

AR TARGET SHEET

The following document was too large to scan as one unit, therefore it has been broken down into sections.

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SECTION 2 OF 2

APPENDIX C
INFORMATION MANAGEMENT OVERVIEW

DEFINITIONS OF TERMS

Action Plan. Action plan for implementation of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994). The Action Plan defines the methods and processes by which hazardous waste permits will be obtained, and by which closure and post-closure actions under *the Resource Conservation and Recovery Act of 1976* (RCRA) and by which remedial actions under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) will be conducted on the Hanford Site.

Administrative Record. The administrative record is the body of documents and information that is considered or relied upon in arriving at a final decision for a remedial action, removal action, corrective measure, interim measure, RCRA permit, or approved RCRA closure plan.

Data Management. The planning and control of activities affecting information (including data, records, documents, etc.).

Data Validation. The process whereby data are reviewed based on a set of criteria. This aspect of quality assurance involves establishing specified criteria for data validation. The quality assurance project plan (QAPJP) must indicate the specified criteria that will be used for data validation.

Document and Information Services. The central facility and services that provide a files management system for processing information.

Hanford Environmental Information System. A computer-based information system used as a resource for the storage, statistical analysis, and display of investigative data collected for use in site characterization and remediation activities. Subject areas include geophysics/soil gas, vadose zone soil (geologic), groundwater, atmospheric, and biota.

Lead Agency. The regulatory agency (U.S. Environmental Protection Agency [EPA] or Washington State Department of Ecology [Ecology]) that is assigned the primary administrative and technical responsibility with respect to actions at a particular operable unit.

Operable Unit. An operable unit at the Hanford Site is a group of land disposal and groundwater sites placed together for the purposes of site cleanup and remediation. The primary criteria for placement of a site into an operable unit are geographic proximity, similarity of waste characteristics and site types, and the possibility for economies of scale.

Primary Document. A document that contains information, documentation, data, and proposals upon which key decisions will be made with respect to the remedial action or permitting process. Primary documents are subject to dispute resolution and are part of the administrative record.

Project Manager. The individual responsible for implementing the terms and conditions of the Action Plan on behalf of his/her respective party. The U.S. Department of Energy (DOE), EPA, and Ecology will each designate one project manager.

Record of Decision. The CERCLA document used to select the method of remedial action to be implemented at a site after the feasibility study/proposed plan process has been completed.

Secondary Document. As distinguished from a Primary Document, a secondary document is considered to be a supporting document providing information or data and does not, in itself, reflect key decisions. A secondary document is subject to review by the regulatory agencies and is part of the administrative record. It is not subject to dispute resolution.

C1.0 INTRODUCTION AND OBJECTIVES

C1.1 INTRODUCTION

An extensive amount of data will be generated over the next several years in connection with the activities planned for the 200 Areas. Data quality is extremely important to the remediation of the operable unit as agreed on by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and interested parties.

This Information Management Overview (IMO) provides an overview of the data management activities at the operable unit level and identifies procedures and plans that control the collection and handling of these data. The IMO provides information for the project manager, unit managers, task lead, remedial investigation/feasibility study coordinators, and other involved personnel and reviewers in order to fulfill their respective roles. All data collected will be in accordance with the Bechtel Hanford, Inc. (BHI) Environmental Investigations Procedures (EIP) contained in the BHI *Environmental Investigations Procedures* manual (BHI-EE-01).

Data Management Plans for Hanford Site Business Functions (DOE-RL 1995) and *ERC Project Procedures* (BHI-MA-02) are plans and procedures for the management of environmental data and documents generated for the Environmental Restoration Contractor (ERC) program. The purpose of these documents is to identify and fulfill the document and data control requirements of the U.S. Department of Energy, Richland Operations Office, the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [Ecology et al. 1994]), BHI, and the DOE Environmental Restoration (ER) Program.

C1.2 OBJECTIVES

This IMO describes the process for the collection and control procedures for data, records, documents, correspondence, and other information associated with this operable unit. This IMO addresses the following:

- Types of data to be collected
- Plans for managing data
- Organizations controlling data
- Databases used to store the data.

C2.0 TYPES OF DATA

C2.1 TYPES OF DATA

The general types of technical data that may be collected in the 200 Areas are listed in Table C-1. BHI-EE-01 provides the procedures for the collection and management of environmental and site characterizations. Documents controlling activities outlined in the group-specific work plans are also included in Table C-1.

All such data are submitted to BHI Document and Information Services (DIS) for retention and are transmitted to the Administrative Record (AR), if appropriate.

C2.2 DATA COLLECTION

Data collection activities are described in each of the group-specific work plans. Additional direction and detail will be provided in sampling and analysis plans. All data collection will be conducted in accordance with the Quality Assurance Project Plan (QAPjP). Section C2.1 listed the controlling procedures for data collection and handling before turnover to the organization responsible for data storage. All procedures for data collection shall be approved in compliance with BHI-EE-01.

C2.3 DATA STORAGE AND ACCESS

Data will be handled and stored according to procedures approved in compliance with the *ERC Quality Program* (BHI-QA-01). The BHI DIS is the central files management and process facility. Data entering the DIS will be indexed and stored. Data designated for placement into the AR will be copied and placed into the Hanford Site AR file, if appropriate. Retrieval of information may be accomplished through hard copy or electronic data.

Public access to applicable documents is through the Administrative Record Public Access Room located in the 2440 Stevens Center facility in Richland, Washington. This facility includes AR file documents (including identified guidance documents and technical literature).

Administrative record documents consist of the documents and information considered or relied upon in order to arrive at a final decision for site cleanup. Requirements governing the AR for CERCLA actions are specified in Section 113(k) of CERCLA. Tri-Party Agreement unit managers determine what additional documents, including sampling and analysis results, sample validation, technical studies, inspection and other studies that may be appropriate for inclusion as part of the AR. The Tri-Party Agreement defines a number of these documents as primary and secondary documents. Definition as primary or secondary determines administrative requirements applicable to the document.

Unit managers may access data that are not in the AR by requesting it at the monthly unit managers' meeting for the waste site group of concern or by contacting the group specific task lead. As the project moves towards the Record of Decision, all of the relevant data will be contained in the AR and the need to access data by requesting it at the unit managers' meetings will be minimal.

In addition to the AR, the following types of data will be accessed from and reside in locations other than the BHI DIS:

- Quality assurance/quality control laboratory data
- Sample status
- Training records
- Meteorological data
- Radiological exposure.

C2.4 DATA QUANTITY

Data quantities for the investigative activities will be estimated based on the sampling and analysis plans developed for investigation of representative sites within each waste site group. Section 6.2 of the 200 Areas Implementation Plan describes the general field investigation activities that will take place.

C3.0 DATA MANAGEMENT

C3.1 OBJECTIVE

A considerable amount of data will be generated through the implementation of the group-specific sampling and analysis plans. This section identifies responsible organizations, databases available, and BHI DIS programs (including documents and records) used to manage data in support of characterization and remediation activities in the 200 Areas. The QAPjP will provide the specific procedural direction and control for obtaining and analyzing samples in conformance with requirements to ensure quality data results. For sampling activities, the work plan and sampling and analysis plans will provide the basis for selecting the location, depth, and frequency of collection of media to be sampled and methods to be employed to obtain samples of selected media for cataloging, shipment, and analysis. Figure C-1 displays the general sample and data management process for data generated through work plan activities.

C3.2 ORGANIZATIONS CONTROLLING DATA

This section addresses the organizations that are involved in the management of data generated from group-specific work plan activities.

C3.2.1 200 Areas Project Team

The 200 Areas Project Team provides the group-specific task lead. The task lead is responsible for interfacing with personnel who maintain and transmit data to DIS. The 200 Areas Project Team is responsible for transmitting the laboratory analytical data to Ecology and EPA per Section 9.6 of the Tri-Party Agreement.

C3.2.2 Tri-Party Agreement Unit Managers

Tri-Party Agreement Unit Managers are responsible for identifying administrative record documents and requesting that copies of these documents are provided to BHI DIS for inclusion in the applicable AR.

C3.2.3 Sample and Data Management

The Sample and Data Management Process consists of 10 integrated steps as shown in Figure C-1. Steps 1 and 2 are planning steps. Steps 3 through 10 are production steps and are integrated electronically. The detailed plans, procedures, and systems used day-to-day by the Sample and Data Management Process users are found in BHI-EE-01 and BHI-EE-09.

Step 1 - Data Quality Objectives. The data quality objectives (DQO) process establishes the mechanism for collecting the right information with the right people. A streamlined approach can then be used for planning environmental data acquisition. By following the DQO process, a collective review of the

project, available data, regulatory concerns, sampling and analytical approaches (ERC Analytical Toolbox), and technical issues can be performed. Once the process is completed, the agreements reached are documented in a DQO Summary Report. This report forms the basis for all project sampling documents.

Step 2 – Sampling Documents. Sampling Documents are designed to provide the performance details for the collection and analysis of appropriate quality and quantity of data. A graded approach is used to determine the types of Sampling Documents needed to implement sampling and analysis activities. The most formal Sampling Documents are Sampling and Analysis Plans, which implement the DQOs.

Step 3 – Sample Event Coordination. Sample Event Coordination takes the sampling and analytical information generated in Step 1 and Step 2 and coordinates the sampling event with the sampling organization and the analytical service provider. Projects initiate services by using the Request for Analytical Services Form. The information on the form is then used to generate an approved Sample Authorization Form (SAF). The SAF is electronically generated by the Sample Data Tracking System. The information loaded into the system is used by the samplers to initiate sample collection and by the projects to track and manage samples through the remaining process steps. Analytical service providers are selected with the aid of the ERC Analytical Toolbox.

Step 4- Sample Collection. Sample Collection is conducted after approval of the Sampling Document and SAF. All sampling activities are conducted to approved procedures and to an approved Quality Assurance Program Plan.

Step 5 – Sample Shipment. Offsite Sample Shipments are transported from the field to a central receiving and shipment facility. Samples for onsite analysis are transported directly from the field to the identified laboratory. The Project Hanford Management Contractor (PHMC) approves all hazardous or radioactive sample shipments.

Step 6 – Sample Analysis. Sample Analysis can be provided at the job site using onsite measurements. Analyses of this type are conducted in accordance with approved procedures and an approved Quality Assurance Program Plan. Analyses of this type generally have higher detection limits and are less accurate; however, turnaround time is within minutes or hours.

Sample Analysis may also be conducted at PHMC, Pacific Northwest National Laboratory (PNNL), or commercial laboratories. Turnaround times for these analyses can be as short as 24 hours, or more typically, several days. Analyses of this type generally have lower detection limits. These laboratories are audited annually by the ERC to ensure the projects that appropriate procedures and Quality Assurance Programs are in place to meet customer needs.

Appropriate Sample Analysis providers are selected during Sample Event Coordination to ensure services are ready to accept samples and turnaround analyses to customer requirements. The ERC Analytical Toolbox contains the approved list of analytical methods and providers currently used by the ERC.

Step 7 – Data Receipt. During the Data Receipt step, the analytical results (hard copy and/or electronic) are received from the onsite measurements or laboratory providers. Hard copies of the data are stored for up to 6 months for the convenience of project customers and to aid in resolving any questions regarding the analytical results.

Step 8 – Verification/Validation. Verification is done on selected data packages to ensure copy quality and completeness prior to transmittal to Document and Information Services. Verification is not a

required process step and is normally conducted on selected data packages based on the following conditions:

1. Use of a new analytical resource that a performance history has not been established.
2. Observation during the Data Receipt process of poor quality and/or poor completeness performance trend with an established analytical provider.

Validation is the process where the data package provided by the analytical provider is subjected to a rigorous review to ensure the total data package is suitable for its intended purpose. Data that is subjected to validation is usually a subset of the total number of data packages used to make closure decisions. The Validation process is currently implemented through subcontracts. Validation requirements are identified in the Project's Sampling Document.

Step 9 – Data Management. Data Management furnishes electronic copies of environmental data reports to ERC customers using Project-Specific Databases or the Hanford Environmental Information System (HEIS). Reports are generated from the HEIS with the current analytical data for soils, biota, and groundwater. Project-Specific Databases may be developed to assist ERC Projects with DQOs, site close-out, and customized data reports.

In addition to analytical reports, Data Management also provides the Hanford Site with geographic and waste information summaries and maps. The Waste Information Data System (WIDS) is the official summary of the history and status of the Hanford waste sites. The Hanford Geographic Information System (HGIS) contains detailed, accurate maps of the site.

Step 10 – Data Quality Assessment. Data Quality Assessment is used to determine whether the type, quantity, and quality of data needed to support decisions has been achieved. This step presumes that the appropriate DQO has been established and planning for sampling (Sampling Documents) has been achieved using a scientifically based information collection strategy. Data Quality Assessment steps include:

1. Review of the DQO.
2. Conduct preliminary data review.
3. Select statistical test.
4. Verify the assumptions.
5. Draw conclusions from the data.

This approach is not intended to be a definitive analysis of a project or problem, but provide an initial assessment of the "reasonableness" of the data that have been generated. Detailed guidance on conducting Data Quality Assessment is found in the *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (EPA 1996).

C3.2.4 BHI Document and Information Services

BHI DIS provides consistent processing and retrieval of Environmental Restoration Program information (data, documents, and records) utilizing management systems for document control and records management. DIS will utilize the AR information repository system to meet Tri-Party Agreement records requirements and information access. It is the responsibility of all ERC personnel to submit documents/records to DIS for appropriate processing per applicable procedures.

C3.2.5 Hanford Environmental Health Foundation

The Hanford Environmental Health Foundation (HEHF) performs the analyses on the nonradiological health and exposure data (Section C3.3.2) and forwards summary reports to the Fire and Protection group and the Safety and Health group within BHI. Nonradiological and health exposure data are maintained also for other Hanford Site contractors (PNNL and ICF Kaiser Engineers Hanford [ICF KH]) associated with other waste group-specific activities. The HEHF provides summary data to the appropriate site contractor.

C3.2.6 BHI Quality, Safety, and Health Organization

The BHI Quality, Safety, and Health (QS&H) organization maintains personal protective equipment fitting records and maintains nonradiological health field exposure and exposure summary reports provided by HEHF for BHI and subcontractor personnel. They are also responsible for QA interface with analytical resources on quality issues and for monitoring ERC data management activities to ensure compliance with designated requirements.

C3.2.7 ERC Functional Organizations

Training records and scheduling of BHI employees for recertifications are currently maintained by secretarial staff in the organization to which the employee is functionally assigned. More information on training records is provided in Section C3.3.4.

C3.2.8 Pacific Northwest National Laboratory

The PNNL operates the Hanford Meteorological Station (HMS) and collects and maintains meteorological data (Section C3.3.1). Data management is discussed in Andrews (1988).

PNNL collects and maintains radiation exposure data (Section C3.3.3).

C3.3 DATABASES

This section addresses databases that will receive data generated from the group-specific work plan activities. All of these databases exist independently of the 200 Areas activities and serve other site functions. Additional databases that are also available are identified in DOE-RL (1995).

C3.3.1 Meteorological Data

The HMS collects and maintains meteorological data. The HMS database contains meteorological data from 1943 to the present, and the document Andrews (1988) contains meteorological data management information.

C3.3.2 Nonradiological Exposure and Medical Records

The HEHF collects and maintains data for all nonradiological exposure records and medical records.

C3.3.3 Radiological Exposure Records

PNNL collects and maintains data on occupational radiation exposure.

C3.3.4 Training Records

Training records for BHI and subcontractor personnel are managed in accordance with Section 8.0, "Environmental, Safety, and Health Training" of *Hanford ERC Environmental, Safety, and Health Program* (BHI-SH-01). Training records for non-BHI personnel are entered into the BHI database to document compliance with BHI-SH-01.

Training records in the database include the following:

- Initial 40-hour hazardous waste worker training
- Annual 8-hour hazardous waste worker training update
- Hazardous waste generator training
- Hazardous waste site specific training
- Radiation safety training
- Cardiopulmonary resuscitation
- Scott air pack
- Fire extinguisher
- Noise control
- Mask fit.

C3.3.5 Environmental Restoration Document and Records Tracking System

DIS will develop, establish, and maintain a database in support of the ER Program. The database will provide an index of key information on all data submitted to DIS. This database will be used to assist in data retrieval and to produce index lists as required. The ER database will be managed by BHI personnel.

C3.3.6 Sample and Data Tracking

Sample Management is responsible for operation of a tracking database that integrates the sample and data management process. Information relating to process activities from event coordination through sample collection and analysis, receipt of data deliverables, verification and validation, data transmittal to DIS, and sample return/disposal is entered and stored in the database. The database system is a tool that can be used to provide status reports and monitor performance.

C3.3.7 Hanford Environmental Information System

The HEIS is the primary Tri-Party Agreement resource for computerized storage, retrieval, and analysis of quality-assured technical data associated with ER programs for cleanup activities being undertaken at the Hanford Site. The HEIS provides interactive access to data sets extracted from other databases relevant to implementation of the Tri-Party Agreement (Ecology et al. 1994). HEIS ensures that data consistency, quality, traceability, and security are achieved through incorporation of all environmental data within a single controlled database.

The following is a list of data subjects available in HEIS:

- Soils (sample)
- Geologic (particle)
- Atmospheric
- Biota
- Groundwater
- Surface water

- Waste site information
- Miscellaneous materials
- Field QC
- Wells.

The HEIS data is currently available to Hanford Site users via the Hanford Local Area Network (HLAN) or Bechtel Local Area Network.

C3.3.8 Hanford Geographic Information System

The HGIS can display detailed maps for the Hanford restoration sites including data from HEIS and the WIDS database. Such spatially related data can be used to support analysis of waste site technical issues and restoration options. The combination of the WIDS for summary waste site information, the HEIS for sample analytical data, and the HGIS spatial displays offers some powerful tools for many users to analyze and collectively evaluate the environmental data from the ER and sitewide monitoring programs.

C3.3.9 Waste Information Data System

Pursuant to the Tri-Party Agreement, the WIDS is the official Hanford source for the validated summary information and status of suspect waste site investigation/classification, remediation, and closure activities. The WIDS is accessible to Hanford Site users via the Hanford Local Area Network or the Bechtel Local Area Network.

C4.0 REFERENCES

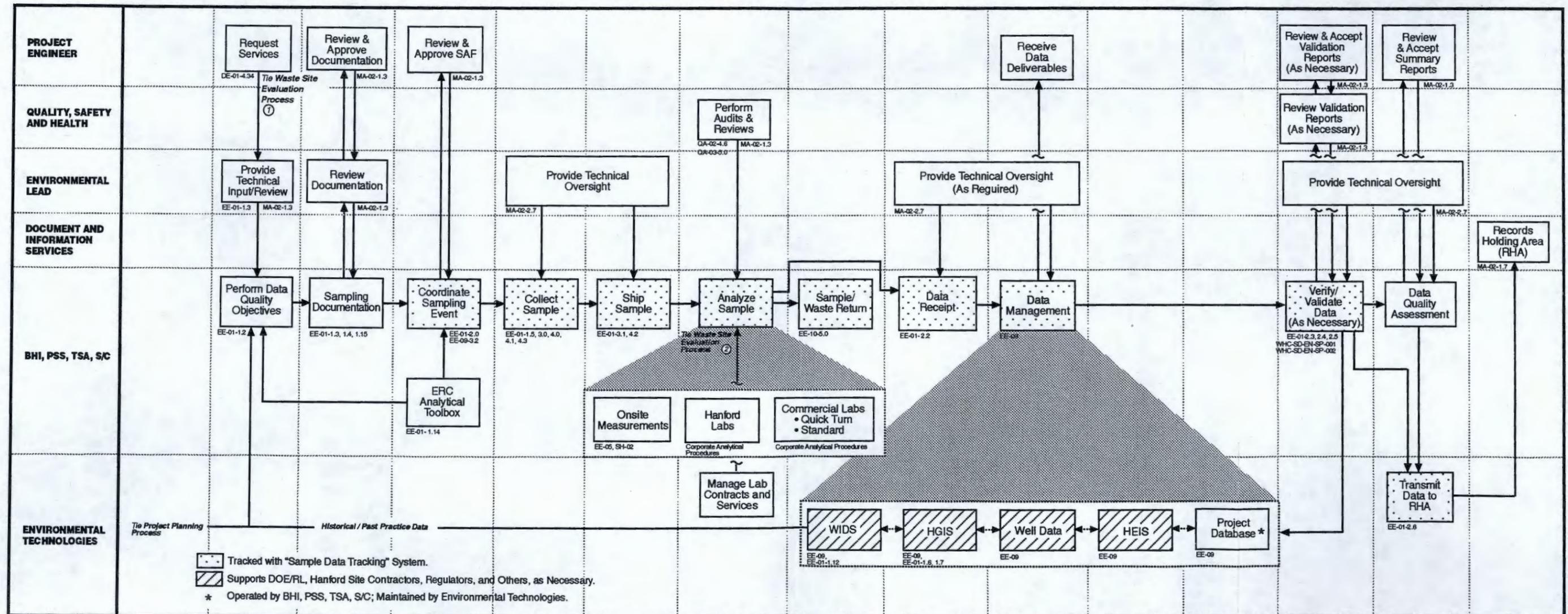
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Figure C-1. Data and Sample Management Process.



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Table C-1. Technical Data Types and Controlling Documents.

Work Plan Task – Type of Data	Controlling Document
Surface Radiological Surveys	BHI-SH-02 ^a
Surface Geophysics Surveys	EIP 7.2 ^b
Soil Sampling	EIP 2.0 - 2.7, 3.0, 4.0, 6.1, 6.2
Test Pit Excavation	EIP 5.2
Cone Penetrometer	EIP 5.0
Well Installation	EIP 6.0
Groundwater Sampling and Water Level Measurement	EIP 2.0 - 2.7, 4.1, 7.1
Air Monitoring	BHI-SH-02
Ecological Monitoring	EIP 2.0 - 2.7
Soil Removal and Confirmatory Sampling	EIP 2.0 - 2.7, 4.0

^a *Safety and Health Procedures*, Vol. 2 (BHI-SH-02).

^b *Environmental Investigations Procedures* (BHI-EE-01).

APPENDIX D

PRELIMINARY REMEDIAL ACTION TECHNOLOGIES

D1.0 INTRODUCTION

The purpose of conducting a feasibility study (FS) is to identify and evaluate alternatives for the remediation of waste sites under *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). This appendix serves as an initial screening level effort to identify potentially viable remedial alternatives and is not intended to constrain future remedial action decisions.

Remediation alternatives are developed by assembling combinations of viable technologies or associated process options for specific media of concern. The initial process of identifying viable remedial action alternatives consists of the following steps:

1. Define remedial action objectives (RAOs) (preliminary RAOs have been developed in Section 5.0)
2. Identify general response actions (GRAs) to satisfy RAOs
3. Identify potential technologies and process options associated with each general response action (GRA)
4. Screen process options to select a representative process for each type of technology based on their effectiveness, implementability, and cost
5. Assemble viable technologies or process options retained in step 4 into alternatives representing a range of removal, treatment, and containment options plus no action.

After a range of suitable alternatives is developed, a detailed analysis is performed as the final step in the FS process. The detailed analysis phase consists of refining and analyzing in detail each alternative, generally on a waste site-specific basis. The results of the final FS are used to select a preferred alternative.

The overall objective of this appendix is to perform steps 1-5 to identify viable remedial action alternatives for contaminated soil and buried solid waste in the 200 Areas (i.e., source waste sites assigned to the Environmental Restoration Program). The alternatives identified will form the basis for subsequent detailed 200 Areas FS on a waste group-specific basis. Only a limited amount of source remedial investigation (RI) has been completed in the 200 Areas and, to a large extent, waste site-specific characterization data are limited. As a result, recommendations for remedial alternatives are general and cover a range of potential actions to reflect the broad range of potential contamination conditions in the 200 Areas. Alternatives are expected to require refinements or modifications based on site characterization data collected during the RI. These refinements will be made in the detailed (final) FS.

A secondary objective of this appendix is to identify additional technology-specific (rather than waste site-specific) information needed to complete the detailed analysis. This information can be satisfied by conducting treatability tests of selected technologies. The intent is to conduct treatability studies for promising technologies that may have broad application in the 200 Areas early in the RI/FS process. Conclusions regarding the feasibility of some individual technologies may change after new data become available.

D2.0 PRELIMINARY REMEDIAL ACTION OBJECTIVES

Preliminary RAOs identified in Section 5.0 are used to develop preliminary remedial action alternatives consistent with reducing the potential hazards of contamination and satisfying potential applicable or relevant and appropriate requirements (ARARs). The preliminary RAOs for the 200 Areas are as follows:

- Prevent or mitigate risk to human and ecological receptors associated with ingestion of, dermal contact with, inhalation of, and external exposure to contaminants at levels that exceed ARARs or a risk of 10^{-4} to 10^{-6} .
- Prevent or mitigate the migration of contaminants to groundwater such that no further groundwater degradation occurs.
- Prevent or mitigate the migration of contaminants to groundwater and through groundwater so that contaminants do not reach the Columbia River at levels that exceed ARARs or a risk of 10^{-4} to 10^{-6} .
- Prevent plants and animals from creating a migration pathway for the contaminants.
- Prevent or mitigate risk to workers performing remedial action.
- Provide conditions suitable for proposed future land use.
- Prevent destruction of significant cultural resources and sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general, and prevent adverse impacts to cultural resources and threatened or endangered species.

The primary media of concern, which are the basis for this analysis, are radionuclide-contaminated and chemically contaminated soils and solid waste.

D3.0 PRELIMINARY GENERAL RESPONSE ACTIONS

GRAs represent broad classes of remedial measures that are intended to satisfy RAOs (Figure D-1). The following are the GRAs:

- No action
- Institutional control
- Containment
- Removal and disposal
- Ex situ treatment
- In situ treatment.

These general response actions are intended to cover the range of options from no action to complete remediation, and are briefly defined below:

No action is included for evaluations as required by the *National Environmental Policy Act (NEPA)* and *National Contingency Plan (40 Code of Federal Regulations [CFR] 300.68 (f)(1)(v))* to provide a baseline

for comparison with other response actions. The no action alternative may be appropriate for some sources of contamination if risks are acceptable to natural resources or humans and no exceedances of contaminant-specific ARARs occur.

Institutional controls involve the use of physical barriers (fences) and access restrictions (deed restrictions) to reduce or eliminate exposure to contamination. Institutional controls can also include groundwater, vadose, surface soil, biotic, and/or air monitoring. Many access and land-use restrictions are currently in place at the Hanford Site and will remain in place during implementation of remedial actions. Because the 200 Areas are already committed to waste management for the long term, institutional controls may be important as a final remedial alternative.

Containment includes physical measures to restrict accessibility to in-place waste or the migration of contaminants from in-place wastes. Containment technologies include the use of engineered surface barriers (caps) and vertical barriers as physical and hydraulic barriers to control the downward or lateral migration of contaminants, and biotic intrusion (including humans). Containment also serves as a barrier to direct radiological exposure and may also be useful in controlling gases. Barriers provide long-term stability with relatively low maintenance requirements. The U.S. Environmental Protection Agency (EPA) has identified containment as a presumptive remedy for CERCLA municipal landfills (EPA 1993a).

Removal and disposal involves the excavation of contaminated material for disposal typically in a landfill. Depending on the nature (e.g. radioactivity levels, hazardous waste classification) of the waste removed, ex situ treatment of the waste may be performed prior to disposal.

Treatment of contaminated material can be performed in situ or ex situ and involves the use of biological, thermal, physical, or chemical technologies. There are three primary treatment strategies including:

- Destruction or alteration of contaminants
- Extraction or separation of contaminants
- Immobilization of contaminants.

Contaminant destruction technologies are generally applicable only to organics. Metals and radionuclides cannot be destroyed or degraded, and as a result, active treatment is limited to separation or immobilization technologies.

Ex situ treatment involves the aboveground treatment of soil after it has been excavated. Typical treatment options include biological land farming, thermal processing, soil washing, and solidification/stabilization.

In situ treatment technologies is distinguishable from ex situ treatment in its ability to attain RAOs without removing the wastes. The final waste form generally remains in place. This feature is advantageous when exposure or worker safety during excavation would be significant or when excavation is technically impractical (e.g., deep contamination). Examples of in situ waste treatment process options include in situ vitrification, in situ stabilization, soil vapor extraction, and in situ biotreatment. Treatment technologies, in general, must often be pilot tested before they can be implemented.

Although **natural attenuation** is not an actual technology, it is addressed as an in situ treatment process for the purpose of this appendix. Natural attenuation encompasses natural subsurface processes or contaminant characteristics that can effectively reduce contaminant toxicity, mobility or volume. Natural attenuation processes include radioactive decay, biodegradation, biological stabilization, volatilization, dispersion, dilution, chemical or biological stabilization, transformation or destruction, and sorption.

The following section discusses the identification of technology types and process options associated with each GRA.

D4.0 IDENTIFICATION OF REMEDIAL TECHNOLOGIES

Several sources of information are available that identify, review, and provide general performance information on technologies applicable to various media. These sources were used to identify technologies that are technically implementable for soil and solid waste, in general, and for conditions that are representative of the 200 Areas, including the presence of a wide variety of contaminant types (organics, metals, radionuclides): coarse-grained, low organic soil; a deep vadose zone; and an arid climate. The primary sources of information used to identify potentially applicable technologies included the following:

- DOE Preferred Alternatives Matrices Remediation/Waste Processing (DOE 1997)
- Federal Remediation Technologies Roundtable, Remediation Technologies Screening Matrix and Reference Guide, Third Edition (AEC 1997)

Other sources of information used in this evaluation included the following:

- *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Sites* (EPA 1988)
- 200 Areas Aggregate Area Management Studies
- Hanford-specific engineering studies and evaluations (e.g., DOE-RL 1996)
- EPA policy on the use of monitored natural attenuation (EPA 1997).

Technology types and process options that satisfied the GRAs are identified in Table D-1.

D5.0 TECHNOLOGY SCREENING

Potentially applicable technology types and process options identified in Section D4.0 can be screened using effectiveness, implementability, and relative cost as criteria to eliminate those process options that are least feasible and retain those process options that are considered most viable. These criteria are only applied to the technology and do not consider waste site-specific characteristics. Site-specific considerations will be made following the RI and during the detailed analysis in the final feasibility study. The remaining process options can then be grouped into remedial alternatives (Section D6.0).

The effectiveness criterion focuses on (1) the potential effectiveness of process options in handling the areas or volumes of media and meeting the RAOs (including associated ARARs), (2) the potential

impacts to human health and the environment during the construction and implementation phase, and (3) how proven and reliable the process is with respect to contaminants. This criterion also concentrates on the ability of a process option to treat a contaminant type (organics, inorganics, metals, radionuclides, etc.) rather than a specific contaminant (nitrate, cyanide, chromium, plutonium, etc.).

The implementability criterion places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions; the availability of treatment, storage, and disposal services; and the availability of necessary equipment and skilled workers to implement the technology. The criterion also focuses on the process option's developmental status, whether it is an experimental or established technology.

The relative cost criterion is an estimate of the overall cost of a process, including capital and operating costs. The cost analysis is based on the Remediation Technologies Screening Matrix and Reference Guide, Third Edition (AEC 1997), and engineering judgment. Each process is evaluated as to whether costs are high, medium, or low relative to other process options.

A process option is rated effective if it can handle the amount of area or volume of media required, if it does not impact human health or the environment during the construction and implementation phases, and if it is a proven or reliable process with respect to the contaminants and conditions representative of the 200 Areas. Also a process option is considered more effective if it treats a wide range of contaminants rather than a specific contaminant. An example of an effective process option would be vitrification because it treats inorganics, metals, and radionuclides. However, chemical reduction may only treat chromium (VI), making it a less useful option.

An easily implemented process option is one that is an established technology; uses readily available equipment and skilled workers; uses treatment, storage, and disposal services that are readily available; and has few regulatory constraints. Preference is given to technologies that are easily implemented.

Preference is given to lower cost options, but cost is not an exclusionary criterion. A process option is not eliminated based on cost alone.

Results of the screening process are shown in Table D-2. Brief descriptions are given of the process options, followed by comments regarding the evaluation criteria. The last column of the table indicates whether the process option is rejected or carried forward for possible alternative formation. The following sections discuss the technologies retained after screening.

D5.1 NO ACTION

The National Contingency Plan (40 CFR 300) requires that a No Action Alternative be evaluated as a baseline for comparison with other alternatives. The No Action Alternative represents a situation where no restrictions, controls, or active remedial measures are applied to the site. No action implies a scenario of walking away from the site, taking no measures to monitor or control contamination. The No-Action Alternative requires that a site pose no unacceptable threat to human health and the environment. Current information indicates that some remedial action is required for most waste sites in the 200 Areas.

D5.2 INSTITUTIONAL CONTROLS

Institutional controls consist of physical and legal barriers to prevent access to contaminants, and monitoring of the groundwater and/or the vadose zone. Institutional controls are usually required when waste is left in place above cleanup levels.

Physical methods of controlling access to waste sites are access controls, which include signs, entry control, artificial or natural barriers, and active surveillance. Physical restrictions are effective in protecting human health by reducing the potential for contact with contaminated media and avoiding adverse environmental, worker safety, and community safety impacts that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal). If used alone, however, physical restrictions are not effective in achieving containment, removal, or treatment of contaminants. They also require ongoing monitoring and maintenance.

Legal restrictions include both administrative and real property actions intended to reduce or prevent future human exposure to contaminants remaining on site by restricting the use of the land, including groundwater use. Land-use restrictions and controls on real property development are effective in providing a degree of human-health protection by minimizing the potential for contact with contaminated media. Restrictions can be imposed through land covenants, which would be enforceable through lawsuits by the United States, and, under Washington State law, the Washington State Department of Ecology. They also avoid adverse environmental, worker safety, and community safety issues that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal). Land-use restrictions are somewhat more effective than access controls if control of a site transfers from the DOE to another party, because they use legal and administrative mechanisms that are already available to the community and the State.

The disadvantages of land-use restrictions are similar to those for access control: they do not contain, remove, or treat contaminants. Also, land-use restrictions are not self-enforcing. They can only be triggered by an effective system for monitoring land use to ensure compliance with the imposed restrictions.

D5.3 CONTAINMENT TECHNOLOGIES

Containment technologies are effective in isolating and preventing the horizontal or vertical spread of contamination by the use of physical measures. The EPA has recognized this by their adoption of containment as the presumptive remedy for CERCLA municipal landfill sites (EPA 1993a). The containment process options retained in this evaluation include surface barriers engineered for arid climates, and slurry wall or grouting process options as vertical barriers.

Surface barriers control the amount of water infiltrating into contaminated media and thus reduce or eliminate potential leaching of contamination to groundwater. Vertical barriers control the horizontal movement of subsurface contaminants. In addition to their hydraulic performance, barriers also function as physical barriers to limit direct human and animal interaction with the contamination, are engineered to limit wind and water erosion, can control the release of organic vapors and radon, and attenuate radiation.

Three **multi-layered surface barrier** designs have been specifically developed for various categories of 200 Area waste sites (Table D-4) and provide a range of protection levels (i.e., graded approach). The barrier designs are described in the *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas* (DOE-RL 1996) and include:

- Hanford Barrier
- Modified RCRA C Barrier
- Modified RCRA D Barrier.

Slurry walls are formed by vertically excavating a trench that is filled with a slurry, typically a mix of soil, bentonite and water, that forms a continuous low-permeability barrier. Slurry walls are often used to contain contaminated groundwater but have application in the vadose zone to limit the horizontal movement of moisture into contaminated materials or control gases.

Grout walls are formed by injecting grout, under pressure, directly into the soil matrix (permeation grouting) or in conjunction with drilling (jet grouting) at regularly spaced intervals to form a continuous low permeability wall. Through the use of directional drilling techniques, angled grout walls can be formed beneath a waste site. This type of vertical barrier is limited (more so than slurry walls) by difficulties in verifying barrier continuity, and materials used. New innovative materials actually can assist with limiting radionuclide mobility through chemical reactions.

Engineered barriers are well-developed and demonstrated technologies effective in containing waste for the duration of their designed functional life and are applicable to all types of contaminants, and both soil and solid media. Alternative surface barrier technologies that are less costly than barrier designs provided in earlier EPA guidance have now been approved by EPA. Surface barriers are most effective for conditions where contamination is relatively shallow (e.g., less than 15m [50 ft]). Surface barriers are generally not effective for deep contamination (e.g., more than 30m [100 ft]), although vertical barriers can be used as a supplemental element in the design to effectively improve containment performance in deeper zones. Surface and vertical barriers are easily implemented and are designed to blend with natural site conditions. However, land use will be impacted. Worker exposure concerns are generally minimal because the waste zone is not exposed as in excavation. Constructability and performance has been demonstrated onsite for the Hanford Barrier, which is the most complex of the three barrier designs.

D5.4 REMOVAL AND DISPOSAL TECHNOLOGIES

Removal and disposal options were retained for further evaluation including excavation of contaminated soils or buried solid waste debris with transportation and disposal to a landfill, either onsite or offsite. Excavation of materials is accomplished using standard earthmoving equipment, such as backhoes and front-end loaders. Selection of construction equipment is based on worker safety, production rates, and potential for additional release of contamination. The removal process starts with excavation of clean overburden, which is set aside for later use as backfill. The contaminated soils are excavated in lifts and surveyed for contamination. Contaminated soils are removed to a depth designated to achieve the remedial goals.

After removal, the soil and/or debris may require ex situ treatment to meet disposal requirements or reduce waste volumes. Materials may be roughly characterized (e.g., combustible, metallic, inorganic, and radioactive) and segregated for different treatment and disposal options.

Both onsite and offsite land disposal options are retained, depending on the volume of soil and the nature of the contaminants. Currently available disposal options for soils and solids include the following:

- Disposal of low-level radioactive waste at the low-level burial grounds located in the 200 Areas.
- Disposal of low-level radioactive waste and/or hazardous waste at the Environmental Restoration Disposal Facility (ERDF) located in the 200 Areas.

- Disposal of hazardous waste offsite at an existing RCRA-approved landfill.
- Disposal of transuranic (TRU) waste offsite in a geologic repository.

Soil that is designated as "mixed waste" with both low-level radionuclides and hazardous chemical contaminants would have to be disposed of at the ERDF. The Central Waste Complex can serve as a storage location for mixed waste that cannot be disposed to the ERDF.

Removal and disposal is effective because contaminated materials are physically removed, there are no long-term requirements for monitoring and maintenance of the site, and there is greater flexibility in future land use. This technology is easily implemented at sites with shallow contamination, as it is a standard construction practice, and methods are available to handle most expected construction-related problems. Requirements for safety, monitoring, and sampling are generally well understood. Radioactive waste will require special handling protocols and may require remotely controlled equipment if levels are high enough to preclude the use of standard construction equipment.

Removal technologies do not require that the extent of contamination be precisely known before excavation. Rather, characterization occurs as the excavation proceeds, and the extent of contamination is determined using the observational approach.

There are several drawbacks to the implementation of this GRA:

- Removal of contaminated material can be hazardous to workers since it requires handling, transporting, and treating or disposing of contaminated materials. Removal can result in a high degree of disturbance to existing natural and cultural resources.
- Control of fugitive dust and vapor emissions may be of particular concern at some sites.
- Extensive safety procedures and monitoring plans may be required to ensure the protection of the workers and the environment. Safety and environmental concerns must be balanced against the benefits of removal.
- Limited to sites with relatively shallow contamination.

Contaminated soil and solids removal with disposal at the ERDF has been the preferred alternative for waste sites in the 100 and 300 Areas, and has been demonstrated to be effective on the Hanford Site. Given the same type of contamination, the suitability of this alternative is enhanced for the 200 Areas because haul distances would be substantially reduced.

D5.5 EX SITU TREATMENT TECHNOLOGIES

Retained ex situ treatment processes include thermal desorption, vapor extraction, vitrification, soil washing, mechanical separation, and solidification/stabilization. Collectively, these processes address a range of contaminants including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), inorganics, and metals.

Mechanical separation involves segregation of materials to allow for proper treatment and/or disposal. The primary separation technique for solid media is sieving to segregate material according to size, but other physical properties may also be used as a basis for segregation (e.g., local discoloration of soil). The general advantage of mechanical separation is the reduction of contaminant volume and segregation

of waste for proper disposal or recycling. The main disadvantages of this technology are that increased waste handling carries the potential for increased worker risk and the production of fugitive dust. This process has been used as a component of removal and disposal actions on the Hanford Site. Experience in the 300 Area burial grounds has shown that certain problems with sieving solid debris may be encountered, specifically clogging of the sieving device.

Soil washing uses a wash solution (e.g., water) to remove soil contaminants by dissolving or suspending them in solution or by concentrating them through particle size separation, gravity separation, and attrition scrubbing. The washing agent and soil fines are residuals that require further treatment. This process is applicable to coarse-grained soils contaminated with a wide variety of metal, radionuclide, and organic contaminants, particularly those that tend to bind to the fine soil fraction. Soil washing has been pilot-scale tested for 100 and 300 Area soil and has been shown to be effective for select contaminants.

Thermal desorption has been identified as a presumptive remedy by EPA (1993b) for the removal of VOCs from soil. This technology uses heat to volatilize organic contaminants from soil. A carrier gas or vacuum is used to collect and transport the volatilized organics to a gas treatment system. Concentrated contaminants can be removed (e.g., by carbon adsorption) from the process stream or destroyed using a secondary combustion chamber or catalytic oxidizer. Residual liquids and spent activated carbon require further treatment. With low-temperature thermal desorption, the decontaminated soil retains its physical properties and ability to support biological growth.

Ex situ vapor extraction uses excavated soil to place over a network of aboveground perforated piping to which vacuum is applied to facilitate the movement of air through the soil and volatilize contaminants. The off-gas is then treated, commonly by activated carbon. Residual liquids and spent activated carbon require secondary treatment. An advantage of ex situ vapor extraction over in situ is that treatment is more uniform and better monitored. Soil vapor extraction is a conventional process for remediating soils contaminated with VOCs and has been identified by the EPA as a presumptive remedy (EPA 1993b).

Ex situ vitrification is applicable to a wide variety of contaminant types, but is mainly applied to metals, radionuclides and other inorganics. The process uses electricity to melt contaminated soil. As the molten material cools the contaminants are encapsulated in a vitrified mass that is high in strength and highly resistant to leaching. Because of the high temperature involved in the melting process, organic contaminants present in the soil are often destroyed. This process can be used as a standalone technology or as a secondary treatment process for concentrated solid residuals from other processes (e.g., contaminated soil fines from mechanical separation).

Solidification/stabilization uses admixtures of stabilizing agents to encapsulate and render inert various hazardous substances. This process is mainly targeted at metal, radionuclides, and other inorganics. Stabilizing agents include cement, asphalt, and polymeric materials. The EPA has identified polymer macroencapsulation as the Best Demonstrated Available Technology for radioactive lead solids and mixed waste debris. The advantage of this technology is that it can satisfy the treatment option for land disposal restricted LDR wastes; wastes treated in this manner could be landfilled.

Ex situ treatment generally requires that material be first excavated and transported to a treatment area. The use of excavation limits the application of ex situ treatment to sites with shallow contamination. Cleaned soil, particularly the coarser fraction, is often returned to the site of excavation. For mixed waste conditions such as those encountered in the 200 Areas, it is unlikely that a single process exists to treat all constituents and as a result several technologies may be required to form a treatment train.

Ex situ treatment can be effective in destroying organics and reducing the toxicity, mobility, and/or volume of contaminants, and requires no site monitoring or maintenance at the end of remediation

because contaminants are removed or stabilized. Metals and radionuclides are not destroyed by ex situ treatment and require eventual disposal as residuals. Soil washing and mechanical separation concentrate radionuclides, which may change the classification of the waste and impact disposal requirements. The advantages of ex situ treatment are often shorter cleanup times than in situ treatment, and a more uniform, controlled and monitored process. A general disadvantage is the increased handling of waste beyond that of the excavation process and the potential increased health and safety risk to site workers through skin contact and air emissions.

Ex situ treatment is generally more effective for matrix materials with low amounts of natural organics that is typical of 200 Areas soils.

D5.6 IN SITU TREATMENT TECHNOLOGIES

Retained in situ treatment processes include vitrification, vapor extraction, grout injection, and soil mixing, dynamic compaction, and natural attenuation. Collectively, these processes address a range of contaminants including VOCs, SVOCs, inorganics, and metals.

In situ soil vapor extraction is a conventional process for remediating soils contaminated with VOCs and has been identified by the EPA as a presumptive remedy (EPA 1993b). This process involves inducing airflow through the soil matrix with an applied vacuum that facilitates the mass transfer of adsorbed, dissolved or free phases to the vapor phase. Vapors are pumped from the subsurface using vertical extraction wells or horizontal piping to the surface for treatment. In situ soil vapor extraction has been commonly used for VOC contamination at Superfund sites and has a history of effectively treating waste in place at a relatively low cost. This process has been successfully implemented in the 200 Areas for removal of carbon tetrachloride and chloroform from the vadose zone in combination with ex situ activated carbon treatment.

In situ vitrification applies an electrical current to melt contaminated soil and forms a stable vitrified mass when cooled that encapsulates contaminants. The process combines thermal treatment with stabilization. The melting process often destroys or removes organic contaminants present in the soil. Off-gases are collected using a vacuum hood and treated. Process depths are limited to less than 6 m (20 ft) in homogeneous soils and are generally applicable to smaller volumes of highly contaminated soil.

Grout injection for soil remediation is an adaptation of a well-developed construction technique of injecting grout into the soil matrix. The injection process encapsulates the material and produces a monolithic solid block that can be left in place or excavated for disposal elsewhere.

Deep soil mixing uses large augers (mixer) and injector head systems to inject and mix solidifying agents (cement- or pozzolanic-based) into contaminated soil in place. The process reduces the mobility of contaminants. The process can be used to inject microorganisms for in-situ bioremediation of sites.

Dynamic compaction is used to densify soil, compact buried solid waste, and/or reduce void spaces by dropping a heavy weight onto the ground surface. Dust control is required, and worker exposure can be a concern because the compaction process can expel contaminated particulates to the surface. The compaction process can reduce the hydraulic conductivity of subsurface soils and correspondingly the mobility of contaminants. Because the compactive energy attenuates with depth, dynamic compaction is limited to shallow applications.

Natural attenuation relies on natural processes to lower contaminant concentrations through physical, chemical, and/or biological processes until cleanup levels are met, including the following:

- Biodegradation, which is effective for most organic compounds given proper conditions
- Sorption, which can immobilize most kind of contaminants
- Oxidation reduction reactions, which can transform contaminants into less mobile or less toxic forms
- Radioactive decay, which significantly reduces the activity of radionuclides with short half-lives (i.e., on the order of several to tens of years).

Radioactive decay is the only process to eliminate nuclear particle emissions, as no available treatment process exists to eliminate radioactivity. Radioactive decay does not affect the mobility of radioelements and as a potential remediation process is considered to be mainly applicable to radioelements with short half-lives and lower mobilities in soil. Examples of 200 Area waste sites where natural attenuation processes are acting to reduce or immobilize contaminants include (1) the Solid Waste Landfill where VOCs found in groundwater have been diminishing with time; (2) the 216-B-5 Reverse Well where plutonium, cesium, and strontium are either strongly sorbed to aquifer soils or are sufficiently immobile such that they are expected to decay to negligible levels before they migrate from the 200 Areas; and (3) The Z-Plant area where "barometric pumping" has been found to be effective in removing carbon tetrachloride vapors from subsurface soils. As discussed in Section 3.0, most of the short-lived isotopes associated with 200 Area processes and disposed of to the ground have decayed to stable isotopes.

EPA (1997) acknowledges that natural attenuation can be an appropriate remedial option for contaminated soil. Because of uncertainties in the science of natural attenuation processes, EPA considers source control and performance monitoring fundamental components of the option. From a technical standpoint, monitored natural attenuation is readily implemented because it requires little or no significant action (e.g., construction activity).

In situ treatment has a significant advantage because waste is treated in place without the need for excavation and transportation, which can have a significant cost savings and minimize worker exposure. In addition, in situ techniques are often the only effective treatment technology type for sites with deep contamination. Disadvantages include generally longer cleanup times, and the process can be difficult to control and to verify its effectiveness. Thermal treatment provides faster cleanup times, but are capital and operations and maintenance (O & M) intensive and can be costly. Generally, technology availability for in situ treatment of inorganics and radionuclides is limited, not well developed, and/or not cost effective, and in many cases natural attenuation and/or removal are the only viable options. Vitrification, grout injection and soil mixing processes are generally not applicable for solid/debris matrices (i.e., landfill waste). For vadose zone with organic contamination, particularly VOCs, effective in situ technologies are available. In situ treatment is generally more effective for matrix materials with low amounts of natural organics (i.e., 200 Areas soils).

D6.0 PRELIMINARY REMEDIAL ACTION ALTERNATIVES

Several remedial alternatives are considered applicable to disposal sites that contain hazardous chemicals, metals, radionuclides, VOCs and/or SVOCs based on the process options retained in Section D5.0. These remedial alternatives are developed and described generically for application in the 200 Areas. The intent is to provide a range of the alternatives that can address the range of contamination conditions expected in the vadose zone 200 Areas. Alternatives that are relevant to a particular waste group will form the basis

for the group's final (i.e., detailed) FS. The detailed evaluation of the alternatives will be performed once site-specific conditions are understood and reported in the final FS to be completed on a waste group-specific basis.

D6.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Potentially feasible remedial technologies were described and evaluated in Section D5.0. Some of those technologies have been proven to be effective and implementable at industrial waste sites and the Hanford Site, while other technologies are less proven or developed. The EPA guidance (EPA 1989a) on FSs for

uncontrolled waste management units recommends that a limited number of candidate technologies be grouped into "Remedial Alternatives."

D6.1.1 General Response Actions

For this study, technologies were combined to provide at least one alternative for each of the following general strategies (i.e., general response actions):

- No action
- Institutional controls
- Containment
- Removal and disposal combined with ex situ treatment, as needed
- In situ treatment.

Figure D-1 shows the relationship of GRAs, technologies, and alternative development.

The alternatives are intended to treat a major component of the 200 Area waste. Alternatives were developed based on treating classes of compounds (radionuclides, heavy metals, inorganics, and organics) rather than specific contaminants. At a minimum, the alternative must be a complete package. For example, disposal of radionuclide-contaminated soil must be combined with excavation and backfilling of the excavated site. One important factor in the development of the preliminary remedial action alternatives is that radionuclides, heavy metals, and some inorganic compounds cannot be destroyed. Rather, these compounds must be physically immobilized, contained, isolated, or chemically converted to less mobile or less toxic forms to satisfy RAOs. Organic compounds can be destroyed, but may represent a smaller portion of the overall soil contamination in the 200 Areas.

No action and institutional control options are required to be considered as part of the CERCLA RI/FS guidance. The purpose of including both of these alternatives is to provide decision makers with information on the entire range of available remedial actions.

For the containment strategy, engineered surface barriers, with or without vertical barriers (depending on the specifics of the remediation) were selected. Two alternatives were selected to represent the removal and disposal strategy. One of these deals with disposal of TRU contaminated soils. Three in situ alternatives were identified; one deals with vapor extraction for VOCs, one with stabilization of soils and the other with vitrification of soils. Finally, monitored natural attenuation is identified as an alternative.

This process does not result in an exhaustive list of all applicable alternatives for each GRA, but does provide a reasonable range of remedial actions that are likely to be evaluated in future detailed feasibility studies.

D6.1.2 Remedial Action Alternatives

The remedial action alternatives are summarized as follows:

- No action.
- Institutional controls.
- Engineered surface barriers with or without vertical barriers. Three conceptual surface barrier designs from DOE-RL (1996) provide a range of protective levels. Feasible vertical barriers include slurry walls and grout curtains. Dynamic compaction is also provided as a foundation improvement technique for surface barriers when needed.
- Excavation and disposal with or without ex situ treatment. Feasible technologies for organic compounds include thermal processing, vapor extraction, and stabilization. Feasible technologies for radionuclides include soil washing, mechanical separation, vitrification, and stabilization. Options for both onsite and offsite disposal are provided.
- Excavation, ex situ treatment, and geologic disposal of soil with TRU radionuclides.
- In situ grouting or stabilization of soil.
- In situ vitrification of soil.
- In situ soil vapor extraction of VOCs.
- Monitored natural attenuation.

These alternatives, except for no action and institutional controls, were developed to satisfy a number of RAOs simultaneously and use technologies that are appropriate for a wide range of contaminant types. For example, constructing an engineered multimedia cover may effectively contain radionuclides, heavy metals, inorganic compounds, and organic compounds simultaneously. It satisfies the RAO of protecting human health and the environment from direct exposures from contaminated soil, biomobilization, and airborne contaminants. In situ soil vapor extraction is more contaminant-specific than the other alternatives, but it addresses a contaminant class (VOCs) that is not readily treated using the other options, such as in situ stabilization. It is possible that some waste sites may require a combination of the identified alternatives to completely address all contaminants.

In all alternatives except the no-action alternative, it is assumed that monitoring and institutional controls may be required, although they may be temporary. These features are not explicitly mentioned, and details are purposely omitted until a more detailed evaluation may be performed in subsequent studies. Also, treatability studies may accompany many of the alternatives during implementation.

In the following sections, the preliminary remedial action alternatives are described in more detail, with the exception of the no-action and institutional control options.

D6.2 ALTERNATIVE 1 - ENGINEERED SURFACE BARRIERS WITH OR WITHOUT VERTICAL BARRIERS

Alternative 1 consists of engineered surface barriers based on three conceptual designs developed in DOE-RL (1996) for various categories of waste types (Table D-3). Vertical barriers such as grout curtains or slurry walls may be used in conjunction with the cover should additional horizontal containment measures be required. The surface barrier designs presented in DOE-RL (1996) are as follows:

Hanford Barrier. This barrier is for sites with Greater-Than-Class C (GTCC) low-level waste (LLW) and/or GTCC mixed waste, and/or significant inventories of TRU constituents. This barrier is designed to remain functional for a performance period of 1,000 years and to provide the maximum practicable degree of containment and hydrologic protection of the three designs. The Hanford Barrier is composed of nine layers of durable material with a combined thickness of 4.5 m (14.7 ft). The barrier layers are designed to maximize moisture retention and evapotranspiration capabilities, and to minimize moisture infiltration and biointrusion, considering long-term variations in Hanford Site climate.

The primary structural differences between the Hanford Barrier and other barriers discussed in this report are the increased thickness of individual layers and the inclusion of a coarse-fractured basalt layer to control biointrusion and to limit inadvertent human intrusion. A full-scale treatability test of the Hanford Barrier has been performed in the 200 Areas. Testing has demonstrated that the barrier performs effectively under ambient and extreme climatic conditions (three times the normal rainfall and 1000-year storms).

Modified RCRA Subtitle C Barrier. This barrier is for sites containing dangerous waste, Category 3 LLW and/or Category 3 mixed LLW, and Category 1 mixed LLW. This barrier is designed to provide long-term containment and hydrologic protection for a performance period of 500 years. The performance period is based on radionuclide concentration and activity limits for Category 3 LLW. The Modified RCRA Subtitle C Barrier is composed of eight layers of durable material with a combined minimum thickness of 1.7 m (5.5 ft). This design incorporates *Resource Conservation and Recovery Act of 1976* (RCRA) "minimum technology guidance" (MTG) (EPA 1989b), with modifications for extended performance. One major change is the elimination of the clay layer, which may desiccate and crack over time in an arid environment. The geomembrane component has also been eliminated because of its uncertain long-term durability.

The Modified RCRA Subtitle C Barrier is similar in structure to the Hanford Barrier, but layer thickness is reduced and there is no fractured basalt layer. The design incorporates provisions for biointrusion and human intrusion control. However, the provisions are modest relative to the corresponding features in the Hanford Barrier design, reflecting the reduced activity of the subject waste and the reduced design-life criterion.

Modified RCRA Subtitle D Barrier. This barrier is the baseline design for nonradiological and nonhazardous solid waste sites as well as Category 1 LLW sites where hazardous constituents are not present. The Modified RCRA Subtitle D Barrier is composed of four layers of durable material with a combined minimum thickness of 0.90 m (2.9 ft). It is designed to provide limited biointrusion and limited hydrologic protection (relative to the other two barrier designs) for a performance period of 100 years. The performance period is consistent with the radionuclide concentrations and activity limits specified for Category 1 LLW. The 100-year design life is also consistent with the minimum expected duration of active institutional control.

Figure D-2 through Figure D-4 provides profiles for each of the three generic conceptual designs. Figure D-5 represents the logic for determining the barrier to be evaluated in the site-specific evaluation and for implementation of the "graded approach" to surface barriers for the 200 Areas. Applying the logic requires that sufficient information is available regarding contaminant constituents and concentrations to classify the radiological component of the waste, and to determine whether dangerous constituents are present at levels of regulatory concern.

Alternative 1 would provide a permanent cover over the affected area. The cover would accomplish the following: minimize the migration of precipitation into the affected soil and contaminant leaching; minimize the potential for biotic intrusion; reduce the migration of windblown dust that originated from contaminated surface soils; reduce the potential for direct exposure to contamination; and reduce the volatilization of VOCs to the atmosphere. If vertical barriers were included, they would limit the amount of lateral migration of contaminants and limit the horizontal movement of moisture beneath the surface barrier. An option for dynamic compaction is also included in this alternative for application at solid waste landfills prior to surface barrier construction to reduce settlements and subsidence that may impact the integrity of a surface barrier. This alternative would not reduce the volume or toxicity of the contaminants, and periodic inspections, maintenance, and monitoring would be required for an indefinite period.

D6.3 ALTERNATIVE 2 - EXCAVATION AND DISPOSAL WITH OR WITHOUT EX SITU TREATMENT

Under Alternative 2, radioactive and hazardous soil or solid debris would be excavated using conventional techniques, with special precautions to minimize fugitive dust generation. Depending on the configuration of the area to be excavated, shoring might be required to comply with safety requirements and to reduce the quantity of excavated soil. If needed, several treatment options could be selected from the physical, chemical, and thermal ex situ treatment process options screened in Section D5.0. For example, thermal desorption with off gas treatment could be used if organic compounds are present; soil washing or mechanical separation could be used to separate contaminated fine-grained soil particles; and stabilization/solidification could be used to immobilize radionuclides and heavy metals or to satisfy the treatment option for land disposal restricted wastes. The specific treatment method would depend on site-specific conditions. Treatability tests would be performed to determine the specific soil treatment protocols and methodology. The treated soil would be backfilled into the original excavation or landfilled. Soil treatment by-products may require additional processing or treatment.

Both onsite and offsite landfill disposal options are included in the alternative depending on the nature of the waste. Section D5.4 identifies currently available disposal options; however, the ERDF located adjacent to the 200 Areas is preferred because it has been specifically constructed to handle low level radioactive and/or hazardous waste from environmental remediation activities on the Hanford Site. The offsite disposal option is identified as a contingency for waste forms or contaminants prohibited at the ERDF.

Alternative 2 would be effective in treating a full range of contamination, depending on the type of treatment processes selected. Attainment of RAOs would depend on the depth to which the material was excavated. If near surface soil or buried waste was treated, airborne contamination, direct exposure to contaminated soil, and bio-mobilization of contamination would be minimized. Because of practical limits on deep excavation, deep contamination may not be removed and would be subject to migration into groundwater. If further degradation of the groundwater were a concern, additional treatment of deep contamination would be needed. For example, Alternative 2 could be used in conjunction with Alternative 4 (in situ grouting or stabilization of soil) to stabilize deep contaminants.

A combination of laboratory treatability tests and pilot-scale field tests might be required to develop the optimum methods for above ground treatment of the excavated soil. The specification of the required treatability tests would depend on the nature of the contaminants at each of the remediation sites and the development status of the process.

D6.4 ALTERNATIVE 3 - EXCAVATION, EX SITU TREATMENT, AND GEOLOGIC DISPOSAL OF MATERIAL WITH TRANSURANIC RADIONUCLIDES

Certain waste sites in the 200 Areas may contain isolated zones where the concentration of TRU radionuclides exceeds 100 nCi/g. For Alternative 3, the soil or solids from those isolated zones would be excavated, stabilized or treated, and shipped to an offsite geologic disposal site. Such a disposal facility has not yet been licensed, so interim storage of the stabilized waste may be required until a final geologic repository is constructed.

Depending on the configuration of the affected area, shoring may be required during excavation to comply with worker safety regulations and to minimize the amount of excavated soil. Special excavation procedures would have to be used to minimize fugitive dust. The excavated waste would be sorted according to TRU concentration. Material with TRU radionuclides exceeding 100 nCi/g would be either vitrified (soil only) or stabilized using an ex situ treatment process, then stored until a geologic disposal facility was available.

Some of the excavated waste could contain TRU radionuclides at concentrations less than 100 nCi/g, and could be treated using a combination of the technologies described in Section D5.0. After the non-TRU waste was treated to achieve appropriate cleanup standards, it could be backfilled into the original excavation or disposed of at an onsite landfill. Imported fill material would be used to restore the site to its original grade. If the residual unexcavated soil or the treated soil used for backfill contained contaminants at concentrations exceeding the RAOs, then an engineered surface barrier (Alternative 1) might have to be installed at the site to prevent direct exposure or groundwater impacts.

This alternative would use many excavation and treatment technologies that have been only partly demonstrated at industrial sites. Extensive treatability testing would be required for the TRU-containing soil to develop optimum methods for treating or stabilizing the TRU radionuclides. Additional treatability studies might be required to support the aboveground treatment of the non-TRU soil. The use of remotely controlled excavation and material handling equipment may be needed.

D6.5 ALTERNATIVE 4 - IN SITU GROUTING OR STABILIZATION OF SOIL

Radioactive and hazardous soil would be grouted in this alternative using in situ injection methods. The end product is monolithic block of contaminated material encapsulated in grout which would significantly reduce the leachability of hazardous contaminants, radionuclides, and/or SVOCs from the affected soil. Grouting may also be used to fill voids, such as in timbered cribs, thereby reducing subsidence. Another variation of this alternative would be to stabilize the soil using in situ mixing of soil with stabilizing compounds such as fly ash.

There are two common methods of in situ grout injection that have been used at industrial sites. In the first method, grout injection wells are installed at prescribed lateral spacing (based on pilot tests) and through the affected vertical zones. Specially formulated grout is then injected at high pressure to provide overlapping zones of influence and allowed to cure. This first method can theoretically be used to

stabilize soil deep below the ground surface. In the second method, a patented large-diameter auger/mixer is used to mechanically agitate and blend grout mixtures that are injected into the soil through ports in the auger. This method has commonly been used to grout large areas of soil down to significant depths. One other technology, jet mixing, uses a jetting process to inject and mix in solidification agents. The jetting process is initiated at the bottom of a small-diameter boring and forms a column of treated soil as the jets are backpulled.

Alternative 4 would provide a combination of immobilization and containment of heavy metal, radionuclide, inorganic, and SVOC contamination. Thus, this alternative would reduce migration of precipitation into the affected soil, reduce the migration of windblown dust that originated from contaminated surface soils, reduce the potential for direct exposure to contaminated soils, and possibly reduce the volatilization of VOCs. Because this alternative would not remove the contaminants from the soil, it is likely that institutional controls would be required.

