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Rev. 0

200-PW-2 Uranium-Rich Process Waste Group Operable Unit RI/FS Work Plan and Process Waste RCRA TSD Unit Sampling Plan

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May 2001

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

EXECUTIVE SUMMARY

This work plan supports the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study (RI/FS) activities for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit (OU). This work plan also integrates the *Resource Conservation and Recovery Act of 1976* (RCRA) facility investigation/ corrective measures study (RFI/CMS) requirements for the OU. The process outlined in the work plan follows the CERCLA format with modifications to concurrently satisfy RCRA requirements. The 200-PW-2 OU is located near the center of the Hanford Site in south-central Washington State and consists of 24 RCRA past-practice (RPP) waste sites; 3 RCRA treatment, storage, and disposal (TSD) units; and 5 associated unplanned release sites as defined in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan) (DOE-RL 1999a). The remedial investigation (RI) 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 RPP sites, whereas the fourth site (i.e., the 216-U-12 Crib) is also 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 recent discussions with the regulators regarding streamlining the 200 Area assessment process the assessment of two additional RCRA TSD units (the 216-A-37-1 Crib and the 207-A South Retention Basin) has been integrated into the RI/FS process as part of the 200-PW-2 OU. By adding the assessment of these two TSD units from the 200-PW-4 General 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.

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 RI/FS and closure plan processes for the OU. A data quality objectives (DQO) process was conducted for the RI to define the chemical and radiological 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 OU. The results of the DQO process form the basis for RI characterization activities presented in the work plan and the associated sampling and analysis plan (SAP) included in Appendix B. The SAP 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 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 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 Semi-Works 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 startup phases that used irradiated uranium, prior to the operation of the three main plants. The process condensates were vapors collected from thermally hot process steps that were condensed and subsequently discharged to the ground.

A preliminary conceptual contaminant distribution model was developed for the 200-PW-2 OU in the *Waste Site Grouping for 200 Areas Soil Investigations* report (DOE-RL 1997). Based on this preliminary model and a range of existing, site-specific environmental data, conceptual contaminant distribution models were developed for each representative site during the DQO process.

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.

- Waste sites in this 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 directly underneath the waste to the groundwater table). Of the 27 RPP waste sites and TSD units, effluent volumes exceeded soil pore volumes beneath 13 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.

- 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 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 are usually 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.

- Uranium mobility is affected by the specific form of the uranium compound. The distribution of uranium through the vadose to 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 due in part to 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 based on the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999) and the associated *Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (64 FR 61615). All of the sites within the 200-PW-2 OU are located within the area designated for industrial land use.

Characterization activities to collect the required data identified during the DQO process for the RI 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 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 SAP (Appendix B) directs sampling and analysis activities that will be performed to characterize the vadose zone at the four representative waste sites and two additional 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 this OU. The scope of RI activities described in the work plan and SAP 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, and the 216-A-36B Crib. Boreholes will be drilled 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.

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

	216-A-19 Trench	216-B-12 Crib	216-A-10 Crib	216-A-36B Crib	Project Total
Chemical Parameters					
Projected maximum number of vadose zone samples	10	9	11	10	40
Detail of quality control samples					
Co-located duplicates – soil	1	1	1	1	4
Equipment blanks – rinsate	1	1	1	1	4
Approximate number of field quality control samples	2	2	2	2	8
Approximate total number of samples	12	11	13	12	48
Physical Properties					
Bulk density, moisture content, particle size distribution	4	2	3	3	12

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ACRONYMS

amsl	above mean sea level
ANN	aluminum nitrate nonahydrate
ARAR	applicable or relevant and appropriate requirement
ASD	ammonia scrubber distillate
bgs	below ground surface
BHI	Bechtel Hanford, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
Ecology	Washington State Department of Ecology
EHQ	environmental hazard quotient
EPA	U.S. Environmental Protection Agency
FS	feasibility study
FY	fiscal year
HASP	health and safety plan
HPGe	high-purity germanium
IDW	investigation-derived waste
LFI	limited field investigation
MCL	maximum contamination level
MIBK	methyl isobutyl ketone
MTCA	*Model Toxics Control Act*
NPH	normal paraffin hydrocarbon
OU	operable unit
PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction (Plant)
QRA	qualitative risk assessment
RAO	Remedial Action Objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR/RAWP	remedial design report/remedial action work plan
REDOX	Reduction-Oxidation (Plant)
RESRAD	RESidual RADioactivity dose model
RFI	*Resource Conservation and Recovery Act* field investigation
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
RLS	Radionuclide Logging System
ROD	Record of Decision
RPP	*Resource Conservation and Recovery Act of 1976* past-practice
SAP	sampling and analysis plan
TBP	tributyl phosphate

Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
UNH	uranyl nitrate hexahydrate
UPR	unplanned release
VCP	vitrified clay pipe
URP	uranium recovery process
WAC	*Washington Administrative Code*
WCP	waste control plan
WESF	Waste Encapsulation Storage Facility
WIDS	Waste Information Data System

METRIC CONVERSION CHART

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries

1.0 INTRODUCTION

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998) identifies approximately 800+ soil waste sites (and associated structures) resulting from the discharge of liquids and solids from 200 Area 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 Operable Unit (OU) and the assessment of the 216-A-37-1 Crib and 207-A South Retention Basin RCRA TSD units from the 200-PW-4 General Process Waste Group OU. This work plan integrates both RCRA and CERCLA requirements for the OU. The process outlined in the work plan follows the CERCLA format with modifications to concurrently satisfy RCRA requirements as described in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (DOE-RL 1999) (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 areas on the Hanford Site that remain on the U.S. Environmental Protection Agency's (EPA) National Priorities List under CERCLA. The 200-PW-2 OU is 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 1999). This was subsequently 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 will no longer be considered in the 200-PW-2 planning. The total number of sites remaining in the 200-PW-2 OU, therefore, is 32.

Of the 23 source OUs in the 200 Areas, the 200-PW-2 OU was assigned a higher priority because waste sites within the 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 in the year 2003.

The 200-PW-2 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

Semi-Works 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 startup phases prior to the operation of the three main plants. The process condensates were vapors collected from thermally hot process steps that were condensed and subsequently discharged to the ground.

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 (i.e., the 216-U-12 Crib) is also a RCRA TSD unit. Two additional RCRA TSD units (the 216-A-10 Crib and 216-A-36B Crib) will also 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. 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 1999).

Based on recent discussions with the Washington State Department of Ecology (Ecology) and EPA on ways to further streamline 200 Area assessment planning, two additional RCRA TSD units have been added into the RI/FS process as part of the 200-PW-2 OU. This more focused approach was also discussed during the annual review of 200 Area work scope priorities conducted during the spring of 2001. As a result of these meetings, Ecology agreed that the assessment of the 216-A-37-1 Crib and 207-A South Retention Basin RCRA TSD units (from the 200-PW-4 General Process Waste Group) may be addressed as part of the 200-PW-2 OU work plan to accelerate the investigation of all process waste-type RCRA TSD units. A separate sampling and analysis plan (SAP) will be prepared for these two RCRA TSD units, the implementation of which will be integrated with the 200-PW-2 RI. Furthermore, the TSD units will also be incorporated into subsequent RI/FS documents under the 200-PW-2 OU. The current Part A Permit applications for these two units 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. 1998). The schedule of work at the Hanford Site is governed by these Tri-Party Agreement milestones. Ecology is the lead regulatory agency for this OU. The milestone controlling the schedule for the 200-PW-2 OU was M-13-25, "Submit Uranium-Rich Process Waste Group Work Plan," which was met with submittal of the work plan by December 31, 2000. Associated project milestones are discussed in Section 6.0. Other associated milestones include Milestone M-20-33, which requires submittal of the 216-A-10 Crib and 216-A-36B Crib closure/post-closure plans to Ecology by October 31, 2003, and M-20-52 and M-20-53 that address submittal of closure/post-closure plans for the 216-A-37-1 Crib and 216-A South Retention Basin by December 31, 2003. The schedule shown in Figure 6-1 proposes new completion dates for these RCRA TSD milestones in order to align them with completion of the FS/closure plan.

1.1 200 AREAS IMPLEMENTATION PLAN

The Implementation Plan 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 OUs in the 200 Areas. The Implementation Plan also lists potential applicable or relevant and appropriate requirements (ARARs) and preliminary remedial action objectives (RAOs), 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 Area facilities, ARARs, RAOs, and post-work plan activities.

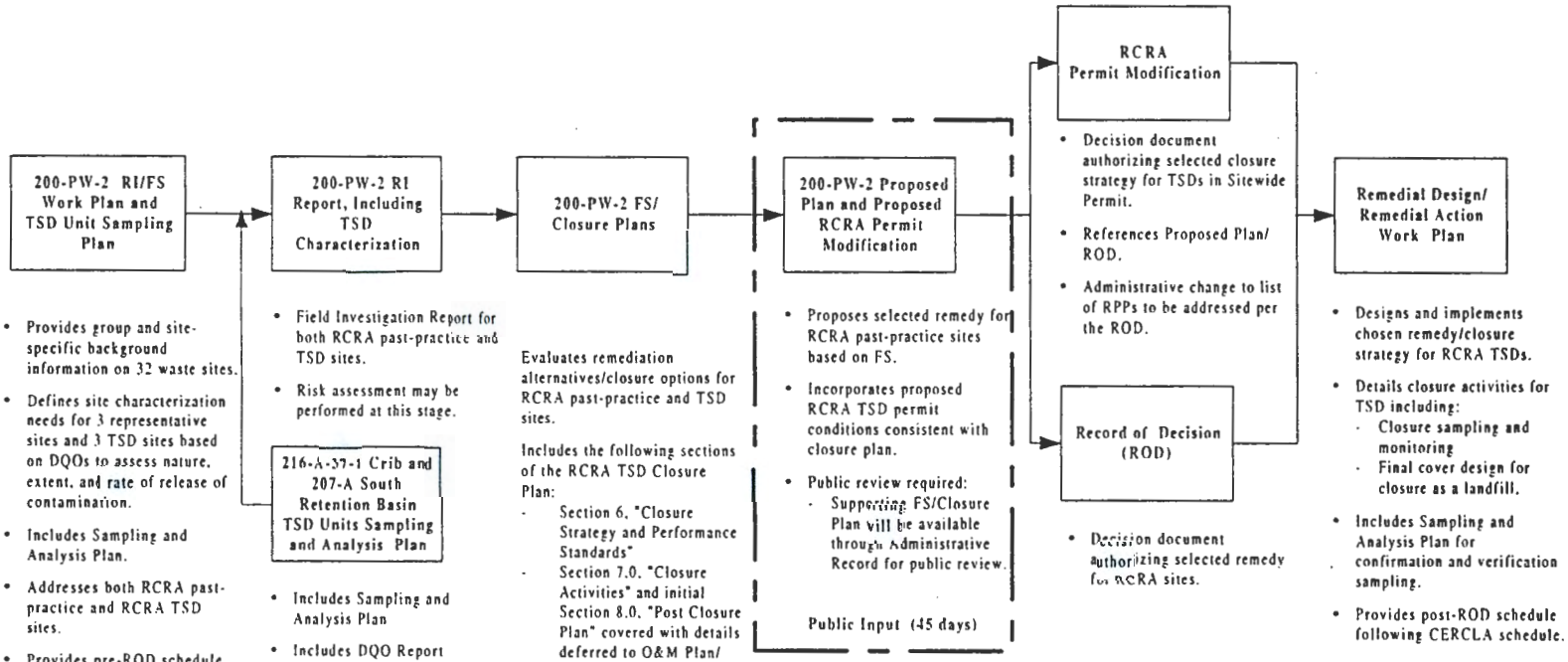
1.2 SCOPE AND OBJECTIVES

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. This work plan documents OU-specific background information, defines OU-specific 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 OU. The general approach to characterization and evaluation of 200 Area OUs is outlined in the Implementation Plan. Operable unit-specific detail is presented in this work plan, including background information on the waste sites in this OU; existing data regarding contamination at the representative waste sites; and the approach that will be used to investigate, characterize, and evaluate the sites.
A discussion of the RI planning and execution process for the OU is included, along with a schedule for the characterization work. Preliminary remedial action alternatives that are likely to be considered for this OU are identified in the work plan. These preliminary remedial alternatives will be further developed and agreed to in the FS/closure plan(s), in the proposed plan/proposed permit conditions to the Hanford Facility RCRA Permit, and in the eventual Record of Decision (ROD) and Permit modification for this OU.

A data quality objectives (DQO) process was conducted for this OU to define the chemical and radiological constituents to be characterized and to specify the number, type, and location of samples to be collected at representative sites within the OU. The results of the DQO process form the basis for the work plan and the associated SAP included in Appendix B. The SAP includes an OU-specific quality assurance project plan (QAPjP) 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 a group-specific RI report that includes the specific RCRA TSD unit characterization. The RI report will include 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 group-specific FS/closure plan. Remedial alternatives may be applied to any or all of the waste sites in an OU, and different alternatives may be applied to different waste sites depending on site characteristics. The schedule for assessment activities at the 200-PW-2 OU is presented in Section 6.0.

Figure 1-1. Integrated Regulatory Process for CERCLA, RCRA Past-Practice, and RCRA TSD Unit Closure (modified from Figure 2-2, DOE-RL 1999).



2.0 BACKGROUND AND SETTING

This section describes the 200-PW-2 Uranium-Rich Process Waste Group OU. Waste site information and the hydrogeologic framework associated with this OU is 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 section 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 1999). Summary information is provided on analogous waste sites that will not be immediately characterized but addressed by future planning efforts. Information in this section is summarized from numerous reports. The following represents a few of the more significant documents:

- *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997)
- *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE-RL 1999)
- *B Plant Source Aggregate Area Management Study Report* (DOE-RL 1993a)
- *REDOX Plant Source Aggregate Area Management Study Report* (DOE-RL 1992c)
- *U Plant Source Aggregate Area Management Study Report* (DOE-RL 1992a)
- *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE-RL 1995b)
- *Focused Feasibility Study for the 200-UP-2 Operable Unit* (DOE-RL 1995a)
- *Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells* (Fecht et al. 1977)
- PNLATLAS Database.

Certain subsections of this section contain information that will be used for portions of the FS/closure plan. Section 2, "Facility Description and Location Information," and Section 3, "Process Information," from a closure plan is found in Sections 2.1 and 2.2 of this work plan. Section 4, "Waste Characteristics," and Section 5, "Groundwater Monitoring," from a closure plan correspond to information found in Sections 2.2.3 and 3.4, respectively.

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 OU. The 200-PW-2 OU is 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 1992a). 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 Appendix F of the Implementation Plan (DOE-RL 1999).

2.1.1 Topography

The 200 Areas, which contain the waste sites comprising the 200-PW-2 OU, are located in the Pasco Basin on the Columbia Plateau. The 200 Area 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 Area 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 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) amsl to 217 m (712 ft). Waste site surface elevations in the 200 East Area range from approximately 200 m (656 ft) amsl in the northern portion of the 200 Area to 220 m (722 ft) 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 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 1988). 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 1994). The subunit is interpreted to be a weathering surface developed on the top of the Ringold Formation (WHC 1994, Bjornstad 1990) and consists of a lower carbonate-rich paleosol (caliche) and an upper eolian facies (Slate 1996). 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 (Bjornstad 1990). Generally, it is well-sorted quartz-rich/basalt-poor silty sand to sandy silt (BHI 1996d).

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 (Wood et al. 2000). The Hanford formation/Plio-Pleistocene unit (?) is made up of two facies and has only been identified in the 200 East Area near the B-BX-BY Tank Farms. The lower facies overlies basalt and is described in Wood et al. (2000) as a loose, unconsolidated sandy gravel to gravelly sand. These gravels contain 50% to 70% 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 has also 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 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 have also 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 has historically been documented above the Plio-Pleistocene unit at locations in the 200 West Area.

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. Artificial recharge occurred when effluent such as cooling water was disposed of to the ground. Zimmerman et al. (1986) 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. The artificial recharge that does continue is largely limited to liquid discharges from sanitary sewer system drainfields, 2 state-approved land disposal structures, and 140 small-volume, uncontaminated, miscellaneous streams. One of the approved land disposal structures, the Treated Effluent Disposal Facility (a liquid waste disposal facility), is located 600 m (2,000 ft) east of the 216-B-3C lobe and receives plant-treated liquid wastes from the 200 East and 200 West Area facilities.

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 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 2000). In general, groundwater flow through the 200 Area 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 resulted in a groundwater mound developing in excess of 26 m (85 ft). Discharges to 216-B-3 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. 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 1997).

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 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 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 is also currently declining at a rate of less than 0.5 m/yr (1.6 ft/yr). A pump-and-treat system associated with technetium-99 and uranium contamination from the 216-U-1 and 216-U-2 Cribs has operated since 1994 as part of remediation activities at the 200-UP-1 groundwater OU and has treated over 350 million liters of groundwater (DOE-RL 2000a).

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. 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 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 flow to the southeast is not discernable because the water table is nearly flat (PNNL 2000). The very gently sloping water table corresponds to a high-transmissivity zone that extends through the 200 East Area (PNNL 2000). The surface of the water table beneath the 200 East Area is currently

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 south: 216-A-34 Ditch, 216-A-18 Trench, 216-A-24 Crib, and 216-A-20 Crib waste site). The ground surface elevation is approximately 200 m (656 ft) and slopes to the north. The general stratigraphy in the vicinity of 216-A-19 Crib includes, from the surface downward, the Hanford formation (gravel- and sand-dominated sequences) and the Ringold Formation (Gravel Unit A) (WHC 1992b). The stratigraphy beneath the site is shown in Figure 2-3 and 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 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 216-B-12 includes, from the surface downward, the Hanford formation (sand and gravel sequences) and the Ringold Formation (Gravel Unit A) (WHC 1992b). Ringold Gravel Unit E may occur in this area, but it is difficult to distinguish from the lower Hanford gravel sequence. Lindsey (1995) 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 1992a). The stratigraphy beneath the 216-B-12 Crib is shown in Figure 2-4.

The unconfined aquifer near the 216-B-12 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, which is approximately 24 m (79 ft) thick.

2.1.5.3 216-U-8 Crib and 216-U-12 Crib. These sites are located near U Plant and are near one another in the southeastern portion of the 200 West Area. Because the hydrogeological conditions are similar at these 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 (1993).

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. These sites are located near PUREX and are near one another in the southeastern portion of the 200 East Area. Because the hydrogeological 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 1992a). The stratigraphy in the vicinity of the two cribs is shown in Figure 2-7.

The unconfined aquifer near the 216-A-10 and 216-A-36B 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 216-A-36B, 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 2000).

2.2 WASTE SITE DESCRIPTION AND HISTORY

Twenty-eight specific waste sites and UPRs within the OU are listed in Appendix G of the Implementation Plan (DOE-RL 1999). This was subsequently updated by 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 will no longer be considered in the 200-PW-2 planning. The total number of sites remaining in the 200-PW-2 OU, therefore, is 32.

Of the 32 waste sites, 15 are located in the 200 West Area and 17 waste sites are located in the 200 East Area. All of the 200-PW-2 waste sites are located within the 200 Area exclusive land-use boundary as defined in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999) (Figure 2-8). Figures 2-9, 2-10, and 2-11 depict the locations of the waste sites. The 200-PW-2 OU contains 3 RCRA TSDs, 24 RPPs, and 5 UPR waste sites. Eleven waste sites received waste from the U and UO_3 Plants, twelve waste sites received waste from PUREX (A Plant), five waste sites received waste from REDOX (S Plant), three waste sites received waste from 221-B/Waste Encapsulation and Storage Facility (WESF) (B Plant), and one site received waste from the Semi-Works 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.

Most of the waste discharged to the soil column in these OUs was generated at the U, REDOX, PUREX, WESF/221-B, and Semi-Works Plants between 1952 to 1988. The locations of these plants are illustrated in Figure 2-12.

2.2.1 Plant History

The U Plant was constructed in 1944 and included the 221-U canyon building and 224-U Building. U Plant was based on the design of T and B Plants and was initially used to train personnel for the bismuth/phosphate plutonium separation and purification operations conducted in 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, U Plant was modified for the URP. From 1952 to 1958, 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 T and B Plants. A later operation conducted at 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 uranium trioxide (UO_3). This operation was accomplished by calcinating the UNH in a batch process within 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 1992a).

The UO_3 Plant operated from 1958 until 1972 when PUREX was put in "stand-down." During that time, the UO_3 Plant converted UNH received from PUREX and REDOX 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. There 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 PUREX. As the feed lines from REDOX and 221-U 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 1992a).

The Reduction/Oxidation or REDOX Plant was the first continuous plutonium separation operation at the Hanford Site. Not only did REDOX separate weapons-grade plutonium from the irradiated fuel rods, but it recovered the uranium as well. 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 1992c).

The PUREX Plant replaced the REDOX 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 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. PUREX was put on standby from 1972 until 1983. PUREX restarted in 1983 and continued operations until 1990 when it was deactivated. Since the PUREX Plant's initial operation, it was modified to reprocess several types of fuel. These fuels included a zirconium alloy (Zircaloy) clad fuel with various enrichments ranging from 0.72% to 2.1% of uranium-235 exposed at various durations (300 to ~3,000 megawatt 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 1993c).

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, 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, strontium-90 and cesium-137, from high-level PUREX and REDOX wastes, and stored a concentrated solution of strontium-90 and cesium-137 at the 221-B Building. In 1968, B Plant underwent renovations and WESF was added. Waste fractionalization and encapsulation efforts continued until 1986 (DOE-RL 1993a).

The Semi-Works 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 Semi-Works 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 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, were also extracted. This facility operated until 1967. The facility remained in safe storage mode until decommissioning began in 1983 (DOE-RL 1993d).

Liquid waste generated at U, A (PUREX), S (REDOX), WESF/221-B, and C (Semi-Works) Plants was routed to underground storage tanks (e.g., S, A, B, and U tank farms) through an underground transfer system. The liquid waste was evaporated (concentrated) and often neutralized before routing to the tanks. The storage tanks were used to settle the heavier constituents out of the liquid effluents, forming sludge. The liquid supernatants in the tanks were ultimately discharged to the soil column via cribs, drains, trenches, and injection/reverse wells. Process distillate and drainages were also sent to cribs and trenches via this underground network (WIDS).

Cribs and drains were designed to inject or percolate wastewater into the soil column. French drains were generally 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 1993a).

Trenches were shallow, long, narrow, unlined excavations and were often located adjacent to other trenches. Some of the trenches have been backfilled and marked as a single group of trenches (DOE-RL 1993a).

2.2.2 Process Information

The processes at U, REDOX, PUREX, WESF, and Semi-Works Plants that generated the primary waste streams into the 200-PW-2 OU waste sites included the following:

- Uranium Recovery Process (URP)-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, 241 and 244 Vaults (waste treatment/storage), and 224-U storm drainage waste streams (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, waste treatment condensers, solvent recovery, and 240 and 241 Vaults (waste treatment/storage) waste streams (DOE-RL 1992c).

- 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 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 1993c).

- WESF/221-B: The waste fractionalization process included a thermal evaporation concentrator in cell 23 to concentrate process wastewaters prior to 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 1993a).

- Semi-Works: The 216-C-1 Crib received 23,400,000 L (6,180,000 gal) of liquid waste. Up until September 1955, the crib received REDOX and PUREX high-salt waste, process condensate from the 201-C Process Building, and material described as "cold-run" waste from the REDOX and PUREX processes. From September 1955 to June 1957, the crib also received the high-salt cold-run waste from the 201-C Process Building. A summary of the radionuclide and chemical waste inventories for the 216-C-1 Crib is presented in Tables 2-2 and 2-3, respectively. WIDS records estimate there is approximately 153 m^3 (200 yd^3) of contaminated soil at this site (DOE-RL 1993d).

Figures 2-13, 2-14, and 2-15 show graphical representations of the U, PUREX, and REDOX Plant processes and the corresponding waste streams that were discharged to the 200-PW-2 OU waste sites.

2.2.2.1 Uranium Recovery and Scavenging Processes. From 1952 to 1958, the URP was implemented at U Plant to recover the spent uranium from the metal waste and first-cycle waste streams generated in T and B Plants for reuse in weapons-grade plutonium production. Figure 2-13 illustrates the URP process flow. The URP was performed in the following three phases (GE 1951b):

- 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 uranium trioxide powder.

The metal waste and first-cycle wastes stored in the T and B Tank Farms were sent to U Plant via a network of underground pipes, tanks, and diversion boxes where they were deposited into cascading underground storage tanks near 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. (pH was usually adjusted and maintained at 10.5 due to 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 (GE 1951b).

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 that was concentrated by evaporation. This concentrated feed solution was then sent to the first-cycle extraction column. The off-gases were vented to the 291-U-1 Stack. Resulting condensate was collected, recondensed, sampled, and routed to the 241 ER and WR Vaults where the condensate was neutralized before disposal in cribs and trenches near the U Plant; these sites are 216-U-1&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 (GE 1951b).

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 was also 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 (GE 1951b).

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 uranium trioxide process in U/UO_3 Plant (GE 1951b) (see Figure 2-13).

The solvent recovery operation at 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 ER and WR vaults, scavenged, and sent to cribs and trenches in the 200-TW-1 OU. Figure 2-13 shows an illustration of the URP process flow conducted at U Plant (Curren 1972, WHC 1990).

The aqueous UNH from the URP was combined with UNH from the REDOX Plant and sent to the uranium trioxide plant for the conversion of the uranyl nitrate solution into uranium trioxide 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 fractionation operation in 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) were also routed to cribs, ditches, and trenches near U Plant for disposal (Curren 1972). The off-gases from the nitric acid fractionation and solvent recovery operations were vented to the 291-U-1 Stack. Resulting condensate was collected and routed to the 241 ER and WR Vaults where the condensate was neutralized and condensed again before disposal in cribs and trenches near U Plant; these sites are the 216-U-1&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 (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 cribs, ditches, and trenches near 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 (GE 1951b).

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 ER and WR Vaults. 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 sample results. In the neutralization tank, the waste was combined with an equal volume of 50% caustic soda (sodium hydroxide) to obtain a pH of 9.5. As a measurable quantity of ammonia was generated by neutralization, additional amounts of 50% caustic soda (sodium hydroxide) were added to raise the pH to 11.5. The caustic waste was condensed again and routed to cascading tanks and the liquid effluent sent to nearby cribs and trenches that are not part of this particular OU (GE 1951b).

In 1953, tests to further treat URP aqueous and organic wastes and the metal waste and first-cycle waste streams generated at 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 1958c, Curren 1972, Agnew et al. 1997).

From 1954 to 1958, this scavenging process was conducted at U Plant after the URP operations. The order of operations was often modified throughout the duration of the scavenging process. Parameters such as pH, addition of other metals to enhance precipitation, and soil retention properties were also continually changing. After URP processing, TBP column wastes were sent to a neutralization tank at 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 were often added to enhance the precipitation of the radioactive strontium-90. Phosphate ions were also added to aid the soil retention of strontium-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 cesium-137 and strontium-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 (GE 1951a, 1958c; WIDS, Borsheim and Simpson 1991).

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 U Plant before the implementation of the scavenging operation that had been returned to the 241- 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 as 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 (Curren 1972). The "in tank" scavenging operations ended in 1957 and the last of the liquid effluents were discharged in 1958 (GE 1954b, 1954c, 1955a, 1956a, 1958c).

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 due to REDOX's 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 a 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 1992c).

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% 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 2-14 illustrates the process flow of REDOX. The REDOX process included the following major components (DOE-RL 1992c):

- 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 (AFAN) was used to dissolve the Zircaloy cladding from fuels. Additional amounts of ammonium nitrate were often 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 were also found in these waste streams. The waste stream was sent directly to the 241-S Tank Farm (DOE-RL 1992c).

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, was also directed to the 241-S Tank Farm. The uranium slugs were then 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 was then transferred to a storage tank to await feed preparation operations (DOE-RL 1992c).

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, ruthenium-106 (fission product) was oxidized by potassium permanganate to form the volatile ruthenium tetra-oxide (DOE-RL 1992c).

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 241-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 1992c).

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 transferred to the feed storage tank (DOE-RL 1992c).

Waste streams generated by the feed preparation process included both gaseous and liquid/solid wastes. Off-gases including ammonia, hydrogen, oxides of nitrogen (NOx), and volatile radionuclides (including iodine-131 and iodine-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, 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 were then discharged to the atmosphere via the 291-S stack complex (GE 1951a).

Off-gases were also 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 ruthenium-106 as sodium ruthenium tetra-oxide. The resulting off-gases were then routed through a condenser and filtered through the J-1 fiberglass and sand filter to remove particulates. The gaseous emissions were then 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 (GE 1951a).

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 sent directly to underground storage tanks for disposal.

The 216-S Cribs include 200-PW-2 OU waste sites 216-S-1&2 and 216-S-7. The 216-S-8 Trench received the same type of waste from earlier "start-up" and "cold runs" in which nonirradiated uranium was used (GE 1951a).

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 241-S Tank Farm via the 240-S and 241-S Diversion Boxes. 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 with other wastes in the 241-S Tank Farm. (Ruthenium-106 was removed because it was the primary contaminant in purified plutonium and uranium streams.) (GE 1951a).

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% of the plutonium, and more than 99% 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. Refer to Figure 2-14 for an illustration of the REDOX process flow (DOE-RL 1992c).

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 was then 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 was then directed to the second and third plutonium cycles, as necessary for further purification (DOE-RL 1992c).

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 1992c).

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 prior to 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 prior to being recycled into the extraction process (DOE-RL 1992c).

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. Prior to any additional plutonium purification cycles, the aqueous plutonium (III) was again oxidized with sodium dichromate to the IV or VI valence states to permit the solvent extraction process to proceed. The purified plutonium stream was then directed to a final isolation process in the 231-S or 234-S Building. The final plutonium product was a plutonium nitrate solution containing approximately 10 g of plutonium and 400 to 600 g of free nitric acid per liter. The uranium impurity in the plutonium product stream was estimated at 0.1 weight percent of the plutonium metal. Other impurities in the plutonium stream were expected to be aluminum and iron at 30,000 and 10,000 ppm parts of plutonium, respectively (DOE-RL 1992c).

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 prior to shipping 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 prior to disposal; therefore, no waste management units received wastes directly from this process. Refer to Figure 2-14 for REDOX process flow (DOE-RL 1992c).

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 prior to final shipping to the Uranium Conversion Plant (224-UA Building) where the uranyl nitrate was calcinated to uranium trioxide (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% operating efficiency. The uranium product stream was a solution containing approximately 1,004 g of UNH per liter. The plutonium impurity in the uranium stream was expected to be approximately 10 ppb. Other impurities in the uranium stream were expected to be nitric acid, sodium, aluminum, and iron at 10,000, 400, 600, and 150 ppm, respectively (DOE-RL 1992c).

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. In addition, the aqueous uranium product stream was steam stripped prior to 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 was then 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 prior to disposal; therefore, no waste management units received wastes directly from this process (GE 1951a, DOE-RL 1992c).

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) were also removed. Additional chemical treatments including washings with demineralized water, nitric acid, and dichromate solutions (similar to those conducted during solvent pre-treatments) 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 (GE 1951a, DOE-RL 1992c).

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 prior to disposal. The second stream was very dilute and was disposed in the 276-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 (GE 1951a, DOE-RL 1992c).

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 222-S Laboratory were blended with the remaining liquid/solids (bottoms) from the waste concentrator and neutralized with caustic to convert the aluminum nitrate to sodium aluminate. (This conversion served to minimize corrosion problems during storage of the waste within the 241-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 (GE 1951a).

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, disposed as low-radioactive waste in the 216-S Cribs including 200-PW-2 OU waste sites 216-S-1&2 and 216-S-7. 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 240/241-S diversion boxes to the 241-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 were also 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 (GE 1951a).

2.2.2.3 PUREX Process. The PUREX process was an advanced solvent extraction process that replaced the REDOX process. PUREX used a recyclable salting agent, nitric acid (which greatly lessened costs and amount of waste generated), and TBP in a NPH solution as a solvent. TBP/NPH proved to be a much safer and 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 1993c).

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 1993c).

With the exception of the feed preparation and dissolution processes, which operated in batch operation, the PUREX process was continuous. Refer to Figure 2-15 for an illustration of the PUREX process. The process steps include the following (DOE-RL 1993c):

- 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 were initially 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 were often added to react with the ammonia and suppress the hydrogen that evolved during decladding operations (GE 1955a, WHC 1989).

Between 1% and 10 % 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% to 10% 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 (GE 1955a, WHC 1989).

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 was then physically separated by centrifugation. The supernatant was sent to the waste treatment system while the solids were either dissolved with a nitric acid/ANN solution and routed to the metals feed tank, or 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 241-A Tank, while the solids were dissolved in nitric acid, neutralized, and routed directly to the 241-A Tank Farm (GE 1955a, WHC 1989).

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, was also directed to 241-A Tank Farm. ANN was added just before the dissolving solution to complex any remaining fluoride anions. The uranium slugs were then 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 was then sent to the first-cycle extraction column. The dissolved off-gases were vented and routed to the off-gas waste treatment system (GE 1955a, WHC 1989).

Off-gases including ammonia, hydrogen, and nitrous oxides, containing various radionuclides including iodine-131 and iodine-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 (GE 1955a, WHC 1989).

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 mainly recovered 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 (GE 1955a, WHC 1989).

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 were then 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 were then 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 (GE 1955a, WHC 1989).

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 releasing the ammonia to the atmosphere. Liquid condensate from the three dissolver towers, their respective ammonia scrubbers, and the back-up facility were all 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 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 strontium-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. If the liquid effluent was not within regulatory discharge, it was either reworked or neutralized with caustic (concentrated sodium hydroxide) and routed as ammonia scrub waste to the 241-A Underground Storage Tanks for final disposal (GE 1955a, WHC 1989).

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 were collected and routed to the nitric acid recovery and/or back cycle waste treatment system (GE 1955a, WHC 1989).

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% 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. Refer to Figure 2-15 for an illustration of the PUREX process (GE 1955a, WHC 1989).

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 plutonium (second and third), final neptunium purification cycles, and a uranium scrub solution (organic phase) from column 1BS. The second extraction column or partition column was essentially 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 due to the addition of concentrated nitric acid in the 1BS column. The recovered uranium was then 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) (GE 1955a, WHC 1989).

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% 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 1 CU 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 (GE 1955a, WHC 1989).

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 prior to 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 prior to being recycled into the extraction process (GE 1955a, WHC 1989).

The final (second and third) plutonium cycles extraction columns operated similar 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 was then 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 first column in the third plutonium cycle. The organic product solution from column 3A was then 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 was then sent to the 3BP plutonium stripper and concentrator units where the volume was reduced and, thus, the plutonium concentrated. After final purification and concentration operations, the plutonium product was routed to Z Plant for final processing and shipment off-site (GE 1955a, WHC 1989).

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 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 prior to shipping. All of the waste streams generated during the second and third plutonium cycles received further treatment prior to disposal; therefore, no waste management units received wastes directly from this process (GE 1955a, WHC 1989).

The aqueous uranium-rich stream from column 1C and 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 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 that minimized corrosion of the final uranium cycle concentrator. The organic product stream was then directed to column 2E. Column 2E served the same purpose of column 1C (to strip the uranium from an organic phase to an aqueous phase by adding dilute nitric acid of less than 2%). The aqueous uranium stream produced by the final uranium extraction cycle was routed to the 2EU concentrator where it was steam stripped prior to final shipment. The purified uranium stream was then directed to the uranium conversion plant (224-UA Building) where the uranyl nitrate was calcinated to uranium trioxide (UO_3) for shipment off-site. Refer to Figure 2-15 for the process flow of PUREX (GE 1955a, WHC 1989).

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 prior to 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 prior to disposal; therefore, no waste management units received wastes directly from this process (GE 1955a, WHC 1989).

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% 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 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 (GE 1955a, WHC 1989).

Phase II of the neptunium recovery operation was similar to phase I. The phases differed in that a solution of concentrated nitric acid was utilized 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 1,0000 g of neptunium, the transition to phase III of the neptunium recovery operations began (GE 1955a, WHC 1989).

Phase III was the transfer of the concentrated neptunium from column 2P to either 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% had been transferred, the neptunium recovery operations reverted to phase I (GE 1955a, WHC 1989).

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 batchwise purification process. The neptunium/nitric acid solution was routed to the stripper/concentrator that 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 the 3X anion exchange column. The anion exchange column contained Amberlite IRA-99 resin that required pre-treatment, including de-gasing and washing with nitric acid and hydrazine. The neptunium was then 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 was then routed back to the waste collection tank in the back-cycle waste treatment system (GE 1955a, WHC 1989).

With repeated use, the organic solvent (TBP/NPH) used by the PUREX process degraded and became contaminated. Due to the high cost of fresh solvent and disposal 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 due to their levels of contamination. The organic waste stream from the final uranium cycle was routed to solvent treatment system 2 due to its level of purity. The impurities removed from spent PUREX solvent included organic degradation products (dibutyl phosphate and MBP), entrained solids (nitrates/aqueous phase salts), fission products (iodine-131, iodine-129, ruthenium-106, and zirconium-niobium-95), and uranium, neptunium, and plutonium contaminants from column processes (GE 1955a, WHC 1989).

To remove these contaminants, an alkaline (sodium carbonate-potassium permanganate) wash was performed batchwise 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 that 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 prior to disposal in underground tanks. The aqueous waste solution from the solvent treatment system 2 wash tank was either rerouted to be used in the solvent treatment system 1 operations or sent to a waste collection tank prior to 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 (GE 1955a, WHC 1989).

The PUREX Plant was provided with facilities for the recovery of the salting agent (nitric acid). More than 80% 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 conducted within the back-cycle waste treatment system. The third main source of recovered nitric acid was recovered in the UO_3 Plant and transferred back to the nitric acid recovery system (206-A Building) via railroad tank cars (GE 1955a, WHC 1989).

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 it was 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% 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% 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 reuse in the PUREX Plant (GE 1955a, WHC 1989).

The back-cycle waste treatment system collected and treated all of the aqueous PUREX waste before release to the atmosphere after the PUREX Plant resumed operations in November 1983. Prior to 1983, some of the low-level process distillates and condensates were released without being recycled or treated. There were three distinct groups of liquid process waste resulting from PUREX operations, and different handling and disposal procedures were employed for each of these waste groups (GE 1955a, WHC 1989).

High-activity waste resulted from the cladding dissolution, metal dissolution, and first extraction column (HA) waste. This waste was sent to the 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 was then transferred batchwise to tank TK-E6 for blending with the feed and 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 (GE 1955a, WHC 1989).

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% 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 was then routed to the nitric acid recovery operation in the 206-A Building for further purification (GE 1955a, WHC 1989).

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 the nitric acid recovery/storage, uranium pre-treatment and storage, 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 for storage or final disposal to 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 sent directly to underground storage tanks for disposal. The 216-A Cribs that received process discharge from PUREX include 200-PW-2 OU waste sites 216-A-10, 216-A-5, 216-A-3, and 216-A-28. 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 also received condensate waste from the 241-A Tank Farm that was condensed in the 241-A-431 Building (GE 1955a, WHC 1989).

2.2.2.4 WESF/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 Semiworks for purification of the strontium-90 fraction and separation of the rare-earth fraction in cerium-144 and a rare-earth fraction including promethium-147. Phase I processing at the 221-B Building ended in June 1966 to accommodate phase II construction (DOE-RL 1993a).

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 PUREX Plant and the B Plant tank farms into fractions that could be immobilized and contained more safely (DOE-RL 1993a).

The phase III waste fractionalization processing began at the 221-B Building in 1968. This process separated the long-lived radionuclides, strontium-90 and cesium-137, from high-level PUREX and REDOX wastes and stored a concentrated solution of strontium-90 and cesium-137 at the 221-B Building. Individual tanks at the B Plant contained up to 35 MCi of strontium-90 and cesium-137 at concentrations up to 10,000 Ci/gal. The combined storage capacity of the tanks was estimated to be 85 MCi of strontium-90 and 25 MCi of cesium-137 (DOE-RL 1993a).

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 PUREX Plant and REDOX tank farms. The solids in these wastes contained about 55% of the strontium and 70% 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 were then 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 1993a).

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 a NPH diluent. The strontium, cerium, and other rare earths were extracted from the aqueous phase into the solvent. The aqueous fraction contained the cesium and was routed to the 241-A or 241-AX underground tank farms in the PUREX Plant for temporary storage to allow the decay of short-lived activity (DOE-RL 1993a).

The strontium fraction was stripped from the solvent with dilute nitric acid and thermally concentrated with the cell 5 concentrator for storage in tanks in the 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 1993a).

The second process used was a feed preparation and solvent extraction process for processing stored sludge wastes from the 241-A, 241-AX, and 241-SX Tank Farms. The sludge was sluiced with supernate and water and pumped out of the tanks to the 244-AR or 244-SR Vault. At these vaults, 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 1993a).

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 transferred to immobilization processing (in-tank solidification) (DOE-RL 1993a).

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 cesium-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% of the adsorbed sodium and 0.5% 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 prior to transfer to in-tank solidification. In 1974, the 221-B Building began using cell 38 to perform final purification of the cesium prior to processing 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 1993a).

The waste fractionalization process included a thermal evaporation concentrator in cell 23 to concentrate process wastewaters prior to 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 that 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 1993a).

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 1993a).

2.2.2.5 Semi-Works 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 Semi-Works Pilot Plant chemical processing. Historical cold-run wastes were likely characterized by high salt content, low organics, and as neutral to basic. Unspecified wastes were also derived from the 201-C Process Building systems decontamination, which were conducted prior to conversion to new processes. Information regarding the waste management units receiving other waste streams is limited (DOE-RL 1993d).

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 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 many of the other compounds listed. Waste streams from the REDOX process were slightly acidic and contained fission products including cesium-137, ruthenium-106, strontium-90, plutonium-239, and uranium based on WIDS. The presence of additional radionuclides including tritium, cobalt-60, and uranium-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 Crib, which received acidic radioactive waste between 1953 and 1954 (DOE-RL 1993d).

The PUREX process generated wastes from decladding of aluminum and Zircaloy fuels that were reportedly 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 prior to reuse of the solvent. The PUREX organic wash wastes primarily included sodium nitrate, sodium carbonate, manganese oxide, and uranium. Process condensate from PUREX 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 are also 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 Crib that received neutral to basic process condensate and cold oven wastes between 1954 to 1956 (DOE-RL 1993d).

The strontium recovery process was performed using a complexant di-2-ethyl-hexyl phosphoric acid to extract strontium from acid solutions of waste fuels. However, none of this waste was disposed to the 200- PW-2 OU waste sites; thus, the strontium recovery process conducted at the Semi-Works facility is not discussed further (DOE-RL 1993d).

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 Semi-Works 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 prior to discharge to the 216-C-1 Crib, and unspecified wastes from the 201-C Process Building hot shop sink (DOE-RL 1993d).

2.2.3 Representative Sites and TSD 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 1999). 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 similar chemical characteristics to the sites that were characterized. Confirmatory investigations of limited scope can be performed at the sites not selected as representative sites, rather than full 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 1999), four representative sites were identified for the 200-PW-2 OU. 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) are also RCRA TSD units and will be characterized as part of the closure/post-closure activities.

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) Building (Figure 2-16). 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 possibly condenser cooling water from the 241-A-431 Building.

Waste from PUREX entered the trench from above-ground piping that emptied into the trench. Condenser cooling water from the 241-A-431 Building may have reached the trench via the 216-A-34 Ditch that lies adjacent to 216-A-19. 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 1997, PNL 1988).

Nitrate salts were disposed at the site. The radionuclide inventory included cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium-238 (PNL 1988). The 216-A-19 Trench and 216-A-34 Ditch were backfilled following use and later covered with several feet of fill (GE 1956b, 1956c, 1958b). 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) and is approximately 8 m (26 ft) deep on one end and 9 m (30 ft) deep on the downgradient end (Figure 2-17) (GE 1956b, RHO 1979, PNL 1988).

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 1991b).

During its service history, the 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 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 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 1979, WIDS).

The waste is low salt and neutral/basic. Records indicate that 180,000 kg (396,832 lb) of ammonium nitrate was disposed at the site. The radionuclide inventory of the site includes cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium-238 (PNL 1988, DOE-RL 1988). An estimated 21,000 kg (46,300 lb) of uranium, 374 g (1 lb) of plutonium, 716 Ci of cesium-137, and 79.3 Ci of strontium-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 1988, DOE-RL 1997).

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) and is 9 m (31 ft) deep (Figure 2-18) (GE 1958b, PNL 1988). Surface elevation was 211 m (692 ft) and the bottom of the crib was at 202 m (662 ft) (GE 1954a). 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 1991a).

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 (GE 1956c; DOE-RL 1988, 1995a). 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 (GE 1954c). 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 (Heid 1957). By 1958, it had received 3.63×10^8 L (9.6×10^7 gal) of liquid materials and 367 g (0.8 lb) of plutonium (Baldridge 1959). In 1959, the crib received an additional 9.08×10^6 L (2.4×10^6 gal) of waste

(Reisenauer 1959). 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 1992a, 1995a).

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 1979). 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 1995b).

The site was characterized in 1995 as part of 200-UP-2 OU characterization activities (DOE-RL 1995b). 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 at the site include nitric acid. The radionuclide inventory includes cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium-238 (PNL 1988). 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 1997).

2.2.3.4 216-U-12 Crib. The 216-U-12 Crib is the first of three RCRA TSD units in this OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1987.

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 1995b). 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 2-19). 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 1991a).

During its operational period beginning in April 1960 and continuing for 28 years, the crib received 150 million liters (40,000,000 gal) of liquid waste. From 1960 to 1967 it received stack drainage from 291-U-1, 244 WR Vault waste, storm drain waste from the 224-U Building, and waste from the C-5 and C-7 tanks within 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 1992a). 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 1979, WHC 1991a, BHI 1996c). 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 1993b).

The site was characterized in 1995 as part of 200-UP-2 OU characterization activities (DOE-RL 1995b). 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, strontium-90, americium-241, cesium-137, plutonium-239, and uranium-238 (DOE-RL 1988). This included an estimated 2.01 x 10^3 kg (4,400 lb) of uranium (DOE-RL 1997). 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 this OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1987.

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) 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 2-20) (GE 1956b). 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 (GE 1958a, 1958b). From 1956 to 1959, the crib received 2.34 x 10^8 L of water (Heid 1956, 1957; Bernard 1958; Baldridge 1958; GE 1960). 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 1979).

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 were also replaced. The crib was inactive from 1978 until 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 1996b).

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 1997). The crib received tritium, strontium-90 (82.5 Ci), iodine-129, americium-241 (0.7 Ci), cesium-137 (80.5 Ci), promethium-147, plutonium-238, plutonium-239, and plutonium-241 (350 g total plutonium), and 241 kg (530 lb) of uranium (DOE-RL 1988, 1997).

2.2.3.6 216-A-36B Crib. The 216-A-36B Crib is the last of three RCRA TSD units in this OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1988.

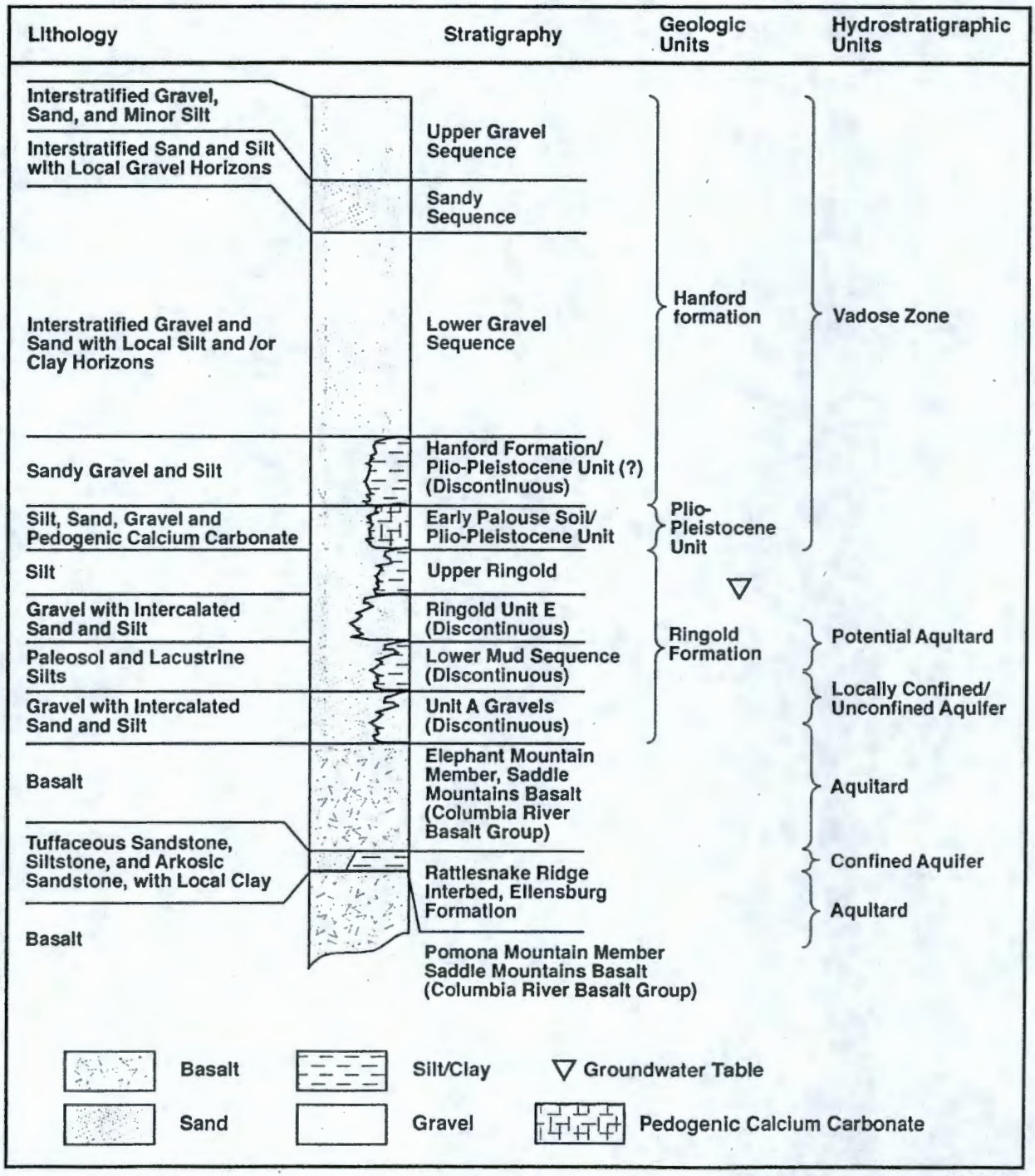
The 216-A-36B Crib is located in the 200 East Area about 366 m (1,200 ft) south of the 202-A (PUREX) Building. Surface elevation is about 217 m (712 ft), and the subsurface elevation of the crib is about 211 m (691 ft). The gravel-filled crib has bottom dimensions of 152 m (500 ft) and a width that varies from 2 to 3.4 m (7 to 11 ft) (Figure 2-21). 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 1988). A 15-cm (6-in.) perforated pipe was placed horizontally 7 m (23 ft) below grade (DOE-RL 1988).

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 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 due to a leaking valve in the scrubber drain to the catch tank (Manry and Prosk 1985). 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 1979). This resulted in the crib's designation as a RCRA TSD unit in the fall of 1987. An interim status indicator parameter evaluation program has been in operation at the crib since May 1988.

The ammonia scrubber distillate waste contained americium-241 (0.2 Ci), cobalt-60, plutonium-239 (258 g), strontium-90 (1,310 Ci), tritium, sulfur-113, iodine-129, cesium-137 (1,200 Ci), promethium-147, and uranium-238 (262 kg). Chemical contaminants included ammonium fluoride, ammonium nitrate, and sodium dichromate (WHC 1988, DOE-RL 1988). Use of the crib was discontinued in the spring of 1988 and the facility was backfilled (BHI 1996b). No stabilization actions have taken place at the waste site.

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



E0005009.9b

Figure 2-2. Groundwater Table Around the 200 East and West Areas, June 1999.

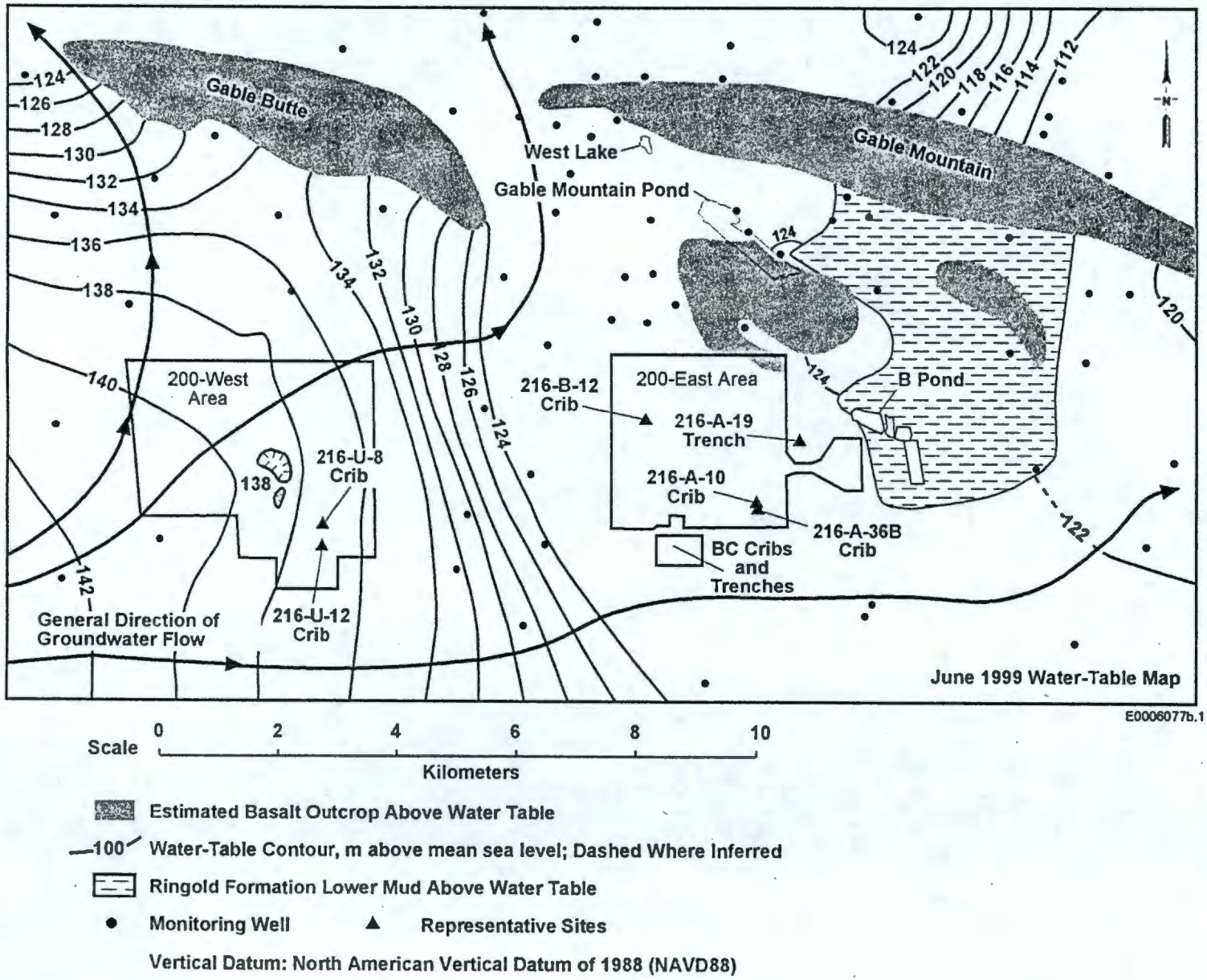


Figure 2-3. Stratigraphy Near the 216-A-19 Trench.

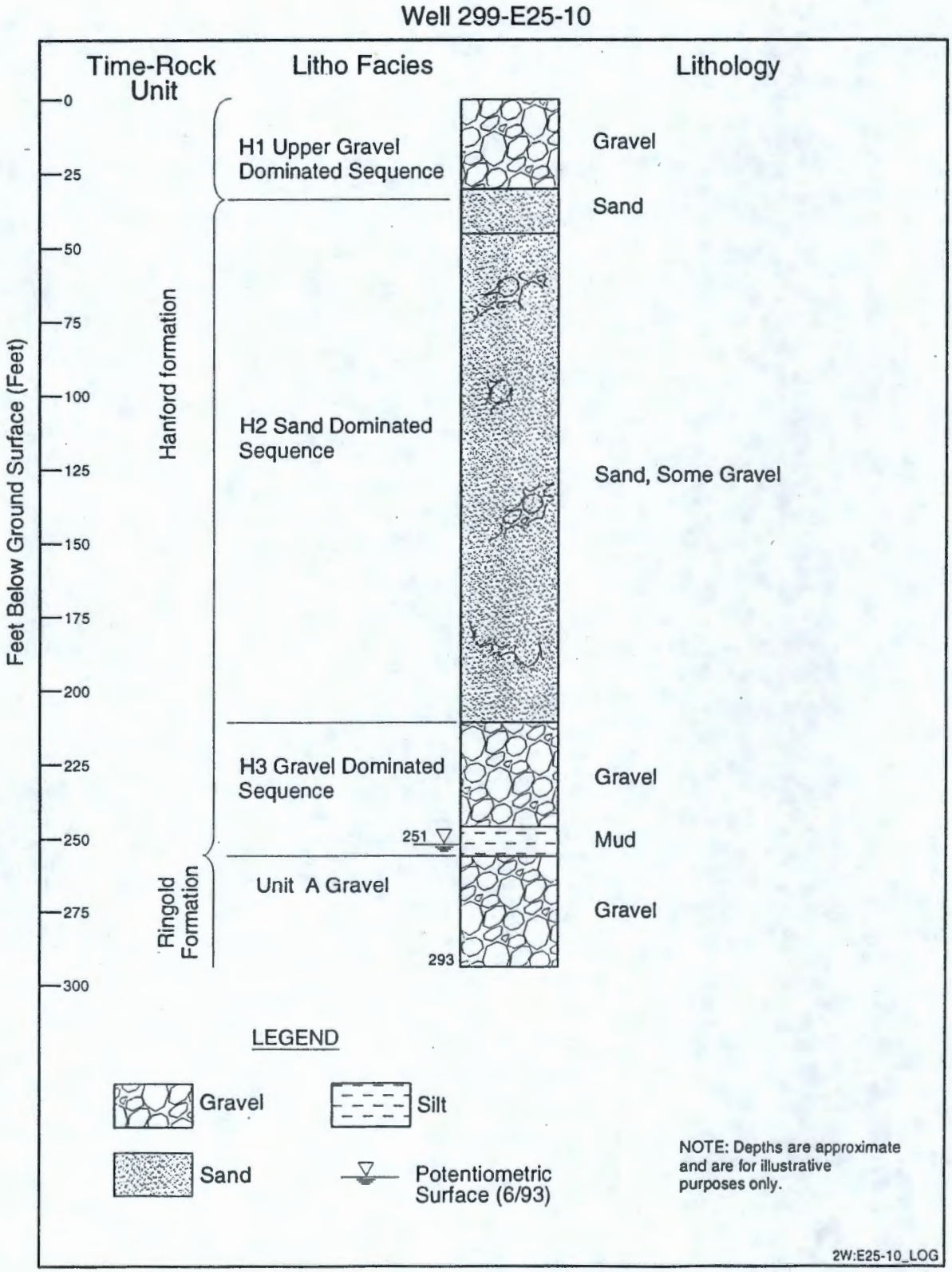


Figure 2-4. Stratigraphy in the Vicinity of the 216-B-12 Crib.

