	Min	96.6	4.4	2630	2.5	2	5.6	182	1020	11.5	2950	12.8	9.2	10.1
	Avg. Detectable Concentration	839.2	17.8	5810	2.5	2	8.25	1822	1775	63.9	4782.5	128.2	7.7	19.9

		Metals (mg/kg)													
	Sample ID	Al	Ba[a]	Ca	Cd	Cu[a]	Fe	Pb[a]	Mg	Mn	K	Na	Ti	V	Zn
216-U-10 Pond	BOBP32	124	32 B	20700	0.44 B	7.9	359 J	0.46 B	4210	27.5	8790	245 B	23.2 J	3.1 BJ	18.5 J
	BOBP33	142	17.5 B	10300	NA	8.5	285	U	4320	22	11600 J	85.2 B	18.9	U	36
	Max	142	32	20700	0.44	8.5	359	0.46	4320	27.5	11600	245	23.2	3.1	36
	Min	124	17.5	10300	0.44	7.9	285	0.46	4210	22	8790	85.2	18.9	3.1	18.5
	Avg. Detectable Concentration	133	24.8	15500	0.44	8.2	322	0.46	4265	24.8	10195	165.1	21.1	3.1	27.3

[a]Contaminant of concern for the 200-PW-2 operable unit. BHI-00033, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit.*
Qualifiers: U = Undetected, B = Analyte found in sample blank, J = Concentration is estimated, NA = Not Analyzed. Undetected Metals: As, Be, Cd, Se, Ag, Tl, Hg, Ni.

Table 3-3. Detectable Radionuclide Concentrations in Vegetation at the 216-U-8 Vitrified Clay Pipeline, 216-U-8 Crib, and 216-U-10 Pond (BHI-00033).

	Radionuclides (pCi/g)																			
	Sample ID	Ac-228	Be-7	Beta	Cs-137[a]	K-40	Pb-212	Pb-214	Pu-239/240[a]	Ra-224	Se-79	Tc-99[a]	Th-232[a]	Th-234	Tl-208	Total Sr[a]	U-234[a]	U-238[a]	U-238G	Total U
216-U-8 Vitrified Clay Pipeline	BOBFL8	U	1.89	817	0.158	9.28	0.024	NA	U	NA	NA	296	NA	NA	NA	328	0.0554	0.0474	NA	0.209
	BOBFL9	NA	2.7	4220	0.974	5.37	0.219	0.193	0.0708	0.234	2.66	117	0.185	NA	0.0425	1380	0.198	0.189	0.193	0.752
	BOBFM0	NA	2.3	879	17.2	3.67	0.0643	NA	0.0228	0.0686	1.44	49.5	0.152	NA	NA	492 J	0.324	0.299	NA	0.782
	BOBFM1	NA	2.21	614	6.32	3.43	0.0463	NA	U	0.0494	1.85	46.8	0.118	NA	0.037	426 J	0.186	0.145	NA	0.613
	BOBFM2	0.0414	2.02	24.8	0.579	5.29	0.0451	0.134	0.0239	0.0423	U	29.4	NA	NA	NA	10.4	U	U	0.134	0.126
	BOBFM3	U	2.61	35.4	0.611	3.58	0.0448	NA	U	0.0479	U	28.7	NA	2.63	0.00774	10 J	0.08	U	NA	0.106
	Max	0.0414	2.7	4220	17.2	9.28	0.219	0.193	0.0708	0.234	2.66	296	0.185	2.63	0.0425	1380	0.324	0.299	0.193	0.782
	Min	0.0414	1.89	24.8	0.158	3.43	0.024	0.134	0.0228	0.0423	1.44	28.7	0.118	2.63	0.0077	10	0.0554	0.0474	0.134	0.106
	Average Detectable Concentration	0.0414	2.3	1098.4	4.307	5.1	0.0739	0.1635	0.0392	0.0884	2.0	94.6	0.1517	2.63	0.0291	441.1	0.1687	0.1701	0.1635	0.4313

	Radionuclides (pCi/g)																			
	Sample ID	Alpha	Am-241	Be-7	Beta	Cs-137[a]	K-40	Pb-212	Pb-214	Pu-239/240[a]	Ra-224	Se-79	Tc-99[a]	Th-232[a]	Th-234	Tl-208	Total Sr[a]	U-234[a]	U-238[a]	U-238G
216-U-8 Crib	BOBKN1	U	U	1.57	117	0.118	6.37	0.0428	NA	U	0.0446	U	5.34	0.0446	NA	0.0106	523 J	0.0484	U	NA
	BOBKN2	7.42	0.0202	NA	235	1.67	6.78	0.257	0.471	0.0748	0.268	U	23.5	0.464	NA	0.165	295 J	0.104	0.134	0.471
	BOBKN3	U	U	2.58	721	0.0723	6.65	0.0128	NA	U	0.0133	1.21	36.1	NA	NA	0.00933	66.9 J	0.0491	0.0629	NA
	BOBKN4	5.88	U	1.8	417	1.11	5.27	0.289	NA	U	0.301	U	45.5	NA	18.4	NA	491 J	0.255	0.191	NA
	Max	7.42	0.0202	2.58	721	1.67	6.78	0.289	0.471	0.0748	0.301	1.21	45.5	0.0464	18.4	0.165	523	0.255	0.191	0.471
	Min	5.88	0.0202	1.57	117	0.0723	5.27	0.0128	0.471	0.0748	0.0133	1.21	5.34	0.0446	18.4	0.0093	66.9	0.0484	0.0629	0.471
	Average Detectable Concentration	6.65	0.0202	1.98	372.5	0.7426	6.2675	0.1504	0.471	0.0748	0.1567	1.21	27.61	0.25	18.4	0.0616	344	0.1141	0.1293	0.471

	Radionuclides (pCi/g)															
	Sample ID	Alpha	Be-7	Beta	Cs-137[a]	K-40	Pb-212	Ra-224	Se-79	Tc-99[a]	Th-232[a]	Tl-208	Total Sr[a]	U-234[a]	U-238[a]	Total U
216-U-10 Pond	BOBP32	U	1.23	1810	0.415	10.4	0.0504	0.0529	U	30	16.6	0.0256	360	0.127	0.128	0.325
	BOBP33	9.61	1.91	1900	3.43	13.6	0.0785	0.0818	1.6	21.1	NA	0.0329	415	0.153	0.131	0.486
	Max	9.61	1.91	1900	3.43	13.6	0.0785	0.0818	1.6	30	16.6	0.0329	415	0.153	0.131	0.486
	Min	9.61	1.23	1810	0.415	10.4	0.0504	0.0529	1.6	21.1	16.6	0.0256	360	0.127	0.128	0.325
	Average Detectable Concentration	9.61	1.57	1855	1.92	12	0.0644	0.0674	1.6	25.55	16.6	0.0293	387.5	0.14	0.1295	0.4055

[a]Contaminants of concern for 200-PW-2 operable unit. BHI-00033, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit.*

Qualifiers: U = Undetected, B = Analyte found in sample blank, J = Concentration is estimated, NA = Not Analyzed.

Undetected Radionuclides: Cm-242, Cm-244, Cs-134, Co-60, Eu-152, Eu, 154, Eu-155, I-129, Na-22, Np-237, Pu-238, Ru-106, U-235

Table 3-4. Soil Sample Data Collected in the Vicinity of 200-PW-2 and 200-PW-4 Operable Unit Sites During 2000 and 2001 (in pCi/g).

Isotope	D037	D040	D041	D042	D043	D044	D045	D046	D073	D077	D078
	near 216-S-8 Trench	216-U-16 Crib	near 216-U-12 Crib	near 216-U-8 Crib	near 216-U-8 Crib	near 216-U-1&2 Crib	near 216-U-1&2 Crib	216-U-17 Crib	near 216-A-19 Trench	near 216-A-36B Crib	near 216-A-10 Crib
Co-60	-8.3E-04	-2.9E-03	2.0E-03	-1.5E-03	5.4E-04	-1.8E-03	4.2E-04	3.3E-03	3.4E-03	6.5E-03	-9.2E-04
Zn-65	-2.5E-03	-1.1E-02	4.6E-03	7.3E-03	1.1E-02	1.1E-02	2.0E-02	5.3E-03	-2.1E-04	1.8E-03	-8/3E-03
Sr-90	5.1E-01	9.3E-01	4.0E-01	7.7E-01	3.8E-01	1.6E+00	3.8E+00	1.0E+00	2.0E-01	-1.1E-01	4.1E-01
Ru-103	-6.5E-03	3.9E-03	-6.4E-03	-3.4E-03	-6.5E-03	-5.8E-03	2.7E-03	-4.2E-03	1.4E-02	7.6E-03	-1.1E-03
Ru-106	1.1E-01	-3.7E-02	1.1E-02	-2.6E-02	2.1E-03	3.1E-02	5.5E-02	-1.5E-02	-9.3E-03	-7.4E-02	2.9E-03
Sn-113	7.5E-03	-4.0E-03	5.9E-03	-1.5E-02	6.6E-03	8.0E-04	1.3E-02	-5.3E-04	-8.0E-03	-7.0E-03	-6.2E-03
Sb-125	4.4E-03	3.3E-03	1.4E-02	1.1E-02	1.1E-02	-5.3E-03	-9.7E-03	1.9E-02	-1.2E-02	7.3E-03	3.2E-03
Cs-134	3.5E-02	3.3E-02	1.7E-02	3.5E-02	3.2E-02	3.2E-02	2.4E-02	3.1E-02	3.9E-02	3.6E-02	2.9E-02
Cs-137	2.0E+00	8.9E-01	7.6E-01	4.6E-01	6.6E-01	1.0E+00	4.4E+00	4.0E-02	1.2E+00	4.6E-01	7.6E-01
Ce-144	2.3E-02	-6.1E-02	1.5E-04	1.5E-02	-1.3E-02	-2.4E-03	-1.2E-01	-2.9E-02	-1.7E-02	-7.5E-02	-9.5E-03
Eu-152	2.3E-04	-1.0E-02	-1.9E-02	1.1E-01	-1.5E-02	-1.2E-02	1.4E-02	4.3E-04	-5.0E-03	2.2E-02	-1.8E-02
Eu-154	-1.7E-02	-1.4E-02	-3.4E-02	-3.0E-03	-1.9E-02	-1.5E-02	-1.5E-02	-1.2E-02	-1.9E-02	-1.8E-02	-1.4E-02
Eu-155	-1.5E-03	3.9E-02	2.9E-02	5.7E-03	-1.5E-02	4.5E-02	3.4E-02	3.0E-02	5.2E-02	4.8E-02	3.8E-02
U-234	2.0E-01	1.9E-01	2.6E-01	2.3E-01	3.7E-01	2.6E-01	2.5E-01	2.7E-01	1.8E-01	2.1E-01	2.6E-01
U-235	7.7E-03	5.6E-03	2.1E-02	1.1E-02	3.3E-02	3.5E-02	1.6E-02	3.0E-02	5.5E-03	1.3E-02	2.4E-02
U-238	2.3E-01	1.8E-01	2.9E-01	2.4E-01	4.1E-01	3.0E-01	2.2E-01	2.5R-01	2.3E-01	2.7E-01	2.3E-01
Pu-238	-3.7E-03	-1.9E-02	2.4E-02	1.2E-02	-1.7E-02	1.6E-02	-5.3E-03	1.4E-02	7.7E-03	2.4E-03	1.8E-03
Pu239/40	2.8E-02	4.9E-02	6.1E-02	8.9E-02	2.0E-02	1.7E-01	1.1E-01	5.4E-01	1.9E-03	2.4E-02	2.4E-02

Note: Even-numbered samples (e.g., D040) were collected and analyzed in 2000 (PNNL-13487, Appendix 2, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 2000*). Odd-numbered samples (e.g., D041) were collected and analyzed in 2001 (PNNL-13910, Appendix 2, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 2001*).

Table 3-5. Vegetation Sample Data Collected in the Vicinity of 200-PW-2 and 200-PW-4 Operable Unit Sites During 2000 and 2001 (in pCi/g).