D6.6 ALTERNATIVE 5 - IN SITU VITRIFICATION OF SOIL

In this alternative, the contaminated soil in a subject site would be immobilized by in situ vitrification. Treatability tests would be performed initially to determine site-specific operating conditions. Import fill would initially be placed over the affected area to reduce exposures to the remediation workers from surface contamination. High-power electrodes would be used to vitrify the contaminated soil under the site to a depth below where contamination is present. A large fume hood would be constructed over the site before the start of the vitrification process to collect and treat emissions. Fences and warning signs may be placed around the vitrified monolith to minimize disturbance and potential exposure.

In situ vitrification would be effective in treating radionuclides, heavy metals, and inorganic contamination, and can also destroy organic contaminants. This would reduce the potential for exposures by leaching to groundwater, windblown dust, and direct dermal contact. However, this alternative would not reduce the mass or toxicity of the radionuclides present onsite. Also, in situ vitrification may be limited to depths of less than about 6 m (20 ft), which may not be adequate to immobilize deep contamination.

D6.7 ALTERNATIVE 6 - IN SITU SOIL VAPOR EXTRACTION FOR VOLATILE ORGANIC COMPOUNDS

Soil vapor is drawn from wells that are screened in permeable soil zones that contain high organic vapor concentrations. The vented air would be treated to remove water vapor, the organic vapor of concern, particulate radionuclides that might be entrained in the air stream, and volatile radionuclides. Water vapor must be removed (usually by condensation) to protect the vacuum pumps. If the condensed water contains organic contamination or radionuclides, then it would have to be treated and/or disposal of in an appropriate manner. Particulate radionuclides that were entrained in the air stream can be effectively removed using banks of conventional high-efficiency particulate air (HEPA) filters. The organic vapors would be treated with activated carbon. The required removal efficiency will be determined based on applicable ARARs.

Alternative 6 utilizes proven technologies to remove the volatilized vapors from the vadose zone soil. No additional treatability testing is expected to be needed for this process because it has been successfully implemented in the 200 Areas near Z Plant. Soil vapor extraction would reduce downward and lateral migration of the VOC vapors through the vadose zone, and thereby reduce potential cross-media migration into the groundwater. Soil vapor extraction would reduce upward migration of VOC through

the soil column into the atmosphere, and thereby minimize inhalation exposures to the contaminants. In some cases where radionuclides were discharged to the disposal sites with VOCs (e.g., carbon tetrachloride), the removal of VOCs could reduce the mobility of the radionuclides, and thereby reduce the potential for downward migration of the radionuclides. Finally, soil vapor extraction would enhance partitioning of the VOC off of the soil and into the vented air stream, resulting in the permanent removal of the VOC. Alternative 6 may be used in conjunction with other alternatives if contaminants other than VOCs are present.

D6.8 ALTERNATIVE 7 - MONITORED NATURAL ATTENUATION

This alternative includes a variety of contaminant-specific physical, chemical, or biological processes to reduce the mass, activity, toxicity, mobility, volume, or concentration of contaminants in soil or solid debris. The alternative would include sampling and environmental monitoring, consistent with EPA guidance (EPA 1997), to verify that contaminants are attenuating as expected and to ensure that contaminants remain isolated (i.e., will not lead to further degradation of groundwater). As part of the site-specific detailed analysis of this alternative, the hazards and mobility of the possible transformation or daughter products must be addressed.

Sampling activities would include:

- Sampling contaminated materials and the soils below the sites to verify the nature and extent of contamination,
- Verify the hydrogeologic, geochemical and/or biological properties of the vadose zone important to the attenuating processes
- Serve as a monitoring baseline
- Support predictive modeling, if needed.

Environmental monitoring (e.g., vadose zone and/or groundwater) would be conducted to ensure waste containment is achieved and no further degradation of groundwater occurs. The existing network of groundwater monitoring wells in the 200 Areas should be adequate for monitoring most sites. Vadose zone monitoring may be appropriate to verify the effectiveness of attenuating processes and as an indicator of potential future groundwater impacts. For example, if the contaminant of concern is a gamma emitter or a radionuclide that emits gamma-radiation can be used as an indicator parameter of other contaminants, than gamma-ray logging of boreholes can be used to track contaminant movement or changes in activity levels. Soil gas probes can be used to track changes in VOC contamination.

Monitored natural attenuation may be used as a complete remedial alternative, in conjunction with other remedial alternatives, or as a follow-up activity to remedial measures already completed. As a standalone option, monitored natural attenuation is considered most applicable to low-mobility contaminants with limited persistence, where the source is controlled, contaminant plumes that are stable or shrinking, and where potential surface exposure is minimal. If the ability of natural attenuation to meet site-specific RAOs is uncertain, contingency measures (e.g., defaulting to another alternative) should be identified. In any case, institutional controls will likely be necessary to ensure long-term protectiveness.

D7.0 PRELIMINARY REMEDIAL ACTION ALTERNATIVES FOR SPECIFIC WASTE GROUPS

The preliminary remedial action alternatives identified previously for use in the 200 Areas comprise the complete list of alternatives. However, not all alternatives are applicable to all waste groups. For example, in situ vapor extraction would not be applicable for waste groups that do not have volatile organic soil contamination. Criteria used to evaluate the applicability of alternatives to specific waste groups include:

- Installing engineered surface barriers with or without vertical barriers (Alternative 1) could be used on sites where contaminants may be leached or mobilized by the infiltration of precipitation or if surface/near-surface contamination exists. Surface barriers would not be effective at sites with deep contamination.
- Excavation and disposal with or without soil treatment (Alternative 2) could be used at most waste sites that contain shallow contamination including; radionuclides, heavy metals, other inorganics compounds, SVOCs, and VOCs.
- Excavation, treatment, and geologic disposal of TRU-containing soils (Alternative 3) could be used only on those sites that contain TRU radionuclides. Since a geologic repository is likely to accept only TRU radioactive soils or TRU/mixed waste, the non-TRU radioactive soils will not be remediated using this alternative.
- In situ grouting or stabilization (Alternative 4) could be used on waste sites that contains heavy metals, radionuclides, and/or other inorganic compounds. In situ grouting could also be effective in filling voids for subsidence control.
- In situ vitrification (Alternative 5) could be used at most waste sites although this alternative is considered to be most applicable to sites that contain high concentrations of contamination in a small area. Vapor extraction may be needed when VOCs are present. In situ vitrification would not be effective at sites where deep contamination or combustible solid debris is present.
- In situ soil vapor extraction (Alternative 6) could be used on any sites that contains VOCs.
- Natural attenuation (Alternative 7) is applicable at any waste site.

Using these criteria, Table D-5 shows preliminary remedial action alternatives that could be used to remediate specific waste groups. Note that a single alternative may not be sufficient to remediate all contamination within a single group. For example, it may be more feasible to place engineered surface barriers at certain waste sites within a group while at other sites excavation and disposal may be more appropriate. Furthermore, some waste sites may require a combination of alternatives. For example, soil vapor extraction to remove organic contaminants could precede in situ vitrification. Also, there may be instances where additional technologies are possible besides those presented in these preliminary alternatives. More specific waste treatment alternatives could be identified and evaluated as more information is obtained. Detailed FSs will be required to refine and more fully evaluate alternatives as they relate to the specific waste sites.

D8.0 TECHNOLOGY NEEDS

Treatability testing may be needed to support the detailed analysis of remedial alternatives identified in Section D6.0 or to support the remedial design and implementation phase. The purpose of this section is to identify potential technology testing needs that should be considered when establishing group-specific needs in work plans or remedial design/remedial action work plans. In most cases, the process options that make up the alternatives are fully developed remedial technologies that have a history of use at Hanford or other sites. With some exceptions, sufficient information exists on each of the process options to support a detailed analyses of the alternatives in the final FS without the need for additional treatability testing. However, site-specific testing may be required to support the remedial design phase and to define operating parameters.

Table D-6 summarizes general testing needs for each of the process options selected in the development of remedial alternatives for the 200 Areas. Testing needs are identified as either technology-specific or site-specific. Technology-specific testing (i.e., nonsite-specific) needs address issues that apply to the process option in general, the results of which would have broad application to 200 Area waste sites. Criteria used to assess testing needs include:

- Have treatability tests been performed on the Hanford Site? Process options that have been tested would generally not require additional technology-specific testing. However, site-specific testing may be needed.
- Has the technology been used to remediate Hanford waste sites? Process options that are well proven for conditions that are representative of the 200 Areas would generally not require additional testing.
- Is the technology sensitive to site-specific conditions, specific matrix conditions, or waste constituents that would require site-specific testing?

A summary of the development status and potential treatability testing needs for each of the alternatives is discussed below.

Engineered surface barriers with or without vertical barriers. Three conceptual designs have been developed for potential application at waste sites in the 200 Areas that provide a range of protective levels depending on site-specific needs (DOE-RL 1996). A full-scale prototype of the Hanford Barrier has been constructed over the 216-B-57 Crib located in the 200 Areas, and 3-years of treatability testing have been completed. Treatability testing has demonstrated that the barrier is constructable, stable and effective at preventing drainage into the waste layer under ambient and extreme precipitation (three times normal rainfall and 1,000-year storms) (Ward et al. 1997). Potential barrier performance testing that remain include the following:

- Assessment of the long-term (500 to 1,000 years) durability of the asphalt layer.
- Assessment of the impacts from potential settlements or subsidence on barrier integrity.
- Material availability for the various barrier layers particularly the silt layer. If materials specified in the three conceptual design are not readily available, alternative materials may be needed that require additional performance testing.

- Full-scale performance testing of the Modified RCRA C and D Barrier designs.

Excavation and disposal, with or without ex situ treatment. Testing would not be required for the excavation and disposal process options because of the significant amount of experience and success gained in implementing this alternative in the 100 and 300 Areas. If needed, ex situ treatment processes will generally require testing before implementation with the possible exception of soil washing and mechanical separation. Pilot-scale soil washing treatability tests completed for 100 and 300 Area waste sites are applicable to the 200 Areas for select contaminants. Treatability testing of thermal desorption, ex situ vapor extraction, ex situ vitrification, and solidification/stabilization processes would generally be needed. It is anticipated that most of the treatability information required could be obtained by a combination of literature research, laboratory screening, and bench-scale studies. However, pilot-scale testing may be required for certain treatment processes.

Excavation, ex situ treatment and geologic disposal of transuranic soil. Treatability testing needs for this alternative is similar to the above alternative. However, the application of excavation and treatment process options at TRU-contaminated soil sites has only been partly demonstrated and will require additional testing. Special handling technologies have been developed (e.g., remotely controlled excavation and handling equipment), but will likely require pilot-scale or demonstration testing. Laboratory- and/or bench-scale tests are expected to be needed to develop optimum methods for ex situ treatment of TRU contaminated soil. Other Hanford Site programs are expected share similar TRU technology needs, and any testing should be integrated, accordingly. In addition, the DOE Office of Technology Development has established the Buried Waste Integrated Demonstration (BWID) at INEL to help resolve some of the issues surrounding retrieval and treatment of TRU-contaminated soil.

In situ grouting or stabilization. The process options that make up this alternative represent mature geotechnical construction-type methods that have been adapted to remediate contaminated soil sites. Operating parameters are controlled by site-specific conditions (e.g., soil type, moisture content) that may require field tests to optimize grout well spacing, grout injection methods or grout properties. Laboratory-, bench-, and/or pilot-scale tests may be required to assess the compatibility of the admixture and waste, and to demonstrate the overall effectiveness in stabilizing the waste (e.g., leachability).

In situ vitrification. In situ vitrification has been tested and field demonstrated on soil sites contaminated with radionuclides, heavy metals, and organic wastes, but is not considered a fully mature technology due to a limited experience base. Pilot-scale testing should be performed to evaluate operating parameters, and reduce cost and performance uncertainties to acceptable levels to support a detailed analysis. The following issues should be considered:

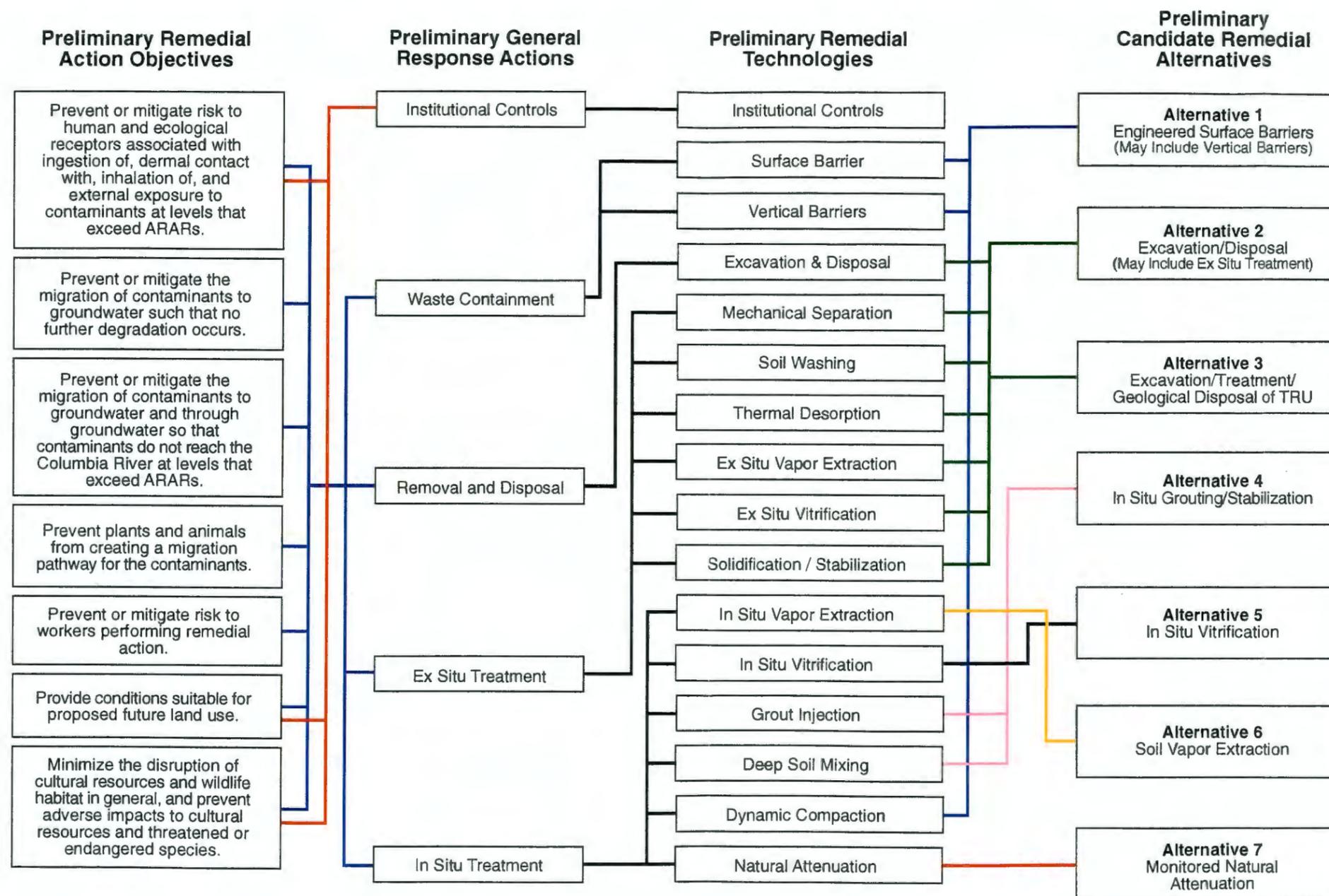
- Subsurface migration of contaminants into clean areas
- Transient gas release events and volatilization of contaminants
- Containment and treatment of offgases
- Secondary waste generation
- Control of melt geometry and measurement of effectiveness
- Operating parameters and costs.

In situ soil vapor extraction. In situ soil vapor extraction is the conventional method for remediating VOC contaminated soil and has been used in the 200 West Area to effectively remediate carbon tetrachloride contaminated soil. No additional testing needs are expected to be needed.

D9.0 REFERENCES

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Figure D-1. Development of Primary Candidate Remedial Alternatives for the 200 Areas.



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Figure D-2. Hanford Barrier Profile from DOE-RL (1996).

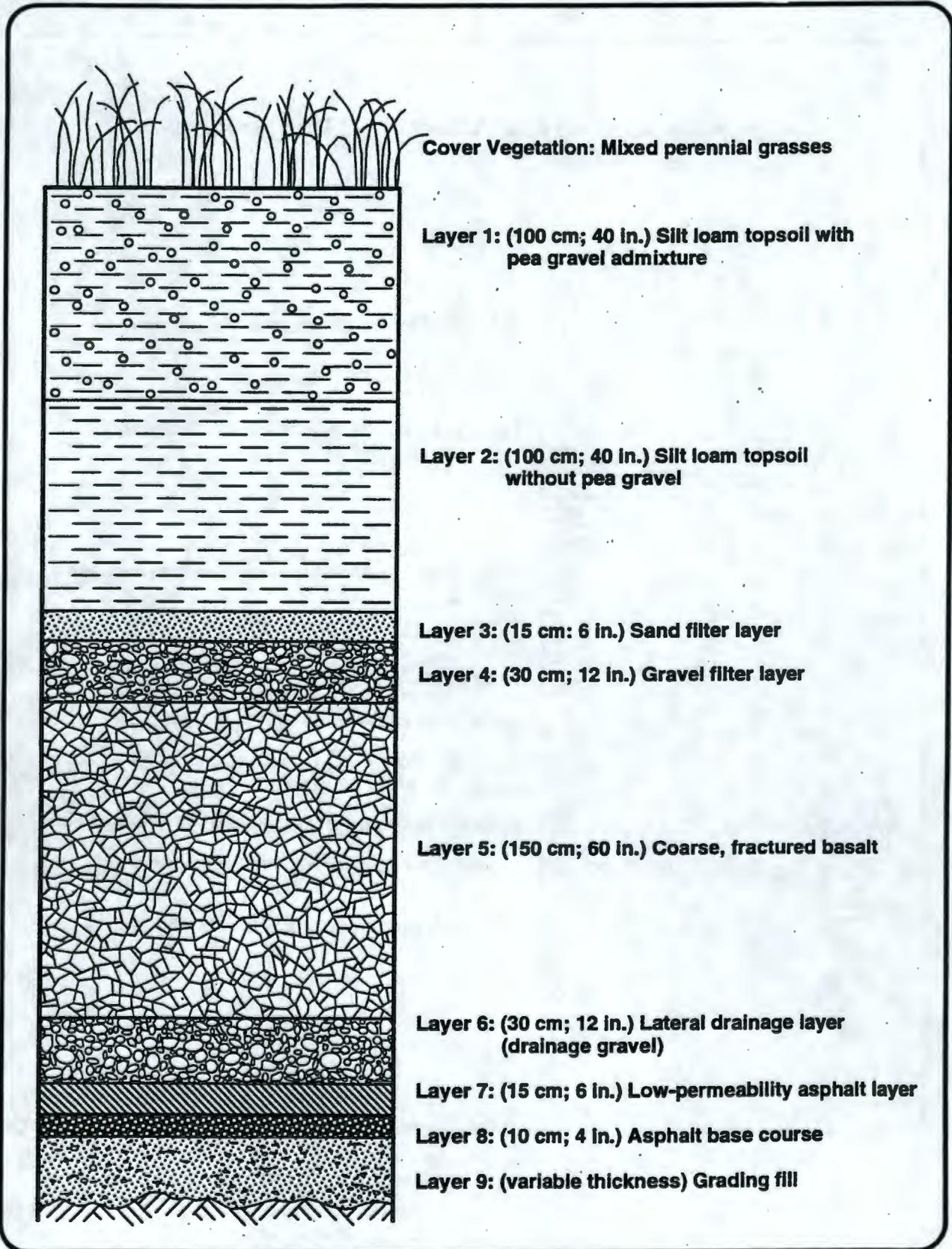


Figure D-3. Modified RCRA Subtitle C Barrier Profile from DOE-RL (1996).

Figure 2. Modified RCRA Subtitle C Barrier Profile.

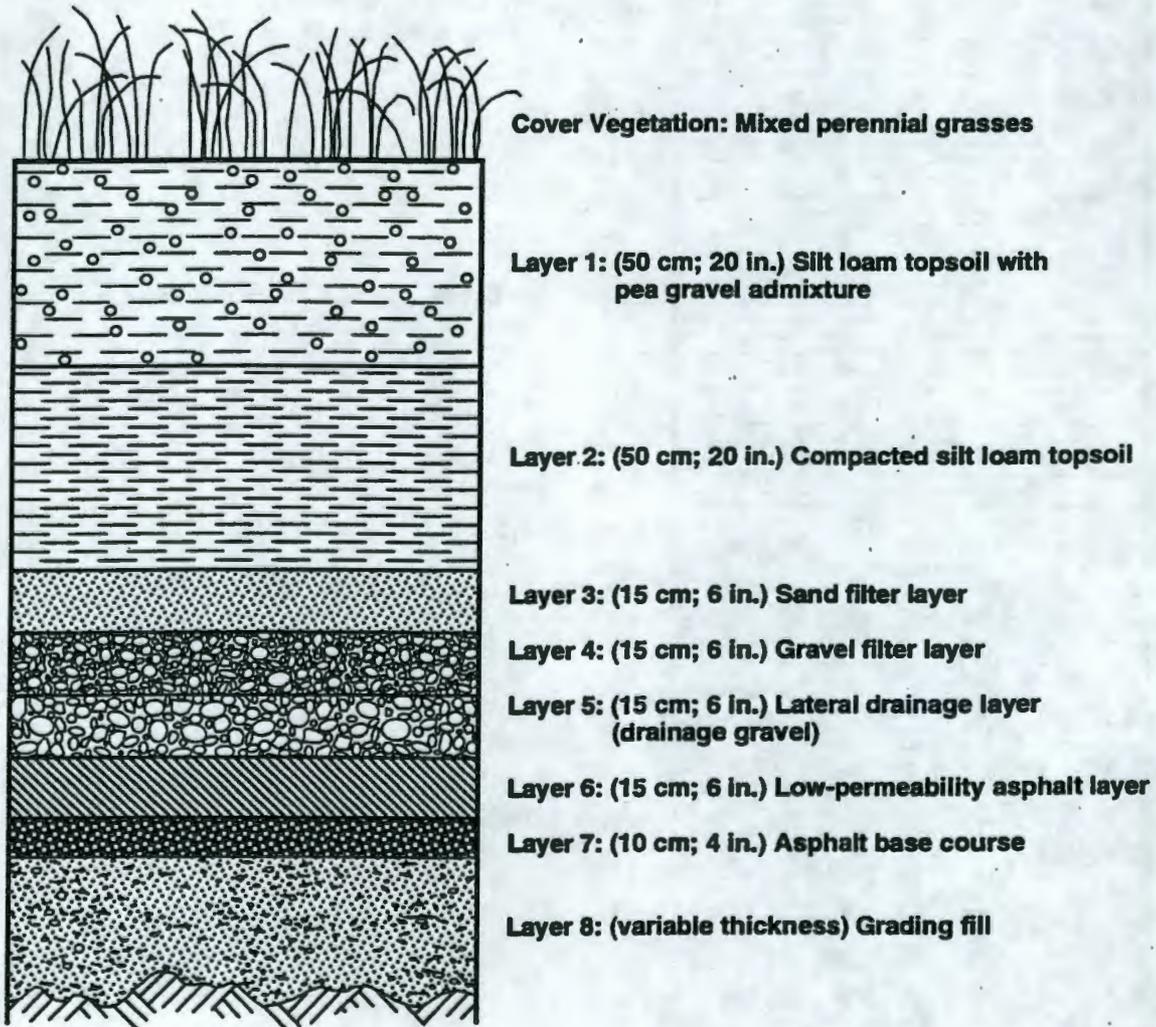


Figure D-4. Modified RCRA Subtitle D Barrier Profile from DOE-RL (1996).

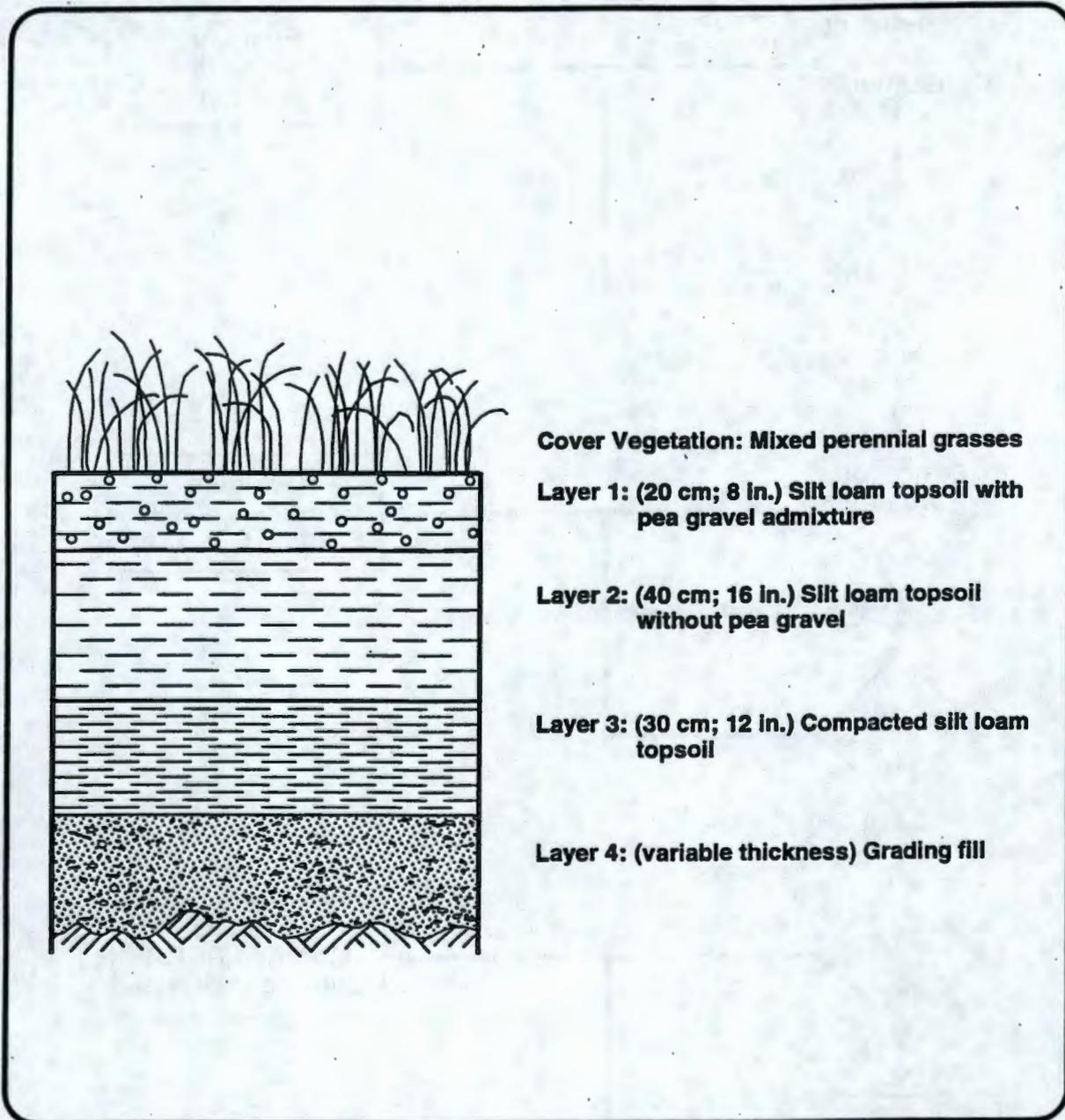
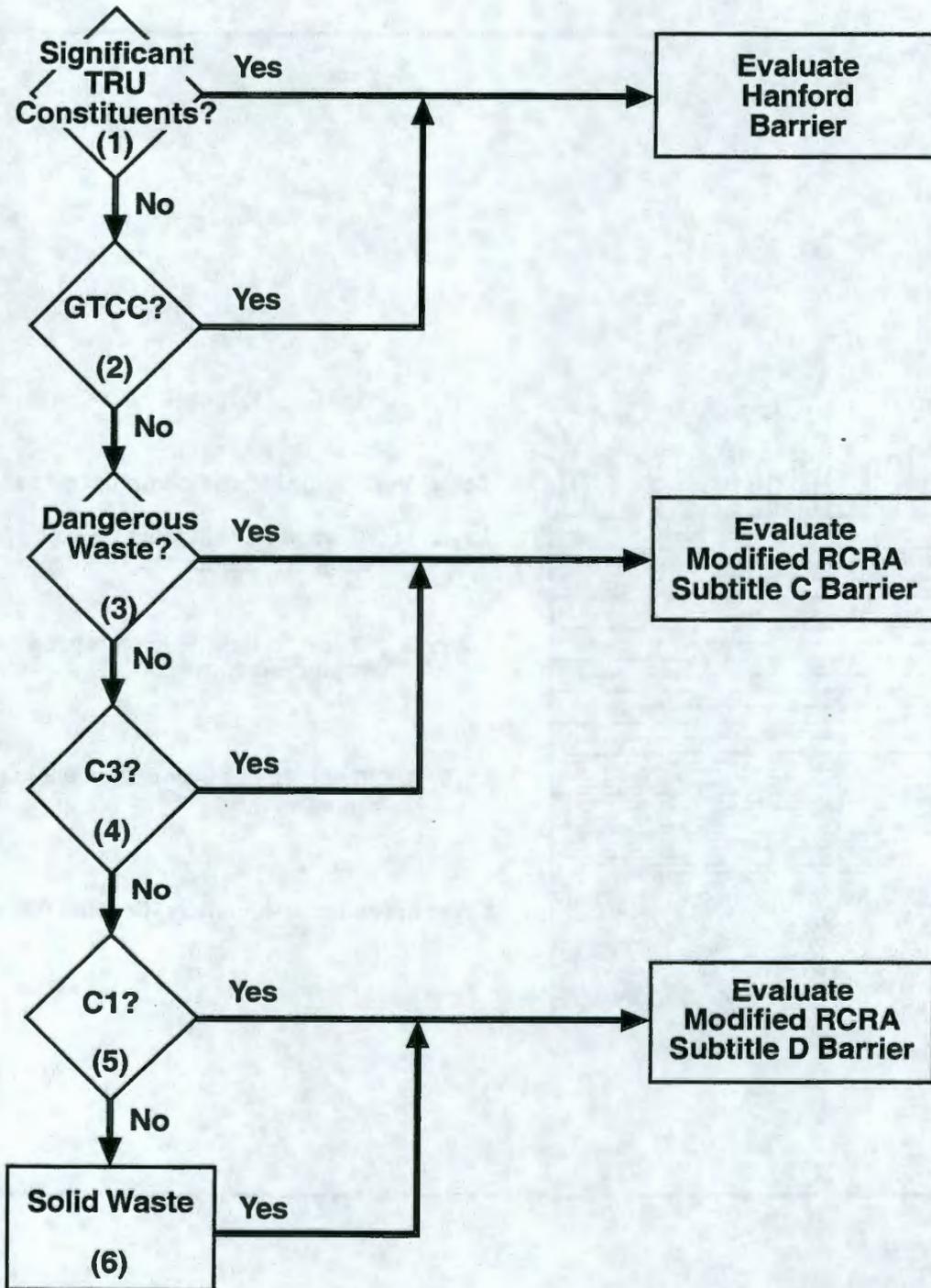


Figure D-5. Implementation Logic for the Graded Barrier Approach from DOE-RL (1996).



TRU = Transuranic
GTCC = Greater-Than-Class C Low Level Waste (LLW)
C3 = Category 3 LLW
C1 = Category 1 LLW

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Table D-1. Technology Types and Process Options for Soil and Solid Media. (2 pages)

General Response Action	Technology Type	Process Option	Contaminants Treated
No Action	No Action	No Action	NA
Institutional Controls	Land Use Restrictions	Deed Restrictions	NA
	Access Controls	Signs/Fences	NA
		Entry Control	NA
Monitoring	Monitoring	NA	
Containment	Surface Barriers	Arid Climate Engineered Cap	I,M,R,O
		Asphalt, Concrete, Cement-Type Cap	I,M,R,O
		RCRA Cap	I,M,R,O
	Vertical Barriers	Slurry Walls	I,M,R,O
		Grout Curtains	I,M,R,O
		Cryogenic Walls	I,M,R,O
Soil Stabilization	Membranes/Sealants/Wind Breaks/Wetting Agents	I,M,R,O	
Removal	Excavation	Conventional	I,M,R,O
Disposal	Landfill Disposal	Onsite Landfill	I,M,R,O
		Offsite Landfill/Repository	I,M,O, T (Non-T radionuclides if mixed with T)
Ex Situ Treatment (Ex situ assumes excavation)	Thermal Treatment	Calcination	I, O
		Thermal Desorption	O
		Incineration	O
		Pyrolysis	O
		Steam Reforming	O
		Vitrification	I, M, R, O
	Physical/Chemical Treatment	Chemical Leaching	I,M,R,O
		Dehalonization	O
		Vapor Extraction	O
		Soil Washing	I, M, R, O
		Mechanical Separation	I,M,R,O
		Solvent Extraction	O
		Chemical Reduction/Oxidation	I, M
Solidification/ Stabilization	I,M,R,O		

Table D-1. Technology Types and Process Options for Soil and Solid Media. (2 pages)

General Response Action	Technology Type	Process Option	Contaminants Treated
	Biological Treatment	Composting	O
		Biological Treatment	O
		Landfarming	O
		Slurry Phase Bio Treatment	O
In Situ Treatment	Thermal Treatment	Vitrification	I,M,R,O
		Thermally Enhanced SVE	O
	Chemical/Physical Treatment	Soil Flushing	I,M,R,O
		Vapor Extraction	O
		Grout Injection	I, M, R
		Soil Mixing	I,M,R
		Dynamic Compaction	NA
	Biological Treatment	Biodegradation	O
		Bioventing	O
	Natural Attenuation	Natural Attenuation	I, M, R, O

I = Other Inorganics contaminants applicability
M = Heavy Metals contaminants applicability
NA = Not Applicable
O = Organic contaminants applicability
R = Radionuclide contaminants applicability
T = Transuranic Radionuclides applicability.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
No Action	No Action	Do nothing to clean up the contamination or reduce the exposure pathways.	Not effective in reducing the contamination or exposure pathways.	Easily implemented, but might not be acceptable to regulatory agencies, local governments, and the public.	Low	Retained as a "baseline" case.
Land Use Restrictions	Deed Restrictions	Identify contaminated areas and prohibit certain land uses such as farming.	Depends on continued implementation. Does not reduce contamination.	Administrative decision is easily implemented.	Low	Retained to be used in conjunction with other process options.
Access Controls	Signs/Fences	Install a fence and signs around areas of soil contamination.	Effective if the fence and signs are maintained.	Easily implemented. Restrictions on future land use.	Low	Retained to be used in conjunction with other process options.
	Entry Control	Install a guard/monitoring system to prevent people from becoming exposed.	Very effective in keeping people out of the contaminated areas.	Equipment and personnel easily implemented and readily available.	Low	Retained to be used in conjunction with other process options.
Monitoring	Monitoring	Analyze soil and soil gas samples for contaminants and scan with radiation detectors.	Does not reduce the contamination, but is very effective in tracking the contaminant levels.	Easily implemented. Standard technology.	Low	Retained to be used in conjunction with other process options.
Surface Barriers	Arid Climate Engineered Cap	Multi-layer design utilizing natural materials; designed for arid climates (DOE 1996); applied over contaminated areas.	Effective on all types of contaminants, use of natural materials enhances design life.	Easily implemented. Restrictions on future land use will be necessary.	Medium	Retained because of long-term effectiveness, implementability, and demonstrated performance.
	Asphalt, Concrete, Cement-Type Cap	Single-layer cover system of asphalt or cement materials.	Effective on all types of contaminants. Temporary and susceptible to weathering settling and cracking.	Easy and relatively fast to implement. Restrictions on future land use will be necessary.	low	Rejected because of limited duration of integrity and protection
	RCRA Cap	Multi-component cap with synthetic membrane over low-permeability soil. Developed for wetter climates.	Effective on many contaminants. Use of synthetics limits design life that may be inadequate for the radioactive waste categories. Low-permeability soil may crack in arid climate.	Easily implemented. Restrictions on future land use will be necessary.	Medium	Rejected because of limited design life considerations.
Vertical Barriers	Slurry Walls	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry.	Effective in blocking lateral movement of all types of soil contamination. May not be effective for deep contamination.	Commonly used practice and easily implemented with standard earth-moving equipment. May not be possible for deep contamination.	Medium	Retained for shallow contamination.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Grout Curtains	Pressure injection of grout in a regular pattern of drilled holes.	Effective in blocking lateral movement of all types of soil contamination.	Commonly used practice and easily implementable, but depends on soil type. May be difficult to ensure continuous wall.	Medium	Retained because of potential effectiveness and implementability.
	Cryogenic Walls	Circulate refrigerant in pipes surrounding the contaminated site to create a frozen curtain with the pond water.	Effective in blocking lateral movement of all types of soil contamination.	Specialized engineering design required. Requires ongoing freezing/maintenance.	Medium	Rejected because it is difficult to implement.
Soil stabilization	Membranes/ Sealants/Wind Breaks/Wetting Agents	Using membranes, sealants, windbreaks, or wetting agents on top of the contaminated soil to keep the contaminants from becoming airborne.	Effective in blocking the airborne pathways of all soil contaminants, but may require regular upkeep.	Commonly used practice and very easy to implement, but land restrictions will be necessary.	Low	Rejected because of limited duration of integrity and protection.
Excavation	Conventional	Contaminated soil is removed and transported to a disposal site.	Well-proven and effective in removing contamination. Dust generation must be controlled.	Readily implemented.	Low	Retained because of potential effectiveness and implementability.
Landfill Disposal	On-Site Landfill Disposal	Place contaminated soil in an existing on-site landfill or off-site RCRA landfill.	Does not reduce the soil contamination but moves all forms of contamination to a more secure place.	Easily implemented with existing facilities for radiological, dangerous, and mixed waste.	Low	Retained because of potential effectiveness and implementability. Construction of a geologic repository onsite is preferred for transuranics disposal.
	Off-Site Landfill/ Repository	Place contaminated soil in an existing off-site RCRA landfill or geologic repository (TRU waste).	Does not reduce the soil contamination but moves all forms of contamination to a more secure place.	Available for dangerous and TRU waste but difficult to implement because of limited availability, and permits for transporting. Requires pretreatment of TRU-contaminated soil.	High	Retained because of effectiveness on transuranic wastes. May be required for other waste restrictions.
Ex Situ Thermal Treatment	Calcination	Use of high temperatures to purify solids by driving off or consuming the volatile or combustible constituents.	Effective in the decomposition of inorganics such as hydroxides, carbonates, nitrates, sulfates, and sulfites. Removes organic components but does not combust them because of the absence of air. Ineffective for radionuclides and heavy metals. Crushing may be required for gravelly soil.	Commercially available. High-volume high throughput. Off-gas treatment is required. Treatability testing would likely be required.	High	Rejected because of limited effectiveness.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Thermal Desorption	Waste heated to 90 to 560°C (200 to 1000°F) to volatilize water and organic contaminants followed by off gas treatment. Liquid residual produced.	Technology targeted at VOC and SVOCs. Effectively destroys the organic soil contaminants. Volatile metals may be removed. Radionuclides will not be treated.	Implementable. Treatability testing would likely be required.	Medium	Retained because of potential effectiveness and implementability. EPA presumptive remedy for VOCs.
	Incineration	High temperatures (870 to 1200°C) used to volatilize and combust organics in a fluidized bed, kiln, etc. Off-gas treatment required. Liquid and solid residuals produced.	Effectively destroys the organic soil contaminants. Heavy metals can produce a bottom ash that requires stabilization. Some heavy metals will volatilize. Radionuclides will not be treated.	Implementable. Technology is well developed. Mobile units are available for relatively small soil quantities. Off-site treatment is available. Air emissions and wastewater generation should be addressed.	High	Rejected because of potential air emissions and wastewater generation and low organic content of soils. EPA presumptive remedy for VOCs.
	Pyrolysis	Transforms organic material into gas components, solid residue (coke) by heating (430°C) waste in the absence of oxygen followed by off-gas treatment. Liquid and solid residuals produced.	Technology targeted at SVOCs. May be effective in halogenated hydrocarbons. Treated media containing heavy metals may require stabilization. Radionuclides will not be treated. May be applicable to mixed waste.	Limited availability. Technology targeted at treatability testing would likely be required.	High	Rejected because of implementation problems.
	Steam reforming	Uses superheated steam to gasify organics followed by a high-temperature reaction chambers/thermal oxidizer to destroy gasified organics. Liquid and solid residuals.	Effectively destroys organic soil contaminants. Metals, radionuclides, and other inorganics are partitioned and isolated for disposal. Mainly applicable to waste high in organics. Applicable to low-level, TRU, and high-level mixed waste forms.	Limited commercial availability. Treatability testing would likely be required.	High	Rejected because of limited effectiveness and difficult implementation.
	Vitrification	Convert soil to glassy materials by application of electric current.	Technology targeted at inorganics. Effective in destroying organics and immobilizing the inorganics and radionuclides. Off-gas treatment for volatile metals and gaseous radionuclides required.	Implementable. Commercial units are available. Laboratory testing required to determine additives, operating conditions, and off-gas treatment. Must pre-treat soil to reduce size of large materials.	High	Retained because of potential ability to immobilize radionuclides and destroy organics.
Ex Situ Physical/Chemical Treatment	Chemical Leaching		Targets organics.			

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Dehalonization	Destroys contaminants by dehalonization process.	Technology targets SVOCs and pesticides. Can be used to treat halogenated VOCs.	Limited availability. Low reliability and high maintenance. Treatability testing would be required.	High	Rejected because of limited effectiveness and difficult implementation.
	Vapor Extraction	Excavated soil is placed over a network of aboveground piping to which vacuum is applied to volatilized gases for additional treatment. Liquid residual.	Technology targeted at VOCs. Treatment is more uniform and easily monitored than its in situ counterpart, although the excavation process poses potential health and safety risk to site workers. Inorganics and radionuclides not treated.	Readily implemented.	Low	Retained because of potential effectiveness and implementability. EPA presumptive remedy for VOCs.
	Soil Washing	Removal of contaminants by dissolving, suspending, or concentrating contaminants from contaminated soil using a washing solution. Liquid and solid residuals.	Applicable to a wide variety of heavy metals, radionuclides, and organics in coarse-grained soils. Generally more effective on contaminants than partition to the fine soil fraction.	Implementable. Treatability tests are necessary. Well-developed technology and commercially available. Requires treatment of the rejected water and contaminated soil fines.	Medium	Retained because of potential effectiveness and implementability.
	Mechanical Separation	Sorts soil into size fractions to physically separate the contaminant matrix.	Effective as a concentration process for all contaminants that partition to a specific soil size fraction.	Implementable. Most often used as a pretreatment to be combined with another technology. Equipment is readily available.	Low	Retained because of potential effectiveness and implementability.
	Solvent Extraction	Separates contaminants by application of a solvent to preferentially dissolve contaminants. Liquid residual.	Technology targeted at SVOCs and VOCs. The selected solvent is often just as hazardous as the contaminants presented in the waste. Solvent can remain in the treated soil matrix and lead to further contamination. Inorganics and radionuclides not treated.	Implementable. Laboratory testing necessary to determine appropriate solvent and operating conditions.	High	Rejected because the solvent may lead to further contamination.
	Chemical Reduction/Oxidation	Reduction/oxidation reactions are used to chemically convert hazardous contaminants to a less toxic and more stable form. Solid residual.	Technology targeted at Inorganics. May be effective in treating heavy metal soil contaminants. Radioactivity will not be reduced.	Difficult to implement for large soil volumes or high contaminant levels. Treatability tests are necessary. Competing reactions may reduce efficiency.	Medium	Rejected because of limited applicability and implementation problems.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Solidification/Stabilization	Mixing of soil with a stabilizing agent to physically bind or enclose contaminants within a stabilized mass or induce a chemical reaction to reduce mobility. Admixtures include cement, asphalt, or polymeric materials.	Target contaminants are inorganics and radionuclides. Generally not effective for organics.	Implementable and reliable. Treatability studies may be needed. Volume of waste is increased.	Medium	Retained because of potential effectiveness and implementability.
Ex Situ Biological Treatment	Composting	Aerobic microbial degradation of contaminants. Excavated soils are mixed with bulking agents and organic amendments. Moisture, temperature, carbon/nitrogen ratio, oxygen, and pH are controlled.	Target contaminants are VOCs, explosives, and fuels. Demonstrated effectiveness on organics is limited. Not effective on inorganics or radionuclides. Addition of water may leach contaminants.	Implementable and all materials and equipment are commercially available. Volume of waste is increased. High contaminant concentrations may be toxic to microorganisms. Treatability tests are required.	Medium	Rejected because of limited effectiveness and difficult implementation.
	Biological Treatment	Aerobic microbial degradation of contaminants. Excavated soils are placed on a treatment area with leachate collection system and aerated. Moisture, heat, nutrients, oxygen, and pH are controlled.	Target contaminants are VOCs, explosives, and fuels. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides and questionable effectiveness for halogenated compounds.	Potentially implementable and all materials and equipment are commercially available. Applicable to large soil volumes. High contaminant concentrations may be toxic to microorganisms. Treatability tests are required.	Medium	Rejected because of limited effectiveness and difficult implementation.
	Landfarming	Aerobic microbial degradation of soil contaminants relying on natural organisms. Moisture, nutrients, oxygen level, soil bulking, and pH are controlled.	Target contaminants are VOCs and fuels. Demonstrated effectiveness on organics is limited. Not effective on inorganics or radionuclides. Addition of water may leach contaminants.	Implementable and all materials and equipment are commercially available. High contaminant concentrations may be toxic to microorganisms. Excavation may not be needed. Treatability tests are required.	Low	Rejected because of limited effectiveness and difficult implementation.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Slurry Phase Biotreatment	Aerobic microbial degradation of contaminants. Excavated soil is treated in a bioreactor vessel as a slurry with microorganism, nutrient, and oxygen additions.	Target contaminants are VOCs, explosives, and fuels. Effectiveness is very contaminant- and concentration-specific. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides and questionable effectiveness for halogenated compounds.	Potentially implementable and commercially available. Soil must be processed to remove large soil fraction. Applicable to smaller volumes of soil. High contaminant concentrations may be toxic to microorganisms. Treatability tests are required. Dewatering of fines required.	Medium	Rejected because of limited effectiveness and difficult implementation.
In Situ Thermal Treatment	Vitrification	Electrodes are inserted into the soil and a carbon/glass frit is placed between the electrodes to act as a starter path for initial melt to take place.	Effective in immobilizing radionuclides and most inorganics. Effectively destroys some organics through pyrolysis. Some volatilization of organics and inorganics may occur.	Potentially implementable. Implementability depends on site configuration, e.g., lateral and vertical extent of contamination. Treatability studies required.	High	Retained because of potential ability to immobilize radionuclides and destroy organics.
	Thermally Enhanced Vapor Extraction	Uses steam/hot-air injection or electric/radio frequency to mobilize and facilitate extraction of contaminants. Liquid residuals.	Primary target is SVOCs. Not effective on inorganics or radionuclides. Contaminants are transferred from soil to air.	Implementable. Emissions treatment and treatability studies required.	Medium	Rejected because of limited applicability.
In Situ Chemical/Physical Treatment	Soil Flushing	Solutions are injected through injection system to flush and extract contaminants.	Potentially effective for all contaminants. Effectiveness depends on chemical additives and hydrogeology. Flushing solutions posing environmental threat likely to be needed. Difficult recovery of flushing solution.	Difficult to implement. Not implementable for complex mixtures of contaminants. Flushing solution difficult to recover. Chemical additives likely to pose environmental threat.	Medium	Rejected because of implementation problems.
	Vapor Extraction	Vacuum is applied by use of wells inducing a pressure gradient that causes volatiles to flow through air spaces between soil particles to the extraction wells.	Effective for volatile organics. Ineffective for semivolatile organics, inorganics, and radionuclides. Emission treatment required.	Easily implementable for proper site conditions. Requires emission treatment for organics and capture system for radionuclides and volatilized metals.	Medium	Retained for potential application to volatile organics. EPA presumptive remedy for VOCs.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Grout Injection	Involves drilling and injection of grout to form barrier, encapsulate contaminated material, or fill voids. Applicable for both soil and buried solid waste	Effective for containing inorganics and radionuclides in soil or solid debris matrices. Effective in filling voids or as structural fill. Difficult to maintain integrity as a barrier. Most effective on uniform coarse soil.	Grouting services or equipment and materials are readily available. Implementable but dependent on site conditions.	Medium	Retained because of ability to limit contaminant migration and potential use for filling void spaces.
	Soil Mixing	Solidification agent is applied to soil by mixing in place. Mobility is reduced by physical and chemical means.	Effective for reducing mobility of inorganics and radionuclides. Effectiveness depends on site conditions and additives used.	Implementable and well demonstrated. Services are available from a number of vendors. Treatability studies required to select proper additives. Thorough characterization of subsurface conditions and continuous monitoring required. Waste volumes are increased.	Medium	Retained because of potential effectiveness and implementability.
	Dynamic Compaction	A heavy weight is dropped onto the ground surface to consolidate soil and solid waste burial sites.	Effective for reduces waste void spaces, increasing material stability, and decreasing the hydraulic conductivity of soil	Implementable, readily available and a common construction technique.	Low	Retained for stabilizing buried solid waste because of potential effectiveness and implementability
In Situ Biological Treatment	Biodegradation	Microbial growth utilizing organic contaminants as substrate is enhanced by injection of or percolation water mixed with nutrients and saturated with dissolved oxygen.	Effective for most organics under proper conditions. Ineffective for inorganics and radionuclides. High concentration of heavy metal or radionuclides, highly chlorinated organics, or inorganic salts are likely toxic to microorganisms. Risk of leaching contaminants.	Difficult to implement. Treatability studies and thorough subsurface characterization required.	Medium	Rejected because of limited applicability and difficult implementation.
	Bioventing	Microbial growth utilizing organic contaminants as substrate is stimulated by injection of oxygen.	Effective for organics in coarse grained soils with natural hydrocarbon-degrading microorganisms. Low soil moisture limits biodegradation. Ineffective for inorganics and radionuclides.	Implementable, but a relatively new technology. Pilot-scale tests and thorough subsurface characterization necessary.	Low	Rejected because of limited applicability.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Natural Attenuation	Natural subsurface processes (e.g., biodegradation, dilution, and radioactive decay) that reduce contaminant concentrations without active treatment.	Target contaminants are VOCs, SVOCs, radionuclides, and metals. Effective for short-lived radionuclides.	Easily implemented. Requires demonstration of effectiveness through modeling, evaluation of degradation rates and pathways and monitoring.	Low	Retained for short-lived radionuclides.

Table D-3. Relationships Between Waste Categories and Cover Designs from DOE-RL 1996.

Cover type	Waste site characterization
Hanford Barrier	Sites with significant inventories of TRU constituents, GTCC LLW, and GTCC Mixed LLW
Modified RCRA Subtitle C Barrier	RCRA Subtitle C (Dangerous) Waste Category 3 LLW and Category 3 Mixed LLW Category 1 Mixed LLW
Standard RCRA Subtitle C Barrier	Dangerous Waste
Modified RCRA Subtitle D Barrier	RCRA Subtitle D (Nondangerous and Nonradiological) Waste Category 1 LLW

TRU = Transuranic

GTCC = Greater-Than-Class C

LLW = Low-Level Waste

NOTE: Classification system for LLW at the Hanford Site is described in WHC (1993).

Table D-4. Preliminary Remedial Action Alternatives Applicable to Representative
200 Area Waste Sites.

Waste Group	Alt. 1 Engineered Multimedia Surface Barrier	Alt. 2 Excavation and Disposal	Alt. 3 Excavation Ex Situ Treatment, and Geologic Disposal of Transuranic Soil	Alt. 4 In Situ Grouting or Stabilization	Alt. 5 In Situ Vitrification of Soil	Alt. 6 In Situ Soil Vapor Extraction	Alt. 7 Monitored Natural Attenuation
200-PW-1, Plutonium/ Organic-Rich Process Waste Group	✓	✓	✓	✓	✓	✓	✓
200-PW-2, Uranium-Rich Process Waste Group	✓	✓		✓	✓		✓
200-PW-3, Organic-Rich Process Waste Group	✓	✓		✓	✓	✓	✓
200-PW-4, General Process Waste Group	✓	✓		✓	✓		✓
200-PW-5, Fission Product-Rich Process Waste Group	✓	✓		✓	✓		✓
200-PW-6, Plutonium Process Waste Group	✓	✓	✓	✓	✓		✓
200-CW-1, Gable Mountain/B-Ponds and Ditches Cooling Water Group	✓	✓					✓
200-CW-2, S-Pond and Ditches Cooling Water Group	✓	✓					✓
200-CW-3, 200 North Cooling Water Group	✓	✓					✓
200-CW-4, T-Pond and Ditches Cooling Water Group	✓	✓					✓
200-CW-5, U-Pond/Z-Ditches Cooling Water Group	✓	✓	✓	✓	✓		✓
200-SC-1, Steam Condensate Group	✓	✓		✓			✓
200-CS-1, Chemical Sewer Group	✓	✓		✓	✓		✓
200-LW-1, 300 Area Laboratory Waste Group	✓	✓		✓	✓	✓	✓
200-LW-2, 200 Areas Chemical Laboratory Waste Group	✓	✓	✓	✓	✓	✓	✓
200-MW-1, Miscellaneous Waste Group	✓	✓		✓	✓		✓
200-TW-1, Scavenged Waste Group	✓	✓		✓	✓		✓
200-TW-2, Tank Waste Group	✓	✓	✓	✓	✓		✓
200-IS-1, Tanks/Lines/ Pits/Boxes Group		✓	✓	✓	✓		✓
200-UR-1, Unplanned Releases Group	✓	✓	✓	✓	✓		✓
200-ST-1, Septic Tank and Drain Fields Group		✓					✓
200-SW-1, Non-Radioactive Landfills and Dumps Group	✓	✓					✓
200-SW-2, Radioactive Landfills and Dumps Group	✓	✓	✓	✓			✓

Table D-5. Technology Status and General Treatability Testing Needs. (2 Sheets)

Alternative	Process Option	Process Option Development Status	Technology-Specific Treatability Testing Needed?	Site-Specific Treatability Testing Needed?	Potential Testing Needs
Engineered Surface Barriers with or without Vertical Barriers	Engineered Surface Barriers	Full	Yes	No	Assess long-term asphalt durability. Assess availability of barrier materials. Assess field performance at Mod. RCRA C and D barrier designs.
	Slurry Walls	Full	No	Yes	Assess compatibility of admix and waste. Assess admix specifications based on site-specific conditions (soil conditions). Verify barrier constructability and integrity.
	Grout Walls	Full	No	Yes	Assess compatibility of admix and waste. Assess admix specifications based on site-specific conditions (soil conditions). Verify barrier constructability and integrity.
	Dynamic Compaction	Full	No	No	
Excavation and Disposal with or without Ex Situ Treatment or Excavation, Ex Situ Treatment and Geologic Disposal of Transuranic Soil	Conventional Excavation	NA	No	No	Assess special handling and treatment needs for TRU-contaminated soil.
	Thermal Desorption	Full	No	Yes	Assess effectiveness and reaction time requirements for matrix and contaminant specific conditions. Assess secondary waste treatment requirements.
	Vitrification	Full	No	Yes	Assess effectiveness for matrix and contaminant specific conditions. Assess process requirements for generating melt based on matrix conditions. Assess secondary waste treatment requirements. Assess potential for use in treating soil residuals from other process options.
	Vapor Extraction	Full	No	Yes	Assess secondary waste treatment requirements.

Table D-5. Technology Status and General Treatability Testing Needs. (2 Sheets)

Alternative	Process Option	Process Option Development Status	Technology-Specific Treatability Testing Needed?	Site-Specific Treatability Testing Needed?	Potential Testing Needs
Excavation and Disposal with or without Ex Situ Treatment or Excavation, Ex Situ Treatment and Geologic Disposal of Transuranic Soil (continued)	Soil Washing	Full	No	Yes	Assess effectiveness based on site-specific conditions (soil conditions) and target contaminants. Formulate washing agent specifications. Assess secondary waste treatment requirements.
	Mechanical Separation	Full	No	No	
	Solidification/Stabilization	Full	No	Yes	Assess compatibility of admix and waste. Assess admix specifications based on matrix conditions and volumetric changes. Verify effectiveness against leaching and waste form stability.
In Situ Grouting or Stabilization	Solidification/Stabilization	Full	No	Yes	Assess compatibility of admix and waste. Assess admix specifications based on site-specific conditions (soil conditions). Verify constructability and effectiveness against leaching.
In Situ Vitrification of Soil	In Situ Vitrification	Full	Yes	Yes	Assess costs. Assess effectiveness and process requirements for generating melt based on site-specific (soil conditions) and target contaminants. Assess secondary waste generation and treatment requirements.
In Situ Soil Vapor Extraction	In Situ Vapor Extraction	Full	No	No	
Monitored Natural Attenuation	Natural Attenuation	NA	No	No	

APPENDIX E
WASTE MANAGEMENT FOR THE 200 AREAS IMPLEMENTATION PLAN

E1.0 PURPOSE

The purpose of this appendix is to establish a flexible approach to the management of investigation-derived waste (IDW) while ensuring protection of human health and the environment during the implementation of the 200 Areas strategy. Storage and disposal of IDW will meet the applicable requirements established in the Washington State Dangerous Waste Regulations (*Washington Administrative Code* [WAC] Chapter 173-303) for *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and *Resource Conservation and Recovery Act* (RCRA) sites at Hanford. Hanford Site IDW that meets the Environmental Restoration Disposal Facility (ERDF) waste acceptance criteria (BHI 1996) and approval authorization will be disposed of in the ERDF.

This appendix is meant to provide an overview of the strategy agreed to in *Strategy for Management of Investigation-Derived Waste* (Ecology et. al. 1995) and other pertinent waste management policies as they apply to the 200 Areas Implementation Plan. Lessons learned from other projects will be incorporated into 200 Areas project documentation. This document is intended to be utilized in conjunction with the "Environmental Protection Policy" (BHI-MA-01, *ERC Policies, Organization, and Responsibilities*, Section 3.2), "Waste Management Program" (BHI-MA-02, *ERC Project Procedures*, Section 9.1), "Control of CERCLA and Other Past Practice Investigation Derived Waste" (BHI-FS-01, *Field Support Administration*, Procedure No. 4.14), and the BHI "*Waste Management Plan*" (BHI-EE-10).

E2.0 APPLICABILITY

This document applies primarily to IDW generated from site characterization and environmental investigations of past-practice units regulated under CERCLA and RCRA. Project managers shall strive to minimize the generation of IDW through proper planning of activities to reduce the need for special storage or disposal requirements. IDW is defined as any waste generated as a result of conducting a CERCLA or RCRA past-practice investigation, treatability study or well construction, maintenance, or abandonment activity. IDW may include, but is not limited to, the following:

- Drilling mud
- Cuttings from test pit and well installation
- Materials from well maintenance, remediation, and abandonment
- Purgewater, soil, and other materials from collection of samples
- Residues (e.g., ash, spent carbon) from testing of treatment technologies
- Contaminated personal protective equipment
- Solutions (aqueous or otherwise) used to decontaminate nondisposable protective clothing and equipment.

Groundwater and free liquids contained in groundwater slurries will be managed according to the Hanford Site purgewater agreement, *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington* (Izatt 1990).

E3.0 REGULATORY BACKGROUND

Administrative requirements such as obtaining permits, documentation, reporting, and record keeping are not applicable to actions undertaken at CERCLA units; however, IDW will be managed in accordance with the substantive requirements of RCRA and WAC 173-303. The substantive requirements associated with management of dangerous waste in containers will be complied with to the extent practicable.

IDW may be placed in the ERDF provided regulatory approval is gained and the waste acceptance criteria are met. A variety of wastes are produced as a result of activities associated with the Hanford Site cleanup effort that are authorized for disposal at ERDF. Since IDW generated during investigations of the operable units is similar in nature and contamination to remedial action waste, the U.S. Environmental Protection Agency (EPA) has authorized disposal of IDW at ERDF. The ERDF provides for safe and environmentally protective disposal of this material.

E4.0 COLLECTION OF WASTE

When an IDW-generating activity is conducted within a waste site or suspect waste site, the resulting waste may be managed at the site or transferred to a designated central storage area. Waste collection and storage will be performed pending receipt of analytical results to enable proper disposition of the waste. Only clean water will be used for dust control or equipment decontamination within the waste site boundary. The use of water shall be minimized.

IDW generated outside a known or suspected waste site will not normally require collection, storage, or sampling unless visual evidence or field screening indicates the potential presence of contamination or the project managers identify a need to do so. If collection is required for IDW outside the waste site boundaries, samples will be analyzed only for the constituents of concern identified by the project. Slurry pits and liquid discharged to the soil outside the waste unit boundary will normally be allowed unless the area is suspected to contain contamination.

Waste requiring sampling will have well defined boundaries (e.g., soil piles). Should the analyses indicate contamination, waste stored on the soil surface will be excavated to a depth to ensure all contaminated material is removed. Contaminated waste, liquid, semi-liquid, and miscellaneous wastes from suspect areas will be contained and stored onsite or at a centralized location until it is dispositioned.

E5.0 WASTE CHARACTERIZATION

In most cases, samples will be routinely collected as part of the investigation process. These samples will be submitted for analysis and will provide the basis for characterization. The results from these analyses, or other documentation as agreed upon by the unit managers, will be used to characterize IDW

materials. If additional data are needed to characterize IDW, samples will be collected and analyzed for the constituents of concern as identified in the associated work plan or equivalent document. Process knowledge and/or waste characterization information will be used in conjunction with field screening to identify those wastes that would be designated as characteristic or listed dangerous waste per WAC 173-303. Where process knowledge is used, "worst case" constituent concentration data will be used as input in the preparation of ERDF waste profiles.

For solid material generated within the boundaries of a waste site, the toxicity characteristic of the waste may be determined if necessary. If a totals analysis of the IDW demonstrates that individual analytes are present in concentrations that could not exceed the toxicity criteria, the IDW in question will not be analyzed using the Toxicity Characteristic Leaching Procedure (TCLP) nor be assigned the toxicity characteristic waste code. If the total analysis indicates concentrations sufficiently high enough to possibly fail the TCLP, the test will be performed on the material and waste codes will be assigned accordingly (WAC 173-340).

In addition to required chemical analysis, samples will be collected and screened for radiological constituents. Screening for radiological contamination will be performed as indicated in the work plan or equivalent document. Waste analysis to identify radiological constituents will be performed when necessary. The above actions, along with the use of existing process knowledge, will serve to identify major risks and to protect human health and the environment during these specific types of activities.

In accordance with the Purgewater Agreement (Izatt 1990), IDW consisting of purgewater from the 200 West Area groundwater plume will be collected and stored. IDW consisting of soil from the unsaturated zone in the 200 West Area will require collection when carbon tetrachloride levels exceed the characteristic dangerous waste designation limit of 500 ppb, regardless of co-contaminates present. Soil IDW containing less than 500 ppb carbon tetrachloride will not require collection under this strategy, nor will such media be considered to "contain" a listed dangerous waste, provided co-contaminants are not present above regulated levels.