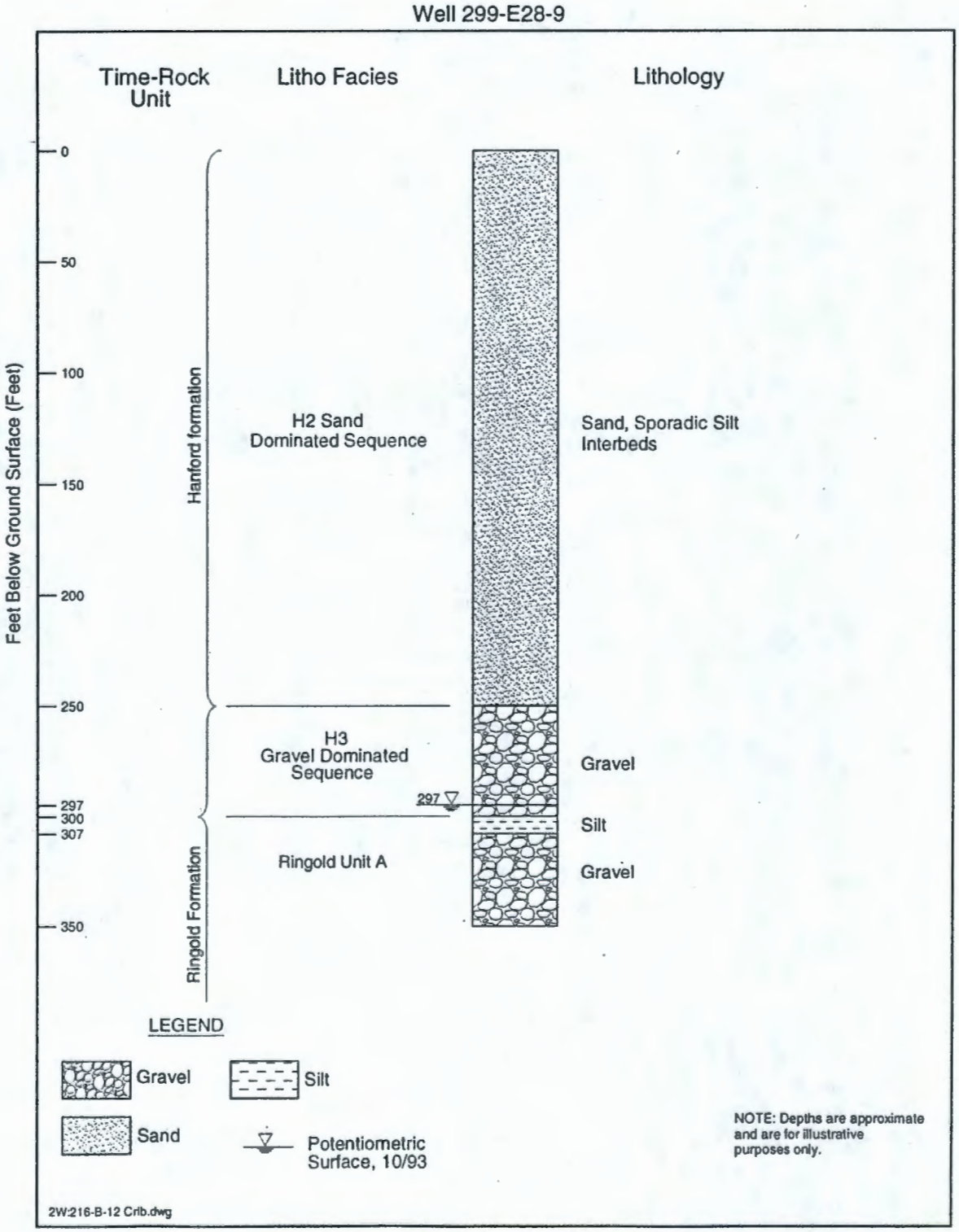


Figure 2-5. Stratigraphy in the Vicinity of the 216-U-8 Crib.

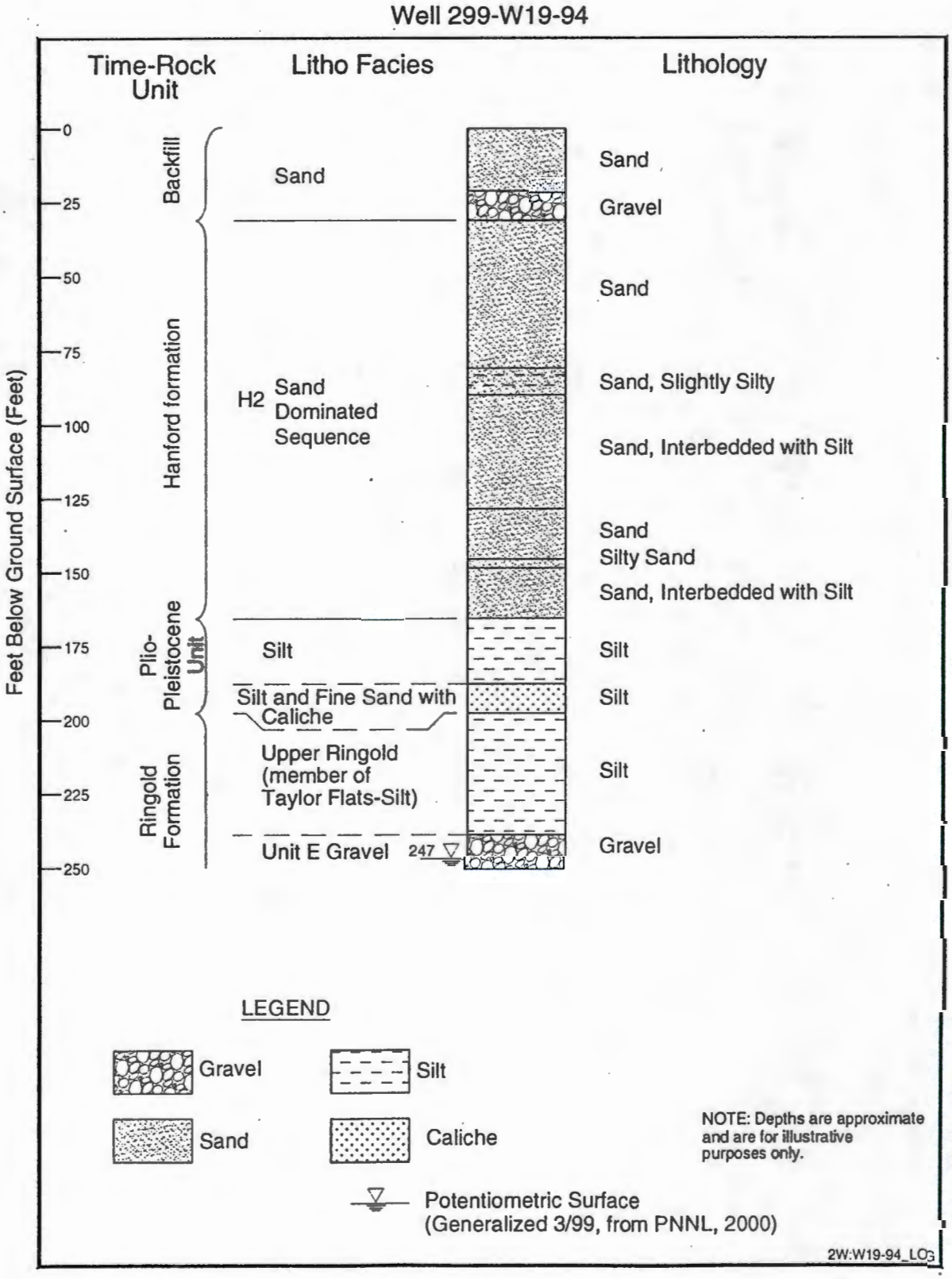


Figure 2-6. Stratigraphy Near the 216-U-12 Crib.

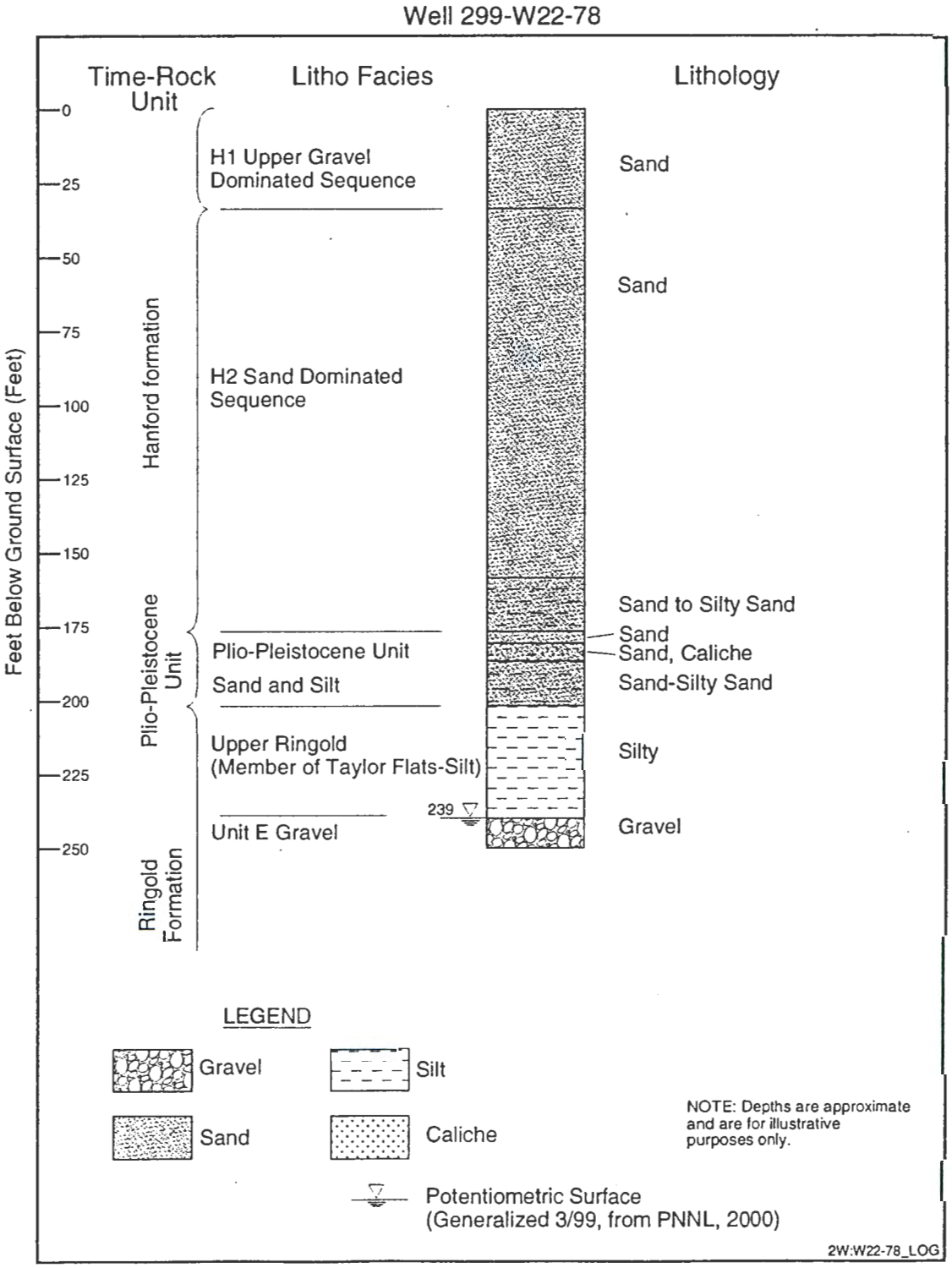


Figure 2-7. Stratigraphy in the Vicinity of the 216-A-10 Crib and the 216-A-36B Crib.

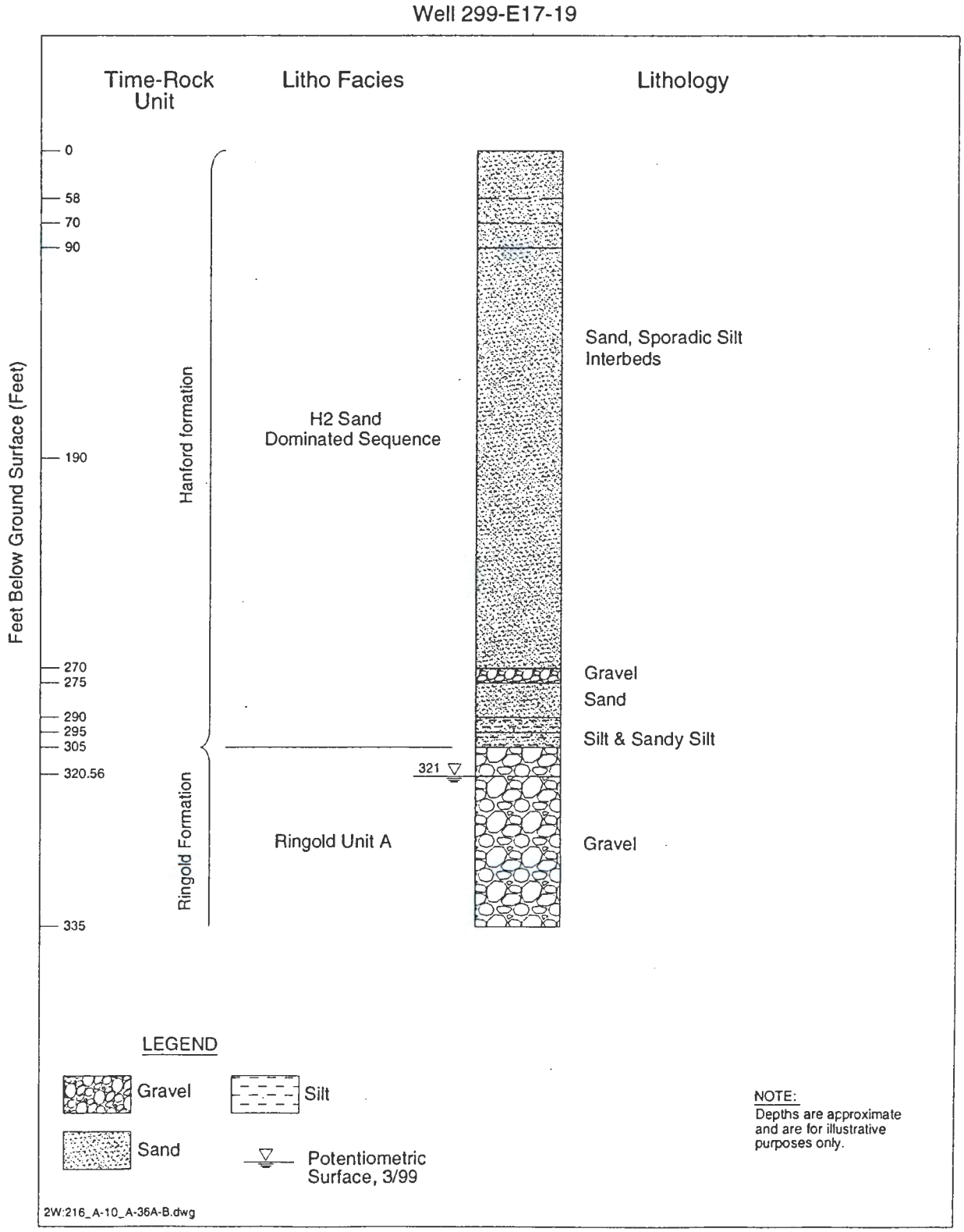


Figure 2-8. Location of the Hanford Site and 200-PW-2 Operable Unit Waste Sites.

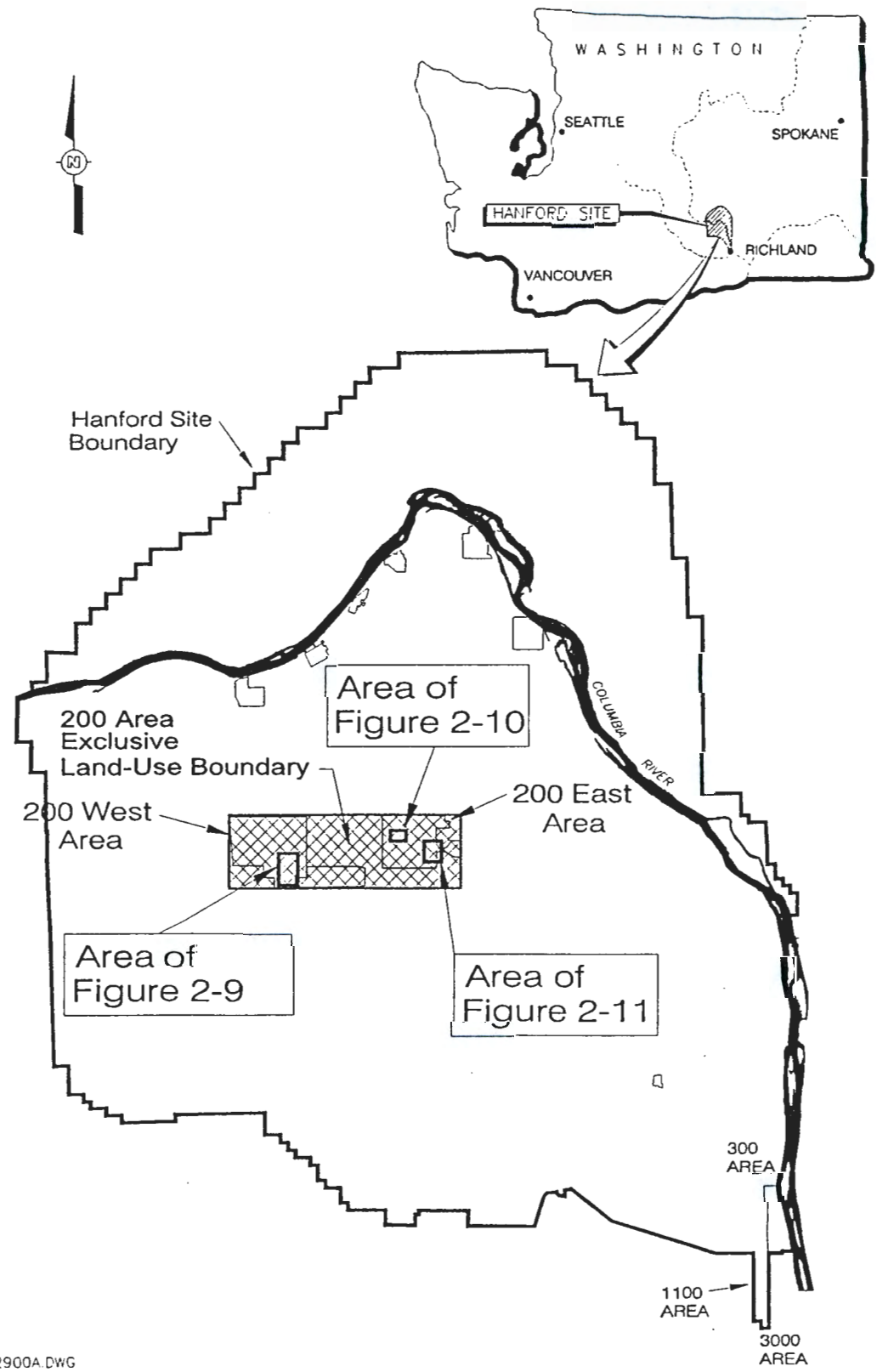
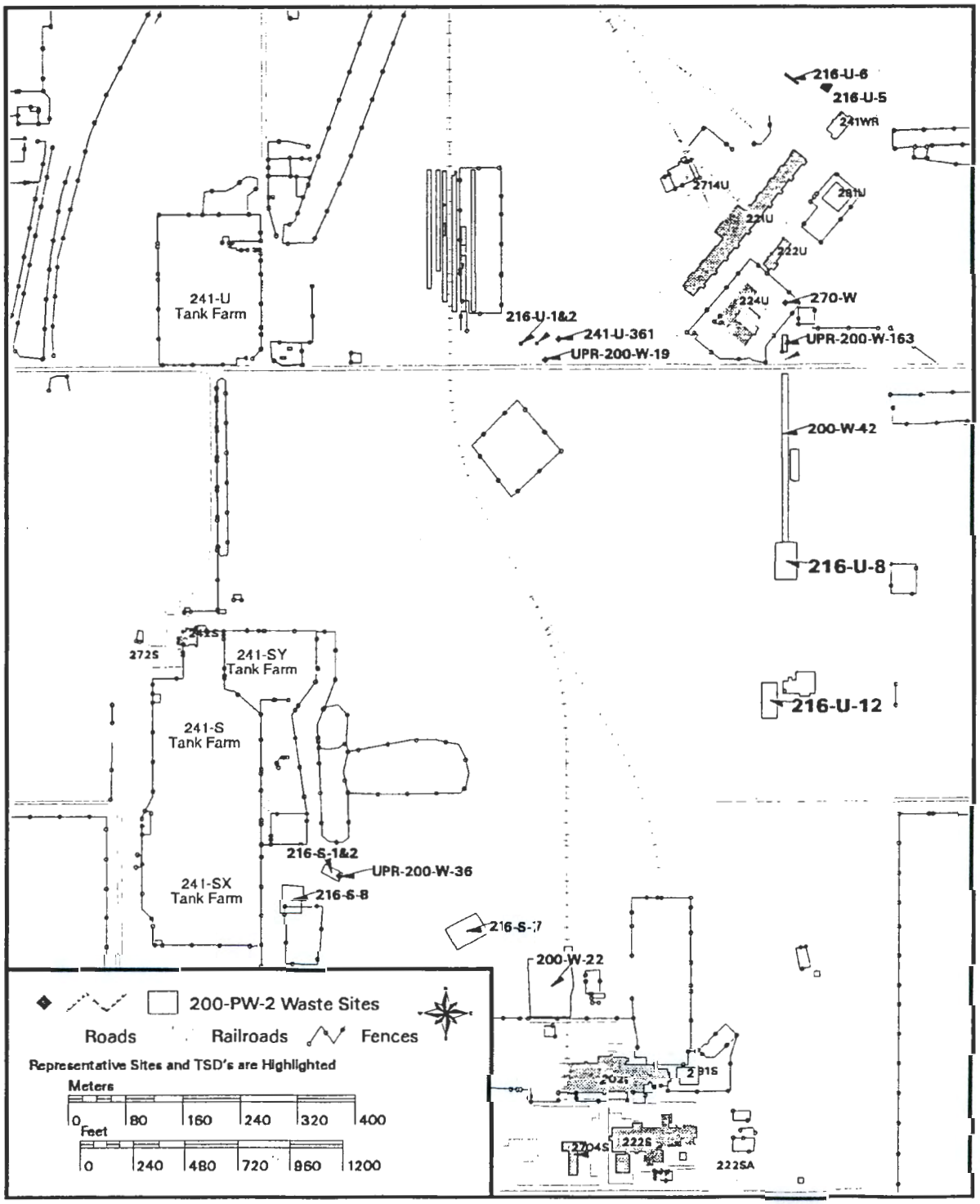
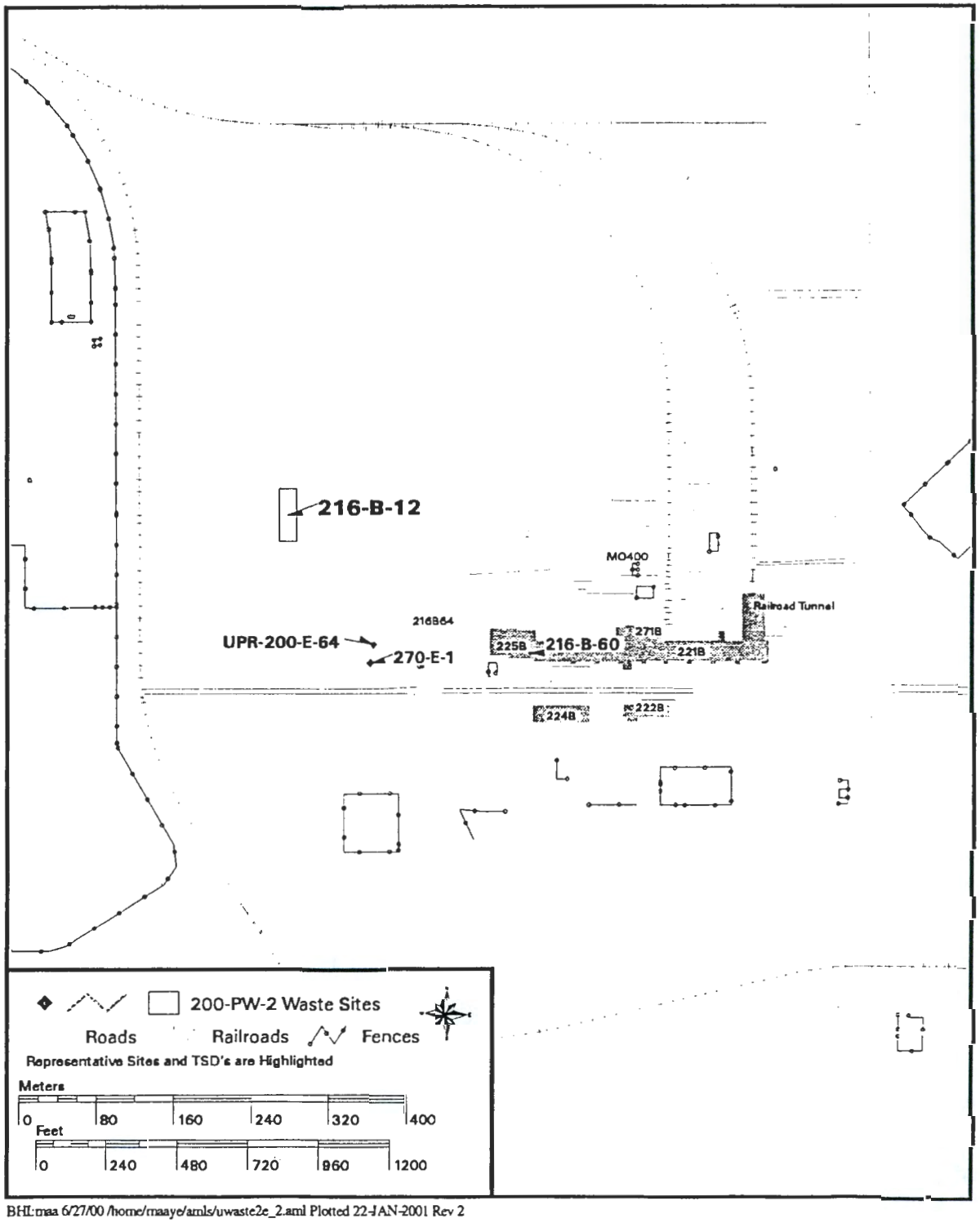


Figure 2-9. Location of 200-PW-2 Waste Sites Inside the 200 West Area.



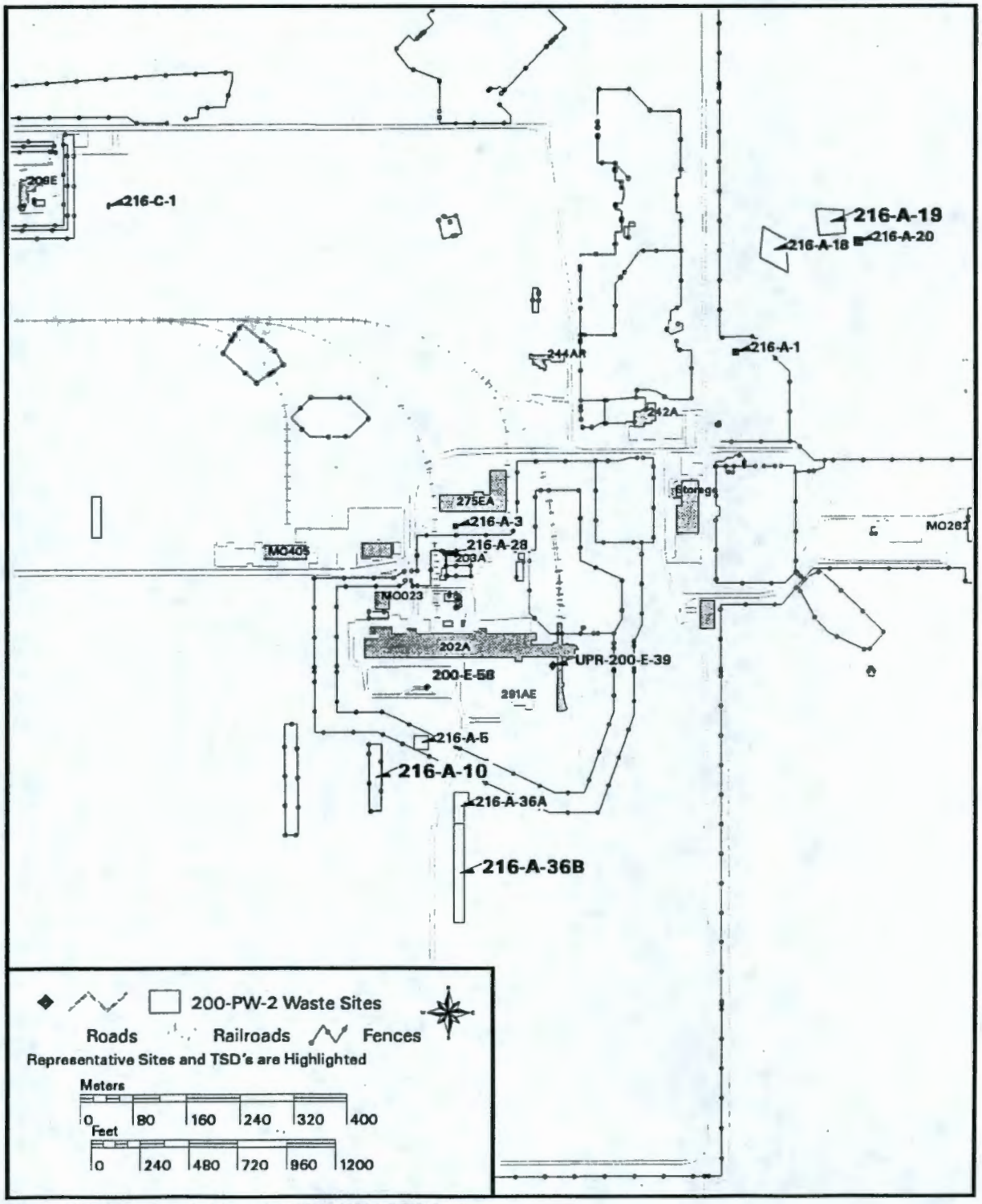
BHI:maa 06/21/00 /home/maaye/amls/uwaste2w.aml Plotted 22-JAN-2001 Rev 4

Figure 2-10. Location of 200-PW-2 Waste Sites on the West Side of the 200 East Area.



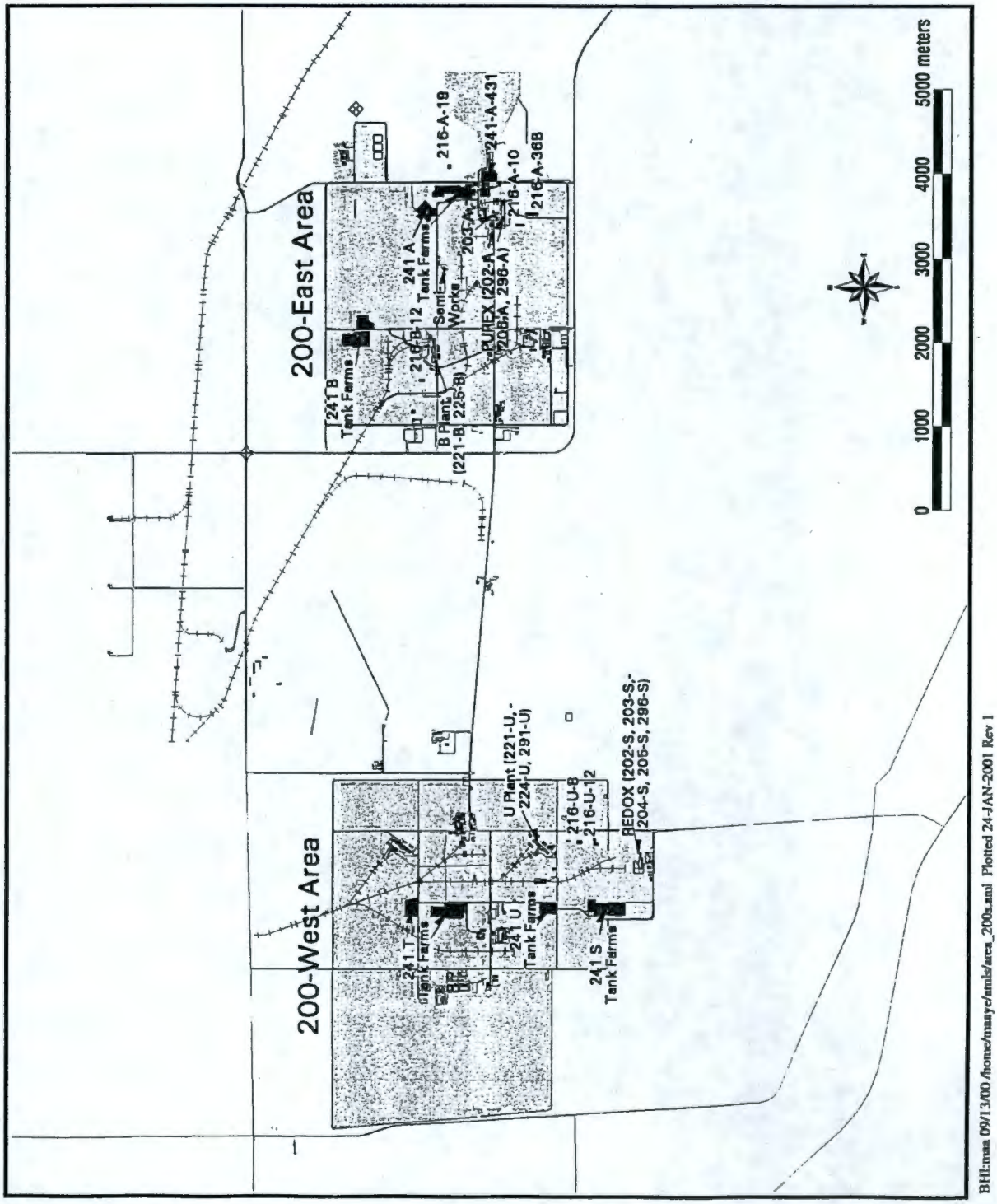
BHI:maa 6/27/00 /home/maaye/amls/uwaste2e_2.aml Plotted 22-JAN-2001 Rev 2

Figure 2-11. Location of 200-PW-2 Waste Sites on the East Side of the 200 East Area.



BHI:mss 06/21/00 /home/maaye/amls/uwaste2e.aml Plotted 28-MAR-2001 Rev 4

Figure 2-12. Source Facilities Associated with 200-PW-2 Operable Unit Representative Waste Sites and TSD Units.



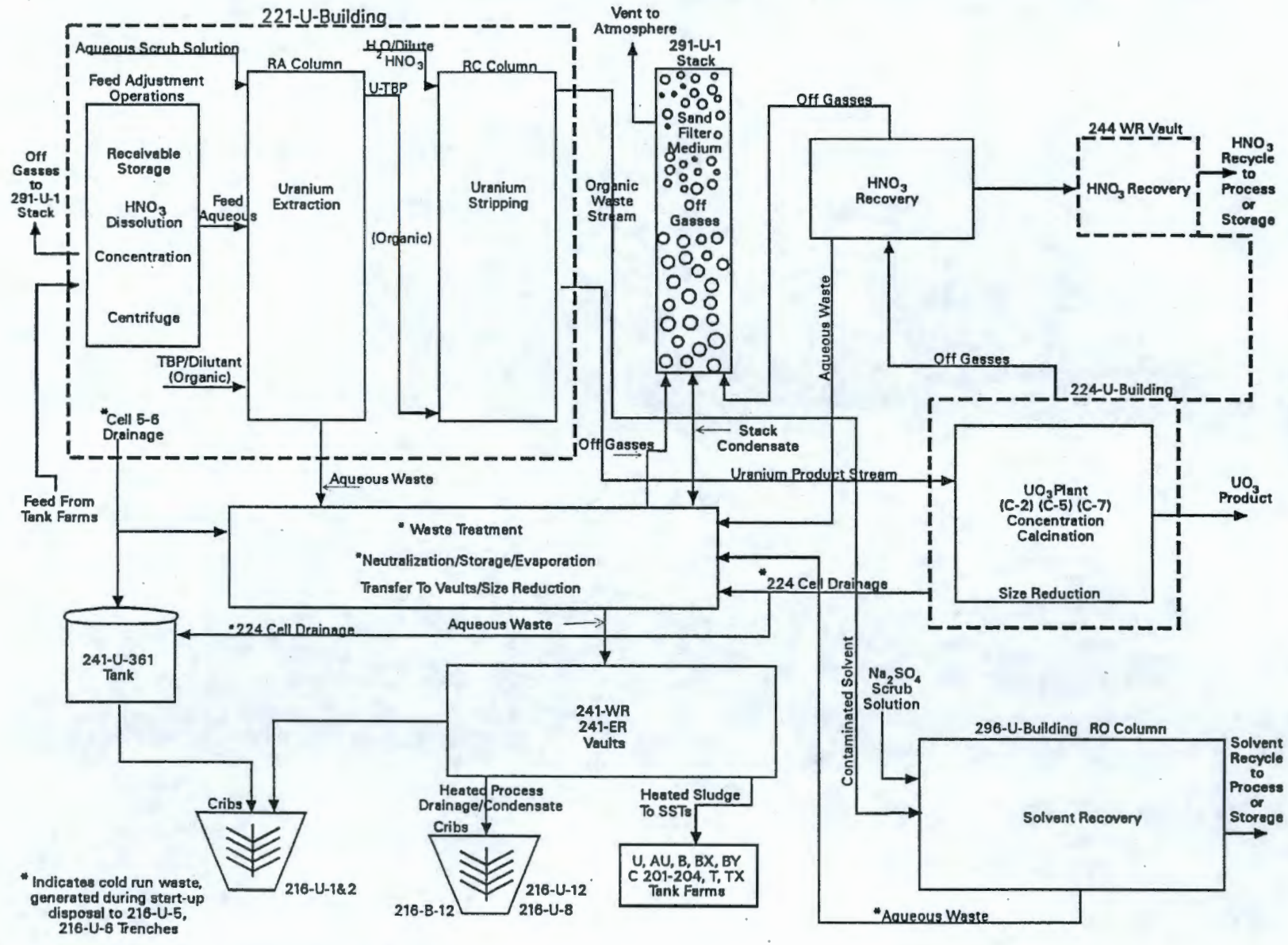


Figure 2-13. Plant Processes and Waste Streams at the U Plant.

Figure 2-14. Plant Processes and Waste Streams at the PUREX Plant.

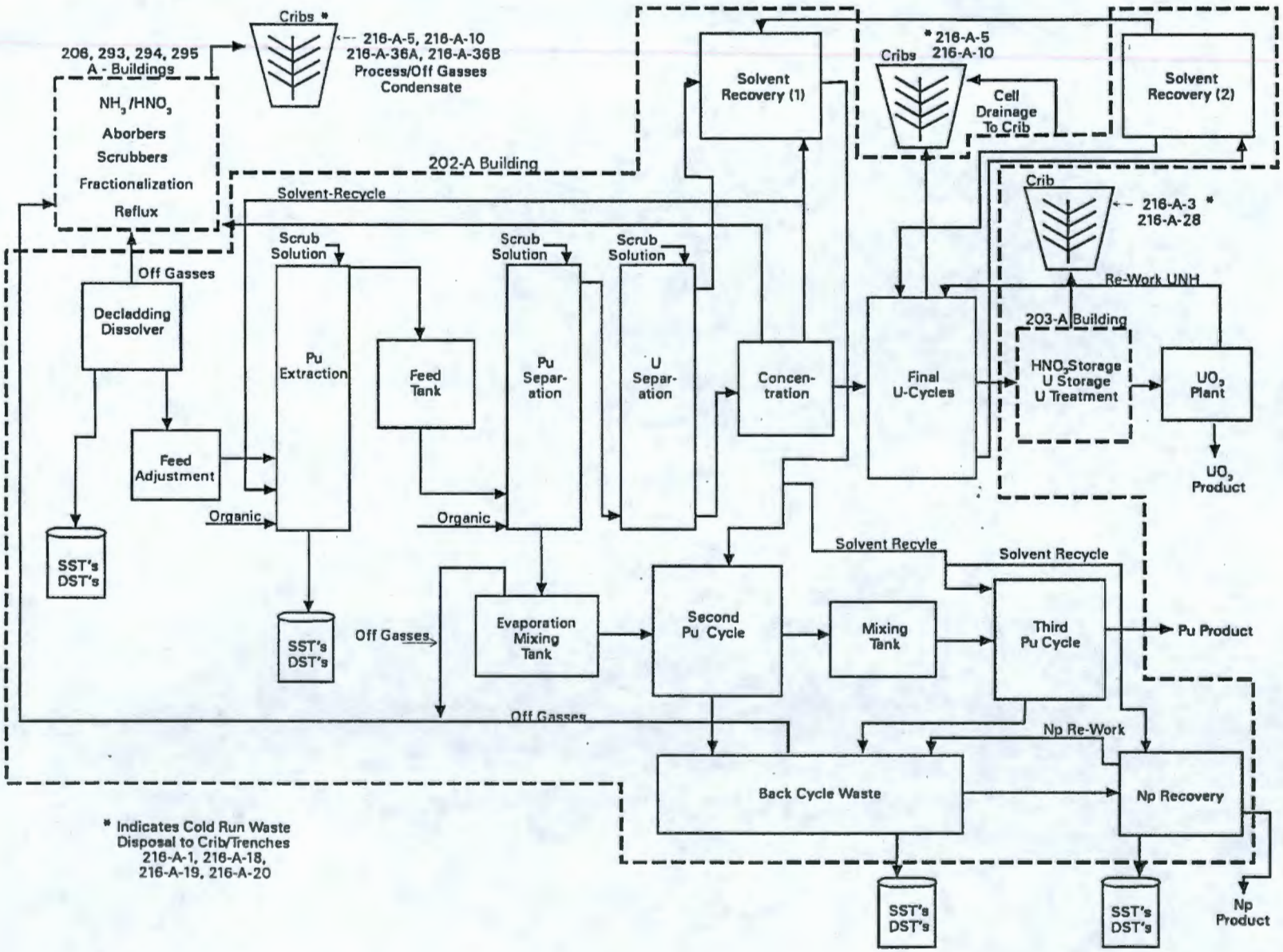


Figure 2-15. Plant Processes and Waste Streams at the REDOX Plant.

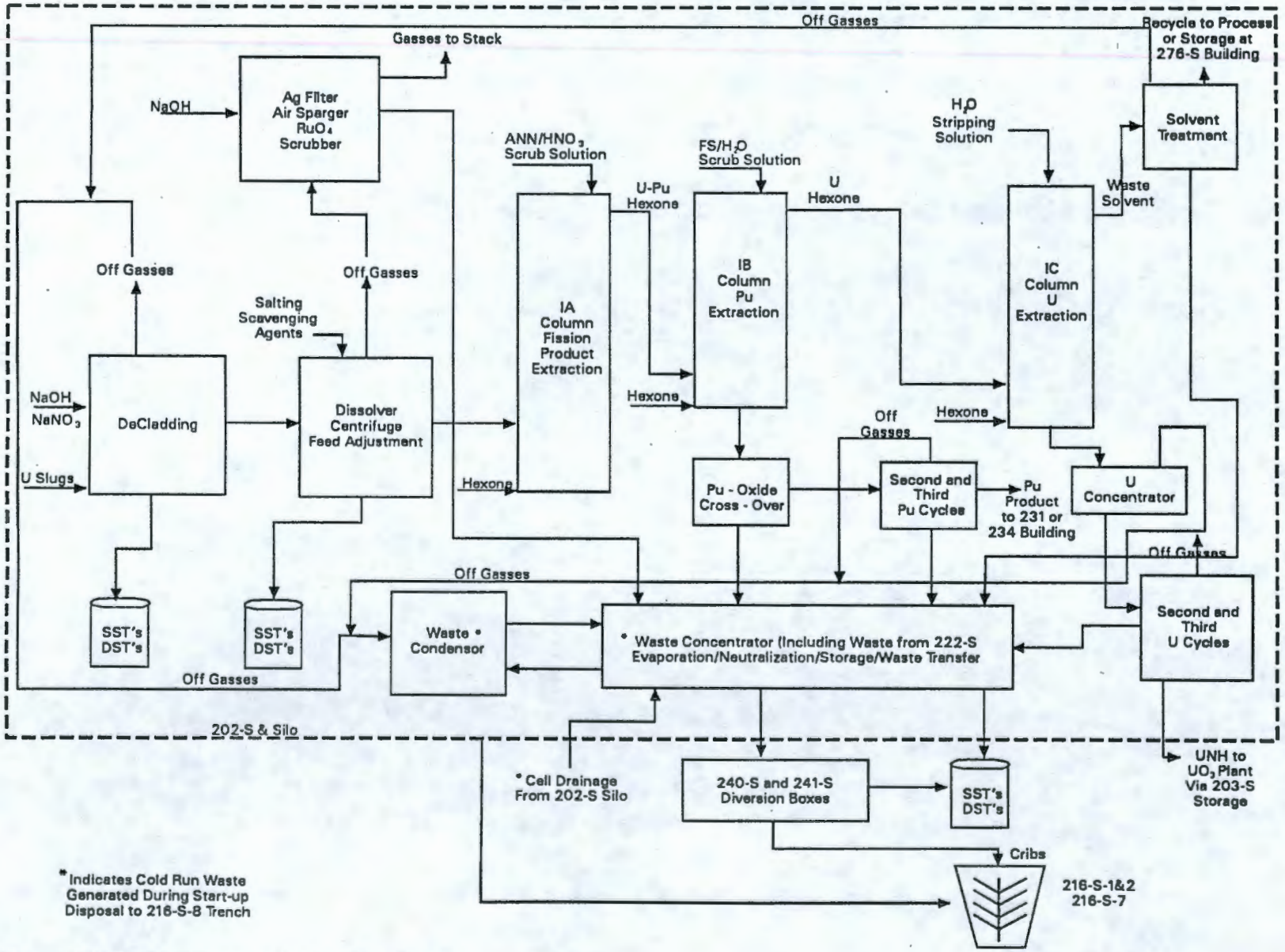


Figure 2-16. 216-A-19 Trench Construction Diagram.

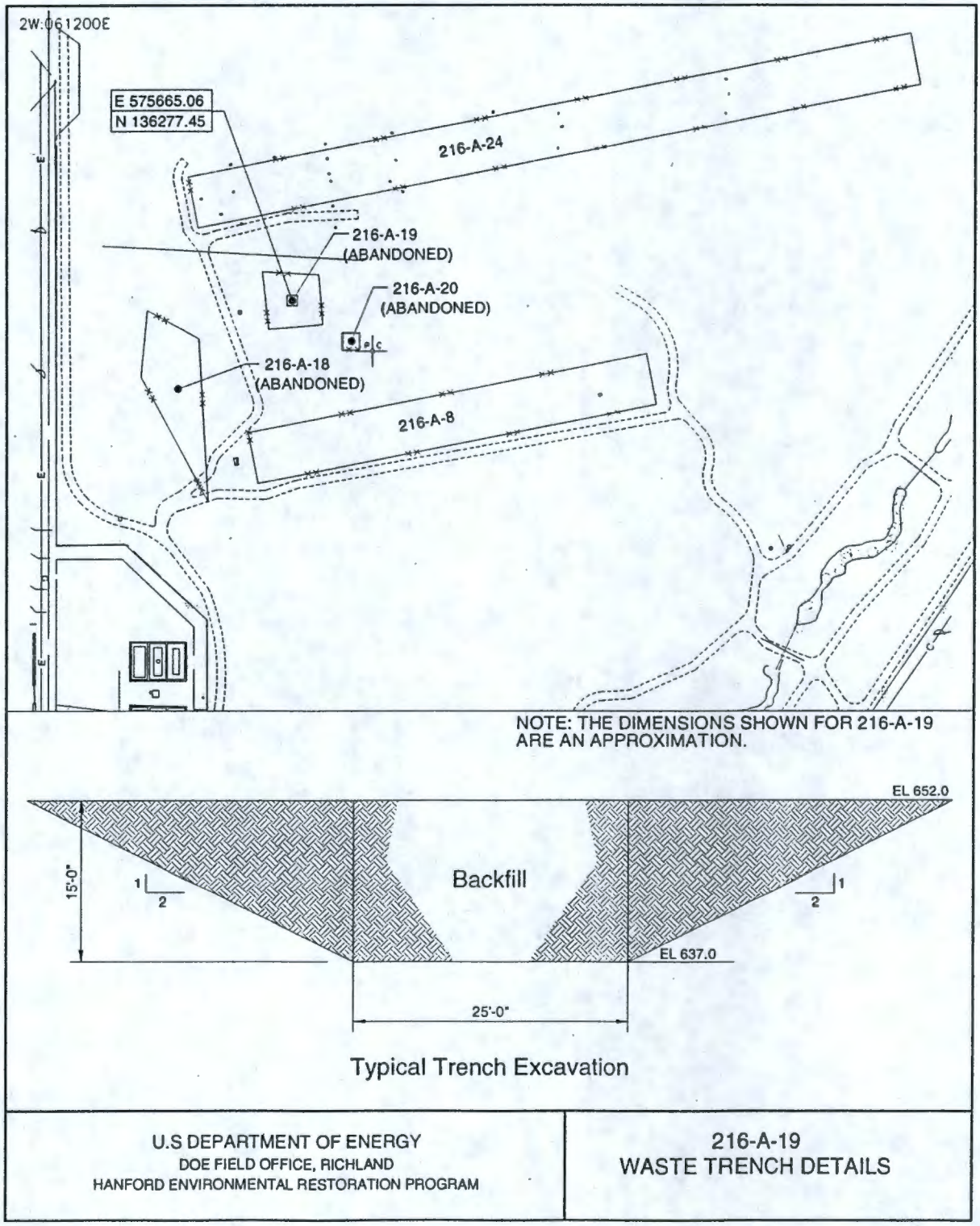


Figure 2-17. 216-B-12 Crib Construction Diagram.

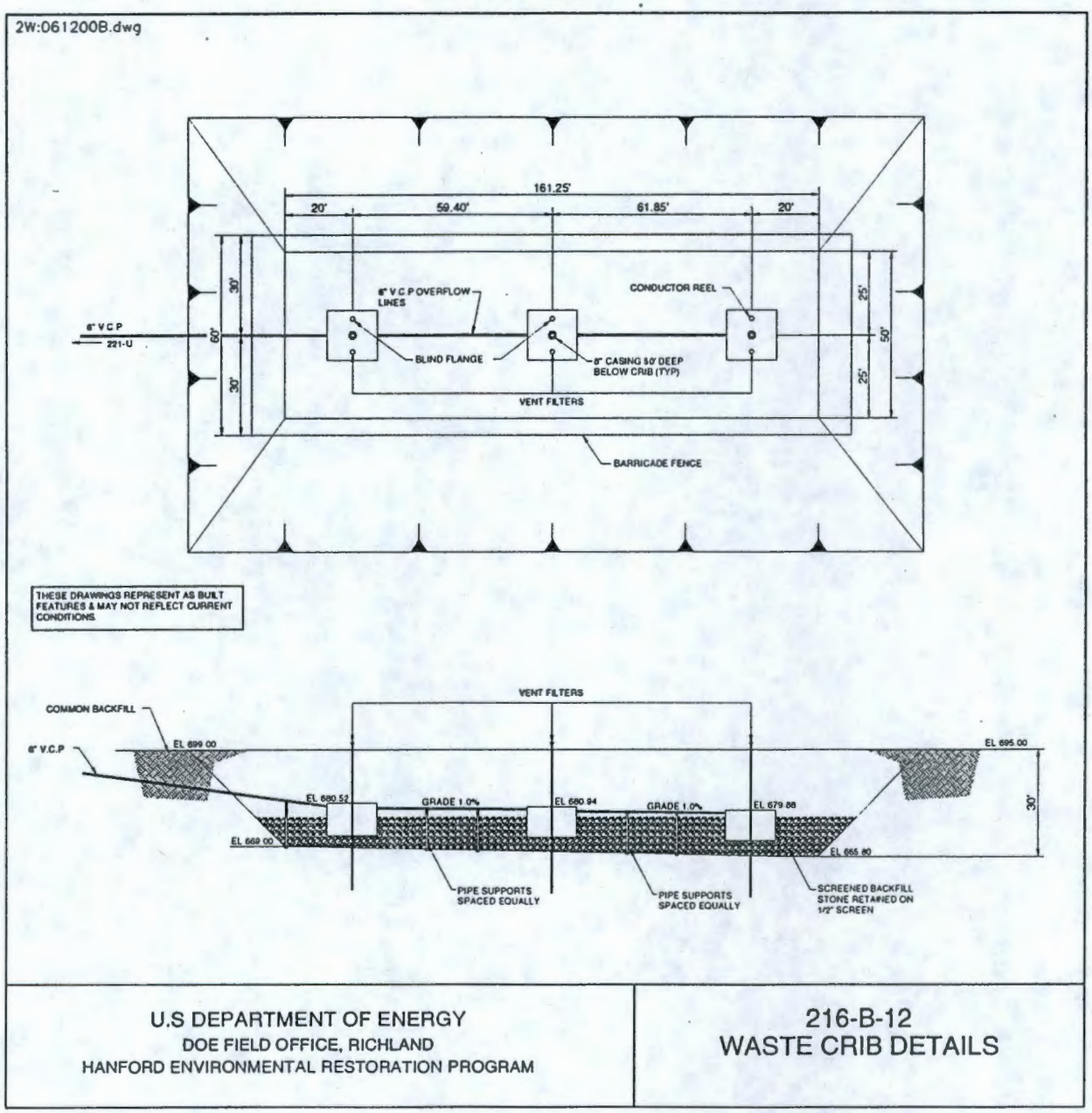


Figure 2-18. 216-U-8 Crib Construction Diagram.

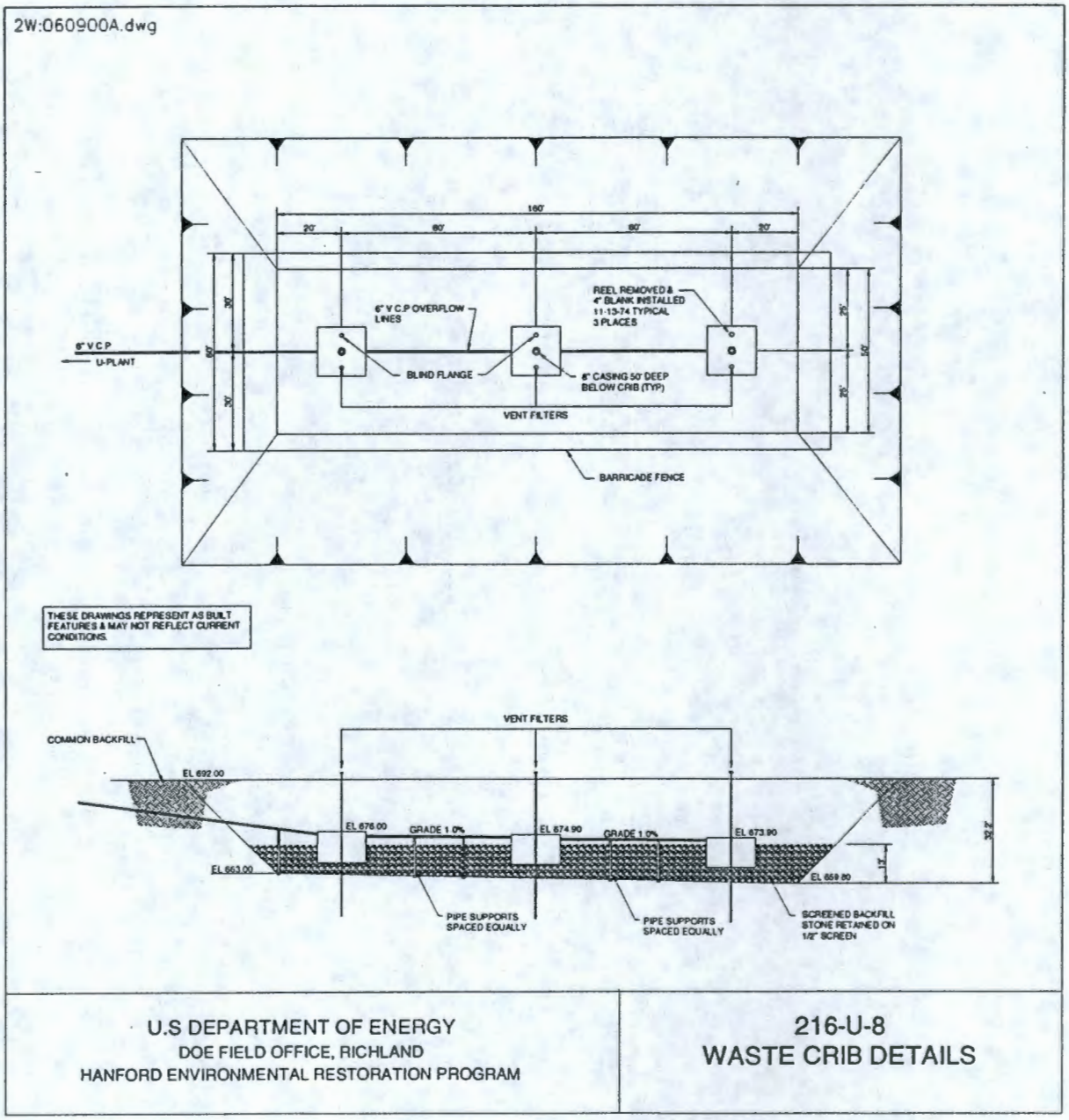


Figure 2-19. 216-U-12 Crib Construction Diagram.

