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200 West Groundwater Aggregate Area Management Study Report

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ACRONYMS AND ABBREVIATIONS

AAMS	aggregate area management study
AAMSR	aggregate area management study report
AEA	Atomic Energy Act
AFAN	ammonium fluoride-ammonium nitrate
AKART	all known, available, and reasonable treatment technologies
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
AR	administrative record
ARARs	applicable or relevant and appropriate requirements
ARCL	allowable residual contamination level
ASIL	acceptable source impact level
ASME	American Society of Mechanical Engineers
BAT	Best Available Technology
BDAT	best demonstrated available treatment technologies
BRC	below regulatory concern
BWIP	Basalt Waste Isolation Project
CCW	constituent concentrations in waste
CCWE	constituent concentrations in waste extract
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	Corrective Measures Studies
CPF	Cancer Potency Factor
CRP	Community Relations Plan
CSTFO	Contaminant Systems Testing Facility
CWA	Clean Water Act
DCG	Derived Concentration Guide
DNAPL	dense non-aqueous phase liquid
DOE	U.S. Department of Energy
DOE/RL	U.S. Department of Energy, Richland Operations Office
DQO	data quality objective
Ecology	Washington State Department of Ecology
EDMC	Environmental Data Management Center
EHS	Environmental Health Services
EHW	extremely hazardous waste
EHPSS	Environmental Health and Pesticide Services Section
EII	Environmental Investigations Instructions
EIMP	Environmental Information Management Plan

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ACRONYMS AND ABBREVIATIONS (cont.)

EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERA	expedited response actions
ERRA	Environmental Restoration Remedial Action
ES&H	Environment, Safety, and Health
FFS	focused feasibility study
FOMP	Field Office Management Plan
FS	feasibility study
FWQC	Federal Water Quality Criteria
GIS	Geographic Information System
HBL	Health Based Level
Health	Washington State Department of Health
HEAST	Health Effects and Assessment Summary Tables
HEDL	Hanford Engineering and Development Laboratory
HEHF	Hanford Environmental Health Foundation
HEIS	Hanford Environmental Information System
HEPA	High Efficiency Particulate Air
HISS	Hanford Inactive Site Survey
HLAN	Hanford Local Area Network
HMS	Hanford Meteorological Station
HRS	Hazard Ranking System
HSP	health and safety plan
HVAC	heating, ventilation, and air conditioning
HWOP	Hazardous Waste Operations Permit
HWSA	Hazardous Waste Staging Area
ICRP	International Commission on Radiological Protection
IMO	Information Management Overview
IRM	interim remedial measure
JSA	Job Safety Analysis
KEH	Kaiser Engineers Hanford
LDR	land disposal restriction
LFI	limited field investigation
LLRW	low-level radioactive waste
LLWMA	low-level waste management area
LLWMU	low-level waste management unit
LSC	liquid scintillation counting
MCL	maximum contaminant levels
MCLGs	maximum contaminant level goals
MCS	Management Control System

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ACRONYMS AND ABBREVIATIONS (cont.)

MEPAS	Multimedia Environmental Pollutant Assessment System
mHRS	modified Hazard Ranking System
MIBK	methyl isobutyl ketone
MTCA	Model Toxics Control Act
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCP	National Contingency Plan
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFA	no further action
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NSPS	New Source Performance Standards
NSTF	Near Surface Test Facility
OGWMN	Operational Groundwater Monitoring Network
OSHA	Occupational Safety and Health Administration
OSM	Office of Sample Management
OSWER	Office of Solid Waste and Emergency Response
PARCC	precision, accuracy, representativeness, completeness, comparability
PA	preliminary assessment
PCE	tetrachloroethylene
PFP	Plutonium Finishing Plant
PIF	Plutonium Isolation Facility
PMP	Project Management Plan
PNL	Pacific Northwest Laboratory
PRF	Plutonium Reclamation Facility
PSPL	Puget Sound Power and Light Company
PUREX	plutonium uranium extraction
PVC	polyvinyl chloride
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
RA	risk assessment
RAO	remedial action objective
RAP	Remedial Action Policy
RARA	Radiation Area Remedial Action
RAS	Routine Analytical Services

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ACRONYMS AND ABBREVIATIONS (cont.)

RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
REDOX	reduction and oxidation
RfD	Reference Doses
RI	remedial investigation
RFI	RCRA Facility Investigations
RLS	Radionuclide Logging System
ROD	Record of Decision
RRI	relative risk index
RSU	retrievable storage unit
RTECS	Registry of Toxic Effects of Chemical Systems
RWP	Radiation Work Permit
SALDS	State Approved Land Disposal Structure
SARA	Superfund Amendments and Reauthorization Act
SAS	Special Analytical Services
SCBA	self-contained breathing apparatus
SCIR	Surveillance and Compliance Inspection Report
SCS	U.S. Department of Agriculture Soil Conservation Service
SDWA	Safe Drinking Water Act
SI	site inspection
SMCLs	secondary maximum contaminant levels
SWMU	solid waste management unit
SRW	Sodium Reactor Experiment
TAP	Toxic Air Pollutant
T-BACT	toxic best available control technology
TBC	to-be-considered material
TCA	trichloroethane
TCE	trichloroethylene
TCLP	toxic characteristic leaching procedure
TLD	thermoluminescent dosimeter
TLV	Threshold Limit Value
TOC	total organic carbon
TOX	total organic halogens
TRAC	Tracks Radioactive Components
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TRU	transuranic
TSD	treatment, storage, or disposal
UO_3	uranium trioxide
USC	U.S. Code

ACRONYMS AND ABBREVIATIONS (cont.)

USGS	U.S. Geological Survey
UV	ultra violet
VOC	volatile organic compound
WAC	Washington Administrative Code
WIDS	Waste Information Data System
WIPP	Waste Isolation Pilot Plant
WISHA	Washington Industrial Safety and Health Act
WMP	Waste Management Plan
WPCA	Washington State Water Pollution Control Act
WPPSS	Washington Public Power Supply System
WWQS	Washington Water Quality Standard

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200 WEST GROUNDWATER AAMS EXECUTIVE SUMMARY

This report presents the results of an aggregate area management study (AAMS) for the 200 West Groundwater Aggregate Area in the 200 Areas of the U.S. Department of Energy (DOE) Hanford Site in Washington State. This scoping level study provides the basis for initiating Remedial Investigation/Feasibility Study (RI/FS) activities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Resource Conservation and Recovery Act (RCRA), Facility Investigations (RFI) and Corrective Measures Studies (CMS) under RCRA. This report also integrates select RCRA treatment, storage or disposal (TSD) closure activities with CERCLA and RCRA past practice investigations.

Through the experience gained to date on developing work plans, closure plans, and permit applications at the Hanford Site, the parties to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) have recognized that all past practice investigations must be managed and implemented under one characterization and remediation strategy, regardless of the regulatory agency lead (as defined in the Tri-Party Agreement). In particular, the parties have identified a need for greater efficiency over the existing RI/FS and RFI/CMS investigative approaches, and have determined that, to expedite the ultimate goal of cleanup, much more emphasis needs to be placed on initiating and completing waste management unit cleanup through interim measures.

This streamlined approach is described and justified in the *Hanford Federal Facility Agreement and Consent Order Change Package,* dated May 16, 1991 (Ecology et al. 1991). To implement this approach, the three parties have developed the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) for streamlining the past practice remedial action process. This strategy provides new concepts for:

- Accelerating decision-making by maximizing the use of existing data consistent with data quality objectives (DQOs)

- Undertaking expedited response actions (ERAs) and/or interim remedial measures (IRMs), as appropriate, to either remove threats to human health and welfare and the environment, or to reduce risk by reducing toxicity, mobility, or volume of contaminants.

The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) describes the concepts and framework for the RI/FS (or RFI/CMS) process in a manner that has a bias-for-action through optimizing the use of interim remedial actions, culminating with decisions on final remedies on both an operable-unit and aggregate-area scale. The strategy focuses on reaching early decisions to initiate and complete cleanup projects, maximizing the use of

existing data, coupled with focused short time-frame investigations, where necessary. As more data become available on contamination problems and associated risks, the details of the longer term investigations and studies will be better defined.

The strategy includes three paths for interim decision-making and a final remedy-selection process for the operable unit that incorporates the three paths and integrates the various contaminant plumes addressed in those paths. The three paths for interim decision-making include the ERA, IRM, and limited field investigation (LFI) paths. The strategy requires that aggregate area management study reports (AAMSRs) be prepared to evaluate existing groundwater contamination data to support initial path decisions. This AAMSR is one of ten reports that will be prepared for each of the ten aggregate areas defined in the 200 Areas.

The near-term past practice strategy for the 200 Areas provides for ERAs, IRMs, and LFIs for individual waste management units, waste management unit groups, and groundwater plumes, and recommends separate source and groundwater operable units. Initial recommendations for each of the groundwater plumes within the 200 West Groundwater Aggregate Area are provided in the report. Work plans will initially focus on limited intrusive investigations at the highest priority plumes as established in the AAMSR. The goal of this initial focus is to establish whether interim remedial measures are justified. Plumes identified as candidate ERAs will be further evaluated following the *Site Selection Process for Expedited Response Actions at the Hanford Site* (Gustafson 1991).

While these elements may mitigate specific contamination problems through interim actions, the process of final remedy selection must be completed for the operable unit or aggregate area to reach closure. The aggregation of information obtained from the LFIs and interim actions may be sufficient to perform the cumulative risk assessment and to define the final remedy for operable unit or aggregate area. If the data are not sufficient, additional investigations and studies will be performed to the extent necessary to support final remedy selection. These investigations would be performed within the framework and process defined for RI/FS programs.

Several integration issues exist that are generic to the overall past practice process for the 200 Areas and include the following:

- **Future Work Plan Scope.** Although the current practice for implementing RI/FS (RFI/CMS) activities is through operable unit based work plans, individual LFI/IRMs may be more efficiently implemented using LFI/IRM-specific work plans.

- **Groundwater Operable Units.** A general strategy recommended for the 200 Areas is to define separate operable units for groundwater affected by 200 Areas

source terms. This requires that groundwater be removed from the scope of the existing source operable units and new groundwater-specific operable units be established. Recommendations for groundwater operable units are developed in the groundwater AAMSRs.

- **Work Plan Prioritization.** Although priorities are established in the AAMSR for operable units within the aggregate area, priorities between aggregate areas have yet to be established. The integration of priorities at the 200 Areas level is considered a prerequisite for establishing a schedule for past practice activities in the 200 Areas.

It is intended that these integration issues be resolved following the completion of all ten AAMSRs (Draft A) scheduled for September 1992. Resolution of these issues will be based on a decisions/consensus process among the Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), and DOE. Following resolution of these issues a schedule for past practice activities in the 200 Areas will be prepared.

Background, environmental setting, and known contamination data are provided in Sections 2.0, 3.0, and 4.1. This information provides the basis for development of the preliminary conceptual model in Section 4.2 and for assessing health and environmental concerns in Section 5.0. Preliminary applicable or relevant and appropriate requirements (ARARs) (Section 6.0) and preliminary remedial action technologies (Section 7.0) are also developed based on this data. Section 8.0 provides a discussion of the DQOs. Data needs identified in Section 8.0 are based on data gaps determined during the development of the conceptual model, human health and environmental concerns, ARARs, and remedial action technologies. Recommendations in Section 9.0 are developed using all the information provided in the sections which precede it.

The Hanford Site, operated by the DOE, occupies about 1,450 km^2 (560 mi^2) of the southeastern part of Washington north of the confluence of the Yakima and Columbia Rivers. The Hanford Site was established in 1943 to produce plutonium for nuclear weapons using production reactors and chemical processing plants. The 200 West Groundwater Aggregate Area includes the Hanford Site's 200 West Area plus other surrounding land where the contamination has spread.

Between 1944 and the present, the 200 Areas have housed various chemical processing plants for extracting plutonium, uranium, and fission products from irradiated fuels and secondary waste streams.

The 200 West Groundwater Aggregate Area contains a large variety of waste disposal and storage facilities. High-level wastes were stored in underground single-shell tanks. Low-level wastes such as cooling and condensate water were allowed to infiltrate into the

ground through cribs, ditches, and open ponds. Detailed descriptions of waste management units that may impact groundwater are provided in Section 2.3.

There are several ongoing programs that affect activities in the 200 West Groundwater Aggregate Area (Section 2.7). These programs include RCRA, the Hanford Surplus Facilities Program, the Radiation Area Remedial Action Program, the Hanford Site Single-Shell Tank Program, and the Defense Waste Management Program. These programs do not affect groundwater remedial activities.

Discussions of surface hydrology and geology are provided on a regional, Hanford Site, and aggregate area basis in Section 3.0. The section also describes the flora and fauna, land use, water use and human resources of the 200 West Area and vicinity.

A preliminary site conceptual model is presented in Section 4.0. Section 4.1 presents the chemical and radiological data that are available for the groundwater in the 200 West Groundwater Aggregate Area and organizes the results in terms of the various plumes.

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Section 9.0 provides management recommendations for the 200 West Groundwater Aggregate Area based on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a). Criteria for selecting appropriate *Hanford Site Past-Practice Strategy* paths (ERA, IRM, and final remedy selection) for individual plumes are developed in Section 9.1. As a result of this process, 1 plume is recommended for an ERA, 5 for IRMs and 27 contaminants for LFIs which could lead to IRMs, and the remainder of the detected constituents (some 55) will be addressed under final remedy selection.

The data evaluation process is discussed in Section 9.2. Recommendations for defining operable unit boundaries and prioritizing operable units for work plan development are provided in Section 9.3. Included in Section 9.3 are the interactions with RCRA and on-going CERCLA investigations. All recommendations for future characterization needs will be more fully developed and implemented through work plans. Sections 9.4 and 9.5 provide recommendations for focused feasibility and treatability studies, respectively. Section 9.6 discusses characterization activities which will be done on an Aggregate Area scale.

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Hanford Site in Washington State is organized into numerically designated operational areas including the 100, 200, 300, 400, 600, and 1100 Areas (Figure 1-1). The U.S. Environmental Protection Agency (EPA), in November 1989, included the 200 Areas of the Hanford Site on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980. Inclusion on the NPL initiates the Remedial Investigation (RI) and Feasibility Study (FS) process for characterizing the nature and extent of contamination, assessing risks to human health and the environment, and selection of remedial actions.

This report presents the results of an aggregate area management study (AAMS) for the 200 West Groundwater Aggregate Area located in the 200 Areas. The study provides the basis for initiating RI/FS under CERCLA or under the Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFI) and Corrective Measures Studies (CMS). This report also integrates RCRA treatment, storage, or disposal (TSD) closure activities with CERCLA and RCRA past practice investigations.

This chapter describes the overall AAMS approach for the 200 Areas, defines the purpose, objectives and scope of the AAMS, and summarizes the quality assurance (QA) program and contents of the report.

1.1 OVERVIEW

The 200 Areas, located near the center of the Hanford Site, encompasses the 200 West, East and North Areas which contain reactor fuel processing and waste management facilities.

Under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), signed by the Washington State Department of Ecology (Ecology), DOE, and EPA (Ecology et al. 1990), the 200 NPL Site encompasses the 200 Areas and selected portions of the 600 Area. The 200 NPL Site is divided into 8 waste area groups largely corresponding to the major processing plants (e.g., B Plant and T Plant), and a number of isolated operable units located in the surrounding 600 Area. Each waste area group is further subdivided into one or more operable units based on waste disposal information, location, facility type, and other site characteristics. The 200 NPL site includes a total of 44 operable units including 20 in the 200 East Area, 17 in the 200 West Area, 1 in the 200 North Area, and 6 isolated operable units. The intent of defining operable units was to group associated waste management units together, so that they could be effectively characterized and remediated under one work plan.

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The Tri-Party Agreement also defines approximately 25 RCRA TSD groups within the 200 Areas which will be closed or permitted (for operation or postclosure care) in accordance with the Washington State Dangerous Waste Regulations (Washington Administrative Code [WAC] 173-303). The TSD facilities are often associated with an operable unit and are required to be addressed concurrently with past-practice activities under the Tri-Party Agreement.

This AAMS is one of ten studies that will provide the basis for past practice activities for operable units in the 200 Areas. In addition, the AAMS will be collectively used in the initial development of an area-wide groundwater model, and conduct of an initial site-wide risk assessment. Recent changes to the Tri-Party Agreement (Ecology et al. 1991), and the *Hanford Site Past-Practice Strategy* document (DOE/RL 1992a) establish the need and provide the framework for conducting AAMS in the 200 Areas.

1.1.1 Tri-Party Agreement

The Tri-Party Agreement was developed and signed by representatives from the EPA, Ecology, and DOE in May 1989, and revised in 1990 and 1991. The scope of the agreement covers all CERCLA past practice, RCRA past practice, and RCRA TSD activities on the Hanford Site. The purpose of the Tri-Party Agreement is to ensure that the environmental impacts of past and present activities are investigated and appropriately remediated to protect human health and the environment. To accomplish this, the Tri-Party Agreement provides a framework and schedule for developing, prioritizing, implementing, and monitoring appropriate response actions.

The 1991 revision to the Tri-Party Agreement requires that an aggregate area approach be implemented in the 200 Areas based on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a). This strategy requires the conduct of AAMS which are similar in nature to an RI/FS scoping study. The Tri-Party Agreement change package (Ecology et al. 1991) specifies that 10 Aggregate Area Management Study Reports (AAMSR) (major milestone M-27-00) are to be prepared for the 200 Areas. Further definition of aggregate areas and the AAMS approach is provided in Sections 1.2 and 1.3.

1.1.2 Hanford Site Past-Practice Strategy

The *Hanford Site Past-Practice Strategy* was developed between Ecology, EPA, and DOE to streamline the existing RI/FS and RFI/CMS processes. A primary objective of this strategy is to develop a process to meet the statutory requirements and integrate CERCLA RI/FS and RCRA Past Practice RFI/CMS guidance into a singular process for the Hanford Site that ensures protection of human health and welfare and the environment. The strategy

refines the existing past practice decision-making process as defined in the Tri-Party Agreement. The fundamental principle of the strategy is a bias-for-action by optimizing the use of existing data, integrating past practice with RCRA TSD closure investigations, focusing the RI/FS process, conducting interim remedial actions, and reaching early decisions to initiate and complete cleanup projects on both operable-unit and aggregate-area scale. The ultimate goal is the comprehensive cleanup or closure of all contaminated areas at the Hanford Site at the earliest possible date in the most effective manner.

The process under this strategy is a continuum of activities whereby the effort is refined based upon knowledge gained as work progresses. Whereas the strategy is intended to streamline investigations and documentation to promote the use of interim actions to accelerate cleanup, it is consistent with RI/FS and RFI/CMS processes. An important element of this strategy is the application of the observational approach, in which characterization data are collected concurrently with cleanup.

For the 200 Areas the first step in the strategy is the evaluation of existing information presented in AAMSR. Based on this information, decisions are made regarding which strategy path(s) to pursue for further actions in the aggregate area. The strategy includes three paths for interim decision making and a final remedy-selection process that incorporates the three paths and integrates sites not addressed in those paths. As shown on Figure 1-2, the three paths for decision making are the following:

- Expedited response action (ERA) path, where an existing or near-term unacceptable health or environmental risk from a site is determined or suspected, and a rapid response is necessary to mitigate the problem

- Interim remedial measure (IRM) path, where existing data are sufficient to indicate that the site poses a risk through one or more pathways and additional investigations are not needed to screen the likely range of remedial alternatives for interim actions; if a determination is made that an IRM is justified, the process proceeds to select an IRM remedy and a focused feasibility study (FFS), if needed, to select a remedy

- Limited field investigation (LFI) path, where minimum site data are needed to support IRM or other decisions, and are obtained in a less formal manner than that needed to support a final Record of Decision (ROD). Data generated from a LFI may be sufficient to directly support an interim ROD. Regardless of the scope of the LFI, it is a part of the RI process, and not a substitute for it.

The process of final remedy selection must be completed for the aggregate area to reach closure. The aggregation of information obtained from LFI and interim actions may be sufficient to perform the cumulative risk assessment and to define the final remedy for the

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aggregate area or associated operable units. If the data are not sufficient, additional investigations and studies will be performed to the extent necessary to support final remedy selection. These investigations would be performed within the framework and process defined for RI/FS or RFI/CMS programs.

1.2 200 NPL SITE AGGREGATE AREA MANAGEMENT STUDY PROGRAM

The overall approach and scope of the 200 Areas AAMS program is based on the Tri-Party Agreement and the *Hanford Site Past-Practice Strategy*.

1.2.1 Overall Approach

As defined in the 1991 revision to the Tri-Party Agreement, the AAMS program for the 200 Areas consists of conducting a series of ten AAMS for eight source (Figures 1-3, 1-4, and 1-5) and two groundwater aggregate areas delineated in the 200 East, West, and North Areas. Table 1-1 lists the aggregate areas, the type of study, and associated operable units. With the exception of 200-IU-6, isolated operable units associated with the 200 NPL site (Figure 1-5) are not included in the AAMS program. Generally, the quantity of existing information associated with isolated operable units is not considered sufficient to require study on an aggregate area basis prior to work plan development. Operable unit 200-IU-6 is addressed as part of the B Plant AAMS because of similarities in waste management units (i.e., ponds).

The eight source AAMS are designed to evaluate source terms on a plant-wide scale. Source AAMS are conducted for the following aggregate areas (waste area groups) which largely correspond to the major processing plants including the following:

- U Plant
- Z Plant
- S Plant
- T Plant
- PUREX
- B Plant
- Semi-Works

- 200 North.

The groundwater beneath the 200 Areas is investigated under two groundwater AAMS on an area-wide scale (i.e., 200 West and 200 East Areas). Groundwater aggregate areas were delineated to encompass the geography necessary to define and understand the local hydrologic regime, and the distribution, migration and interaction of contaminants emanating from source terms. The groundwater aggregate areas are considered an appropriate scale for developing conceptual and numerical groundwater models.

The U.S. Department of Energy, Richland Field Office (DOE/RL) functions as the "lead agency" for the 200 AAMS program. Depending on the specific AAMS, EPA and/or Ecology function as the "Lead Regulatory Agency" (Table 1-1). Through periodic (monthly) meetings information is transferred and regulators are informed of the progress of the AAMS such that decisions established under the *Hanford Site Past-Practice Strategy* (e.g., is an ERA justified?) (Figure 1-2) can be quickly and collectively made between the three parties. These meetings will continually refine the scope of AAMS as new information is evaluated, decisions are made and actions taken. Completion milestones for AAMS are defined in Ecology et al. (1991) and duplicated in Table 1-1. All AAMSR are submitted as Secondary Documents which are defined in the Tri-Party Agreement as informational documents.

1.2.2 Process Overview

Each AAMS consists of three steps: 1) the analysis of existing data and formulation of a preliminary conceptual model, 2) identification of data needs and evaluation of remedial technologies, and 3) conduct of limited field characterization activities. Steps 1 and 2 are components of an AAMSR. Step 3 is a parallel effort for which separate reports will be produced.

The first and primary task of the AAMS investigation process involves the search, compilation and evaluation of existing data. Information collected for these purposes includes the following:

- Facility and process descriptions and operational histories for waste sources
- Waste disposal records defining dates of disposal, waste types, and waste quantities
- Sampling events of waste effluents and affected media

- Site conditions including the site physiography, geology, hydrology, meteorology, ecology, demography, and archaeology

- Environmental monitoring data for affected media including air, surface water, sediment, soil, groundwater and biota.

Collectively this information is used to identify contaminants of concern, to determine the scope of future characterization efforts, and to develop a preliminary conceptual model of the aggregate area. Although data collection objectives are similar, the types of information collected depend on whether the study is a source or groundwater AAMS. The data collection step serves to avoid duplication of previous efforts and facilitates a more focused investigation by the identification of data gaps.

Topical reports referred to as Technical Baseline Reports are initially prepared to summarize facility information. These reports describe individual waste management units and unplanned releases contained in the aggregate area as identified in the Waste Information Data System (WIDS) (WHC 1991a). The reports are based on review of current and historical Hanford Site reports, engineering drawings and photographs and are supplemented with site inspections and employee interviews. Information contained in the reports is summarized in the AAMSR. Other topical reports are used as sources of information in the AAMSR. These reports are as follows:

- U Plant Geologic and Geophysics Data Package

- Z Plant Geologic and Geophysics Data Package

- S Plant Geologic and Geophysics Data Package

- T Plant Geologic and Geophysics Data Package

- PUREX Geologic and Geophysics Data Package

- B Plant Geologic and Geophysics Data Package

- 200 N Geologic and Geophysics Data Package

- Semiworks Geologic and Geophysics Data Package

- Hydrologic Model for the 200 West Groundwater Aggregate Area

- Hydrologic Model for the 200 East Groundwater Aggregate Area

- Unconfined Aquifer Hydrologic Test Data Package for the 200 West Groundwater Aggregate Area

- Unconfined Aquifer Hydrologic Test Data Package for the 200 East Groundwater Aggregate Area

- Confined Aquifer Hydrologic Test Data Package for the 200 Groundwater Aggregate Area Management Studies

- Groundwater Field Characterization Report

- 200 West Area Borehole Geophysics Field Characterization

- 200 East Area Borehole Geophysics Field Characterization

The general scope of the topical reports related to this AAMSR is described in Section 8.0.

Information on waste sources, pathways, and receptors is used to develop a preliminary conceptual model of the aggregate area. In the preliminary conceptual model, the release mechanisms and transport pathways are identified. If the conceptual understanding of the site is considered inadequate, limited field characterization activities can be undertaken as part of the study. Field characterization activities occurring in parallel with and as part of the AAMS process include the following:

- Expanded groundwater monitoring programs (non-Contract Laboratory Program [CLP]) at approximately 80 select existing wells to identify contaminants of concern and refine groundwater plume maps

- In situ assaying of gamma-emitting radionuclides at approximately 10 selected existing boreholes per aggregate area to develop radioelement concentration profiles in the vadose zone.

Wells, boreholes, and analytes are selected based on a review of existing environmental data which is undertaken early in the AAMS process. Field characterization results will be presented later in topical reports.

After the preliminary conceptual model is developed, health and environmental concerns are identified. The purpose of this determination is to provide one basis for determining recommendations and prioritization for subsequent actions at waste management units. Potential applicable or relevant and appropriate requirements (ARARs) and potential remedial technologies are identified. In cases where the existing information is sufficient,

the *Hanford Site Past-Practice Strategy* allows for a focused FS or CMS to be initiated prior to the completion of the study.

Data needs are identified by evaluating the sufficiency of existing data and by determining what additional data are necessary to adequately characterize the aggregate area, refine the preliminary conceptual model and potential ARARs, and/or narrow the range of remedial alternatives. Determinations are made regarding the level of uncertainty associated with existing data and the need to verify or supplement the data. If additional data are needed, the intended data uses are identified, data quality objectives (DQO) established and data priorities set.

Each AAMSR results in management recommendations for the aggregate area including the following:

- The need for ERA, IRM, and LFI or whether to remain in the final remedy selection path
- Definition and prioritization of operable units
- Prioritization of work plan activities
- Integration of RCRA TSD closure activities
- The conduct of field characterization activities
- The need for treatability studies
- Identification of waste management units addressed entirely under other operational programs.

The waste management units recommended for ERA, IRM, or LFI actions are considered higher priority units that require rapid response. Lower priority waste management units will generally follow the conventional process for RI/FS. In spite of this distinction in the priority of sites, RI/FS activities will be conducted for all the waste management units. In the case of the higher priority waste management units, rapid response operations will be followed by conventional RI/FS activities, although these activities may be modified because of knowledge gained through the remediation activities. In the case of the lower priority waste management units, an area-wide RI/FS will be prepared which encompasses these units.

Based on the AAMSR, a decision is made on whether the study has provided sufficient information to forego further field investigations and prepare a FS. An RI/FS work plan

(which may be limited to LFI activities) will be developed and executed. The background information normally required to support the preparation of a work plan (e.g., site description, conceptual model, DQO, etc.) is developed in the AAMSR. The future work plans will reference information from the AAMSR. They will also include the rationale for sampling and analysis, will present detailed, unit-specific DQO, and will further develop physical site models as the data allows. In some cases, there may be insufficient data to support any further analysis than is provided in the AAMSR, so an added level of detail in the work plan may not be feasible.

All ten AAMS are scheduled to be completed by September 1992. This will facilitate a coordinated approach to prioritizing and implementing future past practice activities for the entire 200 Areas.

1.3 PURPOSE, SCOPE, AND OBJECTIVES

The purpose of conducting an AAMS is to compile and evaluate the existing body of knowledge and conduct limited field characterization work to support the *Hanford Site Past-Practice Strategy* decision-making process for an aggregate area. The AAMS process is similar in nature to the RI/FS scoping process prior to work plan development and is intended to maximize the use of existing data to allow a more limited and focused RI/FS. Deliverables for an AAMS consist of the AAMSR and health and safety, project management, and Information Management Overview (IMO) plans.

Specific objectives of the AAMS include the following:

- Assemble and interpret existing data including operational and environmental data
- Describe site conditions
- Conduct limited new site characterization work if data or interpretation uncertainty could be reduced by the work (results from this work may not be available for the AAMSR, but will be included in subsequent topical reports)
- Develop a preliminary conceptual model
- Identify contaminants of concern, and their distribution
- Identify potential ARARs
- Define preliminary remedial action objectives, screen potential remedial technologies, and if possible provide recommendations for focused FS

- Recommend treatability studies to support the evaluation of remedial action alternatives

- Define data needs, establish general DQOs and set data priorities

- Provide recommendations for ERA, IRM, LFI or other actions

- Redefine and prioritize, as data allow, operable unit boundaries

- Define and prioritize, as data allow, work plan and other past practice activities with emphasis on supporting early cleanup actions and records of decisions

- Integrate RCRA TSD closure activities with past practice activities.

Information on single-shell and double-shell tanks is presented in Sections 2.0 and 4.0 of selected AAMSRs. The AAMSR is not intended to address remediation related to the tanks. Nonetheless, the tank information is presented because known and suspected releases from the tanks may influence the interpretation of contamination data at nearby waste management units. Information on other facilities and buildings is also presented for this same reason. However, because these structures are addressed by other programs, the AAMSR does not include recommendations for further action at these structures.

Depending on whether an aggregate area is a source or groundwater aggregate area, the scope of the AAMS varies. Source AAMS focus on source terms, and the environmental media of interest include air, biota, surface water, surface soil, and the unsaturated subsurface soil. Accordingly, detailed descriptions of facilities and operational information are provided in the source AAMSR. In contrast, groundwater AAMS focus on the saturated subsurface and on groundwater contamination data. Descriptions of facilities in the groundwater AAMSR are limited to liquid disposal facilities and reference is made to source AAMSR for detailed descriptions. The description of site conditions in source AAMSR concentrate on site physiography, meteorology, surface water hydrology, vadose zone geology, ecology, and demography. Groundwater AAMSR summarize regional geohydrologic conditions and contain detailed information regarding the local geohydrology on an area-wide scale. Correspondingly, other sections of the AAMSR vary depending on the environmental media of concern.

1.4 QUALITY ASSURANCE

A limited amount of field characterization work is performed in parallel with preparation of the AAMSR. To help ensure that data collected are of sufficient quality to support decisions, all work will be performed in compliance with *Quality Assurance*, DOE

Order 5700.6C (DOE 1991), as well as Westinghouse Hanford's existing QA manual, WHC-CM-4-2 (WHC 1988a), and with procedures outlined in the QA program plan, WHC-EP-0383 (WHC 1990a), specific to CERCLA RI/FS activities. This QA program plan describes the various plans, procedures, and instructions that will be used by Westinghouse Hanford to implement the QA requirements. Standard EPA guidance documents such as the *Contract Laboratory Program Statement of Work for Organic Analysis* (EPA 1988a) will also be followed.

1.5 ORGANIZATION OF REPORT

In addition to this introduction, the AAMSR consists of the following nine sections and appendices:

- Section 2.0, Facility, Process and Operational History Descriptions, describes the major facilities, waste management units and unplanned releases within the aggregate area. A chronology of waste disposal activities is established and waste generating processes are summarized.

- Section 3.0, Site Conditions, describes the physical, environmental, and sociological setting including geology, hydrology, ecology, meteorology, and demography.

- Section 4.0, Preliminary Conceptual Site Model, summarizes the conceptual understanding of the aggregate area with respect to types and extent of contamination, exposure pathways and receptors.

- Section 5.0, Health and Environmental Concerns, identifies chemicals used or disposed within the aggregate area that could be of concern regarding public health and/or the environment and describes and applies the screening process for determining the relative priority of follow-up action at each waste management unit.

- Section 6.0, Potentially Applicable or Relevant and Appropriate Requirements, identifies federal and state standards, requirements, criteria, or limitations that may be considered relevant to the aggregate area.

- Section 7.0, Preliminary Remedial Action Technologies, identifies and screens potential remedial technologies and establishes remedial action objectives for environmental media.

- Section 8.0, Data Quality Objectives, reviews QA criteria on existing data, identifies data gaps or deficiencies, and identifies broad data needs for field characterization and risk assessment. The DQO and data priorities are established.

- Section 9.0, Recommendations, provides guidance for future past practice activities based on the results of the AAMS. Recommendations are provided for ERA at problem sites, IRM, LFI, refining operable unit boundaries, prioritizing work plans, and conducting field investigations and treatability studies.

- Section 10.0, References, list reports and documents cited in the AAMSR.

- Appendix A, Supplemental Data, provides supplemental data supporting the AAMSR.

The following plans are included and will be used to support past practice activities in the aggregate area:

- Appendix B: Health and Safety Plan

- Appendix C: Project Management Plan

- Appendix D: Information Management Overview

Community relations requirements for the 200 West Groundwater Aggregate Area can be found in the *Community Relations Plan for the Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

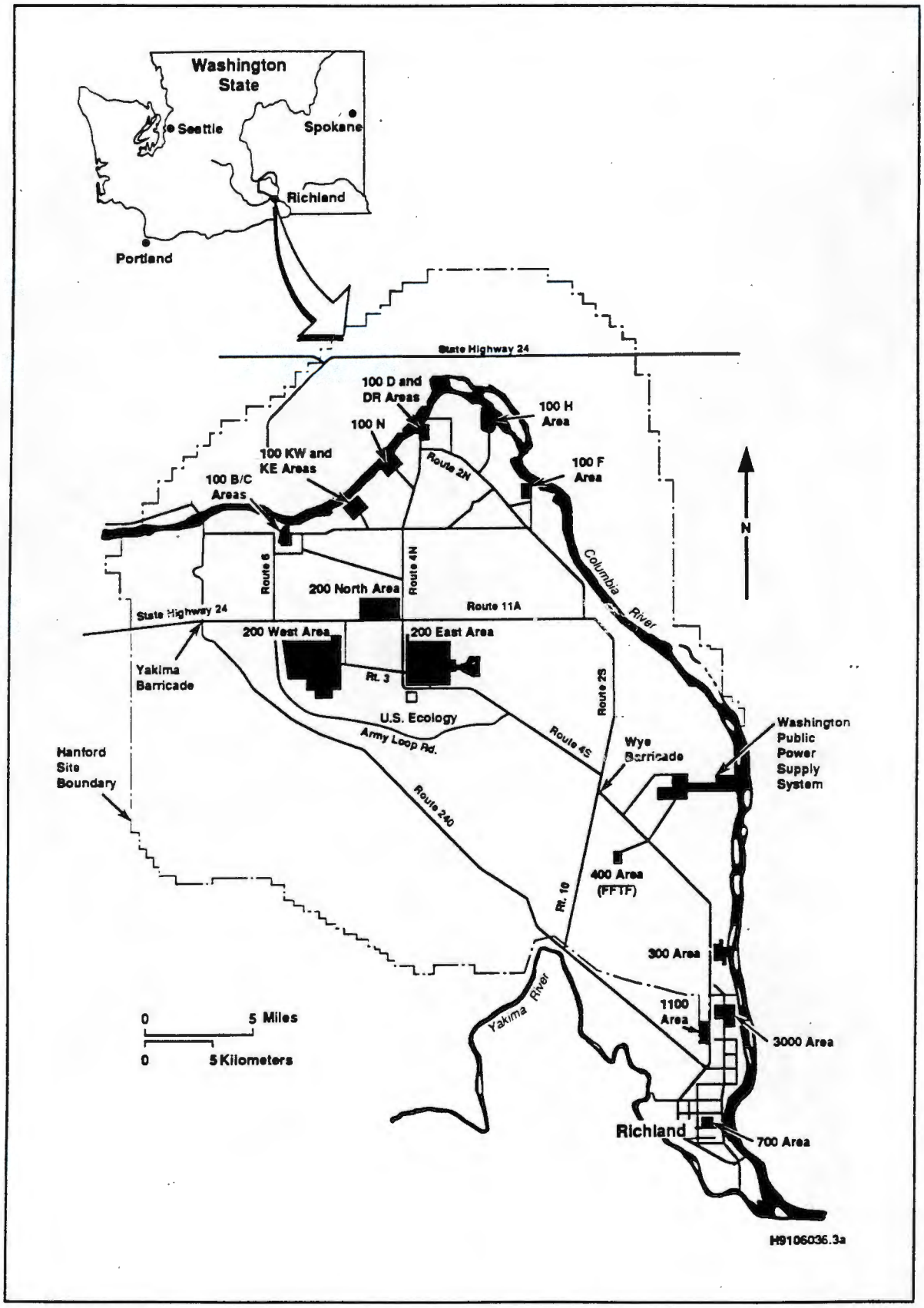

Figure 1-1. Hanford Site Map.

9 2 1 2 6 1 0 0 4 4

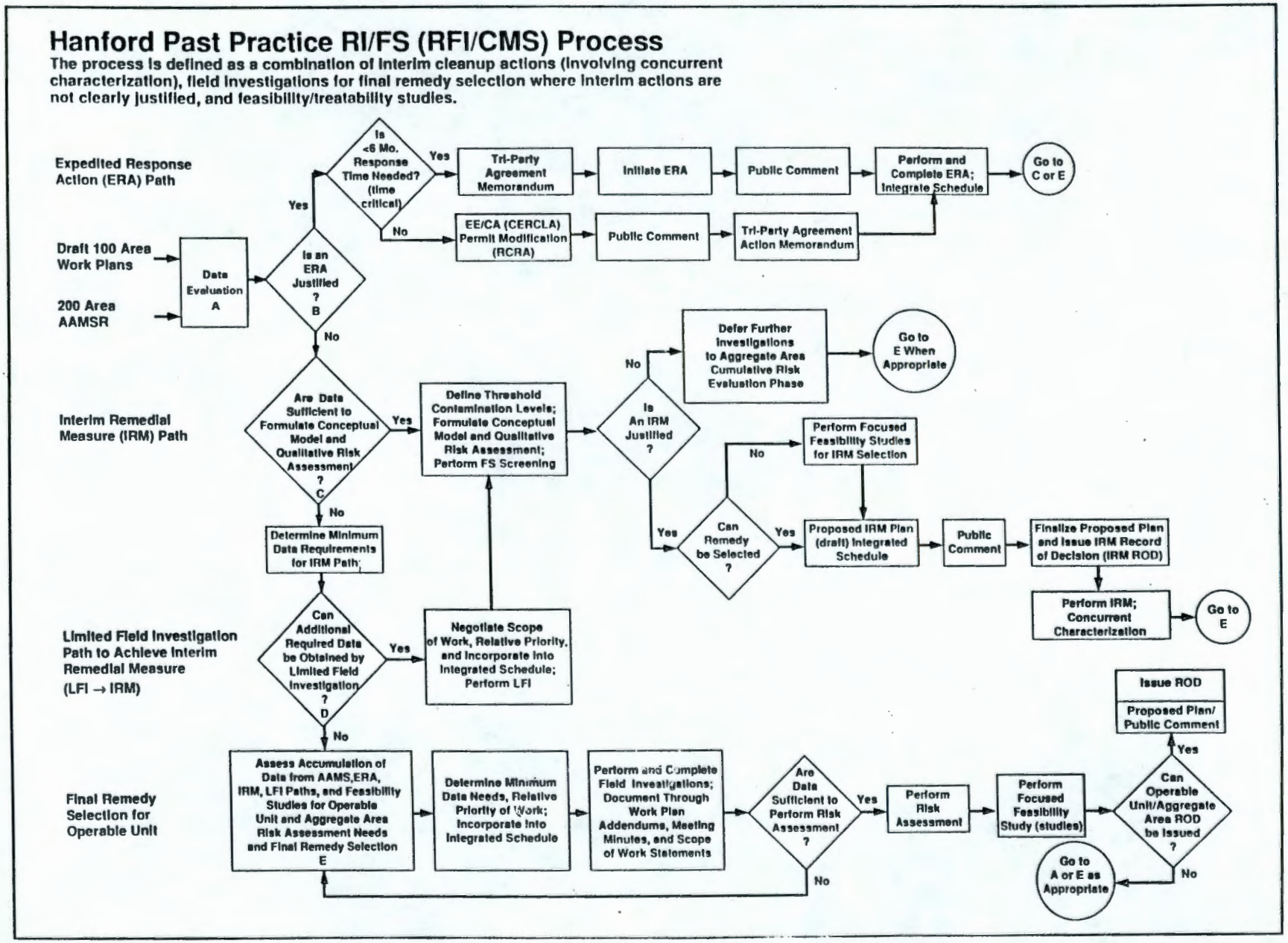

Figure 1-2. Hanford Site Past-Practice Strategy Flow Chart.

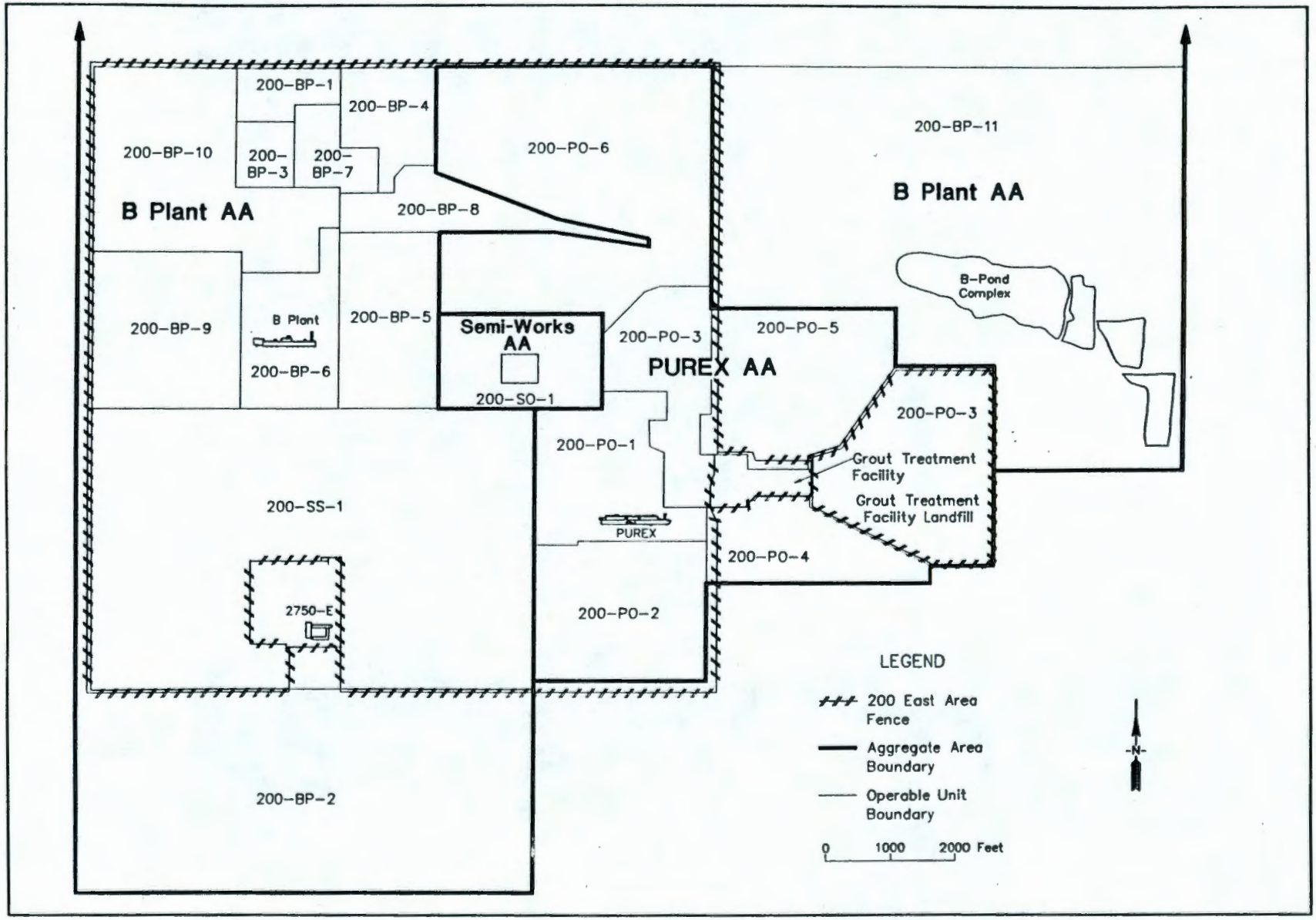

Figure 1-3. 200 East Aggregate Areas.

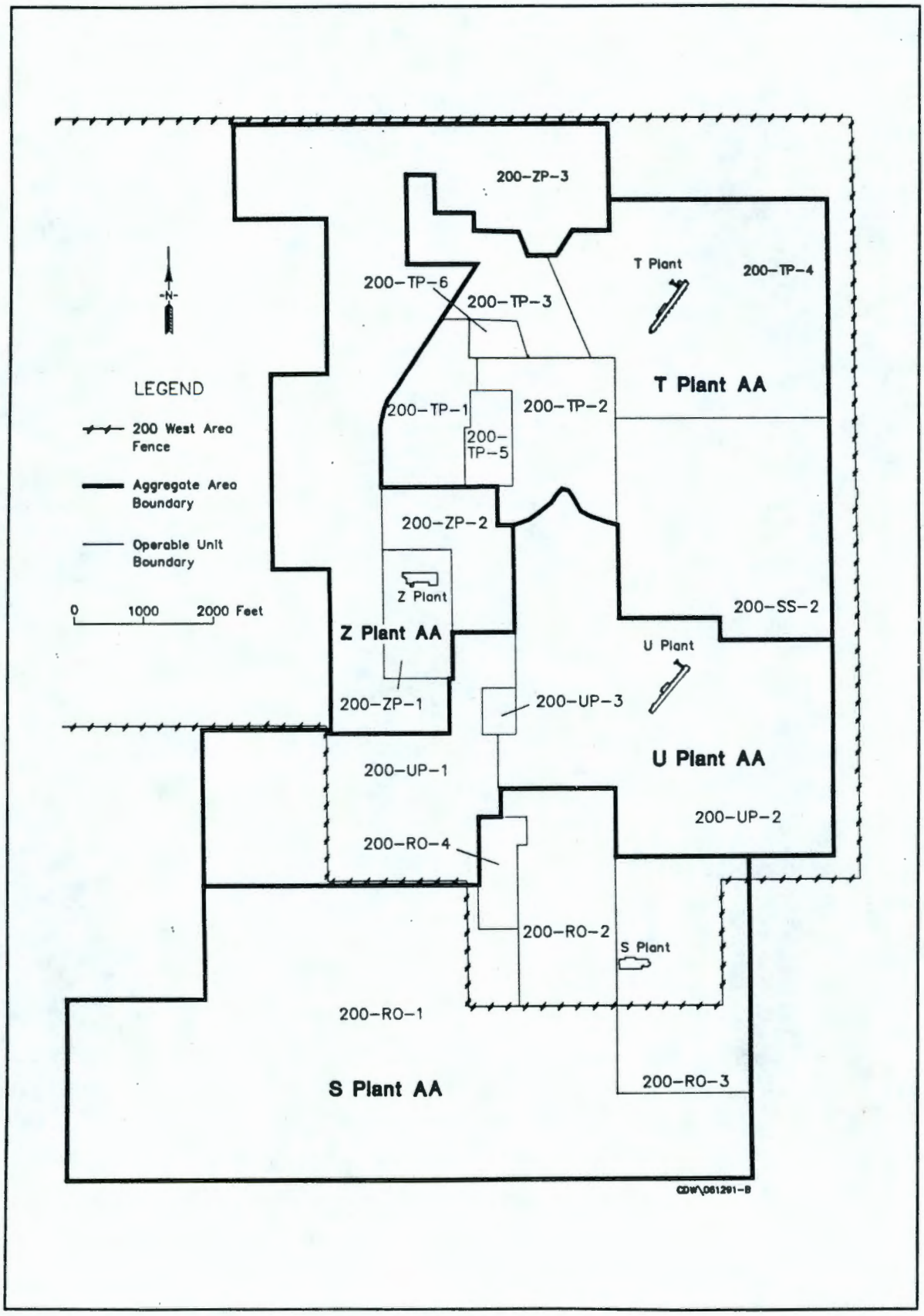

Figure 1-4. 200 West Aggregate Areas.

9 2 1 2 6 0 0 0 4 7

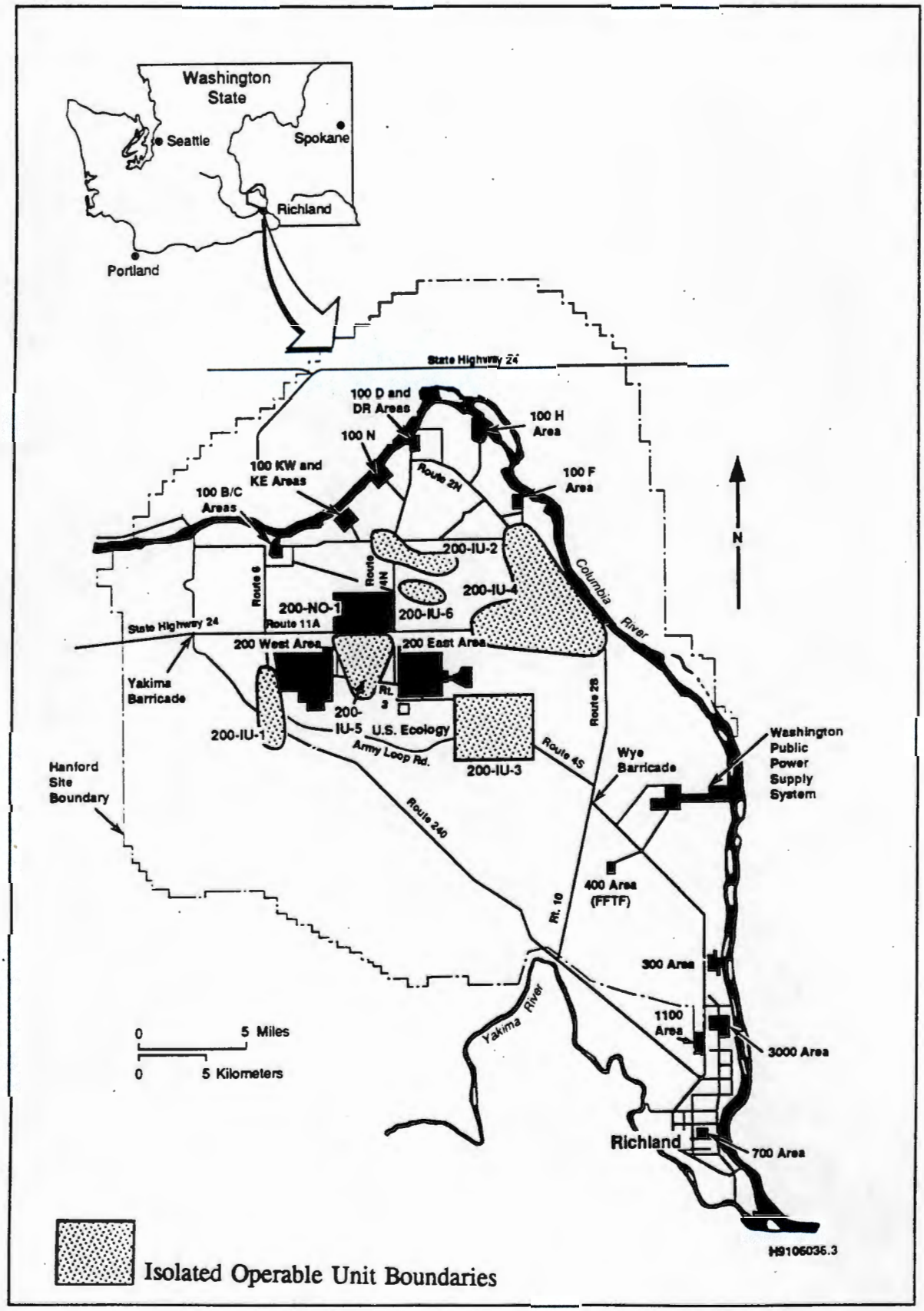

Figure 1-5. 200 NPL Site Isolated Operable Units.

Table 1-1. Overall Aggregate Area Management Study (AAMS) Schedule for the 200 NPL Site.

AAMS Title	Operable Units	AAMS Type	Lead Regulatory Agency	M-27-00 Interim Milestones
U Plant	200-UP-1 200-UP-2 200-Up-3	Source	Ecology	M-27-02, January 1992
Z Plant	200-ZP-1 200-ZP-2 200-ZP-3	Source	EPA	M-27-03, February 1992
S Plant	200-RO-1 200-RO-2 200-RO-3 200-RO-4	Source	Ecology	M-27-04, March 1992
T Plant	200-TP-1 200-TP-2 200-TP-3 200-TP-4 200-TP-5 200-TP-6 200-SS-2	Source	EPA	M-27-05, April 1992
PUREX	200-PO-1 200-PO-2 200-PO-3 200-PO-4 200-PO-5 200-PO-6	Source	Ecology	M-27-06, May 1992
B Plant	200-BP-1 200-BP-2 200-BP-3 200-BP-4 200-BP-5 200-BP-6 200-BP-7 200-BP-8 200-BP-9 200-BP-10 200-BP-11 200-IU-6 200-SS-1	Source	EPA	M-27-07, June 1992
Semi-Works	200-SO-1	Source	Ecology	M-27-08, July 1992
200 North	200-NO-1	Source	EPA	M-27-09, August 1992
200 West	NA	Ground Water	EPA/Ecology	M-27-10, September 1992
200 East	NA	Ground Water	EPA/Ecology	M-27-11, September 1992

9 2 1 2 6 1 0 0 4 9

2.0 FACILITY, PROCESS, AND OPERATIONAL HISTORY DESCRIPTION

Section 2.0 of the 200 West Groundwater Aggregate Area Management Study Report (AAMSR) presents historical data and physical descriptions of waste management units and unplanned releases that are known or may potentially impact groundwater in the four 200 West source aggregate areas, U Plant, Z Plant, S Plant, and T Plant. Detailed physical descriptions and historical data on waste sources and disposal practices are presented in the four source AAMSRs for the U Plant, Z Plant, S Plant, and T Plant Aggregate Areas. This information is summarized in this section and is generally organized by aggregate area in the order listed above. The focus of Section 2.0 is on those waste management units and unplanned releases that potentially could impact groundwater. Section 3.0 describes the environmental setting of those waste management units. Section 4.0 discusses the contaminants detected in the 200 West Area groundwater and qualitatively relates these contaminants to waste management units and unplanned releases.

Section 2.1 describes the location of the 200 West Groundwater Aggregate Area, Section 2.2 summarizes the history of operations for the four source aggregate areas, Section 2.3 describes the waste management units and unplanned releases that could potentially impact groundwater, and Section 2.4 describes the waste generating processes in the four source aggregate areas that could potentially affect groundwater quality. Section 2.5 discusses interactions with the other aggregate areas or operable units. Sections 2.6 and 2.7 discuss interactions with the Resource Conservation and Recovery Act (RCRA) and other Hanford programs. Section 2.8 describes the groundwater monitoring facilities that are currently active in the 200 West Area. Facilities, topography, and monitoring wells are shown in detail on Plates 1, 2, 3a, and 3b, respectively.

2.1 LOCATION

The Hanford Site, operated by the U.S. Department of Energy (DOE), occupies about 1,450 km^2 (560 mi^2) of the southeastern part of Washington State north of the confluence of the Yakima and Columbia Rivers (Figure 1-1). The 200 West Area is a controlled area of approximately 8.3 km^2 (3.2 mi^2) near the middle of the Hanford Site. The 200 West Area is about 8 km (5 mi) from the Columbia River and 11 km (6.8 mi) from the nearest Hanford boundary. There are 17 operable units grouped into four aggregate areas (U Plant, Z Plant, S Plant, and T Plant) in the 200 West Area (Figure 1-4). The 200 West Groundwater Aggregate Area encompasses groundwater impacted by waste disposal operations at the four source aggregate areas. Because the study addresses groundwater contamination originating from facilities in the 200 West Area, its areal extent (which is somewhat loosely defined) includes as much of the administrative "600 Area" as needed to encompass the spread of contamination (plumes) in the unconfined aquifer from the 200 West Area. Also, because of

the different focus, the areal coverage is greater than the combined area of the four source aggregate areas (U Plant, Z Plant, S Plant, and T Plant).

2.2 HISTORY OF OPERATIONS

The Hanford Site, established in 1943, was originally designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants (DOE/RL 1988). In March 1943, construction began on three reactor facilities and three chemical processing facilities. After World War II, six more reactors were built. Beginning in the 1950's, waste management, energy research and development, isotope use, and other activities were added to the Hanford operation. In early 1964, a presidential decision initiated shut down of the reactors. Eight of the reactors were shut down by 1971 (DOE/RL 1988). The one remaining N Reactor operated in steam production mode from about 1971 to 1980 for electricity production, in weapons grade material production mode from 1980 to 1987; and was placed on cold standby status in October 1989. Westinghouse Hanford was notified September 20, 1991, that they should cease preservation and proceed with ultimate decommissioning of the reactor. These activities are scoped within a N Reactor shutdown program which is scheduled to be completed in 1999.

Operations in the 200 Areas (West and East) related mainly to nuclear fuel separation. Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation. The 200 West Area consists of four main spent fuel processing areas (Figure 1-4).

- U Plant, where uranium recovery operations took place
- Z Plant, where plutonium separation and recovery operations took place
- S Plant and T Plant, where processing to separate uranium and plutonium from irradiated fuel rods took place.

The 200 Areas also contain nonradioactive support facilities, including transportation maintenance buildings, service stations, and coal-fired powerhouses for process steam production, steam transmission lines, raw water treatment plants, water storage tanks, electrical maintenance facilities, and subsurface sewage disposal systems (DOE/RL 1988).

2.2.1 U Plant Aggregate Area

The U Plant was constructed in 1944 as one of the three original chemical separation plants (B, T, and U Plants) to support plutonium production during World War II. The plants were built to extract plutonium from fuel rods irradiated in the Hanford production reactors. Each plant was equipped with the bismuth phosphate fuel-separation process. However, U Plant was never used for that purpose because B Plant and T Plant were sufficient to meet the plutonium production needs. The U Plant was used to train B and T Plant operators until 1952.

The 221-U Building is one of the primary U Plant Aggregate Area facilities. Uranium was recovered from bismuth phosphate process waste using a tributyl phosphate process between 1952 and 1958. The 221-U Building went on standby in 1958 and has not been used for fuel separations since that date. Primary waste streams from the 221-U Building include process waste and wastewater from uranium recovery that was discharged to cribs, french drains, ponds, and ditches, and spent solvents and carbonate scrub solution from solvent treatment that was discharged to cribs (Table 4-4).

The 224-U Building began operation in 1952 as a uranium reduction facility. It was converted in 1955 to support plutonium-uranium extraction (PUREX) activities. A stabilization run is scheduled for 1992. Primary waste streams from the 224-U Building include process waste and wastewater from UO_3 conversion that were discharged to ponds, cribs, and ditches (Table 4-4).

The 222-U Laboratory operated from about 1947 to 1970 and provided analytical services in support of the 221-U Building and 224-U Building operations. Primary waste streams from the laboratory included process waste, used reagents, and wastewaters that were discharged to a reverse well and french drains (Table 4-4).

2.2.2 Z Plant Aggregate Area

The Z Plant began operation in 1945 as the Plutonium Isolation Facility which concentrated plutonium nitrate solution produced by one of the separation facilities (T Plant or B Plant) and converted the concentrate to a plutonium nitrate paste for shipment to Los Alamos for further refinement. This operation took place from 1945 to 1949. Primary waste streams from the Plutonium Isolation Facility included process waste and wastewaters that were discharged to a trench, a crib, and a reverse well (Table 4-4).

In 1949, the Z Plant was converted over to producing plutonium metal. The Z Plant Complex, also referred to as the Plutonium Finishing Plant (PFP), operated from 1949 to 1973 and intermittently from 1985 to 1988. This plant processes the plutonium from the

separation facilities to a plutonium metal and/or plutonium oxide. Primary waste streams from the PFP included process waste and wastewaters that were discharged to cribs, tanks, ponds, ditches, and seepage basins (Table 4-4).

Recovery facilities also operated in the Z Plant process area. These included the RECUPLEX Facility (234-5Z Building) which operated from 1955 to 1962 and the Plutonium Reclamation Facility (PRF, 236-Z) which operated from 1964 to 1979 and from 1984 to 1987. These facilities recovered plutonium from the PFP liquid waste stream. The primary waste streams from RECUPLEX included aqueous process waste, organic solvent waste, and spent silica gel that were discharged to a ditch, a pond, a trench, and a french drain. The primary waste streams from PRF included aqueous process waste and organic process waste that were discharged to cribs and tile fields (Table 4-4). The RECUPLEX Facility was shut down after a criticality event in 1962.

A process line also had operated in the 242-Z Building from 1949 to 1959 and 1964 to 1976 to recover americium from the PFP waste stream. The primary waste stream from the americium recovery was spent ion-exchange resin that was discharged to ditches and a pond (Table 4-4). This facility shut down after an explosion in 1976 in one of the recovery units. Operations in the Z Plant are currently suspended.

An analytical laboratory has operated at Z Plant from 1955 to the present. The primary waste stream from the laboratory includes process wastes, used or discarded reagents, and wastewater that has been discharged to cribs (Table 4-4).

2.2.3 S Plant Aggregate Area

The reduction-oxidation (REDOX) or S Plant (202-S) was constructed between May 1950 and August 1951 to separate plutonium and uranium from irradiated fuel rods using a methyl isobutyl ketone (MIBK) solvent extraction process. The plant had operated from the time of its construction until July 1967, when it was shut down. The primary waste streams from S Plant were dissolution waste, aqueous process waste, and organic process waste that were discharged to tanks and cribs (Table 4-4). The associated analytical laboratory (222-S) continues to operate. The laboratory supports the B Plant operations and performs research and development in support of waste management and environmental control operations. It also serves as a backup to the PUREX and Z Plant analytical laboratories. The laboratory waste has been discharged to tanks (Table 4-4).

2.2.4 T Plant Aggregate Area

The T Plant was built in 1944 and operated as one of the first separations facilities completed at the Hanford Site. The T Plant produced a plutonium nitrate solution from irradiated fuel rods using a bismuth phosphate process. The 221-T Building (also known as the T Plant or T Canyon Building) housed the first operational, full-scale, bismuth phosphate separations facility in the world. The dilute plutonium nitrate solution generated through this process was transferred to the 224-T Bulk Reduction Building where it was purified to reduce volume using the lanthanum fluoride process. This solution was then transferred to the Z Plant Aggregate Area for further refinement. Operations in the 221-T and 224-T Buildings ceased in 1956. Primary waste streams from the 221-T and 224-T Buildings included process waste and aqueous process waste that was discharged to tanks, cribs, and trenches. Decontamination wastewater was discharged to a crib. The associated analytical laboratory which had operated from 1944 to 1956 produced aqueous process waste that was discharged to a crib (Table 4-4).

The 221-T Building, presently referred to as the Containment Systems Testing Facility (CSTFO), was used for a series of testing programs from 1964 to 1990. These programs had been managed by Pacific Northwest Laboratory (PNL) from 1964 to 1969, and by Westinghouse Hanford from 1976 to 1990. Currently, operations in the 221-T Building includes services in radioactive decontamination, reclamation, and decommissioning process equipment.

Plutonium scrap in liquid and solid forms was stored in the 224-T Building beginning in the early 1970's. The scrap was removed from the 224-T Building in 1985 (although the building was not decontaminated) when it was officially designated the Transuranic Waste Storage and Assay Facility (TRUSAF). The sealed canyon and an old sealed processing hood, and all the piping associated with the plutonium separation processing, remain entombed in the building. The TRUSAF operation consists of nondestructive assay and nondestructive examination of newly generated contact-handled transuranic (TRU) solid waste packages for general compliance with the Waste Isolation Pilot Plant Waste Acceptance Criteria requirements.

2.3 FACILITIES AND STRUCTURES POTENTIALLY IMPACTING GROUNDWATER

The 200 West Groundwater Aggregate Area contains a large variety of waste disposal and storage facilities that were associated with the operations in the four 200 West Area plants (U, Z, S, and T). High-level wastes were stored in underground tanks. Low-level wastes, such as cooling and condensate water were allowed to infiltrate into the ground through ponds, cribs, and open ditches. However, some high-level waste has been disposed

of in cribs and trenches and unplanned releases have introduced high-level waste into units that normally received low-level waste. These waste types are defined in DOE Order 5820.2:

- High-level waste is highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid that contains a combination of TRU waste and fission products in concentrations as to require permanent isolation.

- The TRU waste is radioactive waste without regard to source or form, which at the end of institutional control periods is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater that 100 nCi/g. Regarding the Waste Isolation Pilot Plant, high-level waste and spent nuclear fuel as defined by this Order are specifically excluded by this definition.

- Low-level waste is radioactive waste not classified as high-level waste, TRU waste, spent nuclear fuel, or byproduct material as defined by the Order.

A discussion and detailed description of the waste management units, and waste disposal practices are presented in the individual source AAMSRs for the four aggregate areas. Also included in those reports is a description of unplanned releases from waste disposal, transfer, or storage units in each of the four aggregate areas.

This section identifies and consolidates waste management units and unplanned releases that may potentially impact groundwater in the four 200 West source aggregate areas. The waste management units within each aggregate area are divided into categories that are consistent with each source area AAMSR. Presented below is a description of waste management unit categories and the method for evaluating the potential impact on groundwater for each waste management unit and unplanned release. Table 2-1 lists the waste management units within the four source aggregate areas. Tables 2-2 and 2-3 present information used in the screening process to evaluate impact to groundwater, with a summary of waste management unit screening presented in Table 2-4. Tables 2-5 and 2-6 present the radionuclide and chemical waste discharge inventory for these waste management units and unplanned releases. Plate 1 shows facility locations.

The waste management unit categories are defined as follows:

- **Tanks and Vaults.** Tanks and vaults store radioactive liquid wastes generated by uranium and plutonium processing activities. Several types of tanks are present in the aggregate areas including catch tanks, settling tanks, and storage tanks.

The catch tanks are generally associated with diversion boxes and other transfer units and were designed to accept overflow and spills; wastes collected in catch tanks were transferred to storage tanks. Settling tanks were used to settle particulates in liquid wastes prior to transfer to cribs. Storage tanks were used to collect and store large quantities of liquid wastes. Storage tanks include single-shell tanks and double-shell tanks, which are described in each source AAMSR.

Vaults typically are deep underground concrete structures that contain tanks as well as associated pumps, valves, and agitators. Vaults do not hold wastes themselves, rather they provide containment for other types of storage features and associated plumbing.

- **Cribs and Drains.** Cribs, drains, and drain fields were designed to percolate low-level radioactive process waste or noncontact liquid waste into the ground without exposing it to the open air. Cribs and drain fields are shallow excavations that are either backfilled with permeable material or held open by wood structures, both of which are covered with an impermeable layer. Water flows directly into the backfilled material or covered open space and percolates into the vadose zone. Drains, referred to as french drains, generally deliver wastewater at a greater depth [to depths of 12 m (40 ft)] and are constructed of steel or concrete pipes that are either open or filled with gravel. The drain diameters are less than their height and are, therefore, registered as Class V underground injection wells under the Safe Drinking Water Act.

- **Reverse Wells.** Most of the reverse wells were installed to dispose of waste liquid directly to the subsurface. The reverse wells were generally designed for disposal of low-level liquid process or laboratory wastes. Often their use was short-lived due to clogging of formation pores around the well screen. The diameter of these wells is less than the height, therefore, they are registered as underground injection wells. By 1954, all reverse wells at the Hanford Site had been removed from service (Fecht et al. 1977).

- **Ponds, Ditches, and Trenches.** Ponds were designed to percolate high volumes of low-level liquid wastewater and noncontact wastewater into the vadose zone. Ditches are long, unlined excavations used to convey wastewaters to the ponds. Several ditches often supplied wastewater to one pond. With the deactivation of a majority of the 200 West Area ponds some ditches have been converted to waste disposal facilities, [e.g., the 216-S-10D Ditch and the 216-U-14 Ditch (WHC 1990b)]. Deactivated ditches and ponds have been generally backfilled or stabilized (Stenner et al. 1988).

Trenches are generally open, unlined shallow excavations used for disposal of low-liquid discharges, such as sludge, often having a high salt content. Trenches were used generally for short periods (less than one year) and were deactivated when the discharge rate exceeded the soil infiltration rate or when the volume of the liquid waste discharge reached 10% of the soil column volume beneath the trench. Trenches were generally backfilled after use. An exception to this typical trench definition is the 216-Z-9 Trench which is essentially a crib 6.4 m (21 ft) deep with sloping walls paved with acid resistant brick and a concrete cover 36.6 x 9.2 m (120 x 30 ft).