E6.0 WASTE MANAGEMENT

When site characterization and environmental investigation operations are conducted within a known or suspected waste site, all IDW will be collected and appropriately managed. When site characterization and environmental investigation operations are conducted outside of or near the boundaries of a known waste site, discussion will be conducted between the U.S. Department of Energy, Richland Operations Office (RL) and the lead regulatory agency to determine the need for IDW collection.

Waste site boundaries within an operable unit shall be determined in concurrence with the lead regulatory agency. This determination will be initially based on existing process knowledge and environmental monitoring data and then substantiated in the field with the use of field screening instrumentation, if necessary. The actual waste site boundary, container storage location, and the need for soil piles and/or slurry pits, if any will be agreed to and documented.

IDW management for sites within a given waste site grouping will be identified in a group-specific waste control plan (WCP) or a site-specific waste management instruction (SSWMI) developed for each waste management activity. These documents shall specifically identify the waste site boundaries, activity-specific waste handling, inspection, storage requirements, and disposal points, if any, and

requirements for IDW sampling. These documents shall be developed in accordance with the requirements identified in the BHI *Waste Management Plan* manual (BHI-EE-10). Waste management procedures are mandated by *Control of CERCLA and Other Past Practice Investigation Derived Waste* (BHI-FS-01, *Field Support Administration*, Procedure No. 4.14), and additional requirements for radioactive waste will be implemented in accordance with HSRCM, *Hanford Site Radiological Control Manual*. Items such as (1) the proper labeling of containers, (2) maintenance of those labels, (3) requirements (or exceptions) for container lids or covers, (4) the process and schedule for routine inspections of waste storage areas, (5) the process for documenting and resolving problems that are identified during inspections, and (6) the use and identification of appropriate sample data for generation of waste profiles are addressed in these procedures and/or manuals. Additional requirements for purgewater will be implemented in accordance with *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington* (Izatt 1990).

The following sections describe management of IDW prior to final disposition (e.g., disposal at ERDF).

E6.1 SOILS

Soils will be characterized as described in the appropriate SSWMI or WCP and Section E5.0 of this appendix. Process knowledge may be used to manage soils as clean material such as when drilling boreholes or digging test pits outside of a waste site. In these cases, soil will be collected in stockpiles at the point of generation provided that evidence does not justify otherwise. Soils may be placed back into the test pit upon completion of the activity.

Contaminated or suspect contaminated soils shall be managed to mitigate the spread of contaminants to the environment (e.g., placed on a tarp, containerized). Upon completion of sampling, test pit soils may be returned to the excavation. Clean soils are placed on the top of the excavation. Containers of soil above dangerous waste designation limits, whether generated inside or outside a waste site boundary, will be managed in accordance with the appropriate SSWMI or WCP and Section E7.0 of this appendix.

E6.2 SLURRY WASTE

Slurry waste includes groundwater slurries and drilling fluids, but excludes groundwater and free liquids separated from groundwater slurries. Slurry waste generated within a waste site boundary, including slurry waste that cannot be chemically/radiologically released, will be containerized and sampled as described in the SSWMI or WCP. Containerized slurry waste will be appropriately managed onsite or in a designated storage area pending analytical results.

Slurry waste generated outside a waste site boundary may be disposed in a pre-excavated, lined (porous membrane liner) slurry pit located adjacent to the drill rig if the area under investigation is not within an area requiring purgewater management as described in the Hanford Site purgewater agreement, *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington* (Izatt et al. 1990). Slurry pit locations must be outside the exclusion zone and will be documented in the project logbook.

E6.3 WELL WASTE

Waste generated as a result of well drilling, sampling, maintenance, remediation, decommissioning, abandonment, or other related activities that are part of a CERCLA or RCRA past-practice shall be managed as IDW. Waste will be managed as described above for onsite or offsite activities, contaminants present, and specific waste form (i.e., solid or liquid). Purgewater will be managed in accordance with Section E6.4.

E6.4 PURGEWATER

Purgewater is considered all waste water generated from a well during development, aquifer testing, routine groundwater sampling, well maintenance, well remediation, and well abandonment activities. Before generating purgewater, an assessment will be completed to determine if the water generated must be stored at a storage facility or can be disposed to the soil column. Management of purgewater will be in compliance with the *Strategy for Handling and Disposal of Purgewater at the Hanford Site, Washington* (Izatt 1990).

Depending on the well status as described in the "Purgewater Strategy Implementation List¹," purgewater will be directly discharged to the ground at the well head, diverted away from the well head via a diversion system, temporarily stored at sites or pumped directly into trucks designed to contain purgewater and transported to the appropriate treatment, storage, and disposal (TSD) unit.

E6.5 DECONTAMINATION FLUIDS AND OTHER LIQUID MATERIALS

Decontamination fluids (water and/or nonhazardous cleaning solutions) and other liquid materials (groundwater and free liquids separated from groundwater slurries) generated from operations conducted within the boundaries of a waste site or suspect waste site will be collected and managed in accordance with Section E7.0 of this strategy or the Hanford Site purgewater strategy as appropriate.

Decontamination fluids and other liquid materials generated from operations conducted outside the boundaries of a waste site or suspect waste site will be managed as noncontaminated unless the area under investigation is suspect as described in Section E4.0. If not a suspect area, these wastes may be disposed to the ground at or near the point of generation. These waste disposal locations will be documented in the project logbook.

¹ List is available from Document Information Services, Pacific Northwest National Laboratory

E6.6 MISCELLANEOUS SOLID WASTE

All miscellaneous solid waste (MSW) that is generated as a result of site characterization and environmental investigation efforts (e.g., rags, personnel protective equipment) and that has contacted potentially contaminated materials (contact MSW) will be segregated from soils, slurries, and liquids to the extent practicable. Contact MSW will be collected upon generation and managed in accordance with Section E7.0.

Waste management determinations for contact MSW will be based on results obtained from characterization activities. Where analytical data indicate that the dangerous and radioactive constituents are below levels of concern, contact MSW will be disposed of at an appropriate facility. If analyses indicate that contaminant limits are exceeded, the contact MSW will be disposed of as IDW at ERDF or other appropriate facility.

All MSW generated that has not contacted waste material (non-contact MSW) will be segregated from all other material generated at the unit and disposed in an appropriate facility.

E7.0 WASTE STORAGE AND CONTAINER MANAGEMENT

E7.1 STORAGE LOCATION

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) has divided the Hanford Site into operable units based on the type of disposal units and characteristics of the waste disposed in a given area. Therefore, for the purposes of this project, the area of contamination will be defined as 200 Areas operable units as delineated in the Tri-Party Agreement. The location of a waste accumulation area will be negotiated and agreed upon during preparation of the group-specific work plans.

Most of the generated IDW will be managed in accordance with the applicable WCP or SSWMI for the waste group from which the waste was generated. Waste will be stored at the waste site or at a centralized storage area(s) until analytical data are evaluated for proper waste designation. Most contaminated IDW will be disposed at the ERDF if it meets the waste acceptance criteria. However, based on field screening instrumentation and/or analytical data, it may be determined that it is appropriate to manage certain types of IDW at another approved facility, rather than at the ERDF.

E7.2 SUBSTANTIVE CONTAINER MANAGEMENT REQUIREMENTS

The federal and state regulatory requirements for management of containers are established in 40 *Code of Federal Regulations* (CFR) 264 Subpart I, WAC 173-303-630, and WAC 173-303-160. All containers of IDW that have been determined to pose a potential threat to human health and the environment will be managed in accordance with the applicable federal and/or state requirement(s), *Control of CERCLA and Other Past Practice Investigation Derived Waste* (BHI-FS-01, *Field Support Administration*, Procedure No. 4.14), and other ERC procedures, as applicable (e.g., HSRCM and/or the Hanford Site purgewater strategy).

Waste will be stored at the waste site or at a centralized storage area(s) until analytical data are evaluated for proper waste designation and subsequent disposal or transport to the appropriate TSD unit.

Radiologically contaminated waste will be segregated from nonradiologically contaminated waste. All containers will be legibly labeled, including HAZARDOUS WASTE or DANGEROUS WASTE labels, waste codes, *Solid Waste Management Tracking Systems* (SWITS) numbers, and identification of major risks, as required. All containers will remain closed and sealed except when it is necessary to add or remove waste. Routine inspections will occur.

E7.3 UNKNOWN WASTE

While being stored, each container of unknown waste must be labeled with the date of sampling and the words "WASTE PENDING ANALYSIS". The following information must be kept in the log for each unknown waste: the container tracking number; the date of discovery; the date samples were shipped to a testing facility; and the name, address, and phone number of the testing facility.

E7.4 LISTED WASTE

The major risk (corrosive, reactive, ignitable, toxic), for listed waste not otherwise designated, shall be labeled on the container (not marked) as an "F-listed" waste. Major risks for other waste shall be consistent with either the waste designation or the U.S. Department of Transportation hazard class. Use descriptive labels (i.e., do not use Class 9 labels as major risk labels).

E7.5 RELEASE REPORTING

WAC 173-303-145 establishes the requirements for reporting releases of hazardous substances. Adherence to all other applicable or relevant and appropriate requirements for notification of releases of hazardous substances in excess of a specified reportable quantity is required.

E8.0 WASTE DETERMINATION

This section provides the basis upon which IDW management determination will be made. IDW will be radiologically released when the waste meets applicable release levels. Waste that is above established release levels and meets the waste acceptance criteria will be transported to the ERDF for disposal. Nonradioactive IDW containing hazardous constituents below dangerous waste designation limits and Model Toxics Control Act (MTCA), Method B soil cleanup standards will be disposed to the ground at or near the point of generation. Waste that exceeds dangerous waste release or MTCA Method B limits and meets the ERDF waste acceptance criteria will be disposed at the ERDF. IDW that does not meet the ERDF waste acceptance criteria will remain on the waste site or in a centralized storage area pending disposal at an appropriate facility or storage at Hanford's Central Waste Complex.

E9.0 DISPOSAL OF INVESTIGATION-DERIVED WASTE

The IDW will be stored within a designated area until the appropriate waste management decision has been made. Upon receiving the analytical results and profiling the waste, waste resulting from that action will be treated, stored, and/or disposed, as appropriate. Contaminated IDW that meets that ERDF waste acceptance criteria will be disposed at the ERDF. Liquids will be managed as described above. Miscellaneous material that does not require disposal in the ERDF will be disposed in an appropriate solid waste disposal facility.

A case-by-case disposal determination shall be made in instances where IDW exceeds the ERDF waste acceptance criteria. In these instances, the IDW of concern shall be appropriately managed to minimize impacts to human health and the environment.

E10.0 SPECIAL CIRCUMSTANCES

The RCRA and CERCLA project managers designated by the respective Tri-Party participants (RL, the Washington State Department of Ecology, and the EPA) shall have authority to negotiate IDW criteria not specified in this document or other regulatory agreements. Any negotiations conducted outside of the scope of this document will only be conducted for unique situations where application of the existing scope of this document is impractical or otherwise inappropriate. Prior to implementation of any special IDW management action negotiated by project managers, they will document the technical and regulatory justifications for their actions. If management of IDW is not conducted in accordance with this document and existing regulatory agreements, and agreement on special management actions cannot be reached by the project managers, the IDW will be managed in accordance with WAC 173-303 until the issue is resolved.

Concurrence with language in RL or contractor IDW procedures that are not addressed in this document and existing regulatory agreements will be the responsibility of the individual project managers during development of each group-specific work plan to control waste and will be based on site-specific conditions.

The provisions of this strategy shall be periodically reviewed by the Tri-Parties or their designees for purpose of amending the document, if it is deemed necessary. If there is a significant need by any of the Tri-Parties for revision at any time, the document may be revised and approved by them.

E11.0 REFERENCES

BHI, 1996, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00139, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-10, *Waste Management Plan*, Bechtel Hanford, Inc., Richland, Washington.

BHI-FS-01, *Field Support Administration*, Bechtel Hanford, Inc., Richland, Washington.

BHI-MA-01, *ERC Policies, Organization, and Responsibilities*, Bechtel Hanford, Inc., Richland, Washington.

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

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

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HSRCM-1, 1996, *Hanford Site Radiological Control Manual*, Hanford site Contractors, Richland, Washington.

Izatt, R. D., 1990, *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington*, letter 90-ERB-075, to P.T. Day and T. L. Nord, MacTech Services, August 20, U.S. Department of Energy, Richland, Washington.

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

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

WAC 173-340, "Model Toxics Control Act-Cleanup," *Washington Administrative Code*, as amended

APPENDIX F
PHYSICAL SETTING

F1.0 INTRODUCTION

Data on the physical characteristics of the contaminated sites and surrounding areas are needed to define potential contaminant transport pathways in the subsurface from the disposal sites toward groundwater and toward potential receptors. These data (which are summarized in Section 3.1) describe the physical setting for the conceptual models of contaminant distribution (presented in Section 3.3) and exposure (presented in Section 5.0). Data on the physical characteristics are also needed to provide sufficient engineering data for development and screening of remedial action alternatives.

Appendix F contains the description of the physical setting for the 200 Areas. This information is included as an appendix to the 200 Areas Implementation Plan so that it can be referenced, rather than repeated, in the individual group-specific work plans. As a result, each work plan will build on a consistent base of information with a minimum of redundancy.

Descriptions of the physical setting of the 200 Areas are included in each of the ten AAMS reports prepared for the geographically-based operable units (Table 3-1). This information is also summarized in the Hanford Site National Environmental Policy Act Characterization report prepared and updated by Pacific Northwest National Laboratory (Neitzel 1997). The descriptions of the 200 Area physical setting included in this appendix are taken largely from these sources. As each group-specific work plan is prepared, the most recent environmental reports will be consulted to ensure that this description of the physical setting is still correct and complete; any significant modifications to the information presented here will be incorporated into these future work plans.

F2.0 TOPOGRAPHY OF THE 200 AREAS

The land surface of the Hanford Site is dominated by low-relief plains and basaltic ridges (Gable Mountain-Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills) in the western portion of the site that rise above these plains (Figure F-1). This general topography of the Hanford Site has been modified by two natural processes, Pleistocene cataclysmic flooding and Holocene eolian activity, and by Hanford Site construction activity.

Cataclysmic flooding occurred when ice dams in western Montana and northern Idaho were breached, allowing large volumes of water to spill across eastern and central Washington. The last major flood occurred about 13,000 years ago, during the late Pleistocene epoch. Flood channels, giant current ripples, and giant flood bars are among the landforms created by the floods. One of these flood bars (Cold Creek Bar) forms a prominent terrace, roughly defined by the 215-m (700-ft) contour line, that is commonly referred to as the "200 Area Plateau" because the surface of the flood bar is a broad, flat area that constitutes a local topographic high (Figure F-1). This terrace drops off to the north and northwest with elevation changes between 15 and 30 m (50 and 100 ft) (DOE-RL 1993b).

Cold Creek bar trends generally east-west. The northern boundary of the flood bar is defined by an erosional channel that runs east-southeast before turning south just east of the 200 East Area. This erosional channel formed during waning stages of flooding as floodwaters drained from the basin (Bjornstad et al. 1987). The northern half of the 200 East Area and the entire 200 North Area lie within this ancient flood channel (Figure F-1). 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 southward off the main channel bisects the 200 West Area (Last et al. 1989). Buried former river and flood channels may provide preferential pathways for groundwater and contaminant movement.

Since the end of the Pleistocene epoch, winds have locally reworked the flood sediments, depositing primarily sand on the low-relief plains and loess (windblown silt) around the margins of the Pasco Basin. In the 200 West Area and southern part of the 200 East Area, these deposits consist dominantly of laterally discontinuous sheets of wind-blown silt and fine-grained sand (Hartman and Dresel 1998). Anchoring vegetation has stabilized much of the dune sand. However, stabilized dunes are easily reactivated in areas where vegetation is disturbed by fire or man. Stabilized sand dunes are present along the southern boundary of the 200 East Area (Last et al. 1989).

Construction and operation of waste management facilities for liquid and solid waste disposal resulted in local modifications to the topography.

The topography of the 200 West Area is generally flat. The elevation ranges from approximately 221 m (725 ft) above mean sea level (msl) along the northern half of the eastern perimeter, situated on the flood bar, to approximately 197 m (647 ft) above msl in the southwestern corner (DOE-RL 1993b).

The topography of the 200 East Area is generally flat. The elevation ranges from approximately 225 m (740 ft) above msl in the southwestern part, situated on the flood bar, to approximately 180 m (590 ft) above msl in the northeastern part, situated within the flood channel (DOE-RL 1993a).

The topography of the 200 North Area slopes gently to the south and east. The elevation in the vicinity of the 200 North Area ranges from approximately 181 m (593 ft) in the northeastern corner to approximately 170 m (560 ft) in the southeastern corner (DOE-RL 1993c).

F3.0 METEOROLOGY OF THE 200 AREAS

The Hanford Site lies east of the Cascade Mountains and has a semi-arid climate because of the rainshadow effect of the mountains. Climatological data are monitored at the Hanford Meteorological Station (HMS), located between the 200 East and 200 West Areas, and at other locations throughout the Hanford Site. Meteorological data from the HMS are available for 1945 through 1996 in a report (Hoitink and Burk 1997) and for 1997 through the present on the HMS internet site (Hoitink and Burk 1998). Historical data tables of temperature and precipitation are also available through the HMS internet site (Hoitink and Burk 1998). Data from the HMS are representative of the general climatic conditions for the region and describe the specific climate of the 200 Area Plateau (Neitzel 1997).

F3.1 WIND

The Cascade Mountains have considerable effect on the wind regime at the Hanford Site by serving as a source of cold air drainage. Because of this gravity drainage, prevailing wind directions on the 200 Areas Plateau are from the northwest in all months of the year (Figure F-2). Secondary maxima occur for winds from the southwest. Winds from the northwest quadrant occur most often during the winter and summer. During the spring and fall, the frequency of winds from the southwest increases with a corresponding decrease in northwest flow. Winds blowing from other directions (e.g., northeast) display minimal variation from month to month (Neitzel 1997).

Monthly average wind speeds are lowest during the winter months, averaging 10 to 11 km/h (6 to 7 mi/h), and highest during the summer, averaging 13 to 15 km/h (8 to 9 mi/h) (Hoitink and Burk 1997). Wind speeds that are well above average are usually associated with southwesterly winds.

However, the summertime drainage winds are generally northwesterly and frequently reach 50 km/h (30 mi/h) (Neitzel 1997).

Winds are a potential agent of contaminant transport for particles at the ground surface. For example, former liquid waste disposal sites at ground surface (e.g., ponds and trenches) that dry out may expose contaminated soils that could be mobilized by wind.

F3.2 BAROMETRIC PRESSURE

The average barometric pressure at the HMS is 98.9 kPa (29.2 in. Hg). In general, the barometric pressure is higher in the winter than in the summer, although both the highest and lowest recorded pressures at the Hanford Site occurred during the winter (DOE 1988). Fluctuations in barometric pressure also tend to be greater in winter than in summer (Figure F-3). Fluctuations in barometric pressure affect the movement of volatile contaminants within the vadose zone by inducing natural subsurface pressure gradients. This naturally-occurring "barometric pumping" phenomenon can also cause release of volatile contaminants to the atmosphere. In general, falling barometric pressure causes subsurface vapor to move to the atmosphere through soil pores or wells, which provide preferential pathways. Barometric pressure fluctuations also produce fluctuations in the elevation of the semi-confined and confined water tables.

F3.3 TEMPERATURE AND HUMIDITY

The mean surface air temperature averages approximately 12°C (53°F) at the HMS (DOE 1988). During the 53 years between 1945 and 1997, the average monthly temperature was coldest in January at -1°C (31°F) and hottest in July at 25°C (76°F) (Hoitink and Burk 1998). The maximum and minimum monthly average temperatures during any single year are listed for each season in Table F-1. The maximum temperature recorded at the HMS was 45°C (113°F) in August 1961; the minimum temperature recorded at the HMS was -31°C (-23°F) in February 1950 (Hoitink and Burk 1998). An average of 174 d/yr at the HMS are free of freezing temperatures, with the recorded range lying between 142 and 215 d/yr (DOE 1988).

The annual average relative humidity at the HMS is 54%. It is highest during the winter months, averaging about 75%, and lowest during the summer, averaging about 35% (Neitzel 1997).

Temperature affects the evapotranspiration of precipitation and thus is one factor determining the amount of recharge to the unconfined aquifer. Precipitation that infiltrates through the vadose zone can mobilize contaminants.

F3.4 PRECIPITATION

Average annual precipitation at the HMS during the 51 years between 1947 and 1997 was 17.3 cm (6.8 in.) (Hoitink and Burk 1998). In the wettest year on record, 1995, 31.2 cm (12.3 in.) of precipitation was measured; in the driest year, 1976, only 7.6 cm (3.0 in.) was measured. On average, winter is the wettest season; approximately 38% of the annual precipitation falls during December, January, and February. Only 14% of the annual precipitation falls during June, July, and August. Even though precipitation is less frequent during the summer months, summer rainfall, when it does occur, is on average twice as intense as winter precipitation (DOE 1988). The maximum monthly average precipitation during any single year is listed for each season in Table F-2.

During the 51 winters between 1946 and 1997, the average monthly snowfall was highest in December at 13.7 cm (5.0 in.) and lowest in March at 1.3 cm (0.5 in.) (Hoitink and Burk 1998). The record monthly snowfall of 59.4 cm (23.4 in.) occurred in January 1950; the second highest monthly snowfall of 57.4 cm (22.6 in.) occurred in December 1996. The seasonal record snowfall of 142.5 cm (56.1 in.) occurred during the winter of 1992-1993. Snowfall accounts for about 38% of all precipitation from December through February (Neitzel 1997). On average, the depth of snow on the ground will exceed 150 mm (5.9 in) in about only one winter out of eight (DOE 1988).

Days with greater than 1.3 cm (0.50 in.) of precipitation occur on average less than one time each year. Rainfall intensities of 1.3 cm/hr (0.5 in/hr) persisting for 1 hour are expected once every 10 years. Rainfall intensities of 2.5 cm/hr (1 in./hr) for 1 hour are expected only once every 500 years (Neitzel 1997).

The average occurrence of thunderstorms is 10 per year. They are most frequent during the summer; however, they have occurred in every month (Neitzel 1997). Lightning strikes in the summer have occasionally ignited grass fires that have burned thousands of acres in the Hanford Site region (DOE 1988).

The frequency and intensity of precipitation at the Hanford Site are of specific interest because of their influence on moisture infiltration to soil and potential recharge to groundwater. The rate and degree of infiltration of snow will also depend on the rate at which it melts. Large amounts of precipitation can enter the ground over relatively small areas as the result of a downpour from a thunderstorm or rapid snow melt. Potential surface run-off and run-on at individual waste sites will depend on the local topography and permeability of ground surface cover. Building and road run-off of relatively low rates of rainfall can lead to precipitation being focused on small areas and ponding in low areas, both of which would increase the infiltration rate. Another cause of increased infiltration is associated with leaks or spills from utility water lines, such as those in the fire hydrant systems.

F3.5 RECHARGE

Recharge to the unconfined aquifer within the 200 Areas may be from natural and artificial sources. If natural recharge occurs, it originates from precipitation because no natural surface waters exist within the 200 Areas. Artificial recharge in the 200 Areas resulted from large volumes of liquid waste disposed to the ground from plant operations that began in 1943. In the 1950's through 1980's the annual volume of effluent discharged to the soil column in the 200 Areas typically ranged from 10 to 25 billion Liters (Hartman and Dresel 1998). Zimmerman et al. (1986) report that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes was discharged to the soil column in the 200 Areas. Currently, most sources of artificial recharge have ceased in the 200 Areas and are largely limited to liquid discharges to sanitary sewers, the two State-Approved Land Disposal Structures, and over 140 small volume, uncontaminated, miscellaneous waste streams (DOE-RL 1997a).

The primary factors affecting the magnitude of precipitation recharge are climate, soils, vegetation/land use, and topography (Fayer and Walters 1995). Evapotranspiration of precipitation is considered to significantly reduce the amount of precipitation that reaches the groundwater (Gee 1987). In general, infiltration to soils is higher in the winter when precipitation is more frequent and evapotranspiration is low (DOE-RL 1997b).

A number of field studies have been conducted on the Hanford Site to assess precipitation, infiltration, water storage changes, and evaporation to evaluate the natural water balance during the recharge process. Precipitation recharge values ranging from 0 to 100 mm/yr (0 to 4 in./yr) have been estimated from these

studies and depend largely on soil texture and the type and density of vegetation. A natural recharge map based on distributions of soil and vegetation types is shown in Figure F-4. Recharge from precipitation is higher in the coarse-textured soils with little or no vegetation, as are found in the 200 Areas (Hartman and Dresel 1998). Historically, the volume of natural recharge was expected to be significantly lower than the volume of recharge contributed by artificial sources throughout the 200 Areas. Graham et al. (1981) estimate that historical artificial recharge from liquid waste disposal in the 200 Areas exceeded all natural recharge on the Hanford Site by a factor of 10 (DOE-RL 1997b).

With the cessation of artificial recharge in the 200 Areas, the downward flux of moisture in the vadose zone to groundwater has decreased underlying liquid disposal sites and is expected to continue to decrease with time. The maximum flux of moisture occurred when plant operations were active, creating many localized areas of saturation/near saturation in the soil column beneath liquid disposal waste sites. When waste sites cease operating, the moisture flux continues to be significant for a period of time because of gravity drainage of the saturated/near-saturated soil column. When unsaturated conditions are reached, moisture flux becomes increasingly less significant because unsaturated hydraulic conductivity decreases with decreasing moisture content. The decrease in artificial recharge in the 200 Areas is reflected in the water table, which continues to decrease in elevation throughout the 200 Areas. In the absence of artificial recharge, the potential for recharge from precipitation becomes more important as a downward driving force for remaining vadose zone contamination (DOE-RL 1997b).

The unconfined aquifer underlying the 200 Areas may also receive natural recharge from two additional sources. Rainfall and run-off from the higher bordering elevations to the west of the site recharge the unconfined aquifer upgradient of the 200 Areas. Also, in areas of upward gradients, the unconfined aquifer may be recharged with water from the underlying confined aquifer system. The direction of the vertical gradients may change as waste water disposal practices change (DOE-RL 1993b).

Water that infiltrates the vadose zone may leach contaminants from both liquid and solid waste disposal sites and transport them to groundwater. Recharge thus represents a potential long-term mechanism for contaminant migration.

F4.0 VADOSE ZONE HYDROGEOLOGY

The vadose zone beneath the 200 Areas ranges in thickness from approximately 55 m (180 ft) beneath the former U Pond in the 200 West Area to approximately 104 m (341 ft) in the southern portion of the 200 East Area to 49 m (160 ft) along the western part of the 200 North Area. The vadose zone thins from the 200 Areas north to 0.3 m (1 ft) near West Lake. Sediments in the vadose zone consist primarily of the Hanford formation, Plio-Pleistocene unit/early Palouse soil, and Ringold Formation, as illustrated in a generalized east-west cross-section through the Hanford Site (Figure F-5). Variable surface topography and the variable elevation of the water table in the underlying uppermost aquifer causes this observed variation in vadose zone thickness. Other important features of the vadose zone include basalt of the Columbia River Basalt Group projecting above the water table north of the 200 East Area, clastic dikes occurring in the Hanford formation, and wind-blown sand and silt deposits at the surface.

Both the Ringold and Hanford formations have been subdivided into different units and facies based on rock type and depositional environment. Detailed stratigraphic sections for the 200 West and 200 East Areas are presented in Figure F-6. Location-specific cross-sections that provide examples of the variability in thickness and continuity of different sedimentary units and facies are presented in Figures F-7 through F-10. Structure and isopach maps of the principal geologic units that make up the vadose zone are included in Connelly et al. (1992a, 1992b).

Although sediments of the Hanford and Ringold formations are present beneath the 200 West, 200 East, and 200 North Areas, the vadose zones at these three locations differ significantly. The Plio-Pleistocene unit/early Palouse soil, which has a relatively low permeability that impacts the migration of liquid and vapor, is found only underlying the 200 West Area. The groundwater table occurs within the less conductive Ringold Formation in the 200 West Area and primarily within the Hanford formation in the 200 East and 200 North Areas (Figure F-11).

Calcium carbontate (CaCO_3) content is typically less than 1% in the Ringold Formation Unit E, less than 1% in the upper Ringold Unit, as much as 10% in the Plio-Pleistocene Unit/early Palouse soil and less than 2% in the Hanford formation.

The following subsections provide a brief description of the units, in descending order, that make up the vadose zone in the 200 Areas.

F4.1 SURFICIAL DEPOSITS

Holocene-aged deposits in the 200 Areas are dominated by eolian sheets of sand that form a thin veneer across the 200 Areas except in localized areas where they have been removed by human activity. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand and are generally less than 3 m thick. Silty deposits (<1 m thick) have also been documented at waste management facilities (e.g., ponds and ditches) where fine-grained windblown material has settled out through standing water over many years.

F4.2 HANFORD FORMATION

The Hanford formation (informal designation) consists of uncemented gravels, sands, and silts deposited by Pleistocene cataclysmic flood waters. As discussed by Lindsey et al. (1991), these cataclysmic flood deposits are divided into three facies: gravel-dominated, sand-dominated, and silt-dominated. Based on the distribution of these facies, the Hanford formation is divided locally into three informal stratigraphic sequences. These sequences are designated as the upper gravel, sand, and lower gravel sequences. However, because of the variability of the Hanford formation sediments, contacts between these sequences are sometimes difficult to distinguish, especially where the sand sequence is missing and the upper gravel directly overlies the lower gravel. Although the Hanford formation as a whole is continuous throughout the vadose zone in the 200 Areas, none of these individual stratigraphic sequences is continuous across the 200 Areas: all three sequences display marked changes in thickness and continuity and are lithologically heterogenous (Figures F-8 through F-10).

F4.2.1 Upper Gravel Sequence of the Hanford Formation

The upper gravel sequence consists of interstratified gravel, sand, and lesser silt. Gravel-dominated deposits generally dominate the sequence. This coarse-grained upper gravel sequence is distinguished by a coarse-grained sand to a boulder gravel that displays massive bedding, plane to low angle bedding, and large-scale cross bedding in outcrop. The matrix is commonly lacking in the gravels, giving them an open-framework texture. The thickness of this coarse-grained sequence is 70 m (230 ft) at the northeast corner of the 200 North Area and thins to zero near the southern border of the 200 East Area. Within the 200 West Area, the thickness of the upper coarse unit ranges from 0 to 45 m (0 to 148 ft). The contact between the coarse-grained sequence and underlying strata is generally sharp.

F4.2.2 Sand Sequence of the Hanford Formation

The sand sequence of the Hanford formation in the 200 Areas is thick, but locally discontinuous. The sequence is 0 to 90 m (0 to 295 ft) thick in the central portion of the 200 East Area and 0 to 32 m (0 to 105 ft) thick in the 200 West Area. To the north, the sand sequence occurs only in the ancient flood channel along the eastern border of the 200 North Area, where it is up to 15 m (50 ft) thick. It is absent elsewhere in the 200 North Area. The sand sequence generally thickens to the south. The sequence is missing in the central part of the 200 West Area as a result of erosional scouring during the cataclysmic flooding events. This erosional scour is elongated in a north-south direction (Connelly et al. 1992b). The sand sequence consists predominantly of silt, silty sand, and sand with interbedded coarser sands.

F4.2.3 Lower Gravel Sequence of the Hanford Formation

The lower gravel sequence is dominated by deposits typical of the gravel-dominated facies. Local intercalated sandy beds typical of the sand-dominated facies are also found. In the 200 West Area this sequence is missing. It is found throughout most of the 200 East Area at a thickness ranging from 0 to 44 m (0 to 135 ft). However, it is absent in the east-central portion of the 200 East Area. In the 200 North area, the lower gravel sequence is up to 23 m (75 ft) thick in the ancient flood channel along the eastern border. Where this unit is overlain directly by the upper gravel sequence, it is not possible to distinguish between the two. Where it is overlain by the sand sequence, the contact between the sand and lower gravel sequences is interpreted to be at the top of the first thick gravelly interval (6 m [20 ft] or greater in thickness) encountered below the sand-dominated strata of the sand sequence.

F4.3 PLIO-PLEISTOCENE/EARLY PALOUSE SOILS

The Plio-Pleistocene/early Palouse soils are missing from the 200 East and North Areas. The early Palouse soil is largely restricted to the vicinity of the 200 West Area. The unit is differentiated from the overlying Hanford slackwater deposits by (1) greater calcium carbonate content, (2) cohesive structure in core samples, (3) uniform fine-grained texture, and (4) high natural-gamma response. It is distinguished from the underlying Plio-Pleistocene unit by the high natural-gamma response and lower calcium carbonate content. The loess-like sediments of the early Palouse are uncemented. The unit pinches out near the southern, eastern, and northern boundaries of the 200 West Area. Boreholes located west of the 200 West Area, however, do encounter the unit. Due to the fine-grained nature of the soil, this unit is also an impediment to downward migration of water and contaminants.

Like the early Palouse soil, the Plio-Pleistocene unit is restricted to the vicinity of the 200 West Area, pinching out to the northern, eastern, and southern boundaries of the area. It represents a highly weathered surface that developed on the surface of the Ringold Formation. In the 200 West Area, the calcrete facies dominates and is locally referred to as the "caliche layer." The differentiating features of this unit are (1) high degree of cementation, (2) presence of roots and animal bores in cores, and (3) white color. This unit is an impediment to vertical migration of water and vapor due to the high degree of cementation. The thickness is very irregular, and there may be erosional windows through the unit.

F4.4 RINGOLD FORMATION

The Ringold Formation is an interstratified sequence of unconsolidated clay, silt, sand, and gravel-to-cobble gravel deposited by the ancestral Columbia River. The Ringold Formation forms the lower part of the vadose zone throughout the 200 West Area and south of the 200 East Area. The Ringold Formation generally occurs completely in the saturated zone in and north of the 200 East Area, although

relatively small isolated pockets of Ringold occur within the 200 East Area vadose zone. In the 200 Areas, these clastic sediments, from youngest to oldest, consist of four major facies: overbank-dominated deposits of the Upper Ringold; fluvial gravels of Unit E; paleosol and lacustrine muds of the lower mud sequence; and fluvial gravels of Unit A. Ringold Units B, C, and D are not present in the 200 Areas with the exception of localized occurrences of fluvial gravel of Unit C in the 200 East Area.

F4.4.1 Upper Ringold Unit

The upper Ringold unit is missing in the 200 East and 200 North Areas and is discontinuous across the 200 West Area because of post-Ringold erosion. The upper unit in the 200 West Area consists of silty overbank deposits and fluvial sands. This unit is recognized by (1) abundance of well-sorted sand, (2) light color, and (3) variable natural-gamma response. It is found only in the west, north, and central portions of the 200 West Area. It dips to the south-southwest.

F4.4.2 Unit E of the Ringold Formation

Unit E is the uppermost unit of the Ringold Formation in the 200 East and North Areas. It is dominantly composed of fluvial gravel, but strata typical of the fluvial sand and overbank facies may be encountered locally. The unit is recognized by (1) coarse texture, (2) high proportion of quartzite and granitic clasts, (3) relatively low calcium carbonate content, (4) partial consolidation, and (5) relatively low natural gamma response. In the 200 West Area, the gravels of Unit E generally thin from north-northwest to east-southeast while the surface dips toward the east-southeast (Figure F-5). Gravels of Unit E occur in the southwest corner of the 200 North Area, at a thickness up to 5 m (16 ft), and in the southwest corner of the 200 East Area, at a thickness up to 35 m (115 ft). From the 200 North and East Areas, Unit E thickens to the south-southwest. Unit E is the only part of the Ringold Formation identified within the 200 North Area.

F4.4.3 Lower Mud Sequence of the Ringold Formation

The overbank and lacustrine deposits of the lower mud sequence occur beneath the gravels of Unit E. The lower mud sequence generally thickens and dips to the west and to the southeast away from the 200 East Area (Figure F-5). The unit appears in the vadose zone as small isolated pockets in the center of the 200 East Area, underneath B Pond and between B Pond and Gable Mountain (Figure F-11). In the 200 West Area, it forms the aquitard at the base of the unconfined aquifer and is not a part of the vadose zone.

F4.4.4 Unit A of the Ringold Formation

In the 200 East Area, the fluvial gravels and sands of Unit A generally thicken and dip to the south (Connelly et al. 1992a). This unit rises above the water table in a small isolated pockets near the western and eastern boundaries of the 200 East Area and south of Gable Mountain (Figure F-11). Unit A is below the unconfined aquifer and therefore is not part of the vadose zone in the 200 West Area.

F4.5 COLUMBIA RIVER BASALT GROUP

The Elephant Mountain Member is the uppermost basalt unit (i.e., bedrock) in the 200 Areas. Except for a small area north of the 200 East Area boundary where it has been eroded away, the Elephant Mountain Member is laterally continuous throughout the 200 Areas. The Elephant Mountain Member is 21 to 30 m thick and thins to the north. Where the Elephant Mountain Member is absent, the Pomona Member forms the uppermost basalt unit. Areas of basalt project above the water table north of the 200 East Area (Figure F-11).

F4.6 CLASTIC DIKES

Clastic dikes are common structures that occur in many of the geologic units in the Pasco Basin and vicinity. One subset, clastic injection dikes, are fissures filled with sand, silt, clay, and minor coarser debris. Many dikes occur as near-vertical tabular bodies filled with multiple layers of unconsolidated sediments. The margins of most dikes and internal layers within dikes are separated by thin clay/silt linings (Fecht et al. 1998).

Clastic dikes range in continuous vertical extent from less than 30 cm to more than 55 m (Fecht et al. 1998). The deepest known occurrence of a clastic dike below ground surface is greater than 75 m (246 ft) in the 200 West Area; the total vertical extent of this clastic injection dike is not known (Fecht et al. 1998). In cross section, clastic dikes range in width from less than 1 mm to over 2 m (Fecht et al. 1998). Attitudes of the dikes range from vertical to horizontal, with near-vertical dikes being more common. Material filling the dikes is locally derived and ranges in size from mud to gravel. Distribution and hydraulic properties of the dikes are not well known. Clastic dikes occur in the Hanford formation in both the 200 West and East Areas. They are most common in the finer grained sand sequence and are rare in the open-framework gravel. Clastic dikes do occur in the Ringold Formation sediments elsewhere, but their occurrences are rare. Clastic dikes can be both preferential pathways for water and vapor and a barrier to water and vapor flow.

F4.7 WATER AND VAPOR FLOW THROUGH THE VADOSE ZONE

The flow of water, vapor, or other fluids through the vadose zone to the water table depends in complex ways on properties of both the soil and the migrating fluid. The flux is a function of the hydraulic conductivity and the hydraulic gradient. If the migrating fluid includes dissolved contaminants, the contaminants will also be transported through the vadose zone unless they are retained as a result of interaction with the soil.

The hydraulic conductivity has dimensions of velocity (e.g., m/day or ft/day) and describes the capability of sediments to transmit water, vapor, or other fluids through the soil. It generally has high values for coarser grained sediments such as sand and gravel and lower values for finer grained sediments such as silt and clay. In addition to hydraulic conductivity, subsurface flow is controlled by:

- Thickness, lateral distribution, and dip of the sediments
- Moisture retention capacity of the sediments
- Fluid density
- Porosity, grain size, and orientation of the sediments
- Permeability of the sediments to water, air, or other fluids
- Amount of natural and artificial recharge
- Degree of saturation of the vadose zone pore spaces.

The hydraulic gradient can be defined as the difference in hydraulic head (pressure and elevation head) between two locations in the subsurface divided by the distance between the two locations. Because both the head and the distance have units of length (e.g., m or ft), the hydraulic gradient is usually dimensionless.

The distribution of contaminants within the vadose zone is a function of the concentration of the contaminants at the source and the physical and chemical interactions of the contaminants with the sediments through which they migrate. The degree to which contaminants interact with sediments depends on the properties of the particular contaminant (e.g., volatility, solubility), the geochemical properties of the sediments (e.g., calcium carbonate content, organic content, clay content), and the physical properties described above. The distribution coefficient (K_d) for a particular contaminant describes the likelihood that the contaminant will partition to the soil matrix rather than to the migrating liquid. A high K_d indicates that the contaminant will tend to be retained on the soil particles, whereas a low K_d indicates that the contaminant will tend to remain dissolved in the water. The retardation factor for a particular contaminant describes how much its travel time is lengthened, compared to that of water, as a result of its retention on soil particles.

The mobility of each contaminant is determined by its K_d , and each contaminant will have a specific K_d for a particular sediment type. In general, the K_d is dependent on the amount of fine-grained material in the sediment. The more fine-grained the material, the higher the K_d and the greater the capacity of the soil to retain moisture and contaminants. In the 200 West Area, the Plio-Pleistocene/early Palouse soils will have higher K_d values than the Hanford or Ringold sands, which will have higher K_d values than the Hanford or Ringold gravels. Further discussions on the mobility of contaminants are provided in Section 3.3.

Perched water zones form when moisture moving downward through the vadose zone accumulates on top of low-permeability soil lenses, highly cemented horizons, or above the contact between a fine-grained horizon and an underlying coarse-grained horizon as a result of the capillary barrier effect. The Plio-Pleistocene/early Palouse soil unit is the most significant aquitard in the 200 West Area above the water table and is a major component controlling the accumulation of perched water where effluent was discharged. The Ringold lower mud sequence also represents a potential perching layer. Up to 2.1 m (7 ft) of perched water has been found above the lower mud sequence in the vicinity of the 216-B-3C Pond lobe in the 200 East Area.

Wastewater discharges since 1943 have contributed to the rise in the water table elevation underlying the 200 Areas and have created local groundwater mounds, most notably under U Pond in the 200 West Area and under B Pond in the 200 East Area. In the 200 West Area, water levels have declined over 6 m (20 ft) since 1984 because of reduced discharges to the cribs and unlined trenches; in the 200 East Area, the water table elevation has been declining since 1988 because wastewater discharges to disposal facilities in the 200 East Area and B Pond were reduced (Hartman and Dresel 1998). A continued decrease in the water table elevations and concomitant increase in the thickness of the vadose zones underlying the 200 Areas is expected.

The thickness, lateral distribution, and dip of the sediments in the vadose zone in the 200 Areas were discussed in the previous sections. Structure and isopach maps of those sediments are provided in Connelly et al. (1992a, 1992b). The lateral continuity and structural orientation of the sediments determine the spatial distribution of hydraulic properties.

The major driving force to move contaminants from the vadose zone to the water table is both artificial and natural recharge. Artificial recharge in the 200 Areas varied widely from small intermittent volumes

applied to cribs to thousands of gallons per day at the ditches and ponds. Since 1995, most artificial recharge in the 200 Areas has ceased, and the principal driving force today is natural recharge, which averages approximately 100 mm/yr (4 in./yr) in the 200 Areas.

In the vadose zone, the pressure head is negative under unsaturated conditions. This reflects the fact that water in the unsaturated zone is held in the soil pores under negative pressure by surface-tension forces. If the volume of water in the vadose zone equals the volume that can be retained by surface tension forces (defined as the field capacity of the soil), no water will be available to migrate. However, as additional water is added to the vadose zone, for example by recharge, it will continue to migrate vertically under the force of gravity. Analyzing water flow in the vadose zone is complicated because both water content and hydraulic conductivity are nonlinear functions of pressure head. As the water content increases, the surface tension holding the water in the pore space decreases, and the water flux increases. Therefore, to analyze flow in the vadose zone, the moisture-retention capacity of the soil must be evaluated by measuring water content as a function of pressure head. The relationship between water content and pressure head is typically displayed graphically on a moisture retention curve. If either the saturated hydraulic conductivity or the unsaturated hydraulic conductivity at a specified water content is known, the moisture-retention curve can be used to generate the unsaturated hydraulic conductivity as a function of moisture content (typically displayed graphically as a curve). Khaleel and Freeman (1995) and Connelly et al. (1992a, 1992b) have cataloged the moisture retention curves as well as the saturated hydraulic conductivity collected for the 200 Areas soils. Knowing the unsaturated hydraulic conductivity allows the travel time for water in the vadose zone to be calculated for various conditions.

Unsaturated hydraulic conductivities may vary by several orders of magnitude depending on moisture content. Moisture content measurements in the 200 Area vadose zone have historically ranged widely from 1% to saturation (perched water) from liquid disposal activities, but typically range from 2% to 10% under ambient conditions. Connelly et al. (1992a, 1992b) summarized hydraulic conductivity measurements made for 200 Area soils under various moisture contents. For Hanford formation samples taken in the 200 East Area, vadose zone hydraulic conductivity values at saturation range from about 10^{-6} to 10 cm/s, with many of the values falling in the 10^{-5} to 10^{-3} cm/s range. However, under unsaturated conditions at a 10% moisture content, hydraulic conductivity values range from about 10^{-16} to 10^{-5} cm/s, with many of the values falling in the 10^{-10} to 10^{-5} m/s range. Unsaturated hydraulic conductivity values for Ringold Unit A gravel samples ranged from less than 10^{-18} to 10^{-10} cm/s at moisture contents near 10% and from 10^{-7} to 10^{-5} cm/s at saturation moisture contents of 39% and 57%, respectively. Ringold lower mud samples had unsaturated hydraulic conductivities ranging from less than 10^{-18} at a 10% moisture content to approximately 10^{-9} at saturation (57%) (DOE-RL 1997b).

A detailed description for using moisture-retention and hydraulic conductivity curves to calculate travel times through the vadose zone for steady-state natural recharge conditions is provided by DOE-RL (1996a in Appendix C). The following steps can be used to calculate the time for dissolved contaminants to travel from a liquid waste site to groundwater (this does not include the reverse well sites or liquids other than water):

1. Use existing geologic maps to determine the lithology at the waste site and establish the thickness of each geologic unit.
2. Use the estimated natural recharge rate and the existing moisture retention curves appropriate for the geologic unit to calculate a steady state moisture content.
3. Use the moisture content to calculate travel time for water through the geologic unit.
4. Sum the travel times through the different geologic units encountered.

5. Apply a contaminant-specific retardation factor for each contaminant based on its distribution coefficient and the density of the soils to obtain the travel time for each contaminant at the waste site to reach groundwater.
6. For a radionuclide, apply the specific half-life to estimate the percentage of concentration remaining by the time the radionuclide arrives at groundwater.

Using this methodology, the travel time for dissolved contaminants to reach the groundwater can be estimated and the potential impact to the groundwater can be evaluated.

F5.0 SURFACE WATER HYDROLOGY OF THE 200 AREAS

Primary surface water features associated with the Hanford Site are the Columbia and Yakima Rivers. The 200 Areas are not on a designated flood plain of the Columbia River based on probable maximum flood data presented by Skaggs and Walters (1981). Calculations indicate that the probable maximum flood of the Columbia River would result in a flood wave crest to an elevation of 125 m (410 ft) above msl. A flood to this elevation would inundate portions of the 100 and 300 Areas along the Columbia River, but would not be expected to affect more central portions of the Hanford Site including the 200 Areas (DOE-RL 1993b, 1993c).

Cold Creek and its tributary, Dry Creek, are ephemeral streams on the Hanford Site that are within the Yakima River drainage system. A probable maximum flood (storm frequency of 500 to 1,000 years) associated with the Cold Creek and Dry Creek drainages southwest of the 200 West Area would inundate approximately the southwestern quarter of the 200 West Area, but not the 200 East or 200 North Areas. Based on this result, Skaggs and Walters (1981) stated that flood protection would be required to an elevation of about 197 m (645 ft) above msl through the part of the Cold Creek Valley in the vicinity of the 200 West Area (DOE-RL 1993b, 1993c).

The 216-N-8 Pond (West Lake), 0.8 km (0.5 mi) east of 200 North Area, is the only natural lake within the Hanford Site and the only naturally occurring surface water body within the vicinity of the 200 Areas. Artificial surface water bodies such as wastewater ponds, cribs, and ditches associated with nuclear fuel reprocessing and waste disposal activities have also been present in the 200 Areas during the last 50 years; and a few are still active.

Before waste water disposal began at the Hanford Site, West Lake was an intermittent seasonal pond located in a natural basin at the base of Gable Mountain. After the introduction of large quantities of water to the 216-A-25 Pond (Gable Mountain Pond) 1.2 km to the southwest in 1957, the water table in the area was elevated sufficiently to provide year-round water to the West Lake (DOE-RL 1993a, 1993c). West Lake is less than 1 m (3 ft) deep and extends over approximately 40,000 m² (10 acres) (DOE 1988).

Bodies of standing water such as ponds are accessible to migratory waterfowl, creating a potential pathway for the dispersion of contaminants (Neitzel 1997). As the ponds dry up, exposed contaminated soil can be transported by wind. West Lake is vegetated with riparian plant species.

F6.0 GROUNDWATER

Groundwater underlying the Hanford Site flows within a multi-aquifer system. The uppermost aquifer currently is within the sediments of the Ringold and Hanford formations overlying the Columbia River Basalt. In general, the uppermost aquifer system is unconfined and is interconnected on a sitewide scale (Neitzel 1997). Locally, however, within the 200 Areas the uppermost aquifer may be confined or semi-confined. The aquifers within the Columbia River Basalt are usually confined. North of the 200 East Area, the unconfined system is in communication with the confined system (DOE-RL 1993b).

Before wastewater disposal operations began at the Hanford Site, the uppermost aquifer was mainly within the Ringold Formation, and the water table extended into the Hanford formation at only a few locations (Newcomb et al. 1972). However, wastewater discharges and upgradient irrigation have elevated the water table across the Hanford Site. Because of the general increase in groundwater elevation, the uppermost aquifer now extends upward into the Hanford formation across most of the eastern half of the Hanford Site (Figure F-11). This change has resulted in an increase in groundwater transmissivity, not only because of the greater volume of groundwater, but also because the newly saturated Hanford sediments are approximately 10 to 100 times more permeable than the Ringold sediments, which are more consolidated and partially cemented (Neitzel 1997).

Since the beginning of Hanford operations in 1943, the water table has risen about 27 m (89 ft) under at least one disposal area in the 200 West Area and about 9 m (30 ft) under disposal ponds near the 200 East Area. The volume of water that has been discharged to the ground at the 200 West Area is actually less than that discharged at the 200 East Area. However, the lower conductivity of the aquifer near the 200 West Area has inhibited groundwater movement in this area and resulted in a higher groundwater mound. Groundwater flow conditions vary between the 200 West and 200 East Areas in part because the water table occurs in different units with different hydraulic properties. In the 200 West Area, the water table occurs primarily in Ringold gravels, while in the 200 East Area, it occurs primarily in the Hanford sands and gravels. In general, the Ringold gravels have a lower hydraulic conductivity than the Hanford sediments (Neitzel 1997).

Prior to the initiation of waste disposal activities at the Hanford Site, the general groundwater flow appears to have been from west to east across the site to the Columbia River with an average horizontal hydraulic gradient of 0.001 (Graham et al. 1981). Wastewater discharges since 1943 have created local groundwater mounds under the primary wastewater disposal areas in the 200 Areas; the locations and heights of the mounds have changed as wastewater discharge locations and rates have changed. Although the general groundwater flow direction has remained from west to east toward the Columbia River, the presence of the groundwater mounds has locally affected the direction of groundwater movement, causing radial flow from the discharge areas. Hydraulic gradients significantly increased as the groundwater elevations increased. In recent years, discharges of water to the ground have been greatly reduced. As a result, the elevation of both the water table and the local groundwater mounds have been declining. As the mounds continue to dissipate, horizontal hydraulic gradients are also expected to decrease and to return to the natural regional easterly direction (DOE-RL 1993b).

Groundwater elevations within the upper Cold Creek Valley rose 15 m between 1944 and 1955 in response to artificial recharge from agricultural irrigation. The continued influence of irrigation recharge within the upper Cold Creek Valley is still evident, and may be responsible for maintaining elevated water levels north and west of the 200 West Area (DOE-RL 1993b).

The groundwater underlying the Hanford Site contains plumes of chemical and radiological contaminants as a result of wastewater discharge since 1943. The sources of these contaminants during Hanford operations, and the waste management practices that introduced them to the environment, are described in Section 3.2. The physical and chemical interactions between the contaminated liquid discharges and the sediments resulted in mobile contaminants migrating to groundwater and less mobile contaminants being retained within the vadose zone, as described in Section 3.3.

F7.0 NATURAL BACKGROUND CONCENTRATIONS OF CHEMICAL AND RADIOLOGICAL ANALYTES

The range of background concentrations in soil at the Hanford Site and associated environments has been documented for both nonradioactive analytes (DOE-RL 1995a) and radionuclides (DOE-RL 1996a). A thorough discussion of the sitewide conceptual model that guided the collection and interpretation of background data is included in these reports.

The characterization of background in soil and groundwater is an important component in environmental restoration activities because it can be used to identify contamination, establish cleanup goals, evaluate restoration alternatives, and assess risk and cleanup levels. Background conditions are also useful for establishing pre-operational conditions for new and existing facilities. The sitewide approach has been determined to be a technically viable and cost-effective method for evaluating background conditions at the Hanford Site, as opposed to establishing background concentrations at each individual waste unit.

To establish nonradioactive background, 104 samples were collected randomly from a variety of locations on or near the Hanford Site. A variety of judgment samples were also collected to include minor soil types that were potentially missed during random sampling. Only the random samples were used to compute the statistics used to define background. A subset of the nonradioactive random background sample set was selected to characterize radionuclide background; some surface samples associated with monitoring activities were also used to establish levels for anthropogenic background (i.e., man-made, from global fallout).

A summary of the background data for nonradioactive and radioactive analytes is presented in Tables F-3 and F-4, respectively. Ecology mandates the use of the 90th percentile of the appropriate distribution for purposes of comparing background to cleanup levels (Ecology 1992). Other statistical approaches may also be used when background is used as a cleanup standard. Ecology has accepted alternate statistical tests for use at Hanford (DOE-RL 1994).

F8.0 ENVIRONMENTAL RESOURCES

Environmental resources for the 200 Areas refers to the wildlife and plants found within the vicinity of these areas. Biological and ecological information aids in evaluating impacts to the environment, including potential effects of implementing remedial actions, and identification of sensitive environments and species.

F8.1 VEGETATION

The vegetation of the 200 Areas Plateau is characterized by native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the dominant shrub is big sagebrush (*Artemisia tridentata*) and the understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*) and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus* spp.), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that are also present include Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine cymopterus (*Cymopterus terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamorhiza (*Balsamorhiza careyana*), milkvetch (*Astragalus* spp.), yarrow (*Achillea millifolium*), and daisy (*Erigeron* spp.).

Disturbed habitat communities are primarily the result of either range fires or mechanical disturbance (e.g., from road clearing or facility construction). Mechanical disturbance typically entails a loss of soil structure and disruption of nutrient cycling, which have a significant effect on the plant species that will re-colonize a site. The principal colonizers of disturbed sites are annual weeds, such as Russian thistle (*Salsola kali*), Jim Hill mustard (*Sisymbrium altissimum*), bur-ragweed (*Ambrosia acanthicarpa*), and cheatgrass. Once disturbed, native stands of vegetation may take decades (or centuries if the soil has been removed) in the mid-Columbia climate to return to a state near to the original condition. Disturbed areas with sandy soils that lack vegetation typically have higher recharge rates than sites with a plant cover (Fayer and Walters 1995).

The vegetation that was present in and around the former waste ponds and ditches on the 200 Areas plateau includes cottonwood (*Populus trichocarpa*), willows (*Salix* spp.), sedges (*Carex* spp.), and cattails (*Typha latifolia*). However, most of this vegetation has died with the cessation of liquid effluents flowing to the ponds and ditches. The only pond that remains in the 200 Areas is the naturally occurring West Lake. It exists because of a naturally shallow water table, and is vegetated with riparian species such as bulrush (*Scirpus* spp.).

F8.2 WILDLIFE

The largest mammal frequenting the 200 Areas plateau is the mule deer (*Odocoileus hemionus*). While mule deer are much more common along the Columbia River, the few that forage throughout the 200 Areas make up a distinct group called the Central Population (Dirkes and Hanf 1997). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve (ALE). Occasionally a few animals have been seen just south of the 200 Areas, and their presence may increase as the herd on ALE continues to grow. Other mammals common to the 200 Areas are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 200 Area radioactive waste sites (O'Farrell et al. 1973). The majority of badger diggings are a result of searches for food, especially other burrowing mammals such as pocket gophers and mice. Pocket gophers and mice (especially Great Basin pocket mice and deer mice) are abundant in the 200 Areas, consume predominantly vegetation, and can excavate large amounts of soil as they construct their burrows (e.g., Hakonson et al. 1982). Mammals associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the 200 Areas include starlings (*Sturnus vulgaris*), horned larks (*Eremophila alpestris*), meadowlarks (*Sturnella neglecta*), western kingbirds (*Tyrannus verticalis*), rock doves

(*Columba livia*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the 200 Areas in abandoned badger or coyote holes. Loggerhead shrikes (*Lanius ludovicianus*) and sage sparrows (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive 200 Areas waste sites.

Common reptiles at the 200 Areas include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Three of the most common groups of insects include darkling beetles, grasshoppers, and ants.

F8.3 SPECIES OF CONCERN

The Hanford Site is home to a variety of species of concern, but many of these are restricted to the Columbia River and associated shoreline. No plants on the federal list of threatened and endangered species are known to occur on the Hanford Site. Two animal species that do occur at Hanford, bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*), depend on the river corridor and are rarely observed at the 200 Areas. Several state-threatened, endangered, and candidate species are found in and near the 200 Areas, such as ferruginous hawks (*Buteo regalis*), burrowing owls, loggerhead shrike, long-billed curlew, and sage sparrow. Migratory bird species are also protected by the *Migratory Bird Treaty Act*. Plant species of concern (which includes those listed as state endangered, threatened, sensitive, and monitored) that may occur at the 200 Areas include Dwarf evening primrose (*Camissonia pygmaea*) and Piper's daisy (*Erigeron piperianus*) (Washington Natural Heritage Program 1998).

Both plant and animal species of concern, their designations, and places of occurrence can change over time. At this time none are suspected of having the potential to significantly affect the characterization or remediation of any waste site, but incorporating the needs of these species into project planning will help to mitigate any potential effects. Especially important is avoiding, where possible, undisturbed shrub-steppe habitat, as this is important to many species of concern. The undisturbed shrub steppe in and near the 200 Areas is Level 3 habitat, which requires mitigation of any disturbance, for example through avoidance and minimization, and possibly rectification and compensation (DOE-RL 1996b). More detailed direction on protecting Level 3 habitats and species of concern is provided in the *Hanford Site Biological Resources Management Plan* (DOE-RL 1996b). In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure ecological resources are adequately protected.

F8.4 SIGNIFICANCE OF ECOLOGICAL RESOURCES TO CONTAMINANT FATE AND TRANSPORT

Wildlife and plants in the 200 Areas have a history of taking up contaminants from waste sites through burrowing and root penetration (e.g., Johnson et al. 1991, 1994). Plant roots can take up radionuclides to varying extents, depending on the radionuclide, plant species, depth of contamination, and soil chemistry. Plants such as Russian thistle that have both deep roots and grow preferentially on disturbed, poor soils are especially known for taking up certain radionuclides and then releasing them to the environment as the plant dies back in the fall or as animals eat the contaminated parts of the plant. Animals that burrow, such as harvester ants, mice, pocket gophers, and badgers, have all been found to distribute contaminants from buried waste sites at Hanford. For example, O'Farrell et al. (1973) documented the spread of radionuclides by black-tailed jackrabbits (*Lepus californicus*) licking contaminated salts in the BC Cribs and leaving contaminated fecal pellets and urine over an area of several square miles. Animals digging into waste sites can distribute contaminants or be affected by contaminants by many pathways, including

(1) wind dispersal of excavated soil, causing spread of contamination; (2) animal consumption of the soil (e.g., if it contains a salt and is consumed on purpose, or is lodged on the pelt of a prey species consumed by a predator); (3) a dose to burrowing animals from radionuclides in the soil; and (4) excavated contaminated materials exposing other animals to an external dose. The probable maximum depths of burrowing and root penetration for the more significant wildlife and plant species are shown in Table F-5.

As radionuclides and other hazardous materials enter the food web, the degree to which they bioaccumulate depends on the specific contaminant, the species of plant or animal it transfers into, and the part of the biota it enters (e.g., bones or seeds may accumulate more or less of a material than muscle or leaf material).

F9.0 CULTURAL RESOURCES

In 1996, the U.S. Department of Energy, Richland Operations Office (RL), the Washington State Historic Preservation Office, and the Advisory Council on Historic Preservation signed a Programmatic Agreement (PA) (DOE-RL 1996c) that modified compliance with Section 106 of the *National Historic Preservation Act* with respect to Hanford's historic buildings. Through the PA, RL created the Hanford Site Manhattan Project and Cold War Era Historic District as a means to replace individual building-by-building documentation and mitigation with the systematic treatment of a representative sample of buildings. As required by the PA, all 200 Area buildings were evaluated for their eligibility for listing in the National Register of Historic Places as contributing or noncontributing properties within the Historic District. Of the 139 buildings determined to be contributing properties, 62 were selected to represent the events and activities that took place within the 200 Areas. Buildings selected included the 202-A PUREX Plant; 212-N Lag Storage Facility; 221-T Plant; 222-S REDOX Plant; 225-B Encapsulation Building; 231-Z Plutonium Metallurgical Laboratory; 232-Z Waste Incinerator Facility; 233-S Plutonium Concentration Building; 234-5Z Plutonium Finishing Plant; 236-Z Plutonium Reclamation Facility; 242-Z Water Treatment Facility; 282-E Pump House and Reservoir Building; 283-E Water Filtration Plant; and 284-E Power House and Stream Plant. If alteration or destruction is planned for buildings in the 200 Areas as a result of this project, mitigation of the impacts will be undertaken in accordance with the conditions of the Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan (DOE-RL 1998).

The Hanford Cultural Resources Laboratory conducted a comprehensive archaeological resources review for the fenced portions of the 200 Areas in 1987-1988. This review incorporated both an examination of the existing literature as well as "an intensive pedestrian survey of all undisturbed portions of the 200 East Area and a stratified random survey [of the undisturbed portions] of the 200 West Area" (Chatters and Cadoret 1990). Two historic-archaeological sites (i.e., can and glass scatters), four isolated historic artifacts, one isolated cryptocrystalline flake, and an extensive linear feature (i.e., the White Bluff Road) were the only materials greater than 50 years old discovered during the field survey. Only the White Bluff Road, in its entirety, was determined eligible for listing in the National Register. This road, which passes diagonally southwest to northeast through the 200 West Area, originated as a Native American trail. It has been in continuous use since antiquity and continued to play a role in Euroamerican immigration, development, agriculture, and Hanford Site operations. Within the 200 West Area, two intact segments of the road are considered contributing elements: (1) the southwest segment from the perimeter fence to approximately 19th Street at Dayton Avenue, and (2) the extreme northeast segment above T Plant to the perimeter fence. A 100-m (328-ft) easement has been created to protect these segments of the road from uncontrolled disturbance. The remaining portions of the road within the 200 West Area have been disturbed or destroyed by previous construction-related activities and are classified as noncontributing.