Isotope	D040	V041	V042	V043	V044	V045	D046	V077	V078
	216-U-16 Crib	near 216-U-12 Crib	near 216-U-8 Crib	near 216-U-8 Crib	near 216-U-1&2 Crib	near 216-U-1&2 Crib	216-U-17 Crib	near 216-A-36B Crib	near 216-A-10 Crib
Co-60	2.4E-02	-1.4E-02	2.2E-03	-2.1E-02	-1.4E-02	1.5E-02	-1.3E-02	-2.4E-02	7.4E-03
Zn-65	-1.9E-02	-1.3E-01	1.7E-02	-1.9E-01	-1.7E-02	8.5E-02	1.0E-01	4.3E-02	-1.1E-02
Sr-90	7.6E-02	-3.7E-02	4.2E-01	-1.2E-01	1.5E-01	1.3E-01	2.0E+00	7.1E-01	5.4E-02
Ru-103	4.1E-02	-5.3E-03	-2.2E-02	2.8E-02	6.4E-04	-2.5E-03	-1.9E-02	1.6E-02	8.5E-04
Ru-106	-2.5E-01	-1.0E-01	5.2E-02	-2.0E-01	1.8E-01	4.7E-01	-3.0E-02	-4.2E-01	-2.3E-01
Sn-113	1.7E-03	-8.0E-03	-1.3E-02	3.6E-02	-3.6E-02	2.0E-02	-1.6E-02	1.2E-02	-3.5E-02
Sb-125	1.6E-02	1.3E-01	2.8E-02	1.2E-02	8.0E-03	9.7E-02	2.5E-02	-2.1E-02	2.2E-03
Cs-134	1.5E-02	-5.8E-02	7.8E-03	2.9E-03	-1.0E-02	2.4E-02	1.4E-02	2.9E-02	-1.5E-02
Cs-137	1.8E-01	1.0E-01	4.1E-02	1.0E-01	1.0E-01	1.2E-01	1.8E-02	2.2E-02	3.1E-02
Ce-144	1.1E-01	3.7E-02	8.6E-02	-6.0E-03	4.1E-02	-3.7E-02	-5.9E-02	-1.5E-01	1.3E-01
Eu-152	4.7E-03	8.1E-04	-2.3E-02	-2.6E-02	-9.4E-04	-5.9E-02	-2.1E-01	-2.1E-02	-3.8E-02
Eu-154	-6.1E-02	-7.0E-03	-4.9E-02	-4.6E-02	6.7E-03	5.9E-02	-3.6E-02	-1.5E-02	6.7E-02
Eu-155	2.5E-02	4.3E-02	-5.1E-02	1.8E-02	-2.2E-03	-7.8E-02	-4.4E-02	-1.2E-01	-1.1E-01
U-234	2.8E-02	4.8E-03	1.8E-02	2.7E-02	2.2E-02	2.6E-02	4.6E-02	1.5E-02	2.1E-02
U-235	5.1E-03	5.2E-03	1.2E-02	1.7E-03	5.1E-03	2.0E-03	2.4E-03	1.1E-03	5.9E-03
U-238	1.5E-02	1.6E-02	6.1E-03	1.3E-02	1.9E-02	1.1E-02	2.4E-02	1.3E-02	1.7E-02
Pu-238	3.3E-03	4.7E-03	-4.6E-03	-1.8E-03	4.7E-03	-4.E-03	2.8E-02	1.0E-02	8.6E-03
Pu239/40	1.1E-02	2.6E-02	3.5E-03	1.9E-02	1.1E-02	1.9E-02	-1.5E-03	3.8E-03	4.3E-03

Note: Even-numbered samples (e.g., D040) were collected and analyzed in 2000 (PNNL-13487, Appendix 2, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 2000*). Odd-numbered samples (e.g., D041) were collected and analyzed in 2001 (PNNL—13910, Appendix 2, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 2001*).

Table 3-6. Summary of Human Health Qualitative Risk Assessment for the 200-UP-2 Operable Unit. (DOE/RL-95-13).

Waste Site Designation	Industrial-Use Scenario		
	Qualitative Risk Classification[a,b]	Major Contaminant	Major Pathway
216-U-1 and 216-U-2 Crib System	Medium	Cesium-137	External Radiation Exposure
216-U-10 Pond System[c]	High (radionuclides)	Cobalt-60 Cesium-137 Europium-154 Sodium-22	External Radiation Exposure
	Medium (organics) Low (inorganics)	Aroclor-1260 Chromium	Ingestion Fugitive Dust Inhalation
216-U-8 Crib System (including 216-U-8 and 216-U-12 Cribs)	High (radionuclides)	Cesium-137	External Radiation Exposure
	Low (inorganics)	Chromium	Fugitive Dust Inhalation
216-U-4 French Drain and 216-U-4a Reverse Well System[c]	Medium	Cesium-137	External Radiation Exposure

[a]Very Low = Very Low Qualitative Risk; Incremental Cancel Risk (ICR) < 1E-06

Low = Low Qualitative Risk; 1E-06 < ICR < 1E-04

Medium = Medium Qualitative Risk; 1E-04 < ICR < 1E-02

High = High Qualitative Risk; ICR > 1E-02

[b]Qualitative risk classification is based on the highest risk category for chemical contaminant of potential concern from waste sites characterized by analytical data.

[c]These waste sites are not part of the 200-PW-2 operable unit.

DOE/RL-95-13, *Limited Field Investigation for the 200-UP-2 Operable Unit.*

Table 3-7. List of Contaminants of Concern at the 200-PW-2 Operable Unit.

Radioactive Constituents	
Americium-241	Plutonium-239/240
Carbon-14	Radium-226
Cesium-137	Radium-228
Cobalt-60	Strontium-90
Europium-152	Technetium-99
Europium-154	Tritium
Europium-155	Thorium-232
Iodine-129	Uranium-233/234
Neptunium-237	Uranium-235/236
Nickel-63	Uranium-238
Plutonium-238	
Chemical Constituents – Metals	
Antimony	Copper
Arsenic	Lead
Barium	Mercury
Beryllium	Nickel
Cadmium	Selenium
Chromium	Silver
Hexavalent Chromium	
Chemical Constituents - Other Inorganics	
Ammonia/Ammonium	Nitrate/Nitrite
Chloride	Phosphate
Cyanide	Sulfate
Fluoride	
Volatile Organics[a]	
Methyl iso butyl ketone (MIBK, Hexone, or (4-methyl-2-pentanone)	
Semivolatile Organics	
AMSCO[b, c] Tributyl phosphate dilutant	Normal paraffin hydrocarbon[b]
Dodecane[b]	Tributyl phosphate

[a]Only present at waste sites 216-S-1, 216-S-2, and 216-S-7 Cribs and 216-S-8 Trench via REDOX process condensate and process cell drainage waste streams only. This constituent will be considered only for the 216-S-7 Crib (see Appendix D).

[b]Analyzed as kerosene or total petroleum hydrocarbons.

[c]Product of Allen Maintenance Supply Company, Inc.

Table 3-8. List of Contaminants of Concern at the 200-PW-4 Operable Unit. (2 Pages)

Radioactive Constituents	
Americium-241	Plutonium-239/240
Carbon-14	Radium-226
Cesium-137	Radium-228
Cobalt-60	Strontium-90
Europium-152	Technetium-99
Europium-154	Tritium
Europium-155	Thorium-232
Iodine-129	Uranium-233/234
Neptunium-237	Uranium-235/236
Nickel-63	Uranium-238
Plutonium-238	
Chemical Constituents – Metals	
Antimony	Copper
Arsenic	Lead
Barium	Mercury
Beryllium	Nickel
Cadmium	Selenium
Chromium	Silver
Hexavalent Chromium	
Chemical Constituents - Other Inorganics	
Ammonia/Ammonium	Nitrate/Nitrite
Chloride	Phosphate
Cyanide	Sulfate
Fluoride	
Volatile Organics	
1,1-dichloroethane (DCA)	Ethylbenzene
1,2-dichloroethane (DCA)	Ethylene glycol
1,1,1-trichloroethane (TCA)	Methyl ethyl ketone (MEK, 2-butanone)
Acetone	Methyl iso butyl ketone (MIBK, hexone)
Benzene	Methylene chloride
Carbon tetrachloride	n-butyl benzene
Cis/trans-1,2-dichloroethylene	Tetrachloroethylene (PCE)
Chlorobenzene	Trichloroethylene (TCE)
Chloroform	Toluene
	Xylene

Table 3-8. List of Contaminants of Concern at the 200-PW-4 Operable Unit. (2 Pages)

Semivolatile Organics	
AMSCO[a, b] Tributyl phosphate dilutant	Normal paraffin hydrocarbon[a]
Dodecane[a]	Tributyl phosphate
Hydraulic fluids (greases)	Phenol
Kerosene[a]	Polychlorinated biphenyls (PCB)

[a]Analyzed as kerosene or total petroleum hydrocarbons.

[b]Product of Allen Maintenance Supply Company, Inc.

4.0 WORK PLAN APPROACH AND RATIONALE

4.1 SUMMARY OF DATA QUALITY OBJECTIVE PROCESS

The RI needs for the 200-PW-2 and 200-PW4 OUs were developed in accordance with the DQO process (EPA/600/R-96/055, *Guidance for Data Quality Objectives Process*, EPA QA/G-4; CP-GPP-EE-01-1.2, *Data Quality Objectives*). The DQO process is a seven-step planning approach that is used to develop a data collection strategy consistent with data uses and needs. The goals of the process are to provide the data needed to refine the preliminary site conceptual model and support remedial decisions.

The DQO process was implemented by a team of subject matter experts and key decision makers. Subject matter experts provided input on regulatory issues, the history and physical condition of the sites, and sampling and analysis methods. Key decision makers from DOE, Ecology, and EPA participated in the process to develop the characterization approach outlined in the DQO summary reports. The DQO process and involvement of the team of experts and decision makers provides a high degree of confidence that the right type and quality of data are collected to fulfill informational needs of the RI decisional process. Results of the DQO process for characterization of the representative sites and TSD units in the 200-PW-2 OU are presented in BHI-01411. During the DQO, it was determined that the characterization data previously obtained for the 216-U-8 Crib are sufficient to support the 200-PW-2 OU RI/FS process without additional data collection. In addition, the 216-U-8 Crib is considered analogous to the 216-U-12 Crib; therefore, no additional sampling activities at the 216-U-12 Crib are required. However, geophysical logging of nearby boreholes for each of these two sites will be conducted as an efficient means to provide additional data to support refinement of the conceptual contaminant distribution models. Results of the DQO process for characterization of the representative sites and TSD units in the 200-PW-4 OU are presented in CP-14176. Characterization activities outlined in this work plan focus on the six remaining representative sites and TSD units (216-A-19 Trench, 216-B-12 Crib, 216-A-10 Crib, 216-A-36B Crib, 207-A South Retention Basin, and 216-A-37-1 Crib).

During subsequent OU consolidation efforts to incorporate the 200-PW-4 OU waste sites, a review of this section in the work plan and of applicable background information was conducted. This review was completed to determine if the information presented in the 200-PW-2 OU DQO adequately described and bounded the 200-PW-4 OU waste sites. A formal evaluation was performed for the consolidated OU waste sites, comparing them with the representative waste site conceptual models in this work plan. This evaluation is summarized in Appendix C in a series of tables that document the alignment of the 200-PW-4 OU waste sites with appropriate analogous representative waste sites.

The goal of this evaluation was to align the consolidated OU waste sites with the appropriate representative waste sites, based on site configuration and vertical extent of contamination, so that remedial alternative(s) chosen for the sites would be an effective and reasonable choice. Several characteristics of the waste sites were reviewed and compared with the representative sites to ensure that these sites indeed were similar and/or bounded the analogous waste sites.

The characteristics considered in the assignment of grouping analogous waste sites with contaminant distribution models included the following:

- Waste site dimensions as indicated by the WIDS, and physical configuration as indicated by the type of waste site (e.g., cribs were used to percolate wastes, while ditches typically channeled waste to other waste sites)

- Vertical extent of contaminants were qualitatively compared based on the calculated pore volume and estimated effluent volume discharged, as documented in Appendix A of the waste site groupings report (DOE/RL-96-81)

- Process information including historical discharge operations, contaminants of concern, and physical properties such as retardation factors that would influence k_d values, illustrated by the known inventories of important radionuclides, key inorganic chemicals, and known organic chemicals released to the ground as documented in Appendix A of the waste site groupings report (DOE/RL-96-81).

A comparison of the analogous waste site's physical setting, geology, and characterization data (if available and applicable) to that of the representative waste site characteristics also was performed in this evaluation. A more detailed look at previous characterization data will be performed during the FS. The representative waste site approach being used for the RI/FS process incorporates the use of historical and current field data obtained from the representative waste sites during the RI reporting phase. During the FS additional evaluation of historical data from analogous waste sites is performed to complete the evaluation of remedial alternatives and confirm the sites as analogous to the OU representative waste sites.