- **Septic Tanks and Associated Drain Fields.** These structures generally received sanitary wastewater and sewage. The drain fields are similar to tile fields consisting of lengths of perforated pipe laid in excavations and covered with gravel.

- **Transfer Facilities, Diversion Boxes and Pipelines.** Liquid wastes were transferred through a system of control structures, diversion boxes, pipelines, and valve pits. These structures are enclosures either containing jumpers or valved manifolds, which enable solution transfers via pipelines between various processes and storage facilities. Diversion boxes and receiving vaults are designed to contain leaks from the transfer operation. Pipelines are not waste management units according to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). High-level waste transfer pipelines will be addressed in detail under the Hanford Surplus Facilities program. Lines associated with a liquid disposal waste management unit will be addressed along with its respective units.

- **Basins.** Retention basins are typically concrete structures (including a concrete bottom) which were used for intermittent storage of liquid wastes before transfer to ponds, ditches, and cribs.

- **Burial Sites.** Burial sites are locations for the disposal of solid wastes. These solid waste disposal facilities include caissons and various types of burial trenches. A burial ground generally consists of one or more of these solid waste disposal facilities. Caissons consist of concrete/steel chambers set below ground surface with an associated steel riser pipe through which waste packages were dropped into the caisson. Drop chutes consist of vertical steel casing or open-ended 55-gallon drums welded end to end and set vertically in an excavation. After filling with solid waste packages, the drop chutes were backfilled and capped with concrete. Burial trenches are open excavations, some with either asphalt pads or polyethylene sheet lining at the base. Solid wastes

were generally placed in 55-gallon drums or boxes, which then were set into the trench. Generally an earthen cover was placed over the burial trenches.

- **Unplanned Releases.** Unplanned releases consist of releases to the atmosphere, soil, or groundwater from the waste management units listed above. The unplanned releases of interest to the 200 West Groundwater AAMS are those releases of wastewater with sufficient volume to reach the water table. These are generally confined to leakages from the single-shell tanks.

Evaluating Potential for Releases of Contaminants to Groundwater. The following sections discuss both waste management units designed to release liquid waste to the ground and unplanned releases that may have affected groundwater. The evaluation focuses on the potential for liquid waste to reach the groundwater. Waste management units were identified as potentially contributing contaminants to groundwater based on a combination of the following criteria:

- Discharge of liquids from the waste management unit to the vadose zone

- Discharge of liquids containing radionuclide or hazardous materials from the waste management unit to the vadose zone

- Comparison between the reported volume of liquid discharged to a unit and the estimated vadose zone soil column pore volume underlying the waste management unit

- Evaluation of geophysical logs indicating movement of liquid or contaminants to the uppermost aquifer.

Another mechanism that potentially has aided downward contaminant migration is the flow of contaminated liquids down the casing of poorly sealed wells. This mechanism is suspected in some cases, but has not been quantified. While this mechanism has not been evaluated directly in this report, review of gross gamma logs should have revealed elevated levels for wells on which such flow has occurred.

The soil column pore volume calculations are analogous to the calculations in the *Expedited Response Action Proposal for the 200 West Area Carbon Tetrachloride Plume* (DOE/RL 1991a). The volume of liquid required for a wetting front to migrate downward to the water table was estimated based on the dimensions of the base of the waste management unit, conservative estimates of soil porosity, and the depth to the water table. Two soil porosities were considered: a low value (0.1) and a high value (0.3). This range of porosities should also account for drainable volumes (field capacities) for these soils. The typical depth from the bottom of the waste management unit to the water table varies across

the 200 West Area from 50 to 70 m (164 to 230 ft). A depth of 50 m (164 ft) was used in the soil column pore volume calculation. Lateral flow or potential perching of the wetting front on a less permeable layer was not considered in this calculation. If the reported volume discharged to the waste management unit exceeded the low pore space volume estimated beneath the waste management unit (assuming a 0.1 porosity), then the unit was listed as having a potential to migrate to the groundwater. This assumption is conservative because typical porosities in the Hanford soils in the vadose zone are greater than 0.2. The hydraulic conductivity of Hanford soils in the vadose zone is very low (Section 3.5.2.1.3), therefore the transit time for unsaturated flow is too long for contaminants to have reached the groundwater via unsaturated flow. In addition this approach assumes vertical flow only. It is highly probable that some lateral spreading of the wetting front would occur.

The results of this screening are presented in Table 2-2. When interpreting the results from the calculations, note that this is a simplified, one-dimensional model that neglects lateral spreading and assumes that discharged liquid is distributed evenly across the waste management unit area and that the discharge volumes in the Waste Information Data System (WIDS, WHC 1991a) are accurate. Therefore, evaluations are to be viewed as conservative approximations that nonetheless provide an estimate for the relative importance of each disposal site. In addition, Table 2-2 identifies waste management units that may have had a significant impact on groundwater flow. Units that discharged greater than 100,000 m^3 (3,531,450 ft^3) of liquid were placed in this category. The choice of 100,000 m^3 (3,531,450 ft^3) was chosen because it is, except for the ponds, one or two orders of magnitude greater than the soil column pore volume. In addition, sources of noncontaminated water (plant irrigation, water supply leaks, construction practices including water compaction of bedding and backfill soils during pipeline placement, etc.) likely contributed water to the vadose zone that may have mixed with waste and contributed to downward migration. However, this potential contribution cannot be quantified. Thus, it has been neglected in this evaluation.

Geophysical log information presented in this report is a summary of the geophysical logs reviewed for each of the four source aggregate areas. A description of the review procedure and general log quality and availability is presented in Appendix A for each AAMSR. The logs reviewed were gross gamma logs; the primary sources for these logs were Fecht et al. (1977) and periodic reports (Hanlon 1991).

The gross gamma logs for each well were compared to the geologic log to identify variabilities in the gross gamma response which could be attributed to changes in lithology. Gross gamma responses that could not be attributed to lithology were called out as possible indications of contamination. The gross gamma log evaluations are semi-quantitative due to the different log vintigages, and lack of quantitative calibration of the various scintillation probes. It is possible that some of the elevated responses are due to radionuclides sorbed to the well casing or annular material rather than radionuclides in the soil, but this would still indicate that contamination has penetrated to that depth. Liquid discharges from waste

management units were identified as potentially impacting the uppermost aquifer if an elevated gross gamma response was noted below or within 10 m (33 ft) of the water table. Elevated gross gamma response within 10 m (33 ft) of the water table should cover areas where the water table has changed elevation and areas where contaminants may have drained out of the lower vadose zone. The results of this screening are presented in Table 2-3. This screening method is limited because wells where logging can be performed are often some distance from the facility being monitored and a release to the soil, even if present, may not be detected due to shielding from intervening soil. It should be noted that failure to detect elevated gross gamma levels in monitoring wells does not disprove downward contaminant migration, as the wells may not intercept the zone through which migration may have occurred. The geophysical logs serve better as positive proof of contaminant migration.

Table 2-1 presents the waste management units that have the potential to impact the uppermost aquifer. The locations of these waste management units are shown in Plate 1. The following sections further screen the waste management units within each aggregate area using the process described in the introduction to Section 2.3. A complete description of each waste management unit is presented in the source AAMSRs. Table 2-4 presents the results of the screening process to identify waste management units that potentially impact the unconfined aquifer. Tables 2-5 and 2-6 present information found regarding the estimated quantities of contaminants discharged to these waste management units.

2.3.1 U Plant Aggregate Area

2.3.1.1 Tanks and Vaults. Tanks and vaults typically handled and stored liquid wastes generated by uranium and plutonium processing activities. One tank farm, 241-U, is part of the U Plant Aggregate Area. Unplanned releases were identified for several of these tanks including the following:

- 241-U-101 Single-Shell Tank/UPR-200-W-154
- 241-U-103 Single-Shell Tank/UPR-200-W-128
- 241-U-104 Single-Shell Tank/UPR-200-W-155
- 241-U-110 Single-Shell Tank/UPR-200-W-156
- 241-U-112 Single-Shell Tank/UPR-200-W-157.

Estimated volumes of tank releases are presented in Table 2-2. To evaluate the potential for these releases to impact groundwater using the comparison of the vadose zone pore volume to the release volume, the area over which the liquid wastes were released

needs to be identified. This information is not available for the unplanned releases from the single-shell tanks; therefore, the potential for impact to groundwater could not be evaluated using this criteria.

Gross gamma log evaluations of the 241-U Tank Farm are summarized in Table 2-3. These geophysical results do not provide evidence that contaminants have reached the groundwater.

2.3.1.2 Cribs, Drains, and Drain Fields. Eight cribs and five french drains are present in the U Plant Aggregate Area. The cribs and drains typically received intermediate and low-level waste for disposal.

The potential for the waste management units to contribute contaminants to the groundwater was evaluated based on a comparison of the waste volume discharged at each unit with the estimated pore volume in the vadose zone soil column below the waste management unit, as discussed in Section 2.3. The results of this screening are presented in Table 2-2.

In the U Plant Aggregate Area, both the 216-U-17 and 216-Z-20 Cribs are active. Waste discharge volumes to these cribs were taken from WIDS for the above calculation (WHC 1991a).

Based on this screening, the following cribs and french drains in the U Plant Aggregate Area may have contributed contaminants to the groundwater:

- 216-S-4 French Drain
- 216-S-21 Crib
- 216-U-1 and 216-U-2 Cribs
- 216-U-8 Crib
- 216-U-12 Crib
- 216-U-16 Crib
- 216-U-17 Crib
- 216-Z-20 Crib
- 216-U-3 French Drain

- 216-U-7 French Drain
- 216-U-4A French Drain
- 216-U-4B French Drain.

Gross gamma log evaluations of the cribs and drains are summarized in Table 2-3. These geophysical results do not provide evidence that contaminants have reached the groundwater from the cribs and drains.

A summary of the screening is presented in Table 2-4. An inventory of the contaminants discharged to these waste management units is presented in Tables 2-5 and 2-6.

2.3.1.3 Reverse Wells. There is only one reverse well, the 216-U-4 Reverse Well, located in the U Plant Aggregate Area. The reverse well was used to inject wastewater into the ground at a greater depth than possible with cribs or french drains. Based on the screening process presented in Table 2-2, the reverse well potentially contributed contaminants to the groundwater.

2.3.1.4 Ponds, Ditches, and Trenches. The ponds, ditches, and trenches in the U Plant Aggregate Area were designed to percolate wastewater into the ground. Until its closure in 1985, the 216-U-10 Pond was at the center of this disposal system and was fed by ditches that originated at the various waste generation facilities. In this report, the 216-U-10 Pond and the 216-U-14, 216-Z-1D, 216-Z-11 and 216-Z-19 Ditches that transferred wastewater to it are collectively called the 216-U-10 Pond System. Generally, low-level liquid waste was disposed of into the 216-U-10 Pond System. Besides the 216-U-10 Pond System, five trenches are identified in the U Plant Aggregate Area:

- 216-U-5 and 216-U-6 Trenches
- 216-U-11 Trench
- 216-U-13 Trench
- 216-U-15 Trench.

A comparison of the volume of liquid waste discharged to these waste management units with the estimated soil column pore volume underlying each unit indicates that the 216-U-10 Pond System and the 216-U-5 and 216-U-6 Trenches potentially contributed contaminants to the groundwater. The results of this screening are presented in Table 2-2.

Gross gamma log evaluations of the 216-U-14 Ditch and 216-U-10 Pond are summarized in Table 2-3. These geophysical results do not provide evidence that contaminants have reached the groundwater.

A summary of the screening process is presented in Table 2-4. The inventory of wastes discharged to 216-U-10 Pond is presented in Tables 2-5 and 2-6.

2.3.1.5 Septic Tanks and Associated Drain Fields. Four septic tanks and their associated drain fields are identified for the U Plant Aggregate Area. The septic tanks accept sanitary wastewater and sewage for discharge. The tanks include the following:

- 2607-W-5 Septic Tank/Drain Field
- 2607-W-7 Septic Tank/Drain Field
- 2607-W-9 Septic Tank/Drain Field
- 2607-WUT Septic Tank/Drain Field.

The septic tanks apparently have contributed a significant volume of water to the aquifer, based on the volumes indicated in Table 2-2. However, chemical and radionuclide contaminants are not known to be associated with this effluent, so the potential for contributing these contaminants to the groundwater likely does not exist. It is possible that these discharges can be interacting in the vadose zone with discharges from other facilities, which could mobilize contaminants from those facilities. As indicated in Table 2-2, disposal via septic tanks probably affects the water table and groundwater flow.

2.3.1.6 Transfer Facilities, Diversion Boxes, and Pipelines. Catch tanks were designed to collect releases from transfer facilities, diversion boxes, and pipelines. Some introduction of waste to the soil likely occurred from these facilities; however, any unplanned releases are considered to have been small and of insufficient volume to migrate to the water table. Therefore, no releases to the groundwater apparently occurred from these facilities.

2.3.1.7 Basins. The 207-U Retention Basin is the only basin within the U Plant Aggregate Area. It consists of two concrete-lined, open, settling ponds where wastewater was held before overflowing into a ditch. While the concrete liners of the basin may have leaked some quantity of wastewater to the soil, such lost fluid has been attributed to the nearby waste management unit (ditch) to which the water was discharged and, thus, has been accounted for. Therefore, no discharge of effluent to the soil is reported for the basin.

2.3.1.8 Burial Sites. There are two identified solid waste burial sites in the U Plant Aggregate Area: the Construction Surface Laydown Area and the Burial Ground/Burning

Pit. No liquids were disposed of at either site, neither had chemical contaminants, and only the Burial Ground/Burning Pit had radioactive contaminants. Thus, no apparent potential exists for either unit to contribute contaminants to the groundwater.

2.3.1.9 Unplanned Releases. Thirty-two unplanned releases are included in the U Plant Aggregate Area. Unplanned releases associated with tanks are listed in Section 2.3.1.1. Other unplanned releases are of small scale and are unlikely to have a potential impact on groundwater. Known unplanned releases are summarized in Section 2.0 of the U Plant AAMSR.

2.3.2 Z Plant Aggregate Area

2.3.2.1 Tanks and Vaults. Three liquid waste holding (settling and treatment) tanks were identified within the Z Plant Aggregate Area (WHC 1991a). These include the following:

- 216-Z-8 Settling Tank
- 241-Z-361 Settling Tank
- 241-Z Treatment Tank.

No vaults were identified in the Z Plant Aggregate Area.

Although hazardous materials and radionuclides were associated with these tanks, no unplanned releases are documented. Therefore, these waste management units are not considered to potentially contribute contaminants or impact groundwater. No monitoring wells were located in the immediate vicinity of these tanks. Therefore, gross gamma logs were not reviewed for these waste management units.

2.3.2.2 Cribs, Drains, and Tile Fields. Nine cribs, four french drains, and one tile field were identified within the Z Plant Aggregate Area (WHC 1991a). No reported discharges of hazardous materials or radionuclides were reported for three of the french drains (216-Z-13, 216-Z-14, 216-Z-15). However, because of accidents or unusual events in the process areas, Owens (1981) reported that low-level contamination can be assumed. These three french drains are currently active. Information on the volume of liquids discharged to these units is not available; therefore, these units may contribute water to the unconfined aquifer, but this aspect could not be evaluated with the current data.

Discharge of liquid effluent containing radionuclides and hazardous materials was reported for the remaining french drain (216-Z-8), cribs, and tile field. The potential for these waste discharge units to contribute contaminants to the groundwater was evaluated

based on the waste volume discharged at each unit and the estimated pore volume in the vadose zone soil column below the waste management unit, as discussed previously. The results of this screening are presented in Table 2-2.

Based on this screening the following cribs, french drains, and tile fields potentially contributed contaminants to groundwater:

- 216-Z-1 and 216-Z-2 Cribs
- 216-Z-3 Crib
- 216-Z-5 Crib
- 216-Z-7 Crib
- 216-Z-12 Crib
- 216-Z-8 French Drain
- 216-Z-1A Tile Field
- 216-Z-16 Crib
- 216-Z-18 Crib.

Gross gamma log results were reviewed for the Z Plant Aggregate Area cribs and drains. The results of this review are presented in Table 2-3. The gross gamma logs support the potential for impact to the unconfined aquifer from the 216-Z-7 Crib as indicated in Well 299-W15-7. An elevated gross gamma response was observed in this well at depths between 7 and 100 m (23 and 328 ft), which extends below the water table. Gross gamma log results also indicate a potential for migration to groundwater from the 216-Z-5 Crib. Measurements at Well 299-W-15-1 show an elevated gross gamma response to a depth of 63 m (207 ft), approximately 10 m (33 ft) below the water table. Gross gamma results for several of the remaining cribs and drains indicate the presence of gamma-emitting radionuclides in the vadose zone but at depths above the water table.

A summary of the screening is presented in Table 2-4. An inventory of the radionuclides and chemicals discharged to the waste management units that potentially impact groundwater is presented in Tables 2-5 and 2-6.

2.3.2.3 Reverse Well. One reverse well, the 216-Z-10 Reverse Well, was identified (WHC 1991a) in the Z Plant AAMSR. Brown and Ruppert (1948) reported that this well received

about 1,000,000 L (264,200 gal) of TRU-contaminated process waste at a rate of 75 L/min (20 gal/min).

Table 2-2 presents the screening process results for the reverse well based on the pore volume of the vadose zone soil column from the bottom of the well [50 m (164 ft)] to the water table. The available soil column pore volume is three orders of magnitude less than the volume of waste discharged to the well. Therefore, based on volume and rate of discharge and pore volume calculations, this reverse well potentially contributed contaminants to the groundwater. The contaminant inventory of the waste stream disposed to this well is presented in Tables 2-5 and 2-6.

Four monitoring wells are in the vicinity of the 216-Z-10 Reverse Well. However, a gross gamma survey has not been conducted in the wells, and consequently gross gamma logs were not available for review.

2.3.2.4 Trenches. Three trenches were identified in the Z Plant Aggregate Area (WHC 1991a). Waste inventories from these three trenches indicate that radionuclides and hazardous materials were discharged to these three waste management units. A comparison of the volume of liquid waste discharged with the vadose zone soil column pore volume underlying the waste management unit identified two trenches, 216-Z-9 and 216-Z-17, as potentially contributing contaminants to the uppermost aquifer (Table 2-2).

Gross gamma logs were only available for the 216-Z-9 Trench. The results of this evaluation are summarized in Table 2-3. The results do not provide evidence that gamma emitters have reached the groundwater from the trench.

A summary of the screening is presented in Table 2-4. The inventory of wastes discharged to the two trenches potentially contributing contaminants to groundwater is shown in Tables 2-5 and 2-6.

2.3.2.5 Septic Tanks and Associated Drain Fields. Five septic tanks and associated drain fields were identified in the Z Plant Aggregate Area (WHC 1991a). These are as follows:

- 2607-Z Septic Tank/Drain Field
- 2607-Z-1 Septic Tank/Drain Field
- 2607-WA Septic Tank/Drain Field
- 2607-WB Septic Tank/Drain Field
- 2607-W-8 Septic Tank/Drain Field.

No radionuclides or hazardous chemicals are associated with these waste management units. Therefore, they are not considered potential contributors of contaminants to groundwater. However, the 2607-Z Septic Tank has potentially affected the groundwater flow, as indicated in Table 2-2.

2.3.2.6 Transfer Facilities, Diversion Boxes, and Pipelines. Diversion boxes and sumps house the switching facilities where wastes can be routed from one process line to another. Two diversion boxes and one sump were identified in the Z Plant Aggregate Area:

- 241-Z Diversion Box No. 1
- 241-Z Diversion Box No. 2
- 231-Z-151 Sump.

A release to the soil from the diversion boxes or sump is reported as an unplanned release. One unplanned release was reported near the 231-Z-151 Sump. This release involved a leaking process line from the 231-Z Building. The WIDS indicate that the contamination from the release was limited to the soil around the waste line; the release volume was not reported (WHC 1991a). The waste line was repaired and covered with 15 cm (6 in.) of clean soil. Data were insufficient to determine if this release could potentially impact groundwater. However, based on the information available the potential for impact is low.

2.3.2.7 Basins. Two seepage basins were identified within the Z Plant Aggregate Area. These are as follows:

- 207-Z Retention Basin
- 216-Z-21 Seepage Basin.

The 207-Z Retention Basin received liquid wastes containing hazardous chemicals and radionuclides. However, no reported releases to the soil column were associated with this basin. Therefore, this waste management unit is not considered a potential source of contaminants to the groundwater.

The 216-Z-21 Seepage Basin was constructed in the 1980's for discharge of noncontact condensate from the 234-5Z heating, ventilation, and air conditioning (HVAC) system and stormwater runoff. This basin was constructed to alleviate backup of the 216-Z-20 Crib. No reports were found to indicate that radionuclides or hazardous materials were released to this crib. Therefore, it is not considered a potential source of contaminants to the groundwater. However, a comparison of the vadose zone pore volume underlying the seepage basin with

an estimated annual discharge to the basin of 1 x 10^8 L (2.6 x 10^7 gal) indicates that discharge from this seepage basin could migrate to the water table (Table 2-2). Therefore, this recharge could contribute water to and affect the groundwater flow regime, and could also remobilize contamination (such as carbon tetrachloride from 216-Z-9) from the vadose zone to the groundwater.

Gross gamma logs were not available for wells in the vicinity of the 207-Z Retention Basin or the 216-Z-21 Seepage Basin.

2.3.2.8 Burial Sites. The Z Plant Aggregate Area solid waste burial grounds were established independent of the main Z Plant process facilities and have operated from about 1944 to the present. The burial grounds receive solid waste from facilities throughout the Hanford Site. The solid waste disposal facilities include caissons, drop chutes, and various types of burial trenches. Caissons consist of concrete/steel chambers set below the ground surface with an associated steel riser pipe through which waste packages were dropped into the caisson. Drop chutes consist of vertical steel casing or open-ended 55-gallon drums, welded end-to-end and set vertically in the excavation. After filling with solid waste packages, the drop chutes were backfilled and capped with concrete.

Wastes disposed of in the burial grounds were limited to solid waste. Therefore, the only potential driving force for migration of contaminants from the burial grounds is natural recharge, which in the 200 West Area is low (see Section 3.5.2.1). The current potential for contribution of contaminants to the uppermost aquifer from these units is considered low.

Gross gamma logs are available for wells in the vicinity of the 218-W-3A, 218-W-3AE, 218-W-4A, 218-W-4B, 218-W-4C, 218-W-5, 218-W-6, and 218-W-11 Burial Grounds. With the exception of one gross gamma log in the vicinity of the 218-W-4C Burial Ground the logs show a natural response to the lithologic unit. Well 299-W15-18 in the northern portion of the 218-W-4C Burial Ground showed a slightly elevated response at depths between 55 and 58 m (180 and 190 ft) which is below the water table. It is possible that this elevated response is related to contaminants in the groundwater rather than an indication of migration from the burial grounds.

2.3.2.9 Unplanned Releases. Unplanned releases reported in the Z Plant Aggregate Area were confined to shallow surface spills. Many of these spills were remediated by either removing the affected soil or covering the spill area with uncontaminated fill material. Based on the low natural recharge rates in the 200 West Area, the potential for unplanned releases in the Z Plant Aggregate Area to contribute contaminants to the uppermost aquifer is low.

2.3.3 S Plant Aggregate Area

2.3.3.1 Tanks and Vaults. There are 27 single-shell tanks within the S Plant Aggregate Area, along with 3 double-shell tanks and 4 catch tanks. The 241-S Tank Farm houses 12 single-shell tanks and the 241-SX Tank Farm houses 15 single-shell tanks (Table 2-1). The focus of the 200 West Groundwater AAMSR is on the waste management units that potentially contribute contaminants to the groundwater. Because the single-shell tanks were designed as storage facilities, the focus is on the unplanned releases from the 241-S and 241-SX Tank Farms. The 241-SY double-shell tanks are not known to have leaked to the environment. The single-shell tanks with reported unplanned releases and the associated unplanned release designation are presented below along with tanks that are assumed or confirmed leakers:

- 241-S-104
- 241-SX-104
- 241-SX-107/UPR-200-W-140
- 241-SX-108/UPR-200-W-141
- 241-SX-109/UPR-200-W-142
- 241-SX-110
- 241-SX-111/UPR-200-W-143
- 241-SX-112/UPR-200-W-144
- 241-SX-113/UPR-200-W-145
- 241-SX-114
- 241-SX-115/UPR-200-W-146.

Unplanned releases UPR-200-W-140 through UPR-200-W-146 were related to leaks from single-shell tanks. The volume of the liquid discharged from the tanks has been estimated (WHC 1991a; Table 2-1); however, the areal size of the tank leaks is not known. Therefore, the comparison between the vadose zone pore volume and the liquid discharged to evaluate the potential for migration to the uppermost aquifer cannot be performed for these unplanned releases.

Gross gamma logs of monitoring wells near these tanks were evaluated for the tanks associated with the unplanned releases. The results of this evaluation are summarized in Table 2-3. The results do not provide evidence that gamma emitters have reached the groundwater from the tanks.

2.3.3.2 Cribs and Drains. Thirteen cribs and one french drain were identified within the S Plant Aggregate Area. There are reports of radionuclides and hazardous materials in the liquid discharged to these 14 waste management units. The potential for these waste discharge units to contribute contaminants to the groundwater was evaluated based on a comparison of the waste volume discharged at each unit with the estimated pore volume in the vadose zone soil column below the waste management unit, as discussed in the introduction to Section 2.3.

The results of this screening are presented in Table 2-2. Based on this screening the following waste management units may have contributed contaminants to the uppermost aquifer:

- Sanitary Crib
- 216-S-1 and 216-S-2 Cribs
- 216-S-5 Crib
- 216-S-6 Crib
- 216-S-7 Crib
- 216-S-9 Crib
- 216-S-13 Crib
- 216-S-20 Crib
- 216-S-23 Crib
- 216-S-25 Crib
- 216 S-26 Crib
- 216 S-3 French Drain.

Available gross gamma logs were reviewed to further evaluate the potential of migration of liquid discharges in cribs and drains to the uppermost aquifer. A summary of this evaluation is presented in Table 2-3. Based on this review, four cribs--216-S-1, 216-S-2, 216-S-7, and 216-S-9, have a potential for migration of gamma-emitting contaminants from the crib to the uppermost aquifer. Elevated gamma responses through the vadose zone to below the water table were detected in monitoring wells in the vicinity of all four of these cribs.

A summary of the screening is presented in Table 2-4. The waste inventory for these waste management units is presented in Tables 2-5 and 2-6.

2.3.3.3 Reverse Wells. No reverse wells were identified within the S Plant Aggregate Area.

2.3.3.4 Ponds, Ditches, and Trenches. Six ponds, three ditches, and four trenches were identified in the S Plant Aggregate Area. Low-level liquid wastes containing hazardous materials and/or radionuclides were discharged to these waste management units. The same criteria were used to evaluate the potential for migration of liquid wastewater to the uppermost aquifer from the ponds, ditches, and trenches. However, the comparison between the vadose zone pore volume and the volume of liquid discharges has additional limitations when applied to the ponds and ditches. This calculation assumes that the bottom of the waste discharge unit is the area available for infiltration of the liquid discharge. The bottoms of ponds are generally concave, i.e., deeper in the center. Therefore, the infiltration area increases with an increase in the volume of liquid discharged. As a result, using the total area of the pond as the infiltration area may not be an accurate assumption. However, as shown in Table 2-2, with the exception of the 216-S-10P and 216-S-15 Ponds, the volumes of liquid discharged to the ponds exceeded the vadose zone pore volume by two to three orders of magnitude.

Because only a portion of the volume of low-level liquid waste discharged to a ditch infiltrated through the bottom of the ditch, it is uncertain whether a ditch exceeds its soil column pore volume. Table 2-2 makes the conservative assumption that soil column pore volume for a ditch was exceeded.

The ponds, ditches, and trenches were evaluated for the potential migration of contaminants to the unconfined aquifer by comparing the vadose zone soil column pore volume to the volume of liquid wastes discharged. Based on this screening the following waste management units may have been potential sources of contaminants to the unconfined aquifer:

- 216-S-11 Pond

- 216-S-16P Pond
- 216-S-17 Pond
- 216-S-19 Pond
- 216-S-10D Ditch
- 216-S-16D Ditch
- 216-S-8 Trench.

Available gross gamma logs were reviewed for the S Plant Aggregate Area pond, ditches, and trenches. The results of this review are presented in Table 2-3. Gross gamma logs were available for four of these waste management units: 216-S-10P Pond, 216-S-11 Pond, 216-S-8 Trench, and 216-S-10D Ditch. The gross gamma responses observed for wells in the vicinity of these units are associated with stratigraphic and moisture content variations and do not indicate the presence of gamma-emitting contaminants in the soil column. The results of gross gamma log interpretations are presented in Table 2-3.

The waste inventory for the seven waste management units that screened positive in the vadose zone soil column versus liquid discharge screening (Table 2-4) is presented in Tables 2-5 and 2-6.

2.3.3.5 Septic Tanks and Associated Drain Fields. Two septic tanks or drain fields were identified within the S Plant Aggregate Area, the 2607 Septic Tank and Tile Field and the 2607 WZ Septic Tank. The area over which the septic tanks discharged waste was not known so the soil column pore volume range could not be determined. However, if these two units have been receiving liquid waste at the rate reported by WIDS (WHC 1991a) throughout their use, they have discharged enough waste to potentially have had a significant impact on the local groundwater.

2.3.3.6 Transfer Facilities, Diversion Boxes, and Pipelines. Control structures, diversion boxes, and valve pits are most often concrete structures that were designed to contain leaks from transfer and drainage operations. Therefore, potential migration of contaminants from these structures to the uppermost aquifer may occur through unplanned releases. Unplanned releases associated with these structures in the S Plant Aggregate Area were small generally affecting surface soil. Therefore, the potential for impact of groundwater quality from these releases is low.

Two unplanned releases (UPR-200-W-108 and UPR-200-W-109) occurred in a pipeline that connects the 216-S-9 and 216-S-23 Cribs. These unplanned releases represent two

separate leaks discovered in these lines. It was not known how long this line had been leaking or the volume of liquid discharged through the leaks (WHC 1991a). However, enough liquid was discharged to be observed bubbling to the surface. Liquid discharged during these two unplanned releases potentially migrated to the uppermost aquifer. Low-level discharge to the 216-S-9 Crib was also identified as potentially contributing contaminants to the uppermost aquifer. The volume of low-level liquid discharge contributed by unplanned releases UPR-200-W-108 and UPR-200-W-109 is probably significantly less than the volume contributed by the 216-S-9 and 216-S-23 Cribs.

2.3.3.7 Basins. Two basins were identified as waste management units in the S Plant Aggregate Area. These are the following:

- 207-S Retention Basin
- 207-SL Retention Basin.

Liquid discharges containing radionuclides and/or hazardous material were released to these basins. However, no reports of releases from the basins to the soil column were found. Therefore, these basins are not considered potential sources of contaminants to the uppermost aquifer. Gross gamma logs are not available for wells in the vicinity of these two basins.

2.3.3.8 Burial Sites. The S Plant solid waste burial grounds 218-W-7 and 218-W-9 consisted of shallow trenches where low-level radioactive, TRU, and radioactive-mixed solid wastes were stored or disposed of since 1944 (Last et al. 1989). The shallow trenches were covered with soil after deposition of waste.

Wastes disposed of in the burial grounds were limited to solid waste. Therefore, the only potential driving force for migration of contaminants from the burial grounds is natural recharge, which in the 200 West Area is low (see Section 3.5.2.1). The current potential for contribution of contaminants to the uppermost aquifer from these units is considered low.

2.3.3.9 Unplanned Releases. Forty-six unplanned releases were documented in the S Plant Aggregate Area (WHC 1991a). A majority of the unplanned releases were low-volume surface spills and releases of radiation by wind and water, sometimes in the form of snow melt. The nine unplanned releases that could potentially impact the uppermost aquifer include the following:

- UPR-200-W-108
- UPR-200-W-109

- UPR-200-W-140
- UPR-200-W-141
- UPR-200-W-142
- UPR-200-W-143
- UPA-200-W-144
- UPR-200-W-145
- UPR-200-W-146.

These unplanned releases were discussed earlier. Unplanned releases UPR-200-W-108 and -109 were discussed in Section 2.3.3.6 and UPR-200-W-140 through -146 were discussed in Section 2.3.3.1. In addition, contamination of the 216-S-17 Pond and the 207-S Basin is reported for the period of 1951 to 1953. Several equipment failures during this period resulted in excessive contamination of the pond and basin (DOE/RL 1991c). Clean soil was spread over 216-S-17 Pond in 1954.

2.3.4 T Plant Aggregate Area

2.3.4.1 Tanks and Vaults. The T Plant Aggregate Area has three tank farms: 241-T Tank Farm, 241-TX Tank Farm, and 241-TY Tank Farm. The tank farms typically have handled and stored liquid wastes generated by uranium and plutonium processing activities. A total of 46 tanks are present within the T Plant Aggregate Area. Tanks that have confirmed leaks or are assumed leakers include the following:

- 241-T-101 Single-Shell Tank
- 241-T-103 Single-Shell Tank/UPR-200-W-147
- 241-T-105 Single-Shell Tank
- 241-T-106 Single-Shell Tank/UPR-200-W-148
- 241-T-107 Single-Shell Tank
- 241-T-108 Single-Shell Tank

- 241-T-109 Single-Shell Tank
- 241-T-111 Single-Shell Tank
- 241-TX-105 Single-Shell Tank
- 241-TX-107 Single-Shell Tank/UPR-200-W-149
- 241-TX-110 Single-Shell Tank
- 241-TX-113 Single-Shell Tank/UPR-200-W-129
- 241-TX-114 Single-Shell Tank
- 241-TX-115 Single-Shell Tank
- 241-TX-116 Single-Shell Tank
- 241-TX-117 Single-Shell Tank
- 241-TY-101 Single-Shell Tank
- 241-TY-103 Single-Shell Tank/UPR-200-W-150
- 241-TY-104 Single-Shell Tank/UPR-200-W-151
- 241-TY-105 Single-Shell Tank/UPR-200-W-152
- 241-TY-106 Single-Shell Tank/UPR-200-W-153.

Because the leaks are apparently from point sources rather than from some specified surface area, no evaluation was possible for the potential of the releases to contribute contaminants to the groundwater. Estimated volumes of releases from seven of the tanks are presented in Table 2-2.

The gross gamma logging does not confirm that any of the T Plant tank releases have contributed contaminants to groundwater. Results of logging are presented in Table 2-3.

2.3.4.2 Cribs, Drains, and Drain Fields. Fifteen cribs, two of which have associated tile fields, are present at the T Plant Aggregate Area as well as a single french drain. The cribs and drains typically received intermediate and low-level waste for disposal.

The potential for the waste management units to contribute contaminants to the groundwater was evaluated based on the waste volume discharged at each unit and the estimated pore volume in the vadose zone soil column below the waste management unit, as discussed previously. The results of this screening are presented in Table 2-2.

Based on this screening, the following cribs potentially contributed contaminants to groundwater:

- 216-T-6 Crib
- 216-T-7TF Crib and Tile Field
- 216-T-8 Crib
- 216-T-18 Crib
- 216-T-19TF Crib and Tile Field
- 216-T-26 Crib
- 216-T-27 Crib
- 216-T-28 Crib
- 216-T-32 Crib
- 216-T-33 Crib
- 216-T-34 Crib
- 216-T-35 Crib
- 216-W-LWC Crib.

The potential for the 216-T-31 French Drain to have contributed contaminants to the groundwater could not be determined because the volume of liquid discharged to this unit is not known.

Available gross gamma logs for waste management units potentially contributing contaminants to groundwater (Table 2-3) were reviewed. Based on the gross gamma log screening, the following cribs show evidence of having released contaminants to the groundwater:

9 2 1 2 5 1 0 0 7 6

- 216-T-7TF Crib and Tile Field
- 216-T-26 Crib
- 216-T-27 Crib
- 216-T-28 Crib.

A summary of the screening by soil pore capacity and gross gamma logs is presented in Table 2-4. An inventory of the contaminants discharged to these waste management units is presented in Tables 2-5 and 2-6.

2.3.4.3 Reverse Wells. Two reverse wells are present in the T Plant Aggregate Area: the 216-T-2 Reverse Well and the 216-T-3 Reverse Well. The reverse wells were used to inject wastewater primarily from laboratories into the ground at a greater depth than possible with cribs or french drains. Based on the screening presented in Table 2-2, the reverse wells potentially contributed contaminants to the groundwater. A review of gross gamma logs from a well adjacent to the 216-T-3 Reverse Well indicates contaminant peaks at depths of 3 to 7 m (10 to 23 ft), 13 to 22 m (43 to 71 ft), and 30 to 37 m (98 to 123 ft, Table 2-3). There is no evidence of significant radioactive contamination of the aquifer in gamma scintillation profiles of Monitoring Well 299-W11-07, although it is known that radioactive wastes were discharged into the soil just above the groundwater at this site (Fecht et al. 1977).

2.3.4.4 Ponds, Ditches, and Trenches. The T Plant Aggregate Area includes three ponds, three ditches, and sixteen trenches. These units were designed to percolate wastewater into the ground. Two of the three ponds are currently active.

As noted in Tables 2-1 and 2-2, the liquid volume received by the 216-T-4B Pond, 216-T-1 Ditch, 216-T-4-1D Ditch, and 216-T-4-2 Ditch is not known, therefore, the potential for these units to have impacted the groundwater is not known.

Based on a comparison of the waste volume received by the ponds, ditches and trenches (Table 2-2), the following potentially contributed contaminants to groundwater:

- 216-T-4A Pond
- 200-W Powerhouse Pond
- 216-T-5 Trench
- 216-T-12 Trench

- 216-T-22 Trench
- 216-T-23 Trench
- 216-T-24 Trench
- 216-T-25 Trench.

Gross gamma logs were reviewed in the T Plant AAMSR for the trenches. The gross gamma logging does not provide evidence that the trenches contributed contaminants to groundwater.

A summary of the screening by soil pore capacity and gross gamma logs is presented in Table 2-4, with an inventory of waste discharged to these units presented in Tables 2-5 and 2-6.

2.3.4.5 Septic Tanks and Associated Drain Fields. Six septic tanks and their associated drain fields are identified for the T Plant Aggregate Area. The septic tanks accept sanitary wastewater and sewage for disposal.

The waste management units apparently have contributed a significant volume of water to the unconfined aquifer, based on the volumes indicated in Table 2-2. However, contaminants are not known to be associated with this effluent, so the potential for contributing contaminants to the groundwater likely does not exist.

2.3.4.6 Transfer Facilities, Diversion Boxes, and Pipelines. Catch tanks were designed to collect releases from transfer facilities, diversion boxes, and pipelines. The volume and area of the unplanned releases associated with these units are not quantified. It is therefore not possible to evaluate the potential of these units to have contributed contaminants to the groundwater.

2.3.4.7 Basins. Basins are waste management units that provide temporary storage for either solid or liquid wastes. The active 207-T Retention Basin is the only basin for liquids in the T Plant Aggregate Area, while the 200-W Ash Disposal Basin and the 200-W Powerhouse Ash Pit are actively used for storage of solid wastes. The 207-T Retention Basin is an active concrete-lined settling pond where wastewater is held before disposal. No reports of releases from the basins to the soil column were found, therefore, the basins are not considered potential sources of contaminants to groundwater.

2.3.4.8 Burial Sites. Two burial sites are located in the T Plant Aggregate Area: the 200-W Burning Pit and 218-W-8 Burial Vault. Neither site has accepted liquid wastes and no apparent discharge of effluent to the soil is reported for these waste management units.

9 2 1 2 6 . 1 0 0 7 8

2.3.4.9 Unplanned Releases. Forty-five unplanned releases are included in the T Plant Aggregate Area. Unplanned releases associated with tanks are included in Section 2.3.4.1. Other unplanned releases are of small scale and are unlikely to have a potential impact on groundwater.

2.4 WASTE GENERATING PROCESSES THAT POTENTIALLY AFFECT GROUNDWATER QUALITY

Operations in the 200 West Area have been related mainly to nuclear fuel separation. Each of these operations generated liquid waste. The following sections briefly describe the waste generating processes and associated waste streams for each of the four 200 West Aggregate Areas. Greater details can be found in the appropriate AAMSR.

2.4.1 U Plant Aggregate Area

The primary waste generating processes in the U Plant Aggregate Area are associated with the operation of the 221-U Building and its ancillary support facilities. Operations in the 221-U Building complex have included uranium reclamation, uranyl nitrate calcination, and decontamination and reclamation of process equipment. The primary waste generating processes in the U Plant Aggregate Area include the following:

- Uranium recovery process
- UO_3 conversion process
- Solvent treatment
- Analytical laboratory programs
- Tank farm condensate.

Table 2-7 summarizes the available information regarding the wastes generated by processes in the U Plant Aggregate Area. In addition, some waste management units within the aggregate area received wastes from other 200 West Area facilities (condensate and cooling water waste from condensers in the 241-S and 241-SX Tank Farms; cooling water and steam condensate waste from various Z Plant Aggregate Area facilities).

2.4.1.1 Uranium Recovery Process. The 221-U Building was the primary location of the uranium recovery program. The 221-U Building was originally designed as a bismuth phosphate (plutonium extraction) facility but was not operated as such because B and T

Plants had the capacity to meet plutonium production requirements. The U Plant complex was converted in 1952 to support the uranium recovery process. The process was designed to use an organic solvent to extract uranium from waste generated by the bismuth phosphate process.

Bismuth phosphate waste sludge was sluiced from underground 3,800 m^3 (1,000,000 gal) single-shell tanks in both the 200 West and 200 East Areas. The sludge was transferred to U Plant where it was dissolved with nitric acid. The uranium in the acidified feed was separated from the bulk of the fission products and small amounts of plutonium in the solvent extraction process. The solvent extraction process used a light phase solvent, tributyl phosphate in a paraffin hydrocarbon (kerosene) diluent, to extract the uranium from the aqueous phase in counter-current extraction columns. The aqueous phase waste stream from the solvent extraction process was neutralized with sodium hydroxide and transferred to cribs and trenches in the B Plant source aggregate area in the 200 East Groundwater Aggregate Area. The cribs and trenches that received this waste are the 216-B-43 through -50 Cribs; the BC Cribs (216-B-14 through -19); and 216-B-20 through -34, -53, -54, and -58 Trenches. The uranium from the organic phase was stripped with nitric acid and then concentrated to a uranyl nitrate hexahydrate feed to the 224-U Building.

Within the extraction process an evaporator condensate stream containing radioactive and chemical contaminants was generated in evaporators which concentrated process solutions. An offgas stream containing radioactive and chemical contaminants was also generated in the evaporation process and the vessel vent system. A steam condensate stream was produced from heating of process equipment and tanks. The steam condensate stream was generally uncontaminated. Cooling water from evaporator condensers and process equipment are additional sources of uncontaminated waste. An additional stream source of waste was from spillage of process liquids within the building. Sumps collected spilled liquids and other cell drainage and discharged the materials to the cribs.

Process wastes were discharged to various waste management units including the following:

- 216-B Crib Complex (in and near the 200 East Area)
- 216-U-1 and 216-U-2 Cribs
- 216-U-7 French Drain
- 216-U-8 Crib
- 216-U-10 Pond

- 216-U-14 Ditch.

2.4.1.2 UO_3 Conversion Process. The UO_3 conversion process was carried out in the 224-U Building. A concentrated uranyl nitrate hexahydrate stream was sent to the 224-U Building from the 221-U Building for conversion to UO_3 by calcination. A process waste stream was generated which included the condensate recovered from the calcining process. Uncontaminated cooling water was generated in the process waste condensers. An offgas waste stream was also generated from the calcining process. Similar waste streams were generated from both operations supporting the uranium recovery operations in the 1950's and PUREX operations in later years.

Process wastes were discharged to various waste management units including the following:

- 216-U-10 Pond
- 216-U-1 and 216-U-2 Cribs
- 216-U-8 Crib
- 216-U-12 Crib
- 216-U-14 Ditch
- 216-U-16 Crib
- 216-U-17 Crib (still active).

2.4.1.3 Solvent Treatment. Organic solvents used in the uranium extraction processes at the 221-U Building were sent to the 276-U Solvent Facility for treatment and makeup. There the solvents (particularly tributyl phosphate) were cleaned by a carbonate scrub process and returned to the 221-U Building. A carbonate scrub solution waste was generated which also contained sludge materials (soils and materials picked up during processing) cleaned from the solvents and discharged to the aggregate area cribs. Spent solvents were also a part of this waste stream.

2.4.1.4 Analytical Laboratory Programs. The 222-U Laboratory supported operations at the 221-U Building complex and other 200 Areas facilities with laboratory services. A liquid waste stream was generated from the laboratory facility which included sample disposal waste and hood and hot cell cleanup waste. Sampling and testing equipment, gloves, empty containers and other materials were buried as solid waste. Laboratory liquid wastes were

largely directed to the 216-U-4 Reverse Well and the 216-U-4A and 216-U-4B French Drains.

2.4.1.5 Tank Farm Condensate. Condensate waste from condensers on the 241-U-104 and 241-U-110 Tanks was directed to the 216-U-3 French Drain. The condensate was primarily water but also included entrained radionuclides and chemicals from the waste in the tanks.

2.4.2 Z Plant Aggregate Area

Z Plant began operations in 1945 to help process irradiated uranium fuel rods and extract metallic plutonium from the Hanford Site's 100 Area production reactors. Using a concentrated nitric acid solution, the plutonium was extracted from the irradiated fuel rods in one of Hanford's chemical separation facilities (B Plant or T Plant) to produce a plutonium nitrate solution. Z Plant processed the plutonium nitrate solution into plutonium metal. The primary waste generating process areas and processes in the Z Plant Aggregate Area include the following:

- Plutonium Isolation Facility (PIF)
- Primary PFP Process Lines
- RECUPLEX plutonium recovery process
- PRF
- Americium Recovery Facility
- Analytical and Development Laboratories.

Table 2-7 summarizes the available information regarding wastes generated by processes in the Z Plant Aggregate Area.

2.4.2.1 Plutonium Isolation Facility. The 231-Z Building was the primary location of the PIF process line that had lasted from 1945 to 1949. The PIF process was the seventh production step where concentrated plutonium nitrate solution was further reduced to a paste. To achieve this, ammonium nitrate was added to the plutonium nitrate solution, thereby reducing the plutonium to the +4 valence state. Sulfates and peroxide were added to precipitate plutonium as plutonium peroxide. Nitric acid then was added to this precipitate, forming a purer and more concentrated plutonium nitrate solution. Finally, the product was placed in small shipping containers and boiled using hot air to form a wet plutonium nitrate

paste. The paste was shipped to Los Alamos, New Mexico for final processing into plutonium metal until 1949 when the PFP was established in 234-5Z Building.

Although little information is reported, the PIF waste streams probably included process wastes and noncontact wastewater. The process wastes are characterized as acidic and corrosive, high in salts, and low in organic content, with minor amounts of fission products, plutonium, and other TRU elements. Process wastes were discharged through the 231-W-151 Sump to various waste management units including the following:

- 216-Z-4 Trench
- 216-Z-5 Crib
- 216-Z-6 Crib
- 216-Z-7 Crib
- 216-Z-10 Reverse Well
- 216-Z-16 Crib
- 216-Z-17 Trench.

2.4.2.2 Primary PFP Process Lines. The 234-5Z Building included three progressive PFP process lines from 1949 to 1989 to convert plutonium nitrate to plutonium metal. These consisted of the RG-RB line (1949 to 1953), the RMA line (1953 to 1959), and the RMC line (1960 to 1989). The 234-5 Z Building contained chemical processing equipment used to convert plutonium nitrate to plutonium oxide and then to metal, if metal was desired. Plutonium oxide was produced by precipitating plutonium as plutonium oxalate and then filtering and calcining the precipitate. To produce the metal, plutonium oxide was first converted to plutonium fluoride by reacting it with hydrofluoric acid. The fluoride was placed in a container within a magnesium oxide crucible containing calcium. A reducing charge was then applied to the crucible to create the plutonium metal, which was then molded into a button. Sometimes the buttons were remelted and cast into a finished shape. Cast forms were coated with nickel and polished to protect from spreading plutonium through handling.

The liquid wastes produced by the primary PFP process lines were either process wastes and condensates or noncontact wastewater. The PFP process waste can be characterized as having been acidic and corrosive (pH 2), high in salts, and low in organic content. The wastes contained only minor amounts of fission products and low concentrations of plutonium and other transuranic elements (Jensen 1990). The wastes were

high in nitrates in the form of nitric acid, aluminum nitrate, magnesium nitrate, ferric nitrate, and calcium nitrate. Other components were aluminum fluoride, potassium hydroxide, potassium fluoride, chromium, lead, and other trace metal ions.

Liquid process wastes and condensates are discharged through the 241-Z Treatment Tank where they undergo addition of sodium hydroxide, ferric nitrate, and sodium nitrite for stabilization and neutralization purposes. Corrosion inhibitors and aluminum compounds for solubilization are also added in this tank. The effluent from this process has a neutral pH. Before 1973, the wastes were discharged via cribs (216-Z-3 and 216-Z-12 Cribs) to the soil column. Beginning in 1973, the treated wastes were placed initially in single-shell tanks, then later in double-shell tanks located in the T Plant Aggregate Area.

Noncontact wastewater, which does not come into direct contact with any of the plutonium separation processes, is characterized as low salt, low organic, neutral to basic aqueous waste. The bulk of this wastewater is equipment cooling water and HVAC steam condensate, although some 80 sources are recognized. Some chemicals are detected consistently at concentrations above background. Noncontact wastewater is currently discharged to the 216-Z-21 Seepage Basin and the 216-Z-20 Crib. Before September 1981, the wastewater flowed to the 216-U-10 Pond through the 216-Z-1, 216-Z-11, and 216-Z-19 Ditches.

2.4.2.3 RECUPLEX Plutonium Recovery Process. From 1955 to 1962 the RECUPLEX process house in the 234-5Z Building had been used by DOE to recover plutonium from PFP waste streams. The process used solvent extraction column technology to remove plutonium from the PFP waste streams. The RECUPLEX solvent extraction technology is based on the formation of an organic-plutonium complex which is preferentially soluble in an organic solvent. The process used nitric acid and hydrofluoric acid to convert plutonium from the purified plutonium nitrate solutions.

The RECUPLEX process produced three primary waste streams: spent aqueous extractants, spent organic solvents, and waste silica gel. Other smaller waste streams included fabrication oil and noncontact wastewater. The aqueous process wastes are characterized as acidic, high salt, low-level radioactive liquid waste containing low levels of plutonium and other TRU elements. Major components of the wastes are nitric acid, fluoride, and phosphate. Carbon tetrachloride was used in combination with dibutyl butyl phosphonate to remove residual plutonium from the aqueous solution prior to its discharge.

Spent organic solvents are characterized as slightly acidic, low salt, high in organic content, radioactive liquid wastes with intermediate levels of plutonium and other TRU elements. Major components of the waste are carbon tetrachloride/tributylphosphate and dibutyl butyl phosphonate. Carbon tetrachloride/tributylphosphate degraded with use to carbon tetrachloride/dibutylphosphate and lost its effectiveness as an extractant. The

degraded solvent was discharged into the 216-Z-9 Trench, which received approximately 4,000,000 L (1,056,800 gal) of waste from RECUPLEX that contained some 83,000 to 300,000 L (21,930 to 79,260 gal) of carbon tetrachloride (WHC 1991a). The waste stream included low levels of plutonium and other transuranic elements. The total volume of liquid wastes disposed of to the soil was 4,090,000 L (1,080,000 gal).

By the time the 216-Z-9 Trench was retired in 1962, it had received 50 to 150 kg (110 to 330 lb) of plutonium. The bulk of this material was expected to be bound up in the upper few inches of sediments and sludge in the bottom of the trench. In 1963 and 1969, the reactivity of the material at the bottom of the trench was measured using the pulsed neutron source technique. Based on these measurements and other data, it was decided in 1973 to actively mine the 216-Z-9 Trench to remove plutonium. This measure was intended to reduce the risk of environmental contamination and to reduce the criticality potential (e.g., the potential for uncontrolled nuclear reactions). The 216-Z-9 Trench was mined with remote mechanical equipment between August 1976 and January 1977. The mining operation removed an estimated 58 kg (128 lb) of plutonium. Based on new data acquired during the mining operation, an estimated 38 to 48 kg (84 to 106 lb) of plutonium remained in the 216-Z-9 Trench after the mining operation.

Noncontact wastewater is currently discharged to the 216-Z-20 Crib. Before September 1981, the wastewater flowed to the 216-U-10 Pond through the 216-Z-19 Ditch. Before the 216-Z-19 Ditch, wastewater was discharged to the 216-Z-1 and 216-Z-11 Ditches.

2.4.2.4 Plutonium Reclamation Facility. The PRF replaced the RECUPLEX process line after a criticality accident forced the closure of the RECUPLEX unit in April 1962. The PRF operated from 1964 to 1978 and again from 1984 to May 1991 in the 236-Z Building of Z Plant. This facility is currently idle but is planned to restart operation in the near future. The PRF is designed to reclaim plutonium from solutions and solids from PRF waste streams. The recoverable material is treated to produce soluble plutonium as plutonium nitrate. The PRF has essentially the same mission as RECUPLEX and uses a similar solvent extraction column technology. The extraction solvent used is carbon tetrachloride/tributyl phosphate in a 80:20 ratio by volume, whereas the ratio in the RECUPLEX process was 85:15.

The primary waste streams generated by the PRF were similar to those produced by RECUPLEX and included spent aqueous solutions, spent organic wastes, and noncontact wastewater. The characteristics of these wastes are essentially the same as those of the RECUPLEX wastes described in Section 2.4.2.3.

Until 1973 spent aqueous and organic wastes from the PRF were discharged to the soil column through a series of cribs. Cribs that are known to have received PRF wastes include the following:

- 216-Z-1A Tile Field - 5/64 to 5/66, 6/66 to 10/67, 10/67 to 4/69
- 216-Z-1 & 216-Z-2 Cribs - 5/66 to 6/66, 10/67
- 216-Z-18 Cribs - 4/69 to 5/73.

Organic wastes from PRF processing operations in the 1980's have been containerized and shipped to the Z Plant RMW storage complex. The organic wastes containers are currently awaiting disposal. The *Expedited Response Action Proposal for the 200 West Area Carbon Tetrachloride Plume* (DOE/RL 1991a) estimated the total volume of all types of PRF liquid waste deposited to PRF waste management units to be as follows:

- 216-Z & 216-Z-2 Cribs 211,000 L (55,750 gal)
- 216-Z-1A Tile Field 5,260,000 L (1,389,800 gal)
- 216-Z-18 Crib 3,860,000 L (1,019,900 gal)

The total amount of spent carbon tetrachloride disposed of from the PRF facility to soil was approximately 280,000 L (73,980 gal).

2.4.2.5 Americium Recovery Facility. The recovery of americium from PRF waste streams started in 1964 in the 242-Z Building of Z Plant. This facility was shut down in 1976 after an explosion in the exchange process. The process used an ion-exchange technique to recover americium from the waste streams. Elutriation and regeneration of the ion-exchange resin were done with nitric acid. Americium was also recovered in the PRF using dibutyl butyl phosphonate in a carbon tetrachloride diluent as an extractant solvent. Dibutyl butyl phosphonate was subsequently replaced with tributyl phosphate in the process.

Information on wastes generated from the americium recovery process is not available. Presumably, these waste streams would have included spent ion-exchange resins and waste organic solvent.

Nonradiological laboratory sinks and emergency showers in the laboratory area drain to the main sanitary wastewater system in the 234-5Z Building. The contents of this wastewater have not been determined, but are likely to contain intermittent releases from laboratory procedures, cleaning glassware, and chemical spills. Wastewater containing hazardous chemicals is routed to the 241-Z Building. This wastewater is combined with nonprocess wastewater and roof drain runoff from other buildings at Z Plant. The combined effluent was discharged to the 216-Z-10 Ditch from 1944 to 1959, to the 216-Z-11 Ditch from 1959 to 1971, to the 216-Z-19 Ditch from 1971 to 1981, and to the 216-Z-20 Crib since 1981. These three ditches and the crib are all located within the U Plant Aggregate Area.

2.4.2.6 Analytical and Development Laboratories. The Z Plant Analytical and Development Laboratories are currently housed in the 234-5Z Building of the Z Plant Aggregate Area. Historically, analytical and development laboratories were also reportedly housed in the 231-Z Building (Stenner et al. 1988). The Z Plant laboratory currently provides analytical services and supports research and development activities for the Plutonium Finishing Operations. Historically, the laboratory provided the same services for the PFP. This support was provided in the following ways:

- Quality assurance/quality control (QA/QC) for the plutonium processing lines
- Liquid scintillation counting
- Preparation work for solvent extraction tests.

Present activities of this unit are limited to research and development, and associated analyses needed to support production processing operations (Jensen 1990). Exact quantities of these chemical and reagents are not known.

There are three types of wastes produced in the laboratory area:

- Laboratory process wastes
- Used or discarded reagents and chemicals
- Wastewater from laboratory sinks and emergency showers.

Laboratory process wastes are characterized as slightly acidic, low salt radioactive wastes. These wastes were routed through the 241-Z-261 Tank to various cribs, including the 216-Z-3 and 216-Z-12 Cribs. These wastes were adjusted to a pH value between 8 and 10 in the 241-Z-261 Treatment Tank before disposal.

Information on the disposition of used or discarded analytical reagents is not available. A large number of chemicals are in use or are stored in the laboratory. Laboratory chemicals were stored in 234-5Z Hazardous Waste Staging Area before disposal.

Nonradiological laboratory sinks and emergency showers in the laboratory area drain into the main sanitary wastewater system in the 234-5Z Building. The contents of this wastewater have not been determined, but are likely to contain intermittent releases from laboratory procedures, cleaning glassware, and chemical spills. Wastewater containing hazardous chemicals is routed to the 241-Z Building. This wastewater is combined with nonprocess wastewater and roof drain runoff from other buildings at Z Plant. The combined effluent is currently discharged to the 216-Z-20 Crib, within the U Plant Aggregate Area.

Formerly, wastewater was discharged in sequence to the 216-Z-1, 216-Z-11, and 216-Z-19 Ditches.

2.4.3 S Plant Aggregate Area

The S Plant Complex (202-S Building) used the redox process to recover both plutonium and uranium from fission products. The 202-S Building was completed in August 1951 and continued operation through 1967, when the plant was shut down. An analytical laboratory (222-S) near the facility is still operating. This laboratory supports B Plant operations and performs research and development in support of waste management and environmental control operations. The laboratory also serves as a backup to the PUREX and Z Plant Analytical Laboratories.

Several processes were developed at the Hanford Site to separate uranium, plutonium, and their fission products from irradiated uranium slugs. In 1951 the redox process replaced the existing bismuth phosphate process because of lower costs, improved throughput, and enhanced recovery of uranium and plutonium. The redox process, used between 1951 and 1967, was a solvent-extraction process that extracted plutonium and uranium from dissolved fuel into a MIBK solvent. This process was carried out in the 202-S Building where irradiated uranium fuel rods from the 100 Area were treated, resulting in numerous waste streams and relatively pure product streams. The slightly acidic waste streams contained fission products and large quantities of aluminum nitrate. Nitric acid and nitrate salts were added to this waste stream to promote the extraction of plutonium and uranium in the redox process. The wastes were neutralized and stored in tanks, or disposed of in cribs, trenches, ditches, or ponds that leached wastes directly into the soil column. Product streams were directed to other processing facilities. The redox process was designed to recover at least 98% of the uranium and plutonium from the irradiated fuel rods. With the exception of the feed preparation and dissolution processes, which operated in batch, the redox process was continuous.

The solvent-extraction process was based on the preferential distribution of uranyl nitrate and the nitrates of plutonium between an aqueous phase and an immiscible organic phase. This process is described in greater detail below; however, the descriptions generally exclude mention of water or water vapor that was present in many of the process streams.

The primary waste generating process in the S Plant Aggregate Area is the waste treatment and disposal.

Table 2-7 summarizes the available information regarding waste generated by processes in the S Plant Aggregate Area.

2.4.3.1 S Plant Waste Generating Processes. The redox process involved several steps to recover both plutonium and uranium from fission products. These steps included feed preparation, extraction, cycling, and solvent recovery. The waste stream generated by feed preparation was composed both of radioactive and chemical constituents.

The primary waste stream generated by the first extraction cycle was an aqueous stream containing fission products from the feed preparation. This stream was composed of sodium aluminate, fission products, and sodium hydroxide. After the desired cycling was achieved, the waste stream was then directed through a solvent recovery process to extract fission products in the spent MIBK. The waste streams generated by this process included an aqueous stream containing plutonium, uranium, fission product impurities, sodium hydroxide, and sodium carbonate.

2.4.3.2 Waste Treatment and Disposal. Generally, waste treatment was intended to treat and segregate aqueous wastes according to their radioactivities and to recover MIBK. Liquid wastes that contained appreciable quantities of radioactive materials (such as aqueous fission product wastes from the extraction, zirconium and niobium scavenging, aluminum jacket removal, and solvent recovery cycles) were concentrated to the highest practicable $Al(NO_3)_3$ content in a waste concentrator, blended with wastes from the ruthenium scrubber and from the 222-S Laboratory, neutralized with caustic to convert the $Al(NO_3)_3$ to $NaAlO_2$ to minimize corrosion problems, and stored in the 241-S Tank Farm. Wastes were routed to the tanks via the 240-S and 241-S Diversion Boxes. The underground storage tanks operated as a cascade system with successive overflow tanks containing less contaminated wastes than upstream tanks.

Condensate from the waste concentrator and condensate from the uranium and plutonium concentrators contained very low levels of radioactive wastes. These streams were combined and put through a condensate stripper to remove residual MIBK, which was returned to the solvent recovery process. The aqueous product stream was evaporated to the extent possible and disposed as low-radioactive waste in the 216-S Cribs. Residuals from the condensate stripper were returned to the waste concentrator. Other liquid wastes that contained only trace quantities of radioactive materials such as floor drain wastes were also disposed in cribs.

Off-specification products were recycled to the process or to parallel columns designed specifically for purifying off-specification products. The 222-S Laboratory generated relatively small quantities of waste, most of which was directed to underground storage tanks. Sanitary wastes were directed to septic tanks with tile fields.

Chemical sewers drained all nonregulated portions of the buildings (such as operating galleries, service areas, and aqueous makeup) and flowed directly to the 216-S-10 Pond 1,070 m (3,500 ft) southwest of 202-S Building. Process sewers received water and steam

condensate from process equipment jackets and coils. This water should not have been contaminated and was directed to the 207-S Retention Basin before discharge to the pond to ensure any leakage of radionuclides from process equipment was within acceptable limits (1.4×10^{-4} mg/L plutonium and 0.5 mCi/L beta emitters). The water in the pond was disposed through evaporation and seepage into the soil column.

Organic wastes from the laboratory or other buildings were decontaminated and treated with aqueous solutions in the laboratory where they were produced. The organic liquids were transported to a designated site for burial.

Waste management units that received liquid wastes from the waste treatment and disposal processes include the following:

- 241-S Tank Farm
- 216-S Cribs
- 207-S Retention Basin
- 216-S-10, S-11, S-16, S-17, and S-19 Ponds.

2.4.4 T Plant Aggregate Area

Built in 1944, T Plant was the first chemical separation facility to produce purified plutonium nitrate for use in atomic testing. Irradiated fuel rods from Hanford Site reactors were transferred to T Plant, where a bismuth phosphate chemical separation process was used to extract the plutonium product until 1956. The process involved dissolving the jacketed fuel rods in nitric acid and conducting multiple purification operations on the resultant aqueous nitrate solution. Chemical separation was achieved by varying the valence states of plutonium from +4 (the reduced state) to +6 (the oxidized or hexavalent state). No attempt was made to recover uranium. The product resulting from the chemical separation process was dilute plutonium solution. The solution was transferred to the 224-T Bulk Reduction Building, where it was purified and reduced in volume. The concentrated batch was transferred to the 231-T Building in the Z Plant Aggregate Area for final treatment. The T Plant presently serves as a decontamination facility for the Hanford Site. The primary waste generating processes in the T Plant Aggregate Area include the following:

- T Plant fuel reprocessing wastes
- Equipment decontamination and laboratory wastes

- Process chemicals.

Table 2-7 summarizes the available information regarding the waste generated by process in the T Plant Aggregate Area.

2.4.4.1 T Plant Fuel Reprocessing Wastes. The first step in the bismuth phosphate process was to remove the metal cladding on the fuel. This resulted in the coating-removal waste that was subsequently combined with the first-cycle decontamination waste for storage in single-shell tanks. The coating waste contained small amounts of fission products (Waite 1991). The next step in the process was to dissolve the uranium and extract the plutonium. This step resulted in the metal waste stream, which contained the bulk of the uranium and approximately 90% of the long-lived fission products (e.g., ^{137}Cs and ^{90}Sr). This waste stream was then sent to the single-shell tanks for storage (Waite 1991).

Once the plutonium had been extracted, two decontamination cycles were performed to purify the plutonium product. The first decontamination cycle waste stream contained almost 10% of the long-lived fission products and was sent to the single-shell tanks for storage. The second decontamination cycle waste stream, which contained less than 0.1% of the fission products, was sent to single-shell tanks for storage until 1948. Because of limited tank space, the second-cycle waste supernatant was discharged to cribs and trenches from 1948 to 1956, when buildings 221-T and 224-T were deactivated. The second-cycle wastes discharged to cribs were combined with two other waste streams, cell drainage waste and scavenged first-cycle wastes. These combined waste streams accounted for more than 85% of the volume discharged to the ground from single-shell tanks in support of the irradiated fuel recovery operations in T Plant, but less than 20% of the radionuclides (Waite 1991).

Cell drainage waste collected from T Plant operations was sent to in-plant tanks (or cells) for interim storage and then discharged to cribs. Between 1951 and 1956, the cell drainage waste had been routed along with the second-cycle wastes and 224-T Building wastes through a single-shell tank cascade before discharging to cribs. This cell drainage waste was never intended for permanent storage in the tanks. Instead, the single-shell tanks were used as settling tanks before discharging the waste to the ground (Waite 1991).

Beginning in 1955, the newly generated first-cycle waste in T Plant was scavenged before it was sent to single-shell tanks for settling and subsequent discharge to the ground. This scavenging involved adding chemicals to the waste to cause the normally soluble ^{137}Cs to precipitate in the settling process before discharge. The scavenging of the first-cycle waste significantly reduced the quantity of long-lived fission products discharged to the ground (Waite 1991).

2.4.4.2 Equipment Decontamination and Laboratory Wastes. From 1959 to 1963, steam condensate, decontamination wastes, and miscellaneous effluents had been sent from the 221-T Building to the tanks for cascading and subsequent discharge to the 216-T-28 Crib. Thereafter, decontamination wastes from the 2706-T equipment decontamination facility were combined with waste from T Plant. Also, 300 Area laboratory wastes were shipped from the 340 Waste Transfer Facility to the 200 West Area and combined with the 221-T Building and 2706-T waste streams (Waite 1991). The 2706-T stream was rerouted directly to a separate crib in 1964. The other streams continued to be discharged to the 216-T-28 Crib via single-shell tanks until 1966. A total of 4.23 x 10^7 L (11.2 Mgal) of waste were routed through the tanks to this crib, resulting in 594 Ci of fission products (Waite 1991). The 340 Waste Transfer Facility waste was rerouted directly to other cribs in 1966 (Waite 1991).

2.4.4.3 Process Chemicals. While procedures were implemented to monitor and control the discharge of long-lived radionuclides to the single-shell tanks, such controls were not always applied to the discharge of chemicals (Waite 1991). Chemicals were a significant component of the waste streams generated. For example, chemicals such as sodium hydroxide (NaOH) were added to neutralize the waste before it was sent to the tanks for storage (Waite 1991). Sodium ferrocyanide was added to process batches to enhance the precipitation of long-lived radionuclides before the supernatant was discharged to the ground. Such practices resulted in the discharge of substantial quantities of chemicals to the ground as part of the tank waste discharges.

2.5 INTERACTIONS WITH OTHER AGGREGATE AREAS OR OPERABLE UNITS

The 200 West Groundwater Aggregate Area interacts with several other organizational units involved in the remedial action process on the Hanford Site. These features include other groundwater aggregate areas, source aggregate areas, and operable units. These interactions can take place at various scales including within the 200 West Area, between the 200 West, 200 East, and 200 North Areas, and across the entire Hanford Site. The interaction can be hydrologic, operational or administrative, and regulatory. This section discusses these interactions.

This study, the 200 West Groundwater Aggregate Area Management Study (AAMS), recommends for future investigative actions for groundwater beneath an area slightly larger than the 200 West Area administratively delineated on the Hanford Site (see Section 2.1). The study addresses groundwater contamination originating from facilities in the 200 West Area, and so its areal extent includes as much of the administrative "600 Area" as needed to encompass the spread of contamination or plumes in the unconfined aquifer from the 200 West Area.

The 200 West Groundwater Aggregate Area must nevertheless be compatible with the four 200 West Area source aggregate areas (U Plant, Z Plant, S Plant, and T Plant), since the contamination addressed in the study must have originated from waste management units in these source areas which discharged to the vadose zone in sufficient quantities to impact the groundwater system (see Section 2.3). It is also possible that some vadose zone or perched water zones still hold contamination from these facilities which can yet be mobilized, and could still impact groundwater quality. In this way remedial actions in the source aggregate areas may affect remedial options for the groundwater aggregate area.