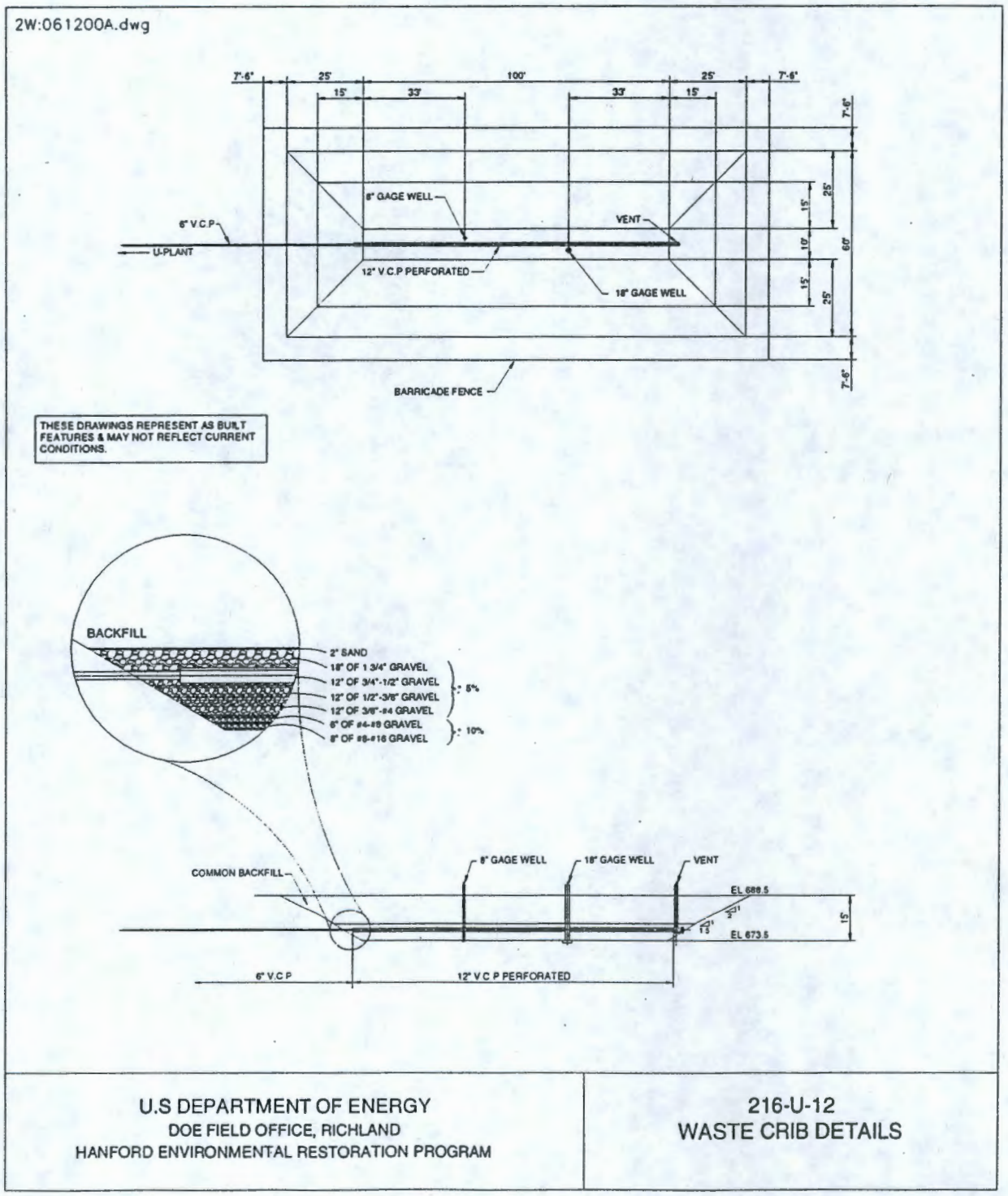


Figure 2-20. 216-A-10 Crib Construction Diagram.

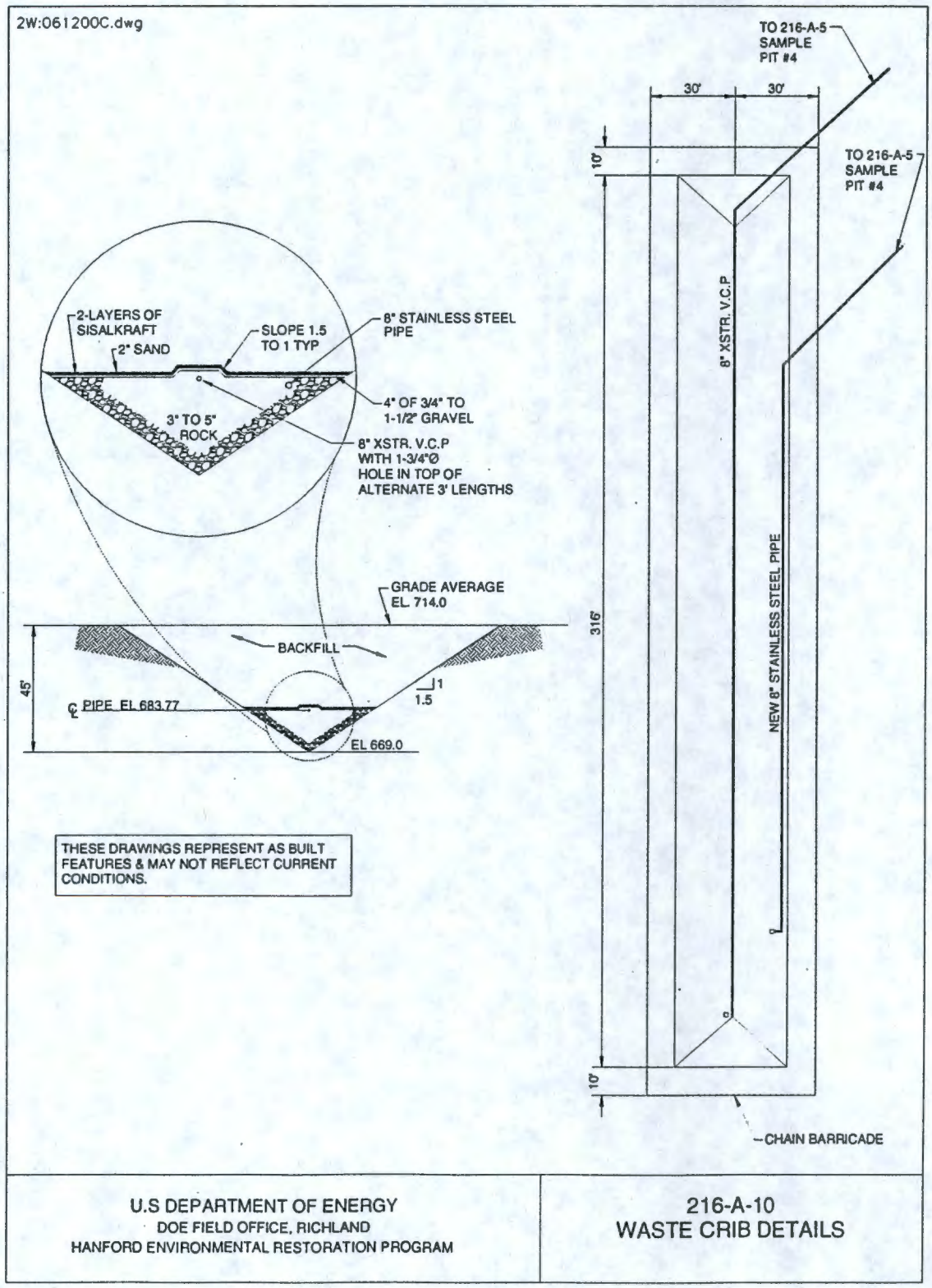


Figure 2-21. 216-A-36B Crib Construction Diagram.

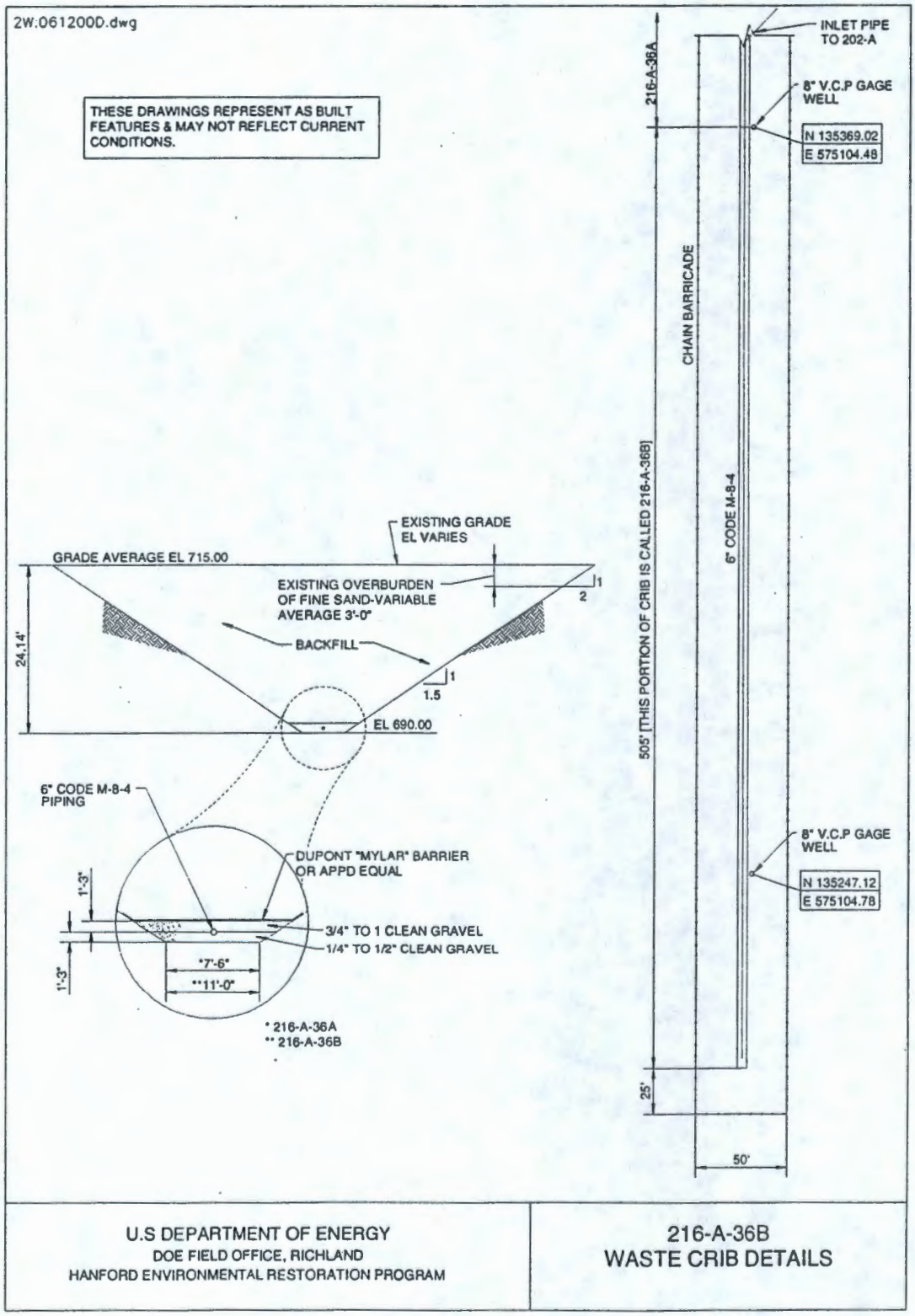


Table 2-1. Uranium-Rich Process Waste Group 200-PW-2. (10 Pages)

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. (10 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
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.
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.
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 million gal) 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 million gal) of acidic waste containing uranium and nitrate	9.1 m (30 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.

Table 2-1. Uranium-Rich Process Waste Group 200-PW-2. (10 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
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.
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-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 french drain 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 french drain 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. (10 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 million gal); low in salt and neutral to basic containing large amounts of uranium	7.6 m (25 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 million gal) 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. (10 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 million gal) 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 million gal); 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).

Table 2-1. Uranium-Rich Process Waste Group 200-PW-2. (10 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
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 million gal); 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.
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 million gal); 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 million gal); 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.

Table 2-1. Uranium-Rich Process Waste Group 200-PW-2. (10 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
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.
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 million gal); 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.

Table 2-1. Uranium-Rich Process Waste Group 200-PW-2. (10 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
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 million gal); 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. Gage 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.
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.

Table 2-1. Uranium-Rich Process Waste Group 200-PW-2. (10 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
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-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.

Table 2-1. Uranium-Rich Process Waste Group 200-PW-2. (10 Pages)

Site Code	Site Name	Location	Dates of Operation	Source Facility	Contaminant/Volume Released	Depth	Waste Site Dimensions	General Description
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.
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.

3.0 INITIAL EVALUATION OF REPRESENTATIVE AND TSD 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 OU to provide a background for understanding the waste sites in this OU. The contaminant inventory effluent volumes, available soil data, and current understanding of the distribution of contamination are also discussed for each of the representative sites.

3.1 KNOWN AND SUSPECTED CONTAMINATION

As discussed in Section 2.0, waste sites in this OU received radionuclides 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), and Semi-Works (C Plant). 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 OU was obtained from the following sources:

- WIDS
- The aggregate area management study reports for the 200 Areas (e.g., DOE-RL 1993a)
- Implementation Plan (DOE-RL 1999)
- *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997)
- PUREX and REDOX Plant Technical Operating Manuals (WHC 1989, GE 1951a)
- *Uranium Recovery Technical Manual* (U Plant) (GE 1951b)
- *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE-RL 1995b)
- *Hanford Facility Dangerous Waste Part A Permit Application* (DOE-RL 1988).

The estimated inventory for the waste sites in this OU 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, semi-volatiles, and volatile organic compounds.

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 the *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1999* (Perkins et al. 2000) and the *Hanford Site Environmental Report for Calendar Year 1999* (Poston et al. 2000). The near-facility document focuses on monitoring activities near facilities that have potential to or have discharged, stored, or disposed of radioactive or hazardous materials, including facilities in the 200 East and 200 West Areas. The Hanford Site Environmental Monitoring Report 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. Results of these monitoring efforts for the 200-PW-2 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 is also 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 are also assessed. Results of groundwater monitoring and remediation are presented in an annual report, the most recent of which is the *Hanford Site Groundwater Monitoring for Fiscal Year 1999* (PNNL 2000). 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. Three waste sites in the 200-PW-2 OU, the 216-A-36B Crib, 216-A-10 Crib, and the 216-U-12 Crib, are part of a 200 Area Liquid Effluent Disposal Facility assessment monitoring program, and are discussed in the Hanford Site Environmental Monitoring Report (Poston et al. 2000). The 216-A-36B inactive crib is monitored with the 216-A-10 and 216-A-37-1 Cribs in a single waste management area based on similar hydrology and waste constituents. The cribs contributed to the large nitrate, iodine-129, and tritium plumes downgradient of the 200 East Area (Poston et al. 2000).

The 216-U-12 Crib, also part of the 200 Area Liquid Effluent Disposal Facility assessment monitoring program, received wastewater containing chemical wastes and radionuclides. Iodine-129, nitrate, technetium-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 nitrate and technetium-99 detected in the downgradient wells (PNNL 1997c).

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 is then 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 OU.

3.3.1 Representative Sites and TSD 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 with the RLS in the borehole. The locations of boreholes in the vicinity of the 216-A-19 Trench are shown in Figure 3-1.

The effluent volume discharged at this site is approximately 90% of the soil pore volume 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 (2000). The report indicates that iodine-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 Fecht et al. 1977) 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 cpm) 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 cpm.

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 to 9,000 cpm. 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 cpm. Background levels (2,000 to 8,500 cpm) 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 discharged at this site is greater than the soil pore volume 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 (2000). The report indicates that the iodine-129 and 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 the *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE-RL 1995b), *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West* (BHI 1995), and the *Focused Feasibility Study for the 200-UP-2 Operable Unit* (DOE-RL 1995a). 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 were also 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; semi-volatile organic compounds; inorganics; cyanide; fluoride; chloride; nitrate; nitrite; sulfate; gross alpha and gross beta; total uranium; radioisotopes including cesium-137, cobalt-60, and strontium-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.

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 strontium-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, cesium-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), cesium-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 cesium-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 cesium-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 (1994).

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, uranium-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), uranium-238 concentrations ranged between 4.3 and 19 pCi/g. The maximum concentration of uranium-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 uranium-238 concentration was less than 1 pCi/g.

Uranium-233/234 and uranium-235 were distributed similarly to uranium-238. However, contaminant concentrations were not as high. Near the bottom of the crib, concentrations ranged between 1.1 to 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 uranium-238, elevated levels of uranium-233/234 and uranium-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 to 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, americium-241, europium-154, neptunium-237, plutonium-238, plutonium-239/240, radium-226, radium-228, and thorium-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 (1995).

The effluent volume discharged at this site is greater than the soil pore volume 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-8 Crib is described in PNNL (2000) and indicates that this site in the past was one of several contributing sources. The report indicates that nitrate, carbon tetrachloride, iodine-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 was finally discontinued in 1995 because well 299-W19-2 did not produce enough water for sampling due to 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 to 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 was also 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 and soil samples were also 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 (1994) and DOE-RL (1995b).

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 was also 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 americium-241, cesium-137, plutonium-239/240, and strontium-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 (1994).

3.3.1.4 216-U-12 Crib. The nature and extent of contamination at the 216-U-12 Crib was evaluated using 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 LFI (DOE-RL 1995b). Although soil chemistry data are not available to evaluate contamination directly beneath the 216-U-12 Crib, DOE-RL (1995b) and DOE-RL (1995a) 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 (cesium-137, uranium-235, and uranium-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 uranium-235 in this zone is approximately 20 pCi/g and also corresponds to maximum uranium-238 concentrations detected with the RLS. The maximum concentration (500 pCi/g) of uranium-238 was detected 23 m (77 ft) bgs and indicates that higher concentrations were detected with depth. Uranium-238 was initially 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 1995b). Higher levels of contaminants were likely 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 discharged at this site is greater than the soil pore volume 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 (2000) and indicates that the site in the past was one of several contributing sources.

The report indicates that nitrate, carbon tetrachloride, iodine-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, cobalt-60, and europium-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 cesium-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 cesium-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 cesium-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 cesium-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 cobalt-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 europium-154 activity in the two midline borings is similar in both holes. The total europium-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 discharged at this site is greater than the soil pore volume as indicated in Table 3-1. These data indicated 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 (2000) and is partially attributed to these two waste sites. The report indicates that tritium, nitrate, iodine-129, strontium-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 cesium-137 and strontium-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 cesium-137 and strontium-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 strontium-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 cesium-137) may be due to the presence of ammonium that was discharged to the crib or unsealed boreholes. Results and contaminant profiles of strontium-90 and gamma activity are presented in Smith and Kasper (1983).

Soil samples were next 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, 299-E17-18) located adjacent to the crib. Soil samples from borehole 299-E17-55 were analyzed for americium-241, uranium-235, cesium-137, cobalt-60, ammonia, ammonia-potassium chloride, nitrate, fluoride, and hydrogen ion concentration (pH). Samples collected from boreholes adjacent to the crib were only analyzed for nonradiological constituents. Sediment samples collected within the crib were collected to a maximum depth of 19 m (61 ft). Samples collected adjacent to the crib were collected to a maximum depth of 70 m (230 ft). Additionally, spectral gamma data were collected 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, cobalt-60, americium-241, and uranium-235 were detected in soil samples collected from borehole 299-E17-55. Americium-241 and uranium-235 were detected in a single sample at 9 m (30 ft) bgs. Their concentrations were 18,200 and 1,225 pCi/g, respectively. This elevated zone of contamination also corresponds to the depth of maximum cesium-137 (1,640,000 pCi/g) and cobalt-60 (1,025 pCi/g) activity. Trend analysis indicates that cesium-137 activity generally increased with depth to 9 m (30 ft); however, most results were typically less than 4 pCi/g. Activities decreased with depth greater than 9 m (30 ft) bgs to total depth (19 m [61 ft]) and ranged between 1.38 to 153 pCi/g. The distribution of cobalt-60 is similar to cesium-137. Cobalt activities, with exception of the 9-m (30-ft) sample, ranged between 0.32 to 11.5 pCi/g.

Soil samples collected in the vicinity of the crib indicate that ammonia concentrations ranged between 0.15 and 353.6 ppm. Within the crib, concentrations ranged between 0.15 to 105.7 ppm 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 353.6 ppm 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 ppm in boreholes in the vicinity of the crib. Only one sample exceeded this threshold. A maximum concentration of 6.08 ppm was detected in borehole 299-E17-15 at a depth of 27 m (90 ft).

Nitrate concentrations in the soil column ranged between 1.3 and 582.8 ppm in the vicinity of the crib. Higher concentrations of nitrate were typically 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 to 44 ppm. The pH in all samples ranged between 7.76 to 10.11.

The spectral gamma logging system identified three man-made radionuclides (cesium-137, cobalt-60, and antimony-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 cesium-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 antimony-125 is similar to cobalt-60. This contaminant was detected in the same upper zone of cobalt-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 discharged at this site is greater than the soil pore volume 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 (2000) and attributes some of the contamination to the discharges to this crib. The report indicates that tritium, nitrate, iodine-129, strontium-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.

3.3.2 Conceptual Contaminant Distribution Models

Preliminary conceptual contaminant distribution models were first developed for the 200-PW-2 OU in the waste site grouping report (DOE-RL 1997), 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 remedial investigations proposed for each of the representative sites and TSD units. Conceptual contaminant distribution models are shown in Figures 3-10 through 3-15.

Information pertaining to contaminant sources, release mechanisms, transport media, exposure route, and receptors has also 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 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 1999). 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.

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 can also 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. Primary radiological contaminants of potential concern (COPCs) 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 in comparison 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 (1997) 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 strontium-90 (K_d = 0.4 to 50 mL/g), are also present throughout the vadose zone and their concentrations may increase in the lower half of the soil column. However, impact to groundwater is not expected to be significant. In the 200 Areas, the distribution of strontium-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 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 due in part to sorption, porosity changes, and the presence of elements, molecules, or compounds that act as reductants for most uranium species.

  Uranium is generally considered to be poorly sorbed by sandy sediments; estimates of uranium K_d range from 0 to 25 mL/g or higher (DOE-RL 2000b). 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 waste sites; and (3) once dissolved the uranium is transported through the vadose zone to different horizons or 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 pre-existing 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 OU no longer receive effluent. Sites in this OU 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 equilibrate with the natural recharge rate, thus reducing the potential for future impacts to groundwater.

3.3.3 Environmental Information

A summary of ecological resources for the 200 Areas is provided in Appendix F, Sections 8.0 and 9.0 of the Implementation Plan (DOE-RL 1999). Available information pertaining to sampling of vegetation and biota within the 200-PW-2 OU waste sites is presented in this section

in order 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 contain data that, while not pertinent to a specific representative site, provide useful data in the vicinity of the sites.

A 1978 report by Cataldo et al. studied the relationship between soil concentrations of two radionuclides and uptake by cheatgrass (*Bromus tectorum*) and tumbleweed (*Salsola kali*). A number of soil factors were believed to influence the bioavailability of cesium and strontium, such as soil mineralogy, pH, particle size, and concentrations of available macro-ions. The chemical behavior of cesium and strontium is similar to that of potassium and calcium, which occur naturally in soils and are involved in soil sorption reactions. Analyses showed cesium and strontium uptake in cheatgrass and strontium uptake in tumbleweed to be related to cation exchange capacity and concentrations of extractable strontium, barium, and magnesium. Cesium uptake by tumbleweed showed weak correlations with extractable and exchangeable potassium. These results have been used to compare and further characterize the relationship between contaminant concentrations in soil and contaminant uptake by various species of vegetation.

Eighty-five environmental monitoring records of wildlife and vegetation at the 200 East and 200 West Areas since 1965 were reviewed and summarized by Johnson et al. (1994). The report indicates that areas in the vicinity of the 200-PW-2 OU waste sites have been sampled from 1965 to 1993. About 4,500 individual cases of monitoring for radionuclide uptake or transport in biota in the 200 Area environs were included in the documents reviewed by Johnson et al. (1994). Approximately 2,400 samples were collected from near the operations areas, and only about 120 samples (i.e., approximately 5%) exceeded 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%) exceeded concentrations of 10 pCi/g, indicating that radionuclide contamination has remained relatively localized even though it has spread beyond intended waste site boundaries. Johnson et al. (1994) further state that the routine monitoring is targeted to detect potential radioactive contamination at nuclear facilities and waste sites and the special investigative samples are usually targeted at known incidents of biotic uptake and transport. Therefore, both results are biased towards 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 have historically been house mice and deer mice, but other animals such as birds (including waterfowl), coyotes, cottontail rabbits, mule deer, and elk have been sampled (Johnson et al. 1994, Perkins et al. 1999). 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 *Environmental Monitoring Plan United States Department of Energy Richland Operations Office* (DOE-RL 2000c).

Plant species may be potentially exposed to contaminated soils and/or groundwater present in the vadose zone soil. Johnson et al. (1994) demonstrated radionuclide uptake by plants within the 200 Areas. 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 are generally tolerant of ionizing radiation (IAEA 1982), 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. The largest numbers and levels of radionuclide uptake or transport occurred at several sites unrelated to the 200-PW-2 OU, including the 216-Z Ditches, 216-B-3 Ditches, the 216-BC Cribs, the 241-B Tank Farm, and the 241-BX/BY Tank Farms. Much of this information was collected prior to stabilization activities 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 (Johnson et al. 1994).

A 1994 field investigation of the 200-UP-2 OU by Wasemiller et al. (BHI 1994), which was conducted in conjunction with the 200-UP-2 LFI (DOE-RL 1995b), 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 WIDS), the 216-U-1&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 can also be found in Appendix B of BHI (1994). Metal and radionuclide COCs for the 200-PW-2 OU were identified at each site. Four surface soil 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 americium-241, cesium-137, plutonium-239/240, technetium-99, thorium-232, total strontium, uranium-234, and uranium-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 cesium-137 and strontium-90. Both constituents were also found in the surface soil (DOE-RL 1995b). 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 cesium-137, plutonium-239/240, technetium-99, thorium-232, total strontium, uranium-234, and uranium-238, were detected in vegetation samples near the 216-U-8 VCP site. Three metal COCs and six radionuclide COCs (including barium, copper, lead, cesium-137, technetium-99, thorium-232, total strontium, uranium-234, and uranium-238) were detected in vegetation near the 216-U-10 Pond.

In 1993 and 1994, Mitchell and Weiss (1995) summarized a sampling effort to collect ecological samples at four sites within 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 the 200-PW-2 OU sites 216-A-18, 216-A-19, and 216-A-20. The other three sampling locations, shown in Mitchell and Weiss (1995), 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 EPA's Target Analyte List constituents, strontium-90, total uranium, and gamma-emitting radionuclides using gamma spectroscopy. Soil and vegetation samples were also analyzed for technetium-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 strontium-90 (in both Russian thistle samples and both grass samples), cesium-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 were also 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 strontium-90 (three out of four samples), cesium-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: technetium-99, cobalt-60, cadmium, cyanide, lead, mercury, nickel, and silver.

Mitchell and Weiss (1995) concluded that Russian thistle is the preferred vegetative indicator for radionuclide and metal uptake, and pocket mice are preferred mammalian indicators of contaminant uptake at terrestrial sites. Of the four sites sampled by Mitchell and Weiss, the 216-A-24 Crib had the highest reported vegetation concentrations of strontium-90, cesium-137, chromium, zinc, and copper.

In a 1998 sampling effort described in the Hanford Site Environmental Report (Poston et al. 2000), 55 soil samples and 48 vegetation samples were taken in the 200/600 Areas. Radionuclide analysis indicated that cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium were consistently detectable in both soil and vegetation. Fission products were most common in the 200 Areas. Fifty-one investigative samples were analyzed for radionuclides in 1998. Of the samples analyzed, 50 showed measurable levels of activity. Of three tumbleweed samples with the highest field readings, two were windblown weeds collected from the 200 East Area fence and the third was collected from the diversion box on the transfer line between the 200 East and 200 West Areas. Analysis of tumbleweeds showed strontium-90 levels as high as 7,360,000 pCi/g and cesium-137 levels as high as 1,410,000 pCi/g (Poston et al. 2000). Perennial vegetation samples consisted of the current year's growth of leaves, stems, and new branches collected from sagebrush and rabbitbrush. Surveillance of perennial vegetation in 1998 generally confirmed observations of past sampling efforts. Activities of cesium-137, uranium-238, and technetium-99 were all below nominal detection limits. Plutonium-239/240 was measured in one perennial vegetation sample (0.004 ± 0.001 pCi/g).

As reported in the *Hanford Site Near-Facility Environmental Monitoring Data Report* for calendar years 1998 and 1999 (Perkins et al. 1999, 2000), soil and vegetation samples were collected near a number of 200-PW-2 OU waste sites. Results for radionuclide analyses conducted on nine soil samples in the proximity of seven sites, including five representative waste sites, are indicated in Table 3-4. Seven vegetation samples were also collected near five

200-PW-2 OU waste sites, four of which are representative 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 are also 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 the Hanford Site Environmental Monitoring Plan (DOE-RL 2000c).

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 1998, 34 wildlife samples were submitted for analysis. All 34 wildlife-related samples showed detectable levels of contamination. The maximum radionuclide activities in 1998 were in mouse feces collected near the 241-ER-151 diversion box (part of the 200-IS-1 OU) south of B Plant in the 200 East Area. Contaminants included strontium-90 (450,000 pCi/g), cesium-137 (460,000 pCi/g), europium-154 (560 pCi/g), plutonium-238 (45 pCi/g), plutonium-239/240 (170 pCi/g), and total uranium (2.0 pCi/g) (Poston et al. 2000). The number of animals found to be contaminated with radioactivity, their radioactivity levels, and the range of radionuclide activities were within historical levels (Johnson et al. 1994).

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). In a contamination area, ants are capable of bringing radioactive materials to the surface, where they could potentially become available to other means of transport by wind, plant uptake, birds, or mammals. The biological transport of contamination by harvester ants was documented 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/hr. 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 is currently 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 INTERIM STATUS GROUNDWATER MONITORING

This section presents descriptions and results of interim status groundwater monitoring at the 216-U-12 Crib, 216-A-10 Crib, and 216-A-36B Crib. The purpose of this section is to present interim status groundwater monitoring information to be included in a FS/closure/post-closure plan. This information will be used by reference or will be inserted into the FS/closure/post-closure plan that will form the basis for the modification to the Permit. This section does not

include the proposed final status groundwater monitoring program since they are in interim status. Final status of groundwater monitoring plans will be provided in the future in concert with the FS/closure/post-closure plan.

The current interim status groundwater monitoring plans (as required by WAC 173-303-400 and 40 *Code of Federal Regulations* [CFR] 265, Subpart F) are contained in two separate documents: *Combined RCRA Groundwater Monitoring Plan for the 216-A-10, 216-A-36B, and 216-A-37-1 PUREX Cribs* (PNNL 1997a), and *Interim-Status Groundwater Quality Assessment Plan for the 216-U-12 Crib* (WHC 1993). These documents contain further details regarding the geology, hydrology, and current groundwater monitoring programs for the RCRA TSD sites. Excerpts from *Hanford Site Groundwater Monitoring for Fiscal Year 1999* (PNNL 2000) are presented below for the current monitoring network and groundwater conditions.

Quarterly RCRA groundwater compliance monitoring reports were first published in 1986 on the Hanford Site. In addition to quarterly reports, annual reports commenced in 1988. The RCRA-compliant monitoring networks were implemented at different times for the various facilities, as defined under Tri-Party Agreement Milestone M-24-00. Sample collection and analyses for the RCRA groundwater monitoring program on the Hanford Site 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 1992b). Annual reports for the RCRA groundwater monitoring program have been included in the Hanford Site groundwater monitoring report since 1997 (PNNL 1997b, 1998b).

3.4.1 216-U-12 Interim Status Groundwater Monitoring

3.4.1.1 History of RCRA Groundwater Monitoring. An interim status 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 as required by interim status regulations (40 CFR 265). The specific conductance in two downgradient wells exceeded the background critical mean (WHC 1993). The Groundwater Quality Assessment Program at the 216-U-12 Crib (PNNL 1997c) concluded that the crib was the source of the elevated specific conductance. The crib was also identified as a source of nitrate, calcium, and technetium-99 in the groundwater. The objective of assessment monitoring is to evaluate the flux of constituents into the groundwater beneath the crib and monitor the known constituents until a corrective action is defined or final status monitoring plan is implemented for the crib. The RCRA phase I and II assessments contained in PNNL (1997c) concluded that the 216-U-12 Crib must remain in interim status assessment monitoring until attainment of final status, at which time the system will be reevaluated for compliance with final status standards (WAC 173-303-645). Site-specific parameters selected for the interim status quality assessment monitoring, in addition to specific conductance, include gross alpha, gross beta, iodine-129, nitrate, technetium-99, and tritium.

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 is currently declining less than 0.5 m/yr (1.6 ft/yr) (DOE-RL 2000a). A pump-and-treat system located approximately 500 m (1,640 ft) northeast of the crib has operated since 1994 and treated over 350 million liters of groundwater.

3.4.1.3 Well Location and Design. The historic monitoring plan (WHC 1993) 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 replaced wells 299-W22-41 and 299-W22-42 in 1999. Therefore, the current interim status groundwater monitoring network includes just two downgradient wells: one new well (299-W22-79) and 699-36-70A. WHC (1993) 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 assessments. The current and past interim status groundwater monitoring wells and boreholes in the vicinity of the 216-U-12 Crib are shown in Figure 3-5. One new upgradient well is proposed for installation in fiscal year (FY) 2001.

3.4.1.4 Results of RCRA Interim Status Groundwater Monitoring Data. The wells are sampled quarterly for gross alpha and beta, tritium, technetium-99, total dissolved solids, alkalinity, and anions, and annually for inductively coupled plasma metals and iodine-129. The new well was initially sampled for the Appendix IX constituents upon completion. The crib is a source of elevated nitrate and technetium-99 detected in downgradient wells 299-W22-41, 299-W22-42, 299-W22-79, and 699-36-70A. The nitrate and technetium-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 ranged from 21.2 to 103 pCi/L in downgradient wells, well below the 900 pCi/L drinking water standard. 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.

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-W22-42, 299-W22-79, and 699-36-70A. Iodine-129 in these wells measured 7.64, 2.58, and 15.2 pCi/L, respectively, in FY 1999. During FY 1999, 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 wells 299-W22-42, 299-W22-79, and 699-36-70A. The most recently reported concentrations are 21,600 and 83,300 pCi/L in wells 299-W22-79 and 699-36-70A, respectively.

3.4.2 216-A-10 and 216-A-36B Interim Status Groundwater Monitoring

3.4.2.1 History of RCRA Groundwater Monitoring. Groundwater monitoring is conducted near the PUREX Plant for several Hanford Site programs, including interim status assessment monitoring. 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 1999 in accordance with ongoing RCRA monitoring requirements. The PUREX cribs and the 216-A-45 Crib all 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.

An interim status indicator parameter evaluation 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 were sampled for contaminant indicator parameters, groundwater quality parameters, drinking water parameters, and site-specific parameters as required by interim status regulations (40 CFR 265). Although semi-annual statistical evaluations of the contaminant indicator parameter data 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.

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 towards 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 2000).

3.4.2.3 Well Location and Design. The current monitoring plan (PNNL 1997a) proposed monitoring 11 near-field wells, located near PUREX, and 57 far-field wells, most located between 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, and wells 299-E17-14, 299-E17-18, and 299-E17-9 as the near-field downgradient monitoring wells for the 216-A-36B Crib. Wells 299-E17-1, 299-E17-19, 299-E17-18, and 299-E17-9 are sampled semi-annually; wells 299-E24-16 and 299-E17-14 are sampled quarterly (well 299-E17-9 is going dry. It may be replaced by 299-E17-16 in the near future). Well 299-E24-18 serves as the upgradient monitoring well for the 216-A-10 Crib and is sampled semi-annually. Three other wells are identified as near-field downgradient monitoring wells for the 216-A-37-1 Crib, one well is identified as the upgradient monitoring well for 216-A-37-1 Crib, and 57 other wells are identified for far-field monitoring. PNNL (1997a) 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 and 216-A-36B Cribs are shown in Figure 3-9.

3.4.2.4 Results of RCRA Interim Status Groundwater Monitoring Data. 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 iodine-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 strontium-90. The most extensive and significant contaminants are tritium, iodine-129, and nitrate. Monitoring results indicate that the impact to groundwater also originates from other facilities as well as these three 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 3.87 million pCi/L in well 299-E17-9 next to the 216-A-36B Crib (PNNL 2000). 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 is probably due to 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 that has higher tritium concentrations.

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 from 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.

The highest iodine-129 (drinking water standard of 1.0 pCi/L) concentrations observed in the 200 East Area in FY 1999 were near the PUREX Plant cribs. Concentrations of iodine-129 in groundwater near the PUREX cribs are generally declining slowly or are stable. The maximum concentration of iodine-129, 12.5 pCi/L, was measured in a monitoring well associated with the 216-A-36B Crib (well 299-E17-14). The iodine-129 plume extends southeast into the 600 Area and appears to coincide with the tritium and nitrate plumes.

High nitrate concentrations continue to be found near the 216-A-36B Crib. The maximum nitrate concentration detected was 191 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 strontium-90 (a beta emitter) in FY 1999. The strontium-90 concentration measured 17.2 pCi/L. The impact is very localized because of the

lower mobility of strontium-90 compared to iodine-129, nitrate, and tritium. Strontium-90 was detected at levels below the drinking water standard at four other wells near the 216-A-10 and 216-A-36B Cribs during FY 1999. The concentrations have remained stable since 1994.

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 OU. Information pertaining to contaminant sources, release mechanisms, transport media, exposure routes, and receptors is discussed to develop a conceptual understanding of potential risks and exposure pathways. This information will be used to support an evaluation of potential human health and environmental risk in the RI and FS documents for the 200-PW-2 OU.

3.5.1 Contaminant Sources and Release Mechanisms

The primary sources of contamination at waste sites in this OU were major facilities (e.g., U Plant, REDOX, PUREX, B Plant, and Semi-Works 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 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 (including dust inhalation), sediments, or biota
- 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 would primarily involve incidental soil/sediment ingestion (including dust inhalation), 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 would primarily 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 OU is shown in Figure 3-16.

3.5.3 Potential Impacts

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* (NEPA) process (DOE 1999) and documented in a record of decision (64 FR 61615) is industrial (exclusive). Outside the 200 Area boundary, the selected land use is conservation (limited mining and grazing by permit only). The 200-PW-2 sites are located within the 200 Area 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 at waste sites within the 200 Areas (Perkins et al. 2000, Rogers and Rickard 1977, Stegen 1993). The vegetation cover within the 200 Area 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 due to stabilization activities that have been conducted.

3.5.3.1 Human Health Risk. A qualitative risk assessment (QRA) was performed as part of the 200-UP-2 LFI (216-U-8 and 216-U-12) to evaluate potential human health risks to workers under an industrial scenario. The QRA followed the methodology in the *Hanford Site Risk Assessment Methodology* (DOE-RL 1994). Maximum concentrations of contaminants of concern (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 were initially screened against natural background then against risk-based screening concentrations identified as described in *Hanford Site Risk Assessment Methodology* (DOE-RL 1994). 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 were also 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 LFI. 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 area: Uptake of contaminants from soil by vegetation was considered that 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 and direct exposure to radioactive contaminants.

The evaluation was conducted based on biological monitoring data (Johnson et al. 1994) and modeling results using relative risks to evaluate the sites. Risks were assigned to each of the waste sites based on environmental hazard quotient (EHQ) results and are presented below:

- High (EHQ ≥ 100)
- Medium (EHQ >10 and <100)
- Low (EHQ ≤ 10).

Plants collected from the 216-U-8 Crib during the 200-UP-2 LFI were analyzed for both radionuclides and metals. Modeling concentrations of metals as measured in plants into a mouse resulted in a HQ>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% 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 no chemicals of potential ecological concern 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 in order 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 OU, data obtained during the 200-UP-2 LFI for the 216-U-10 Pond and the 216-U-11 Trench can also be considered indicative of conditions in the area. At these two sites chemical 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 greater than one 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 a hazard quotient greater than one 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 (Gano 1979). Soil data were also 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 decimeter below the surface. Based on the risk modeling conducted for the 200-UP-2 LFI, the ecological risk associated with the 216-U-10 Pond and 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. However, it is an expectation that an assessment for the 200 Areas is needed that would further evaluate ecological impacts for the 200 Area Central Plateau in a more holistic manner.

3.6 DEVELOPMENT OF CONTAMINANTS OF CONCERN

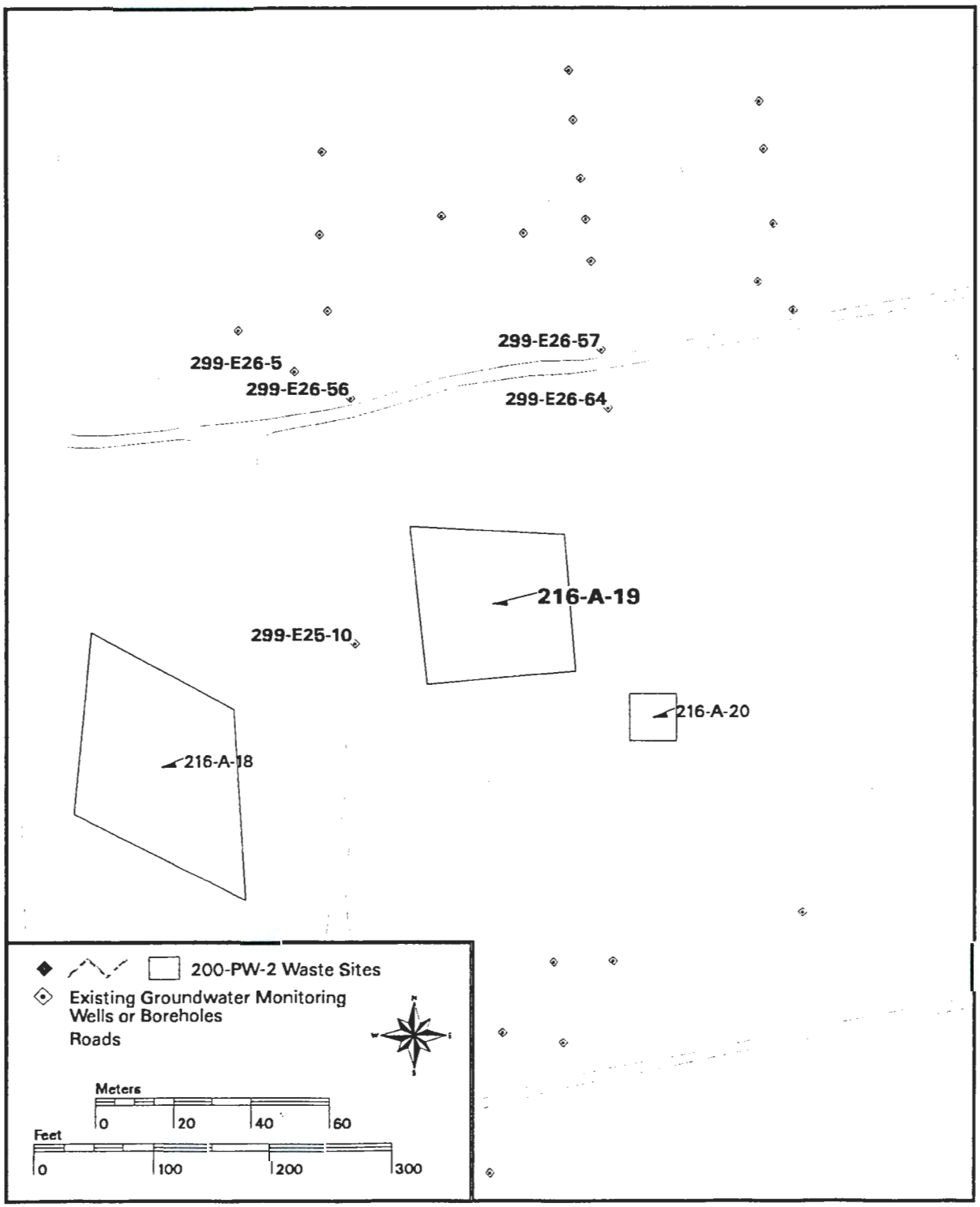
The development of the list of COPCs and refinement to the list of COCs for this OU were main objectives of the DQO process. The preliminary list of COPCs for the OU included the complete set of contaminants that were potentially discharged to this waste group from facilities discussed in Section 2.2. 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 report (BHI 2000 pending), are as follows:

- Short-lived radionuclides with half-lives less than 3 years
- Radionuclides that constitute less than 1% 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% 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 due to volatilization, biological degradation, or other natural mitigating features
- Chemicals that are not persistent in the vadose zone due to high mobility and previous confirmatory sampling/analysis activities.

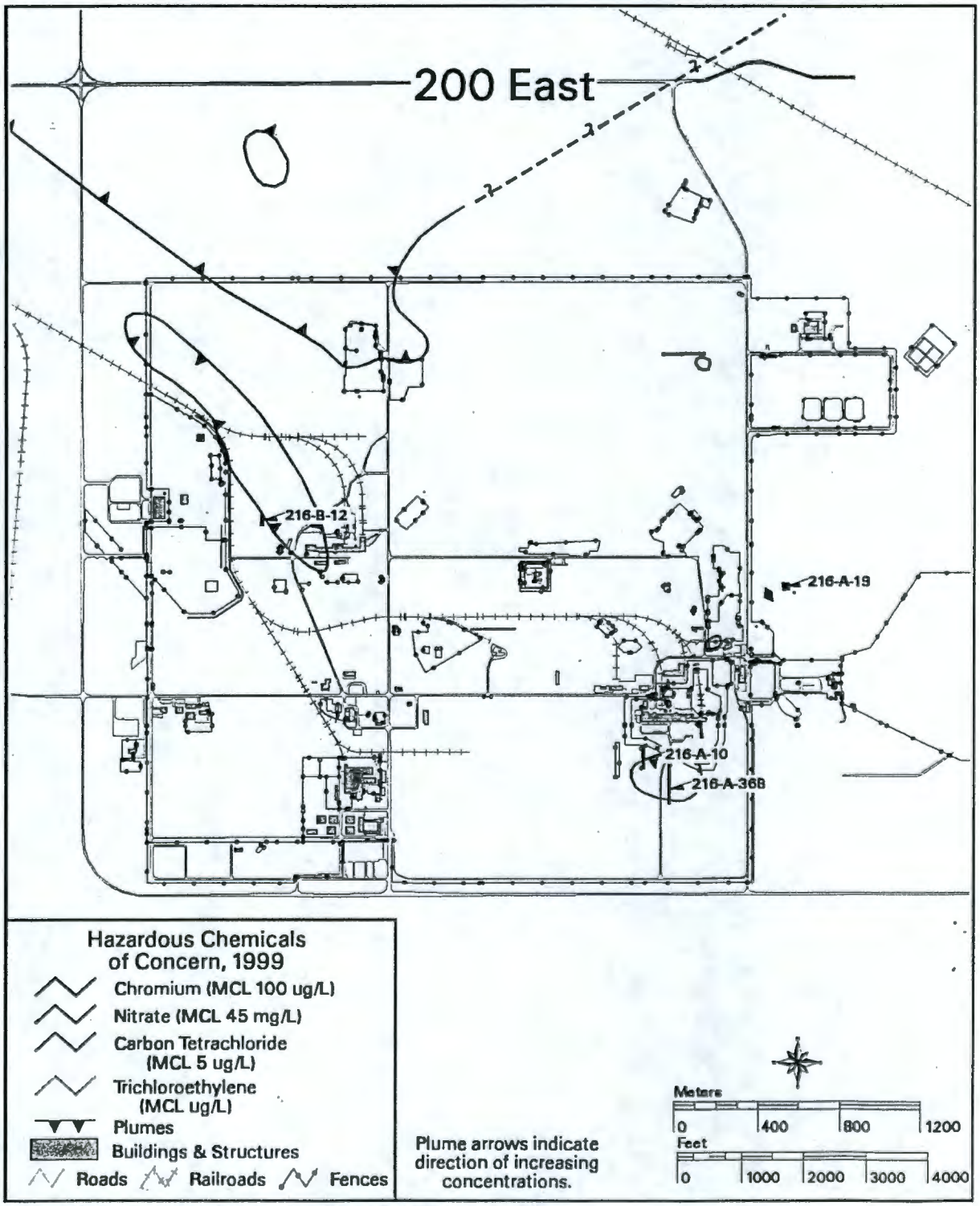
The exclusion process resulted in a final list of COCs for the OU, which is presented in Table 3-7. The preliminary list of COPCs, the excluded analytes and, the rationale for exclusion are presented in the DQO summary report (BHI 2000 pending).

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



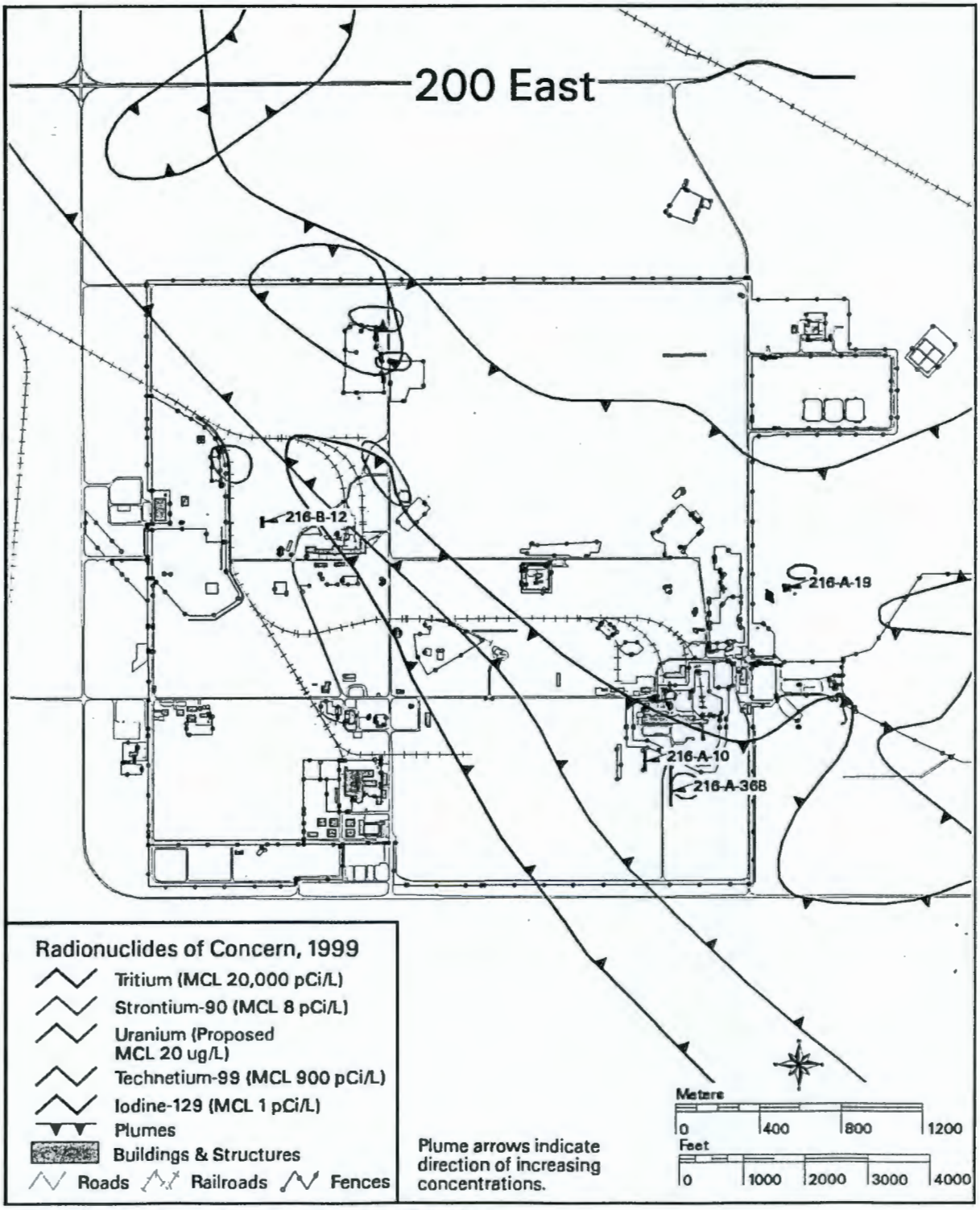
BHL:maa 06/27/00 /home/maaye/amls/uwaste_borehole2e <without> Plotted 22-JAN-2001 Rev 4

Figure 3-2. Major Nonradiological Groundwater Plumes in the Vicinity of the 200 East Area (Modified from PNNL 2000).



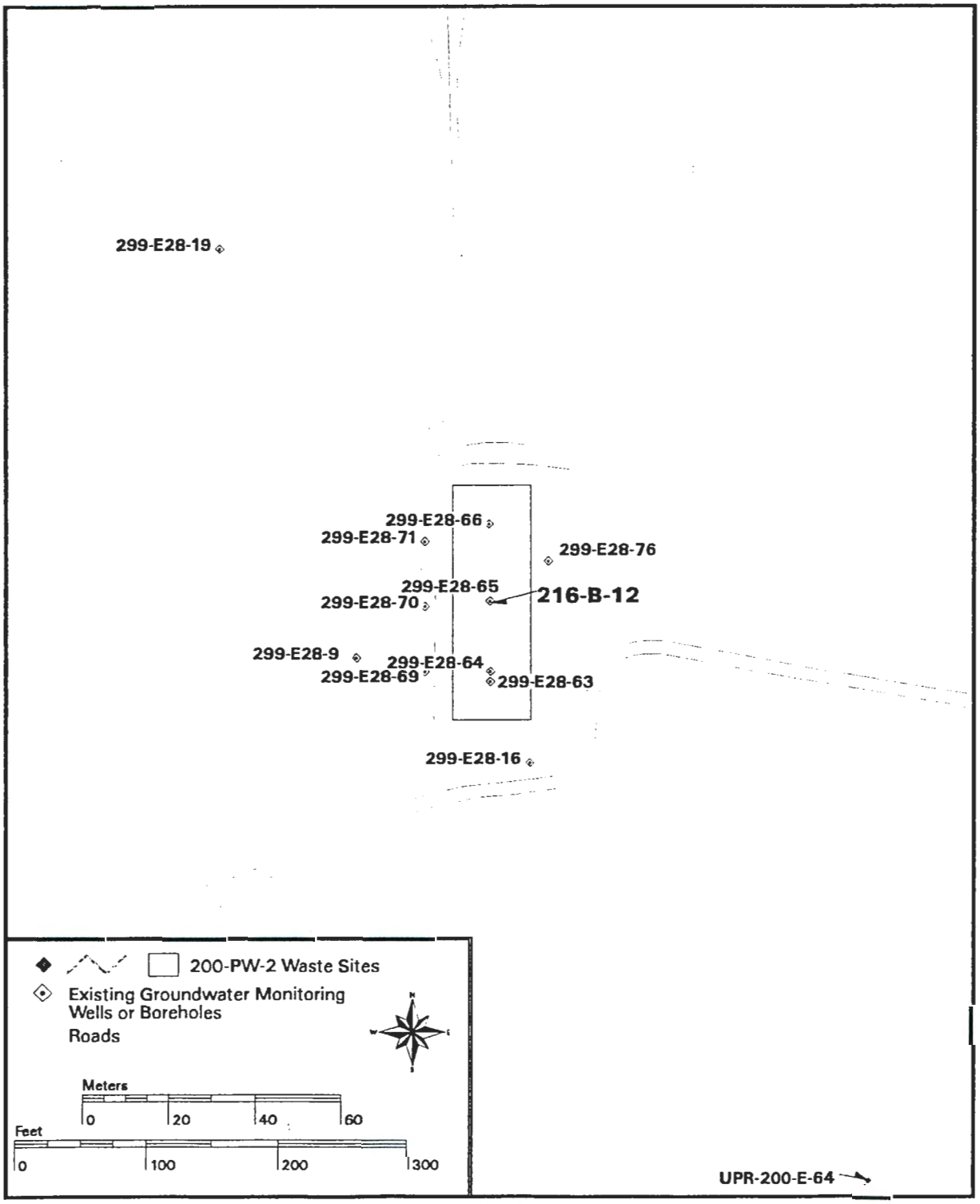
BHI:maa 06/20/00 /home/maayc/amls/uplume_2e.aml Plotted 10-APR-2001 Rev 1

Figure 3-3. Major Radiological Groundwater Plumes in the Vicinity of the 200 East Area (Modified from PNNL 2000).