A series of tables is provided in Appendix C that documents the assessment of consolidated waste sites. The tables and their contents include the following:

- Table C-1 – Provides an overall listing of the waste sites, their WIDS classification status (accepted versus rejected), and an indication of where these sites have been placed in subsequent tables

- Table C-2 – Indicates which waste sites have been rejected or reclassified by the WIDS classification procedures (per Tri-Party Agreement Milestone MP-14 [Ecology et al. 1989])

- Table C-3 – Lists the waste sites that align well with the 200-PW-2 OU representative waste site conceptual contaminant distribution models in this work plan

- Table C-4 – Identifies waste sites that do not align well with the 200-PW-2 OU representative waste site conceptual contaminant distribution models, but that are better represented or bounded by the conceptual contaminant distribution models of representative waste sites or TSD units from other OUs. For these waste sites, the more appropriate conceptual contaminant distribution model figures from other OUs are provided in Appendix C following Table C-5.

  Because the waste sites listed in Table C-4 are not aligned with the 200-PW-2 OU representative waste sites, they will rely on the RI data being collected from the

analogous representative waste sites in other OUs. The evaluation of that data and the associated conceptual models will be performed in the FS.

- Table C-5 – Lists the waste sites in which no conceptual contaminant distribution model has been developed. Thus, waste sites listed in Table C-5 will require development of new conceptual contaminant distribution models and additional characterization before the nature and vertical extent of contamination can be known and a reasonable remedial action alternative(s) can be selected.

4.1.1 Data Uses

Data generated during characterization of the representative sites and TSD units will consist mainly of soil contaminant data. These contaminant data will be used along with existing data from the 216-U-8 and 216-U-12 Cribs representative sites to define the nature and vertical extent of radiological and chemical contamination, support an evaluation of risks, and assist in the evaluation and selection of a remedial alternative. By defining the type and vertical distribution of contamination, the conceptual model for contaminant distribution can be verified or refined. The lateral extent of contamination is assumed to be confined within the site boundaries. Geophysical logging results can be used to evaluate the lateral extent of contamination in sites where existing boreholes are accessible and distant from the planned sampling locations. Additional evaluation of the lateral extent will be done during the confirmatory sampling phase as necessary to support remedial design. Verification of the current model will direct the application of the analogous site concept at the remaining 200-PW-2 and 200-PW-4 OU waste sites. A limited amount of data also will be collected to characterize the physical properties of soils that will be used to support an assessment of risk (e.g., RESidual RADioactivity [RESRAD] dose model or other risk modeling, as required [ANL 2002, *RESRAD for Windows*, Version 6.21]). Contaminant and soil property data will be obtained by sampling and analyzing soils.

In addition, representative waste site data from other OUs will be used to support conceptual models for contaminant distribution verification in certain of the consolidated OU waste sites as discussed in Section 4.1.

4.1.2 Data Needs

A considerable amount of information has been presented in Chapters 2.0 and 3.0 regarding the 200-PW-2 and 200-PW-4 OU waste sites. Existing data were sufficient to develop an understanding of radiological and chemical contaminant distribution for the 216-U-8 Crib and the 216-U-12 Crib. However, data are insufficient to develop a distribution model for the other six representative sites and TSD units. The most pertinent existing information was used to develop site-specific conceptual models for the 216-A-19 Trench, 216-B-12 Crib, 216-A-10 Crib, 216-A-36B Crib, 207-A South Retention Basin, and 216-A-37-1 Crib waste sites; additional information is provided by reference. For the representative waste sites and TSD units (and the other waste sites in the OUs in general), information is available regarding location, construction design, and major types of waste disposed. For several of the sites considerable data exist (those associated with 200-UP-2 OU investigation activities), while at

others soil data exist to a lesser extent (216-A-10, 216-A-36B, and 216-A-37-1 Cribs), or are almost nonexistent (216-A-19 Trench, 216-B-12 Crib, and 207-A South Retention Basin). Therefore, data are needed to verify and/or refine the contaminant distribution models at these six sites. These data are needed to support remedial decision making at these sites and at any analogous sites. As defined by the DQO process, the focus of the 200-PW-2 and 200-PW-4 OU RI is to determine the nature and extent of contamination in the vadose zone within the boundary of the representative waste sites and TSD units. Specifically, determinations of the type, concentration (particularly the highest concentration), and vertical distribution of radiological and chemical contamination in the vadose zone at the 216-A-19 Trench, 216-B-12 Crib, 216-A-10 Crib, 216-A-36B Crib, the 207-A South Retention Basin, and the 216-A-37-1 Crib are the major data needs. Data also are required to determine the physical properties of soils; these data will provide additional inputs to support an evaluation of risk through the use of models for fate and transport of contaminants through the vadose zone to groundwater, exposure to radionuclides, and exposure to chemicals.

4.1.3 Data Quality

Data quality was addressed during the DQO session. The data quantity and quality for the 216-U-8 and 216-U-12 Cribs were determined to be sufficient to support the RI/FS process. The COCs were identified for these sites based on data previously collected under an approved work plan (DOE/RL-95-13).

The process of identifying potential COCs is summarized in Section 3.6. Analytical performance criteria were established by evaluating potential ARARs and preliminary remediation goals (PRG), which are regulatory thresholds and/or standards or derived risk-based thresholds. These potential ARARs and PRGs represent chemical-, location-, and action-specific requirements that are protective of human health and the environment. Regulatory thresholds and/or standards or preliminary action levels provide the basis for establishing cleanup levels and dictate analytical performance levels (i.e., laboratory detection-limit requirements). Detection-limit requirements and standards for precision and accuracy are used to define data quality.

To provide the necessary data quality, detection limits should be lower than preliminary action levels. Additional data quality is gained by establishing specific policies and procedures for the generation of analytical data and field quality assurance/quality control requirements. These requirements are discussed in detail in the SAP (Appendix B). Analytical performance requirements are specified in Table 3-6 of the DQO summary reports (BHI-01411 and CP-14176) and in Table B-3 of the SAP. The potential ARARs and PRGs for 200 Areas waste sites are discussed in Chapters 4.0 and 5.0 of the Implementation Plan (DOE/RL-98-28).

4.1.4 Data Quantity

Data quantity refers to the number of samples collected. The number of samples needed to refine the site conceptual model and make remedial decisions is based on a biased sampling approach. Biased sampling is the intentional location of a sampling point within a waste site, based on process knowledge of the waste stream and expected behavior of the potential COC(s). It is the preferred sampling approach as defined in Section 6.2.2 of the Implementation Plan

(DOE/RL-98-28) for the RI phase. Using this approach, sampling locations can be selected that increase the chance of encountering the highest contamination in the local soil column.

Sample locations at the representative sites and TSD units were selected based on the preliminary conceptual models of contaminant distribution presented in the DQO summary reports. A single borehole location in each of the six representative sites and TSD units identified in the previous section was selected for sampling, with the exception of the 207-A South Retention Basin where several shallow boreholes will be sampled. The locations were selected with the goal of intersecting the highest areas of contamination and to determine the type and vertical extent of contamination at the representative sites. Because the 216-A-19 Trench being investigated covers a relatively small area, lateral extent of contamination within the site boundary is not required. At the 216-B-12 Crib, geophysical logging at existing boreholes within the crib will be used to guide placement of the borehole. At the 216-A-10 Crib, geophysical logging at six locations along the length of the crib will help to determine the location for the borehole. For the 216-A-36B Crib, the lateral extent of contamination within the site boundaries will be evaluated with a borehole and augmented with geophysical logging. At the 216-A-37-1 Crib, the borehole will be placed near the inlet, which also happens to be topographically at a lower elevation than the remainder of the crib. For the 207-A South Retention Basin, shallow boreholes will be drilled through the concrete basin at locations near the basin drain structures. Soil samples will be taken at each representative site and TSD unit from a deep borehole (to near the groundwater table) (except the 207-A South Retention Basin) and will be collected from different depths at the waste site to evaluate the vertical extent of contamination. Extra soil samples may be collected as warranted by observations such as changes in lithology, visual indications of contamination, and field screening results. This biased sampling approach was designed to provide the data needed to meet DQOs for this phase of the RI/FS process.

4.2 CHARACTERIZATION APPROACH

This section provides an overview of characterization activities that are planned to collect the required data identified in the DQO process. These activities include borehole drilling and sampling and geophysical logging using spectral gamma and neutron moisture tools. Sample analysis will be conducted by an onsite or offsite laboratory under a contract-required quality program. The sampling strategy is designed to provide access to potentially contaminated subsurface areas. Sample collection will be guided by field screening and a sampling scheme that identifies critical sampling depths.

4.2.1 Geophysical Logging Through Direct-Push Holes

The location of the area of highest potential contamination within the 216-A-10 Crib is uncertain because of the manner in which effluent was discharged to the crib. Therefore, locating the borehole for this site requires some preliminary geophysical logging activities to target the area of highest contamination. A series of up to six direct-push (e.g., GeoProbe® or cone

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penetrometer) holes or drill casings will be installed and logged with a gamma detector. The location of the borehole will be identified based on the results of this logging. The depth of direct-push holes may be limited based on subsurface conditions (i.e., cobbles, gravel). The holes will be pushed to a maximum depth of approximately 27 m (90 ft) bgs (or approximately 14 m [45 ft] below the crib bottom). 14 m (45 ft) below the crib is considered sufficient to locate the zone of highest contamination, which is expected to be above 27 m (90 ft) bgs as shown in the conceptual contaminant distribution model for this site (Figure 3-15).

4.2.2 Drilling and Sampling

The 216-A-19 Trench borehole will be drilled and sampled from a location near the center of the crib to a depth just above the groundwater table (Figure 4-1). Surface geophysical methods will be used to help locate the trench boundaries. Alternately, direct-push holes or drive casings may be installed and logged to help determine the area of highest contamination. The 216-B-12 Crib borehole will be located with the support from geophysical logging of existing boreholes within the crib (Figure 4-2). The borehole at the 216-A-10 Crib will be located near the direct-push hole with the maximum indication of contamination based on the geophysical logging as described in Section 4.2.1 (Figure 4-3). The 216-A-36B Crib borehole will be drilled and sampled from a location near the north end of the crib to maximize the effects that contaminants from the adjacent 216-A-36A Crib will have on the vadose zone (Figure 4-3). The borehole at the 216-A-37-1 Crib will be located near the head end of the crib in an area topographically lower than the rest of the crib (Figure 4-4). Each of these five boreholes also will be drilled to a depth just above the groundwater table. These locations were chosen to target the areas of maximum contamination within each site. Therefore, the sediments that will be collected should provide a worst case scenario for maximum contamination levels at depth. Boreholes/ groundwater wells not labeled on Figures 4-1 through 4-4 are not pertinent to the discussion of the representative waste site because of the absence of any data or being located within another waste site. Maps within the Hanford Site Atlas (BHI-01119) can be used to identify the borehole/groundwater well numbers. Boreholes to be installed at the 207-A South Retention Basin are to be located adjacent to drains in the three basins, and at one potential crack location, to maximize the probability of intercepting contamination that may be found in the subsurface under the concrete structure of the basin.

The sample collection strategy has been designed to characterize the vadose zone materials beneath the sites to the top of the groundwater table. Sampling generally will begin at the first sign of radiological contamination, as determined by field measurements. This contamination is expected to begin at the historic bottom of the site (i.e., crib or trench bottom), but if contamination is detected in backfill materials above the waste site bottom, the backfill materials also will be sampled. Borehole soil samples typically will be collected at more frequent intervals from the effluent release point (i.e., the bottom of the crib or trench), then at decreasing frequency with depth. Samples that were identified as critical during the DQO process also will be collected at 4.6 m (15 ft) bgs. For excavation and disposal sites, the decision-making depth is 4.6 m (15 ft), as directed by WAC 173-340 direct exposure requirements. A 7.6-m (25-ft) bgs sample also is identified as a desirable sample for determining the cost effectiveness of placing a barrier over a waste site versus the excavation of contaminants. For containment sites, cost models show that RCRA surface barriers can become more cost effective than excavation in the 7.6- to 9.1-m (25- to 30-ft) depth range. Additional samples may be collected at the discretion of

the geologist/sampler based on field screening and geologic information (e.g., changes in lithology). A detailed sample schedule for each borehole is presented in the SAP (Appendix B).

All drilling will be via procedures approved by Fluor Hanford or via qualified subcontractor procedures and will conform to site-specific technical specifications for environmental drilling services. The drill rig generally will require a 23-m (75-ft) square pad with a 5-m (16-ft)-wide access road. Cleaning and decontamination requirements also will be performed according to Fluor Hanford-approved procedures.