In general, archaeological sites have been recorded primarily in areas of high topographic relief and near water sources on the Hanford Site. Because of the lack of nearby water supplies, a terrain of low relief, and large open inland flats, the 200 Areas maintain only limited archaeological potential, with the exception of trail-associated isolated finds. Previous construction-related activities for the 200 Areas facilities, such as buildings and waste sites, further reduce the likelihood of archeological resources being located in these areas of high disturbance. Historic-archaeological sites and isolated finds are similarly limited in their distribution. However, site-specific cultural resource surveys will be required before ground disturbance can occur to ensure that archaeological resources are adequately identified and protected. This is particularly important for remedial actions that will take place outside the fenced portions of the 200 Areas.

With the exception of project-specific information provided for undertakings that have, or might have, impacted the sacred sites of Gable Mountain and Gable Butte, no comprehensive consultations have been conducted with Tribal representatives to identify other locations within the vicinity of the 200 Areas that might be of concern to the Native American community. Archaeological surveys of nearby areas in 1968 and in the late 1980's identified numerous sites believed to represent religious and hunting activities (Rice 1968, 1987). In addition to these sites marked by rock cairns, rock alignments, and/or artifacts, other sites relating to subsistence and ceremonial activities, which are not marked by physical remains, may be present but unrecognized within the project area. For example, subsistence, medicinal, and ceremonial plants were all gathered on the Hanford Site; however, the existence and significance of such locations often can be ascertained only through interviews with knowledgeable users of the area. Plants, and the areas from which they are gathered, qualify as Traditional Cultural Properties, and could merit inclusion in the National Register of Historic Places because of their "association with the cultural practices and beliefs of a living community" (Parker and King 1990). This is also true for sites of spiritual significance to the Tribes. The identification of sacred, ceremonial, and traditional use areas cannot be accomplished without the use of traditional elders and spiritual leaders. Their involvement is needed to identify those areas for which no on-the-ground evidence exists. Therefore, consultations with representatives of the Native American communities with ancestral ties to the Hanford Site will be required before ground disturbance can occur to ensure that traditional cultural resources are adequately identified and protected.

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Figure F-1. Topography of the Hanford Site.

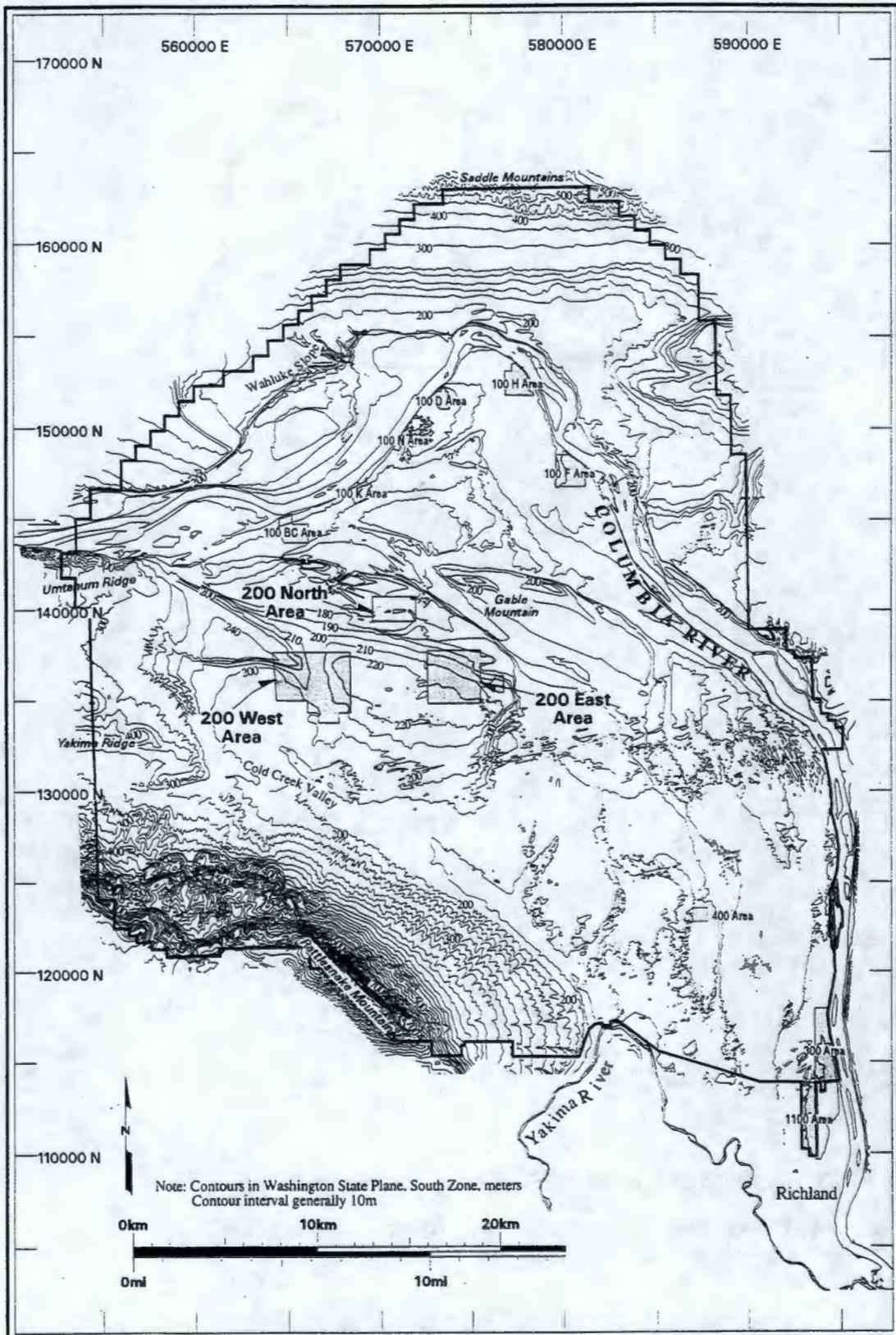
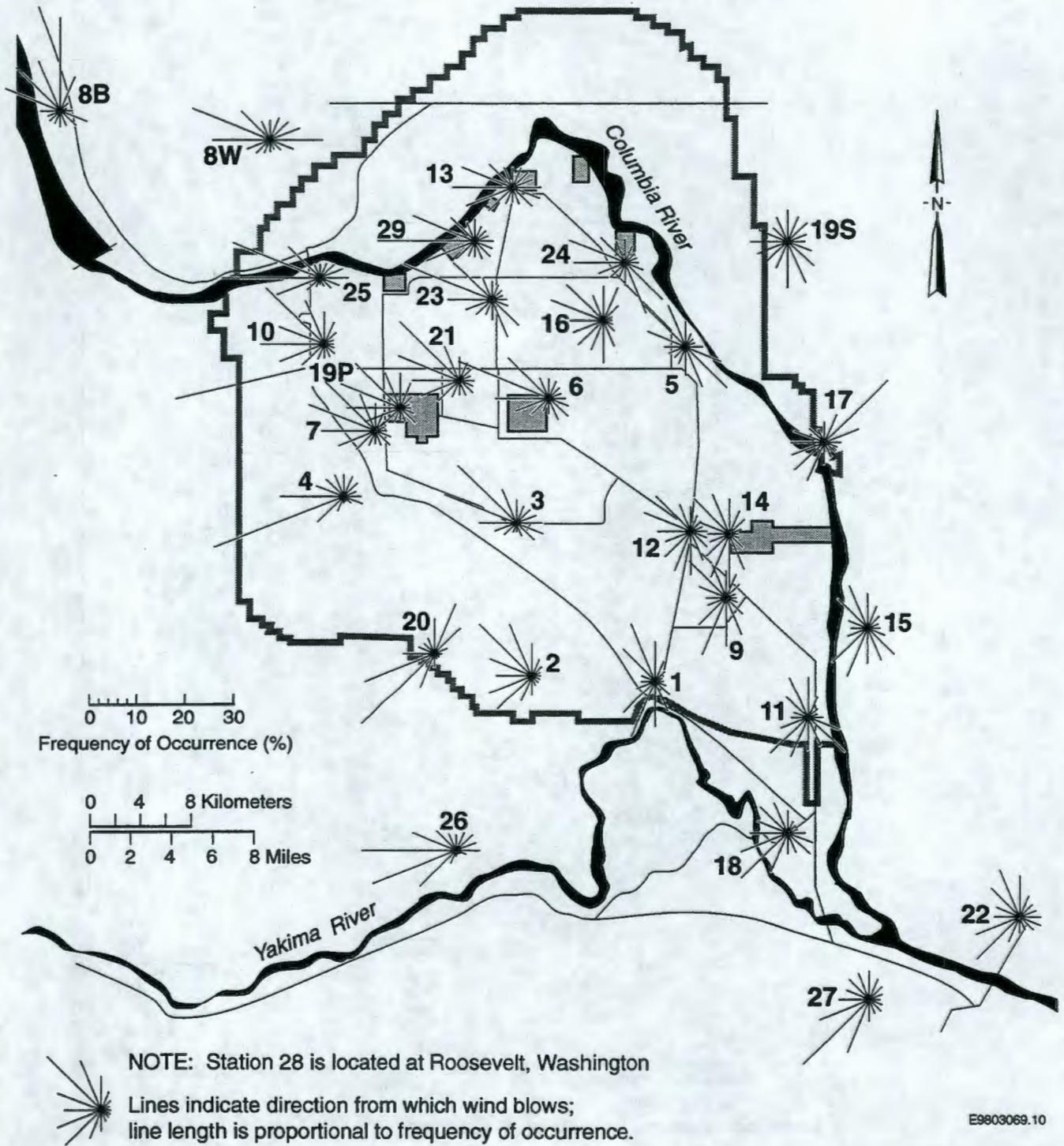


Figure F-2. Wind Roses at the 10-m (30-ft) Level of the Hanford Meteorological Monitoring Network, 1982-1996 (from Neitzel 1997).



**Figure F-3. Average Daily Barometric Pressure at the Hanford Meteorological Station, 1997
(averaged from hourly observations provided by HMS).**

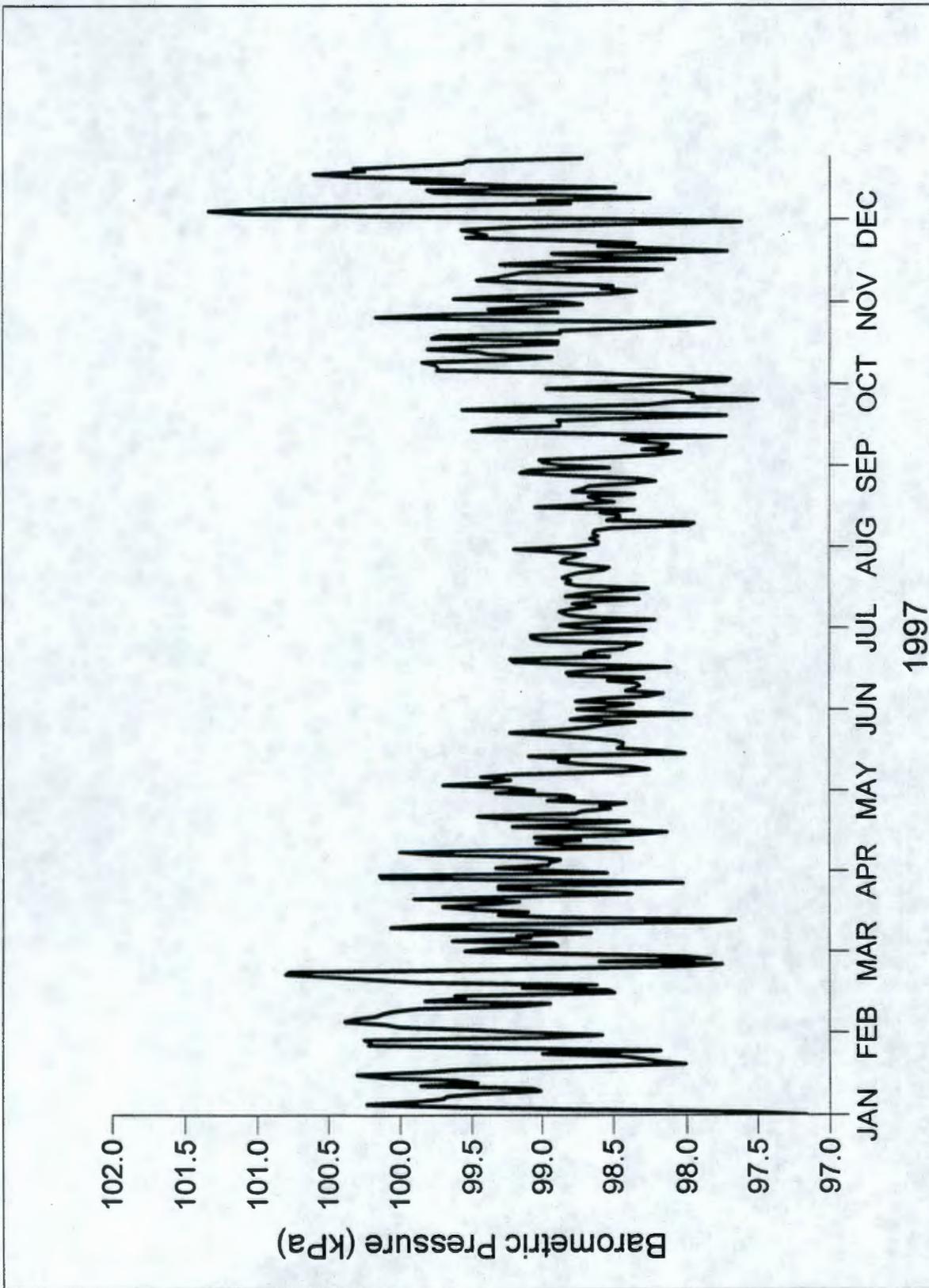
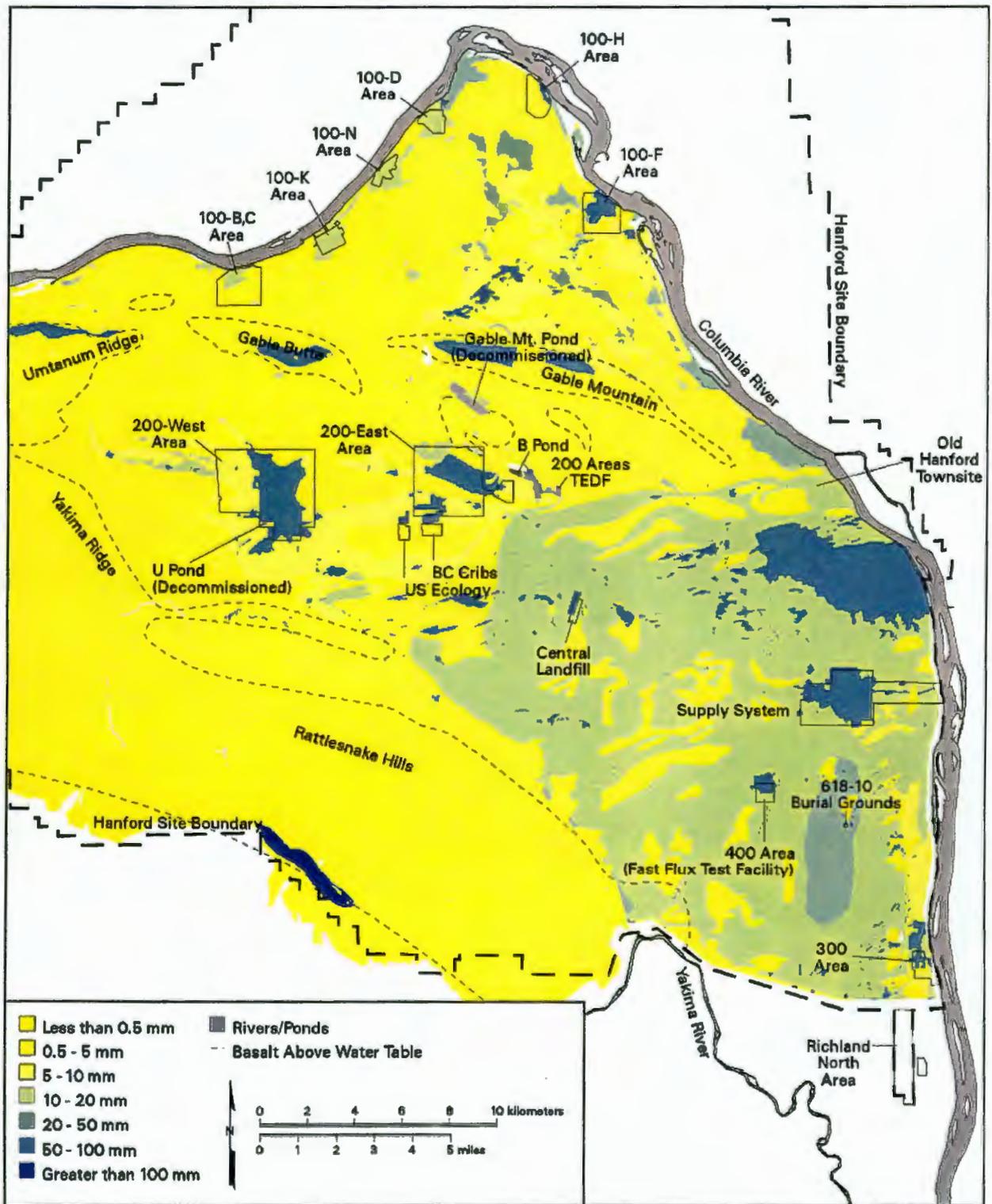
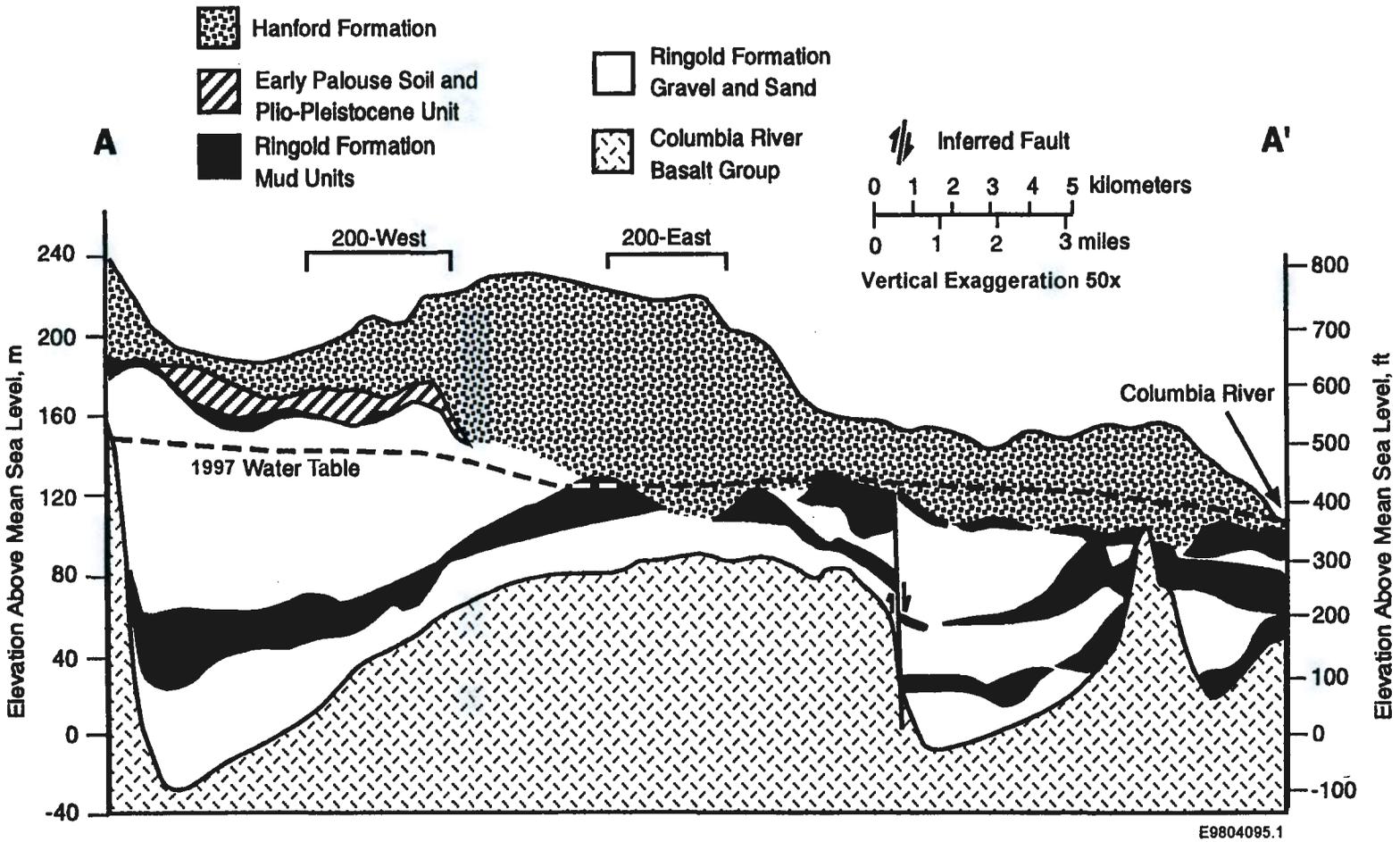


Figure F-4. Estimated Recharge at the Hanford Site from Infiltration of Precipitation and Irrigation (from Fayer and Walters 1995).



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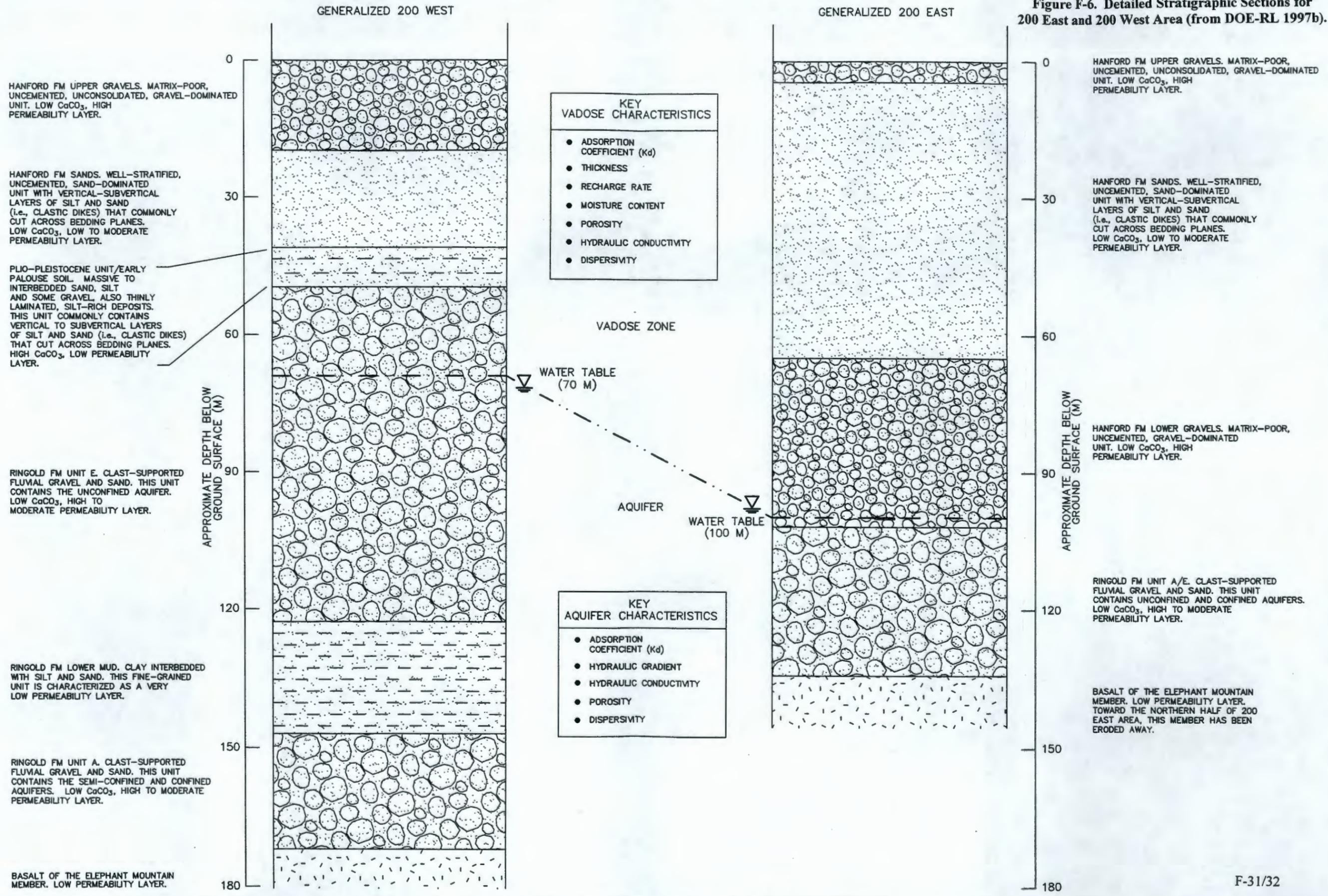
Figure F-5. Generalized Hanford Site Geologic Cross-Section (from Hartman and Dresel 1998).
Location of Cross-Section Shown in Figure F-11.





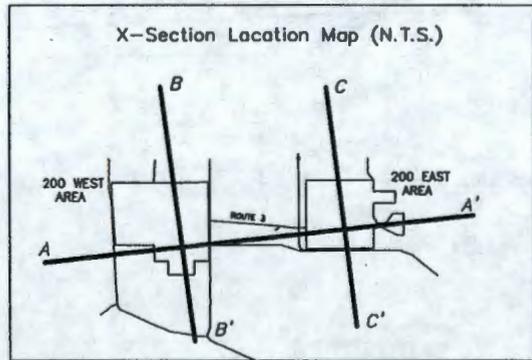
2W: 031798F

Figure F-6. Detailed Stratigraphic Sections for 200 East and 200 West Area (from DOE-RL 1997b).



2W:071796F

<i>EO</i>	<i>Surfical Eolian Sand/Silt Deposits</i>	Stratigraphy		
<i>H</i>	<i>Hanford Formation Undifferentiated</i>	 Sandy GRAVEL	 Gravelly SAND	 SILT/CLAY
<i>HUC</i>	<i>Hanford Formation Upper Coarse Unit</i>	 Silty sandy GRAVEL	 SAND	 BASALT
<i>HLF</i>	<i>Hanford Formation Lower Fine Unit</i>	 Silty GRAVEL	 Sandy SILT	
<i>HLC</i>	<i>Hanford Lower Coarse Unit</i>			
<i>EP/PPU</i>	<i>Early Palause Soil / Plio-Pleistocene Unit</i>			
<i>RU</i>	<i>Ringold Formation Upper Unit</i>			
<i>RE</i>	<i>Ringold Formation Unit E</i>			
<i>RLM</i>	<i>Ringold Formation Lower Mud</i>			
<i>RA</i>	<i>Ringold Formation Unit A</i>			
<i>SBM/EM</i>	<i>Columbia River Basalt Group / Saddle Mountain Basalt / Elephant Mountain Member</i>			
<i>SMB/PO</i>	<i>Columbia River Basalt Group / Saddle Mountain Basalt / Pomona Member</i>			



Stratigraphic Key

Figure F-7. Stratigraphic Key for Figures F-8 Through F-10 (from DOE-RL 1997b).

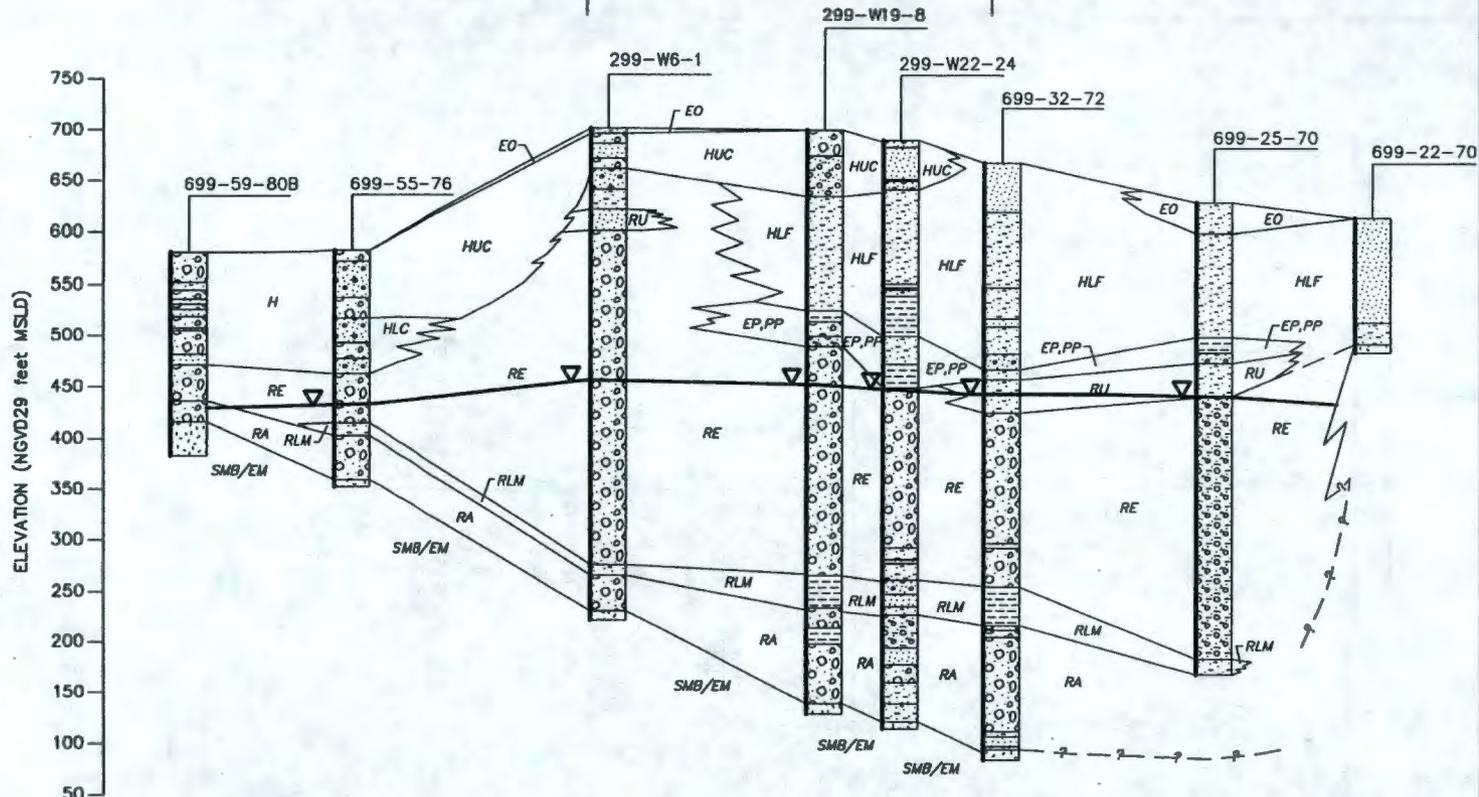
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B

200 AREA CROSS SECTION 200 WEST AREA

B'



LEGEND

- | | | |
|--------------------|---------------|-------------|
| Sandy GRAVEL | Gravelly SAND | SILT/CLAY |
| Silty sandy GRAVEL | SAND | BASALT |
| Silty GRAVEL | Sandy SILT | WATER TABLE |



Vertical Exaggeration = 9.83

Cross Section View B-B'

F-35

Figure F-9. North-South Cross Section Through the 200 West Area (View B-B')
(from DOE-RL 1997b).

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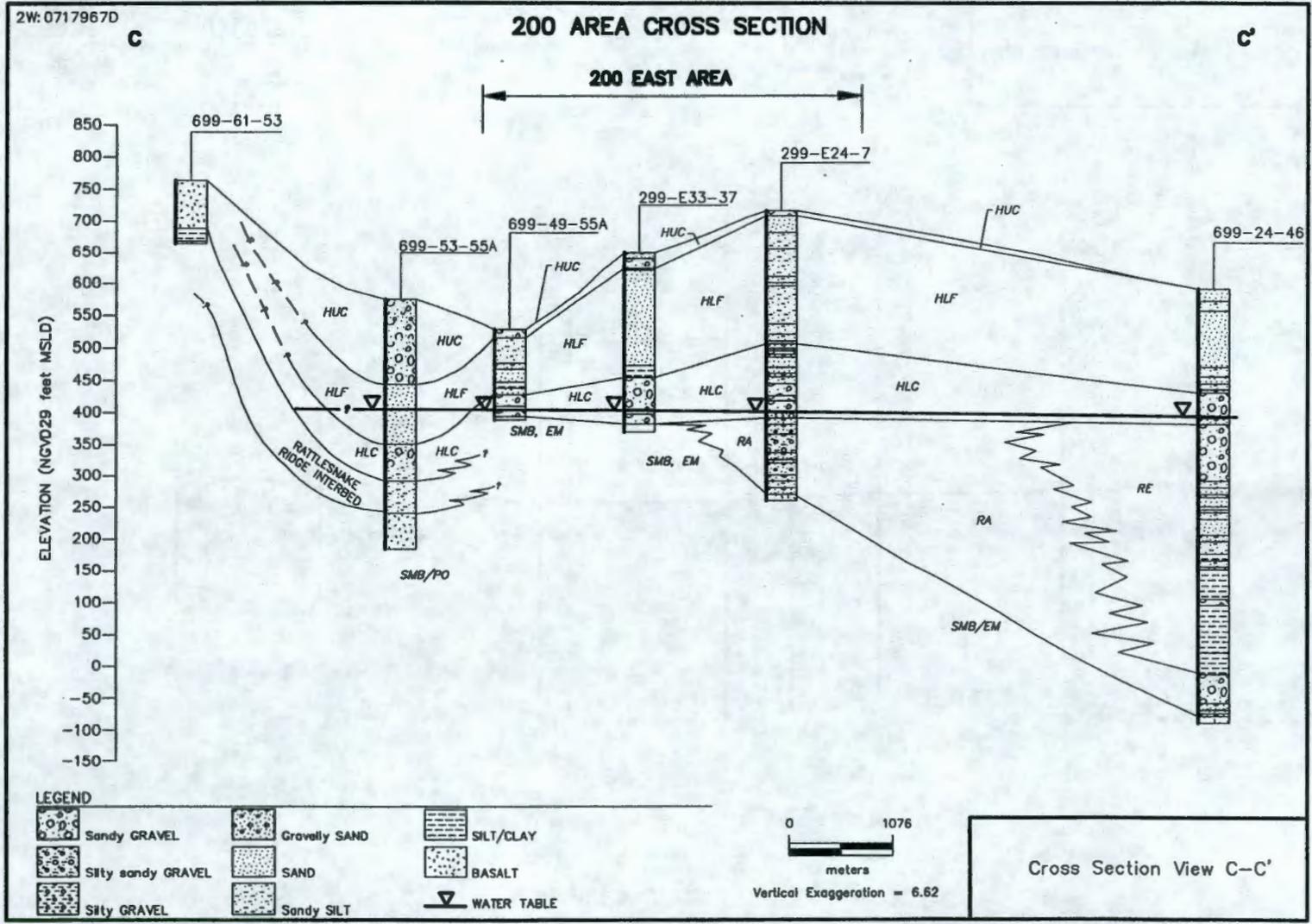
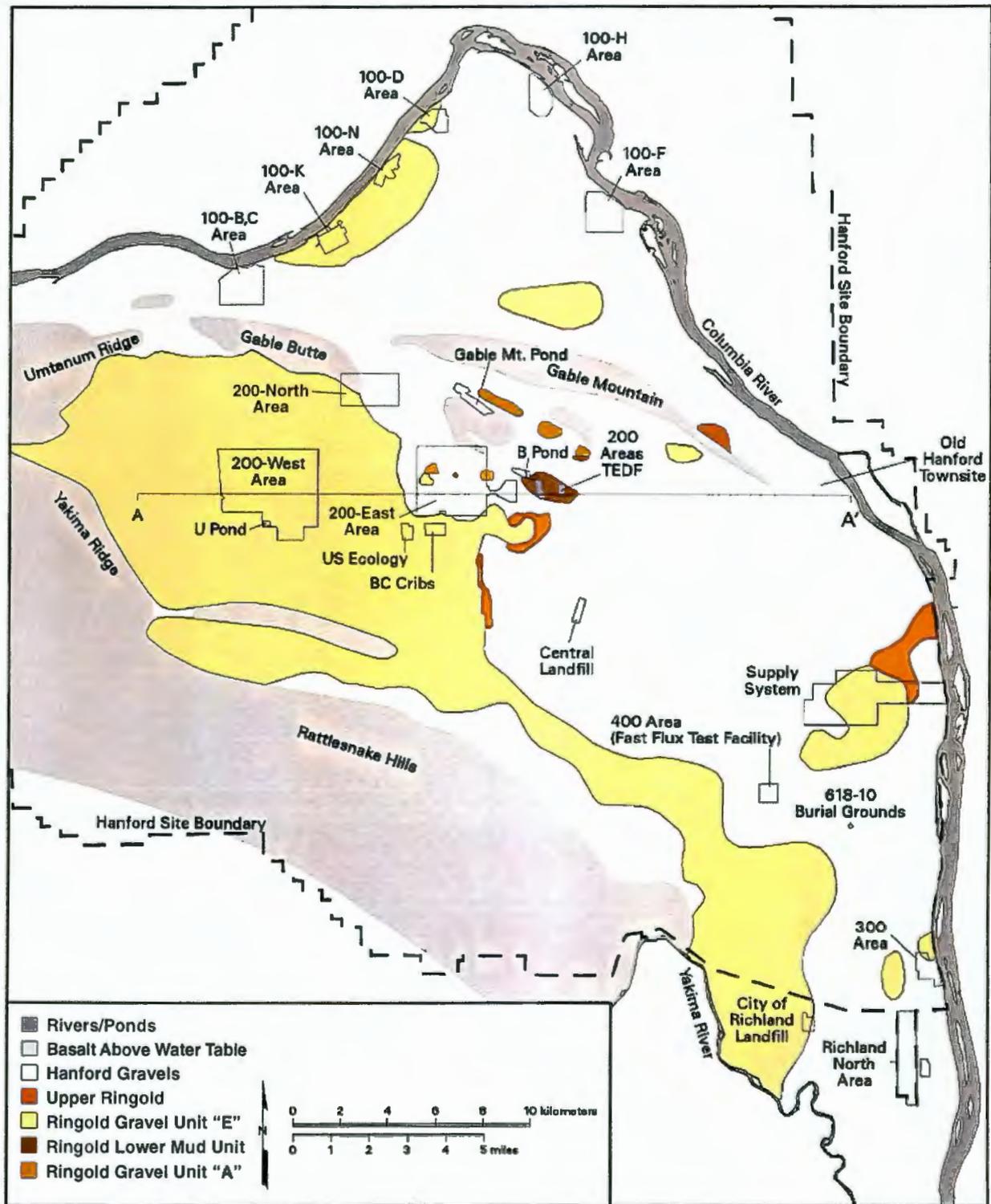


Figure F-10. North South-Cross Section Through the 200 East Area (View C-C')
 (from DOE-RL 1997b).

Figure F-11. Geologic Units Present at the Water Table (from Hartman and Dresel 1998).



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Table F-1. Average Monthly Temperatures by Season (compiled from Hoytink and Burk 1998).

Season	Winter		Spring		Summer		Autumn	
Months	Dec – Feb		Mar – May		Jun – Aug		Sep – Nov	
Maximum	45°F	Feb 1958	69°F	May 1947	82°F	Jul 1985	72°F	Sep 1990
	7°C		20°C		28°C		22°C	
Minimum	12°F	Jan 1950	39°F	Mar 1955	63°F	Jun 1953	25°F	Nov 1985
	-11°C		4°C		17°C		-2°C	

Table F-2. Monthly Average Precipitation by Season (compiled from Hoytink and Burk 1998).

Season	Winter		Spring		Summer		Autumn	
Months	Dec – Feb		Mar – May		Jun – Aug		Sep - Nov	
Maximum	3.7 in.	Dec 1996	2.0 in.	May 1972	2.9 in.	Jun 1950	2.7 in.	Oct 1957
	9.4 cm		5.2 cm		7.4 cm		6.9 cm	

Table F-3. Statistical Characteristics of the Sitewide Background Data for Nonradioactive Analytes (from DOE-RL 1995a). (2 Pages)

Analyte	Systematic random samples, concentration (mg/kg)		Overall maximum concentration of all samples (mg/kg)	90 th Percentile of the Lognormal Distribution
	Minimum	Maximum		
Aluminum	3,940	18,100	28,800	11800
Antimony	15.7	15.7	31	~
Arsenic	3	11.4	27.7	6.47
Barium	45.2	221	480	132
Beryllium	0.6	2.1	10	1.51
Cadmium	0.66	0.66	11	~
Calcium	3,820	86,600	105,000	17200
Chromium	2.9	30.6	320	18.5
Cobalt	5.7	16.9	110	15.7
Copper	8.1	36.1	61	22
Iron	13,200	35,100	68,100	32600
Lead	1.1	26.6	74.1	10.2
Lithium	34	38.2	38.2	33.5
Magnesium	2,900	10,100	32,300	7060
Manganese	196	704	1,110	512
Mercury	0.16	3.8	3.8	0.33
Molybdenum	2	2	6	~
Nickel	7.2	28.2	200	19.1
Potassium	851	3,280	7,900	2150
Selenium	5	6	6	~
Silicon	5.2	583	1,203	44
Silver	1.4	14.6	14.6	0.73
Sodium	101	5620	6,060	690
Thallium	3.7	3.7	3.7	~
Titanium	524	2940	3,180	2570
Vanadium	24.3	97.9	140	85.1
Zinc	30.9	119	366	67.8
Zirconium	11	84.8	84.8	39.8
Alkalinity	31	37,600	150,000	7710
Ammonia	0.6	26.4	26.4	9.23

Table F-3. Statistical Characteristics of the Sitewide Background Data for Nonradioactive Analytes (from DOE-RL 1995a). (2 Pages)

Analyte	Systematic random samples, concentration (mg/kg)		Overall maximum concentration of all samples (mg/kg)	90 th Percentile of the Lognormal Distribution
	Minimum	Maximum		
Chloride	1	1,480	1,480	100
Fluoride	1	73.3	73.3	2.81
Nitrate	0.6	538	906	52
Nitrite	21	21	36.5	~
O-Phosphate	2	225	225	0.785
Sulfate	1	4,340	12,600	237

Table F-4. Selected Values for the Sitewide Background Radionuclide Data Set (pCi/g) (from DOE-RL 1996a).

Analyte	Minimum	Maximum	Arithmetic Mean	Standard Deviation	90 th percentile
K-40	9.29	19.7	13.1	2.71	16.6
Co-60 ^a	-0.0111	0.0387	0.00132	0.00591	0.00842
Sr-90	0.00661	0.366	0.0806	0.0688	0.178
Cs-137	-0.00156	1.64	0.417	0.338	1.05
Eu-154 ^a	-0.0732	0.0790	0.000826	0.0250	0.0334
Eu-155 ^a	-0.0187	0.0984	0.0234	0.0184	0.0539
Ra-226	0.298	1.16	0.561	0.202	0.815
Th-232	0.468	1.58	0.945	0.260	1.32
U-234	0.399	1.51	0.793	0.233	1.10
U-235 ^b	0.00462	0.386	0.0515	0.0373	0.109
U-238	0.354	1.21	0.763	0.216	1.06
Pu-238 ^a	-0.000489	0.0193	0.00158	0.00332	0.00378
Pu-239/240	-0.0050	0.0331	0.00935	0.00782	0.0248
Gross Beta	13.6	25	19.78	2.40	22.96

^a Majority of the data are below detection; included here for completeness.

^b Uranium-235 statistics were computed using 47 samples: 17 above and 30 below detection limits. Two data were suspended owing to negative values.

Percentiles are based on the lognormal distribution.

Table F-5. Root Penetration and Burrowing Depths of Selected 200 Area Wildlife and Plant Species (adapted from DOE-RL 1995b).

Species	Root Penetration or Burrowing Depth		
	Average Maximum Depth (meters)	Maximum Depth (meters)	Reference
PLANTS			
Cheatgrass	0.7	1.2	Foxx et al. 1984
Gray rabbitbrush	1.83	2.5	Klepper et al. 1985
Green rabbitbrush	1.53	1.6	Klepper et al. 1985
Tumblemustard (Jim Hill mustard)	1.0	2.0	Estimated (DOE-RL 1995b)
Big sagebrush	2.0	2.5	Klepper et al. 1985 (at Hanford)
Antelope bitterbrush	2.96	3.0	Klepper et al. 1985
Russian thistle	1.72	3.0	Klepper et al. 1985
Sandberg's bluegrass	-	0.35	Link et al. 1990
Needle and thread grass	1.39	1.6 1.83	Klepper et al. 1985; Schaffer et al. 1979
ANIMALS			
Deer mice	0.4	-	Estimated (DOE-RL 1995b)
Great Basin pocket mouse	0.9	2.0	O'Farrell et al. 1975; McKenzie et al. 1982
Northern pocket gopher	0.3	2	OSU 1998; UC 1998
Badger	2.5	-	McKenzie et al. 1982
Harvester ant colony	2.3	2.7	Rogers et al. 1988

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APPENDIX G
WASTE SITE LISTING



G1.0 WASTE SITE LISTING

Appendix G expands upon the discussion of waste site groupings presented in Section 3.3 by describing the waste category characteristics in more detail. Appendix G also presents a tabulation of all 200 Area Waste Information Data System (WIDS) liquid and solid waste sites, unplanned releases and outside-the-fence tank farm-related facilities considered by this Implementation Plan. In addition, this appendix discusses the evolution of waste sites, design characteristics of the respective waste site types and potential impacts of plant operations. This information, along with data presented in Appendix H, Process Descriptions and Flow Diagrams, is important to developing a logical conceptual contaminant transport model for each group to show how contaminants may be distributed within and below a waste site. Data in these two appendices will serve as the basis for developing both group-specific DQOs and work planning documents and will help to direct additional waste site historical research, if needed.

Table G-1 is a revised list of the waste sites and grouping information that updates a list presented in Appendix A of the *Waste Site Groupings for 200 Area Soil Investigations* document (DOE-RL 1997d). The Appendix A list was collected from a database compiled from the eight source Aggregate Area Management Study reports. At the time the report was being compiled, the Appendix A list was checked against the current WIDS to insure that all appropriate 200 Area sites were included. The waste sites were grouped by waste type categories, subdivided as appropriate into 23 waste groups, and representative sites selected. The Appendix G tabulation in this document transitions from the old AAMS database to WIDS, which by *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) requirements, is now the official tracking mechanism for all Hanford waste sites. This listing is consistent with TPA Change Package 98-01 (approved October 21, 1998) which incorporates the 200 Areas waste site grouping information into the Tri-Party Agreement.

Revisions to the list from the earlier version in DOE-RL (1997a) are based on the current waste site list in WIDS. Some of the changes that have occurred include the following:

- Some sites may have been deleted from the 200 Areas Waste Site Groupings document (DOE-RL 1997a), based on a Tri-Party Agreement-approved WIDS determination that the site is already covered by another designation. With regulator approval, duplicate information was combined, although the deleted number is retained as an "alias." An example of these is the deletion of the 216-T-30 waste site, a site that is listed in WIDS as an unplanned released (UPR-200-W-38).
- A decision has been made to delete the sites from the 200 Areas Waste Site Groupings document (DOE-RL 1997) for specific reasons. For example, the three pipelines listed originally in the 200 North Ponds Cooling Water group and the 216-C-9 Pond Diversion Box have been deleted. A unified approach to address all waste site pipelines and associated structures has not yet been generated. A specific future task for the WIDS program is to track all pipelines and associated structures in the 200 Areas. Until this task has been completed, these sites will not be addressed.
- Some sites were split to allow for two or more DOE programs to be responsible for a specific part of a waste site (e.g., the 216-A-36A and 216-A-36B Cribs). This resulted in the addition of several waste site (site code) numbers. The previous waste site number is retained as an alias or as an associated waste site. The final result of this effort was a Memorandum of Agreement (MOA), which was approved and signed by all the DOE program representatives (DOE-RL 1997b, 1997c, 1997d).

- In other instances, such as UPR-200-E-124 (200 Areas Laboratory Chemical Wastes group), no WIDS references exist to substantiate the site's existence other than a reference in the AAMS report. Efforts to confirm the site's existence have not been successful for UPR-200-E-124, therefore, the site has been rejected by the WIDS. The sanitary crib designation has been replaced with the designation 216-SX-2. Both names apply to the same structure, but the latter has been accepted to better suit the waste stream sent to the ground.
- In many cases, waste sites have been moved between waste site groups. For example, UPR-200-E-95 has been moved from the General Unplanned Release group into the Gable Pond/B-Ponds and Ditches Cooling Water group, based on better definition of the nature and location of the site. Conversely, UPR-200-W-63 has been moved from the Radioactive Landfills group to the General Unplanned Releases category since it has been determined that the site of the release was primarily outside of the boundaries of the 218-W-3/4 Burial Grounds. Also, a large number of Unplanned Release group sites have been linked to releases from outside-the-fenceline tank waste sites and have been transferred to the Tanks/Lines/Pits/Boxes group.
- Several sites that were "discovery" sites at the time the 200 Areas Waste Site Grouping document (DOE-RL 1997a) was compiled have now been changed to "accepted" waste sites by WIDS and are now included in the appropriate group in this appendix. As a result, several new sites have been added to the Nonradioactive Landfills group.

The procedure of evaluating new sites that are identified will follow the *Maintenance of the Waste Information Data System (WIDS)* (TPA-MP-14). A large number of discovery waste sites have been reported and are undergoing review for inclusion in the database. This is anticipated to be an ongoing occurrence, and 200 Areas Project personnel will review and group new sites on a regular basis.

During the DQO process that will occur as part of the development of the group-specific work plans, all ER sites will be evaluated to determine whether there are any candidates that may be reclassified as "rejected," "closed out," "deleted from NPL," or "no action" sites. Tri-Party Agreement Handbook Guideline TPA-MP-14 will be utilized for this purpose to reclassify sites. Reclassified sites will be kept in a separate list for tracking purposes. Candidates for reclassification may include instances where (1) waste disposal facilities were constructed but not used, (2) duplicate labeling (as discussed earlier) exists for a waste site produced by an unplanned release, (3) sites have been cleaned up, (4) the contamination has decayed to background levels, (5) sites were miss-classified as a waste site, or (6) a voluntary action such as a housekeeping activity may be used to remediate a site. All reclassifications are expected to be based on data packages provided to the Tri-Party Agreement reclassification team and will require reclassification approval from the team.

G1.1 WASTE STREAM TYPES AND GROUPINGS

An examination of the 250 + waste disposal sites used by the 200 Areas process and waste management facilities suggests that there are many variables in waste stream chemistry, volume, and other factors which interfere with a logical and meaningful grouping of sites. A review of plant designs and operations, processing chemistries used, process upsets, and facility clean-out campaigns would seem to confound any grouping strategy. Also, due to the fact that radionuclides were the primary waste stream contaminants of concern during plant operations, little attention was given to inorganic and organic chemical constituents released in the waste stream. While there is general understanding of radionuclide inventories and radionuclide migration in the soil column, the impact of the nonradioactive waste components on radionuclide movement is not as well understood. Further, waste site inventory data is

largely calculated from effluent samples taken as part of the plant operations. Some waste streams were routinely sampled and provided representative results, but many waste stream sampling routines are not well known and may have been sampled in less representative ways, thus casting some doubt on the inventory reports.

Despite these uncertainties, an effective characterization approach can be developed using appropriate caution. Much of the uncertainty inherent in waste stream chemistry must be accepted and allowances must be built-in to the characterization plans to cover the exceptions. One good approach to assessing impacts of uncertainties is the development of conceptual models, which depict the current level of knowledge of both the waste stream and the site's physical setting. Models can be used to identify data gaps, test the effects of data uncertainties and to indicate suitable sampling and characterization responses to those uncertainties. Conceptual models must be applied to a reasonably uniform set of site and waste stream contaminant conditions. A conceptual model for an organic-rich waste stream cannot be reasonably expected to explain contaminant distributions in the soil column for a waste stream with a significant inorganics content.

Previous waste site groupings were based on geographic relationships. There was a need to more thoroughly characterize operable units where low- and high-volume waste streams were mixed in with more and less highly contaminated waste streams. Thus, to insure adequate characterization, a greater number of sites in each of the geographically defined operable units were required to be characterized. A very few groups were both geographically isolated and unified by a single waste stream type to suggest a waste stream-based approach which could be used to reduce characterization efforts.

The general approach in planning characterization activities is to study a limited number of sites that cover a reasonable number of variables without sampling for every possible permutation. Grouping sites according to similar characteristics is the primary mechanism by which characterization activities are optimized. Application of the analogous waste site concept directs characterization activities at a few sites, which have been selected to represent average and worst-case waste site conditions. These are based primarily on inventory, waste volumes discharged, and similar waste site types.

This report relies on an understanding of how plants generate wastes as a means of grouping the sites. This has led to the recognition that there are a relatively limited number of actual waste stream types coming from any process plant. In general terms, most plants emitted waste streams as one or more of the following types - gas/vapor, liquid or solid phase streams. Gas/vapor phase wastes, discussed in G1.1.1, are not considered in detail in this report, other than as contributors in unplanned releases. Solid wastes are quite variable in characteristics, inventory and form but have been traditionally segregated within large burial grounds. In addition, solid wastes are not noted for their impact to the vadose zone and groundwater.

Liquid wastes, by their nature, past disposal practices, and contaminant inventory, have had the greatest impact on the 200 Areas. There are two general types of liquid wastes, those derived from intimate contact with process liquids and those where a barrier separated the process liquids from water used for heating or cooling in a process step. For waste streams where barriers were present, typically cooling or heating coil pipe walls, contamination of the stream required either small- or large-scale failures of pipe material. For these waste streams, surface disposal sites were used due to the low contaminant concentrations and the generally low potential for pipe failures.

For waste streams derived from intimate contact with process chemicals, contamination concentrations were determined by the volatility, chemical constituents and temperatures of the process solutions. The radiological and chemical content of contact process liquid could be of a highly- or mildly concentrated nature. In all cases, the material driven off in the vapor phases of the process were condensed offline and

then disposed of according to the radionuclide content. Tank farm wastes were derived from vapors released from boiling acidic solutions used to digest fuel rods. Later process steps requiring heating or boiling generated less contaminated vapors, and the condensates were usually disposed to the ground.

G1.1.1 Vapor/Gaseous Streams

Gaseous or vapor releases from the 200 Area plants are not considered in this document, except where the process discharged liquid wastes to the ground, or as a number of unplanned releases associated largely with plant ventilation or stack upsets. However, the ventilation system was a key part in overall plant operation and was the subject of elaborate designs or administrative controls to prevent or mitigate releases of contaminants.

Two major streams dominated the flow of air through the plants-building ventilation and process vacuum streams. Stacks were the primary exhaust point for both streams and were equipped with alarms plus monitoring and sampling equipment to ensure proper operation. Ventilation stacks were typically constructed to heights of 61 m (200 ft) to ensure good dilution of the gaseous components that bypassed or escaped the filter/treatment systems. Some condensed liquids were typically associated with the various ventilation plenums, fans, stack gas sampling facilities, and the stacks themselves.

A multi-source ventilation system provided large volumes of fresh air to all parts of the canyon buildings and attached support buildings. Flow configuration and forced exhaust established an airflow pattern from noncontaminated to contaminated areas, to cells, and then to the exhaust ductwork. Particulate, vapor, and fume-based contaminants in cells and galleries were passed through sand- or paper-filter systems prior to discharge into the stack. Large electric fans maintained a vacuum on the ventilation system, but steam turbine-driven exhaust fans were also provided as an emergency backup. The ventilation liquids disposed to the ground in the 200 Areas were generated either from stack or fan and plenum ventilation operations and were sent to waste sites such as french drains, reverse wells, and small cribs. This waste stream is categorized in the Miscellaneous Waste group.

Process vacuum systems were largely responsible for collecting and transferring vessel fumes, vapors, condensates, and particulate matter away from the decladding, dissolver, and process vessels' headspace. This system drew process gases to the condenser/treatment system or release point using vacuum steam jets. At all fuel processing plants, the decladding/dissolving step generated a significant vapor phase. Dissolver fumes, gases, particulates, and vapors were either released at the bottom of the stack (at the BiPO₄ processes in 221-B and T Plants) or through a silver reactor system (at the 202-S REDOX and 202-A PUREX Plants). The remaining vapor phase was released either directly at the bottom of the stack or between the exhaust fan units and the stack. Some short-lived ($t^{1/2}$ = minutes to days) fuel fission product fractions such as iodine-131 (I-131), xenon-133 (Xe-133), and ruthenium-103 (Ru-103) were very mobile and vaporized significantly or completely in the dissolver vessels.

Initial BiPO₄ dissolver operations were occasionally limited by poor atmospheric circulation associated with weather inversions. In these cases, dispersion tended to keep contamination close to the ground and required temporary cessation of fuel rod processing. This limitation was overcome with improved ventilation systems and longer aging of the fuel rods, either at the 200 North facilities or in the reactor storage pools. Later, PUREX and REDOX used silver reactors to remove the I-131 from the gases. Typical pre-reactor treatment steps included condensing, de-entraining, drying and reheating the gases and fumes before entering the silver reactor, and a filtration step after the reactor. Liquids condensed from the decladding/dissolver operations were recovered and sent to the tank farms as a small volume, highly contaminated stream. Other processing ventilation systems did not require silver reactor systems, but did rely on sand or paper filter banks to contain particulate contaminants borne out of process vessels or hoods as fumes, gases, or vapors.

Declassing and dissolver vessels were not required steps at the 221-U (URP), Waste Fractionization (221-B), or the Plutonium Finishing Plants (PFP). The URP process at 221-U Plant used the existing sand filter for certain process vessel and general plant ventilation requirements. Cloth and/or fiberglass filters were used for vault and selected roof-based, process vessel ventilation systems. The Waste Fractionization program at 221-B relied on the existing B Plant building filter and ventilation system for operational areas. For process vessels, two systems consisting of heaters, vacuum transport jets, high efficiency particulate air (HEPA) filters, condensers, and receiver tanks were added to treat ammonia-rich and nonammonia vapor streams. Fractionization process condensates from these systems were discharged to the 216-B-12 and 216-B-62 Cribs.

Process upsets associated with ventilation system releases were mostly the result of solids building up in the ventilation system which were then blown out the high stacks. This occurred for the first several years following startup of the REDOX facility, and sporadically at PUREX. Contamination releases were also reported for the 221-B and -T Plants in 1947-1948.

G1.1.2 Solid Waste Steams

Solid wastes typically consist of radiologically contaminated equipment, tools, clothing, paper, or other forms. Contact or potential contact with process solutions, materials or wastes resulted in the classification of solid material as contaminated. "Potential contact" wastes dominate the volume of solids sent to the burial grounds. Free release of these materials has always been difficult due to the risk of making a "not-contaminated" decision based on inefficient portable detectors. This dilemma and the inability to standardize release levels have consistently blocked free release to offsite sources.

Beyond the day-to-day solids generated from routine operations, large volumes of nonroutine solid wastes were commonly generated when a process revision or equipment repair or replacement produced excess contaminated parts and materials. If decontamination was not able to remove or reduce the contamination to acceptable levels, the equipment or material was disposed of in solid waste burial grounds. Small volume radioactive laboratory samples were frequently disposed to nearby vaults.

In addition to the radiological waste, large quantities of nonhazardous and hazardous wastes have been generated over the years, much of which was not considered hazardous at the time. Certain laboratory wastes, particularly unused chemicals, fell into this category. Large pits for the powerplant ash were placed close to the respective facilities. Debris piles from the demolition of old buildings are another typical, although usually smaller, waste site type found in and around the 200 Areas. With the advent of environmental regulations in the 1960s and 1970s, some attempt at segregating hazardous and dangerous wastes was made, independent of actual legal application to the Hanford Site. This resulted in the construction/operation of the Nonradioactive Dangerous Waste Landfill (NRDWL) and the adjacent Solid Waste Landfill.

G1.1.3 Liquid Waste Stream Types

Low-level liquid waste stream disposal sites constitute a significant concern for the Implementation Plan's characterization and follow-up remediation activities. Virtually all liquid waste sites are presently inactive. As discussed below, a wide variety of liquid wastes were generated through a number of individual process steps at each plant or facility.

G1.1.3.1 Process Condensate/Process Waste Category. This family of waste streams originates from direct contact with the process chemistry or from direct contact with a process side stream, such as acid or solvent recovery processes. Process condensates, as the name implies, were derived from plutonium-, uranium-, fission product-, or chemical-rich process streams, which had been heated to boiling or

near-boiling conditions, or which were evolving a vapor, gas, or fume phase. Process wastes are defined as nonirradiated wastes resulting from the cold start-up testing of a process, a step that typically included decladding and dissolving fuel rods. Process condensates differ from process wastes in that the latter has no or negligible quantities of fission products or plutonium. Individual groupings have been developed based on the relative quantities of specific constituents such as uranium, plutonium, organic-plutonium, organic, fission product, and general waste constituents. This waste category is the most diverse in contaminant content and concentrations of all major liquid discharges in the 200 Areas.

Process Condensates. Process condensates consisted mostly of water but contained varying, albeit minor, concentrations of chemical and radiological constituents. Contamination of the condensate resulted from two primary pathways, entrainment and volatilization. Entrainment is carryover of normally minute droplets of liquid from the heated vessel (pot) to the condenser. Entrainment would thus carry even nonvolatile salts into the condensate stream. Good design minimized entrainment, but even the best Hanford units typically operated with an approximately 1 ppm carryover (e.g., nonvolatile concentrations in the condensate one-one millionth of the pot concentration). Entrainment in the uranium concentrator condensates from U Plant resulted in the highest quantities of uranium discharged to the soil column, over 45,000 kg (99,000 lb). Entrainment in the evaporator process condensates (from treating neutralized tank farm wastes high in fission products) accounts for the bulk of the radionuclides in these streams.

Any volatile component that had a finite vapor pressure at the concentrator pot temperature was carried to the condenser to a greater or lesser degree, depending on the component's boiling point. If sufficiently volatile, some, or essentially all, of a given component would remain in the vapor phase and leave via the ventilation system (e.g., iodine venting during fuel dissolution). Acid recovery processes at PUREX, REDOX, and URP produced and discharged condensates with generally low pH, although neutralization of acidic wastes is reported for a few of the known acidic process wastes. Organic recovery processes produced condensates that contained quantities of hexone, tributyl phosphate/NPH, or carbon tetrachloride, depending on the plant from which they originated.

Since chemical reactions were commonly driven to faster rates by elevating process chemistry to boiling or near boiling temperatures, condensates from these operations became a major component of the 200 Areas waste disposal process. They were generally associated with the fuel dissolution or waste concentration steps at the separations and radionuclide recovery programs such as REDOX, PUREX, URP, and B Plant Waste Fractionation processes. The BiPO_4 process plants did not generate separate process condensate waste streams as piping was not provided to allow off-line treatment of vapors.