Implementation of remedial actions based on the 200 Areas Groundwater AAMS (East and West), can also interact in a variety of ways. Most significantly, changes in the geohydrologic system in the 200 East Area can directly change flow pathways of groundwater migrating from the 200 West Area. Currently the effect of large discharges to the ground occurring in the 200 East Area causes a mounding of the groundwater beneath the site, and thereby affects groundwater to the west. This effect is partly to stagnate (reduce the gradient of) the groundwater in the region between the two 200 Areas (where stagnation primarily underlies the western portion of the 200 East Area) and partly to divert these flows toward the north or south around the mound. This hydrologic linkage would also extend to remedial actions which may be recommended for the 200 East Groundwater Aggregate Area. Pump and treat, or containment alternatives can cause similar effects (qualitatively although probably not quantitatively if at a smaller scale of discharge). The cause and effect relationship could also occur in the opposite direction (200 West to 200 East), since alteration of groundwater flow in the 200 East Area may affect groundwater flow beneath the 200 West Area.

There is also potentially a similar interaction with the 100 Areas operable units in that contamination from the 200 West Groundwater Aggregate Area (particularly the northern portion) if unremediated could pass through Gable Gap and reach the Columbia River through one or more of the 100 Areas (under present groundwater conditions it could be any of these). This would complicate monitoring of concentration changes in those areas and could even interfere with remediation that might be proposed for these areas. Because of uncertainties in flow patterns and future modifications in groundwater recharge, this possibility is a very uncertain, long term, and limited inference.

Finally, the 200 West Groundwater AAMS also interacts with the operable units in the 200 West source aggregate areas by defining new groundwater operable units. An operable unit is a portion or aspect of a remedial action site which can best be planned and remediated as a single entity. At the Hanford Site, an operable unit is usually a group of waste management units which are spatially close to each other and generally shared a similar disposal history. Before the AAMS process, 9 of the 17 operable units in the 200 West Area were combined source and groundwater operable units (WHC 1989). These included:

- 200-UP-1
- 200-UP-2
- 200-ZP-1
- 200-ZP-2
- 200-RO-1
- 200-RO-2
- 200-RO-3
- 200-TP-2
- 200-TP-4.

These combined operable units have been incorporated implicitly into the Tri-Party Agreement (Ecology et al. 1989) by prioritizing the operable units (based partly on their groundwater impacts) and setting milestones for completion of work plans for some of them.

The current combined source and groundwater operable units are proposed to be redefined into separate source and groundwater operable units. The groundwater operable units would, under this redefinition, be defined more on the basis of flow patterns and plume distributions (see Section 9.3).

In addition, some remedial actions may be undertaken in the various source aggregate areas. Already an expedited response action (ERA) is occurring in Z Plant Aggregate Area. The ERA within the Z Plant Aggregate Area involves the construction and operation of a vapor extraction system to recover carbon tetrachloride in the soil beneath the 216-Z-1A Tile Field, the 216-Z-18 Crib, and the 216-Z-9 Trench. The presence of this operating vapor extraction system will have to be considered in the planning and implementation of potential groundwater remediation systems in the 200 West Groundwater Aggregate Area.

2.6 INTERACTION WITH RESOURCE CONSERVATION AND RECOVERY ACT PROGRAMS

Groundwater monitoring is currently being conducted at 19 RCRA TSD units and one nondangerous waste facility (Solid Waste Landfill). The Solid Waste Landfill is not subject to RCRA but is included in the RCRA reporting for completeness. This facility is not

included in the 200 West Groundwater Aggregate Area, therefore it is not discussed in this section.

The RCRA groundwater monitoring projects are conducted at three levels, as described below:

- **A background monitoring program.** The purpose of this program is to gather data from upgradient monitoring wells to determine the levels of constituents and parameters in groundwater unaffected by the monitored RCRA facility.

- **An indicator evaluation program.** The purpose of this program is to compare background monitoring program data with indicator program data to determine if significant differences exist between upgradient and downgradient groundwater constituents or parameters. This program is frequently run simultaneously with the background monitoring program, if possible.

- **A groundwater quality assessment program.** The purpose of this program is to determine if the groundwater is being adversely affected by wastes managed at the monitored RCRA facility. It is initiated if the indicator program shows significant differences.

Several RCRA groundwater monitoring projects may be encompassed in the 200 West Area Groundwater Aggregate Area. As of June 6, 1991, the associated RCRA groundwater monitoring projects and their respective groundwater monitoring program status were as follows:

- **216-S-10 Pond.** This project is currently in a background monitoring program.

- **216-U-12 Crib.** This project is currently in a background monitoring program.

- **Low-Level Waste Management Area 3 (LLWMA 3).** This project is currently in a groundwater quality assessment program.

- **Low-Level Waste Management Area 4 (LLWMA 4).** This project is currently in an indicator parameter evaluation program.

- **Low-Level Waste Management Area 5 (LLWMA 5).** This project is currently in a background monitoring program, with drilling of groundwater wells in progress.

- **Single-Shell Tanks Waste Management Area S/SX.** This project is currently in a background monitoring program, with groundwater wells completed.

- **Single-Shell Tanks Waste Management Area T.** This project is currently in a background monitoring program, with groundwater wells completed.

- **Single-Shell Tanks Waste Management Area TX/TY.** This project is currently in a background monitoring program, with drilling of groundwater wells in progress, with groundwater wells completed.

- **Single-Shell Tanks Waste Management Area U.** This project is currently in a background monitoring program, with drilling of groundwater wells in progress.

These projects are described in greater detail in Section 2.8.2.

Existing groundwater contamination detected from RCRA monitoring wells is expected to be largely mitigated under a CERCLA remedial action program. During implementation of the CERCLA program, it is anticipated that RCRA site-specific groundwater cleanup levels and procedures will be identified, considered, and incorporated as potential ARARs. In the event that remediation is not completed in a timely manner, the Tri-Party Agreement is revised, or that future releases from RCRA facilities are detected, remediation under RCRA authority could be initiated.

Hanford Site monitoring programs are discussed in Section 2.8. The integration of potential 200 West Aggregate Area remedial actions with other programs is discussed in more detail in Section 9.3.3 of this AAMSR.

2.7 INTERACTIONS WITH OTHER HANFORD PROGRAMS

In addition to the RCRA groundwater monitoring program discussed in Section 2.6, and other groundwater programs discussed in Sections 2.8 and 2.9, several other ongoing Hanford programs have potential to interact with characterization and remedial activities related to the 200 West Groundwater AAMS. These programs include:

- Hanford Site Single-Shell Tank Programs

- Emergency Response Action Programs

- Effluent Treatment Programs

- Decommissioning and Decontamination Program

- Surplus Facilities Program

- Defense Waste Management Program
- Remedial Technology Development Programs.

Each of these programs and their interaction is discussed briefly below, based on information provided in the Environmental Restoration and Waste Management Site-Specific Plan for the Richland Operations Office (DOE/RL 1991e).

2.7.1 Hanford Site Single-Shell Tank Programs

The Hanford Site Single-Shell Tank Programs include the near-term waste management activities related to interim storage of waste in single-shell tanks, and long-term decommissioning. As part of the Hanford Site Single-Shell Tank Program, RCRA closure plans are developed for single-shell tanks and ancillary equipment. Currently, the single-shell RCRA closure plans incorporate groundwater assessment and mitigation activities being planned as part of the 200 West Groundwater AAMSR. Following remediation of single-shell tank facilities, related soil and groundwater contamination is anticipated to be remediated under either the CERCLA or RCRA Past Practices program.

2.7.2 Emergency Response Action Programs

Current Hanford Emergency Response Action programs relevant to the 200 West Groundwater Aggregate Area include construction and operation of a vapor extraction system to recover carbon tetrachloride in the soil beneath several cribs in the Z Plant Aggregate Area (DOE/RL 1991b). The Emergency Response Action vapor extraction activities are expected to reduce the volume and concentrations of carbon tetrachloride in vadose zone soils which may act as a contaminant source to groundwater. Also, the technology utilized in the Emergency Response Action (vapor stripping) is potentially similar to technologies utilized in groundwater remediation (groundwater stripping). The Emergency Response Action performance will be monitored and assessed with regard to application as a transferable technology for 200 West Groundwater AAMS remediation. This potential transfer is discussed further in section 7.3.3. Remediation of other chemical constituents is generally not considered as part of the carbon tetrachloride Emergency Response Action, and is expected to be deferred to the AAMS program.

2.7.3 Effluent Treatment Programs

The Effluent Treatment Program is implemented as part of the Hanford Defense Waste Management Program, as discussed in Section 2.7.6. The Effluent Treatment Program is responsible for developing best available technologies (BAT) for regulated effluents being produced throughout the Hanford Site. In addition, several classes of effluents are being evaluated for BAT treatment and subsequent disposal into State Approved Land Disposal Structures (SALDS). As a result, the Effluent Treatment Program interacts with the 200 West Groundwater AAMS characterization and remedial strategies in several ways.

First, groundwater which is extracted for treatment from the 200 West Area may be similar to liquids being evaluated under the Effluent Treatment Program, and may therefore be adaptable to the BAT developed. This interaction is further discussed in Section 7.0. Secondly, as part of Effluent Treatment Program milestones discussed in the Tri-Party Agreement, process effluent discharges to existing cribs and ditches in the 200 West Area will be discontinued. Third, treated effluent from the C-018H facility is anticipated to be discharged at the proposed SALDS facility located approximately 200 m (650 ft) north of the 200 West Area fence line (Figure 2-1). Tri-Party Agreement Milestone M-17-14 (Ecology et al. 1992) indicates that discharge of treated effluent to the soil column at the C-018H facility will begin in October 1994. Modeling has been performed in support of the Effluent Treatment Program to demonstrate that new discharges will not affect groundwater in the 200 Areas. It is anticipated that the information obtained from the Effluent Treatment Program and related support programs will be utilized during assessment and remediation for the 200 West Groundwater AAMS.

A second proposed SALDS facility (Project W-049H) is a candidate site 3.5 km (2.1 mi) east of the 200 East Area and just east from the current 216-B-3 Pond System. Project W-049H will accept treated effluent from the 200 Areas that meets discharge limits without additional treatment. Changes to the groundwater flow pattern in this area (Project C-018H) will provide standby treatment and discharge for effluent that does not meet discharge limits for W-049H. Tri-Party Milestone M-17-08 (Ecology et al. 1992) indicates that this second SALDS facility will be initiated in June 1995. Project C-0184 wil provide standby treatment and discharge for effluent that does not meet discharge limits of W-049H.

2.7.4 Decommissioning and Decontamination Program

The Hanford Decommissioning and Decontamination Program is primarily concerned with decontamination and decommissioning of buildings and other structures with elevated levels of radioactivity. The Decommissioning and Decontamination program does not typically involve mixed waste issues or groundwater studies.

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2.7.5 Surplus Facilities Program

The Hanford Surplus Facilities Program is responsible for the surveillance and decommissioning of surplus facilities at the Hanford Site. As with the Hanford Site Single-Shell Tank closure projects, the Surplus Facilities Program is anticipated to incorporate data from 200 West Groundwater AAMS characterization and remedial activities to address RCRA groundwater mitigation requirements. Remediation of soil and groundwater contamination related to past waste disposal activities at surplus facilities is expected to be deferred to the AAMS program.

The Surplus Facilities Program also implements the Radiation Area Remedial Action (RARA) program. The RARA program is primarily concerned with management and control of surface soil contamination and does not directly interact with groundwater activities.

2.7.6 Defense Waste Management Program

The Hanford Defense Waste Management Program is responsible for operation and maintenance of active waste management units and facilities. Several of these waste management units are currently RCRA interim status facilities. During the final permitting of active RCRA waste management units, data from remedial assessment and mitigation for the 200 West Groundwater AAMS will likely be incorporated into the RCRA permits. The Defense Waste Management Program includes activities implemented under the Effluent Treatment Program as discussed in Section 2.7.3.

2.7.7 Remedial Technology Development Programs

Innovative technologies for use in remedial action at Hanford are evaluated by several groups and organizations. These organizations include the DOE Office of Technology Development, Westinghouse Integrated Programs and Demonstrations (funded by the DOE Office of Technology Development), and the Pacific Northwest Laboratory (PNL). It is anticipated that technologies developed or evaluated by these groups will be applied to remedial actions implemented as part of the 200 West Groundwater AAMS, as practical.

2.8 GROUNDWATER MONITORING FACILITIES

Groundwater monitoring facilities within the 200 West Area include groundwater monitoring wells as well as single and nested (multiple) piezometers. These facilities provide data for monitoring the groundwater conditions throughout the 200 West Area. They have been constructed to monitor discrete horizons within the unconsolidated sediments as well as

the deeper confined basalt aquifers within the Saddle Mountain, Wanapum, and Grande Ronde formations. Plates 3a and 3b show the location of all groundwater monitoring wells within and adjacent to the 200 West Area.

Groundwater monitoring facilities at the Hanford Site are associated with five monitoring programs: the Westinghouse Hanford Operational Groundwater Monitoring Network, RCRA, CERCLA, PNL Environmental Monitoring Program, and the Hanford Sanitary Water Quality Surveillance program administered by the Hanford Environmental Health Foundation (HEHF). These programs all help determine the impact of Hanford past, present, and future waste disposal practices on human health and the environment across the Hanford Site. The Hanford Sanitary Water Quality Surveillance program is the only one that does not monitor groundwater within the 200 West Area.

Monitoring wells at the Hanford Site were first installed in 1944 and continue to the present. During this period, three general well designs were implemented, as shown in Figure 2-1 (Serkowski and Jordan 1989). Regardless of the design used, the vast majority of wells at the Hanford Site were drilled using the cable-tool method. The oldest and simplest design consists of a single 15- to 20-cm (6- to 8-in.) -diameter carbon-steel casing, which is perforated at the top of the aquifer to allow groundwater to enter the well. This design has two major shortcomings: (1) the well lacks a seal that is necessary to block downward movement of contaminants along the outside of the casings; and (2) the size of the perforations are often too large to prevent the entry of sand into the well. In the early 1980's, a modified design was developed to address these design problems. In the modified design, an 20-cm (8-in.) carbon-steel casing was installed to a depth slightly above the aquifer and perforated along its entire length. A 15-cm (6-in.) carbon-steel casing was then inserted into the first casing and drilling continued to the desired depth. A telescoping stainless-steel screen assembly was lowered to the bottom of the well and the 15-cm (6-in.) casing was pulled back to expose the screen. A grout mixture was poured into the annulus between the two casings and allowed to flow out through the perforations to create a seal between the well and the formation. Finally, a cement surface seal was installed to inhibit erosion at the well head.

Beginning in 1986 and continuing to the present, the sealed, screened well design was further modified to more closely conform with RCRA well construction guidelines (Serkowski and Jordan 1989). The implemented changes include placing a sand pack around the screen, sealing the well with bentonite granules or other dry sealant, removing the outer casing as sealant is injected, and completing the well with 10-cm (4-in.) diameter stainless-steel casing. To lessen the back-pull friction and permit removal of the temporary outer casing, several progressively smaller casings are often used in deeper wells.

A program was initiated in 1986 to renovate the older wells to this new standard by perforating the casing, installing a liner, and grouting the annular spaces. Wells that were

closest (less than 300 m, 1,000 ft) to liquid waste disposal facilities were assigned the highest priority under this program.

Groundwater monitoring wells that are currently being constructed at the Hanford Site are being completed in accordance with requirements set forth in the Washington State Administrative Code (WAC 173-160 through 162) as well as *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* requirements (EPA 1986a).

Piezometers were installed on the Hanford Site to assist in evaluations of potentiometric surfaces and hydraulic gradients. Borings with nested piezometers originally were installed with separate screen depths but with sand filling the well casing the entire distance between screened intervals. Many of these have since been retrofitted with proper seals between screened materials. Others have been abandoned (Newcomer et al. 1992.)

To support the 200 West Groundwater AAMS, a sampling and analysis program is underway which includes a classification of Hanford Site wells based on their fitness for sampling. In a previous screening of wells at the Hanford Site (Golder Associates 1989), 70% of the wells evaluated require remediation or decommissioning. As part of the sampling and analysis program, maps of groundwater contaminant plumes are anticipated to be periodically updated.

2.8.1 Westinghouse Operational Groundwater Monitoring Network

The DOE maintains a groundwater monitoring program for the Hanford Site as part of its waste management responsibilities. This monitoring program is based on DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements." These requirements mandate the evaluation of impacts of Hanford Site operations on the aquifers from liquid waste discharges to the ground.

Westinghouse Hanford is the operations and engineering contractor for the DOE at the Hanford Site. As part of the requirements imposed by DOE Order 5484.1, Westinghouse Hanford manages the facilities within the Hanford Site. Westinghouse Hanford, therefore, conducts an Operational Surveillance Program to control the impact of effluent releases and waste management practices at and near the waste management units.

One component of this surveillance program is the OGWMN. The OGWMN was originally established to observe the response of groundwater to storage and disposal of radioactive waste in soil at the 200 Areas. Groundwater monitoring in other operational areas of the Hanford Site was conducted by contractors responsible for these sites or was conducted by PNL as part of its groundwater monitoring program. In 1987, DOE

consolidated all operational responsibilities into a single contract to be carried out by one contractor, and a five-year contract was awarded to Westinghouse Hanford.

The scope of this consolidation was to expand the OGWMN to incorporate all waste management units at the Hanford Site (including the 100, 200, 300, 400, 600, and 1100 Areas). Even after consolidation, the emphasis of the network remains on the 200 Areas, due in part to the significance of the 200 Areas as the major waste disposal areas on the Hanford Site.

Historically, the OGWMN has emphasized the monitoring of radioactive constituents and nitrates. In 1985 the list of constituents monitored was expanded to include other hazardous chemicals. The OGWMN now routinely includes both radiological as well as nonradiological constituents in groundwater analyses. The radiological constituents analyzed for under the OGWMN are gross alpha, gross beta, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{106}Ru, ^{129}I, total uranium, and $^{239,240}Pu$ (Schmidt et al. 1991). The OGWMN program is intended to provide environmental data to Hanford Site waste management programs. Specific objectives of the OGWMN include the following:

- Assess the quality of groundwater under waste management units to determine compliance with DOE water quality standards
- Monitor the performance of inactive and active waste management units
- Determine the impact to the groundwater from waste management unit activities.

The groundwater monitoring network (1990) for the 200 Areas consists of 166 wells. Of these, 86 wells were installed to monitor groundwater of the uppermost aquifer (for which this aquifer system primarily exhibits unconfined conditions but also contains localized areas of semiconfined to confined conditions), 9 wells were installed to monitor groundwater of the confined aquifer within the 200 East and 600 Areas, and the remaining 71 wells monitor the vadose zone. The 9 confined aquifer wells monitor the Rattlesnake Ridge and Mabton interbeds. Within the 200 West Area, there were 49 wells sampled during the 1990 calendar year. These wells are shown on Figure 2-2 and summarized on Table 2-8. The principal waste management units and their associated well networks are described below.

The 49 groundwater monitoring wells of the 200 West Area were selected to monitor 11 active waste management units which include the 241-S, -SX, -T, -TX, and -TY Tank Farms, 216-Z-20 Crib, 216-S-3, -8, -25, and -26 Cribs, the 216-U-17 Crib, 216-U-14 Ditch, and the 216-W-LWC Crib. There are also 10 inactive waste management units which include the 216-Z-18 and -21 Cribs, 216-T-3, -33, and -34 Cribs, and the 216-U-1, -2, -8, -12, and 16 Cribs.

The sampling frequencies of wells within the OGWMN are based on a number of objectives. Wells monitoring active liquid waste management units are sampled monthly. Wells monitoring inactive waste management units containing radionuclides with a high potential for being remobilized are sampled monthly. Wells monitoring inactive waste management units containing radionuclides with a low potential for being remobilized are also sampled monthly or quarterly, depending upon the level and trend of concentration. Wells monitoring background concentrations are sampled semiannually. Samples from these wells were collected by PNL for Westinghouse Hanford and analyzed for the following parameters: ^{60}Co, ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs, ^{106}Ru, ^{3}H, total U, and $^{238,239,240}Pu$. These parameters were chosen for analysis based upon effluent inventories and historical groundwater monitoring results.

2.8.2 Resource Conservation and Recovery Act Monitoring Facilities

The RCRA groundwater monitoring program monitors active and recently inactive hazardous waste treatment, storage, or disposal units at the Hanford Site which are governed by RCRA regulations. There are currently nine RCRA monitoring projects ongoing within the 200 West Area. These are shown on Figure 2-3 and summarized in Table 2-9. The RCRA projects are monitored under three programs: (1) a background monitoring program; (2) an indicator evaluation program; and (3) a groundwater quality assessment program. The background monitoring and indicator evaluation programs provide two phases of detection level monitoring (DOE/RL 1992b).

Once a groundwater monitoring well has been installed, a background monitoring program is also commenced. Samples and water levels are obtained from upgradient well(s) and analyzed quarterly to obtain relevant background groundwater quality for the unit. These samples are analyzed for several general constituents. The specific site parameters are listed in the appropriate sections that follow. Due to the termination of the analytical support contract, sampling was temporarily halted on June 1, 1990 and restarted on June 6, 1991 under a new analytical laboratory. Therefore, current interpretations are based on a limited quantity of new data.

Once background groundwater quality has been determined an indicator evaluation program commences. During this program groundwater samples and water levels are obtained semiannually. Indicator data are then compared to background data. If significant differences are identified, then a groundwater quality assessment plan must be implemented. Groundwater monitoring wells installed under the RCRA program must meet the requirements set forth in WAC 173-160 through 162, and current RCRA regulations. The following is a brief discussion of the RCRA units within the 200 West Area and their associated groundwater monitoring networks.

2.8.2.1 Low-Level Waste Management Areas. There are three low-level waste management areas (LLWMAs) within the 200 West Area. These include LLWMA 3, 4, and 5. These disposal facilities received waste in solid form predominantly (although some drummed liquids may have been included in some of the older areas). They are proposed to be permitted under a Part B RCRA permit (DOE/RL 1989). The RCRA regulations (40 CFR 265) require groundwater monitoring at landfills although studies of moisture transport through the vadose zone at the Hanford Site (see Sections 3.5.1.2 and 4.2.2.1.2) indicate that any leachate generated in these facilities has probably not reached groundwater yet. Nevertheless, the required monitoring provides an opportunity for the groundwater to be sampled and to answer other broader issues as well.

The LLWMA 3 is located within the north-central portion of the 200 West Area and is subdivided into low-level burial grounds 218-W-3A, 218-W-3AE, and 218-W-5 (Figure 2-4). There are currently 17 groundwater monitoring wells associated with LLWMA 3. These groundwater monitoring wells are summarized in Table 2-9. This facility covers an area of 184 acres (74 ha). Burial ground 218-W-3A began receiving wastes in 1970 consisting of primarily ion-exchange resins and failed equipment (tanks, pumps, ovens, agitators, heater, vehicles, hoods, and accessories). This burial ground also contains spent fuel in retrievable storage units (RSUs). Burial ground 218-W-3AE began receiving wastes in 1981. These wastes included rags, paper, rubber gloves, broken tools, and industrial wastes. Burial ground 218-W-5 began receiving wastes in 1986. This burial ground contains low-level mixed wastes including lead bricks and shielding.

Quarterly groundwater sampling at LLWMA 3 began in 1988. A list of constituents being monitored is included in Table 2-10. During the second phase of sampling (indicator evaluation program), elevated levels of total organic halogens (TOX) were detected in downgradient Well 299-W7-4. In addition, total organic carbon (TOC) was also found to be above background levels in downgradient Wells 299-W7-5 and 299-W8-1 and upgradient well 299-W10-13. Based on these detections a groundwater quality assessment program was implemented. Groundwater samples were collected in the third and fourth quarters of 1991 and the first quarter of 1992. Results of sampling are discussed in Section 4.1.1.

The LLWMA 4 area covers 60 acres (24 ha) and is located in the south-central portion of the 200 West Area (Figure 2-5). It is composed of two burial grounds, 218-W-4B and 218-W-4C. Burial ground 218-W-4B began receiving wastes in 1968 and includes mixed and retrievable TRU wastes in trenches in 12 caissons of which one is believed to contain mixed waste. Burial ground 218-W-4C began receiving wastes in 1978 and includes contaminated soil, equipment, and spent fuel. Groundwater monitoring for LLWMA 4 is currently in Phase II detection monitoring. There are currently 16 groundwater monitoring wells associated with this LLWMA. Figure 2-5 shows the location of these wells. Current constituents detected in groundwater above background levels include chromium, manganese, iron, chloroform, trichlorethylene, carbon tetrachloride, nitrates, and alpha contamination.

The LLWMA 5 is located in the north-central portion of the 200 West Area. It contains the future burial ground 218-W-6. This burial ground has not yet received any waste. Future plans consist of 35 trenches covering approximately 44 acres (18 ha). Currently eight groundwater monitoring wells have been sampled in association with LLWMA 5 which are shown on Figure 2-6.

2.8.2.2 Single-Shell Tanks. There are four RCRA single-shell tank areas within the 200 West Area. These include the 241-T, -TY, -TX, -S, -SX, and -U Tank Farms. Within these four tank farms there are 83 single-shell tanks that range in size from 208,000 to 3,785,300 L (55,000 to 1,000,000 gal). The single-shell tanks were decommissioned as disposal facilities in 1980 but because they are currently storing hazardous and radioactive wastes they have been designated as RCRA facilities.

The single-shell tanks are a RCRA past practice unit for which a draft closure plan has been submitted to the Washington State Department of Ecology (Ecology). A closure plan is scheduled to be prepared in 1994 according to the Tri-Party Agreement. Locations of the facilities and their associated groundwater monitoring networks are shown in Figures 2-7 and 2-8. Table 2-9 contains a summary of single-shell tank facilities and their associated groundwater monitoring wells. Groundwater monitoring beneath the single-shell tanks is by an interim-status RCRA detection level groundwater monitoring network that was initiated in 1989. Sampling was initiated within the 241-T, -TX, and -TY Tank Farm in February 1990 but was suspended until 1991 because of lack of analytical laboratory support. Sampling resumed in July 1991 at the 241-T, -TX, and TY Tank Farms. Quarterly background sampling are currently being collected at the tank farms for those wells completed for calendar year 1989 through 1991. There are currently 42 groundwater monitoring wells included in the network for the tank farm facilities.

Installation of new groundwater monitoring wells began in August 1991 and is continuing. These new wells will monitor the upper portion of the unconfined aquifer and in anticipation of falling water table levels caused by the cessation of artificial recharge by discharge to the now closed 216-U-10 Pond. Wells within the 241-S, -SX, and -U Tank Farms will have larger screened intervals, up to 11 m (35 ft), thereby extending their useful life.

Groundwater samples from single-shell tank monitoring wells are analyzed for drinking water standards, indicator parameters, and water quality parameters (Table 2-11). Gamma scans are also run on samples from these wells.

2.8.2.3 216-U-12 Crib. The 216-U-12 Crib is located south of U Plant Aggregate Area within the 200 West Area (Figure 2-3). The crib is an unlined, gravel-bottom, percolation crib measuring 93 m^2 (1,000 ft^2) and 4.3 m (14 ft) deep. Wastes discharged to the subsurface through the crib include effluent from U Plant and includes stack drainage and

process condensate from the 224-U Building. These effluents were composed of low-level radioactive wastes known to have included dilute nitric acid as well as radioactive wastes of plutonium, strontium, ruthenium, and uranium. The crib was active from April 1960 until 1972 when it was deactivated. The crib was reactivated in November 1981, and received waste until it was permanently retired in February 1988. Ongoing hydrogeologic evaluation (as of 1983) below the crib has indicated radioactive contamination to a depth of at least 43 m (140 ft) and there is also the possibility that the effluent line to 216-U-12 Crib may have leaked. Because the crib is not expected to receive further waste effluent, DOE/RL has proposed that the facility be closed under RCRA interim status (EPA 1989a). A closure plan is scheduled to be prepared in 1994 according to milestone M-20-37 of the Tri-Party Agreement (Ecology et al. 1991).

The monitoring network consists of one upgradient well, 299-W22-43, and three downgradient wells, 299-W22-40, 299-W22-41, and 299-W22-42 screened in the upper portion of the unconfined aquifer (Figure 2-9). These wells were constructed in the first half of 1990. Groundwater samples were collected for the first time from the network during 1991. Table 2-12 shows a list of constituents being analyzed for at the 216-U-12 Crib.

2.8.2.4 216-S-10 Ditch and Pond. The 216-S-10 Facility is located in the S Plant Aggregate Area southeast of the 200 West Area, directly outside the perimeter fence (Figure 2-3). The facility included an open unlined ditch 1.8 m (6 ft) deep and 1.2 m (4 ft) wide at the bottom, and 689 m (2,260 ft) long. In addition to the ditch a 5-acre pond was active during part of the time the ditch was receiving wastes.

The ditch began receiving wastes in August 1951 from the REDOX Plant. The 216-S-10 Pond was constructed and put in service in February 1954. The waste effluent included cooling water, steam condensate, water tower overflow, and drain effluent. Releases of radioactive and chemical contaminants are poorly documented. Radioactive disposal to the facility is reported from floor and sewer drain discharge from the REDOX Plant and hazardous chemical releases are documented in 1954 and 1983.

In October 1985, the 216-S-10 Pond and portions of the ditch were decommissioned, backfilled, and stabilized. The remaining portion of the 216-S-10 Ditch receives nonhazardous materials from the 202-S Building chemical sewer. It is reported that these discharges do not contact hazardous materials (DOE/RL 1992b).

The monitoring network presently consists of two upgradient wells, 299-W26-7 and 299-W26-8, three downgradient wells, 299-W26-9, 299-W26-10, and 299-W26-12, and one downgradient perched water zone well, 299-W26-11. Well locations are shown on Figure 2-10. Groundwater samples were collected for the first time from this network during the third and fourth quarters of 1991 and the first quarter of 1992. The results are summarized in Section 4.1.1. Constituents being analyzed for are listed on Table 2-13. A RCRA Part B

closure plan is scheduled to be submitted for this facility by May 1996 according to milestone M-20-39 of the Tri-Party Agreement (Ecology et al 1991).

2.8.3 200 West Groundwater AAMS Groundwater Monitoring Program (CERCLA)

The Hanford Site is organized into numerically designated operational areas including the 100, 200, 300, 400, 600, and 1100 Areas. The 100, 200, 300, and 1100 Areas are listed separately on the EPA's National Priorities List (NPL). The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) outlines procedures for approaching the various sites within the framework of the CERCLA guidelines.

2.8.3.1 200 West Groundwater Aggregate Area. Under the Tri-Party Agreement, the 200 NPL Site has been divided into ten aggregate areas. Currently, the 200 West Area is divided into four source aggregate areas as well as one groundwater aggregate area.

Part of the fiscal year 1992 effort for the 200 West Groundwater AAMS is the selection and sampling of an aggregate area well network. The current well network, which was sampled for the first time in the last quarter of 1991, consists of 37 wells (Table 2-14). The associated analytical requirements are summarized on Table 2-15 and well locations are shown on Figure 2-11. Sampling of these wells is continuing for the first three quarters of 1992.

2.8.3.2 Expedited Response Action for Carbon Tetrachloride Remediation. The carbon tetrachloride disposal sites include the 216-Z-1A Tile Field, the 216-Z-9 Trench, and the 216-Z-18 Crib. These facilities are located in the Z Plant Aggregate Area between the 216-Z-20 Ditch and Z Plant (Plate 1).

These facilities received liquid waste from the Z Plant facility operations starting in 1949 and continuing until 1973. The amount of carbon tetrachloride estimated to have been discharged is 363,000 to 580,000 L (96,000 to 153,000 gal).

Carbon tetrachloride has been detected during drilling operations in and around the location of disposal sites, both above and below the Plio-Pleistocene (caliche) stratum, in the 200 West Area. The groundwater is contaminated with carbon tetrachloride and a plume emanates from the disposal sites to the northern sections of the area (see Figure 4-6).

Currently several remediation procedures are being evaluated for the carbon tetrachloride contamination. These include the extraction of the liquids and/or vapors, biological metabolism of the carbon tetrachloride, in situ stabilization or solidification, and vitrification. Because of the characteristics of the soil, the vapor extraction method is the

most favorable. Extraction tests are being conducted at the disposal sites. Once this decision is finalized and the method tested, a groundwater monitor network will be established.

2.8.4 Pacific Northwest Laboratory Environmental Monitoring Network

The PNL, operated for the DOE by Battelle Memorial Institute (Contract No. DE-AC06-76-RLO 1830), assesses the impact of Hanford Site operations on the groundwater. This program is performed independently of the other monitoring programs discussed above.

This groundwater monitoring network is designed to comply with the environmental surveillance portions of DOE Order 5400.1. As such, it evaluates existing and potential pathways of exposure to radioactivity and hazardous chemicals from site operations. The objectives of this program are as follows:

- Verify compliance with environmental laws and regulations
- Verify compliance with environmental commitments
- Characterize impacts of Hanford Site operations to the environment.

Although PNL's groundwater monitoring program is performed independently of the other programs, data collected from all monitoring programs at the Hanford Site are used in assessing the groundwater quality across the site. Sampling schedules from each of the site groundwater monitoring programs are reviewed by project staff in context with the requirements for the environmental surveillance needs. A supplemental monitoring program is developed each year to meet the objectives of the groundwater surveillance program.

For calendar year 1990 there were 100 wells sampled in and around the 200 West Area (Evans et al. 1990). These included RCRA, OGWMN, and other wells. These wells are summarized on Table 2-16 and the locations are shown on Figure 2-12. A list of constituents being evaluated under this program is listed on Table 2-17.

2.8.5 Hanford Sanitary Water Quality Surveillance

Sanitary water quality surveillance on the Hanford Site is conducted as a joint effort by the HEHF Environmental Health Services and PNL Environmental Health Sciences Department. The HEHF oversees surveillance in the areas of chemical and microbial quality, while PNL efforts focus on radiological quality.

The primary purpose of the surveillance program is the protection of the health of persons consuming water on the Hanford Site by regulating sanitary water with applicable drinking water standards. There are no groundwater wells within the 200 West Area that are used as a supply of drinking water. The nearest drinking water well being sampled under this program is at the Yakima Barricade (Well 699-49-100C) about 5 km (3 mi) west (upgradient) of the 200 West Area. Other wells potentially downgradient of the 200 West Area but much farther away include Well S28-EO at the Patrol Training Academy and 3 wells (499-SJ, 499-S08, and 499-S07) at the 400 Area (Fast Flux Test Facility). It is possible that some constituents could migrate to and be detected by these or other wells under this program, but this is not observed to date.

Drinking water constituents that are monitored for under this program include selected inorganics, volatile organics, microbiological constituents, and radiological constituents including total alpha and beta, tritium, and ^{90}Sr. These constituents are sampled quarterly.

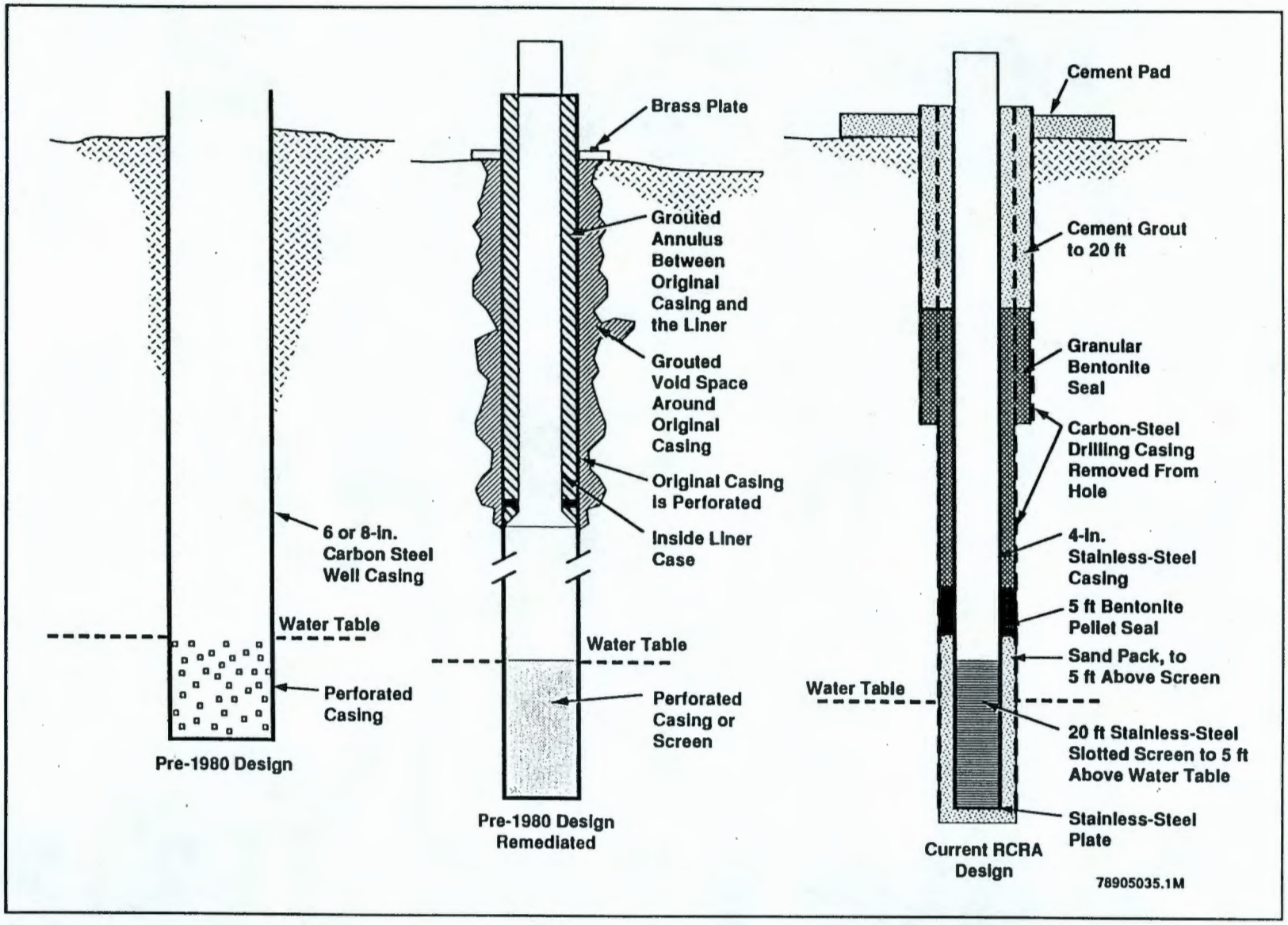

Figure 2-1. Schematic Design of Typical Hanford Site Monitoring Wells (Serkowski and Jordan 1989).

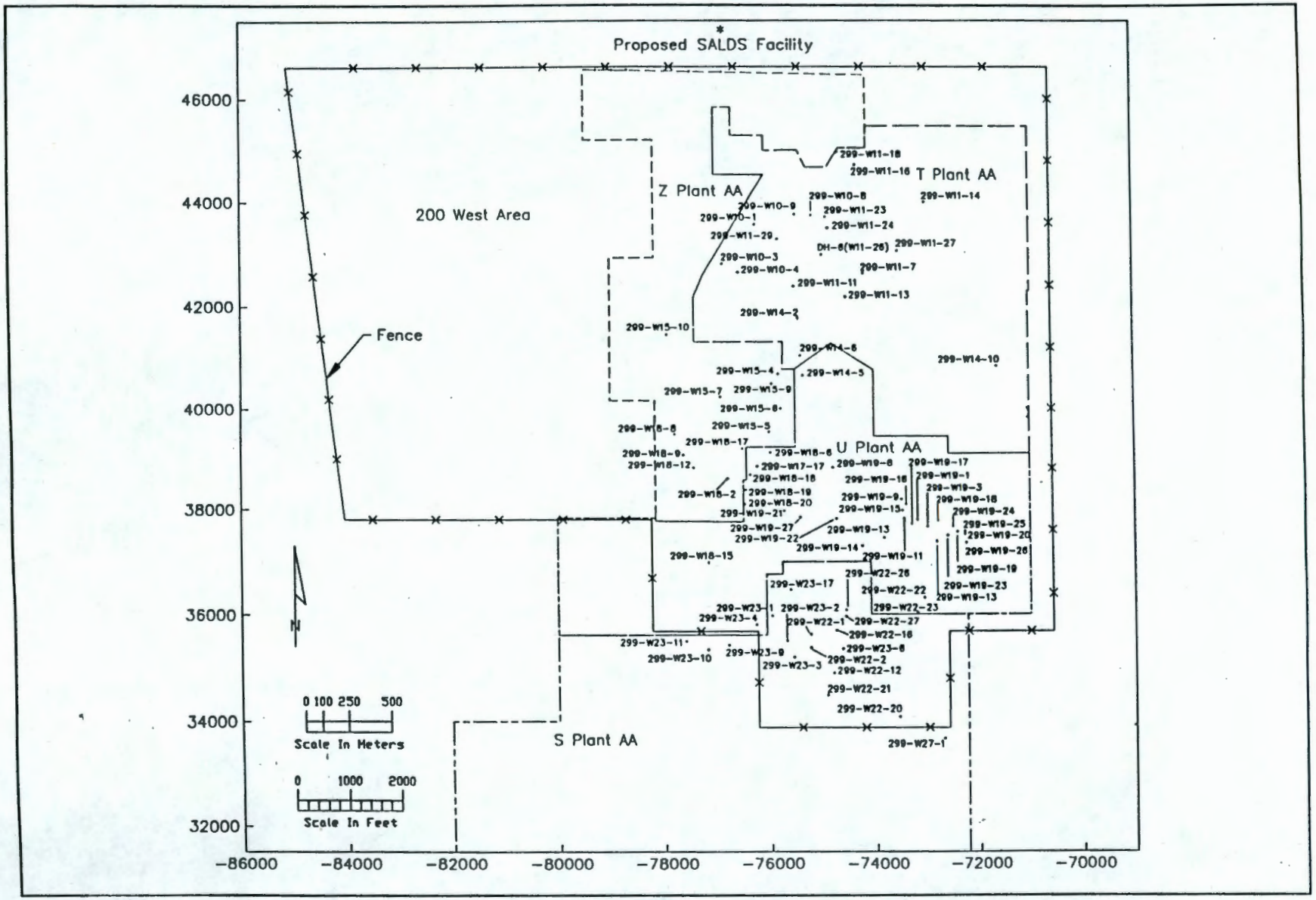

Figure 2-2. Westinghouse Hanford Operational Groundwater Monitoring Network in the 200 West Area.

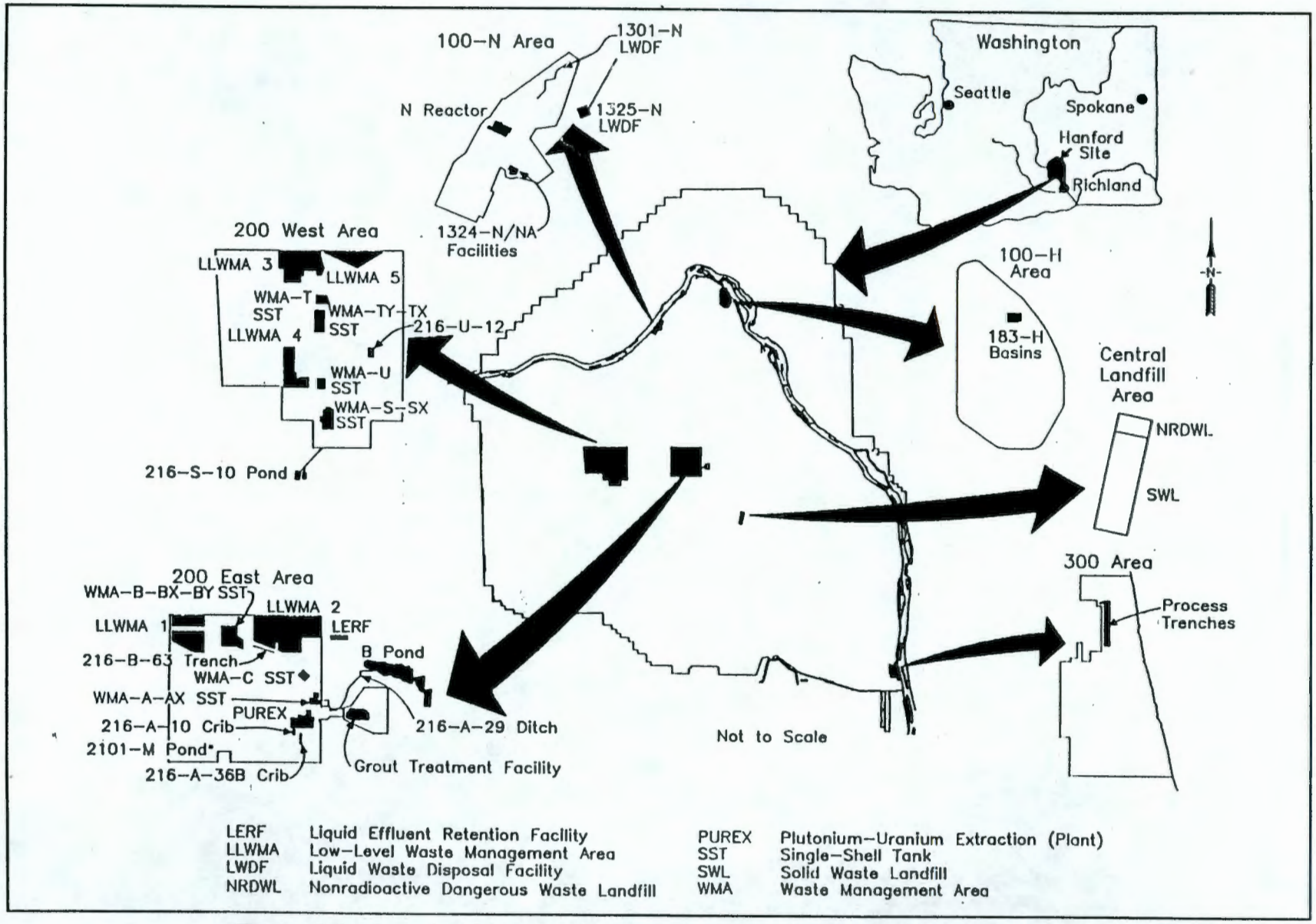

Figure 2-3. Location of RCRA Facilities at the Hanford Site (DOE/RL 1991b).

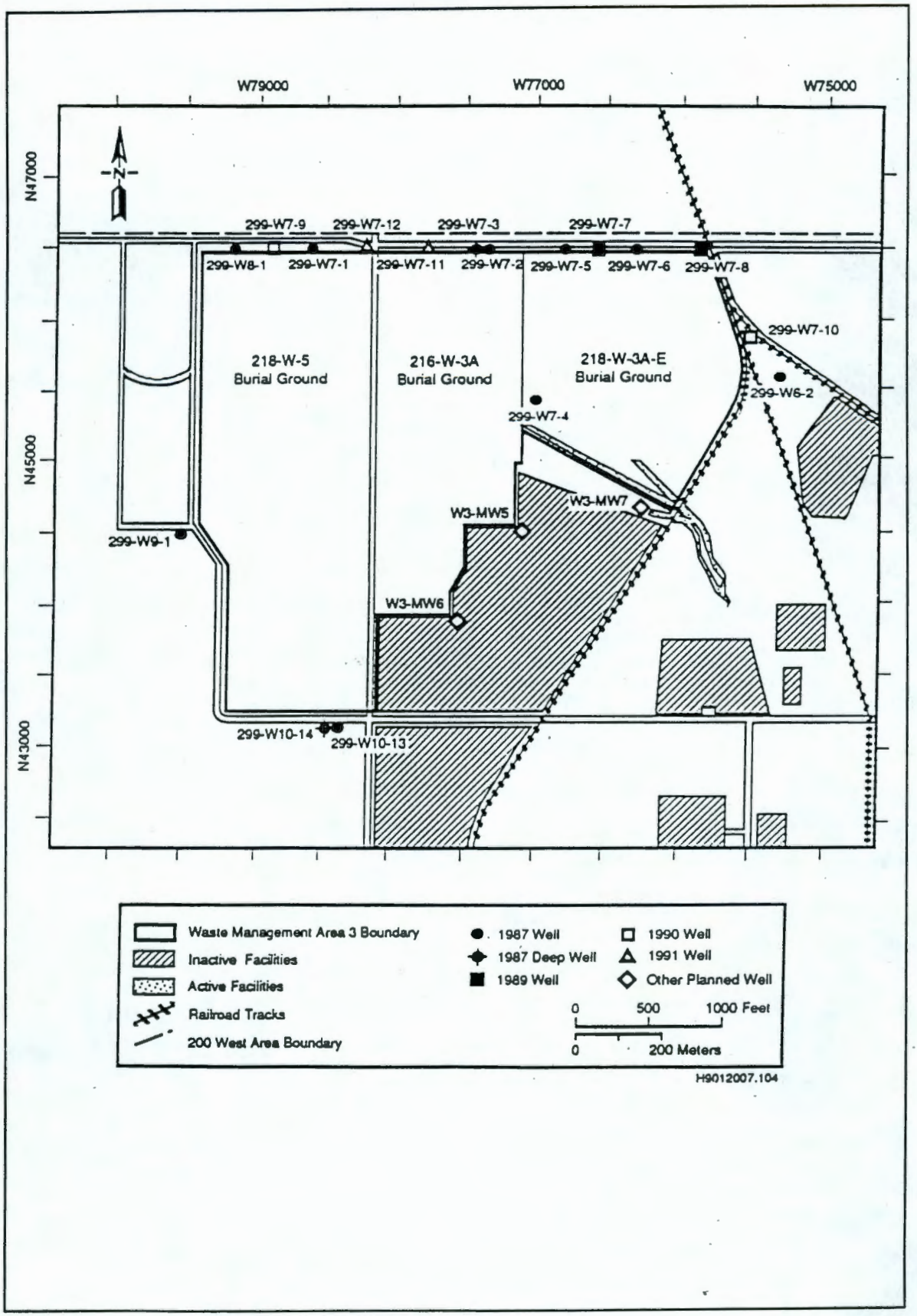

Figure 2-4. Low-Level Management Area Three Groundwater Monitoring Well Network (DOE/RL 1991b).

9 2 1 2 6 1 0 1 1 3

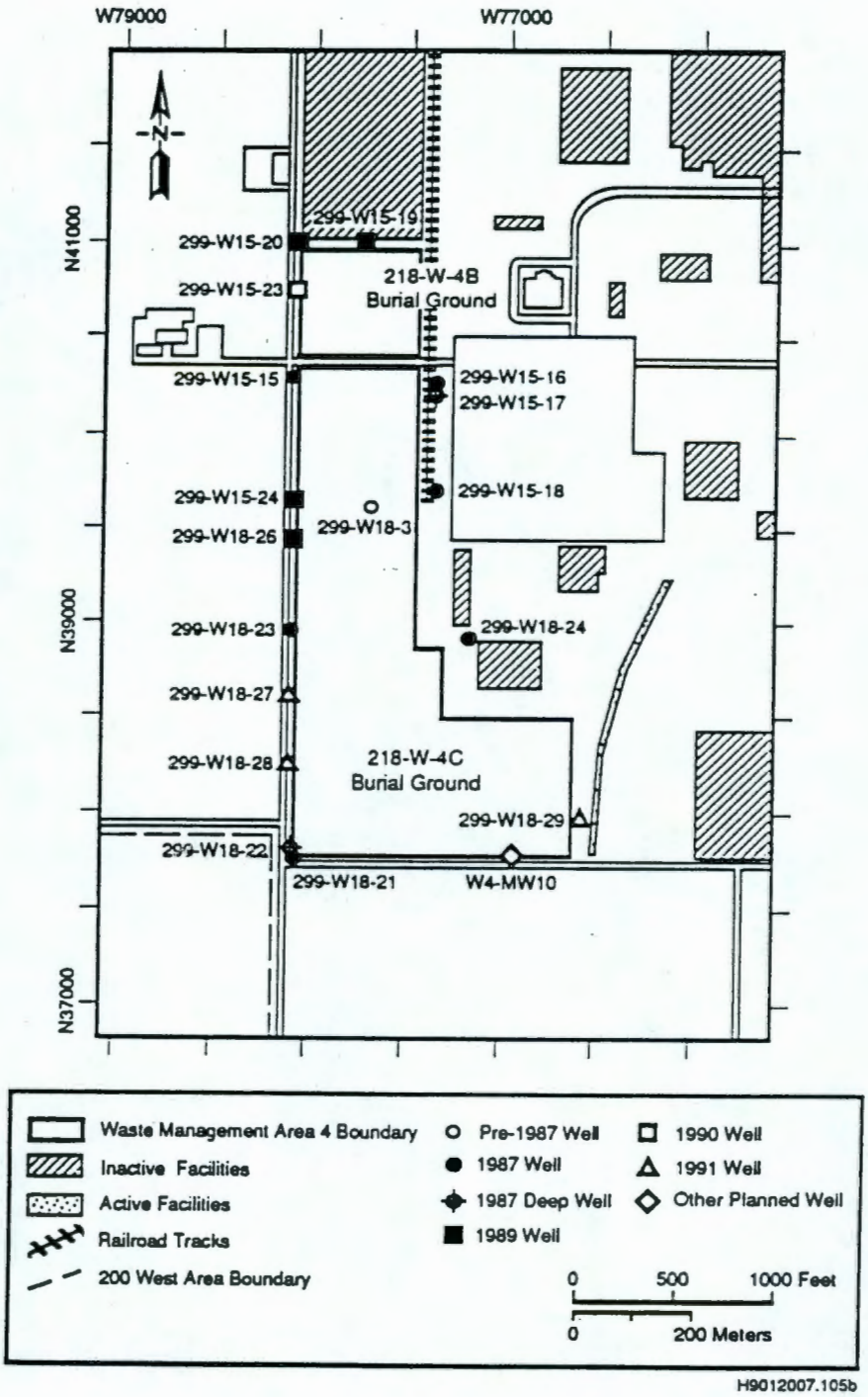

Figure 2-5. Low-Level Management Area Four Groundwater Monitoring Well Network (DOE/RL 1991b).

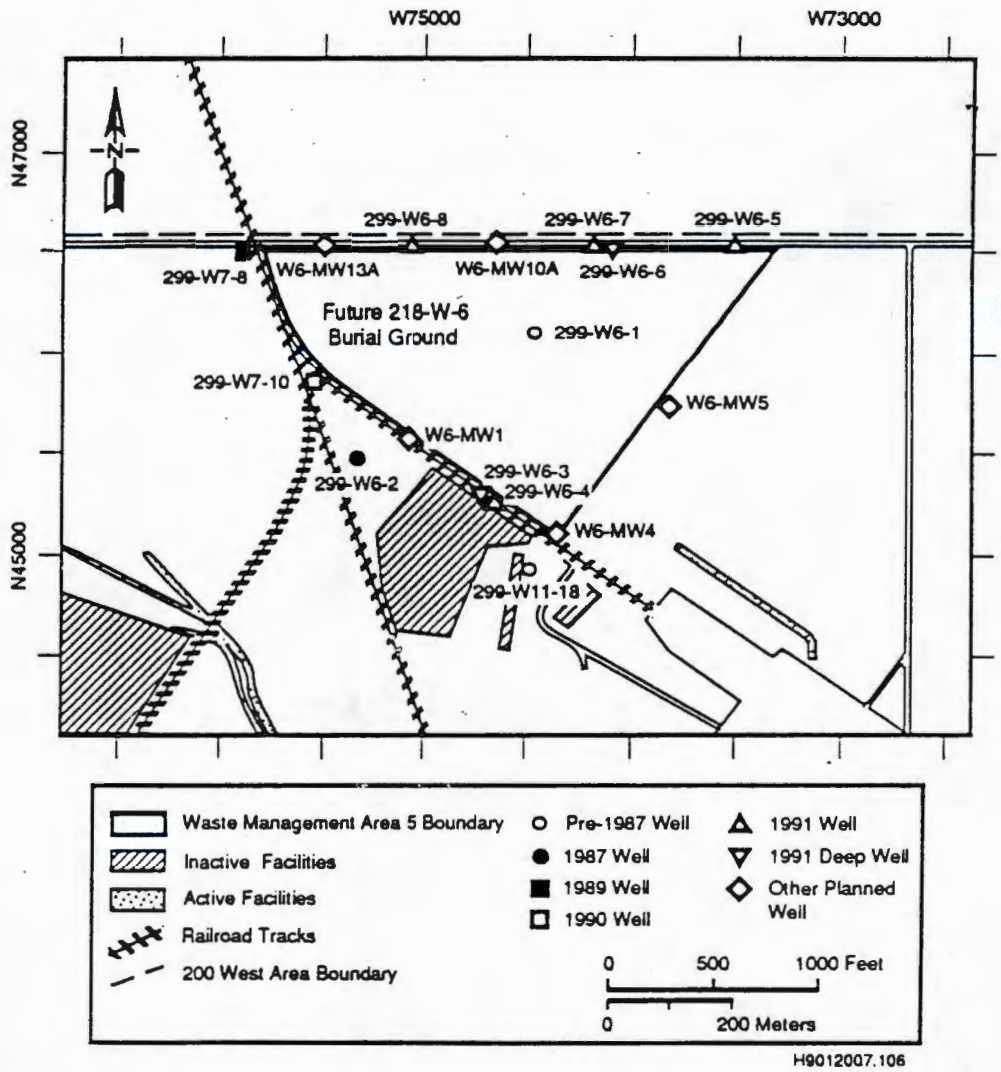

Figure 2-6. Low-Level Management Area Five Groundwater Monitoring Well Network (DOE/RL 1991b).

9 2 1 2 6 1 0 1 1 5

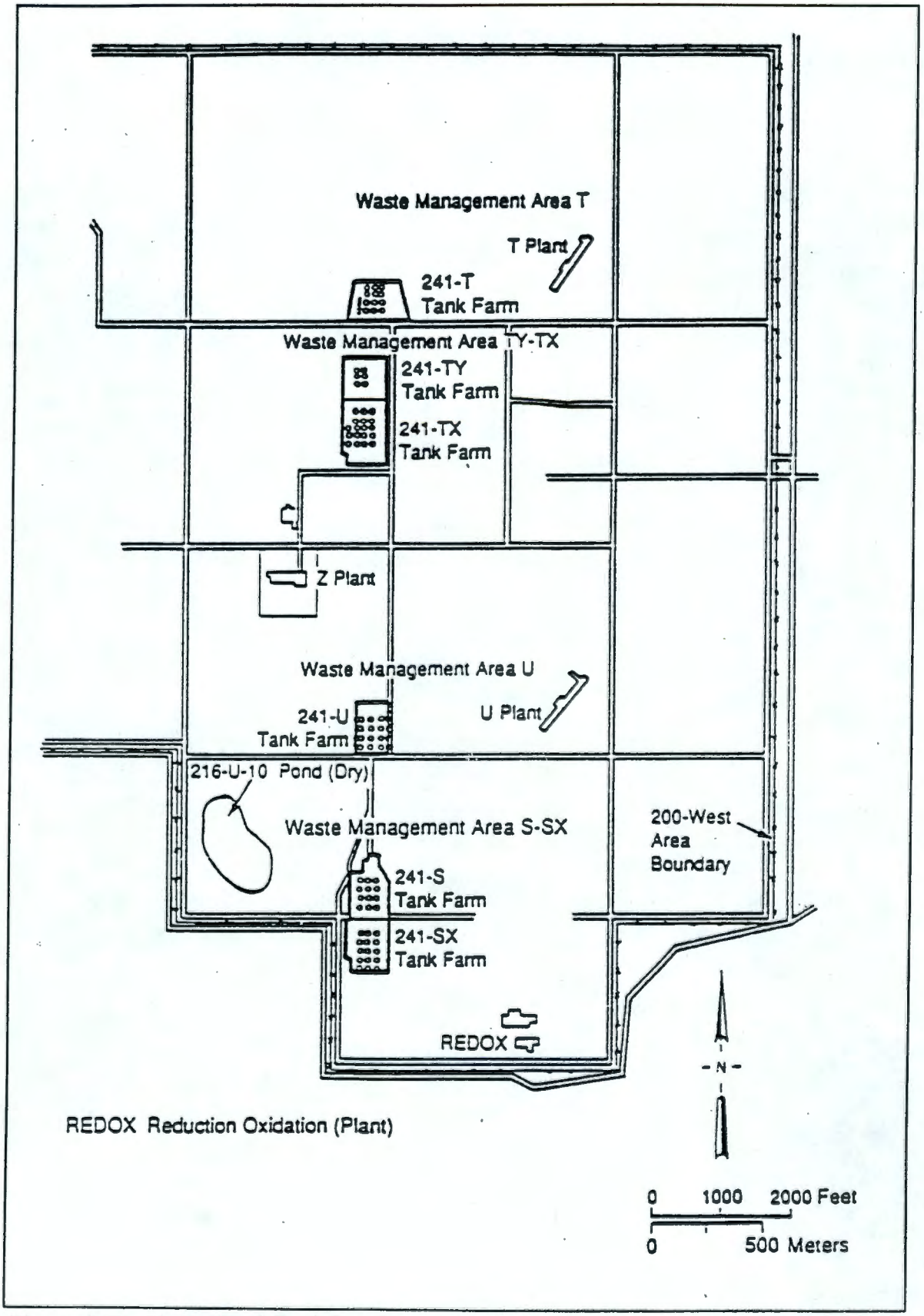

Figure 2-7. Single-Shell Tank Locations within the 200 West Area (DOE/RL 1991b).

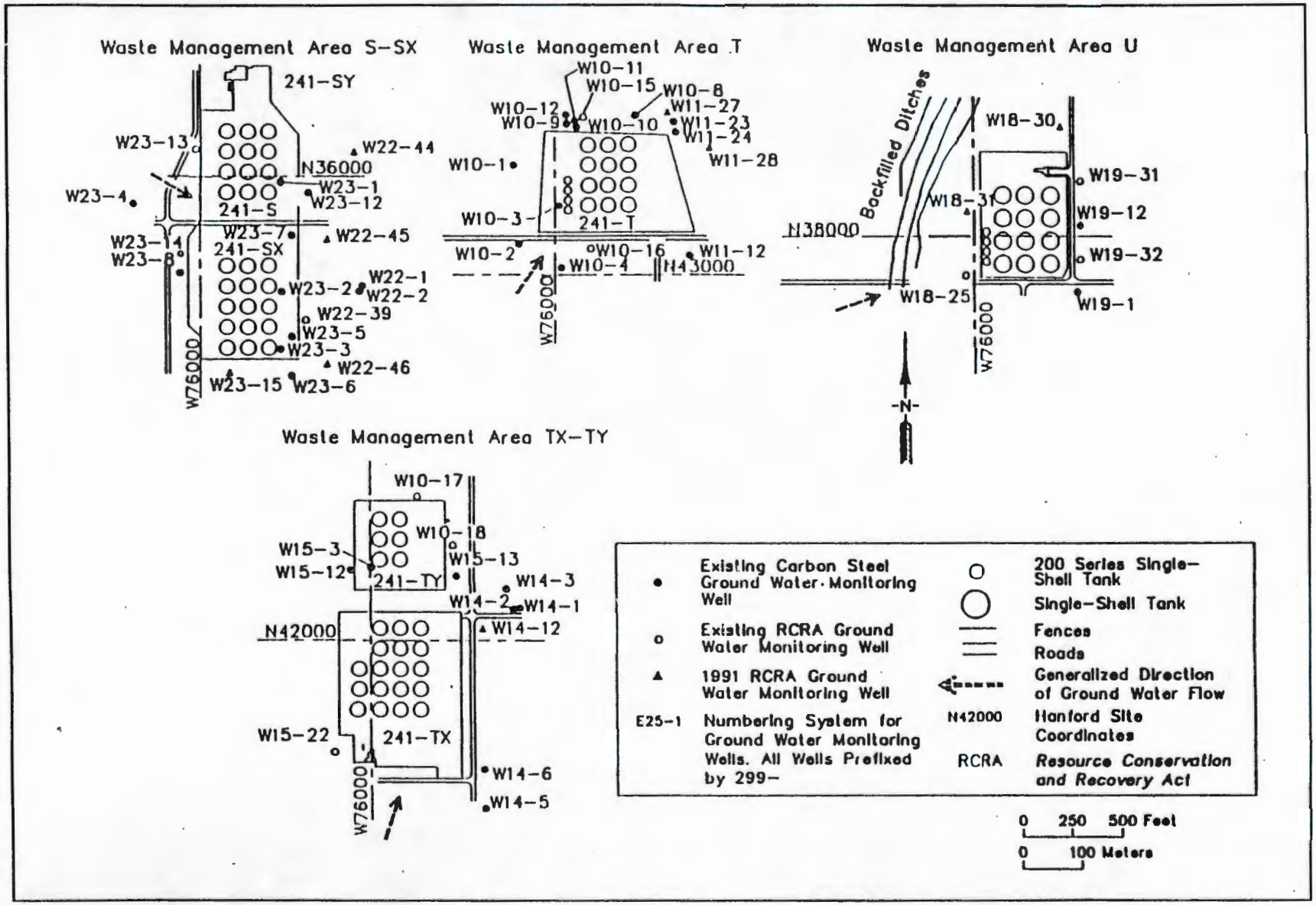

Figure 2-8. Groundwater Monitoring Wells Associated with the Single-Shell Tanks (DOE/RL 1991b).

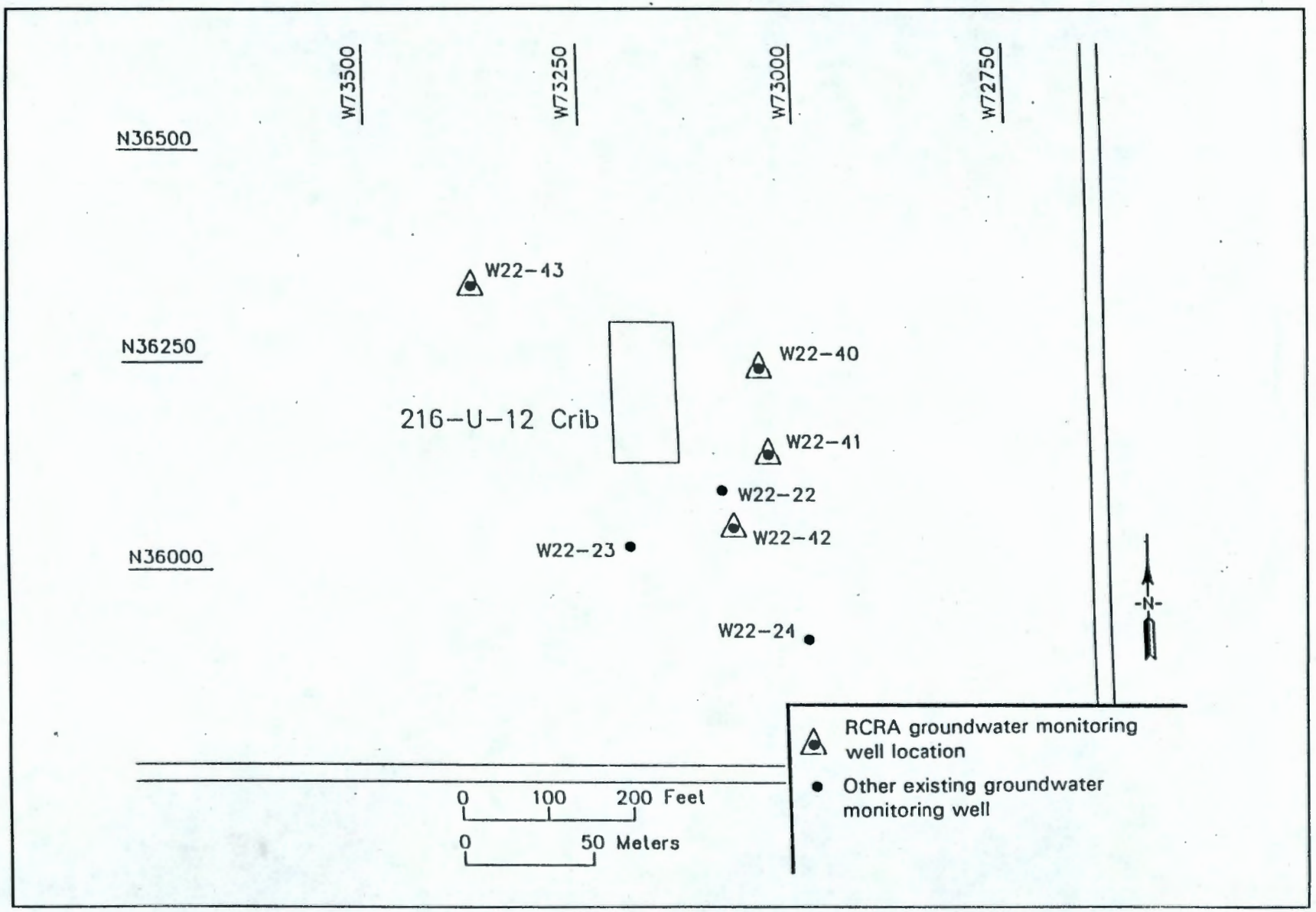

Figure 2-9. Groundwater Monitoring Wells Associated with the 216-U-12 Crib (DOE/RL 1991b).