Likely drilling methods for this project include cable tool, sonic, and diesel hammer. The drilling method must allow the use of a 13-cm (5-in.) outside-diameter split-spoon sampler. Use of a split-spoon sampler will necessitate compositing the sample over most or all of the sampler to obtain enough sample volume for analysis. The drilling method must not use any system that circulates air or water. Air-based drilling methods may compromise the sample collection and data quality for volatile constituents through the introduction of air to the soils. Controlling contamination with these methods is difficult, potentially increasing risks to workers. In addition, the air circulated in these methods may dry out the formation and negatively impact the moisture-logging activities. If a drilling method other than cable tool drilling will be used, Ecology will be notified.

All five boreholes will be drilled to the top of the water table. The maximum total depth of the investigation below ground surface is approximately as follows: the 216-A-19 Trench will be 76 m (250 ft), the 216-B-12 Crib will be 91 m (300 ft), the 216-A-10 Crib and 216-A-36B Crib both will be 97 m (320 ft), and the 216-A-37-1 Crib will be 84 m (275 ft). In the boreholes, the presence of water-saturated soils at the expected water table elevation will indicate the end of the borehole. This will be determined by the site geologist. Up to three strings of casing may be telescoped to the proposed depth to minimize the transport of contaminants in the vadose zone from the drilling operations. The casing will be of sufficient size to accommodate a split-spoon sampler and geophysical logging tools to the bottom of the borehole. Downsizing of the casing will be commensurate with the expected decrease in contamination levels with depth. Actual conditions during drilling may warrant changes; the changes may be implemented after consultation with and the approval of the task lead and the subcontract technical representative. All casings will be removed from the boreholes when drilling and sampling are completed. If required to support Hanford Site groundwater monitoring needs, boreholes may be completed as wells, and samples of groundwater may be taken. Otherwise, the borehole will be backfilled with bentonite or an appropriate alternative decommissioning procedure in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

At the 207-A South Retention Basin it is anticipated that samples of the concrete will be obtained by drilling several co-located holes to collect enough concrete debris for analysis at each location. Removal of sufficient remaining concrete to expose the underlying soils will be performed by using either cutting or coring methods. Once the concrete in the basin is removed, a direct-push (e.g., GeoProbe) or similar method will be used to obtain samples from the three, or possibly four, boreholes that will be required to go to a depth of 6 m (20 ft) bgs. The boreholes will be backfilled with bentonite or an appropriate alternative decommissioning procedure in accordance with WAC 173-160.

4.2.3 Field Screening

All samples and/or cuttings from the boreholes will be field screened for evidence of radionuclides. Radioactivity screening of the soils will assist in the selection of sampling intervals (in addition to those already identified as critical sampling depths).

4.2.4 Analysis of Soil

Soil samples via split-spoon samplers will be collected for nonradiological and radionuclide analysis and the determination of select soil properties. The list of analytes for this investigation was developed based on an evaluation of all potential contamination that was discharged to the waste sites. Development of this list of COCs is presented in Section 3.6, Table 3-7, and in the DQO summary reports (BHI-01411 and CP-14176). Tables B-3 and B-4 of the SAP (Appendix B) list details of the analytical methods, holding times, and quality assurance and quality control procedures for each contaminant. A limited number of samples also will be analyzed to determine soil physical properties, such as moisture content and particle size.

4.2.5 Soil Vapor Sampling

As drilling at the 207-A South Retention Basin proceeds, the industrial hygiene technician who is present will monitor for volatile organics in the vicinity of the boreholes. As the concrete of the basin is removed, the technician will monitor the air space immediately below the concrete. If any detections are made, a soil sample will be taken for volatile organic analysis. If volatile organics continue to be present during the drives to 20 ft, it will be necessary to drive a soil gas sampling probe to depth (after soil sampling has been completed) to obtain a soil gas sample for analysis.

At the 216-A-37-1 Crib, continuous monitoring for volatile organics will be performed by an industrial hygiene technician. The industrial hygiene technician will monitor the air space immediately surrounding the borehole as the borehole drilling proceeds and during soil-sample removal. If volatile organics are detected during drilling, it will be necessary to install a packer system into the borehole casing to obtain a vapor sample before drilling resumes. This separate soil gas sample will be necessary to determine the nature of the volatile organics that are present.

Vapors will be collected in Tedlar® bags and delivered to an onsite laboratory for analysis using a B&K[1] gas monitor or other field screening instrument that can differentiate carbon tetrachloride and chloroform at the target-required quantitation limits. No offsite analyses will be performed for any of the vapor analyses. The COC for vapor sampling is carbon tetrachloride. Chloroform is a degradation product of carbon tetrachloride that also will be reported. Tables B-4 and B-5 of the SAP in Appendix B list the details of the analytical

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[1] B&K is a trademark of Brüel and Kjær, Nærum, Denmark.

methods, holding times, and quality assurance and quality control procedures for the contaminants.

4.3 GEOPHYSICAL LOGGING

The five boreholes (described in Section 4.2.2) will be logged with a high-resolution spectral gamma-ray logging system to provide continuous vertical logs of gamma-emitting radionuclides, and with a neutron moisture-logging system to identify moisture changes. In addition to the logging performed on the new borings, spectral gamma logging is proposed in existing wells near the 216-B-12, 216-U-8, 216-U-12, 216-A-10, 216-A-36B, and 216-A-37-1 Cribs waste sites. The spectral gamma logging of existing wells in the vicinity of a waste site can be a cost-effective method of providing supplemental data on the vertical and lateral distribution of gamma-emitting radionuclides, provided that the wells are located sufficiently close to the waste site and are appropriately constructed (e.g., single well casing in contact with the formation). The spectral gamma logging system uses instrumentation to identify and quantify gamma-emitting radionuclides in wells as a function of depth.

The neutron moisture-logging system that measures moisture employs a weak radioactive neutron source and neutron detector to provide a direct reading of hydrogen atom distribution in the soil surrounding the borehole. This detector will be used to measure continuous vertical moisture in the vadose zone.

The spectral gamma logs will be used to supplement the laboratory radionuclide data to determine the vertical distribution of radionuclides in the vadose zone beneath the units and to aid in geological interpretation of subsurface stratigraphy. The deep boreholes will be logged through the casing before a new casing string is added and after the well has reached total depth. The spectral gamma logging equipment calibration is conducted annually, and the data acquired during the calibrations are used to derive factors that convert measured peak-area count rate to radionuclide concentrations in picocuries per gram. Corrections are applied to the data to compensate for the gamma ray attenuation by the casing. A list of wells to be logged is identified in the SAP (Appendix B).

Logging runs will be made before the casing sizes are changed and at the total depth of the borehole. The downhole tools and cable will be subject to the same rules as are the drill rig and equipment. The downhole tools and cable will be cleaned between boreholes. The upper part of each borehole will be the most contaminated and will be logged first. The site geologist will record the types of geophysical surveys and the depth intervals of initial and repeat runs on form A-6003-658, "Well Construction Summary Report," per CP-GPP-EE-02-14.0, *Drilling, Maintaining, Remediation, and Decommissioning Resource Protection Wells, Geoprobe, and Geotechnical Soil Borings*.

Existing wells in the vicinity of representative sites and TSD units may be logged with the gamma ray logging tool. The construction of the existing wells near these waste sites was evaluated to determine if geophysical logging would provide useful information. Existing wells with annular seals containing bentonite, cement, or other well construction materials or contoured double casings cannot be used for logging. Logging, therefore, only will be conducted in existing wells that have one casing string and lack annular seals. Data from these wells will

provide a better indication of formation contacts, grain size changes, and contamination. A list of the wells to be logged is identified in the SAP (Appendix B).

Figure 4-1. Sample Location Map for the 216-A-19 Trench.

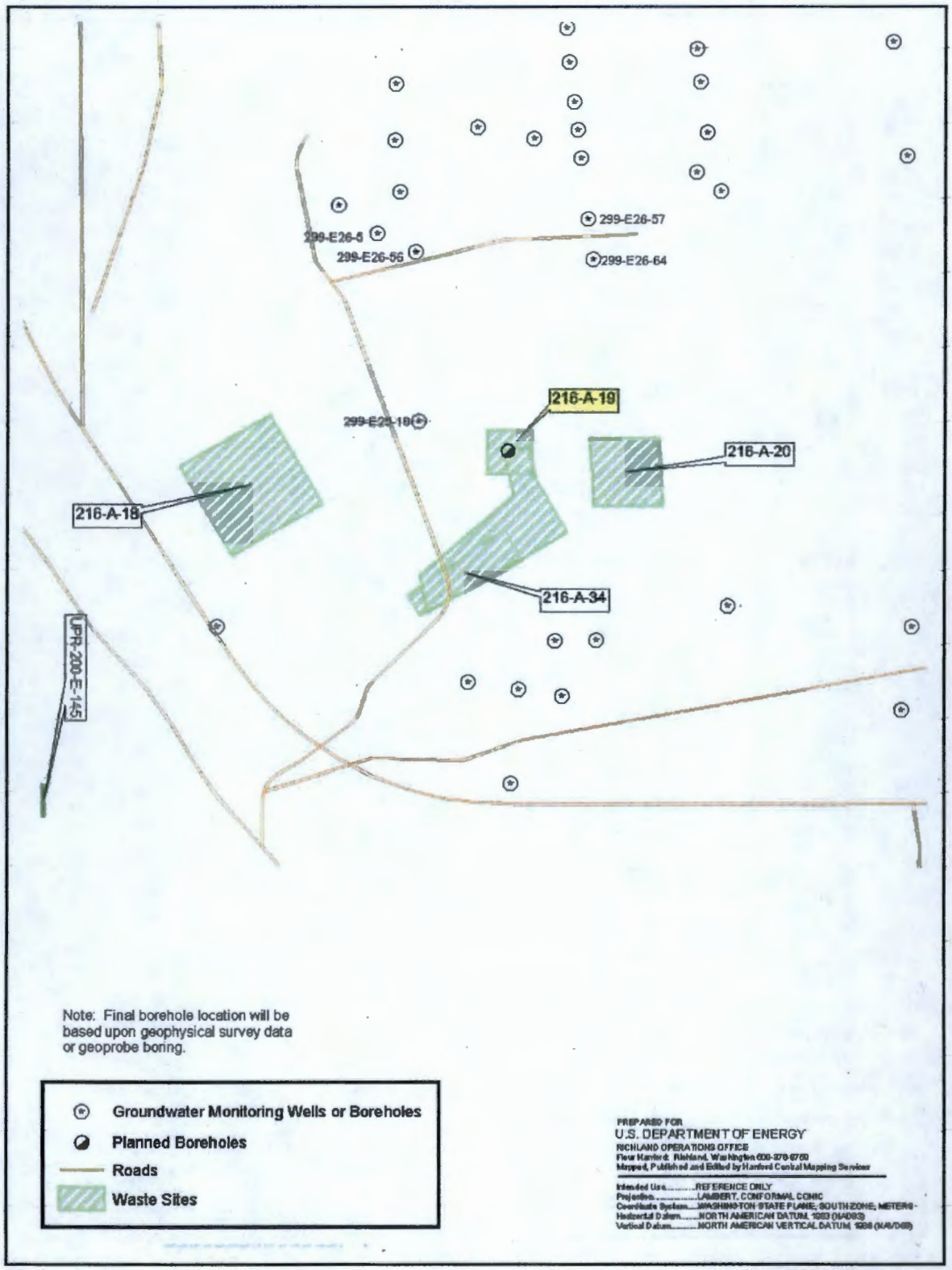


Figure 4-2. Sample Location Map for the 216-B-12 Crib.