Concentration steps/vessels were another high volume source of contaminated condensate liquids in the 200 Areas. The 202-S REDOX, 202-A PUREX, Z Plant, and 221-B Waste Fractionation/WESF processes relied on concentrators to reduce the volume of purified product (e.g., plutonium, uranium) and waste streams. URP used concentrators in the 221-U to reduce the volume of the sluiced tank wastes prior to processing as well as for concentrating the uranium-bearing solutions recovered by the solvent extraction process. In addition, concentrators were at the core of volume reduction steps at the 242-A, -B, -S, -T, and -Z evaporator facilities. Condenser units were used at the boiling waste tank farms (241-A and 241-SX) to liquefy the vapors and return them to either the tanks or a waste site. Process condensates were also generated during the regeneration of process chemicals, such as acids and solvents, at the REDOX, PUREX, URP, and Waste Fractionation/WESF plants.

Although most process condensates were considered to be low-salt (not chemically neutralized) and neutral-basic, a few contained one or more compounds that are suspected or known to have increased the mobility of otherwise rather immobile contaminants. Acidic waste streams are known at most of the major process plants, except for the BiPO_4 streams. Organic agents were routinely discharged in one or

more waste streams from the URP, PUREX, REDOX, and PFP facilities. Detergents and cleaning compounds were used for plant vessel and piping decontamination washes at the conclusions of REDOX, B Plant, and T Plant operations and were often discharged to the soil column. In virtually all cases, these waste streams were discharged to cribs.

Process Wastes. Process wastes comprise a small volume of this category and are almost completely composed of cold startup wastes. Prior to startup of every major process, a charge of feed material was introduced to the plant and run through some (e.g., decladding/dissolving) or all of the individual steps. This step was used for process scale-up evaluations, troubleshooting and training purposes. Unirradiated fuel rods were decladded and dissolved for the REDOX and PUREX processes while URP processing used an unirradiated uranium solution to test its system. The full chemical nature of these wastes is not well documented. Commonly, these waste streams were reported to consist of depleted or unirradiated uranium along with small quantities of nitrates (Stenner et al. 1988). One REDOX waste site was also reported to have received contaminated hexone from initial test runs. The cold startup waste sites are generally notable for their significant quantities of uranium. Process wastes were almost exclusively discharged to trench waste sites.

G1.1.3.2 Steam Condensates/Cooling Water/Chemical Sewer Category. Cooling water, steam condensates, and chemical sewers were common to all separations process facilities in the 200 Areas. Most other facilities were generators of at least steam condensate and cooling water wastes. For the BiPO₄ processes, these three stream types were all dealt with as one discharge stream and sent to the respective pond systems. For the solvent extraction process, radionuclide recovery programs and waste volume reduction programs, these streams were often isolated and sent to separate waste sites. This was made necessary by the significant volumes of each stream produced by continuous operations. Discharges of this type were targeted for elimination in the late 1980s and early 1990s, and were effectively terminated by 1995.

These waste streams are grouped together because they may be regarded as largely non-contact waste streams with very low concentrations of radionuclides and/or chemicals. Typically, a physical barrier (e.g., the wall thickness of a heating or cooling pipe coil) separated the steam condensate and cooling water streams from the process liquids. In the case of chemical sewers, the wastes were not routinely exposed to radiologically contaminated solutions or vessels. At PUREX, chemical sewer sources also included floor drain discharges from the cold shops area. All three streams were apparently regarded to have such low quantities of contaminants that operational sampling only looked for key radionuclides.

Ideally, these waste stream groups should not have become radiologically contaminated. However, minute quantities of radiological contamination were routinely present. This is especially true for steam condensates and cooling water streams, where the combined steam heating and cooling water coil systems were placed directly into the chemical process solutions. When operating in highly corrosive environments or when subject to significant thermal gradients, chemical attack or mechanical pipe wear resulted in the formation of pinholes or hairline cracks. Usually, this was not a problem as the pressures of steam or cooling water in the pipe coils were greater than the process or condenser vessel pressure and any leaks would flow into the process vessel. However, at times when coils were not under pressure, minor leakage through the flaws occurred and contamination exited the tank. The presence of such flaws was detectable by indirectly measuring process parameters, such as the process liquid's specific gravity. Failing equipment could often be detected and repaired or replaced before major process upsets occurred.

In the corrosive operating environment both internal and external to the pipe coil, flaws would occasionally go to complete failure. Radiological monitoring of waste streams was performed at certain points, often for combined waste lines exiting a plant, rather than for an individual waste generator. Coil

failures in the REDOX dissolver and concentrators and PUREX process vessels were reported as unplanned releases and were responsible for some of the serious unplanned releases in the 200 Areas.

Steam Condensates. As noted in the process waste discussion, chemical reactions were frequently conducted at temperatures significantly above ambient. This was done to accelerate a process, to prevent precipitation and settling of material, or to ensure that a reaction went to completion. Temperature adjustments to process steps were made with steam, which either was directly injected into the chemical solution (sparging) or was circulated through heating coils inside a process vessel. The rate of steam entering the coil or sparger determined how much heat was brought into the system. In the case of heating coils, the spent steam was collected in an off-line condenser or reheated in a closed-loop system. At a condenser, spent steam would come into contact with a pipe coil carrying cooling water, which would chill and condense the steam to a liquid. The condensed steam was then discharged to a plant sewer or piping system that, in turn, discharged to a ditch/pond system or crib. Generally, if a single stream, this water was still hot when it reached a crib.

The waste site types to which steam condensate was discharged varied over time. As noted above, the BiPO_4 process used steam heating extensively. The condensate was routed directly into the plant sewer line and sent to the 216-B and -T ponds and ditches, along with the cooling water and chemical sewer streams. Similarly, operations at the URP also combined the three waste streams. The 242-T evaporator discharged steam condensate to the 216-T-4-1 ditch and pond system, while the 242-A evaporator first routed its steam condensate to the 207-A North retention basins for sampling and holding, prior to release to the 216-B-3 pond and ditch system.

Steam condensate generated by the REDOX, PUREX, and Waste Fractionization program, along with steam condensate from the 242-S and 242-B Evaporators, was discharged to cribs. The change in waste disposal site types versus steam condensate disposal to ponds appears to correlate with a series of coil failures in REDOX that contaminated the original waste site, the 216-S-17 Pond. PUREX and Waste Fractionization activities continued this trend, with the probable explanation that concentrator and dissolver coil failures carried greater potential for contamination release and should therefore be disposed of to underground sites.

Under normal operating conditions, the steam condensates were not expected to be acidic or otherwise rich in chemical constituents. However, some chemical additions to inhibit corrosion or scale buildup are reported at the powerhouses. The wastes were released as warm or hot water and vapors tended to carry some contamination to the surface through crib vent systems. Plastic or paper barriers installed in cribs at the top of gravel layers did not always sufficiently prevent vapor, or radionuclide, migration to the ground surface.

Steam was generated at the 284 East and West powerhouses and piped to each major plant from the inception of 200 Areas operations until 1997. Steam was also provided to the major separations plants for emergency plant ventilation needs in event of electrical grid power loss. This source alone contributed a significant fraction of steam liquids to a plant's total steam condensate consumption.

Cooling Water. Cooling water was used in virtually every separations, waste recovery, waste storage, and waste volume reduction facility in the 200 Areas. It followed plant steam heating requirements for most processes in a near-synchronous relationship. However, noncontact cooling is a relatively inefficient method of cooling process vessels. Based on pounds needed per degree change in temperature, a much larger quantity of heat can be added to a process using steam than is removed using cooling water. Consequently, in every plant, cooling water was volumetrically the greatest source of waste liquids any facility produced. Cooling water was derived from the 200 Area raw water supply, which was pumped directly from the Columbia River. With little or no treatment beyond filtration, this water was sent to the

facilities for use in plant processes. The waste liquid was typically benign with only very small concentrations of radionuclides in the stream.

As was the case for steam condensate, cooling water was generally regarded to be uncontaminated until it came in contact with cooling coils and condenser chambers in vessels throughout a plant. Cooling coil failures with significant contaminant releases occurred, but at less frequent intervals than noted for steam coils.

Wastewater associated with 284-East and 284-West powerplant operations was discharged to the environment in ditches which drained, respectively, to either the 216-B-3 or 216-U-10 Ponds and their associated ditches. This waste stream consisted of cooling water for turbines, boiler water jackets, compressors, generators, water softener system regeneration, and boiler blowdown (scale removal) discharge. Low-volume chemical additions such as sodium chloride, sodium sulfite, sodium hydroxide, and ethylenediaminetetraacetic acid (EDTA) were used to soften the water, and suppress corrosion and scale buildup (WHC 1990).

Chemical Sewer. Virtually every process step in any of the separations and radionuclide recovery projects required addition of solid chemicals, or more routinely, pre-mixed chemical solutions. Liquid concentrated nitric, phosphoric, and formic acids; sodium hydroxide; and aluminum nitrate were brought to the canyon buildings in railcar quantities and unloaded into the 211 Chemical Storage Tank Farm at each separation building. Most other chemical solutions were mixed on site to pre-established concentrations and volumes in the Aqueous or Solvent Makeup sections of the plant. Dry chemicals were weighed and added to demineralized water, also produced in the plants. Liquids such as acids and caustics were piped into large tanks in the same area.

As described in the introduction, chemical sewer wastes consisted primarily of makeup tank rinses, with lesser quantities of off-specification batches of chemicals, or overflow chemicals from tanks during aqueous makeup. Improper valving at outdoor chemical storage tanks during chemical unloading or transfer operations may have also yielded chemical sewer wastes.

The construction of separate waste sites for chemical sewer wastes generally emerged as a development in the REDOX plant's waste treatment and was later applied to the PUREX and Waste Fractionation processes. These wastes were discharged to separate ditches or ditch/pond systems. The Laundry waste stream is included here because of the significant quantities of detergents used in cleaning contaminated and noncontaminated work clothing.

In almost all respects, the inventory of contaminants in these waste streams is difficult to assess. Only incomplete records of wastes disposed to sites in this waste group are known. However, several sites were issued RCRA Part A Permits based on reported but unreferenced waste discharge inventories. Most of the chemicals disposed to these streams are expected to have broken down or reacted in the environment and are expected to be largely undetectable. Some inorganic compounds (e.g., cadmium, chromium, and nitrate) could remain sufficiently intact and would be detectable in the environment. Except for chlorinated hydrocarbons, most organic compounds and reactive inorganic compounds are expected to have been biodegraded or to have reacted in the environment.

G1.1.3.3 Chemical Waste Category. The radionuclide species potentially associated with laboratory wastes reflect the operations of the facility supported. Except for the PFP facility laboratory, all 200 Area laboratories potentially handled any radionuclide associated with irradiated fuel. The PFP facility routinely processed only actinide (e.g., plutonium, americium) radioisotopes and actively excluded materials with significant amounts of fission products. The 222-S and 300 area "320 series" laboratories

provided the widest support to overall Hanford operations and were equipped to accept the highest activity samples into remotely-operated "hot cells."

The nonradioactive contaminants potentially associated with laboratory operations compete with chemical sewers as the most poorly defined and most variable of all the waste group streams. A well-stocked analytical laboratory chemical stockroom may have hundreds of different chemicals (varying from small to multi-kilogram quantities). This is particularly true at facilities where nonroutine analytical or developmental work (e.g., at 222-S and the "320's" facilities) was being performed. Routine and specific product-related laboratories (e.g., 222-T, 222-U) were normally much less variable in waste output compositions. It should be noted that the laboratories associated with the PUREX and PFP facilities were part of the "main" building. Liquid wastes were combined with other facility wastes not routinely discharged as separate streams.

Overall discharges of laboratory waste were usually small in comparison to operating production facilities in the 200 Areas. Even the highest use chemicals were consumed in bottle and drum quantities, not tank car and truck amounts. The primary high-use chemicals fall into three major categories, acids, bases, and solvents. Acids and bases were heavily used in sample dissolution and preparation, as nearly all analyses require that the component to be measured be reduced to liquid form at least some point during the analytical process. Historically, most solvent use was for separations and cleaning. Most aqueous streams associated with this group were neutralized before discharge and did not contain visible separable organic layers.

Ongoing operations (primarily at 222-S) minimize the potential for discharge of radioactive or hazardous chemicals to the environment, but will remain a potential source of waste materials for the future.

G1.1.3.4 Miscellaneous Waste Category. Miscellaneous wastes are composed of a wide variety of waste streams characterized by a generally small volume of liquid, very limited quantities of radiological and chemical contaminants, and the small size of the respective receiving waste sites. There are several subgroups among the waste generating processes but no unifying theme, as for the previous groups. The primary waste-generating processes in this section are equipment decontamination, and plant, stack, and tank ventilation systems with a number of minor sources. French drains and reverse wells commonly received liquids from the low-volume streams. Cribs receiving moderate flows are also included. These cribs were often waste sites receiving multiple waste streams which could not be readily assigned to another waste grouping.

At least six waste sites (216-S-12; 216-T-9, -10, -11, -13, -33; and 216-U-13), mostly clustered around 221-T Plant, are related to decontamination of vehicles and equipment. Most sites were trenches active between 1951 and 1956, although a few remained active into 1963-64. The 221-T Building became the site equipment decontamination facility in 1958 and remains so to the present. The trenches were exhumed in 1972 and downposted from radiological contamination status at that time. Data indicate that the T-13 and T-33 waste volumes were monitored and sampled with low concentrations of constituents noted.

Most facility building ventilation systems were equipped with liquid waste disposal sites such as cribs, reverse wells, and french drains. Reverse wells are associated with the 291-B and 291-C stacks (216-B-13 and 216-C-2) and received unknown and presumably small quantities of both liquids and radionuclides. The BiPO₄ building stacks also were capable of collecting and diverting condensed liquids to the 241-Tank Farms. The PUREX canyon building utilized a large number of french drains (216-A-11, -12, -13, -14, -26, -26A, -33, -35, and -41) and cribs (216-A-4, -21, and -27) for ventilation-related wastes. These sites were used primarily to dispose of liquids generated from stack condensates and liquids associated with either the stack sampling equipment, fan motor cooling, or ventilation seal water.

A number of minor waste streams were associated with tank farm ventilation systems for the 241-A and 241-U Tank Farms. In the case of the 241-U-110 tank condenser, liquid wastes were discharged to the 216-U-3 Crib. Similarly, the 216-A-22 Crib received a combination of steam condensate and sump waste from the 203-A Uranium Storage Tank Farm as well as from the drain at the 203-U truck loadout facility. The 216-A-4, 216-A-21 and 216-A-27 Cribs, consecutively, received laboratory cell drainage from 202-A, sump waste from the 293-A Facility, and the 291-A stack drainage between 1955 and 1970.

Constituents associated with the waste streams are largely unknown. PUREX laboratory wastes are assumed to have been similar to those noted in Section G1.1.3.3, but were mixed in unknown proportions with ventilation wastes. Decontamination wastes are also unknowns and are expected to vary over time. Also included in this group are those waste sites constructed, but never used, for waste disposal. These sites include the 216-A-38-1, 216-B-56, and 216-B-61 Cribs.

G1.1.3.5 Tank and Scavenged Waste Category. Tank wastes include those liquids that were derived from the overflow of highly radioactive wastes stored in the 241-B, -C, -T, and U Tank Farms generated from the BiPO₄ processes at 221/224-B and -T Plant. Scavenged wastes are also derived from these same tank wastes but were processed to recover the uranium held in solution. Soil column discharge was used to create extra tank space by reducing the volume of liquids held in the tank. Both processes relied specifically on the active precipitation of solids in the waste settling out of solution either by cooling and stilling of the liquid or through the addition of precipitating (scavenging) agents such as ferrocyanides. In both cases, the waste streams were not considered to be high activity wastes. Waite (1991) provides a historical overview of these wastes. Haney and Honstead (1958) provide an earlier view of tank waste discharge problems, with special attention to the operation of specific retention facilities, associated with the disposal of scavenged wastes. In addition, discharge of intermediate activity level streams from BiPO₄ process waste collection tanks contributed significant quantities of radionuclides and chemicals to the soil column.

A few waste sites in the tank wastes group received multiple streams over the life of the 221/224-B and -T Plants' operations. The generally high level of contaminants in these streams resulted in cribs being taken out of service when crib loading factors were reached and reactivated when radioactive decay allowed or need required them to be used again. Some waste streams diverted from one waste site were sent to another for several months or years before being rerouted to yet a third site, which makes assigning a particular portion or quantity of the site inventory to a specific waste stream difficult. Crib and trench waste sites were commonly used for waste disposal, but several reverse well sites were active in the first years of the BiPO₄ process.

Tank Wastes. Direct releases of contaminants to the ground are reported from almost the start of tank farm operations in the 200 Areas. Tank capacity was taxed by production demands and construction of new tanks was required. One solution was to release to the soil column the lowest of the four high-level radioactive tank farm waste streams, the second-cycle decontamination waste. Second-cycle decontamination waste contained an estimated 0.1% of the initial long-lived fission product inventory and less than 1% of the total plutonium inventory.

Most of the high activity tank farm process wastes coming out of the BiPO₄ plants were rich in suspended or dissolved materials (sludge), which contained a large fraction of both the uranium and radioactive fission products in neutralized acidic wastes. Decanting of these wastes in a three-tank cascade system led to a clarified less radioactive supernatant, with much of the original suspended radionuclide load deposited as a salt cake at the bottom of the tanks.

Wastes from these sources were discharged to several cribs adjacent to the 241-B (cribs 216-B-7, 216-B-8, 216-B-9) and 241-T (216-T-5, 216-T-7, 216-T-19, 216-T-32) tank farms. These tank wastes

were relatively well characterized prior to release. An average of 10%, by weight, inorganic anions (phosphate, sulfate, fluoride, nitrate) and cations (sodium, potassium, ammonium) is reported in Stenner et al. (1988). Accordingly, these wastes were termed high-salt wastes. All of the waste sites had relatively short lives and were taken out of service when contamination began showing up in nearby groundwater wells. Ground disposal of second-cycle cascade liquid streams lasted from 1946 to 1952 and 1956 for B Plant and T Plant, respectively (Waite 1991).

First-cycle decontamination wastes were discharged to the soil column, in a more limited and controlled manner between 1953 and 1954. These wastes originally contained an estimated 10% of the fission product load entering the BiPO₄ plants and small concentrations of plutonium and uranium. The wastes were discharged to specific retention facilities, notably the 216-BX, -T and -TX trenches (216-B-35, 216-36, 216-B-38-41; 216-T-14 to-17 and 216-T-21 to -24). Specific retention disposal, described in more detail in Scavenged Wastes below, was a requirement to not saturate or flood the soil column under the trench or crib when discharging more highly contaminated liquids. Specific retention used about 30-50% of the 20% soil column pore volume as a basis for both sizing the receiving facility and capping the quantity of wastes discharged.

In contrast to the second-cycle decontamination wastes, the first-cycle decontamination liquids had been stored in tanks for a number of years, and much of the fission products and plutonium originally present had either decayed or more fully settled. Nonetheless, the concentration of radionuclides in this waste stream was slightly higher than for second-cycle decontamination wastes. The inorganics present were also slightly more concentrated and of a somewhat different mix than the second-cycle wastes. With approximately a 20% by weight average chemical content, this waste stream was also considered to be a high-salt waste.

Intermediate Wastes. Two intermediate-level waste streams grouped as part of the tank wastes were discharged to the soil column from the BiPO₄ process. One waste stream from the 224-B and -T Concentrator Building's waste concentration tank were noted for a relatively high plutonium concentration which was initially discharged to deep reverse wells (216-B-5 and 216-T-3) and later to cribs (216-B-7, 216-T-6, and others). This stream was also high in precipitated material and the 136,260-L (36,000-gal) 241-B/T-361 settling tanks were used to contain much of the resulting sludge. For a part of the facilities' operations, only decanted liquid was introduced into the soil column. After some period of time, the tank filled up with sludge, and more of the highly contaminated, suspended load was able to enter the reverse wells. A plume of short-lived alpha and beta contaminants was detected around the 216-B-5 reverse well in September 1947 (Brown and Ruppert 1950), resulting in that waste site's abandonment. The waste stream directed to the 216-T-3 reverse well had already been diverted to the 216-T-6 Crib by August 1946, and contamination was not observed in the groundwater.

The other waste stream, the 221-B and -T canyon building's cell 5-6 drainage, was a low- to intermediate-level stream that received diluted process liquids from cell rinses and spills to the plant waste collection tank, #6, located in cell 5. This stream was a composite of the individual steps used in the BiPO₄ process. The wastes were discharged to a series of cribs clustered near the 241-B and T tank farms (216-B-7, 216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32). The waste stream had a relatively lower, but still significant, quantity of both chemicals and radionuclides than did the other streams in this category.

One other stream in this group is the 242-B and 242-T Evaporator bottoms waste discharged to the 216-B-37 and 216-T-25 Trenches. The waste stream for 216-B-37 Trench is defined (Stenner et al. 1988) as first-cycle bottom supernatant wastes from the waste evaporator and 242-B. The waste stream for the 216-T-25 Trench is a similar stream from the 242-T (evaporator) Building. The evaporator bottoms were discharged back to the BY and TY tank farms, respectively, with residual supernate disposal to the trenches. There is nearly a four-fold increase in the quantity of chemicals sent to the B-37 trench

compared to the T-25 trench because of the longer operational time of 242-B. Both waste streams contained large quantities of Cs-137 (1,470 to 4,220 Ci), and short-lived beta emitters (2,820 to 8,080 Ci) with minor quantities of Sr-90, Pu-239/240, U-238, and Co-60 (DOE-RL 1997a, Appendix A).

Scavenged Wastes. Scavenged waste was generated from the treatment of high-level metal (uranium) waste originally discharged to tank farms from the BiPO_4 process. Metal waste contained 95% or more of the uranium in a chemical-rich solution along with ~ 90% of the long-lived fission products (GE 1945). This material was the most contaminated of the four waste streams generated, and comprised a greater volume of waste than any of the other high activity waste stream. Tank space and a shortage of uranium became a problem at about the same time and reprocessing of the stored wastes was undertaken at the URP at 221/224-U Plant.

The recovery process generated more waste liquids than it removed. Disposal to the soil column was the chosen solution if the fission product concentration could be reduced. The Sr-90 fraction was already in an insoluble sludge form and would readily settle out in tanks without adding a chemical scavenger. A step was developed that added ferrocyanide and nickel salts to the end of the URP stream, precipitating out much of the Cs-137. The wastes were then transferred to the 241-B tank farms, and passed through a tank cascade. The supernate was then overflowed to the ground, relatively free of fission product contaminants. This step was implemented after the URP had been operational for several years. The stream carried a moderate uranium inventory, a negligible plutonium inventory, and small quantities of Tc-99, H-3, and Co-60. The scavenged wastes contained an inventory of salts that averaged approximately 26% by weight of the total liquid solution. Most of the scavenged wastes were discharged to the ground in 200 East Area, at the 216-BY Cribs (216-B-42 to B-49) and, later, at the 216-BC Cribs/Trenches (216-B-14 to B-34), south of the 200 East Area. One crib site, 216-T-18, is known in the 200 West Area.

Beginning in 1955, the stored unscavenged tank wastes from early URP runs were treated in the 241-CR Vault using the same scavenging agents as at URP. The wastes were then transferred to 241-B tank farms for decanting, in what was termed "In-farm" scavenging. It is unclear if the URP-scavenged waste was segregated from or mixed with the in-farm scavenged waste at the time of discharge, or if only certain cribs or trenches received liquid wastes from one of the two sources. Scavenged waste discharges were halted in early 1958, shortly after the cessation of the URP in December 1957.

Scavenged waste discharges contributed perhaps the largest liquid fraction of contaminants to the ground in the 200 Areas. Based on data in Haney and Honstead (1958), Stenner et al. (1988), and Maxfield (1978), the total included over 4.749×10^7 kg of inorganics, 10,800 Ci of Cs-137, 19,700 Ci of Sr-90, 5,700 kg of uranium, and 108 g of plutonium. In addition, Waite (1991) indicated that over 1,000,000 Ci of short-lived beta emitters were also discharged at these sites. The short-lived beta-emitting radionuclides have decayed to undetectable levels, while Sr-90 and CS-137 have decayed to levels no more than 35% to 38% of the original amount discharged.

The scavenged waste discharged to the BY cribs may have behaved as a high-density liquid ($\text{Sp G.}=1.2$) mass upon reaching the groundwater table. The limited evidence for this behavior has been summarized in Kasza (1993) and discussed in Smith (1980) and DOE-RL (1996). This mechanism is considered to be viable from a chemical/material behavior standpoint. The wastes are thought to have descended to the bottom of the unconfined aquifer and remained as a coherent mass for some time, slowly dissolving into the groundwater. Smith (1980) noted increased concentrations of fission products at the top of basalt around the B-5 site, possibly attributed to the density phenomena.

G1.1.3.6 Tanks/Lines/Pits/Boxes Category. This group of waste sites contains all the pipelines, encasements, diversion boxes, valve pits, catch tanks, vaults, and other structures that were used to

convey high-level liquid wastes between tank farms, separations buildings, evaporators, vaults, etc., in both 200 East and 200 West Areas. The 241-Tank Farm operable units are not considered to be part of current Implementation Plan scope, as they are currently managed by the Project Hanford Management Contractors (PHMC). Since these operable units are normally bounded by their fence lines, the Tanks/Lines/Pits/Boxes group covers those related facilities outside the fence lines. Although the generating processes have stopped, high-level waste treatment is expected to continue for several more decades and future uses for the waste units in this group must be considered.

The diversion boxes, valve pits, pipelines, sampler pits, and other structures directing and regulating wastewater flow to crib, pond or ditch waste sites are considered to be separate from the structures in the Tanks/Lines/Pits/Boxes group. Rather, these structures are regarded as being part of the respective waste group sites characterization effort, equal in importance to that of the actual waste site.

At the beginning of 200 Area operations, a number of pipelines connected each separations building with its respective tank farms. With time, new facilities and more tank farms were required. Construction of new tank farms and the startup of new processes generally required the additional construction of new pipelines, encasements, diversion boxes, catch tanks, storage vaults, etc. The URP required construction of (1) a multi-pipe, cross-site transfer line between the 200 East and 200 West Areas; (2) a vent station, (3) terminal diversion boxes at either end of the cross-site line, (4) several large vaults for waste pre-treatment and storage, and (5) high-pressure pipelines running between the tank farms and the terminal diversion boxes and vaults. Inside the tank farms, two to three new diversion boxes (one per active tank cascade) and a master diversion box were added to facilitate extraction and pumping transfers. A smaller but similar construction program was required for the Waste Fractionization program at B Plant and included construction of the 244-AR Vault, a lift station, and pipelines connecting the 241-A tank farms to the vault.

In the early 1980s, the pipeline and diversion box system was reconfigured to isolate unused pipeline, encasements, catch tanks, and diversion boxes from active facilities and transfer lines. Pipelines constructed before approximately 1960 were not routinely provided with any secondary containment to protect against leaks. Many of these were later encased in covered concrete boxes with regularly spaced access risers to permit leak detection.

It is expected that contamination is present at most, if not all, of the sites in this group due to leaks, spills, and unplanned releases. Most encasements are known to be contaminated, as are all diversion boxes, catch tanks, lift stations, and vaults. Spills and releases to the surrounding areas are also known and are correlated with those facilities where data allows.

G1.1.3.7 Unplanned Releases Category. In general, an unplanned release site is the result of an airborne release, or liquid or solid spill that contaminates surrounding areas. Unplanned releases have been tracked over the years and, where possible, were related to the generating facility or activity. The releases have been categorized and labeled several times with either a UPR (Stenner et al. 1988) or UN letter prefix, an area code (200-E, 200-W) and a unique number. Over time, several unplanned releases have been duplicated using different numbers or have been dually classified as a liquid or solid waste site. The WIDS database is the current means for tracking these releases and resolving discrepancies.

In the Implementation Plan at least three separate subdivisions of unplanned releases are considered. The first are the releases that can be correlated to a specific waste site in one of the other groups or categories in DOE-RL (1997d). Another subdivision is attributed to those from facilities in the 200 Areas Tank Farm Operable Units, which are listed in Appendix B of the *Waste Site Groupings for 200 Areas Soil Investigations* (DOE-RL 1997a). The final subdivision of Unplanned Releases is the Grouping Document's Unplanned Releases category. This broadly defined group covers a host of waste sites

generated by generally unknown facilities or by spills and releases tied to transporting waste materials on site.

One-hundred eleven of the 283 unplanned releases originally counted are grouped with their respective waste sites. Another 79 unplanned releases are grouped with the tank farms operable units and result from incidents at tanks, vaults, boxes, and pipelines inside or directly adjacent to the tank farm fence line. Some of the remaining 93 unplanned releases may be reassigned to other groups as more information is found.

G1.1.3.8 Septic Wastes Category. There are at least 55 septic tanks and/or drain fields in the 200 Areas and adjacent 600 Areas. Virtually every building where office or workspace was provided to employees had its own septic system or shared one. Few septic systems are close to soil column disposal sites. Sanitary waste streams included toilet discharge, shower water, kitchen wastewater, janitorial sink wastewater, and similar liquid wastes. The systems were sized depending on the office capacity of the building being served.

Radiological contamination of these waste streams is assumed to be exceptionally low, although there are reports that some of the contents sampled for disposal at to the 100-N-Area sewage lagoon are mildly contaminated. The volume and inventory of these sites were not routinely tracked. These are one of the few continuing sources of soil column discharge at the Hanford Site.

G1.1.3.9 Active Waste Sites Category. Two active, state-approved liquid waste disposal sites are located in the 200 Areas. The State Approved Land Disposal Site (SALDS) crib is located north approximately 360 m (1,200 ft) of the 200 West Area fence line. It receives slightly tritiated but otherwise uncontaminated water from the Effluent Treatment Facility, located in the 200 East Area. Effluent is batch collected and discharged after verification through laboratory analysis. Each tank batch averages 1,892,500 to 2,460,250 L (500,000 to 650,000 gal) and is emptied on an as-needed basis. The Treated Effluent Disposal Facility (TEDF) consists of two ponds located east of the 216-B-3C Pond. TEDF receives treated effluent from 221-T Plant, PFP, 222-S Laboratory, 283-W Water Treatment Facility, 283-E Water Treatment Facility, 241-A Tank Farm, 242-A Evaporator, 242-A-81 Water Services Building, 244-AR, WESF, and package boiler annexes. During routine operations, this site receives an average of 75.7 to 567.8 L/min (20 to 150 gal/min). Discharge rates increase to approximately 11,355 L/min (3,000 gal/min) when steam condensate and cooling water are discharged during 242-A Evaporator operations. No treatment is performed at the TEDF.

In addition, there are over 140 minor, uncontaminated, unregulated liquid waste sites associated with the 200 Areas. No radiological or hazardous/dangerous chemical waste components are associated with these streams. These minor streams arise from a number of sources: steam traps, high tank overflows, equipment drains, air conditioner condensate drains, etc. (DOE-RL 1997e).

At present, solid waste is being disposed of to the 218-E-10, E-12B, W-3A, W-3AE, W-4B, W-4C, and W-5 Burial Grounds, and property lines are designated for future use at the 218-W-6 Burial Ground. These sites will remain active until individual burial ground capacity is reached or until the Hanford site facilities are permanently closed.

G1.2 Waste Site Types and Operational Parameters

Previous sections provided background data related to the origins, chemical and radionuclide constituents, and volumes of wastewater discharged to the soil column (see Table 3-10). The waste sites themselves exerted some control over the distribution and depth of placement of contamination, especially the larger ponds, cribs, and trenches. This section discusses important characteristics of waste site design and

construction, as well as plant and waste site operation. These data will assist in understanding conceptual model development and site characterization requirements. For additional discussion on these structures, refer to Maxfield (1979), the ten AAMS report documents (DOE-RL 1992a, 1992b, 1992c, 1992d, 1993a-f), the six technical baseline documents prepared for the AAMS reports, and the WIDS database.

Pipelines, holding tanks, diversion boxes, retention basins, valve pits, sampler pits, and a host of related engineered structures are associated with many of the waste sites described below. These items are not specifically addressed for each site, but are considered to be part of the site and need to be addressed either by plant D&D activities or by this project.

Except for certain types of trenches, waste site operations and usage were unregulated; i.e., unlimited flow over any number of years was permitted to the waste sites as long as waste stream contaminants were routinely below discharge standards. From at least the mid-1950s on, waste site's operation was regulated by its impact to the groundwater, as defined by standards in force at the time of operation. A 200 Area crib was able to receive waste as long as radionuclides with half-lives less than 3 years were not observed in the groundwater by nearby wells (Haney and Honstead 1958). This was based on an assumed travel time to the Columbia River of 50 to 100 years. Discharge standards were changed over time with regulatory standards promulgated by the responsible government agency.

G1.2.1 Waste Site Types

A number of waste site types were used at the Hanford Site for liquid and solid waste disposal. Terminology for these sites has changed over the years, and misuse has caused some confusion. This section provides a definition for specific waste site types and discusses the design, design changes, and improvements made over time.

Liquid wastes were discharged either to surface sites (ponds and ditches) or to underground sites (cribs, trenches, french drains, and reverse wells) depending on the levels of radiological contaminants. As part of the design process for a generating facility or for a process modification, waste stream characteristics were estimated before a waste site was designed. Underground disposal was required for those contact streams that had known levels of contamination or where there was some potential for large-scale releases through vessel failure. Surface disposal was acceptable where noncontact operations yielded large quantities of wastewater with negligible radiological contamination or with smaller potential vessel failures.

In the early stages of the Hanford project, impacts of exposure to contaminated wastewater were not well understood. Further, almost no data were available that documented the impacts of any type of chemical or radiological waste disposal to the soil, or consequences of migration to groundwater. Initial plans for the less concentrated, non-tank wastes recommended disposal to surface pond sites. However, this idea was quickly abandoned when the potential for contamination spread via drying and blowing of soils was recognized (Brown and Ruppert 1948). Underground disposal in reverse wells and wood crib structures became the design basis and was implemented before the start of plant operations.

Simultaneously or shortly afterward, research was initiated on the soil column's retention properties for radionuclides. It was quickly realized that the 200 Area's thick vadose zone, combined with the sorptive properties of the sediments, was able to provide considerable protection against groundwater and, ultimately, Columbia River contamination by 200 Area wastes. Specifically, Pu-239/240, Cs-137, and Co-60 were recognized to be generally immobile in the soil, and strontium was shown to be somewhat more mobile.

G1.2.1.1 Reverse Wells. Reverse wells were the first type of liquid waste disposal sites constructed in the 200 Areas, and all are associated with either the BiPO₄ separations or the 231-Z isolation buildings. As the name suggests, a reverse well, also known as an injection well or dry well, is a drilled, cased borehole, with perforations (holes were drilled or punched in the casing) along the bottom of the well. Liquid wastes were discharged either directly from the generating facility into the pipe or were first passed through settling tanks, as at 216-B-5 and 216-T-3. These tanks were labeled 241-B/T/U/Z-361. Each tank was 6.1 m (20 ft) in diameter and had a 136,260-L (36,000-gal) storage capacity at an overflow depth of 4.6 m (15 ft). The term "dry well" was often used in place of reverse well, but was also confusingly applied to both french drains and tank farm monitoring wells (GE 1945).

Eight reverse wells were drilled in the 200 Areas, to depths of 22.9 to 92.1 m (75 to 302 ft). Most reverse wells were 61 m (200 ft) deep or less and were typically 10.2, 15.2, or 20.3 cm (4, 6, or 8 in.) in diameter with starter casings up to 50.8 cm (20 in.) in diameter for the first 9.2 to 12.2 m (30 to 40 ft). Smaller diameter pipe was telescoped into the larger casing and grouted in place until the design depth was reached. Two reverse wells (216-B-5 and the first 216-T-3) were drilled to depths of 85.4 to 92.1 m (280 to 302 ft), and may have been drilled into or very near groundwater. A 92.1-m-(302 ft) deep reverse well was drilled at the 214-U-361 settling tank, but was never used for waste disposal. (This unused reverse well was the location where uranium-rich perched crib water from 216-U-16 penetrated the 200 West Area caliche zone in the 1980s and migrated to the groundwater.) Waste volumes discharged to the reverse wells are generally unknown, but are assumed to be fairly low. Where known, as at 216-B-5 and T-3, the systems appear to have been cyclically flooded, based on routine batch discharge operations (GE 1945).

Use of reverse wells was recognized as a mistake early in Hanford's operating history due in part to operating difficulties, but more so because several sites had probably contaminated groundwater (Brown and Rupert 1948, Parker 1954). The main waste disposal problem associated with reverse wells was that a much smaller thickness of sediments was available to neutralize the impacts and spreading of wastes below the bottom of the well casing. Operating difficulties included plugging of perforations by running sand, which was caused by intermittent operation. Sludge in the waste stream may have also plugged the well. Reverse well use began in 1945, and the last well was taken out of service in 1955. However, most sites were closed by 1950. Two other structures, 216-B-11A and 216-B-11B, are referred to as reverse wells, but their actual design is that of a french drain, and they are considered as such in this appendix.

G1.2.1.2 Cribs. Cribs were designed to receive low to moderate volume waste streams with generally higher levels of radionuclides resulting from direct contact with process chemistry. Cribs were also constructed to receive steam condensates at continuously operating separations plants where coil failures were possible and significant contamination releases were possible.

A crib's basic design created a greater unit volume of below-ground, open void space than otherwise occurred as a result of the soil column's porosity. This design offered a significant underground receiving space, a physical barrier against surface exposure, and restricted upward moisture/vapor migration or animal and plant root penetration.

The term "crib" was derived from the initial wood timber design, which resembled embankment or mining support structures. The initial crib designs consisted of a series of six wood beams assembled into a square frame with two parallel crossbraces. The frames were stacked, rotated 90 degrees to one another, forming a box-like structure with four internal columns at the crossbrace overlaps, and nine open cells. The boxes were roofed with beams, and the sides were usually covered with tarpaper. Two cribs usually served one waste stream. Each box was buried in a separate excavation, and the downstream box was connected with an overflow pipe. Several 231-Z cribs were constructed of wood, but to different designs. Several pipes penetrated both the sides and the roof, providing access for the effluent pipes, ventilation

pipes, liquid-level gauging wells, and soil column monitoring wells. Wooden cribs were usually 3.7 to 4.9 m (12 to 16 ft) square, 1.2 to 2.7 m (4 to 9 ft) tall, and were commonly buried beneath a 4.6- to 6.1-m (15- to 20-ft) thick soil cover. Past collapses are known and/or assumed probable for all wood cribs. Concrete beams, cinder blocks, and steel plates were occasionally used in place of wood at several sites across the 200 Areas.

Crib effluent data suggest that effluent pipeline placement did not allow much liquid to reach the second crib. The effluent lines entering the cribs were placed at levels at or above the crib roof. To get liquid into the second crib required flooding of, or high flow rates into, the first crib. Drilling data (Brown and Ruppert 1948) support the observation that little liquid flow ever reached the downstream crib, where the amount of contamination found beneath several 241-T Tank Farm cribs was much greater under the first box than under the second box.

Designs using multiple wooden cribs in one large gravel-filled excavation (216-B-12 and 216-U-8) and single wooden cribs with a gravel tile field for overflow (216-B-9, 216-T-7) represented transitional steps between the all-wood and all-gravel designs. However, cribs had evolved into the standard, coarse gravel/cobble-filled excavation by the early to mid-1950s, and appear to be similar to tile field designs used for septic systems. At that time, the gravel-filled cribs were called "caverns," to distinguish them from the wooden structures, but this terminology was not used after 1956.

The all-gravel cribs usually consisted of a single, 20-40 cm (8-16 in.)-diameter, horizontal, perforated pipe that extended the length of the crib. The pipe was typically submerged just beneath the top of a 1.2- to 2.1-m (4- to 7-ft) thick, coarse gravel/cobble fill, which in turn was covered with a heavy plastic or sisalkraft-paper (brown-bag) vapor and root barrier. This barrier was covered with a backfill of the excavation soils. Other piping designs included a herringbone arrangement of perforated lateral pipes connected to the main distribution line and a series of unperforated distribution lines with 90-degree connections to perforated laterals. Liquids sent to the 216-BY Cribs went to four 1.2-m-(4-ft) diameter culvert pipe segments placed vertically in the gravel fill.

Gravel crib sizes vary significantly. Small cribs (i.e., 216-U-3, A-22, and A-28) are 3.0 to 6.1 m (10 to 20 ft) in diameter and 3.0 to 3.7 m (10 to 12 ft) deep with a gravel fill placed in the excavation bottom. The largest cribs (i.e., 216-A-24, A-30, A-37-2) have bottom dimensions of 426.8 to 457.3 m (1,400 to 1,500 ft) long, 3.0 m (10 ft) wide, and 3.0 to 4.6 m (10 to 15 ft) deep. Most cribs are smaller, with an average length of 60.1 to 152.4 m (200 to 500 ft), widths of 3.0 to 6.1 m (10 to 20 ft), and 4.6 to 10.7 m (15 to 35 ft) deep. In general, at least 1.5 to 1.8 m (5 to 6 ft) of soil covered the gravel bed. All linear cribs were constructed with a 0.5% to 1% slope along the axis of the excavation to facilitate flow along the structure. Several cribs such as the 216-S-5/S-6, 216-U-16, and 216-W-LC Cribs were large rectangular structures, 60.1 to 91.5 m (200 to 300 ft) in length and 30 to 45.7 m (100 to 150 ft) in width.

Uniformly graded coarse gravel, fine to medium cobbles, and, on occasion, crushed rock were used to provide a network of large, interconnecting pore spaces that would quickly accept discharged liquids and conduct the liquids to the bottom and along the length of the crib excavation. Porosities of 40% to 45% could be expected using these materials compared with the 20% to 30% pore space found in sands and well-graded sediments. In addition, the individual pore spaces in gravels are much coarser than in well-graded sands and gravels. Layering of gravel- and cobble-sized rock was tried at several sites.

Gravel cribs were usually equipped with ventilation/filters systems to allow the crib gravels to "breathe" as water entered the structure. These fixtures were ready sources for localized surface contamination of the risers and the surrounding soils. In addition, liquid-level gauges using floats or conductivity probes were installed to monitor crib percolation performance. Vadose zone and groundwater monitoring wells

were often drilled through or at the edge of the crib to monitor vertical contaminant migration into the soil column and to detect contamination reaching the groundwater.

For several processes associated with PUREX and REDOX, two or three waste sites were constructed for higher volume streams. These sites were equipped with diversion boxes and valve pits to control routing between cribs. Sampler pits and flow-measuring/recording devices were also placed on some of the waste streams. Most of these facilities were not given separate identification numbers. The 216-A-8/A-24 and 216-A-30/A-37-2 Cribs are representative of crib system complexity and required several diversion structures. Diversion boxes were also built at the 426.8- to 457.3-m (1,400- to 1,500-ft) long 216-A-24, 216-A-30, and 216-A-37-2 Cribs to split wastewater flow between crib lines that discharged at the head end and at the center of the crib. This design ensured a more even distribution of wastewater to the entire length of the crib, which would otherwise not be able to accept the potentially large volumes of water generated by the waste stream.

Neutralization of crib wastes was occasionally performed on-line at underground, limestone-charged, flowthrough tanks. This treatment was applied at the 216-B-12 and 216-U-8 Cribs, which received large volumes of acidic process condensate from the URP. Laboratory tests indicated that this step could neutralize low pH values of acidic wastes from 2 to 4 to 6 or greater. Several concerns were associated with this practice, one of which was the regularity with which the limestone was monitored and replaced. There was also some concern that calcium liberated from the limestone actually out-competed cesium for exchange sites in the soil column.

Lint buildup was an isolated problem specific to the laundry crib. That structure was designed to allow access to unclog the individual drainage laterals. In addition, filters were installed in large terminal caissons to capture and remove lint.

G1.2.1.3 French Drains. French drains were commonly used for very low-volume streams where contamination through contact with a process stream was likely. French drains were constructed out of metal or concrete culvert piping placed on end in an excavation. The culvert pipe varied from 76 to 180 cm (30 in. to 6 ft) in diameter and was installed to depths of 3 to 12 m (10 to 40 ft). For consistency, the 1.2-m (48-in.) diameter/ 12.2-m (40 ft)-deep 216-B-11A and -11B "reverse wells" are considered here as french drains. Also, the term has been incorrectly applied to several small cribs (216-U-3, 216-A-22, 216-A-28), which were essentially excavated holes into which a thickness of gravel was placed and into which a pipe emptied. The typical french drain structure was partially filled with gravel and was covered with a wood, steel, or concrete lid. Effluent and vent pipes commonly penetrated the lids or culvert sides. Discharge rates and contaminant concentrations to these structures were usually not documented but likely did not exceed 5 to 10 L/min.

G1.2.1.4 Ponds. High-volume, low-concentration waste streams were discharged primarily to surface structures, or ponds. The first ponds were initially termed "swamps," primarily because the waste stream was routed to a topographic low point around the plant and allowed to flow across the ground. Seven swamps/ponds began operating in the 1940s with startup in the 200 Areas (Haney and Honstead 1950), by discharges from the B Plant, 200-E Powerhouse, 200-W Powerhouse, the T Plant, and the three 212 buildings in the 200 North Area. Ponds supporting REDOX and PUREX discharges were built later. The wetted areas became marshy and were noted for the potential to spread contamination during windstorms. Dikes and embankments across the drainages were apparently constructed, but the early structures appear to have been little more than a bulldozed dike, with no engineering design.

Ponds were typically the end point for any pond-ditch system and were regarded as the primary soil column percolation sites of the two components. Wastewater was conveyed to the ponds through a combination of buried pipelines, retention basins, and open ditches. Wastewater from the BiPO₄,

REDOX, and URP plants was initially collected in one of two 1,892,500-L (500,000-gal) basins at the 207 Retention Sites. When the basin was filled, the basin water was sampled and held until contaminant levels were below release standards. Upon release of wastewater from the first basin, the other basin was closed to allow filling. Offline retention basins were provided for the PUREX wastewater. This system relied on waste stream beta and gamma monitors connected to valves which automatically diverted water to the basin if elevated levels of contamination were detected.

All waste sites were subject to loss of percolation/porosity due to deposition of windblown debris. Ponds were especially susceptible to such losses because of their open construction and large surface exposure. Occasional experiments to control and settle out unplanned release contamination through the addition of clays reduced pond percolation capacity significantly. Percolation rates for some ponds dropped to less than 40.7 l/m³/day (1 gal/ft²/day) over their operational life. By the latter part of its operations, most of the wastewater entering the main lobe of B Pond was passing through to the downstream lobes. Vegetation such as trees, shrubs, cattails, and water grasses commonly grew in or along the margins of ponds and ditches. The growth was regarded as beneficial in maintaining percolation rates through plant root action.

Surface soil, vegetation, and algal uptake and concentration of contaminants is well documented and posed occasional problems, particularly following major releases. On these occasions, new material was usually bulldozed over the pond margins to isolate the soil-, algae- and vegetation-concentrated radionuclides. Old pond margins need to be carefully defined for characterization and remediation purposes.

Pond sizes varied depending on the generating plant's output, but ranged from 6,073 to 323,914 m² (1.5 to 80 acres). Depths were generally shallow, 0.6 to 2.4 m (2 to 8 ft), but B Pond was at least 3.7 m (12 ft) deep. Ponds were usually built in connected or cascading systems, such as the U-10 Pond/U-9 and -11 Ditch system, and the 216-A-25/B-3 pond lobes and ditches. Cascades and lobes were constructed as necessary for increased flows or as the result of releases from breached dikes. When lobes were added, spillways, pipes, diversion structures, and gates were also added to regulate the flow of liquids to the downstream structures. In areas where early operations discharged to swamps rather than ponds, the extent of contamination across an area is likely greater than shown by early drawings and has generally been defined by radiological boundaries.

An operational penalty of sorts was exacted on plants that discharged to ponds and ditches. Due to previously deposited contamination, temporary interruptions of liquid discharges to a site were not allowed. The contaminated soil had to remain covered with water to prevent drying out contaminated sediments, which could then be transported by wind. Consequently, a significant fraction of wastewater discharged to ponds was raw water and carried no process contamination. Raw water was routinely discharged from inactive plants and facilities to maintain liquid levels.

G1.2.1.5 Ditches. Ditches were constructed either to convey wastewater to a pond or to serve as the only soil column percolation structure. It is uncertain why ditches were added to pond disposal systems or why ponds were not directly connected to retention basins only by pipelines. Cost of construction and the then-significant distance from the plant are the most likely reasons.

A number of ditches, (e.g., 216-S-10, 216-T-1, and 216-B-63) were operated either without connecting to a pond or with only short-lived pond connections. Ditches were generally not considered important percolation structures, particularly when they were part of a pond system. They were, in fact, responsible for a significant (if largely unknown) fraction of percolation to the ground. Ditches were generally 1.8 m (6 ft) wide at the bottom of the excavation and constructed with side slopes that averaged at a 1.5:1 (H:V) ratio. Ditch depths and widths varied with topography, but were usually 1.8 to 3 m (6 to 10 ft) deep. The

maximum surface width of a ditch at the 216-S-10 site was approximately 15.2 m (50 ft). Ditches normally began at the concrete headwalls of pipeline outfalls and occasionally returned to pipelines at engineered structures.

G1.2.1.6 Trenches. Trenches were excavated to handle one-time "emergency" discharges of high-level wastes, or otherwise low-level, "un-cribbable" wastes. Specifically, significant quantities of scavenged and tank wastes were discharged to both trench and crib facilities on an as-needed basis. However, a number of trenches were used for disposal of other materials, including cold startup wastes and retention basin sludges. Wastes in these categories were richer in radionuclides and/or chemical contaminants than most other waste streams. The term "un-cribbable" waste was given to wastes that exceeded the normal concentration standards for continuous discharge of radioactive liquid wastes to the ground.

Trenches were excavated close to the process facility, at the tank farms where the waste was stored, or at more remote locations (e.g., south of the 200 East Area at the BC-Cribs/Trenches area) connected by pipelines. Most trenches that received tank or scavenged waste were 61.0 to 152.4 m (200 to 500 ft) in length, 3 m (10 ft) wide, and at least 3 m (10 ft) deep. Trenches receiving cold start-up wastes were usually smaller, on the order of 6.2 by 15.2 m (20 by 50 ft). Other trenches, which received wet contaminated sludge from retention basins or 212 Building cleanout sludge were 3.0 to 6.1 m (10 to 20 ft) wide, 4.6 to 24.4 m (15 to 80 ft) long, and 1.8 m (6 ft) deep. Wastes were delivered by over-ground hose or pipeline connections from a holding tank, valve pit or diversion box. Holding tanks are present at both the 216-BY and 216-BC areas. Other trenches in the 216-BC area continued to receive low volumes of liquid wastes. Until 1967, the 300 Area Laboratory waste collected in the 340 Facility was discharged to the 216-B-54 to 216-B-58 Trenches.

A means of ensuring greater excavation utilization was required at the longer BC Trenches. Typically, low dams or berms were built at regular intervals along the excavation axis, and piping/hose connections were routed to the individual segments to ensure more even waste distribution. Also, at most trenches, temporary vapor barriers were built of wood frames and plastic covers to prevent drying and dispersion of the liquids. When a trench reached its design capacity, the excavation was backfilled. It is uncertain if the wood and plastic covers were buried in place or reused (Corley 1956).

An evolution of trench design and use parallels experiences with disposal of the tank and scavenged wastes described in Section G1.1.3.5. Cribs located around the 241-B and 241-T tank farms were the first sites that routinely received tank overflow wastes. With a shift toward specific retention-type operations, these cribs were replaced in both areas with a series of smaller trenches that were located at the 241-BX (216-B-36, 38-41) and 241-T tank farms (216-T-14 to T-17). Then, as noted above, the URP wastes exceeded available tank capacity but were too rich in fission products to be discharged to the soil column. A chemical process inducing precipitation, or scavenging, of the fission products was developed, and lower activity liquid wastes were then sent to the ground after some residence time in the tanks.

Based on the generally successful operation of the 216-BX trenches, other sites were developed to receive decanted scavenged wastes. The 216-BY waste sites were designed as cribs but were proposed to be the first waste sites to test specific retention (Clukey 1954). However, the sites were either treated as cribs or their retention capacity was overestimated. Cesium and cobalt were detected in the groundwater within 10 months of start of operations. Cobalt-60 was an unexpected contaminant in the groundwater as its mobility was generally very low (Thomas et al. 1956).

Six new cribs were built at the 216-BC area before problems with the BY cribs were fully realized. The 216-BC Cribs were presumably operated as specific retention facilities, but were later supplanted by trenches. The BC facilities were specifically operated to the most conservative standards of any specific

retention facility. The BC-trenches received wastes between 1956 and 1958 with no obvious signs of contamination in the groundwater.

G1.2.1.7 Solid Waste Burial Grounds. There are two general types of radioactive, solid waste disposal sites and a wide variety of nonradioactive sites. For storage of a broad array of solid radioactive wastes, large multi-trench burial grounds were constructed. Several currently active burial grounds will be utilized well into the future. Alternately, smaller one-trench burial grounds were created adjacent to surface storage pads for one-time disposal of contaminated equipment and materials. In a few cases, in-place disposal of failed utility lines was considered as a burial ground.

In addition, there are wooden, small-volume disposal vaults/caissons near the 222-B, -S and -T Buildings for laboratory wastes and at least 16 steel-drum caissons at several 200 West Area burial grounds for storage of small volume, highly radioactive and TRU wastes. Low-level solid wastes were placed in drums, plastic bags, and cardboard or wooden boxes and stored in trenches. Small volumes of liquids were placed in the burial grounds but were encased in concrete-filled drums.

Trench bottom dimensions varied considerably. Trench lengths were proportional to the site boundaries (avg. 61 – 274.4 m [200 - 900 ft long]), were usually less than 16.8 m (55 ft) wide, and were typically 3.7 – 7.6 m (12 to 25 ft) deep. They were constructed with sideslopes of 1.5:1 (H:V) ratios and had surface footprints up to 27.4 m (90 ft) wide. As a general rule, trench spacing was equal to, or somewhat less than, the footprint of the individual trench excavation. A standard 1.2-m (4-ft) soil cover was required over all low-level wastes to avoid cave-in problems associated with cardboard or wooden boxes and settling wastes.

Waste segregation was not practiced initially at the Hanford Site, but became standard practice by 1970. Segregation of the site's TRU waste to the 200 Areas was initiated in 1963. By 1967, all solid waste from the 100-N and 300 Areas was shipped to the 200 Areas burial grounds, along with offsite waste including naval vessel reactor cores, Three Mile Island wastes, and the Shippingport pressure vessel. The burial grounds constitute the largest concentration of radionuclides of all waste site types addressed by the Implementation Plan, and have significant inventories of plutonium, uranium, and fission products.

Depending on their nature and volume, nonradioactive wastes were either segregated according to type and disposed to landfills or dumped in less controlled manners. Generally, large volume solid wastes were disposed to engineered burial grounds or non-engineered pits and landfills. Pits near the 200 Areas power plants received coal ash. Other pits were used to burn solvents, paint, office wastes, and tumbleweeds, or to detonate shock-sensitive chemicals. The large Central Waste landfill (CWL) southeast of the 200 East Area received large quantities of office solid waste (paper), construction and demolition debris, medical wastes, empty containers, appliances, office furniture, and inert debris. The adjacent NRDWL received small quantities of laboratory chemicals, spent organic chemicals, spent solvents, paints and thinners, and their containers. Liquid sewage and 1100 Area catch basin wastes were discharged to trenches in the CWL.

Other landfills and dumps were scattered throughout the 200 Areas in the early days of operations, but are not well documented. A number of discovery sites are known and tracked by WIDS. These waste sites are generally smaller in areal extent and are associated with old construction or support function activities/sites.

G1.2.1.8 Septic Tanks and Tile Fields. The sites for human sewage, kitchen wastes, and janitorial wastes disposal were very similar in design to gravel cribs. These facilities usually consisted of a large holding tank for solids and a gravel tile field for liquid overflow percolation. Piping in the tile fields is normally configured in a herringbone arrangement and is made of concrete, vitrified clay, or plastic pipe.

At least 56 of these sites are currently known to exist in the 200 Areas. Historical records of old facilities and plans for new facilities are also known. Many current sites use the same designation as the older septic systems they replaced. Consequently, a precise count on the number of sites is difficult to determine.

Each septic system is sized for the human occupancy in the facilities served, and dimensions of holding tanks and tile fields vary accordingly. Septic tank size varied from several hundred to several thousand gallons capacity. The tile fields average about 15.2 m (50 ft) wide by 30.5 m (100 ft) long. The WIDS database indicates that most of the septic tanks have drain fields associated with them, but few details are available.

G1.2.2 Waste Site Design Considerations

Several aspects of waste site operations may have impacted the distribution of contaminants in the waste site and soil column, and should be considered during characterization. Factors affecting the distribution of contaminants will require additional investigation and research for each group. This section suggests some approaches by which the factors may be evaluated. At larger facilities such as cribs, ponds, ditches, and trenches, these factors are expected to be more clearly demonstrated than at the smaller sites.

G1.2.2.1 Contamination Form. The form of contaminants entering a waste site is important to determine where they might enter the soil column. Specifically, the contaminants may exist as dissolved solids in the wastewater, may be colloidal in nature, or may occur as particulate matter. The former condition would imply contaminant spreading evenly in the waste site and the soil column. Particulate matter would settle out according to Stoke's Law such that, as the velocity of water in motion drops, particulates would drop out of suspension according to size. As a result, although the specific sizes of suspended matter are unknown, contamination would be expected to be more concentrated near the head end of the crib or pond. Also, if contamination were in a particulate form, there would be less potential for contaminant migration into the soil column. Colloidal material, being intermediate in size, would be expected to occupy an intermediate position in the waste site. These effects are known or expected to have impacted all waste site types. Of the waste site types, cribs, ponds, and ditches are expected to demonstrate impacts of contaminant form differences.

Determining the form of contaminants in waste streams that have been out of service for a long period of time poses significant problems. Existing literature documenting process flow and laboratory testing of contaminated soils or wastes is available and may provide an indication. A basic understanding of Hanford process chemistry, coupled with data regarding the specific gravity of waste streams, might also be helpful.

G1.2.2.2 Waste Site Sizing. While not reported in most cases, engineering studies were usually conducted to determine the porosity and/or percolation rates for the larger waste sites and, specifically, the cribs. Engineering documentation on crib design is rare and most likely exists in the specific project documentation for crib construction. Percolation testing was reported for several cribs, but it is unclear what methods were used. Regardless of the test results, an average design value of 407.2 L/m²/day (10 gal/ft²/day) was accepted for an active waste site with a saturated soil column and appears to have been used as the design basis for many waste sites. Over time, percolation rates declined as the waste site pore space became clogged, and replacement facilities were occasionally built.

From data presented in Appendix A of DOE-RL (1997a), among the various categories and groups, process cooling water waste streams comprised the overwhelming majority (93.6%) of liquid wastes, by volume. In decreasing order, process condensate, chemical sewers, steam condensates, chemical laboratory wastes, tank and scavenged waste, and miscellaneous wastes constitute the remainder of the

liquid wastes. For solid wastes, radiologically contaminated materials far exceed the nonradiological wastes.

G1.2.2.3 Rate of Discharge to a Waste Site. It is unclear if an average discharge rate or a daily volume was the basis for crib sizing and, further, if either approach affected contaminant distributions in the soil column and the crib. Based in part on the form of the contamination discussed in Section G1.2.2.2, discharge rates to facilities may be important to the distribution of contaminants in a waste site and soil column. As suggested above, there were different styles of liquid discharge rates to waste sites. Continuous discharges were commonly associated with pond and ditch operation where plant water flows were continuous. When occurring as separate streams, steam condensate and chemical sewer discharges were also continuously operated. At the other extreme, batch release was a common method of liquid waste discharge. The rate of release from the holding tank storing the liquid depended on its capacity and the rating of the pump used to drain the tank. The daily total volume depended on the number of times the holding tank was emptied.

Wastewater flowing through a crib is assumed to be retarded by the tortuosity of the combined flowpaths through the crib pipe and the gravel pore spaces. Water entering a crib exited the pipe at the first available perforations and flowed down through the gravel to the crib floor. At that point, the water began to move laterally through the gravel. Under any rate of flow greater than the instantaneous percolation rate of the crib's underlying sediments, the level in the crib will rise. Similarly, when the wastewater cannot exit the pipe perforations fast enough for the upstream flow, or where the uppermost part of the crib becomes flooded, some part of the wastewater will flow further down the pipe and exit into the gravel where it can again move away from the pipe. At some flow rate the crib will flood and lateral movement into the surrounding soil column will begin to occur. At discharges where the rate of release is less than the crib's instantaneous percolation rate, only vertical flow into the soil column will occur.

This model influences the distribution of contaminants in the waste site and the soil column, depending on the nature of the contaminants. Cribs that are flooded or saturated are expected to deliver each size fraction of contamination to greater areas of the crib. Cribs in which only partial saturation occurred would be expected to have contaminants concentrated around the head end and centerline of the crib.

Continuous flooding results when plant waste discharge exceeds the crib's design capacity and results in continuously standing water in the waste site. The level of standing water may increase over time and indicate an approaching waste site failure. Routine flooding conditions are known at a few sites (e.g., the 216-U-16, S-5, S-26, and A-8 Cribs), and suspected at others. Flooded cribs sometimes exhibited signs of excessive liquid or vapor migration to the ground surface.

Rough approximations regarding the degree of waste site saturation or flooding can be made using available monthly discharge data and using an assumed design percolation rate. More refined estimates can be obtained from details of the process and support equipment feeding the waste site, coupled with operating procedures. Operational surveillance records for waste sites may provide indications of waste site performance, but would be difficult to locate.

G1.2.2.4 Waste Stream Characteristics. Although chemical properties of waste streams have been discussed elsewhere, physical waste stream characteristics have not. Factors of concern here are viscosity, density, and temperature. In general, most waste streams were classified as low salt (i.e., not needing significant in-plant neutralization) and neutral or basic. They are regarded as having density and viscosity properties equivalent to that of water. In several groups, high-salt conditions are noted, which were produced either by actual neutralization of acidic wastes (as required for release to tank farms) or the result of post-tank farm processing such as for the URP/Scavenged Wastes. These wastes had higher

density values (specific gravity = 1.2) and may have been more viscous. Available literature to document the latter parameter is not available.

Temperatures of waste streams varied from ambient to near boiling, depending on process origin and proximity to the generating facility. For example, process condensates discharged from the URP left the holding tanks at temperatures of 170°F. Those wastes sent to the 216-B-12 Crib were reported to have been at 110-120°F following a more than 6.4-km (4-mile) path through buried pipelines, and are expected to have been much warmer at the 216-U-12 Crib. Imperfections in or the lack of a vapor barrier may have allowed transport of contaminants to the ground surface. Maxfield (1979) reported the presence during the winter of 1971-1972 of a white, slightly radioactive alkaline deposit that formed on the entire surface of the 426.8-m (1,400-ft) long 216-A-30 Crib. The deposit was covered with a layer of sand and a plastic sheet, which in turn was covered with a 0.6-m (2-ft) layer of sand. Thermal impacts of wastewater at other sites are not known, but may exist.