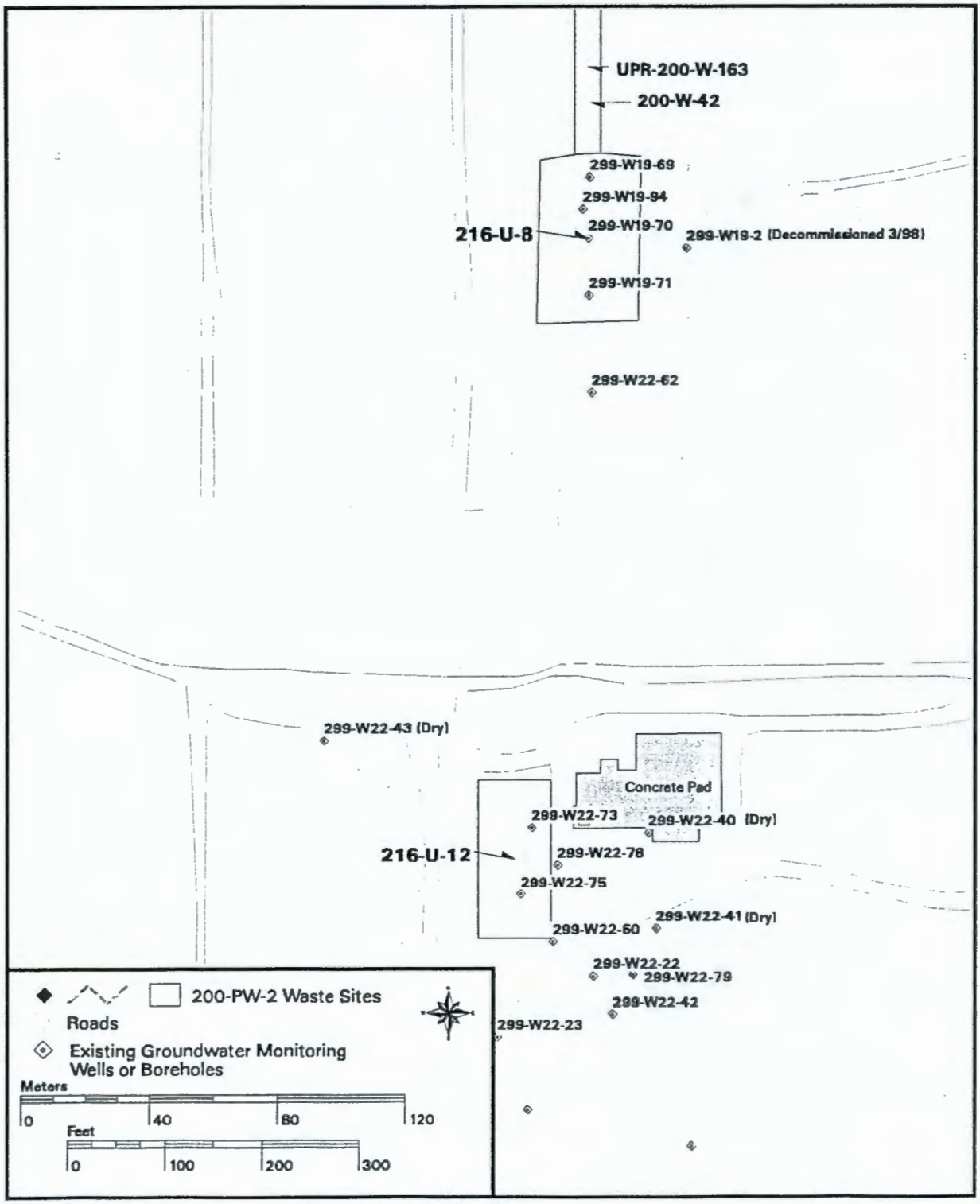
BHI:maa 06/20/00 /home/maaye/amls/uplume_2e.aml Plotted 11-APR-2001 Rev 1

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



BHI:maa 06/27/00 /home/maaye/amls/uwaste_borehole2e <without> Plotted 22-JAN-2001 Rev 4

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



BHI:maa 06/27/00 /home/maaye/amls/uwaste_borehole2w.aml Plotted 24-JAN-2001 Rev 3

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

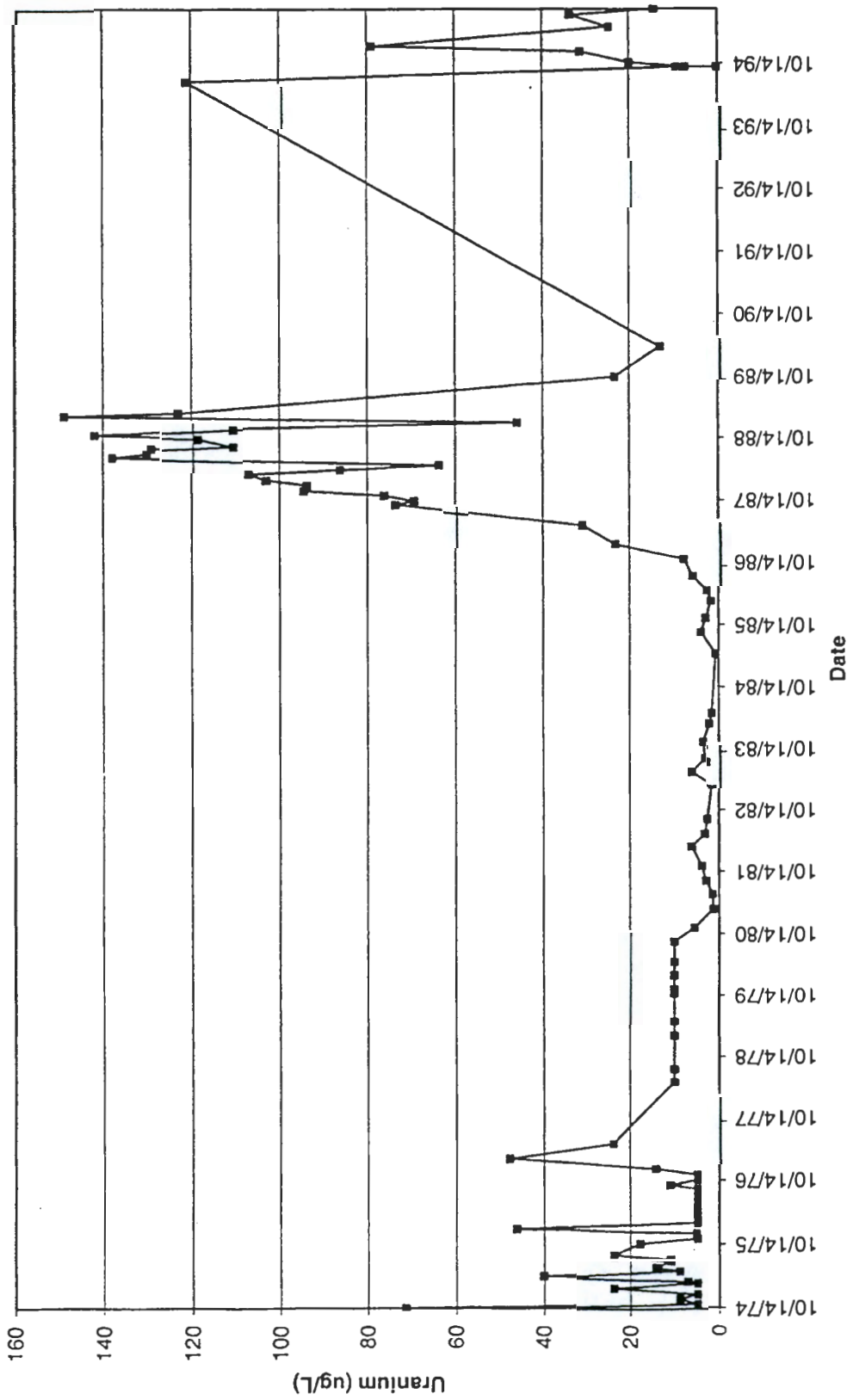
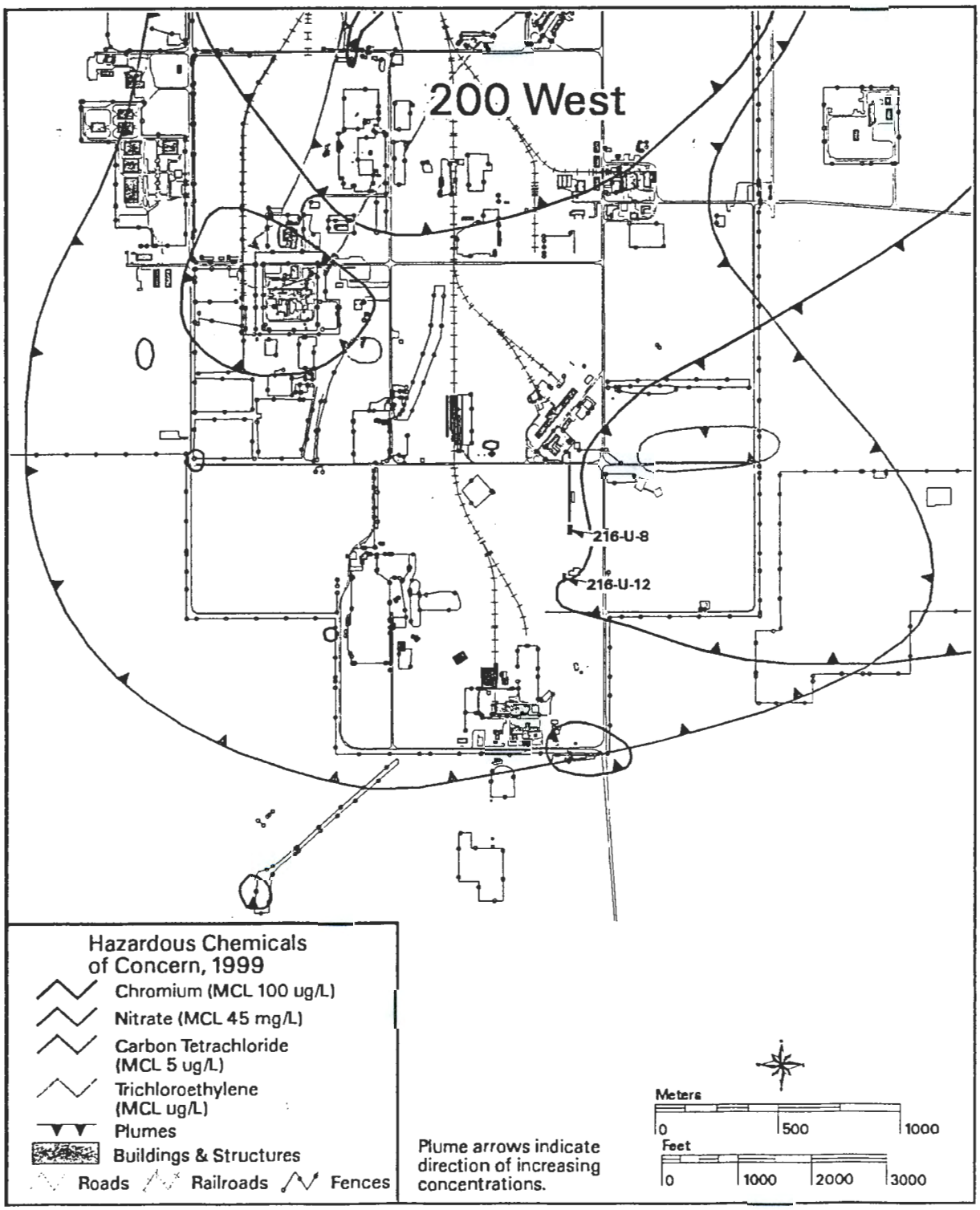
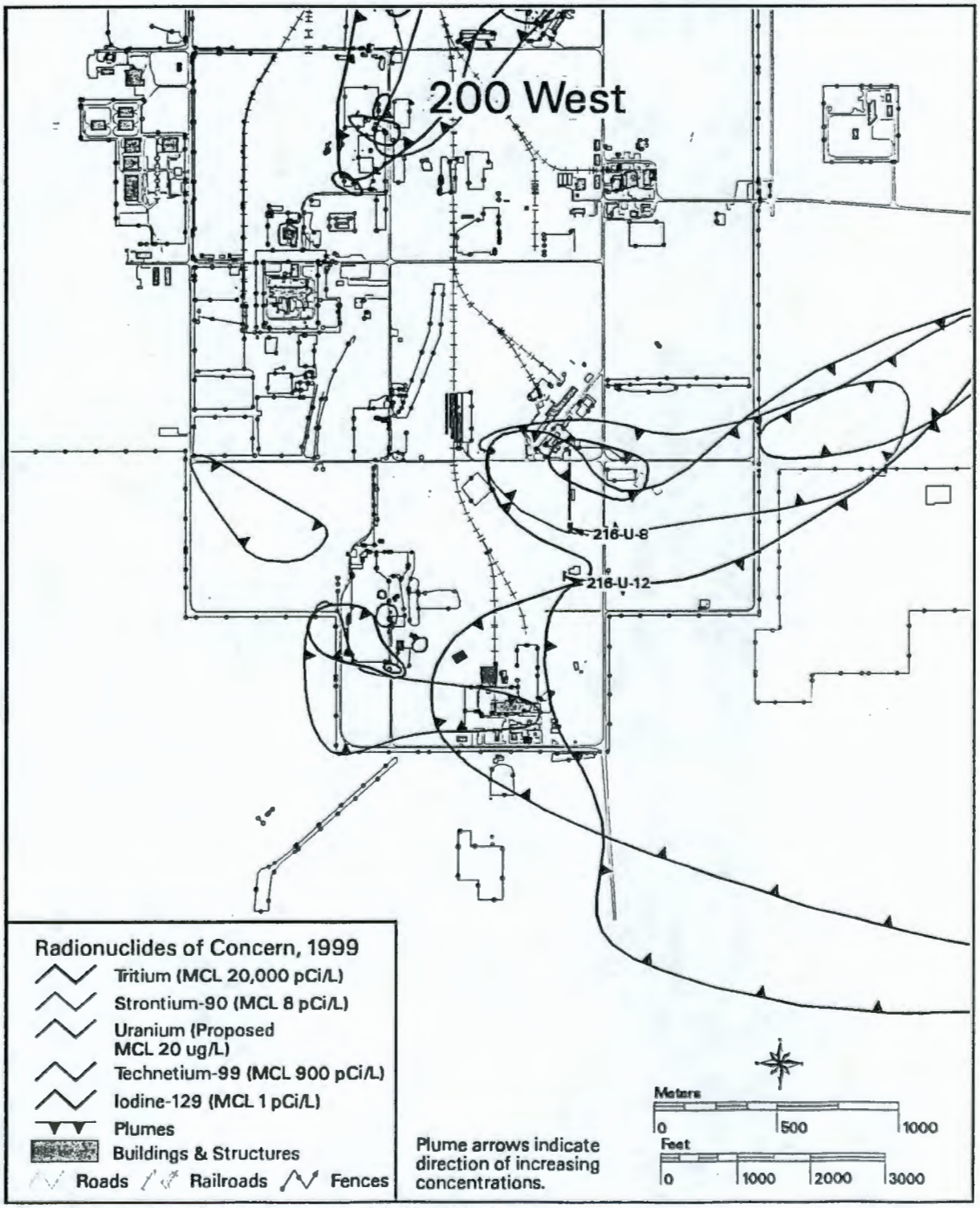


Figure 3-7. Major Nonradiological Groundwater Plumes in the Vicinity of the 200 West Area (Modified from PNNL 2000).



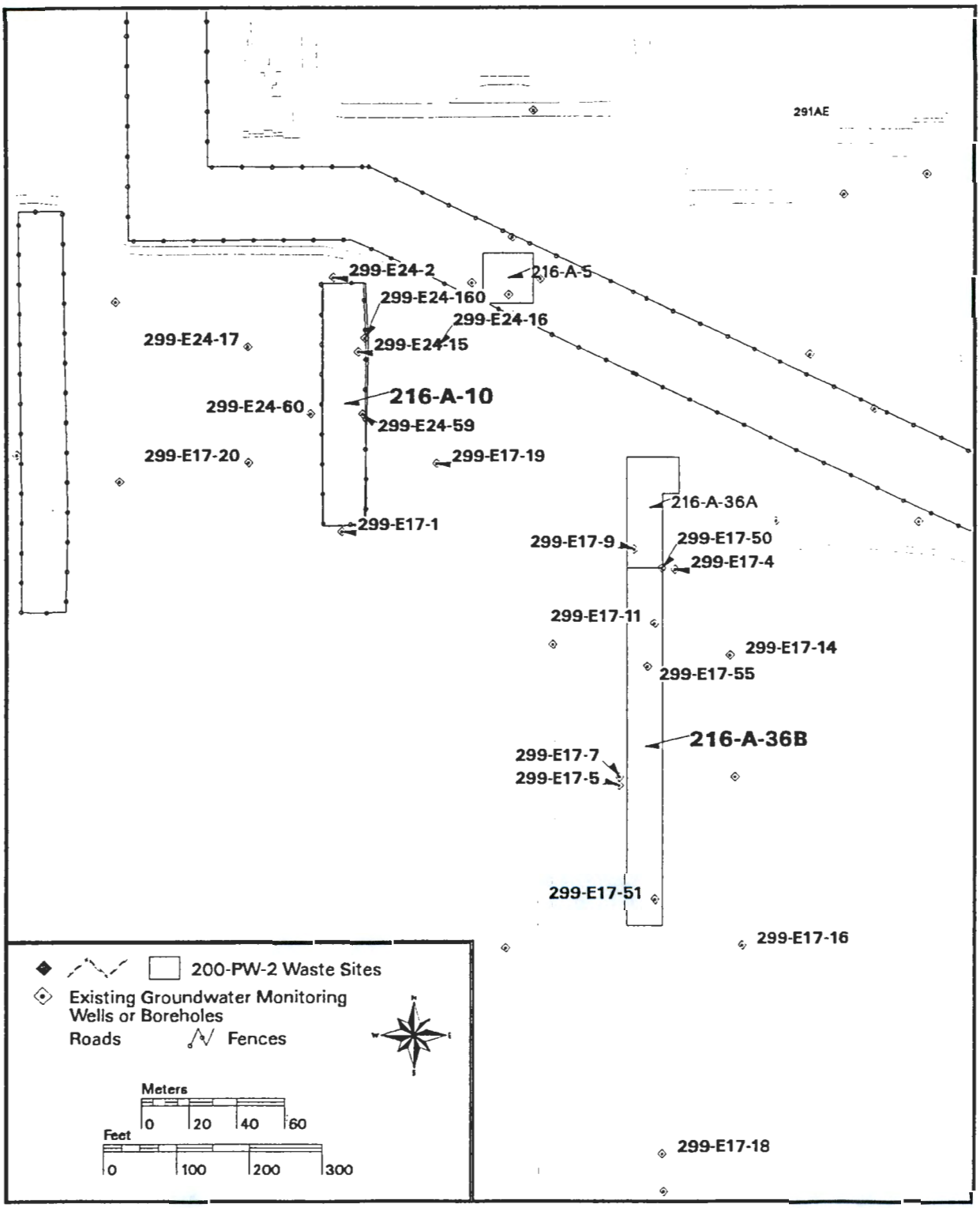
BHI:maa 06/20/00 /home/maaye/amls/uplume_2w.aml Plotted 10-APR-2001 Rev 2

Figure 3-8. Major Radiological Groundwater Plumes in the 200 West Area (Modified from PNNL 2000).



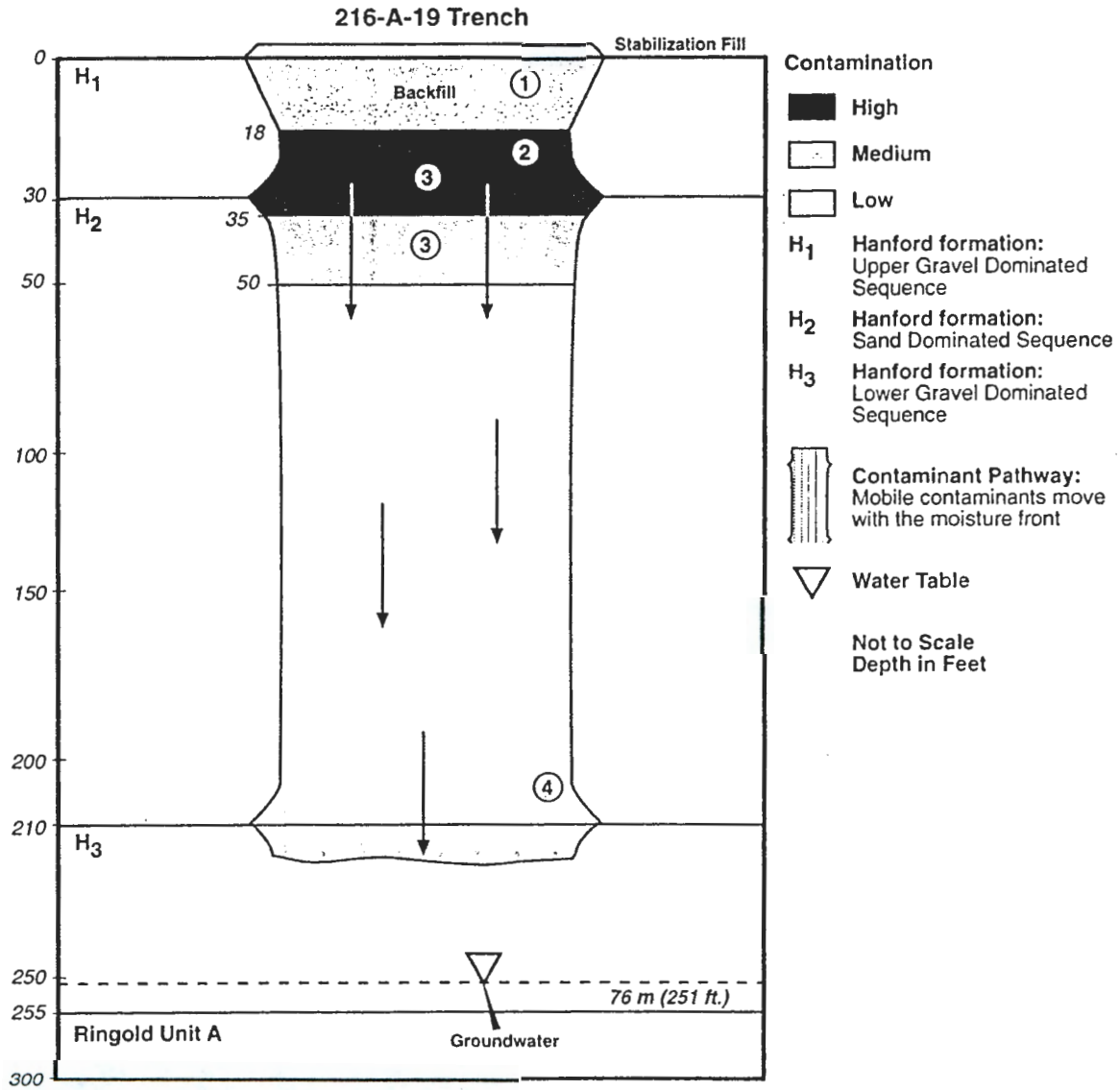
BHI:maa 06/20/00 /home/maaye/amls/uplume_2w.aml Plotted 10-APR-2001 Rev 2

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



BHI:maa 06/27/00 /home/maaye/amls/uwaste_borehole2e <without> Plotted 22-JAN-2001 Rev 4

Figure 3-10. 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.

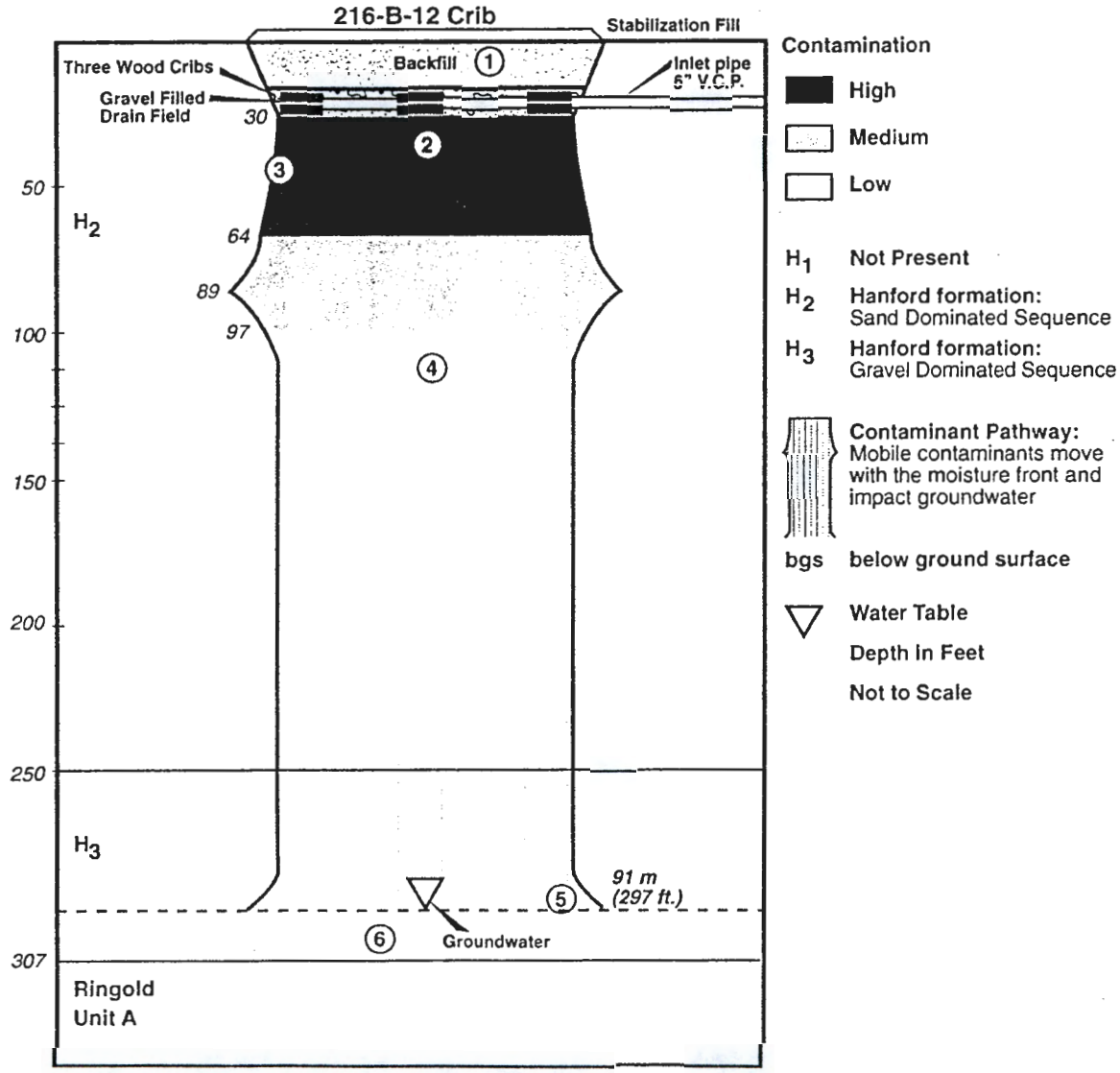
(2) Effluent and contaminants were released into H1. The wetting front and contaminants moved vertically down beneath the crib. There is little or no lateral spreading as evidenced by the lack of contamination in borehole 299-E25-10 which is located 18 m (60 ft) west of the trench.

(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 3-11. 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.

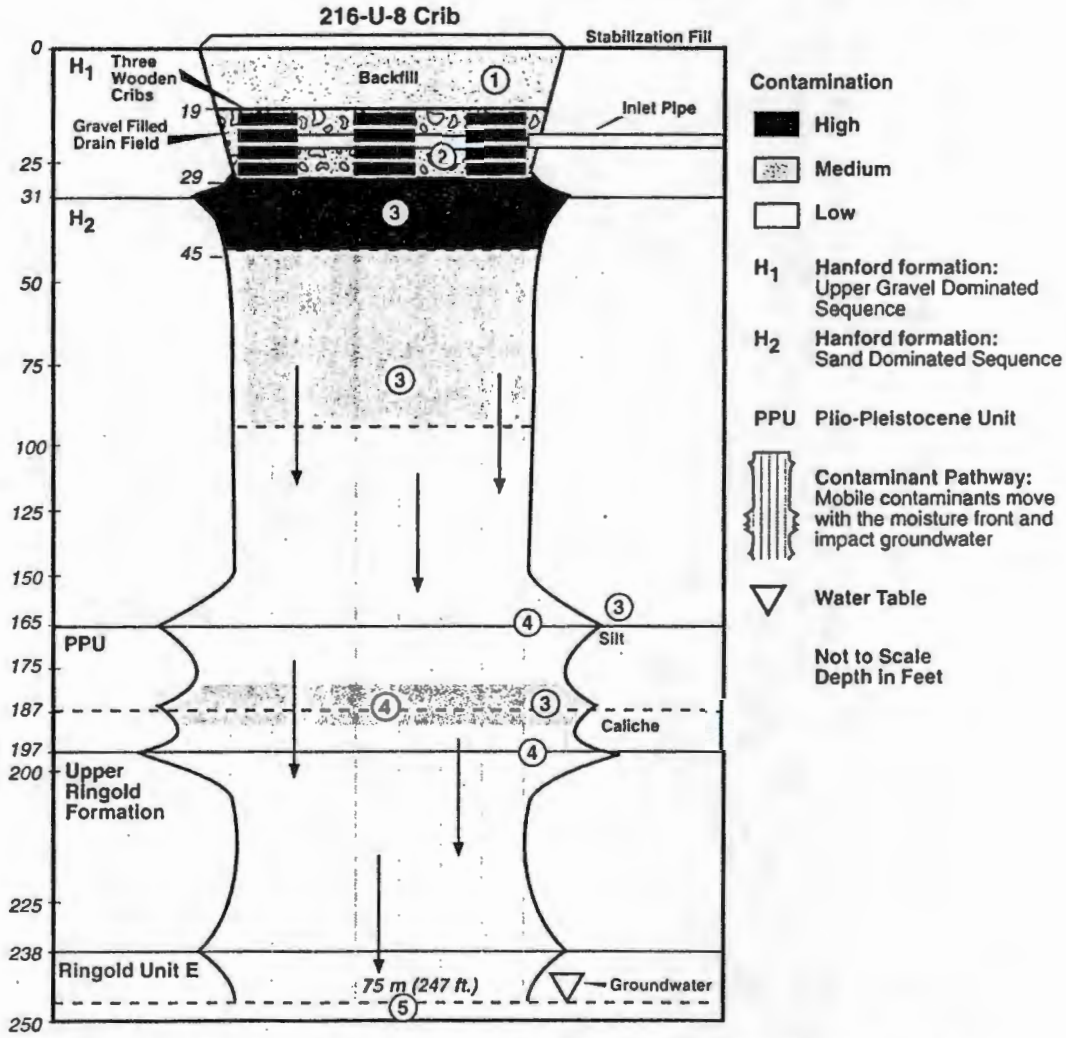
(4) Contaminants with large contaminant distribution coefficients, such as cesium-137, sorb to soils with the highest concentrations within 34 ft. of the crib bottom. Contaminant concentration generally decreases with depth. Contaminants with moderate contaminant distribution coefficients, such as cobalt-60, 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 3-12. 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).

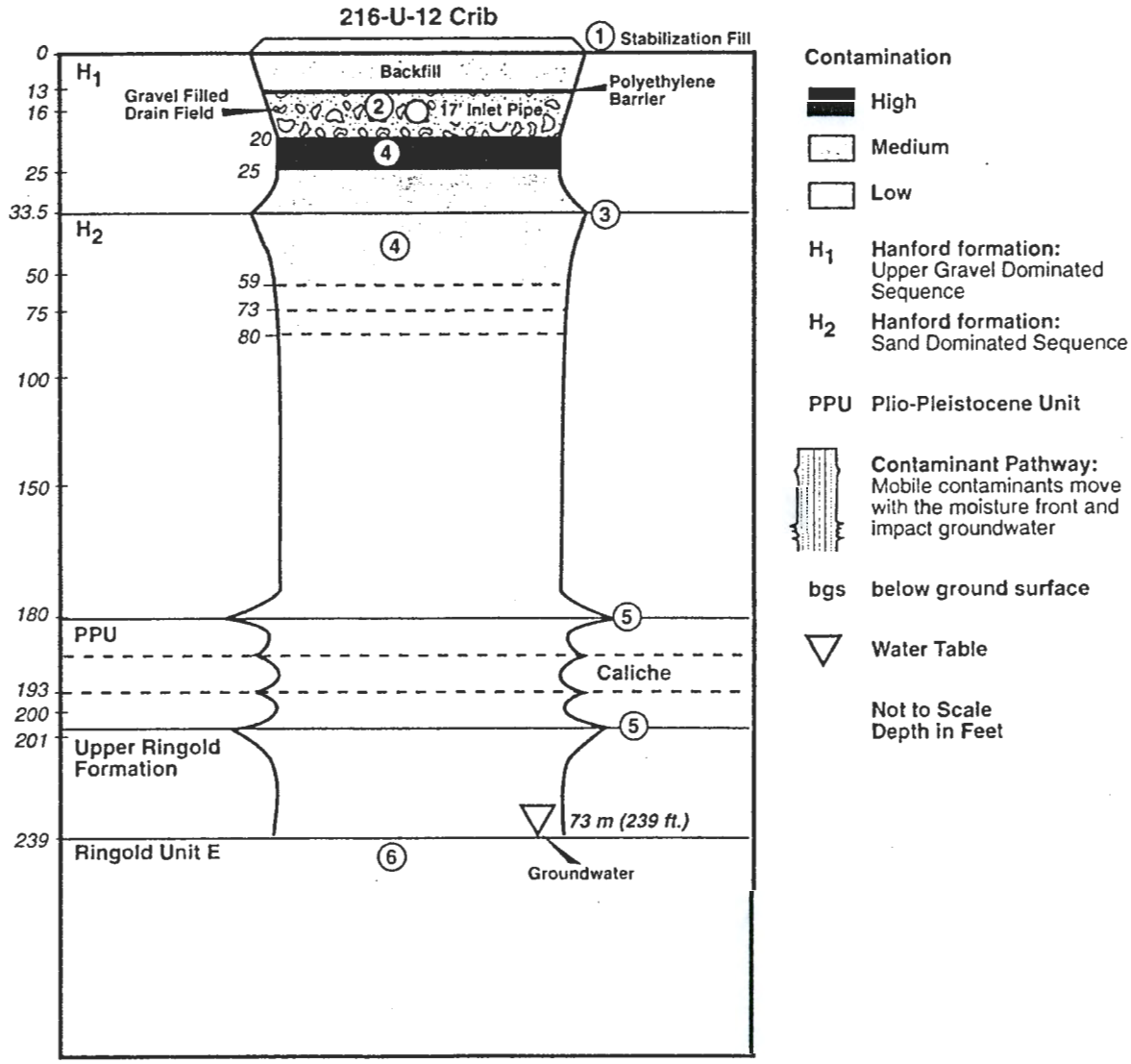
(3) The zone of greatest contamination is detected from the bottom of the crib to a depth of 12.8 m (42 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the trench. Cesium-137 concentrations are highest at depths less than 12.8 (42 ft); they decreased with depth 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 3-13. 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 1.5×10^8 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.

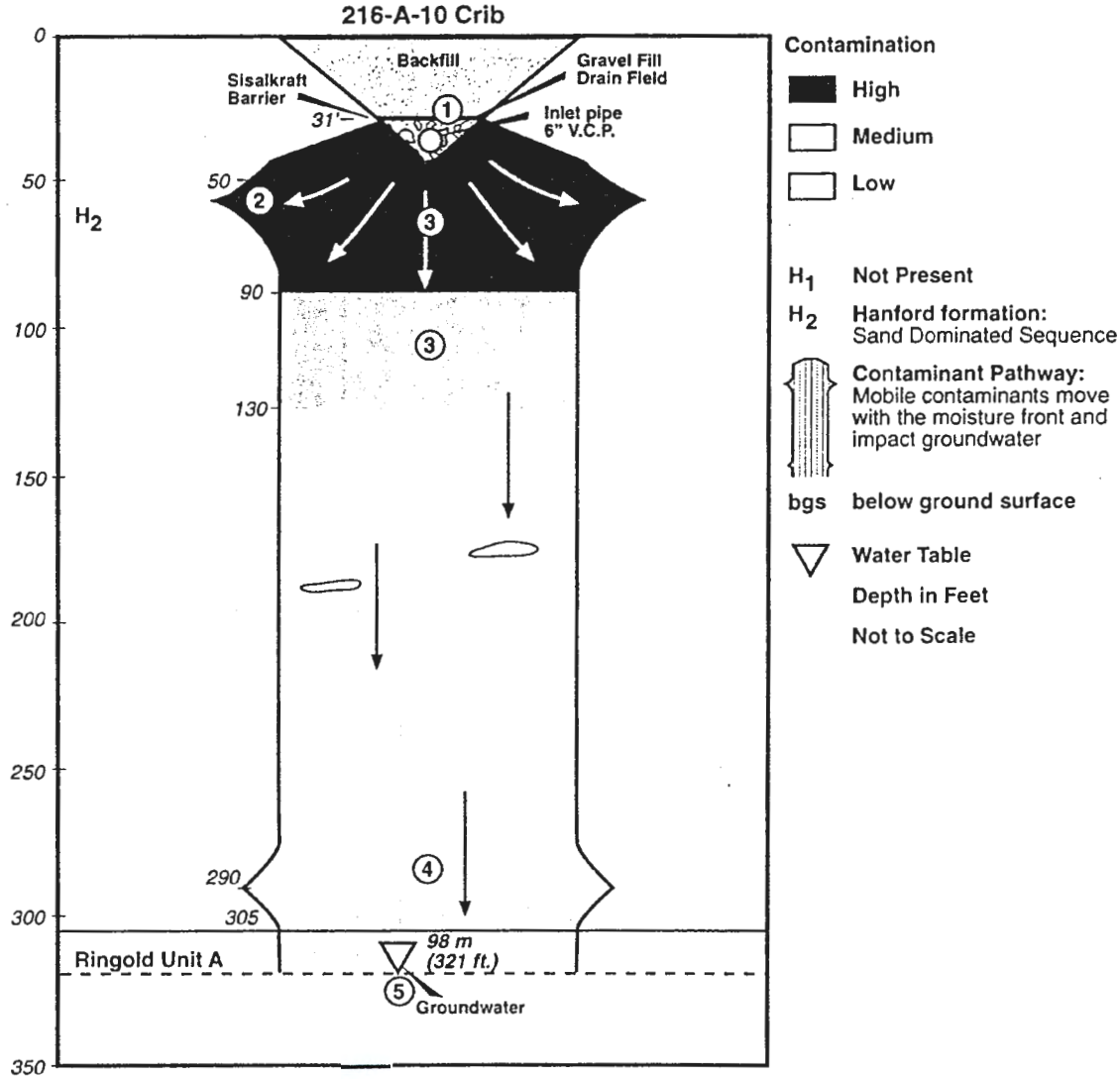
4. Contaminants such as cesium-137 have large contaminant distribution coefficients and sorb to soils with higher concentrations within 5 feet of the bottom of the crib. Cesium-137 concentrations generally decrease with depth and were not detected greater than 59 ft bgs. Uranium, which can have small 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 3-14. 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.

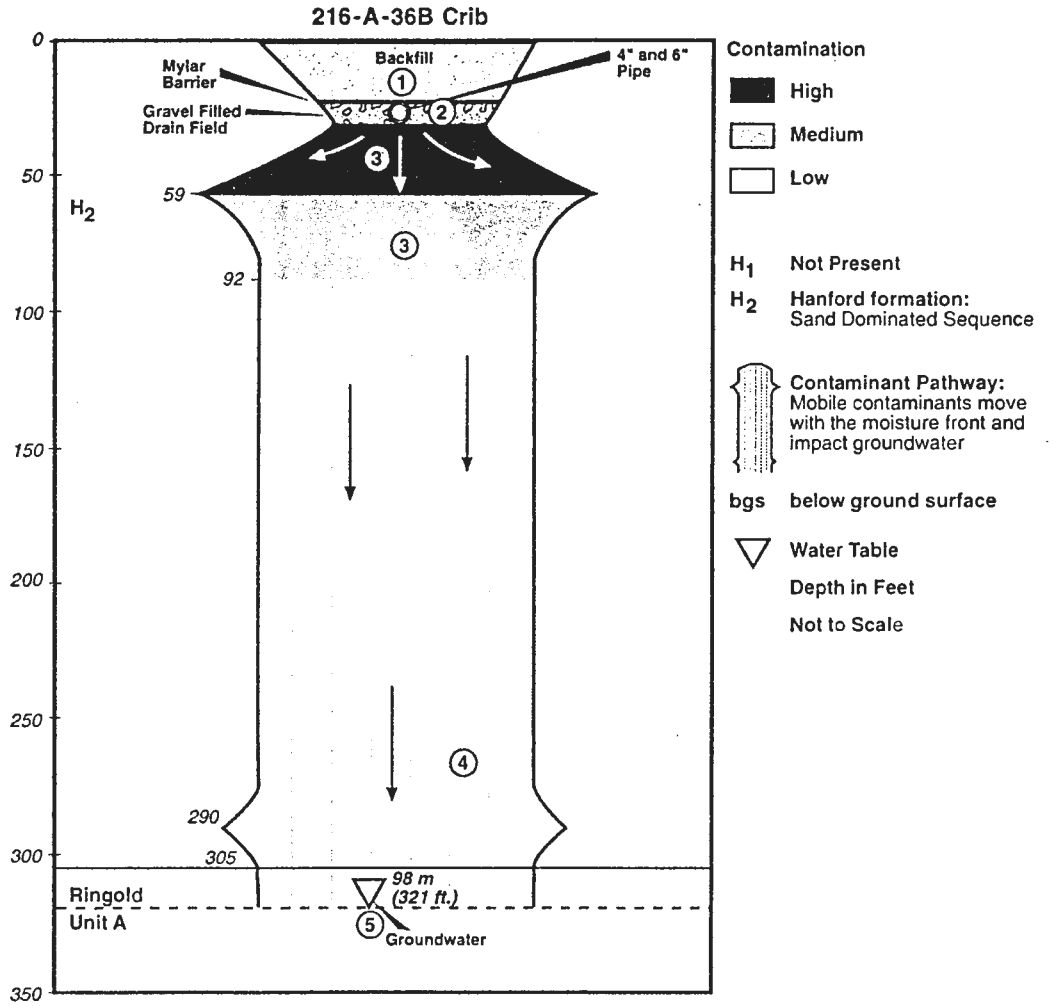
(3) The zone of greatest contamination is detected near the discharge pipe to a depth 27.4 m (90 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the crib. Cesium-137 concentrations are highest (10,000 pCi/g) 18 to 23 m (59 to 76 ft) bgs. Contaminants that are 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 3-15. 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 3.17×10^8 liters (8.37×10^7 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 (1.6×10^6 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 3-16. Conceptual Exposure Model for the 200-PW-2 Operable Unit.

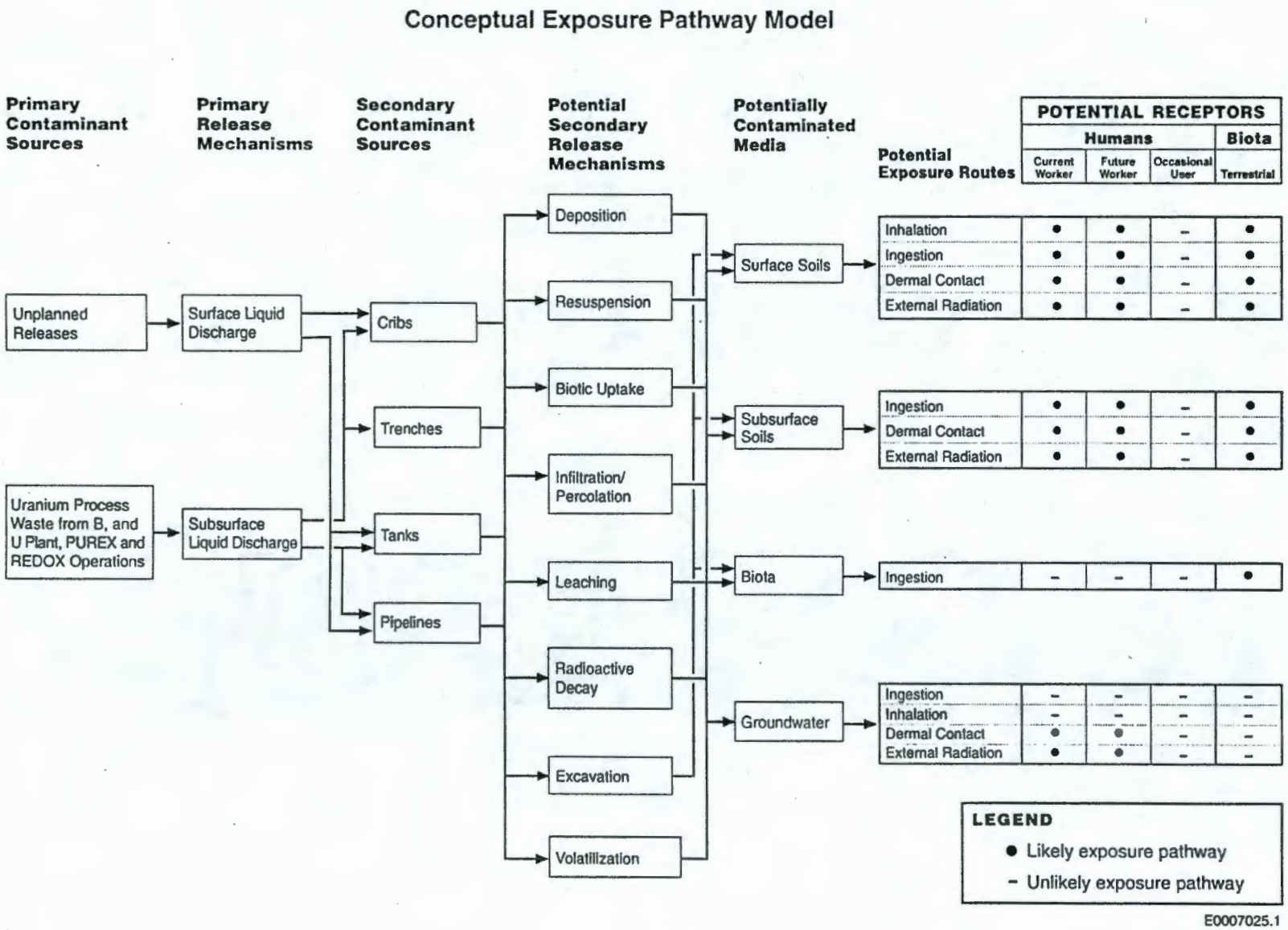


Table 3-1. 200-PW-2 Operable Unit – Estimated Contaminant Inventory. (2 Pages)

Site	Total U (Kg)	Total Pu (gm)	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															
216-A-1	1.53E+02	1.00E-01	-	4.44E-02	4.22E-02	-	-	-	80	-	-	-	98	1980	0.0495
216-A-3	1.66E+03	2.00E-01	-	4.55E-02	4.31E-02	-	-	-	-	-	-	-	3050	952	3.2038
216-A-5	2.61E+02	6.50E+01	-	1.21E+01	4.16E+01	-	-	-	1000000	-	-	-	1630049	2925	557.2817
216-A-10	**2.41E+02**	**3.50E+02**	**7.73E-01**	**8.05E+01**	**8.25E+01**	-	-	-	-	-	-	-	**3210096**	**28072**	114.3522
216-A-18	1.39E+03	1.00E-01	-	4.44E-02	4.20E-02	-	-	-	730	-	-	-	488	13050	0.0374
216-A-19	**3.87E+04**	**1.00E-01**	-	**4.44E-02**	**4.20E-02**	-	-	-	**20000**	-	-	-	**1100**	**1232**	0.8929
216-A-20	4.01E+02	1.00E-01	-	4.44E-02	4.20E-02	-	-	-	210	-	-	-	961	1274	0.7543
216-A-28	6.27E+02	-	-	-	-	-	-	-	300	-	-	-	30	191	0.1571
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**	19.4818
216-B-12	**2.10E+04**	**3.74E+02**	-	**7.16E+02**	**7.93E+01**	-	-	-	-	-	-	-	**520000**	**18300**	28.4153
216-B-60	7.20E+02	-	-	-	-	-	-	-	-	-	-	-	18.9	438	0.0432
216-C-1	3.00E+02	8.00E+00	-	4.55E-02	8.55E+01	-	-	-	-	-	-	-	23400	785	29.8089
216-S-1&2	2.25E+03	1.20E+03	-	1.10E+03	1.25E+03	-	-	-	60000	-	-	-	160000	6020	26.5781
216-S-7	2.56E+03	4.40E+02	-	7.03E+02	1.39E+03	-	-	-	110000	-	-	-	390000	8361	46.6451
216-S-8	1.93E+02	2.00E+00	-	4.92E+00	3.86E-01	-	-	-	100	-	-	-	10000	10033	0.9967
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	1.3636
216-U-6	3.63E+02	-	-	-	-	-	-	-	200	-	-	-	4500	3300	1.3636
216-U-8	**2.39E+04**	**3.70E+02**	-	**4.55E-02**	**4.31E-02**	-	-	-	-	-	-	-	**379000**	**11100**	34.1441
216-U-12	**2.01E+03**	**1.00E+00**	**6.45E-03**	**5.66E-02**	**5.59E+01**	-	-	-	-	-	-	-	**150000**	**1400**	107.1429
241-U-361	4.00E+03	-	-	-	-	-	-	-	-	-	-	-	-	-	
270-E CNT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
270-W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-E-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-E-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-E-64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-W-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
UPR-200-W-36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

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

Site	Total U (Kg)	Total Pu (gm)	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															
UPR-200-W-163	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-E-58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-W-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-W-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200-W42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

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 (e.g., DOE-RL 1992c, 1992a, 1993). All Radionuclide inventories decayed through 1989 unless otherwise noted in AAMSR. Sites shown in bold were selected as representative sites and/or are TSD units in the Implementation Plan (DOE-RL 1999) and the Waste Site Grouping Report (DOE-RL 1997).
"-" indicates data not available.

Table 3-2. Detectable Metal Concentrations in Vegetation at the 216-U-8 VCP, 216-U-8 Cribs, and 216-U-10 Pond (BHI 1994).

		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 Pipe	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
	Average 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
	Average 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
	Average 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]COC for the 200-PW-2 OU.
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 VCP, 216-U-8 Cribs, and 216-U-10 Pond (BHI 1994).

		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 Pipe	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]COC for 200-PW-2 OU.
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 Sites During 1998 and 1999 (in pCi/g).

Isotope	D037	D041	D042	D043	D044	D045	D073	D077	D078
	near 216-S-8 Trench	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	near 216-A-19 Trench	near 216-A-36B Crib	near 216-A-10 Crib
Co-60	1.6E-03	-9.8E-04	1.6E-03	-2.2E-03	5.8E-03	2.4E-03	4.0E-03	-2.0E-03	1.8E-03
Zn-65	-7.5E-03	-7.5E-03	-1.1E-03	-2.6E-03	-1.1E-02	3.3E-03	7.3E-04	3.4E-03	-2.3E-03
Sr-90	2.5E+00	2.9E-01	9.5E-04	7.1E-01	4.7E-02	2.2E+00	-6.2E-02	7.5E-02	1.1E-01
Ru-103	1.7E-03	2.2E-03	9.3E-04	3.6E-03	-1.6E-03	-6.0E-04	-1.0E-04	1.2E-03	-1.1E-02
Ru-106	1.3E-02	-1.5E-02	-3.3E-02	1.5E-03	1.0E-02	-7.9E-03	-4.4E-02	1.1E-02	3.0E-03
Sn-113	9.7E-04	-5.5E-03	-1.1E-03	-1.8E-03	3.6E-05	-1.2E-02	-1.5E-03	-3.2E-04	-6.2E-03
Sb-125	-1.1E-02	1.2E-02	5.5E-03	-2.8E-03	-1.6E-02	2.3E-03	1.1E-03	3.9E-03	1.1E-02
Cs-134	3.1E-02	3.4E-02	2.2E-02	3.5E-02	2.9E-02	2.8E-02	8.6E-03	2.2E-02	3.0E-02
Cs-137	1.7E+00	8.8E-01	9.1E-02	1.5E+00	1.1E-01	5.2E+00	2.5E-02	2.5E-01	5.2E-01
Ce-144	-4.3E-02	-5.2E-02	-3.9E-02	3.2E-02	-1.1E-02	-4.4E-03	-3.9E-02	6.6E-03	2.7E-02
Eu-152	-1.3E-02	-1.9E-03	9.7E-03	-9.3E-03	-1.1E-02	-2.1E-02	-1.5E-02	-1.1E-02	8.2E-03
Eu-154	3.7E-03	-1.5E-03	-2.4E-02	-1.1E-02	-1.3E-02	1.9E-02	-1.8E-02	-4.0E-03	3.7E-02
Eu-155	4.2E-02	2.9E-02	-2.7E-03	1.7E-02	2.6E-02	3.1E-02	4.2E-00	2.3E-02	-7.3E-04
U-234	2.8E-01	2.0E-01	2.2E-01	4.1E-01	1.7E-01	3.1E-01	2.2E-01	2.1E-01	2.2E-01
U-235	2.4E-02	2.1E-02	2.0E-02	3.6E-02	2.0E-02	2.5E-02	1.6E-02	2.1E-02	2.5E-02
U-238	2.9E-01	1.8E-01	2.0E-01	3.8E-01	1.8E-01	2.6E-01	1.7E-01	2.1E-01	2.0E-01
Pu-238	-7.3E-03	-8.0E-03	9.3E-04	4.1E-03	4.7E-03	6.1E-03	1.6E-02	6.0E-03	3.9E-03
Pu239/40	2.4E-02	5.0E-02	1.6E-02	6.1E-02	7.5E-03	1.8E-01	4.1E-03	2.6E-02	1.8E-02

Note: Even-numbered samples (e.g., D042) were collected and analyzed in 1998 (Perkins et al. 1999). Odd-numbered samples (e.g., D041) were collected and analyzed in 1999 (Perkins et al. 2000).

Table 3-5. Vegetation Sample Data Collected in the Vicinity of 200-PW-2 Sites During 1998 and 1999 (in pCi/g).

Isotope	V041	V042	V043	V044	V045	V077	V078
	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	near 216-A-36B Crib	near 216-A-10 Crib
Co-60	1.4E-02	4.2E-02	7.3E-03	-1.3E-02	3.2E-03	9.1E-03	8.4E-03
Zn-65	4.6E-02	-7.6E-02	-7.8E-02	-2.1E-01	-6.7E-02	-4.0E-02	-7.3E-02
Sr-90	1.8E-01	1.1E-02	5.1E-02	-1.2E-02	1.5E-01	1.4E+00	8.2E-02
Ru-103	-9.6E-03	-2.1E-02	4.0E-03	-1.4E-02	6.0E-03	3.4E-04	-1.4E-02
Ru-106	-2.2E-02	1.8E-02	1.2E-01	2.8E-01	2.1E-02	1.5E-02	-1.3E-01
Sn-113	-2.8E-02	-7.2E-02	6.6E-03	-5.5E-02	-4.7E-03	4.5E-03	7.6E-03
Sb-125	-3.5E-02	-4.6E-02	2.4E-02	-1.5E-02	-2.7E-02	-1.2E-02	8.6E-03
Cs-134	3.8E-03	3.9E-02	1.4E-02	5.9E-02	-1.3E-02	1.6E-03	-3.1E-02
Cs-137	7.1E-02	6.2E-02	2.3E-01	5.3E-02	9.6E-02	3.5E-02	1.8E-02
Ce-144	1.3E-02	2.9E-01	-5.3E-02	2.7E-01	-5.7E-03	3.1E-02	-1.2E-01
Eu-152	3.5E-02	3.5E-02	3.4E-02	-2.0E-02	4.4E-02	2.1E-02	-3.6E-02
Eu-154	-3.7E-02	1.5E-02	-2.5E-02	6.7E-02	-2.7E-02	-2.7E-03	9.8E-02
Eu-155	8.5E-02	-1.3E-01	2.5E-02	4.2E-02	-1.1E-01	1.8E-02	3.8E-02
U-234	3.3E-02	1.4E-02	1.4E-02	1.0E-02	2.6E-02	3.4E-02	1.1E-02
U-235	8.3E-03	4.1E-03	7.4E-03	1.2E-03	5.6E-03	1.7E-02	1.0E-02
U-238	1.8E-02	8.6E-03	1.4E-02	5.9E-03	1.5E-02	1.8E-02	1.1E-02
Pu-238	3.6E-03	5.6E-04	-5.1E-03	2.7E-03	8.1E-04	-9.1E-03	2.6E-03
Pu239/40	1.2E-02	6.0E-04	1.1E-02	3.3E-03	8.1E-03	-4.6E-03	1.1E-03

Note: Even-numbered samples (e.g., D042) were collected and analyzed in 1998 (Perkins et al. 1999). Odd-numbered samples (e.g., D041) were collected and analyzed in 1999 (Perkins et al. 2000).

Table 3-6. Summary of Human Health Qualitative Risk Assessment for the 200-UP-2 Operable Unit. (DOE-RL 1995b)

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) Medium (organics) Low (inorganics)	Cobalt-60 Cesium-137 Europium-154 Sodium-22 Aroclor-1260 Chromium	External Radiation Exposure Ingestion Fugitive Dust Inhalation
216-U-8 Crib System (including 216-U-8 and 216-U-12)	High (radionuclides) Low (inorganics)	Cesium-137 Chromium	External Radiation Exposure 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 OU.

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
Neptunium-237	Uranium-234
Nickel-63	Uranium-235
Plutonium-238	Uranium-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]	
Hexone (4-methyl-2-pentanone)	
Semi-Volatile Organics	
AMSCO[b]	Normal paraffin hydrocarbon[b]
Dodecane[b]	Tributyl phosphate and derivatives (mono, di)

[a]Only present at waste sites 216-S-1&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 not be considered further in this document because it was not disposed to any of the representative or TSD waste sites being considered in this SAP. It will be addressed in future efforts such as confirmatory sampling following the record of decision.
[b]Analyzed as kerosene or total petroleum hydrocarbons.

4.0 WORK PLAN APPROACH AND RATIONALE

4.1 SUMMARY OF DATA QUALITY OBJECTIVE PROCESS

The RI needs for the 200-PW-2 OU were developed in accordance with the DQO process (EPA 1994a; BHI-EE-01, *Environmental Investigations Procedures*, Procedure 1.2). 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 report. 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 200-PW-2 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 the *Remedial Investigation DQO Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit* (BHI 2000 pending). 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 RI/FS process without additional data collection. In addition, the 216-U-8 Crib is considered analogous to the 216-U-12 Crib, and therefore no additional sampling activities at the 216-U-12 Crib are required. Geophysical logging of nearby boreholes for each of these two sites will, however, be conducted as an efficient means to provide additional data to support refinement of the conceptual contaminant distribution models. Characterization activities outlined in this work plan focus on the four remaining representative sites and TSD units (216-A-19, 216-B-12, 216-A-10, and 216-A-36B).

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 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 waste sites. A limited amount of data will also 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). Contaminant and soil property data will be obtained by sampling and analyzing soils.

4.1.2 Data Needs

A considerable amount of information has been presented in Sections 2.0 and 3.0 regarding the 200-PW-2 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 four representative sites and TSD units. The most pertinent existing information was used to develop site-specific conceptual models for the 216-A-19, 216-B-12, 216-A-10, and 216-A-36B waste sites; additional information is provided by reference. For the representative waste sites and TSD units (and the other waste sites in the OU in general), information is available regarding location, construction design, and major types of waste disposed. For several of the sites (those associated with 200-UP-2 investigation activities) considerable data exist, while at others (216-A-10 and 216-A-36B) soil data exist to a lesser extent or are almost nonexistent (216-A-19 and 216-B-12). Therefore, data are needed to verify and/or refine the contaminant distribution models at these four sites. These data are needed to support remedial decision making at these sites and any analogous sites. As defined by the DQO process, the focus of the 200-PW-2 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, and 216-A-36B Crib are the major data needs. Data are also 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.