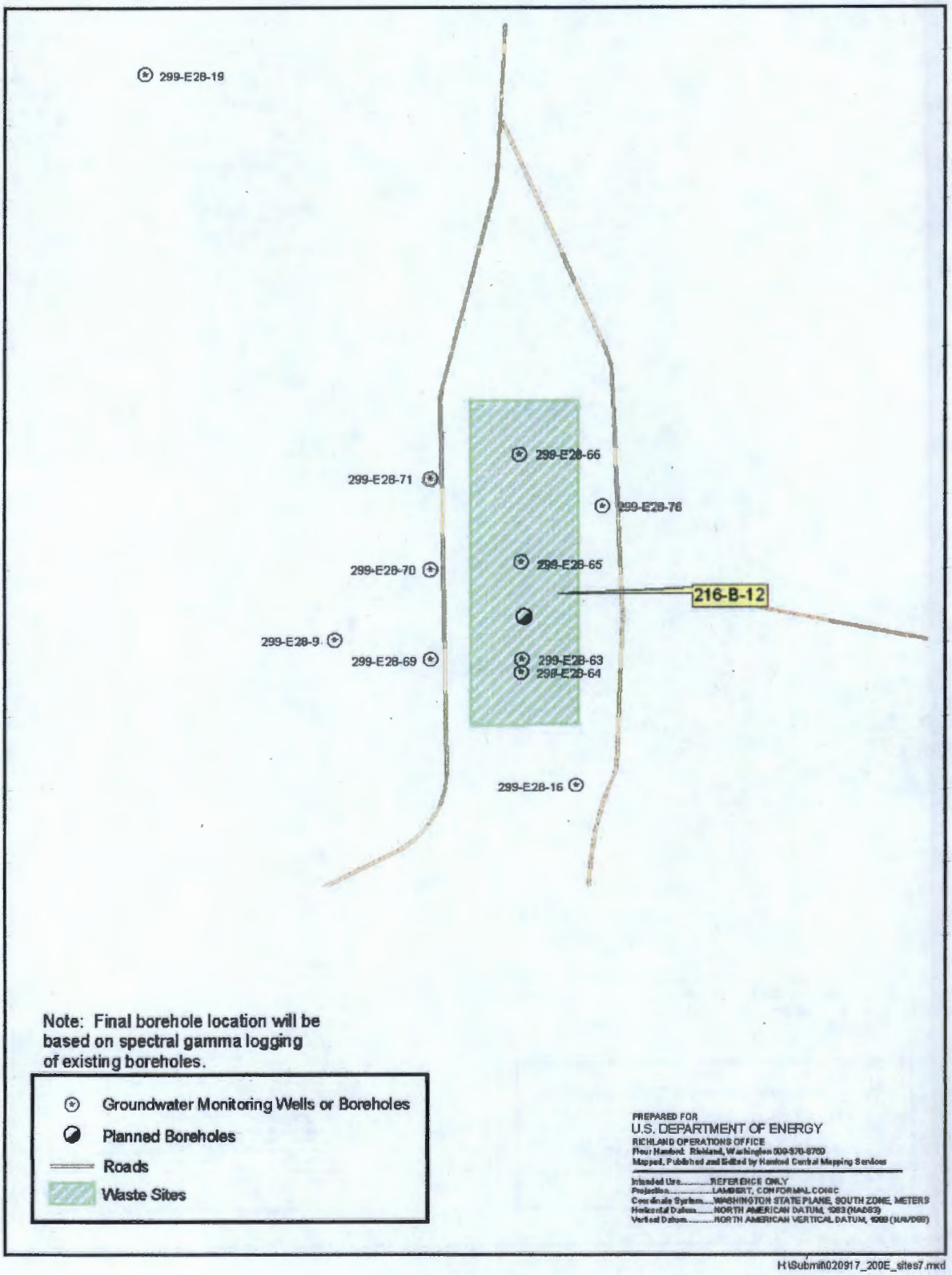


Figure 4-3. Sample Location Map for the 216-A-10 Crib and 216-A-36B Crib.

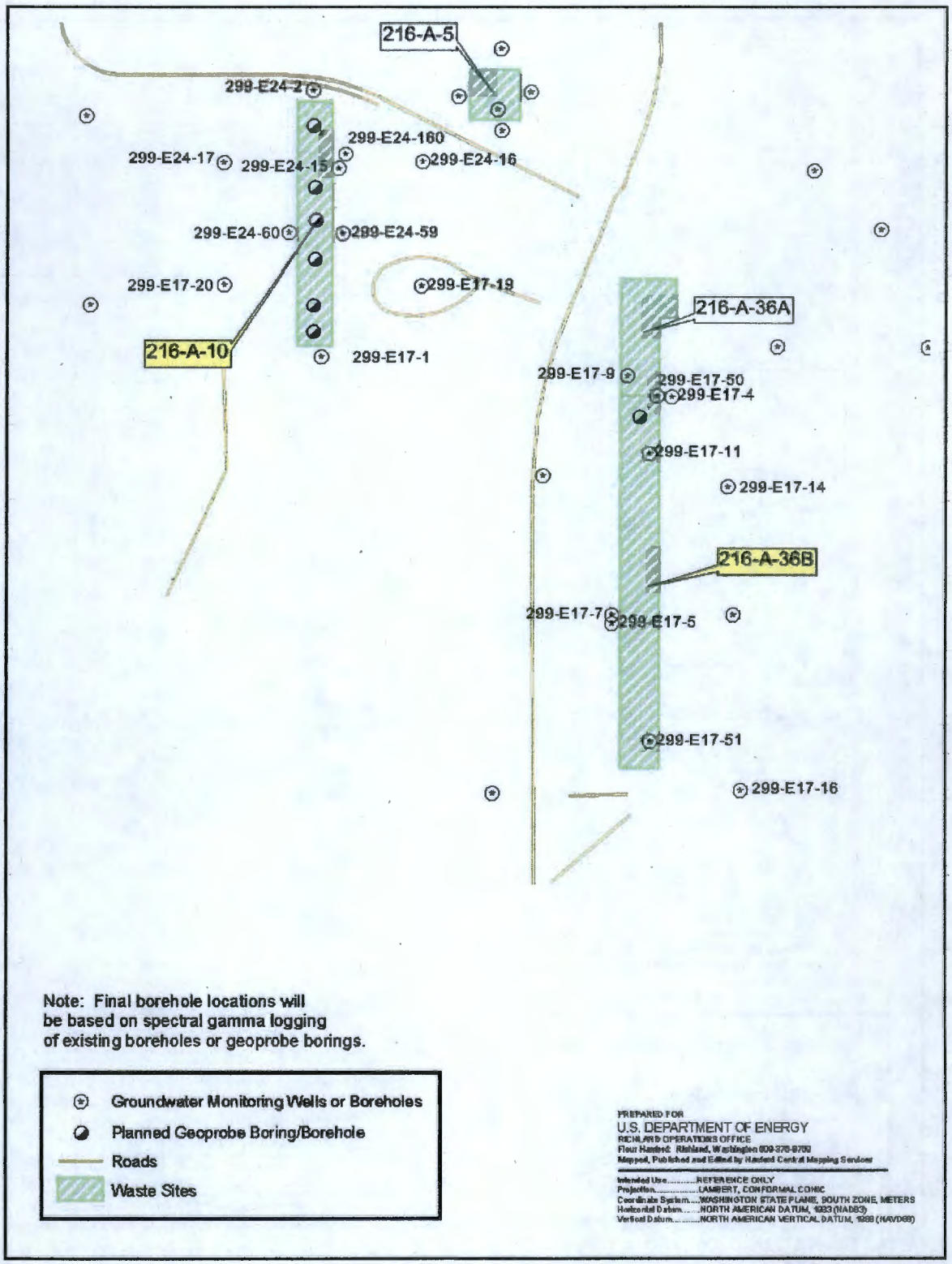
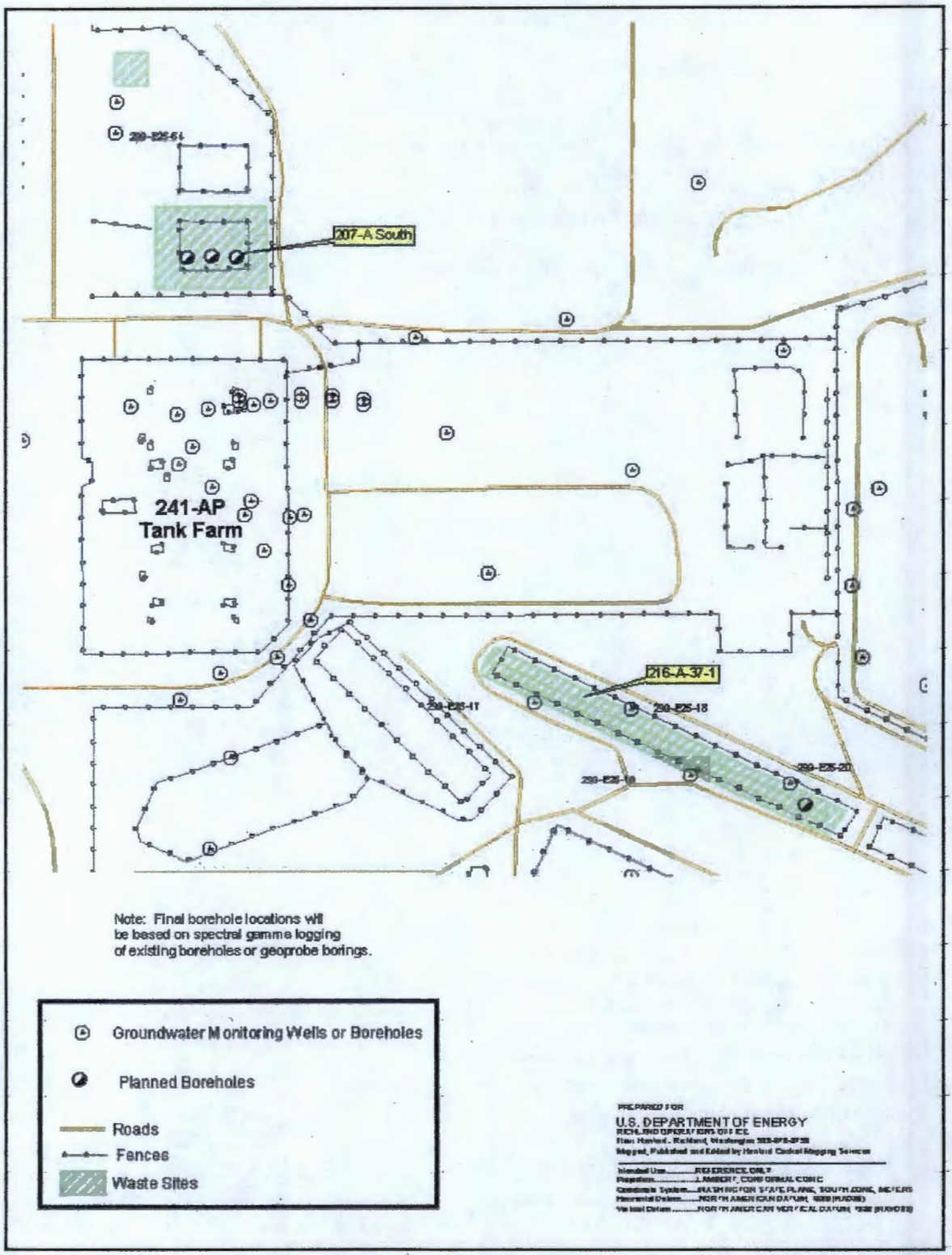


Figure 4-4. Sample Location Map for the 207-A South Retention Basin and the 216-A-37-1 Crib.



5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROCESS

This section describes the RI/FS (assessment) process for the 200-PW-2 and 200-PW-4 OUs. The development of and rationale for this process are provided in the Implementation Plan (DOE/RL-98-28) and are summarized in Figure 1-1. The process follows the CERCLA format with modifications to concurrently satisfy the requirements specific to RPP waste sites and RCRA TSD units undergoing closure. A summary of the integrated regulatory process is provided in Section 5.1.

Section 5.2 outlines the tasks to be completed during the RI phase, including planning and conducting field sampling activities and preparing the RI report. These tasks are designed to effectively manage the work, satisfy the DQOs (identified in Chapter 4.0), document the results of the RI, and manage the waste generated during field activities. The general purpose of the RI is to characterize the nature, extent, concentration, and potential transport of contaminants and to provide data to determine the need for and type of remediation. The detailed information that will be collected to carry out these tasks is presented in the SAP (Appendix B).

Tasks to be completed following the RI include an FS/closure plan (Section 5.3), a proposed plan, and proposed RCRA Permit (WA7890008967) modification for RCRA TSD units, followed by an ROD and a RCRA permit modification for RCRA TSD units (Section 5.4).

Project management occurs throughout the RI/FS process. Project management is used to direct and document project activities (so that the objectives of the work plan are met) and to ensure that the project is kept within budget and on schedule. The initial project management activity will be to assign individuals to roles established in Section 7.2 of the Implementation Plan. Other project management activities include day-to-day supervision of and communication with project staff and support personnel; meetings; control of cost, schedule, and work; records management; progress and final reports; quality assurance; health and safety; and community relations.

Appendix A of the Implementation Plan provides the overall quality assurance framework that was used to prepare an OU-specific quality assurance project plan for the 200-PW-2 and 200-PW-4 OU RI (Appendix A, Section A2.0). Appendix C of the Implementation Plan reviews data management activities that are applicable to the 200-PW-2 and 200-PW-4 OU RI/FS and describes the process for the collection/control of data, records, documents, correspondence, and other information associated with OU activities.