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Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-PW-1, Plutonium/Organic-Rich Process Waste Group								
Lead Regulatory Agency: EPA								
200-PW-1	216-T-19	216-T-19, 241-TX-153 Crib and Tile Field, 216-TX-1, 241-TX-3, 216-T-19TF	Crib	Inactive	CPP	EM-40	200-TP-2	
200-PW-1	216-Z-1&2	216-Z-1&2, 234-5 No. 1 Crib, 216-Z-7, 234-5 No. 2 Crib, 216-Z-1 & 2TF, 216-Z-1 and 216-Z-2 Cribs	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-1	216-Z-1A	216-Z-1A, 216-Z-1A Tile Field, 216-Z-7, 234-5 Tile Field, 216-Z-1AA, 216-Z-1AB, 216-Z-AC	Drain/Tile Field	Inactive	CPP	EM-40	200-ZP-2	X
200-PW-1	216-Z-3	216-Z-3, 216-Z-3 Culvert, 216-Z-8, 234-5 No. 3 & 4 Cribs	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-1	216-Z-9	216-Z-9, 216-Z-9 Cavern, 234-5 Recuplex Cavern, 216-Z-10, 216-Z-9 Crib, 216-Z-9 Trench	Trench	Inactive	CPP	EM-60	200-ZP-2	X
200-PW-1	216-Z-12	216-Z-12, 241-Z-12	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-1	216-Z-18	216-Z-18, 216-Z-18 Crib	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-1	241-Z-361	241-Z-361, 241-Z-361 Settling Tank	Settling Tank	Inactive	CPP	EM-60	200-ZP-2	
200-PW-1	UPR-200-W-103	UPR-200-W-103, 216-Z-18 Line Break, UN-216-W-13, UN-200-W-103	Unplanned Release	Inactive	CPP	EM-60	200-ZP-2	
200-PW-1	UPR-200-W-110	UPR-200-W-110, Contaminated Soil at 216-Z-1, UN-216-W-20	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-PW-2, Uranium-Rich Process Waste Group								
Lead Regulatory Agency: Ecology								
200-PW-2	216-A-1	216-A-1, 216-A-1 Cavern, 216-A-1 Trench	Crib	Inactive	RPP	EM-40	200-PO-5	
200-PW-2	216-A-3	216-A-3, 216-A-3 Cavern, 216-A-3 Crib	Crib	Inactive	RPP	EM-40	200-PO-2	
200-PW-2	216-A-5	216-A-5, 216-A-5 Cavern	Crib	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	216-A-10	216-A-10, 216-A-10 Crib	Crib	Active	TSD	EM-40	200-PO-2	X
200-PW-2	216-A-18	216-A-18, 216-A-18 Excavation, 216-A-18 Grave, 216-A-18 Sump, 216-A-18 Crib	Trench	Inactive	RPP	EM-40	200-PO-5	
200-PW-2	216-A-19	216-A-19, 216-A-19 Test Hole, 216-A-19 Grave, 216-A-19 Sump, 216-A-19 Crib	Trench	Inactive	RPP	EM-40	200-PO-5	X
200-PW-2	216-A-20	216-A-20, 216-A-20 Test Hole, 216-A-20 Grave, 216-A-20 Sump, 216-A-20 Crib	Trench	Inactive	RPP	EM-40	200-PO-5	
200-PW-2	216-A-28	216-A-28, 216-A-28 French Drain, 216-A-28 Crib	Crib	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	216-A-36A	216-A-36A, 216-A-36 Crib	Crib	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	216-A-36B	216-A-36B, 216-A-36 Crib, Purex Ammonia Scrubber Distillate (ASD)	Crib	Active	TSD	EM-40	200-PO-2	X
200-PW-2	216-B-12	216-B-12, 216-ER Crib, 216-ER-1,2,3 Cribs	Crib	Inactive	RPP	EM-40	200-BP-9	X
200-PW-2	216-B-60	216-B-60, 216-B-60 Crib	Crib	Inactive	RPP	EM-60	200-BP-6	
200-PW-2	216-C-1	216-C-1, 216-C Crib	Crib	Inactive	RPP	EM-40	200-SO-1	
200-PW-2	216-S-1&2	216-S-1&2, 216-S-5 Crib, 216-S-1 & 2	Crib	Inactive	RPP	EM-40	200-RO-2	
200-PW-2	216-S-7	216-S-7, 216-S-15	Crib	Inactive	RPP	EM-40	200-RO-2	
200-PW-2	216-S-8	216-S-8, Cold Aqueous Trench, Cold Aqueous Crib, 216-S-3, Unirradiated Uranium Waste Trench, Cold Aqueous Grave	Trench	Inactive	RPP	EM-40	200-RO-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-PW-2	216-U-1&2	216-U-1&2, 361-WR (Crib 2), 216-U-3, 216-UR #1&2 Cribs, 216-U-1 & 2	Crib	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	216-U-5	216-U-5, 216-U-4, 221-U Cold U Trench #2	Trench	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	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	Trench	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	216-U-8	216-U-8, 216-WR-1,2,3 Cribs, 216-U-9	Crib	Inactive	RPP	EM-40	200-UP-2	X
200-PW-2	216-U-12	216-U-12, 216-U-12 Crib	Crib	Active	TSD	EM-40	200-UP-2	X
200-PW-2	241-U-361	241-U-361, 241-U-361 Settling Tank, 361-U-TANK	Settling Tank	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	270-E-1	270-E-1, 270--E CNT, 270-E Condensate Neutralization Tank, 216-ER-1	Neutralization Tank	Inactive	RPP	EM-60	200-BP-6	
200-PW-2	270-W	270-W, 270-W Tank, 270-W Neutralization Tank	Neutralization Tank	Inactive	RPP	EM-30	200-UP-2	
200-PW-2	UPR-200-E-39	UPR-200-E-39, Release from 216-A-36B Crib Sampler, UN-200-E-39	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	UPR-200-E-40	UPR-200-E-40, Release from the 216-A-36B Crib Sampler, UN-200-E-40	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	UPR-200-E-64	UPR-200-E-64, UN-216-E-64, Radioactive Contamination from 270-E-1 Neutralization Tank, UN-200-E-64 UN-216-E-36	Unplanned Release	Inactive	RPP	EM-60	200-BP-9	
200-PW-2	UPR-200-W-19	UPR-200-W-19, 361-U Overflow, UN-200-W-19	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	UPR-200-W-36	UPR-200-W-36, Groundwater Contamination at 216-S-1 and 216-S-2	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-PW-2	UPR-200-W-163	UPR-200-W-163, Contaminated Vegetation at the 216-U-8 Pipeline, UN-216-W-33	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-PW-3, Organic-Rich Process Waste Group								
Lead Regulatory Agency: EPA								
200-PW-3	216-A-2	216-A-2, 216-A-2 Cavern	Crib	Inactive	CPP	EM-60	200-PO-2	X
200-PW-3	216-A-7	216-A-7, 216-A-7 Cavern	Crib	Inactive	CPP	EM-40	200-PO-5	
200-PW-3	216-A-8	216-A-8, 216-A-8 Crib	Crib	Inactive	CPP	EM-30	200-PO-5	X
200-PW-3	216-A-24	216-A-24	Crib	Inactive	CPP	EM-40	200-PO-5	
200-PW-3	216-A-31	216-A-31	Crib	Inactive	CPP	EM-60	200-PO-2	
200-PW-3	216-A-524	216-A-524, 216-A-524 Control Structure, 216-A 524 Weir	Control Structure	Inactive	CPP	EM-40	200-PO-5	
200-PW-3	216-C-4	216-C-4	Crib	Inactive	CPP	EM-40	200-SO-1	
200-PW-3	216-S-13	216-S-13, 276-S Crib, 216-S-6	Crib	Inactive	CPP	EM-40	200-RO-2	X
200-PW-3	216-S-14	216-S-14, Buried Contaminated Hexone, Cold Organic Trench or Grave, 216-S-4 Burial Contaminated Hexone	Trench	Inactive	CPP	EM-40	200-RO-3	
200-PW-3	216-U-15	216-U-15, UN-216-W-10, 388-U Tank Dumping, UPR-200-W-125, UN-200-W-158, U-152 Interface Crud Burial	Trench	Inactive	CPP	EM-40	200-UP-2	
200-PW-3	UPR-200-E-56	UPR-200-E-56, Excavated Contamination Adjacent to 216-A-24 Crib, UN-200-E-56, UN-216-E-33, 200-E-18	Unplanned Release	Inactive	RPP	EM-40	200-PO-5	
200-PW-3	UPR-200-W-125	UPR-200-W-125, 216-U-15, UN-200-W-125	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-PW-4, General Process Waste Group								
Lead Regulatory Agency: Ecology								
200-PW-4	209-E-WS-3	209-E-WS-3, Critical Mass Laboratory Valve Pit	Valve Pit	Inactive	RPP	EM-30	200-SO-1	
200-PW-4	207-A-SOUTH	207-A-SOUTH, 207-A, 207-A Retention Basin, 207-A-SOUTH Retention Basin, 207-A South	Retention Basin	Active	TSD	EM-30	200-PO-5	X
200-PW-4	216-A-34	216-A-34, 216-A-34 Ditch, 216-A-34 Crib	Ditch	Inactive	RPP	EM-40	200-PO-5	
200-PW-4	216-A-37-1	216-A-37-1, 216-A-37 Crib	Crib	Active	TSD	EM-40	200-PO-4	X
200-PW-4	216-A-45	216-A-45, 216-A-45 Crib	Crib	Inactive	RPP	EM-60	200-PO-2	
200-PW-4	216-C-3	216-C-3, 201-C Leaching Pit, 216-C-3 Crib	Crib	Inactive	RPP	EM-40	200-SO-1	X
200-PW-4	216-C-5	216-C-5	Crib	Inactive	RPP	EM-40	200-SO-1	
200-PW-4	216-C-7	216-C-7, 216-C-7 Crib	Crib	Inactive	RPP	EM-30	200-SO-1	
200-PW-4	216-C-10	216-C-10	Crib	Inactive	RPP	EM-40	200-SO-1	
200-PW-4	216-S-4	216-S-4, 216-S-7, 216-S-4 Sump or Crib, UN-216-W-1	French Drain	Inactive	RPP	EM-40	200-UP-2	
200-PW-4	216-S-22	216-S-22	Crib	Inactive	RPP	EM-40	200-RO-3	
200-PW-4	216-S-23	216-S-23	Crib	Inactive	RPP	EM-40	200-RO-2	
200-PW-4	216-T-20	216-T-20, 155-TX, 216-TX-2, 216-T-20 Crib, Contaminated Acid Grave	Trench	Inactive	RPP	EM-40	200-TP-2	
200-PW-4	216-U-16	216-U-16, UO3 Crib	Crib	Inactive	RPP	EM-30	200-UP-2	
200-PW-4	216-U-17	216-U-17	Crib	Inactive	RPP	EM-30	200-UP-2	
200-PW-4	UPR-200-E-145	UPR-200-E-145, W049H Green Soil	Unplanned Release	Inactive	RPP	EM-30	200-PO-5	
200-PW-5, Fission Product-Rich Process Waste Group								
Lead Regulatory Agency: EPA								
200-PW-5	216-B-11A&B	216-B-11A&B, 216-B-11 Crib, 242-B-1 Crib, 216-B-11A & B	French Drain	Inactive	CPP	EM-40	200-BP-4	
200-PW-5	216-B-50	216-B-50, 216-BY-8 Crib, 216-BY-8 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-PW-5	216-B-57	216-B-57, 216-B-57 Enclosed Trench	Crib	Inactive	CPP	EM-40	200-BP-1	X
200-PW-5	216-B-62	216-B-62, 216-B-62 Enclosed Trench, 216-B-62 Crib	Crib	Inactive	CPP	EM-30	200-BP-9	
200-PW-5	216-C-6	216-C-6, 241-CX Crib	Crib	Inactive	CPP	EM-40	200-SO-1	
200-PW-5	216-S-9	216-S-9	Crib	Inactive	CPP	EM-40	200-RO-2	X
200-PW-5	216-S-21	216-S-21, 216-SX-1, 216-SX-1 Cavern or Crib	Crib	Inactive	CPP	EM-40	200-UP-2	
200-PW-5	UPR-200-W-108	UPR-200-W-108, Line leak at 216-S-9 Crib, UN-216-W-18, UN-200-W-108	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-PW-5	UPR-200-W-109	UPR-200-W-109, UN-216-W-19, UN-200-W-109	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-PW-6, Plutonium Process Waste Group								
Lead Regulatory Agency: EPA								
200-PW-6	216-Z-4	216-Z-4, 231-W-3 Pit, 231-W-3 Sump, 231-W-3 Crib, 216-Z-3, 216-Z-4 Crib	Trench	Inactive	CPP	EM-40	200-ZP-2	
200-PW-6	216-Z-5	216-Z-5, 231-W Sumps, 231-W-1 & 2 Crib	Crib	Inactive	CPP	EM-40	200-ZP-2	X
200-PW-6	216-Z-6	216-Z-6, 231-W-4 Crib, 231-Z-6, 216-W-4, 231-W "Trench" Crib, 216-Z-4, 216-Z-6 & 6A Crib	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-6	216-Z-8	216-Z-8, 234-5 Recuplex French Drain, 216-Z-9, 216-Z-8 Crib	French Drain	Inactive	CPP	EM-40	200-ZP-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-PW-6	216-Z-10	216-Z-10, 216-Z-2, 231-W Reverse Well, 231-W-150 Dry Well or Reverse Well	Injection/Reverse Well	Inactive	CPP	EM-40	200-ZP-2	X
200-PW-6	241-Z-8	241-Z-8, 241-Z-TK-8, Silica Slurry Tank, 216-Z-8	Settling Tank	Inactive	CPP	EM-30	200-ZP-2	
200-PW-6	231-W-151	231-W-151, 231-W-151 Vault, 231-W-151-001 (Tank), 231-W-151-002 (Tank), 231-Z Sump	Receiving Vault	Inactive	RPP	EM-30	200-ZP-2	
200-PW-6	UPR-200-W-130	UPR-200-W-130, Line Leak at 231-W-151 Sump, UN-200-W-130	Unplanned Release	Inactive	RPP	EM-30	200-ZP-2	
200-CW-1, Gable Mountain/B-Ponds and Ditches Cooling Water Group								
Lead Regulatory Agency: Ecology								
200-CW-1	200-E PD	200-E PD 200-E Powerhouse Ditch, 200 East Powerhouse Pond	Ditch	Active	RPP	EM-70	200-SO-1	
200-CW-1	207-B	207-B, B Plant Retention Basin, 207-B Retention Basin	Retention Basin	Inactive	RPP	EM-60	200-BP-8	
200-CW-1	216-A-9	216-A-9	Crib	Inactive	RPP	EM-40	200-PO-2	
200-CW-1	216-A-25	216-A-25, Gable Mountain Swamp, 216-A-25 Swamp, Gable Mountain Pond	Pond	Inactive	RPP	EM-40	200-IU-6	X
200-CW-1	216-A-40	216-A-40, 216-A-39 Crib, 216-A-39 Trench, 216-A-40 Ditch, 216-A-39 Ditch	Retention Basin	Inactive	RPP	EM-30	200-PO-2	
200-CW-1	216-A-42	216-A-42, 207-AA Retention Basin, 216-A-42 Trench, 216-A-42 Retention Basin, 207-A Retention Basin	Retention Basin	Active	RPP	EM-60	200-PO-4	
200-CW-1	216-B-2-1	216-B-2-1, 216-B-1, B Swamp Ditch, 216-B-2, B Ditch	Ditch	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	216-B-2-2	216-B-2-2, 216-B-2-2W, 216-B-1 Ditch	Ditch	Inactive	RPP	EM-40	200-BP-11	X
200-CW-1	216-B-2-3	216-B-2-3, B Pond Ditch, B Swamp Ditch, 216-B-2-2E	Ditch	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	216-B-3	216-B-3, B Pond, B-3 Pond, B Swamp, 216-B-3 Swamp, B Plant Swamp	Pond	Active	TSD	EM-40	200-BP-11	X
200-CW-1	216-B-3-1	216-B-3-1, B Swamp Ditch, 216-B-2, 216-B-3 Ditch	Ditch	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	216-B-3-2	216-B-3-2, 216-B Ditch, 216-B-1 Ditch, B Swamp Ditch, 216-B-2-2E	Ditch	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	216-B-3-3	216-B-3-3, B Swamp Ditch, 216-B-3-3 Ditch	Ditch	Active	TSD	EM-40	200-BP-11	X
200-CW-1	216-B-3A RAD	216-B-3A, B Pond Lobe A, B Pond First Expansion Lobe	Pond	Inactive	TSD	EM-30	200-BP-11	X
200-CW-1	216-B-3B RAD	216-B-3B, B Pond Lobe B, B Pond Second Expansion Lobe	Pond	Inactive	TSD	EM-30	200-BP-11	X
200-CW-1	216-B-3C RAD	216-B-3C, B Pond Lobe C, B Pond Third Expansion Lobe	Pond	Inactive	TSD	EM-30	200-BP-11	X
200-CW-1	216-B-59	216-B-59, 216-B-58 Trench, 216-B-58 Ditch, 216-B-59 Retention Basin, 216-B-59B	Trench	Inactive	RPP	EM-60	200-BP-6	
200-CW-1	216-B-59B	216-B-59 Retention Basin	Retention Basin	Inactive	RPP	EM-60	200-BP-6	
200-CW-1	216-C-9	216-C-9, 216-C-7 Swamp, Former 221-C Canyon Excavation, 216-C-9 Swamp, Semi-Works Swamp, 216-C-9 C Canyon Excavation Semiworks Swamp	Pond	Inactive	RPP	EM-40	200-SO-1	
200-CW-1	216-E-28	216-E-28, 216-E-25, 200 East Area Contingency Pond	Pond	Inactive	RPP	EM-30	200-BP-11	
200-CW-1	216-N-8	216-N-8, West Lake, West Pond, 216-N-8 Pond, Honeyhill Pond, Seepage Pond	Pond	Inactive	RPP	EM-40	200-IU-6	
200-CW-1	UPR-200-E-14	UPR-200-E-14, UN-200-E-14, 216-B-3 Pond Dike Break	Unplanned Release	Inactive	RPP	EM-30	200-BP-11	
200-CW-1	UPR-200-E-32	UPR-200-E-32, UN-200-E-32, Coil Leak from 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-8	

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-CW-1	UPR-200-E-34	UPR-200-E-34, Liquid Release to B-Pond and Gable Pond, UN-200-E-34	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	UPR-200-E-51	UPR-200-E-51, Liquid Release from Purex to B-Pond, UN-200-E-51	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	UPR-200-E-94	UN-216-E-22, UN-200-E-94, Vehicle Decon Area	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	UPR-200-E-66	UPR-200-E-66, 216-A-42 Basin Contamination Release, UN-216-E-66, UN-200-E-66	Unplanned Release	Inactive	RPP	EM-60	200-PO-4	
200-CW-1	UPR-200-E-138	UPR-200-E-138, Liquid release from B-Plant, UN-200-E-138, UPR-200-W-66, UN-216-W-66	Unplanned Release	Inactive	RPP	EM-40	200-BP-8	
200-CW-2, S-Pond and Ditches Cooling Water Group								
Lead Regulatory Agency: EPA								
200-CW-2	207-S	207-S, REDOX Retention Basin, 207-S, 207-S Retention Basin	Retention Basin	Inactive	CPP	EM-40	200-RO-2	
200-CW-2	216-S-16D	216-S-16D, 202-S Swamp (New) and Ditch, 202-S Swamp #1, REDOX Pond #2, 216-S-24 Ditch	Ditch	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	216-S-16P	216-S-16P, 202-S Swamp and Ditch, 202-S Swamp #1, REDOX Pond #2	Pond	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	216-S-17	216-S-17, 202-S Swamp, 202-S REDOX Swamp, 216-S-1 REDOX Pond No. 1, REDOX Swamp, 216-S-1	Pond	Inactive	CPP	EM-40	200-RO-1	X
200-CW-2	216-S-172	216-S-172, 216-S-172 Weir Box and Control Structure, 2904-S-172 Weir, 216-S-172 Control Structure	Control Structure	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	2904-S-160	2904-S-160, 2904-S-160 Control Structure, 2904-S-160 Weir	Control Structure	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	2904-S-170	2904-S-170, 2904-S-170 Weir Box, 2904-S-170 Control Structure	Control Structure	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	2904-S-171	2904-S-171, 2904-S-171 Weir Box, 2904-S-171 Control Structure	Control Structure	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	UPR-200-W-13	UPR-200-W-13, Liquid Release from REDOX to 207-S and Swamp, UN-200-W-13	Unplanned Release	Inactive	CPP	EM-40	200-RO-2	
200-CW-2	UPR-200-W-15	UPR-200-W-15, Liquid Release from REDOX to the 207-S and Swamp, UN-200-W-15	Unplanned Release	Inactive	CPP	EM-40	200-RO-2	
200-CW-2	UPR-200-W-47	UPR-200-W-47, 216-S-16P Dike Release, UN-200-W-47	Unplanned Release	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	UPR-200-W-59	UPR-200-W-59, Contaminated Liquid Released to 216-S-16P	Unplanned Release	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	UPR-200-W-95	UPR-200-W-95, UN-216-W-2, 216-S-207 Redox Retention Basin	Unplanned Release	Inactive	CPP	EM-40	200-RO-2	
200-CW-3, 200 North Cooling Water Group								
Lead Regulatory Agency: EPA								
200-CW-3	216-N-1	216-N-1, 212-N Swamp, 216-N-1 Swamp, 216-N-1 Covered Pond	Pond	Inactive	CPP	EM-40	200-NO-1	
200-CW-3	216-N-2	216-N-2, 212-N Storage Basin Crib #1, 212-N #1 Trench, 216-N-1 Trench, 216-N-2 Trench	Trench	Inactive	CPP	EM-40	200-NO-1	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-CW-3	216-N-3	216-N-3, 212-N Storage Basin Crib #2, 212-N #2 Trench, 212-N #2 Grave, 212-N-2 Trench, 212-N-3 Trench	Trench	Inactive	CPP	EM-40	200-NO-1	
200-CW-3	216-N-4	216-N-4, 216-N-2, 216-N-4 Swamp, 212-P Swamp	Pond	Inactive	CPP	EM-40	200-NO-1	X
200-CW-3	216-N-5	216-N-5, 212-P Storage Basin Crib, 212-P Trench, 212-P Grave, 216-N-5 Trench	Trench	Inactive	CPP	EM-40	200-NO-1	
200-CW-3	216-N-6	216-N-6, 212-R Swamp, 216-N-6 Swamp	Pond	Inactive	CPP	EM-40	200-NO-1	
200-CW-3	216-N-7	216-N-7, 212-R Storage Basin Crib, 212-R Trench, 212-R Grave, 216-N-7 Trench	Trench	Inactive	CPP	EM-40	200-NO-1	
200-CW-4, T-Pond and Ditches Cooling Water Group								
Lead Regulatory Agency: EPA								
200-CW-4	207-T	207-T, T Plant Retention Basin, 207-T, 207-T Retention Basin	Retention Basin	Inactive	CPP	EM-30	200-TP-3	
200-CW-4	216-T-1	216-T-1, 221-T Ditch, 221-T Trench, 216-T-1 Trench	Ditch	Inactive	CPP	EM-30	200-TP-4	
200-CW-4	216-T-4-1D	216-T-4-1D, 216-T-4 Ditch, 216-T-4 Swamp	Ditch	Inactive	CPP	EM-40	200-TP-3	
200-CW-4	216-T-4-2	216-T-4-2, 216-T-4-2 Ditch	Ditch	Inactive	CPP	EM-30	200-TP-3	
200-CW-4	216-T-4A	216-T-4A, 216-T-4 Swamp, 216-T-4-1 (P), 216-T-4-1 Pond	Pond	Inactive	CPP	EM-40	200-TP-3	X
200-CW-4	216-T-4B	216-T-4B, 216-T-4 New Pond, 216-T-4-2 (P), 216-T-4-2 Pond	Pond	Inactive	CPP	EM-30	200-TP-3	
200-CW-4	216-T-12	216-T-12, 207-T Sludge Grave, 207-T Sludge Pit, 216-T-11	Trench	Inactive	CPP	EM-30	200-TP-3	
200-CW-5, U-Pond/Z-Ditches Cooling Water Group								
Lead Regulatory Agency: EPA								
200-CW-5	207-U	207-U, 207-U Retention Basin	Retention Basin	Active	CPP	EM-40	200-UP-2	
200-CW-5	216-U-9	216-U-9, U Swamp-S Swamp Ditch, 216-U-6	Ditch	Inactive	CPP	EM-40	200-RO-1	
200-CW-5	216-U-10	216-U-10, 231 Swamp, U Swamp, 216-U-1, 216-U-10 Pond	Pond	Inactive	CPP	EM-40	200-UP-2	X
200-CW-5	216-U-11	216-U-11, U Swamp Extension Ditch, 216-U-12, 216-U-11 Trench, 216-U-11 Ditch, 216-U-11 (old ditch), 216-U-11 (new ditch)	Ditch	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	216-U-14	216-U-14, Laundry Ditch, 216-U-14 Ditch	Ditch	Inactive	CPP	EM-40/EM	200-UP-2	X
200-CW-5	216-Z-1D	216-Z-1D, 216-Z-1, Drain Ditch to U Swamp, Z Plant Ditch	Ditch	Inactive	CPP	EM-40/EM	200-UP-2	
200-CW-5	216-Z-11	216-Z-11, 216-Z-11 Ditch, Z Plant Ditch	Ditch	Inactive	CPP	EM-40	200-UP-2	X
200-CW-5	216-Z-19	216-Z-19, 216-U-10 Ditch, Z Plant Ditch, 216-Z-19 Ditch	Ditch	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	216-Z-20	216-Z-20, Z-19 Ditch Replacement Tile Field	Crib	Inactive	CPP	EM-30	200-UP-2	
200-CW-5	UPR-200-W-18	UPR-200-W-18	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-104	UPR-200-W-104, UN-216-W-14, 216-U-10 Pond Leach Trench	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-105	UPR-200-W-105, UN-216-W-15, 216-U-10 Pond Leach Trench	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-106	UPR-200-W-106, UN-216-W-16, 216-U-10 Pond Leach Trench	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-107	UPR-200-W-107, UN-216-W-17, 216-U-10 Pond Flood Plain, 216-U-10 Pond Leach Trench	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-CW-5	UPR-200-W-111	UPR-200-W-111, Sludge Trench at 207-U, UN-216-W-21	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-112	UPR-200-W-112, Sludge Trench at 207-U, UN-216-W-22	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-139	UPR-200-W-139, Liquid Release to the 216-U-9 Ditch, UN-200-W-139, UPR-200-W-18	Unplanned Release	Inactive	CPP	EM-40	200-RO-1	
200-SC-1, Steam Condensate Group								
Lead Regulatory Agency: EPA								
200-SC-1	207-A-NORTH	207-A-NORTH, 207-A, 207-A Retention Basin, 207-A-NORTH Retention Basin, 207-A North	Retention Basin	Active	CPP	EM-30	200-PO-5	
200-SC-1	207-Z	207-Z, 207-Z Retention Basin, 241-Z Retention Basin, 241-Z-RB	Retention Basin	Inactive	CPP	EM-60	200-ZP-2	
200-SC-1	216-A-6	216-A-6, 216-A-6 Cavern	Crib	Inactive	CPP	EM-40	200-PO-4	X
200-SC-1	216-A-30	216-A-30, 216-A-30 Crib	Crib	Inactive	CPP	EM-30	200-PO-4	
200-SC-1	216-A-37-2	216-A-37-2, 216-A-37-2 Crib	Crib	Inactive	CPP	EM-30	200-PO-4	
200-SC-1	216-B-55	216-B-55, 216-B-55 Enclosed Trench, 216-B-55 Crib	Crib	Inactive	CPP	EM-30	200-BP-9	
200-SC-1	216-B-64	216-B-64, 216-B-64 Retention Basin, 216-B-64 Trench, 216-B-64 Crib	Retention Basin	Inactive	CPP	EM-60	200-BP-9	
200-SC-1	216-S-5	216-S-5, 216-S-5 Cavern #1, 216-S-6 Crib, 216-S-9	Crib	Inactive	CPP	EM-40	200-RO-1	X
200-SC-1	216-S-6	216-S-6, 216-S-6 Cavern #2, 216-S-5 Crib, 216-S-13 Crib	Crib	Inactive	CPP	EM-40	200-RO-1	
200-SC-1	216-S-25	216-S-25, 216-S-25 Crib	Crib	Inactive	CPP	EM-30	200-RO-1	
200-SC-1	216-T-36	216-T-36	Crib	Inactive	CPP	EM-40	200-TP-1	
200-SC-1	UPR-200-E-19	UPR-200-E-19, Contamination Release at 216-A-6 Sampler, UN-200-E-19	Unplanned Release	Inactive	CPP	EM-60	200-PO-2	
200-SC-1	UPR-200-E-21	UPR-200-E-21, 216-A-6 Overflow, UN-200-E-21	Unplanned Release	Inactive	CPP	EM-40	200-PO-4	
200-SC-1	UPR-200-E-29	UPR-200-E-29, 216-A-6 Overflow, UN-200-E-29	Unplanned Release	Inactive	CPP	EM-40	200-PO-4	
200-CS-1, Chemical Sewer Group								
Lead Regulatory Agency: Ecology								
200-CS-1	216-A-29	216-A-29, Snow's Canyon, PUREX Chemical Sewer (CSL)	Ditch	Active	TSD	EM-40	200-BP-11	X
200-CS-1	216-B-63	216-B-63, B Plant Chemical Sewer, 216-B-63 Trench	Ditch	Active	TSD	EM-30	200-BP-11	X
200-CS-1	216-S-10D	216-S-10D, 216-S-10D Ditch, 202 Chemical Sump #1 and Ditch, Chemical Sewer Trench, Open Ditch to the Chemical Sewer Trench, 216-S-10 Ditch	Ditch	Active	TSD	EM-40	200-RO-1	X
200-CS-1	216-S-10P	216-S-10P, 216-S-10P Pond, 202-S Chemical Sump #1 and Ditch, Chemical Sewer Trench	Pond	Active	TSD	EM-40	200-RO-1	X
200-CS-1	216-S-11	216-S-11, 202-S Chemical Sump #2 and Chemical Sewer Trench, 216-S-11 Swamp	Pond	Inactive	RPP	EM-40	200-RO-1	
200-CS-1	216-W-LWC	216-W-LWC, 216-W-LC, Laundry Waste Crib, 216-W-LWC Crib, 216-W-1	Crib	Inactive	RPP	EM-30	200-SS-2	
200-CS-1	UPR-200-W-34	UPR-200-W-34, Overflow at 216-S-10 Ditch, UN-200-W-34	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-LW-1, 300 Area Laboratory Waste Group								
Lead Regulatory Agency: Ecology								
200-LW-1	216-B-53A	216-B-53A, 216-B-53A Trench	Trench	Inactive	RPP	EM-40	200-BP-2	
200-LW-1	216-B-53B	216-B-53B, 216-B-53 Trench, 216-B-53B Trench	Trench	Inactive	RPP	EM-40	200-BP-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-LW-1	216-B-54	216-B-54, 216-B-54 Trench	Trench	Inactive	RPP	EM-40	200-BP-2	
200-LW-1	216-B-58	216-B-58, 216-B-58 Trench, 216-B-59 Crib	Trench	Inactive	RPP	EM-40	200-BP-2	X
200-LW-1	216-T-27	216-T-27, 216-TY-2 Cavern, 216-TY-2 Crib, 216-TX-2 Cavern, 216-TX-2 Crib	Crib	Inactive	RPP	EM-40	200-TP-2	
200-LW-1	216-T-28	216-T-28, 216-TY-3 Cavern, 216-TY-3 Crib, 216-TX-3 Cavern, 216-TX-3 Crib	Crib	Inactive	RPP	EM-40	200-TP-2	X
200-LW-1	216-T-34	216-T-34	Crib	Inactive	RPP	EM-40	200-TP-4	
200-LW-1	216-T-35	216-T-35	Crib	Inactive	RPP	EM-40	200-TP-4	
200-LW-2, 200 Areas Chemical Laboratory Waste Group								
Lead Regulatory Agency: Ecology								
200-LW-2	207-SL	207-SL, 222-S Retention Basin, REDOX Lab Retention Basin, 207-SL Retention Basin	Retention Basin	Active	RPP	EM-30	200-RO-3	
200-LW-2	216-A-15	216-A-15	French Drain	Inactive	RPP	EM-60	200-PO-2	
200-LW-2	216-B-6	216-B-6, 222-B-110 Reverse Well, 216-B-6 Dry Well, 216-B-6 Crib, 222-B-110 Dry Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-BP-6	
200-LW-2	216-B-10A	216-B-10A, 222-B-1 Crib, 216-B-10 Crib, 292-B	Crib	Inactive	RPP	EM-40	200-BP-6	
200-LW-2	216-B-10B	216-B-10B, 222-B-2 Crib, 216-B-10 Crib	Crib	Inactive	RPP	EM-40	200-BP-6	
200-LW-2	216-S-19	216-S-19, 222-S Lab Swamp, 216-SL-1, REDOX Lab Swamp, 216-S-19 Pond	Pond	Inactive	RPP	EM-40	200-RO-1	
200-LW-2	216-S-20	216-S-20, 216-SL-1&2 Crib, 216-SL-2	Crib	Inactive	RPP	EM-40	200-RO-3	X
200-LW-2	216-S-26	216-S-26, 216-S-19 Replacement Facility, 216-S-26 Crib	Crib	Inactive	RPP	EM-30	200-RO-3	
200-LW-2	216-T-2	216-T-2, 222-T-110 Dry Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-TP-4	
200-LW-2	216-T-8	216-T-8, 222-T-1 & 2 Cribs	Crib	Inactive	RPP	EM-40	200-TP-4	
200-LW-2	216-U-4	216-U-4, 222-U Dry Well, 222-U-110 Dry Well, 216-U-2, 216-U-4 Dry Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-UP-2	
200-LW-2	216-U-4A	216-U-4A, 216-U-4 Reverse Well/4a French Drain, 216-U-4 Dry Well	French Drain	Inactive	RPP	EM-40	200-UP-2	
200-LW-2	216-U-4B	216-U-4B, 216-U-4B Dry Well, 216-U-4B French Drain	French Drain	Inactive	RPP	EM-40	200-UP-2	
200-LW-2	216-Z-7	216-Z-7, 231-W Crib, 231-W Trench, 216-Z-6	Crib	Inactive	RPP	EM-40	200-ZP-2	X
200-LW-2	216-Z-16	216-Z-16	Crib	Inactive	RPP	EM-40	200-ZP-2	
200-LW-2	216-Z-17	216-Z-17, 216-Z-17 Ditch	Trench	Inactive	RPP	EM-40	200-ZP-2	
200-LW-2	CTFN 2703-E	CTFN 2703-E, Chemical Tile Field North of 2703-E	Drain/Tile Field	Inactive	RPP	EM-70	200-SS-1	
200-MW-1, Miscellaneous Waste Group								
Lead Regulatory Agency: EPA								
200-MW-1	200-E-4	200-E-4, Critical Mass Laboratory Dry Well North	French Drain	Active	CPP	EM-30	200-SO-1	
200-MW-1	200-W PP	200-W PP, 200-W Powerhouse Pond, 200 West Powerhouse Ponds, 284-W-B	Pond	Inactive	CPP	EM-70	200-UP-2	
200-MW-1	209-E-WS-1	209-E-WS-1, 209-E French Drain	French Drain	Inactive	CPP	EM-30	200-SO-1	
200-MW-1	209-E-WS-2	209-E-WS-2, Critical Mass Lab French Drain	French Drain	Inactive	CPP	EM-30	200-SO-1	
200-MW-1	216-A-4	216-A-4, 216-A-4 Cavern	Crib	Inactive	CPP	EM-60	200-PO-2	X
200-MW-1	216-A-11	216-A-11	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-12	216-A-12	French Drain	Inactive	CPP	EM-60	200-PO-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-MW-1	216-A-13	216-A-13	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-14	216-A-14, French Drain - Vacuum Cleaner Filter Pit	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-21	216-A-21	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-22	216-A-22, 216-A-22 French Drain, 216-A-22 Crib	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-26	216-A-26, 216-A-26 French Drain, 216-A-26B	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-26A	216-A-26A, 216-A-25 Crib, 216-A-26 French Drain, 291-A French Drain	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-27	216-A-27	Crib	Inactive	CPP	EM-40	200-PO-2	
200-MW-1	216-A-32	216-A-32	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-33	216-A-33, 216-A-33 Dry Well, 216-A-26B	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-35	216-A-35 French Drain, 216-A-35 Dry Well	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-38-1	216-A-38-1, 216-A-38	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-41	216-A-41	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-B-4	216-B-4, 216-B-4 French Drain, 216-B-4 Dry Well	Injection/Reverse Well	Inactive	CPP	EM-60	200-BP-6	
200-MW-1	216-B-13	216-B-13, 216-B-13 French Drain, 291-B Crib, 216-B-B, 216-B-13 Crib	French Drain	Inactive	CPP	EM-60	200-BP-6	
200-MW-1	216-B-56	216-B-56	Crib	Inactive	CPP	EM-40	200-BP-6	
200-MW-1	216-B-61	216-B-61	Crib	Inactive	CPP	EM-60	200-BP-1	
200-MW-1	216-C-2	216-C-2, 291-C Dry Well, 216-C-2 Dry Well	Injection/Reverse Well	Inactive	CPP	EM-40	200-SO-1	
200-MW-1	216-S-12	216-S-12, UPR-200-W-30, 291-S Stack Wash Sump, REDOX Stack Flush Trench	Trench	Inactive	CPP	EM-40	200-RO-3	
200-MW-1	216-S-18	216-S-18, 241-SX Steam Cleaning Pit, 216-S-14 Steam Cleaning Pit	Trench	Inactive	CPP	EM-40	200-RO-2	
200-MW-1	216-SX-2	Sanitary Crib	Crib	Inactive	CPP	EM-30	200-RO-4	
200-MW-1	216-T-9	216-T-9, Decontamination Trenches, Equipment Decontamination Area	Trench	Inactive	CPP	EM-40	200-TP-4	
200-MW-1	216-T-10	216-T-10, Decontamination Trenches, Equipment Decontamination Area	Trench	Inactive	CPP	EM-40	200-TP-4	
200-MW-1	216-T-11	216-T-11, Decontamination Trenches, Equipment Decontamination Area	Trench	Inactive	CPP	EM-40	200-TP-4	
200-MW-1	216-T-13	216-T-13, 269-W Regulated Garage, 269-W Decontamination Pit or Trench, 216-T-12, 269-W Regulated Garage Decontamination Pit	Trench	Inactive	CPP	EM-40	200-TP-2	
200-MW-1	216-T-29	216-T-29, 291-T Sand Filter Sewer, 216-T-29 French Drain	French Drain	Inactive	CPP	EM-30	200-TP-4	
200-MW-1	216-T-31	216-T-31	French Drain	Inactive	CPP	EM-30	200-TP-2	
200-MW-1	216-T-33	216-T-33	Crib	Inactive	CPP	EM-40	200-TP-4	X
200-MW-1	216-U-3	216-U-3, 216-U-11, 216-U-3 French Drain	French Drain	Inactive	CPP	EM-40	200-UP-2	X
200-MW-1	216-U-7	216-U-7, 221-U Vessel Vent Blower Pit French Drain	French Drain	Inactive	CPP	EM-40	200-UP-2	
200-MW-1	216-U-13	216-U-13, 216-U-13 Cribs, 216-U-13, 241-UR Steam Cleaning Pit	Trench	Inactive	CPP	EM-40	200-UP-2	
200-MW-1	216-Z-13	216-Z-13, 234-5 Dry Well #1, 216-Z-13 Dry Well	French Drain	Active	CPP	EM-60	200-ZP-2	
200-MW-1	216-Z-14	216-Z-14, 234-5 Dry Well #2, 216-Z-14 Dry Well	French Drain	Active	CPP	EM-60	200-ZP-2	

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-MW-1	216-Z-15	216-Z-15, 234-5 Dry Well #3, 216-Z-15 Dry Well	French Drain	Active	CPP	EM-60	200-ZP-2	
200-MW-1	216-Z-21	216-Z-21, 216-Z-21 Seepage Basin, PFP Cold Waste Pond	Pond	Inactive	CPP	EM-30	200-ZP-2	
200-MW-1	2704-C-WS-1	2704-C-WS-1, 2704-C French Drain, Gatehouse French Drain	French Drain	Inactive	CPP	EM-40	200-SO-1	
200-MW-1	2718-E-WS-1	2718-E-WS-1, 2718 French Drain	French Drain	Inactive	CPP	EM-30	200-SO-1	
200-MW-1	616-WS-1	616-WS-1, 616 NDWSF French Drain	French Drain	Active	RPP	EM-30	200-IU-5	
200-MW-1	299-E24-111	299-E24-111	Injection/Reverse Well	Inactive	CPP	EM-40	200-PO-2	
200-MW-1	UPR-200-E-13	UPR-200-E-13, Overflow from 216-A-4, UN-200-E-13	Unplanned Release	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	UPR-200-E-15	UPR-200-E-15, Overflow at 216-A-4, UN-200-E-15	Unplanned Release	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	UPR-200-E-17	UPR-200-E-17, Overflow at 216-A-22, UN-200-E-17	Unplanned Release	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	UPR-200-W-30	UPR-200-W-30, 216-S-12, UN-200-W-30	Unplanned Release	Inactive	CPP	EM-40	200-RO-3	
200-MW-1	UPR-200-W-138	UPR-200-W-138, 221-U Vessel Vent Blower Pit French Drain, UN-216-W-11, UN-200-W-138, UN-200-W-22,	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-TW-1, Scavenged Waste Group								
Lead Regulatory Agency: EPA								
200-TW-1	200-E-14	200-E-14, 216-BC-201 Siphon Tank, 216-B-201	Storage Tank	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-14	216-B-14, 216-BC-1 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-15	216-B-15, 216-BC-2 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-16	216-B-16, 216-BC-3 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-17	216-B-17, 216-BC-4 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-18	216-B-18, 216-BC-5 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-19	216-B-19, 216-BC-6 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-20	216-B-20, 216-BC-7 Trench, 216-B-20 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-21	216-B-21, 216-BC-8 Trench, 216-B-21 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-22	216-B-22, 216-BC-9 Trench, 216-B-22 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-23	216-B-23, 216-BC-10 Trench, 216-B-23 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-24	216-B-24, 216-BC-11 Trench, 216-B-24 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-25	216-B-25, 216-BC-12 Trench, 216-B-25 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-27	216-B-27, 216-BC-14 Trench, 216-B-27 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-26	216-B-26, 216-BC-13 Trench, 216-B-26 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-28	216-B-28, 216-BC-15 Trench, 216-B-28 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-29	216-B-29, 216-BC-16 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-30	216-B-30, 216-BC-17 Trench, 216-B-30 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-31	216-B-31, 216-BC-18 Trench, 216-B-31 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-32	216-B-32, 216-BC-19 Trench, 216-B-32 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-33	216-B-33, 216-BC-20 Trench, 216-B-33 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-34	216-B-34, 216-BC-21 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-42	216-B-42, 241-BX-8 Grave, 216-BX-8 Trench, 216-B-42 Trench	Trench	Inactive	CPP	EM-40	200-BP-3	
200-TW-1	216-B-43	216-B-43, 216-BY-1 Crib, 216-BY-1 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-44	216-B-44, 216-BY-2 Crib, 216-BY-2 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-45	216-B-45, 216-BY-3 Crib, 216-BY-3 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-TW-1	216-B-46	216-B-46, 216-BY-4 Crib, 216-BY-4 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	X
200-TW-1	216-B-47	216-B-47, 216-BY-5 Crib, 216-BY-5 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-48	216-B-48, 216-BY-6 Crib, 216-BY-6 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-49	216-B-49, 216-BY-7 Crib, 216-BY-7 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-51	216-B-51, 216-BY-9 Crib	French Drain	Inactive	CPP	EM-40	200-BP-4	
200-TW-1	216-B-52	216-B-52, 216-B-52 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-BY-201	216-BY-201, Flush Tank 241-BY, 216-BY-47, Supernatant Disposal Flush Tank	Settling Tank	Inactive	CPP	EM-30	200-BP-1	
200-TW-1	216-T-18	216-T-18, Test Crib for 221-T Building, Scavenged TBP Waste, 216-T-17, 241-T-17 Crib	Crib	Inactive	CPP	EM-40	200-TP-2	
200-TW-1	216-T-26	216-T-26, 216-TY-1 Cavern, 216-TY-1 Crib, 241-TX-1 Cavern, 216-TX-1 Crib	Crib	Inactive	CPP	EM-40	200-TP-2	X
200-TW-1	UPR-200-E-9	UPR-200-E-9, Liquid Overflow at 241-BY-201, UN-200-E-9	Unplanned Release	Inactive	RPP	EM-40	200-BP-1	
200-TW-2, Tank Waste Group								
Lead Regulatory Agency: Ecology								
200-TW-2	216-B-5	216-B-5, 241-B-361 Reverse Well, 241-B-361 Dry Well, 241-B-5 Dry Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-BP-6	X
200-TW-2	216-B-7A&B	216-B-7A&B, 241-B-1 Crib, 216-B-7 Crib, 216-B-7A Sump, 216-B-7B Sump, 241-B-1 and 2 Cribs, 216-B-7A & B	Crib	Inactive	RPP	EM-40	200-BP-4	X
200-TW-2	216-B-8	216-B-8, 241-B-3 Crib, 216-B-8, 216-B-8TF	Crib	Inactive	RPP	EM-40	200-BP-4	
200-TW-2	216-B-9	216-B-9, 241-B-361 Crib, 216-B-361 Crib, 216-B-9TF	Crib	Inactive	RPP	EM-40	200-BP-6	
200-TW-2	216-B-35	216-B-35, 241-BX-1 Grave, 216-BX-1 Trench, 216-B-35 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-36	216-B-36, 241-BX-2 Grave, 216-BX-2 Trench, 216-B-36 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-37	216-B-37, 241-BX-3 Grave, 216-BX-3 Trench, 216-B-37 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-38	216-B-38, 241-BX-4 Grave, 216-BX-4 Trench, 216-B-38 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	X
200-TW-2	216-B-39	216-B-39, 241-BX-5 Grave, 216-BX-5 Trench, 216-B-39 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-40	216-B-40, 241-BX-6 Grave, 241-BX-6 Trench, 216-B-40 Trench, 216-BX-6 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-41	216-B-41, 241-BX-7 Grave, 216-BX-7 Trench, 216-B-41 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-T-3	216-T-3, 241-T-361-A Dry Well or Reverse Well, 361-T Reverse Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-TP-4	
200-TW-2	216-T-5	216-T-5, 216-T-5 Grave, 216-T-12, 216-T-5 Trench, 241-T-5 Trench	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-6	216-T-6, 241-T-361 (1&2 Cribs), 216-T-5, 361-T-1&2 Cribs	Crib	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-7	216-T-7, 216-T-7TF, 216-T-7 Tile Field, 241-T-3 Tile Field	Crib	Inactive	RPP	EM-40	200-TP-1	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-TW-2	216-T-14	216-T-14, 241-T-1 Trench, 216-T-1 Grave, 216-T-13, 216-T-14	Trench	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-15	216-T-15, 241-T-2 Trench, 241-T-2 Grave, 216-T-14, 216-T-15 Crib	Trench	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-16	216-T-16, 241-T-3 Trench, 241-T-3 Grave, 216-T-15, 216-T-16 Crib	Trench	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-17	216-T-17, 241-T-4 Trench, 216-T-4 Grave, 216-T-16	Trench	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-21	216-T-21, 241-TX-1 Trench, 216-TX-1 Grave, 216-TX-3	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-22	216-T-22, 241-TX-2 Trench, 216-TX-2 Grave, 216-TX-4	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-23	216-T-23, 241-TX-3 Trench, 216-TX-3 Grave, 216-TX-5, 241-TX-3 Grave	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-24	216-T-24, 241-TX-4 Trench, 216-TX-4 Grave, 216-TX-6	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-25	216-T-25, 241-TX-5 Trench, 216-TX-5 Grave, 216-TX-7	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-32	216-T-32, 241-T #1 & 2 Cribs, 216-T-6	Crib	Inactive	RPP	EM-30	200-TP-1	
200-TW-2	241-B-361	241-B-361, 241-B-361 Settling Tank	Settling Tank	Inactive	RPP	EM-40	200-BP-6	
200-TW-2	241-T-361	241-T-361, 241-T-361 Settling Tank, 361-T-TANK	Settling Tank	Inactive	RPP	EM-40	200-TP-4	
200-TW-2	UPR-200-E-7	UPR-200-E-7, UN-200-E-7, Cave-In Near 241-B-361 Crib	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1, Tanks/Lines/Pfts/Boxes Group								
Lead Regulatory Agency: Ecology								
200-IS-1	200-W-7	200-W-7, 246-L, 243S-TK-1, 243-S-TK1	Catch Tank	Inactive	RPP	EM-30	200-UP-2	
200-IS-1	200-W-16	200-W-16, 292-T Underground Tanks	Storage Tank	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	216-TY-201	216-TY-201, Supernatant Disposal Flush Tank	Settling Tank	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	224-B	224-B, 224-B Concentration Facility	Process Unit/Plant	Inactive	RPP	EM-40	200-BP-6	
200-IS-1	240-S-151	240-S-151, 240-S-151 Diversion Box	Diversion Box	Active	TSD	EM-30	200-RO-3	X
200-IS-1	240-S-152	240-S-152, 240-S-152 Diversion Box	Diversion Box	Active	TSD	EM-30	200-RO-3	X
200-IS-1	240-S-302	240-S-302, 240-S-302 Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-RO-3	
200-IS-1	241-A-151	241-A-151, 241-A-151 Diversion Box	Diversion Box	Active	RPP	EM-30	200-PO-2	
200-IS-1	241-A-302A	241-A-302A, 241-A-302-A Catch Tank	Catch Tank	Active	RPP	EM-30	200-PO-2	
200-IS-1	241-A-302B	241-A-302B, 241-A-302-B Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-PO-5	
200-IS-1	241-B-154	241-B-154, 241-B-154 Diversion Box	Diversion Box	Active	TSD	EM-30	200-BP-6	X
200-IS-1	241-B-302B	241-B-302B, 241-B-302-B Catch Tank, 241-B-302	Catch Tank	Inactive	RPP	EM-30	200-BP-6	
200-IS-1	241-BX-154	241-BX-154, 241-BX-154 Diversion Box	Diversion Box	Active	TSD	EM-30	200-BP-6	X
200-IS-1	241-BX-155	241-BX-155, 241-BX-155 Diversion Box	Diversion Box	Active	TSD	EM-30	200-BP-6	X
200-IS-1	241-BX-302B	241-BX-302B, 241-BX-302-B Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-BP-6	
200-IS-1	241-BX-302C	241-BX-302C, 241-BX-302-C Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-BP-6	
200-IS-1	241-C-154	241-C-154, 241-C-154 Diversion Box	Diversion Box	Active	TSD	EM-30	200-SO-1	X
200-IS-1	241-CX-70	241-CX-70, 241-CX-TK-70 Tank, Strontium Hot Semi-works	Storage Tank	Active	TSD	EM-40	200-SO-1	X
200-IS-1	241-CX-71	241-CX-71, 241-CX-TK-71, 241-CX Neutralization Tank, Strontium Hot Semi-works	Neutralization Tank	Active	TSD	EM-40	200-SO-1	X
200-IS-1	241-CX-72	241-CX-72, 241-CX-TK-72 Vault and Tank, 241-CX-72 Waste Self Concentrator, Strontium Hot Semi-works	Storage Tank	Active	TSD	EM-40	200-SO-1	X

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-IS-1	241-ER-151	241-ER-151, 241-ER-151 Diversion Box	Diversion Box	Active	RPP	EM-30	200-BP-9	
200-IS-1	241-ER-152	241-ER-152, 241-ER-152 Diversion Box	Diversion Box	Active	RPP	EM-30	200-BP-6	
200-IS-1	241-ER-311	241-ER-311, 241-ER-311 Catch Tank	Catch Tank	Active	RPP	EM-30	200-BP-9	
200-IS-1	241-ER-311A	241-ER-311A, 241-ER-311 Catch Tank, old 241-ER-311	Catch Tank	Inactive	RPP	EM-30	200-BP-9	
200-IS-1	241-SX-302	241-SX-302, 241-SX-302 Catch Tank, SX-304	Catch Tank	Inactive	RPP	EM-30	200-RO-2	
200-IS-1	241-TX-152	241-TX-152, 241-TX-152 Diversion Box	Diversion Box	Active	RPP	EM-30	200-TP-2	
200-IS-1	241-TX-154	241-TX-154, 241-TX-154 Diversion Box	Diversion Box	Active	RPP	EM-30	200-TP-4	
200-IS-1	241-TX-155	241-TX-155, 241-TX-155 Diversion Box	Diversion Box	Active	TSD	EM-30	200-TP-2	X
200-IS-1	241-TX-302B	241-TX-302B, 241-TX-302-B Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	241-TX-302BR	241-TX-302BR, 241-TX-302BR Catch Tank, 241-TXR-302BR	Catch Tank	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	241-TX-302C	241-TX-302C, 241-TX-302-C Catch Tank	Catch Tank	Active	RPP	EM-30	200-TP-4	
200-IS-1	241-U-151	241-U-151, 241-U-151 Diversion Box	Diversion Box	Active	RPP	EM-30	200-UP-2	
200-IS-1	241-U-152	241-U-152, 241-U-152 Diversion Box	Diversion Box	Active	RPP	EM-30	200-UP-2	
200-IS-1	241-UX-154	241-UX-154, 241-UX-154 Diversion Box	Diversion Box	Active	RPP	EM-30	200-UP-2	
200-IS-1	241-UX-302A	241-UX-302A, 241-U-302 Catch Tank, 241-UX-302 Catch Tank, 241-UX-302	Catch Tank	Active	RPP	EM-30	200-UP-2	
200-IS-1	241-WR VAULT	241-WR VAULT, 241-WR Vault (Tanks -001 through -009), 241-WR Diversion Station Vault	Receiving Vault	Inactive	RPP	EM-40	200-UP-2	
200-IS-1	200-W-58	200-W-58, Z-Plant Diversion Box #1	Diversion Box	Inactive	RPP	EM-60	200-ZP-2	
200-IS-1	200-W-59	200-W-59, Z-Plant Diversion Box #2	Diversion Box	Inactive	RPP	EM-60	200-ZP-2	
200-IS-1	241-Z	241-Z, 241-Z Treatment and Storage Tanks, 241-Z Tank Farm, 241-Z Treatment and Storage System, 241-Z-D-4, 241-Z-D-5, 241-Z-D-7, 241-Z-D-8, 241-Z Sump	Neutralization Tank	Active	TSD	EM-60	200-ZP-2	X
200-IS-1	276-S-141	276-S-141, 276-S-TK-141, 276-S-306A, 276-S-141 Solvent Storage Tank, Tank 276-141, Hexone Storage Tank, 244-SX-15	Storage Tank	Active	TSD	EM-40	200-RO-2	X
200-IS-1	276-S-142	276-S-142, 276-S-TK-142, 276-S-306B, 276-S-142 Solvent Storage Tank, Tank 276-142, Hexone Storage Tank, 244-SX-15	Storage Tank	Active	TSD	EM-40	200-RO-2	X
200-IS-1	HSVP	HSVP, Hot Semiworks Valve Pit, 201-C Diversion Box, Semiworks Valve Pit	Valve Pit	Inactive	RPP	EM-40	200-SO-1	
200-IS-1	UPR-200-E-1	UPR-200-E-1, Waste Line Failure on South Side of 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-3	UPR-200-E-3, Line leak from 221-B to 241-BX-154, UN-200-E-3	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-41	UPR-200-E-41, UN-200-E-41 Soil Contamination in the Vicinity of R-13 Stairwell (221-B), UPR-200-E-85	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-44	UPR-200-E-44, UN-200-E-44, Waste Line Leak South of 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-45	UPR-200-E-45, UN-200-E-45	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-77	UPR-200-E-77, UN-216-E-5, 241-B-154 Diversion Box Ground Contamination, UN-200-E-77	Unplanned Release	Inactive	RPP	EM-30	200-BP-6	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-IS-1	UPR-200-E-78	UPR-200-E-78, UN-216-E-6, 241-BX-155 Diversion Box ground contamination, UN-200-E-78	Unplanned Release	Inactive	RPP	EM-30	200-BP-6	
200-IS-1	UPR-200-E-80	UPR-200-E-80, UN-216-E-8, 221-B R-3 Line Break, R-3 Radiation Zone, UN-200-E-80	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-85	UPR-200-E-85, Line Leak at 221-B Stairwell R-13, UN-216-E-13, UPR-200-E-41, UN-200-E-85, UN-200-E-41	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-87	UPR-200-E-87, UN-216-E-15, 224-B South Side Plutonium Ground Contamination, UN-200-E-87, 216-E-15	Unplanned Release	Inactive	RPP	EM-40	200-BP-6	
200-IS-1	UPR-200-E-84	UPR-200-E-84, 241-ER-151 Catch Tank Leak, UN-200-E-84, UN-216-E-12	Unplanned Release	Inactive	RPP	EM-30	200-BP-9	
200-IS-1	UPR-600-20	UPR-600-20, UN-216-E-41, Cross Country Transfer Line	Unplanned Release	Inactive	RPP	EM-30	200-IU-5	
200-IS-1	UPR-200-E-25	UPR-200-E-25, Contamination Spread from the 241-A-151 Diversion Box, UN-200-E-25	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-26	UPR-200-E-26, 241-A-151 Release, UN-200-E-26	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-31	UPR-200-E-31, 241-A-151 Release, UN-200-E-31	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-42	UPR-200-E-42, 241-AX-151 Release, UN-200-E-42	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-65	UPR-200-E-65, UN-216-E-65, 241-A-151 Diversion Box Radioactive Contamination, UN-200-E-65	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-96	UPR-200-E-96, Ground Contamination SE of PUREX, UN-216-E-24, UN-200-E-96	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-IS-1	UPR-200-E-117	UPR-200-E-117, Contaminated Liquid Spill, UN-200-E-117	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-IS-1	UPR-200-E-67	UPR-200-E-67, UN-216-E-67, Radioactively Contaminated Pipe Encasement, UN-200-E-67	Unplanned Release	Inactive	RPP	EM-30	200-PO-5	
200-IS-1	UPR-200-W-32	UPR-200-W-32, UNH Transfer Line Break, UN-200-W-32	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-IS-1	UPR-200-W-33	UPR-200-W-33, Ground Contamination at 224-U, UN-200-W-33	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-IS-1	UPR-200-W-49	UPR-200-W-49, UN-200-W-49	Unplanned Release	Inactive	RPP	EM-30	200-RO-2	
200-IS-1	UPR-200-W-114	UPR-200-W-114, UN-216-W-24, Ground Contamination East of 241-SX Tank Farm, UN-200-W-114	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-IS-1	UPR-200-W-35	UPR-200-W-35, Ground Contamination Near UNH Process Line, UN-200-W-35, REDOX to 224-U UNH Line Leak	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-IS-1	UPR-200-W-5	UPR-200-W-5, Overflow at 241-TX-155, UN-200-W-5	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	UPR-200-W-28	UPR-200-W-28, Release from 241-TX-155, UN-200-W-28	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	UPR-200-W-29	UPR-200-W-29, Transfer Line Leak, UN-200-W-29, UPR-200-W-27, UN-200-W-27, UN-216-W-5, 23rd and Camden Line Break	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-IS-1	UPR-200-W-113	UPR-200-W-113, Soil Contamination East of 241-TX, UN-216-W-23, UN-200-W-113	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-IS-1	UPR-200-W-131	UPR-200-W-131, Release from 241-TX-155	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	UPR-200-W-135	UPR-200-W-135, Release from 241-TX-155, UN-200-2-135	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	UPR-200-W-2	UPR-200-W-2, UN-200-W-2	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-IS-1	UPR-200-W-21	UPR-200-W-21, UN-200-W-21, Ground Contamination at 241-TX-154 Diversion Box	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-27	UPR-200-W-27, Transfer Line Leak, UN-200-W-27	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-IS-1	UPR-200-W-38	UPR-200-W-38, Line Break at 241-TX-302, UPR-200-W-160, UPR-200-W-40, UN-200-W-38, 216-T-30, UN-216-W-36,	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-40	UPR-200-W-40, Line Break at 241-TX-154, UPR-200-W-38, UPR-200-W-160, 216-T-30, UN-200-W-40,	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-98	UPR-200-W-98, UN-216-W-6, 221-T at R-19 Waste Line Break, UPR-200-W-98, UN-200-W-98	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-102	UPR-200-W-102, UN-216-W-12, UN-200-W-102	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-IS-1	UPR-200-W-160	UPR-200-W-160, Line Break at 241-TX-302C, UPR-200-W-38, UPR-200-W-40, 216-T-30	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-115	UPR-200-W-115, UN-216-W-25, Ground contamination Along Cooper Street	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-IS-1	UPR-200-W-161	UPR-200-W-161, UN-216-W-35, UN-200-W-161	Unplanned Release	Inactive	RPP	EM-30	200-UP-2	
200-IS-1	UPR-200-W-164	UPR-200-W-164, Overhead UNH Line Leak, UN-216-W-29	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-IS-1	UPR-200-W-79	UPR-200-W-79, Contamination Spread at 241-Z, UN-200-W-79	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-IS-1	UPR-200-W-6	N-200-W-6	Unplanned Release	Inactive	RPP	EM-30	200-UP-2	
200-IS-1	UPR-200-W-64	Road Contamination, UN-200-W-97	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-IS-1	UPR-200-W-97	Transfer Line Leak, UN-216-W-5, UN-200-W-97	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-UR-1, Unplanned Releases Group								
Lead Regulatory Agency: Ecology								
200-UR-1	UPR-200-E-63	UPR-200-E-63, Radioactively Contaminated Tumbleweeds, UN-216-E-63, UN-200-E-63	Unplanned Release	Inactive	RPP	EM-40	200-BP-2	
200-UR-1	UPR-200-E-89	UPR-200-E-89, UN-216-E-17, UN-200-E-89, Contamination Migration to the North East & West of BX-BY Tank Farms	Unplanned Release	Inactive	RPP	EM-40	200-BP-1	
200-UR-1	UPR-200-E-112	UPR-200-E-112, UN-200-E-112, Contaminated Railroad Track from B-Plant to the Burial Ground	Unplanned Release	Inactive	RPP	EM-60	200-BP-10	
200-UR-1	UPR-200-E-92	UPR-200-E-92, 216-E-20, UN-216-E-20, UN-216-20, Ground Contamination Outside 200 East Fence, UN-200-E-92, UN-216-E-92	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-UR-1	UPR-200-E-93	UPR-200-E-93, UN-216-E-21 Ground contamination along 200 East Area fence	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-UR-1	UPR-600-21	UPR-600-21, Contamination found Northeast of 200 East Area, UN-216-E-31	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-UR-1	UPR-200-E-83	UPR-200-E-83, UN-216-E-11, BC Cribs Controlled Area, UN-200-E-83	Unplanned Release	Inactive	RPP	EM-40	200-BP-2	
200-UR-1	UPR-200-E-144	UPR-200-E-144, Soil Contamination North of 241-B, UN-216-E-44	Unplanned Release	Inactive	RPP	EM-30	200-BP-4	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-UR-1	200-E-26	200-E-26, Heavy Equipment Storage Area, Diesel Fuel Contaminated Soil	Unplanned Release	Inactive	RPP	EM-70	200-BP-6	
200-UR-1	UPR-200-E-2	UPR-200-E-2, UN-200-E-2, Spotty Contamination Around the B and T Plant Stacks	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-52	UPR-200-E-52, UN-200-E-52, Contamination Spread Outside the North Side of 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-54	UPR-200-E-54, UN-200-E-54, Contamination Outside 225-B Doorway	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-55	UPR-200-E-55, UN-200-E-55	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-69	UPR-200-E-69, UN-216-E-69, Railroad Car Flush Water Radioactive Spill, UN-200-E-69	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-90	UPR-200-E-90, UN-216-E-18, Ground Contamination around B Plant Sand Filter, UN-216-E-90, Radioactive Spill Near 221-B Building, UN-200-E-90	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-103	UPR-200-E-103, UN-200-E-103, BCS Line Leak South of R-17 at 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-140	UPR-200-E-140, PCB Oil Spill at 211-B Bulk Storage Area, UN-200-E-140	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-600-12	UPR-600-12, UN-600-12	Unplanned Release	Inactive	RPP	EM-40	200-IU-3	
200-UR-1	UPR-200-N-1	UPR-200-N-1, Unplanned release near 212-R railroad spur	Unplanned Release	Inactive	RPP	EM-70	200-NO-1	
200-UR-1	UPR-200-N-2	UPR-200-N-2, 200-N-2, Unplanned release near Well Pump House No. 2	Unplanned Release	Inactive	RPP	EM-40	200-NO-1	
200-UR-1	UPR-200-E-10	UPR-200-E-10, Contaminated Purex Railroad Spur, UN-200-E-10	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-11	UPR-200-E-11, Railroad Track Contamination Spread, UN-200-E-11	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-12	UPR-200-E-12, Contaminated Purex Railroad Spur, UN-200-E-12	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-20	UPR-200-E-20, Contaminated Purex Railroad Spur, UN-200-E-20	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-22	UPR-200-E-22, 291-A-1 Stack Fallout Area, UN-200-E-22,	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-28	UPR-200-E-28, Contamination Release Inside the PUREX Exclusion Area, UN-200-E-28	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-33	UPR-200-E-33, Contaminated Purex Railroad tracks, UN-200-E-33	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-49	UPR-200-E-49, Roadway Contamination, UN-200-E-49	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-58	UPR-200-E-58, Contaminated Tumbleweeds found on dirt road, UN-200-E-58	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-60	UPR-200-E-60, UN-216-E-60, Radioactively Contaminated Dirt Spill, UN-200-E-60	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	