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 (PRGs), 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 report (BHI 2000 pending) and in Table B-3 of the SAP. The potential ARARs and PRGs for 200 Area waste sites are discussed in Sections 4.0 and 5.0 of the Implementation Plan (DOE-RL 1999).

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 1999) 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 report. A single borehole location in each of the four representative sites and TSD units identified in the previous section was selected for sampling. 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, lateral extent of contamination within the site boundaries will be evaluated with a borehole and augmented with geophysical logging. Soil samples will be taken at each representative site and TSD unit from a deep borehole (to near the groundwater table) 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 either an onsite or an 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 due to 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 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 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 3-14).

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. Alternatively, 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). Each of these four boreholes will also 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.

The sample collection strategy has been designed to characterize the vadose zone materials beneath the sites to the top of the groundwater table. Sampling will generally 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 will also be sampled. Borehole soil samples will typically 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 will also 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 *Model Toxics Control Act* (MTCA) direct exposure requirements. A 7.6-m (25-ft) bgs sample is also 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

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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 Bechtel Hanford, Inc. or by 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 will also be performed according to Bechtel Hanford, Inc.-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 four 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), and both the 216-A-10 Crib and 216-A-36B Crib will be 97 m (320 ft). In the boreholes, the presence of water-saturated soils at the expected water table elevation will indicate the end of the borehole and 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 size 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."

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 (besides 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 3-5, and in the DQO summary report (BHI 2000 pending). 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 will also be analyzed to determine soil physical properties, such as moisture content and particle size.

4.3 GEOPHYSICAL LOGGING

The four 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, and 216-A-36B 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.

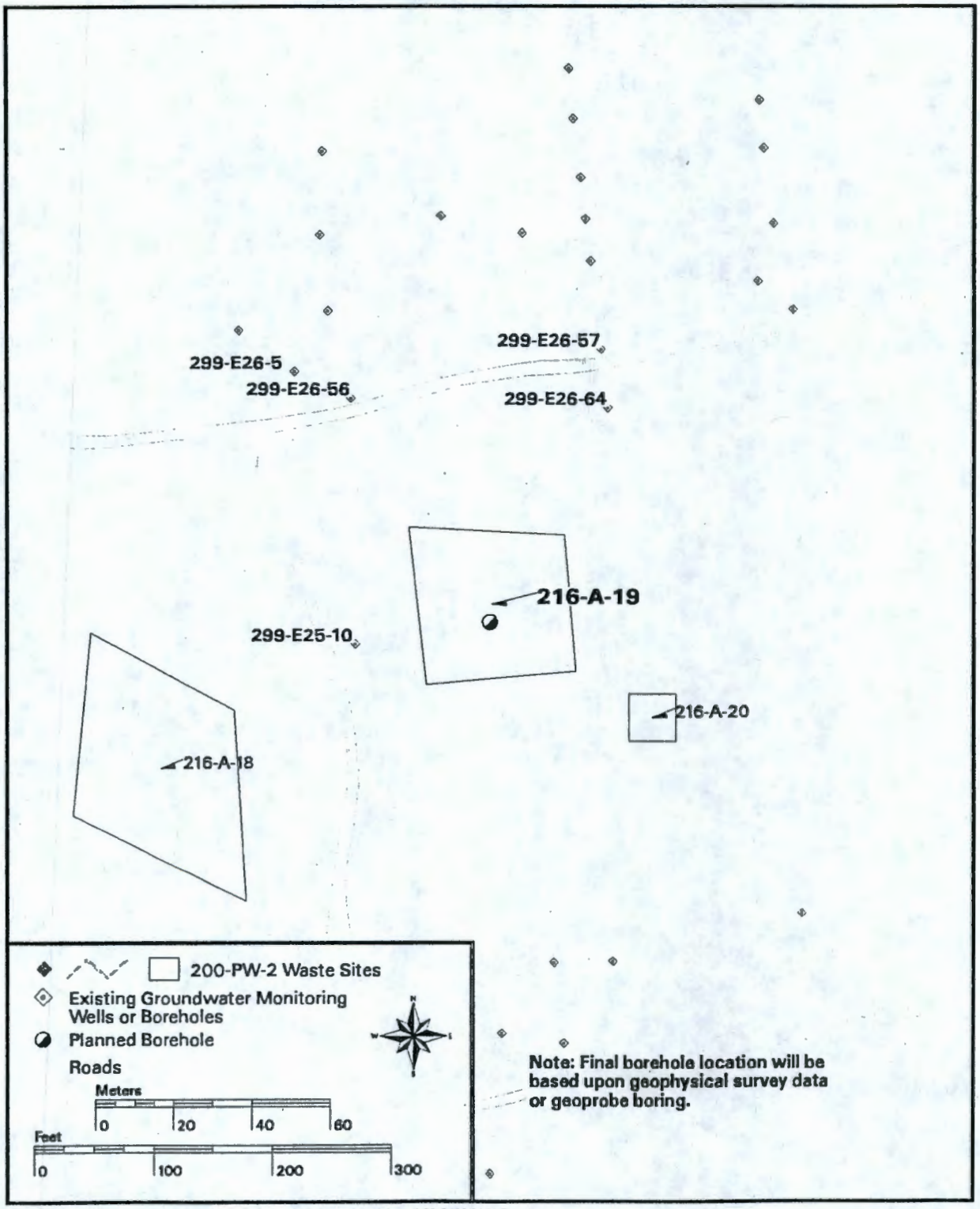
The neutron moisture-logging system that measures moisture employs a weak radioactive neutron source and neutron detector to provide a direct reading of hydrogen atom distribution in the soil surrounding the borehole. This detector will be used to measure continuous vertical moisture in the vadose zone.

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 aid in geological interpretation of subsurface stratigraphy. The deep boreholes will be logged through the casing prior to the addition of a new casing string 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 pCi/g. 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 prior to changing casing sizes and at the total depth of the borehole. The downhole tools and cable will be subject to the same rules as 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 BHI-EE-181, Well Construction Summary Report form.

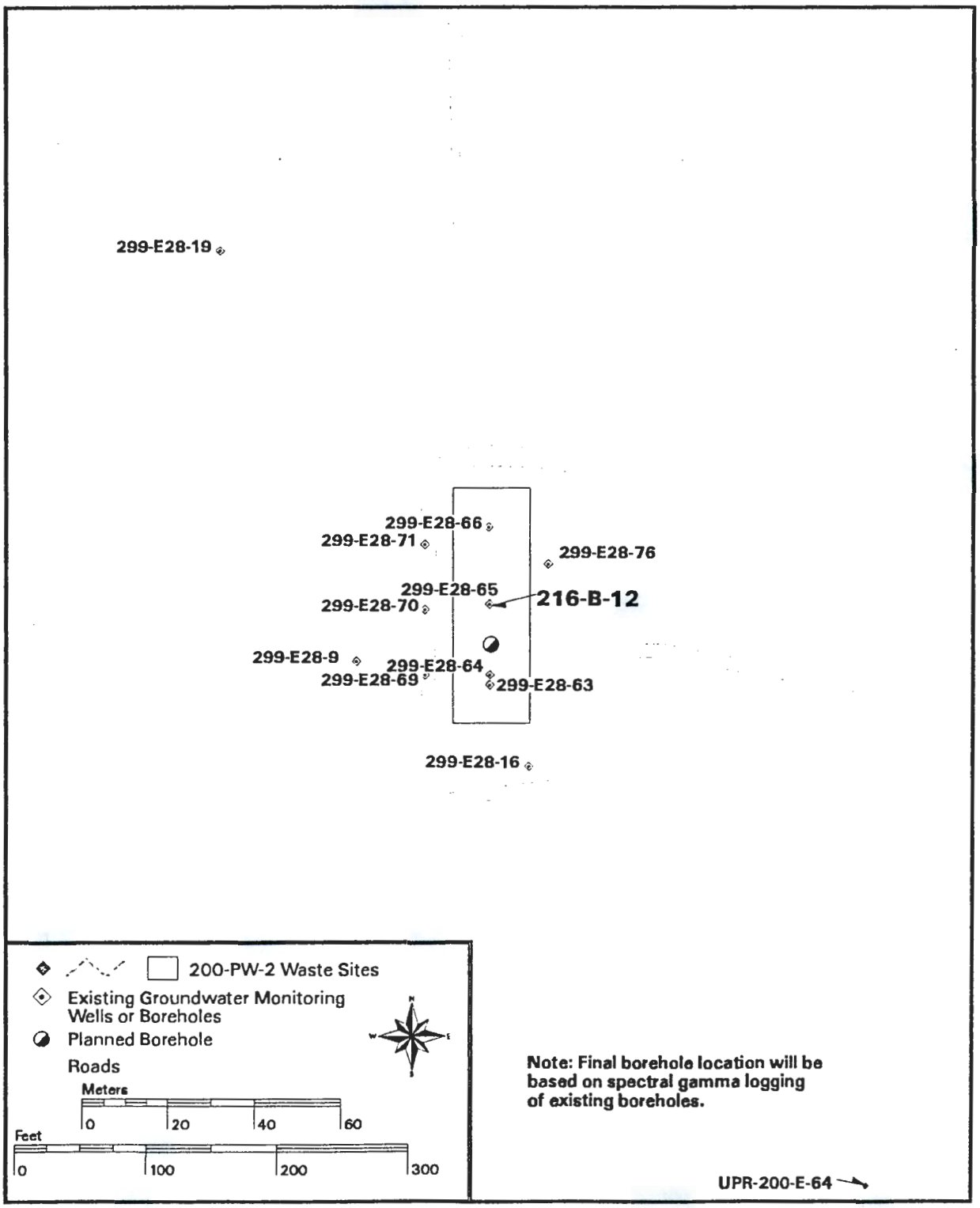
Existing wells in the vicinity of representative sites and TSD units may be logged with the gamma ray logging tool. The construction of the existing wells near these waste sites was evaluated to determine if geophysical logging would provide useful information. Existing wells with annular seals containing bentonite, cement, or other well construction materials or contoured double casings cannot be used for logging. Logging, therefore, will only be conducted in existing wells that have one casing string and lack annular seals. Data from these wells will provide better indication of formation contacts, grain size changes, and contamination. A list of wells to be logged is identified in the SAP (Appendix B).

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



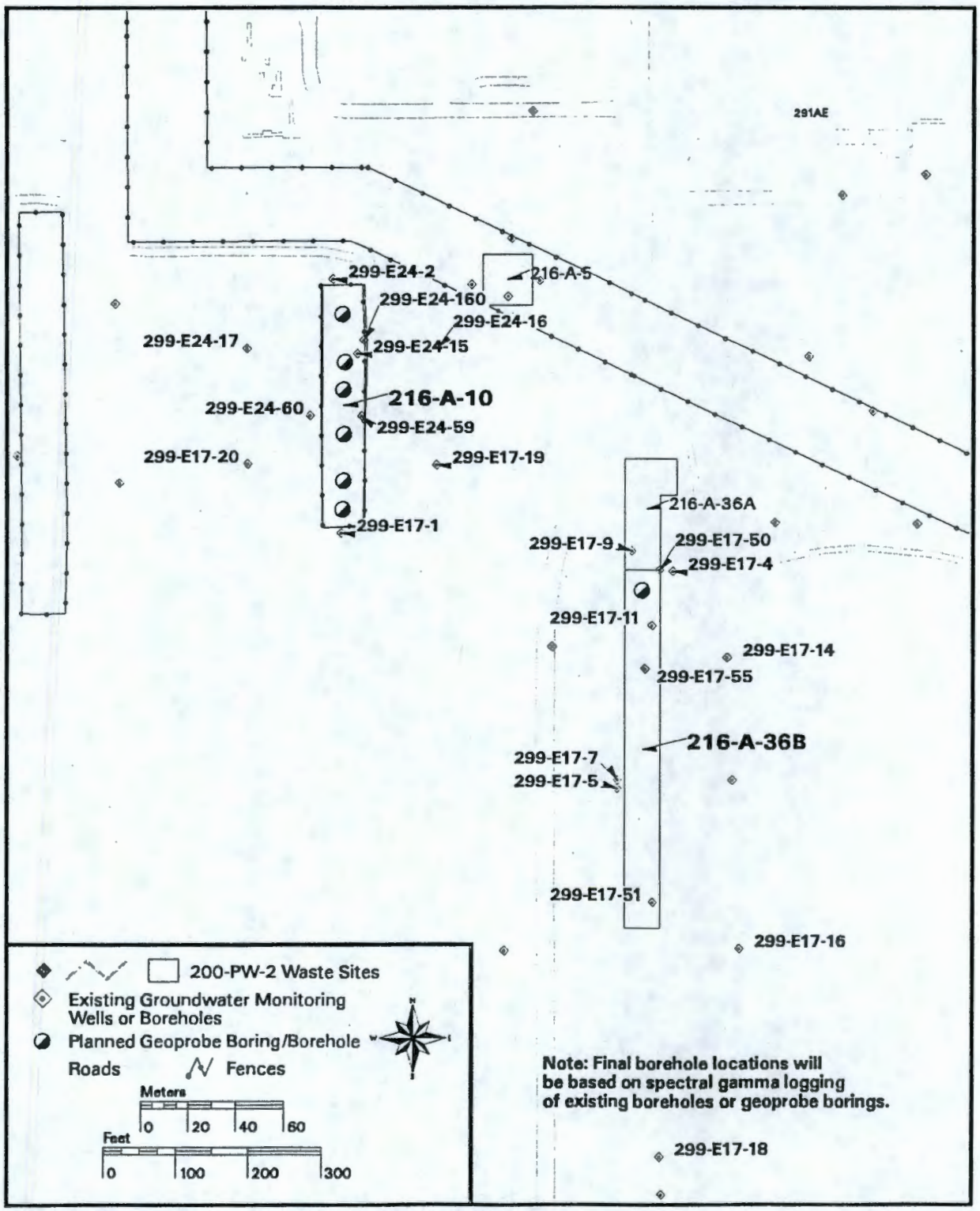
BHI:maa 06/27/00 /home/maaye/arnls/uwaste_borehole2e <with> Plotted 22-JAN-2001 Rev 4

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



BHI:maa 06/27/00 /home/maaye/arnls/uwaste_borehole2e <with> Plotted 22-JAN-2001 Rev 4

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



BHI:msa 06/27/00 /home/maaye/amls/uwaste_borehole2c <with> Plotted 22-JAN-2001 Rev 4

5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROCESS

This section describes the RI/FS (assessment) process for the 200-PW-2 OU. The development of and rationale for this process are provided in the Implementation Plan (DOE-RL 1999) 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 Section 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) and a proposed plan and proposed RCRA Permit modification for RCRA TSD units, followed by a ROD and 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 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 (DOE-RL 1999). 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 (DOE-RL 1999) provides the overall quality assurance framework that was used to prepare an OU-specific quality assurance project plan for the 200-PW-2 RI (Appendix A, Section A2.0). Appendix C of the Implementation Plan reviews data management activities that are applicable to the 200-PW-2 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

The RCRA closure and corrective action authorities have clear jurisdiction over waste with chemical constituents (in particular, dangerous waste and dangerous waste constituents) and the chemical constituents in mixed wastes (i.e., mixtures of dangerous waste and radiological contaminants), but not jurisdiction over waste with radiological contaminants only. By applying CERCLA authority concurrently with RCRA closure and corrective action requirements through

integration, cleanup will be addressing all regulatory and environmental obligations at this OU, including compliance with MTCA, as effectively and efficiently as possible. Also, by applying CERCLA authority jointly with that of RCRA, additional options for disposal of closure, corrective action, and remedial action wastes at the Environmental Restoration Disposal Facility are possible. By allowing flexibility in final disposal options, DOE, Ecology, and EPA intend to minimize disposal costs as much as possible while remaining fully protective of human health and the environment.

The integrated process for characterization of the 200-PW-2 OU uses this RI/FS work plan in combination with the Implementation Plan (DOE-RL 1999) to satisfy the requirements for both an RI/FS work plan and an RFI/CMS work plan. General facility background information, potential ARARs, preliminary RAOs, and preliminary remedial technologies developed in the Implementation Plan are incorporated by reference into this work plan. This work plan also provides RCRA TSD unit closure plan information on facility description, location, and process information (Sections 2.1 and 2.2), waste characteristics (Section 3.1), and groundwater monitoring (Section 3.2). Following the completion of the work plan, an RI will be performed that will satisfy the requirements for an RFI and will provide the data needed to support the selection of a closure strategy for RCRA TSD units. The RI will be limited to the concurrent investigation of representative waste sites and RCRA TSD units undergoing closure. A report summarizing the results of the RI will then be prepared that will satisfy the requirements for an RFI report. The report will also contain the characterization information required in a RCRA TSD unit closure plan.

Based on recent discussions with Ecology and EPA on ways to further streamline 200 Area assessment planning, two additional RCRA TSD units have been added into the RI/FS process as part of the 200-PW-2 OU. This more focused approach was also discussed during the annual review of 200 Area work scope priorities conducted during the spring of 2001. As a result of these meetings, Ecology agreed that the assessment of the 216-A-37-1 Crib and 207-A South Retention Basin RCRA TSD units (from the 200-PW-4 General Process Waste Group) may be addressed as part of the 200-PW-2 OU work plan to accelerate the investigation of all process waste-type RCRA TSD units. A separate SAP will be prepared for these two RCRA TSD units, the implementation of which will be integrated with the 200-PW-2 RI. Furthermore, the TSD units will also be incorporated into subsequent RI/FS documents under the 200-PW-2 OU.

After the RI is complete, remedial alternatives/closure strategies will be developed and evaluated against performance standards and evaluation criteria. The integration process for the evaluation of remedial alternatives includes the preparation of an FS/closure plan that will satisfy the requirements for a CMS report. Both documents are required to include identification and development of corrective measure/remedial alternatives and an evaluation of those alternatives. The CMS generally also includes a recommended alternative, which is typically the purpose of the proposed plan under CERCLA. The FS will include a section that provides corrective action recommendations for RPPs and closure plans will address the RCRA TSD units in the OU. The FS will also include further evaluation and refinement of ARARs that were identified in the Implementation Plan.

The RCRA TSD closure options (i.e., landfill, modified, and clean closure as defined in Condition II.K. of the Hanford Facility RCRA Permit) will be determined based on the alternative selected and the amount of cleanup that can be attained by the alternative. Landfill closure under RCRA could include the construction of an engineered barrier over the unit and equates to what is typically termed as a "containment alternative" under CERCLA. A modified closure option includes alternatives that leave contaminants in place above MTCA Method B cleanup standards in soil, debris, or groundwater, but below MTCA Method C. A clean closure option requires that all contaminated material and media be removed and decontaminated to levels below MTCA Method B.

Recent revisions prompted by the EPA and codified in the June 2000 amendments to WAC 173-303-610(1)(d) for closure/postclosure plans and WAC 173-303-645(1)(e) for corrective actions allow for alternative requirements for closure, post-closure, groundwater monitoring, or corrective action at TSD units. WAC 173-303-645(1)(e) states:

> "The director may, in an enforceable document, replace all or part of the requirements of this section with alternative requirements for ground water monitoring and corrective action when he or she determines: (i)A dangerous waste unit is situated among other solid waste management units or areas of concern, a release has occurred, and both the dangerous waste unit and one or more of the solid waste management units or areas of concern are likely to have contributed to the release; and (ii) It is not necessary to apply the requirements of this section because the alternative requirements will protect human health and the environment."

These revisions allow certain TSD units to be addressed through the corrective action program rather than through the TSD closure requirements. This flexibility is intended to reduce the potential for confusion and inefficiency created by the application of two different regulatory requirements at the same unit or between units within close proximity of one another. Under these new provisions, closure and postclosure plans may be eliminated as stand-alone documents in favor of generating a more holistic document that includes the closure/postclosure elements within the details of the corrective action requirements at TSD, RPP, and CERCLA past-practice units. The application of these revised regulations to OUs within the 200 Areas of the Hanford Site will require further discussion between Ecology and DOE and may result in changes to the integrated RCRA/CERCLA process presented in the Implementation Plan (DOE-RL 1999), Figure 1-1 of this work plan, and this section.

The decision-making process for the 200-PW-2 OU will be based on the use of a proposed plan, ROD, and Hanford Facility RCRA Permit modification. Based on the FS/closure plan, a proposed plan will be prepared that identifies the preferred remedial alternative for waste sites within the OU. The proposed plan will include a draft permit modification with unit-specific permit conditions for RPP waste sites and the RCRA TSD units within the OU for incorporation into the Hanford Facility RCRA Permit. The CERCLA ROD will document the RCRA TSD unit closure and RCRA corrective action decisions for these units. The lead regulatory agency (Ecology) will prepare the CERCLA ROD following completion of the public involvement process for the proposed plan, which, after signature by the Tri-Parties, will authorize the

selected remedial action. The remedy selected under CERCLA will be incorporated into the Hanford Facility RCRA Permit as the RCRA closure/corrective action after issuance of the public notice and the comment process.

The technical and procedural elements of RCRA and CERCLA are each addressed in full in this process. The CERCLA public involvement, including public notice and opportunity to comment, will be enhanced, as necessary, to concurrently satisfy the public involvement requirements for the RCRA closure and RPP processes. The public will be given an opportunity to review and comment on the FS/closure plan and the proposed permit conditions that will be contained in the proposed plan. The proposed plan with a draft permit modification will be issued for a minimum 45-day public review and comment period. Supporting documents, including the FS/closure plan, will also be made available to the public for review at this time. A combined public meeting/public hearing may be held during the comment period to provide information on the proposed action and permit modification and to solicit public comment.

5.2 REMEDIAL INVESTIGATION ACTIVITIES

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

- Planning
- Field investigation
- Management of investigation-derived waste (IDW)
- 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 Section 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 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 4-3 will be located using a global positioning satellite system.

With the addition of the 216-A-37-1 Crib and 207-A South Retention Basin RCRA TSD units from the 200-PW-4 OU to the scope of work for this work plan, it will be necessary to prepare a separate SAP for these two RCRA TSD units. All required approvals and necessary planning activities identified above will be completed prior to initiating field activities. Field activities for these two TSD units will be initiated in sequence with the remainder of the assessment activities identified in this work plan.

Appendix B of the Implementation Plan (DOE-RL 1999) 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 two RCRA TSD units (216-A-10 Crib and 216-A-36B Crib).

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. Four boreholes are planned to collect samples at a depth to the top of the groundwater table at four waste sites (216-A-19 Trench, 216-B-12 Crib, 216-A-10 Crib, and 216-A-36B Crib). Samples will be collected with split-spoon samplers and packaged for shipment to either 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.

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 may be also 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 IDW containers, geological logs, field screening results, and geophysical logging results.

5.2.3 Management of Investigation-Derived Waste

Waste generated during the RI will be managed in accordance with a WCP to be prepared for the OU. Appendix E of the Implementation Plan (DOE-RL 1999) provides general waste management processes and requirements for the IDW and forms the basis for activity-specific WCPs. The WCP addresses the handling, storage, and disposal of IDW generated during the RI phase. Furthermore, the plan identifies governing Environmental Restoration Contractor (ERC) procedures and discusses the types of waste expected to be generated, the waste designation process, and the final disposal location. The IDW management task begins at the start of the field investigation, when IDW 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 are provided in Tables B2-1 and B2-2 of the SAP (Appendix B). This task includes the laboratory analysis of samples, the compilation of laboratory results in data packages, and the 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 (DQA); 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 DQA 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 DQA 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 (e.g., MTCA tests) or more complex comparisons such as nonparametric hypothesis tests (e.g., Wilcoxon Rank-Sum Test). These tests may also compare the data to appropriate cleanup levels.

All of these statistical evaluations will aid in refining the conceptual model for this OU and selecting the remedial alternative.

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 5.2.5.3).

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 Qualitative Risk Assessment. For the 200-PW-2 OU, a QRA will be prepared to evaluate risk to human receptors from potential exposure to contaminants in accessible surface sediments and shallow subsurface soils. The QRA will also evaluate the impact to groundwater that may result from contaminants migrating to the water table through the vadose zone underlying wastes sites in the 200-PW-2 OU.

The application of risk assessment in the characterization and remediation of the 200 Areas will follow a graded approach as described in Section 5.5 of the Implementation Plan (DOE-RL 1999). A QRA will be performed as part of the RI report and FS. When additional data are

available for all the sites in an OU, a more quantitative risk assessment may be performed. A quantitative, cumulative risk assessment will be used to evaluate remedial actions and close out the sites in the 200 Areas.

For the 200-PW-2 OU, a QRA will be prepared to evaluate risk to human receptors from potential exposure to contaminants in accessible surface sediments and shallow subsurface soils. The QRA will also evaluate the impact to groundwater that may result from contaminants migrating to the water table through the vadose zone underlying waste sites in this OU.

The computer program RESRAD will be used to model radionuclide dose. Other contaminant fate and transport models may be used to assess impact to the groundwater from chemicals and radionuclides in the vadose zone. The chemical and physical characterization data obtained in this study will be used in the RESRAD modeling, as well as input parameters appropriate for the land use. Because waste sites within the 200-PW-2 OU are all located inside the 200 Area boundary, only a QRA for industrial land use will be performed. The input parameters recommended by the Washington State Department of Health (WDOH 1997) may be considered for this effort. Section 5.5 of the Implementation Plan (DOE-RL 1999) contains additional information on the application of the risk assessment process to the OU.

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 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 no action.

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.

Appendix D of the Implementation Plan (DOE-RL 1999) identifies the following remedial action alternatives as potentially applicable to the 200-PW-2 OU:

- 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 criteria, community acceptance, will be applied following the FS at the proposed plan and ROD phase.

NEPA values will also be evaluated as part of DOE's responsibility under this authority. The NEPA 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]) will also be used to evaluate the ability of alternatives to comply with RCRA closure requirements. These standards require the closure of TSD units in a manner that achieves the following:

- Minimizes the need for further maintenance

- Controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of dangerous waste, dangerous waste constituents, leachate, contaminated run-off, or dangerous waste decomposition products to the ground, surface water, groundwater, or the atmosphere

- Returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity.

In addition, RCRA corrective action performance standards (WAC 173-303-646[2]) will be used to evaluate alternative compliance with RCRA corrective action requirements. These standards state that corrective action must achieve the following:

- Protect human health and the environment for all releases of dangerous wastes and dangerous constituents, including releases from all solid waste management units at the facility
- Occur regardless of the time at which waste was managed at the facility or placed in such units, and regardless of whether such facilities or unit were intended for the management of solid or dangerous waste
- Be implemented by the owner/operator beyond the facility boundary where necessary to protect human health and the environment.

The FS will also 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 (Section 4.0, DOE-RL 1999)
- Refine potential RAOs and PRGs identified in the Implementation Plan (Section 5.0, DOE-RL 1999) 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 1999) 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 to address RCRA TSD units in the OU. 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 post-closure information.

Additional RCRA integration guidance for preparing an FS/closure plan is provided in Section 2.4 of the Implementation Plan (DOE-RL 1999).

5.4 PROPOSED PLAN AND PROPOSED RCRA PERMIT MODIFICATION

The decision-making process for the 200-PW-2 OU will be based on the use of a proposed plan, ROD, and modification to the Hanford Facility RCRA Permit. Following the completion of the FS/closure plan, a proposed plan will be prepared that identifies the preferred remedial alternative for the OU (which will include RCRA closure and corrective action requirements). In addition to identifying the preferred alternative, the proposed plan will also serve the following purposes:

- Provide a summary of the completed RI/FS.
- Provide criteria by which analogous waste sites within the OU not previously characterized will be evaluated after the ROD to confirm that the contaminant distribution model for the site is consistent with the preferred alternative. Contingencies to move a waste site to a more appropriate waste group will also be developed.
- Identify performance standards and ARARs applicable to the OU.

The proposed plan will also include a draft permit modification with unit-specific permit conditions for RPPs and the RCRA TSD units for incorporation into the Hanford Facility RCRA Permit. After the public review process is complete, Ecology (as the lead regulatory agency), in concert with DOE and EPA, will make a final decision on the remedial action to be taken, which is documented in a ROD. The Hanford Facility RCRA Permit will subsequently be modified by Ecology to incorporate the ROD (and subsequent amendments) by reference, authorizing the RCRA actions.

5.5 POST-RECORD OF DECISION ACTIVITIES

After the ROD and modification to the Hanford Facility RCRA Permit 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. Prior to beginning remediation, 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 OU, to collect data necessary for the remedial design, and to support future risk assessments, if needed. Verification sampling will be performed after the remedial action is complete to determine if ROD requirements have been met and if the remedy was effective. Additional guidance for confirmatory and verification sampling is provided in Section 6.2 of the Implementation Plan (DOE-RL 1999).

The RDR/RAWP will include an integrated schedule of remediation activities for the OU, including the schedule for RCRA TSD unit closure, and will satisfy the requirements for a RPP corrective measures implementation work plan and corrective measures design report. 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. Certification of closure in accordance with WAC 173-303-610(6) 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, post-closure 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 post-closure at the completion of the post-closure period.

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 are also shown in Figure 6-1. The schedule concludes with the preparation of a ROD. Modification of the Hanford Facility RCRA Permit 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 milestone that has been completed involved submittal of Draft A of the work plan to the regulators by December 31, 2000 (Milestone M-13-25). Existing outyear RCRA TSD unit milestones include M-20-33, which requires submittal of the 216-A-10 Crib and 216-A-36B Crib closure/post-closure plans to Ecology by October 31, 2003, and M-20-52 and M-20-53, which require submittal of the 216-A-37-1 Crib and 207-A South Retention Basin closure/post-closure plans to Ecology by December 31, 2003. The schedule shown in Figure 6-1 proposes new completion dates for these RCRA TSD milestones in order to align them with completion of the FS/closure plan. Modifications to major milestone M-20-00 will be proposed at a later date as part of a comprehensive package to address all other remaining M-20 interim milestones.

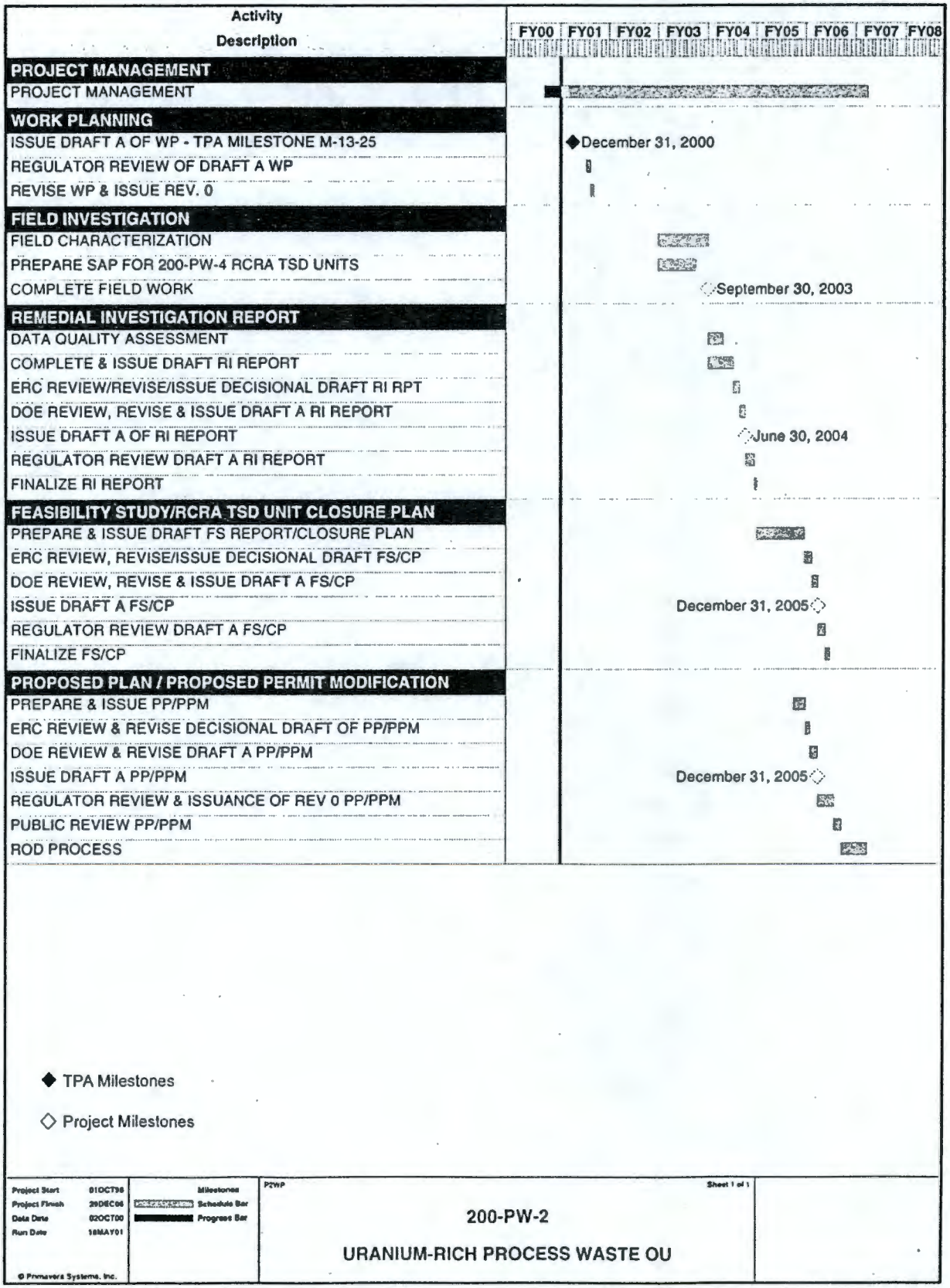
The following are proposed project milestone completion dates for key activities:

- Complete field activities (M-15-43A) – September 30, 2003*
- Submit Draft A RI report for regulatory review (M-15-43B) – June 30, 2004*
- Submit Draft A FS/closure plan and Draft A proposed plan/permit modification for regulator review (M-15-43C) – December 31, 2005*.

Interim milestones to be designated under the Tri-Party Agreement will be established through negotiations between the Tri-Parties. 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. Currently field activities are scheduled to begin in FY 2003.

**Target project milestone*

Figure 6-1. Project Schedule for the 200-PW-2 Operable Unit.



7.0 REFERENCES

40 CFR 265, "Interim Status for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

64 FR 61615, "Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS), Hanford Site, Richland, Washington; Record of Decision (ROD)," *Federal Register*, Vol. 64, No. 218, pp. 61615, November 12, 1999.

Agnew, S. F., J. Boyer, R. S. Corbin, T. B. Duran, J. R. Fitzpatrick, K. S. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*, LA-UR-96-3860, Rev. 4, Los Alamos National Laboratory, Los Alamos, New Mexico.

Baldridge, K. F., 1958, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through June 1958*, HW-57649, General Electric Company, Richland, Washington.

Baldridge, K. F., 1959, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through December 1958*, HW-59359, General Electric Company, Richland, Washington.

Bernard, R. M., 1958, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through December 1957*, HW-55593, General Electric Company, Richland, Washington.

BHI, 1994, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit,* BHI-00033, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1995, *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area,* BHI-00034, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1996a, *216-A-10 Crib Supplemental Information to the Hanford Facility Contingency Plan (DOE/RL-93-75)*, BHI-00119, Rev. 2, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1996b, *216-A-36B Crib Supplemental Information to the Hanford Facility Contingency Plan (DOE/RL-93-75)*, BHI-00121, Rev, 2, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1996c, *216-U-12 Crib Supplemental Information to the Hanford Facility Contingency Plan (DOE/RL-93-75)*, BHI-00123, Rev. 2, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1996d, *Preoperational Baseline and Site Characterization Report for the Environmental Restoration Disposal Facility*, BHI-00270, Vols. 1 and 2, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1997, *Hanford Sitewide Groundwater Remediation Strategy – Groundwater Contaminant Predictions*, BHI-00469, Rev. 1, Bechtel Hanford Company, Richland, Washington.

BHI, 2000, *Remedial Investigation DQO Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit*, BHI-01411, Rev. 0, pending, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-01, *Environmental Investigations Procedures,* Bechtel Hanford, Inc., Richland, Washington.

Bjornstad, B. N., 1990, *Geohydrology of the 218-W-5 Burial Ground, 200 West Area, Hanford Site*, PNL-7336, Pacific Northwest Laboratory, Richland, Washington.

Borsheim, G. L. and B. C. Simpson, 1991, *An Assessment of the Inventories of the Ferrocyanide Watchlist Tanks*, WHC-SD-WM-ER-133, Westinghouse Hanford Company, Richland, Washington.

Cataldo, D. A., R. C. Routson, D. Paine, and T. R. Garland, 1978, *Relationship Between Properties of Hanford Area Soils and the Availability of ^{134}Cs and ^{85}Sr for Uptake by Cheatgrass and Tumbleweed,* PNL-2496, Pacific Northwest Laboratory, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

Curren, E. F., 1972, *200 Areas Disposal Sites for Radioactive Liquid Wastes*, ARH-947, Atlantic Richfield Hanford Company, Richland, Washington.

DOE, 1988, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washingto*n, DOE/RW-0164, U.S. Department of Energy, Washington, D.C.

DOE, 1999, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, DOE/EIS-0222-F, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1988, *Information on Hanford Site Cribs and Septic Systems*, DOE/RL-88-19, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992a, *U Plant Source Aggregate Area Management Study Report*, DOE/RL-91-52, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992b, *Annual Report for RCRA Groundwater Monitoring Projects for Hanford Site Facilities for 1991,* DOE/RL-92-03, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992c, *REDOX Plant Source Aggregate Area Management Study Report*, DOE/RL-91-60, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993a, *B Plant Source Aggregate Area Management Study Report*, DOE/RL-92-05, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993b, *Hanford Facility Dangerous Waste Part A Permit Application*, DOE/RL-88-21, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993c, *PUREX Plant Source Aggregate Area Management Study Report*, DOE/RL-92-04, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993d, *Semiworks Plant Source Aggregate Area Management Study Report*, DOE/RL-92-18, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994, *Hanford Site Risk Assessment Methodology,* DOE/RL-91-45, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995a, *Focused Feasibility Study for the 200-UP-2 Operable Unit,* DOE/RL-95-106, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995b, *Limited Field Investigation for the 200-UP-2 Operable Unit,* DOE/RL-95-13, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997, *Waste Site Grouping for 200 Areas Soil Investigations,* DOE/RL-96-81, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2000a, *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*, DOE/RL-99-79, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2000b, *Focused Feasibility Study for the 300-FF-2 Operable Unit,* DOE/RL-99-40, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2000c, *Environmental Monitoring Plan United States Department of Energy Richland Operations Office*, DOE/RL-91-50, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1998, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1994a, *Guidance for Data Quality Objectives Process*, EPA QA/G-4, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1994b, *RCRA Corrective Action Plan*, OSWER Directive 9902.3-2A, U.S. Environmental Protection Agency, Office of Waste Programs Enforcement and Office of Solid Waste, Washington, D.C.

Fecht, K. R., G. V. Last, and K. R. Price, 1977, *Evaluation of Scintillation Probe Profiles From 200 Area Crib Monitoring Wells,* ARH-ST-156, Atlantic Richfield Hanford Company, Richland, Washington.

Gano, K. A., 1979, *Analysis of Small Mammal Populations Inhabiting the Environs of a Low-Level Radioactive Waste Pond*, PNL-2479, Pacific Northwest Laboratory, Richland, Washington.

Gano, K. A, 1980, "Mortality of the Harvester Ant (Pogonomyrmex owyheei) After Exposure to 137Cs Gamma Radiation," *Environmental Entomology*, 10:39-44.

GE, 1951a, *REDOX Technical Manual*, HW-18700-DEL, General Electric Company, Richland, Washington.

GE, 1951b, *Uranium Recovery Technical Manual*, HW-19140, General Electric Company, Richland, Washington.

GE, 1954a, *Radioactive Liquid Waste Disposal Facilities*, HW-33305, General Electric, Richland, Washington.

GE, 1954b, *Recovery of Cesium-137 from Uranium Recovery Process Wastes*, HW-31442, General Electric Company, Richland, Washington.

GE, 1954c, *Summary of Liquid Radioactive Wastes Discharged to the Ground - 200 Areas (July 1952 Through June 1954)*, HW-33591, General Electric Company, Richland, Washington.

GE, 1955a, *PUREX Technical Manual*, HW-31000-DEL, General Electric Company, Richland, Washington.

GE, 1955b, *Radioactive Contaminants in Liquid Wastes Discharged to Ground at Separation Facilities Through June 1955*, HW-38562, General Electric Company, Richland, Washington.

GE, 1956a, *Cobalt-60 in Groundwater and Separation Waste Streams*, HW-42612, General Electric Company, Richland, Washington.

GE, 1956b, *Tabulation of Radioactive Liquid Waste Disposal Facilities*, HW-43121, General Electric, Richland, Washington.

GE, 1956c, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas*, HW-41535, General Electric, Richland, Washington.

GE, 1958a, *Index of CPD Crib Building Numbers Designs of CPD Radioactive Liquid Waste Disposal Sites*, HW-55176, General Electric Company, Richland, Washington.

GE, 1958b, *Isolation of Abandoned or Depleted Waste Disposal Sites*, HW-57830, General Electric, Richland, Washington.

GE, 1958c, *Record of Scavenged TBP Waste (Logbook),* General Electric Company, Richland, Washington.

GE, 1960, *Radioactive Contamination in Liquid Wastes Discharged to Ground at the Separations Facilities Through December 1959*, HW-64375, General Electric Company, Richland, Washington.

Heid, K. R., 1956, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through June 1956*, HW-44784, General Electric Company, Richland, Washington.

Heid, K. R., 1957, *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through December 1956*, HW-48518, General Electric, Richland, Washington.

Heid, K. R. and H. J. Paas, 1954, *Summary of Liquid Radioactive Wastes Discharged to the Ground – 200 Areas (July 1952 Through June 1954)*, HW-33591, General Electric Company, Richland, Washington.

IAEA, 1982, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards,* IAEA-TECDOC-332, International Atomic Energy Agency, Vienna, Austria.

Johnson, A. R., B. M. Markes, and J. W. Schmidt, 1994, *Historical Records of Radioactive Contamination in Biota at the 200 Areas of the Hanford Site*, WHC-MR-0418, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Lindsey, K. A., 1995, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*, BHI-00184, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Manry, C. W. and W. Prosk, 1985, *PUREX Plant Final Safety Analysis Report*, Revisions 3, 4, and 5, SD-HS-SAR-001, Rockwell Hanford Operations, Richland, Washington.

Mitchell, T. H. and S. G. Weiss, 1995, *Ecological Sampling at Four Waste Sites in the 200 Areas,* BHI-00032, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

National Environmental Policy Act of 1969, 42 U.S.C. 4321, et seq.

Perkins, C. J, B. M. Markes, S. M. McKinney, R. M. Mitchell, and R. C. Roos, 1999, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1998,* PNNL-12088, App. 2, Pacific Northwest National Laboratory, Richland, Washington.

Perkins, C. J, B. M. Markes, S. M. McKinney, R. M. Mitchell, and R. C. Roos, 2000, *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1999,* PNNL-13230, App. 2, Pacific Northwest National Laboratory, Richland, Washington.

PNL, 1988, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*, PNL-6456, Vol. 2, Pacific Northwest Laboratory, Richland, Washington.

PNNL, 1997a, *Combined RCRA Groundwater Monitoring Plan for the 216-A-10, 216-A-36B, and 216-A-37-1 PUREX Cribs*, PNNL-11523, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 1997b, *Hanford Site Groundwater Monitoring for Fiscal Year 1996*, PNNL-11470, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 1997c, *Results of RCRA Groundwater Quality Assessment Program at the 216-U-12 Crib,* PNNL-11574, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 1998a, *Composite Analysis for Low-Level Disposal in the 200 Area Plateau of the Hanford Site*, PNNL-11800, Pacific Northwest National Laboratory, Richland, Washington.

PNNL 1998b, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*, PNNL-11793, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, PNNL-13116, Pacific Northwest National Laboratory, Richland, Washington.

Poston, T. M., R. W. Hanf, and R. L. Dirkes, 2000, *Hanford Site Environmental Monitoring Report for Calendar Year 1999,* PNNL-13230, Pacific Northwest National Laboratory, Richland, Washington.

Reisenauer, A. E., 1959, *Laboratory Studies of Hanford Waste Cribs*, HW-63121, General Electric Company, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

RHO, 1979, *Handbook 200 Area Waste Sites*, RHO-CD-673, Volumes I & II, Rockwell Hanford Operations, Richland, Washington.

Rogers, L. E. and W. H. Rickard, 1977, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*, PNL-2253, Pacific Northwest Laboratory, Richland, Washington.

Slate, J. L., 1996, "Buried Carbonate Paleosols Developed in Pliocene-Pleistocene Deposits of the Pasco Basin, South Central Washington, USA," In *Quaternary International* 34-36:191-196.

Smith, R. M. and R. B. Kasper, 1983, *Serviceability of Crib Affected by PUREX Startup*, RHO-HS-EV-18, Rockwell Hanford Operations, Richland, Washington.

Stegen, J. A., 1993, *Vegetation Communities Associated with the 100 Area and the 200 Area Facilities on the Hanford Site*, WHC-SD-EN-TI-216, Westinghouse Hanford Company, Richland, Washington.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, as amended.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WDOH, 1997, *Hanford Guidance for Radiological Cleanup*, WDOH/320-015, Washington State Department of Health, Olympia, Washington.

WHC, 1988, *Properties and Environmental Impact of Ammonia Scrubber Discharge Waste to the 216-A-36B Crib*, WHC-EP-0100, Westinghouse Hanford Company, Richland, Washington.

WHC, 1989, *PUREX Technical Manual*, WHC-SP-0479, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990, *History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991a, *200-UP-2 Operable Unit Technical Baseline Report*, WHC-EP-0400, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991b, *B Plant Aggregate Area Management Study Technical Baseline Report*, WHC-IP-0809, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992a, *Geologic Setting of the 200 East Area: An Update*, WHC-SD-EN-TI-012, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992b, *Hydrogeologic Model for the 200-East Groundwater Aggregate Area*, WHC-SD-EN-TI-019, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Interim-Status Groundwater Quality Assessment Plan for the 216-U-12 Crib*, WHC-SD-EN-AP-108, Westinghouse Hanford Company, Richland, Washington.

WHC, 1994, *Geologic Setting of the Low-Level Burial Grounds*, WHC-SD-EN-TI-290, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WMNW, 1998, *Sampling Services Procedures Manual,* ES-SSPM-001, Rev. 0, Waste Management Northwest, Richland, Washington.

Wood, M. I., T. E. Jones, R. Schalla, B. N. Bjornstad, and S. M. Narbutovskih, 2000, *Subsurface Condition Report for the B-BX-BY Waste Management Area*, HNF-5507 Rev. 0A, CH2M Hill Hanford Group Inc., Richland, Washington.

Zimmerman, D. A., A. E. Reisenauer, G. D. Black, and M. A. Young, 1986, *Hanford Site Water Table Changes 1950 through 1980, Data Observation and Evaluation*, PNL-5506, Pacific Northwest Laboratory, Richland, Washington.

APPENDIX A

PART A PERMIT APPLICATIONS

PART A, FORM 3 PERMIT APPLICATION FOR THE 216-U-12 CRIB

Please print or type in the unshaded areas only
(fill-in areas are spaced for elite type, i.e., 12 character/inch).

FORM 3

DANGEROUS WASTE PERMIT APPLICATION

1. EPA/STATE I.D. NUMBER: W A 7 8 9 0 0 0 8 9 6 7

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED *(mo., day, & yr.)*	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below (mark one box only) to indicate whether this is the first application you are submitting for your facility or a revised application. If this is your first application and you already know your facility's EPA/STATE I.D. Number, or if this is a revised application, enter your facility's EPA/STATE I.D. Number in Section I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate date)*

☐ 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

MO. 0 4 | DAY | YR. 6 0 — FOR EXISTING FACILITIES, PROVIDE THE DATE *(mo., day, & yr.)* OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*

☐ 2. NEW FACILITY *(Complete item below)*

MO. | DAY | YR. — FOR NEW FACILITIES, PROVIDE THE DATE *(mo., day, & yr)* OPERATION BEGAN OR IS EXPECTED TO BEGIN

B. REVISED APPLICATION *(place an "X" below and complete Section I above)*

☒ 1. FACILITY HAS AN INTERIM STATUS PERMIT

☐ 2. FACILITY HAS A FINAL PERMIT

III. PROCESSES - CODES AND CAPACITIES

A. PROCESS CODE - Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the *(Section III-C)*.

B. PROCESS DESIGN CAPACITY - For each code entered in column A enter the capacity of the process.

1. AMOUNT - Enter the amount.

2. UNIT OF MEASURE - For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER (barrel, drum, etc)	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D80	GALLONS OR LITERS
LANDFILL	D81	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D82	*ACRES OR HECTARES*
OCEAN DISPOSAL	D83	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D84	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER (Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Section III-C.)	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U

UNIT OF MEASURE	UNIT OF MEASURE CODE
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS PER HOUR	W
GALLONS PER HOUR	E
LITERS PER HOUR	H

UNIT OF MEASURE	UNIT OF MEASURE CODE
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q

EXAMPLE FOR COMPLETING SECTION III *(shown in line numbers X-1 and X-2 below): A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons.* The facility also has an incinerator that can burn up to 20 gallons per hour.

LINE NUMBER	A. PROCESS CODE *(from list above)*	B. PROCESS DESIGN CAPACITY 1. AMOUNT *(specify)*	B. 2. UNIT OF MEASURE *(enter code)*	FOR OFFICIAL USE ONLY	LINE NUMBER	A. PROCESS CODE *(from list above)*	B. PROCESS DESIGN CAPACITY 1. AMOUNT *(specify)*	B. 2. UNIT OF MEASURE *(enter code)*	FOR OFFICIAL USE ONLY
X-1	S 0 2	600	G		5				
X-2	T 0 3	20	E		6				
	D 8 1	50,000	U		7				
2					8				
3					9				
4					10				

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Continued from the front.

III. PROCESSES (continued)

SPACE FOR ADDITIONAL PROCESS CODES OR FOR DESCRIBING OTHER PROCESS (code "T04"). FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY.

D81

The 216-U-12 Crib was used to dispose of UO_3 (uranium-oxide) Plant corrosive process condensate. The 216-U-12 Crib, a percolation unit, was designed to receive mixed waste from the UO_3 Plant for approximately 5 minutes every hour, 100 gallons (379 liters) per minute, and to dispose of the process condensate by percolation into the soil column.

Process condensate discharges were considered only a dangerous waste due to corrosivity caused by UO_3 Plant operations. After January 1987, process condensate was administratively controlled to prevent corrosive dangerous waste discharge to the 216-U-12 Crib. The unit continued to receive process condensate until the crib pipeline was cut and permanently capped on January 30, 1988. The 216-U-12 Crib will be closed under interim status.

IV. DESCRIPTION OF DANGEROUS WASTES

A. DANGEROUS WASTE NUMBER - Enter the four digit number from Chapter 173-303 WAC for each listed dangerous waste you will handle. If you handle dangerous wastes which are not listed in Chapter 173-303 WAC, enter the four digit number(s) that describes the characteristics and/or the toxic contaminants of those dangerous wastes.

B. ESTIMATED ANNUAL QUANTITY - For each listed waste entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each characteristic or toxic contaminant entered in column A estimate the total annual quantity of all the non-listed waste(s) that will be handled which possess that characteristic or contaminant.

C. UNIT OF MEASURE - For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE	METRIC UNIT OF MEASURE	CODE
POUNDS	P	KILOGRAMS	K
TONS	T	METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure taking into account the appropriate density or specific gravity of the waste.

D. PROCESSES

1. PROCESS CODES:

For listed dangerous waste: For each listed dangerous waste entered in column A select the code(s) from the list of process codes contained in Section III to indicate how the waste will be stored, treated, and/or disposed of at the facility.

For non-listed dangerous wastes: For each characteristic or toxic contaminant entered in Column A, select the code(s) from the list of process codes contained in Section III to indicate all the processes that will be used to store, treat, and/or dispose of all the non-listed dangerous wastes that possess that characteristic or toxic contaminant.

Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of Item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code(s).

2. PROCESS DESCRIPTION: If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: DANGEROUS WASTES DESCRIBED BY MORE THAN ONE DANGEROUS WASTE NUMBER - Dangerous wastes that can be described by more than one Waste Number shall be described on the form as follows:

1. Select one of the Dangerous Waste Numbers and enter it in column A. On the same line complete columns B, C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other Dangerous Waste Number that can be used to describe the waste. In column D(2) on that line enter "included with above" and make no other entries on that line.
3. Repeat step 2 for each other Dangerous Waste Number that can be used to describe the dangerous waste.

EXAMPLE FOR COMPLETING SECTION IV *(shown in line numbers X-1, X-2, X-3, and X-4 below)* - A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non-listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. DANGEROUS WASTE NO. *(enter code)*	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE *(enter code)*	D. PROCESSES 1. PROCESS CODES *(enter)*	D. PROCESSES 2. PROCESS DESCRIPTION *(If a code is not entered in D(1))*
	K 0 6 4	900	P	T 0 3 D 8 0	
X-2	D 0 0 2	400	P	T 0 3 D 8 0	
X-3	D 0 0 1	100	P	T 0 3 D 8 0	
X-4	D 0 0 2			T 0 3 D 8 0	*included with above*

Continued from page 2.
NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

I.D. NUMBER *(entered from page 1)*

[illegible]	A	7	8	9	0	0	0	8	9	6	7

IV. DESCRIPTION OF DANGEROUS WASTES (continued)

LINE NO.	A. DANGEROUS WASTE NO. *(enter code)*	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE *(enter code)*	D. PROCESSES 1. PROCESS CODES *(enter)*				D. PROCESSES 2. PROCESS DESCRIPTION *(if a code is not entered in D(1))*
1	D002	4,454,000	P	D81				Percolation
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								

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(enter "A", "B", "C", etc. behind the "3" to identify photo copied pages)

Continued from the front.

DESCRIPTION OF DANGEROUS WASTES (continued)

USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM SECTION D(1) ON PAGE 3.

The 216-U-12 Crib was used to dispose of corrosive (D002) UO_3 Plant process condensate until January 1987, at which time administrative controls were implemented to neutralize the condensate before discharge. Waste consisted of process condensate off-gases from the production of UO_3 powder from uranium nitrate hexahydrate solutions. When the plant was operating, the pH of this waste ranged from 0.5 to 1.5.

When the UO_3 Plant was shut down for periods of time, the pH of the process condensate ranged from 2.0 to 4.0. The UO_3 Plant has been permanently shut down and no process condensate is being discharged to the 216-U-12 Crib. Past process rates show that approximately 1,700,000 gallons (6,440,000 liters) per year of process condensate were disposed in the 216-U-12 Crib.

V. FACILITY DRAWING

All existing facilities must include in the space provided on page 5 a scale drawing of the facility *(see instructions for more detail)*.

VI. PHOTOGRAPHS

All existing facilities must include photographs *(aerial or ground-level)* that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas *(see instructions for more detail)*.