5.1 INTEGRATED REGULATORY PROCESS

Because the 200 Areas are composed of CERCLA Past Practice, RCRA Past Practice, and Treatment, Storage and Disposal sites, the Tri-Parties have committed that the cleanup strategies will be integrated to the maximum extent possible. This is consistent with specific recommendations for integration in the Tri-Party Agreement, Section 2.4 of the Implementation Plan (DOE/RL-98-28), and can be accommodated under the Hanford Facility RCRA Permit.

5.2 REMEDIAL INVESTIGATION ACTIVITIES

This section summarizes the planned tasks that will be performed during the RI phase for the 200-PW-2 and 200-PW-4 OUs, including the following:

- Planning
- Field investigation
- Management of investigation-derived waste
- Laboratory analysis and data validation
- Preparing an RI report.

These tasks and subtasks reflect the work breakdown structure that will be used to manage the work and to develop the project schedule discussed in Chapter 6.0.

5.2.1 Planning

The planning subtask includes activities and documentation that need to be completed before field activities can begin. These include the preparation of a job hazard analysis and a site-specific health and safety plan (HASP), radiation work permits, excavation permits and supporting surveys (e.g., cultural, radiological, wildlife, and utilities), work instructions, personnel training, and the procurement of materials and services (e.g., drilling and geophysical logging services). In addition, borehole locations identified in Figures 4-1 through 4-4 will be located using a global positioning satellite system.

Appendix B of the Implementation Plan (DOE/RL-98-28) provides a general HASP that outlines health and safety requirements for RI activities. Site-specific HASPs will be prepared for test pit excavation and drilling following the requirements of the general HASP. Initial surface radiological surveys will be performed to document any radiological surface contamination and the background levels in and around the sampling locations. This information will be used to document initial site conditions and prepare HASPs and radiation work permits.

5.2.2 Field Investigation

The field investigation task involves data-gathering activities performed in the field that are required to satisfy DQOs. The field characterization approach is summarized in Section 4.2 and is detailed in the SAP (Appendix B). The scope includes soil/sediment sampling and analysis to characterize the vadose zone at the two representative RPP waste sites (216-A-19 Trench and 216-B-12 Crib) and the other four RCRA TSD units (216-A-10 Crib, 216-A-36B Crib, 216-A-37-1 Crib, and 207-A South Retention Basin).

Major subtasks associated with the field investigation include the following:

- Borehole drilling and sampling and associated geophysical logging
- Preparing field reports.

5.2.2.1 Borehole Drilling and Sampling

This subtask involves drilling boreholes for the purpose of collecting soil and sediment samples and creating a geophysical log of the borehole. Five boreholes are planned to collect samples at a depth to the top of the groundwater table at five waste sites (216-A-19 Trench, 216-B-12 Crib, 216-A-10 Crib, 216-A-36B Crib, and 216-A-37-1 Crib). Samples will be collected with split-spoon samplers and packaged for shipment to an onsite or offsite laboratory. At the completion of sampling, the boreholes will be decommissioned and initial site conditions will be reestablished. Alternatively, the borehole may be completed as a groundwater monitoring well, if needed by the Hanford Site groundwater monitoring program. Other activities include work zone setup, equipment mobilization/demobilization, equipment decontamination, and field analyses. Planned field analyses include radiological field screening, pH, bulk density, and geophysical logging. In addition, as discussed in the 200-PW-4 DQO report (CP-14176), at the 207-A South Retention Basin several shallow borings will be installed to a depth of approximately 6 m (20 ft) bgs. Activities similar to those at the deeper boreholes will be conducted.

All samples and drill cuttings will be field screened (i.e., additional field screening analyses) for radionuclides to provide additional characterization data, to assist in the selection of sample intervals (e.g., hot spots), to assist in establishing radiation control measures, and for worker health and safety. Monitoring of volatile organic compounds also may be performed at the borehole casing for worker health and safety.

Geophysical logging will be used to gather in situ radiological concentrations and moisture content data from the planned boreholes and from several existing wells. Spectral gamma logging will be performed on planned boreholes and at a number of existing wells, as identified in the SAP, to assess the distribution and type of gamma-emitting radionuclides, and neutron logging will be performed for moisture content distribution over the borehole or well interval.

5.2.2.2 Preparation of Field Reports

At the completion of the field investigation, a field report will be prepared to summarize the activities performed and the information collected in the field. The report will include survey data for borehole locations, the number and types of samples collected and associated Hanford Environmental Information System database numbers, inventory of investigation-derived waste containers, geological logs, field screening results, and geophysical logging results.

5.2.3 Management of Investigation-Derived Waste

A waste designation DQO activity will be performed before the initiation of the characterization activities to ensure that the proper information is collected during the field investigation to support the designation of all project investigation-derived waste. During the investigation-derived waste DQO activity, any listed waste issues also will be resolved. Any additional sampling requirements or analytes needed to support designation activities will be identified and implemented through the waste designation DQO summary report that will be prepared at that time.

Waste generated during the RI will be managed in accordance with a waste control plan to be prepared for the OUs. Appendix E of the Implementation Plan (DOE/RL-98-28) provides general waste management processes and requirements for the investigation-derived waste and forms the basis for activity-specific waste control plans. The waste control plan addresses the handling, storage, and disposal of investigation-derived waste generated during the RI phase. Furthermore, the plan identifies governing procedures and discusses the types of waste expected to be generated, the waste designation process, and the final disposal location.
The investigation-derived waste management task begins at the start of the field investigation, when investigation-derived waste is first generated, through waste designation and disposal.

5.2.4 Laboratory Analysis and Data Validation

Soil and sediment samples collected from the boreholes will be analyzed for a comprehensive suite of radionuclides and chemicals and for select physical properties, based on established DQOs and as defined in the SAP (Appendix B). The list of analytes, methods, and associated target detection limits is provided in Table B-4 of the SAP (Appendix B). This task includes laboratory analysis of samples, compilation of laboratory results in data packages, and validation of a representative number of laboratory data packages.

5.2.5 Remedial Investigation Report

This section summarizes data evaluation and interpretation subtasks leading to the production of an RI report. The primary activities include performing a data quality assessment; evaluating the nature, extent, and concentration of contaminants based on sampling results; assessing contaminant fate and transport; refining the site conceptual models; and evaluating risks through a QRA. These activities will be performed as part of the RI report preparation task.

5.2.5.1 Data Quality Assessment

A data quality assessment will be performed on the analytical data to determine if the data are the right type, quality, and quantity to support the intended use. The data quality assessment completes the data life cycle of planning, implementation, and assessment that began with the DQO process. For this task, the data will be examined to determine if they meet the analytical quality criteria outlined in the DQO and to determine if the data are adequate to evaluate the decision rules in the DQO.

5.2.5.2 Data Evaluation and Conceptual Model Refinement

This task will include evaluating the information collected during the investigation.
The chemical and radiological data obtained from the boreholes will be compiled, tabulated, and statistically evaluated to gain as much information as possible to satisfy the data needs.
Data evaluation tasks may include the following:

- Graphically evaluating the data for vertical distribution of contamination within each borehole

- Stratifying the data and computing basic statistical parameters such as mean and standard deviation for individual levels. This will provide an indication of lateral and vertical contaminant distribution

- Constructing contour diagrams and variograms to evaluate spatial correlations within each stratum, which will indicate if contamination is concentrated in a particular area (e.g., near the influent end for the units, or at the head end of the ditches)

- Performing analyses on the data to evaluate the presence or absence of contamination. There are many facets to this step, including determining data distribution and selecting the appropriate statistical tests. The initial screening for contamination should evaluate the data with respect to background by using simple comparisons of an upper bound of the data to background concentrations or more complex comparisons such as nonparametric hypothesis tests (e.g., Wilcoxon Rank-Sum Test). These tests also may compare the data to appropriate cleanup levels.

- For RCRA TSD units, the data collected during the RI also will be evaluated against WAC 173-303-610 performance standards.

All of these statistical evaluations will aid in refining the conceptual model for these OUs and selecting the remedial alternative. However, because the sites within these OUs generally represent point-source-type releases, statistical analysis many not always be possible. Single boreholes are planned at the sites. If the data are not sufficient for statistical analysis, maximum or average concentrations will be used in the data evaluation process.

If contaminants not identified as COPCs are detected during laboratory analysis, the data will be evaluated against regulatory standards (or risk-based levels if exposure data are available) and existing process knowledge in support of remedial action decision making.

Data on the soil physical properties will be used to determine the sediment type, which will assist in choosing the proper unsaturated hydraulic conductivity/moisture retention curve. Knowing the soil type and soil moisture will allow the determination of unsaturated hydraulic conductivity, which will be used in modeling flow and transport (see Section 5.3.5.3).

The chemical, physical, and geophysical data will be used for correlating subsurface data, for further refining the conceptual model, and as input to a QRA.

5.2.5.3 Risk Assessment

The Tri-Parties recently undertook the task of developing a risk framework to support risk assessments in the Central Plateau. This included a series of workshops with representatives from DOE, EPA, Ecology, the Hanford Advisory Board (HAB), the Tribal Nations, the State of Oregon, and other interested stakeholders. The workshops focused on the different programs involved in activities in the Central Plateau and the need for a consistent application of risk assessment assumptions and goals. The results of the risk framework are documented in HAB advice #132 (HAB 132, "Exposure Scenarios Task Force on the 200 Area"), in the Tri-Parties response to the HAB advise (Klein et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area"), and in HAB 2002, *Report of the Exposure Scenarios Task Force.*

The following items summarize the risk framework description from the Tri-Parties response to the HAB.

1. The Core Zone (200 Areas including B Pond (main pond) and S Pond) will have an industrial scenario for the foreseeable future.

2. The Core Zone will be remediated and closed, allowing for "other uses" consistent with an industrial scenario (environmental industries) that will maintain active human presence in this area, which in turn will enhance the ability to maintain the institutional knowledge of waste left in place for future generations. Exposure scenarios used for this zone should include a reasonable maximum exposure to a worker/day user, to possible Native American users, and to intruders.

3. DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and remedial action objectives. It is anticipated that groundwater contamination under the Core Zone will preclude beneficial use for the foreseeable future, which is at least the period of waste management and institutional controls (150 yr). It is assumed that the tritium and I-129 plumes beyond the Core Zone boundary will exceed the drinking water standards for the period of the next 150 to 300 yr (less for the tritium plume). It is expected that other groundwater contaminants will remain below, or be restored to, drinking water levels outside the Core Zone.

4. No drilling for water use or otherwise will be allowed in the Core Zone. An intruder scenario will be calculated for in assessing the risk to human health and environment.

5. Waste sites outside the Core Zone but within the Central Plateau (200 North Area, Gable Mountain Pond, B/C Crib Controlled Area) will be remediated and closed based on an evaluation of multiple land-use scenarios to optimize land use, institutional control cost, and long-term stewardship.

6. An industrial land-use scenario will set cleanup levels on the Central Plateau. Other scenarios (e.g., residential, recreational) may be used for comparison purposes to support decision making, especially for:
   - The post-institutional controls period (>150 yr)
   - Sites near the Core Zone perimeter to analyze opportunities to "shrink the site"
   - Early (precedent-setting) closure/remediation decisions.

7. This framework does not deal with the tank retrieval decision.

These items form the basis for the OU risk assessments to be conducted in the RI and FS reports.

5.2.5.3.1 Human Health Risk Assessment

For the 200-PW-2 and 200-PW-4 OUs, a quantitative, baseline human health risk assessment for the representative sites will be prepared, as part of the RI report, to evaluate risk to human receptors from potential exposure to contaminants in accessible surface sediments and shallow subsurface soils. The risk assessment also will evaluate the potential for contaminants currently

in the vadose zone beneath the waste sites to impact groundwater in the future. Risks from current groundwater contamination will not be evaluated; this evaluation will be conducted as part of the RI/FS process for the groundwater OUs.

The risk assessment in the RI report will focus on the representative sites, because data collected through the RI at these sites are sufficient to allow quantification of risk. The risk assessment will follow the risk guidelines identified through the Risk Framework workshops as documented in the Tri-Parties response to HAB Advice #132 (Klein et al 2002).

The human health risk assessment will be conducted in accordance with WAC-173-340-745 and WAC-173-340-747 and with the following DOE and EPA guidance documents:

- *Hanford Site Risk Assessment Methodology* (DOE/RL-91-45)
- *Risk Assessment Guidance for Superfund (RAGS), Volume I -- Human Health Evaluation Manual, Part A (Interim Final),* (EPA/540/1-89/002)
- *Risk Assessment Guidance for Superfund, Vol. I Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, (Interim Final)* (OSWER Directive 9285.6-03) (EPA 1991)
- *Exposure Factors Handbook* (EPA/600/P-95/002Fa)
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim* (EPA/540/R-99/005)
- *Proposed Guidelines for Carcinogen Risk Assessment* (EPA/600/P-92/003C)
- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (OSWER Directive 9285.7-081) (EPA 1992).