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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-UR-1	UPR-200-E-88	UPR-200-E-88, TC-4 Spur Contaminated Railroad Track, UN-216-E-88, UN-216-E-16, UN-200-E-88. Ground Contamination Around the Western Purex Railroad Spur	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-97	UPR-200-E-97, PUREX Railroad Tunnel Contamination, UN-216-E-25, UN-200-E-97	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-114	UPR-200-E-114, UN-200-E-114	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-142	UPR-200-E-142, 202-A Diesel Fuel Spill, UN-200-E-142	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-143	UPR-200-E-143, Contamination Adjacent to 244-AR Lift Station, UN-216-E-43	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-UR-1	200-E-8	200-E-8, 200 East Trench 94 Diesel Spill	Unplanned Release	Inactive	RPP	EM-30	200-PO-6	
200-UR-1	UPR-200-E-50	UPR-200-E-50, Soil Contamination at the Overground Equipment Storage Yard, UN-200-E-50	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-UR-1	UPR-200-E-62	UPR-200-E-62, Transportation spill near 200-E Burning Ground, UN-216-E-62, UN-200-E-62,	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-UR-1	UPR-200-W-41	UPR-200-W-41, Railroad Contamination, UN-200-W-41	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-42	UPR-200-W-42, Contamination found at 2706-S, UN-200-W-42	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-51	UPR-200-W-51, UN-200-W-51, UPR-200-W-52	Unplanned Release	Inactive	RPP	EM-30	200-RO-2	
200-UR-1	UPR-200-W-52	UPR-200-W-52, UN-200-W-52, UPR-200-W-51	Unplanned Release	Inactive	RPP	EM-30	200-RO-2	
200-UR-1	UPR-200-W-69	UPR-200-W-69, Railroad Contamination, UN-200-W-69	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-83	UPR-200-W-83, Radioactive Spill Near 204-S Radiation Zone, UN-216-W-82, UN-200-W-83	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-123	UPR-200-W-123, 204-S Unloading Facility Frozen Discharge Line, UN-200-W-123	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-127	UPR-200-W-127, Liquid Release from 242-S Evaporator to the Ground, UN-200-W-127	Unplanned Release	Inactive	RPP	EM-30	200-RO-2	
200-UR-1	UPR-200-W-165	UPR-200-W-165, Contamination Area East of 241-S, UN-216-W-30	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-43	UPR-200-W-43, Contaminated Blacktop East of 233-S, UN-200-W-43	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-56	UPR-200-W-56, Contamination at the REDOX Column Carrier Trench, UN-200-W-56	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-57	UPR-200-W-57, UPR-200-E-120 (misassignment of area), UN-200-W-57	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-61	UPR-200-W-61, REDOX Ground Contamination, UN-200-W-61	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-87	UPR-200-W-87, UN-216-W-87, Radioactive Spill from Filter Housing, UN-200-W-87	Unplanned Release	Inactive	RPP	EM-30	200-RO-3	
200-UR-1	UPR-200-W-96	UPR-200-W-96, UN-216-W-4, 233-S Floor Overflow, 233-SA Floor Overflow	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-116	UPR-200-W-116, UN-216-W-26, Ground Contamination North of 202-S, UN-200-W-116	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-UR-1	UPR-200-E-36	UPR-200-E-36, Road Contamination North of Semiworks, UN-200-E-36	Unplanned Release	Inactive	RPP	EM-40	200-SO-1	
200-UR-1	UPR-200-E-37	UPR-200-E-37, Contamination East of Hot Semi-Works, UN-200-E-37, UN-216-E-37	Unplanned Release	Inactive	RPP	EM-40	200-SO-1	
200-UR-1	UPR-200-E-98	UPR-200-E-98, UN-216-E-26, Ground Contamination East of C Plant, UN-200-E-98	Unplanned Release	Inactive	RPP	EM-40	200-SO-1	
200-UR-1	UPR-200-E-141	UPR-200-E-141, 2718-E Building Uranyl Nitrate Spill to Ground, UN-200-E-141	Unplanned Release	Inactive	RPP	EM-40	200-SO-1	
200-UR-1	UPR-200-W-88	UPR-200-W-88, Radioactive Spill from UNH Trailer, UN-216-W-88, UN-200-W-88	Unplanned Release	Inactive	RPP	EM-40	200-SS-2	
200-UR-1	UPR-200-W-14	UPR-200-W-14, Waste Line Leak at 242-T Evaporator, UN-200-W-14	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-UR-1	UPR-200-W-99	UPR-200-W-99, UN-216-W-7, 153-TX Diversion Box Contamination Spread, UN-200-W-99	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-UR-1	UPR-200-W-167	UPR-200-W-99, UN-216-W-7, 153-TX Diversion Box Contamination Spread, UN-200-W-99	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-UR-1	UPR-200-W-166	UPR-200-W-166, Contamination Migration from 241-T Tank Farm, UN-216-W-31	Unplanned Release	Inactive	RPP	EM-40	200-TP-3	
200-UR-1	200-W-9	200-W-9, W291 Excavation VCP Contamination	Unplanned Release	Active	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-3	UPR-200-W-3, Railroad Contamination, UN-200-W-3	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-UR-1	UPR-200-W-4	UPR-200-W-4, Railroad Contamination, UN-200-W-4	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-UR-1	UPR-200-W-58	UPR-200-W-58, Railroad Track Contamination, UN-200-W-58	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-UR-1	UPR-200-W-65	UPR-200-W-65, Contamination in the T-Plant Railroad Cut, UN-200-W-65	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-67	UPR-200-W-67, Contamination near 2706-T, UN-200-W-67	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-73	UPR-200-W-73, Contaminated Railroad Track at 221-T, UN-200-W-73	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-77	UPR-200-W-77, Contaminated Coyote Feces, UN-200-W-77	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-UR-1	UPR-200-W-85	UPR-200-W-85, Radioactive Spill from Multipurpose Transfer Box, UN-216-W-85, UN-200-W-85	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-39	UPR-200-W-39, UN-200-W-39, 224-U Buried Contamination	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-46	UPR-200-W-46, Contaminated Railroad Track, UN-200-W-46	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-48	UPR-200-W-48, Contaminated Railroad Track near 221-U, UN-200-W-48	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-55	UPR-200-W-55, Uranium Powder Spill at 224-U, UN-200-W-55	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-60	UPR-200-W-60, Railroad Contamination, UN-200-W-60	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-68	UPR-200-W-68, Road Contamination, UN-200-W-68	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-78	UPR-200-W-78, UO3 Powder Spill at 224-U, UN-200-W-78	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-UR-1	UPR-200-W-86	UPR-200-W-86, Contaminated Pigeon Feces at 221-U and 204-S, UN-200-W-86, UN-216-W-86	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-101	UPR-200-W-101, UN-216-W-9, 221-U Acid Spill R-1 through R-5, UN-200-W-101	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-117	UPR-200-W-117, Railroad Track Contamination, UN-216-W-27, UN-200-W-117	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-118	UPR-200-W-118, Contamination at 211-U, UN-216-W-28, UN-200-W-118	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-162	UPR-200-W-162, Contaminated Area on East Side of 221-U, UN-216-W-37	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-23	UPR-200-W-23, Waste Box Fire at 234-5Z, UN-200-W-23	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-74	UPR-200-W-74, Overground Line Leak at 241-Z, UN-200-W-74	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-75	UPR-200-W-75, Contamination Spread at 241-Z, UN-200-W-75	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-89	UPR-200-W-89, Radioactive Contamination Southwest of 236-Z Building, UN-216-W-89, UN-200-W-89	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-90	UPR-200-W-90, Radioactive Contamination South of 236-Z Building, UN-216-N-90, UN-200-W-90	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-91	UPR-200-W-91, Radioactive Contamination near 234-5Z Building, UN-216-W-91, UN-200-W-91	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-159	UPR-200-W-159, Caustic Spill at Plutonium Finishing Plant, UN-200-W-159	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-44	UPR-200-W-44, Railroad Track Contamination, UN-200-W-44	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-UR-1	200-W-56	241-C Waste Line Leak #1	Unplanned Release	Inactive	RPP		200-SO-1	
200-UR-1	200-W-57	241-C Waste Line Leak #2	Unplanned Release	Inactive	RPP		200-SO-1	
200-ST-1, Septic Tank and Drain Fields								
Lead Regulatory Agency: Ecology								
200-ST-1	200-E-5	200-E-5, 2607-E2, 2607-E2 Septic Tank & Tile Field	Septic Tank	Unknown	RPP	EM-70	200-SS-1	
200-ST-1	200-E-6	200-E-6, Septic Tank, Sanitary Sewer Repair and Replacement 2607-E4	Septic Tank	Active	RPP	EM-60	200-BP-6	
200-ST-1	200-E-7	200-E-7, 2607-EO Septic Tank & Tile Field	Septic Tank	Unknown	RPP	EM-70	200-SS-1	
200-ST-1	200-E-9	200-E-9, 2607-EN, 2727-E Septic System, 2607-EN Septic Tank/Pump Station	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	200-E-24	200-E-24, 6607-11, 2704-HV Septic System	Septic Tank	Active	RPP	EM-30	200-BP-9	
200-ST-1	2607-E1	2607-E1	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-E3	2607-E3	Septic Tank	Active	RPP	EM-60	200-BP-6	
200-ST-1	2607-E4	2607-E4	Septic Tank	Inactive	RPP	EM-60	200-BP-6	
200-ST-1	2607-E5	2607-E5	Septic Tank	Active	RPP	EM-30	200-SO-1	
200-ST-1	2607-E6	2607-E6	Septic Tank	Active	RPP	EM-70	200-PO-2	
200-ST-1	2607-E7A	2607-E7A, 2607-E7	Septic Tank	Active	RPP	EM-30	200-SO-1	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-ST-1	2607-E7B	2607-E7B, 2607-E	Septic Tank	Active	RPP	EM-30	200-SS-1	
200-ST-1	2607-E8	2607-E8	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-E9	2607-E9	Septic Tank	Active	RPP	EM-30	200-BP-8	
200-ST-1	2607-E11	2607-E11	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-E12	2607-E12, 2607-E12 Septic System	Septic Tank	Active	RPP	EM-30	200-PO-5	
200-ST-1	2607-EA	2607-EA, 2607-EA Septic Tank and Drywell	Septic Tank	Active	RPP	EM-30	200-PO-2	
200-ST-1	2607-EC	2607-EC	Septic Tank	Active	RPP	EM-30	200-PO-5	
200-ST-1	2607-EE	2607-EE, 2607-EL	Septic Tank	Inactive	RPP	EM-60	200-PO-2	
200-ST-1	2607-EH	2607-EH	Septic Tank	Active	RPP	*	200-SS-1	
200-ST-1	2607-EK	2607-EK	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-EL	2607-EL Septic Tank/Pump Station	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-EM	2607-EM	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-EP	2607-EP	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-EQ	2607-EQ	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-ER	2607-ER	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-FSM	2607-FSM, 609 Building Septic Tank 2607-FSM, 100 Area Fire Station Septic Tank, 1607-FSM, 6607-FSM	Septic Tank	Active	RPP	EM-70	200-IU-2	
200-ST-1	2607-FSN	2607-FSN, 609A Building Septic Tank 2607-FSN	Septic Tank	Inactive	RPP	EM-70	200-IU-5	
200-ST-1	2607-GF	2607-GF	Septic Tank	Active	RPP	*	200-SS-1	
200-ST-1	2607-N	2607-N	Septic Tank	Inactive	RPP	EM-40	200-NO-1	
200-ST-1	2607-P	2607-P	Septic Tank	Inactive	RPP	EM-40	200-NO-1	
200-ST-1	2607-R	2607-R	Septic Tank	Inactive	RPP	EM-40	200-NO-1	
200-ST-1	2607-W1	2607-W1	Septic Tank	Active	RPP	EM-70	200-SS-2	
200-ST-1	2607-W2	2607-W2	Septic Tank	Active	RPP	EM-70	200-SS-2	
200-ST-1	2607-W3	2607-W3	Septic Tank	Active	RPP	EM-30	200-TP-4	
200-ST-1	2607-W4	2607-W4	Septic Tank	Active	RPP	EM-30	200-TP-4	
200-ST-1	2607-W5	2607-W5	Septic Tank	Active	RPP	EM-40	200-UP-2	
200-ST-1	2607-W6	2607-W6	Septic Tank	Active	RPP	EM-30	200-RO-3	
200-ST-1	2607-W7	2607-W7	Septic Tank	Active	RPP	EM-40	200-UP-2	
200-ST-1	2607-W8	2607-W8	Septic Tank	Active	RPP	EM-60	200-ZP-2	
200-ST-1	2607-W9	2607-W9	Septic Tank	Active	RPP	EM-30	200-UP-2	
200-ST-1	2607-WA	2607-WA	Septic Tank	Active	RPP	EM-60	200-ZP-2	
200-ST-1	2607-WC	2607-WC, 2607-WC Septic System	Septic Tank	Active	RPP	EM-30	200-UP-2	
200-ST-1	2607-WL	2607-WL, 2607-WL Septic System	Septic Tank	Active	RPP	EM-30	200-ZP-3	
200-ST-1	2607-WWA	2607-WWA	Septic Tank	Active	RPP	*	200-ZP-3	
200-ST-1	2607-WZ	2607-WZ	Septic Tank	Inactive	RPP	*	200-RO-1	
200-ST-1	2607-Z	2607-Z	Septic Tank	Active	RPP	EM-60	200-ZP-2	
200-ST-1	2607-Z8	2607-Z8	Septic Tank	Active	RPP	EM-60	200-ZP-2	
200-ST-1	600 ESST	600 Area Exploratory Shaft Septic Tank, Septic Tank - Exploratory Shaft	Septic Tank	Inactive	RPP	EM-40	200-IU-1	
200-ST-1	600 NSTFST	600 NSTFST, 600 Area Near Surface Test Facility Septic Tank, Septic Tank, Near Surface Test Facility	Septic Tank	Inactive	RPP	EM-40	200-IU-2	

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-IS-1	600 NSTFUT	600 NSTFUT, 600 Area Near Surface Test Facility Underground Tank, Underground Tank, Near Surface Test Facility	Storage Tank	Inactive	RPP	EM-40	200-IU-2	
200-ST-1	622-R ST	622-R ST, 622-R Septic Tank, 622-R Atmospheric Physics Laboratory Septic Tank	Septic Tank	Active	RPP	EM-30	200-IU-5	
200-ST-1	6607-1	6607-1, H-40 Gun Site Septic Tank	Septic Tank	Inactive	RPP	EM-40	200-IU-3	
200-ST-1	6607-2	6607-2, Gun Site H-42 Septic Tank	Septic Tank	Inactive	RPP	EM-40	200-IU-3	
200-ST-1	6607-3	6607-3, Anti-Aircraft Artillery Site H-51 Septic Tank	Septic Tank	Inactive	RPP	EM-40	200-IU-1	
200-ST-1	6607-5	6607-5	Septic Tank	Active	RPP	EM-30	200-IU-5	
200-ST-1	TFS OF 218-E-4	TFS OF 218-E-4, Tile Field South of 218-E-4	Drain/Tile Field	Active	RPP	EM-60	200-BP-6	
200-SW-1, Non-Radioactive Landfills and Dumps Group								
Lead Regulatory Agency: Ecology								
200-SW-1	200 CP	200 CP, 200 Area Construction Pit, 200 Area Construction Waste Site, Hanford Site Gravel Pit #29	Depression/Pit (nonspecific)	Inactive	RPP	EM-40	200-BP-10	
200-SW-1	200-E BP	200-E BP, 200-E Burning Pit, 200 East Burning Pit	Burn Pit	Inactive	RPP	EM-40	200-PO-6	
200-SW-1	200-E PAP	200-E PAP, 200-E Powerhouse Ash Pit	Coal Ash Pit	Active	RPP	EM-70	200-SS-1	
200-SW-1	200-E-1	200-E-1, 284E Inert Landfill	Dumping Area	Inactive	RPP	EM-70	200-SS-1	
200-SW-1	200-E-2	200-E-2, 2101-M SW Parking Lot, MO-234 parking Lot	Unplanned Release	Inactive	RPP	EM-70	200-SS-1	
200-SW-1	200-E-10	200-E-10, Paint Dump Near Sub Trenches	Dumping Area	Inactive	RPP	EM-40	200-PO-6	
200-SW-1	200-E-12	200-E-12, Sand Piles from RCRA General Inspection #200EFY95 Item #5	Dumping Area	Inactive	RPP	EM-70	200-PO-2	
200-SW-1	200-E-13	200-E-13, Rubble Piles from RCRA General Inspection #200EFY95 Item #7	Dumping Area	Inactive	RPP	EM-70	200-PO-2	
200-SW-1	200-N-3	200-N-3, Ballast Pits	Depression/Pit (nonspecific)	Inactive	RPP	EM-70	200-NO-1	
200-SW-1	200-W ADB	200-W ADB, 200-W Ash Disposal Basin	Coal Ash Pit	Active	RPP	EM-70	200-SS-2	
200-SW-1	200-W BP	200-W BP, 200-W Burning Pit	Burn Pit	Inactive	RPP	EM-40	200-SS-2	
200-SW-1	200-W CSLA	200-W CSLA, 200-W Construction Surface Laydown Area, Non-Rad Burial Ground, Construction Surface Laydown Area	Burial Ground	Inactive	RPP	EM-40	200-UP-2	
200-SW-1	200-W PAP	200-W PAP, 200-W Powerhouse Ash Pit	Coal Ash Pit	Inactive	RPP	EM-70	200-SS-2	
200-SW-1	200-W-1	200-W-1, REDOX Mud Pit West	Mud Pit	Inactive	RPP	EM-40	200-RO-2	
200-SW-1	200-W-2	200-W-2, REDOX Berms West	Spoils Pile/Berm	Inactive	RPP	EM-40	200-RO-2	
200-SW-1	200-W-3	200-W-3, 2713-W North Parking Lot, 220-W-1	Dumping Area	Inactive	RPP	EM-70	200-SS-2	
200-SW-1	200-W-6	200-W-6, 200-W Painter Shop paint solvent disposal area	Dumping Area	Inactive	RPP	EM-70	200-UP-2	
200-SW-1	200-W-10	200-W-10, Item 10 (RCRA General Inspection), Grout Wall Test	Depression/Pit (nonspecific)	Inactive	RPP	EM-30	200-UP-2	
200-SW-1	200-W-11	200-W-11, Concrete Foundation South of 241-S, S-Farm Foundation and Dump Site	Dumping Area	Abandoned	RPP	EM-70	200-RO-1	
200-SW-1	218-E-6	218-E-6, B Stack Shack Burning Pit, Buried Contamination	Burial Ground	Inactive	RPP	EM-40	200-BP-6	
200-SW-1	218-W-6	218-W-6	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-1	600 CL	600 CL, 600 Area Central Landfill, Central Landfill, Central Waste Landfill, CWL, Solid Waste Landfill, SWL	Sanitary Landfill	Inactive	RPP	EM-70	200-IU-3	

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Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-SW-1	600 BPHWSA	600 BPHWSA, 600 Area Batch (Plant HWSA, Hazardous Waste Storage Area (Batch Plant))	Storage Pad (<90 Day)	Active	RPP	EM-70	200-IU-5	
200-SW-1	600-ESHWSA	600 Area Exploratory Shaft Hazardous Waste Storage Area/600 Area Exploratory Shaft HWSA	Storage Pad (<90 Day)	Inactive	RPP	EM-40	200-IU-1	
200-SW-1	600 NRDWL	600 NRDWL, 600 Area Nonradioactive Dangerous Waste Landfill, NRDW Landfill, Nonradioactive Dangerous Waste Landfill (Central Landfill), NRDWL	Sanitary Landfill	Active	TSD	EM-40	200-IU-3	X
200-SW-1	600 OCL	600 OCL, 600 Area Original Central Landfill, Original CLF	Sanitary Landfill	Inactive	RPP	EM-40	200-IU-3	
200-SW-1	600-38	600-38, Railroad Siding "Susie", 600-25, Susie Junction	Dumping Area	Inactive	RPP	EM-70	200-NO-1	
200-SW-1	600-40	600-40, West of West Lake Dumping Area	Dumping Area	Inactive	RPP	EM-70	200-IU-6	X
200-SW-1	600-51	600-51, Chemical Dump	Dumping Area	Inactive	RPP	EM-70	200-NO-1	
200-SW-1	600-70	600-70, SWMU #2 - Miscellaneous Solid Waste	Dumping Area	Inactive	RPP	EM-40	200-RO-3	
200-SW-1	622-1	622-1	Dumping Area	Inactive	RPP	EM-40	200-IU-5	
200-SW-1	628-2	628-2, 100 Area Fire Station Burn Pit	Burn Pit	Inactive	RPP	EM-70	200-IU-2	
200-SW-1	OCSA	OCSA, Old Central Shop Area, Central Shop Area	Foundation	Inactive	RPP	EM-70	200-IU-5	
200-SW-1	Z PLANT BP	Z PLANT BP, Z Plant Burning Pit	Burn Pit	Inactive	RPP	EM-30	200-ZP-3	
200-SW-1	UPR-200-E-106	UPR-200-E-106, Contamination at a Burning Ground, UN-200-E-106	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-SW-1	UPR-200-W-37	UPR-200-W-37, Contaminated Boxes Found at 200 West Burning Ground	Unplanned Release	Inactive	RPP	EM-40	200-SS-2	
200-SW-1	UPR-200-W-70	UPR-200-W-70, Contamination Found at the 200 West Burning Ground	Unplanned Release	Inactive	RPP	EM-40	200-SS-2	
200-SW-2, Radioactive Landfills and Dumps Group								
Lead Regulatory Agency: Ecology								
200-SW-2	200-W-5	Burial Ground/Burning Pit, U-Plant Burning Pit, UPR-200-W-8	Burial Ground	Inactive	RPP	EM-40	200-UP-2	
200-SW-2	218-C-9	218-C-9, Dry Waste No.0C9, 218-C-9 Burial Ground	Burial Ground	Inactive	RPP	EM-40	200-SO-1	
200-SW-2	218-E-1	218-E-1, 200 East Dry Waste No. 001	Burial Ground	Inactive	RPP	EM-40	200-PO-2	
200-SW-2	218-E-2	218-E-2, 200 East Industrial Waste No. 002	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-2A	218-E-2A, Regulated Equipment Storage Site No. 02A, Burial Trench	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-3	218-E-3, Construction Scrap Pit	Burial Ground	Inactive	RPP	EM-40	200-SS-1	
200-SW-2	218-E-4	218-E-4, 200 East Minor Construction No. 4	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-5	218-E-5, 200 East Industrial Waste No. 05	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-5A	218-E-5A, 200 East Industrial Waste No. 005A	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-7	218-E-7, 200 East 222-B Vaults	Burial Ground	Inactive	RPP	EM-40	200-BP-6	
200-SW-2	218-E-8	218-E-8, 200 East Construction Burial Grounds	Burial Ground	Inactive	RPP	EM-40	200-PO-6	
200-SW-2	218-E-9	218-E-9, 200 East Regulated Equipment Storage Site No. 009, Burial Vault (HISS)	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-10	218-E-10, 200 East Industrial Waste No. 10	Burial Ground	Active	TSD	EM-30	200-BP-10	X
200-SW-2	218-E-12A	218-E-12A, 200 East Dry Waste No. 12A	Burial Ground	Inactive	RPP	EM-40	200-PO-6	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-SW-2	218-E-12B	218-E-12B, 200 East Dry Waste No. 12B, 218-E-12B Burial Ground - Trench 94	Burial Ground	Active	TSD	EM-30	200-PO-6	X
200-SW-2	218-W-1	218-W-1, 200-W Area Dry Waste No. 001 Solid Waste Burial Ground	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	X
200-SW-2	218-W-1A	218-W-1A, 200-W Area Industrial Waste Burial Ground #1, Industrial Waste No. 01A, Industrial Waste No. 001	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	218-W-2	218-W-2, 200-W Area Dry Waste No. 002, Dry Waste Burial Ground No. 2	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	218-W-2A	218-W-2A, Industrial Waste No. 002, 218-W-02A Burial Ground, 200-W Area Industrial Waste No. 02A	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	X
200-SW-2	218-W-3	218-W-3, Dry Waste No. 003	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	218-W-3A	218-W-3A, Dry Waste No. 003A	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-3AE	218-W-3AE, Industrial Waste No. 3AE, Dry Waste No. 3AE	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-4A	218-W-4A, Dry Waste No. 04A	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	X
200-SW-2	218-W-4B	218-W-4B, Dry Waste No. 04B	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-4C	218-W-4C, Dry Waste No. 004C	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-5	218-W-5, Dry Waste Burial Ground, Low-Level Radioactive Mixed Waste Burial Grounds	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-7	218-W-7, 222-S Vault	Burial Ground	Inactive	RPP	EM-40	200-RO-3	
200-SW-2	218-W-8	218-W-8, 222-T Vault	Burial Ground	Inactive	RPP	EM-40	200-TP-4	
200-SW-2	218-W-9	218-W-9, Dry Waste Burial Ground No. 9, Non-TRU Dry Waste No. 009	Burial Ground	Inactive	RPP	EM-40	200-RO-2	
200-SW-2	218-W-11	218-W-11, Regulated Storage Site	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	291-C-1	291-C-1, 291-C-1 Stack, 291-C Stack Burial Trench	Burial Ground	Inactive	RPP	EM-40	200-SO-1	
200-SW-2	600-25	600-25, Susie Junction	Dumping Area	Inactive	RPP	EM-70	200-NO-1	
200-SW-2	UPR-200-E-24	UPR-200-E-24, Contamination Plume from the 218-E-12A Burial Ground, UN-200-E-24	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-SW-2	UPR-200-E-30	UPR-200-E-30, Contamination Within 218-E-12A, UN-200-E-30	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-SW-2	UPR-200-E-35	UPR-200-E-35, Buried Contaminated Pipe, UN-218-E-1, 218-E-13	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-SW-2	UPR-200-E-53	UPR-200-E-53, UN-200-E-53, Contamination at 218-E-1	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-SW-2	UPR-200-E-61	UPR-200-E-61, Radioactive Contamination from Railroad Burial Cars, UN-216-E-61, UN-200-E-61	Unplanned Release	Inactive	RPP	EM-30	200-BP-10	
200-SW-2	UPR-200-E-95	UPR-200-E-95, UN-216-E-23, UN-200-E-95, Ground Contamination Around RR Spur Between 218-E-2A and 218-E-2	Unplanned Release	Inactive	RPP	EM-60	200-BP-10	
200-SW-2	UPR-200-W-8	UPR-200-W-8, UN-200-W-8, 200-W-5, Old Burial/Burning Pit, U-Plant Burning Pit/Burial Ground	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-SW-2	UPR-200-W-11	UPR-200-W-11, Burial Ground Fire, UN-200-W-11, UPR-200-W-16	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-16	UPR-200-W-16, Fire at 218-W-4A Burial Ground	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-SW-2	UPR-200-W-26	UPR-200-W-26, Contamination Spread During Burial Operation	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-45	UPR-200-W-45, Burial Box Collapse	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-53	UPR-200-W-53, Burial Box Collapse	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-63	UPR-200-W-63, Road Contamination along the South Shoulder of 23rd Street, UN-200-W-63	Unplanned Release	Inactive	RPP	EM-40	200-TP-3	
200-SW-2	UPR-200-W-72	UPR-200-W-72, Contamination at 218-W-4A	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-84	UPR-200-W-84, Ground Contamination During Burial Operation	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-134	UPR-200-W-134, Improper Drum Burial	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-137	UPR-200-W-137, 218-W-7, UN-200-W-137	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-SW-2	UPR-200-W-158	UPR-200-W-158, Burial Box Collapse	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	

APPENDIX H
PROCESS DESCRIPTIONS AND FLOW DIAGRAMS

H1.0 PROCESS DESCRIPTIONS

This appendix presents a detailed summary of the major process activities in the 200 Areas and at each of the major facilities and supports summary information presented in Section 3.2.2, "Operational History." The text presents a brief description of each process, some of the details of which are shown in the accompanying figures (Figures H-1 to H-8). The text also presents the historical evolution of separations and waste management processes. Figures H-1 through H-8 take a more facility- and area-specific view and depict the important processes at the major plant buildings. These figures summarize the process steps leading to generation of liquid waste streams and the disposal of these streams to waste sites. The order of presentation generally follows that of radiological material moving through the 200 Areas. The figures do not track wastes currently generated and disposed at either the State Approved Land Disposal Site or the 200 Areas Effluent Treatment Facility. Likewise, solid and gaseous wastes are not tracked in this appendix.

This appendix also provides an expanded discussion of the nuclear interactions and processes, described in Section 3.2.1, used to manufacture plutonium. This information is valuable to understanding why many of the major potential radionuclide contaminants are regarded as important and others are not. Similarly, descriptions of the chemicals used in process steps will help to focus future sampling efforts on appropriate analytes at specific waste sites.

Process descriptions are keyed to the buildings where the individual steps took place. In the figures, arrows show the flow of materials and wastes. The raw materials (fuel rods, stored high-level tank wastes, raw water) entering the building are documented under the "Source" heading and are tracked across through the Process Building to the Process description. The Process description depicts, vertically, the general steps used in the specific plant's process and the key chemicals added at those steps. Alternately, the Process column depicts the different process projects used to recover key constituents such as plutonium at the Plutonium Finishing Plan. The Liquid Waste/Product Stream column shows the types of wastes generated by the general process steps or the movement of the process solutions. The Waste Disposal Site column shows the specific soil column disposal site(s) that received the liquid wastes.

Although the complexity inherent in many of these processes is demonstrated in the detail of the figures, the details of the process steps are much greater and have been simplified for presentation. The individual processes are described in the specific technical manuals, referenced in Section 3.0 of this document.

H1.1 OVERVIEW AND EVOLUTION OF THE 200 AREAS PROCESSES

The 200 Areas comprised three of a number of reserved areas throughout the Hanford Site, designated for a group of specific activities. Early in 200 Areas operations, the 200 North Area received irradiated fuel rods for storage in cooling water pools to allow decay of several of the more volatile, short-lived vapor-phase radionuclides. At the 200 East and 200 West Areas, efforts concentrated on extracting plutonium from fuel rods. All major chemical processing operations in the 200 Areas routed high-activity waste streams to massive underground storage tanks contained in multi-tank "farms." The waste management activities associated with these tanks became a major operation in the 200 Areas as well (see Section H1.1.2). All other liquid wastes were discharged (with or without minimal treatment) to the environment. Originally, environmental discharge methods were based primarily on expected activity and stream flow. The historical ordering of discharge site type, described in Appendix G, was injection

(or reverse) wells, trenches, cribs, and ponds, in roughly decreasing activity and increasing overall flow volume.

H1.1.1 Fuel Rod Composition, Enrichment, and Major Potential Radiological Contaminants

Throughout the history of Hanford reactor operations, the primary fuel used was metallic uranium. Initially, the fuel rods were solid "slugs" clad in aluminum. Later designs, primarily at N Reactor, used an annular "ring within ring" design clad in a high-purity zirconium alloy (Zircoalloy). Some uranium oxide-based fuels were tested at the Hanford reactors, but these materials were incompatible with the primary recovery processes run in the 200 Areas. Irradiated thorium-based targets were also processed at the 200 Areas.

The isotope uranium-235 (U-235) was the fissionable fuel used in the Hanford reactors to generate neutrons and energy. The initial fuel rods contained primarily natural, unenriched levels of U-235 (0.72% by weight), while U-238 comprised the bulk (>99% in natural enrichment fuels) of the material present in the fuel rods. As power levels were increased in the reactors, slightly enriched uranium was also used. Data available for the C Reactor show that, over its operating life, 89% of the fuel rods charged were of natural enrichment (Roblyer 1997). Most of the remaining 11% of fuel rods were at 0.947% U-235 enrichment. Limited numbers of special slugs with U-235 enrichment levels of 1.75% to 7.5% were used in all reactors for power "smoothing." The maximum "normal" enrichment used at Hanford (at N Reactor) was 1.25% U-235, which did not comprise more than approximately 20% of a reactor charge. Reactor operations consume (burn) U-235, reducing its enrichment levels in the discharged fuel rods. Approximately 15% to 25% of the U-235 in the fuel as charged was consumed during the fuel rod's residence in the reactor. Overall enrichment levels in fuel processed in the 200 Areas may be assumed to be less than 0.9% U-235, and much was actually less than the 0.72% natural levels.

Radionuclides brought to the 200 Areas within irradiated fuel rods have three primary sources: radioisotopes from the unirradiated fuel elements (primarily the uranium isotopes making up the fuel), fission products, and products of neutron activation.

When uranium is found in nature, it is in equilibrium with nearly 30 radioactive daughter products. Decay of a radioisotope produces a new isotope, either radioactive or stable. The new isotope is the "daughter" of the "parent" from which it descended along an isotope-specific decay "chain." Decay chains for natural uranium isotopes are shown in Figure H-9. In nature, most of these daughters have the same "activity" (number of decays per minute) as the primary parents, U-238 or U-235. Note that, due to its low concentration, U-235 activity is less than 5% of U-238 activity in natural uranium. U-235 and its daughters do not contribute significantly to overall radioactivity of uranium materials until enriched to levels greater than 10%. Chemical separation and purification of uranium prior to fabrication into fuel rod elements effectively removes all daughter isotopes except uranium-234 (U-234). The removed daughters begin to be formed again immediately as (1) uranium decay produces radioactive daughters, and then (2) as those daughters decay to additional products further "down" the decay chain. Most uranium daughters "grow-in" very slowly (due to several long half-life daughters early in the decay chain). Daughter isotopes in the lower portions of the decay chain, those with mass number less than 231 (e.g., radon-226 [Ra-226], polonium-210 [Po-210]), require greater than 1,000 years and often greater than 10,000 years before returning to even 1% of the activity of the parent uranium. Thus, those daughters lower in the decay chain are not considered to be abundant in the 200 Areas.

Fission of U-235 yields a broad spectrum of isotopes, most of which are radioactive. Binary fission, the primary reaction, produces two new isotopes and free neutrons, which can produce further U-235 fission, or be captured by other elements via neutron activation. The favored fission path is asymmetrical, with one isotope at approximately one-third and the other at approximately two-thirds of the initial mass weight of the U-235 atom and, normally, two to three free neutrons. Sr-90 and Cs-137 are typical

examples of this approximate split, although these two isotopes are not formed from the fission of a single U-235 atom. Other isotopes with shorter half-lives are formed as the fission pair. Formation (yield) of lighter or heavier fission product isotopes decreases rapidly from the one thirds and two thirds favored mass maximums. Thus, binary fission product isotopes are essentially limited to those with mass numbers of approximately 72 (e.g., zinc-72 [Zn-72]) through 166 (e.g., europium-166 [Eu-166]).

Most fission products are intensely radioactive. Fission product decay accounts for a significant fraction of the heat generated in an operating reactor. Fortunately, the relationship between isotope-specific activity (rate of decay per amount, usually weight, of isotope) and half-life is inverse (i.e., the highest activity has the shortest half-life). High-activity isotopes rapidly deplete themselves, ultimately forming stable isotopes. After 15 years of decay, more than 99% of the initial fission product activity has been exhausted. The high-activity fission products initially present in irradiated fuel (and of greatest importance during processing) have decayed to insignificance in Hanford material. Due to their half-lives (approximately 30 years) and significant fission yields, Cs-137, Sr-90, and their primary decay daughters now account for over 99% of all remaining nonactinide radioactivity (fission product and activation products) from the fuels materials brought to the 200 Areas.

Two other fission products may be included as potential contaminants because of their half-lives, yields, and potential for concentration or potential for high mobility: tritium (H-3) and technetium-99 (Tc-99). Tritium (typically as tritiated water) behaves chemically as any other water in separation processes. The potential exists for condensates from any contaminated aqueous streams to have H-3 as the primary (or only) radionuclide present. Tc-99 tended to follow the uranium in chemical processes used at the 200 Areas and potentially contributes significantly to the total radioactivity of uranium-rich streams and wastes.

Neutron activation (capture of a neutron by the nucleus of an atom of U-238) to ultimately form plutonium-239 (Pu-239) was the primary purpose and product (on a mass basis) of the Hanford reactors. Neutron activation is the source for all transuranium (elements with atomic number greater than 92 [e.g., uranium, neptunium, plutonium]) elements present in the fuel rods except U-234, U-235, and U-238. Once formed, each new isotope could accept another neutron. Thus, a fraction of the Pu-239 formed was converted to plutonium-240 (Pu-240) and a fraction of the Pu-240 became plutonium-241 (Pu-241). This step-wise addition of neutrons to form higher mass number isotopes was, at the highest Hanford reactor exposures (function of time in the reactor and reactor power level), only approximately 10% efficient for each additional isotope formed. Thus, on a weight basis, 1 g of initial U-238 yielded no more than approximately 0.1 g of Pu-239, which in turn produced no more than approximately 0.01 g of Pu-240, from which formed no more than approximately 0.001 g of Pu-241, etc). Mass numbers produced with at least four neutron additions were of inconsequential yield (less than 0.01%) at the Hanford Site. The primary actinide isotopes of concern from irradiation of U-238 are Pu-239, Pu-240, and Pu-241. Pu-241 is a special case due to its short half-life (14.4 years) and primary mode of decay (beta). Much of the Pu-241 generated at the Hanford Site has already decayed (the youngest irradiated N Reactor fuel is now at least 10 years old) to Am-241, which must be considered as a potential contaminant of concern whenever plutonium is known or expected to be present.

U-235, the primary fuel in the reactor, also was "neutron activated" to form uranium-236 (U-236). Fuel elements manufactured with recycled uranium recovered from reactor operations also contained U-236 as a result of this activation. Neutron addition to U-236, similar to that described for U-238, produced Np-237 and Pu-238. The overall yield of Np-237 was low (due to the relatively small amount of initial U-235) but may be included as a potential contaminant based on process knowledge of specific plant operations. Pu-238 yields at Hanford were even lower, but the significantly greater specific activity (relative to Pu-239) of Pu-238 results in a potential significant contribution to overall plutonium alpha decay activity in Hanford samples. Pu-238 is routinely measured as part of plutonium analyses.

Other contaminants in the fuel rods may have also undergone neutron activation to form a potentially radioactive isotope. The composition of the fuel and cladding materials was controlled to minimize the inclusion of elements having detrimental effects on reactor operations (neutron "poisons"). The vast majority of potential activation products have short to very short half-lives. Decay since discharge from the reactors (10 to 50 years) has reduced the number of isotopes potentially present at levels of potential concern to cobalt-60 (Co-60), nickel-63 (Ni-63), carbon-14 (C-14), and H-3. Tritium may also be present as a fission product. Co-60 has the shortest half-life of these (5.27 years) and is currently approaching its practical detection limits for routine analytical techniques.

Processing of irradiated thorium targets was a "special case" process performed on a very limited scale at the Hanford Site. The primary purpose of irradiation of thorium was to produce uranium-233 (U-233) by neutron activation of natural thorium-232 (Th-232). U-233 is another fissionable isotope of uranium and can be used as the heat source for remote (e.g., outer space) thermoelectric generators. The thorium targets would be expected to have similar levels of nonactinide activation products (similar trace contamination in the thorium metal and similar cladding materials) and essentially no fission products. The thorium processing was performed in specific "campaigns" in the same processes used for uranium/plutonium recovery (primarily REDOX and PUREX). Thorium targets represent a small fraction of these plants' overall production and contributed only a small potential additional source for radionuclides in the 200 Areas. For any streams unique to thorium processing, U-233 and Th-232 would be potential contaminants. During initial processing of the thorium, natural decay daughter products (except thorium-228 [Th-228]) would have been removed, analogous to uranium discussed earlier. However, unlike uranium, Th-232 decay daughters grow in much more quickly. In the 20 years since the last thorium recovery runs took place at the Hanford Site, any Th-232-containing material will have had the full decay chain rebuilt. All daughters are assumed to have returned to equilibrium with the parents within this time frame.

H1.1.2 Primary Processing – Fuel Dissolution and Plutonium Recovery

Three chemical extraction methods were used to recover plutonium in 45+ years of process operations: the bismuth phosphate (BiPO₄) batch process at the 221/224-B and -T Plants, the Reduction Oxidation (REDOX) continuous solvent extraction process at the 202-S Building, and the Plutonium/Uranium Extraction (PUREX) continuous solvent extraction process at the 202-A Plant. All processes were characterized by the initial dissolution of the fuel rod jackets; sodium hydroxide was used for aluminum-clad fuels and ammonium nitrate/ammonium fluoride was used for zirconium-clad fuels. Fuel decladding wastes were processed and routed to underground tank storage. The plutonium-bearing uranium fuel rods were dissolved using concentrated nitric acid. The chemical extraction of plutonium from the fuel rod solution then proceeded on either a batchwise or continuous basis depending on the plant. Multiple steps were usually required to separate plutonium from the associated uranium and fission products.

The two BiPO₄ plants had essentially the same design and operation. They began operating in late 1944 and 1945. Due to uncertainties in process design, each plant was constructed to a general design without exact specifications. The plants were fitted with a number of sections, groups of which contained similar sets of process vessels, centrifuges, receiving tanks, and utility connections suitable to a specific process step. The 221-T Plant was built with several additional sections, termed the head-end, that were used as a hot semiworks laboratory to test small batches of full-strength chemical solutions for use in trouble-shooting steps in the process. This facility had a number of other uses over time, for which documentation is not readily available.

The BiPO_4 process relied on multiple carrier-precipitation steps where BiPO_4 was used as the carrier in the initial steps and lanthanum fluoride was used in the final step to recover and purify plutonium. Three separate high-activity waste streams were produced in the process, plus the decladding waste stream. "Metal" wastes generated from the BiPO_4 process (which contained the bulk of the uranium and fission products) were recognized as the richest "deposit" of uranium known at that time. The first and second decontamination waste streams removed most of the remaining fission products and were normally sent to separate underground storage tanks (first-cycle wastes were frequently co-mingled with decladding wastes). The major drawbacks of the BiPO_4 process were its reliance on a time-consuming, step-wise batch processing with an attendant needed to heat, mix, cool, and mechanically separate solids and liquids and the quantities of high-activity wastes generated. In addition, uranium was discharged as a waste stream.

Emerging organic solvent extraction technologies during the 1940s were implemented for plutonium/uranium recovery. The REDOX process provided significant production improvements over the BiPO_4 process, which allowed the 221/224-B Plant operation to be shut down in 1952. With the advent of the PUREX process and process modifications in the REDOX plant, production rates were great enough that, even with significantly increased demands for weapons materials (Gerber 1997), the separations processes in 221/224-T Plant were concluded in 1956. Both the REDOX and PUREX systems used counter-current flow, solvent extraction columns to bring the organic solvents into intimate and well-mixed contact with the plutonium and uranium-bearing dissolved fuel rod solutions.

The first large-scale solvent extraction separation process was implemented in 1951 at the 202-S REDOX plant where MIBK was used to separate plutonium and uranium from the dissolved fuel rod solutions. The highly flammable nature of hexone placed stringent operating constraints on the process (e.g., inert gas blanketing of process vessels, explosion-proof electrical gear). The process used a multi-column approach to (1) extract the bulk of the fission products from the dissolved fuel rod solution, (2) separate the plutonium from uranium, and (3) refine both from the remaining fission products in two- or three-step decontamination systems. Large quantities of aluminum nitrate were used as a "salting" agent to increase plutonium and uranium extraction efficiencies. Highly radioactive wastes from fuel rod decladding and the first decontamination column were discharged to underground tank storage with minimal volume-reducing concentration steps. Wastes from other columns were collected and concentrated before discharge, and spent hexone solvent was recovered for reuse. Plutonium nitrate solution was concentrated, first in a loadout hood and later at the 233-S facility before being sent to the Plutonium Finishing Plant (PFP) facility. Uranium nitrate solution was sent to the 224-U facility for calcination into uranium oxide (UO_3) and was then shipped offsite. Limited quantities of other radionuclides were also recovered during REDOX processing, which ended in 1967. A waste concentrator was active at REDOX until 1973. It was used to concentrate decontamination waste from 221-T, N Reactor, 222-S Laboratory, and the 340 Facility.

The PUREX process was similar to the REDOX process in that it used solvent extraction technology to separate plutonium and uranium from fission products. The PUREX process featured a number of improvements over the REDOX process. It used a two-part solvent composed of tributyl phosphate (TBP) and a kerosene-like organic termed normal paraffin hydrocarbon (NPH). The TBP was the prime extractant that reacted with plutonium and uranium. The NPH functioned as a diluent, into which the TBP was dissolved to lower the overall solvent viscosity. The higher flashpoint for the TBP-NPH solution resulted in much less stringent operating conditions at PUREX than were required for REDOX. Additional improvements at PUREX included nitric acid reclamation, more effective pulse column (as opposed to Raschig-ring packed designs at REDOX) designs, and a headend treatment process capable of reducing the ruthenium content from the waste gas stream. PUREX also provided for recovery and reuse of the organic solvent. Most recovered plutonium nitrate solution was shipped to the PFP for conversion and refining, but some was calcined to plutonium oxide at PUREX. Uranium nitrate solution was sent to

the 224-U Building for calcining into UO_3 . PUREX operated continuously from 1955 to 1972, and intermittently from 1983 to 1989 when it was shut down.

H1.1.3 Plutonium Purification and Finishing Operations

Initially, the plutonium product of the $BiPO_4$ process was refined to a wet/pasty nitrate mass at 231-Z, prior to shipment offsite. Later, after startup of the Plutonium Finishing Plant (a.k.a., PFP, 234-5Z facility or Z Plant) in 1949, the 231-Z Plant was used only for initial steps in converting $BiPO_4$ -based plutonium to a liquid nitrate form usable by PFP processes that yielded plutonium in a pure metallic form. The 231-Z Plant's production role was phased out when the $BiPO_4$ process at T Plant concluded; the building was cleaned out (Gerber 1997), and converted to perform other waste-generating tasks. Specifically, the building was used for plutonium metallurgical studies, weapons components fabrication and development, and reactor fuel development through the early 1980s. The last significant mission for this facility was to house the Soils and Sedimentation Characterization laboratory, a task completed in the late 1980s.

Z Plant was designed in 1946 to convert plutonium into more stable and safer oxalate, oxide, and metallic forms, and to fabricate plutonium metal shapes for assembly into weapons. The facility was operational by 1949, using a series of gloveboxes and a chemical process that required manual handling. This short-lived system continued operating into 1953, but was replaced in 1952 by the Remote Mechanical A line (RMA) process. A second Remote Mechanical line, RMB, was developed and assembled, but never operated. Additions and modifications to this line proceeded throughout the 1950's as new reactors and separations plants were brought online and continued through the mid-1960's. Modifications to the RMA line in 1959 made it a continuous process that remained active to 1979. Construction of the Remote Mechanical-C Line (RMC) an advanced self-contained, glovebox work space capable of converting plutonium solutions into metal or oxide form, began in 1955. The line became operational in 1960, and last ran in 1989.

Interest in plutonium waste treatment and recovery from metal and compound scraps generated during fabrication of plutonium buttons started at the beginning of PFP operations and became a target of studies at the 234-5 development laboratories. A recovery program design was finalized with the development of the RECUPLEX (RECOVERY of Uranium and Plutonium by Extraction) process, which became operational in 1955 and ceased operation in April 1962, following a criticality incident. Recovery from scrap was next undertaken by the Plutonium Reclamation Facility (PRF), housed in the 236-Z Building, which started in 1964 and was last run in 1987. Both the RECUPLEX and PRF processes were based on solvent extraction using TBP, like the PUREX process, as the active agent. Unlike PUREX, the diluent fluid chosen was carbon tetrachloride, primarily because of its extremely low flammability. The 232-Z incinerator was developed to recover plutonium from the combined treatment of leachable and burnable solid wastes. This facility operated from 1962 to 1973, when it was taken out of service. Another key waste recovery process was conducted at the 242-Z Waste Treatment Facility, which began operation in late 1963. The process utilized ion exchange extraction technology to recover both plutonium and americium-241 from RMA and RMC wastes. The facility was taken out of service in 1976 after a chemical explosion.

H1.1.4 Tank Waste Storage and Processing

In the $BiPO_4$ process, large quantities of uranium and fission products were stored as high-activity wastes in the 200 Area's underground waste storage tanks (tank farms). In the solvent extraction processes, fission product-rich wastes were sent to the respective tank farms. High-level waste production from the REDOX and PUREX processes was less on a per ton basis but typically more concentrated in fission

products, and led to boiling tank waste conditions. The BiPO_4 tank wastes were heated by fission product decay, but did not boil.

Waste storage became an important separations area issue. Each BiPO_4 plant initially had two dedicated tank farms available for waste storage, both of which filled up rapidly. The 221-B Plant was connected to the 241-B and -C farms, while the 221-T Plant utilized the 241-T and U farms. By 1946, tank space limits in some of the three-tank cascades were being approached and less active supernatant liquids were discharged to the ground. This approach was restricted to the least contaminated waste streams and was allowed after precipitated solids were allowed to settle in either the smaller 208,125 L (55,000-gal) 200 Series tanks or in the 100 Series tank farm cascades. This material was discharged to cribs between 1946 and 1950. Even with this discharge, tanks filled up. Two new, nearly identical tank farms, 241-BX and -TX, were constructed and began receiving liquid by January 1948 and July 1949, respectively. Two additional farms, 241-BY and 241-TY, were constructed and became operational by January 1950 and March 1953, respectively.

Due to the recognition that high-activity waste storage problems could not be solved by additional tank farm construction, it was determined that volumetric waste reduction was necessary. A number of solutions were investigated. The 242-T Batch Evaporator at the 241-T Tank Farms began in May 1951, and the 242-B Batch Evaporator began operation in December 1951. Both facilities yielded an ~80% volume reduction in two passes for the B and T tank farm wastes and returned concentrated evaporator wastes to the tanks for cooling and settling. Discharge to the ground also resumed during 1953-1956 when additional treated BiPO_4 wastes were sent to cribs. Waite (1991) estimates that a total of 259 million liters (68,428,000 gal) of liquids were discharged to the soil column from the evaporators.

To resolve the tank waste storage problem, as well as the declining supply of mined uranium, a TBP organic separations program, effectively a forerunner of the PUREX process, was designed and installed in the 200 East and 200 West Areas. The tank wastes of concern were the Metal wastes where the BiPO_4 uranium and fission products were first separated from the plutonium. Although the Uranium Recovery Project (URP) process was centered at the 221-U Plant, a complex of tank waste removal equipment, interconnecting transfer lines, vaults, and diversion boxes within and between the 200 East and 200 West Areas, as well as waste disposal sites, were constructed. (These structures were designated with an R in the letter designator portion of the facility ID, such as the 241-CR Vault.) The project operated from 1952 to 1958 and was effective in recovering uranium.

Although the URP process recovered much of the uranium, it also generated new liquid wastes (requiring underground tank storage) at a 2:1 ratio for each gallon of tank waste processed. Wastes from the URP process were returned to any tank space available. Once this waste problem was recognized, methods of dealing with the declining tank space were sought. Since the 242-B and T evaporators were just becoming active, some space was made available in which to store the URP waste streams. The main approach, however, was the initiation of a ferrocyanide scavenging program at the end of the URP process. In this process, ferrocyanide was added and the fission products in the URP waste streams precipitated from solution in the Tank Farms. The liquid supernatant was sent to the ground via cribs.

Scavenging first occurred in October 1953, but did not become a standard practice until September 1954. It ran until 1957 when the URP was shut down. When the scavenging process was active, the scavenged waste was sent to 200 East Tank Farms for holding. The supernatant liquid was discharged to cribs and trenches, primarily north of the BY-Tank Farms and south of the 200 East Area in the 216-BC Cribs area. Samples were taken and analyzed before release to ensure the supernatant met the 1950's release limits. Some scavenged wastes were discharged to 200 West Area cribs as well.

Wastes discharged to the BY Cribs were found in the groundwater beneath the cribs shortly after discharge. (At present, a hot spot of Co-60, Tc-99, nitrate, and cyanide contamination centered at the 699-50-53A well is attributed to these wastes and was the target of one pump-and-treat test conducted at the 200-BP-5 Operable Unit in 1995 [DOE-RL 1996]). After some study, a release approach using the concept of specific waste retention was developed. Using specific waste retention, discharging a volume of liquid waste that was some small fraction of the total soil column pore volume was thought to slow, or prevent, the radionuclides from reaching the groundwater and, ultimately, the Columbia River.

By the time URP scavenging became routine, over 80.3 million liters (21.2 million gallons) of unscavenged waste had been returned to the 200 East and 200 West Area tank farms. The URP wastes held from pre-scavenging runs were treated between 1955 and 1957 at the 241-CR Vault, in what was termed the in-tank scavenging process. The URP material was pumped from the tank cascades, treated with ferrocyanide, and returned to available tank cascades for settling of precipitates. Once release criteria were met, the supernatant was discharged to the soil column, typically at the 216-BC cribs located south of the 200 East Area. Waste disposal at the BC crib and trench disposal structures followed, in part, the guidelines established for specific retention disposal.

High efficiencies were achieved in plutonium and uranium extraction by the PUREX and REDOX processes. Significant concentration of fission products in the high-level tank farm wastes was also realized and led to the investigation of allowing the wastes to boil (self-concentrate). The vapor condensate driven off was then discharged to the ground via cribs or returned to the tanks as makeup liquid, if needed. The technique was first used in the 241-SX farm tanks and was later applied at the 241-A, AX, AY, and AZ tanks. Not all tanks in the 241-A or SX farms became self-concentrating due to the more dilute startup nature of some wastes received. Many of the tanks required the addition of water to control the in-tank heating by maintaining a source of evaporative cooling. Boiling wastes in the 241-S and -SX Tank Farms resulted in the breaching of several tank bottoms in these farms and in the direct discharge of high-level waste materials to the soil underneath these tanks.

Two continuous evaporators were constructed in the 1970's to assist in reducing the liquid content of the 241-S series and 241-A series tank farms. The 242-S Evaporator began operating in 1973, and the 242-A Evaporator began operating in 1977. The 242-S Evaporator was taken out of service in 1979. Part of the 242-S Evaporator was used in 1986-87 to treat uranium-contaminated groundwater extracted from beneath the U-1/U-2 cribs, using ion exchange technology (Delegard et al. 1987). The 242-A Evaporator was taken out of service for several years in 1989 when halogenated solvents and ammonia-rich constituents were found in the process condensate. Prior to this, all evaporator condensates had been discharged to the ground at dedicated cribs. Extensive modifications followed and, when active, the 242-A process condensate is now sent to the Effluent Treatment Facility.

H1.1.5 Other 200 Areas Processes

New waste-generating missions were frequently developed for facilities whose previous mission was no longer required. The process of cleaning out a plant for equipment maintenance, removal, or facility overhaul yielded an additional set of waste streams. Each plant was subject to a major cleanout campaign to remove residual contaminants from vessels, pipes, and tanks at the end of a process' life. Strongly acidic solutions were used to attack and remove precipitates, heels, or sludges from the insides of the process system. Such solutions were usually processed to recover the plutonium (or other target analyte) and were then neutralized before being sent to the tank farms. Acid rinses were repeated as necessary and usually continued until the recovered solution showed little increase in target analyte content. A considerable variety of chemicals (e.g., boric acid, sodium dichromate, and ammonium compounds) were usually paired with sodium hydroxide to decontaminate the vessels, tanks, and piping. Water rinses usually followed these steps and concluded the internal decontamination. Most of the waste was

discharged to the ground but usually represented a fairly small volume of liquid compared to that received over the life of the waste site.

Large quantities of solid waste were generated from the cleanout of major separations plants, particularly when a new process was being installed. Old vessels were usually too radiologically contaminated to be safely reconfigured for the incoming process, or were not of an acceptable design and needed to be replaced. In such cases, following decontamination, the equipment and piping would be packaged and transported to the burial grounds for disposal where it would join previously failed equipment, contaminated clothing, laboratory equipment, reactor wastes, and contaminated equipment and materials from offsite.

Within several years of cessation of the BiPO_4 process, the 221-T Plant was converted to a decontamination facility capable of handling both small and large items and equipment. The 221-U Plant was briefly used for decontamination. Decontamination permitted reuse of items, allowed less complex (i.e., direct) handling of contaminated equipment for burial, or allowed release and sale of clean material as scrap/salvage. Two separate decontamination lines were maintained, one for small equipment and one for larger items. The chemical constituents used for decontamination varied with time and experience. Strong acid washes followed by washes of caustic (sodium hydroxide) combined with sodium phosphate, sodium citrate, boric acid, versene, tartrate, and sodium dichromate were often followed by sand- and steam-blasting, high-pressure water spraying, and scrubbing with detergents (Gerber 1994). These were replaced by 1,1,1-trichloroethane or perchloroethene and chloride-based detergents. By the mid-1960s, commercial products based on oxalic acid-, phosphates-, potassium permanganate-, sodium bisulfate-, or nitric acid-ferrous ammonium sulfate-based compounds were used. Extremely contaminated solutions were routed to tank storage; low-level solutions were discharged to the ground via cribs. When internal decontamination was complete, external decontamination was then undertaken, whether the equipment was to be reused or removed for disposal to a burial ground.

Throughout the years of operation, the head-end section of T Plant was intermittently used and generated some volume of liquid wastes. Initial hot semiworks scale-up testing of the BiPO_4 process were conducted from 1944 to 1947. No further use of the facility appears to have occurred before 1964, when the facility was modified to test the explosive degradation of irradiated fuel elements. Thereafter, PNNL occupied the T Plant head-end for unspecified experimental work. Based on data presented in the T Plant AAMS report (DOE-RL 1992) a series of tests related to liquid metal reactor safety were conducted in either this facility or in the main part of T Plant between 1976 and 1985. Light-water reactor tests using nonradioactive materials were conducted from 1985 to 1990. PNNL's activities apparently terminated in 1990 with several light-water reactor experiments using nonradioactive materials and a plasma torch.

Fission product recovery from tank farm-stored wastes was undertaken at the refurbished B Plant. This began in 1963 with the start of a three-part waste fractionization program that concluded in the Waste Encapsulation and Storage Facility (WESF). Following decontamination of the 221-B facility, a number of the process cells were refitted with new process vessels. The process redissolved tank farm wastes, then separated and concentrated specific radionuclides from wastes primarily derived from PUREX and REDOX. The program developed and installed a multi-process approach for recovering cesium, strontium, technetium, cerium, promethium, rhodium, palladium, americium, neptunium, and antimony (to name a few) from a wide variety of high-level tank waste streams. Ion exchange column technology was applied to the recovery of cesium and technetium (as well as rhodium and palladium) from alkaline supernatant tank wastes. This process also used extensive quantities of complexants (primarily ethylene diamine- tri- and tetra-acetic acids - HEDTA and EDTA) to minimize coabsorption of metals on the ion exchange columns. Ammonium carbonate was used to elute and regenerate the ion exchange column. A sulfate-based precipitation process was used for separation of strontium, promethium, and rare earth elements and radionuclides. Solvent extraction technology based on the solvent mix of TBP and

Di-(2ethylhexyl) phosphoric acid (D2EHPA), again diluted with NPH, was applied to cesium, strontium, cerium, and promethium, recovery from specific waste PUREX streams and selected tank wastes. The main target radionuclides were strontium, cesium (primarily to reduce the heat generation in the tank farms but also, potentially, as a source for these radionuclides), and limited rare earth radionuclides, which were proposed for use for satellite and remote-location power applications (Richardson 1962). The 244-AR vault, located near the PUREX tank farms, was constructed to accumulate, sample, and blend B Plant bound wastes from the PUREX tank farms. Additionally, several lift stations and diversion boxes were added to provide routings to and from the tank farms to the 244-AR vault and B Plant.

The WESF was added to the 221-B Building and began operation in 1974. At WESF the solutions produced by the Waste Fractionization Program were used and the cesium carbonate and strontium nitrate liquids were converted into dry cesium chloride and strontium fluoride salts. The salts were then doubly sealed in welded capsules, which were externally decontaminated prior to storage in cooling pools. Waste fractionization activities continued into 1983, and the WESF chemical processes were stopped shortly thereafter. Capsule storage and cooling continues to the present.

In 1944, a laundry was established in the 200 West Area to clean all work clothing from the Hanford Site. "Hot" and "cold" areas of the laundry were used to segregate the radiologically contaminated (hot) and nonradiologically contaminated (cold) clothing. The laundry, which was enlarged during its years of operation, was closed in 1995 due to the costs to upgrade the aging facility and problems caused by the liquid discharge crib, which was plugged with lint. At this time, an offsite contractor took over the laundry task. In addition, the use of disposable clothing was implemented. Respirator cleaning, which previously was done at a facility near the laundry, was also turned over to the offsite contractor. Liquid wastes from the laundry were characterized by the presence of detergents, noted by Knoll (1957) to potentially increase the movement of radionuclides through the soil column.