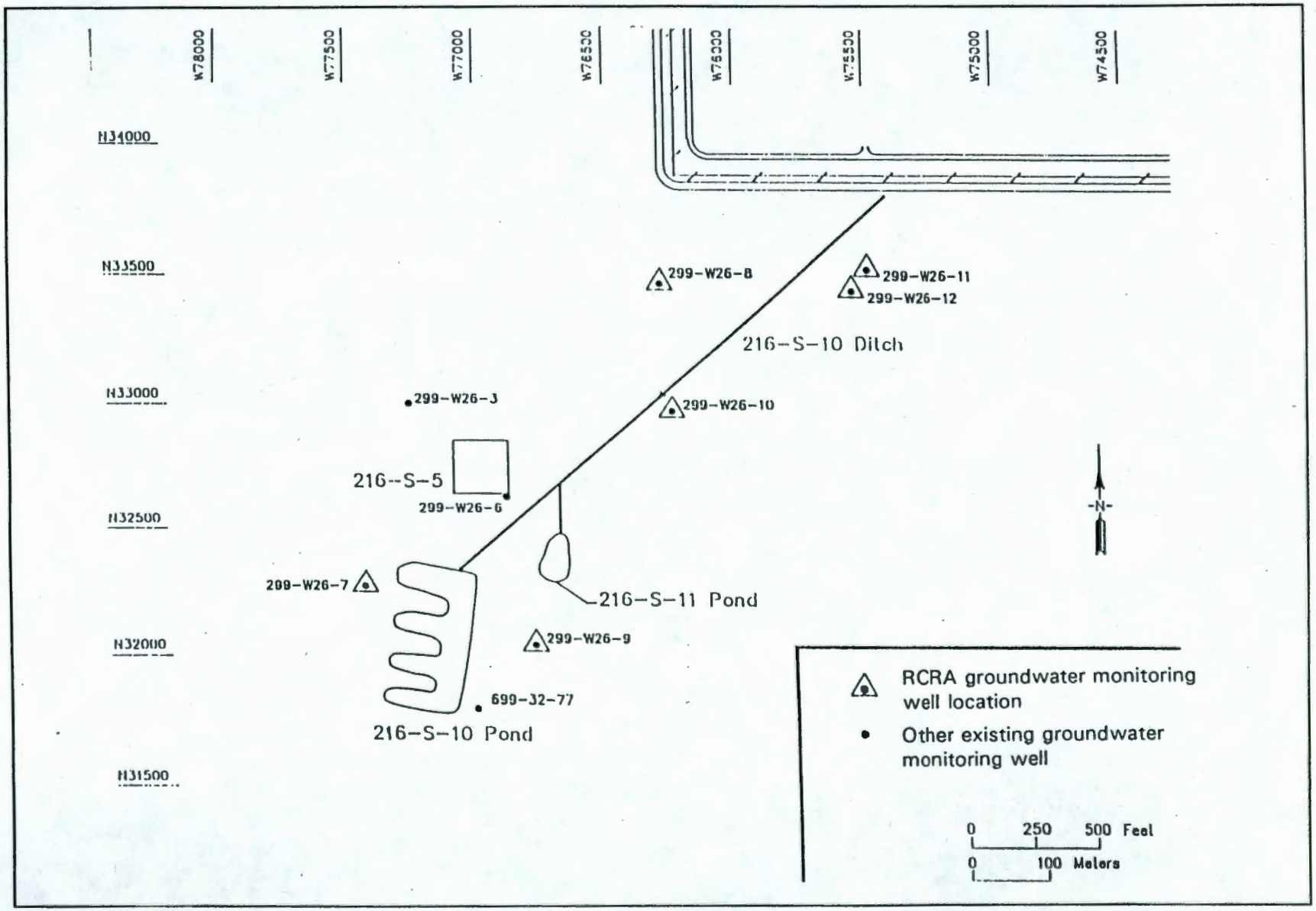

Figure 2-10. Groundwater Monitoring Wells Associated with the 216-S-10 Ditch (DOE/RL 1991b).

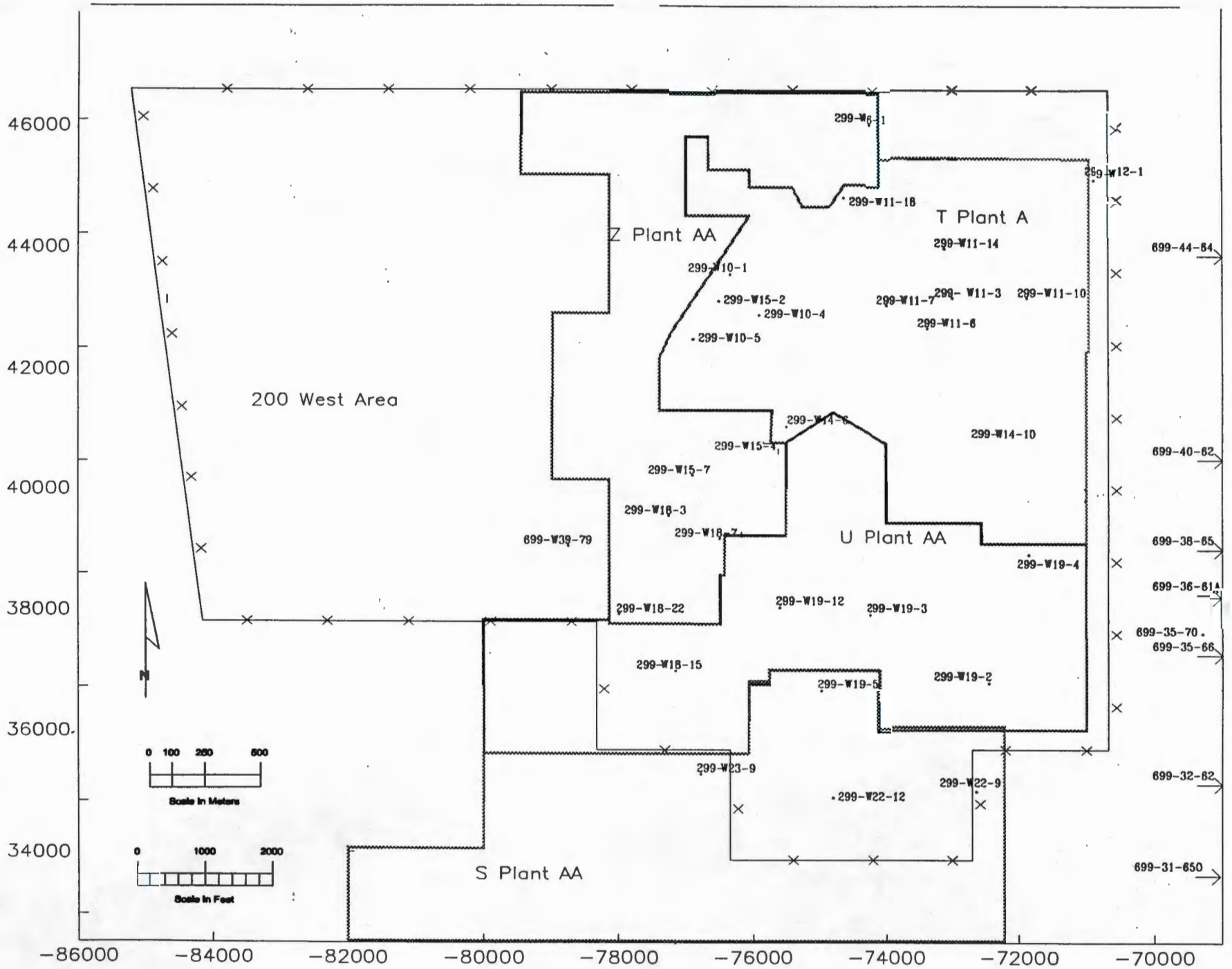

Figure 2-11. CERCLA Groundwater Monitoring Well Network (Connelly et al. 1992).

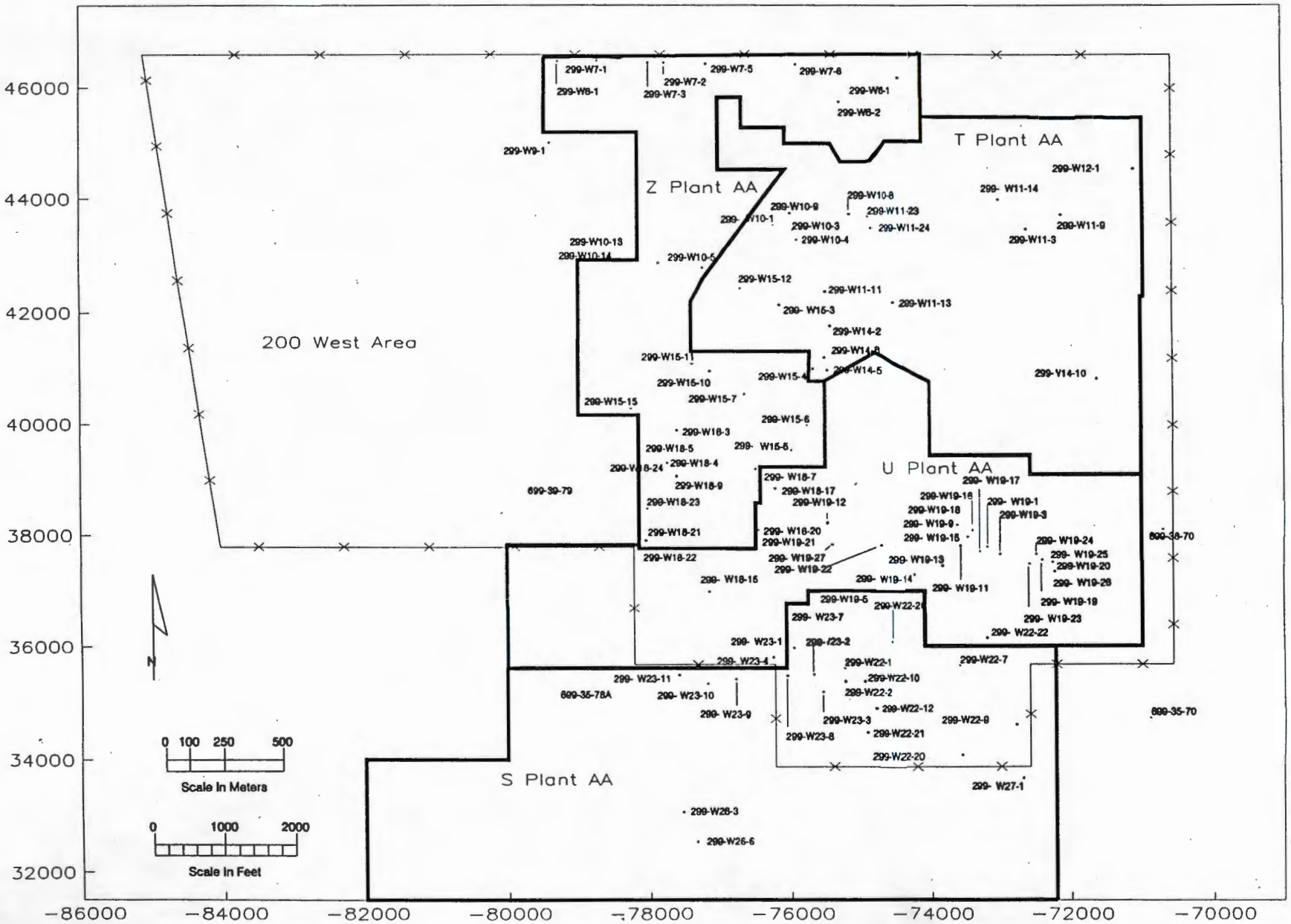

Figure 2-12. Pacific Northwest Laboratory Groundwater Monitoring Network in the 200 West Area (Evans et al. 1990).

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a/]	Liquid Discharge to Soil
U Plant Aggregate Area				
Tanks and Vaults				
241-U-101 Single-Shell Tank	1949-1959 and 1969-1972 *inactive*	$BiPO_4$ metal waste, REDOX high-level waste, fuel elements, shroud tubes, and samarium balls	94.6	Yes
241-U-102 Single-Shell Tank	1946-1979 *inactive*	$BiPO_4$ metal waste, 242-T evaporator waste, $HNO_4/KMnO_4$ solution, REDOX high-level waste	14.2	No
241-U-103 Single-Shell Tank	1947-1978 *inactive*	$BiPO_4$ metal waste, 242-T evaporator waste, $HNO_4/KMnO_4$ solution, REDOX high-level waste	1,771.4	Yes
241-U-104 Single-Shell Tank	1947-1956 *inactive*	$BiPO_4$ metal waste	461.8	Yes
241-U-105 Single-Shell Tank	1947-1978 *inactive*	$BiPO_4$ metal waste, 242-T evaporator waste and coating waste from 241-U Tank Farm	1,582.1	No
241-U-106 Single-Shell Tank	1948-1977 *inactive*	$BiPO_4$ metal waste, REDOX high-level waste, PUREX and B Plant low-level waste	855.4	No
241-U-107 Single-Shell Tank	1948-1980 *inactive*	$BiPO_4$ metal waste, $HNO_4/KMnO_4$ solution, N Reactor and PNL waste, coating, lab and REDOX waste	1,536.7	No
241-U-108 Single-Shell Tank	1949-1979 *inactive*	$BiPO_4$ metal waste, REDOX coating waste, N-Reactor, decon. lab, PNL waste, evaporator bottoms	1,771.4	No
241-U-109 Single-Shell Tank	1949-1978 *inactive*	$BiPO_4$ metal waste, REDOX high-level waste, coating waste, and evaporator bottoms	1,752.5	No
241-U-110 Single-Shell Tank	1946-1975 *inactive*	$BiPO_4$ metal waste, REDOX coating and high-level waste, lab waste and PNL waste	704	Yes
241-U-111 Single-Shell Tank	1947-1980 *inactive*	$BiPO_4$ first cycle waste, REDOX high level waste, $HNO_4/KMnO_4$; N-Reactor, PNL, decon. waste	1,245.3	No
241-U-112 Single-Shell Tank	1947-1970 *inactive*	$BiPO_4$ first-cycle waste, REDOX high-level waste from 241-U Tank Farm	15.1	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
241-U-201 Single-Shell Tank	1956-1977 *inactive*	REDOX high-level wastes from 241-U Tank Farm	19	No
241-U-202 Single-Shell Tank	1956-1977 *inactive*	REDOX high-level wastes from 241-U Tank Farm	19	No
241-U-203 Single-Shell Tank	1956-1977 *inactive*	REDOX high-level wastes from 241-U Tank Farm	12	No
241-U-204 Single-Shell Tank	1956-1977 *inactive*	REDOX high-level wastes from 241-U Tank Farm	12	No
241-U-301 Catch Tank	1946-present *active*	Processing and decon. wastes	18.5	No
241-UX-302A Catch Tank	1946-present *active*	Processing and decon. wastes	26.5	No
241-U-361 Settling Tank	1951-1967 *inactive*	Radioactive liquid, plutonium sludge	104	No
244-U Receiver Tank	1987-present *active*	Processing and decon. wastes	NA	No
241-WR Vault	1952-1976 *inactive*	Contains radioactive equipment and structure	NA	No
244-UR Vault	1946-1979 *inactive*	Contains radioactive tank and concrete surfaces and asbestos	NA	No
Cribs and Drains				
216-S-21 Crib	1954-1969 *inactive*	Received 241-SX condensate	87,100	Yes
216-U-1 and 216-U-2 Cribs	1951-1968 *inactive*	Various wastes from 221-U and 224-U Buildings	46,200	Yes
216-U-8 Crib	1952-1960 *inactive*	Process condensate from 221-U and 224-U Buildings and 291-U Stack drainage	379,000	Yes

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Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a/]	Liquid Discharge to Soil
216-U-12 Crib	1960-1988 *active*	Stack drainage, vault waste, process condensate	150,000	Yes
216-U-16 Crib	1984-1988 *inactive*	224-U Building steam condensate, chemical sewer waste, cooling water	409,000	Yes
216-U-17 Crib	1987-present *active*	UO_3 plant process condensate	2,110	Yes
216-Z-20 Crib	1981-present *active*	Cooling water, steam condensate, storm sewer, chemical drains	3,800,000	Yes
216-S-4 French Drain	1953-1956 *inactive*	Received condensate and cooling waste from 101-S and 104-S Single-Shell Tanks	1,000	Yes
216-U-3 French Drain	1954-1957 *inactive*	Condensed vapors from 110-U	791	Yes
216-U-4A French Drain	1955-1970 *inactive*	Decon. waste from 222-U Laboratory and PNL operations decon. waste	545	Yes
216-U-4B French Drain	1960-1970 *inactive*	Waste from hot cell and hood in 222-U Laboratory, PNL operation wastes from hot cell and hood	33	Yes
216-U-7 French Drain	1952-1958 *inactive*	Counting Box floor drainage	7	Yes
Reverse Wells				
216-U-4 Reverse Well	1947-1955 *inactive*	Decon. waste from 221-U Laboratory	300	Yes
Ponds, Ditches, and Trenches				
216-U-10 Pond	1944-1985 *inactive*	Cooling water, wastewater, steam condensate, laboratory wastes	165,000,000	Yes
216-U-14 Ditch	1944-present *active*	Powerhouse wastewater, laundry wastewater, chemical sewer waste	NA	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
216-Z-1D Ditch	1944-1959 *inactive*	Process cooling water and steam condensate from several buildings	1,000	Yes
216-Z-11 Ditch	1959-1971 *inactive*	Process cooling water and steam condensate, seal water	NA	Yes
216-Z-19 Ditch	1971-1981 *inactive*	Process cooling water and steam condensate, seal water	NA	Yes
216-U-5 and 216-U-6 Trenches	1952 *inactive*	Unirradiated uranium waste from cold start-up of U-Plant	2,250 each	Yes
216-U-11 Trench	1944-1985 *inactive*	Overflow from U-10 Pond	NA	Yes
216-U-13 Trench	1952-1956 *inactive*	Drainage from equipment decon. processes within trenches	11	Yes
216-U-15 Trench	1957 *inactive*	Interface crud, activated charcoal diatomaceous earth	NA	Yes
Septic Tanks and Associated Drain Fields				
2607-W-5 Septic Tank/Drain Field	1944-present *active*	Sanitary wastewater and sewage	4417/yr	Yes
2607-W-7 Septic Tank/Drain Field	1954-present *active*	Sanitary wastewater and sewage	365/yr	Yes
2607-W-9 Septic Tank/Drain Field	1950-present *active*	Sanitary wastewater and sewage	365/yr	Yes
2607-WUT Septic Tank/Drain Field	1951-present *active*	Sanitary wastewater and sewage	372/yr	Yes
Transfer Facilities, Diversion Boxes, and Pipelines				
241-U-A Valve Pit	1946-present *active*	Processing and decon. wastes	NA	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
241-U-B Valve Pit	1946-present *active*	Processing and decon. wastes	NA	No
241-U-C Valve Pit	1946-present *active*	Processing and decon. wastes	NA	No
241-U-D Valve Pit	1946-present *active*	Processing and decon. wastes	NA	No
241-U-151 Diversion Box	1946-present *active*	Processing and decon. wastes	NA	No
241-U-152 Diversion Box	1946-present *active*	Processing and decon. wastes	NA	No
241-U-153 Diversion Box	1946-1981 *inactive*	Processing and decon. wastes	NA	No
241-U-252 Diversion Box	1946-1983 *inactive*	Processing and decon. wastes	NA	No
241-UR-151 Diversion Box	1949-1983 *inactive*	Processing and decon wastes	NA	No
241-UR-152 Diversion Box	1949-1983 *inactive*	Processing and decon. wastes	NA	No
241-UR-153 Diversion Box	1946-1983 *inactive*	Processing and decon. wastes	NA	No
241-UR-154 Diversion Box	1949-1983 *inactive*	Processing and decon. wastes	NA	No
241-UX-154 Diversion Box	1946-present *active*	Processing and decon. wastes	NA	No
Basins				
207-U Retention Basin	1952-present *active*	Received steam condensate and cooling water from 224-U Building	NA	No

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Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
Burial Sites				
Burial Ground/Burning Pit	Unknown	Unsure, contaminated coveralls and soil discovered at the site	NA	No
200-W Construction Surface Laydown Area	1945-1950 *inactive*	Unusable valves, piping, and other pumping material	NA	No
Z Plant Aggregate Area				
Tanks and Vaults				
216-Z-8 Settling Tank	1955-62 *inactive*	Organic, radioactive waste from RECUPLEX process (234-5Z) Building	29	No
207-Z-361 Settling Tank	1949-76 *inactive*	Acidic, organic, radioactive waste from PFP and plutonium recovery processes (234-5Z Building, RECUPLEX process, and 242-Z Building)	NA	No
207-Z Treatment Tank	1948-present *active*	Corrosive aqueous waste from 234-5Z PFP	NA	No
Cribs and Drains				
216-Z-1 and 216-Z-2 Cribs	1949-52; 1964-66; 1968-69 *inactive*	PRF (236-Z) and 242-Z process waste; process, analytical and 234-5Z lab wastes; development lab waste from 234-5Z via 241-Z Settling Tanks	33,700 (38,900)	Yes
216-Z-3 Crib	1952-59 *inactive*	234-5Z process, analytical, and development wastes in via 241-Z-361 Settling Tank	178,000	Yes
216-Z-5 Crib	1945-47 *inactive*	Process waste from 231-Z Building via 231-W-151 sump	31,000 (30,000)	Yes
216-Z-6 Crib	1945 *inactive*	Process waste from 231-Z Building via 231-W-151 sump	98	Yes
216-Z-7 Crib	1946-67 *inactive*	Laboratory waste from 231-Z Building and 340 Laboratory	79,000	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
216-Z-12 Crib	1959-73 *inactive*	234-5Z process, analytical, and development wastes via 241-Z-361 Settling Tank	281,000	Yes
216-Z-16 Crib	1968-79 *inactive*	Radioactive process waste from 231-Z Building	102,000	Yes
216-Z-18 Crib	1969-73 *inactive*	High, soft, acidic, organic waste from 236-Z Building	3,860	Yes
216-Z-8 French Drain	1955-62 *inactive*	Overflow from Z-8 Settling Tank	9.59	Yes
216-Z-13 French Drain	1949-present *active*	ET-8 turbine steam condensate and 291-Z Building floor drain	NA	Yes
216-Z-14 French Drain	1949-present *active*	ET-9 turbine steam condensate and 291-Z Building floor drain	NA	Yes
216-Z-15 French Drain	1949-present *active*	Aqueous waste from S-12 evaporative cooler (291-Z Building)	NA	Yes
216-Z-1A Tile Field	1949-59; 1964-69 *inactive*	Overflow from 216-Z-1, 216-Z-2, or 216-Z-3 Cribs, PFP process wastes (234-5Z Building), PRF process waste (236-Z Building), and 242-Z process wastes	5,210 6,200	Yes
Reverse Well				
216-Z-10 Reverse Well	1945 *inactive*	Process and laboratory waste from 231-Z Building via 231-W-151 sump	1,000	Yes
Ponds, Ditches, and Trenches				
216-Z-4 Trench	1945 *inactive*	Process and laboratory waste from 231-Z Building	11	Yes
216-Z-9 Trench	1955-62 *inactive*	Radioactive, acidic, organic wastes from RECUPLEX process (234-5Z Building), 242-Z Building inorganic process wastes, and 236-Z CAW	4,090	Yes
216-Z-17 Trench	1967-68 *inactive*	Process waste from 231-Z Building via 231-W-151 sump	36,800 (36,700)	Yes

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Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
Septic Tanks				
2607-Z Septic Tank/Drain Field	1949-present *active*	Sanitary wastewater for 234-5Z and 2704-Z Buildings	8395/yr	Yes
2607-Z-8 Septic Tank/Drain Field	1965-present *active*	Sanitary wastewater	274/yr	Yes
2607-WA Septic Tank/Drain Field	1968-present *active*	Sanitary wastewater	2190/yr	Yes
2607-WWA Septic Tank/Drain Field	1955-present *active*	Sanitary wastewater from 272-WA Building	1241/yr	Yes
2607-W-8 Septic Tank/Drain Field	1959-present *active*	Sanitary wastewater from 231-Z Building	2008/yr	Yes
Transfer Facilities, Diversion Boxes, and Pipelines				
241-Z Diversion Box No. 1			NA	No
241-Z Diversion Box No. 2			NA	No
231-Z-151 Sump		Process and laboratory waste from 231-Z Building	NA	No
Basins				
207-Z Retention Basin	1949-59 *inactive*	May have received contaminated waste, steam condensate, and/or cooling water	NA	No
216-Z-21 Seepage Basin	1983-present *active*	Storm water runoff from north of 234-5Z building	100,000/yr	Yes
Burial Sites				
218-W-1 Burial Ground	1944-53 *inactive*	Transuranic mixed solid waste	NA	No
218-W-1A Burial Ground	1944-54 *inactive*	Mixed industrial solid waste	7,000	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
218-W-2 Burial Ground	1953-56 *inactive*	Transuranic mixed solid waste	16,000	No
218-W-2A Burial Ground	1954-85 *inactive*	Mixed industrial solid waste	8,200	No
218-W-3 Burial Ground	1957-61 *inactive*	Transuranic mixed solid waste	19,000	No
218-W-3A Burial Ground	1970-present *active*	Transuranic mixed solid waste	24,000	No
218-W-3AE Burial Ground	1981-present *active*	Mixed industrial solid waste	NA	No
218-W-4A Burial Ground	1958-68 *inactive*	Transuranic mixed solid waste	18,000	No
218-W-4B Burial Ground	1967-present *active*	Transuranic mixed solid waste	10,000	No
218-W-4C Burial Ground	1974-present *active*	Transuranic mixed solid waste	16,000	No
218-W-5 Burial Ground	1986-present *active*	Low level/mixed solid waste	32,500	No
218-W-6 Burial Ground	Proposed	Low level/mixed solid waste (Proposed Facility)	none	No
218-W-11 Burial Ground	1960 *inactive*	Low level/mixed solid waste	1,160	No
Z Plant Burn Pit	1950-60 *inactive*	Office and nonhazardous waste	2,000	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
S Plant Aggregate Area				
Tanks and Vaults				
241-S-101 Single-Shell Tank	1953 - 1980 *inactive*	202-S Building high-level waste, 202-S Building coating waste, and supernatant containing Pacific Northwest Laboratory waste, coating waste, laboratory waste, Purex low-level waste, B Plant high-level waste, Battelle Northwest Laboratory waste, terminal liquor and evaporator bottoms, partial neutralization feed, N Reactor waste, ion exchange waste, and double-shell tank slurry feed from 241-U, -S, and -SX Tank Farms.	1,935	No
241-S-102 Single-Shell Tank	1953 - 1980 *inactive*	202-S Building high-level waste, nitric acid/potassium permanganate ($HNO_3/KMnO_4$) solution, and supernatant containing 202-S Building high-level waste, evaporator bottoms, noncomplexed waste, double- shell tank slurry feed, and partial neutralization feed from 241-S, -SX, -SY, and -U Tank Farms.	2,949	No
241-S-103 Single-Shell Tank	1953 - 1980 *inactive*	202-S Building high-level waste, 202-S Building coating waste, $HNO_3/Kmno_4$ solution, and supernatant containing 202-S Building high-level waste, evaporator bottoms, noncomplexed wastes, partial neutralization feed, and double-shell tank slurry feed from 241-S, -SX, -SY, and -U Tank Farms.	1,260	No
241-S-104 Single-Shell Tank	1953 - 1968 *inactive*	202-S Building coating waste, 202-S Building high-level waste, and supernatant containing 202-S Building high-level waste from 241-S Tank Farm.	1,219	Yes
241-S-105 Single-Shell Tank	1953 - 1974 *inactive*	202-S Building coating waste and 202-S Building high-level waste.	1,859	No
241-S-106 Single-Shell Tank	1953 - 1979 *inactive*	202-S Building high-level waste, supernatant containing 202-S Building high-level wastes and evaporator bottoms from the 241-S Tank Farm.	2,491	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
241-S-107 Single-Shell Tank	1953 - 1980 *inactive*	202-S Building high-level waste, 202-S Building coating waste, supernatant containing decontamination waste, B Plant high- and low-level waste, Battelle Northwest Laboratory waste, 202-S Building high-level waste, Pacific Northwest Laboratory waste, N Reactor waste, PUREX low-level waste, ion exchange waste, fractionization waste, evaporator bottoms, double-shell tank slurry feed, partial neutralization feed and complexed concentrate from 241-BX, -C, -S, -SX, -SY, and -U Tank Farms.	1,563	No
241-S-108 Single-Shell Tank	1953 - 1979 *inactive*	202-S Building high-level waste, and supernatant containing 202-S Building high-level waste and evaporator bottoms from the 241-S and -SX Tank Farms.	2,676	No
241-S-109 Single-Shell Tank	1953 - 1979 *inactive*	202-S Building high-level supernatant containing evaporator bottoms from the 241-S-102 Tank.	2,619	No
241-S-110 Single-Shell Tank	1953 - 1979 *inactive*	202-S Building high-level waste, 202-S Building coating waste, supernatant containing S Plant ion exchange waste, 224-U waste, coating waste, decontamination waste, B Plant low-level waste, and organic wash waste from 241-BX, -S, -SX, -T, -TX, and -U Tank Farms.	2,846	No
241-S-111 Single-Shell Tank	1953 - 1975 *inactive*	202-S Building high-level waste and supernatant containing evaporator bottoms from the 241-S Tank Farm.	2,983	No
241-S-112 Single-Shell Tank	1953 - 1974 *inactive*	202-S Building high-level waste and supernatant containing 202-S Building high-level wastes and evaporator bottoms from the 241-S Tank Farm.	2,964	No
241-SX-101 Single-Shell Tank	1954 - 1980 *inactive*	202-S Building high-level waste, supernatant containing 202-S Building ion exchange waste, evaporator bottoms, partial neutralization feed, and complexed waste from 241-S, -BX, -SX, and -U Tank Farms.	2,275	No
241-SX-102 Single-Shell Tank	1954 - 1980 *inactive*	202-S Building high-level waste, 202-S Building ion exchange waste, evaporator bottoms, and partial neutralization feed from 241-BX, -SX, -TX, and -U Tank Farms.	2,748	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
241-SX-103 Single-Shell Tank	1954 - 1980 *inactive*	202-S Building high-level waste, concrete, and supernatant containing 202-S Building high-level waste, coating waste, evaporator bottoms, organic wash waste, and partial neutralization feed from 241-BX, -SX, and -S Tank Farms.	3,384	No
241-SX-104 Single-Shell Tank	1955 - 1980 *inactive*	202-S Building high-level waste, and supernatant containing 202-S Building ion exchange waste, and evaporator bottoms from the 241-S and -SX tanks.	2,846	Yes
241-SX-105 Single-Shell Tank	1955 - 1980 *inactive*	202-S Building high-level waste and supernatant containing 202-S Building high-level waste, 202-S Building ion exchange waste, double-shell tank, slurry feed, evaporator bottoms, and partial neutralization feed from 241-BX, -S, -TX, and -U Tank Farms.	3,573	No
241-SX-106 Single-Shell Tank	1954 - 1980 *inactive*	Hanford Laboratory waste, Battelle Northwest Laboratory waste, Pacific Northwest Laboratory waste, $HNO_3/KMnO_4$ solution, supernatant containing 202-S Building and fractionization ion exchange waste, evaporator bottoms, B Plant low-level waste, coating waste, 202-S Building high-level waste, PUREX low-level waste and complexed and noncomplexed waste and partial neutralization feed from 241-B, -BX, -C, -S, -SX, -SY, -TX, and -U Tank Farms.	2,771	No
241-SX-107 Single-Shell Tank	1956 - 1964 *inactive*	202-S Building high-level waste, 202-S Building coating waste, concrete, and supernatant containing 202-S Building high-level waste from 241-SX Tank Farm. Also contains neutralized waste from the 100-F Reactor site	413	Yes
241-SX-108 Single-Shell Tank	1955 - 1962 *inactive*	202-S Building high-level waste, concrete, and supernatant containing 202-S Building high-level waste from 241-SX Tank Farm.	458	Yes
241-SX-109 Single-Shell Tank	1955 - 1965 *inactive*	202-S Building high-level waste and supernatant containing 202-S Building high-level waste from the 241-SX Tank Farm.	984	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
241-SX-110 Single-Shell Tank	1960 - 1976 *inactive*	202-S Building high-level waste, concrete, supernatant containing 202-S Building high-level waste, Battelle Northwest Laboratory waste, Pacific Northwest Laboratory waste, B Plant low-level waste, ion exchange waste, evaporator bottoms, and 244-U waste from 241-B, -BX, and -SX Tank Farms. Also added to this unit: uranium, enriched uranium and ^{239}PU.	235	Yes
241-SX-111 Single-Shell Tank	1956 - 1974 *inactive*	202-S Building high-level waste and supernatant containing 202-S Building high-level waste and 202-S Building ion exchange waste from 241-SX tanks.	500	Yes
241-SX-112 Single-Shell Tank	1959 - 1969 *inactive*	202-S Building high-level waste and supernatant containing 202-S Building high-level waste from the 241-SX tanks.	360	Yes
241-SX-113 Single-Shell Tank	1958 *inactive*	202-S Building high-level waste with added diatomaceous earth.	98	Yes
241-SX-114 Single-Shell Tank	1956 - 1972 *inactive*	202-S Building high-level waste and supernatant containing 202-S Building high-level waste, 202-S Building ion exchange waste, and evaporator bottoms from 241-SX tanks.	738	Yes
241-SX-115 Single-Shell Tank	1959 - 1965 *inactive*	202-S Building high-level waste and supernatant containing 202-S Building high-level waste.	45	Yes
241-SY-101 Double-Shell Tank	1977 - present *active*	Receives complexant waste which consists of concentrated product from the evaporation of dilute complexed waste. Waste is received from 102-SY, and transferred in from 106-SX and 111-U.	3,017	No
241-SY-102 Double-Shell Tank	1977 - present *active*	Receives dilute noncomplexed waste and plutonium finishing plant 202-S Building transuranic solids originating from T and S Plants, the 300 and 400 Areas, PUREX facility miscellaneous wastes, 100 North Area sulfate waste, B Plant, waste saltwells, supernatant, and transuranic solids from the West Area. These facilities include the Remote Mechanical "C" Line and the Plutonium Reclamation Facility.	2,427	No
241-SY-103 Double-Shell Tank	1977 - present *active*	Receives complexant waste which consists of concentrated product from the evaporation of dilute complexed waste.	667	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
240-S-302 Catch Tank	1950 - 1987 *inactive*	Low level mixed wastes, including dilute laboratory waste containing 0.021 mole/L sodium; greater than 0.01 mole/L sodium hydroxide; greater than 0.011 mole/L nitrous oxide; and 0.00007% g/L total plutonium.	Received approximately 200 m^3/yr transferred through 240-S-151 Diversion Box. Currently contains approximately 9 m^3 waste.	No
241-S-302A Catch Tank	1952 - present *inactive*	Received drainage from secondary containment of transfer routes of liquid mixed waste solutions from processing and decontamination.	Volume received was variable according to specific plant operation. Currently contains 5.8 m^3 of waste.	No
241-S-302B Catch Tank	1952 - 1985 *inactive*	Received waste solutions from processing and decontamination operations for transfer.	Volume received was variable according to specific plan operation. Presently holds 12.3 m^3 waste.	No
241-SX-302 Catch Tank	1954 - 1983 *inactive*	Received waste from processing and decontamination operations for transfer.	Volumes received were variable according to specific plant operations.	No
244-S Receiver Tank	1987 - present *active*	Transports waste solutions from processing and decontamination operations	41	No
Cribs and Drains				
216-S-1 and 216-S-2 Cribs	1950 - 1983 *inactive*	Received cell drainage from D-1 Receiver Tank and redistilled condensate from D-2 Receiver Tank in 202-S Building. Radioactive waste contains aluminum nitrate, nitrate, nitric acid, and sodium.	160,000	Yes
216-S-5 Crib	1954 - 1957 *inactive*	Radioactive, acidic process vessel cooling water and steam condensate from the 202-S Canyon Building.	4,100,000	Yes
216-S-6 Crib	1954 - 1972 *inactive*	Received process vessel cooling water and steam condensate from 202-S Building and steam condensate from the D-12 and D-14 Waste Concentrators in the 202-S Building.	4,470,000	Yes
216-S-7 Crib	1956 - 1965 *inactive*	Received cell drainage from the D-1 Receiver Tank, process condensate from the D-2 Receiver Tank, and condensate from the H-6 Condenser.	390,000	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a/]	Liquid Discharge to Soil
216-S-9 Crib	1965 - 1969 *inactive*	Received process condensate from the D-2 Receiver Tank in the 202-S Building. Waste is radioactive and acidic.	50,300	Yes
216-S-13 Crib	1952 - 1972 *inactive*	Received liquid waste from the 203-S Decontaminated Metal Storage Facility, the 204-S Uranyl Nitrate Hexahydrate Lag Storage Facility, and the 276-S Organic Solvent Make-up Facility. Also received occasional waste from the 204-S Uranyl Nitrate Hexahydrate Facility. Waste is low-salt and neutral/basic.	5,000	Yes
216-S-20 Crib	1952 - 1973 *inactive*	Received miscellaneous waste from laboratory hoods and decontamination sinks in the 222-S Building via the 219-S Retention Building. Also received above waste via the 207-SL Retention Basin and 219-S Retention Basin and 300 Area laboratory waste via the manhole. Received miscellaneous waste from laboratory hoods and decontamination sinks in 222-S via 219-S Retention Building.	135,000	Yes
216-S-22 Crib	1957 - 1967 *inactive*	Received liquid waste from the acid recovery facility in the 293-S Building.	98	Yes
216-S-23 Crib	1969 - 1972 *inactive*	Received S Plant process condensate from the D-2 Receiver Tank in the 202-S Building. Waste is low sale and neutral/basic.	34,100	Yes
216-S-25 Crib	1973 - present *active*	Received 242-S Evaporator process steam condensate, and 241-SX Tank Farm cooling water.	300,000	Yes
216-S-26 Crib	1984 - present *active*	Receives steam condensate and sink wastes, which are product radioactive wastes from the 222-S Laboratory via the 207-SL Retention Basin. Wastes contain a variety of chemicals, including acetone, nitric acid, and lesser amounts of sulfuric and hydrofluoric acids.	164,000	Yes
Sanitary Crib	1944 - present *active*	Receives nonhazardous/nonradioactive sanitary wastewater and sewage.	8395/yr	Yes
216-S-3 French Drain	1953 - 1956 *inactive*	Received condensate from condensers on the 241-101 and -102 Tanks in the 241-S Tank Farm.	4,000	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a/]	Liquid Discharge to Soil
Ponds, Ditches, and Trenches				
216-S-10P Pond	1954 - 1984 *inactive*	Received chemical sewer waste from 202-S and overflow from the high water tower via the 216-S-10 Ditch. Also received bearing cooling water from 202-S.	7,100	Yes
216-S-11 Pond	1954 - 1965 *inactive*	Received waste from air conditioning and drains in 202-S and the chemical sewer waste from 202-S via the 216-S-10 Ditch.	2,230,000	Yes
216-S-15 Pond	1951 - 1952 *inactive*	Received condenser spray cooling water from the 100-S Tank in the 241-S Tank Farm.	10	Yes
216-S-16P Pond	1957 - 1975 *inactive*	Received process cooling water and steam condensate from the 202-S Building. Also received condenser and vessel cooling water from the concentrator boil-down operations in the 202-S Building.	40,700,000	Yes
216-S-17 Pond	1951 - 1954 *inactive*	Received process cooling water and steam condensate from the 202-S Building, also received the 202-S Building effluent and overflow from the 216-U-10 Pond via the 216-U-9 Ditch.	6,440,000	Yes
216-S-19 Pond	1952 - 1984 *inactive*	Received effluents from the 222-S/SA. Laboratory ventilation cooling water and miscellaneous wastes from laboratory hoods and decontamination sinks via the 207-SL Retention Basin.	1,330,000	Yes
216-S-10D Ditch	1951 - 1991 *inactive*	Received hazardous waste salts and received chemical sewer waste from 202-S, 241-S Tank Farm, 211-S Station, 276-S Building, and overflow from the high water tower.	8,604,000	Yes
216-S-16D Ditch	1957 - 1975 *inactive*	Received process cooling water and steam condensate from 202-S Building. Also received condenser and vessel cooling water from concentrator boil-down operations in the 202-S Building.	400,000	Yes
216-U-9 Ditch	1952 - 1954 *inactive*	Received overflow from the 216-U-10 Pond.	NA	Yes
216-S-8 Trench	1951 - 1952 *inactive*	Received unirradiated start-up waste from the 202-S Building.	10,000	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
216-S-12 Trench	1954 - 1975 *inactive*	Received flush waste containing ammonium nitrate from the 291-S Stack.	76	Yes
216-S-14 Trench	1951 - 1952 *inactive*	Received contaminated (unirradiated uranium) uranyl nitrate hexahydrate from the initial test runs in the 202-S Building.	76	Yes
216-S-18 Trench	1954 *inactive*	Received vehicle decontamination waste.	NA	Yes
Septic Tanks and Associated Drain Fields				
2607-W6 Septic Tank and Tile Field	1951 - present *active*	Receives sanitary nonhazardous/nonradioactive wastewater and sewage.	Receives estimated 35/day	Yes
2607-WZ Septic Tank	1944 - present *active*	Receives sanitary nonhazardous/nonradioactive wastewater and sewage.	Receives estimated 8395/yr	Yes
Sanitary Crib	1944 - present *active*	Receives nonhazardous/nonradioactive sanitary wastewater from the 241-SX-701 Compressor House	23/day 8395/yr	Yes
Transfer Facilities, Diversion Boxes, and Pipelines				
216-S-172 Control Structure	1956 - 1976 *inactive*	Diverted low-level radioactive S Plant process vessel cooling water and steam condensate to the 216-S-16 Ditch.	NA	No
2904-S-160 Control Structure	1954 - 1976 *inactive*	Diverted process vessel cooling water and steam condensate from S Plant to Ponds 216-S-17, 216-S-6, or 216-S-16. Contains low-level contaminated concrete and piping.	NA	No
2904-S-170 Control Structure	1954 - 1976 *inactive*	Regulated and measured process waster flow from S Plant prior to routing liquid to waster disposal site. Contains low-level contaminated concrete and piping.	NA	No
2904-S-171 Control Structure	1954 - 1976 *inactive*	Regulated and measured process water being routed to the 216-S-6 Crib. Contains low-level contaminated concrete and piping.	NA	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
240-S-151 Diversion Box	1950 - 1987 *inactive*	Received low- and high-level mixed waste solutions from processing and decontamination operations for transfer to the 216-S-16 Ditch, the 216-S-16 and 216-S-17 Ponds, and the 216-S-5 and 216-S-6 Cribs. Waste was also transferred to the 216-S-7, 216-S-9, and 216-S-23 Cribs and the 240-S-152 and 241-S-151 Diversion Boxes, and interacted with the 241-U-153 Diversion Box. The structure drained to the 240-S-302 Catch Tank.	Volumes variable according to specific plant operation.	No
240-S-152 Diversion Box	1977 - 1980 *inactive*	Received high-level waste solutions from processing and decontamination operations for transfer from the 240-S-151 Diversion Box and transfers it to the 205-S Storage Area.	Volumes variable according to specific plant operation.	No
241-S-151 Diversion Box	1952 - present *active*	Receives low- and high-level waste solutions from process and decontamination operations for transfer from the 240-S-151 Diversion Box to the 216-S-1 and -2 Cribs, the 241-SX-151 and -152 Diversion Boxes, the 241-S Tank Farm, and the 244-S Catch Stations. The unit interacts with the 241-U-151 and 241-UX-154 Diversion Boxes. The unit drains to the 241-S-302A and -302B Catch Tanks	Volumes variable according to specific plant operation.	No
241-S-152 Diversion Box	1977 - 1980 *inactive*	Received high-level waste solutions from processing and decontamination operations from the 241-S and 241-SX Tank Farms to the 242-S evaporator for separation.	Volumes variable according to specific plant operation.	No
241-SX-151 Diversion Box	1954 - 1983 *inactive*	Received high-level mixed waste solutions from processing and decontamination operations for transfer from the 241-S-151 Diversion Box to the 241-SX Tank Farm. The structure drains to the 241-SX-302 Catch Tank.	Volumes variable according to specific plant operation.	No
241-SX-152 Diversion Box	1954 - 1981 *inactive*	Received high-level mixed waste solutions from processing and decontamination operations for transfer from the 241-S-151 Diversion Box to the 241-SX Tank Farm and 244-S Catch Station and interacts with the 241-U-151 and 241-UX-151 Diversion Boxes. The unit drains to the 241-SX-302 Catch Tank.	Volumes variable according to specific plant operation.	No
241-S-A Valve Pit	1952 - present *active*	Receives waste solutions from processing and decontamination operations for transfer to a double- or single-shelled tank.	Volumes variable according to specific plant operation.	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
241-S-B Valve Pit	1952 - present *active*	Receives waste solutions from processing and decontamination operations for transfer to a double- or single-shelled tank.	Volumes variable according to specific plant operation.	No
241-S-C Valve Pit	1952 - present *active*	Receives waste solutions from processing and decontamination operations for transfer to a double- or single-shelled tank.	Volumes variable according to specific plant operation.	No
241-S-D Valve Pit	1952 - present *active*	Receives waste solutions from processing and decontamination operations for transfer to a double- or single-shelled tank.	Volumes variable according to specific plant operation.	No
241-SX-A Valve Pit	1954 - 1980 *inactive*	Receives waste solutions from processing and decontamination operations for transfer.	Volumes variable according to specific plant operation.	No
241-SX-B Valve Pit	1954 - 1980 *inactive*	Receives waste solutions from processing and decontamination operations for transfer.	Volumes variable according to specific plant operation.	No
241-SY-A Valve Pit	1977 - present *active*	Receives waste solutions from processing and decontamination operations for transfer.	Volumes variable according to specific plant operation.	No
241-SY-B Valve Pit	1977 - present *active*	Receives waste solutions from processing and decontamination operations for transfer.	Volumes variable according to specific plant operation.	No
Basins				
207-S Retention Basin	1951 - 1954 *inactive*	Received liquid low-level waste such as process cooling water and steam condensate from the 202-S Building.	NA	No
207-SL Retention Basin	1952 - present *active*	Received low-level waste including ventilation cooling water and miscellaneous wastes from laboratory hoods and sinks in the 222-S Laboratory. Before 1954 wastes were discharged to the 216-S-19 Pond. Currently discharges to the 216-S-26 Crib.	NA	No
Burial Sites				
218-W-7 Burial Ground	1952 - 1960 *inactive*	Received dry, packaged laboratory and sample waste from the 222-S Laboratory.	159	No
218-W-9 Burial Ground	1954 *inactive*	Contains metal scrap including the 211-S Tank taken from the 202-S Building.	490	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
T Plant Aggregate Area				
Tanks and Vaults				
241-T-101 Single-Shell Tank	1944?-1979 *inactive*	Bismuth phosphate metal, tributyl phosphate, supernatant containing coating waste, REDOX ion exchange waste, REDOX high-level waste, PNL, decontamination waste, evaporator, bottom 224-U waste.	504	No
241-T-102 Single-Shell Tank	1945-1975? *inactive*	Bismuth phosphate metal, REDOX coating supernatant containing REDOX high-level waste, evaporator bottoms, B Plant ion exchange, and B Plant low-level waste from tank farms.	121	No
241-T-103 Single-Shell Tank	1946-1975 *inactive*	Bismuth phosphate metal, coating waste and supernatant containing B Plant low-level waste, REDOX ion exchange, REDOX high-level waste, and evaporator bottoms.	102	Yes
241-T-104 Single-Shell Tank	1946-1975 *inactive*	Bismuth phosphate metal, coating waste and supernatant containing B Plant low-level waste, REDOX ion exchange, REDOX high-level waste, and evaporator bottoms.	1,684	No
241-T-105 Single-Shell Tank	1945-1976? *inactive*	Bismuth phosphate first-cycle and second-cycle waste, REDOX coating, decontamination waste, Hanford Laboratory operations waste, supernatant containing low-level, and ion exchange waste from tanks.	370	Yes
241-T-106 Single-Shell Tank	1947-1973 *inactive*	Bismuth phosphate first-cycle and supernatant containing coating waste, B Plant low-level waste and ion exchange waste from tank farms.	79	Yes
241-T-107 Single-Shell Tank	1944?-1976 *inactive*	Bismuth phosphate first-cycle, tributyl phosphate, supernatant containing bismuth phosphate first-cycle, ion exchange, and coating waste from tank farms.	681	Yes
241-T-108 Single-Shell Tank	1945-1974 *inactive*	Tributyl phosphate, bismuth phosphate first-cycle, Hanford Laboratory operations waste, supernatant tributyl phosphate, B Plant low-level waste, ion exchange and evaporator bottoms from tank farms.	166	Yes
241-T-109 Single-Shell Tank	1945-1974 *inactive*	Bismuth phosphate first-cycle, tributyl phosphate, and supernatant containing tributyl phosphate, ion exchange, and PNL waste from tank farms.	219	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
241-T-110 Single-Shell Tank	1944-1976 *inactive*	Bismuth phosphate second-cycle and 224-U-Building waste.	1,434	No
241-T-111 Single-Shell Tank	1945-1974 *inactive*	Bismuth phosphate second-cycle and 224-U Building waste.	1,733	Yes
241-T-112 Single-Shell Tank	1946-1977 *inactive*	Bismuth phosphate second-cycle waste, PNL, and supernatant containing B Plant low-level waste, ion exchange from 241-T tanks, and a decontamination waste.	253	No
241-T-201 Single-Shell Tank	1952-1976 *inactive*	224-U Building waste	109	No
241-T-202 Single-Shell Tank	1952-1976 *inactive*	224-U Building waste	79	No
241-T-203 Single-Shell Tank	1952-1976 *inactive*	224-U Building waste	132	No
241-T-204 Single-Shell Tank	1976 *inactive*	224-U Building waste	143	No
241-TX-101 Single-Shell Tank	1949-1980 *inactive*	Bismuth phosphate metal, supernatant containing REDOX and high level waste, coating waste, tributyl phosphate, bismuth phosphate first-cycle waste, REDOX and waste fractionization ion exchange, B Plant high-level and low-level waste, non-complexed waste, PUREX low-level waste, organic wash, partial neutralization feed, and evaporator bottoms and decontamination waste from tanks.	329	No
241-TX-102 Single-Shell Tank	1950-1977 *inactive*	Bismuth phosphate metal, 242-T Evaporator waste, supernatant containing REDOX high-level waste, evaporator bottoms from 241-TX tanks.	427	No
241-TX-103 Single-Shell Tank	1950-1980 *inactive*	Bismuth phosphate metal, 242-T Evaporator waste, supernatant containing bismuth phosphate metal, non-complexed waste, tributyl phosphate, and partial neutralization feed from 241-TX tanks.	594	No
241-TX-104 Single-Shell Tank	1950-1977 *inactive*	Bismuth phosphate metal, 242-T Evaporator waste, supernatant containing REDOX ion exchange, and high-level waste, PUREX organic wash waste, B Plant low-level waste and tributyl phosphate from 241-TY and -TX tanks.	246	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a/]	Liquid Discharge to Soil
241-TX-105 Single-Shell Tank	1951-1977 *inactive*	Bismuth phosphate metal, 242-T Evaporator waste, supernatant containing REDOX ion exchange, and high-level waste, PUREX organic wash waste from 241-BX and -SX tank farms.	2,305	Yes
241-TX-106 Single-Shell Tank	1951-1977 *inactive*	Bismuth phosphate metal, tributyl phosphate, 242-T Evaporator waste, supernatant containing REDOX ion high-level waste, PUREX organic wash waste, evaporator bottoms, and coating waste from 241-TX tanks.	1,714	No
241-TX-107 Single-Shell Tank	1950-1977 *inactive*	Bismuth phosphate metal, 242-T Evaporator waste, supernatant containing bismuth phosphate metal, and REDOX high-level waste from 241-TX tanks.	136	Yes
241-TX-108 Single-Shell Tank	1950-1977 *inactive*	Bismuth phosphate metal, REDOX high-level waste, 242-T Evaporator waste, supernatant containing decontamination waste, tributyl phosphate, and evaporator bottoms from 241-TX and -TY tanks.	507	No
241-TX-109 Single-Shell Tank	1949?-1977 *inactive*	Bismuth phosphate first-cycle waste, 242-T Evaporator waste, supernatant containing bismuth phosphate first-cycle waste, and evaporator bottoms from 241-T, -TX, -TY tanks.	1,453	No
241-TX-110 Single-Shell Tank	1949-1977 *inactive*	Bismuth phosphate first-cycle waste, and 242-T Evaporator waste.	1,749	Yes
241-TX-111 Single-Shell Tank	1950-1977 *inactive*	Bismuth phosphate first-cycle waste, and 242-T Evaporator waste, and supernatant containing tributyl phosphate waste from 241-TX tanks.	1,400	No
241-TX-112 Single-Shell Tank	1950-1974 *inactive*	242-T Evaporator waste, bismuth phosphate first-cycle waste, and supernatant containing evaporator bottoms from 241-TX tanks.	2,457	No
241-TX-113 Single-Shell Tank	1950-1971 *inactive*	242-T Evaporator waste and supernatant containing evaporator bottoms from 241-TX tanks.	2,298	Yes
241-TX-114 Single-Shell Tank	1951-1971 *inactive*	242-T Evaporator waste and supernatant containing bismuth phosphate first-cycle waste and evaporator bottoms from 241-TX tanks.	2,025	Yes
241-TX-115 Single-Shell Tank	1951-1977 *inactive*	242-T Evaporator waste, tributyl phosphate waste, coating waste, decontamination waste, supernatant containing bismuth phosphate metal, evaporator bottoms from 241-U, -S, -T, -TX tanks.	2,422	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a/]	Liquid Discharge to Soil
241-TX-116 Single-Shell Tank	1951-1969 *inactive*	Supernatant containing evaporator bottoms from 241-TX tanks.	2,388	Yes
241-TX-117 Single-Shell Tank	1951-1969 *inactive*	Supernatant containing first-cycle waste and evaporator bottoms from 241-TX tanks.	2,369	Yes
241-TX-118 Single-Shell Tank	1951-1980 *inactive*	242-T Evaporator feed tank waste, 234-Z and 235-Z buildings 3waste, caustic solution, tributyl phosphate, decontamination waste, supernatant containing tributyl phosphate, bismuth phosphate first-cycle waste, evaporator bottoms, partial neutralization feed, and coating waste from 241-T, -TX, -TY, -U tanks.	1,313	No
241-TY-101 Single-Shell Tank	1953-1973 *inactive*	Bismuth phosphate first-cycle waste and supernatant containing bismuth phosphate, first cycle waste; tributyl phosphate waste; and evaporator bottoms from 241-TY, -TX, and -SX tank farms.	447	Yes
241-TY-102 Single-Shell Tank	1953-1979 *inactive*	Supernatant containing B Plant low-level, REDOX high-level waste, PUREX organic wash waste, REDOX ion exchange waste, and evaporator bottoms from 241-TX and -TY tanks.	242	No
241-TY-103 Single-Shell Tank	1953-1973 *inactive*	Bismuth phosphate first-cycle waste and supernatant containing bismuth phosphate, first cycle waste; tributyl phosphate waste; PUREX organic wash waste, REDOX ion exchange waste, coating waste, evaporator bottoms, and decontamination waste from 241-BX, -T, -TX, -TY and -AX tanks.	613	Yes
241-TY-104 Single-Shell Tank	1953-1974 *inactive*	Tributyl phosphate waste; supernatant containing REDOX ion exchange waste; PUREX organic wash waste, bismuth phosphate first-cycle waste, tributyl phosphate waste, and decontamination waste from 241-TX and -TY farms.	174	Yes
241-TY-105 Single-Shell Tank	1953-1960 *inactive*	Tributyl Phosphate waste	874	Yes
241-TY-106 Single-Shell Tank	1953-1959 *inactive*	Tributyl phosphate waste.	64	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
241-T-361 Settling Tank	1976 *inactive*	Radioactively contaminated liquid with estimated 75,700 L (28,000 gal) of sludge. Drainage from T Plant.	105.98	No
241-T-361 Catch Tank	Unknown	Mixed waste liquid.	NA	No
241-T-302 Catch Tank	Unknown *inactive*	Mixed waste liquid.	NA	No
241-TX-302A Catch Tank	1949-1982 *inactive*	Waste solutiona from processing and decontamination operations.	NA	No
241-TX-302B Catch Tank	1949-1982 *inactive*	Waste solutions from processing and decontamination operations.	NA	No
241-TX-302C Catch Tank	1949 *inactive*	Waste solutions from processing and decontamination operations.	NA	No
Cribs and Drains				
216-T-6 Crib	1946-1952[b] *inactive*	Cell drainage from tanks in 221-T building. The waste is low salt and neutral/basic.	45,000	Yes
216-T-7TF Crib and Tile Field	1948-1955 *inactive*	Second-cycle supernatant waste from 221-T Building. Effluents plus waste via tank farm. The waste is high salt and neutral/basic.	110,000	Yes
216-T-8 Crib	1950-1951 *inactive*	Decontamination sink waste and sample slurper waste. The waste is neutral/basic.	500	Yes
216-T-18 Crib	1953 *inactive*	First-cycle scavenged tributyl phosphate supernatant waste.	1,000	Yes
216-T-19TF Crib and Tile Field	1951-1980[b] *inactive*	Process condensate from waste evaporator, cell drainage, second-cycle supernatant waste, condensate and steam condensate.	455,000	Yes
216-T-26 Crib	1955-1956 *inactive*	First-cycle scavenged tributyl phosphate supernatant waste.	12,000	Yes
216-T-27 Crib	1965 *inactive*	300 Area laboratory waste from 340 facility	7,190	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
216-T-28 Crib	1960-1966 *inactive*	Steam condensate decontamination waste, laboratory waste, miscellaneous waste via tank farm.	42,300	Yes
219-T-29 Crib	1949-1964 *inactive*	Condensate runoff from sand filter. The waste type is potentially acidic.	74	Yes
216-T-32 Crib	1946-1952 *inactive*	Waste from 224-T Building via tank farm.	29,000	Yes
216-T-33 Crib	1963 *inactive*	Decontamination waste from 2706-T.	1,900	Yes
216-T-34 Crib	1966-1967 *inactive*	300 area laboratory waste from the 340 facility.	17,300	Yes
216-T-35 Crib	1967-1968 *inactive*	300 area laboratory waste from the 340 facility.	5,720	Yes
216-T-36 Crib	1967-1969 *inactive*	Steam condensate decontamination waste, and misc. waste from 221-T and 221-U buildings.	522	Yes
216-W-LWC Crib	1981-present *active*	All process wastewater from 2724-W and 2723-W buildings.	1,200,000	Yes
216-T-31 French Drain	1954-1962[b] *inactive*	Contaminated steam condensate.	NA	Yes
Reverse Wells				
216-T-2 Reverse Well	1945-1950 *inactive*	Decontamination sink waste and sample slurper waste from 221-T Building.	6,000	Yes
216-T-3 Reverse Well	1945-1946 *inactive*	Cell drainage from Tank 5-6 in the 221-T Building and overflow waste from 214-T-361 Settling Tank.	11,300	Yes
Ponds, Ditches, and Trenches				
200-W Powerhouse Pond	1984-present *active*	Wastes from steam production and water treatment activities.	19,920/yr	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
216-T-4A Pond	1944-1972 *inactive*	Process cooling water, steam condensate and condenser cooling water.	42,500,000	Yes
216-T-4B Pond	1972-present *active*	Steam condensate, condenser cooling water, and nonradioactive wastewater from 221-T. This unit is considered dry from 1977 to present.	NA	Yes
216-T-1 Ditch	1944-present *active*	Miscellaneous waste from pilot plant experimental work, intermittent decontamination waste, and waste from the head end of the 221-T building.	NA	Yes
216-T-4-1D Ditch	1944-1972 *inactive*	Process cooling water, steam condensate and decontamination waste from 2706-T.	NA	Yes
216-T-4-2 Ditch	1972-present *active*	Steam condensate, condenser cooling water and nonradioactive wastewater.	NA	Yes
216-T-5 Trench	1955	Second-cycle supernatant waste, the waste is high salt and neutral/basic.	2,600	Yes
216-T-9 Trench	1951-1954[b] *inactive*	Heavy equipment and vehicle decontamination waste.	NA	No
216-T-10 Trench	1951-1954[b] *inactive*	Heavy equipment and vehicle decontamination waste.	NA	No
216-T-11 Trench	1951-1954[b] *inactive*	Heavy equipment and vehicle decontamination waste.	NA	No
216-T-12 Trench	1954 *inactive*	Contaminated sludge.	5,000	Yes
216-T-13 Trench	1954-1964 *inactive*	Vehicle decontamination sludge.	NA	No
216-T-14 Trench	1954 *inactive*	First cycle supernatant waste.	1,000	Yes
216-T-15 Trench	1954 *inactive*	First cycle supernatant waste.	1,000	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
216-T-16 Trench	1954 *inactive*	First cycle supernatant waste.	1,000	Yes
216-T-17 Trench	1954 *inactive*	First cycle supernatant waste.	785	Yes
216-T-20 Trench	1952 *inactive*	Contaminated nitric acid.	18.9	Yes
216-T-21 Trench	1954 *inactive*	First cycle supernatant waste.	460	Yes
216-T-22 Trench	1954 *inactive*	First cycle supernatant waste.	1,530	Yes
216-T-23 Trench	1954 *inactive*	First cycle supernatant waste.	1,480	Yes
216-T-24 Trench	1954 *inactive*	First cycle supernatant waste.	1,530	Yes
216-T-25 Trench	1954 *inactive*	First-cycle evaporator bottoms.	3,000	Yes
Septic Tanks and Associated Drain Fields				
2607-W1 Septic Tank	1944 *active*	Sanitary wastewater and sewage.	6683/yr	Yes
2607-W2 Septic Tank	1944 *active*	Sanitary wastewater and sewage.	3723/yr	Yes
2607-W3 Septic Tank	1944 *active*	Sanitary wastewater and sewage.	5183/yr	Yes
2607-W4 Septic Tank	1944 *active*	Sanitary wastewater and sewage.	3869/yr	Yes
2607-WT Septic Tank	1952 *active*	Sanitary wastewater and sewage.	7.3/yr	Yes

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a]	Liquid Discharge to Soil
2607-WTX Septic Tank	1950 *active*	Sanitary wastewater and sewage.	270/yr	Yes
Transfer Facilities, Diversion Boxes, and Pipelines				
241-T-151 Diversion Box	1944-1980 *inactive*	Transfer waste solutiona from processing and decontamination operations.	NA	No
241-T-152 Diversion Box	1944-1983 *inactive*	Transfer waste solutions from processing and decontamination operations. Volumes were variable.	NA	No
241-T-153 Diversion Box	Unknown *inactive*	Unknown	NA	No
241-T-252 Diversion Box	1944-1983 *inactive*	Transfer waste solutions from processing and decontamination operations. Volumes were variable.	NA	No
241-TR-152 Diversion Box	1944-1980 *inactive*	Waste solutions from processing and decontamination operations.	NA	No
241-TR-153 Diveraion Box	1944-1983 *inactive*	Waste solutions from processing and decontamination operations.	NA	No
241-TX-153 Diversion Box	1949-1982 *inactive*	Waste solutions from processing and decontamination operations.	NA	No
241-TX-154 Diversion Box	1949-present *active*	Waste solutions from processing and decontamination operations.	NA	No
241-TX-155 Diversion Box	1949-1980 *inactive*	Waste solutions from processing and decontamination operations	NA	No
241-TXR-152 Diversion Box	1949-1980 *inactive*	Waste solutions from processing and decontamination operations.	NA	No
241-TXR-153 Diversion Box	1949-1980 *inactive*	Waste solutions from processing and decontamination operations.	NA	No
242-T-151 Diversion Box	Unknown *inactive*	Unknown	NA	No

Table 2-1. Summary of 200 West Area Waste Management Units.

Waste Management Unit	Years in Service *status*	Source Description	Total Fluid Volume Received (m^3)[a/]	Liquid Discharge to Soil
Basins				
200-W Ash Disposal Basin	Unknown *active*	Various hazardous organic chemicals.	NA	No
200-W Powerhouse Ash Pit	1943-present *active*	Ash from the 200 West Area Powerhouse cooling and ventilation steam condensate.	NA	Yes
207-T Retention Basin	1944-present *active*	T Plant process cooling water and ventilation steam condensate	NA	No
Burial Sites				
200-W Burning Pit	1950-1970 *inactive*	Construction and office waste, paint waste, and chemical solvents.	NA	No
218-W-8 Burial Ground	1945-1952 *inactive*	Laboratory process sample waste from 222-T Building.	NA	No

Volume data derived from Waste Information Data System (WIDS) - WHC 1991a.
(30,000,000) Parenthetical data from Stenner et al. 1988.
NA No information available.
[a/] Tank volumes represent the current volume in the tank.
[b/] Indicates a discrepancy between the sources; in such case, the data given is from WHC 1991a.

Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer.

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
U Plant Aggregate Area				
241-U-101 Single-Shell Tank	110	--	No	No
241-U-103 Single-Shell Tank	Undetermined	--	No	No
241-U-104 Single-Shell Tank	208	--	No	No
241-U-110 Single-Shell Tank	31	--	No	No
241-U-112 Single-Shell Tank	32	--	No	No
216-S-21 Crib	87,100	1,200 to 3,500	Yes	No
216-U-1 and 216-U-2 Cribs	46,200	130 to 390	Yes	No
216-U-8 Crib	379,000	3,700 to 11,100	Yes	Yes
216-U-12 Crib	150,000	460 to 1,400	Yes	Yes
216-U-16 Crib	409,000	5,500 to 16,500	Yes	No
216-U-17 Crib	2,110	700 to 2,100	Yes	No
216-Z-20 Crib	3,800,000	7,400 to 22,200	Yes	Yes
216-S-4 French Drain	1,000	50 to 150	Yes	No
216-U-3 French Drain	791	13 to 39	Yes	No
216-U-4A French Drain	545	7 to 21	Yes	No
216-U-4B French Drain	33	3 to 9	Yes	No
216-U-7 French Drain	7	2 to 6	Yes	No
216-U-4 Reverse Well	300	0.1 to 0.3	Yes	No
216-U-10 Pond	165,005,000	600,000 to 1,800,000	Yes	Yes
216-Z-1D Ditch	1,000	7,800 to 23,400	No	No
216-U-14 Ditch	Undetermined	19,000 to 57,000	No	No
216-Z-11 Ditch	Undetermined	4,800 to 14,400	No	No
216-Z-19 Ditch	Undetermined	5,100 to 15,300	No	No
216-U-5 and 216-U-6 Trenches	4,500	1,100 to 3,300	Yes	No
216-U-11 Trench	Undetermined	7,800 to 23,400	No	No
216-U-13 Trench	11	3,300 to 9,900	No	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 2 of 7

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a]	Indicates Possible Migration to Uppermost Aquifer[b]	Significant Impact on Groundwater Flow[c]
216-U-15 Trench	undetermined	180 to 560	No	No
2607-W-5 Septic Tank/Drain Field	212,000[d]	6,200 to 18,600	Yes	Yes
2607-W-7 Septic Tank/Drain Field	13,900[d]	undetermined	No	No
2607-W-9 Septic Tank/Drain Field	15,300[d]	160 to 480	Yes	No
2607-WUT Septic Tank and Drain Field	15,300[d]	2,200 to 6,600	Yes	No
Z Plant Aggregate Area				
216-Z-1 and 216-Z-2 Cribs	33,700	220 to 660	Yes	No
216-Z-3 Crib	178,000	150 to 450	Yes	Yes
216-Z-5 Crib	31,000	160 to 480	Yes	No
216-Z-6 Crib	98	180 to 540	No	No
216-Z-7 Crib	79,000	10,000 to 30,000	Yes	No
216-Z-12 Crib	281,000	500 to 1,500	Yes	Yes
216-Z-16 Crib	100,000	750 to 2,250	Yes	Yes
216-Z-18 Crib	3,860	3,700 to 11,100	Yes	No
216-Z-8 French Drain	10	4 to 12	Yes	No
216-Z-13 French Drain	Undetermined	3 to 9	No	No
216-Z-14 French Drain	Undetermined	3 to 9	No	No
216-Z-15 French Drain	Undetermined	3 to 9	No	No
216-Z-1A Tile Field	6,200 5,210	14,700 to 44,100	Yes[e]	No
216-Z-4 Trench	11	55 to 165	No	No
216-Z-9 Trench	4,090	840 to 2,520	Yes	No
216-Z-17 Trench	37,000	1,100 to 3,300	Yes	No
216-Z-10 Reverse Well	1,000	<1	Yes	No
2607-Z Septic Tank/Drain Field	361,000[d]	Undetermined	Yes	Yes
2607-Z-8 Septic Tank/Drain Field	7,665[d]	Undetermined	No	No
2607-WA Septic Tank/Drain Field	53,000[d]	Undetermined	No	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer.