Risks initially will be evaluated by comparison to risk-based standards such as WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties." Contaminants present at concentrations exceeding these risk-based standards will be considered further in the risk assessment process. Risks from nonradiological noncarcinogens will be evaluated by calculating hazard quotients (HQ) for individual constituents and a hazard index (HI) for cumulative risk. Risks from nonradiological carcinogens and radionuclides will be evaluated by calculating incremental cancer risks for individual constituents and a cumulative cancer risk.

The computer program RESRAD (ANL 2002) will be used to obtain dose estimates from direct-contact exposure to radiological constituents present in the shallow zone of the waste sites. The RESRAD model also will be used to obtain dose estimates for the protection of the groundwater pathway. The results obtained from the RESRAD model for the groundwater protection model are limited to screening purposes only. Additional analysis will be performed using an appropriate fate and transport model (e.g., STOMP [PNNL-11216, *STOMP -- Subsurface Transport Over Multiple Phases: Application Guide*]) to assess impact to the groundwater from chemicals and radionuclides in the vadose zone.

Because waste sites in the 200-PW-2 and 200-PW-4 OUs all are located inside the 200 Areas boundary, risk assessment will be performed for an industrial-exposure scenario to establish the baseline risk. As part of the FS, additional risk assessment may be performed to evaluate other scenarios, such as a Native American scenario or an intruder scenario, to evaluate post-remediation residual risks.

5.2.5.3.2 Ecological Risk Assessment

The screening-level ecological risk assessment in DOE/RL-2001-54 is meant to be a conservative evaluation of risk to ecological receptors from stressors, in this case the introduction of contaminants and habitat elimination. The screening–level ecological risk assessment identifies pathways for ecological receptors to be exposed to the contamination and evaluates potential risk from those exposures. The following describes the information found in specific sections of DOE/RL-2001-54.

Chapter 2.0 of DOE/RL-2001-54 describes the physical and ecological setting of the Central Plateau and identifies important aspects of the ecology and the condition of the waste sites to consider during the ecological risk assessment. For instance, while most waste sites are in a disturbed habitat with little vegetation to support wildlife, the nearby shrub-steppe offers a more habitable location for wildlife and needs protection in this region because of the encroachment and elimination of this habitat in other parts of eastern Washington. Individual species whose populations are limited and are designated as sensitive species also must be protected. Recent surveys of the biological diversity on the Hanford Site have identified a number of new-to-science species, and the protection status of these species has not yet been determined. More information is needed to help with this determination. Regarding the waste sites, most of the waste in the waste sites has been stabilized, thereby limiting ecological access. The decisions to stabilize and remediate waste sites must balance the potential disruption to the ecosystem both at and adjacent to the waste sites as well as from a distant location (e.g., borrow source sites).

The conceptual site model in DOE/RL-2001-54, Chapter 3.0, provides an understanding of the ecological resources and the ways that receptors may be exposed. It shows where chemicals and radionuclides from the waste sites are likely to come into contact with receptors in the environment. The exposure pathways that are expected to be complete at most waste sites include the following:

- Direct contact with, or ingestion of, soil by invertebrates (e.g., beetles, ants) and burrowing mammals
- Uptake of contaminants in soil by vegetation
- Bioaccumulation and bio-magnification through ingestion of food items (e.g., food chain effects) consumed by wildlife that may forage at the waste sites.

Chapter 4.0 of DOE/RL-2001-54 discusses the toxicity values that are available for contaminants believed to be present in the Central Plateau. Contaminants were identified from preliminary sampling data available from a subset of waste sites. These contaminants were then screened, primarily with respect to the likelihood to be present in the environment (i.e., half-life and persistence). A literature search for bird and mammalian toxicity values was performed.

Toxicity values are not available for some contaminants. A risk management decision will be needed to determine how contaminants that do not have toxicity values will be handled during the risk assessment for each OU.

Chapter 5.0 of DOE/RL-2001-54 presents the exposure parameters used for estimating the exposure in a quantitative manner. In a screening-level ecological risk assessment, most exposure parameters are set conservatively at 100 percent. The only organism-specific factor necessary will be body weight, and these data are available in the literature. This section further evaluated the exposure pathways and constructed a food chain exposure model for wildlife specific to the Central Plateau. The wildlife are shown in the food chain and habitat model in DOE/RL-2001-54.

DOE/RL-2001-54, Chapter 6.0, is the screening-level risk calculation for the Central Plateau. The state and DOE provide contaminant-specific numerical values (WAC 173-340-900, "Tables," and biota concentration guides [BCG] [see DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*]) to potential risks. These are conservative numbers designed to address all possibilities without leaving potential risks out of consideration. Data are available for a subset of the Central Plateau waste sites.
These maximum concentrations of contaminants detected at the waste sites were compared with the state and DOE screening-level values. For chemicals, 12 metals, pentachlorophenol, and 4-dinitrophenol were detected at a maximum concentration above the screening level. The high number of metals presenting a risk requires closer examination. Site-specific bioavailability data would be helpful for understanding whether this is a reflection of the conservative nature of the screening assessment or an actual risk to the ecosystems at the waste sites. For radionuclides, Cs-137, Ra-226, Ra-228, and Sr-90 were above acceptable limits in the soil samples. It is important to recognize the limitations and uncertainty associated with risks identified by screening-level assessments. The risk calculations are useful for determining relative risks between waste sites, not site-specific risk. The information should be considered carefully along with actual biological evidence from the waste site area to determine if a hazard exists.
There are data available for hundreds of wastes sites in the Central Plateau (see Appendix C of DOE/RL-2001-54). These data include soil from the waste site, vegetation, and soil invertebrates. As each OU quantifies their risk using the exposure models available, these data will be useful in verifying the mathematical estimates.

The screening-level ecological risk assessment in DOE/RL-2001-54 leads to the problem formulation stage of a baseline ecological risk assessment. During problem formulation, the risk managers and others consider the toxicity evaluation, conceptual model exposure pathways, and assessment endpoints to support cleanup decisions. As a result, they are then able to better define the initial risks and determine direction for the DQO process, if needed. The DQO process will include the following activities:

- Establish the level of effort needed to assess ecological risk at a particular site or OU
- Identify relevant and available data
- Design a conceptual model of the ecological threats at a site and the measures to assess those threats

- Select methods and models to be used in the various components of the risk assessment
- Develop assumptions to fill data gaps for toxicity and exposure assessments, based on logic and scientific principles
- Interpret the ecological significance of observed or predicted effects.

Ecological risk will be evaluated using the EPA eight-step process as outlined in DOE/RL-2001-54. DOE/RL-2001-54 serves as the screening-level assessment for the Central Plateau. For the 200-PW-2 and 200-PW-4 OUs, DOE/RL-2001-54 provides the starting point for OU-specific ecological evaluations that will include a screening-level evaluation based on the data collected during the RI and other existing data as available, which will be compared to screening-level concentrations protective of wildlife. Because the waste sites in these OUs are all within the core zone, only terrestrial wildlife risks will be evaluated. Consistent with this approach, WAC 173-340-7490 (3)(b), "Terrestrial Ecological Evaluation Procedures," "Goals," specifies that for industrial or commercial properties, current or potential exposure to soil contamination need only be evaluated for terrestrial wildlife protection. Plants and biota need not be considered unless the species is protected under the Federal *Endangered Species Act of 1973*. EPA guidance does not limit the scope of ecological risk assessment in the same manner as WAC 173-340-7490. Currently, no Federally listed threatened or endangered species are known to exist on the waste sites. Surveys conducted before field activities begin will confirm the presence of protected species.

For radionuclides, screening levels have been developed in DOE/STD-1153-2002. The international community has been involved for more than 20 years in evaluating the effects of ionizing radiation on plants and animals. The International Atomic Energy Agency (IAEA) issued a study in 1992 (IAEA 332), endorsing the 1977 International Commission on Radiological Protection (ICRP) reports *Recommendations of the International Commission on Radiological Protection* (ICRP Publication 26 and ICRP Publication 60) and stating that chronic radiation dose rates below 0.1 rad/d will not harm plant and animal populations and that radiation standards for human protection also will protect populations of nonhuman biota. The report implies that dose limits of 0.1 rad/d for animals and 1 rad/d for plants will protect populations, but additional evaluation of effects may be needed if sensitive species are present.

ORNL/TM-13141, *Effects of Ionizing Radiation on Terrestrial Plants and Animals: A Workshop Report*, presents information from a DOE-sponsored workshop held in 1995. The workshop was attended by 12 experts in radioecology and ecological risk assessment. The goal of the workshop was to evaluate the adequacy of current approaches to radiological protection, as exemplified by the IAEA report. The attendees reviewed DOE's perspective and responsibilities, rationales underlying the IAEA conclusions, and a summary of ecological data from the former Soviet Union. The consensus of the workshop participants was that the 0.1 rad/d limit for animals and the 1 rad/d limit for plants recommended by the IAEA are adequately supported by the available scientific information. However, they concluded that guidance on implementing the limits is needed and that the existing data support application of the recommended limits for populations of terrestrial and aquatic organisms to representative rather than maximally exposed individuals.

In response to the workshop findings, DOE produced DOE/STD-1153-2002, which provides a graded approach to ecological risk assessment for radionuclides and screening level BCGs. For radiological constituents, no promulgated screening or cleanup levels are available. The BCGs from DOE/STD-1153-2002 will be used as one element in the ecological evaluation of radiological constituents. Both WAC 173-340-7490 and EPA guidance use a "weight-of-evidence" approach to evaluating ecological risk. The use of DOE/STD-1153-2002 as a screening criterion is consistent with a weight-of-evidence approach.

DOE/RL-2001-54 is foundational to the Central Plateau ecological evaluation DQO process to be conducted in fiscal years 2003 and 2004. This DQO process will further develop data gaps identified in DOE/RL-2001-54 and will identify data needs for the Central Plateau to support remedial decision making. An ecological evaluation SAP will be prepared and implemented for the Central Plateau, either on an area-wide basis or by OU, depending on the actual data needs.

Based on the results of the DQO and the screening-level evaluation, additional risk assessment activities, including a baseline ecological risk assessment, may be conducted using the eight-step process. The evaluation will be conducted based on soil data collected during the RI, existing soil and ecological data, and, if identified during the Central Plateau ecological evaluation DQO, newly collected ecological data.

5.3 FEASIBILITY STUDY/RCRA TREATMENT, STORAGE, AND DISPOSAL UNIT CLOSURE PLAN

After the RI is complete, remedial alternatives/closure strategies will be developed and evaluated against WAC 173-303-610(2) performance standards and evaluation criteria in the FS/closure plan. The FS process consists of several steps:

1. Defining RAO and RCRA closure and RCRA corrective action performance standards

2. Identifying general response actions to satisfy RAOs

3. Identifying potential technologies and process options associated with each general response action

4. Screening process options to select a representative process for each type of technology based on their effectiveness, implementability, and cost

5. Assembling viable technologies or process options into alternatives representing a range of treatment and containment plus the no-action alternative

6. Evaluating alternatives and presenting information needed to support remedy selection and RCRA closure of the unit as a landfill or under modified or clean closure pursuant to Hanford Facility RCRA Permit Condition II.K (WA7890008967).

Appendix D of the Implementation Plan (DOE/RL-98-28) identifies the following remedial action alternatives as potentially applicable to the 200-PW-2 and 200-PW-4 OUs:

- No-action alternative
- Engineered surface barriers with or without vertical barriers
- Excavation and disposal with or without soil treatment
- Excavation, ex situ treatment, and geologic disposal of transuranic soil
- In situ grouting or stabilization
- In situ vitrification
- Monitored natural attenuation (with institutional controls).

During the detailed analysis, each alternative will be evaluated against the following criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance.

One additional modifying criterion, community acceptance, will be applied following the FS at the proposed plan and ROD phase.

National Environmental Policy Act of 1969 values also will be evaluated as part of DOE's responsibility under this authority. These values include impacts to natural, cultural, and historical resources; socioeconomic aspects; and irreversible and irretrievable commitments of resources.

The RCRA closure performance standards (WAC 173-303-610[2]) also will be used to evaluate the ability of alternatives to comply with RCRA closure requirements.

In addition, RCRA corrective action performance standards (WAC 173-303-646[2], "Closure and Post-Closure," "Corrective Action," "Requirements,") will be used to evaluate alternative compliance with RCRA corrective action requirements.