VII. FACILITY GEOGRAPHIC LOCATION This information is provided on the attached drawings and photos.

LATITUDE *(degrees, minutes, & seconds)*	LONGITUDE *(degrees, minutes, & seconds)*

VIII. FACILITY OWNER

[X] A. If the facility owner is also the facility operator as listed in Section VII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

B. If the facility owner is not the facility operator as listed in Section VII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. *(area code & no.)*

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
John D. Wagoner, Manager U.S. Department of Energy Richland Operations Office	John D. Wagoner	6/30/94

X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
SEE ATTACHMENT		

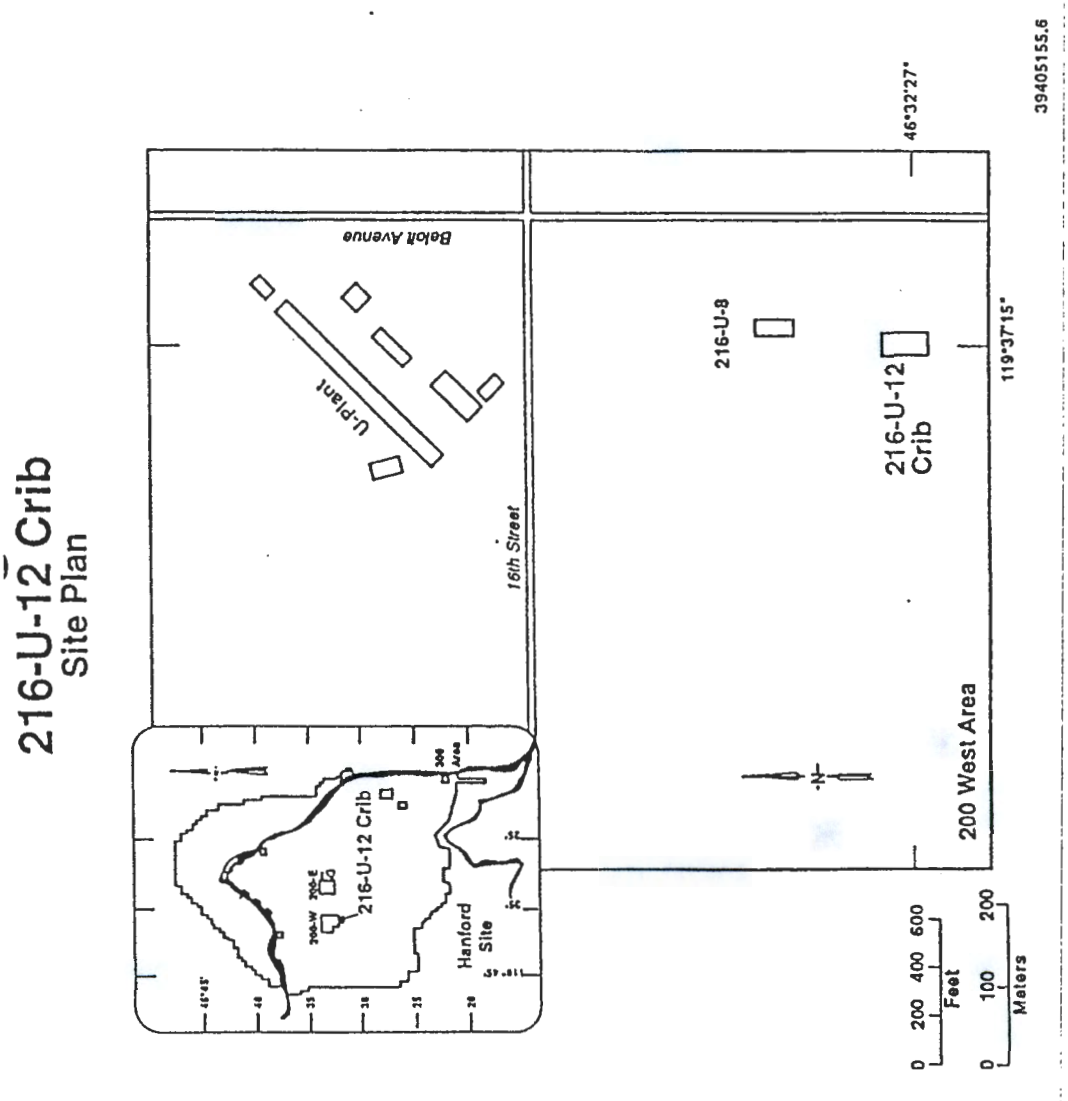
X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

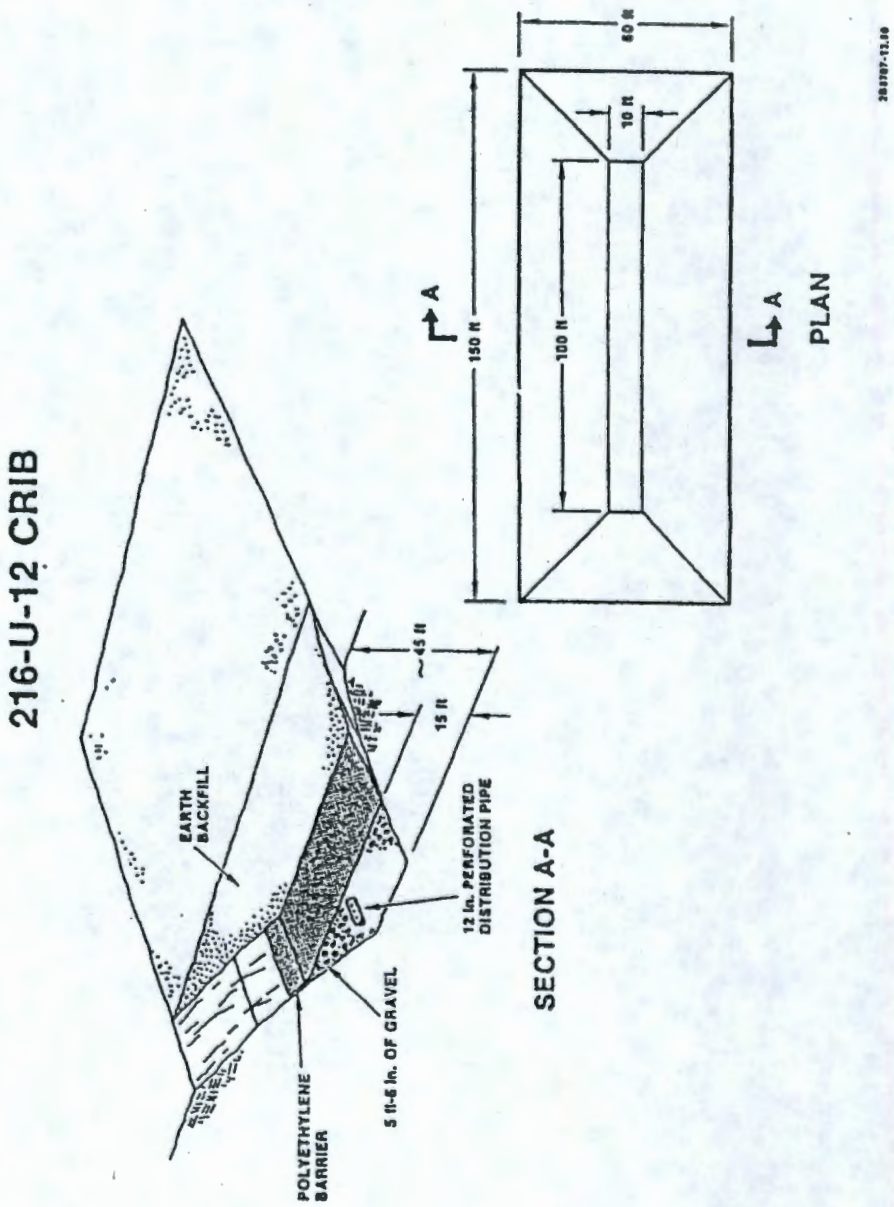
John D. Wagoner — 6/30/94
Owner/Operator — Date
John D. Wagoner, Manager
U.S. Department of Energy
Richland Operations Office

Edward S. Keen — 6/30/94
Co-operator — Date
Edward S. Keen, President
Bechtel Hanford, Inc.

WA7890008967



WA7890008967

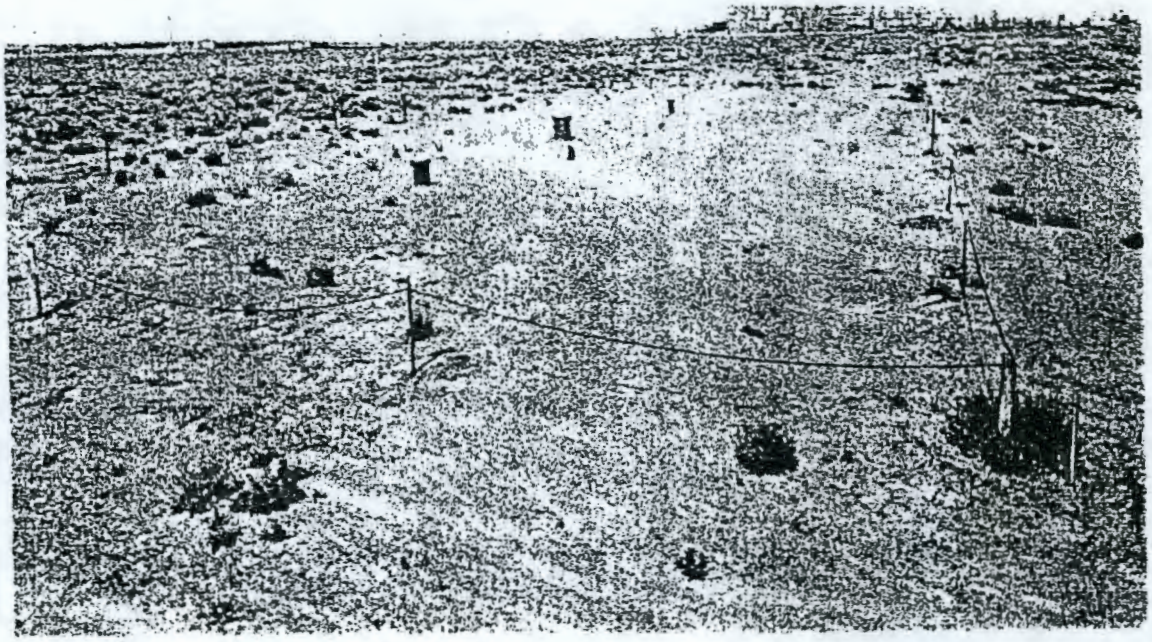


For conversions, apply the following:

Feet to meters--multiply feet by 0.3048
Inches to centimeters--multiply inches by 2.54.

WA7890008967

216-U-12 CRIB



46°32'27"
119°37'15"

8704509-1CN
(PHOTO TAKEN 1987)

PART A, FORM 3 PERMIT APPLICATION FOR THE 216-A-10 CRIB

Please print or type in the unshaded areas only
(fill-in areas are spaced for elite type, i.e., 12 character/inch).

FORM 3

DANGEROUS WASTE PERMIT APPLICATION

1. EPA/STATE I.D. NUMBER: W A 7 8 9 0 0 0 8 9 6 7

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED *(mo., day, & yr.)*	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below (mark one box only) to indicate whether this is the first application you are submitting for your facility or a revised application. If this is your first application and you already know your facility's EPA/STATE I.D. Number, or if this is a revised application, enter your facility's EPA/STATE I.D. Number in Section I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate date)*

☐ 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

MO. 1 0 | DAY 1 5 | YR. 6 1 — FOR EXISTING FACILITIES, PROVIDE THE DATE *(mo., day, & yr.)* OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*

☐ 2. NEW FACILITY *(Complete item below)*

MO. | DAY | YR. — FOR NEW FACILITIES, PROVIDE THE DATE *(mo., day, & yr)* OPERATION BEGAN OR IS EXPECTED TO BEGIN

B. REVISED APPLICATION *(place an "X" below and complete Section I above)*

☒ 1. FACILITY HAS AN INTERIM STATUS PERMIT

☐ 2. FACILITY HAS A FINAL PERMIT

III. PROCESSES - CODES AND CAPACITIES

A. PROCESS CODE - Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the *(Section III-C)*.

B. PROCESS DESIGN CAPACITY - For each code entered in column A enter the capacity of the process.

1. AMOUNT - Enter the amount.

2. UNIT OF MEASURE - For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER (barrel, drum, etc)	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D80	GALLONS OR LITERS
LANDFILL	D81	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D82	*ACRES OR HECTARES*
OCEAN DISPOSAL	D83	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D84	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER (Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Section III-C.)	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS PER HOUR	W
GALLONS PER HOUR	E
LITERS PER HOUR	H
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q

EXAMPLE FOR COMPLETING SECTION III *(shown in line numbers X-1 and X-2 below): A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons.* The facility also has an incinerator that can burn up to 20 gallons per hour.

LINE NUMBER	A. PROCESS CODE *(from list above)*	B. PROCESS DESIGN CAPACITY 1. AMOUNT *(specify)*	B. PROCESS DESIGN CAPACITY 2. UNIT OF MEASURE *(enter code)*	FOR OFFICIAL USE ONLY	LINE NUMBER	A. PROCESS CODE *(from list above)*	B. PROCESS DESIGN CAPACITY 1. AMOUNT *(specify)*	B. PROCESS DESIGN CAPACITY 2. UNIT OF MEASURE *(enter code)*	FOR OFFICIAL USE ONLY
X-1	S 0 2	600	G		5				
X-2	T 0 3	20	E		6				
1	D 8 1	72,000	U		7				
2					8				
3					9				
4					10				

Continued from the front.

III. PROCESSES (continued)

SPACE FOR ADDITIONAL PROCESS CODES OR FOR DESCRIBING OTHER PROCESS (code "T04"). FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY.

D81

The 216-A-10 Crib was used for the disposal of the process distillate discharge (PDD) from the Plutonium-Uranium Extraction (PUREX) process. The 216-A-10 Crib received the corrosive/mixed waste PDD at an average flow rate of 60 gallons (227 liters) per minute. The 216-A-10 Crib was a percolation unit designed for the disposal of liquid wastes by way of the soil column. The process design capacity for the 216-A-10 Crib was 72,000 gallons (272,500 liters) per day. The 216-A-10 Crib has not received waste since March 1987, and will be closed under interim status.

IV. DESCRIPTION OF DANGEROUS WASTES

A. DANGEROUS WASTE NUMBER - Enter the four digit number from Chapter 173-303 WAC for each listed dangerous waste you will handle. If you handle dangerous wastes which are not listed in Chapter 173-303 WAC, enter the four digit number(s) that describes the characteristics and/or the toxic contaminants of those dangerous wastes.

B. ESTIMATED ANNUAL QUANTITY - For each listed waste entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each characteristic or toxic contaminant entered in column A estimate the total annual quantity of all the non-listed waste(s) that will be handled which possess that characteristic or contaminant.

C. UNIT OF MEASURE - For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE	METRIC UNIT OF MEASURE	CODE
POUNDS	P	KILOGRAMS	K
TONS	T	METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure taking into account the appropriate density or specific gravity of the waste.

D. PROCESSES

1. PROCESS CODES:

For listed dangerous waste: For each listed dangerous waste entered in column A select the code(s) from the list of process codes contained in Section III to indicate how the waste will be stored, treated, and/or disposed of at the facility.

For non-listed dangerous wastes: For each characteristic or toxic contaminant entered in Column A, select the code(s) from the list of process codes contained in Section III to indicate all the processes that will be used to store, treat, and/or dispose of all the non-listed dangerous wastes that possess that characteristic or toxic contaminant.

Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of Item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code(s).

2. PROCESS DESCRIPTION: If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: DANGEROUS WASTES DESCRIBED BY MORE THAN ONE DANGEROUS WASTE NUMBER - Dangerous wastes that can be described by more than one Waste Number shall be described on the form as follows:

1. Select one of the Dangerous Waste Numbers and enter it in column A. On the same line complete columns B, C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other Dangerous Waste Number that can be used to describe the waste. In column D(2) on that line enter "Included with above" and make no other entries on that line.
3. Repeat step 2 for each other Dangerous Waste Number that can be used to describe the dangerous waste.

EXAMPLE FOR COMPLETING SECTION IV *(shown in line numbers X-1, X-2, X-3, and X-4 below)* - A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non-listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. DANGEROUS WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (if a code is not entered in D(1))
	K 0 5 4	900	P	T 0 3 D 8 0	
X-2	D 0 0 2	400	P	T 0 3 D 8 0	
X-3	D 0 0 1	100	P	T 0 3 D 8 0	
X-4	D 0 0 2			T 0 3 D 8 0	Included with above

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Continued from page 2.
NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

I.D. NUMBER *(entered from page 1)*

[redacted]	A	7	8	9	0	0	0	8	9	6	7

IV. DESCRIPTION OF DANGEROUS WASTES (continued)

LINE NO.	A. DANGEROUS WASTE NO. *(enter code)*	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE *(enter code)*	D. PROCESSES 1. PROCESS CODES *(enter)*	D. PROCESSES 2. PROCESS DESCRIPTION *(if a code is not entered in D(1))*
1	D002	138,096,000	P	D81	Percolation
2					
3					
4					
5					
6					
7					
8					
9					
10					
[redacted]					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
[redacted]					
25					
26					

ECL30 - 271 - ECY 030-31 Form 3 PAGE 3 ____ OF 5 CONTINUE ON REVERSE
(enter "A", "B", "C", etc. behind the "3" to identify photo copied pages)

Continued from the front.

DESCRIPTION OF DANGEROUS WASTES (continued)

USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM SECTION D(1) ON PAGE 3.

The 216-A-10 Crib received PDD, which is an acidic waste stream generated from two product concentrators in the PUREX process. The pH of this waste ranged from as low as 1.0 to 2.5 standard units. Thus, this waste was a corrosive mixed waste. Approximately 138,096,000 pounds (62,640,345 kilograms) of waste were disposed of in the 216-A-10 Crib in 1986.

V. FACILITY DRAWING

All existing facilities must include in the space provided on page 5 a scale drawing of the facility *(see instructions for more detail)*.

VI. PHOTOGRAPHS

All existing facilities must include photographs *(aerial or ground-level)* that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas *(see instructions for more detail)*.

VII. FACILITY GEOGRAPHIC LOCATION This information is provided on the attached drawings and photos.

LATITUDE *(degrees, minutes, & seconds)*	LONGITUDE *(degrees, minutes, & seconds)*

VIII. FACILITY OWNER

[X] A. If the facility owner is also the facility operator as listed in Section VII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

B. If the facility owner is not the facility operator as listed in Section VII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. *(area code & no.)*

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
John D. Wagoner, Manager U.S. Department of Energy Richland Operations Office	John D. Wagoner	6/30/94

X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
SEE ATTACHMENT		

CONTINUE ON PAGE 5

X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

John D. Wagoner 6/30/94

Owner/Operator
John D. Wagoner, Manager
U.S. Department of Energy
Richland Operations Office

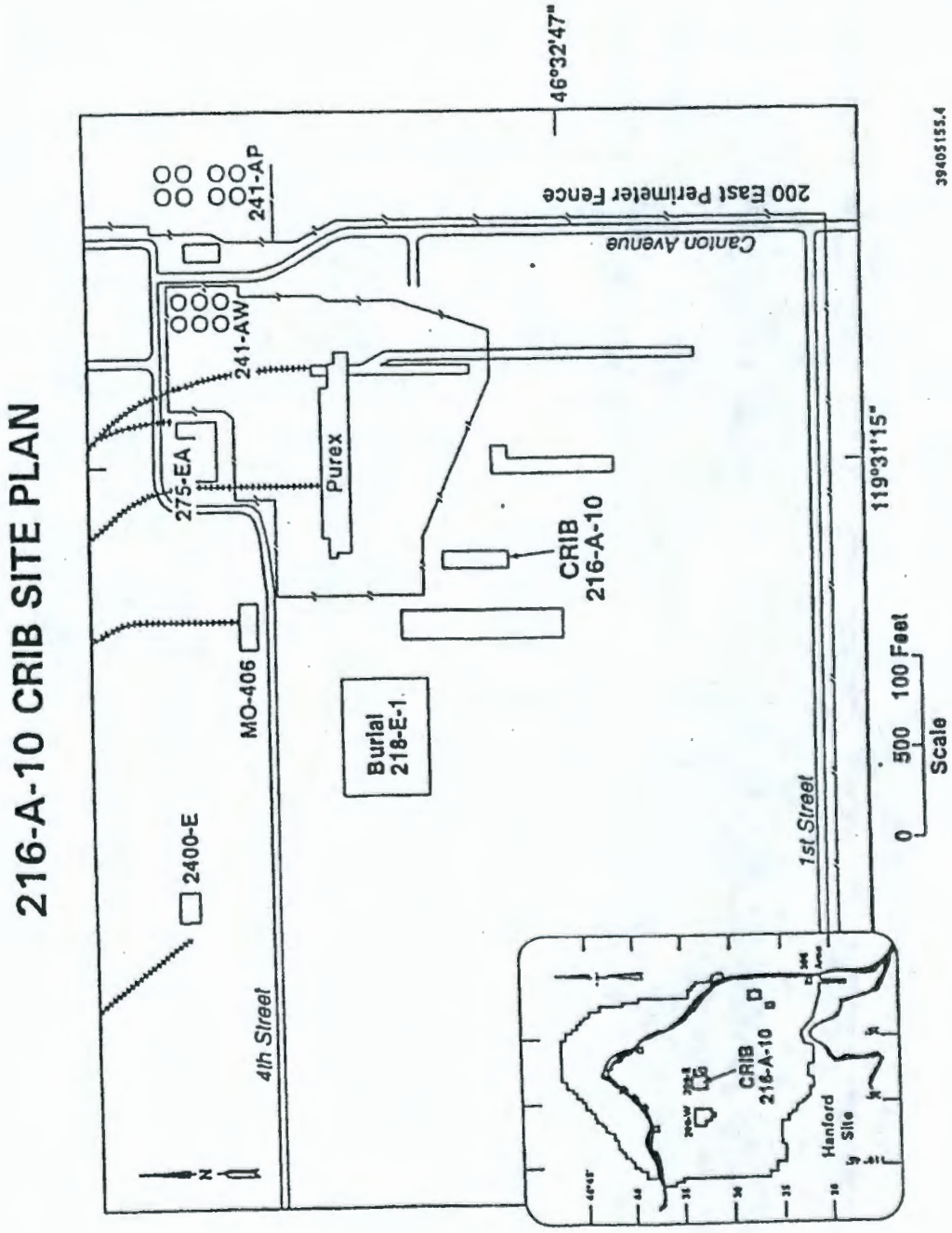
Date

Edward S. Keen 6/30/94

Co-operator
Edward S. Keen, President
Bechtel Hanford, Inc.

Date

WA7890008967



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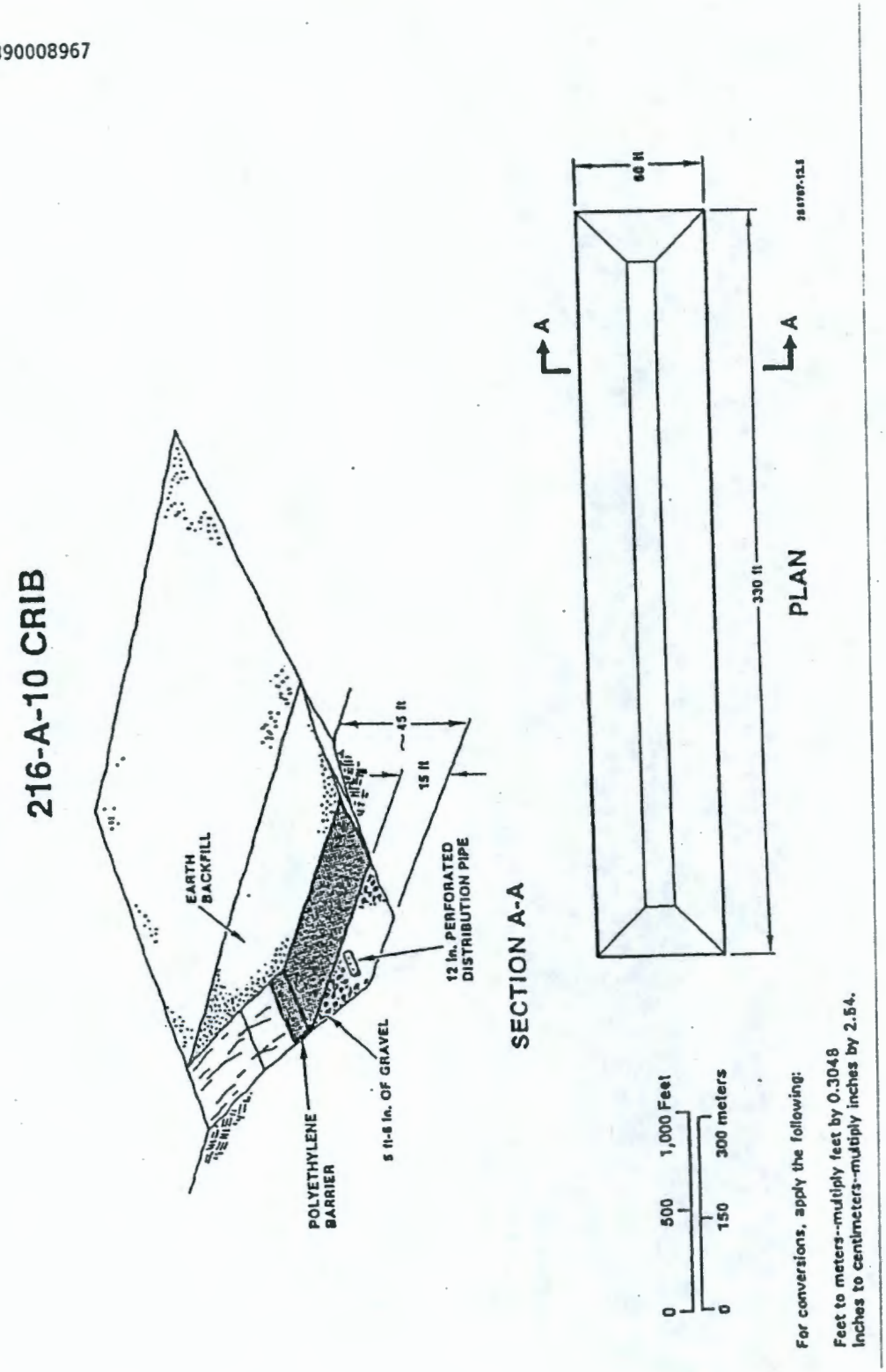
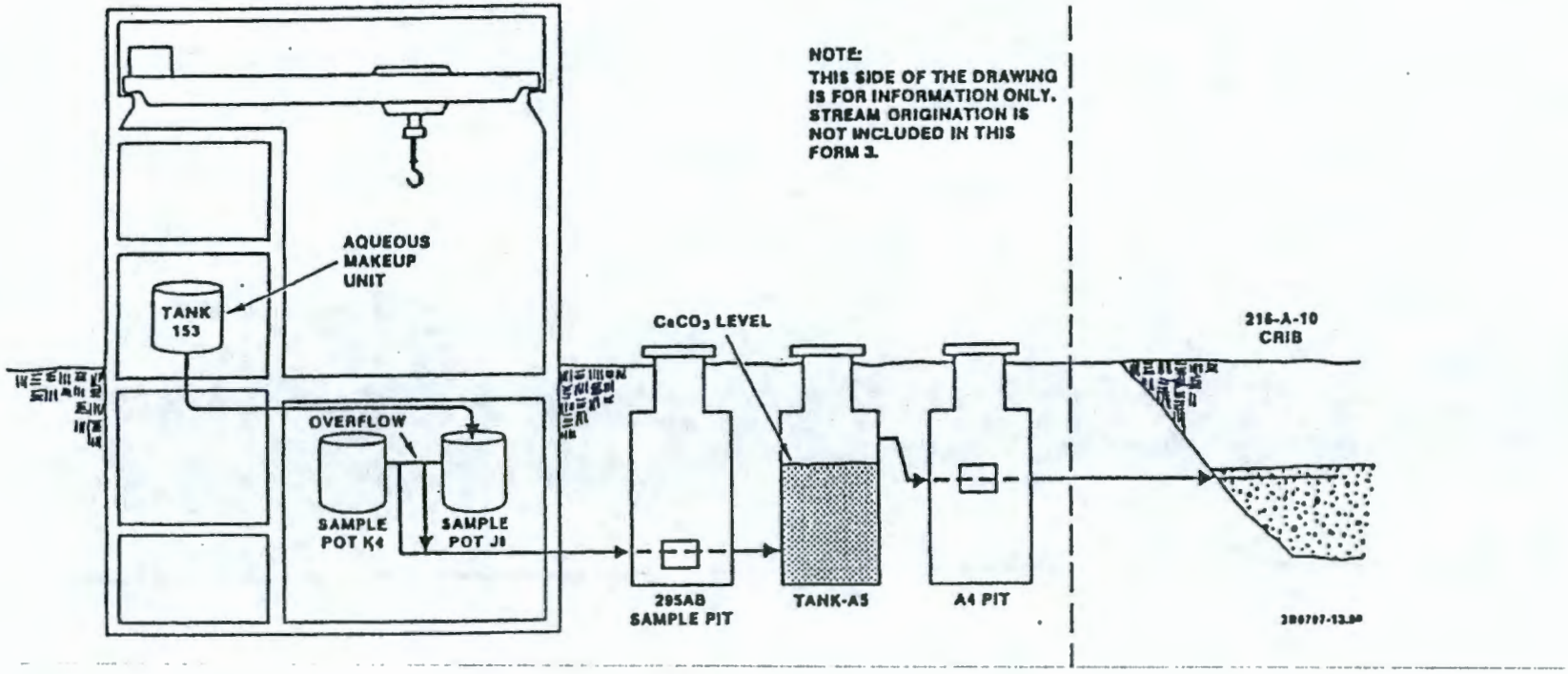


WA7890008967

PDD WASTE STREAM ORIGINATION



WA7890008967

216-A-10 CRIB

46°32'51.9"
119°31'16.3"

94061005-2CN
(PHOTO TAKEN 1994)

PART A, FORM 3 PERMIT APPLICATION
FOR THE
216-A-36B CRIB

Please print or type in the unshaded areas only
(fill-in areas are spaced for elite type, i.e., 12 character/inch).

FORM 3

DANGEROUS WASTE PERMIT APPLICATION

I. EPA/STATE I.D. NUMBER: W A 7 8 9 0 0 0 8 9 6 7

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED *(mo., day, & yr.)*	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below (mark one box only) to indicate whether this is the first application you are submitting for your facility or a revised application. If this is your first application and you already know your facility's EPA/STATE I.D. Number, or if this is a revised application, enter your facility's EPA/STATE I.D. Number in Section I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate date)*

☐ 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

MO.	DAY	YR.	
0 9	1 5	6 5	FOR EXISTING FACILITIES, PROVIDE THE DATE *(mo., day, & yr.)* OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*

☐ 2. NEW FACILITY *(Complete item below)*

MO.	DAY	YR.	
			FOR NEW FACILITIES, PROVIDE THE DATE *(mo., day, & yr)* OPERATION BEGAN OR IS EXPECTED TO BEGIN

B. REVISED APPLICATION *(place an "X" below and complete Section I above)*

☒ 1. FACILITY HAS AN INTERIM STATUS PERMIT

☐ 2. FACILITY HAS A FINAL PERMIT

III. PROCESSES - CODES AND CAPACITIES

A. PROCESS CODE - Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the *(Section III-C)*.

B. PROCESS DESIGN CAPACITY - For each code entered in column A enter the capacity of the process.

1. AMOUNT - Enter the amount.

2. UNIT OF MEASURE - For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER (barrel, drum, etc)	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D80	GALLONS OR LITERS
LANDFILL	D81	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D82	*ACRES OR HECTARES*
OCEAN DISPOSAL	D83	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D84	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER (Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Section III-C.)	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U

UNIT OF MEASURE	UNIT OF MEASURE CODE
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS PER HOUR	W
GALLONS PER HOUR	E
LITERS PER HOUR	H

UNIT OF MEASURE	UNIT OF MEASURE CODE
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q

EXAMPLE FOR COMPLETING SECTION III *(shown in line numbers X-1 and X-2 below): A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons.* The facility also has an incinerator that can burn up to 20 gallons per hour.

LINE NUMBER	A. PROCESS CODE *(from list above)*	B. PROCESS DESIGN CAPACITY 1. AMOUNT *(specify)*	B. 2. UNIT OF MEASURE *(enter code)*	FOR OFFICIAL USE ONLY
X-1	S 0 2	600	G	
X-2	T 0 3	20	E	
1	D 8 1	116,000	U	
2				
3				
4				
5				
6				
7				
8				
9				
10				

ECL30 - 300 - ECY 030-31 Form 3 Rev. 2/84 PAGE 1 OF 5 CONTINUE ON REVERSE

Continued from the front.

III. PROCESSES (continued)

C. SPACE FOR ADDITIONAL PROCESS CODES OR FOR DESCRIBING OTHER PROCESS (code "T04"). FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY

D81

The 216-A-36 Crib, placed into operation in September 1965, was divided into A and B sections. The A section is the first 100 feet (30.5 meters) on the north end of the crib and is bypassed by the process pipe. The A section was closed in 1966. The B section was operational from March 1966 to October 1972, and was reactivated in November 1982 for the Plutonium-Uranium Extraction (PUREX) Plant restart. Discharges to the B section were stopped in August 1987. The mixed waste discharged to the 216-A-36B Crib came from the PUREX ammonia scrubber distillate (ASD) stream. The process design capacity for the 216-A-36B Crib was 116,000 gallons (440,000 liters) per day. The 216-A-36B Crib will be closed under interim status.

IV. DESCRIPTION OF DANGEROUS WASTES

A. DANGEROUS WASTE NUMBER - Enter the four digit number from Chapter 173-303 WAC for each listed dangerous waste you will handle. If you handle dangerous wastes which are not listed in Chapter 173-303 WAC, enter the four digit number(s) that describes the characteristics and/or the toxic contaminants of those dangerous wastes.

B. ESTIMATED ANNUAL QUANTITY - For each listed waste entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each characteristic or toxic contaminant entered in column A estimate the total annual quantity of all the non-listed waste(s) that will be handled which possess that characteristic or contaminant.

C. UNIT OF MEASURE - For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE	METRIC UNIT OF MEASURE	CODE
POUNDS	P	KILOGRAMS	K
TONS	T	METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure taking into account the appropriate density or specific gravity of the waste.

D. PROCESSES

1. PROCESS CODES:

For listed dangerous waste: For each listed dangerous waste entered in column A select the code(s) from the list of process codes contained in Section III to indicate how the waste will be stored, treated, and/or disposed of at the facility.

For non-listed dangerous wastes: For each characteristic or toxic contaminant entered in Column A, select the code(s) from the list of process codes contained in Section III to indicate all the processes that will be used to store, treat, and/or dispose of all the non-listed dangerous wastes that possess that characteristic or toxic contaminant.

Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of Item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code(s).

2. PROCESS DESCRIPTION: If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: DANGEROUS WASTES DESCRIBED BY MORE THAN ONE DANGEROUS WASTE NUMBER - Dangerous wastes that can be described by more than one Waste Number shall be described on the form as follows:

1. Select one of the Dangerous Waste Numbers and enter it in column A. On the same line complete columns B, C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other Dangerous Waste Number that can be used to describe the waste. In column D(2) on that line enter "Included with above" and make no other entries on that line.
3. Repeat step 2 for each other Dangerous Waste Number that can be used to describe the dangerous waste.

EXAMPLE FOR COMPLETING SECTION IV *(shown in line numbers X-1, X-2, X-3, and X-4 below)* - A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non-listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. DANGEROUS WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (If a code is not entered in D(1))
	K 0 5 4	900	P	T 0 3 D 8 0	
X-2	D 0 0 2	400	P	T 0 3 D 8 0	
X-3	D 0 0 1	100	P	T 0 3 D 8 0	
X-4	D 0 0 2			T 0 3 D 8 0	Included with above

Continued from page 2.
NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

I.D. NUMBER *(entered from page 1)*

A 7 8 9 0 0 0 8 9 6 7

IV. DESCRIPTION OF DANGEROUS WASTES (continued)

LINE NO.	A. DANGEROUS WASTE NO. *(enter code)*	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE *(enter code)*	D. PROCESSES 1. PROCESS CODES *(enter)*				D. PROCESSES 2. PROCESS DESCRIPTION *(if a code is not entered in D(1))*
1	W T 0 2	265,000,000	P	D81				Percolation
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								

Continued from the front.

IV. DESCRIPTION OF DANGEROUS WASTES (continued)

E. USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM SECTION D(1) ON PAGE 3.

The ASD waste stream is a basic byproduct waste stream generated by the ammonia scrubbers during decladding operations in the PUREX process. The waste stream came from the coating dissolution stage where ammonium fluoride and ammonium nitrate were used to dissolve the zirconium alloy cladding from fuel elements. Ammonia gas was produced as a byproduct during this reaction. The gas stream from the dissolver was scrubbed with water, which absorbed and reacted with most of the ammonia to form liquid ammonium hydroxide. This waste stream was sent to the 216-A-36B Crib for disposal.

This waste was determined to be a state-only toxic waste (WT02) under the Washington State Department of Ecology's waste mixture rule because the concentrations of ammonium hydroxide were in excess of 1% by weight.

V. FACILITY DRAWING

All existing facilities must include in the space provided on page 5 a scale drawing of the facility *(see instructions for more detail)*.

VI. PHOTOGRAPHS

All existing facilities must include photographs *(aerial or ground-level)* that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas *(see instructions for more detail)*.

VII. FACILITY GEOGRAPHIC LOCATION This information is provided on the attached drawings and photos.

LATITUDE *(degrees, minutes, & seconds)*	LONGITUDE *(degrees, minutes, & seconds)*

VIII. FACILITY OWNER

[x] A. If the facility owner is also the facility operator as listed in Section VII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

B. If the facility owner is not the facility operator as listed in Section VII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. *(area code & no.)*

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
John D. Wagoner, Manager U.S. Department of Energy Richland Operations Office	John D. Wagoner	6/30/94

X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
SEE ATTACHMENT		

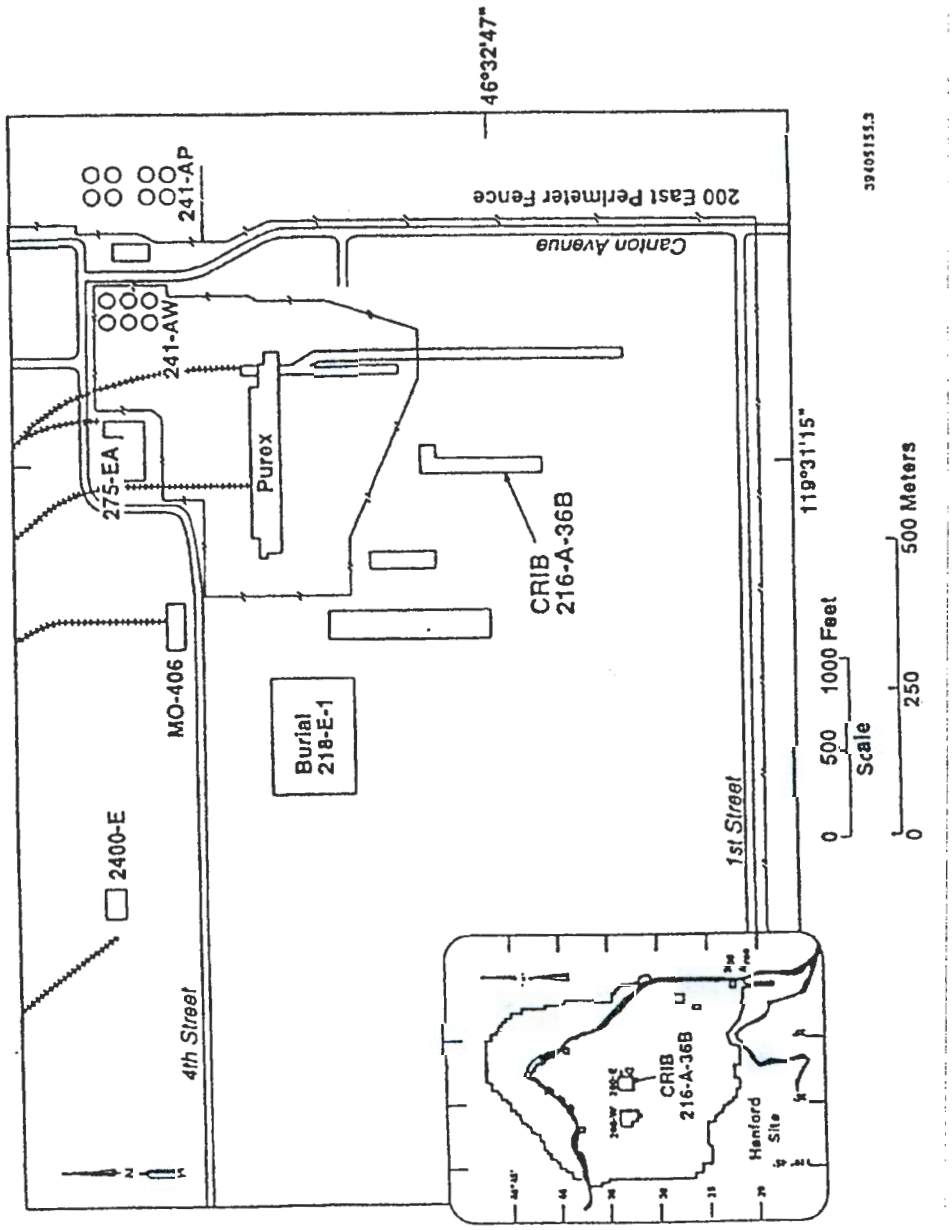
X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

John D. Wagoner 6/30/94
Owner/Operator Date
John D. Wagoner, Manager
U.S. Department of Energy
Richland Operations Office

Edward S. Keen 6/30/94
Co-operator Date
Edward S. Keen, President
Bechtel Hanford, Inc.

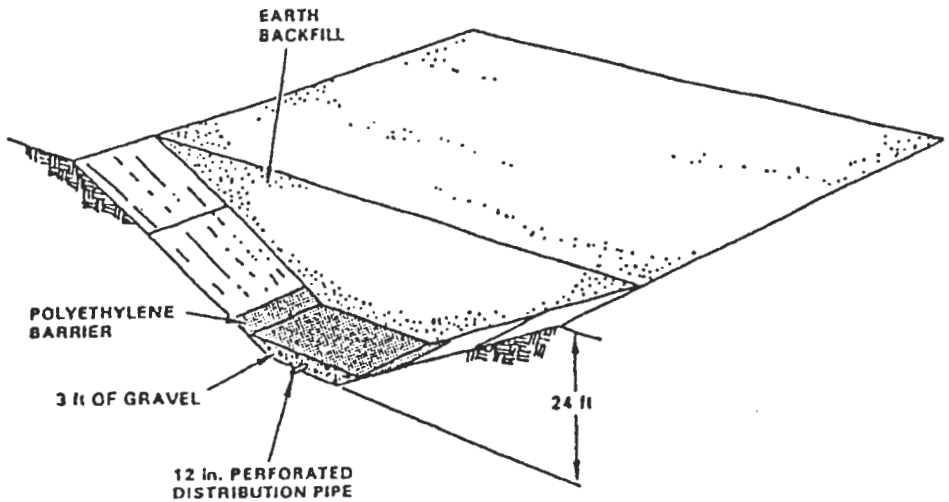
WA7890008967



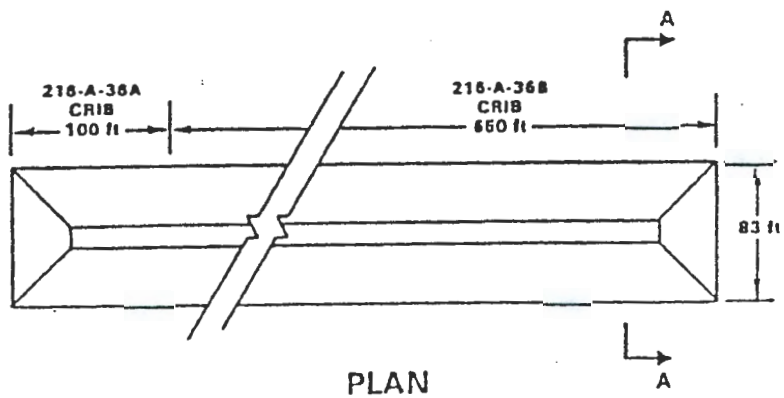
216-A-36B CRIB SITE PLAN

WA7890008967

216-A-36 A AND B CRIBS



SECTION A-A



PLAN

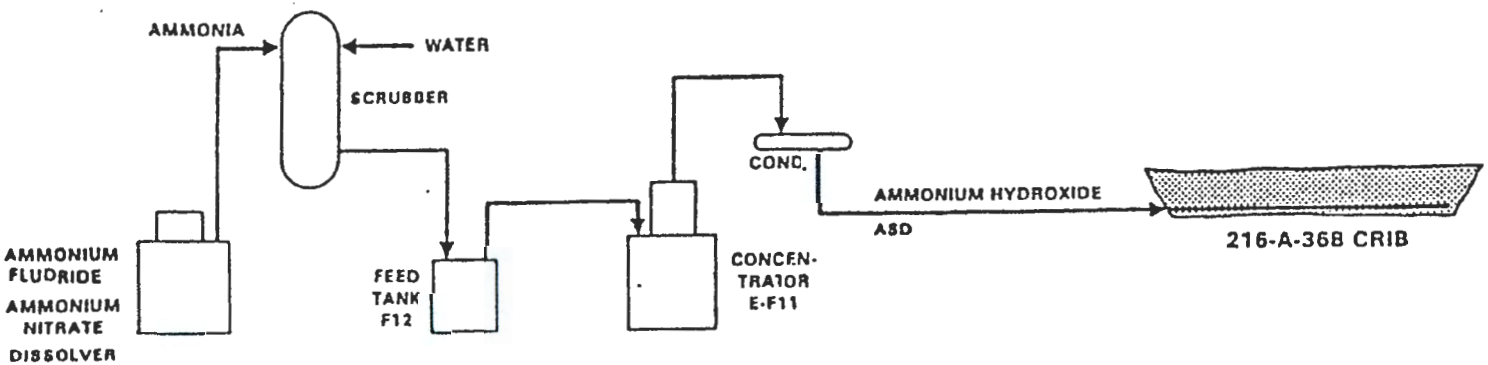
For conversions, apply the following:

Feet to meters--multiply feet by 0.3048
Inches to centimeters--multiply inches by 2.54.

28710-023.12

WA7890008967

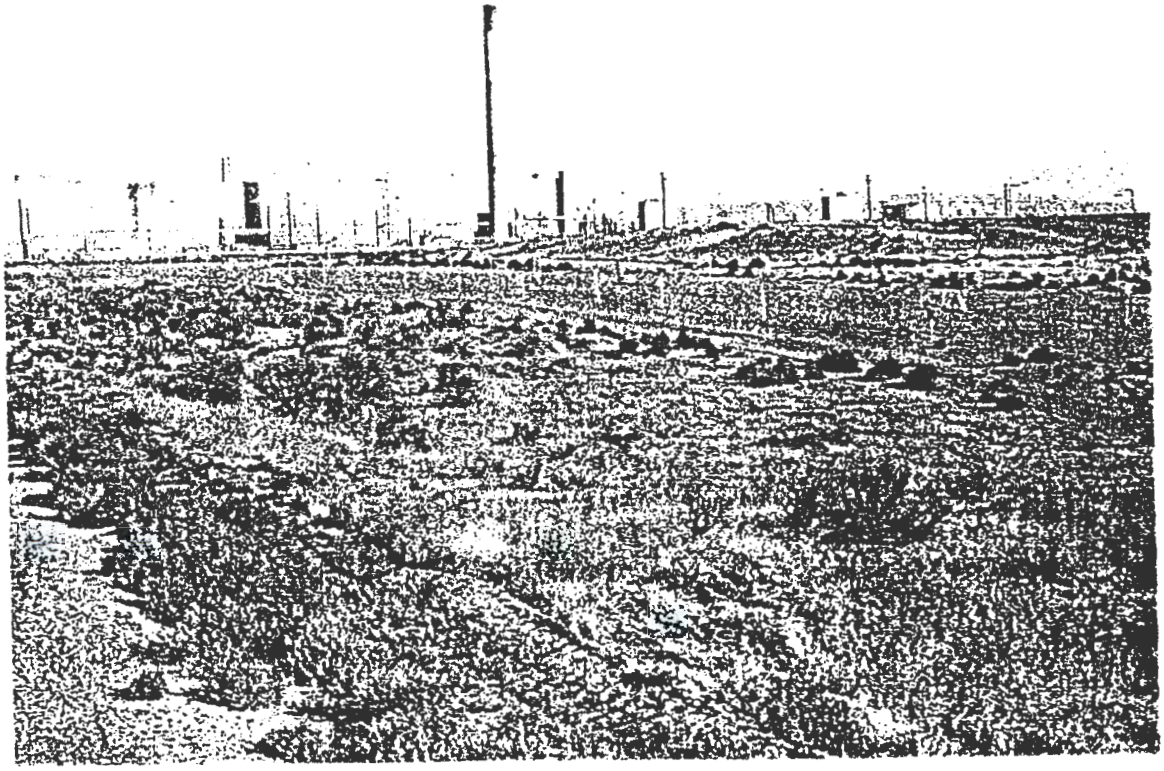
216-A-36B CRIB WASTE STREAM FLOW DIAGRAM



36710-023.24

WA7890008967

216-A-36B CRIB



46°32'47"
119°31'15"

8706243-2CN
(PHOTO TAKEN 1987)

PART A, FORM 3 PERMIT APPLICATION FOR THE 207-A SOUTH RETENTION BASIN

DOE/RL-88-21
207-A South Retention Basin
Rev. 2, 10/01/96
Page 1 of 7

Please print or type in the unshaded areas only
(Fill-in areas are spaced for elite type, i.e., 12 characters/inch).

FORM 3

DANGEROUS WASTE PERMIT APPLICATION

1. EPA/STATE I.D. NUMBER: W A 7 8 9 0 0 0 8 9 6 7

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED (mo., day, & yr.)	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below (mark one box only) to indicate whether this is the first application you are submitting for your facility or a revised application. If this is your first application and you already know your facility's EPA/STATE I.D. Number, or if this is a revised application, enter your facility's EPA/STATE I.D. Number in Section I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate date)*

☐ 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

MO.	DAY	YR.
0 3	2 2	4 3

* FOR EXISTING FACILITIES, PROVIDE THE DATE *(mo., day, & yr.)* OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*
*The date construction of the Hanford Facility commenced.

☐ 2. NEW FACILITY *(Complete item below)*

MO.	DAY	YR.

FOR NEW FACILITIES, PROVIDE THE DATE *(mo., day, & yr.)* OPERATION BEGAN OR IS EXPECTED TO BEGIN

B. REVISED APPLICATION *(place an "X" below and complete Section I above)*

☒ 1. FACILITY HAS AN INTERIM STATUS PERMIT

☒ 2. FACILITY HAS A FINAL PERMIT

III. PROCESSES - CODES AND CAPACITIES

A. PROCESS CODE - Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the *(Section III-C)*.

B. PROCESS DESIGN CAPACITY - For each code entered in column A enter the capacity of the process.

1. AMOUNT - Enter the amount.

2. UNIT OF MEASURE - For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER (barrel, drum, etc)	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D80	GALLONS OR LITERS
LANDFILL	D81	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D82	*ACRES OR HECTARES*
OCEAN DISPOSAL	D83	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D84	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER (Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Section III-C.)	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS PER HOUR	W
GALLONS PER HOUR	E
LITERS PER HOUR	H
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q

EXAMPLE FOR COMPLETING SECTION III *(shown in line numbers X-1 and X-2 below): A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons.* The facility also has an incinerator that can burn up to 20 gallons per hour.

LINE NUMBER	A. PROCESS CODE (from list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT (specify)	2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY	LINE NUMBER	A. PROCESS CODE (from list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT (specify)	2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY
X-1	S 0 2	600	G		6				
X-2	T 0 3	20	E		8				
1	S 0 4	794,937	L		7				
2					8				
3					9				
4					10				

ECL30 - 300 - ECY 030-31 Form 3 Rev. 2/84 PAGE 1 OF 5 CONTINUE ON REVERSE

DOE/RL-88-21
207-A South Retention Basin
Rev. 2, 10/01/96
Page 2 of 7

Continued from the front.

III. PROCESSES (continued)

C. SPACE FOR ADDITIONAL PROCESS CODES OR FOR DESCRIBING OTHER PROCESS (code "T04"). FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY.

S04 .

The 207-A South Retention Basin (207-A Basin), which also is known as the Process Condensate (PC) Basins 1, 2, and 3 (i.e., PC-1, PC-2, and PC-3), began operation in March of 1977. The 207-A Basin consists of three concrete cells (S04), each with a 264,979-liter (70,000-gallon) design capacity for a total capacity of 794,937 liters (210,000 gallons). 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. Discharge of 242-A Evaporator process condensate to the 207-A Basin was terminated on April 12, 1989, when it was determined that the 242-A Evaporator process condensate contained mixed waste regulated under Washington Administrative Code 173-303. The 207-A Basin was emptied and is no longer used to receive or store mixed waste. The 207-A Basin will remain out of service and will be closed. Closure activities for the 207-A Basin are in the planning phase.

IV. DESCRIPTION OF DANGEROUS WASTES

A. DANGEROUS WASTE NUMBER - Enter the four digit number from Chapter 173-303 WAC for each listed dangerous waste you will handle. If you handle dangerous wastes which are not listed in Chapter 173-303 WAC, enter the four digit number(s) that describes the characteristics and/or the toxic contaminants of those dangerous wastes.

B. ESTIMATED ANNUAL QUANTITY - For each listed waste entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each characteristic or toxic contaminant entered in column A estimate the total annual quantity of all the non-listed waste(s) that will be handled which possess that characteristic or contaminant.

C. UNIT OF MEASURE - For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE	METRIC UNIT OF MEASURE	CODE
POUNDS	P	KILOGRAMS	K
TONS	T	METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure taking into account the appropriate density or specific gravity of the waste.

D. PROCESSES

1. PROCESS CODES:

For listed dangerous waste: For each listed dangerous waste entered in column A select the code(s) from the list of process codes contained in Section III to indicate how the waste will be stored, treated, and/or disposed of at the facility.

For non-listed dangerous wastes: For each characteristic or toxic contaminant entered in Column A, select the code(s) from the list of process codes contained in Section III to indicate all the processes that will be used to store, treat, and/or dispose of all the non-listed dangerous wastes that possess that characteristic or toxic contaminant.

Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code(s).

2. PROCESS DESCRIPTION: If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: DANGEROUS WASTES DESCRIBED BY MORE THAN ONE DANGEROUS WASTE NUMBER - Dangerous wastes that can be described by more than one Waste Number shall be described on the form as follows:

1. Select one of the Dangerous Waste Numbers and enter K in column A. On the same line complete columns B, C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other Dangerous Waste Number that can be used to describe the waste. In column D(2) on that line enter "included with above" and make no other entries on that line.
3. Repeat step 2 for each other Dangerous Waste Number that can be used to describe the dangerous waste.

EXAMPLE FOR COMPLETING SECTION IV *(shown in line numbers X-1, X-2, X-3, and X-4 below)* - A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non-listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. DANGEROUS WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (If a code is not entered in D(1))
X-1	K 0 5 4	900	P	T 0 3 D 8 0	
X-2	D 0 0 2	400	P	T 0 3 D 8 0	
X-3	D 0 0 1	100	P	T 0 3 D 8 0	
X-4	D 0 0 2			T 0 3 D 8 0	*included with above*

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Continued from page 2.
NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

I.D. NUMBER *(entered from page 1)*: WA7890008987

IV. DESCRIPTION OF DANGEROUS WASTES (continued)

LINE NO.	A. DANGEROUS WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (If a code is not entered in D(1))
1	F001	793,469	K	S04	Storage - Surface Impoundment
2	F002				
3	F003				
4	F004				
5	F005				
6	WT02				Included With Above
7					
8					
9					
10					
11					
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PAGE 3 ____ OF 5
(enter "A", "B", "C", etc. behind the "3" to identify photo copied pages)

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Continued from the front.

IV. DESCRIPTION OF DANGEROUS WASTES (continued)

E. USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM SECTION D(1) ON PAGE 3.

The 207-A Basin was taken out of service on April 12, 1989, emptied, and no longer receives or stores mixed waste. A description of the mixed waste residue at the 207-A Basin follows.

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

V. FACILITY DRAWING Refer to attached drawing(s).

All existing facilities must include in the space provided on page 5 a scale drawing of the facility *(see instructions for more detail)*.

VI. PHOTOGRAPHS Refer to attached photograph(s).

All existing facilities must include photographs *(aerial or ground-level)* that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas *(see instructions for more detail)*.

VII. FACILITY GEOGRAPHIC LOCATION This information is provided on the attached drawing(s) and photograph(s).

LATITUDE *(degrees, minutes, & seconds)*	LONGITUDE *(degrees, minutes, & seconds)*

VIII. FACILITY OWNER

[x] A. If the facility owner is also the facility operator as listed in Section VII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

B. If the facility owner is not the facility operator as listed in Section VII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. *(area code & no.)*

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
John D. Wagoner, Manager U.S. Department of Energy Richland Operations Office	John D. Wagoner	9/26/96

X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
SEE ATTACHMENT		

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X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

John D Wagoner 9/26/96

Owner/Operator
John D. Wagoner, Manager
U.S. Department of Energy
Richland Operations Office

Date

9/13/96

Co-operator
H. J. Hatch,
President and Chief Executive Officer
Fluor Daniel Hanford, Inc.

Date

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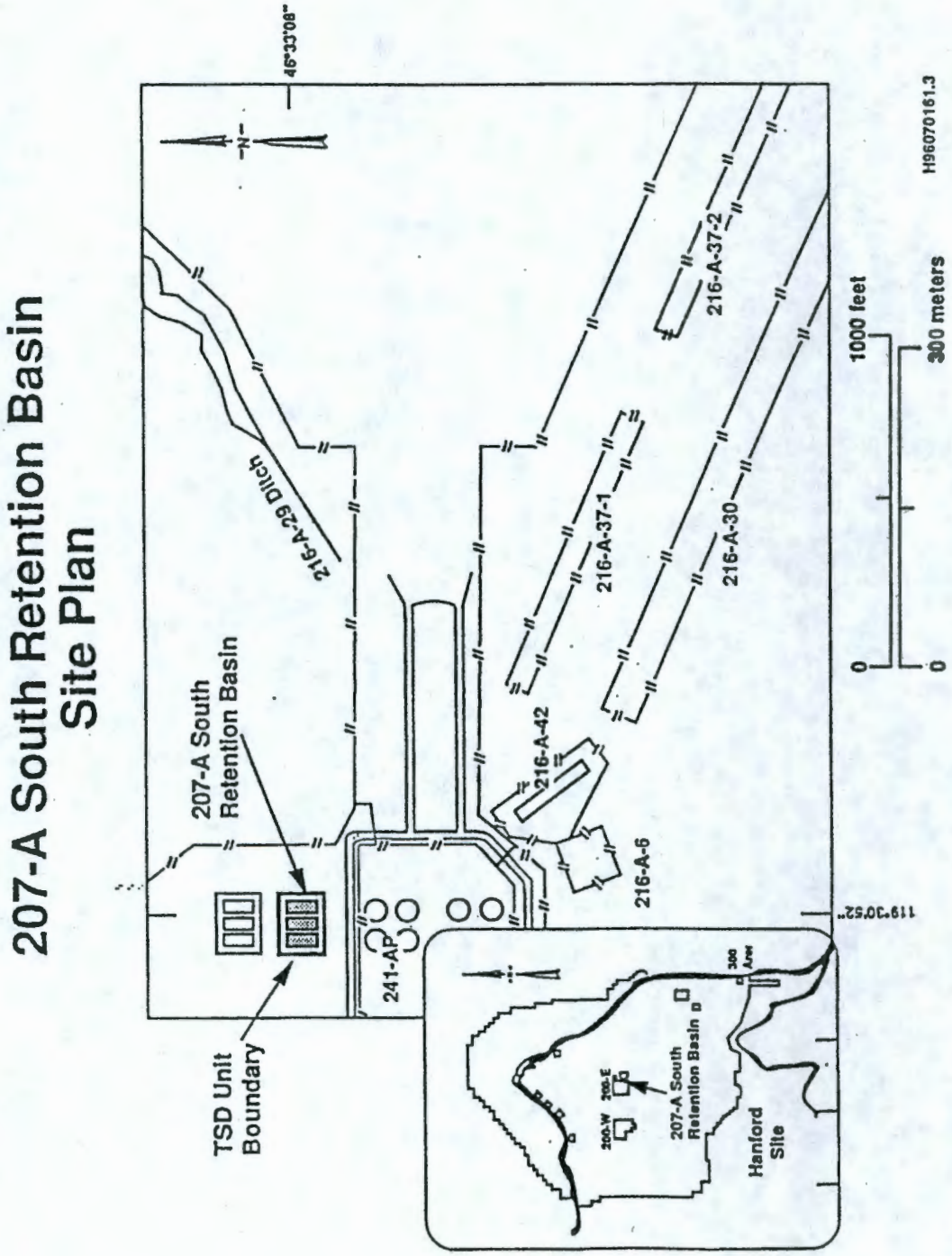

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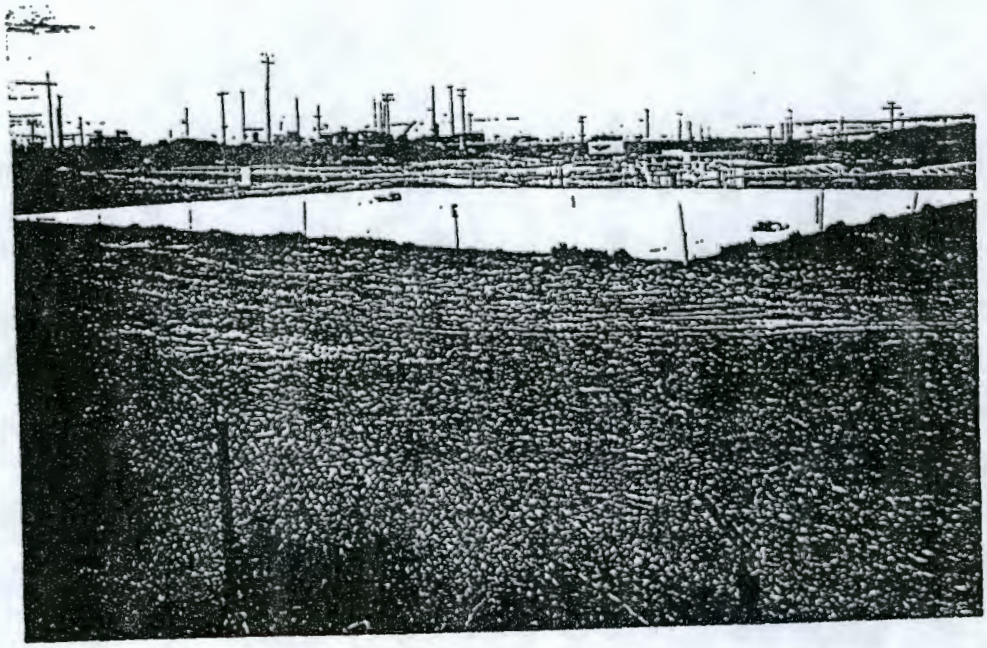
207-A SOUTH RETENTION BASIN



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PART A, FORM 3 PERMIT APPLICATION FOR THE 216-A-37-1 CRIB

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Please print or type in the unshaded areas only
(Fill-in areas are spaced for elite type, i.e., 12 character/inch).