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
2607-WWA Septic Tank/Drain Field	45,917[d/]	Undetermined	No	No
2607-W-8 Septic Tank/Drain Field	66,000[d/]	Undetermined	No	No
216-Z-21 Seepage Basin	900,000[d/]	4,500 to 13,500	Yes	Yes
S Plant Aggregate Area				
241-S-104 Single-Shell Tank	Undetermined	--	No	No
241-SX-104 Single-Shell Tank	416	--	No	No
241-SX-107 Single-Shell Tank	19	--	No	No
241-SX-108 Single-Shell Tank	9	--	No	No
241-SX-109 Single-Shell Tank	20	--	No	No
241-SX-110 Single-Shell Tank	Undetermined	--	No	No
241-SX-111 Single-Shell Tank	6.6	--	No	No
241-SX-112 Single-Shell Tank	100	--	No	No
241-SX-113 Single-Shell Tank	57	--	No	No
241-SX-114 Single-Shell Tank	Undetermined	--	No	No
241-SX-115 Single-Shell Tank	200	--	No	No
Sanitary Crib	428,948	870 to 2,610	Yes	Yes
216-S-1 and 216-S-2 Cribs	227,400	1,700 to 5,100	Yes	Yes
216-S-5 Crib	4,100,000	16,000 to 48,000	Yes	Yes
216-S-6 Crib	4,470,000	12,000 to 36,000	Yes	Yes
216-S-7 Crib	390,000	2,300 to 6,900	Yes	Yes
216-S-9 Crib	50,300	4,200 to 12,600	Yes	Yes
216-S-13 Crib	5,000	700 to 2,100	Yes	No
216-S-20 Crib	135,000	1,700 to 5,100	Yes	Yes

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer.

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
216-S-22 Crib	98	160 to 480	No	No
216-S-23 Crib	34,100	1,700 to 5,100	Yes	No
216-S-25 Crib	288,000	2,600 to 7,800	Yes	Yes
216-S-26 Crib	164,000	2,000 to 6,000	Yes	Yes
216-S-3 French Drain	4,300	93 to 279	Yes	No
216-S-10P Pond	7,100	100,000 to 300,000	No	No
216-S-11 Pond	2,300,000	30,000 to 90,000	Yes	Yes
216-S-15 Pond	10	83 to 249	No	No
216-S-16P Pond	40,700,000	630,000 to 1,890,000	Yes	Yes
216-S-17 Pond	6,440,000	430,000 to 1,290,000	Yes	Yes
216-S-19 Pond	1,330,000	71,000 to 213,000	Yes	Yes
216-S-10D Ditch	4,340,000	6,300 to 18,900	Yes	Yes
216-S-16D Ditch	400,000	5,600 to 16,800	Yes	Yes
216-U-9 Ditch	Undetermined	11,000 to 33,000	No	No
216-S-8 Trench	10,000	2,800 to 8,400	Yes	No
216-S-12 Trench	76	830 to 2,490	No	No
216-S-14 Trench	76	370 to 1,100	No	No
216-S-18 Trench	76	880 to 2,640	No	No
2607-W6 septic Tank and Tile Field	520,782	Undetermined	Yes	Yes
2607-WZ Septic Tank	395,952	Undetermined	Yes	Yes
T Plant Aggregate Area				
241-T-101 Single-Shell Tank	1500	--	No	No
241-T-103 Single-Shell Tank	5	--	No	No
241-T-105 Single-Shell Tank	435	--	No	No
241-T-106 Single-Shell Tank	Undetermined	--	No	No
241-T-107 Single-Shell Tank	Undetermined	--	No	No
241-T-108 Single-Shell Tank	Undetermined	--	No	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 5 of 7

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
241-T-109 Single-Shell Tank	Undetermined	--	No	No
241-T-111 Single-Shell Tank	Undetermined	--	No	No
241-TX-105 Single-Shell Tank	Undetermined	--	No	No
241-TX-107 Single-Shell Tank	Undetermined	--	No	No
241-TX-110 Single-Shell Tank	Undetermined	--	No	No
241-TX-113 Single-Shell Tank	Undetermined	--	No	No
241-TX-114 Single-Shell Tank	Undetermined	--	No	No
241-TX-115 Single-Shell Tank	Undetermined	--	No	No
241-TX-116 Single Shell Tank	Undetermined	--	No	No
241-TX-117 Single-Shell Tank	Undetermined	--	No	No
241-TY-101 Single-Shell Tank	Undetermined	--	No	No
241-TY-103 Single-Shell Tank	11.4	--	No	No
241-TY-104 Single-Shell Tank	5.3	--	No	No
241-TY-105 Single-Shell Tank	133	--	No	No
241-TY-106 Single-Shell Tank	75.7	--	No	No
216-T-6 Crib	45,000	440 to 1,320	Yes	No
216-T-7TF Crib and Tile Field	110,000	3,000 to 9,000	Yes	Yes
216-T-8 Crib	500	370 to 1,110	Yes	No
216-T-18 Crib	1,000	230 to 690	Yes	No
216-T-19TF Crib and Tile Field	455,000	4,200 to 12,600	Yes	Yes
216-T-26 Crib	12,000	230 to 690	Yes	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 6 of 7

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
216-T-27 Crib	7,190	230 to 690	Yes	No
216-T-28 Crib	42,300	230 to 690	Yes	No
216-T-29 Crib	74	900 to 2,700	No	No
216-T-31 French Drain	Undetermined	4 to 12	No	No
216-T-32 Crib	29,000	880 to 2,640	Yes	No
216-T-33 Crib	1,900	220 to 660	Yes	No
216-T-34 Crib	17,300	2,100 to 6,300	Yes	No
216-T-35 Crib	5,720	4,300 to 12,900	Yes	No
216-T-36 Crib	522	1,300 to 3,900	No	No
216-W-LWC Crib	1,200,000	2,000 to 6,000	Yes	Yes
216-T-2 Reverse Well	6,000	0	Yes	No
216-T-3 Reverse Well	11,300	0	Yes	No
216-T-4A Pond	42,500,000	4,600 to 13,800	Yes	Yes
216-T-4B Pond	Undetermined	6,400 to 19,200	No	No
200-W Powerhouse Pond	159,362	9,300 to 27,900	Yes	Yes
216-T-1 Ditch	undetermined	13,000 to 39,000	No	No
216-T-4-1D Ditch	undetermined	3,100 to 9,300	No	No
216-T-4-2 Ditch	undetermined	6,400 to 19,200	No	No
216-T-5 Trench	2,600	320 to 960	Yes	No
216-T-12 Trench	5,000	71 to 213	Yes	No
216-T-14 Trench	1,000	1,600 to 4,800	No	No
216-T-15 Trench	1,000	1,600 to 4,800	No	No
216-T-16 Trench	1,000	1,600 to 4,800	No	No
216-T-17 Trench	1,000	1,600 to 4,800	No	No
216-T-20 Trench	18.9	22 to 66	No	No
216-T-21 Trench	460	1,200 to 3,600	No	No
216-T-22 Trench	1,530	1,200 to 3,600	Yes	No
216-T-23 Trench	1,480	1,200 to 3,600	Yes	No
216-T-24 Trench	1,530	1,200 to 3,600	Yes	No
216-T-25 Trench	3,000	930 to 2,790	Yes	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 7 of 7

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
2607-W1 Septic Tank	322,000[d/]	3,500 to 10,500	Yes	Yes
2607-W2 Septic Tank	179,000[d/]	840 to 2,520	Yes	Yes
2607-W3 Septic Tank	249,000[d/]	Undetermined	Yes	Yes
2607-W4 Septic Tank	186,000[d/]	140 to 420	Yes	Yes
2607-WT Septic Tank	300[d/]	Undetermined	No	No
2607-WTX Septic Tank	11,000[d/]	Undetermined	No	No
216-W Powerhouse Ash Pit	Undetermined	9,300 to 27,900	No	No
218-W-18 Burial Ground	68	110 to 330	No	No

Assumptions:
- Area for infiltration equal to the dimension of the base of crib/trench/tile field/drain/well
- No evapotranspiration
- No lateral flow assumed
- Liquid effluent volume received by soil is accurate

a/ Pore volume calculation: (waste unit section area) x (Nominal depth to groundwater) x (porosity). Pore volume based on nominal depth of 50 m (164 ft) for all waste unit structures with the exception of the reverse wells (the depth of the wells was subtracted from the nominal depth). Low pore volume value reflects 0.10 porosity, higher pore volume value reflects 0.30 porosity. Pore volume calculation does not account for the ability of the soil to retain the liquid discharged.

b/ Yes, when liquid effluent volume received by soil exceeds the lower range of soil column pore volume.

c/ Discharge exceeded 100,000 m^3 and pore volume calculation indicates water reached the unconfined aquifer.

d/ Based on reported daily rates from first year through 1991.

e/ The calculation assumes that the liquid waste was discharged over the entire base of the tile field, which may not be accurate given that the waste was distributed through an array of perforated pipes.

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Table 2-3. Summary of Well Geophysical Log Results for Units Potentially Contributing Contaminants to Groundwater. Page 1 of 4

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response	Evidence of Release to Groundwater
U Plant Aggregate Area			
241-U-101 Single-Shell Tank	2	Background	No
241-U-103 Single-Shell Tank	5	Surface	No
241-U-104 Single-Shell Tank	4	16 to 18 m	No
241-U-110 Single-Shell Tank	5	0 to 8 m 15 to 18 m	No
241-U-112 Single-Shell Tank	5	0 to 3 m 15 to 30 m	No
216-U-1 and 216-U-2 Cribs	7	0 to 31 m	No
216-U-8 Crib	3	9 to 24 m 26 to 31 m	No
216-S-21 Crib	1	12 to 15 m	No
216-U-12 Crib	10	6 to 18 m	No
216-U-16 Crib	2	Background	No
216-U-17 Crib	4	Background	No
216-U-3 French Drain	2	Background	No
216-U-14 Ditch	6	0 to 12 m	No
216-U-10-Ponda	1	6 to 8 m	No
Z Plant Aggregate Area			
216-Z-1 Crib	2	7 to 20 m	No
216-Z-2 Crib	5	7 m and 17 to 20 m	No
216-Z-3-Crib	1	Background	No
216-Z-5 Crib	2	8 to 23 m, 30 to 40 m, and 50 to 63 m	Yes
216-Z-7 Crib	6	7 to 100 m	Yes
216-Z-12 Crib	17	5 to 10 m	No

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Table 2-3. Summary of Well Geophysical Log Results for Units Potentially Contributing Contaminants to Groundwater. Page 2 of 4

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response	Evidence of Release to Groundwater
216-Z-16 Crib	2	Background	No
216-Z-18 Crib	13	6 to 18 m	No
216-Z-1A Tile Field	29	2 to 30 m	No
216-Z-9 Trench	10	1 to 9 m and 15 to 38 m	No
S Plant Aggregate Area			
241-S-104 Single-Shell Tank	2	6 to 14 m	No
241-SX-104 Single-Shell Tank	7	6 m	No
241-SX-107 Single-Shell Tank	7	16 to 20 m. Response in Borehole 41-08-07 increasing	No
241-SX-108 Single-Shell Tank	9	13 to 22 m	No
241-SX-109 Single-Shell Tank	10	19 to 24 m. Response in Borehole 41-10-01 increasing at 23 m	No
241-SX-110 Single-Shell Tank	11	19 to 20 m	No
241-SX-111 Single-Shell Tank	10	18 to 21 m	No
241-SX-112 Single-Shell Tank	10	19 to 22 m	No
241-SX-113 Single-Shell Tank	3	Background	No
241-SX-114 Single-Shell Tank	10	9 to 21 m	No
241-SX-115 Single-Shell Tank	9	16 to 18 m	No
215-S-1 and S-2 Crib	14	7 to 61 m	Yes
216-S-5 Crib	4	2 to 12 m	No
216-S-6 Crib	2	1 to 21 m	No
216-S-7 Crib	5	7 to 13 m	Yes

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Table 2-3. Summary of Well Geophysical Log Results for Units Potentially Contributing Contaminants to Groundwater. Page 3 of 4

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response	Evidence of Release to Groundwater
216-S-9 Crib	4	9 to 19 m	Yes
216-S-13 Crib	1	2 to 30 m	No
216-S-20 Crib	2	12 m	No
216-S-22 Crib	1	Background	No
216-S-23 Crib	5	Background	No
216-S-25 Crib	3	Background	No
216-S-8 Trench	1	Background	No
216-S-10P Pond	1	Background	No
216-S-11 Pond	2	Background	No
216-S-10-D Ditch	4	Background	No
216-S-8 Trench	1	Background	No
T Plant Aggregate Area			
241-T-101 Single-Shell Tank	1	0 to 37 m	No
241-T-103 Single-Shell Tank	1	0 to 25 m	No
241-T-106 Single-Shell Tank	1	0 to 33 m	No
241-T-107 Single-Shell Tank	3	13 m	No
241-T-108 Single-Shell Tank	6	Shallow	No
241-T-109 Single-Shell Tank	6	12 m	No
241-TX-105 Single-Shell Tank	6	Background	No
241-TX-107 Single-Shell Tank	1	Shallow	No
241-TX-110 Single-Shell Tank	1	17 m	No
241-TX-113 Single-Shell Tank	1	Background	No
241-TX-114 Single-Shell Tank	1	13+ m	No

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Table 2-3. Summary of Well Geophysical Log Results for Units Potentially Contributing Contaminants to Groundwater. Page 4 of 4

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response	Evidence of Release to Groundwater
241-TX-115 Single-Shell Tank	1	Shallow	No
241-TX-116 Single-Shell Tank	1	Shallow	No
241-TX-117 Single-Shell Tank	1	Background	No
241-TY-101 Single-Shell Tank	1	Background	No
241-TY-103 Single-Shell Tank	2	Shallow	No
241-TY-104 Single-Shell Tank	5	Background	No
241-TY-105 Single-Shell Tank	2	Shallow	No
241-TY-106 Single-Shell Tank	1	Shallow	No
216-T-6 Crib	15	3 to 17 m	No
216-T-7TF Crib and Tile Field	9	2 to 50+ m	Yes
216-T-15, -16, and -17 Trenches	4	9 m	No
216-T-21, -23, -24, and -25 Trenches	5	6 to 31+ m	No
216-T-26, -27, and -28 Cribs	8	0 to 34 m 46+ m	Yes
216-T-32 Crib	8	9 to 15 m	No
216-T-34 and -35 Cribs	7	6 to 17 m	No
216-T-36 Crib	1	Background	No
216-T-3 Reverse Well	1	3 to 7 m 13 to 22 m 30 to 38 m	No
216-T-5 Trench	1	Background	No
216-T-14 Trench	1	Background	No
216-T-22 Trench	1	Background	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Potential Based on Geophysical Logs (Table 2-3)	Criteria Indicates Possible Contribution to Uppermost Aquifer
U Plant Aggregate Area				
241-U-101 Single-Shell Tank	1949-1959	No	No	No
241-U-103 Single-Shell Tank	1947-1978	No	No	No
241-U-104 Single-Shell Tank	1947-1956	No	No	No
241-U-110 Single-Shell Tank	1946-1975	No	No	No
241-U-112 Single-Shell Tank	1947-1970	No	No	No
216-S-21 Crib	1954-1969	Yes	No	Yes
216-U-1 and 216-U-2 Cribs	1951-1968	Yes	No	Yes
216-U-8 Crib	1952-1960	Yes	No	Yes
216-U-12 Crib	1960-1968	Yes	No	Yes
216-U-16 Crib	1984-1987	Yes	No	Yes
216-U-17 Crib	1988-present	Yes	No	Yes
216-Z-20 Crib	1981-present	Yes	No logs	Yes
216-S-4 French Drain	1953-1956	Yes	No logs	Yes
216-U-3 French Drain	1954-1955	Yes	No	Yes
216-U-4A French Drain	1955-1970	Yes	No logs	Yes
216-U-4B French Drain	1960-1970	Yes	No logs	Yes
216-U-7 French Drain	1952-1958	Yes	No logs	Yes
216-U-4 Reverse Well	1947-1955	Yes	No logs	Yes
216-U-10 Pond	1944-1985	Yes	No	Yes
216-U-14 Ditch	1944-present	No	No	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Potential Based on Geophysical Logs (Table 2-3)	Criteria Indicates Possible Contribution to Uppermost Aquifer
216-Z-10 Ditch	1944-1959	No	No logs	No
216-Z-11 Ditch	1959-1971	No	No logs	No
216-Z-19 Ditch	1959-1972	No	No logs	No
216-U-5 and 216-U-6 Trenches	1952	Yes	No logs	Yes
216-U-11 Trench	1944-1985	No	No logs	No
216-U-13 Trench	1952-1956	No	No logs	No
216-U-15 Trench	1957	No	No logs	No
2607-W-5 Septic Tank/Drain Field	1944-present	Yes	No logs	Yes
2607-W-7 Septic Tank/Drain Field	1954-present	No	No logs	No
2607-W-9 Septic Tank/Drain Field	1950-present	Yes	No logs	Yes
2607-WUT Septic Tank/Drain Field	1951-present	Yes	No logs	Yes
Z Plant Aggregate Area				
216-Z-1 and 216-Z-2 Cribs	1949-1969	Yes	No	Yes
216-Z-3 Crib	1952-1959	Yes	No	Yes
216-Z-5 Crib	1945-1947	Yes	Yes	Yes
216-Z-6 Crib	1945	No	No logs	No
216-Z-7 Crib	1946-1967	Yes	Yes	Yes
216-Z-12 Crib	1959-1973	Yes	No	Yes
216-Z-16 Crib	1968-1979	Yes	No	Yes
216-Z-18 Crib	1969-1973	Yes	No	Yes
216-Z-8 French Drain	1955-1962	Yes	No logs	Yes

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Potential Based on Geophysical Logs (Table 2-3)	Criteria Indicates Possible Contribution to Uppermost Aquifer
216-Z-13 French Drain	1949-present	No	No logs	No
216-Z-14 French Drain	1949-present	No	No logs	No
216-Z-15 French Drain	1949-present	No	No logs	No
216-Z-1A Tile Field	1949-1964	Yes	No	Yes
216-Z-10 Reverse Wells	1945	Yes	No logs	Yes
216-Z-4 Trench	1945	No	No logs	No
216-Z-9 Trench	1955-1962	Yes	No	Yes
216-Z-17 Trench	1967-1968	Yes	No logs	Yes
2607-Z Septic Tank/Drain Field	1949-present	Yes	No logs	Yes
2607-Z-8 Septic Tank/Drain Field	1965-present	No	No logs	No
2607-WA Septic Tank/Drain Field	1968-present	No	No logs	No
2607-WB Septic Tank/Drain Field	1955-present	No	No logs	No
2607-W-8 Septic Tank/Drain Field	1959-present	No	No logs	No
216-Z-21 Seepage Basin	1983-present	Yes	No logs	Yes
S Plant Aggregate Area				
241-S-104 Single-Shell Tank	1953-1968	No	No	No
241-SX-104 Single-Shell Tank	1955-1980	No	No	No
241-SX-107 Single-Shell Tank	1956-1964	No	No	No
241-SX-108 Single-Shell Tank	1955-1962	No	No	No
241-SX-109 Single-Shell Tank	1955-1965	No	No	No
241-SX-110 Single-Shell Tank	1960-1976	No	No	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Potential Based on Geophysical Logs (Table 2-3)	Criteria Indicates Possible Contribution to Uppermost Aquifer
241-SX-111 Single-Shell Tank	1956-1974	No	No	No
241-SX-112 Single-Shell Tank	1959-1969	No	No	No
241-SX-113 Single-Shell Tank	1958	No	No	No
241-SX-114 Single-Shell Tank	1956-1972	No	No	No
241-SX-115 Single-Shell Tank	1959-1965	No	No	No
Sanitary Crib	1944-present	Yes	No logs	Yes
216-S-1 and 216-S-2 Crib	1950-1983	Yes	Yes	Yes
216-S-5 Crib	1954-1957	Yes	No	Yes
216-S-6 Crib	1954-1972	Yes	No	Yes
216-S-7 Crib	1956-1965	Yes	Yes	Yes
216-S-9 Crib	1965-1969	Yes	Yes	Yes
216-S-13 Crib	1952-1972	Yes	No	Yes
216-S-20 Crib	1952-1973	Yes	No	Yes
216-S-22 Crib	1957-1967	No	No	No
216-S-23 Crib	1969-1972	Yes	No	Yes
216-S-25 Crib	1973-present	Yes	No	Yes
216-S-26 Crib	1984-present	Yes	No logs	Yes
216-S-3 French Drain	1953-1956	Yes	No logs	Yes
216-S-10P Pond	1954-1984	No	No	No
216-S-11 Pond	1954-1965	Yes	No	Yes
216-S-15 Pond	1951-1952	No	No logs	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Potential Based on Geophysical Logs (Table 2-3)	Criteria Indicates Possible Contribution to Uppermost Aquifer
216-S-16P Pond	1957-1975	Yes	No logs	Yes
216-S-17 Pond	1951-1954	Yes	No logs	Yes
216-S-19 Pond	1952-1984	Yes	No logs	Yes
216-S-10D Ditch	1951-1991	Yes	No	Yes
216-S-16D Ditch	1957-1975	Yes	No logs	Yes
216-U-19 Ditch	1952-1954	No	No logs	No
216-S-8 Trench	1951-1952	Yes	No	Yes
216-S-12 Trench	1954-1975	No	No logs	No
216-S-14 Trench	1951-1952	No	No logs	No
216-S-18 Trench	1954	No	No logs	No
2607-W6 Septic Tank and Tile Field	1951-present	Yes	No logs	Yes
2607-WZ Septic Tank	1944-present	Yes	No logs	Yes
T Plant Aggregate Area				
241-T-101 Single-Shell Tank	1944?-1979	No	No	No
241-T-103 Single-Shell Tank	1946-1975	No	No	No
241-T-105 Single-Shell Tank	1945-1976?	No	No logs	No
241-T-106 Single-Shell Tank	1947-1973	No	No	No
241-T-107 Single-Shell Tank	1944?-1976	No	No	No
241-T-108 Single-Shell Tank	1945-1974	No	No	No
241-T-109 Single-Shell Tank	1945-1974	No	No	No
241-T-111 Single-Shell Tank	1945-1974	No	No logs	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Potential Based on Geophysical Logs (Table 2-3)	Criteria Indicates Possible Contribution to Uppermost Aquifer
241-TX-105 Single-Shell Tank	1951-1977	No	No	No
241-TX-107 Single-Shell Tank	1950-1977	No	No	No
241-TX-110 Single-Shell Tank	1949-1977	No	No	No
241-TX-113 Single-Shell Tank	1950-1971	No	No	No
241-TX-114 Single-Shell Tank	1951-1971	No	No	No
241-TX-115 Single-Shell Tank	1951-1977	No	No	No
241-TX-116 Single Shell Tank	1951-1969	No	No	No
241-TX-117 Single-Shell Tank	1951-1969	No	No	No
241-TY-101 Single-Shell Tank	1953-1973	No	No	No
241-TY-103 Single-Shell Tank	1953-1973	No	No	No
241-TY-104 Single-Shell Tank	1953-1974	No	No	No
241-TY-105 Single-Shell Tank	1953-1960	No	No	No
241-TY-106 Single-Shell Tank	1953-1959	No	No	No
216-T-6 Crib	1946-1952	Yes	No	Yes
216-T-7TF Crib and Tile Field	1948-1955	Yes	Yes	Yes
216-T-8 Crib	1950-1951	Yes	No logs	Yes
216-T-18 Crib	1953	Yes	No logs	Yes
216-T-19TF Crib and Tile Field	1951-1980	Yes	No logs	Yes
216-T-26 Crib	1955-1956	Yes	Yes	Yes
216-T-27 Crib	1965	Yes	Yes	Yes

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Potential Based on Geophysical Logs (Table 2-3)	Criteria Indicates Possible Contribution to Uppermost Aquifer
216-T-28 Crib	1960-1966	Yes	Yes	Yes
216-T-29 Crib	1949-1964	No	No logs	No
216-T-31 French Drain	1954-1962	No	No logs	No
216-T-32 Crib	1946-1952	Yes	No	Yes
216-T-33 Crib	1963	Yes	No Logs	Yes
216-T-34 Crib	1966-1967	Yes	No	Yes
216-T-35 Crib	1967-1968	Yes	No	Yes
216-T-36 Crib	1967-1969	No	No	No
216-W-LWC Crib	1981-present	Yes	No logs	Yes
216-T-2 Reverse Well	1945-1950	Yes	No logs	Yes
216-T-3 Reverse Well	1945-1946	Yes	No	Yes
216-T-4A Pond	1944-1972	Yes	No logs	Yes
216-T-4B Pond	1972-present	No	No logs	No
216-T-1 Ditch	1944-present	Yes	No logs	Yes
216-T-4-1D Ditch	1944-1972	No	No logs	No
216-T-4-2 Ditch	1972-present	No	No logs	No
216-T-5 Trench	1955	Yes	No	Yes
216-T-12 Trench	1954	Yes	No logs	Yes
216-T-14 Trench	1954	No	No	No
216-T-15 Trench	1954	No	No	No
216-T-16 Trench	1954	No	No	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Potential Based on Geophysical Logs (Table 2-3)	Criteria Indicates Possible Contribution to Uppermost Aquifer
216-T-17 Trench	1954	No	No	No
216-T-20 Trench	1952	No	No logs	No
216-T-21 Trench	1954	No	No logs	No
216-T-22 Trench	1954	Yes	No	Yes
216-T-23 Trench	1954	Yes	No	Yes
216-T-24 Trench	1954	Yes	No	Yes
216-T-25 Trench	1954	Yes	No	Yes
2607-W1 Septic Tank	1944-present	Yes	No logs	Yes
2607-W2 Septic Tank	1944-present	Yes	No logs	Yes
2607-W3 Septic Tank	1944-present	Yes	No logs	Yes
2607-W4 Septic Tank	1944-present	Yes	No logs	Yes
2607-WT Septic Tank	1952-present	No	No logs	No
2607-WTX Septic Tank	1950-present	No	No logs	No
216-W Powerhouse Ash Pit	1943-present	No	No logs	No
216-W-18 Burial Ground	1945-1952	No	No logs	No

Waste Management Unit	Quantity of Reported Radionuclides (Ci)[a]															Reported Waste
	^{241}Am	^{60}Co	^{137}Cs	^{3}H	^{238}Pu	^{239}Pu	^{240}Pu	^{241}Pu	Total Pu[b]	^{106}Ru	^{90}Sr	^{238}U	Other Radio-nuclides	Alpha	Beta	Volume Received (L)
U Plant Aggregate Area																
216-S-21 Crib		0.333[c]	3.55			0.119[c]	3.2E-2[c]		2.08	1.39E-6	21.8	1.4E-3[c]		0.128	208	8.71E+7
216-U-1 & 216-U-2 Cribs		1.57E-3[c]	4.36			2.43[c]	0.656[c]		42.6	6.0E-7	2.11	0.702		2.62	12.6	4.62E+7
216-U-12 Crib	6.45E-3		5.66E-2	1.88E-3		1.23E-2[c]			1.0	2.18E-6	55.9	0.677		0.105	112	1.5E+8
216-Z-20 Crib	1.01		8.64E-2		0.153	2.03		2.51	0.148	1.07E-4	6.3E-2			2.22	0.409	3.8E+9
216-S-4 French Drain				0.02												1.0E+6
216-U-10 Pond	0.492		11	196		7.68E-2[c]			8.0E+3	2.78E-5	11	1.88		505	44.2	1.65E+11
Z Plant Aggregate Area																
216-Z-1 & 216-Z-2 Cribs		1.71E-2	4.0E-2 (0.165)			2.68E+3	9.92E+2		7.0E+3	1.6E-11	3.7E-2 (1.59E-2)	2.7E-2				3.37E+7
216-Z-3 Crib			4.8E-2		1.7E-5	325	87.8		5.7E+3	6.0E-9 (16.9)	4.5E-2 (9.7E-2)	1.7E-5				1.78E+8
216-Z-5 Crib		2.6E-3	3.6 (3.92)			19.4	5.24		340	5.2E-12	1.7 1.83	1.7E-5 2.0E-5				3.1E+7
216-Z-7 Crib		7.65E-2	200 (224)			114	30.8		2.0E+3	5.1E-6	2.0E+2 (2.23E+2)	1.5E-3				7.9E+7
216-Z-12 Crib		5.15E-3	5.3E-2 (5.28E-2)			1.43E+3	386		2.5E+4	9.3E-7	5.1E-2 (5.62E-2)	1.7E-5				2.81E+8
216-Z-16 Crib						4.09	1.1		72							1.02E+8
216-Z-8 French Drain	1.37E+3				0.13	2.76	0.745		2.0		5.62E-2					9.59E+3
216-Z-1A Tile Field	3.43E+3		0.16			137	37		5.7E+4	5.2E-6	0.15					5.21E+6
216-Z-10 Reverse Well	1.0				0.14	2.85	0.77	2.0	50							1.0E+6
216-Z-9 Trench	8.58E+3	3.95E-3	5.2E-2 (5.56E-2)			2.19E+3	5.9E+2		4.8E+4	1.9E-8	4.9E-2 (5.35E-2)	1.7E-5 2.0E-5				4.09E+6
216-Z-17 Trench					5.0E-5	2.87	0.225		50			5.0E-5				3.68E+7

Table 2-5. Radionuclide Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

9 2 1 2 6 5 1 0 1 7 0

Waste Management Unit	Quantity of Reported Radionuclides (Ci)[a]													Reported Waste
	^{241}Am	^{60}Co	^{137}Cs	^{3}H	^{239}Pu	^{240}Pu	^{241}Pu	Total Pu[b]	^{106}Ru	^{90}Sr	^{238}U	Other Radio-nuclines	Alpha	Beta	Volume Re-ceived (L)
S Plant Aggregate Area															
216-S-1 & 216-S-2 Cribs			1.1E+3					1.2E+3	6.19E-8	1.25E+3		4.8E+3			1.6E+8
216-S-3 French Drain			21.9					0.5	1.09E-9	0.414		43			4.0E+6
216-S-5 Crib			26.4					580	7.14E-10	54.1		190			4.1E+9
216-S-6 Crib			115					473	5.89E-6	204		660			4.47E+9
216-S-7 Crib			70.3					440	1.3E-6	1.39E+3		4.3E+3			3.9E+8
216-S-9 Crib			290					65	2.87E-4	96.3		760			5.03E+7
216-S-20 Crib			5.65					171	2.49E-7	22.7		170			1.35E+8
216-S-22 Crib			0.478						1.41E-9	0.455		1.8			9.8E+4
216-S-23 Crib			3.47					0.994	3.49E-5	1.14		9.1			3.41E+7
216-S-25 Crib			6.47E-2	148				4.66E-2	1.6E-5	4.1E-2		0.31			3.0E+8
216-S-26 Crib			3.09E-3		1.72E-4					1.83E-3		1.1E-2			1.64E+8
216-S-11 Pond			0.82					0.31	0.292	0.814		2.0			2.23E+9
216-S-16P Pond			0.3						4.47E-6	45		170			4.07E+10
216-S-17 Pond			12.7					3.0	3.12E-10	15.9		56			6.44E+9
216-S-19 Pond			1.29	1.87E-1				20.6	3.89E-7	1.3		6.4			1.33E+9
216-S-10D Ditch			1.24		4.68E-3			0.1	0.346	1.07		3.6			4.34E+9
216-S-8 Trench			4.92					2.0	1.3E-10	0.386		11			1.0E+7
216-S-12 Trench			0.434					1.0	1.38E-11	0.41		1.7			7.6E+4

Table 2-5. Radionuclide Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

9 2 1 2 6 5 1 0 1 7 1

Waste Management Unit	Quantity of Reported Radionuclides (Ci)[a]															Reported Waste
	^{241}Am	^{60}Co	^{137}Cs	^{3}H	^{238}Pu	^{239}Pu	^{240}Pu	^{241}Pu	Total Pu[b]	^{106}Ru	^{90}Sr	^{238}U	Other Radio-nuclines	Alpha	Beta	Volume Received (L)
T Plant Aggregate Area																
216-T-6 Crib		3.05E-2	1.1E+2			22.3	6.01		3.9E+2	6.07E-11	124	7.6E-3				4.5E+7
216-T-7TF Crib & Tile Field		1.42E-2	21.2			7.42	2.0		1.3E+2	2.02E-9	24	3.04E-3				1.1E+8
216-T-8 Crib		9.9E-4	4.01E-2			0.285	7.7E-2		5.0	6.63E-12	3.76E-1	1.5E-3				5.0E+5
216-T-18 Crib		0.137	24.2	0.8[c]		103	27.7		1.8E+3	1.38E-9	2.8	9.11E-3				1.0E+6
216-T-19TF Crib & Tile Field	9.82E-3		17.5	4.25					14.4	6.03E-6	27.8					4.55E+8
216-T-26 Crib		1.89E-2	75.6			3.37	0.908		59	8.02E-8	282	0.503				1.2E+7
216-T-27 Crib		6.7E-2	55.9			0.742	0.2		13	4.09E-5	75.3	2.43E-3				7.19E+6
216-T-28 Crib		0.319	193			4.0	1.08		70	1.96E-5	106	0.131				4.23E+7
216-T-32 Crib		8.27E-3	9.71			1.83	49.3		3.2E+3	4.44E-11	10.9	7.6E-3				2.9E+7
216-T-33 Crib		5.15E-2	0.267			0.285	7.7E-2		5.0	6.86E-8	0.256	1.52E-3				1.9E+6
216-T-34 Crib		0.585	157			6.11	1.65		107	5.98E-6	178	1.38E-3				1.73E+7
216-T-35 Crib		0.298	11.7			3.78	1.02		66.2	1.44E-5	11.4	1.64E-2				5.72E+6
216-T-3 Reverse Well			21.3			191	51.5		3.35E+3	5.22E-12	18.6					1.63E+7
216-T-5 Trench		8.99E-2	31.1			10.3	2.77		180	8.25E-10	0.42	1.52E-3				2.6E+6
216-T-12 Trench		3.41E-2	4.34			5.71	1.54E-2		1.0	1.38E-10	2.05	1.52E-2				5.0E+6
216-T-14 Trench		0.236	204	0.8[c]		5.02E-2	0.135		0.88	2.07E-10	2.46	1.02E-3				1.0E+6
216-T-22 Trench		1.57E-2	803	1.2[c]		0.114	30.8		2.0	4.14E-10	20.9	6.7E-4				1.53E+6
216-T-23 Trench		1.57E-2	577	1.2[c]		5.71E-2	1.54E-2		1.0	3.59E-10	16.8	3.4E-4				1.48E+6
216-T-24 Trench		1.57E-2	617	1.20[c]		0.114	3.08E-2		2.0	4.42E-10	16.4	2.78E-3				1.53E+6
216-T-25 Trench		1.57E-3	3.86E+3	2.4[c]		0.571	0.154		1.0	1.38E-9	1.64	3.0E-4				3.0E+6

Notes:

a/ Values decayed through Dec. 31, 1989 unless otherwise noted.

b/ Values reported in grams.

c/ Values are from HISS database (Stenner et al., 1988) and are decayed through April 1, 1986.

d/ Also received 4.0E-5 Ci of ^{242}Pu.

Table 2-5. Radionuclide Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

9 2 1 2 6 5 1 0 1 7 2

Waste Management Unit	Quantity of Reported Chemicals (kg)[a]																										Volume Received (L)
	Aluminum Fluoride Nitrate	Aluminum Nitrate	Calcium Nitrate	CCl_4	DBBP	Ferric Nitrate	Ferro-Cyanide	Fluoride	HNO_3	H_2SO_4	K	Magnesium Nitrate	Na	NaOH	NH_4NO_3	Nitrate	Nitrite	Phosphate	Sodium Aluminate	Sodium Dichromate	Sodium Oxalate	Sodium Silicate	Sulfate	TBP	
U Plant Aggregate Area																											
216-S-21 Crib													130		8.0E+2	1.2E+6		7.0E+4					1.0E+5		8.71E+7
216-U-1 & 2 Cribs													5.0E+5												4.62E+7
216-U-12 Crib																									1.5E+8
216-Z-20 Crib																									3.8E+9
216-S-4 French Drain																1.0									1.0E+6
216-U-10 Pond																3.4E+3									1.65+11
216-U-4 Reverse Well																400									3.0E+5
Z Plant Aggregate Area																											
216-Z-1 & 216-Z-2 Cribs								3.0E+4					8.0E+4			1.0E+5									3.37E+7
216-Z-3 Crib								1.6E+5					4.0E+5			6.0E+5									1.78E+8
216-Z-5 Crib																1.0E+5									3.1E+7
216-Z-7 Crib													1.0E+5			2.0E+4									7.9E+7
216-Z-12 Crib								3.0E+5					6.0E+5			9.0E+5									2.81E+8
216-Z-18 Crib																									3.86E+6
216-Z-1A Tile Field				2.68E+5	2.03E+4			900					900			3.0E+3								3.0E+4	5.21E+6
216-Z-10 Rev. Well													30			100							1.0E+4		1.0E+6
216-Z-9 Trench	2.1E+5	1.9E+5	1.3E+5	1.31E+5		4.0E+4			3.9E+4			1.8E+5	2.0E+5			5.0E+5									4.09E+6

Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

9 2 1 2 6 5 1 0 1 7 3

Waste Management Unit	Quantity of Reported Chemicals (kg)[a]																								Volume Received (L)
	Aluminum Fluoride Nitrate	Aluminum Nitrate	Calcium Nitrate	CCl_4	DBBP	Ferric Nitrate	Ferro-Cyanide	Fluoride	HNO_3	H_2SO_4	K	Magnesium Nitrate	Na	NaOH	NH_4NO_3	Nitrate	Nitrite	Phosphate	Sodium Aluminate	Sodium Dichromate	Sodium Oxalate	Sodium Silicate	Sulfate	TBP	
S Plant Aggregate Area																									
216-S-1, -2, & -5 Cribs		6.0E+4							1.0E+5							6.0E+4									1.68E+8
216-S-3 French Drain																9.0									4.0E+6
216-S-5 Crib													1.0E+4			1.0E+2									4.1E+9
216-S-6 Crib		4.0E+4							2.5E+5							1.4E+2									4.47E+9
216-S-7 Crib									3.0E+4							1.1E+2									3.9E+8
216-S-9 Crib													7.0E+3												5.03E+7
216-S-20 Crib																2.0E+4									1.35E+8
216-S-22Crib																7.0E+3									9.8E+4
216-S-23 Crib									3.0E+2																3.41E+7
216-S-25 Crib																1.0									3.0E+8
216-S-26 Crib																30									1.64E+8
216-S-17 Pond																140									6.44E+9
216-S-15 Pond																1.0									1.0E+4
216-S-16P Pond																10									4.07E+10
216-S-8 Trench																100									1.E+7

Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

9 2 1 2 6 5 1 0 1 7 4

Waste Management Unit	Quantity of Reported Chemicals (kg)[a]																								
	Aluminum Fluoride Nitrate	Aluminum Nitrate	Calcium Nitrate	CCl_4	DBBP	Ferric Nitrate	Ferro-Cyanide	Fluoride	HNO_3	H_2SO_4	K	Magnesium Nitrate	Na	NaOH	NH_4NO_3	Nitrate	Nitrite	Phosphate	Sodium Aluminate	Sodium Dichromate	Sodium Oxalate	Sodium Silicate	Sulfate	TBP	Volume Received (L)
T Plant Aggregate Area																									
216-T-6-Crib								2.4E+4					1.6E+5		2.6E+3	1.8E+5		1.3E+4			6.0E+3		1.5E+3		4.5E+7
216-T-7TF Tile Field								1.7E+5			2.5E+5		1.7E+6		1.4E+5	2.3E+6		5.0E+5		10	4.0E+4		7.0E+4		1.1E+8
216-T-8 Crib									1.0E+3	1.0E+3															5.0E+5
216-T-18 Crib								2.5E+3					6.0E+4	8.0E+3		8.0E+4	9.0E+3	1.9E+4	8.0E+3			3.2E+3	4.0E+3		1.0E+6
216-T-19F Tile Field													9.0E+4		1.8E+4	1.5E+5		6.0E+4					9.0E+3		4.55E+8
216-T-26 Crib							6.0E+3	3.0E+4					7.0E+5	1.0E+5		1.0E+6	1.1E+5	2.3E+5	1.0E+5			4.0E+4	5.0E+4		1.2E+7
216-T-27 Crib																1.0E+3									7.19E+6
216-T-28 Crib																1.0E+4									4.23E+7
216-T-32 Crib								1.6E+5					1.1E+6		1.6E+3	1.2E+6		9.0E+4			4.0E+4		1.0E+4		2.9E+7
216-T-33 Crib														10											1.9E+6
216-T-34 Crib																1.0E+3									1.73E+7
216-T-35 Crib																1.0E+3									5.72E+6
216-T-2 Rev. Well									6.0E+3	1.0E+4										200					6.0E+6
216-T-3 Rev. Well								4.0E+4			6.0E+4		2.5E+5		4.0E+3	2.9E+5		2.1E+4					2.4E+3		1.63E+7
216-T-1 Ditch														1.0E+3											1.78E+8
216-T-4A Pond[b]																									4.25E+10

Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

9 2 1 2 6 6 1 0 1 7 5

Waste Management Unit	Quantity of Reported Chemicals (kg)a/																									Volume Received (L)
	Aluminum Fluoride Nitrate	Aluminum Nitrate	Calcium Nitrate	CCl_4	DBBP	Ferric Nitrate	Ferro-Cyanide	Fluoride	HNO_3	H_2SO_4	K	Magnesium Nitrate	Na	NaOH	NH_4NO_3	Nitrate	Nitrite	Phosphate	Sodium Aluminate	Sodium Dichromate	Sodium Oxalate	Sodium Silicate	Sulfate	TBP	
T Plant Aggregate Area (Continued)																										
216-T-5 Trench								8.0E+3					1.0E+5		2.0E+4	1.4E+5		6.0E+4				8.0E+3	9.0E+3			2.6E+6
216-T-14 Trench								2.5E+3					6.0E+4	8.0E+3		8.0E+4	9.0E+3	1.9E+4	8.0E+3			3.2E+3	4.0E+3			1.0E+6
216-T-22 Trench								4.0E+3					9.0E+4	1.2E+4		1.2E+5	1.4E+4	2.9E+4	1.3E+4			5.0E+3	6.0E+3			1.53E+6
216-T-23 Trench								4.0E+3					9.0E+4	1.2E+4		1.2E+5	1.4E+4	2.8E+4	1.2E+4			5.0E+3	6.0E+3			1.48E+6
216-T-24 Trench								4.0E+3					9.0E+4	1.2E+4		1.2E+5	1.4E+4	2.9E+4	1.3E+4			5.0E+3	6.0E+3			1.53E+6
216-T-25 Trench								4.0E+4					9.0E+5	1.2E+5		1.2E+6	1.4E+5	2.9E+5	1.3E+5			5.0E+4	6.0E+4			3.0E+6

Notes: Source: WHC 1991a

a/ Not all sites have reported inventories. These inventories do not necessarily list all of the contaminants disposed of at a site.

b/ Inventory of 216-T-4-2 Trench and 216-T-4B Pond are included in the 216-T-4A inventory.

Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

9 2 1 2 6 5 1 0 1 7 6

Table 2-7. Summary of Waste-Producing Processes in the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
U Plant Aggregate Area						
Uranium recovery	Process waste	Nitric acid, bismuth phosphate, NaOH	High	Acidic (neutralized before disposal)	Low	High
	Wastewater	Nitrates	Low	Acidic to neutral/basic	Low	Low
UO_3 conversion	Wastewater	Nitrates	Low	Acidic to neutral	Low	Low
Solvent treatment	Spent solvents	Tributyl phosphate, normal paraffin hydrocarbons	Low	Acidic to neutral	High	Intermediate
	Carbonate scrub solution	Carbonate, tributyl phosphate, normal paraffin hydrocarbons	Low	Acidic to neutral	High	Intermediate
Analytical laboratory	Laboratory process waste	Unknown	Unknown	Acidic	Low	Unknown
	Used or discarded reagents	Unknown	Unknown	Acidic	Low	Unknown
	Wastewater	Unknown	Low	Acidic to basic	Low	Low (Pu and TRU)
Tank farm condensate	Wastewater	Unknown	Low	Neutral/basic	Low	Low

Table 2-7. Summary of Waste-Producing Processes in the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
			Z Plant Aggregate Area			
Plutonium Finishing Plant (PFP)	Process waste	Nitric acid, nitrate salts, fluoride	High	Acidic (pH 2) neutralized before disposal	Low	Low (Pu and TRU)
	Wastewater	Sodium, fluoride, sulfate	Low	Neutral	Low	Trace alpha
RECUPLEX	Aqueous process waste	Nitric acid, fluorides, nitrates, phosphate	High	Acidic	Low	Low
	Organic solvent waste	CCl_4, TBP, DBBP	Low	Slightly acidic	High	Intermediate (Pu and TRU)
	Spent silica gel	Silica gel, Pu	Unknown	Unknown	Unknown	Unknown
Plutonium Reclamation Facility (PRF)	Aqueous process waste	Nitric acid, fluorides, nitrates, phosphate	High	Acidic	Low	Low
	Organic process waste	CCl_4, TBP, DBBP	Low	Slightly acidic	High	Intermediate (Pu and TRU)
Americium recovery	Spent ion exchange resin	^{241}Am, resin	High	Unknown	Unknown	Unknown (^{241}Am)
Analytical laboratory	Laboratory process wastes	Unknown	Low	Slightly acidic	Unknown	Unknown
	Used or discarded reagents	Unknown	Unknown	Unknown	Moderate to low	Unknown
	Wastewater	Sanitary and lab water	Low	Neutral/basic after adjust	Unknown	Unknown

Table 2-7. Summary of Waste-Producing Processes in the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
Plutonium Isolation Facility (PIF)	Process waste	Nitric acid	Unknown	Unknown	Low	Low (Pu and TRU)
	Wastewater	Unknown	Unknown	Unknown	Unknown	Unknown
S Plant Aggregate Area						
Feed preparation	Jacket dissolution	Fission products, jacket constituents (alloy) sodium hydroxide, sodium aluminate	High	Basic	Low	High
	Slug dissolution	Sodium hydroxide, ferrous sulfamate, zirconium, niobium	High	Basic	Low	High
Extraction cycles	Aqueous process waste	Sodium aluminate, fission products, sodium hydroxide	High	Neutral-Basic	Low	Low
	Organic process waste	Hexone	Low	Neutral	High	Low
Solvent recovery	Aqueous waste	Sodium hydroxide, sodium carbonate	High	Basic	Low to medium	High
Analytical laboratory	Laboratory waste	Sodium hydroxide, organics, fission products	Low	Basic	Low	Low

Table 2-7. Summary of Waste-Producing Processes in the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
T Plant Aggregate Area						
Bismuth phosphate	Process waste	Nitric acid	High	Acidic	Low	High
	Aqueous process waste	Phosphoric acid, nitrate solution, uranium, plutonium	High	Acidic	Low	High
Lanthanum fluoride	Process waste	Plutonium, sodium bismuthate, phosphoric acid, nitric acid, hydrogen fluoride, lanthanum salts	NA	NA	NA	High
	Aqueous process waste	Plutonium, sodium bismuthate, phosphoric acid, nitric acid, hydrogen fluoride, lanthanum salts	NA	NA	NA	High
"Hot" Semi-Works	Aqueous process waste	Ammonium silico-fluoride	NA	NA	NA	High
Decontamination and equipment refurbishment	Wastewater	Bismuth phosphate	Low	Neutral	Low	Low-high
Containment Systems Test Facility (CSTF)	NA	NA	NA	NA	NA	NA

Table 2-7. Summary of Waste-Producing Processes in the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
Analytical laboratory	Aqueous process waste	Sodium, lithium, sodium iodine	NA	NA	NA	Low
Analytical laboratory	Aqueous process waste	Cesium, manganese, zinc, lithium, sulfate, iodine and hydrogen iodine	NA	NA	NA	Low

NA = No information available.

Table 2-8. Westinghouse Operational Groundwater Monitoring Network.

Location	Type of Facility	Well Number	Date Installed	Screened Interval (ft)	Formation Screened Within[a/]	Current Depth to Water (ft)
U Plant Aggregate Area						
216-U-1 & 2	Crib	299-W19-17	Dec-85	230-255	Unit E	232
		299-W19-11	Apr-83	220-250	Unit E	233
		299-W19-9	Aug-44	214-244	Unit E	230
		299-W19-16	Jun-85	225-175	Unit E	229
		299-W-18-18	Nov-85	230-355	Unit E	235
		299-W19-3	Sep-57	230-280	Unit E	231
		299-W19-15	June-85	225-275	Unit E	229
216-U-8	Crib	299-19-2	Aug-57	235-295	Unit E	231
216-U-12	Crib	299-W22-22	Jul-60	0-210	Unit E	231.71
216-U-16	Crib	299-W19-14	Jun-84	210-250	Unit E	230
		299-W19-13	Jun-84	210-250	Unit E	232
216-U-17	Crib	299-W19-23	Mar-81	235-255	Unit E	DNF
		299-W19-24	Apr-87	235-255	Unit E	238
		299-W19-26	Apr-87	228-248	Unit E	233
		299-W19-19	Jan-87	230-250	Unit E	234.9
		299-W19-25	Apr-87	226-246	Unit E	232
216-U-10	Pond	299-W18-15	Apr-80	170-243	Unit E	188
U	Tank Farm	299-W18-21	Jul-87	196-226	Unit E	199
		299-W18-27	Mar-90	217-238	Unit E	DNF
		299-W18-32	Jun-90	202-222	Unit E	DNF
Z Plant Aggregate Area						
216-Z-12		299-W18-2	Nov-58	205-255	Unit E	244
216-Z-18		299-W18-9	Dec-68	180-218	Unit E	214
216-Z-20		299-W18-17	Sep-81	220-250	Unit E	DNF
		299-W18-7	Jan-64	190-228	Unit E	206
216-Z-21	Crib	299-W15-9	Dec-56	0-210	Unit E	191
LLBG-4	Burial Ground	299-W15-6	Mar-59	0-350	Base of Unit E	304

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Table 2-8. Westinghouse Operational Groundwater Monitoring Network.

Location	Type of Facility	Well Number	Date Installed	Screened Interval (ft)	Formation Screened Within[a/]	Current Depth to Water (ft)
		299-W15-2	Aug-54	218-258	Unit E	221
S Plant Aggregate Area						
SX	Tank Farm	299-W23-7	Oct-69	0-210	Unit E	200.9
		299-W23-3	Feb-56	176-228	Unit E	202
		299-W23-2	Sep-54	184-225	Unit E	200
		299-W23-4	Jun-57	180-300	Unit E	197
		299-W23-1	Aug-53	150-260	Unit E	201
216-S-8	Crib	299-W22-10	Jun-56	203-311	Unit E	208
		299-W22-1	June-56	190-280	Unit E	244
		299-W22-2	May-56	195-285	Unit E	204
		299-W22-16	Jul-56	DNF	Unit E	DNF
		229-W22-8	Apr-56	223-308	Unit E	226
216-S-25	Crib	299-W23-9	Aug-72	164-230	Unit E	201
		299-W23-10	Oct-72	165-230	Unit E	202
		299-W23-11	Nov-72	165-230	Unit E	199
216-S-26	Crib	299-W27-1	Jun-84	216-236	Unit E	217
T Plant Aggregate Area						
T	Tank Farm	299-W10-1	Aug-47	190-270	Unit E	207
		299-W10-3	Nov-51	181-234	Unit E	209
		299-W11-24	Aug-73	200-250	Unit E	224
TX/TY	Tank Farm	299-W14-6	Dec-74	195-255	Unit E	196
216-T-3	Crib	299-W11-7	Sep-51	0-265	Unit E	248
216-T-33	Crib	299-W11-14	Dec-62	250-313	Unit E	255
216-T-34	Crib	299-W11-16	Dec-65	0-240	Unit E	230
216-W-LWC	Crib	299-W14-10	Jul-81	260-275	Unit E	DNF

Well Network for calendar year 1990.
DNF Data not found.
[a/] See Figures 3-18 through 3-23 for formation.

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Table 2-9. RCRA Groundwater Monitoring Network within the 200 West Area.

Facility	Type of Facility	Monitoring Well	Date of Installa -tion	Screened Interval (ft)	Formation Screened Within[a/]	Current Depth to Water (ft)
LLWMA 3	Burial Ground	299-W6-2	87	224-245	Unit E	233
		299-W7-1	87	224-244	Unit E	231
		299-W7-2	87	202-222	Unit E	217
		299-W7-3	87	449-470	Base of Unit E	217
		299-W7-4	87	203-233	Unit E	211
		299-W7-5	87	208-228	Unit E	215
		299-W7-6	87	209-220	Unit E	219
		299-W7-7	89	207-228	Unit E	217
		299-W7-8	89	220-241	Unit E	230
		299-W7-9	90	220-241	Unit E	232
		299-W7-10	90	221-241	Unit E	231
		299-W7-11	91	219-240	Unit E	222
		299-W7-12	91	211-232	Unit E	228
		299-W8-1	87	236-256	Unit E	241
		299-W9-1	87	266-296	Unit E	275
		299-W10-13	87	227-247	Unit E	235
		299-W10-14	87	427-447	Base of Unit E	235
LLWMA 4	Burial Ground	299-W15-15	87	223-253	Unit E	230
		299-W15-16	87	208-238	Unit E	219
		299-W15-17	87	422-432	Base of Unit E	215
		299-W15-18	87	208-238	Unit E	218
		299-W15-19	89	214-235	Unit E	225
		299-W15-20	89	220-240	Unit E	232
		299-W15-23	90	219-223	Unit E	233
		299-W15-24	89	220-241	Unit E	233
		299-W18-21	87	196-226	Unit E	202
		299-W18-22	87	416-417	Lower Mud	199
		299-W18-23	87	221-251	Unit E	230
		299-W18-24	87	205-235	Unit E	213

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Table 2-9. RCRA Groundwater Monitoring Network within the 200 West Area.

Facility	Type of Facility	Monitoring Well	Date of Installa -tion	Screened Interval (ft)	Formation Screened Within[a/]	Current Depth to Water (ft)
		299-W18-26	89	222-243	Unit E	233
		299-W18-27	91	217-238	Unit E	224
		299-W18-28	91	208-229	Unit E	214
		299-W18-29*	91	119-135	Hanford Fine	128
LLWMA 5	Burial Ground	299-W6-2	87	224-225	Unit E	233
		299-W6-3	91	DNF	Bottom of Unit E	242
		299-W6-4	91	235-256	Unit E	238
		288-W7-10	90	221-241	Unit E	231
		299-W6-8	91	220-240	Unit E	238
		299-W6-5	91	264-284.7	Unit E	256
		299-W6-7	91	224-265	Unit E	255
		299-W6-6	91	419-429	Base of Unit E	277
WMA-T	Single-Shell Tank	299-W10-16	89	198-219	Unit E	210
		299-W11-27	91	213-234	Unit E	223
		299-W11-28	91	224-225	Unit E	230
		299-W10-15	89	201-222	Unit E	212
		299-W10-4	52	190-245	Unit E	206
		299-W10-2	53	201-229	Unit E	209
		299-W11-12	53	200-250	Unit E	214
		299-W10-3	51	181-234	Unit E	208
		299-W10-8	73	211-251	Unit E	217
		299-W10-9	73	200-220	Unit E	212
		299-W10-10	74	196-248	Unit E	212
		299-W10-11	74	196-248	Unit E	212
		299-W10-12	74	196-248	Unit E	212
		299-W11-23	73	200-240	Unit E	222
		299-W11-24	73	200-250	Unit E	224
WMA-TY/TX	Single-Shell Tank	299-W15-22	90	198-222	Unit E	204
		299-W14-12	91	198-218	Unit E	206

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Table 2-9. RCRA Groundwater Monitoring Network within the 200 West Area.

Facility	Type of Facility	Monitoring Well	Date of Installa -tion	Screened Interval (ft)	Formation Screened Within[a/]	Current Depth to Water (ft)
		299-W10-17	90	201-222	Unit E	208
		299-W10-18	90	199-221	Unit E	207
		299-W15-13	73	197-225	Unit E	206
		299-W15-12	73	195-215	Unit E	206
		299-W15-3	52	200-245	Unit E	202
WMA-U	Single-Shell Tank	299-W18-25	90	193-214	Unit E	197
		299-W18-30	91	197-234	Unit E	205
		299-W18-31	91	DNF	Unit E	196
		299-W19-31	90	201-222	Unit E	206
		299-W19-32	90	201-222	Unit E	203
		299-W19-1	57	320-370	Base of Unit E	205
		299-W19-12	83	210-250	Unit E	205
WMA-S/SX	Single-Shell Tank	299-W23-13	90	195-217	Unit E	201
		299-W23-4	57	180-300	Unit E	197
		299-W23-14	91	193-215	Unit E	200
		299-W22-39	90	199-221	Unit E	231
		299-W22-44	91	205-242	Unit E	211
		299-W23-1	52	150-260	Unit E	201
		299-W22-46	91	193-229	Unit E	197
		299-W23-7	60	170-248	Unit E	200
		299-W23-2	54	184-235	Unit E	200
		299-W23-8	72	165-230	Unit E	200
		299-W23-5	68	215-245	Unit E	206
		299-W23-3	56	176-228	Unit E	202
		299-W23-12	10	189-218	Unit E	201
		299-W23-15	91	186-222	Unit E	184
		299-W23-6	69	172-248	Unit E	203
216-U-12	Crib	299-W22-43	91	223-244	Unit E	208
		299-W22-42	91	223-243	Unit E	233

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Table 2-9. RCRA Groundwater Monitoring Network within the 200 West Area.

Facility	Type of Facility	Monitoring Well	Date of Installa -tion	Screened Interval (ft)	Formation Screened Within[a/]	Current Depth to Water (ft)
		299-W22-41	90	224-245	Unit E	233
		299-W22-40	90	224-244	Unit E	234
216-S-10	Ditch/Pond	299-W26-7	91	DNF	DNF	181
		299-W26-8	90	195-215	Unit E	205
		299-W26-10	91	190-250	Unit E	189
		299-W26-11*	90	115-135	Hanford Fine	DNF
		299-W26-9	90	184-204	Unit E	195
		299-W26-12	91	175-290	Unit E	212

The shading indicates an upgradient well.
* Indicates a well that is screened within a perched water zone.
a/ See Figures 3-18 through 3-23 for formation.

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Table 2-10. Constituents Analyzed for at Low-Level Burial Ground.

Contamination Indicator Parameters	
pH	Total Organic Carbon (TOC)
Specific Conductance	Total Organic Halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform Bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross Alpha	Toxaphene
Gross Beta	2,4-D
Lead	2,4,5-Silvex
Site Specific Parameters	
1,1,2,2-Tetrachloroethane	Cyanide
1,2-Dichloroethane	Ethylbenzene
1,2-Dichloropropane	Naphthalene
Acetonitrile	Toluene
Benzene	Tetrachloroethlyene
Beryllium	trans-1,1-Dichloroethylene
Bromoform	Trichloroethylene
Carbon tetrachloride	Uranium
Chlorobenzene	Vinyl Chloride
cis-1,1-Dichloroethylene	Xylenes
Copper	

Source: DOE/RL 1991b

Table 2-11. Constituents Analyzed for at the Single-Shell Tanks.

Contamination Indicator Parameters	
pH	Total Organic Carbon (TOC)
Specific Conductance	Total Organic Halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform Bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross Alpha	Toxaphene
Gross Beta	2,4-D
Lead	2,4,5-Silvex
	Turbidity
Site-Specific Parameters	Gamma Scan
Ammonium	Cesium-137
Tritium	Uranium
Total Organics	Ruthenium-106
	Plutonium
	Strontium-90
	Cobalt-60

Source: DOE/RL 1991b

Table 2-12. Constituents Analyzed for at the 216-U-12 Facility.

Contamination Indicator Parameters	
pH	Total Organic Carbon (TOC)
Specific Conductance	Total Organic Halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform Bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross Alpha	Toxaphene
Gross Beta	2,4-D
Lead	2,4,5-Silvex
Site-Specific Parameters	
Tritium	Uranium
Technetium-99	Volatile Organic Analysis

Source: DOE/RL 1991b

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Table 2-13. Constituents Analyzed for at the 216-S-10 Facility.

Contamination Indicator Parameters	
pH	Total Organic Carbon (TOC)
Specific Conductance	Total Organic Halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform Bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross Alpha	Toxaphene
Gross Beta	2,4-D
Lead	2,4,5-Silvex
Site-Specific Parameters	
Tritium	Uranium
Technetium-99	Volatile Organic Analysis

Source: DOE/RL 1991b

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Table 2-14. Groundwater Monitoring Wells within the 200 West Groundwater Aggregate Area Network. Page 1 of 2

Monitoring Well	Date of Installation	Screened Interval (ft)	Formation Screened Within	Current Depth of Water (ft)
299-W6-1	57	230-280	Unit E	245
299-W10-1	47	190-270	Unit E	207
299-W10-4	52	190-245	Unit E	206
299-W10-5	54	175-220	Unit E	207
299-W11-3	51	254-320	Unit E	257
299-W11-6	50	DNF	Unit E	256
299-W11-7	51	245-290	Unit E	246
299-W11-10	56	256-304	Unit E	273
299-W11-14	62	250-313	Unit E	255
299-W11-18	67	227-295	Unit E	249
299-W12-1	56	274-309	Unit E	276
299-W14-6	74	195-255	Unit E	196
299-W14-10	81	195-230	Unit E	DNF
299-W15-2	54	218-258	Unit E	271
299-W15-4	56	170-216	Unit E	195
299-W15-7	66	182-350	Unit E	--
299-W18-3	59	195-254	Unit E	218
299-W18-7	64	190-228	Unit E	206
299-W18-15	59	200-256	Unit E	193
299-W18-22	87	DNF	Basal Ringold	202
299-W19-2	57	235-295	Unit E	235
299-W19-3	57	230-280	Unit E	231
299-W19-4	--	--	--	256
299-W19-5	68	205-230	Unit E	224

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Table 2-14. Groundwater Monitoring Wells within the 200 West Groundwater Aggregate Area Network. Page 2 of 2

Monitoring Well	Date of Installation	Screened Interval (ft)	Formation Screened Within	Current Depth of Water (ft)
299-W19-12	83	210-250	Unit E	205
299-W22-9	56	220-299	Unit E	219
299-W22-12	56	194-319	Unit E	216
299-W23-9	72	164-230	Unit E	201
699-31-650	65	240-260	Unit E	242
699-32-62	76	365-370	Basal Ringold	278
699-35-66	57	280-317	Unit E	286
699-35-70	48	233-253	Unit E	243
699-36-61A	48	330-389	--	340
699-38-65	59	220-395	--	323
699-39-79	48	195-295	Unit E	207
699-40-62	49	335-374	--	342
699-44-64	60	316-360	Basal Ringold	319

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Table 2-15. Constituents Analyzed for Under the CERCLA Groundwater Monitoring Program.

Groundwater Quality Parameters	
pH	Total Organic Carbon (TOC)
Specific Conductance	Total Organic Halogen (TOX)
Anions	Total Dissolved Solids
Drinking Water Parameters	
Hydrazine	Cyanide
Pesticides	Semivolatile Organic Compounds
Volatile Organic Compounds	Lindane
Coliform Bacteria	Mercury
Gross Alpha	Selenium
Gross Beta	Lead
Other Parameters	Gamma Scan
Technetium-99	Cesium-137
Tritium	Uranium
U-Chem	Ruthenium-106
	Plutonium
	Strontium
	Cobalt-60

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Table 2-16. Groundwater Monitoring Wells within the PNL Monitoring Network.

Monitoring Well	Date of Installation	Screened Interval (ft)	Formation Screened within	Current Depth to Water (ft)
299-W6-1	57	230-280	Unit E	245
299-W6-2	87[a]	224-245	Unit E	233
299-W7-1	87	224-244	Unit E	231
299-W7-2	87	202-222	Unit E	217
299-W7-3	87	449-470	Unit E	217
299-W7-4	87	203-233	Unit E	211
299-W7-5	87	208-228	Unit E	215
299-W7-6	87[a]	209-229	Unit E	219
299-W8-1	87	236-256	Unit E	241
299-W9-1	87	266-286	Unit E	275
299-W10-1	47	190-270	Unit E	207
299-W10-3	51	181-234	Unit E	208
299-W10-4	52	190-245	Unit E	206
299-W10-5	54	175-220	Unit E	209
299-W10-8	73	211-251	Unit E	217
299-W10-9	73	200-220	Unit E	212
299-W10-13	87	227-247	Unit E	235
299-W10-14	87	427-447	base of Unit E	235
299-W11-3	51	254-320	Unit E	257
299-W11-7	51	245-290	Unit E	246
299-W11-11	56	198-246	Unit E	198
299-W11-14	62	250-313	Unit E	--
299-W11-15	65	240-263	Unit E	--
299-W11-18	67	227-295	Unit E	249
299-W11-23	73	200-240	Unit E	222
299-W11-24	73	210-250	Unit E	224
299-W12-1	56	274-309	Unit E	275
299-W14-2	55	181-222	Unit E	201
299-W14-5	74	190-225	Unit E	202
299-W14-6	74	195-225	Unit E	204
299-W15-2	54	218-258	Unit E	--
299-W15-4	56	170-216	Unit E	--
299-W15-6	59	175-408	base of Unit E	--
299-W15-7	66	182-350	Unit E	--

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Table 2-16. Groundwater Monitoring Wells within the PNL Monitoring Network.

Monitoring Well	Date of Installation	Screened Interval (ft)	Formation Screened within	Current Depth to Water (ft)
299-W15-8	66	--	Unit E	--
299-W15-10	68	183-297	Unit E	210
299-W15-11	68	183-297	Unit E	212
299-W15-12	73	195-215	Unit E	206
299-W15-15	87	223-253	Unit E	230
299-W15-16	87	208-238	Unit E	219
299-W15-17	87	422-432	base of Unit E	215
299-W15-18	897	208-238	Unit E	--
299-W18-3	59	200-256	Unit E	225
299-W18-4	59	194-254	Unit E	218
299-W18-7	64	190-298	Unit E	206
299-W18-9	68	180-218	Unit E	214
299-W18-15	80	170-243	Unit E	--
2999-W18-17	81	220-250	Unit E	--
299-W18-20	82	220-249	Unit E	--
299-W18-21	87	196-226	Unit E	--
299-W18-22	87	416-447	base of Unit E	--
299-W18-24	87	205-235	Unit E	--
299-W19-1	59	178-299	Unit E	205
299-W19-2	57	235-295	Unit E	234
299-W19-3	57	230-280	Unit E	231
299-W19-5	68	205-230	Unit E	224
299-W19-9	44	214-244	Unit E	230
299-W19-12	83	210-250	Unit E	205
299-W19-13	84	210-250	Unit E	232
299-W19-14	84	210-250	Unit E	230
299-W19-15	85	225-275	Unit E	229
299-W19-16	85	235-275	Unit E	229
299-W19-17	85	230-355	Unit E	232
299-W19-18	85	230-355	Unit E	235
299-W19-19	87	260-250	Unit E	235
299-W19-20	86	231-251	Unit E	233
299-W19-21	86	201-226	Unit E	--

Table 2-16. Groundwater Monitoring Wells within the PNL Monitoring Network.

Monitoring Well	Date of Installation	Screened Interval (ft)	Formation Screened within	Current Depth to Water (ft)
299-W19-23	87	235-255	Unit E	--
299-W19-24	87	235-255	Unit E	238
299-W19-25	87	226-246	Unit E	232
299-W19-26	87	228-248	Unit E	233
299-W19-27	87	208-228	Unit E	217
299-W21-1	57	221-290	Unit E	244
299-W22-1	56	190-280	Unit E	204
299-W22-2	56	195-285	Unit E	206
299-W22-7	56	223-308	Unit E	228
299-W22-9	56	220-299	Unit E	219
299-W22-10	56	195-305	Unit E	208
299-W22-12	56	194-319	Unit E	216
299-W22-18	56	212-298	Unit E	208
299-W22-20	57	205-299	Unit E	219
299-W22-21	57	200-285	Unit E	210
299-W22-22	60	255-300	Unit E	230
299-W22-26	63	200-298	Unit E	218
299-W23-2	53	150-260	Unit E	200
299-W23-4	54	184-265	Unit E	197
299-W23-7	57	180-300	Unit E	200
299-W23-8	69	170-248	Unit E	200
299-W23-9	72	165-230	Unit E	201
299-W23-10	72	164-230	Unit E	202
299-W23-11	72	165-230	Unit E	199
299-W26-3	72	165-230	Unit E	181
299-W26-6	83	191-221	Unit E	189
299-W27-1	84	216-236	Unit E	217
699-35-70	48	233-253	Unit E	--
699-37-82A	80	155-175	Unit E	--
699-38-70	57	255-380	Unit E	--
699-45-69A	48	274-366	Unit E	--
699-48-71	56	239-302	Unit E	--
699-49-79	48	225-265	Unit E	--

a/ RCRA monitor well
b/ Perched water well

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Table 2-17. Constituents Evaluated Under the Pacific Northwest Laboratory (PNL) Surveillance Program.

General Water Quality Parameters		
pH		Total Organic Carbon (TOC)
Specific Conductance		Total Organic Halogen (TOX)
Alkalinity		Total Dissolved Solids
Sulfide		Anions
Chloride		Phenols
Iron		Sodium
Manganese		Sulfate
Drinking Water Parameters		
Thallium		Herbicides
ICP		PCBs
Hexane		Hydrazine
Arsenic		Lindane
Barium		Methoxychlor
Cadmium		Mercury
Chromium		Nitrate
Coliform Bacteria		Radium
Endrin		Silver
Fluoride		Selenium
Gross Alpha		Toxaphene
Gross Beta		2,4-D
Lead		2,4,5-Silvex
Gross Gamma		Turbidity
Other Parameters		
Niobium-63	U-Chem	U-Iso
Ammonium	Radium	Technetium-99
Tritium	Cesium-137	Plutonium
Total Organics	Uranium	Strontium-90
Iodine-129	Ruthenium-106	Cobalt-60

Source: DOE/RL 1991b

3.0 SITE CONDITIONS

The following sections describe the physical nature and setting of the Hanford Site and the 200 West Area. The site conditions are presented in the following sections:

- Physiography and Topography (Section 3.1)
- Meteorology (Section 3.2)
- Surface Hydrology (Section 3.3)
- Geology (Section 3.4)
- Hydrogeology (Section 3.5)
- Environmental Resources (Section 3.6)
- Human Resources (Section 3.7).