A number of laboratories operated in the 200 Areas over the years in support of plant and facility operation. The 221-B, -U, and -T canyon facilities each had a 222 Laboratory that generated several small waste streams. These laboratories were used for process chemistry control, and analyses were primarily directed to determining the plutonium (uranium for 221-U) content during BiPO_4 processing. Similarly, analytical laboratories were included to support operation of the PFP plant, the 202-S REDOX plant, and the 202-A PUREX plant where other analytes of concern (uranium, americium, fission products, etc.) were also considered. The PFP, PUREX, and REDOX laboratories all generated much larger waste volumes than the B, T, and U laboratory, but still much smaller than the associated production facility. The diversity of the potential contaminants used in the laboratories is much greater than for the production facilities. The 222-S Laboratory was designed for more broad-based support activities to the 200 Areas and includes a number of hot cells capable of accepting high-activity samples such as tank wastes and the concentrated fission products recovered during B Plant's fission product recovery. The 222-S also performs routine monitoring analyses on near-environmental level media (soils, water, and air) samples.

The laboratories typically closed at the end of a separation mission for a plant. The 222-B, -T, and -U laboratories were closed in 1952, 1956, and 1970, respectively. The PUREX laboratory was closed in 1996. The PFP and 222-S laboratories remain operational. The 222-S facility is expected to continue operations into the future, although some environmental analytical work may be transferred to the Waste Sampling and Characterization Facility.

Major plant developments, initiated in the 1940s and 1950s, were conducted at the 201-C Hot Semiworks facility in the 200 East Area. This facility and its support buildings were used for pilot-scale tests using irradiated fuel rods or actual tank waste material for the REDOX, PUREX, and URP processes discussed above. Refinements to the BiPO_4 process were also tested here. The facility provided space and

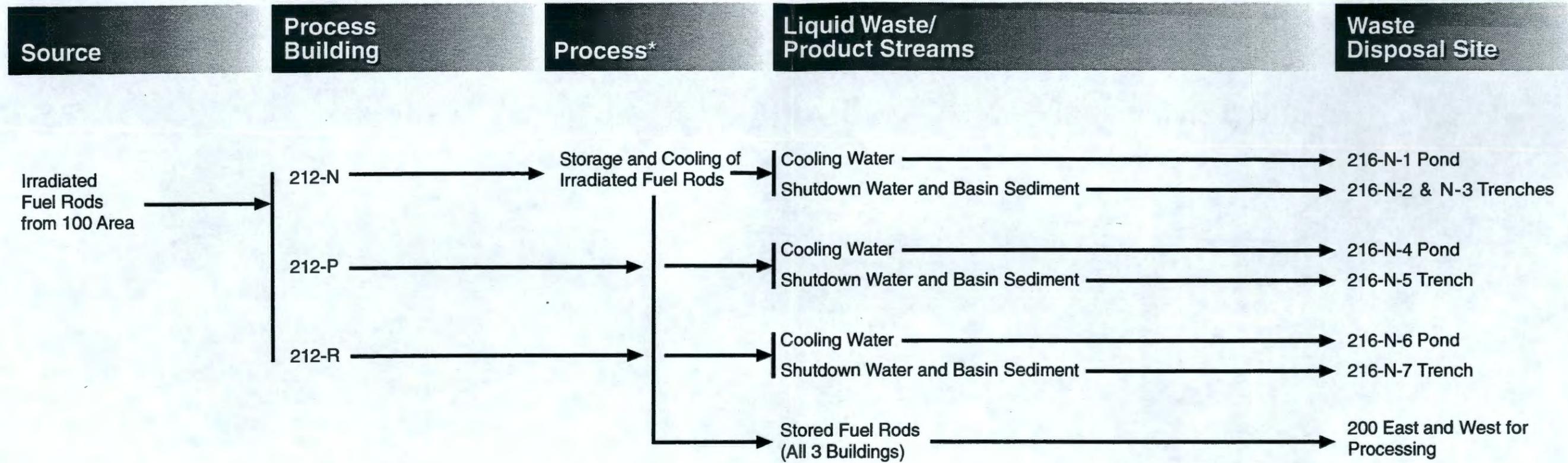
equipment sufficient to decontaminate and dissolve fuel rods, operate and test solvent extraction columns or process vessels, store chemicals, sample the process solutions, and handle waste storage and disposal. The Semiworks area was connected to the 241-C Tank Farm for ready disposal of high-level wastes. Follow-on activities at Semiworks included a strontium recovery project; a cerium-promethium recovery run; and a combined americium, curium, and promethium recovery run that concluded Semiworks operations in 1967. Other activities in the Hot Semiworks area focused on criticality testing in the 209-E Building from 1961 to 1983. The 201-C area underwent D&D in the early 1990s.

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- Waite, J. L., 1991, *Tank Wastes Discharged Directly to the Soil at the Hanford Site*, WHC-MA-0277, Westinghouse Hanford Company, Richland, Washington.

200 North Storage Building Major Waste Processes

Figure H-1. 200 North Storage Building Major Waste Processes.



* Storage was for purpose of decaying off short half-life radionuclides primarily Iodine, 40-60 day period

Figure H-2. T-Plant Aggregate Area. (2 Pages)

T-Plant Aggregate Area

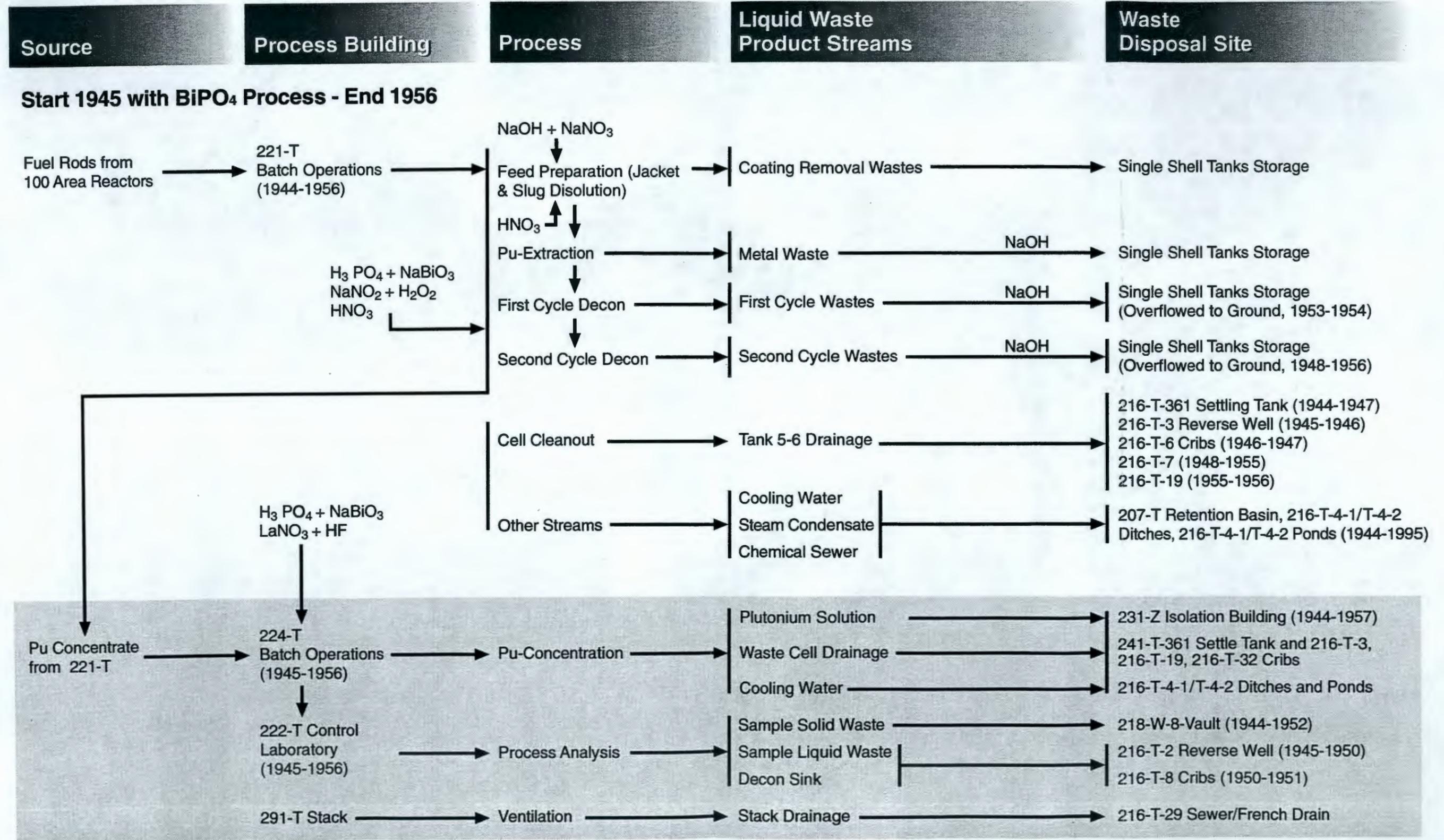


Figure H-2. T-Plant Aggregate Area. (2 Pages)

T-Plant Aggregate Area

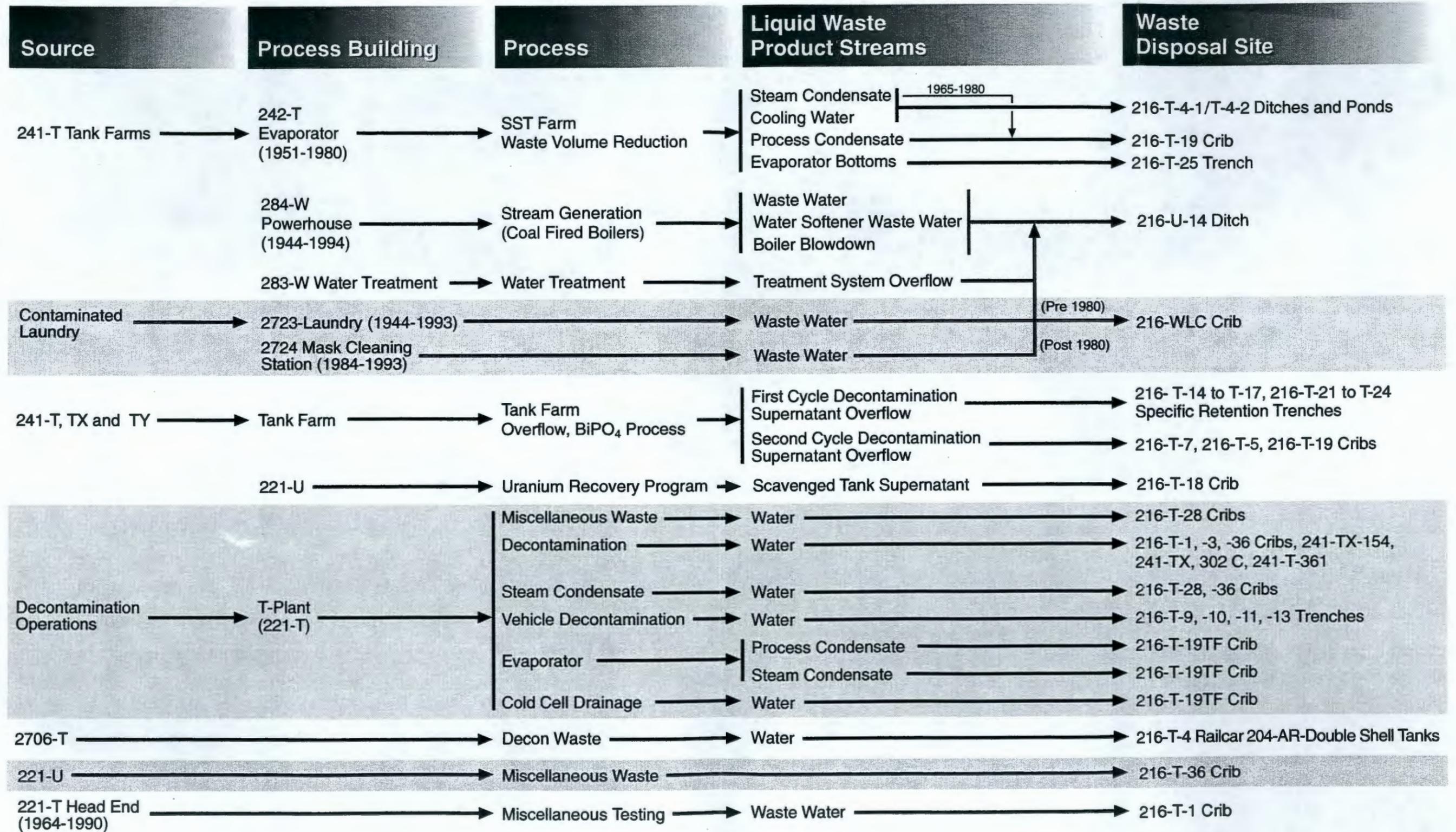


Figure H-3. B-Plant Aggregate Area. (3 Pages)

B-Plant Aggregate Area

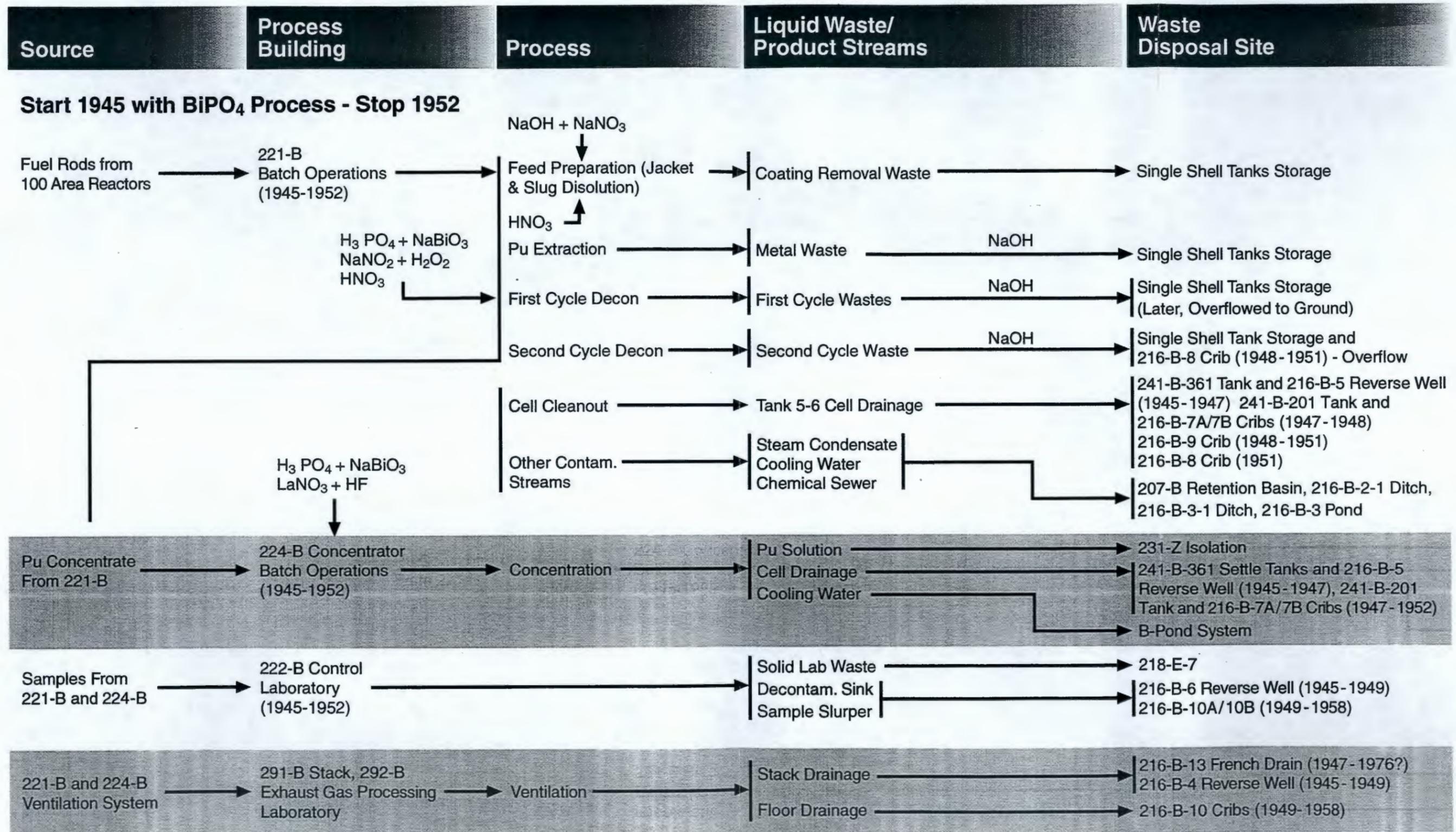


Figure H-3. B-Plant Aggregate Area. (3 Pages)

B-Plant Aggregate Area

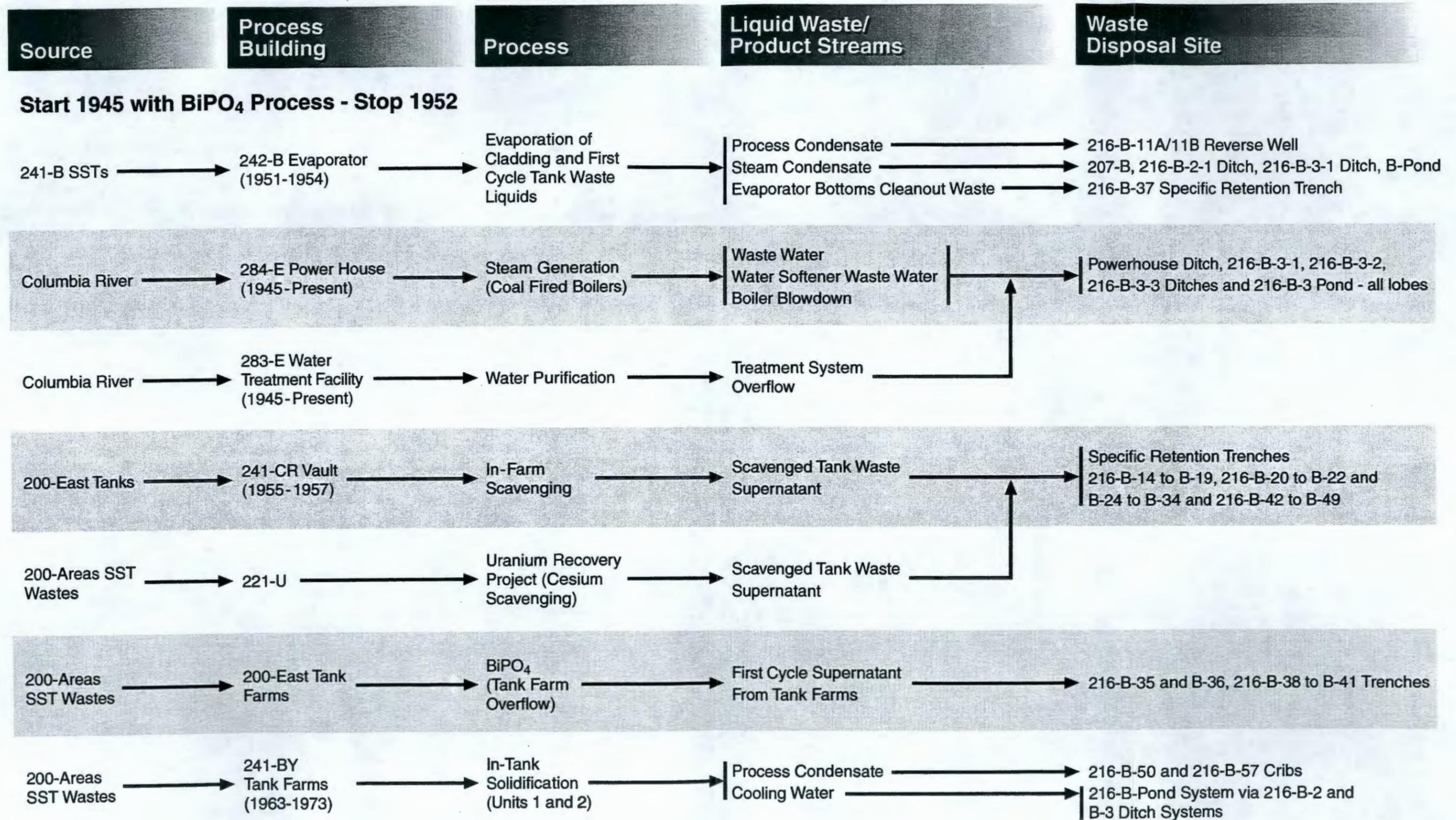


Figure H-3. B-Plant Aggregate Area. (3 Pages)

B-Plant Aggregate Area

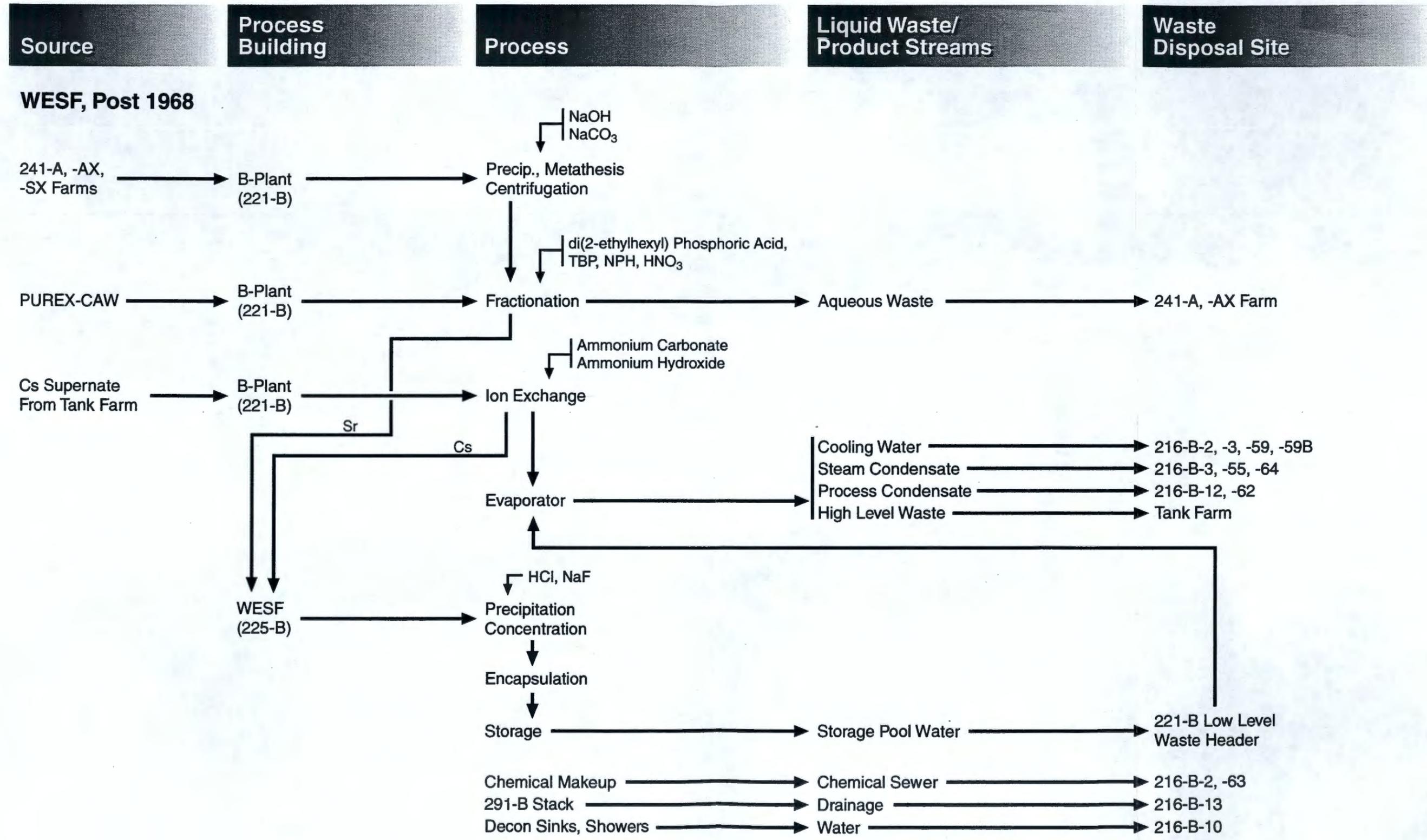
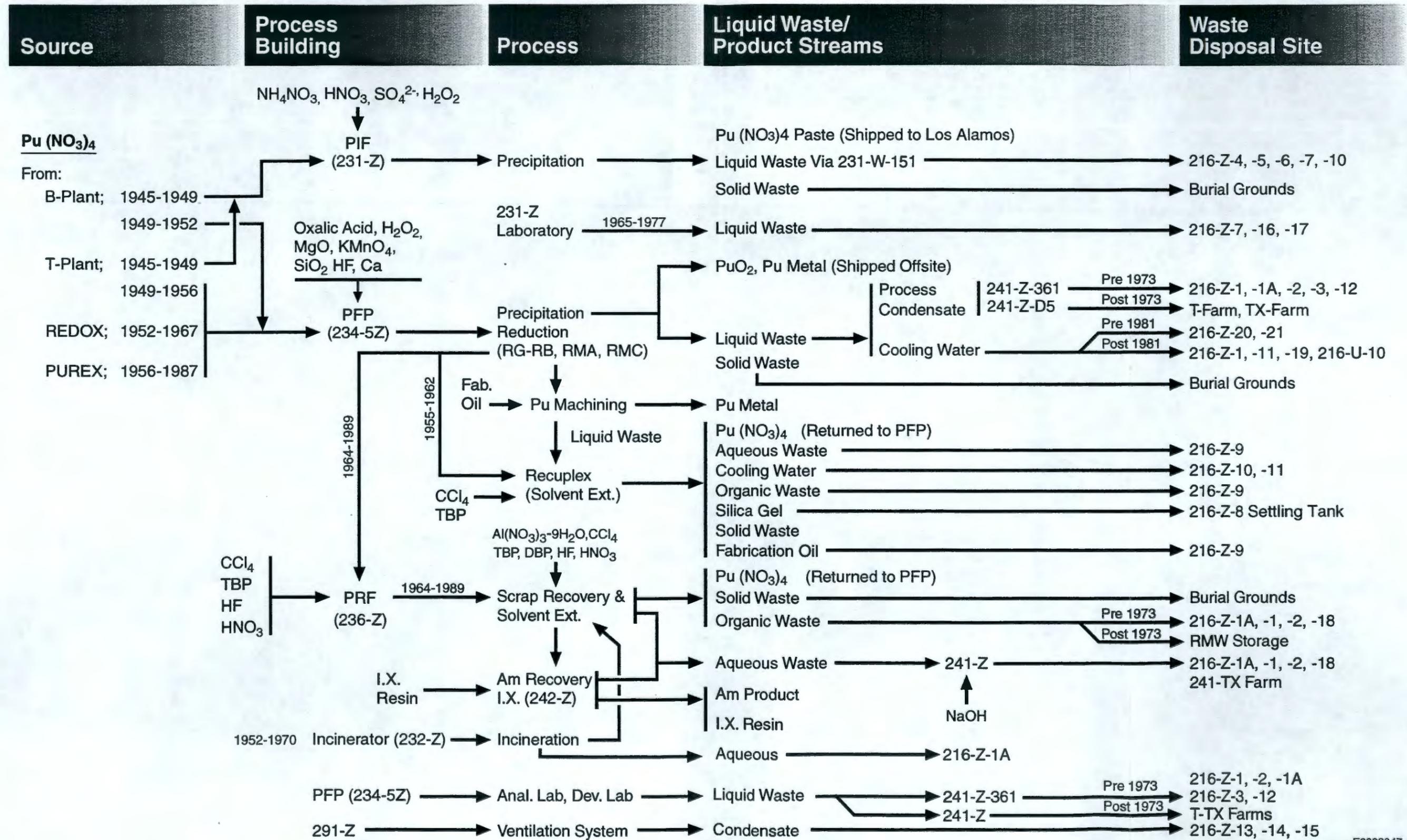


Figure H-4. Z-Plant Aggregate Area Major Processes.

Z-Plant Aggregate Area Major Processes



E9803047 .4

Figure H-5. Semi-Works.

Semi-Works

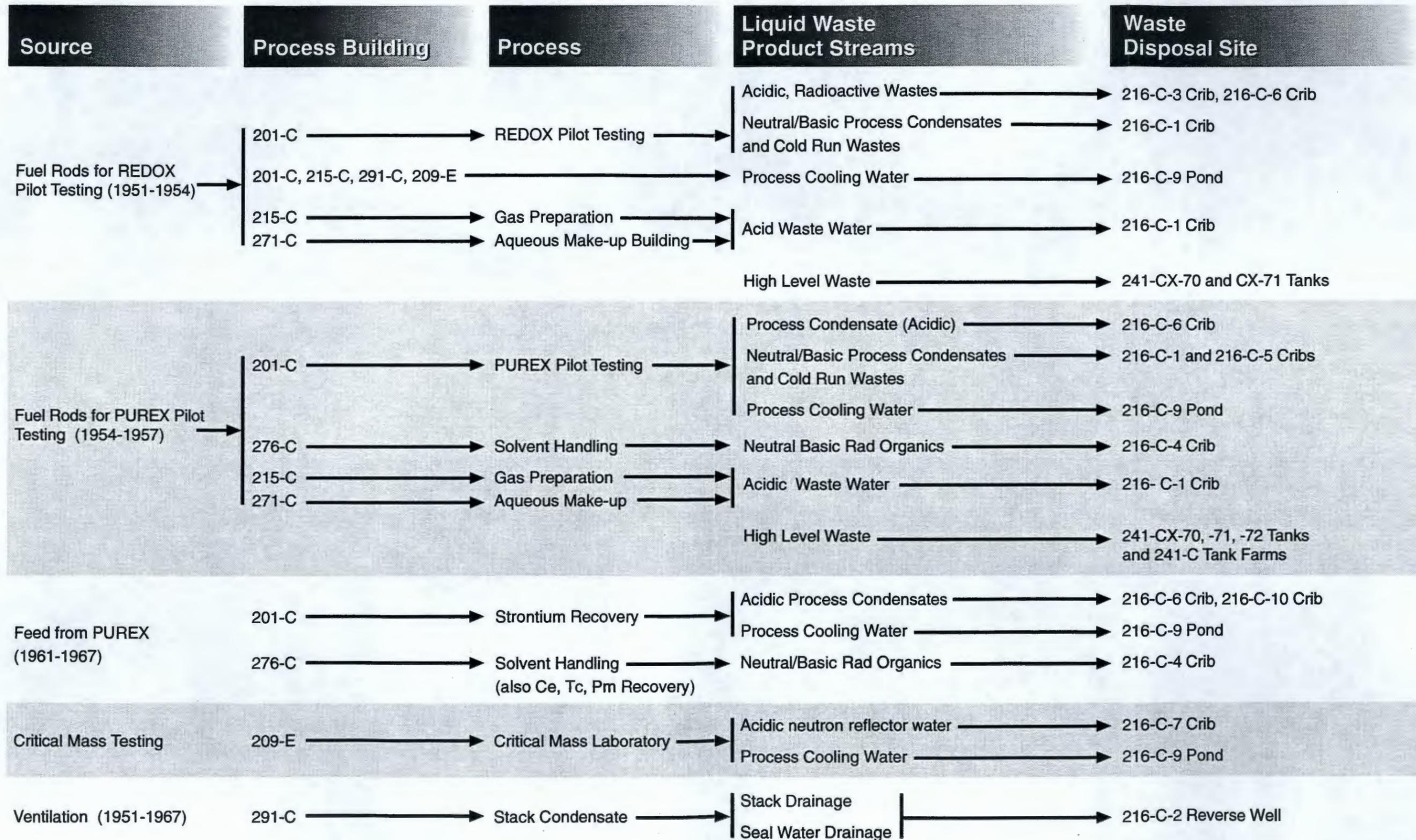


Figure H-6. S-Plant Major Waste Producing Processes. (2 Pages)

S-Plant Major Waste Producing Processes

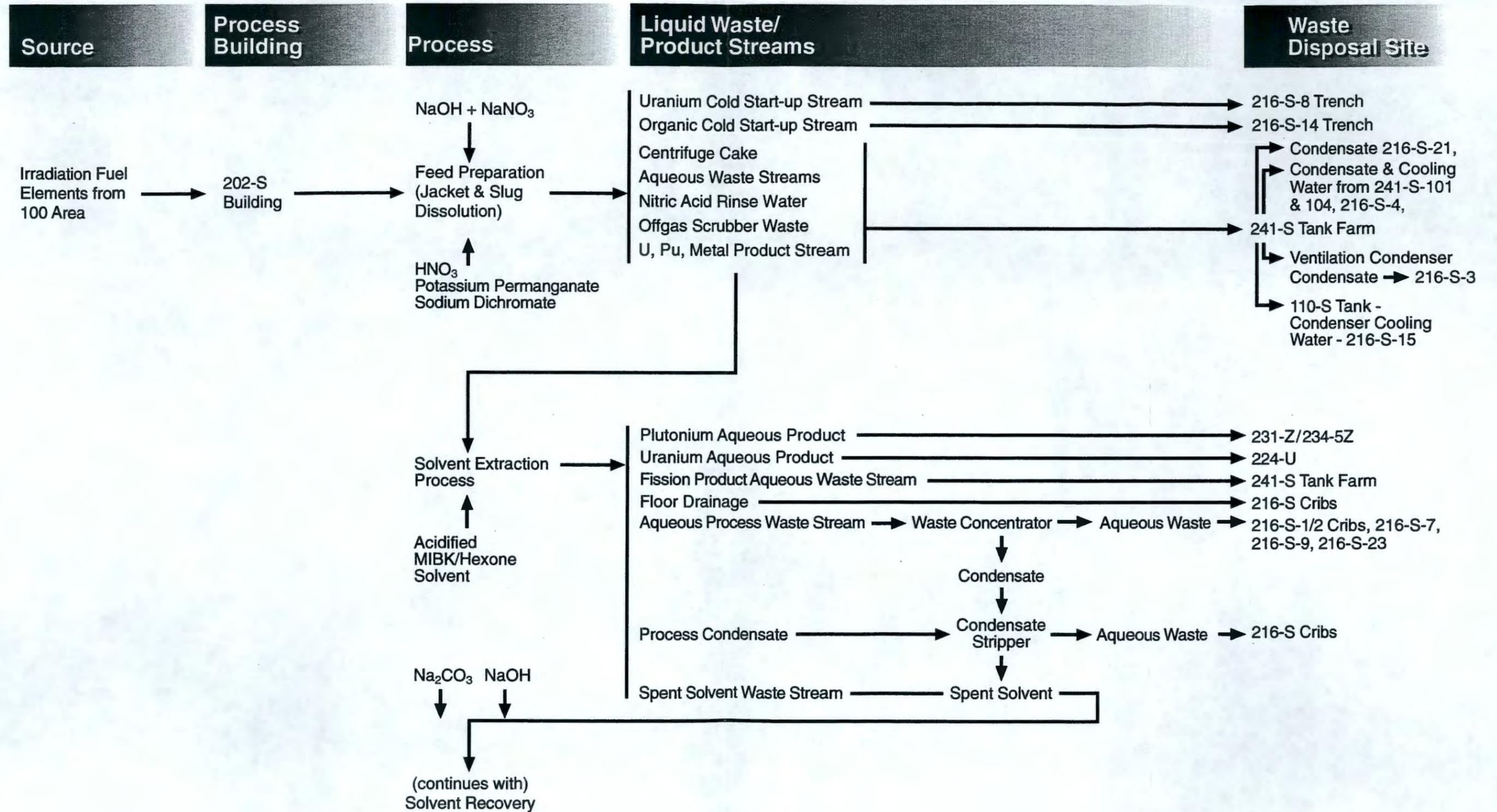


Figure H-6. S-Plant Major Waste Producing Processes. (2 Pages)

S-Plant Major Waste Producing Processes

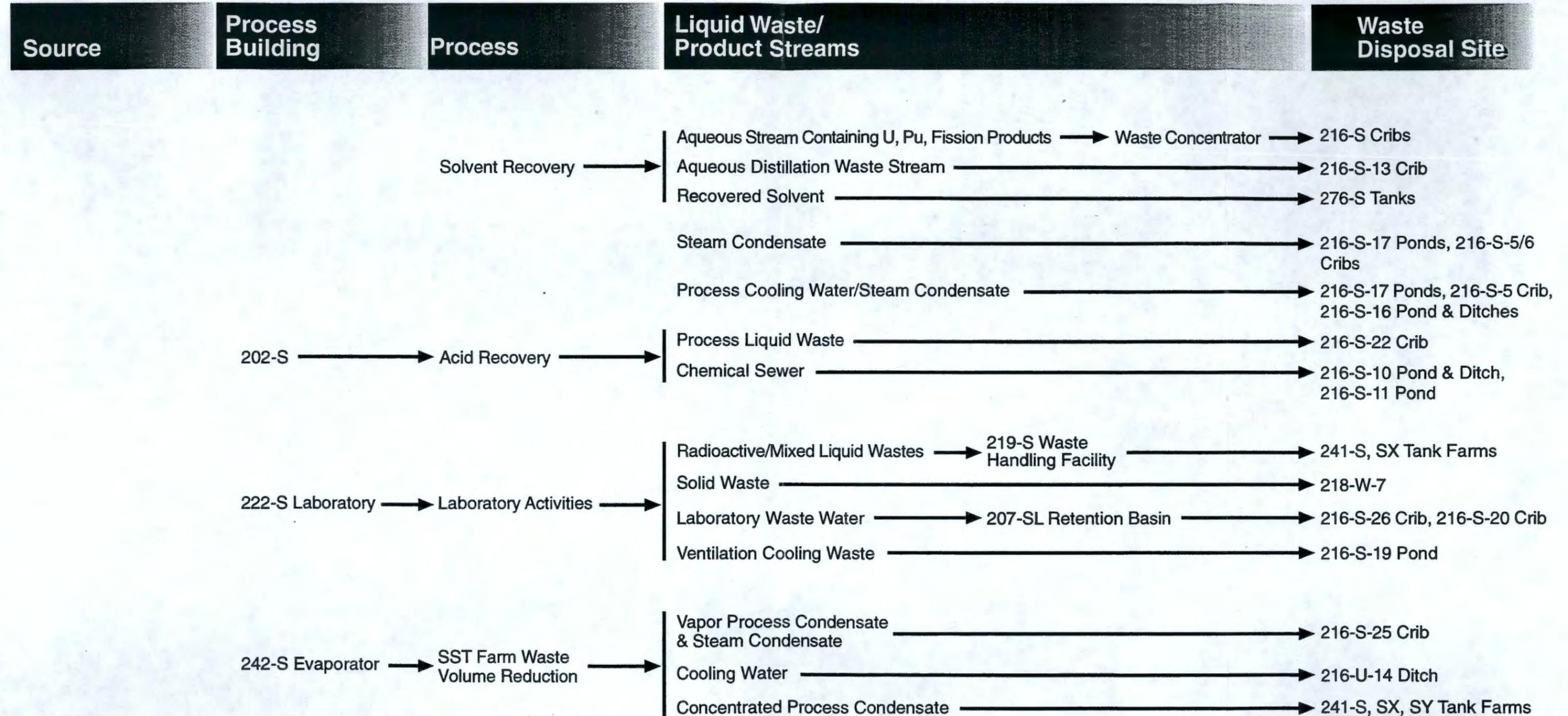
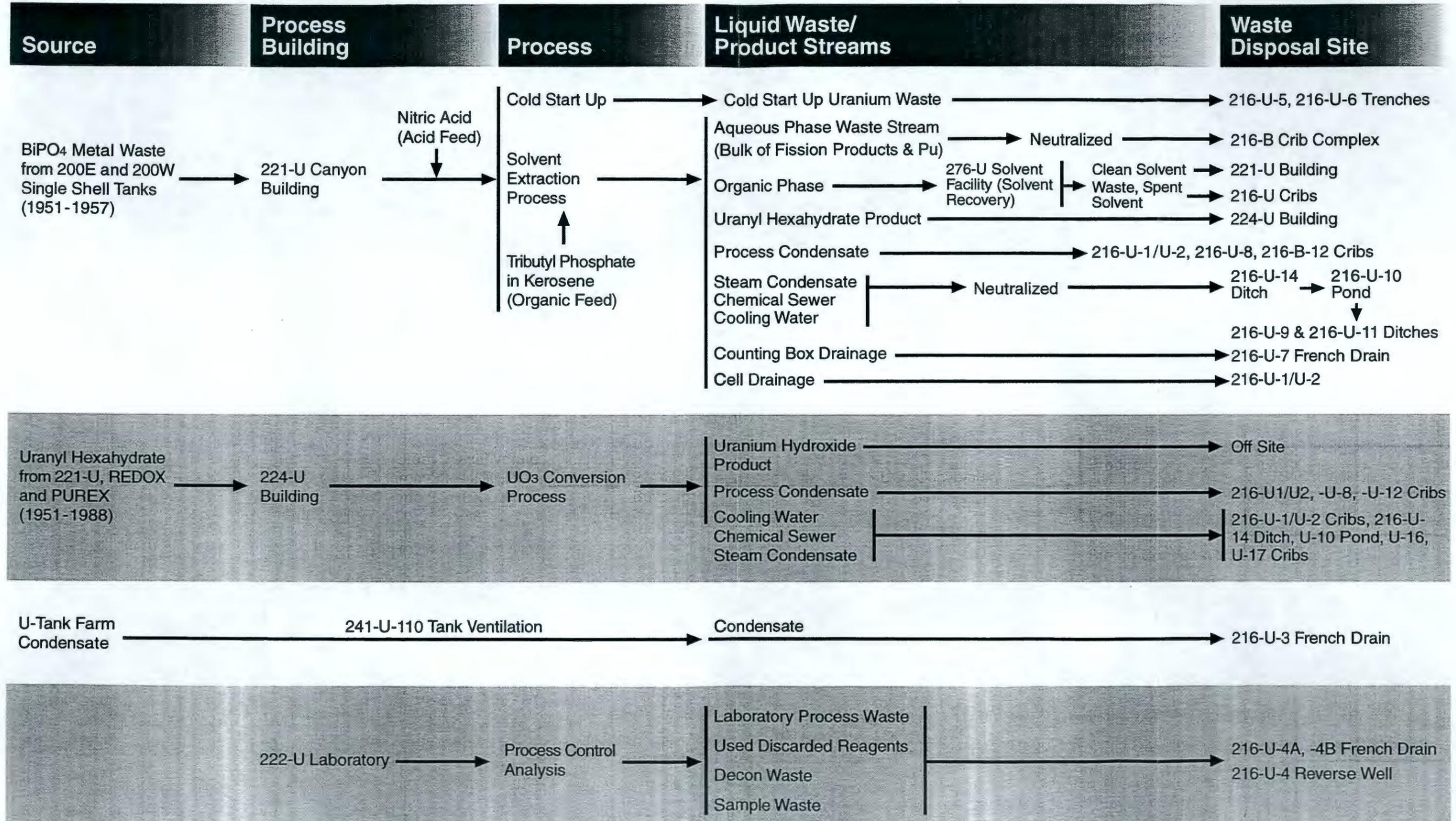


Figure H-7. U-Plant Aggregate Area Major Processes.

U-Plant Aggregate Area Major Processes



PUREX Aggregate Area Major Processes

Figure H-8. PUREX Aggregate Area Major Processes. (2 Pages)

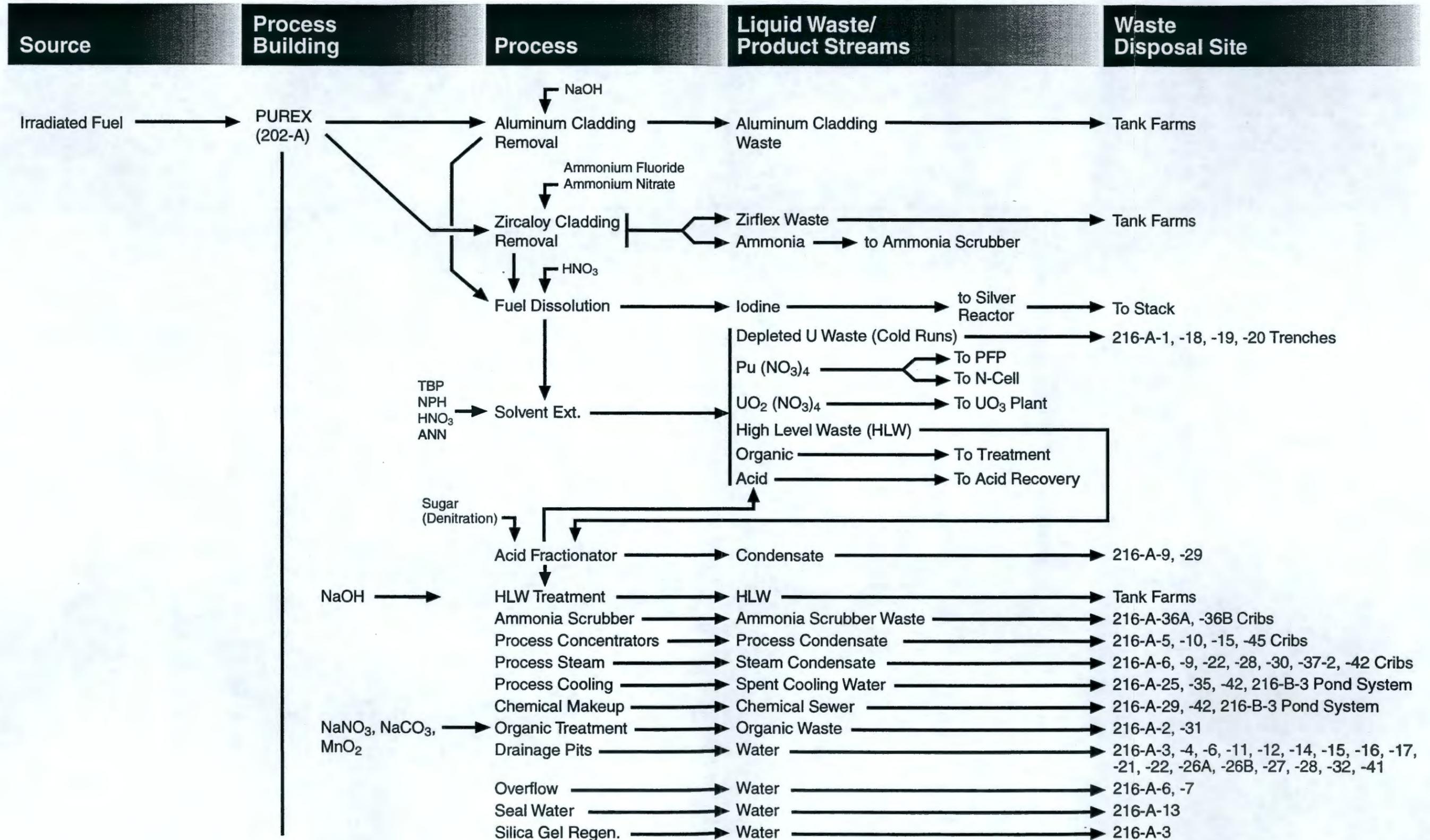
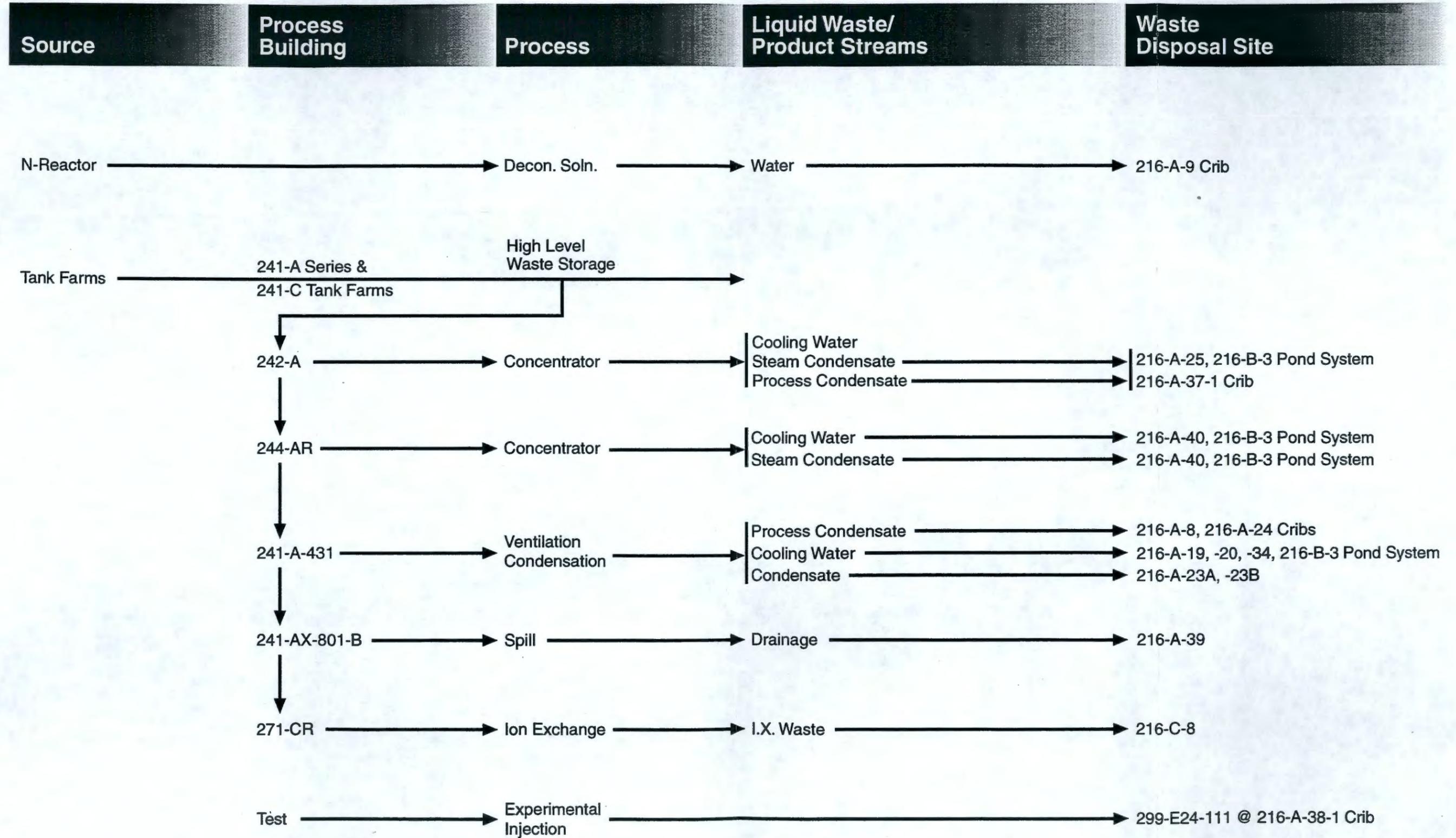


Figure H-8. PUREX Aggregate Area Major Processes. (2 Pages)

PUREX Aggregate Area Major Processes



U-238 → Th-234 → Pa-234m → Pa-234

4.47e9y 2.41d

↓ 1.17m ↙ 6.70h

U-234 → Th-230 → Ra-226 → Rn-222 → Po-218 → Pb-214

2.24e5y 7.70e4y 1.60e3y 3.82d ↓ 3.05m ↓ 26.8m

At-218 → Bi-214 → Po-214

1.6s ↓ 19.9m ↓ 6.37e-5s

Tl-210 → Pb-210 → Bi-210 → Po-210

1.3m 22.3y ↓ 5.01d ↓ 138d

Tl-206 → Pb-206

4.20m STABLE

U-235 → Th-231 → Pa-231 → Ac-227 → Th-227

7.04e8y 2.55h 3.28e4y

↓ 21.8y ↓ 18.7d

Fr-223 → Ra-223 → Rn-219 → Po-215 → Pb-211

21.8m 11.4d 3.96s ↓ 7.78e-4s ↓ 36.1m

At-215 → Bi-211 → Tl-207

1.0e-4s ↓ 2.13m ↓ 4.77m

Po-211 → Pb-207

.516s STABLE

Half lives are shown in seconds (s), minutes (m), and years (y)

Figure H-9. Uranium Decay Chains.

APPENDIX I

**ANNOTATED OUTLINE FOR A GROUP-SPECIFIC WORK PLAN
AND RCRA TSD SAMPLING PLAN**

11.0 INTRODUCTION

During the development of the 200 Areas Implementation Plan, discussions were held to determine the content of future group-specific work plans. It was agreed that, in order to ensure consistency in future documents, an annotated outline for these work plans would be developed and included in the Implementation Plan.

As discussed in Section 2.3 of the Implementation Plan, it is the intent that these work plans provide group and site-specific background information for the waste site group being considered. Site characterization needs will be defined based on the data quality objective (DQO) process that will be conducted prior to, or in parallel with, development of each work plan. The work plan will include a sampling and analysis plan that will address the needs of both past-practice sites and *Resource Conservation and Recovery Act* (RCRA) treatment, storage, and/or disposal (TSD) units, where appropriate. Information contained in the work plan will also satisfy the requirements for the first five chapters of information typically found in RCRA closure plans, where a TSD unit is included in the waste site group being considered.

In addition to the standard executive summary, table of contents, and acronym list, the format of the work plan shall be as specified below.

12.0 ANNOTATED OUTLINE

1.0 INTRODUCTION

The purpose of the work plan will be presented as a means to provide the waste group-specific details of field activities that were generally outlined in the Implementation Plan. The scope will include details for specific characterization activities (e.g., borehole or test pit designs, and sample locations) that are focused on representative sites that have been confirmed during group-specific DQO sessions. The work plan will include a discussion of how RCRA/*Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) integration will be applied to this specific waste group, a description of items that have been addressed in the Implementation Plan, and a schedule for subsequent assessment documentation for this particular waste group.

2.0 BACKGROUND AND SETTING

Provide a detailed description of the waste group, including site location, geologic, hydrogeologic, or other information that is pertinent to this particular waste group or the representative sites that have been selected for characterization. Discuss the common features found in the group-specific contaminant distribution model that were the basis for this group and the rationale for selection of the representative sites. Where a TSD unit is included in the waste group, the RCRA unit description and location information, and the Part A/Form 3 (Permit Conditions) will also be provided. (Note: Information from Section 4.2 to 4.24 of DOE/RL-96-81 {group description, known and suspected contamination, and conceptual model summary} will be incorporated in this section, or the next, of each respective group-specific work plan.)

3.0 INITIAL EVALUATION

A review of known and suspected contamination, including estimated waste volumes, will be presented for each representative site that has been identified. This will include a discussion of available monitoring information, including groundwater data where available. For RCRA TSD units, a description of the processes in place at the unit, including container, waste management, and waste generating practices, will be provided. Potential impacts to human health and the environment are represented in a conceptual exposure model, specific to the waste group and representative sites. This information is used to develop the Contaminants of Concern list.

4.0 WORK PLAN APPROACH AND RATIONALE

Results of the DQO process discussions for each representative site will be presented in order to discuss data uses, needs, quality, and quantity for the investigations to be conducted. This is followed by a discussion of the general approach to the investigation/characterization activities, with reference to the sampling and analysis plan in the appendices for more details.

5.0 REMEDIAL INVESTIGATION PROCESS

A detailed discussion of the work breakdown structure, project management organization, and approach is presented. This is followed by a description of field activities that cover all areas of characterization, including field procedures and protocols, laboratory analyses, data evaluation tasks, waste management, etc. This is typically followed by a discussion of the remaining portions of the remedial investigation/feasibility study (RI/FS) process, which include the RI report, feasibility studies/corrective measures studies, proposed plans, record of decision (ROD), and post-ROD activities. These post-ROD activities include confirmation sampling, generation of a Sampling Plan to be included in the Remedial Design Report/Remedial action Work Plan, remedial actions, verification sampling, and post-closure care. (Note: Options to perform the confirmation sampling pre-ROD will be investigated, pending the availability of funds to perform this activity. For waste groups containing TSD units, a description of where specific portions of the closure plan are located or where requirements have been met will be included. A brief discussion of Preliminary Remedial Action Objectives, General Response Actions, and Remedial Action Alternatives will also be included with reference to the Implementation Plan for details. A discussion of treatability testing needs will be included if enough information is available. However, this may need to be addressed in the RI report after data evaluations have been completed. Further analysis of applicable or relevant and appropriate requirements (ARARs) and remedial action alternatives will be addressed at the FS/corrective measures study (CMS) stage. (The ARARs discussion will include reference to the *Model Toxics Control Act* as the requirement for TSD units.)

6.0 PROJECT SCHEDULE

This chapter presents a detailed review of the schedule for all of the tasks to be completed for this waste group, including field activities, data evaluation, and document submittal, and presents potential milestones. It also addresses future activities through issuance of the ROD, and RCRA permit modification (if a TSD unit is included in the group). (Note: This schedule is just for characterization activities. The closure schedule for any TSD unit that is included will be located in the remedial design/remedial action work plan.)

7.0 REFERENCES

APPENDICES:

Sampling and Analysis Plan
Quality Assurance Project Plan
Project Management Plan
Others, as necessary
 Waste Management Plan
 Site-Specific Health and Safety Plan

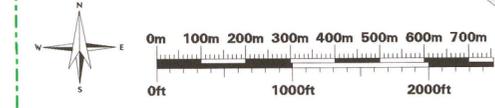
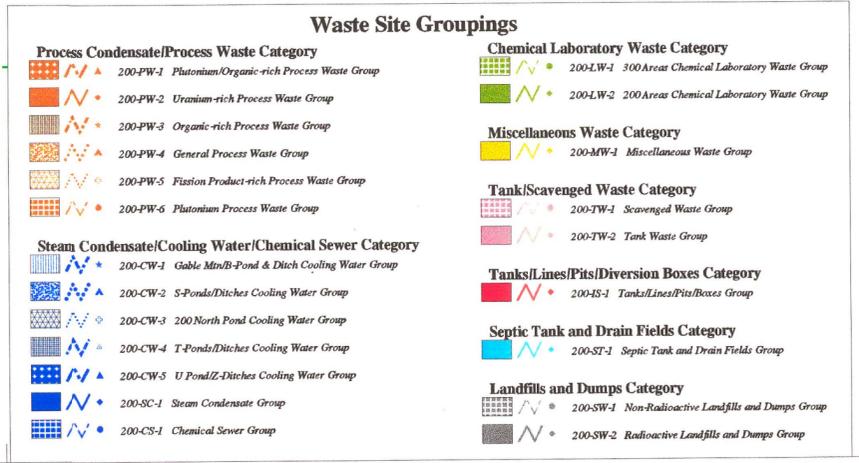
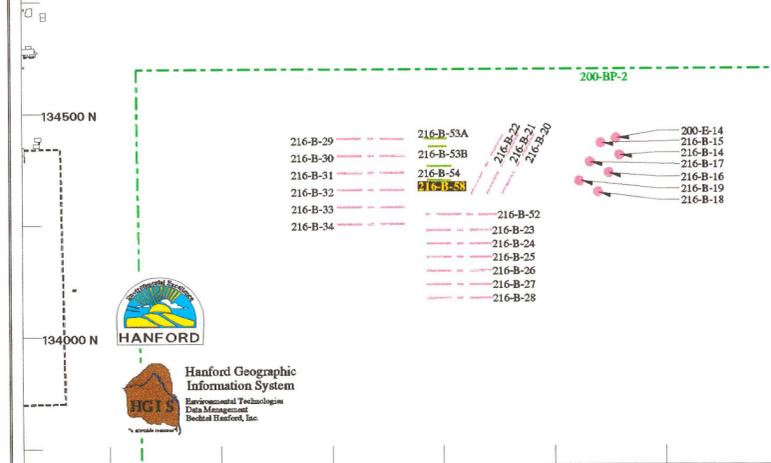
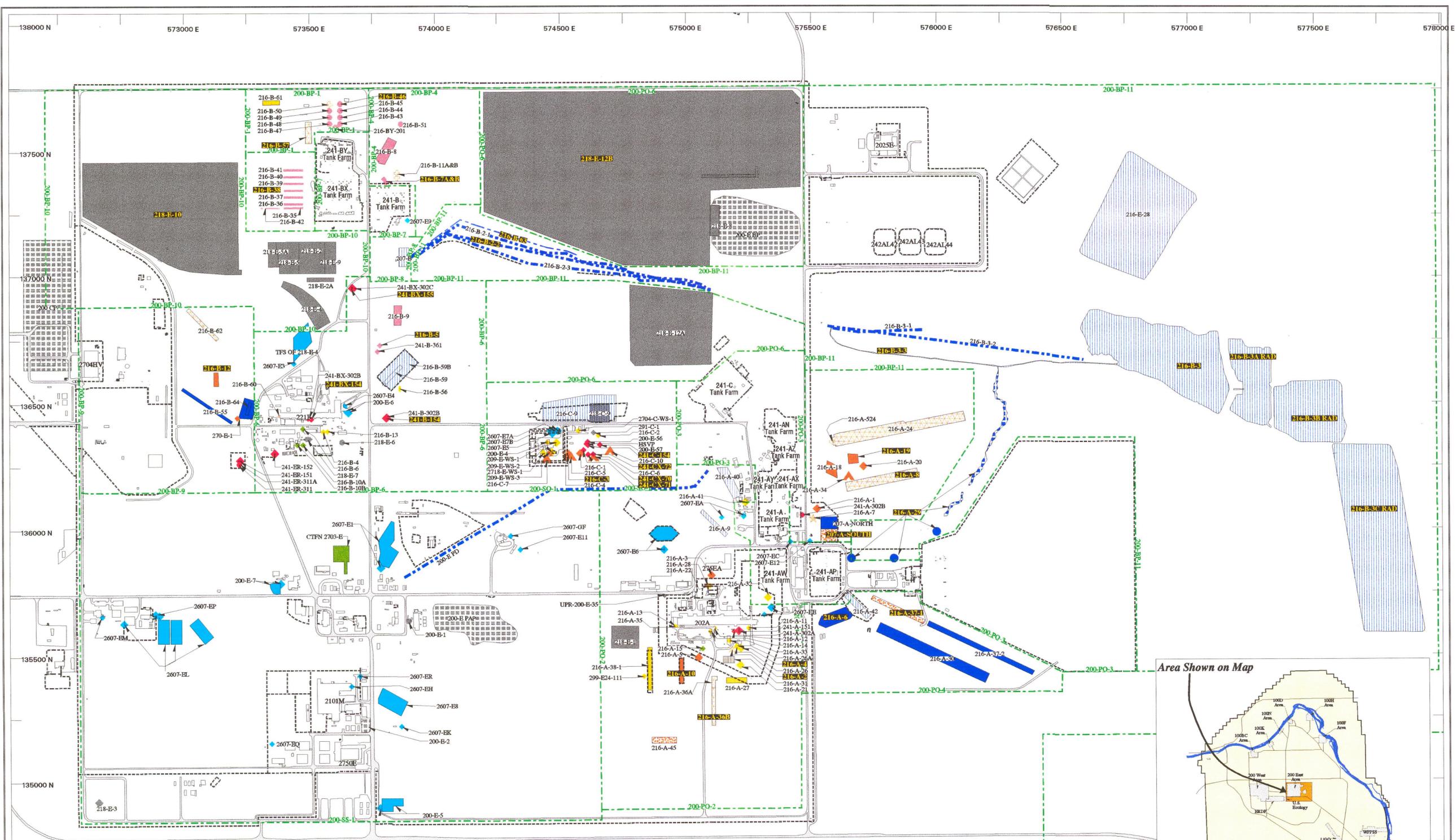


Plate II
200 East Waste Sites

SITECODE - Representative Sites and/or TSD Units