FORM [redacted]

DANGEROUS WASTE PERMIT APPLICATION

1. EPA/STATE I.D. NUMBER: W A 7 8 9 0 0 0 8 9 6 7

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED *(mo., day, & yr.)*	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below (mark one box only) to indicate whether this is the first application you are submitting for your facility or a revised application. If this is your first application and you already know your facility's EPA/STATE I.D. Number, or if this is a revised application, enter your facility's EPA/STATE I.D. Number in Section I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate date)*

☐ 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

MO. 0 3 | DAY 1 8 | YR. 7 7 — FOR EXISTING FACILITIES, PROVIDE THE DATE *(mo., day, & yr.)* OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*

☐ 2. NEW FACILITY *(Complete item below)*

MO. | DAY | YR. — FOR NEW FACILITIES, PROVIDE THE DATE *(mo., day, & yr.)* OPERATION BEGAN OR IS EXPECTED TO BEGIN

B. REVISED APPLICATION *(place an "X" below and complete Section I above)*

☒ 1. FACILITY HAS AN INTERIM STATUS PERMIT

☐ 2. FACILITY HAS A FINAL PERMIT

III. PROCESSES - CODES AND CAPACITIES

A. PROCESS CODE - Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the *(Section III-C)*.

B. PROCESS DESIGN CAPACITY - For each code entered in column A enter the capacity of the process.

1. AMOUNT - Enter the amount.

2. UNIT OF MEASURE - For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
[redacted]orage:		
CONTAINER (barrel, drum, etc)	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D80	GALLONS OR LITERS
LANDFILL	D81	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D82	*ACRES OR HECTARES*
OCEAN DISPOSAL	D83	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D84	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER (Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Section III-C.)	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE	UNIT OF MEASURE	UNIT OF MEASURE CODE	UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G	LITERS PER DAY	V	ACRE-FEET	A
LITERS	L	TONS PER HOUR	D	HECTARE-METER	F
CUBIC YARDS	Y	METRIC TONS PER HOUR	W	ACRES	B
CUBIC METERS	C	GALLONS PER HOUR	E	HECTARES	Q
GALLONS PER DAY	U	LITERS PER HOUR	H		

EXAMPLE FOR COMPLETING SECTION III *(shown in line numbers X-1 and X-2 below): A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons.* The facility also has an incinerator that can burn up to 20 gallons per hour.

LINE NUMBER	A. PROCESS CODE *(from list above)*	B. PROCESS DESIGN CAPACITY 1. AMOUNT *(specify)*	B. 2. UNIT OF MEASURE *(enter code)*	FOR OFFICIAL USE ONLY	LINE NUMBER	A. PROCESS CODE *(from list above)*	B. PROCESS DESIGN CAPACITY 1. AMOUNT *(specify)*	B. 2. UNIT OF MEASURE *(enter code)*	FOR OFFICIAL USE ONLY
X-1	S 0 2	600	G		5				
X-2	T 0 3	20	E		6				
[redacted]0	8 1	86,400	U		7				
2					8				
3					9				
4					10				

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III. PROCESSES (continued)

C. SPACE FOR ADDITIONAL PROCESS CODES OR FOR DESCRIBING OTHER PROCESS (code "T04"). FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY.

D81

The 216-A-37-1 Crib (Crib) began operation in March 1977 and was used for the percolation of the 242-A Evaporator (Evaporator) process condensate to the soil column. The process design capacity of 86,400 gallons (327,000 liters) per day is based on the daily output of the 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 Washington Administrative Code 173-303. The Crib is out of service and will be closed under interim status.

IV. DESCRIPTION OF DANGEROUS WASTES

A. DANGEROUS WASTE NUMBER - Enter the four digit number from Chapter 173-303 WAC for each listed dangerous waste you will handle. If you handle dangerous wastes which are not listed in Chapter 173-303 WAC, enter the four digit number(s) that describes the characteristics and/or the toxic contaminants of those dangerous wastes.

B. ESTIMATED ANNUAL QUANTITY - For each listed waste entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each characteristic or toxic contaminant entered in column A estimate the total annual quantity of all the non-listed waste(s) that will be handled which possess that characteristic or contaminant.

C. UNIT OF MEASURE - For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE	METRIC UNIT OF MEASURE	CODE
POUNDS	P	KILOGRAMS	K
TONS	T	METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure taking into account the appropriate density or specific gravity of the waste.

D. PROCESSES

1. PROCESS CODES:

For listed dangerous waste: For each listed dangerous waste entered in column A select the code(s) from the list of process codes contained in Section III to indicate how the waste will be stored, treated, and/or disposed of at the facility.

For non-listed dangerous wastes: For each characteristic or toxic contaminant entered in Column A, select the code(s) from the list of process codes contained in Section III to indicate all the processes that will be used to store, treat, and/or dispose of all the non-listed dangerous wastes that possess that characteristic or toxic contaminant.

Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of Item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code(s).

2. PROCESS DESCRIPTION: If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: DANGEROUS WASTES DESCRIBED BY MORE THAN ONE DANGEROUS WASTE NUMBER - Dangerous wastes that can be described by more than one Waste Number shall be described on the form as follows:

1. Select one of the Dangerous Waste Numbers and enter it in column A. On the same line complete columns B, C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other Dangerous Waste Number that can be used to describe the waste. In column D(2) on that line enter "Included with above" and make no other entries on that line.
3. Repeat step 2 for each other Dangerous Waste Number that can be used to describe the dangerous waste.

EXAMPLE FOR COMPLETING SECTION IV *(shown in line numbers X-1, X-2, X-3, and X-4 below)* - A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non-listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. DANGEROUS WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (If a code is not entered in D(1))
X	0 5 4	900	P	T 0 3 D 8 0	
X-2	D 0 0 2	400	P	T 0 3 D 8 0	
X-3	D 0 0 1	100	P	T 0 3 D 8 0	
X-4	D 0 0 2			T 0 3 D 8 0	*included with above*

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NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

I.D. NUMBER *(entered from page 1)*: A 7 8 9 0 0 0 8 9 6 7

IV. DESCRIPTION OF DANGEROUS WASTES (continued)

LINE NO.	A. DANGEROUS WASTE NO. *(enter code)*	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE *(enter code)*	D. PROCESSES 1. PROCESS CODES *(enter)*	D. PROCESSES 2. PROCESS DESCRIPTION *(if a code is not entered in D(1))*
1	F001	108,290,000	P	D81	Disposal - Landfill (Percolation)
2	F002				
3	F003				
4	F004				
5	F005				
6	WT02				Included With Above
7					
8					
9					
10					
11					
12					
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IV. DESCRIPTION OF DANGEROUS WASTES (continued)

USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM SECTION D(1) ON PAGE 3.

The Crib was taken out of service on April 12, 1989, and no longer receives dangerous waste. A description of the dangerous waste discharged to the Crib is as follows.

The Evaporator process condensate has since been determined to be regulated as a mixed waste due to the presence of spent halogenated and nonhalogenated solvents (F001, F002, F003, F004, and F005), and for the toxicity of ammonia (WT02, toxic state-only). The Estimated Annual Quantity of Dangerous Waste (item III.B.1.) of 108,290,000 pounds (4,912,000 kilograms) represents the maximum annual output of Evaporator process condensate during operating campaigns.

V. FACILITY DRAWING

All existing facilities must include in the space provided on page 5 a scale drawing of the facility *(see instructions for more detail)*.

VI. PHOTOGRAPHS

All existing facilities must include photographs *(aerial or ground-level)* that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas *(see instructions for more detail)*.

VII. FACILITY GEOGRAPHIC LOCATION This information is provided on the attached drawings and photos.

LATITUDE *(degrees, minutes, & seconds)*	LONGITUDE *(degrees, minutes, & seconds)*

VIII. FACILITY OWNER

[X] A. If the facility owner is also the facility operator as listed in Section VII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

B. If the facility owner is not the facility operator as listed in Section VII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. *(area code & no.)*

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
John D. Wagoner, Manager U.S. Department of Energy Richland Operations Office	John D. Wagoner	6/30/94

X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

NAME *(print or type)*	SIGNATURE	DATE SIGNED
SEE ATTACHMENT		

CONTINUE ON PAGE 5

X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

John D. Wagoner 6/30/94

Owner/Operator
John D. Wagoner, Manager
U.S. Department of Energy
Richland Operations Office

Date

Edward S. Keen 6/30/94

Co-operator
Edward S. Keen, President
Bechtel Hanford, Inc.

Date

WA7890008967

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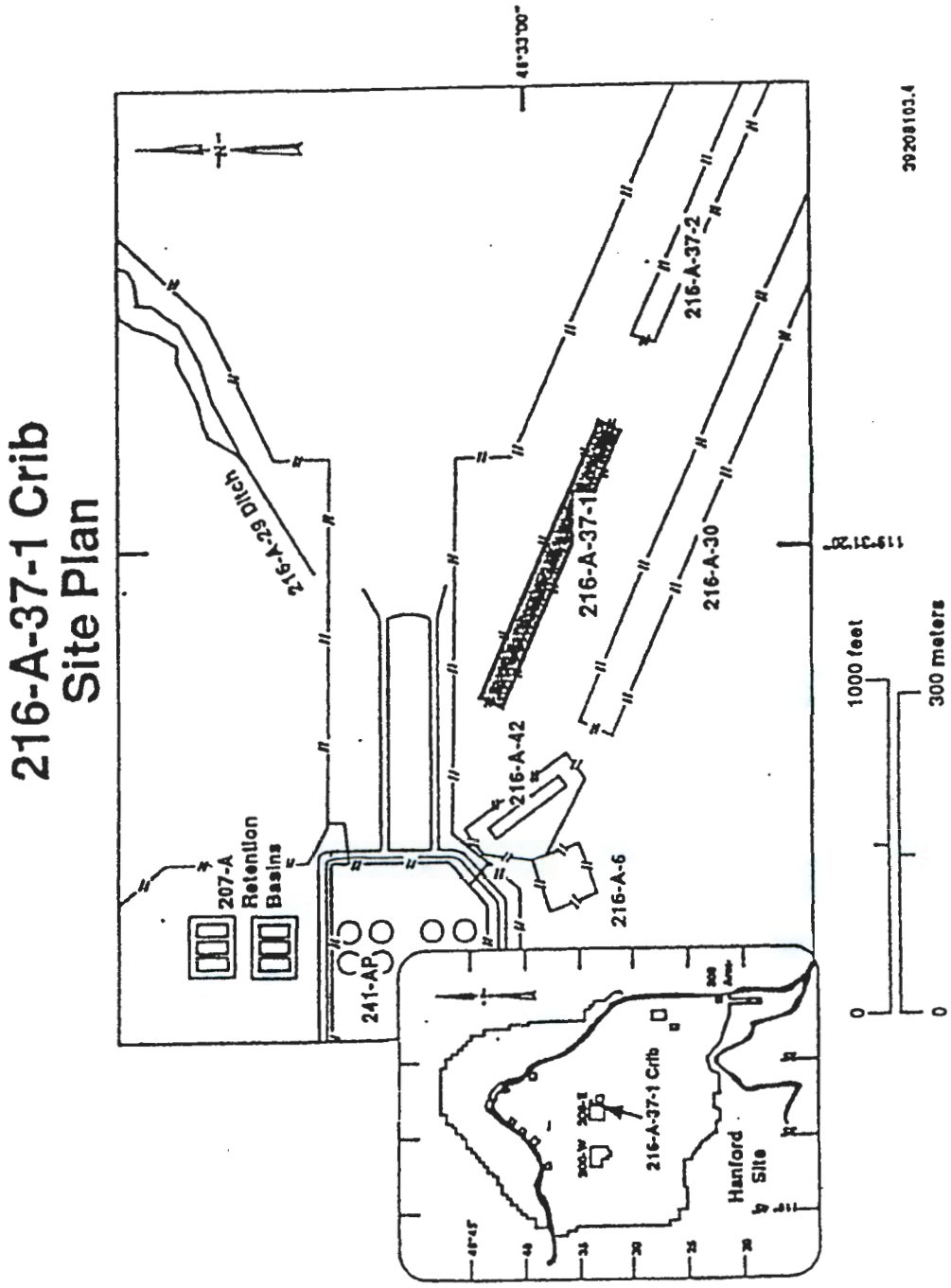

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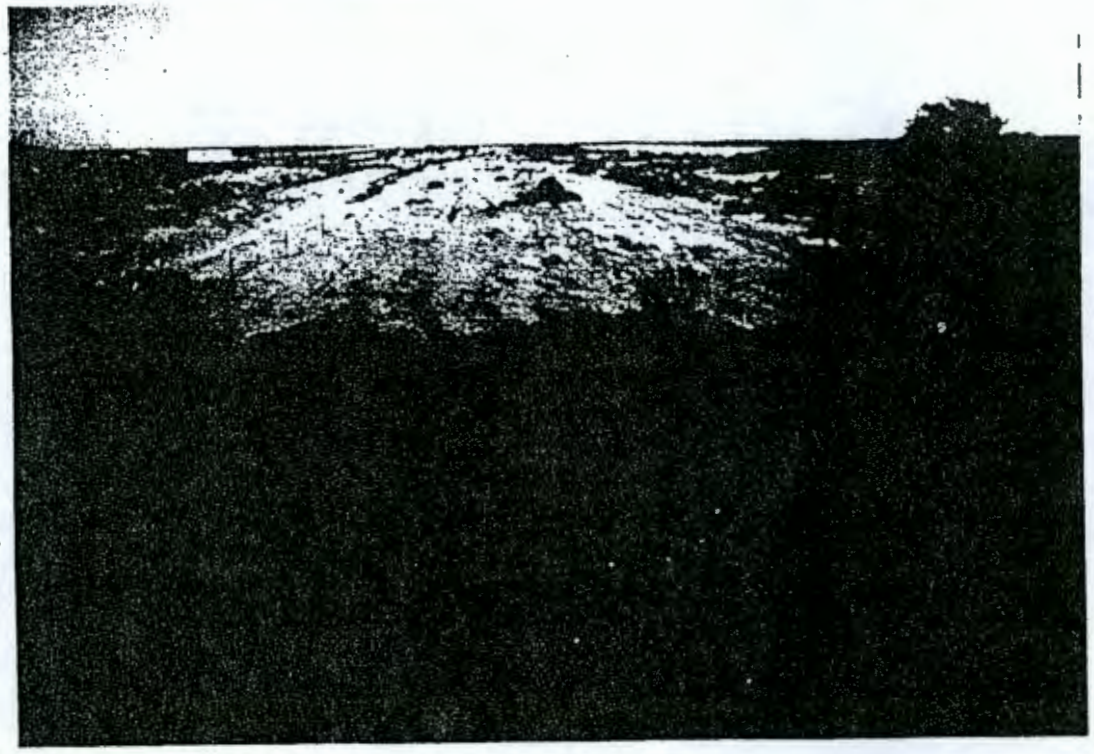

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(PHOTO TAKEN 1987)

APPENDIX B

SAMPLING AND ANALYSIS PLAN

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ACRONYMNS

ASTM	American Society for Testing and Materials
BHI	Bechtel Hanford, Inc.
bgs	below ground surface
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
FS	feasibility study
FSP	field sampling plan
HEIS	Hanford Environmental Information System
OU	operable unit
PUREX	Plutonium/Uranium Extraction
QAPjP	quality assurance project plan
QC	quality control
RCF	Radiological Counting Facility
RCRA	*Resource Conservation and Recovery Act of 1976*
RCT	radiological control technician
REDOX	Reduction/Oxidation
RESRAD	RESidual RADioactivity Dose Model
RI	remedial investigation
SAP	sampling and analysis plan
TSD	treatment, storage, and disposal

APPENDIX B

SAMPLING AND ANALYSIS PLAN

B.1 INTRODUCTION

This sampling and analysis plan (SAP) for the remedial investigation (RI) of the 200-PW-2 Operable Unit (OU) directs sampling and analysis activities that will be performed to characterize the vadose zone at six waste sites: the 216-A-19 Trench, the 216-B-12 Crib, the 216-U-8 Crib, the 216-U-12 Crib, the 216-A-10 Crib, and the 216-A-36B Crib. These waste sites are part of the 200-PW-2 Uranium-Rich Process Waste Group OU in the 200 Areas of the Hanford Site. The sampling and analyses described in this document will provide soil data to refine the conceptual contaminant distribution models, support an assessment of risk, and evaluate a range of remedial alternatives for waste sites in this OU. Characterization activities described in this plan are based on the implementation of the data quality objectives (DQO) process as documented in the *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Units* (BHI 2000 pending).

The scope of activities described in this SAP involves sampling and geophysical logging of four deep boreholes to be drilled at four waste sites and geophysical logging of existing boreholes to obtain additional information on the distribution of contamination at three of those four waste sites. In addition, geophysical logging will also be performed at two additional waste sites (216-U-8 Crib and 216-U-12 Crib) for which no further borehole drilling or soils characterization is required. Boreholes will be drilled to groundwater at the 216-A-19 Trench, the 216-B-12 Crib, the 216-A-10 Crib, and the 216-A-36B Crib. Soil samples will be collected and analyzed for radiological and nonradiological contaminants of concern (COCs) and physical properties.

B.1.1 Background

The 32 waste sites associated with the 200-PW-2 OU primarily received mostly process drainage, process distillate discharge, and miscellaneous condensates. Most of the waste discharged to the soil column in this OU was generated at U Plant, the Reduction/Oxidation (REDOX) Plant, the Plutonium/Uranium Extraction (PUREX) Plant, B Plant (i.e., Waste Encapsulation and Storage Facility [WESF]), and the Semiworks Facility (C Plant) from 1952 through 1988. In general, the majority of the waste generated by operations associated with these waste sites can be described as a variety of liquid effluents, all containing relatively large amounts of uranium. The pH of the waste ranges from acidic to basic depending on source. The waste contains various constituents that include radionuclides, metals, inorganic chemicals, and semi-volatile and volatile organic chemicals. Contamination has penetrated the vadose zone and reached the aquifer beneath some of the waste sites.

Four of the waste sites (216-A-19, 216-B-12, 216-A-10, and 216-A-36B) within this OU will be characterized to determine the nature and vertical extent of contamination via soil sampling and geophysical logging. Two additional sites (216-U-8 and 216-U-12) will be characterized only by

geophysical surveys of existing boreholes to obtain information to supplement existing data. Knowledge gained from the RI of characterizing these sites will be used to refine the conceptual contaminant distribution models and facilitate the use of the analogous site approach in reaching remedial action decisions for all the waste sites in this OU. The analogous site approach is described in detail in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (Implementation Plan) (DOE-RL 1999).

B.1.2 200-PW-2 Group/Waste Site Locations

The 200-PW-2 OU is located on the Hanford Site in southeastern Washington State, in the vicinity of the 200 East and 200 West Areas. All waste sites are located within the 200 Area exclusive land-use boundary identified in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999). Figures 2-9 through 2-11 in the work plan show the specific locations of waste sites in the 200-PW-2 OU.

B.1.3 Site Description and History

The following sections provide brief descriptions of the six waste sites that will be investigated. More detail is provided in Section 2.2 of the work plan. Section 3.3 of the work plan contains information on the nature and extent of contamination and previous investigations.

B.1.3.1 216-A-19 Trench. The 216-A-19 Trench is one of several cribs/trenches that received startup wastes from the PUREX facility. The 216-A-19 Trench is located in the 200 East Area about 800 m (2,625 ft) northwest of the 202-A (PUREX) Building. It is approximately 7.6 by 7.6 by 4.6 m (25 by 25 by 15 ft) deep. It operated from November 1955 until January 1956. During that period it received PUREX startup wastes and possibly condenser cooling water from the 241-A-431 Building. Waste from PUREX entered the trench from above-ground piping that emptied into the trench. Condenser cooling water from the 241-A-431 Building may have reached the trench via the 216-A-34 Ditch, which lies adjacent to 216-A-19. The trench and ditch were later covered with several feet of fill. The site was surface stabilized again in 1990.

B.1.3.2 216-B-12 Crib. The 216-B-12 Crib received process condensate from the 221-U and 224-U Buildings and B Plant (221-B). The 216-B-12 Crib is located in the 200 East Area about 305 m (1,000 ft) northwest of the 221-B Building. It was constructed in 1952 and consisted 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 crib operated from November 1952 through December 1957 and from May 1967 through November 1973. The crib was abandoned in November 1973 when the ground above the crib started to subside. The subsidence was backfilled and the fill line 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.

B.1.3.3 216-U-8 Crib. The 216-U-8 Crib received process condensate from U Plant (221-U), the 224-U Tanks, and 291-U-1 stack drainage. 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, in a manner similar to the 216-B-12 Crib described in the preceding section. The crib operated from June 1952 to March 1960. 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. 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 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 1994 as part of 200-UP-2 OU characterization activities. Waste in the site was considered to be acidic due to the large amounts of nitric acid disposed at the site.

B.1.3.4 216-U-12 Crib. 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 from U Plant. The 46-m (150-ft)-long gravel-filled crib has no constructed internal structure and is about 5 m (15 ft) below grade. From 1960 to 1967 it received stack drainage from 291-U-1, 244-WR Vault waste, stormdrain waste from the 224-U Building, and waste from the C-5 and C-7 tanks 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. From May 1967 to September 1972, it 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 process condensate from the 224-U Building. The crib received process condensate until January 1988 when it was replaced by the 216-U-17 Crib. The site was characterized in 1994 as part of 200-UP-2 OU characterization activities. The site is permitted as a *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal (TSD) unit due to the acidic nature of the nitric acid disposed at the site. The crib was stabilized with at least 0.6 m (2 ft) of soil.

B.1.3.5 216-A-10 Crib. The 216-A-10 Crib is the second of three RCRA units in this OU. The crib is located in the 200 East Area approximately 82 m (270 ft) south of the southwest corner of the 202-A (PUREX) Building. The crib is rock filled with dimensions of 84 by 14 by 14 m (275 by 45 by 45 ft) deep. The crib was designed as a percolation unit for the disposal of liquid wastes from the PUREX facility. 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. Liquid wastes included an acidic waste stream (nitric acid) from the process distillate discharge from PUREX, which resulted in the site being permitted as a RCRA TSD unit. The crib operated until 1987. Following operational use the crib was backfilled.

B.1.3.6 216-A-36B Crib. The 216-A-36B Crib is the third RCRA TSD unit in this OU. The 216-A-36B Crib is located in the 200 East Area about 366 m (1,200 ft) south of the 202-A (PUREX) Building. 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). The 216-A-36B Crib is the southern portion of a longer crib, originally known as the 216-A-36 Crib. The original 216-A-36 Crib received effluent from September 1956 to March 1966. A substantial inventory of radionuclides was

disposed to the crib and is assumed to have infiltrated sediments near the inlet of the crib. To continue effluent discharge to the crib, it was divided into two sections: 216-A-36A and 216-A-36B. Grout was injected into the gravel layer to form a barrier between the two sections. Replacement piping was inserted through the original discharge piping, effectively moving the discharge point further south along the length of the trench into the section that became the 216-A-36B Crib. The 216-A-36B Crib operated from 1966 to 1972 and was reactivated in 1982 for the PUREX Plant restart and remained active until early 1988. During its operational use, it received ammonia scrubber distillate waste from the 202-A Building. The caustic nature of the waste (WT02) resulted in the site being permitted as a RCRA TSD unit. Use of the crib was later discontinued and the facility backfilled. No stabilization actions have taken place at the waste site.

B.1.4 Contaminants of Concern

Step 1 of the DQO process identifies the need to develop a list of contaminants of potential concern (COPCs) for 200-PW-2 OU waste sites. Development of the COPCs is an essential step towards refining the preliminary conceptual contaminant distribution model to obtain site-specific models for the representative sites. From an investigation of historical sources including process documents, logbooks, original plant technical manuals, and interviews of plant operators, a list of potential contaminants was identified. Screening of this list was conducted during the DQO to arrive at a final list of 45 COCs for the 200-PW-2 OU. Development of this list is described in the 200-PW-2 DQO summary report (BHI 2000 pending) and is summarized in Section 3.6 of the work plan. The COCs are identified in Table B-1.

B.1.5 Data Quality Objectives

The U.S. Environmental Protection Agency (EPA) document, *Guidance for the Data Quality Objectives Process* (EPA 1994a), was used to support the development of this SAP. The DQO process is a strategic planning approach that provides a systematic process for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This section summarizes the key outputs resulting from the implementation of the seven-step DQO process for the RI of the OU. Additional details are included in the DQO summary report (BHI 2000 pending).

B.1.5.1 Statement of the Problem. The 200-PW-2 OU consists of 32 waste sites that received mostly uranium-rich process drainage, process distillate discharge, and miscellaneous condensates that were generated at U Plant, REDOX, PUREX, B Plant (i.e., WESF), and the Semiworks Facility (C Plant) from 1952 through 1988. Twenty-nine of the sites in this group are RCRA past-practice waste sites and three are RCRA TSD units. Five RCRA past-practice sites are unplanned release sites. Vadose zone soils and the aquifer have been impacted by effluent released to the 200-PW-2 waste sites.

The objective of the DQO process for this OU is to determine the environmental measurements necessary to support the remedial investigation/feasibility study (RI/FS) process and remedial decision making, including refinement of the preliminary conceptual contaminant distribution model. Additionally, the DQO process supports development of this SAP.

Possible alternatives identified in the Implementation Plan (DOE-RL 1999) include the following:

- No action alternative (no institutional controls)
- Engineered multimedia barrier
- Excavation and disposal of waste
- Excavation, ex situ treatment, and geologic disposal of transuranic soil (if present)
- In situ vitrification of soil
- In situ grouting or stabilization
- Monitored natural attenuation (with institutional controls).

B.1.5.2 Decision Rules. Decision rules are developed from the combined results of DQO Steps 2, 3, and 4. These results include the principal study questions, decision statements, remedial action alternatives, data needs, COC action levels, analytical requirements, and scale of the decision(s). Decision rules are generally structured as "IF...THEN" statements that indicate the action that will be taken when a prescribed condition is met. Decision rules incorporate the parameters of interest (e.g., COCs), the scale of the decision (e.g., location), the preliminary action level (e.g., COC concentration), and the resulting action(s). The 200-PW-2 decision statements are summarized in Table B-2.

B.1.5.3 Error Tolerance and Decision Consequences. The consequence of selecting an inadequate nonstatistical sampling design is not considered severe. Based on Section 6.0 of the DQO summary report (BHI 2000 pending), the sampling design rigor requirements are not significant because of the combination of low severity and accessibility after remedial investigation sampling. If the sampling design is determined to be inadequate, additional sampling can be performed because the sites will be still accessible. Section 5.5 of the work plan summarizes the sampling activities that are planned after the evaluation of initial characterization efforts that are described in this SAP.

B.1.5.4 Sample Design Summary. A nonstatistical sampling design (i.e., professional judgement) was used to select sample locations at the waste sites. This biased (or focused) sampling approach was selected based on the Washington State Department of Ecology's document, *Guidance on Sampling and Data Analysis Methods* (Ecology 1995). The intended use of the data and the process knowledge, expected behavior of COCs, the observed distribution of contamination, waste site configuration, and the conceptual contaminant distribution models developed for the waste sites support the focused sampling approach. Using this approach, sample locations are selected that increase the likelihood of encountering the worst-case conditions or maximum concentrations of contaminants.

The total number of samples for the waste sites is selected based on the conceptual contaminant distribution models and the physical setting of the waste sites. The models suggest that the highest contaminant concentrations should be detected near the bottom of the crib/trench and decrease with depth. Therefore, a greater frequency of sampling is planned in the zone immediately below the release point of the contaminants (i.e., the bottom of the cribs/trenches). Sample frequency will decrease with depth based on the expected distribution of contamination. Additional samples will be collected at the discretion of the site geologist based on the field screening data. All drill cuttings and soil samples will be screened as described in Section B.3.2.2. Field screening will be performed to reduce the potential of overlooking zones of significant contamination and for worker safety. The optimal sample design for this RI is presented in Section B.3.

Table B-1. 200-PW-2 Operable Unit Final COC List. (3 Pages)

Final COCs	Rationale for Inclusion
Radioactive Constituents	
Americium-241	Reactor product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Carbon-14	Fission/activation product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Cesium-137	Known fission product (GE 1944, Sections A, B, and C; Borsheim and Simpson 1991).
Cobalt-60	Known activation product (GE 1944, Sections A, B, and C; Borsheim and Simpson 1991; Jacques and Kent 1991).
Europium-152	Known fission product (GE 1944, Sections A, B, and C; Diediker 1999).
Europium-154	Known fission product (GE 1944, Sections A, B, and C; Diediker 1999).
Europium-155	Known fission product (GE 1944, Sections A, B, and C; Borsheim and Simpson 1991).
Hydrogen-3 (tritium)	Fission/activation product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Neptunium-237	Reactor product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Nickel-63	Activation product and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Plutonium-238	Reactor product (GE 1944, Sections A, B, and C).
Plutonium-239/240	Reactor product (GE 1944, Sections A, B, and C).
Radium-226	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Radium-228	Known production from fission reaction and listed via tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Strontium-90	Known fission product (GE 1944, Sections A, B, and C; Borsheim and Simpson 1991).
Technetium-99	Known fission product (GE 1944, Sections A, B, and C; Jacques and Kent 1991).
Thorium-232	Reactor feed (GE 1944, Sections A, B, and C; Diediker 1999).
Uranium-234	Reactor feed (GE 1944, Sections A, B, and C).
Uranium-235	Reactor feed (GE 1944, Sections A, B, and C).
Uranium-238	Reactor feed (GE 1944, Sections A, B, and C).
Chemical Constituents – Metals	
Antimony	Metal byproduct from uranium fuel rod (GE 1951).
Arsenic	RCRA constituent.
Barium	Metal byproduct from uranium fuel rod (GE 1951).
Beryllium	Metal used in braze to seal end of fuel rod (GE 1951).
Cadmium	Metal used in lead-dipped cladding and thus cladding waste stream (1952 to 1956) (GE 1944, Section A).
Chromium	Due to sodium/potassium dichromate added during first- and second-cycle decontamination and concentration operations of bismuth phosphate process (GE 1944, Section C; Anderson 1990).

Table B-1. 200-PW-2 Operable Unit Final COC List. (3 Pages)

Final COCs	Rationale for Inclusion
Chromium (VI)	Due to sodium/potassium dichromate added during first- and second-cycle decontamination and concentration operations of bismuth phosphate process (GE 1944, Section C; Anderson 1990).
Copper	Metal used in triple-dip process of cladding and thus cladding waste stream (1944 to 1952) (GE 1944, Section A).
Lead	Metal used in lead-dipped cladding and thus cladding waste stream (1952 to 1956) (GE 1944, Section A). Lead oxide was added as an oxidizing agent to the first- and second-cycle decontamination operations of bismuth phosphate process (GE 1944, Section C).
Mercury	Several uses in bismuth phosphate campaign including addition to cladding and metal waste streams to prevent gaseous generations and miscellaneous laboratory uses. Listed by the basis of knowledge gained by interviews and via tank farm integration (Agnew et al. 1997).
Nickel	Experimental additions of nickel sulfate during the bismuth phosphate process to serve as a scavenging agent. Listed as a result of tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991) and extensive use (1954 to 1958) as nickel ferro/ferric cyanide during scavenging and recovery processes (Borsheim and Simpson 1991).
Selenium	Several uses in bismuth phosphate campaign including filtering of gases generated in the 1950's and miscellaneous laboratory uses. Listed by the basis of knowledge gained by previous sampling efforts in the 200 Areas.
Silver	Several uses in bismuth phosphate campaign, including filtering of gas generated in the 1950's and miscellaneous laboratory uses. Listed by the basis of knowledge gained by interviews.
Chemical Constituents -- General Inorganics	
Ammonia/ammonium	Several compounds contained ammonium. The most widely used included ammonium silica fluoride which was used as a cleaning and decontamination compound based on ability to dissolve metals and fission products (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945).
Chloride	Several compounds contained chloride. The most widely used included ferrous chloride, which was used as a carrier, and potassium/sodium chloride, which was used as salting agents during the bismuth phosphate process (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945).
Cyanide	Extensive use (1954 to 1958) as nickel ferro/ferric cyanide during scavenging and recovery processes; listed as a result of tank farm integration (Agnew et al. 1997, Borsheim and Simpson 1991).
Fluoride	Several compounds contained fluoride. The most widely used included lanthanum fluoride, which was used during the concentration operations of the bismuth phosphate process, and ammonium silica fluoride, which was used as a cleaning and decontamination compound based on the ability to dissolve metals and fission products (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945).

Table B-1. 200-PW-2 Operable Unit Final COC List. (3 Pages)

Final COCs	Rationale for Inclusion
Nitrate/nitrite	Several compounds contained nitrates/nitrites. The most widely used included sodium nitrite, a salting agent during the cladding removal, nitric acid, which was used throughout the bismuth phosphate and uranium recovery processes, and bismuth subnitrate, which was used to create the bismuth phosphate/ plutonium solid during the first- and second-cycle decontamination process (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945).
Phosphate	Several compounds contained phosphate. The most widely used included phosphoric acid, which was used throughout bismuth phosphate process (GE 1944, Section C; HEW 1945).
Sulfate	Several compounds contained sulfate. The most widely used included sulfuric acid, which was used in the dissolving of the fuel rod during the bismuth phosphate process (GE 1944, Section C; Borsheim and Simpson 1991; HEW 1945). Many other sulfate complexes were used as carriers for various metals.
Semi-Volatile Organics	
AMSCO[a]	Extensive use (1953 to 1957) in solvent extraction operation as the dilutant for tributyl phosphate in the uranium recovery processes (Borsheim and Simpson 1991).
Dodecane[a]	Used (1953 to 1957) in solvent extraction operation as the dilutant for tributyl phosphate in the uranium recovery processes (Borsheim and Simpson 1991).
Normal paraffin hydrocarbons[a]	Extensive use (1953 to 1957) in solvent extraction operation as the dilutant for tributyl phosphate in the uranium recovery processes (Borsheim and Simpson 1991).
Tributyl phosphate and derivatives (mono, bi)	Extensive use (1953 to 1957) in solvent extraction in the uranium recovery and PUREX processes (Borsheim and Simpson 1991, GE 1955).
Volatile Organics	
Hexone[b]	Used as solvent for solvent extraction of uranium and plutonium from fission products in REDOX (S Plant). Present in process drainage and possibly in process condensates (GE 1951).

[a]Analyzed as kerosene total petroleum hydrocarbons.
[b]Only present at 216-S-1&2 Cribs, 216-S-7 Cribs, and 216-S-8 Trench via REDOX process condensate and process cell drainage waste streams only. This constituent will not be considered further in this document because it was not disposed to any of the representative or TSD waste sites being considered in this SAP. It will be addressed in future efforts such as confirmatory sampling following the record of decision.

Table B-2. Decision Rules.

DR #	Decision Rule
1 & 2	If the analytical results of the vadose zone soil samples within the geographic boundaries of the individual 200-PW-2 OU representative and TSD waste sites over the next 5 years meet all of the following conditions: • The RESRAD analysis of maximum detected soil sampling results for the radiological COCs in the 200-PW-2 OU representative waste site vadose soils do not exceed the annual exposure limits for human health protection. • The fate and transport analysis (TBD) of the maximum detected soil sampling results for the radiological COCs in the 200-PW-2 OU representative waste site vadose soils do not exceed the annual exposure limits for protection of groundwater. • The analytical results of the 200-PW-2 OU representative waste sites indicate that maximum detected values do not exceed the respective nonradiological COC preliminary action levels for direct exposure. • The analytical results of the 200-PW-2 OU representative waste site vadose soils indicate that the maximum detected values do not exceed the respective nonradiological COC preliminary action levels for protection of groundwater. Then evaluate for site closure with no remedial action. If any of these conditions are not met, then evaluate the need for conventional remedial action alternatives within a feasibility study/closure plan, or evaluate a streamlined approach to site closure to be applied administratively via an existing record of decision.
3	If the maximum detected values indicate that the contamination distribution and physical characteristics in the 200-PW-2 OU waste sites do not differ significantly from the preliminary conceptual contaminant distribution model, then the preliminary conceptual contaminant distribution model will not be revised prior to use for remedial decision making or remedial action planning. If the maximum detected values indicate that the contamination distribution and physical properties in the 200-PW-2 OU waste sites differ significantly from the preliminary conceptual contaminant distribution model, then the preliminary conceptual contaminant distribution model will be revised prior to use for remedial decision making or remedial action planning.

[a]The use of the term "remedial action" is used collectively to refer to one of the alternatives described in the project objectives discussion. The selection of the appropriate alternative action is beyond the scope of this DQO summary report.
DR = decision rule
TBD = to be determined

B.2 QUALITY ASSURANCE PROJECT PLAN

The quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection, including sampling, field measurements, and laboratory analysis. The overall QAPjP for Environmental Restoration waste sites in the 200 Areas is included in Appendix A of the Implementation Plan (DOE-RL 1999). The QAPjP complies with the requirements of the following:

- U.S. Department of Energy (DOE) Order 5700.6c, *Quality Assurance*
- *Code of Federal Regulations* (CFR), 40 CFR 830.120, "Quality Assurance Requirements"
- *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 1994b)
- *Hanford Analytical Services Quality Assurance Requirements Documents* (DOE-RL 1996a).

The Implementation Plan provides the general framework of technical and administrative requirements that apply to OUs in the 200 Areas.

To meet the site-specific needs for the 200-PW-2 OU, this QAPjP identifies supplemental requirements developed during the DQO process and described in the group-specific SAP. These requirements are listed below:

- **Analytical Performance.** Requirements for detection limits, precision, and accuracy are presented in Table B-3. The analytical methods are also shown in this table.
- **Field Quality Control.** The frequency and type of quality control (QC) samples to be collected are addressed in Section B.2.1.
- **Sample Preservation, Containers, and Holding Time.** The requirements for the specific test/laboratory methods are addressed in Section B.2.3 and in Table B-4.
- **Onsite Measurements Quality Control.** The specific types of QC samples for onsite measurements and the frequency of collection are addressed in Section B.2.4.
- **Data Validation and Usability.** Specific validation requirements, including the frequency and level of validation, are addressed in Section B.2.6.

The following sections describe the supplemental waste group quality requirements and the procedural controls applicable to this investigation. The 200 Areas QAPjP (Appendix A of the Implementation Plan [DOE-RL 1999]) and this section of the SAP will serve as the QAPjP for the 200-PW-2 RI.

B.2.1 Field Quality Control

Field QC samples shall be collected to evaluate the potential sources for error including cross-contamination and laboratory performance that could bias the results. A data quality assessment will be performed to assess the quality of the data collected to support the RI/FS activities for the 200-PW-2 OU. Field QC for sampling in the 200-PW-2 OU will require the collection of co-located duplicate, field split, and equipment rinsate blank samples. The QC samples are described in this section with the required frequency of collection.

B.2.1.1 Co-Located Duplicates. Co-located duplicates are independent samples collected as close as possible to the same point in space and time, taken from the same source, stored in separate containers, and analyzed independently. These samples provide a relative measure of the degree of local heterogeneity in the sample medium, unlike laboratory duplicates that are used to evaluate precision and the analytical process. It is important that these samples are not homogenized together.

A minimum of 5% of the total collected soil samples will be duplicated (i.e., 1 field duplicate will be collected for every 20 soil samples). At least one co-located duplicate will be collected from each borehole. The duplicates should generally be collected from an interval that is expected to have some contamination, so that valid comparisons between the samples can be made (i.e., at least some of the COCs will be above detection limit). When sampling with a split spoon, the duplicate sample will probably be from a separate split spoon either above or below the main sample because of sample volume requirements.

B.2.1.2 Equipment Rinsate Blanks. Equipment rinsate blanks shall be collected at the same frequency as co-located duplicate samples, where applicable, and are used to assess the possibility of cross-contamination caused by sampling equipment, sample containers, or laboratory procedures and verify the adequacy of sampling equipment decontamination procedures. The field geologist may request that additional equipment blanks be taken. Equipment blanks shall consist of pure deionized water washed over decontaminated sampling equipment and placed in containers identical to those used for actual soil samples.

Equipment rinsate blanks shall be analyzed for the following:

- Gross alpha
- Gross beta
- Metals (excluding hexavalent chromium and mercury)
- Anions (except cyanide).

These analytes are considered to be the best indicators of decontamination effectiveness.

B.2.1.3 Prevention of Cross-Contamination. Special care should be taken to prevent cross-contamination of soil samples. Particular care will be exercised to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting them on or near potential contamination sources, such as uncovered ground
- Handling bottles or equipment with dirty hands
- Improperly decontaminating equipment before sampling or between sampling events.

B.2.2 Quality Objectives and Criteria for Measurement Data

Quality objectives and criteria for soil measurement data are presented in Table B-3 for chemical and radiological analytes, as well as physical properties of interest. Analysis of soil physical properties will be performed according to American Society for Testing and Materials (ASTM) procedures, if applicable.

B.2.3 Sample Preservation, Containers, and Holding Times

Soil sample preservation, containers, and holding times for chemical and radiological analytes of interest and physical property test are presented in Table B-4. Final sample collection requirements will be identified on the Sampling Authorization Form per procedure BHI-EE-01, Section 2.0.

B.2.4 Onsite Measurements Quality Control

The collection of QC samples for onsite measurements is not applicable to field-screening techniques described in this plan. Field-screening instrumentation will be calibrated and controlled according to the procedures identified in Section B.2.7.

B.2.5 Data Management

Data resulting from the implementation of this QAPjP will be managed and stored by the Environmental Restoration Contractor (ERC) organization responsible for sampling and characterization, in accordance with procedure BHI-EE-01, Section 2.0, "Sample Management." At the direction of the task lead, all analytical data packages will be subject to final technical review by qualified personnel before their submittal to regulatory agencies or inclusion in reports. Electronic data access, when appropriate, will be via a database (e.g., Hanford Environmental Information System [HEIS] or a project-specific database). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998).

B.2.6 Validation and Verification Requirement

Validation will be performed on completed data packages by qualified ERC Sample Management personnel or by a qualified independent contractor. Validation will consist of verifying required deliverables, requested versus reported analyses, and transcription errors. Validation will also include the evaluation and qualification of results based on holding time, method blanks, matrix spikes, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate to the methods used. No other validation or calculation checks will be performed. At least 5% of all data will be validated.

Assuming that about 50 samples will be collected during the 200-PW-2 OU representative site investigations (including full QC sets, but exclusive of discretionary samples; see Tables B-6 through B-10), approximately 6 to 13 sample delivery groups will be submitted to the laboratory containing between 4 and 8 samples in each sample delivery group. At least one data validation package will be generated for each waste site. Validation requirements identified in this section are consistent with Level C validation, as defined in data validation procedures (WHC 1993a, 1993b). No validation for physical property data will be performed.

B.2.7 Technical Procedures and specifications

Soil sampling and onsite environmental measurements will be performed according to approved procedures. Sampling and field measurements will be conducted according to BHI-EE-01, *Environmental Investigations Procedures*; BHI-EE-05, *Field Screening Procedures*; and other approved procedures listed below. Individual procedures that may be used during performance of this SAP include the following:

- BHI-EE-01, *Environmental Investigations Procedures*

  Section 1.0, General Information

  - Procedure 1.5, "Field Logbooks"
  - Procedure 1.6, "Survey Requirements and Techniques"

  Section 2.0, Sample Management

  - Procedure 2.0, "Sample Event Coordination"
  - Procedure 2.1, "Sampling Documentation Processing"

  Section 3.0, General Sampling

  - Procedure 3.0, "Chain of Custody"
  - Procedure 3.1, "Sample Packaging and Shipping"
  - Procedure 3.2, "Field Decontamination of Sampling Equipment"

  Section 4.0, Soil, Groundwater, and Biotic Sampling

  - Procedure 4.0, "Soil and Sediment Sampling"
  - Procedure 4.2, "Sample Storage and Shipping Facility"

Section 6.0, Drilling

- Procedure 6.2, "Field Cleaning and/or Decontamination of Geoprobe and Drilling Equipment"

Section 7.0, Geologic and Hydrologic Data Collection

- Procedure 7.0, "Geologic Logging"
- Procedure 7.2, "Geophysical Survey Work"

- BHI-EE-02, *Environmental Requirements*

  - Section 14.0, "Drilling, Maintaining, Remediation, and Decommissioning Resource Protection Wells, Geoprobe, and Geotechnical Soil Borings"

- BHI-EE-05, *Field Screening Procedures*

  - Procedure 1.0, "Routine Field Screening"
  - Procedure 2.5, "Operation of Mobile Surface Contamination Monitor II"
  - Procedure 2.12, "Eberline E-600 Usage for Environmental Surveys"
  - Procedure 2.22, "Operation of the Global Positioning Environmental Radiological Surveyor (GPERS-11)"

- BHI-EE-10, *Waste Management Plan*, Part II

  - Section 9.0, "Control of CERCLA and Other Past-Practice Investigation-Derived Waste"

Work shall also be performed in accordance with the following manuals:

- BHI-EE-02, *Environmental Requirements*, Section 11.0, "Solid Waste System Operations"

- BHI-QA-01, *ERC Quality Program*

- BHI-QA-03, *ERC Quality Assurance Program Plans*

  - Plan 5.1, "Field Sampling Quality Assurance Program Plan"
  - Plan 5.2, "Onsite Measurements Quality Assurance Program Plan"
  - Plan 5.3, "Environmental Radiological Measurements Quality Assurance"

- BHI-MA-02, *ERC Project Procedures*

- BHI-SH-01, *ERC Safety and Health Program*

- BHI-SH-02, *Safety and Health Procedures*, Volumes 1 through 4

- BHI-SH-05, *Industrial Hygiene Work Instructions*
- BHI-EE-10, *Waste Management Plan*
- BHI-RC-01, *Radiation Protection Program Manual*
- BHI-RC-04, *Radiological Control Work Instructions*
- *Hanford Site Radiation Control Manual* (DOE-RL 1996b)
- Specification for environmental drilling services specific to 200-PW-2
- *Sampling Services Procedures Manual*, ES-SSPM-001, Rev. 0, Procedure 2-5, "Laboratory Cleaning of Sampling Equipment," Waste Management Northwest (WMNW 1998).

B.2.7.1 Sample Location. Sample locations (e.g., geophysical surveys and boreholes) will be staked and labeled before starting the activity. Locations will be staked by the technical lead or field team leader assigned by the project manager. After the locations have been staked, minor adjustments to the location may be made to mitigate unsafe conditions, avoid structural interferences, or bypass utilities. Locations will be identified during or after sampling following BHI-EE-01, Procedure 1.6, "Survey Requirements and Techniques." Changes in sample locations that do not impact the DQOs will require approval of the project manager. However, changes to sample locations that result in impacts to the DQOs will require lead regulator concurrence.

B.2.7.2 Sample Identification. The ERC Sample and Data Tracking database will be used to track the samples through the collection and laboratory analysis process. The HEIS database is the repository for the laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project in accordance with BHI-EE-01, Procedure 2.0, "Sample Event Coordination." Each chemical/radiological and physical properties sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook.

Each sample container will be labeled with the following information using a waterproof marker on firmly affixed, water-resistant labels:

- HEIS number
- Sample collection date/time
- Name/initials of the person collecting the sample
- Analysis required
- Preservation method, if applicable.

B.2.7.3 Field Sampling Log. All information pertinent to field sampling and analysis will be recorded in bound logbooks in accordance with BHI-EE-01, Procedure 1.5, "Field Logbooks." The sampling team will be responsible for recording all relevant sampling information including, but not limited to, the information listed in Appendix A of Procedure 1.5. Entries made in the logbook will be dated and signed by the individual who made the entry.

B.2.7.4 Sample Custody. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples (cooler) shipped to any laboratory in accordance with BHI-EE-01, Procedure 3.0, "Chain of Custody." The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. Each time responsibility for custody of the sample changes, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and transmit it to ERC Sample Management within 24 hours of shipping, as detailed in BHI-EE-01, Procedure 2.1, "Sampling Documentation Processing."

A custody seal (i.e., evidence tape) shall be affixed to the lid of each sample jar. The container seal will be inscribed with the sampler's initials and the date and then sealed. Though not anticipated at these sites, if sample jars are collected inside a glovebag or glovebox because of contamination levels and "bagged out," the evidence tape may be affixed to the seal of the bag or box to demonstrate that tampering has not occurred. This will eliminate problems associated with contaminated soils adhering to the custody tape while inside the glovebox.

B.2.7.5 Sample Containers and Preservatives. Level I EPA pre-cleaned sample containers will be used for soil samples collected for chemical and radiological analysis. Container sizes may vary depending on laboratory-specific volumes needed to meet analytical detection limits. If, however, the dose rate on the outside of a sample jar or the curie content exceeds levels acceptable by an offsite laboratory, the sampling lead and task lead can send smaller volumes to the laboratory after consultation with ERC Sample Management to determine acceptable volumes. Smaller sample volumes may not be able to meet QA/QC requirements as discussed in Table B-3. Preliminary container types and volumes are identified in Table B-4. Final types and volumes will be provided in the Sample Authorization Form.

B.2.7.6 Sample Shipping. The outside of each sample jar will be surveyed by the radiological control technician (RCT) to verify that the container is free of smearable surface contamination. The RCT will also measure the radiological activity on the outside of the sample container (through the container) and will mark the container with the highest contact radiological reading in either disintegrations per minute (dpm) or millirems per hour (mrem/hr), as applicable. Unless pre-qualified, all samples will have total activity analysis performed by the Radiological Counting Facility (RCF), 222-S Laboratory, or other suitable onsite laboratory, before shipment. This information, along with other data that may pre-qualify the samples, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR), International Air Transport Association requirements, and to verify that the sample can be received by the offsite analytical laboratory in accordance with the laboratory's acceptance criteria. The sampler will send copies of the shipping

documentation to ERC Sample Management within 24 hours of shipping, as detailed in BHI-EE-01, Procedure 2.1, "Sampling Documentation Processing."

As a general rule, samples with activities <1 mR/hr will be shipped to an offsite laboratory. Samples with activities between 1 mR/hr and 10 mR/hr may be shipped to an offsite laboratory; samples with activities in this range will be evaluated on a case-by-case basis by ERC Sample Management. Samples with activities >10 mR/hr will be sent to an onsite laboratory arranged by Sample Management. Potential impacts of onsite laboratory measurements are discussed in footnote a of Table B-3.

Table B-3. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		RR[b] (pCi/g)	C/I[b] (pCi/g)	GW Protection[b,c] (pCi/g)		Water[d] Low Activity (pCi/L)	Water[d] High Activity (pCi/L)	Soil-Other Low Activity (pCi/g)	Soil-Other High Activity (pCi/g)				
Americium-241	14596-10-2	31	210	TBD	Americium isotopic – AEA	1	400	1	4,000	±20%	70-130%	±35%	70-130%
Carbon-14	14762-75-5	5.2[e]	33,100	TBD	Carbon-14 - liquid scintillation	200	N/A	50	N/A	±20%	70-130%	±35%	70-130%
Cesium-137	10045-97-3	6.2	25	TBD	GEA	15	200	0.1	2,000	±20%	70-130%	±35%	70-130%
Cobalt-60	10198-40-0	1.4	5.2	TBD	GEA	25	200	0.05	2,000	±20%	70-130%	±35%	70-130%
Europium-152	14683-23-9	3.3	12	TBD	GEA	50	200	0.1	2,000	±20%	70-130%	±35%	70-130%
Europium-154	15585-10-1	3	11	TBD	GEA	50	200	0.1	2,000	±20%	70-130%	±35%	70-130%
Europium-155	14391-16-3	125	449	TBD	GEA	50	200	0.1	2,000	±20%	70-130%	±35%	70-130%
Hydrogen-3	10028-17-8	359[e]	14,200	TBD	Tritium – liquid scintillation	400	400	400	400	±20%	70-130%	±35%	70-130%
Neptunium-237	13994-20-2	2.5	62.2	TBD	Neptunium-237 - AEA	1	N/A	1	8,000	±20%	70-130%	±35%	70-130%
Nickel-63	13981-37-8	4,026	3,008,000	TBD	Nickel-63 - liquid scintillation	15	N/A	30	N/A	±20%	70-130%	±35%	70-130%
Plutonium-238	13981-16-3	37	483	TBD	Plutonium isotopic – AEA	1	130	1	1,300	±20%	70-130%	±35%	70-130%
Plutonium-239/240	Pu-239/240	34	243	TBD	Plutonium isotopic – AEA	1	130	1	1,300	±20%	70-130%	±35%	70-130%
Radium-226	13982-63-3	1.1	7.4	TBD	GEA	50	N/A	0.1	2000	±20%	70-130%	±35%	70-130%
Radium-228	15262-20-1	1.7	8.5	TBD	GEA	50	N/A	0.2	2000	±20%	70-130%	±35%	70-130%
Strontium-90	Rad-Sr	4.5	2,500	TBD	Total radioactive strontium - GPC	2	80	1	800	±20%	70-130%	±35%	70-130%
Technetium-99	14133-76-7	5.7[e]	410,000	TBD	Technetium-99 - liquid scintillation	15	400	15	4,000	±20%	70-130%	±35%	70-130%
Thorium-232	TH-232	1	5.1	TBD	Thorium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	70-130%	±35%	70-130%
Uranium-234	13966-29-5	160	1,200	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	70-130%	±35%	70-130%
Uranium-235	15117-96-1	26	100	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	70-130%	±35%	70-130%
Uranium-238	U-238	85	420	TBD	Uranium isotopic - AEA (pCi) ICPMS (mg)	1	0.002 mg/L	1	0.02 mg/kg	±20%	70-130%	±35%	70-130%

Table B-3. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[f] (mg/kg)	Method C[g] (mg/kg)	GW Protection[h] (mg/kg)		Water[d] Low Conc. (mg/L)	Water[d] High Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)	Soil-Other High Conc. (mg/kg)				
Metals													
Antimony	7440-36-0	32	1750	0.6	Metals - 6010 - ICP	0.06	0.12	6	12	i	i	i	i
Antimony	7440-36-0	32	1750	0.6	Metals – 6010[k]– ICP (trace)	0.01	NA	1	NA	i	i	i	i
Arsenic	7440-38-2	1.67	219	0.00583	Metals - 6010 - ICP	0.1	0.2	10	20	i	i	i	i
Arsenic	7440-38-2	1.67	219	0.00583	Metals - 6010 – ICP (trace)	0.01	NA	1	NA	i	i	i	i
Barium	7440-39-3	5600	245,000	200	Metals - 6010 - ICP	0.2	0.2	20	20	i	i	i	i
Barium	7440-39-3	5600	245,000	200	Metals - 6010 – ICP (trace)	0.005	NA	0.5	NA	i	i	i	i
Beryllium	7440-41-7	0.233	30.5	0.00203	Metals - 6010 - ICP	0.005	0.01	0.5	1	i	i	i	i
Cadmium	7440-43-9	80	3,500	0.5[j]	Metals - 6010 - ICP	0.005	0.01	0.5	1	i	i	i	i
Cadmium	7440-43-9	80	3,500	0.5[j]	Metals - 6010 – ICP (trace)	0.005	N/A	0.5	N/A	i	i	i	i
Chromium (total)	7440-47-3	80,000[l]	Unlimited[l]	10[j]	Metals - 6010 - ICP	0.01	0.01	1	2	i	i	i	i
Chromium (total)	7440-47-3	80,000[l]	Unlimited[l]	10[j]	Metals - 6010 – ICP (trace)	0.01	N/A	1	N/A	i	i	i	i
Chromium VI	18540-29-9	400	17,500	8	Chromium (hex) - 7196 - colorimetric	0.01	4	0.5	200	i	i	i	i
Copper	7440-50-8	2,960	130,000	59.2	Metals - 6010 - ICP	0.025	0.025	2.5	2.5	i	i	i	i
Lead	7439-92-1	353[m]	1,000[n]	1.5[o]	Metals - 6010 - ICP	0.1	0.2	10	20	i	i	i	i
Lead	7439-92-1	353[m]	1,000[n]	1.5[o]	Metals - 6010 - ICP (trace)	0.01	N/A	1	N/A	i	i	i	i
Mercury	7439-97-6	24	1,050	0.2[j]	Mercury - 7470 - CVAA	0.0005	0.005	N/A	N/A	i	i	i	i
Mercury	7439-97-6	24	1,050	0.2[j]	Mercury - 7471 - CVAA	N/A	N/A	0.2	0.2	i	i	i	i
Nickel	7440-02-0	1,600[p]	70,000[p]	32	Metals - 6010 - ICP	0.04	0.04	4	4	i	i	i	i
Selenium	7782-49-2	400	17,500	5[q]	Metals - 6010 - ICP	0.1	0.2	10	20	r	r	r	r
Silver	7440-22-4	400	17,500	8	Metals - 6010 - ICP	0.02	0.02	2	2	i	i	i	i
Silver	7440-22-4	400	17,500	8	Metals - 6010 - ICP (trace)	0.005	N/A	0.5	N/A	i	i	i	i
Uranium (total)	7440-61-1	240[p]	10,500[p]	2[q]	Uranium total - kinetic phosphorescence analysis	0.0001	0.02	1	0.2	±20%	70-130%	±35%	70-130%
Inorganics													
Ammonia/ ammonium	7664-41-7	Unlimited	Unlimited	27,200	Ammonia - 350.N[r]	0.05	800	0.5	8,000	i	i	i	i
Chloride	16887-00-6	25,000[h]	25,000[h]	25,000[h]	Anions - 300.0 - IC	0.2	5	2	5	i	i	i	i
Cyanide	57-12-5	1,600	70,000	20[j]	Total cyanide - 9010 - colorimetric	0.005	0.005	0.5	0.5	i	i	i	i
Fluoride	16984-48-8	4,800	210,000	96	Anions - 300.0 - IC	0.5	5	5	5	i	i	i	i

Table B-3. Analytical Performance Requirements – Shallow and Deep Zone Soils. (3 Pages)

COCs	CAS #	Preliminary Action Level[a]			Name/Analytical Technology	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method B[f] (mg/kg)	Method C[g] (mg/kg)	GW Protection[h] (mg/kg)		Water[d] Low Conc. (mg/L)	Water[d] High Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)	Soil-Other High Conc. (mg/kg)				
Nitrate	14797-55-8	128,000	Unlimited	4,400	Anions - 300.0 - IC	0.25	10	2.5	40	i	i	i	i
Nitrite	14797-65-0	8,000	350,000	160	Anions - 300.0 - IC	0.25	15	2.5	20	i	i	i	i
Nitrate/Nitrite	NO_3/NO_2-N	128,000	Unlimited	4,400	NO_3/NO_2 - 350.N[r]	0.075	5	0.75	10	i	i	i	i
Phosphate	14265-44-2	N/A	N/A	None	Anions - 300.0 - IC	0.5	15	5	40	i	i	i	i
Sulfate	14808-79-8	25,000[h]	25,000[h]	25,000[h]	Anions - 300.0 - IC	0.5	15	5	40	i	i	i	i
Organics													
Kerosene (normal paraffin hydrocarbons)	8008-20-6	200[n]	200[n]	200[n]	Nonhalogenated VOA - 8015M - GC modified for hydrocarbons	0.5	0.5	5	5	i	i	i	i
Tributyl phosphate	126-73-8	None	None	None	Semi-volatiles - 8270 – GCMS	0.1	0.5	3.3	5	i	i	i	i
Total organic carbon	TOC	N/A	N/A	None	TOC - 9060-combustion	1	1	100	100	±20%	70-130%	±35%	70-130%

[a]The preliminary action level is the regulatory or risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the FS, finalized in the ROD, and will drive remediation of the sites.
[b]RR = rural residential, C/I = commercial industrial, GW = groundwater protection radionuclide values from the Washington State Department of Health's (WDOH's) *Hanford Guidance for Radiological Cleanup* (WDOH 1983). Radionuclide values are calculated using parameters from WDOH guidance. RR and C/I values show a possible range of lookup values for comparison with analytical detection limits.
[c]The "100 times groundwater" rule does not apply to residual radionuclide contaminants. For radionuclides, groundwater protection is demonstrated through technical evaluation using RESRAD (DOE-RL 2000).
[d]Water values for sampling quality control (e.g., equipment blanks/rinses) or drainable liquid (if recovered).
[e]If quantitation to action level lower than nominal reliable detection level is required, prior notification/concurrence with the laboratory will be required to address special low-level detection limits.
[f]MTCA Method B soil values for direct exposure.
[g]MTCA Method C industrial soil values for direct exposure.
[h]MTCA Method B soil values for groundwater protection.
[i]Precision and accuracy requirements as identified and defined in the referenced EPA procedures.
[j]Based on *Federal Primary Drinking Water Standards* (40 CFR 141), which is more restrictive than MTCA.
[k]All four-digit numbers refer to *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA 1986).
[l]Value based on chromium (III) MTCA soil concentrations.
[m]Based on EPA's *Integrated Exposure Uptake Biokenetic Model for Lead In Children* (EPA 1994c).
[n]This value is based on MTCA Method A values.
[o]This value is based on 100 times the *National Primary Drinking Water Regulations* action level.
[p]Value based on nickel or uranium soluble salts value.
[q]Based on a proposed drinking water standard.
[r]From *Methods of Analysis of Water and Waste* (EPA 1983).