These sections incorporate information from other documents which are referenced as applicable.

3.1 PHYSIOGRAPHY AND TOPOGRAPHY

The following sections describe surface features and topographic characteristics of the Hanford Site and the 200 West Area, and are modified from discussions by Delaney et al. (1991).

The Hanford Site (Figure 3-1) is situated within the Pasco Basin of south-central Washington. The Pasco Basin is one of a number of topographic depressions located within the Columbia Basin Subprovince of the Columbia Intermontane Province (Figure 3-2), a broad basin located between the Cascade Range and the Rocky Mountains. Existing landforms of the Columbia Intermontane Province are dominantly the result of Miocene continental flood basalt volcanism [about 17 to 6 Ma (million years before present)] and regional deformation. Deformation began before eruption of the Columbia River Basalt Group and continues to the present. The Pasco Basin is bounded on the north by the Saddle Mountains, on the east by the Palouse Slope and on the south by Rattlesnake Mountain, Rattlesnake Hills, and the Horse Heaven Hills anticline. (Figure 3-1). The Pasco Basin is bounded on the west by the Hog Ranch-Naneum uplift. The uplift is located just west of the segments of Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills shown on the figure.

The physiography of the Hanford Site is dominated by the low-relief plains of the Central Plains physiographic region and anticlinal ridges of the Yakima Folds physiographic region (Figure 3-3). Surface topography seen at the Hanford Site is the result of: (1) uplift of anticlinal ridges; (2) Pleistocene cataclysmic flooding; and (3) Holocene eolian activity (DOE 1988). Uplift of the ridges began in the Miocene epoch and continues to the present. 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. Anastomosing flood channels, giant current ripples, bergmounds, and giant flood bars are among the landforms created by the floods. Since the end of the Pleistocene epoch, winds have locally reworked the flood sediments, depositing dune sands in the lower elevations and loess (windblown silt) around the margins of the Pasco Basin. Generally, sand dunes have been stabilized by anchoring vegetation except where they have been reactivated where vegetation is disturbed (Figure 3-4).

A series of numbered areas have been delineated at the Hanford Site. The 100 Areas are situated in the northern part of the Hanford Site adjacent to the Columbia River in an area commonly called the "Horn." The elevation of the "Horn" is between 120 and 140 m (390 and 470 ft) above mean sea level (msl) with a slight increase in elevation away from the river. The 200 Areas are situated on a broad flat area called the 200 Areas Plateau. The 200 Areas Plateau is near the center of the Hanford Site at an elevation of approximately 200 to 230 m (650 to 750 ft) above msl. The plateau decreases in elevation to the north, northwest, and east toward the Columbia River, and plateau escarpments have elevation changes of between 15 to 30 m (50 to 100 ft).

The 200 West Area is situated on the northern slope of the 200 Areas Plateau at the edge of a relatively flat prominent terrace (Cold Creek Bar) formed during the late Pleistocene flooding (Figure 3-5). Cold Creek Bar trends generally east to west and is bisected by a flood channel that trends north to south. This terrace drops off rather steeply to the north and northwest with elevation changes between 15 and 30 m (50 to 100 ft). There are no natural surface drainage channels in the area.

The topography of the 200 West Area is generally flat (Figure 3-1). The elevation ranges from approximately 221 m (725 ft) above msl along the eastern edge of the T Plant Aggregate Area to about 197 m (647 ft) above msl in the western part of the S Plant Aggregate Area. A detailed topographic map of the area is provided as Plate 2. There are no natural surface drainage channels within the 200 West Area.

3.2 METEOROLOGY

The following sections provide information on Hanford Site meteorology including precipitation (Section 3.2.1), wind conditions (Section 3.2.2), and temperature variability (Section 3.2.3). The text information is taken from Stone et al. (1983).

The Hanford Site lies east of the Cascade Mountains and has a semi-arid climate because of the rainshadow effect of the mountains. The weather is monitored at the Hanford Meteorology Station, located between the 200 East and 200 West Areas, and at other points situated through the reservation. The following sections summarize the Hanford Site meteorology.

3.2.1 Precipitation

The Hanford Site receives an annual average of 16 cm (6.3 in.) of precipitation. Precipitation falls mainly in the winter, with about half of the annual precipitation occurring between November and February. The maximum 25 yr/24 hr storm event has been calculated at 3.8 cm (1.5 in.). The maximum 100 yr/24 hr storm event is approximately 5 cm (2 in.). On the average there are only two occurrences per year of 24-hour amounts of precipitation of 1.1 cm (0.5 in.) or more. Average winter snowfall ranges from 13 cm (5.3 in.) in January to 0.8 cm (0.31 in.) in March. The record snowfall of 62 cm (24.4 in.) occurred in February 1916. During December through February, snowfall accounts for about 38% of all precipitation in those months. The frequency and intensity of precipitation at the Hanford Site are of specific interest due to their influence on moisture infiltration to soil and potential recharge to groundwater. Natural groundwater recharge at the Hanford Site is discussed in Section 3.5.2.2.

The average yearly relative humidity at the Hanford Site from 1946 to 1980 was 54.4%. The monthly averages for the same period range from 32.2% for July to 80% in December. In the winter humidity is higher, atmospheric pressure averages are higher, and record-breaking absolute highs and lows also occur.

3.2.2 Winds

The Cascade Mountains have considerable effect on the wind regime at the Hanford Site by serving as a source of cold air drainage. This gravity drainage results in a northwest to west-northwest prevailing wind direction. The average mean monthly wind speed from 1945 to 1980 was 3.4 m/s (7.7 mph). Peak gust speeds range from 28 to 36 m/s (63 to 80 mph) and are generally southwest or west-southwest winds.

Figure 3-6 shows wind roses for the Hanford Telemetry Network. The gravity drainage from the Cascades produces a prevailing west-northwest wind in the 200 West Area. In July, hourly average wind speeds range from a low of 2.3 m/s (5.2 mph) from 9 to 10 a.m. to a high of 6 m/s (13.0 mph) from 9 to 10 p.m.

3.2.3 Temperature

Based on data from 1914 to 1980, minimum winter temperatures vary from -33 °C (-27 °F) to -6 °C (+22 °F), and maximum summer temperatures vary from 38 °C (100 °F) to 46 °C (115 °F). Between 1914 and 1980, a total of 16 days with temperatures -29 °C (-20 °F) or below had been recorded. There are 10 days of record when the maximum temperature failed to go above -18 °C (0 °F). Prior to 1980, there were three summers on record when the temperatures were 38 °C (100 °F) or above for 11 consecutive days.

3.3 SURFACE HYDROLOGY

The following sections provide information on regional (Section 3.3.1), Hanford Site (Section 3.3.2), and 200 West Area (Section 3.3.3) surface water including surface water features and their relationship to Hanford Areas. Sections 3.3.1 and 3.3.2 are taken from Delaney et al. (1991) and incorporate information from DOE (1988).

3.3.1 Pasco Basin Surface Hydrology

Surface drainage enters the Pasco Basin from several other basins, which include the Yakima River Basin, Walla Walla River Basin, Palouse/Snake Basin, and Big Bend Basin (Figure 3-7). Within the Pasco Basin, the Columbia River is joined by major tributaries including the Yakima, Snake, and Walla Walla Rivers. No perennial streams originate within the Pasco Basin. Columbia River inflow to the Pasco Basin is recorded at the United States Geological Survey (USGS) gage below Priest Rapids Dam, and outflow is recorded below McNary Dam. Average annual flow volumes at these recording stations are approximately 1.1×10^{11} m^3 (8.7×10^7 acre-ft) at the USGS gage and 1.6×10^{11} m^3 (1.3×10^8 acre-ft) at the McNary Dam gage.

Total estimated precipitation over the basin averages less than 15.8 cm/yr (6.2 in./yr). Mean annual runoff from the basin is estimated to be less than 3.1×10^7 m^3/yr (2.5×10^4 acre-ft/yr), or approximately 3% of the total precipitation. The remaining precipitation is assumed to be lost through evapotranspiration with a small component (perhaps less than 1%) recharging the groundwater system.

3.3.2 Hanford Site Surface Hydrology

Primary surface water features associated with the Hanford Site, located near the center of the Pasco Basin, are the Columbia and Yakima Rivers and their major tributaries, the Snake and Walla Walla Rivers. West Lake, about 4 hectares (10 acres) in area and less than 1 m (3 ft) deep, is the only natural lake within the Hanford Site. Wastewater ponds and ditches associated with nuclear fuel reprocessing and waste disposal activities are also present on the Hanford Site.

The Columbia River flows through the northern part of the Hanford Site and along the eastern border of the Hanford Site. This section of the river, the Hanford Reach, extends from Priest Rapids Dam to the headwaters of Lake Wallula (the reservoir behind McNary Dam) and is the last free-flowing (i.e., not impounded) segment of the Columbia River left in the United States. Flow along the Hanford Reach is controlled by Priest Rapids Dam. Several drains and intakes are also present along this reach, including irrigation outfalls from the Columbia Basin Irrigation Project, the Washington Public Power Supply System (WPPSS) Nuclear Project 2, and Hanford Site intakes for onsite water use. Much of the northern and eastern parts of the Hanford Site is drained by the Columbia River.

Routine water-quality monitoring of the Columbia River is conducted by the U.S. Department of Energy (DOE) for both radiological and nonradiological parameters and has been reported by Pacific Northwest Laboratory (PNL) since 1973 (e.g., Bisping and Woodruff 1992; Woodruff et al. 1991). The Washington State Department of Ecology (Ecology) has issued a Class A (excellent) quality designation for Columbia River water along the Hanford Reach from Grand Coulee Dam, through the Pasco Basin, to McNary Dam. This designation requires that all industrial uses of this water be compatible with other uses, including drinking, wildlife habitat, and recreation. In general, the Columbia River water is characterized by a very low suspended load, a low nutrient content, and an absence of microbial contaminants.

Approximately one-third of the Hanford Site is drained by the Yakima River system. Cold Creek and its tributary, Dry Creek, are ephemeral streams on the Hanford Site that are within the Yakima River drainage system. Both streams drain areas along the western part of the Hanford Site and cross the southwestern part of the Hanford Site toward the Yakima River. Surface flow, which may occur during spring runoff or after heavier-than-normal precipitation, infiltrates and disappears into the surface sediments. Rattlesnake Springs, located on the western part of the Hanford Site, forms a small surface stream that flows for about 2.9 km (1.8 mi) before infiltrating into the ground.

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3.3.3 200 West Area Surface Hydrology

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). Skaggs and Walters indicated that the probable maximum flood would result in a flood wave crest to an elevation of 125 m (410 ft) above mean sea level. 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. Skaggs and Walters (1981) also indicated that analogous conclusions apply to two other flooding scenarios for the Columbia River: (1) a 200-year flood concurrent with a 765,000 m^3 (1,000,000 yd^3) landslide along the river [resulting in a flood wave crest 122 m (400 ft)]; and (2) a 50% breach of Grand Coulee Dam (flood wave crest elevation not reported). A probable maximum flood 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 (see Figure 12 in Skaggs and Walters 1981). Based on this result, Skaggs and Walters (1981) stated that flood protection would be required to an elevation of about 197 m (645 ft) through the part of the Cold Creek valley in the vicinity of the 200 West Area.

The following sections describe artificial surface water bodies within each of the 200 West Aggregate Areas, and the potential for flooding related to these structures. Locations of the facilities described are identified in Plate 1.

3.3.3.1 U Plant Aggregate Area. Within the U Plant Aggregate Area existing artificial surface water bodies are the 207-U Retention Basin, the open stretches of the 216-U-14 Ditch, and the 200-W Powerhouse Pond. The 200-W Powerhouse Pond receives water from the 284-W Powerplant. The pond is a deepened and widened portion of the 216-U-14 Ditch. The other active portion of the 216-U-14 Ditch runs from northeast to southwest for an additional 1.6 km (1 mi). The 216-U-14 Ditch originated about 610 m (2,000 ft) north of U Plant and terminated at the 216-U-10 Pond, but today approximately three-quarters of its length is backfilled. The open stretches include a small distance (the 200-W Powerhouse Pond) at the north boundary of the U Plant Aggregate Area and a segment just east and south of the 241-U Tank Farm. These discontinuous open portions of the ditch represent minor, if any, flooding potential due to the lack of a contributing drainage basin and the nature of the soil that allows for rapid infiltration of surface water into the ground. The ditch is also constructed with high bermed sides which also minimize the flood potential. The 207-U Retention Basin presents no threat of flooding because it also has no catchment area and it discharges directly into the 216-U-14 Ditch.

3.3.3.2 Z Plant Aggregate Area. In the Z Plant Aggregate Area, existing man-made surface water bodies are the 216-Z-21 Seepage Basin and 207-Z Retention Basin. The 216-Z-21 Seepage Basin is an unlined infiltration basin located about 300 m (1,000 ft) southeast of the main Z Plant building complex. The 207-Z Retention Basin consists of a pair of

concrete-lined basins located about 100 m (330 ft) southeast of the main Z Plant building complex. The 216-Z-21 Seepage Basin presents minor, if any, flooding potential due to the permeable nature of the underlying soil as the facility was designed to promote rapid infiltration of wastewater into the ground. The 207-Z Retention Basin also has no potential for flooding because of the lack of catchment area.

3.3.3.3 S Plant Aggregate Area. Existing man-made water bodies in the S Plant Aggregate Area include a portion of the 216-S-10 Ditch and the west fork of the 216-U-9 Ditch, both of which remain open for surface disposal of liquid waste. The unlined 216-S-10 Ditch has approximately 0.3 m (1 ft) of standing water in the unstabilized portion. Neither of these ditches pose a potential for flooding because they have been cut off from any contributing catchment area.

3.3.3.4 T Plant Aggregate Area. Existing artificial surface water bodies in the T Plant Aggregate Area are the 207-T Retention Basins, and open stretches of the 216-T-4 Ditch. The 216-T-4 Ditch runs from northwest to southeast for about 460 m (1,500 ft). The ditch originates about 30 m (100 ft) north of the T Tank Farm, and terminates at the old 216-T-4A Pond, which has been backfilled and stabilized. The open portion of the ditch presents minimal potential for flooding, since it has no catchment area. The 207-T Retention Basins also have no catchment area and also discharge into the 216-T-4 Ditch, therefore presenting little potential for flooding.

3.4 GEOLOGY

The following sections provide information pertaining to geologic characteristics of south-central Washington, the Hanford Site, and the 200 West Area. Topics included are the regional tectonic framework (Section 3.4.1), Pasco Basin and Hanford Site stratigraphy (Section 3.4.2), known or suspected faulting and other subsurface structures in the West-Central portion of the Hanford Site (Section 3.4.3), and 200 West Area geology (Section 3.4.4).

The geologic characterization of the Hanford Site, including the 200 West Area, is the result of many previous site investigation activities at Hanford. These activities include the siting of nuclear reactors, characterization activities for the Basalt Waste Isolation Project (BWIP), waste management activities, and related geologic studies supporting these efforts. Geologic investigations have included regional and Hanford Site surface mapping, borehole/well sediment logging, field and laboratory sediment classification, borehole geophysical studies (including gamma radiation logging), and in situ and laboratory hydrogeologic properties testing.

3.4.1 Regional Tectonic Framework

The following sections provide information on the geologic structure of the Columbia Plateau (Section 3.4.1.1), Pasco Basin and Hanford Site structural geology (Section 3.4.1.2), and regional and Hanford Site seismology (Section 3.4.1.3). These sections have been modified from text provided by Lindsey et al. (1991) and Delaney et al. (1991). Discussions in Section 3.4.1 focus on large-scale, regional syncline and anticline features. More detailed discussion of known and suspected faulting and other subsurface structures in the West-Central portion of the Hanford Site is provided in Section 3.4.3 following introduction of stratigraphic nomenclature in Section 3.4.2.

3.4.1.1 Columbia Plateau Geologic Structure. The Columbia Plateau is a part of the North American continental plate and lies in a back-arc setting east of the Cascade Range. It is bounded on the north by the Okanogan Highlands, on the east by the Northern Rocky Mountains and Idaho Batholith, and on the south by the High Lava Plains and Snake River Plain (Figure 3-8).

The Columbia Plateau can be divided into three informal structural subprovinces (Figure 3-9): Blue Mountains, Palouse, and Yakima Fold Belt (Tolan and Reidel 1989). These structural subprovinces are delineated on the basis of their structural fabric, unlike the physiographic provinces that are defined on the basis of landforms (Section 3.1). The Hanford Site is located in the Yakima Fold Belt Subprovince near its junction with the Palouse Subprovince.

The principal characteristics of the Yakima Fold Belt (Figure 3-10) are a series of segmented, narrow, asymmetric anticlines that have wave lengths between 5 and 32 km (3 and 19 mi) and amplitudes commonly less than 1 km (0.6 mi) (Reidel et al. 1989a; Reidel 1984). The northern limbs of the anticlines generally dip steeply to the north, are vertical, or even overturned. The southern limbs generally dip at relatively shallow angles to the south. Thrust or high-angle reverse faults with fault planes that strike parallel or subparallel to the axial trends are principally found on the north sides of these anticlines. The amount of vertical stratigraphic offset associated with these faults varies but commonly exceeds hundreds of meters. These anticlinal ridges are separated by broad synclines or basins that, in many cases, contain thick accumulations of Tertiary- to Quaternary-age sediments. The Pasco Basin is one of the larger structural basins in the Yakima Fold Belt Subprovince.

Deformation of the Yakima folds occurred under a north-south compression and was contemporaneous with the eruption of the basalt flows (Reidel 1984; Reidel et al. 1989a). Deformation occurred during the eruption of the Columbia River Basalt Group and continued through the Pliocene epoch, into the Pleistocene epoch, and perhaps to the present.

3.4.1.2 Pasco Basin and Hanford Site Structural Geology. The Pasco Basin, in which the Hanford Site is located, is a structural depression bounded on the north by the Saddle Mountains anticline, on the east by the Palouse Slope, and on the south by the Rattlesnake Mountain anticline, Rattlesnake Hills, and the Horse Heaven Hills anticline (Figure 3-11). The Pasco Basin is bounded on the west by the Hog Ranch-Naneum uplift (not shown on Figure 3-11). The Hog Ranch-Naneum uplift is located about 16 km (10 mi) west of Sentinel Gap, and lies just west of the segments of Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills shown on the figure.

The Pasco Basin includes the Wahluke syncline on the north, Cold Creek syncline on the south, and the Gable Mountain anticline, which is the eastern-most extension of the Umtanum Ridge anticline. The Pasco Basin is divided by the Gable Mountain anticline, the easternmost extension of the Umtanum Ridge anticline, into the Wahluke syncline in the north, and the Cold Creek syncline in the south. Both the Cold Creek and Wahluke synclines are asymmetric and relatively flat-bottomed structures. The north limbs of both synclines dip gently (approximately 5°) to the south and the south limbs dip steeply to the north. The deepest parts of the Cold Creek syncline (the Wye Barricade depression, and the Cold Creek depression) are approximately 12 km (7.5 mi) southeast of the Hanford Site 200 Areas, and just to the west-southwest of the 200 West Area, respectively. The deepest part of the Wahluke syncline lies just north of Gable Gap.

The 200 West Area is situated on the generally southward dipping north limb of the Cold Creek syncline about 1 to 5 km (0.6 to 3 mi) north of the syncline axis. The Gable Mountain-Gable Butte segment of the Umtanum Ridge anticline lies approximately 4 km (2.5 mi) north of the 200 West Area. The axes of the anticline and syncline are separated by a distance of 9 to 10 km (5.6 to 6.2 mi) and the crest of the anticline (as now exposed) is over 200 m (656 ft) higher than the uppermost basalt layer in the syncline axis. As a result, the basalts and overlying sediments dip to the south and southwest beneath the 200 West Area.

Faults have been identified on the anticlinal ridges of the Pasco Basin during geologic mapping, trenching and drilling. Additional evidence for faulting associated with the Pasco Basin synclines has been obtained from borehole geologic data and from geophysics. Discussion of faulting associated with the Umtanum Ridge-Gable Mountain anticline, Yakima Ridge anticline, and the portion of the Cold Creek syncline near the 200 West Area is provided in Section 3.4.3.

3.4.1.3 Regional and Hanford Site Seismology. Western Washington, especially the Columbia Plateau region, is seismically inactive when compared to the rest of the western United States (DOE 1988). The historical seismic record for eastern Washington began in approximately 1850, and no earthquakes large enough to be felt during this period had epicenters on the present-day Hanford Site. The closest regions of historical moderate-to-

large earthquake generation are in western Washington and Oregon and western Montana and eastern Idaho. The most significant event relative to the Hanford Site is the 1936 Milton-Freewater, Oregon, earthquake that had a magnitude of 5.75 and that occurred more than 90 km (54 mi) away. The largest Modified Mercalli Intensity for this event was felt about 105 km (63 mi) from the Hanford Site at Walla Walla, Washington, and was Intensity VII.

Seismic monitoring was initiated at the Hanford Site in 1969. Swarms of small earthquakes have been recorded along the Columbia River north of the 100B Area (Coyote Rapids) and east of the 400 Area (Wooded Island). The earthquakes could be related to tectonic breccia zones of limited extent in the Columbia River Basalt Group (see Section 3.4.3.3). Low-magnitude earthquakes (up to about a magnitude of 2.0 to 3.0) in basalt have also occurred in the vicinity of the 200 West Area.

Geologic evidence of past moderate or possibly large earthquake activity is shown by the anticlinal folds and faulting associated with Rattlesnake Mountain, Saddle Mountain, and Gable Mountain. The currently recorded seismic activity related to these structures consists of micro-size earthquakes. The suggested recurrence rates of moderate- and larger-size earthquakes on and near the Hanford Site are measured in geologic time (tens of thousands of years).

3.4.2 Pasco Basin and Hanford Site Stratigraphy

This section summarizes regional stratigraphic characteristics of the Columbia River Basalt Group and the overlying sediments. Specific references to the Hanford Site and the 200 West Area are made where applicable to describe the general occurrence of these units within the Pasco Basin. Much of the text is modified from Lindsey et al. (1991), with additional information in Section 3.4.2.1 (Regional Columbia River Basalt Group) included from DOE (1988). Information in Section 3.4.2.2 (Ellensburg Formation) was included from Delaney et al. (1991) and DOE (1988). Additional information regarding distinguishing features of the sediments overlying the basalt was taken from Bjornstad (1990) and cited where applicable.

The principal geologic units within the Pasco Basin include the Miocene age basalt of the Columbia River Basalt Group, and overlying late Miocene to Pleistocene unconsolidated sediments (Figure 3-12). Sedimentary interbeds within the Columbia River Basalt Group collectively comprise the Ellensburg Formation. Older Cenozoic sedimentary and volcaniclastic rocks underlying the basalts are not exposed at the surface near the Hanford Site. The basalts and sediments thicken into the Pasco Basin and generally reach maximum thicknesses in the Cold Creek syncline. The suprabasalt sedimentary sequence at the Hanford Site pinches out against the anticlinal structures of Saddle Mountains, Gable Mountain/Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills.

The suprabasalt sediment sequence is up to approximately 230m (750 ft) thick and is dominated by laterally extensive deposits assigned to the late Miocene- to Pliocene-age Ringold Formation and the Pleistocene-age Hanford formation (Figure 3-13). Locally occurring strata informally referred to as pre-Missoula gravels, Plio-Pleistocene unit, and early "Palouse" soil comprise the remainder of the sedimentary sequence. The pre-Missoula gravels are encountered between the Ringold Formation and the Hanford formation in the east-central Cold Creek syncline, and at the east end of Gable Mountain anticline east and south of 200 Areas. The pre-Missoula gravels have not been identified in the 200 West Area. As discussed in Sections 3.4.2.4 and 3.4.2.6, the Plio-Pleistocene unit and the early "Palouse" soil are encountered in the western Cold Creek syncline in the vicinity of the 200 West Area. Most of these sediments, particularly the Ringold Formation, are at least partially consolidated. Relatively thin surficial deposits of eolian sand, loess, alluvium, and colluvium discontinuously overlie the Hanford formation.

The following sections describe the stratigraphic characteristics of the Columbia River Basalt Group (Section 3.4.2.1), Ellensburg Formation (Section 3.4.2.2), Ringold Formation (Section 3.4.2.3), Plio-Pleistocene unit (Section 3.4.2.4), pre-Missoula gravels (Section 3.4.2.5), early "Palouse" soils (Section 3.4.2.6), Hanford formation (Section 3.4.2.7), and surficial deposits (Section 3.4.2.8).

Stratigraphic features of the Saddle Mountains Basalt and the Ellensburg Formation are described for the following reasons:

- Groundwater elevation data presented by DOE (1988), Kasza and Schatz (1989), Kasza et al. (1990), Kasza et al. (1991), and Jackson (1992) indicate that a downward hydraulic gradient exists between the uppermost aquifer in the suprabasalt sediments and the confined aquifers of the Saddle Mountains Basalt-Ellensburg Formation interbeds. As discussed in Section 3.5, the uppermost aquifer is dominated by unconfined conditions, but is locally semiconfined to confined where the Ringold lower mud sequence is present. The data indicate that the downward gradient continues with depth through the Saddle Mountains Basalt and Ellensburg Formation interbeds (Section 3.4.2.2). The area over which the downward gradient is present occurs mainly in areas of artificial recharge at the Hanford Site, including liquid waste disposal sites associated with the 200 West Area. Because of the apparent vertical downward gradient, potential exists for migration of contaminated groundwater from the uppermost aquifer to deeper groundwater-bearing zones. Hydrostratigraphic units, groundwater flow, hydraulic parameters, and groundwater elevation contour maps are discussed in detail in Sections 3.5.1 (Pasco Basin and Hanford Site Hydrogeology) and 3.5.2 (200 West Area Hydrogeology).

- Although, there is currently little evidence for downward migration of contaminated groundwater from the relatively shallow unconfined aquifer in the 200 West Area, this conclusion is based on limited information. Groundwater wells have not been specifically installed in the confined aquifer to assess groundwater quality with regard to chemical and radionuclide contaminants of concern.

- Basalt intraflow structures (Section 3.4.2.1.2), erosional windows, and faults (none currently identified) (Section 3.4.3) could potentially represent conduits for downward groundwater migration in the 200 West Area. In general, previous Hanford Site investigations did not determine "how leaky" basalt intraflow structures and faults may be.

- The confined aquifers represent a potential source of future potable water supply on the Hanford Site, and are currently an important source of agricultural and domestic water adjacent to the Hanford Site.

3.4.2.1 Columbia River Basalt Group. The Columbia River Basalt Group (Figure 3-12) comprises an assemblage of tholeiitic, continental flood basalts of Miocene age. These flows cover an area of more 163,700 km^2 (63,000 mi^2) in Washington, Oregon, and Idaho and have an estimated volume of about 174,356 km^3 (40,800 mi^3) (Tolan et al. 1989). Isotopic age determinations indicate that basalt flows were erupted approximately 17 to 6 Ma, with more than 98% by volume being erupted in a 2.5 million-year period (17 to 14.5 Ma) (Reidel et al. 1989b; Reidel and Fecht 1981).

Columbia River Basalt Group flows were erupted from north-northwest trending fissures of linear vent systems in north-central and northeastern Oregon, eastern Washington, and western Idaho (Swanson et al. 1979). The Columbia River Basalt Group is formally divided into five formations (from oldest to youngest): Imnaha Basalt, Picture Gorge Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. Of these, only the Picture Gorge Basalt is not known to be present in the Pasco Basin.

3.4.2.1.1 Saddle Mountains Basalt. The Saddle Mountains Basalt, divided into the Umatilla, Wilbur Creek, Asotin, Esquatzel, Pomona, and Elephant Mountain Members from bottom to top (Figure 3-12), forms the uppermost basalt unit throughout most of the Pasco Basin. Members of this formation were erupted intermittently over a period from about 14.5 to 6 Ma, during a waning phase of Columbia River Basalt Group volcanism. Distribution of the Saddle Mountains Basalt is limited compared with older Columbia River Basalt Group units, with many of its members confined to structural lows or paleoriver canyons (DOE 1988). The Wilbur Creek Member occurs north of Gable Mountain-Umtanum Ridge. The Asotin Member occurs in the north-central portion of the Cold Creek syncline, north and east of the 200 East Area. The Esquatzel Member is present in the central and east-central

portions of the Cold Creek syncline. The Ice Harbor Member is confined primarily to the southern and eastern Pasco Basin and surrounding area. On anticlinal ridges bounding the Pasco Basin, the Saddle Mountains Basalt is locally absent, exposing the Wanapum and Grande Ronde Basalts.

On the Hanford Site, the Saddle Mountains Basalt reaches a maximum thickness of about 314 m (1,030 ft) near the 300 Area, and commonly reaches thicknesses of 280 m (918 ft) or more along the axis of the Cold Creek syncline southwest of the 200 West Area. Throughout most of the Hanford Site south of the Gable Mountain-Gable Butte structures, the Saddle Mountains Basalt is comprised primarily of the Umatilla, Esquatzel, Pomona, and Elephant Mountain Members. Maximum thicknesses of individual flows within the Saddle Mountains Basalt on the Hanford Site range from about 39 m (128 ft) for the Esquatzel Member, to about 87 m (285 ft) for the Umatilla Member. The Umatilla and the Esquatzel Members reach maximum thicknesses along the axis of the Cold Creek syncline southwest of the 200 West Area. The Pomona and Elephant Mountain Members are thickest along the eastern side of the Hanford Site and generally thin to the west.

Over part of the eastern portion of the Hanford Site, the Elephant Mountain Member consists of a lower flow unit (Elephant Mountain flow), and an upper flow unit (Ward Gap flow) (Lindsey et al. 1991; Jensen 1987). Additional description of the distribution of the two flow units in the vicinity of the 200 East Area is provided in the 200 East Aggregate Area Management Study Report (AAMSR).

With a few localized exceptions, the Elephant Mountain Member is the uppermost unit beneath most of the Hanford Site. Near the 300 Area, the Ice Harbor Member is found stratigraphically above the Elephant Mountain Member. In the Gable Gap area, erosion has locally occurred down to the Umatilla Member (Myers and Price 1981; Graham et al. 1984; Figure 3-14). Additional areas of erosion of the Elephant Mountain Member are present to the southeast of Gable Gap, in the vicinity of the 200 East Area. The areas of basalt erosion near Gable Gap and to the southeast are significant because they represent locations of potential groundwater intercommunication between the upper sedimentary interbeds of the Ellensburg Formation, and the unconfined groundwater system. The potential for groundwater intercommunication between aquifers is further discussed in Sections 3.5.1.3.3 and 3.5.2.3.3.

Near the northwest corner of the Hanford Site, the Saddle Mountains Basalt thins to only 64 m (211 ft) or less, probably due to nondeposition and erosion. Farther to the north and northwest (near the southeast end of Umtanum Ridge and west of Gable Butte) the Pomona or Umatilla Members are the uppermost units of the Saddle Mountains Basalt. In this area, flows higher in the basalt sequence (Asotin, Esquatzel, Pomona, and Elephant Mountain Members), and the associated Ellensburg Formation sedimentary interbeds were not deposited, or have been completely removed by erosion. Drilling and geophysical

information in DOE (1986 and 1988) is to determine whether the Ellensburg Formation sedimentary interbeds were truncated by erosion, or were pinched out between basalt flows. If the flows and interbeds were truncated by erosion, a zone of potential groundwater intercommunication between the interbed aquifers and the overlying unconfined groundwater system may be present.

3.4.2.1.2 Basalt Intraflow Structures and Cooling Joints. This section describes intraflow structures and cooling joints typical for Columbia River Basalt Group flows. Intraflow structures are primary, internal features or stratified portions of basalt flows exhibiting grossly uniform macroscopic characteristics. These features originate during the emplacement and solidification of each flow. Intraflow structures therefore differ from tectonically-induced fractures and joints formed after consolidation of the flow (DOE 1988). As applied to the Saddle Mountains Basalt, the intraflow structures are significant because they represent potential conduits for groundwater flow within the basalts and between intervening sedimentary interbeds.

Intraflow structures for typical Columbia River Basalt Group flows, including the Saddle Mountains Basalt, can be described according to their position in the flow top, flow interior, or flow bottom, and are shown diagrammatically on Figure 3-15. Flow top structures consist of vesicular to rubbly or brecciated basalt in the glassy, chilled upper crust of the flow. The predominant intraflow structures within flow interiors are zones characterized by patterns of cooling joints, commonly referred to as colonnade and entablature (Figure 3-15). Contacts between colonnade tiers and entablature may be distinct, or they may be gradational. Other intraflow features observed within flow interiors include pipes, cylinders, sheets of vesicles and vesiculated zones; and platy horizontal fracturing. The basal part of a typical Columbia River Basalt Group flow is predominantly a thin, glassy, chilled zone a few centimeters thick, which may be vesicular, rubbly, or brecciated. Additional detailed description of intraflow structures is presented by DOE (1988). Intraflow features may be continuous in flows over long distances but in some cases change abruptly. Lateral variation in thickness of intraflow structures can occur gradually in some flows and suddenly in others at a given location. Clays and other alteration minerals are common along cooling joints and tend to retard the movement of fluids as well as increase sorptive properties.

Cooling joints in basalt flows are ubiquitous fractures that resulted from tensional stress in response to contraction of solidified portions of the flow as it cooled. Cooling joints form columns, subdivisions of columns, and zones of irregular basalt blocks. Cooling joints are primary features that are distinct from secondary tectonic fractures such as faults, shears, and joint sets.

At the Hanford Site in general, and in the 200 West Area in particular, little compiled intraflow or fracture information was available for the Saddle Mountains Basalt in the

documents reviewed for this report. Moak and Wintczak (1980) compiled and reported cooling joint data from the Pomona flow entablature during mapping of the underground Near Surface Test Facility (NSTF) completed within Gable Mountain. However, the applicability of these data to subsurface occurrences of the Pomona Member and other flows of the Saddle Mountains Basalt near the 200 West Area is not discussed in the documents reviewed.

3.4.2.2 Ellensburg Formation. The Ellensburg Formation consists of all sedimentary units that occur between the basalt flows of the Columbia River Basalt Group in the central Columbia Basin. The age of the Ellensburg Formation is principally Miocene, although locally it may be equivalent to early Pliocene. The Ellensburg Formation generally displays two main lithologies: volcaniclastics (Reidel and Fecht 1981; Smith et al. 1989), and siliciclastics (DOE 1988). The volcaniclastics consist mainly of primary pyroclastic air fall deposits and reworked epiclastics derived from volcanic terrains west of the Columbia Plateau. Siliciclastic strata in the Ellensburg Formation consists of clastic, plutonic, and metamorphic detritus derived from the Rocky Mountain terrain. These two lithologies occur both individually and together in the Pasco Basin. A detailed discussion of the Ellensburg Formation in the Hanford Site is given by Reidel and Fecht (1981). Smith et al. (1989) provide a discussion of age equivalent units adjacent to the Columbia Plateau.

As discussed in Section 3.4.2, discussion of Ellensburg Formation is included in this report due to potential for downward migration of groundwater from the uppermost aquifer to the confined aquifers associated with the sedimentary interbeds. The stratigraphic names for individual units of the Ellensburg Formation are given in Figure 3-12. The Ellensburg Formation nomenclature was derived by considering the lateral extent of the upper and lower basalt flows bounding each of the interbeds. Each of these interbeds is present only where the bounding flows occur within Pasco Basin and Hanford Site, and the interbed names are only valid for these areas. The interbed names on Figure 3-12 are therefore applicable to the Pasco Basin and Hanford Site, except where the bounding flows are not present. From bottom to top, the sedimentary interbeds of the Ellensburg Formation associated with the Saddle Mountains Basalt include the Mabton interbed (dividing the Saddle Mountains Basalt from the underlying Wanapum Basalt, the Cold Creek interbed, the Selah interbed, the Rattlesnake Ridge interbed, and the Levey interbed.

The following descriptions include Ellensburg Formation sedimentary interbeds from bottom to top for the Saddle Mountains Basalt.

3.4.2.2.1 Mabton Interbed. The Mabton interbed lies stratigraphically below the Umatilla Member of the Saddle Mountains Basalt and above the Priest Rapids Member of the Wanapum Basalt in the Pasco Basin. The Mabton interbed is thickest in the central Pasco Basin area (including the 200 West Area) and thins out in all directions from there. Vertical lithologic and textural changes in the Mabton interbed are relatively uniform from there.

From bottom to top, the interbed generally consists of: (1) a thin, basal silty clay; (2) a quartzitic to arkosic sandstone with interlayered, tuffaceous sandstones and siltstones; (3) a fine-grained, tuffaceous, clayey quartzitic sandstone; and (4) a well-indurated, lapilli tuffstone, locally baked.

3.4.2.2.2 Cold Creek Interbed. The Cold Creek interbed refers to the sequence of Ellensburg sediments that occur stratigraphically between the Esquatzel and Umatilla Members of the Saddle Mountains Basalt. The Asotin Member of the Saddle Mountains Basalt partly controlled the distribution of the Cold Creek interbed. Three separate units of the interbed are identified on the basis of the bounding basalt flows. These intervals are the Umatilla-Esquatzel, Umatilla-Asotin, and Asotin-Esquatzel intervals. The Umatilla-Esquatzel interval is present over the much of the central part of the Hanford Site, including the 200 West Area. The Umatilla-Asotin and Asotin-Esquatzel intervals are present to the northeast of the 200 East Area where the Asotin Member of the Saddle Mountains Basalt occurs.

The Umatilla-Esquatzel interval is the thickest interval and has the largest areal extent. This interval is divided into two textural facies: (1) a finer-grained, tuffaceous sandstone facies; and (2) a coarser-grained sandstone and conglomerate facies with tuffaceous siltstone and clays. The coarser-grained facies follows an arcuate trend to the northwest across the central part of the Hanford Site. The coarser-grained facies represents the high-energy, main channel of a fluvial system which is interpreted to have flowed parallel to the flow front of the Asotin flow (to the northeast). The finer-grained facies is present along the southwest bounding-edge of the coarser-grained facies and in the southeastern part of the Hanford Site.

The Umatilla-Asotin and Asotin-Esquatzel intervals are not present in the vicinity of the 200 West Area and are not discussed further herein.

3.4.2.2.3 Selah Interbed. The Selah interbed is bounded on the top by the Pomona Member and on the bottom by the Esquatzel Member. The interbed is a variable mixture of silty to sandy vitric tuff, arkosic sands, tuffaceous clays, and locally thin stringers of predominantly basaltic gravels. The Selah interbed is found beneath most of the Hanford Site.

3.4.2.2.4 Rattlesnake Ridge Interbed. The Rattlesnake Ridge interbed is bounded on the top by the Elephant Mountain Member and on the bottom by the Pomona Member. The interbed is up to 33 m (108 ft) thick and dominated by three facies at the Hanford Site: (1) a lower clay or tuffaceous sandstone; (2) a middle, micaceous-arkosic and/or tuffaceous sandstone; and (3) an upper, tuffaceous siltstone to sandstone. The unit is found beneath most of the Hanford Site.

3.4.2.2.5 Levey Interbed. The Levey interbed is the uppermost unit of the Ellensburg Formation and occurs between the Ice Harbor Member and the Elephant

Mountain Member. It is confined to the vicinity of the 300 Area. The Levey interbed is a tuffaceous sandstone along its northern edge and a fine-grained tuffaceous siltstone to sandstone along its western and southern margins.

3.4.2.3 Ringold Formation. The Ringold Formation at the Hanford Site is up to 185 m (607 ft) thick in the deepest part of the Cold Creek syncline south of the 200 West Area and 170 m (558 ft) thick in the western Wahluke syncline near the 100B Area. The Ringold Formation pinches out against the Gable Mountain, Yakima Ridge, Saddle Mountains, and Rattlesnake Mountain anticlines. It is largely absent in the northern and northeastern parts of the 200 East Area and adjacent areas to the north in the vicinity of West Lake. The Ringold Formation is assigned a late Miocene to Pliocene age (Fecht et al. 1987; DOE 1988) and was deposited in alluvial and lacustrine environments (Bjornstad 1985; Fecht et al. 1987; Lindsey et al. 1991).

Recent studies of the Ringold Formation (Lindsey and Gaylord 1989; Lindsey et al. 1991) indicate that it is best described and divided on the basis of sediment facies associations and their distribution. Facies associations in the Ringold Formation (defined on the basis of lithology, petrology, stratification, and pedogenic alteration) include fluvial gravel, fluvial sand, overbank deposits, lacustrine deposits, and alluvial fan. The facies associations are summarized as follows.

- Fluvial gravel--Clast-supported granule to cobble gravel with a sandy matrix dominates the association. Intercalated sands and muds also are found. Clast composition is very variable, with common types being basalt, quartzite, porphyritic volcanics, and greenstones. Silicic plutonic rocks, gneisses, and volcanic breccias also are found. Sands in this association are generally quartzo-feldspathic, with basalt contents generally in the range of 5 to 25%. Low angle to planar stratification, massive channels, wide-shallow channels, and large-scale cross-bedding are found in outcrops. The association was deposited in a gravelly fluvial system characterized by wide, shallow shifting channels.

- Fluvial sand--Quartzo-feldspathic sands displaying cross-bedding and cross-lamination in outcrop dominate this association. These sands usually contain less than 15% basalt lithic fragments, although basalt contents as high as 50% may be encountered. Intercalated strata consist of lenticular silty sands and clays up to 3 m (10 ft) thick and thin (<0.5 m) gravels. Fining upwards sequences less than 1 m (3 ft) to several meters thick are common in the association. Strata comprising the association were deposited in wide, shallow channels.

- Overbank deposits--This association predominantly consists of laminated to massive silt, silty fine-grained sand, and paleosols containing variable amounts of calcium carbonate. Overbank deposits occur as thin lenticular interbeds [<0.5 m

to 2 m (<1.6 to 6 ft)] in the fluvial gravel and fluvial sand associations, and as thick [up to 10 m (33 ft)], laterally continuous sequences. These sediments record deposition in a floodplain under proximal levee to more distal floodplain conditions.

- Lacustrine deposits--Plane-laminated to massive clay with thin silt and silty sand interbeds displaying some soft-sediment deformation characterize this association. Coarsening upwards sequences less than 1 to 10 m (3 to 30 ft) thick are common in the association. Strata comprising the association were deposited in a lake under standing water to deltaic conditions.

- Alluvial fan--Massive to crudely stratified, weathered to unweathered basaltic detritus dominates this association. These basaltic deposits are generally found around the periphery of the basin. This association was deposited largely by debris flows in alluvial fan settings.

The lower half of the Ringold Formation contains five separate stratigraphic intervals dominated by fluvial gravels. These gravels, designated units A, B, C, D, and E (Figure 3-13), are separated by intervals containing deposits typical of the overbank and lacustrine facies associations. The lowermost of the fine-grained sequences, overlying unit A, is designated the lower mud sequence. The uppermost gravel unit, unit E, grades upwards into interbedded fluvial sand and overbank deposits. These sands and overbank deposits are overlain by lacustrine-dominated strata.

Fluvial gravel units A and E correspond to the lower basal and middle Ringold units, respectively, as defined by DOE (1988). Gravel units B, C, and D do not correlate to any previously defined units. The lower mud sequence corresponds to the upper basal and lower units as defined by DOE (1988). The upper basal and lower units are not differentiated. The sequence of fluvial sands, overbank deposits, and lacustrine sediments overlying unit E corresponds to the upper unit as seen along the White Bluffs in the eastern Pasco Basin. This essentially is the same usage as originally proposed by Newcomb (1958) and Myers et al. (1979).

3.4.2.4 Plio-Pleistocene Unit. Unconformably overlying the Ringold Formation in the western Cold Creek syncline in the vicinity of 200 West Area (Figures 3-11, 3-12 and 3-13) is the laterally discontinuous Plio-Pleistocene unit (DOE 1988; Baker et al. 1991). The unit is up to 25 m (80 ft) thick and divided into two facies: (1) sidestream alluvium and (2) calcic paleosol (Stage III and Stage IV) (DOE 1988; Baker et al. 1991). The calcic paleosol facies consists of massive calcium carbonate-cemented silt, sand, gravel (caliche) to interbedded caliche-rich and caliche-poor silts and sands. The basaltic detritus facies consists of weathered and unweathered basaltic gravels deposited as locally derived slope wash, colluvium, and sidestream alluvium. The Plio-Pleistocene unit appears to be correlative to

other sidestream alluvial and pedogenic deposits found near the base of the ridges bounding the Pasco Basin on the north, west, and south. These sidestream alluvial and pedogenic deposits are inferred to have a late Pliocene to early Pleistocene age on the basis of stratigraphic position and magnetic polarity of interfingering loess units. The white color of the unit, high degree of cementation, and the presence of animal burrows and root traces in cores also support the pedogenic nature of the Plio-Pleistocene unit (Bjornstad 1990). Bjornstad (1990) also indicates that natural gamma activity within the Plio-Pleistocene unit is erratic, high in places and moderate to low elsewhere.

3.4.2.5 Pre-Missoula Gravels. Quartzose to gneissic clast-supported pebble to cobble gravel with a quartzo-feldspathic sand matrix underlies the Hanford formation in the east-central Cold Creek syncline and at the east end of Gable Mountain anticline east and south of the 200 East Area (Figures 3-11, 3-12 and 3-13). These gravels, called the pre-Missoula gravels (PSPL 1982), are up to 25 m (80 ft) thick, contain less basalt than underlying Ringold gravels and overlying Hanford deposits, have a distinctive white or bleached color, and sharply truncate underlying strata. The nature of the contact between the pre-Missoula gravels and the overlying Hanford formation is not clear. In addition, it is unclear whether the pre-Missoula gravels overlie or interfinger with the early "Palouse" soil and Plio-Pleistocene unit. Magnetic polarity data indicate the unit is no younger than early Pleistocene in age (>1 Ma) (Baker et al. 1991).

3.4.2.6 Early "Palouse" Soil. The early "Palouse" soil consists of up to 20 m (65 ft) of massive, brown-yellow, and compact loess-like silt and minor fine-grained sand (Tallman et al. 1979; 1981; Bjornstad 1984; DOE 1988). These deposits overlie the Plio-Pleistocene unit in the western Cold Creek syncline around the 200 West Area (Figures 3-11, 3-12 and 3-13). The unit is differentiated from overlying graded rhythmites (Hanford formation) by greater calcium carbonate content, massive structure in core, and high natural gamma response in geophysical logs (Bjornstad 1984; DOE 1988). This natural gamma response is due to the inherent stratigraphic properties of the unit, rather than from effects of radionuclide contamination. Other distinguishing features include uniform fine-grained texture, unconsolidated nature, and high mica content (Bjornstad 1990). Bjornstad also indicates that it may be difficult to differentiate the early "Palouse" soil from the underlying Plio-Pleistocene unit without careful analysis of calcium carbonate data and gross gamma logs. The upper contact of the unit is poorly defined, and it may grade up-section into the lower part of the Hanford formation. Based on a predominantly reversed polarity the unit is inferred to be early Pleistocene in age (Baker et al. 1991).

3.4.2.7 Hanford Formation. The Hanford formation consists of pebble to boulder gravel, fine- to coarse-grained sand, and silt (Baker et al. 1991). These deposits are divided into three facies: (1) gravel-dominated; (2) sand-dominated; and (3) silt dominated facies. These facies are referred to as coarse-grained deposits, plane-laminated facies, and rhythmite facies, respectively by Baker et al. (1991). The silt dominated deposits also are referred to as the

"Touchet Beds," while the gravelly facies are generally referred to as the Pasco Gravels. The Hanford formation is thickest in the Cold Creek bar in the vicinity of 200 East and 200 West Areas where it is up to 65 m (210 ft) thick (Figures 3-11, 3-12 and 3-13). The Hanford formation was deposited by cataclysmic flood waters that drained out of glacial Lake Missoula (Fecht et al. 1987; DOE 1988; and Baker et al. 1991). Hanford deposits are absent on ridges above approximately 385 m (1,260 ft) above sea level. The following sections describe the three Hanford formation facies.

3.4.2.7.1 Gravel-Dominated Facies. The gravel-dominated facies is dominated by coarse-grained basaltic sand and granule to boulder gravel. These deposits display massive bedding, plane to low-angle bedding, and large-scale planar cross-bedding in outcrop, while the gravels generally are matrix-poor and display an open-framework texture. Lenticular sand and silt beds are intercalated throughout the facies. Gravel clasts in the facies generally are dominated by basalt (50 to 80%). Other clast types include Ringold and Plio-Pleistocene rip-ups, granite, quartzite, and gneiss. The relative proportion of gneissic and granitic clasts in Hanford gravels versus Ringold gravels generally is higher (up to 20% as compared to less than 5%). Sands in this facies usually are very basaltic (up to 90%), especially in the granule-size range. Locally Ringold and Plio-Pleistocene rip-up clasts dominate the facies comprising up to 75% of the deposit. The gravel facies dominates the Hanford formation in the 100 Areas north of Gable Mountain, the northern part of 200 East Area, and the eastern part of the Hanford Site including the 300 Area. The gravel-dominated facies was deposited by high-energy flood waters in or immediately adjacent to the main cataclysmic flood channels.

3.4.2.7.2 Sand-Dominated Facies. The sand-dominated facies consists of fine-grained to coarse-grained sand and sand displaying plane lamination and bedding and less commonly plane cross-bedding in outcrop. These sands may contain small pebbles and rip-up clasts in addition to pebble-gravel interbeds and silty interbeds less than 1 m (3 ft) thick. The silt content of these sands is variable, but where it is low an open framework texture is common. These sands are typically very basaltic, commonly referred to as black or gray or salt and pepper sands. This facies is most common in the central Cold Creek syncline, in the central to southern parts of the 200 East and 200 West Areas, and in the vicinity of the WPPSS facilities. The sand-dominated facies was deposited in and adjacent to the main flood channelways as flow velocity decreased, and the coarser-grained materials were deposited as channel competency was lost. The facies is transitional between gravel-dominated facies and silt-dominated facies.

3.4.2.7.3 Silt-Dominated Facies. The silt-dominated facies consists of thinly bedded, plane laminated and ripple cross-laminated silt and fine- to coarse-grained sand that commonly displays normally graded rhythmites similar to Bouma sequences, a few centimeters to several tens of centimeters thick in outcrop (Myers et al. 1979; DOE 1988). This facies dominates the Hanford formation throughout the central, southern, and western

Cold Creek syncline within and south of 200 East and West Areas. These sediments were deposited under slackwater conditions and in backflooded areas (DOE 1988).

3.4.2.7.4 Clastic Dikes. The following description of clastic dikes was taken from Hoffmann et al. (1992), Connelly et al. (1992), and Lindsey et al. (1991). In addition to the three Hanford formation facies outlined above, clastic dikes also are commonly found at the Hanford Site. These dikes, while common in the Hanford formation, also are found locally in other sedimentary units in the Pasco Basin. The dikes do not occur in Holocene deposits, but are sometimes truncated by Hanford formation sediments and therefore their age is probably Pleistocene. Clastic dikes are found in all facies of the Hanford formation but they are more common in the finer-grained facies and rare in open-work gravel. Whether in the Hanford formation or other sedimentary units, clastic dikes generally cross-cut bedding, although they do locally parallel bedding.

The dikes may be simple and composed of one layer or filling, or composite and composed of multiple layers (typically vertical to subvertical) of alternating silt, sand, and granules, with silt and sand being most common. Individual layers may be millimeters to centimeters in thickness, with overall dike widths commonly one centimeter to over a meter. In some cases, filling materials can be traced to underlying, overlying or interbedded sediments. A geomorphic feature known as patterned ground may be present at locations where clastic dikes intersect the ground surface.

Origin of clastic dikes in the Columbia Plateau has been attributed to earthquakes, melting of buried ice and frozen sediments, upward injections of groundwater, thermal contraction of permafrost, desiccation cracks or deep frost cracks, and extension fracturing from sediment loading on unstable deposits. None of the suggested origins can explain all the physical characteristics of the clastic dikes, suggesting that the dikes may have more than one origin. As a possible mechanism, Black (1980) proposed that the dikes were formed during Pleistocene cataclysmic flooding and are the result of hydraulic injection of water and sediment into cracks formed by the sudden loading of water on the ground surface.

3.4.2.8 Surficial Deposits. Surficial deposits consist of silt, sand, and gravel that form a thin [<10 m (30 ft)] veneer across much of the Hanford Site. These sediments were deposited by a mix of eolian and alluvial processes.

3.4.3 Known or Suspected Faulting and Other Subsurface Structures in the West-Central Portion of the Hanford Site

At the Hanford Site, faults have been identified on the Umtanum Ridge-Gable Mountain structure and on the Yakima Ridge from geologic mapping, trenching and drilling (Figures 3-10 and 3-14). There is no direct evidence of faulting in the 200 West Area, but

good exposures of faults are present in the Gable Mountain area north of the 200 East Area. Like the intraflow structures of the Saddle Mountains Basalt (as discussed in Section 3.4.2.1.2), faults and tectonic fractures could potentially provide conduits for groundwater intercommunication between confined aquifers, and between the uppermost and confined systems.

The structural geology of the Hanford Site including the vicinity of the 200 West Area is summarized by Lindsey et al. (1991), DOE (1988), and Myers and Price (1981). These discussions describe folding and faulting, results of geophysical studies, and tectonic brecciation and shearing of basalt. The following sections summarize information from these sources for structures for the Umtanum Ridge-Gable Mountain anticlines (Section 3.4.3.1), the Yakima Ridge anticline (Section 3.4.3.2), and the Cold Creek syncline (Section 3.4.3.3). For the Cold Creek syncline, only data applicable to the vicinity of the 200 West Area are discussed. In general, very limited structural and geophysical data are available for the 200 West Area itself.

3.4.3.1 Umtanum Ridge-Gable Mountain Anticlines. Near the southeastern end of Umtanum Ridge, several northwest/southeast- to north/south-striking normal "cross faults" (oriented roughly perpendicular to the axis of Umtanum Ridge) were identified. The faults have offsets of several meters. Locations of these faults are shown in DOE (1988). To the west, a buried, northwest/southeast-striking reverse or thrust fault was mapped along the north side of the ridge and is known as the Umtanum fault. DOE (1988) reports that the continuity of the Umtanum fault eastward toward Gable Mountain cannot be established by exposures, but the current interpretation is that the fault dies out near the southeast end of Umtanum Ridge [about 12 km (7.5 mi) northwest of the 200 West Area]. DOE (1988) also indicates, however, that "topographic and structural relief" (as a possible expression of the fault) extends to the east end of Gable Mountain, suggesting that faulting could occur along the entire north side of the ridge structure.

Faults investigated on Gable Mountain during geologic mapping, trenching, and drilling include the west, central, and south faults. The fault nomenclature is presented by DOE (1988), and the faults are named based on their general geologic occurrence on Gable Mountain. The west and central faults are oriented roughly perpendicular to the axis of Gable Mountain. The central fault is notable because the top of the Esquatzel Member of the Saddle Mountains Basalt has been offset by about 50 m (164 ft) of reverse, dip-slip movement along the fault. The south fault is oriented east/west (nearly parallel the trend of Gable Mountain) and has 12 m (39 ft) of reverse displacement. Several other faults in the Gable Mountain area were identified from borehole data or via trenching, including a northwest/southeast-striking fault with a shallow northward dip and 98 m (321 ft) of stratigraphic throw. Additionally, two faults were identified in borehole DB-10, just south of Gable Mountain (Figure 3-14). Repetition of the stratigraphic section of the Pomona, Esquatzel, and Asotin Members of the Saddle Mountains Basalt across the DB-10 faults

indicates that they are reverse faults with about 55 m (180 ft) of combined, dip-slip off-set. Additional boreholes drilled near DB-10 indicated that the upper fault in DB-10 is a north/south-striking structure which dips moderately to the west.

3.4.3.2 Yakima Ridge Anticline. South of the main ridge crest, along the southeastern end of the exposed part of the ridge, a north-dipping reverse fault was mapped. The inferred location of the fault parallels the trend of Yakima Ridge and reportedly accounts for the main escarpment and apparent structural displacement of the extreme eastern and southern ends of the ridge (DOE 1988). A cross fault is associated with the reverse fault structure, but is of limited extent and cannot be traced north of the southern limb of Yakima Ridge. The cross fault is interpreted as a north-trending tear fault (DOE 1988).

Along the buried extension of the eastern part of Yakima Ridge [about 5 km (3.1 mi) southwest of the 200 West Area], geophysical investigations were conducted to assess the nature of related subsurface structures. These investigations included gravity and ground magnetic surveys supplemented by borehole, aeromagnetic, and seismic data (DOE 1988). Geophysical trends observed in this area may be related to cross folds or faults associated with the buried structure, but the relationship between Yakima Ridge and its easterly extension is not clearly defined. Faulting, folding, or both of these mechanisms with subsequent erosional modification can explain the available data (DOE 1988).

3.4.3.3 Cold Creek Syncline. The characteristics of potential structures in the Cold Creek syncline, including faults, were investigated using geologic data from boreholes and from geophysical surveys. This section summarizes information presented by DOE (1988) for zones of tectonic brecciation and shearing in basalt that were identified in the boreholes and results of geophysical investigations. The geophysical methods described are, in general, capable of providing relatively limited resolution of potential structures.

3.4.3.3.1 Tectonic Brecciation and Shearing. Field studies have identified tectonic brecciation and shear zones related to geologic structures in the Columbia River Basalt Group in the Pasco Basin and elsewhere. Tectonic breccias are attributed to localized fracturing of in-place rock in response to regional tectonic forces (DOE 1988). The Vantage, Washington area, 96.5 km (60 mi) north of the Hanford Site, was investigated as an analog to the Cold Creek syncline to determine the properties of brecciated zones. As discussed in Section 3.4.1.3 tectonic breccias may be associated with micro-earthquakes (up to about magnitude 2.0 to 3.0) recorded at Coyote Rapids and Wooded Island. Although undocumented, potential zones of the tectonic brecciation in the Saddle Mountains Basalt beneath the 200 West Area would, if present, represent significant structures for channeling groundwater flow. This is particularly so if potential brecciated zones are associated with larger fault structures such as those seen in borehole DB-10 (Figure 3-14), as discussed below.

In the thousands of feet of core drilled in the Columbia River Basalt Group flows of the Cold Creek syncline, zones of tectonic brecciation are relatively infrequent (DOE 1988). Where observed in core, brecciated zones are typically bounded by fracturing, resulting in a distinct demarcation between the zone and the surrounding intact rock. Breccia zones that do occur are most common in the Grande Ronde Basalt, followed by the Wanapum Basalt, and then the Saddle Mountains Basalt. The nearest occurrences of tectonic brecciation are noted in the Saddle Mountains Basalt (Umatilla Member) in borehole DB-11 which is 2 km (1.2 mi) west-northwest of the 200 West Area, and in borehole DC-12 which is 10 km (6.2 mi) southeast of the 200 West Area. Tectonic brecciation in the Saddle Mountains Basalt was also observed in borehole DB-10, which is 12 km (7.5 mi) east-northeast of the 200 West Area (Pomona, Esquatzel, and Asotin Members), and is associated with the reverse faults discussed in Section 3.4.3.1. No breccia zones have been observed in the overlying unconsolidated sediments, although a thin zone of slickensides, thought to be of tectonic origin, is present in the Ringold Formation in borehole DH-27 (DOE 1988).

Where they occur in boreholes in the Cold Creek syncline, tectonic breccias are similar in appearance to those observed in the gentle-dipping south limb of the Frenchman Hills anticline. This suggests that the breccias are not necessarily associated with areas of greatest deformation in a fold, and could possibly be related to other fault structures (DOE 1988). The repeated stratigraphic interval in borehole DB-10 (northeast of the 200 East Area) is a candidate for such a fault, although similar repeats in section are not observed in adjacent boreholes. The magnitude of the feature in borehole DB-10 is therefore uncertain, but can indicate a potential conduit for intercommunication of the confined aquifers in the Ellensburg Formation sediments.

3.4.3.3.2 Geophysical Investigations. A variety of geophysical investigations involving gravity, magnetic, seismic refraction, and seismic reflection surveys were completed in portions of the Cold Creek syncline in the vicinity of the 200 West Area. Many of the investigations were completed in support of BWIP characterization activities that identified subsurface faulting and other structures (DOE 1988). Results of these investigations (summarized below) describe subsurface structures that could affect groundwater flow.

A notable feature of the Cold Creek syncline is a deflection in the syncline axis that occurs about 5 km (3.1 mi) southwest of the 200 West Area. The syncline axis changes from nearly east/west to a more northwesterly trend for a short distance over the area of the deflection, and then resumes a nearly east/west trend in the upper Cold Creek valley to the west. The exact nature of this deflection is uncertain because of limited borehole and geophysics information in that area (DOE 1988).

North of the deflection zone, on the northern limb of the Cold Creek syncline [about 7 km (4.4 mi) northwest of the 200 West Area)], a gravity anomaly suggestive of a fault or

other subsurface structure is present. The feature is a north/south trending gravity gradient and is known as the Yakima Barricade geophysical anomaly. The feature correlates with an aeromagnetic anomaly and is also associated with an area across which large head differences in the confined aquifers of the Saddle Mountains Basalt have been observed. Geologic information from boreholes DH-27 and DH-28 (Figure 3-14) drilled on either side of the geophysical feature show that the Pomona Member of the Saddle Mountains Basalt increases in elevation relatively rapidly in an east to west direction across the geophysical anomaly. Also, the overlying Elephant Mountain Member apparently pinches out across the feature but the overlying Ringold Formation appears to be undeformed. These data suggest that the geophysical feature is either a steeply dipping fold or a high angle fault in the Saddle Mountains Basalt (DOE 1988), and could therefore potentially affect flow of groundwater within the confined aquifers of the Ellensburg Formation.

Additional geophysical evidence of possible faulting west of the 200 West Area is presented by DOE (1988) from aeromagnetic data. The data describe two northeast-trending magnetic linear features known as the Juniper Springs linear which passes about 10 km (6.2 mi) northwest of the 200 West Area, and the Nancy linear which passes about 3 km (1.9 mi) northwest of the 200 West Area. The aeromagnetic linears are shown in DOE (1988). The Juniper Springs linear may be related to faulting, and the interpretation is based on apparent offsets in magnetic anomalies associated with Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills at their intersection with the linear (DOE 1988). DOE (1988) indicates that information does not support interpretation of the Nancy linear as a continuous geologic structure, and geologic explanation for the linear is not determined.

Seismic refraction surveys were used to investigate the faults identified in borehole DB-10, south of Gable Mountain (Section 3.4.3.1), but were not able to confirm the presence of these structures (DOE 1988). Seismic reflection data from the area about 1 km (0.6 mi) southeast of the borehole did show a possible fault feature, but the trend of the feature and other characteristics could not be determined. Seismic refraction data near the 200 West Area were used mainly to determine depths to top of basalt and to delineate the structure and stratigraphy of the overlying unconsolidated sediments, rather than to characterize potential faults and other structures within the basalts. Seismic reflection surveys in the vicinity of the 200 West Area were not able to delineate the presence of bedrock structural features, and were complicated by difficulties in data processing and interpretation. Similarly, borehole geophysical logging (sonic, density, and gravity logs; and vertical seismic profiling) was completed for selected boreholes in the vicinity of 200 West Area. However, the latter studies either have focused on the unconsolidated sediments or have not provided specific data about potential faulting within the basalt. As discussed in Section 3.4.1.3 micro-earthquakes in basalt (up to about magnitude 2.0 to 3.0) have been recorded in the vicinity of the 200 West Area.

DOE (1988) presents several overall conclusions regarding geophysical anomalies at the BWIP Reference Repository Location, including the 200 West Area. Gravity and aeromagnetic data indicate that the rock in the area is not an evenly layered, homogenous mass. There is less geophysical variability, however, than in adjacent structures such as the buried extension of Yakima Ridge. From this information, DOE (1988) conclude that the BWIP Reference Repository Location including the 200 West Area, although probably not free of structures, contains smaller structures than the surrounding areas. Alternatively, the thickness of the unconsolidated sediments could conceivably mask potential structures.

3.4.4 200 West Area Geology

The following sections describe the occurrence of the Saddle Mountains Basalt, Ellensburg Formation and suprabasalt sediments in the 200 West Area. The sections discuss notable stratigraphic characteristics, thickness variations, dip trends, and geometric relationships of the sediments. Stratigraphic variations pertinent to the 200 West Area are presented in the overall context of regional stratigraphic trends. Descriptions of the suprabasalt units in Sections 3.4.4.4 through 3.4.4.7 are modified from Lindsey et al. (1991).

Figure 3-16 illustrates the cross sections locations, with a legend for symbols used provided on Figure 3-17. Geologic cross sections depicting the distribution of basalt and sedimentary units within and near the 200 West Area are presented on Figures 3-18 through 3-24. The cross sections are based on geologic information from wells shown on the figures, as interpreted in Lindsey et al. (1991). To develop these stratigraphic interpretations, logs for wells and boreholes in the 200 West Area were reviewed and the most relevant logs were selected. For a given area, well logs were identified which provided the most representative stratigraphic information. The logs were selected based on well depth, vertical stratigraphic coverage, and completeness of boring log and sediment sample descriptions. Chamness et al. (1991a, 1991b, 1991c, 1992; Teel 1992) provide a compilation of these geologic logs, a listing of other logs that are available, and additional geological, geochemical, and geophysical data available from these and other boreholes. This information was compiled as topical reports in support of the AAMSRs for U Plant, Z Plant, S Plant, and T Plant. The cross sections depict subsurface geology in the 200 West Area. For each cross section, locations of pertinent waste management units are identified for reference. Figures 3-25 through 3-42 present isopach maps depicting the thicknesses of the sedimentary units and contour maps showing the elevation of the top of each sedimentary unit and basalt. The structure and isopach maps are included from Connelly et al. (1992). Plate 1 should be consulted to identify locations of the 200 West Area buildings and waste management units referenced in the text.

Structure contours and isopach data on Figures 3-27 through 3-40 were extrapolated beyond actual known data points by incorporating the projected dip and change in unit thickness into the computer plotting routine. These dip and thickness data were based primarily on the projected orientation of the top of basalt, and assumed similar configuration of the suprabasalt sediments.

3.4.4.1 Saddle Mountains Basalt. During the 1970's and early to mid-1980's, numerous boreholes were completed at the Hanford Site to characterize physical and chemical properties of the Grande Ronde Basalt and overlying basalts and sedimentary interbeds. The boreholes were completed in support of the BWIP and other Hanford Site programs. During review of documents for the 200 West Groundwater AAMSR, specific data describing the thickness and other characteristics of Saddle Mountains Basalt units across the 200 West Area were found for boreholes RRL-2, RRL-2A, RRL-3, RRL-4, DC-3, and DC-20C (DOE 1988). The locations of these drill holes are shown on Figure 3-14. The following discussion of Saddle Mountains Basalt structural and thickness characteristics is based on borehole intercept data from the above references and from Lindsey et al. (1991).

In the 200 West Area, the Saddle Mountains Basalt consists of (from bottom to top) the Umtanum, Esquatzel, Pomona, and Elephant Mountain Members. Each of these flows is continuous beneath the 200 West Area and there is little evidence of significant erosion within the units. The Saddle Mountains Basalt flows (and intervening sedimentary interbeds of the Ellensburg Formation) dip gently to the southwest and south, into the Cold Creek syncline. Figure 3-25 is a structure contour map of the top of the Elephant Mountain Basalt which reflects the overall orientation of the Saddle Mountains flows. The depth to the top of the Elephant Mountain Member from ground surface ranges from about 160 m (525 ft) to about 182 m (596 ft) across the 200 West Area. Over the 200 West Area, the entire Saddle Mountains Basalt/Ellensburg Formation interbeds package maintains a fairly uniform thickness of about 280 m (918 ft). Thicknesses of individual flows range from about 46 to 70 m (150 to 230 ft) for the Umatilla Member, 25 to 35 m (82 to 115 ft) for the Esquatzel Member, 40 to 49 m (131 to 161 ft) for the Pomona Member, and 18 to 36 m (59 to 118 ft) for the Elephant Mountain Member.

Additional lithologic information, such as compiled intraflow structure and fracture data were not available for the Saddle Mountains Basalt in the 200 West Area.

3.4.4.2 Ellensburg Formation. In the 200 West Area, thickness data for the sedimentary interbeds of the Ellensburg Formation were found for boreholes RRL-2/2A (DOE 1988) and for borehole DC-3 (Myers and Price 1981). Thicknesses of the interbeds ranged from 37 to 50 m (121 to 165 ft) for the Mabton interbed; 20 to 30 m (66 to 100 ft) for the Umatilla-Esquatzel interval of the Cold Creek interbed; 12 to 23 m (39 to 75 ft) for the Selah interbed; and 24 to 29 m (80 to 95 ft) for Rattlesnake Ridge interbed. Additional

information regarding the lithologic properties of the sediments or structural characteristics was not available for the Ellensburg Formation in the 200 West Area.

3.4.4.3 Ringold Formation. Within the 200 West Area, the Ringold Formation includes the fluvial gravels of unit A, the paleosol and lacustrine muds of the lower mud sequence, the fluvial gravels of unit E, and the sands and minor muds of the upper unit. Ringold units B, C, and D are not found in the immediate vicinity of the 200 West Area.