The FS also will include supporting information needed to complete the detailed analysis and meet regulatory integration needs, including the following:

- Summarize the RI, including the nature and extent of contamination, the contaminant distribution models, and an assessment of the risks to help establish the need for remediation and to estimate the volume of contaminated media

- Refine the conceptual exposure pathway model to identify pathways that may need to be addressed by remedial action

- Provide a detailed evaluation of ARARs, beginning with potential ARARs identified in the Implementation Plan (Chapter 4.0, DOE/RL-98-28)
- Refine potential RAOs and PRGs identified in the Implementation Plan (Chapter 5.0, DOE/RL-98-28) based on the results of the RI, ARAR evaluation, and current land-use considerations
- Refine the list of remedial alternatives identified in the Implementation Plan (Appendix D, DOE/RL-98-28) and in this section, based on the RI
- Provide corrective action recommendations for RPPs to fulfill the requirements for a CMS report
- Include closure plan information, per WAC 173-303-610(3), "Closure Plan; Amendment of Plan," to address RCRA TSD units in the OUs. The information will incorporate, by reference, specific sections of the work plan or RI report containing specific closure plan information. The information will include closure performance standards, a closure strategy, general closure activities including verification sampling, and general postclosure information.

Additional RCRA integration guidance for preparing an FS/closure plan is provided in Section 2.4 of the Implementation Plan (DOE/RL-98-28).

5.4 PROPOSED PLAN AND PROPOSED RCRA PERMIT MODIFICATION

Under the strategy developed for the Hanford Facility RCRA Permit, TSD units that are not already in the Permit and that will not actively operate in the future are added as units undergoing closure via the permit modification process. This consists of preparing a draft permit modification, seeking public comment, and making a final permit modification pursuant to WAC 173-303-830 and -840.

At the Hanford Site, a permit modification adding a closure plan is typically initiated by Ecology. The draft permit modification identifies permit conditions applicable to the closure and is based on the closure plan.

Under CERCLA, the decision-making process consists of a proposed plan and a ROD. Based on the evaluation of alternatives in the Feasibility Study and in accordance with the Tri-Party Agreement, the DOE and the lead regulatory agency, in consultation with the supporting regulatory agency, select a proposed alternative and present it for public review and comment in a document called a proposed plan. After the public comment period on the proposed plan has closed, the ROD is prepared by the lead regulatory agency. The decision-making process for the 200-PW-2 and 200-PW-4 OUs will be based on the use of a proposed plan, ROD, and modification of the Hanford Facility RCRA Permit (WA7890008967).

During the RI/FS process, a number of options for development of proposed plans and RODs will be evaluated. Remedial decisions may proceed on an OU-by-OU basis, but it also is likely

that alternative site groupings will be considered for waste sites in the Central Plateau. Several alternatives are currently under consideration, some of which may be used for the waste sites addressed in this work plan.

Three alternatives to the OU-by-OU remediation approach have been identified to provide flexibility in the decision-making process, facilitate early action, and remediate and close specific areas or zones. Examples of these alternatives are presented below.

5.4.1 High Risk Waste Sites Identified for Early Action

This alternative accelerates the start of remedial actions and closure of the waste sites that present an ongoing or expected future threat to groundwater. Some high-risk sites already have been identified for early actions within the BC Controlled Area, and near the U Plant, PUREX, and Plutonium Finishing Plant. These sites will be included in a proposed plan and ROD that promote early action.

5.4.2 Regional Site Closure

Waste site remedial decision making may be realigned under a regional closure strategy that aligns wastes sites into groups defined by geographical zones. For example, several waste sites within the 200-PW-2 and 200-PW-4 OUs are within the U Plant Area (See Section 1.2) and would be considered for inclusion in a U Plant area closure via proposed plans and RODs.

5.4.3 Waste Site Grouping by Characteristics or Hazards

A third example of remedial decision-making strategies would be based on a specific characteristic or hazard that mandates additional requirements, such as supplemental ARARs, or more robust remedial alternatives. For example a number of waste sites in other OUs are suspected to contain concentrations of transuranic radionuclides in excess of the 100 nCi/g concentration limit for designation as TRU waste[1]. Waste sites containing concentrations of TRU radionuclides above 100 nCi/g may require selective removal actions or more protective barrier designs to prevent intrusion, based on this particular hazard. Such alternatives might not be required for other process condensate or process waste sites within the 200-PW-2 or 200-PW-4 OUs where only low levels of radionuclides are present. Grouping waste sites with other similarly contaminated soil sites in other OUs could streamline the decision-making process and tailor the requirements and alternatives to these specific hazards.

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[1] Transuranic (waste materials contaminated with 100 nCi/g of transuranic materials having half-lives longer than 20 years).

5.5 POST-RECORD OF DECISION ACTIVITIES

After the ROD and modification to the Hanford Facility RCRA Permit (WA7890008967) have been issued, a remedial design report (RDR) and remedial action work plan (RAWP) will be prepared to detail the scope of the remedial action (which will include RCRA closure and corrective action requirements). As part of this activity, DQOs will be established and SAPs will be prepared to direct confirmatory and verification sampling and analysis efforts. Before remediation begins, confirmation sampling will be performed to ensure that sufficient characterization data are available to confirm that the selected remedy is appropriate for all waste sites within the OUs, to collect data necessary for the remedial design, and to support final cumulative risk assessments for the 200 Areas National Priorities List (NPL) site (40 CFR 300, Appendix B). Verification sampling will be performed after the remedial action is complete to determine if ROD requirements have been met and if the remedy was protective of human health and the environment. Additional guidance for confirmatory and verification sampling is provided in Section 6.2 of the Implementation Plan (DOE/RL-98-28).

The RDR/RAWP will include an integrated schedule of remediation activities for the OUs, including the schedule for RCRA TSD unit closure, and will satisfy the requirements for an RPP corrective measures implementation work plan and corrective measures design report. The available options for remedy implementation throughout the 200 Areas will be explored during the course of the RI/FS process and may be reflected in the RAWP. Following the completion of the remediation effort, closeout activities will be performed as specified in the ROD, RDR/RAWP, and the Permit.

The RCRA closure activities and schedules will be defined in the FS/closure plan and will be consistent with those identified in the RDR/RAWP. Enforceable sections of the FS/closure plan will be stated in the modification to the Hanford Facility RCRA Permit (WA7890008967). Certification of closure in accordance with WAC 173-303-610(6), "Certification of Closure," will be performed after completion of cleanup actions. The site will be restored as appropriate for future land use. If clean closure is not attained at a TSD unit, postclosure care requirements will be met. These requirements will include final status groundwater monitoring, maintenance and monitoring of institutional controls and/or surface barriers, and certification of postclosure at the completion of the postclosure period.

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6.0 PROJECT SCHEDULE

The project schedule for activities discussed in this work plan is shown in Figure 6-1. This schedule will serve as the baseline for the work planning process and will be used to measure the progress of the implementation of this process. The schedule for field activities and the preparation, review, and issuance of the RI report, the FS/closure plan, and the proposed plan/ proposed permit modification also are shown in Figure 6-1. The schedule concludes with the preparation of an ROD. Modification of the Hanford Facility RCRA Permit (WA7890008967) will occur after issuance of the ROD, during Ecology's annual modification process.

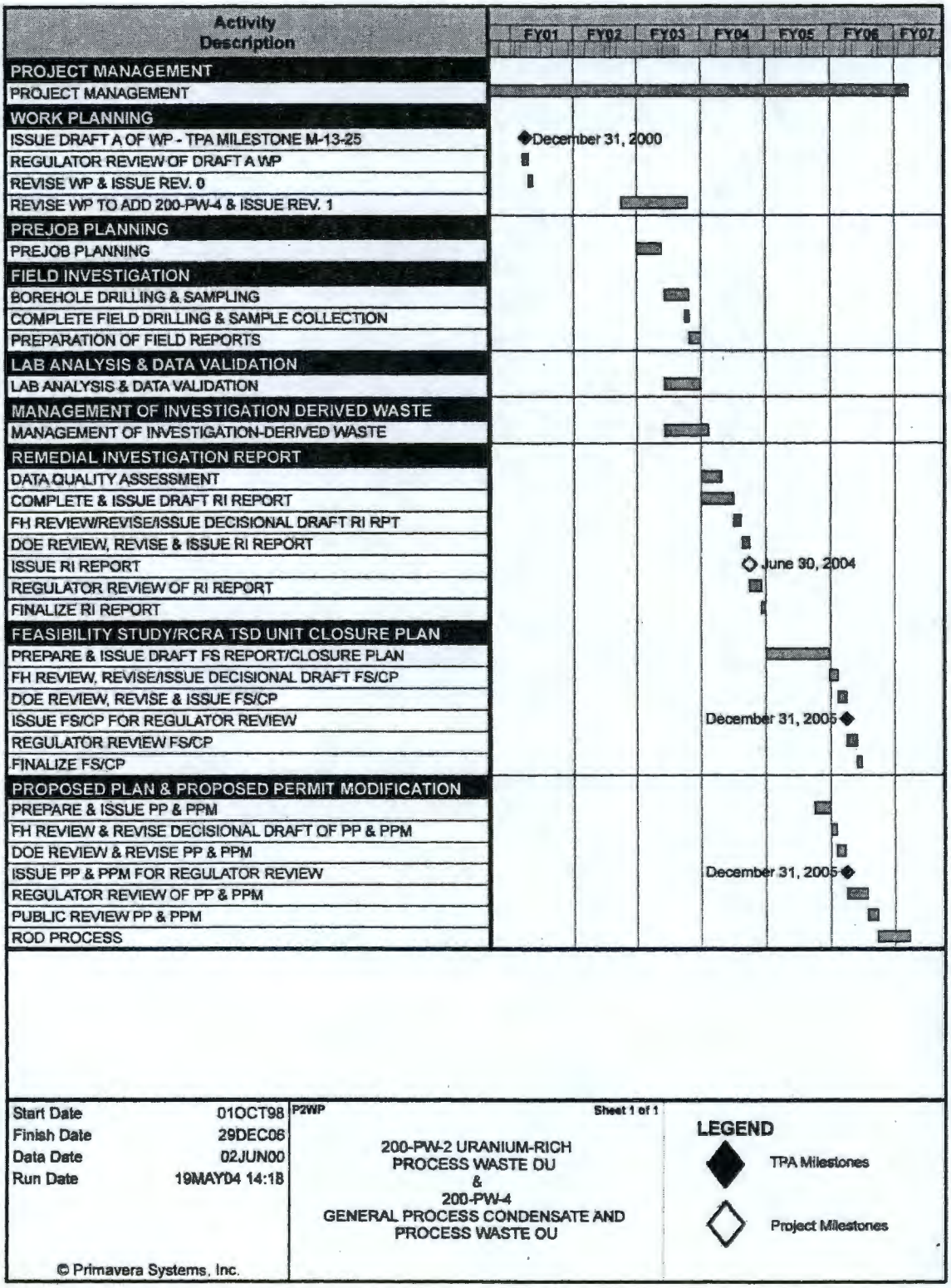
The portion of the schedule most germane to this work plan and the SAP (Appendix B) are FY 2001 through FY 2003. One Tri-Party Agreement (Ecology et al. 1989) milestone that has been completed involved submittal of Draft A of the work plan to the regulators by December 31, 2000 (Tri-Party Agreement Milestone M-13-25). Existing outyear RCRA TSD unit milestones include M-20-33, which requires submittal of the 216-A-10 Crib, 216-A-36B Crib, 216-A-37-1 Crib, and 207-A South Retention Basin closure/post-closure plans to Ecology by December 31, 2005. The schedule shown in Figure 6-1 presents these milestones and the following project milestone completion dates for key activities:

- M-15-43B: Submit 200-PW-2 OU RI report for regulatory review, including the Past Practice Waste Sites in the 200-PW-4 General Process Waste Group – June 30, 2004

- M-15-43C: Submit 200-PW-2 OU FS/closure plan and proposed plan/permit modification for regulator review, including the Past Practice Waste Sites in the 200-PW-4 General Process Waste Group – December 31, 2005.

These dates are consistent with and support the Tri-Party Agreement Major Milestone M-015-00C for completion of all non-tank farm 200 Areas pre-ROD site investigations under approved work plan schedules by December 31, 2008. A Class II change form will be submitted to Ecology and EPA to request the addition of any interim milestones. Any updates to the project schedule or associated milestones will be reflected in the annual work planning process. Field activities began in FY 2003.

Figure 6-1. Project Schedule for the 200-PW-2 and 200-PW-4 Operable Units.



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