AEA = alpha energy analysis
CVAA = cold vapor atomic absorption
GC = gas chromatograph
GCMS = gas chromatograph/mass spectrometry
GPC = gas proportional counter
IC = ion chromatography
ICPMS = inductively coupled plasma mass spectrometer
N/A = not applicable
TBD = to be determined
TOC = total organic carbon
VOA = volatile organic analysis

Table B-4. Sample Preservation, Container, and Holding Time Guidelines. (2 Pages)

Analytes	Analytical Priority	Matrix	Bottle		Amount[a,b,c]	Preservation	Packing Requirements	Holding Time
			Number	Type				
Radionuclides								
Americium-241	10	Soil	1	G/P	10-1000 g	None	None	6 months
Carbon-14	7	Soil	1	G/P	10-1000 g	None	None	6 months
Cesium-137	1	Soil	1	G/P	100-1500 g	None	None	6 months
Cobalt-60	1	Soil						
Europium-152	1	Soil						
Europium-154	1	Soil						
Europium-155	1	Soil						
Radium-226	1	Soil						
Radium-228	1	Soil						
Tritium – H3	15	Soil	1	G	100-500 g	None	None	6 months
Neptunium-237	6	Soil	1	G/P	10-1000 g	None	None	6 months
Nickel-63	6	Soil	1	G/P	10-1000 g	None	None	6 months
Plutonium-238	1	Soil	1	G/P	10-1000 g	None	None	6 months
Plutonium-239/240	1	Soil						
Strontium-90	1	Soil	1	G/P	10-1000 g	None	None	6 months
Technetium-99	6	Soil	1	G/P	10-1000 g	None	None	6 months
Thorium-232	5	Soil	1	G/P	10-1000 g	None	None	6 months
Uranium-234	1	Soil	1	G/P	10-1000 g	None	None	6 months
Uranium-235	1	Soil						
Uranium-238	1	Soil						
Chemicals								
Ammonia/ ammonium – 350.1	11	Soil	1	G/P	50-500 g	None	Cool 4°C	28 days
Conductivity – 9050	12	Soil	1	G/P	200 g	None	Cool 4°C	28 days
IC anions – 300.0	3	Soil	1	G/P	50-500 g	None	None	28 days/ 48 hours
IC anions – 353.1 for nitrate/nitrite	3	Soil	1	G/P	-250 g	None	None	28 days/ 48 hours
ICP metals – 6010A	2	Soil	1	G/P	10-500 g	None	None	6 months
Chromium hex – 7196	4	Soil	1	G/P	5-500 g	None	Cool 4°C	30 days
Mercury – 7471 – (CVAA)	2	Soil	1	G	5-125 g	None	None	28 days
Total cyanide – 9010	13	Soil	1	G	10-1000 g	None	Cool 4°C	14 days
pH (soil) – 9045	14	Soil	1	G/P	10-250 g	None	None	ASAP
pH (soil) – field measurement	14	Soil	N/A	N/A	N/A	N/A	N/A	N/A
SVOA – 8270A	8	Soil	1	aG	125-1000 g	None	Cool 4°C	14/40 days
Total organic carbon - 9060	9	Soil	1	G	125-250 g	None	Cool 4°C	14 days
VOA - 8260	19	Soil	1	G	10-50 g	None	Cool 4°C	14 days
Nonhalogenated VOA – 8015M	8	Soil	1	G	10-50 g	None	Cool 4°C	14 days
Physical Properties								
Bulk density – D2937	16	Soil	1	Liner	Liner	None	None	None established for analysis
Moisture content – ASTM D2216	17	Soil	1	Moisture Tin[d]	250 g	None	None	None established for analysis

Table B-4. Sample Preservation, Container, and Holding Time Guidelines. (2 Pages)

Analytes	Analytical Priority	Matrix	Bottle		Amount[a,b,c]	Preservation	Packing Requirements	Holding Time
			Number	Type				
Particle size distribution – ASTM D422	18	Soil	1	G/P	100-4000 g	None	None	None established for analysis

[a]Optimal volumes, which may be adjusted downward to accommodate the possibility of retrieval of small amount of sample. Minimum sample size will be defined in the Sampling Authorization Form.

[b]Should samples be liquid rather than soils, the following volumes need to be collected:

Radionuclides – 4 L for all radionuclides (except carbon-14, tritium, and technetium-99; they require approximately 500 mL each sample).

Chemicals – All liquid samples require the amount as listed for soil samples. Preservation and holding times are also affected if liquid samples are collected. Consult ERC Sample Management staff for details.

[c]Mixed soil samples may be obtained and submitted to the analytical laboratory for analyses for specific analytes, including the following:

Radionuclides – 100 g of soil for all radionuclides (except carbon-14, tritium, and technetium-99; they require approximately 10 g each sample).

Chemicals – A 10-g soil sample is required for all ICP analysis, 10-g soil sample is required for IC anion analysis, 5-g soil sample for hexavalent chromium analysis, 10-g soil sample for CA analysis, 10-g soil sample for 8015 analysis, and 125-g soil samples for each 8270 and TOC analyses.

[d]Note: Vessel must be sealed.

aG = amber glass
ASAP = as soon as possible
G = glass
P = plastic
TBD = to be determined

B.3 FIELD SAMPLING PLAN

B.3.1 Sampling Objectives

The primary objective of the field sampling plan (FSP) is to identify and describe sampling and analysis activities that will be conducted to resolve decision rules identified in Step 5 of the DQO process (see Section B.1.2.2). Decision rule statements indicate that remedial action may be necessary if preliminary action levels and annual exposure protection limits are exceeded. The FSP uses the sampling design proposed in Step 7 of the DQO process and describes pertinent elements of the sampling program. Sample methods, procedures, locations, frequencies, parameters of interest, and bottle requirements are identified in this section.

A borehole will be drilled through each of the representative sites identified in the DQO as needing additional data to support the RI/FS or TSD closure processes: the 216-A-19 Trench, the 216-B-12 Crib, the 216-A-10 Crib, and the 216-A-36B Crib. The boreholes will be drilled to the top of groundwater and soil samples will be collected through the vadose zone for laboratory analysis. Physical property samples will be collected at major lithologic changes and as determined by the site geologist. The boreholes will be geophysically logged for gamma-emitting radionuclides and neutron moisture content. A spilt-spoon sampler will be the primary sampling device used to collect the samples from the boreholes. The locations of planned and existing boreholes are shown in Figures B-1 through B-3.

B.3.2 Field Measurements

B.3.2.1 Surface Radiation Survey. A surface radiation survey will be performed at each waste site to be investigated to document existing surface contamination and to support preparation of supporting health and safety documentation. Surface radiation surveys will be conducted by qualified RCTs in accordance with applicable health and safety procedures. A survey report will be prepared for each site. Surveys will be performed according to BHI-EE-05, Procedure 2.22, "Operation of the Global Positioning Environmental Radiological Surveyor (GPERS-11)," and Procedure 2.5, "Operation of the Mobile Surface Contamination Monitor II," or other applicable approved procedures. A post-sampling survey will also be performed at each sampling site to ensure that sampling activities have not contributed to surface contamination.

B.3.2.2 Soil Screening. All samples and cuttings from boreholes will be field screened for evidence of radioactive contamination by the RCT or other qualified personnel. Surveys of these materials will be conducted visually and with field instruments. Potential screening instruments are listed in Table B-5 with their respective detection limits. The RCT will record all field measurements, noting the depth of the sample and the instrument reading.

Prior to drilling, a local area background reading will be taken with the field screening instruments at a background site to be selected in the field. Field screening will be used to identify the bottom of the waste site (i.e., crib/trench) and adjust sampling points, assist in determining sample shipping requirements, and support worker health and safety monitoring. The site geologists will use professional judgment, screening data, and the information provided in Tables B-6 through B-9 to finalize sampling decisions.

The field action level for radionuclide screening is twice background. Intervals above this field action level will be assessed for sampling by the field geologist. Samples exceeding 0.5 mrem/hr will be stored at a temporary radioactive material storage area, separated from other samples, until shipment to the laboratory.

Additional field screening for volatile organics will be performed by the health and safety technician using a photoionization detector or other methods, if required by the site-specific health and safety plan. Field screening instruments will be used, maintained, and calibrated in accordance with the manufacturer's specifications and approved procedures such as those found in BHI-EE-05. The field geologist will record field screening results on the borehole log.

B.3.3 Soil Sampling and Analysis

The following sections discuss the details of sampling soil from boreholes.

B.3.3.1 Borehole Sampling and Analysis. Nonradiological and radiological samples will be collected from four deep boreholes. Borehole C3245 will be drilled in the 216-A-19 Trench. Borehole C3246 will be in drilled in the 216-B-12 Crib. Borehole C3247 will be drilled in the 216-A-10 Crib. Borehole C3248 will be drilled in the 216-A-36B Crib. Borehole sample collection will be guided by the sampling approaches outlined in Tables B-6, B-7, B-8, and B-9. Actual sampling intervals may vary from these approaches depending on the thickness of clean soil cover or stabilization fill placed over the cribs and trench, field screening results, and varying subsurface conditions. The intent of the sampling design is to begin sample collection at approximately 4.6 m (15 ft) below ground surface (bgs). This is followed by samples beginning at the base of the crib or trench where the highest levels of contamination are expected. Samples from 4.6 m (15 ft) are critical for evaluation of direct exposure scenarios, whereas a sample from 7.6 m (25 ft) is considered desirable for remedial alternative evaluation. Samples from depths greater than the base of the waste site will be used to verify the conceptual contaminant distribution model and to evaluate remedial action alternatives and groundwater impacts.

From the base of the crib or trench samples will be collected with greater frequency while contamination is at the highest concentrations. As depth increases, the level of contamination is expected to decrease and the frequency of sampling will also decrease. Samples will be taken at the transitions from high to medium to low contamination zones as guided by the site's conceptual contamination distribution model, results of nearby borehole logging events, and professional judgement of the field geologist. Samples will also be taken at major changes in lithology as noted by the field geologist. Drilling and sampling will stop when the water table is encountered. Figures B-4 through B-7 illustrate the anticipated sampling intervals in each of the boreholes to be drilled.

Sampling will be performed in accordance with BHI-EE-01, Procedure 4.0, "Soil and Sediment Sampling," using a split-spoon sampler. The split-spoon samplers will be equipped with four separate stainless steel (for chemical analyses) or lexan liners (for physical property analyses). Site personnel will use caution not to overdrive the sampling device. With the exception of the co-located duplicate samples, soil will be transferred to a pre-cleaned, stainless steel mixing bowl, homogenized, and then containerized in accordance with the sampling procedure.

Radiological and nonradiological analytes of interest are presented in Table B-3. If sample volume requirements cannot be met, samples will be collected according to the priority presented in Table B-4. Radiological and nonradiological samples will always take precedence over physical property samples.

Physical property samples will be collected from the boreholes to provide site-specific values to support the RESidual RADioactivity (RESRAD) dose model or other modeling efforts. Soil properties of interest are moisture content, grain-size distribution, and soil density. Samples for soil density shall generally be collected with a split-spoon sampler equipped with four separate lexan liners. Samples will be analyzed in accordance with the ASTM methods listed in Table B-4 (ASTM 1993) or in accordance with approved field procedures. The physical property samples will be collected from lithologies that represent the major facies in the vadose zone as identified in Tables B-6 and B-9. The samples will be collected coincident with nonradiological and radiological split-spoon sample intervals, where possible.

Investigation-derived waste generated during this activity will be handled according to procedures in Section B.2.7 and the waste control plan.

B.3.3.2 Pre-Shipment Sample Screening. A representative portion of each sample to be shipped to an offsite laboratory will be submitted to the RCF, 222-S Laboratory, or other suitable onsite laboratory for total activity analysis prior to shipment. Total activities will be utilized for sample pre-shipment characterization. Samples that slightly exceed the offsite laboratory criterion discussed in Section B.2.7.6 may be reduced in volume to allow offsite shipment. Onsite and offsite laboratories will be identified prior to initiating field activities and will be mutually acceptable to the ERC's Sample and Data Management group and to the task lead.

B.3.3.3 Summary of Sampling Activities. A summary of the number and types of samples to be collected at all four waste sites is presented in Table B-10.

B.3.4 Geophysical Logging

The planned boreholes and selected existing boreholes will be geophysically logged with the high-resolution spectral gamma-ray logging system to assess the vertical distribution and concentration of gamma-emitting radionuclides. Soil moisture will also be assessed using a neutron logging tool for all new boreholes only. These methods are described in Section 4.3 of the work plan. The new boreholes will be logged prior to telescoping of casing and before decommissioning activities. The starting point for logging will be recorded; this is usually ground surface or top of casing. The site geologist will witness logging runs and verify before and after field calibrations and repeat log intervals. The list of boreholes and wells that will be logged with the spectral gamma logging system is presented in Table B-11. These wells represent data collection points in the vicinity of the individual waste sites. Logging of these wells will provide additional, updated, site-specific information on gamma contaminant distribution, both laterally and vertically in the area of the waste sites.

The location of the area of highest potential contamination within the 216-A-10 Crib is uncertain due to 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 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 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 (see Figure 3-14 of the work plan).

B.3.5 Surveying

The location of all new boreholes will be surveyed after the sampling and decommissioning activities are completed. Surveys will be performed according to BHI-EE-01, Procedure 1.6, "Survey Requirements and Techniques." Data will be recorded in the North American Vertical Datum of 1988 (NAVD 1988) and the Washington State Plane (South Zone) North American Datum of 1983 (NAD 1983), with the 1991 adjustment for horizontal coordinates. All survey data will be recorded in meters and feet.

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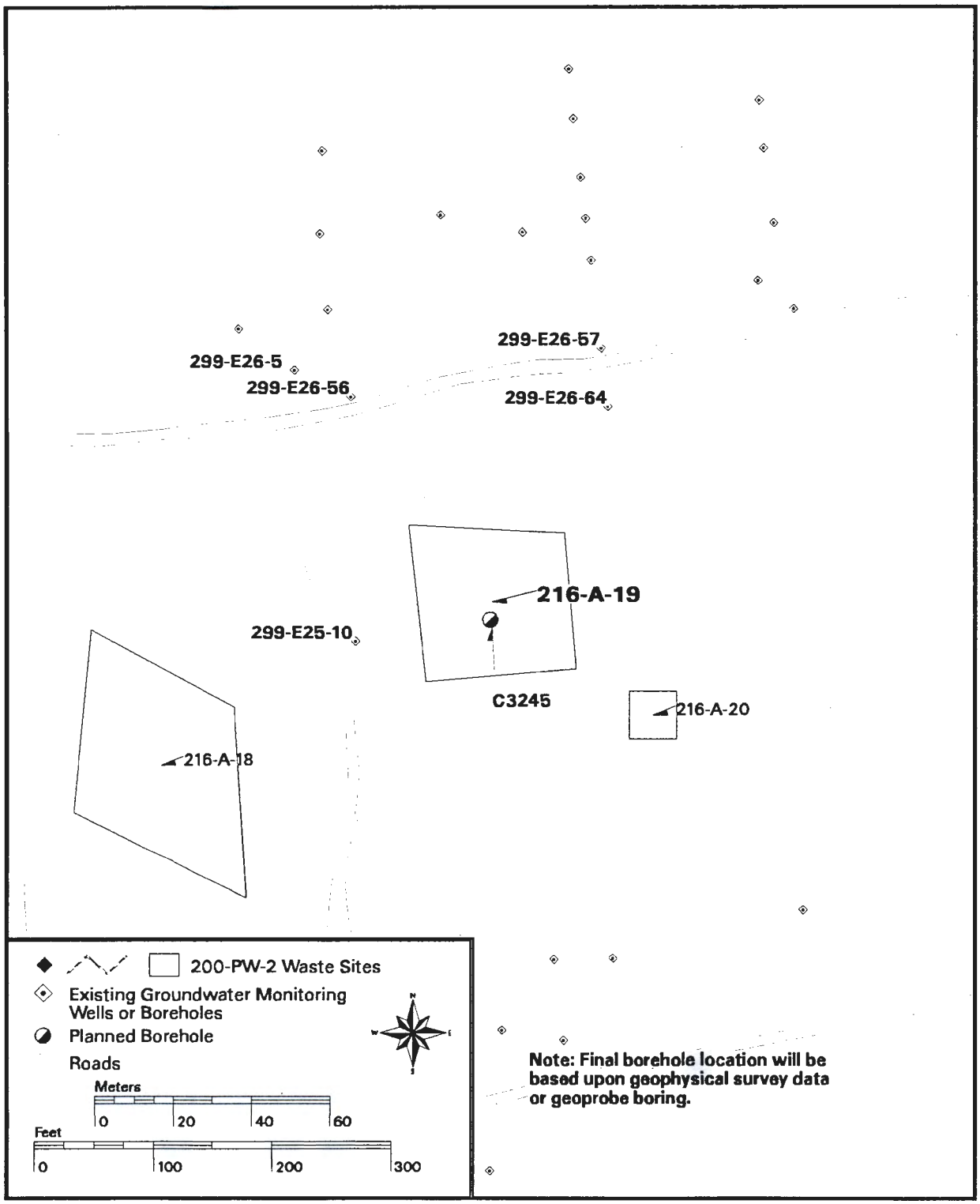
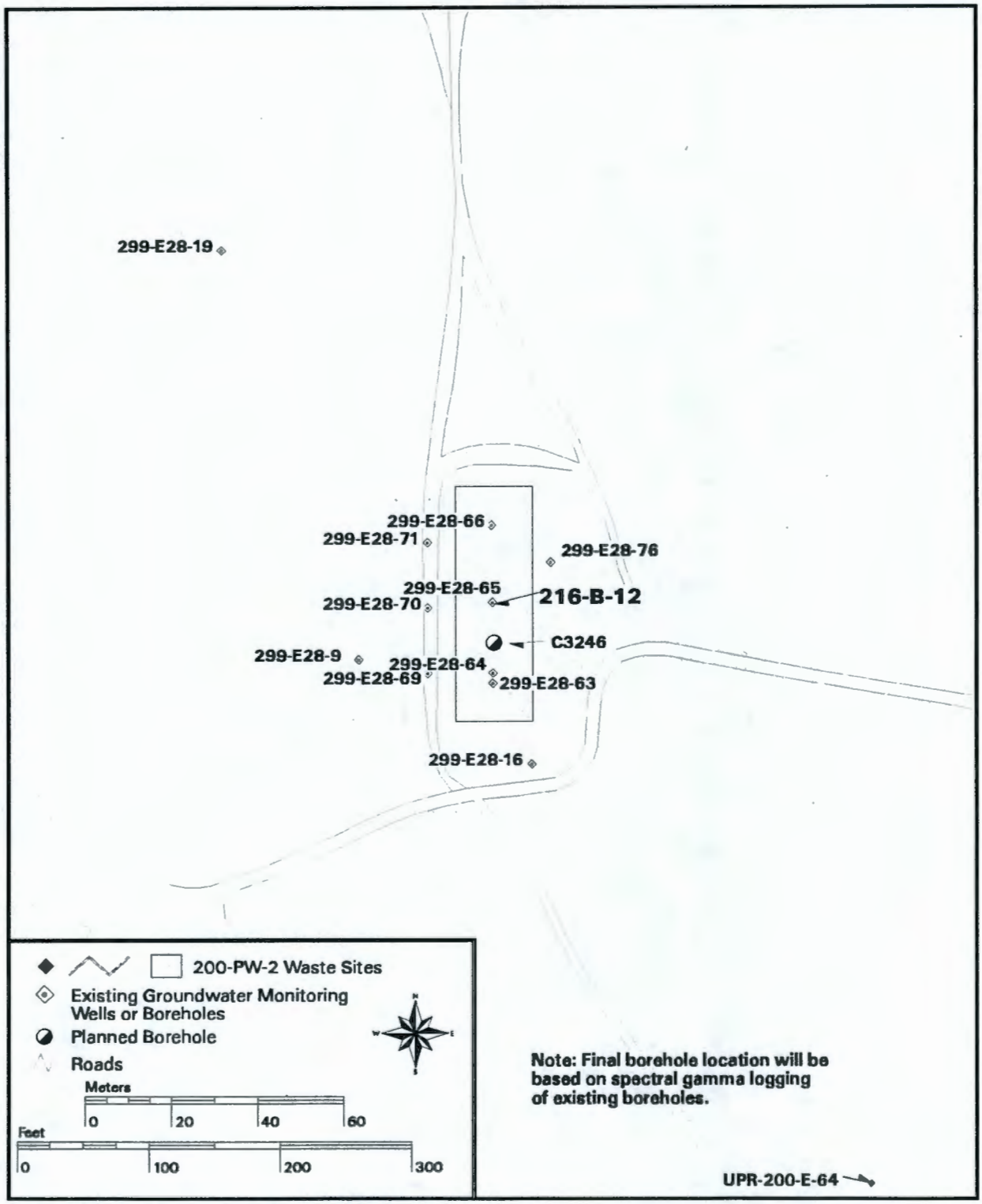
Figure B-1. Location of Planned and Existing Boreholes and Wells at the 200-PW-2 216-A-19 Trench.



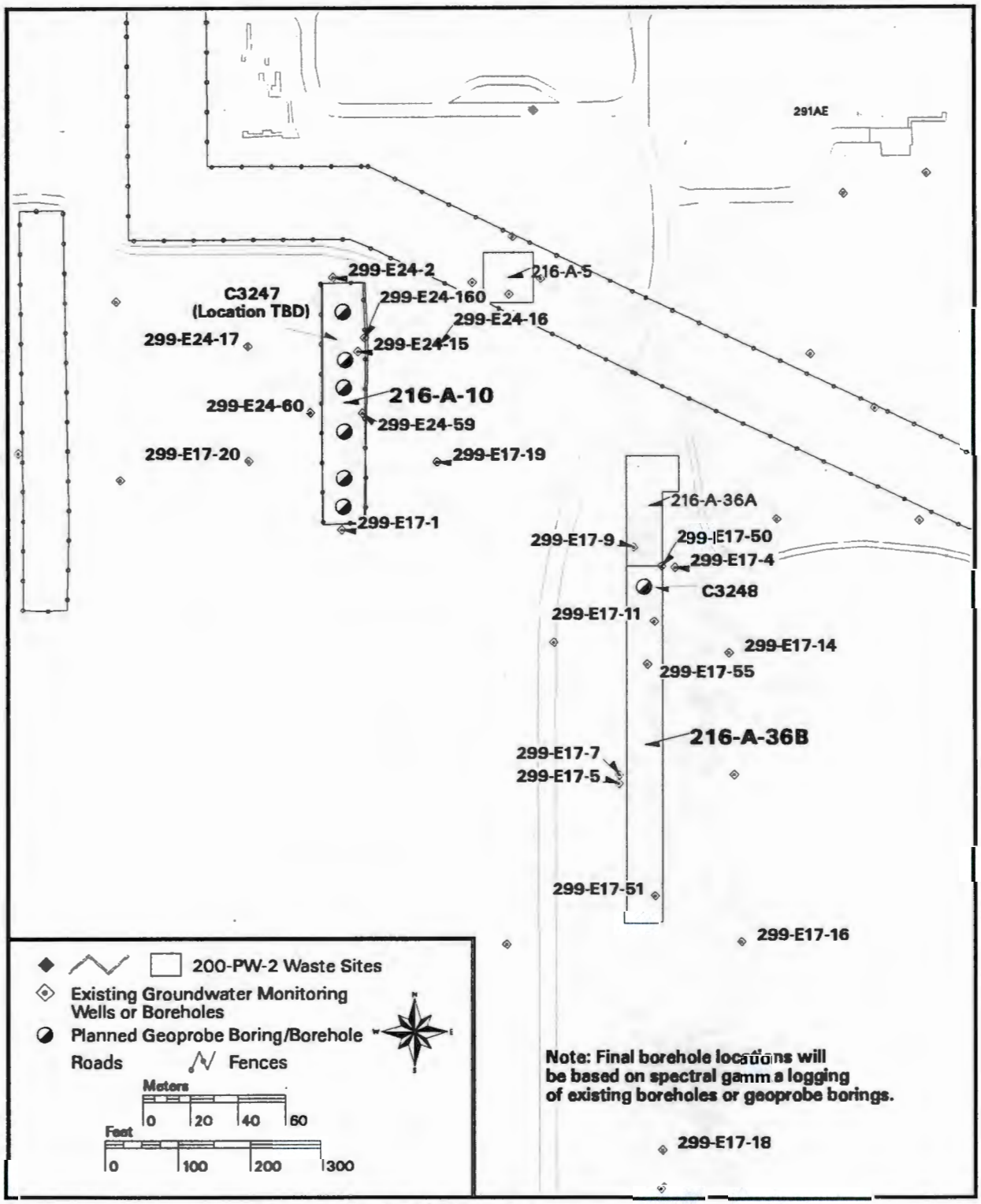
BHI:maa 06/27/00 /home/maaye/amls/uwaste_borehole2e <both> Plotted 22-JAN-2001 Rev 4

Figure B-2. Location of Planned and Existing Boreholes and Wells at the 200-PW-2 216-B-12 Crib.



BHI:maa 06/27/00 /home/maaye/amls/uwaste_borehole2e <both> Plotted 22-JAN-2001 Rev 4

Figure B-3. Location of Planned and Existing Boreholes and Wells at the 200-PW-2 216-A-10 Crib and 216-A-36B Crib.



BHI:maa 06/27/00 /home/maaye/amls/uwaste_borehole2e <both> Plotted 22-JAN-2001 Rev 4

Figure B-4. Approximate Sampling Intervals in the 216-A-19 Borehole.

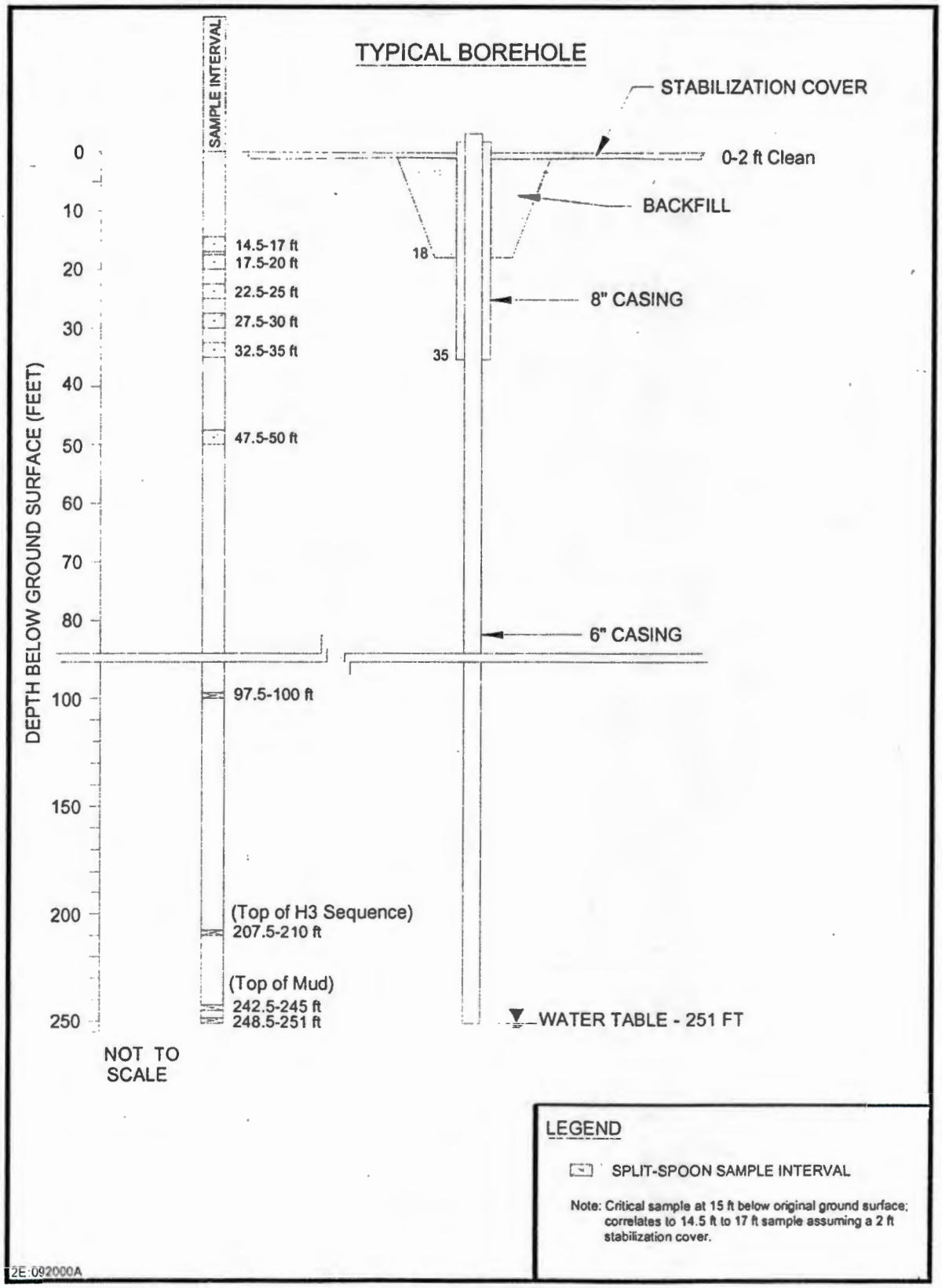


Figure B-5. Approximate Sampling Intervals in the 216-B-12 Borehole.

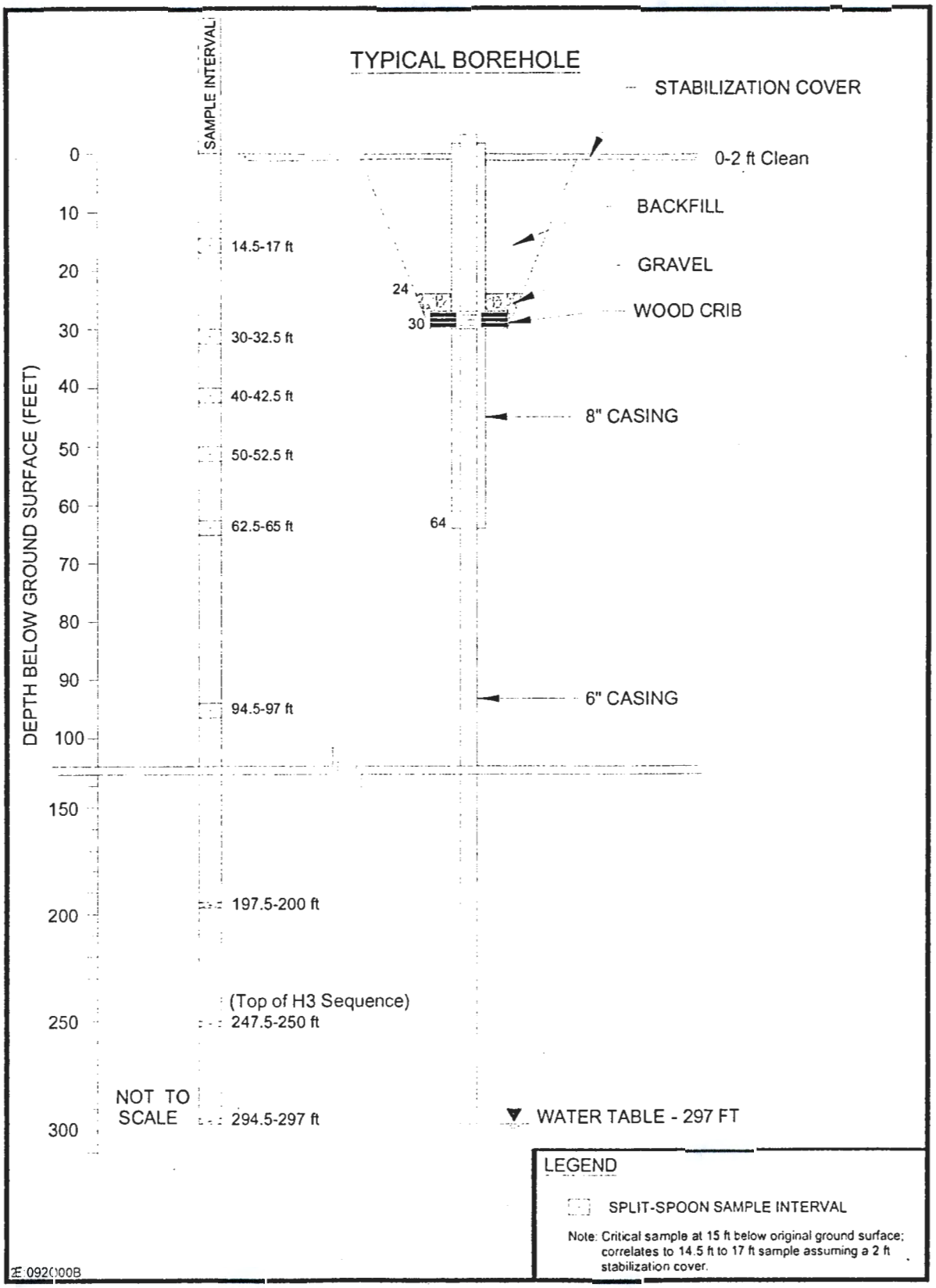


Figure B-6. Approximate Sampling Intervals for the 216-A-10 Borehole.

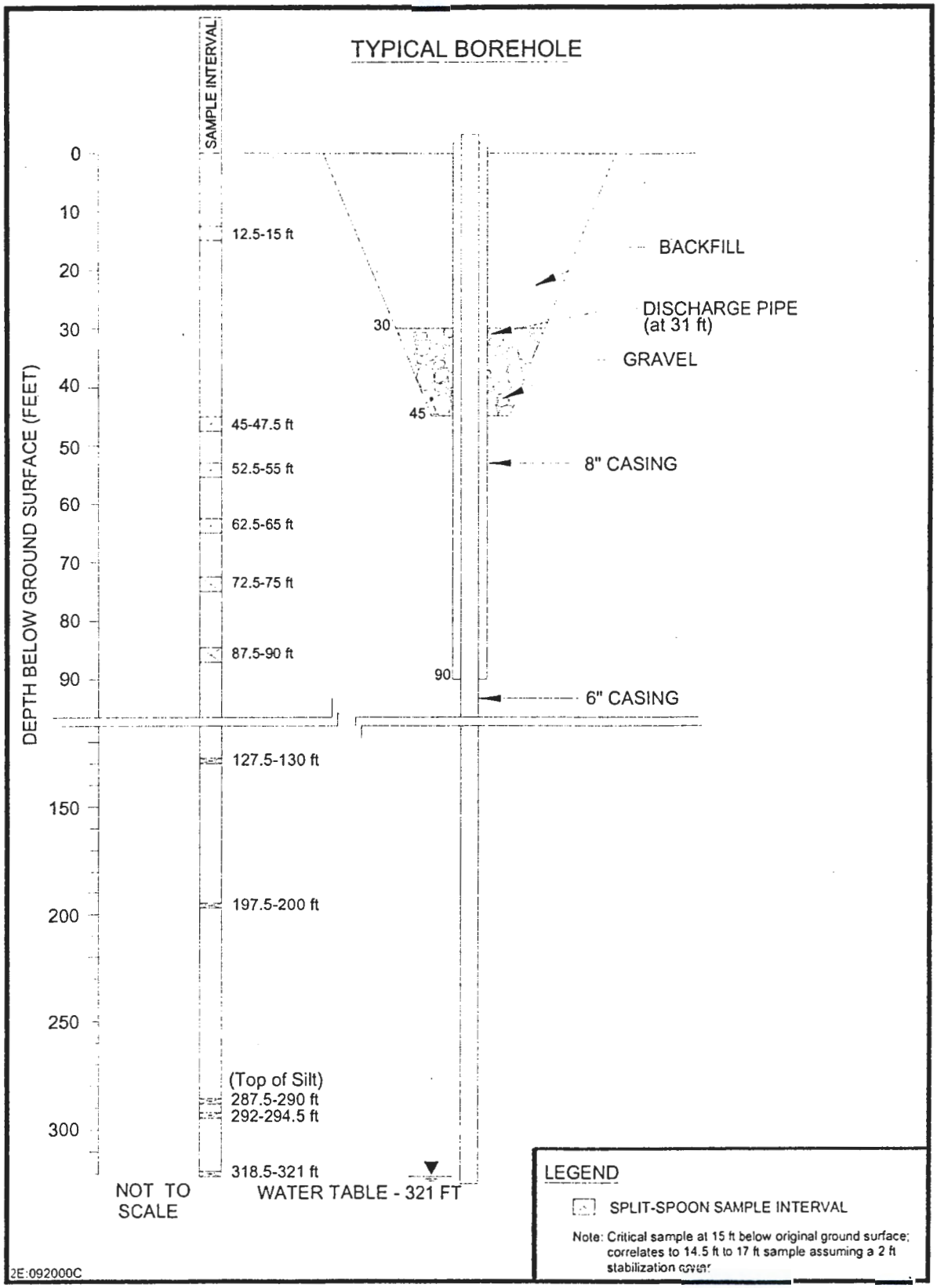


Figure B-7. Approximate Sampling Intervals for the 216-A-36B Borehole.

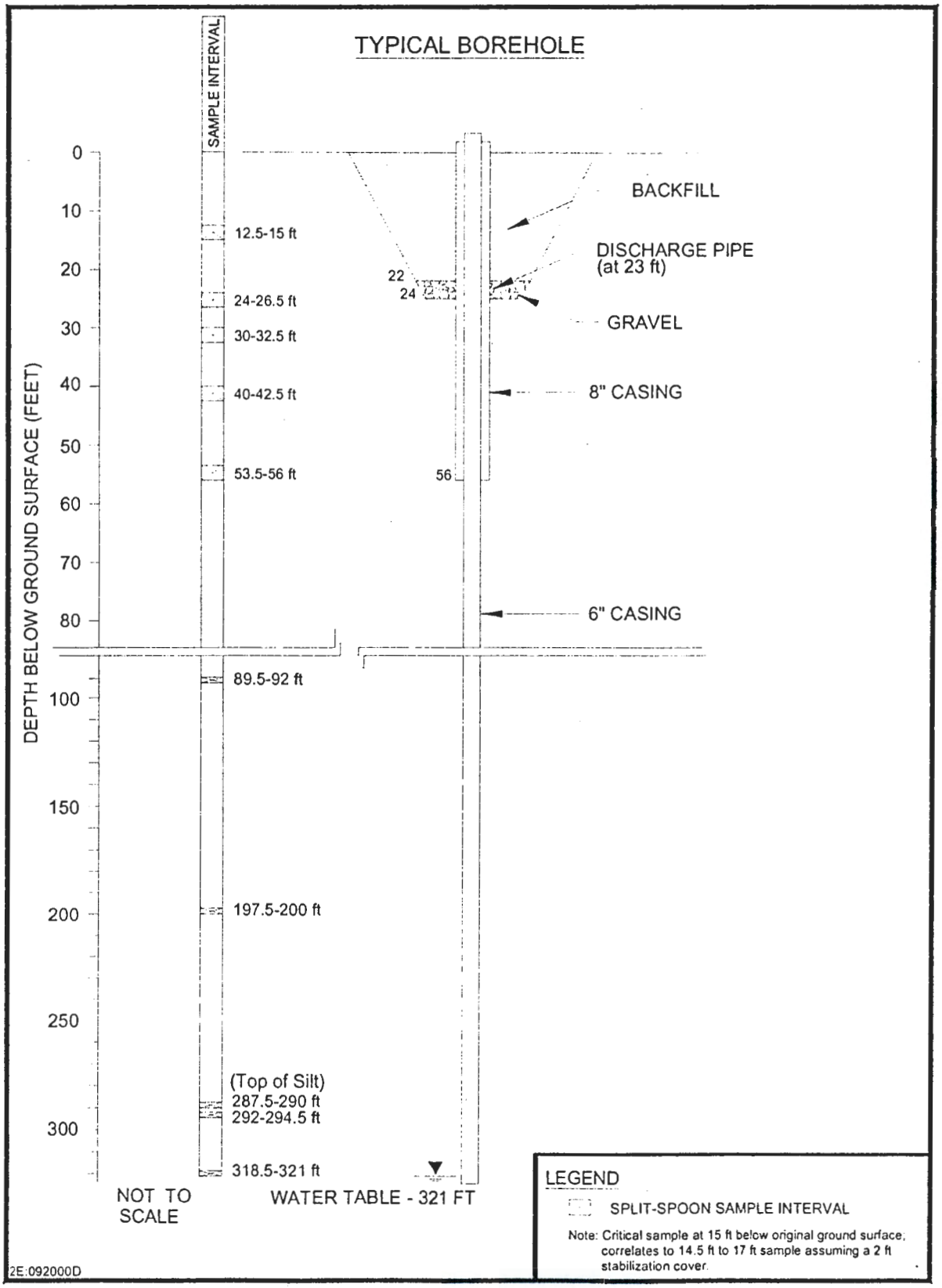


Table B-5. Field Screening Methods.

Measurement Type	Emission Type	Method/Instrument	Detection Limit
Exposure/dose rate	Beta/gamma	RO-20/RO-03 portable ionization chamber	0.5 Mr/hr
Contamination level	Alpha/beta-gamma	E-600 ratemeter with a SHP380-A/B scintillation probe	100 dpm α 1,921 dpm β–γ

Table B-6. 216-A-19 Trench Sampling Plan.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft) bgs[a]	Analyte List[b]	Physical Properties	
					Sample Interval	Parameters
Borehole C3245	C3245	251 ft bgs	14.5-17, 17.5-20, 22.5-25, 27.5-30, 32.5-35, 47.5-50, 97.5-100, 207.5-210, 242.5-245, 248.5-251	Table B-4	One sample from each of the following: • H_1 • H_2 • H_3 • Mud Sequence	Bulk density, moisture content, particle size distribution
Maximum Number of Samples		10				
Approximate Number of Field QC Samples		2[c]				
Approximate Total Number of Samples		12				

[a]Actual sampling depths may vary depending on the amount of backfill/overburden used in interim stabilization activities at the waste site, field screening results, and varying subsurface conditions.
[b]See Table B-3 for detection limits and other analytical parameters.
[c]See Table B-10 for details of QC samples.
bgs = below ground surface
H_1 = Hanford formation Upper Gravel Sequence
H_2 = Hanford formation Sandy Sequence
Note: Approximate coordinates of center of trench: N136277.45, E575665.06

Table B-7. 216-B-12 Crib Sampling Plan.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft) bgs[a]	Analyte List[b]	Physical Properties	
					Sample Interval	Parameters
Borehole C3246	C3246	297 ft	14.5-17, 30-32.5, 40-42.5, 50-52.5, 62.5-65, 94.5-97, 197.5-200, 247.5-250, 294.5-297	Table B-4	One sample from each of the following: • H_2 • H_3	Bulk density, moisture content, particle size distribution
Maximum Number of Samples		9				
Approximate Number of Field QC Samples		2[c]				
Approximate Total Number of Samples		11				

[a]Actual sampling depths may vary depending on the amount of backfill/overburden used in interim stabilization activities at the waste site, field screening results, and varying subsurface conditions.
[b]See Table B-3 for detection limits and other analytical parameters.
[c]See Table B-10 for details of QC samples.
bgs = below ground surface
H_2 = Hanford formation Sandy Sequence
H_3 = Hanford formation Gravel Sequence

Table B-8. 216-A-10 Crib Sampling Plan.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft) bgs[a]	Analyte List[b]	Physical Properties	
					Sample Interval	Parameters
Borehole C3247	C3247	321 ft	12.5-15, 45-47.5, 52.5-55, 62.5-65, 72.5-75, 87.5-90, 127.5-130, 197.5-200, 287.5-290, 292-294.5, 318.5-321	Table B-4	1 sample from each of the following: • H_2 • Silt Sequence • Ringold Unit A	Bulk density, moisture content, particle size distribution
Maximum Number of Samples		11				
Approximate Number of Field QC Samples		2[c]				
Approximate Total Number of Samples		13				

[a]Actual sampling depths may vary depending on the amount of backfill/overburden used in interim stabilization activities at the waste site, field screening results, and varying subsurface conditions.
[b]See Table B-3 for detection limits and other analytical parameters.
[c]See Table B-10 for details of QC samples.
bgs = below ground surface
H_2 = Hanford formation Sandy Sequence

Table B-9. 216-A-36B Crib Sampling Plan.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft) bgs[a]	Analyte List[b]	Physical Properties	
					Sample Interval	Parameters
Borehole C3248	C3248	321 ft	12.5-15, 24-26.5, 30-32.5, 40-42.5, 53.5-56, 89.5-92, 197.5-200, 287.5-290, 292-294.5, 318.5-321	Table B-4	One sample from each of the following: • H_2 • Silt Sequence • Ringold Unit A	Bulk density, moisture content, particle size distribution
Maximum Number of Samples		10				
Approximate Number of Field QC Samples		2[c]				
Approximate Total Number of Samples		12				

[a]Actual sampling depths may vary depending on the amount of backfill/overburden used in interim stabilization activities at the waste site, field screening results, and varying subsurface conditions.
[b]See Table B-3 for detection limits and other analytical parameters.
[c]See Table B-10 for details of QC samples.
bgs = below ground surface
H_2 = Hanford formation Sandy Sequence
H_3 = Hanford formation Gravel Sequence

Table B-10. Summary of Projected Sample Collection Requirements.

	216-A-19 Trench	216-B-12 Crib	216-A-10 Crib	216-A-36B Crib	Project Total
Chemical Parameters					
Projected maximum number of characterization samples	10	9	11	10	40
Detail of QC samples					
Co-located duplicates	1	1	1	1	4
Equipment blanks	1	1	1	1	4
Approximate number of field QC samples	2	2	2	2	8
Approximate total number of samples	12	11	13	12	48
Physical Properties					
Bulk density, moisture content, particle size distribution	4	2	3	3	12

Table B-11. List of Boreholes for Spectral Gamma-Ray Logging.

Borehole Number	Approximate Location	Coordinates (Wash. State Plane, NAD83[91])	
		Northing	Easting
C3245[a]	Within the boundaries of the 216-A-19 Trench	TBD	TBD
C3246	Within the boundaries of the 216-B-12 Crib	TBD	TBD
C3247[a]	Within the boundaries of the 216-A-10 Crib; will also log direct push holes to help define borehole location	TBD	TBD
C3248[a]	Within the boundaries of the 216-A-36B Crib	TBD	TBD
299-E28-64	Within the boundaries of the 216-B-12 Crib	136584.01	573127.762
299-E28-65	Within the boundaries of the 216-B-12 Crib	136600.469	573127.558
299-E28-66	Within the boundaries of the 216-B-12 Crib	136618.537	573127.34
299-E28-71	West of the 216-B-12 Crib	136614.438	573112.438
299-E28-76	Eastern edge of the 216-B-12 Crib	136609.872	573141.211
299-E28-16	South of the 216-B-12 Crib	136562.635	573136.748
299-W19-70	Within the boundaries of the 216-U-8 Crib	134697.757	567615.853
299-W19-71	Within the boundaries of the 216-U-8 Crib	134679.761	567616.007
299-W22-75	Within the boundaries of the 216-U-12 Crib	134490.421	567594.191
299-E17-1	Southern edge of the 216-A-10 Crib	135386.153	574977.079
299-E24-2	Northern edge of the 216-A-10 Crib	135493.023	574973.639
299-E24-59	Eastern edge of the 216-A-10 Crib	135435.478	574985.793
299-E24-60	Western edge of the 216-A-10 Crib	135435.779	574964.093
299-E17-5	Western edge of the 216-A-36B Crib	135278.548	575093.967
299-E17-11	Within the boundaries of the 216-A-36B Crib	135347.191	575109.138
299-E17-51	Within the boundaries of the 216-A-36B Crib	135230.501	575109.364

NOTE: Initial selection of existing wells was based on a review of well construction as-built diagrams. A single casing in contact with the formation is the preferred configuration for logging. A field inspection of the well configuration will be performed for final selection of boreholes. No logging of existing boreholes at 216-A-19 is planned because the closest borehole in this area was recently logged.
[a] Planned boreholes.

B.4 HEALTH AND SAFETY

All field operations will be performed in accordance with BHI health and safety requirements outlined in BHI-SH-01, *ERC Safety and Health Program*, and in accordance with the requirements of the *Hanford Site Radiological Control Manual* (DOE-RL 1996b). In addition, a work control package will be prepared in accordance with BHI-MA-02, *ERC Project Procedures*, which will further control site operations. This package will include an activity hazard analysis, site-specific health and safety plan, and applicable radiological work permits. BHI-FS-01, Volume 1, Procedure 2.4, "Pre-Job Walkdowns, Hazard Identification, and Analysis," will also be used during work control package preparation.

The sampling procedures and associated activities will take into consideration exposure reduction and contamination control techniques that will minimize the radiation exposure to the sampling team as required by BHI-QA-01, *ERC Quality Program*, and BHI-SH-01.

B.5 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Investigation-derived waste generated by characterization activities will be managed in accordance with BHI-EE-10, *Waste Management Plan*, and Appendix E of the Implementation Plan. Containment, labeling, and tracking requirements are specified in BHI-EE-10, Part II, Section 9.0, "Control of CERCLA and Other Past Practice Investigation Derived Waste." These procedures have been prepared to implement the requirements of the Washington State Department of Ecology, found in *Strategy for Management of Investigation Derived Waste* (Ecology et al. 1999). Management of investigation-derived waste, minimization practices, and waste types applicable to 200-PW-2 waste control are described in the waste control plan.

Unused samples and associated laboratory waste for the analysis will be dispositioned in accordance with the offsite laboratory contract, which in most cases will require the laboratory to dispose of this material. Similar materials from onsite laboratories will either be disposed by the laboratory or returned to the project. The approval of the remedial project manager is required before returning unused samples or waste from offsite laboratories.

B.6 REFERENCES

40 CFR 830.120, "Quality Assurance Requirements," *Code of Federal Regulations*, as amended.

49 CFR, "Transportation," *Code of Federal Regulations*, as amended.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

Agnew, S. F., J. Boyer, R. S. Corbin, T. B. Duran, J. R. Fitzpatrick, K. S. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*, LA-UR-96-3860, Rev. 4, Los Alamos National Laboratory, Los Alamos, New Mexico.

ASTM, 1993, *1993 Annual Book of ASTM Standards*, Volume 04.08, American Society for Testing and Materials, Philadelphia, Pennsylvania.

BHI, 2000, *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Units*, BHI-01411, Rev. 0 Pending, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-02, *Environmental Requirements*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-05, *Field Screening Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-10, *Waste Management Plan,* Bechtel Hanford, Inc., Richland, Washington.

BHI-FS-01, *Field Support Administration*, Volume 1, Bechtel Hanford, Inc. Richland, Washington.

BHI-MA-02, *ERC Project Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-01, *ERC Quality Program*, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-03, *ERC Quality Assurance Program Plans*, Bechtel Hanford, Inc., Richland, Washington.

BHI-RC-01, *Radiation Protection Program Manual*, Bechtel Hanford, Inc., Richland, Washington.

BHI-RC-04, *Radiological Control Work Instructions*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-01, *ERC, Safety and Health Program*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-02, *Safety and Health Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-05, *Industrial Hygiene Work Instructions*, Bechtel Hanford, Inc., Richland, Washington.

Borsheim, G. L. and B. C. Simpson, 1991, *An Assessment of the Inventories of the Ferrocyanide Watchlist Tanks*, WHC-SD-WM-ER-133, Westinghouse Hanford Company, Richland, Washington.

Comprehensive environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

Diediker, L. P., 1999, *Radionuclide Inventories of Liquid Waste Sites at Hanfor*d, HNF-1744, Fluor Daniel Hanford, Richland, Washington.

DOE Order 5700.6c, *Quality Assurance*, as amended, U.S. Department of Energy, Washington, D.C.

DOE, 1999, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, DOE/EIS-0222-F, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1993, *B Plant Source Aggregate Area Management Study Report*, DOE/RL-92-05, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996a, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD), DOE/RL-96-68, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996b, *Hanford Site Radiological Control Manual* (HSRCM), DOE/RL-96-109, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2000, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, 1995, *Guidance on Sampling and Data Analysis Methods*, Publication No. 94-049, Washington State Department of Ecology, Olympia, Washington.

Ecology, EPA, and DOE, 1998, *Hanford Federal Facility Agreement and Consent Order*, 2 vols, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ecology, EPA, and DOE, 1999, *Strategy for Management of Investigation Derived Waste*, (letter from R. Stanley, Washington State Department of Ecology, D. R. Sherwood, U.S. Environmental Protection Agency, and K. M. Thompson, U.S. Department of Energy, Richland Operations Office, dated July 26, 1995), Richland, Washington.

EPA, 1983 *Methods of Analysis of Water and Wastes*, EPA-600/4-79-020, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1994a, *Guidance for the Data Quality Objectives Process*, EAP QA/G-4, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1994b, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, QA/R-5, U.S. Environmental Protection Agency, Quality Assurance Division, Washington, D.C.

EPA, 1994c, *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA/540/R-93/081, Publication Number 9285.7-15, U.S. Environmental Protection Agency, Washington, D.C.

GE, 1944, *Hanford Engineer Works Technical Manual (T/B Plants),* Parts A, B, and C, HW-10475, General Electric Company, Richland, Washington.

GE, 1951, *Uranium Recovery Technical Manual,* HW-19140, General Electric Company, Richland, Washington.

GE, 1955, *Radioactive Contaminants in Liquid Wastes Discharged to Ground at Separation Facilities Through June 1955*, HW-38562, General Electric Company, Richland, Washington.

HEW, 1945, *History of Operations (1 January 1944 to 20 March 1945),* OUT-1462, Hanford Engineer Works, Richland, Washington.

Jacques, I. D. and S. K. Kent, 1991, *200-BP-5 Operable Unit Technical Baseline Report*, WHC-MR-0270, Westinghouse Hanford Company, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

WDOH, 1983, *Hanford Guidance for Radiological Cleanup*, WDOH/320-015, Washington State Department of Health, Olympia, Washington.

WHC, 1993a, *Data Validation Procedures for Radiological Analysis*, WHC-SD-EN-SPP-001, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993b, *Data Validation Procedures for Chemical Analysis*, WHC-SD-EN-SPP-002, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WMNW, 1998, *Sampling Services Procedures Manual*, ES-SSPM-001, Rev. 0, Waste Management Northwest, Richland, Washington.

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