Several observations can be made regarding the variation of sediment types within the Ringold units in the 200 West Area. In the Ringold unit A gravels, intercalated lenticular sand and silt are most common in the western and southern portions of the 200 West Area. In the overlying lower mud sequence, stratigraphic trends seen elsewhere in the Pasco Basin suggest that paleosols in the unit become more common progressing structurally up-dip (Lindsey 1991). In the Ringold unit E gravels, intercalated lenticular beds of sand and silt occur throughout the 200 West Area, although predicting where they will occur is difficult. The upper unit of the Ringold in the 200 West Area tends to be dominated by sand, unlike the upper unit elsewhere in the Pasco Basin where paleosols tend to dominate the upper unit.

Beneath the 200 West Area, the fluvial gravels of Ringold unit A and the Ringold lower mud sequence tend to thicken and dip to the south-southwest, toward the axis of the Cold Creek syncline (Figures 3-26 through 3-29). The top of unit A is relatively flat in the 200 West Area, dipping gently to the west and southwest. Unit A gravels reach a maximum thickness of 30 m (100 ft) in the southern part of the 200 West Area, and pinch out just north of northern boundary of the area. Like the unit A gravels, the Ringold lower mud sequence thickens and dips to the south and southeast beneath the 200 West Area (Figures 3-28 and 3-29). The top of the lower mud unit is less regular, however, and the unit pinches out in the northeastern corner of the 200 West Area. The lower unit reaches a thickness of about 34 m (110 ft) in the west-central portion of the 200 West Area (Figure 3-28).

Isopach and structure contour maps of fluvial gravel unit E (Figures 3-30 and 3-31) and the upper unit (Figures 3-32 and 3-33) show trends not seen in the underlying unit A and the lower mud sequence. The gravels of unit E generally thin from north-northwest to the east-southeast. Unit E thicknesses vary between about 107 m (350 ft) in the north to less than about 55 m (179 ft) in the southwest part of the area. The top of the unit is irregular, displaying several highs in the northern and southern parts of the area and several lows in the central part of the 200 West Area. The top of unit E generally dips to the southeast and climbs to the northeast.

The upper unit of the Ringold Formation is present only in the western, northern, and central portion of the 200 West Area (Figures 3-32 and 3-33). Where the upper unit is present, the top generally dips to the south-southwest. The upper unit reaches a thickness of 14 m (45 ft) or more in the central and northwest portions of the 200 West Area.

3.4.4.4 Plio-Pleistocene Unit. The carbonate-rich strata of the Plio-Pleistocene unit largely is restricted to the vicinity of 200 West Area, pinching out near the northern, eastern, and southern boundaries of the area (Figures 3-34 and 3-35). Boreholes located adjacent to Yakima Ridge indicate the unit extends into the area west of the 200 West Area. Thickness variations in the unit are very irregular. It is thickest in the southeast, southwest, and north-central parts of the area while it thins in the south-central and central parts of the area. Undocumented eroded zones through the unit may possibly exist, especially where the unit thins. In addition, fracturing in the carbonate is potentially common and interbedded carbonate-poor lithologies are found at many locations. The top of the unit generally dips to the south and southwest although irregularities occur, especially in the center of the 200 West Area.

3.4.4.5 Pre-Missoula Gravels. As discussed in Section 3.4.2.5, the pre-Missoula gravels are present only in the east-central Cold Creek syncline and at the east end of Gable Mountain anticline east and south of the 200 East Area. The gravels have not been identified in the 200 West Area.

3.4.4.6 Early "Palouse" Soil. Like the Plio-Pleistocene unit, the early "Palouse" soil is largely restricted to the vicinity of the 200 West Area (Figures 3-36 and 3-37). The unit pinches out in the west-central part of the 200 West Area and near the southern, eastern, and northern boundaries. Limited data from a small number of boreholes located west of the 200 West Area suggest that the unit extends to the west. The thickness of the unit varies irregularly. It is thickest in the southwest and southeast parts of the 200 West Area. The early "Palouse" soil is also apparently absent at two locations in the west-central part of the 200 West Area.

Although carbonate is present in the unit in the 200 West Area, no obvious caliches like those seen in the underlying Plio-Pleistocene unit are documented. The loess-like sediments of the early "Palouse" soils are uncemented.

3.4.4.7 Hanford Formation. As discussed in Section 3.4.2.7, the cataclysmic flood deposits of the Hanford formation are divided into three facies: (1) gravel-dominated, (2) sand-dominated, and (3) the silt-dominated facies. Typical lithologic successions consist of fining upwards packages, major fine-grained intervals, and laterally persistent coarse-grained sequences. Mineralogic and geochemical data were not used in differentiating units because of the lack of a comprehensive mineralogic and geochemical data set. The Hanford formation is divided into two units, upper coarse-grained and lower fine-grained, based on lithology. These are essentially the same units as defined in Last et al. (1989). Neither of these units is continuous across the entire 200 West Area; they both display marked changes in thickness and continuity, and they are very heterogeneous.

9 2 1 2 6 . 1 0 2 2 7

The lower fine-grained unit of the Hanford formation in the 200 West Area is thick, but locally discontinuous (Figures 3-38 and 3-39). The lower unit is zero to 32 m (105 ft) thick and consists dominantly of silt, silty sand, and sand typical of the silt-dominated facies interbedded with coarser sands like those comprising the sand-dominated facies. This lower unit is cross-cut in places by vertical clastic dikes. These dikes, believed to be the product of dynamic loading from floodwaters, are apparently distributed randomly throughout this lower unit. They are commonly filled with fine sands and silts and oriented near vertical. Thin [<3 m (10 ft)] intervals dominated by the gravel facies are found locally. The distribution of facies within the unit is variable, although the unit generally fines to the south where silt-dominated facies deposits become more common. The lower unit is not found in the northern part of the 200 West Area and it generally thickens to the south. Eroded zones in the unit are found, most notably in the central part of the 200 West Area. These eroded areas are elongated in a north-south direction.

The upper coarse-grained unit of the Hanford formation consists of interstratified gravel, sand, and lesser silt (Figures 3-40 and 3-41). Gravel-dominated deposits typical of the gravel facies generally dominate the upper unit. However, at some localities the unit is dominated by deposits typical of the sand-dominated facies consisting of sand containing lesser silt and gravel. Minor silty deposits such as those forming the silt-dominated facies are found locally. The thickness and distribution of these facies are very variable. Fining upwards sequences going from coarser to finer gravel, and gravel, sand and/or silt are present at some locations. The upper coarse unit is up to 45 m (148 ft) thick and laterally discontinuous, being found in the northern, east-central, and eastern parts of the 200 West Area. The base of the unit is incised into the underlying strata of the lower fine unit and where that unit is absent, the upper coarse unit fills an erosional scour area. The contact between the upper coarse unit and underlying strata is generally sharp, consisting of gravel facies strata overlying the fines of the lower unit, the early "Palouse" soil, and the Plio-Pleistocene unit.

An isopach map of the entire Hanford formation is presented on Figure 3-42. The total formation thickness in the 200 West Area ranges from approximately 10 to 75 m (33 to 250 ft), showing a general thickening from north to south.

3.4.4.8 Holocene Surficial Deposits. Holocene-age surficial deposits in the 200 West Area are dominated by eolian sands. These deposits have been removed from much of the area by construction activities. Where the eolian sands are found they tend to consist of thin [<3 m (10 ft)] sheets that cover the ground (Figure 3-43). Dunes are not generally well developed within the 200 West Area.

3.5 HYDROGEOLOGY

The following sections discuss Pasco Basin and Hanford Site hydrogeology (Section 3.5.1) and 200 West Area hydrogeology (Section 3.5.2). Each section discusses hydrostratigraphic units of interest, hydraulic properties, groundwater recharge, groundwater flow, and vadose zone characteristics.

3.5.1 Pasco Basin and Hanford Site Hydrogeology

The hydrogeology of the Pasco Basin and Hanford Site is characterized by a multi-aquifer system that consists of four hydrogeological units that correspond to the upper three formations of the Columbia River Basalt Group (Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt) and the sediments overlying the Columbia River Basalt Group (Figure 3-44). The basalt aquifers are usually confined and occur in the sedimentary interbeds of the Ellensburg Formation and the basalt flowtop and flowbottom zones adjacent to the sedimentary interbeds. Near areas of erosion where the interbeds are exposed, such as north of the 200 East Area, the basalt aquifers are locally unconfined. The uppermost aquifer in most places consists of the suprabasalt sediments comprised of fluvial, lacustrine, and glaciofluvial sediments. The uppermost aquifer is generally unconfined but is also semiconfined and confined in parts of the 200 Areas. The uppermost aquifer is contained largely within the Ringold Formation and Hanford formation. Within the suprabasalt sediments a vadose zone of variable thickness overlies the uppermost aquifer. Localized perched water zones were also identified in the vadose zone and are associated with carbonate-rich strata in the 200 West Area.

The following sections describe hydrogeologic characteristics of the basalt aquifers, uppermost aquifer, vadose zone, and potential perching horizons (Sections 3.5.1.1 through 3.5.1.4). Discussions incorporate general geologic and hydrologic material from Lindsey et al. (1991), Connelly et al. (1992), Delaney et al. (1991), and specific information from other documents referenced where appropriate. Hydraulic properties are summarized for these lithologies based on published aquifer testing data for the Hanford Site. Groundwater recharge and flow for the Pasco Basin and the Hanford Site are discussed in Sections 3.5.1.5 and 3.5.1.6, respectively.

3.5.1.1 Basalt Aquifers. A number of regionally extensive confined water-bearing zones are associated with Saddle Mountains Basalt-Ellensburg Formation hydrogeologic unit. As discussed in Section 3.4.2.1, confined aquifers associated with these interbeds are included herein because of the potential for downward migration of contaminants from the unconfined aquifer.

From bottom to top, the Saddle Mountains Basalt hydrogeologic unit is comprised of seven basalt flows (the Umatilla, Wilbur Creek, Asotin, Esquatzel, Pomona, Elephant Mountain, and Ice Harbor Members). The hydrogeologic unit also includes the intervening sedimentary interbeds of the Ellensburg Formation (Mabton, Cold Creek, Selah, Rattlesnake Ridge, and Levey interbeds). As discussed in Sections 3.4.2.1 and 3.4.2.2, the Wilbur Creek and Ice Harbor flows, and the Levey interbed are not present over much of the Hanford Site, including the 200 East and 200 West Areas. The Asotin flow is not present in the western and south central portions of the Hanford Site. Within the confined aquifers, groundwater flow primarily occurs within the permeable sedimentary interbeds of the Ellensburg Formation and to a lesser extent within the adjacent flowtop and flowbottom zones of the basalt flow Members.

Beneath most of the Hanford Site, the Rattlesnake Ridge interbed is the uppermost regionally confined aquifer and is separated from the overlying uppermost aquifer system by the Elephant Mountain Member of the Saddle Mountains Basalt. The Elephant Mountain Member was locally removed by erosion prior to subsequent deposition between the 200 East Area and Gable Mountain (Sections 3.4.2.1.1 and 3.5.1.6.3). In these areas the Rattlesnake Ridge interbed is in contact with the unconfined portion of the uppermost aquifer, and the Selah interbed forms the uppermost confined system. Similarly, erosion exposed the Umatilla flow prior to deposition at the Ringold Formation in the Gable Gap area, thereby allowing potential intercommunication between the confined aquifers in the Saddle Mountains Basalt and the uppermost aquifer.

With the exception of the Rattlesnake Ridge interbed, most of the reported hydraulic property data for the Ellensburg Formation were obtained in the vicinity of the 200 West Area in support of the BWIP. Reported hydraulic conductivities for the interbeds range from 2×10^{-8} to 1.6×10^{-4} m/s (6.0×10^{-3} to 30 ft/day) (Ledgerwood and Deju 1976; Strait and Mercer 1987). Many of the Rattlesnake Ridge conductivity values included in this range were obtained from testing north of the 200 East Area. Reported transmissivities for the Rattlesnake Ridge aquifer range from 3×10^{-13} to 5×10^{-8} m^2/s (3×10^{-3} to 1.2×10^{3} ft^2/day) (Graham et al. 1981; Graham et al. 1984; and DOE 1988) and are summarized by Newcomer 1992b).

Within individual basalt flows, zones of increased permeability may be associated with vesicles, rubble zones, and other intraflow structures (Graham et al. 1984; Gephart et al. 1979). A description of basalt intraflow structures is presented in Section 3.4.2.1.1. The vesicle and rubble zones are usually found at the top and bottom flow boundaries and generally contribute to the interbed permeability (Graham et al. 1984). Within the Elephant Mountain Member, an interflow zone consisting of interconnected vesicles and rubble zones is present south and west of the 200 East Area (Graham et al. 1984; Gephart et al. 1979). The interflow zone was removed by erosion in the northeast part of the 200 East Area (Graham et al. 1984). Deju and Fecht (1979) reported a hydraulic conductivity value for

fractured zones within Saddle Mountains Basalt flow interiors of 1 x 10^{-7} m/s (3 x 10^{-2} ft/day). The Elephant Mountain interflow zone reportedly exhibits higher transmissivity values [8 x 10^{-6} to 7 x 10^{-3} m^2/s (7.5 to 6,120 ft^2/day)] than the bounding flows (Graham et al. 1984).

In addition to intraflow structures, tectonic fractures and faults, if present, can also potentially contribute to increased permeability if these structures are not closed or filled with clay gouge-like materials. As discussed in Sections 3.4.2.1.1. and 3.4.3, a limited amount of fault and fracture information from geological and geophysical investigations was available from the documents reviewed for this report.

3.5.1.2 Uppermost Aquifer System. The uppermost regional aquifer in the Pasco Basin and the Hanford Site generally occurs within fluvial/lacustrine sediments of the Ringold Formation and glaciofluvial sands and gravels of the Hanford formation (Figure 3-44). The uppermost aquifer system primarily displays unconfined to locally confined or semiconfined conditions, although for ease of discussion it is referred to simply as the unconfined aquifer. Groundwater ranges from less than 0.3 m (1 ft) below ground surface near West Lake and the Columbia and Yakima Rivers, to greater than 107 m (350 ft) in the central portion of the Cold Creek syncline. The saturated thickness of the unconfined aquifer system ranges from approximately 67 m (220 ft) in the 200 West Area to near zero in the northeastern part of the 200 East Area. This is where the aquifer thins out and laps into basalt extending above the water table. Semiconfining to confining conditions in the 200 East Area are discussed in the 200 East AAMSR. A second type of confining condition has been identified near the water table in the north-central parts of the 200 West Area, and area to the north is discussed in Section 3.5.2.

Semiconfined to confined conditions occur locally in the otherwise unconfined aquifer at the Hanford Site. Within the lower part of the aquifer, semiconfined to confined groundwater exists in the Ringold unit A gravels where the unit is overlain by fine-grained sediments of the Ringold lower mud sequence. In the 200 West Area, the thickness of the Ringold unit A semiconfined to confined zone ranges from 38 m (125 ft) or more in the southeastern portion of the area to zero where the unit A gravels and the lower mud sequence pinch out near the northern and northeastern portions of the area, respectively. The confining zone overlying unit A gravels is up to 30 m (100 ft) thick below the south-central part of the 200 West Area. Semiconfining and confining conditions in the 200 West Area are discussed in Section 3.5.2.1.

Because the uppermost aquifer transports of potential chemical and radionuclide contaminants, the uppermost aquifer is generally the most characterized hydrologic unit beneath the Hanford Site. Numerous wells have been installed in the unconfined aquifer to obtain groundwater elevation data, samples for chemical analyses, and aquifer properties data.

Hydraulic Properties/Uppermost Aquifer. The following discussion summarizes hydraulic properties data for the unconfined portion of the uppermost aquifer at the Hanford Site. It is organized to first reference the sources of the data followed by the testing methods used to acquire the data. Methods of analysis are presented along with several factors, or assumptions, which affect the final value and this is followed by a discussion of differences between testing methods applied. Finally the ranges of estimated aquifer hydraulic conductivity, storativity, specific yield, and porosity are presented.

Table 3-1 presents a summary of hydraulic conductivity and transmissivity data based on information compiled by Newcomer et al. (1992a), Connelly et al. (1992), Delaney et al. (1991), Bjornstad (1990), and Last et al. (1989). Most of the data for the unconfined portion of the uppermost aquifer (Ringold unit E gravels) presented on Table 3-1 represents testing results for the 200 West Area. Data for the Ringold A Gravels represent the confined or semiconfined portion of the uppermost aquifer. Information compiled from Delaney et al. (1991) and Last et al. (1989) however, includes Hanford Site data--primarily from the 200 East Area. The original data tables from Newcomer et al. (1992a) and Connelly et al. (1992) for the 200 West Area are provided as Appendix A Tables A-7 and A-8.

Hydraulic conductivity and transmissivity data presented in Table 3-1 represent information obtained from a variety of aquifer testing methods. Data reported by Newcomer et al. (1992a) consists of field aquifer test results from Last et al. (1989), Graham et al. (1981), PNL file data, and older pumping/recovery data for the 200 West Area. The Newcomer et al. (1992a) information was used by Connelly et al. (1992) during preparation of a hydrogeologic model for the 200 West Area, and was supplemented by previously unpublished slug test data collected over the last several years. Hydraulic properties information reported by Bjornstad (1990) included aquifer pump test data, laboratory permeameter testing (vertical hydraulic conductivities), and some re-analysis of the Last et al. (1989) data.

Results of the aquifer test data can vary greatly depending on a number of factors. These factors include the well location and depth of wells tested, well screen interval and construction features, and analytical/data reduction methods. Major factors affecting aquifer test results are the heterogeneity of the sediments within the screened interval, and whether the well screened is only partially penetrating the aquifer. Most of the aquifer analysis methods assume a fully-penetrating well screen and a homogenous, isotropic aquifer (e.g., Theis or modified analysis). Differing estimates of saturated thickness of the aquifer produce different estimates of hydraulic conductivity in the references cited in previous paragraphs. Additionally, aquifer tests conducted using clustered piezometers in the same borehole may not represent true aquifer responses due to potential hydraulic intercommunication of the tested zones. Intercommunication can occur if the sandpack material used to isolate each open interval provides a conduit for groundwater migration between the tested zones through the well annulus. This was reported for some wells by Newcomer et al. (1992a).

Differences in field testing methods also promote variations in the data. In general, hydraulic properties obtained from aquifer recovery tests may be the most representative of the actual aquifer conditions, since the well response is not affected by fluctuations in pumping rates and a relatively large volume of the aquifer is involved. Slug testing may provide a less representative estimate of hydraulic conductivity because of the limited volume of the aquifer stressed during testing. Also, medium grained sands are commonly used for sand pack for RCRA well screens to inhibit influx of material from localized silty layers in Hanford formation and Ringold Formation gravels. The sand pack would typically have a lower hydraulic conductivity than the surrounding gravels in the screened interval and could therefore promote a low bias for slug testing results. In recent evaluations of slug interference testing at the Hanford Site, however, slug tests with large head displacements monitored in observation wells 3 to 30 m (10 to 100 ft) away from the test well may provide representative estimates of hydraulic conductivity and specific yield.

Generally, higher hydraulic conductivities and transmissivities for the uppermost aquifer at the Hanford Site are associated with Hanford formation. For the Hanford formation, hydraulic conductivities vary from about 1.8×10^{-3} to 0.7 m/s (500 to 20,300 ft/day), and transmissivities vary from about 0.02 to 0.6 m^2/s (14,000 to 594,000 ft^2/day). In comparison, conductivities for the Ringold unit A and unit E gravels vary from about 3×10^{-7} m/s to 2×10^{-3} m/s (0.1 to 600 ft/day). Transmissivities in the Ringold gravels vary from about 2×10^{-5} to 0.05 m^2/s (20 to 51,000 ft^2/day).

Graham et al. (1981) evaluate other hydraulic properties for the uppermost aquifer for the Hanford Site and conclude that the ratio of horizontal to vertical hydraulic conductivity ranges between 13 and 16, primarily due to anisotropy in the sedimentary structure of the deposits. For wells completed just below the water table in the Hanford formation, Graham et al. (1981) report specific yield values ranging from 0.15 to 0.18 and a storativity value of 0.07. Graham et al. (1981) estimate that the effective porosity of the uppermost aquifer ranges from 10 to 30%. The lower value is more representative of the sediments of the Ringold Formation. The higher value is representative of the Hanford formation sediments.

3.5.1.3 Vadose Zone. The vadose zone at the Hanford Site is composed of several units, including: (1) Holocene surficial deposits such as loess, sand dunes, alluvium, and talus; (2) Hanford formation; (3) early "Palouse" soils; (4) Plio-Pleistocene unit; and (5) Ringold Formation. The vadose zone beneath the Hanford Site ranges in thickness from approximately 0.3 m (1 ft) near West Lake to approximately 107 m (350 ft) west of the 200 East Area (Last et al. 1989). Variable surface topography and the variable elevation of the water table in the underlying uppermost aquifer causes this observed variation in vadose zone thickness.

For the Hanford formation, vadose zone hydraulic conductivity values at saturation range from 10^{-6} to 10^{-4} m/s (0.3 to 30 ft/day). These saturated hydraulic conductivity values

were measured at volumetric water contents of 40 to 50% (Bjornstad 1990). Hydraulic conductivity values corresponding to volumetric water contents ranging from 2 to 10% typically range from 2×10^{-13} to 7×10^{-9} m/s (6×10^{-8} to 2×10^{-3} ft/day). Unsaturated hydraulic conductivities may vary by orders of magnitude with varying moisture contents and among differing lithologies with significantly different soil textures.

Additional data regarding vadose zone conductivities and other hydraulic properties were obtained during infiltration and recharge studies at the Hanford Site. These hydraulic properties are discussed in the section on regional groundwater recharge (Section 3.5.1.5).

3.5.1.4 Perched Water Zones. 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. If sufficient moisture accumulates, the soil pore space in these perching zones may become saturated. In this case, the capillary pressure within the horizon may locally exceed atmospheric pressure, i.e., a water table condition may develop. Additional input of downward percolating moisture to this horizon may lead to a hydraulic head buildup above the top of the horizon. Consequently, a monitoring well screened within or above this horizon would be observed to contain free water.

The Plio-Pleistocene unit and early "Palouse" soil form potential perching horizons within the vadose zone in the vicinity of the 200 West Area. Locations at which perched water has been observed in the 200 West Area are discussed in Section 3.5.2.4. As discussed in Section 3.4, the Plio-Pleistocene unit and early "Palouse" soils extend west of the 200 West Area, and therefore represent potential perching horizons in this area as well.

The Plio-Pleistocene unit, consisting of calcium-carbonate cemented silt, sand, and gravel, occurs at depths of 12 to 61 m (40 to 200 ft) in the vicinity of the 200 West Area, and is up to 9 m (30 ft) thick. These depths correspond to elevations ranging from about 149 to 186 m (490 to 610 ft) above sea level. Measured saturated hydraulic conductivities for this unit range from 10^{-8} to 10^{-6} m/s (0.003 to 0.3 ft/day).

The early "Palouse" soil horizon, consisting of loess-like silt and minor fine-grained sand, ranges in depth from 12 to 46 m (40 to 150 ft) in the vicinity of the 200 West Area, and is up to 12 m (40 ft) thick in the vicinity of the 200 West Area. These depths correspond to elevations ranging from about 152 to 192 m (500 to 630 ft) above sea level.

3.5.1.5 Groundwater Recharge. Natural and artificial sources recharge the unconfined aquifer within the sedimentary rocks of the Pasco Basin. Rainfall and runoff within area of basalt outcrop along the margins of the Pasco Basin recharge the basalt aquifers as does downward groundwater movement from the overlying sediments, but a lesser extent.

Downward groundwater movement is discussed in Section 3.5.1.6. The following sections discuss natural and artificial groundwater recharge.

3.5.1.5.1 Natural Groundwater Recharge. Rainfall and runoff from the higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Yakima and Columbia Rivers naturally recharge the uppermost aquifer system within the Pasco Basin. The principal source of recharge occurs along the periphery of the basin where precipitation runoff infiltrates to the water table (Graham et al. 1981). Small ephemeral streams draining the western slopes, such as Cold Creek and Dry Creek, lose water to the ground as they spread out on the valley plain. Water conducted in these streams is lost through both infiltration to the ground and evapotranspiration to the air. Most of the infiltrating water eventually percolates to the water table. Larger rivers either gain or lose water to the aquifer depending on the river stage, location, and groundwater flow direction. The Yakima River, for example, recharges the unconfined aquifer along its reach from Horn Rapids to Richland, Washington. Along the Columbia River, some river water is transferred during high stages to bank storage as groundwater. Some of this bank storage may recharge the aquifer, but the rest will flow back into the river when the stage drops.

The Cold Creek and Dry Creek valleys to the west of the 200 West Area naturally recharge the unconfined aquifer. Total annual recharge to the unconfined aquifer by Cold and Dry Creeks in the western portion of the Hanford Site is estimated at 548,000,000 L/yr (145,000,000 gal/yr). Gee (1987) more recently reports that natural recharge to the 200 West Area is approximately 130,000 L/yr (34,000 gal/yr). Further discussion is presented in Section 3.5.2.2.1.

Natural precipitation infiltration at or near waste management units or unplanned releases may provide a driving force for mobilizing contaminants previously introduced to surface or subsurface soils. For this reason, many previous investigations focus on determining precipitation recharge rates at the Hanford Site. Previous field programs were designed to assess precipitation, infiltration, water storage changes, and evaporation to evaluate the natural water balance during the recharge process. Precipitation recharge values ranging from zero to 10 cm/yr (4 in./yr) are estimated from various studies.

The primary factors affecting precipitation recharge appear to be surface soil type, vegetation type, topography, and spatial and temporal variations in seasonal precipitation. In general, infiltration to soils is higher in the winter when precipitation is more frequent and evapotranspiration is low. Examples of precipitation recharge studies at the Hanford Site, and some of the conclusions reached, are given below:

- Gee and Heller (1985) describe various models used to estimate natural recharge rates. Many of the models use a water retention relationship for the soil. This is the relation between soil moisture content and the suction required to remove (or

move) the moisture. Gee and Heller (1985) developed two of these models for soils in lysimeters on the Hanford Site. As an example of available data, the particle size distribution and the water retention curves of these two soils are shown on Figure 3-45. Additional data and information about possible models for unsaturated flow may be found in Brownell et al. (1975) and Rockhold et al. (1990).

- Moisture contents were obtained from a number of core-barrel samples in the 200 Areas (East and West) and varied from 1 to 18% (by weight), with most samples in the range of 2 to 6% (Last et al. 1989). The data appear to indicate zones of increased moisture content that can be interpreted as signs of moisture transport. Also, during monitoring well drilling near 200 West Area single-shell tanks, measured moisture contents in silty sediments have been as high 26 to 28% (by weight). The high moisture contents indicate local saturation or near-saturation in vadose zone sediments.

- Gee (1987) describes results of lysimeter studies and indicates greater soil moisture infiltration is associated with winter and early spring precipitation and runoff.

- Routson and Johnson (1990) describe a lysimeter study conducted at a location 1.6 km (1 mi) south of the 200 East Area. During much of the lysimeter's 13-year study period between 1972 and 1985, the ground surface above the lysimeter was kept unvegetated by using herbicides. No information regarding the soil types in which the lysimeter was installed is provided. To a precision of $\pm$ 0.2 cm (0.08 in.), no downward moisture movement was observed in the instruments during periodic neutron-moisture measurements or as a conclusion of a final soil sample collection and moisture content analysis episode.

- Rockhold et al. (1990) also report on a weighing lysimeter study conducted at a grassy plot approximately 5 km (3 mi) northwest of the 300 Areas. The grassy test site was located in a broad, shallow topographic depression approximately 900 m (2,953 ft) wide, several hundred meters long, trending southwest. The area is covered with annual grasses (i.e., cheatgrass and bluegrass). The upper 3.5 m (11.5 ft) of the soil profile consist of slightly silty to silty sand (sandy loam) with an estimated saturated hydraulic conductivity of 9×10^{-5} m/s. Rockhold et al. (1990) estimate that approximately 0.8 cm (0.3 in.) of downward moisture movement occurred between July 1987 and June 1988. This represents approximately 7% of the total precipitation recorded in that area during that period.

- Fayer and Jones (1990) developed the computer model UNSAT-H to simulate the infiltration of recharge through typical Hanford vadose zone soils. To date, however, the model has been used only for very location-specific studies rather than the Hanford Site or the 200 Areas as a whole.

- Rockhold et al. (1990) discuss a gravel-covered lysimeter study conducted at the 622 Area Lysimeter Site, approximately 0.5 km (0.3 mi) east of the 200 West Area. Approximately 4 cm (1.6 in.) of downward moisture movement was observed in two gravel-covered lysimeters during 1988 and 1989. This represented approximately 25% of the total precipitation recorded in the area during the study period. The authors conclude that gravel placed on the soil surface reduces evaporation and facilitates precipitation infiltration.

- Smoot et al. (1989) conducted a modeling analysis and indicate that 68 to 86% of the precipitation falling on a gravel-covered site might infiltrate to a depth greater than 2 m (6 ft).

Smoot et al. (1989) present an example of the potential use of this vadose zone hydraulic parameter information in which precipitation infiltration and subsequent contaminant plume movement near a prototype single-shell tank was evaluated using a numerical computer code. Smoot et al. (1989) used the UNSAT-H computer code to predict the precipitation infiltration for several different soil horizon combinations and characteristics. The researchers used statistically generated precipitation values based on actual daily precipitation values recorded at the Hanford Site between 1947 and 1989 to simulate precipitation infiltration from January 1947 to December 2020. The same authors also used the PORFLO-3 computer code to simulate ^{106}Ru and ^{137}Cs movement through the unsaturated zone.

3.5.1.5.2 Artificial Groundwater Recharge. Artificial recharge to the groundwater in the Pasco Basin comes from two sources: agricultural irrigation and liquid waste disposal operations on the Hanford Site. Agricultural land on the eastern and northern sides of the Columbia River and in the Cold Creek valley to the west of the Hanford Site is currently irrigated; however, the volume of irrigation water used has not been quantified. Possibly as much as 40% of this irrigation water reaches the water table (U.S. Bureau of Reclamation 1971).

Hanford liquid waste disposal practices artificially recharge mainly the 200 East and West Areas. Graham et al. (1981) estimate that historical artificial recharge from liquid waste disposal in the separations areas exceeded all natural recharge on the Hanford Site by a factor of ten. Zimmerman et al. (1986) report that between 1943 and 1980, 6.33×10^{11} L (1.7×10^{11} gal) of liquid wastes were discharged to the soil column in the 200 Areas.

Artificial recharge is further discussed in Section 3.5.2.2.2. Potential recharge to the Rattlesnake Ridge confined aquifer is presented in Section 3.5.1.6.2.

3.5.1.6 Regional Groundwater Flow. Groundwater flow beneath the 200 West Area is affected by regional groundwater flow conditions. This section describes regional and Hanford Site groundwater flow patterns for the uppermost aquifer and basalt aquifers.

3.5.1.6.1 Uppermost Aquifer. The areal pattern of groundwater flow for the past and present in the uppermost aquifer can be determined from potentiometric surface maps presented on Figures 3-46 and 3-47. Areas of anisotropic hydraulic conductivity in the suprabasalt sediments may result in local deflection of groundwater flow from the general pattern shown on the figures.

Natural groundwater inflow to the uppermost aquifer primarily occurs along the western boundary of the Hanford Site. In the past, groundwater flow across the Hanford Site in the uppermost aquifer generally moved toward the east-northeast, although flow north of Gable Mountain was more to the north and flow south of Gable Mountain was more to the east. Figure 3-46 is a hindcast map of the 1944 groundwater table generated by ERDA (1975) from relatively few data points and estimates of flow. In the context of the 200 West Groundwater AAMS report, the term "hindcast" is used to describe the historical groundwater flow pattern based on the limited groundwater table elevation and flow data. Additional discussion of the parameters used for generating the hindcast map is provided by ERDA (1975). The uppermost aquifer ultimately discharges to the Columbia River, either near the 100 Areas, north of the 200 Areas through Gable Gap, or between the 100 Areas and the 300 Area, east of the 200 Areas.

Groundwater flow north of Gable Mountain now trends in a more northeasterly direction as a result of mounding near reactors and flow through Gable Gap. Figure 3-47 is a June 1991 groundwater table map for the Hanford Site. South of Gable Mountain, flow is interrupted locally by the groundwater mounds in the 200 Areas. Groundwater flow directions are affected to a large degree by wastewater discharge and groundwater mounding in the 200 East Area (Delaney et al. 1991). During periods of increased recharge from the 200 East Area, more of the recharge from the 200 West Area is diverted north through Gable Gap toward the 100 Areas. There is also a component of groundwater flow to the north between Yakima Ridge and Gable Butte from the 200 Areas. As liquid waste disposal to soil column operations are halted in the 1990's the regional groundwater flow pattern will begin to shift. Due to increased irrigation in the Pasco Basin, the flow pattern will probably never match the 1944 flow pattern (hindcast map), but the flow direction may roughly approach previous flow directions.

Graham et al. (1981) calculated horizontal hydraulic gradients for the 200 West Area of 0.004 to 0.015 for data collected in December 1979. Before operations at the Hanford Site

began in 1944, the average hydraulic gradient in all but the southwestern-most portion of the Hanford Site was approximately 1.5 m/km (0.0009 ft/ft or 5 ft/mi). These data indicate an overall increase in gradients across the site. The largest increase is in the vicinity of the groundwater mounds below the 200 Areas. Graham et al. (1981) estimated that vertical hydraulic gradients in the uppermost aquifer exceed 10% in some areas of the aquifer. Information on gradients and flow velocities is presented in Section 3.5.2.3.1.

3.5.1.6.2 Basalt Aquifers. Lateral groundwater movement within the Saddle Mountains Basalt hydrogeologic unit occurs from upland recharge areas along the periphery of the Pasco Basin and along anticlinal ridges to discharge areas along the Columbia River. A potentiometric surface map is presented in Figure 3-48.

3.5.1.6.3 Uppermost/Basalt Aquifer Interconnection. Erosional windows through Saddle Mountains Basalt flows, areas of nondeposition, or poor groundwater well seals, may allow communication between the uppermost aquifer system and underlying confined aquifers (Ledgerwood and Deju 1976; Graham et al. 1984). Also, flow through basalt intraflow structures or fractures could potentially serve as higher permeability zones of connection. In zones of potential intercommunication, contaminants could be transported from the shallow unconfined portion of the uppermost aquifer to deeper water bearing zones via density-driven plumes. Downward gradients in the erosional window areas, for example, would allow recharge to the deeper formations, but vertical gradients vary with depth and location across the site. Deju and Fecht (1979) and DOE (1988) present data that indicate that overall potentiometric head decreases with depth in the Wanapum Basalt causing downward gradients. Gradients in the Saddle Mountains Basalt, which contact the suprabasalt sediments, are believed to have been upward before the start of wastewater disposal (DOE 1988), but subsequently may have reversed and become downward (Graham et al. 1984; DOE 1988).

Graham et al. (1984) discuss interconnection between the uppermost aquifers and a potentially-unconfined portion of the aquifer related to the Rattlesnake Ridge interbed. The area of study was south and east of Gable Mountain and extended to near the northern boundary of the 200 East Area. Potentiometric maps, barometric efficiency, geochemical data, and well construction logs were used to assess possible areas of interconnection and groundwater flow directions. The study located two areas of direct connection between the aquifers where the intervening Elephant Mountain Basalt was completely eroded (Figure 3-49). Two other areas of suspected interconnection were identified based on barometric efficiency. Interconnection along the unsealed casing in Well 299-E33-12 was reported.

Graham et al. (1984) reported no areas of downward gradients at the time of the study which coincided with areas of interconnection. In the Rattlesnake Ridge aquifer, groundwater flows from the southeast to the northwest within the study area. Graham et al.

(1984) report that the Rattlesnake Ridge aquifer discharges to the uppermost aquifer in the vicinity of West Lake. No comment is made as to whether the Rattlesnake Ridge aquifer recharges the overlying unconfined portion of the uppermost aquifer through erosional windows in areas other than near West Lake. The report does state, however, that downward gradients in areas of erosional windows could be attained during years when water levels in the uppermost aquifer were high. The report also speculates that the last time this had occurred was in the late 1960's and early 1970's. During periods in which upward gradients exist, density driven plumes of contamination could impact the underlying basalt aquifer system. Comparison of head values in the Rattlesnake Ridge and uppermost aquifer is presented on Figure 3-50.

The Saddle Mountains Basalt interbeds do not appear to be directly exposed to the uppermost aquifer in the areas of nondeposition (DOE 1988), however, flow through fractures or vesicles in basalt could serve as higher permeability zones of connection (see Section 3.4.2.1.2). Gradients in the Saddle Mountain Basalts, which contact the suprabasalt sediments, are believed to have been upward before the start of wastewater disposal (DOE 1988).

3.5.2 200 West Area Hydrogeology

Sections 3.5.2.1.1 through 3.5.2.1.4 describe the hydrogeologic characteristics of the basalt aquifers, uppermost aquifer, and vadose zone sediments in the 200 West Area. Sections 3.5.2.2 and 3.5.2.3 describe 200 West Area groundwater recharge and flow, respectively.

3.5.2.1 200 West Area Hydrostratigraphy. The primary hydrostratigraphic units in the 200 West Area are (1) the Rattlesnake Ridge interbed and deeper interbeds of the Ellensburg Formation (confined water-bearing zone); (2) the Elephant Mountain Basalt Member and deeper flows of the Saddle Mountains Basalt (confining horizon); (3) the Ringold Formation (unconfined and semiconfined water-bearing zones and lower part of the vadose zone); (4) the Hanford formation (vadose zone); and (5) the Plio-Pleistocene unit and early "Palouse" soil (primary vadose zone perching horizons and/or perched groundwater zones). The hydrogeologic designations for the 200 Areas were determined by examining borehole logs and integrating these data with stratigraphic correlations from existing reports. Figure 3-51 summarizes hydrogeologic units identified in the 200 West Area.

3.5.2.1.1 Basalt Aquifers. Regionally confined aquifers exist within the Saddle Mountains Basalt-Ellensburg Formation hydrogeologic unit in the 200 West Area. From bottom to top, the water-bearing zones occur within the Mabton, Cold Creek, Selah, and Rattlesnake Ridge interbeds of the Ellensburg Formation, and associated Saddle Mountain

Basalt flow tops/bottoms. The Wilbur Creek, Asotin, and Ice Harbor flows, and the Levey interbed are not present in the 200 West Area (Section 3.4.2).

As discussed in Section 3.5.1.1, most of the Hanford Site hydraulic testing data for the basalt aquifers (with the exception of the Rattlesnake Ridge interbed) was collected from wells and deep boreholes in the vicinity of the 200 West Area. Hydraulic conductivity and transmissivity data reported in Section 3.5.1.1 are therefore the currently best available data representative of conditions in the confined aquifers in the 200 West Area.

3.5.2.1.2 Uppermost Aquifer System. The following discussion addresses the uppermost aquifer system that primarily is comprised of the unconfined aquifer but also includes localized semiconfined and confined areas. For ease of discussion this system will be referred to as the unconfined aquifer. The uppermost aquifer system in the 200 West Area is contained within the fluvial/lacustrine sediments of the Ringold Formation. As shown on Figure 3-49 the depth to groundwater in the uppermost (unconfined) aquifer underlying the 200 West Area ranges from about 50 m (165 ft) to more than 100 m (328 ft). The saturated thickness of the unconfined portion of the uppermost aquifer ranges from approximately 67 to 112 m (220 to 368 ft) in the 200 West Area (Figure 3-52).

The upper part of the uppermost aquifer in the 200 West Area consists of generally unconfined groundwater within the Ringold unit E. The lower part of the uppermost aquifer consists of confined to semiconfined groundwater within the gravelly sediments of Ringold unit A. The Ringold unit A is generally confined by fine-grained sediments of the Ringold lower mud sequence. The extent of the lower mud sequence and hence the extent of the confined Ringold A gravel is shown in Figures 3-28 and 3-29. The thickness of this confined zone ranges from greater than 38 m (125 ft) in the southeastern portion of the 200 West Area to zero m where it pinches out just north of the northern 200 West Area boundary. The lower mud sequence is absent in the northeastern portion of the 200 West Area. The confining zone overlying unit A is up to 30 m (100 ft) thick below the south-central section of the 200 West Area before pinching out in the northeastern corner of the 200 West Area.

Recent drilling in the northeastern part of the Z Plant Aggregate Area, and a location about 600 m (2,000 ft) to the north has indicated that the water table may locally be confined at several locations beneath carbonate-rich sediments in the Ringold unit E gravels. The condition is apparently associated with carbonate buildup on gravel fragments and in the sediment pore spaces. During drilling, boreholes penetrating this layer [possibly 0.5 m (1.5 ft) or more in thickness] have subsequently encountered water which immediately rises about 2 to 3 m (6.5 to 10 ft) or more above the gravel layer. The water level typically falls below the elevation of the carbonate-rich layer as drilling progresses deeper. The confining condition has been observed in Wells 299-W6-4 through 299-W6-7, and 699-48-77A (Plates 3a and 3b). Borehole data describing the confining condition are preliminary and hydrologic

testing of these zones has not been completed. The lateral persistency of the confining condition is currently uncertain.

As discussed in Section 3.5.1.2.1, Hanford Site hydraulic properties data presented on Table 3-1 for the uppermost aquifer in the Ringold Formation were compiled primarily from aquifer test results from the 200 West Area. For this reason, hydraulic conductivities and transmissivities summarized for the 200 West Area on Table 3-1 are comparable in magnitude to Hanford Site-wide values. However, the higher hydraulic conductivity values reported for the 200 West Area are slightly lower than higher values for the entire Hanford Site [1×10^{-5} m/s (4 ft/day) for the 200 West Area Ringold unit A gravels versus 3×10^{-5} m/s (10 ft/day) for the entire Hanford Site; and 7×10^{-4} m/s (200 ft/day) for the 200 West Area Ringold Unit E gravels versus 2×10^{-3} m/s (600 ft/day) for the entire Hanford area]. Laboratory measurements reported by Bjornstad (1990) for vertical hydraulic conductivity in the Ringold lower mud sequence in the 200 West Area are much lower: 1×10^{-10} to 3×10^{-10} m/s (3.0×10^{-5} to 8.0×10^{-5} ft/day).

Using 200 West Area testing data reported by Newcomer et al. (1992a) and previously unpublished slug test data since about 1989, Connelly et al. (1992) prepared maps of transmissivity and hydraulic conductivity for the 200 West Area (Figures 3-53 and 3-54). Figure 3-53 indicates that there are two relatively lower areas of transmissivity: one of about 2×10^{-5} m^2/s (20 ft^2/day) located at the north end of the 200 West Area, and one located at the south end of the area with a transmissivity value of 1×10^{-3} m^2/s (1,000 ft^2/day). Between the two zones of low transmissivity, a relatively high transmissivity zone is present with values ranging from 0.01 to 0.05 m^2/s (10,000 to 50,000 ft^2/day). The distribution of transmissivity values resembles the water table contours in this area. The higher transmissivity values are associated with the groundwater mound present beneath the 200 West Area where the saturated thickness of the unconfined aquifer is relatively large (Connelly et al. 1992). Hydraulic conductivity (Figure 3-54), however, is not influenced by the thickness of the saturated zone. Hydraulic conductivity values used to configure the map were determined directly with the use of the Bouwer-Rice slug test analysis or indirectly determined from transmissivity values resulting from constant discharge-recovery tests. The map of hydraulic conductivity shows similar trends as the map for transmissivity. The areas of high hydraulic conductivity correspond to the high transmissivity areas.

3.5.2.1.3 Vadose Zone. In the vicinity of the 200 West Area the vadose zone units primarily include the (1) fluvial gravel of Ringold unit E; (2) the upper unit of the Ringold Formation; (3) Plio-Pleistocene unit; (4) early "Palouse" soil; and (5) Hanford formation. Only the Hanford formation is continuous throughout the vadose zone in the 200 Areas. The upper units of the Ringold Formation, the Plio-Pleistocene unit, and the early "Palouse" soil only occur in the 200 West Area. The stratigraphic characteristics of each of these units is discussed in Section 3.4.4. The vadose zone beneath the 200 West Area ranges from less

than 50 m (165 ft) near the southwest corner of the 200 Area to more than 100 m (328 ft) in the northwest corner of the area (Figure 3-55).

The flow of water through unsaturated soils in the vadose zone depends in complex ways on several factors, including most significantly the moisture content of the soils and its hydraulic properties. Although a variety of methods have been developed to directly measure a soil's hydraulic properties, most of them are costly and difficult to implement, in particular, unsaturated hydraulic conductivity. An alternative to direct measurement of unsaturated hydraulic conductivity is to use theoretical methods that predict the conductivity based on measured soil moisture retention data and saturated hydraulic conductivity (Van Genuchten et al. 1991).

Van Genuchten's computer program RETC is commonly used to develop wetting and drying curves for soils, based on laboratory data. The program uses a nonlinear least squares fit to generate a θ-φ (θ being moisture content and φ being matric potential or suction head) curve from lab data. An example of the wetting and drying curves, and corresponding unsaturated hydraulic conductivity functions, is provided on Figure 3-56. A relative hydraulic conductivity function $K_r(\theta)$ is required to relate saturated hydraulic conductivity K_s, generally measured in the laboratory, to the unsaturated conductivity $K(\theta)$ function.

$$K(\theta) = K_s K_r(\theta)$$

Van Genuchten developed a closed form predictive function to generate relative hydraulic conductivities from the θ-φ data. With the saturated hydraulic conductivity (K_s) and the relative hydraulic conductivity function ($K_r(\theta)$), unsaturated hydraulic conductivity values ($K(\theta)$) can be generated for a specific moisture content. An example of the $K(\theta)$ curves generated by this method is presented on Figure 3-57.

Rockhold et al. (1988) compared direct measurement of unsaturated hydraulic conductivities to those predicted from measured water retention data for three locations on the Hanford Site. He found that each method produced results different from other methods and recommends that several methods should be used to determine unsaturated hydraulic conductivities. Only water retention data were reported in the sources reviewed for this report.

Knowledge of hydraulic conductivity values for a soil and a gradient, allows the calculation of flow through that soil. Darcy's law, although originally conceived for saturated flow only, was extended by Richards to unsaturated flow, with the provisions that the soil hydraulic conductivity becomes a function of the water content of the soil, $K(\theta)$, and the driving force is predominantly differences in moisture level. The moisture flux, θ, in

centimeters per second in one direction is then described by a modified form of Darcy's law commonly referred to as Richards' Equation (Hillel 1971) as follows:

$$q = K(\theta)\left(\frac{\partial\varphi}{\partial\theta}\right)\left(\frac{\partial\theta}{\partial x}\right) \qquad \text{(Richard's Equation)}$$

where

- $K(\theta)$ is the water-content-dependent unsaturated hydraulic conductivity in cm/s
- $\partial\varphi/\partial\theta$ is the slope of the soil-moisture retention curve $\varphi(\theta)$ at a particular volumetric moisture content θ [a soil-moisture retention curve plots volumetric moisture content observed in the field or laboratory against suction values for a particular soil, see Figure 3-38 from Gee and Heller (1985) for an example]
- $\partial\theta/\partial x$ is the water content gradient in the x direction.

More complicated forms of this equation are also available to account for the effects of more than one dimensional flow and the effects of other driving forces such as gravity.

In practice, applying Richards' Equation is quite difficult because the various parameters involved are difficult to measure and because soil properties vary depending on whether the soil is wetting or drying (hysteresis). As a result, soil heterogeneities affect unsaturated flow even more than saturated flow. Several investigators at the Hanford Site have measured the vadose zone moisture flux and hydraulic conductivity directly using lysimeters and permeameters, respectively (e.g., Rockhold et al. 1990; Routson and Johnson 1990). These direct measurements are discussed in 200 West Area Groundwater Recharge (Section 3.5.2.2).

Once the relationship between unsaturated hydraulic conductivity and moisture content is known for a particular lithologic unit, travel time can also be estimated for a steady-state flux passing through each layer by assuming a unit hydraulic gradient. Under the unit gradient condition, only the force of gravity is acting on water and all other forces are considered negligible. These assumptions may be met for flows due to natural recharge since moisture differences smooth out after sufficient time. Travel time for each lithologic unit of a set thickness and calculated for any given recharge rate, and the total travel time is equivalent to the sum of the travel times for each individual lithologic unit. To calculate the travel time for any particular site the detailed layering of the lithologic units should be

considered. For sites with artificial recharge (e.g., cribs and trenches) more complicated analyses are required to account for the effects of variable saturation.

Thirty-five soil samples from the 200 West Area have had moisture retention data measured. These samples were collected from Wells 299-W18-21, 299-W15-16, 299-W15-2, 299-W10-13, 299-W7-9, and 299-W7-2. Eleven of these samples were reported by Bjornstad (1990). The remaining 24 were analyzed as part of an ongoing performance assessment of the low-level burial grounds (Connelly et al. 1992). For each of these samples, soil moisture retention data were measured, and soil moisture curves were generated from the data. Saturated hydraulic conductivity (K_s) values were also measured in the laboratory for these samples.

Ringold Unit E. Connelly et al. (1992) report that two laboratory drainage curves were generated for this unit. The unsaturated hydraulic conductivity curves are presented in Figure 3-57. These soil samples were collected from Well 299-W7-2 on the northern edge of the 200 West Area at depths of 47 and 67 m (155 and 220 ft). As can be seen in Figure 3-55 there is considerable difference between the two curves. Bjornstad (1990) indicates that the sample collected at 67 m (220 ft) may be significantly compacted or cemented judging by its relatively low saturated volumetric moisture content of 24%. Therefore, the sample collected at 47 m (155 ft) may be more representative of this unit than the sample collected at 67 m (220 ft). Unfortunately, there are too few samples for comparison.

Upper Ringold Unit. Connelly et al. (1992) report a total of 11 drainage and 10 imbibition (wetting) curves were generated for the upper Ringold unit. The predicted hydraulic conductivity relationships are presented on Figures 3-58 and 3-59. All but one sample were measured as part of the ongoing performance assessment for the low-level burial grounds. These samples came from sampling intervals of 30 to 43 m (98 to 142 ft) in Well 299-W7-9. The other sample was reported by Bjornstad (1990). This sample is from Well 299-W7-2 at a depth of 29 m (95 ft). The range in laboratory-measured saturated hydraulic conductivity is from 2×10^{-6} to 1.1×10^{-5} m/s (0.5 to 3 ft/day) for the samples from Well 299-W7-9. The sample from Well 299-W7-2 has a saturated hydraulic conductivity of 3.7×10^{-4} m/s (100 ft/day) which is thirty-times higher than the highest value measure in Well 299-W7-9. To account for this difference, a close examination of the well log from 299-W7-2 shows that this sample was taken very close to the contact with the Ringold unit E and may be part of the transition between these units.

Plio-Pleistocene Unit. This unit is hydrologically important because of the highly cemented calcic soils (caliche) which could cause lateral spreading and perched water table development from downward percolating water. Perched water table conditions are discussed in Section 3.5.2.1.3. Five drainage and four imbibition curves were used to generate the hydraulic conductivity functions shown on Figures 3-60 and 3-61 (Connelly et al. 1992). These curves show a high degree of variability for both saturated hydraulic

conductivities [1.3×10^{-8} to 1.3×10^{-6} m/s for samples from Well 299-W7-9 (calcrete) and 7.6×10^{-4} m/s for the sample from Well 299-W7-2 (calcic soils)] and saturated water content (33 to 52%). The variation between the samples taken from Well 299-W7-9 is partly due to differences in grain size and degree of cementation and compaction.

Early "Palouse" Soils. Two moisture retention curves and associated unsaturated hydraulic conductivity curves were generated for the early "Palouse" soils and reported by Connelly et al. (1992) (Figures 3-62 and 3-63). These soil samples were collected at depths of 21 to 21.6 m (69 to 71 ft) from Well 299-W7-9. Both of these samples were very fine-grained, comprised of fine sand and silt, with little variability between the samples. Measured laboratory saturated hydraulic conductivities were in the range of 1×10^{-6} m/s (0.3 ft/day). Additional data points would be required to assess formation variability.

Hanford Formation. Thirteen drying and six wetting curves and unsaturated hydraulic conductivity curves were generated for the Hanford formation (Figures 3-64 and 3-65). Samples were collected from Wells 299-W7-5, 299-W7-9, 299-W10-13, 299-W15-2, 299-W15-16, and 299-W18-21. Bjornstad (1990) reported results for soil samples collected from Wells 299-W7-5, 299-W10-13 [14 to 24 m (45 to 80 ft)], 299-W15-16, and 299-W18-21. Other samples were collected, evaluated as part of the performance assessment effort on the low-level waste burial grounds, and reported by Connelly et al. (1992). All of these samples, except sample 170 [299-W15-2, 30 m (100 ft) depth], were measured in the coarse-grained gravel facies. Sample 170 was measured in the fine-grained facies.

The measured saturated hydraulic conductivity values varied widely, ranging from 7×10^{-8} to 5.5×10^{-4} m/s (0.02 to 160 ft/day). Particle size analyses of the samples indicated that some of the samples were sand and silt rather than gravels. If these samples are eliminated, the range of saturated hydraulic conductivity for the gravel facies is much smaller, 1.1×10^{-4} to 5.5×10^{-4} m/s. It should be noted that calculated unsaturated conductivities range over several orders of magnitude at lower moisture contents and that finer-grained facies may have higher conductivities than a coarse-grained facies, for the same moisture content.

3.5.2.1.4 Perched Water Zones. The lateral extent and composition of the Plio-Pleistocene and early "Palouse" soil units may provide conditions amenable to the formation of perched water zones in the vadose zone above the unconfined aquifer in the 200 West Area. The calcic paleosol facies of the Plio-Pleistocene unit, consisting of calcium-carbonate-cemented silt, sand, and gravel, is a potential perching horizon due to its likely low hydraulic conductivity. However, the Plio-Pleistocene unit may be fractured and may have erosional scours in some areas, potentially allowing deeper infiltration of groundwater, a factor which may limit the lateral extent of accumulated perched groundwater. The early "Palouse" soil horizon, consisting of compact, loess-like silt and minor fine-grained sand, is also a likely candidate for accumulating moisture percolating

downward through the sand and gravel-dominated Hanford formation. As discussed in Section 3.5.1.4, the Plio-Pleistocene unit is present in the 200 West Area at elevations ranging from about 149 to 186 m (490 to 610 ft) above sea level, and the early "Palouse" soil is present at elevations ranging from about 152 to 192 m (500 to 630 ft) above sea level.

The following sections describe specific occurrences of documented or suspected perched water zones in the U Plant, Z Plant, and S Plant Aggregate Areas. Currently, no occurrences of perched water have been documented in the T Plant Aggregate Area, although the potential exists for accumulation of downward moving moisture above the Plio-Pleistocene unit near sources of natural or artificial recharge in that area. Also, information regarding hydraulic properties specific to the perched zones was found only for Well 299-W26-11 near the 216-S-10 Ditch, as discussed below for the S Plant Aggregate Area.

U Plant Aggregate Area. Within the U Plant Aggregate Area, perched water was encountered in three groundwater monitoring wells completed near the active portion of the 216-U-14 Ditch. The ditch is located about 150 m (492 ft) southeast of the 241-U Tank Farm. The wells (299-W19-91, 299-W19-92, and 299-W19-93) are each screened at a depth of about 30 to 36 m (100 to 120 ft) below ground surface (bottom of screened interval elevation around 169 m (555 ft) above mean sea level). This elevation is about 3 m (10 ft) above the top of the early "Palouse" soil, and thus, into the Hanford formation based on the contours shown on Figures 3-37 and 3-39. Water levels in these wells were measured in December 1989 through September 1990. Wells 299-W19-91 and 299-W19-92 had an average water level of 172 m (563 ft) above sea level and Well 299-W19-93 (the most southerly of the three) had a level of about 176 m (576 ft), some 4 m (13 ft) higher. The water levels measured in these wells are probably indicative of perched water zones in the early "Palouse" soil above the Plio-Pleistocene unit.

A perched zone appears to exist under the 216-U-1 and 216-U-2 Cribs and extends at least as far as the 216-U-16 Crib. Apparently, extremely large volumes of liquid discharged to the 216-U-16 Crib (close to 5 x 10^8 L over its brief operational history) produced a perched water zone on top of the Plio-Pleistocene unit. In the area of the 216-U-1 and 216-U-2 Cribs, the perched water zone was approximately 24 to 27 m (80 to 90 ft) thick. No wells appear to screen this zone in this portion of the site. The existence of the perched zone was inferred from the detection of contaminants disposed of to the 216-U-1 and 216-U-2 Cribs in a groundwater monitoring well completed downgradient of the 216-U-16 Crib.

Goodwin (1990) presents the results of slug tests in four wells installed at the 216-U-12 Crib in 1990, although review of the screen depths and well logs indicates that these wells may be screened in a small section of the upper Ringold which is likely to be different (and lower in conductivity) than the main aquifer in the middle Ringold.

Z Plant Aggregate Area. Perched water was reportedly encountered during drilling of groundwater Monitoring Well 299-W18-29. The well is located near the southern end of the 216-Z-20 Crib, near the Z Plant/U Plant Aggregate Area boundary. The well is screened between 169 m (555 ft) and 164 m (539 ft) above sea level, intersecting the Plio-Pleistocene unit. Water has been reported in this well; however, a current water level is not available. The presence of water in this zone is likely due to waste disposal practices at the 216-Z-20 Crib.

Perched water was encountered in May 1992 during groundwater well drilling southeast of the 216-Z-9 Trench. The well is located about halfway between the 216-Z-9 Trench and the 216-Z-21 Seepage Basin. Reportedly, perched water was encountered between about 29.6 m (97 ft) and 35.2 m (115.5 ft) below ground surface [approximately 70 to 165 m (558 to 541 ft) above mean sea level], and is perched on top of the Plio-Pleistocene unit. Based on preliminary soils data from the well, the top of the perched zone extends just above the top of the early "Palouse" soil into the lower-most Hanford formation.

S Plant Aggregate Area. It is reported that in 1966, perched water was detected at approximately 43 m (140 ft), or 164 m (538 ft) above sea level, in Wells 299-W22-26 and 299-W22-27A. These wells are located near the 216-S-9 Crib, which was active at the time but is no longer used for liquid waste disposal. More recently perched water was detected at approximately 38 m (125 ft), or 167 m (548 ft) above sea level, in Well 299-W-26-11 and at approximately 45 m (146 ft), or 160 m (525 ft) above sea level, in Well 299-W-26-12. A hydraulic conductivity value of 2×10^{-8}m/s (0.006 ft/day) was measured at test interval depth range of 37.5 to 42.4 m (123 to 139 ft) in Well 299-W26-11. These wells are located near the 216-S-10 Ditch which is no longer active. Waste disposal activities were taking place when the perched water was identified in the wells.

3.5.2.2 200 West Area Groundwater Recharge. Recharge for the unconfined portion of the uppermost aquifer within the 200 West Area is from artificial and possibly natural sources. If natural recharge occurs, it is only from precipitation as there are no natural surface water bodies within the 200 West Area. Artificial recharge occurs from several active and recently active cribs, trenches, ditches, ponds, and drains located throughout the 200 West Area, as well as from leaks in pipelines, transfer lines, and spills.

3.5.2.2.1 Natural Recharge. Within the 200 West Area, natural recharge originates from precipitation. As discussed in Section 3.2.1, annual precipitation for the 200 West Area is approximately 16 cm (6.3 in.). Evapotranspiration of precipitation is considered to reduce the amount of precipitation that reaches the groundwater. Estimates for the percentage of evapotranspiration range from 38 to 99%. The variability of the effect of evapotranspiration is discussed by Gee (1987). Gee included an analysis for recharge from precipitation for two different soil types. One type, a fine-textured soil with deep-rooted

vegetation, contributed recharge at a maximum rate of 0.10 cm/yr (0.04 in./yr). A second type included a coarse-grained soil (gravel) devoid of vegetation. Recharge rates for this soil type were two orders of magnitude greater at 10 cm/yr (4 in./yr). Using the more conservative figure of 0.10 cm/yr (considering that much of the 200 West Area is covered by sparse vegetation and eolian sands), the total annual natural recharge volume for the 200 West Area can be estimated approximately at 130,000,000 L/yr (34,000,000 gal/yr). These values are significantly lower (approximately one order of magnitude) than the volumes of recharge historically contributed by artificial sources throughout the 200 West Area (Graham et al. 1981).

3.5.2.2.2 Artificial Recharge. Artificial recharge to the groundwater system began in late 1944 and has continued to the present. Sources of artificial recharge include cribs, ditches, trenches, ponds, basins, and drains. The following sections discuss sources of artificial recharge within the U, Z, S, and T Plant Aggregate Areas, respectively. The location of these facilities are shown in Plate 1. Quantities of discharge to these facilities are shown in Table 2-2.

Artificial Recharge in the U Plant Aggregate Area. The principal source of artificial recharge within the U Plant Aggregate Area during the Hanford Site operational period has been the 216-U-10 Pond, which was closed at the end of 1984. Other sources that have been active and have discharged significant volumes of wastewater to soils within the U Plant Aggregate Area include the 216-U-1 and -2, 216-U-3, 216-U-8, 216-U-12, and 216-U-16 Cribs. Currently the only active waste management units are the 216-U-17 Crib and portions of the 216-U-14 Ditch. The 216-U-14 Ditch, which currently receives water from a hydrant, is scheduled for closure as a Resource Conservation and Recovery Act (RCRA) facility in late 1994.

There are also four septic tank and drain fields that are actively discharging water to the soil. These are the 2607-W-5, 2607-W-7, 2607-W-9, and 2607-WUT Drain Fields. The combined discharge volumes are estimated at 12,120 L/day (3,202 gal/day), according to the Waste Information Data System (WIDS) database (WHC 1991a). The combined amount of wastewater discharged from these facilities between 1944 and 1992 is therefore estimated to be 166 billion liters (44 billion gallons).

Artificial Recharge in the S Plant Aggregate Area. Principal historical sources of artificial recharge within the S Plant Aggregate Area include the 216-S-10, -11, -16, -17, and -19 Ponds, and the 216-S-1, -2, -5, -7, and -25 Cribs. Other sources that have been active within the S Plant Aggregate Area include the 216-S-9, -13, -20, and -23 Cribs, the 216-S-12 and -18 Trenches, and the 216-S-15 Pond. Currently there are two facilities that are active within the S Plant Aggregate Area: the 216-S-25 and 216-S-26 Cribs. The 216-S-10 Ditch was closed in October 1991.

There are also two septic tank and drain fields active within this aggregate area. These include the 2607-W-6 and 2607-W-7 Drain Fields. The combined amount of wastewater discharged from these facilities between 1944 and the 1992 estimated to be 68 billion liters (17.8 billion gallons).

Artificial Recharge in the T Plant Aggregate Area. The principal historical sources of artificial recharge within the T Plant Aggregate Area include the 216-T-4A and B Ponds, the 216-W-LWC and 216-T-18 Cribs, and the 216-T-1 Ditch. Other sources that have contributed significant volumes of wastewater discharge to the soil include the 216-T-6, -7TF, -8, -19TF, -26, -27, -28, -32, and -34 Cribs, and the 216-T-12 and 216-T-13 Trenches. There are three active waste management units within the T Plant Aggregate Area, which include the 216-W-LWC Crib, the 216-T-1 Ditch, and the 216-T-2 Ditch.

There are also six septic tank and drain fields reported to be active within the T Plant Aggregate Area. These include the 2607-W1, -W2, -W3, -W4, -WT, and -WTX Drain Fields. The combined amount of wastewater discharge from these facilities between 1944 and 1992 is estimated to be 2.1 billion liters (550 million gallons).

Artificial Recharge in the Z Plant Aggregate Area. The principal historical sources of artificial recharge within the Z Plant Aggregate Area include the 216-Z-1 -2, -3, -5, -6, -9, -12, -16, -18, and -20 Cribs and the 216-Z-4, and -17 Trenches. Active waste management units within the Z Plant Aggregate Area include five septic tank and drain fields (2607-Z, 2607-Z-8, 2607-WA, -WWA, and 2607-W-8). The combined amount of wastewater discharged to these facilities is estimated to be approximately 624 million liters (165 million gallons).

3.5.2.3 200 West Area Groundwater Flow. Groundwater has been actively monitored at the Hanford Site since 1944. This monitoring has been in response to artificial wastewater discharges to the soils which have impacted the natural flow system of the groundwater beneath the Hanford Site. Several monitoring programs, discussed in Section 2.8, have been implemented in the past to monitor response of the unconfined aquifer to discharges from various artificial sources throughout the Hanford Site.

3.5.2.3.1 Unconfined Aquifer.

Historic Groundwater Flow Conditions. Data regarding groundwater conditions prior to the construction and operation of the Hanford Site are not available. However, the pre-Hanford groundwater flow conditions have been presented by Kipp and Mudd (1973). This "hindcast" map was developed from well data accumulated between 1948 and 1951.

Prior to the initiation of waste disposal activities at the Hanford Site in the mid-40's, groundwater elevations across the 200 West Area varied from approximately 126 m (415 ft)

above sea level at the western boundary to approximately 123 m (405 ft) at the eastern boundary (Figure 3-46). The general groundwater flow direction appears to have been from west to east across the site with an average hydraulic gradient of 0.001 (Graham et al. 1981). These flow lines are shown on Figure 3-66. Vertical gradients within the upper unconfined aquifer were probably negligible although a slight upward gradient was present between the lower basalt aquifers and the upper unconfined aquifer due to recharge to the basalt aquifers at higher elevations at the edge of the Pasco Basin.

A natural decrease in hydraulic gradient appears to occur just west of 200 East Area after groundwater has flowed from the west through an area with a greater hydraulic gradient between the 200 West and 200 East Areas. This may be due partially to the fact that the Ringold Formation, which exhibits lower hydraulic conductivities than the Hanford formation, thins to the east and so the flow moves into the more permeable Hanford formation, and to the fact that the basalt dips in a southeasterly direction which increases the saturated thickness of the unconfined aquifer.

Waste disposal activities at the Hanford Site have greatly influenced the character of the unconfined aquifer. Within the 200 West Area, discharges to the various waste management units have created a groundwater mound in the vicinity of the now closed 216-U-10 Pond. Conditions of the unconfined aquifer have varied with the amount of wastewater discharge from the various waste management units. These changes are shown on a series of groundwater contour maps for historical periods.

Figures 3-65 through 3-72 show groundwater contour elevations and flow directions for the years 1944, 1951, 1955, 1965, 1970, 1973, and 1987. These maps were updated here to show groundwater flow directions. The following discussion focuses on the historical effects that waste disposal practices have had on the dynamics of the unconfined aquifer.

Groundwater Flow from 1944 to 1955. Groundwater levels increased dramatically between 1944 and 1955 (Figures 3-66 and 3-68). Artificial recharge from wastewater discharges created a mound under the active 216-U-10 Pond. The elevation of groundwater in the vicinity of the mound increased by approximately 23 m (75 ft) during this time. Groundwater elevations within the upper Cold Creek valley rose 15 m (50 ft) in response to artificial recharge from agricultural irrigation. Groundwater mounding under the 216-U-10 Pond has altered the general west to east groundwater flow direction to more of a radial configuration under the 200 West Area (Figure 3-64). Flow gradients increase to the east of the mound, and west of the mound the flow direction has temporarily reversed and redirected flows to the north and south. Groundwater flowing to the west due to this gradient reversal appears to have headed toward the gap between Yakima Ridge and Gable Butte. The 1955 groundwater contour map also shows the mound is located somewhat north of the 216-U-10 Pond. This may be due to wastewater discharges from T Plant Aggregate Area sources.

Groundwater Flow from 1955 to 1965. The 1965 groundwater contour map (Figure 3-69) shows that the center of the mound has shifted slightly to the south in the vicinity of the 216-U-10 Pond. This shift may be due to increased wastewater discharges from facilities in the S and U Plant Aggregate Areas from 1955 to 1965. The hydraulic gradient east of the mound has increased slightly while flow west of the mound has decreased in response to elevated groundwater levels from irrigation in the upper Cold Creek valley. Groundwater flow is outward from the center of the groundwater mound in a northerly, southerly, and easterly direction.

Groundwater Flow from 1970 to 1973. The configuration of the groundwater contours from 1970 to 1973 remains relatively constant during this period (Figures 3-69 and 3-71). Flow outward from the mound towards the west has shifted towards the north with a greater component of flow toward Gable Gap and the gap west of Gable Butte. A slight increase is also evident in groundwater levels within the upper Cold Creek valley. Groundwater flow directions are still generally radial outward from the center of the mound but the gradient reversal no longer exists (Figures 3-70 and 3-71).

Groundwater Flow from 1987 to 1991. Groundwater elevations have declined significantly between 1987 and 1991 (Figures 3-72 and 3-78). During the last half of the 1980's, the water table declined in excess of 3 m (10 ft), primarily from the decommissioning of the 216-U-10 Pond in the fall of 1984 (Newcomer et al. 1990). The greatest decreases of groundwater elevations during this period are in the vicinity of the U Pond. Also evident during this period is the continued influence of irrigation recharge within the upper Cold Creek valley. This may be responsible for maintaining elevated water levels north and west of the 200 West Area.

Well hydrographs prepared for the four aggregate areas within the 200 West Area, and presented on Figures 3-73 through 3-76, show the response over time of the unconfined aquifer to wastewater discharges from 200 West facilities. Also shown on these hydrographs are the historical operational periods of the waste management units located within each aggregate area.

Hydrographs from seven wells within the U Plant Aggregate Area are plotted in Figure 3-73. These wells all appear to be significantly impacted by historical discharges from the U Plant and REDOX Plant (S Plant). After the shutdown of the S Plant in 1967, water levels dropped several feet through 1973. The return rise to a plateau at these earlier levels started in about 1974 which must be attributed to increased discharges to the 216-U-10 Pond, although the major contributor to this facility, the 202-S Evaporator, did not go on line until 1975. The retirement of the evaporator in 1980 had only a minor effect on the groundwater elevations, but the subsequent decommissioning of the 216-U-10 Pond in 1984 began a steady decline in the water levels. The general consistency (parallelness) of the hydrographs in Figure 3-73 indicates that, in general, the direction and approximate gradient

have been maintained during the period of observation. Also evident is that as distance from the center of the mound increases the water levels drop off rapidly. This decrease is most pronounced in a easterly direction where the water levels drop off roughly 21.3 m (70 ft) in 4.8 km (3 mi).

Hydrographs were prepared for six wells within the Z Plant Aggregate Area (Figure 3-74). The general trend of water levels within the Z Plant Aggregate Area are very similar to those of the T Plant Aggregate Area.

Hydrographs are included for ten wells within the S Plant Aggregate Area (Figure 3-75). Wells 299-W23-1 and -4, 299-W22-7, -8, -11, -14, and -17, and 299-W26-3 are all near the center of the S Plant Aggregate Area and show the most influence due to wastewater discharges. Wells 299-W21-1 and 299-W22-19 are located east and south of the S Plant Aggregate Area and show much less of an effect. The general trend of water levels within the S Plant Aggregate Area is very similar to those of the U Plant Aggregate Area discussed above.

Twelve wells are used to prepare hydrographs for the T Plant Aggregate Area (Figure 3-76). These include Wells 299-W6-1, 299-W10-1, -2, and -5, 299-W11-2, -7, -10, -12, and -13, 299-W12-1, and 299-W14-1 and -2. The hydrographs from these wells show that for the T Plant Aggregate Area there are two periods where artificial discharge has significantly impacted the groundwater levels. During the time from 1949 to 1956 the water table rose in the vicinity of Well 299-W10-1 to a peak of approximately 148 m (485 ft) above mean sea level. Several waste management units were active during this time, including the 216-T-6, -7TF, -8, -18, -26, and -32 Cribs, 216-T-4A Pond, the 216-T-5 Trench, and the 216-T-1 Ditch. This period corresponds to the slight northward shift of the groundwater mound under the 200 West Area (Figure 3-67). During the time from 1944 to 1958 these waste management units discharged approximately 146 million liters (38 million gallons) of wastewater (T Plant AAMS). These wells also show the effect of discharges to the 216-U-10 Pond (1944 to 1985).

Groundwater Flow Velocities. Groundwater flow in the unconfined aquifer within the 200 West Area occurs primarily within the Ringold fluvial gravel unit E. Prior to activity at the Hanford Site (1944), the horizontal hydraulic gradient across the 200 West Area averaged 0.001 (Graham et al. 1981; Last et al. 1989). The calculated natural flow velocity [approximated from the 1944 contour map presented in Kipp and Mudd (1973)] varied from approximately 0.001 to 0.07 m/day (0.0032 to 0.23 ft/day) and was directed eastward across the 200 West Area. Hydraulic gradients significantly increased as the groundwater elevations increased beneath and to the west of the 200 West Area. Maximum hydraulic gradients were approximately 0.005 and were directed east to northeast. The associated flow velocities ranged from approximately 0.005 to 0.35 m/day (0.016 to 1.15 ft/day).

Vertical Hydraulic Gradients. Groundwater monitoring wells that are screened within the upper portion of the unconfined aquifer exhibit a greater head than the few wells that are screened in the lower portion of the unconfined aquifer. This difference in groundwater levels indicates a downward vertical gradient. Wells 299-W7-2 and 299-W7-3 are located in the northern portion of the 200 West Area and are screened in the upper and lower portion of the unconfined aquifer within 6 m (20 ft) of each other. Plots of hydrographs from these wells are shown on Figure 3-77. The approximate value of the vertical hydraulic gradient for these wells is calculated to be 0.0044. As the amount of discharge from the waste management units decreases, the vertical gradients between these wells are also anticipated to decrease.

The lower mud sequence of the Ringold Formation occurs in all but the extreme north-northeast areas of the 200 West Area (Figure 3-28). Where this unit is present it acts as an aquitard separating the basal Ringold gravel (unit A) from the upper unconfined aquifer. Thus local confined conditions apparently exist in the lower portion of what is otherwise the unconfined aquifer. The thickness of the lower mud unit and its low hydraulic conductivity [2×10^{10} m/s (5.3×10^{-5} ft/day)] are probably sufficient to preclude a significant amount of recharge between the unconfined aquifer and the confined basal gravel A.

Current Groundwater Flow Conditions. Groundwater elevations in December 1991 for the uppermost aquifer are shown in Figure 3-78 (Kasza et al. 1992). Groundwater flow is generally towards the east, in the direction of the 200 East Area, and north through Gable Gap. The groundwater mound beneath the 216-U-10 Pond continued to dissipate and seems to be shifting towards the northeast in response to discharges from recent Z Plant activities, including the 216-U-14 Ditch and 216-Z-20 Crib. The presence of the mound has created larger than normal hydraulic gradients within the 200 West Area. The groundwater contours shown on Figure 3-78 steepen near the eastern side of the 200 West Area. This may be due to lower hydraulic conductivities in this portion of the Ringold Formation. Present day gradients exceed 0.01; vertical downward hydraulic gradients have exceeded 10% of this in some areas (Graham 1981).

As the mound continues to dissipate, horizontal hydraulic gradients are also expected to decrease and return to the natural direct easterly direction. Groundwater movement west of 216-U-10 Pond continues to be redirected around the mound. As flow from the mound proceeds to the east, gradients are fairly steep, but where the groundwater eventually exits the 200 West Area, they flatten out. This flattening out of the gradient is due in part to the increase in the depth of basalt, which increases the thickness of the saturated zone, and the increased hydraulic conductivity as the flow enters the Hanford formation. The difference of saturated thickness in this area causes the decrease in groundwater flow velocities.

The regional flow direction as discussed previously is from west to east, but this flow has been greatly affected by the artificial discharges from waste management units throughout the 200 West Area. The mound has shifted slightly to the northeast toward beneath the 216-U-14 Ditch which indicates that a sizable amount of wastewater continues to be disposed of at this facility.

Hydraulic gradients for December 1991 can be calculated for groundwater flow paths based on the contours presented in Figure 3-77 for the potentiometric surface of the uppermost aquifer. Hydraulic gradients (based on these contour lines) on the eastern slope of the mound are approximately 0.004. The gradient on the northeasterly side of the mound is approximately 0.002. The velocity of the groundwater in these directions [assuming a hydraulic conductivity of 1×10^{-5} to 8×10^{-4} m/s (3.2 to 230 ft/day) and an average porosity of 0.2] is approximately 0.02 to 1.4 m/day (0.065 to 4.6 ft/day) in the easterly direction and approximately 0.01 to 0.7 m/day (0.03 to 2.5 ft/day) in the northerly direction.

Well hydrographs for selected wells within the S and U Plant Aggregate Areas show generally declining groundwater elevations for the past six years (Figures 3-79 and 3-80). This period correlates with the closure of the U Pond. There is a slight difference in the amount of decrease per year for the two sources. S Plant wells show an average decline of about 0.37 m/yr (1.22 ft/yr) whereas the U Plant wells show an average decrease of about 0.27 m/yr (0.91 ft/yr). This may be because the wells that were selected within the S Plant are closer to the center of the mound whereas those for the U Plant are located to the east of the center of the mound.

If the current water levels continue to drop at approximately 0.34 m/yr (1 ft/yr), it is possible that the northwesterly component of the hydraulic gradient will become negligible and the gradient will approach the pre-Hanford value of approximately 0.001 within 20 years. This change will in turn direct a larger component of groundwater flow towards the east and southeast away from Gable Gap. However, future discharges from active waste management units will continue to influence the water levels and thus gradient and flow directions.

3.5.2.3.2 Basalt Aquifers.

Historic Groundwater Conditions. The main occurrence of groundwater in the basalt sequence beneath the 200 West Area is in the interbeds of the Ellensburg Formation. These interbed units generally offer the least resistance (greatest permeability) for flow. The principal basalt aquifers within the 200 West Area include the three interbeds of the Ellensburg Formation within the Saddle Mountains Basalt Formation (Rattlesnake Ridge, Selah, Cold Creek) and the Mabton interbed which separates the Saddle Mountains and Wanapum basalt formations. Hydraulic properties of these interbeds are presented in Section 3.5.2.1.4.

The uppermost aquifer within the basalt is the Rattlesnake Ridge interbed. The Rattlesnake Ridge interbed is confined between the upper Elephant Mountain Member above and the Pomona Member below. The interbed is 15 to 25 m (50 to 82 ft) thick beneath the 200 West Area and generally thickens towards the west (Graham et al. 1981; 1984). There are no reported erosional windows through the Elephant Mountain Member to higher aquifers within the 200 West Area. Figure 3-48 shows the most complete groundwater levels for the Rattlesnake Ridge interbed. Also superimposed on this map are the water table elevations for the uppermost unconfined aquifer. In general there is a greater head within the unconfined aquifer than in the lower Rattlesnake Ridge interbed over the entire 200 West Area.

This relationship shows that for the 200 West Area, a downward vertical gradient exists between the unconfined and uppermost confined basalt aquifer. The groundwater flow within the Rattlesnake Ridge interbed appears to be radially outward from the 200 West Area with a component of flow through the gaps to the north as well as eastward towards the Columbia River.

This flow pattern is similar to the flow of the unconfined aquifer which may suggest that flow within the Rattlesnake Ridge aquifer is influenced by seepage from the upper unconfined aquifer.

Considerably less data are available for the deeper Selah, Cold Creek, and Mabton interbeds. Generally flow through these interbeds is in a similar direction to that in the Rattlesnake Ridge interbed, from west to east across the 200 West Area. A slight upward gradient has been reported within these interbeds (Ledgerwood and Deju 1976).

3.5.2.3.3 Uppermost Aquifer/Basalt Aquifer Intercommunication. The groundwater potentiometric map averaged across the Rattlesnake Ridge, Selah, and Cold Creek aquifers is presented in Figure 3-48 (DOE 1988). A comparison of the potentiometric surfaces of the Rattlesnake Ridge interbed and the uppermost aquifer is presented in Figure 3-50. The figures show that a downward vertical gradient exists for some locations within the separation areas. No erosional windows within the Elephant Mountain Basalt Member (uppermost basalt unit within the 200 West Area) have been identified within the 200 West Area, whereas they have been identified in the vicinity of Gable Gap, north of the 200 West Area, and north of the 200 East Area. Nevertheless, secondary fractures (created from cooling, settlement, and faulting), discussed in Section 3.4.2.1.2, are present within many of the basalt flow interiors (DOE 1988). The presence of these features coupled with the downward vertical gradient could allow groundwater to flow from the uppermost aquifer into these confined aquifers.

Groundwater levels have risen in response to artificial recharge from both wastewater discharges in the 200 Areas as well as from agricultural irrigation in the upper Cold Creek

valley. The elimination of wastewater discharges from waste management units on the Hanford Site will eventually dissipate the mounds that have existed under the 216-U-10 Pond (200 West Area) and the 216-B-3 Ponds (200 East Area). But groundwater elevations will still remain higher than those present in 1944 due to the artificial recharge from irrigation and sanitary wastewater discharge within the 200 West Area. These levels may continue the downward vertical gradient between the uppermost and basalt aquifers over much of the 200 East and West Areas.

3.6 ENVIRONMENTAL RESOURCES

The following sections discuss Hanford Site and 200 West Area environmental resources including flora and fauna (Section 3.6.1), land use (Section 3.6.2), and water use (Section 3.6.3).

3.6.1 Flora and Fauna

The Hanford Site is characterized as a cool desert or a shrub-steppe and supports a biological community typical of this environment. The 200 Areas Plateau in particular is represented by a number of plant, mammal, bird, reptile, amphibian, and insect species as discussed below.

3.6.1.1 Vegetation of the 200 Areas Plateau. The 200 Areas Plateau is characterized by native shrub steppe interspersed with large areas of disturbed ground with a dominant annual grass component. The native stands are classified as an *Artemisia tridentate/Poa sandbergii - Bromus tectorum* community (Rogers and Rickard 1977) meaning that the dominant shrub is big sagebrush (*Artemisia tridentate*) and the understory is dominated by the native Sandberg's bluegrass (*Poa sandbergii*) and the introduced annual cheatgrass (*Bromus tectorum*). Other shrubs that are typically present include gray rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*C. viscidiflorus*), spiny hopsage (*Grayia spinosa*), and occasionally antelope bitterbrush (*Purshia tridentate*). Other native bunchgrasses that are typically present include bottlebrush squirreltail (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread (*Stipa commode*), and prairie junegrass (*Koeleria cristata*). Common and important herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeraica munroana*), balsamroot (*Balsamorhiza careyana*), several milk vetch species (*Astragalus caricinus*, *A. sclerocarpus*, *A. succumbens*), long-leaf phlox (*Phlox longifolia*), the common yarrow (*Achillea millifolium*), pale evening-primrose (*Oenothera pallida*), thread-leaf phacelia (*Phacelia linearis*), and several daisy/fleabane species (*Erigeron poliospermus*, *E. Filifolius*, and *E. pumilus*). In all, well over 100 plant species have been documented to occur in native stands on the 200 Areas Plateau.

Disturbed communities on the 200 Areas Plateau are primarily the result of either mechanical disturbance or range fires. Mechanical disturbance, including construction activities, soil borrow areas, road clearings, and fire breaks, results in drastic changes to the plant community. This type of disturbance usually entails a complete loss of soil structure and total disruption of nutrient cycling. The principle colonizers of mechanically disturbed areas are the annual weeds Russian thistle (*Salsola kali*), Jim Hill mustard (*Sisymbrium altissimum*), and bur-ragweed (*Ambrosia acanthicarpa*). If no further disturbance occurs, the areas will eventually become dominated by cheatgrass. All of these annual weeds are occasionally found in native stands, but only at relatively low frequencies.

Range fires also have dramatic effects on the overall ecosystem, the most obvious being the complete removal of sagebrush from the community, and the rapid increase in cheatgrass coverage. Unlike the native grasses, the other important shrubs, and many of the perennial herbaceous species, sagebrush is unable to resprout from rootstocks after being burned. Therefore, there is no dominant shrub component in burned areas until sagebrush is able to become re-established from seed. Burning also opens the community to the invasion by cheatgrass which is capable of quickly utilizing the nutrients that are released through burning. The extensive cover of cheatgrass may then prevent the re-establishment of many of the native species, including sagebrush. The species richness in formerly burned areas is usually much lower than in native stands, often consisting of only cheatgrass, Sandberg's bluegrass, Russian thistle, and Jim Hill mustard, with very few other species.

The vegetation in and around the ponds and ditches on the 200 Areas Plateau is significantly different from that of the surrounding dryland areas. Several tree species are present, especially cottonwood (*Populus trichocarpa*) and willows (*Salix* spp.). A number of wetland species are also present including several sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), cattails (*Typha latifolia* and *T. angustifolia*), and pond-weeds (*Potamogeton* spp.).

3.6.1.2 Plant Species of Concern. The Washington State Department of Natural Resources, Natural Heritage Program classifies rare plants in the state of Washington in three different categories, depending on the overall distribution of the taxon and the state of its natural habitat. These categories are: *Endangered*, which is a "vascular plant taxon in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. Populations of these taxa are at critically low levels or their habitats have been degraded or depleted to a significant degree"; *Threatened*, which is a "vascular plant taxon likely to become endangered within the near future in Washington if factors contributing to its population decline or habitat degradation or loss continue"; and *Sensitive*, which is a taxon that is "vulnerable or declining, and could become endangered or threatened in the state without active management or removal of threats" (definitions taken from Natural Heritage Program [1990]). Of concern to the Hanford Site, there are two Endangered taxa, two Threatened taxa, and at least eleven Sensitive taxa; these are listed in

Table 3-2. All four of the Threatened and Endangered taxa are presently candidates for the Federal Endangered Species List.

Of the two Endangered taxa, persistantsepal yellowcress is well documented along the banks of the Columbia River throughout the 100 Areas, and is unlikely to occur in the 200 Areas. The northern wormwood (*Artemisia campestris* spp. *borealis*) is known in the state of Washington by only two populations, one across from The Dalles, Oregon, and the other near Beverly, Washington, just north of the Hanford Site. This taxon has not been found on the Hanford Site, but would probably occur only on rocky areas immediately adjacent to the Columbia River if it were present. Neither of the Threatened taxa listed in Table 3-2 have been observed on the Hanford Site. The Columbia milk vetch (*Astragalus columbianus*) is known to be relatively common on the Yakima Firing Range, and has been documented to occur within 1.6 to 3.2 km (1 to 2 mi) to the west of the Hanford Site on both sides of Umtanum Ridge. This species could occur on the 200 Areas Plateau. Hoover's desert parsley (*Lomatium tuberosum*) inhabits the steep talus slopes near Priest Rapids Dam. Potentially, it could be found on similar slopes on Gable Mountain and Gable Butte, but has yet to be documented in these areas.

Of the eleven Sensitive species, five are inhabitants of aquatic or moist habitats and the other six are inhabitants of dry upland habitats. Dense sedge (*Carex densa*), shining flatsedge (*Cyperus rivuloris*), southern mudwort (*Limosella acoulis*), and false-pimpernel (*Lindernia anagallidea*) are all known to occur in the 100 Areas, especially near the 100 B-C Area, in or near the Columbia River. Some of these species could be present in or near ponds and ditches in the 200 Areas. The few-flowered collinsia (*Collinsia sparsiflora* var. *bruciae*) may also occur in these habitats. The gray cryptantha (*Cryptantha leucophaea*) occurs on open dunes throughout the Hanford Site. Piper's daisy (*Erigeron piperianus*) is fairly common on Umtanum Ridge and Rattlesnake Ridge, but has also been documented in the vicinity of B Pond, the A-24 Crib, and 100-H Area. Bristly cryptantha (*Cryptantha interrupta*) and dwarf evening-primrose (*Oenothera pygmaea*) have been found at the south end of the White Bluffs, approximately 3.2 km (2 mi) upstream from the 300 Area. The Palouse milk vetch (*Astragalus arrectus*) and coyote tobacco (*Nicotiana attenuata*) are not as well documented but are known to inhabit dry sandy areas such as the 200 Areas Plateau.

In addition to the three classifications for species of concern listed above, the Natural Heritage Program also maintains a "Monitor" list, which is divided into three groups. Group 1 consists of taxa in need of further field work before a formal status can be assigned. The tooth-sepal dodder (*Cuscuta denticulata*), which has been found in the state of Washington only on the Hanford Site, is the only taxon in this group that is of concern to Hanford operations. This parasitic species has been found in the area west of McGee Ranch. Group 2 of the Monitor list includes species with unresolved taxonomic questions. Thompson's sandwort (*Arenaria franklinii* var. *thompsonii*) is of concern to Hanford operations. However, the representatives of this species in the state of Washington are now believed to

all be variety *franklinii* which is not considered particularly rare. Group 3 of the Monitor list includes taxa that are either more abundant or less threatened than previously believed. There are approximately 15 taxa on the Hanford Site that are included on this list.

3.6.1.3 Fauna of the 200 Areas Plateau. The mammals, birds, reptiles, amphibians inhabiting the 200 Areas Plateau are discussed below.

3.6.1.3.1 Mammals. The largest mammal occurring on the 200 Areas Plateau is the mule deer (*Odocoileus hemionus*). Although mule deer are much more common to riparian sites along the Columbia River, they are frequently observed foraging throughout the 200 Areas. Elk (*Cervus elaphus*) also occur at the Hanford Site but they have only been observed at the Arid Lands Ecology Reserve. Other mammal species common to the 200 Areas include badgers (*Taxidea taxus*), coyotes (*Canis latrans*), blacktail jackrabbits (*Lepus californicus*), Townsend ground squirrels (*Spermophilus townsendii*), Great Basin pocket mice (*Perognathus parvus*), pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging capability and have been implicated several times for encroaching into inactive burial grounds throughout the 200 Areas. The majority of the badger excavations in the 200 Areas are a result of badgers searching for prey (mice and ground squirrels). Coyotes are the principal predators, consuming such prey as rodents, insects, rabbits, birds, snakes and lizards. The Great Basin pocket mouse is the most abundant small mammal, which thrives in sandy soils and lives entirely on seeds from native and revegetated plant species. Townsend ground squirrels are not abundant in the 200 Areas but they have been seen at several different sites.

Other small mammals that occur in low numbers include the western harvest mouse (*Reithrodontomys megalotis*) and the grasshopper mouse (*Onychomys leucogaster*). Mammals associated more closely with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and some bat species. Bats probably play a minor role in the 200 Areas' ecosystem but no documentation is available on bat populations at the Hanford Site. Mammals such as skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), weasels (*Mustela* spp.), porcupines (*Erethizon dorsatum*), and bobcats (*Lynx rufus*) have only been observed on very few occasions.

3.6.1.3.2 Birds. Over 235 species of birds have been documented to occur at the Hanford Site (Landeen et al. 1991). At least 100 of these species have been observed in the 200 Areas. The most common passerine birds include starlings (*Sturnus vulgaris*), horned larks (*Ermophila alpestris*), meadowlarks (*Sturnella neglecta*), western kingbirds (*Tyranus verticalis*), rock doves (*Columba livia*), barn swallows (*Hirundo rustica*), cliff swallows (*Hirundo pyrrhonota*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Common raptors include the northern harrier (*Circus cyaneus*), American kestrel (*Falco sparvarius*), and red-tailed hawk (*Buteo jamaicensis*). Swainson's hawks (*Buteo swainsoni*) sometimes nest in the trees located at some of the army bunker sites that were used in the 1940's.

Golden eagles (*Aquila chrysaetos*) are observed infrequently. Burrowing owls (*Athene cunicularia*) nest at several locations throughout the 200 Areas. The most common upland game birds found in the 200 Areas are California quail (*Callipepla californica*) and Chukar partridge (*Alectoris chukar*); however, ring-necked pheasants (*Phasianus colchicus*) and gray partridge (*Perdix perdix*) may be found in limited numbers. The only native game bird common to the 200 Areas Plateau is the mourning dove (*Zenaida macroura*), which migrates south each fall. Other species of note which nest in undisturbed sagebrush habitats in the 200 Areas include sage sparrows (*Amphispiza belli*) and loggerhead shrikes (*Lanius ludovicianus*). Long-billed curlews (*Numenius americanus*) also use the sagebrush areas and revegetated burial grounds for nesting and foraging.

Waterfowl and aquatic birds visit 216-B-3 Pond and other areas where there is running or standing water. However, these areas (such as 216-A-29 Ditch) are becoming more scarce due to stabilization and remedial action cleanup activities. Aquatic birds and waterfowl common to 216-B-3 Pond on a seasonal basis include Canada geese (*Branta canadensis*), American coot (*Fulica americana*), mallard (*Anas platyrhynchos*), ruddy duck (*Oxyura jamaicensis*), redhead (*Aythya americana*), bufflehead (*Bucephala albeola*), and great blue heron (*Ardea herodius*).

3.6.1.3.3 Reptiles and Amphibians. Common reptiles include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Other reptiles and amphibians that are infrequently observed include sagebrush lizards (*Sceloporus graciosus*), horned toads (*Phryosoma douglassii*), western spadefoot toads (*Scaphiopus intermontana*), yellow-bellied racer (*Coluber constrictor*), Pacific rattlesnake (*Crotalus viridis*), and striped whipsnake (*Masticophis taeniatus*). Both lizards and snakes are prey of mammalian and avian predators.

3.6.1.3.4 Insects. There are hundreds of insect species that inhabit the 200 Areas. Two of the most common groups of insects include several species of darkling beetles and grasshoppers. Harvester ants are also common and have been implicated in the uptake of radionuclides from some of the burial grounds in the 200 Area. Harvester ants can excavate and bring up material from as far down as 5 to 6 m (15 to 20 ft). Other major groups of insects include bees, butterflies, and scarab beetles. Insects impact the surrounding plant community as well as serving as the prey base for many species of birds, reptiles and mammals.

3.6.1.4 Wildlife Species of Concern. Some animals which inhabit the Hanford Site have been given special status designations by the state and federal government. Some of these designations include state and federal threatened and endangered species, federal candidate, state monitor, state sensitive, and state candidate species. Species listed in Table 3-3 as state and\or federal threatened and endangered such as the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), American white pelican (*Pelecanus erythroryhnchos*),

ferruginous hawk (*Buteo regalis*), and sandhill crane (*Grus canadensis*) do not inhabit the 200 Areas. The bald eagle and American white pelican utilize the Columbia River and associated habitats for roosting and feeding. Peregrine falcons and sandhill cranes fly over the Hanford Site during migration. Ferruginous hawks nest on the Hanford Site but nesting has not been documented for this species on the 200 Areas Plateau. Other species listed in Table 3-3 as state and/or federal candidates and state monitor species such as burrowing owls, great blue herons, prairie falcons (*Falco mexicanus*), sage sparrows, and loggerhead shrikes are not uncommon to the 200 Areas Plateau.

3.7 HUMAN RESOURCES

The following sections provide an overview of the demography (Section 3.7.1), land use (Section 3.7.2), water use (Section 3.7.3), archaeology (Section 3.7.4), historical resources (Section 3.7.5), and community involvement (Section 3.7.6) relating to the Hanford Site and 200 West Area.

The environmental conditions at the 200 West Area must be evaluated in relationship to the surrounding population centers and other human resources. A very brief summary of demography, archaeology, historical resources, and community involvement is given below.

3.7.1 Demography

There are no residences on the Hanford Site. The nearest inhabited residences are farm homes on land located 10 km (6 mi) west of the 200 West Area at the orchard across from the Ste. Michelle vineyard, and on the farm next to the vineyard on Cold Creek and Highway 29. There are approximately 411,000 people living within a 80 km (50 mi) radius of the 200 Areas Plateau. The primary population centers are the cities of Richland, Kennewick, and Pasco, located southeast of the Hanford Site, Prosser to the south, Sunnyside to the southwest, and Benton City to the southeast.

3.7.2 Land Use

Operations in the 200 West Area have been related to nuclear fuels processing, separation, and recovery. Activities at the U Plant (uranium recovery), Z Plant (plutonium separation and recovery), and T and S Plants (initial uranium and plutonium separation and processing from irradiated fuel rods), are described in detail in Sections 2.2 and 2.3. Waste management units that remain active are noted in Table 2-1. A summary of the land use within each of these facilities is presented below.

Access to the entire Hanford Site is administratively controlled and is expected to remain this way to ensure public health and safety and for reasons of national security.

The U Plant Aggregate Area is the location of the U Plant and its attendant facilities and structures [Uranium Trioxide (UO_3) Plant, 271-U Building, 222-U Laboratory, etc.]. Past activities at U Plant and related facilities were mainly uranium extraction processes and the conversion of uranyl nitrate hexahydrate to UO_3, at the UO_3 Plant. Other buildings within the unit served mainly as storage or office space. Currently, the UO_3 Building is on standby status but is expected to begin operations again in 1992.

The Z Plant Aggregate Area is the location of the Z Plant and its attendant facilities (e.g., 234-5Z Building, 231-Z Building, 242-A Building, and other structures) and the 218-W Solid Waste Burial Grounds. Past activities at Z Plant included plutonium separation from waste streams generated in other 200 Areas facilities and plutonium and americium recovery from in-plant waste streams. Historically, liquid waste generated in Z Plant was disposed of to various land disposal units. Low-level and mixed waste from Z Plant, other Hanford facilities, and offsite facilities were deposited in the 218-W Burial Grounds. Various storage facilities, offices, and laboratories are also located in Z Plant.

The T Plant Aggregate Area is the location of the T Plant and its attendant facilities (e.g., 234-5T Building, 231-T Building, 242-T Building, and other structures) and the 218-W solid waste burial grounds. Past activities at T Plant included plutonium separation from waste streams generated in other 200 Areas facilities and plutonium and americium recovery from in-plant waste streams. Historically, liquid waste generated in T Plant was disposed of to various land disposal units. Low-level and mixed waste from T Plant, other Hanford facilities, and off-site facilities were deposited in the 218-W Burial Grounds. Various storage facilities, offices, and laboratories are also located in T Plant.

The S Plant Aggregate Area is the location of the S Plant (REDOX Plant) and its attendant facilities (e.g., 202-S Building, 222-S Analytical Laboratory, and other structures). The 202-S Building was constructed between May 1950 and August 1951. Operations continued through July 1967, when the plant was shut down. An analytical laboratory (222-S) near the facility is still operating. This laboratory supports B Plant operations and performs research and development in support of waste management and environmental control operations. Liquid wastes generated from T Plant were disposed of to various land disposal units.

3.7.3 Water Use

There is no consumptive use of groundwater within the 200 West Area. Water for drinking and emergency use, and facilities process water is drawn from the Columbia River, treated, and imported to the 200 West Area. The nearest wells used to supply drinking water are located at the Yakima Barricade (Well 699-49-100-C) about 5 km (3.1 mi) west of the 200 West Area; at the Hanford Safety Patrol Training Academy (Well 699-528-E0) about 40

km (25 mi) to the southeast; at the Hanford Safety Patrol Academy (Well 699-528-E0) about 40 km (25 mi) to the southeast; at the PNL Observatory (Well 6652-C); and near the Fast Flux Test Facility in the 400 Area (Well 699-S1-8J) about 32 km (20 mi) to the southeast. The nearest water supply wells located offsite are about 15 km (9.4 mi) to the northwest (upgradient). The latter wells obtain their water from the basalt and the basalt interbeds (the Berkshire Well and Chateau Ste. Michelle No. 1 and No. 2). Three wells for emergency cooling water are located near the B Plant in the 200 East Area and are reportedly used for irrigation although they may also be used to supply drinking water.

The environmental conditions at the 200 West Area must be evaluated in relationship to the surrounding population centers and other human resources. A very brief summary of demography, archaeology, historical resources, and community involvement is given below.

3.7.4 Archaeology

An archaeologic survey has been conducted of undeveloped portions of the 200 West Area by the Hanford Cultural Resources Laboratory. Isolated artifacts and sites of interest were identified in the vicinity of the 200 West Area. The closest site of interest is the remains of the White Bluffs Road which was previously an Indian trail, located approximately 1.6 km (1 mi) northwest of the U Plant Aggregate Area.

3.7.5 Historical Resources

The only historic site in 200 West Area is the old White Bluffs road which crosses diagonally through the vicinity. This site is not considered to be eligible for the National Register.

3.7.6 Community Involvement

A Community Relations Plan (CRP) (Ecology et al. 1989) has been developed for the Hanford Site Environmental Restoration Program which includes any potentially affected community with respect to the 200 West Groundwater AAMSR. The CRP includes a discussion on analysis of key community concerns and perceptions regarding the project, along with a list of all interested parties.

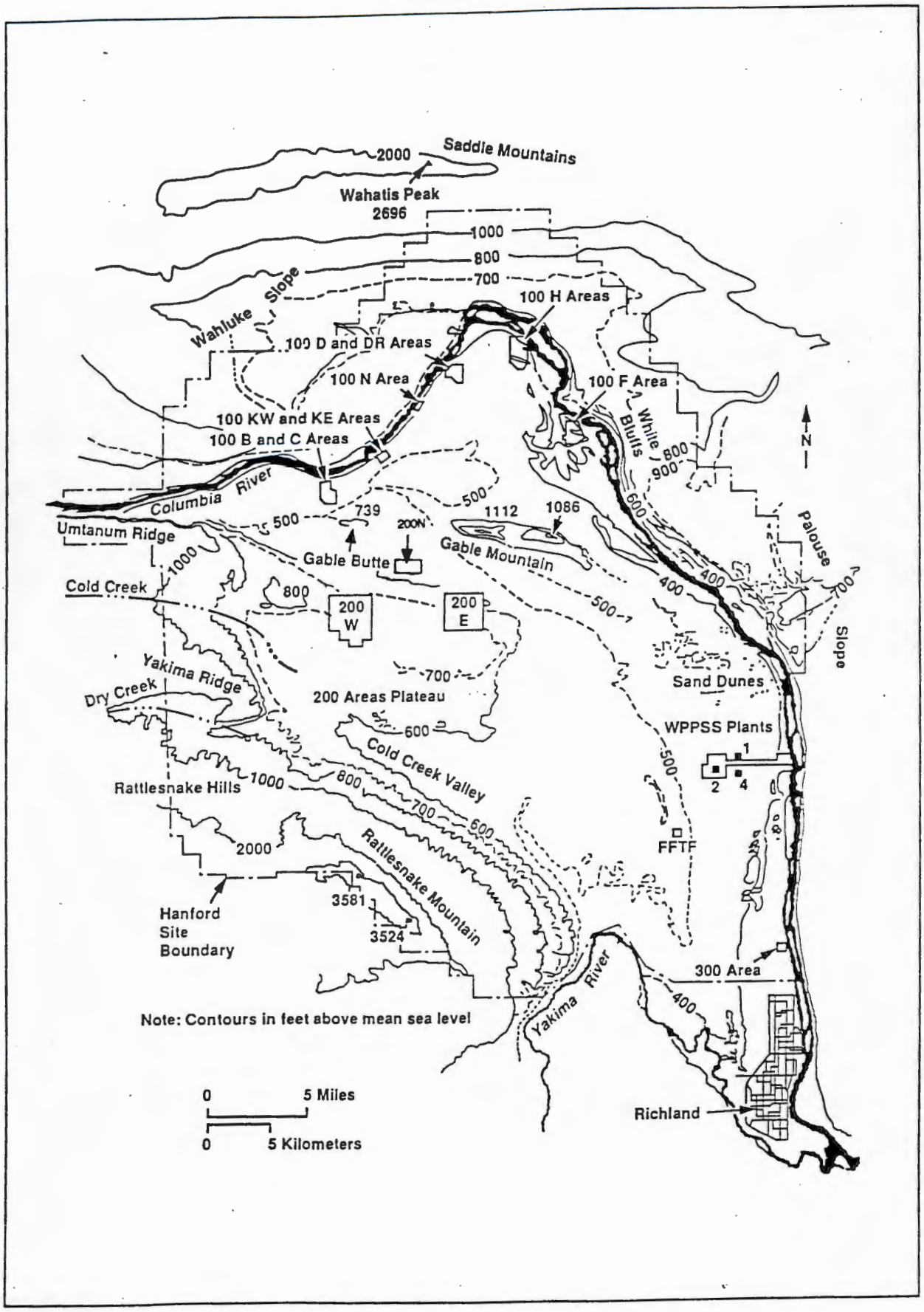

Figure 3-1. Topography and Location Map for the Hanford Site.

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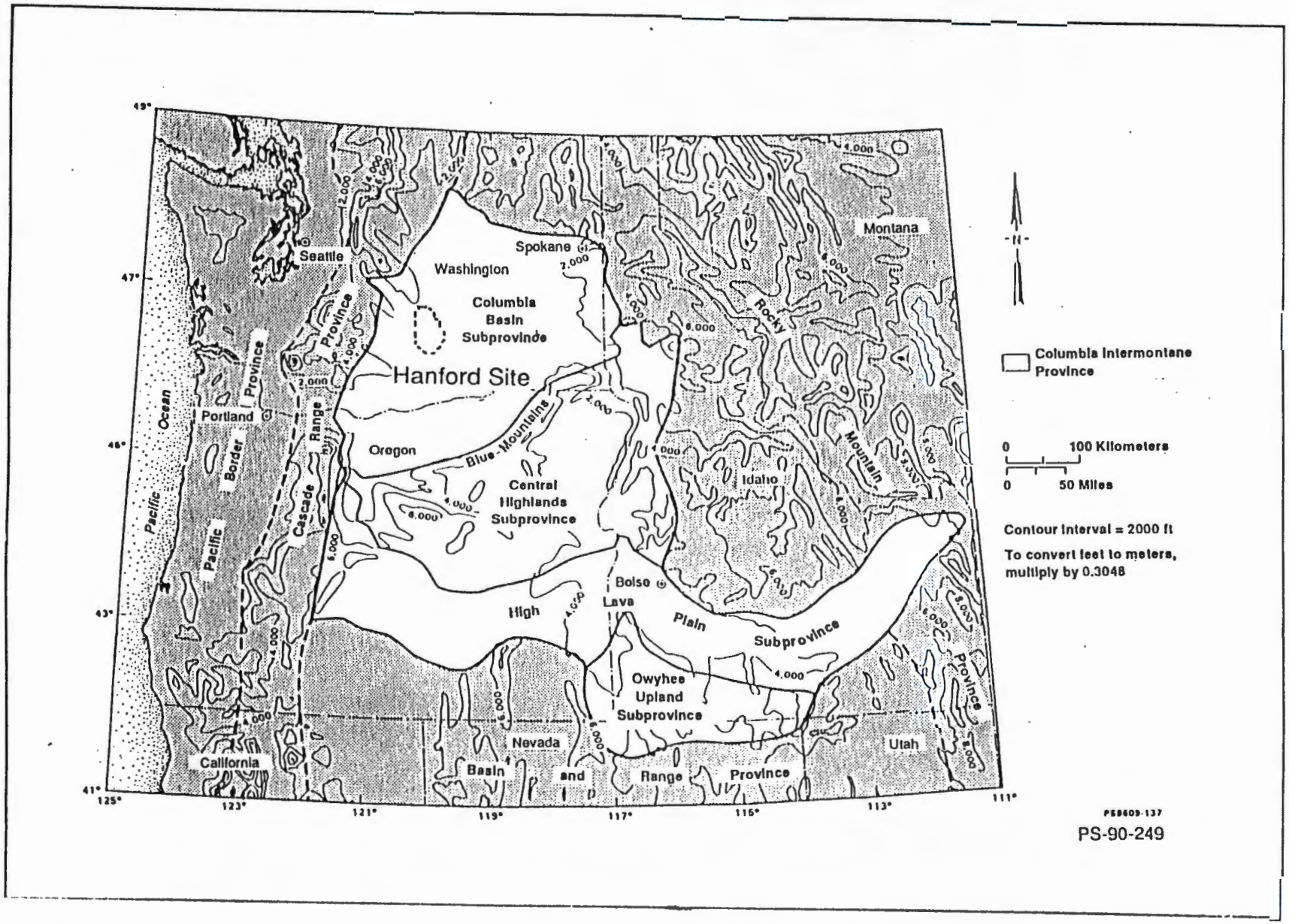

Figure 3-2. Divisions of the Columbia Intermontane Province and Adjacent Snake River Plains Province (DOE 1988).

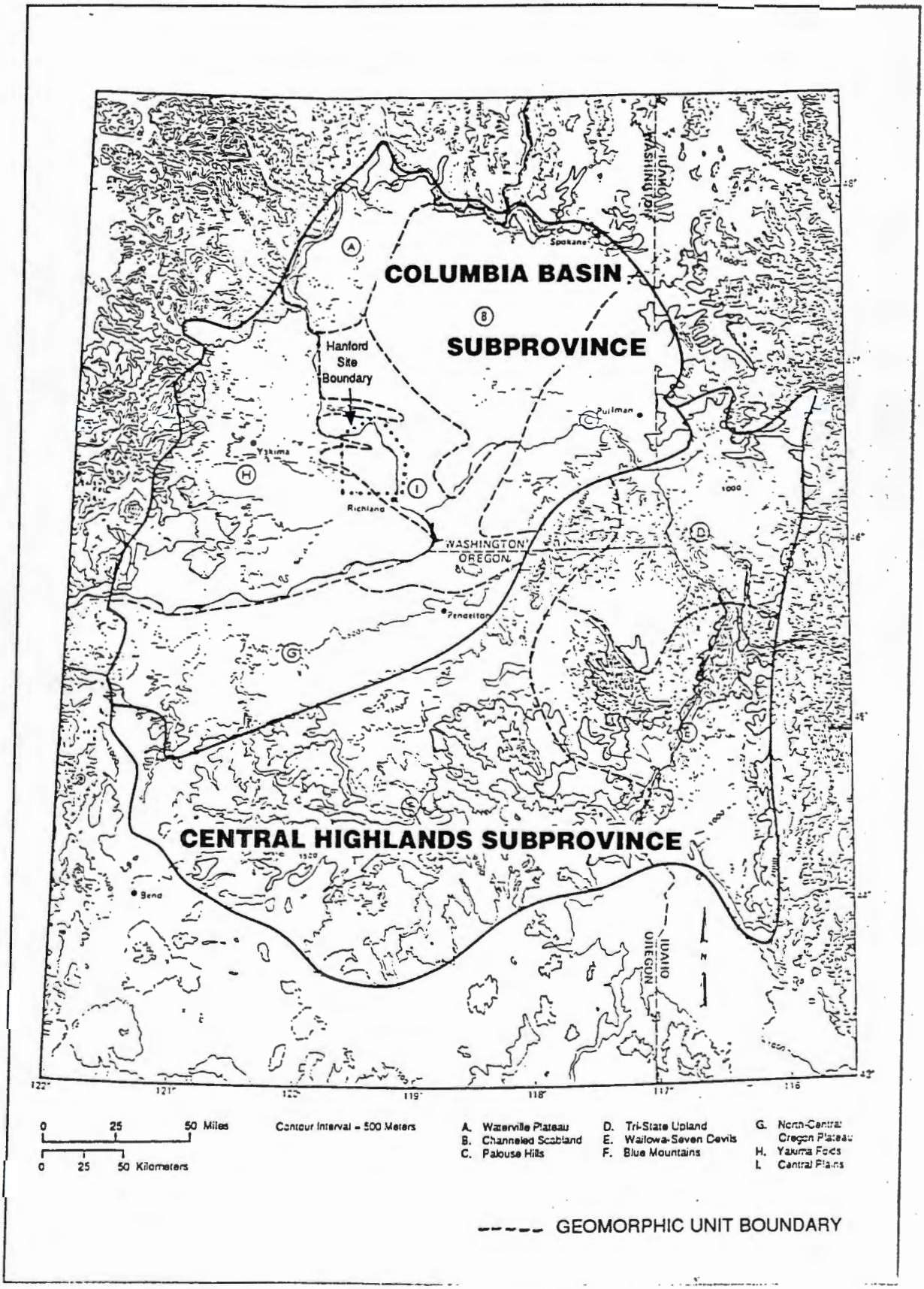

Figure 3-3. Geomorphic Units Within the Central Highlands and Columbia Basin Subprovinces that Contain the Columbia River Basalt Group (DOE 1988).

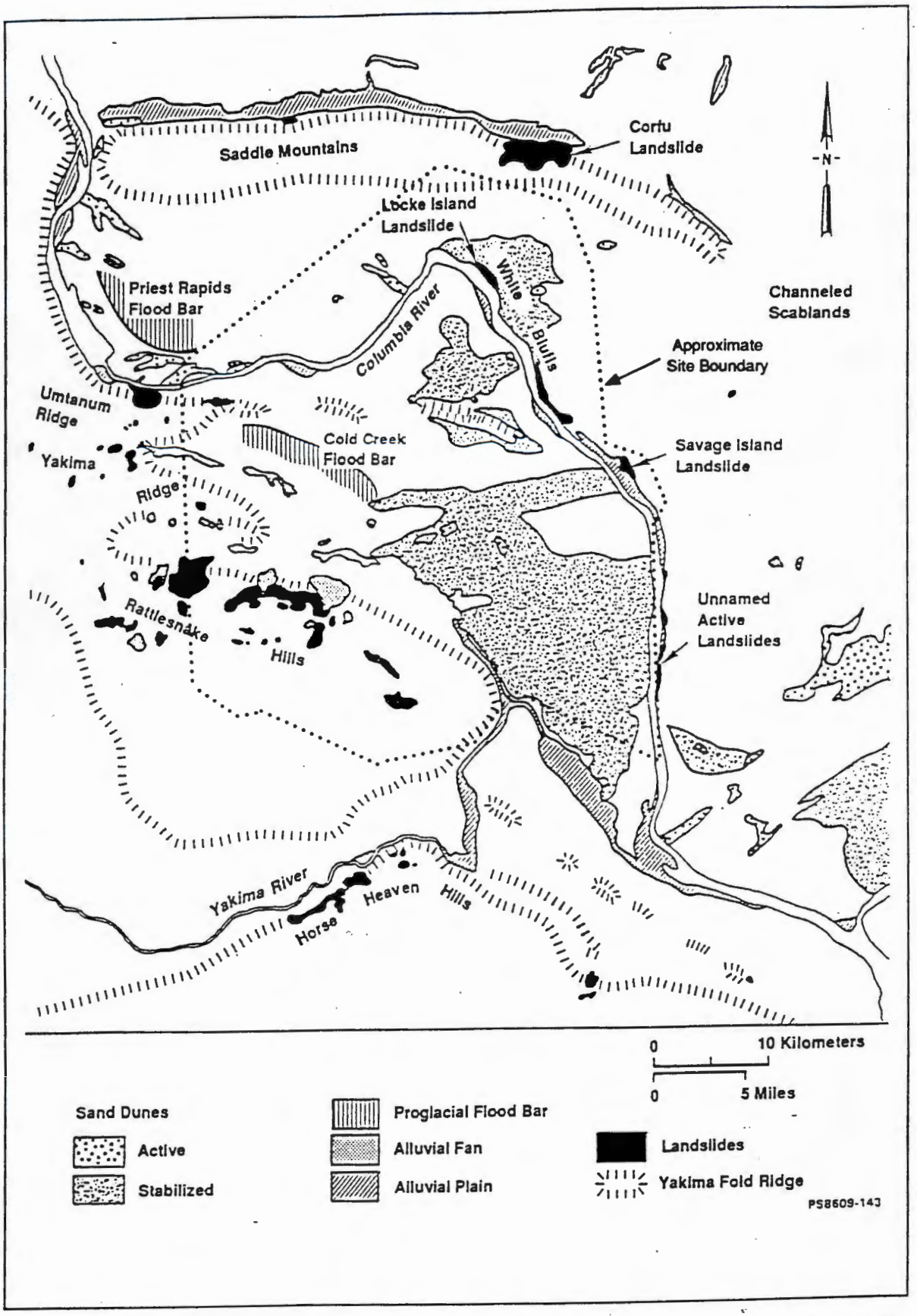

Figure 3-4. Landforms of the Pasco Basin and the Hanford Site (DOE 1988).

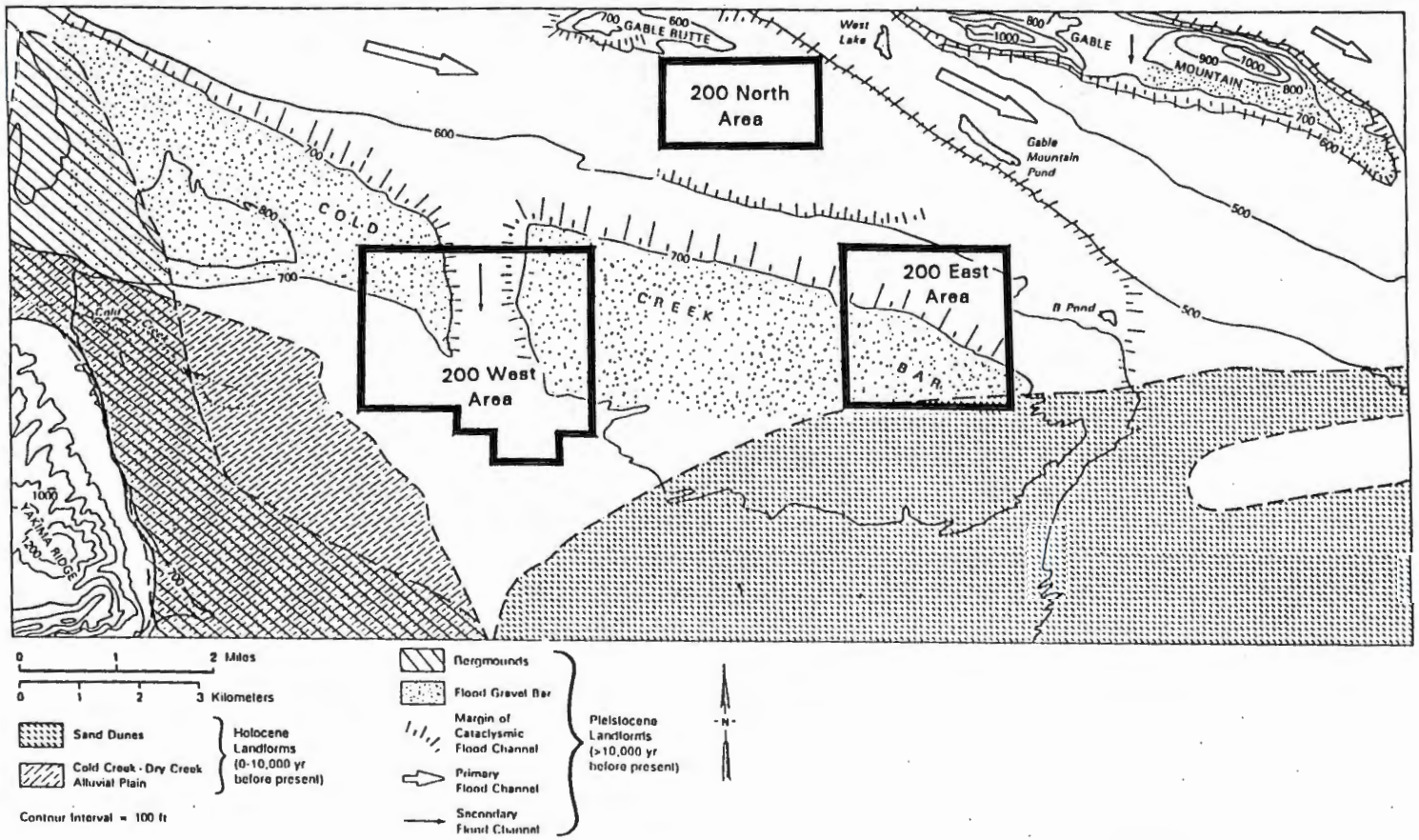

Figure 3-5. Geomorphic Features Surrounding the 200 Areas (Last et al. 1989).

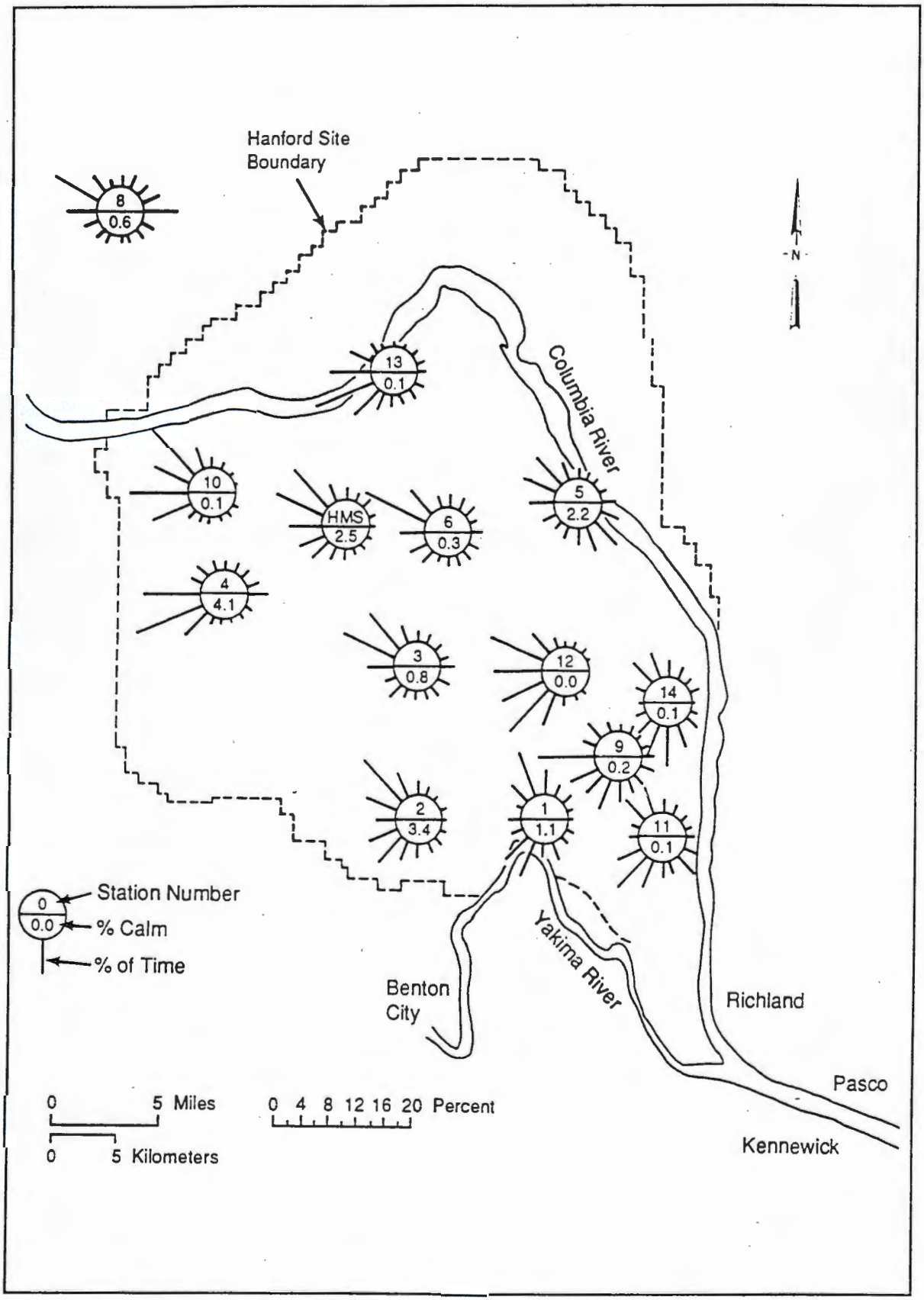

Figure 3-6. Hanford Site Wind Roses, 1979 through 1982 (Stone et al. 1983).

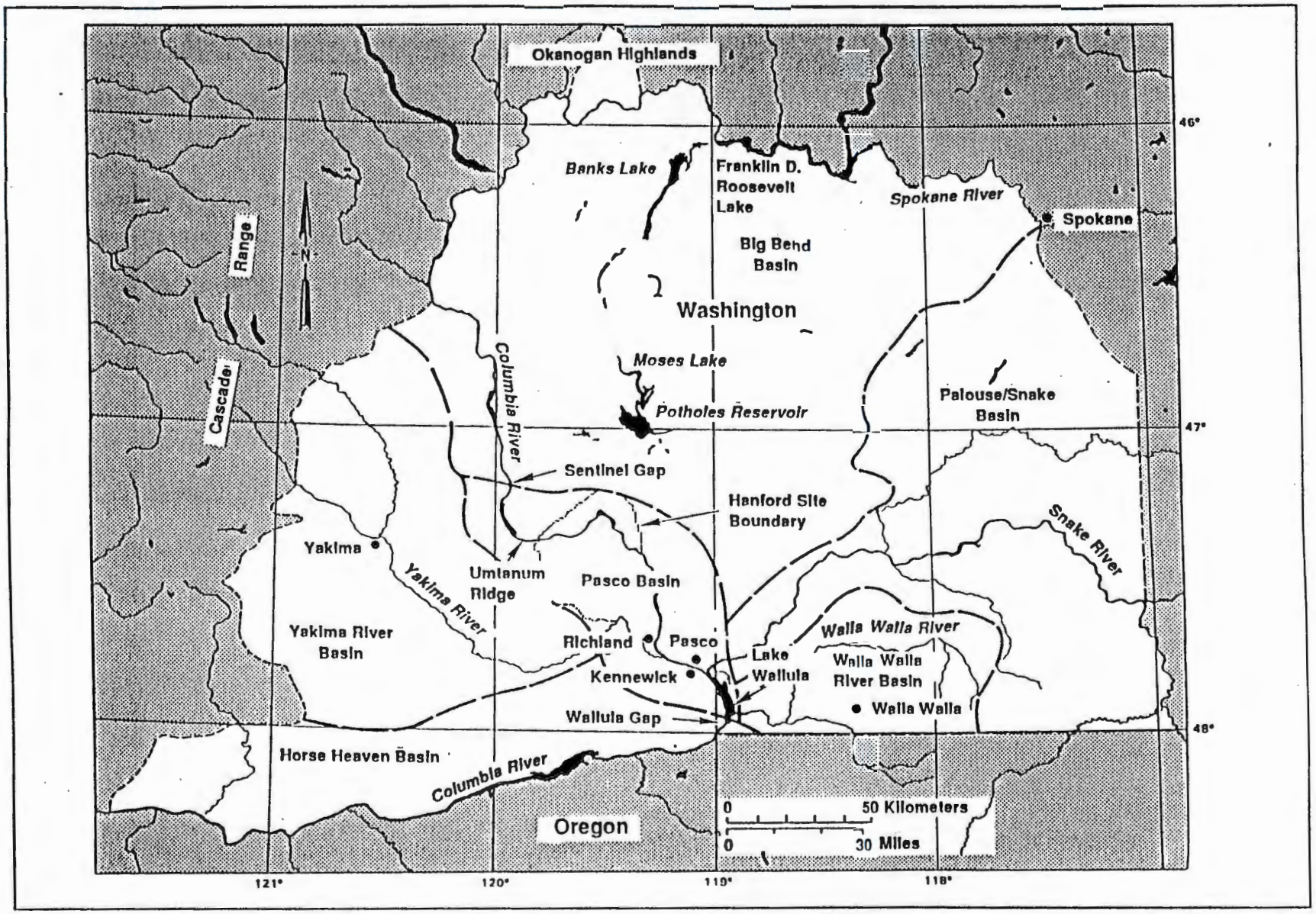

Figure 3-7. Hydrologic Basins Designated for the Washington State Portion of the Columbia Plateau (DOE 1988).

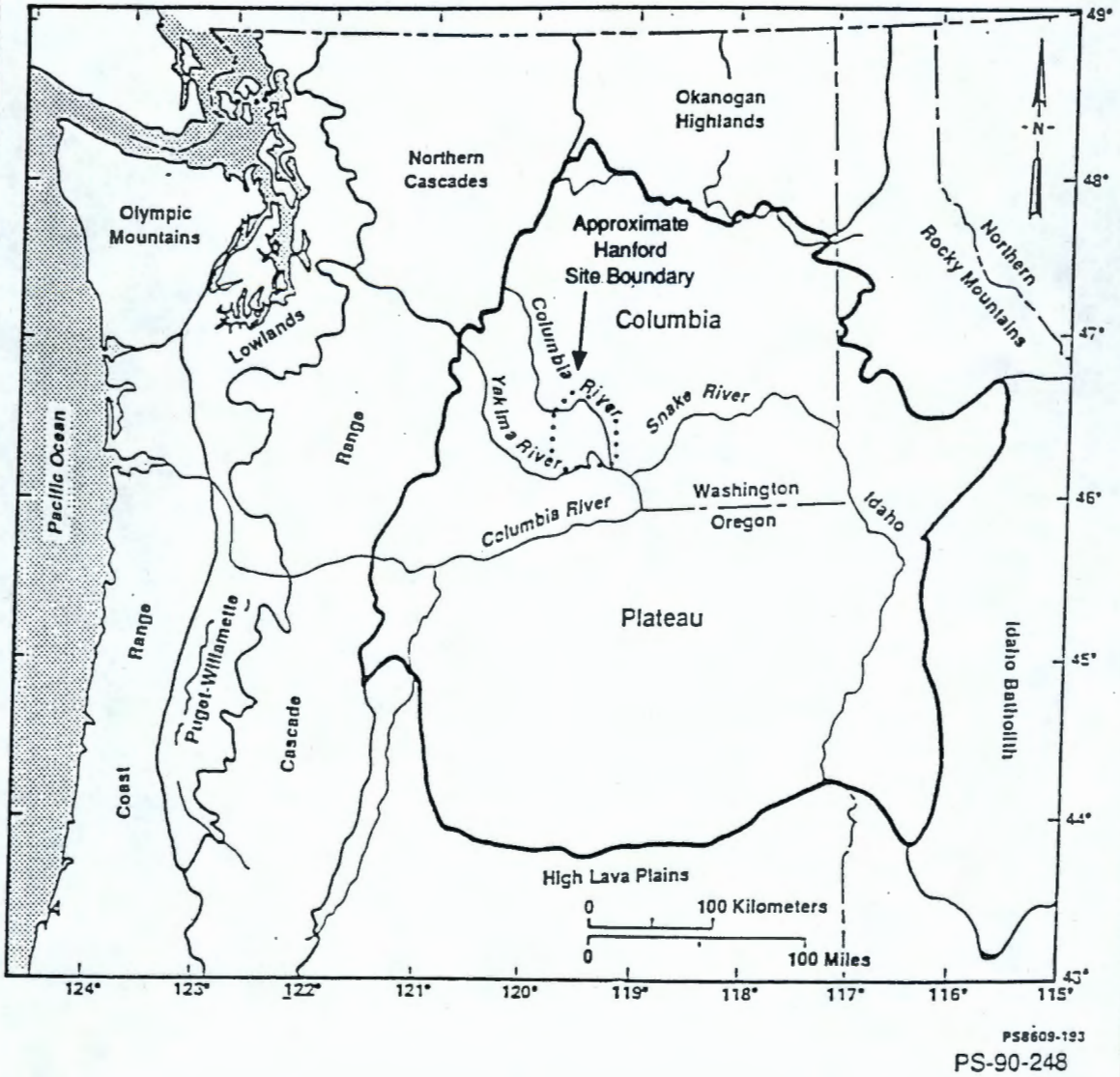

Figure 3-8. Columbia Plateau and Surrounding Structural Provinces (DOE 1988).

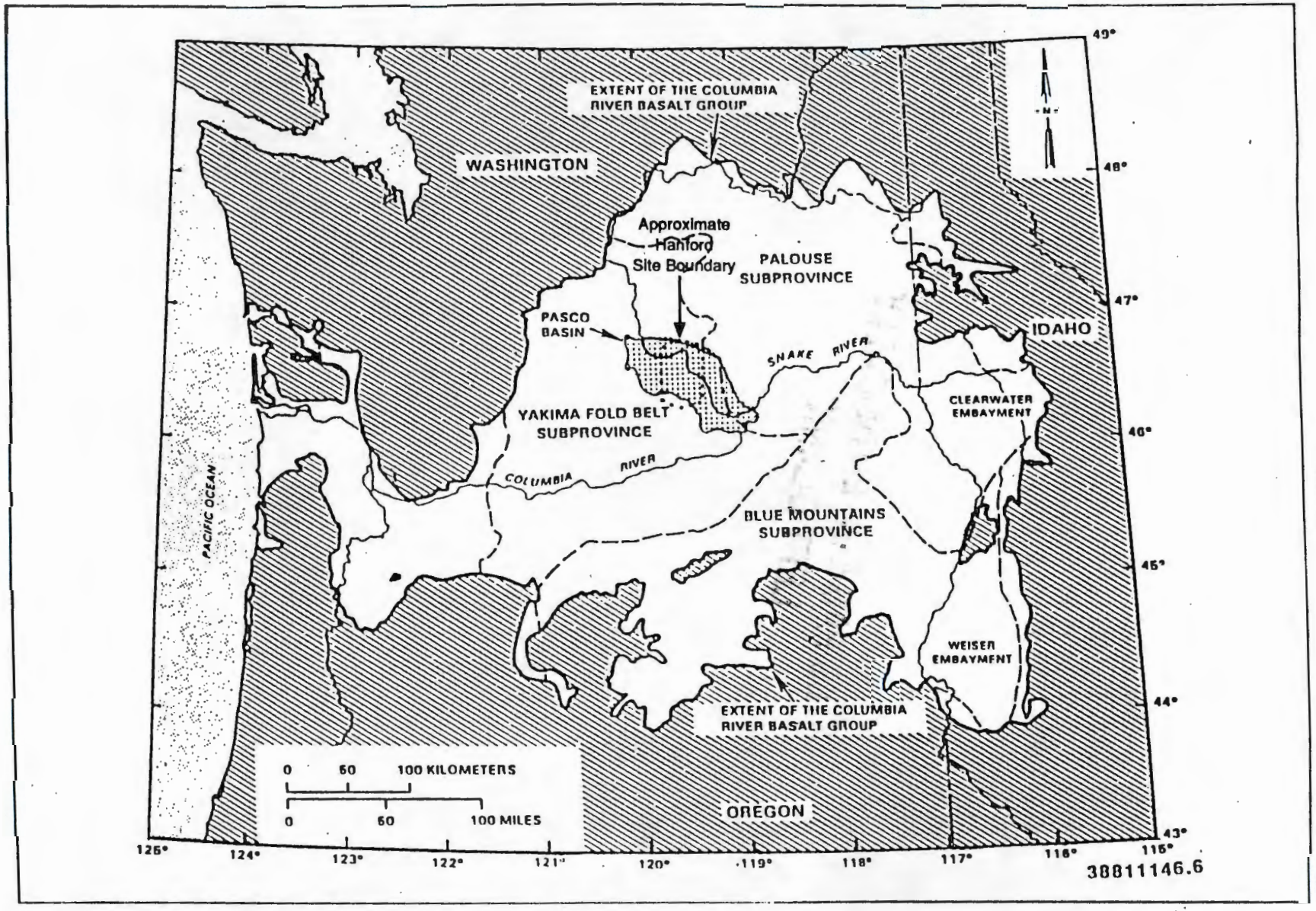

Figure 3-9. Structural Subprovinces of the Columbia Plateau (DOE 1988b)

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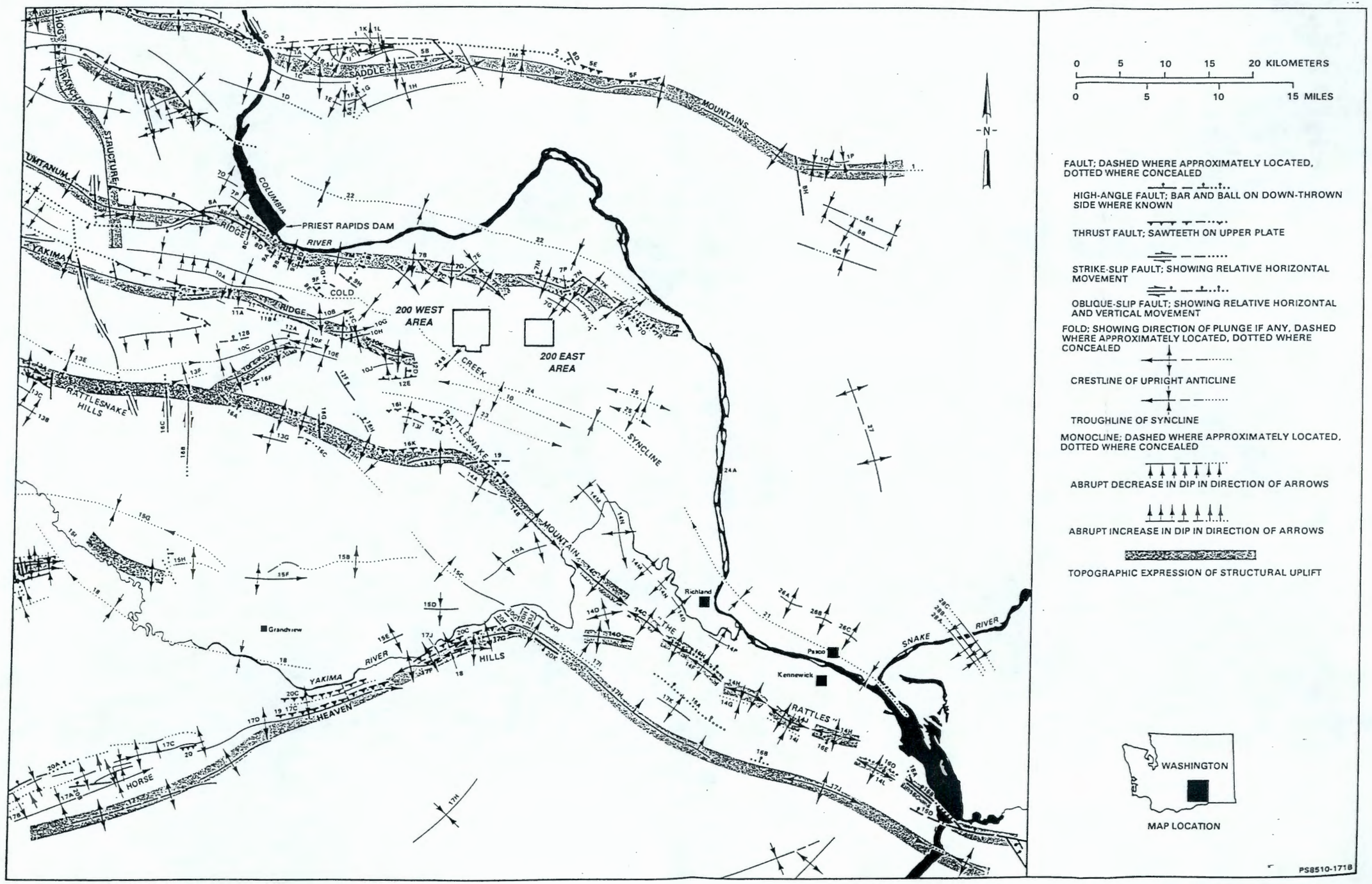

Figure 3-10. Structural Elements of the Yakima Fold Belt Subprovince (DOE 1988).

9 2 1 2 6 5 1 0 2 7 4

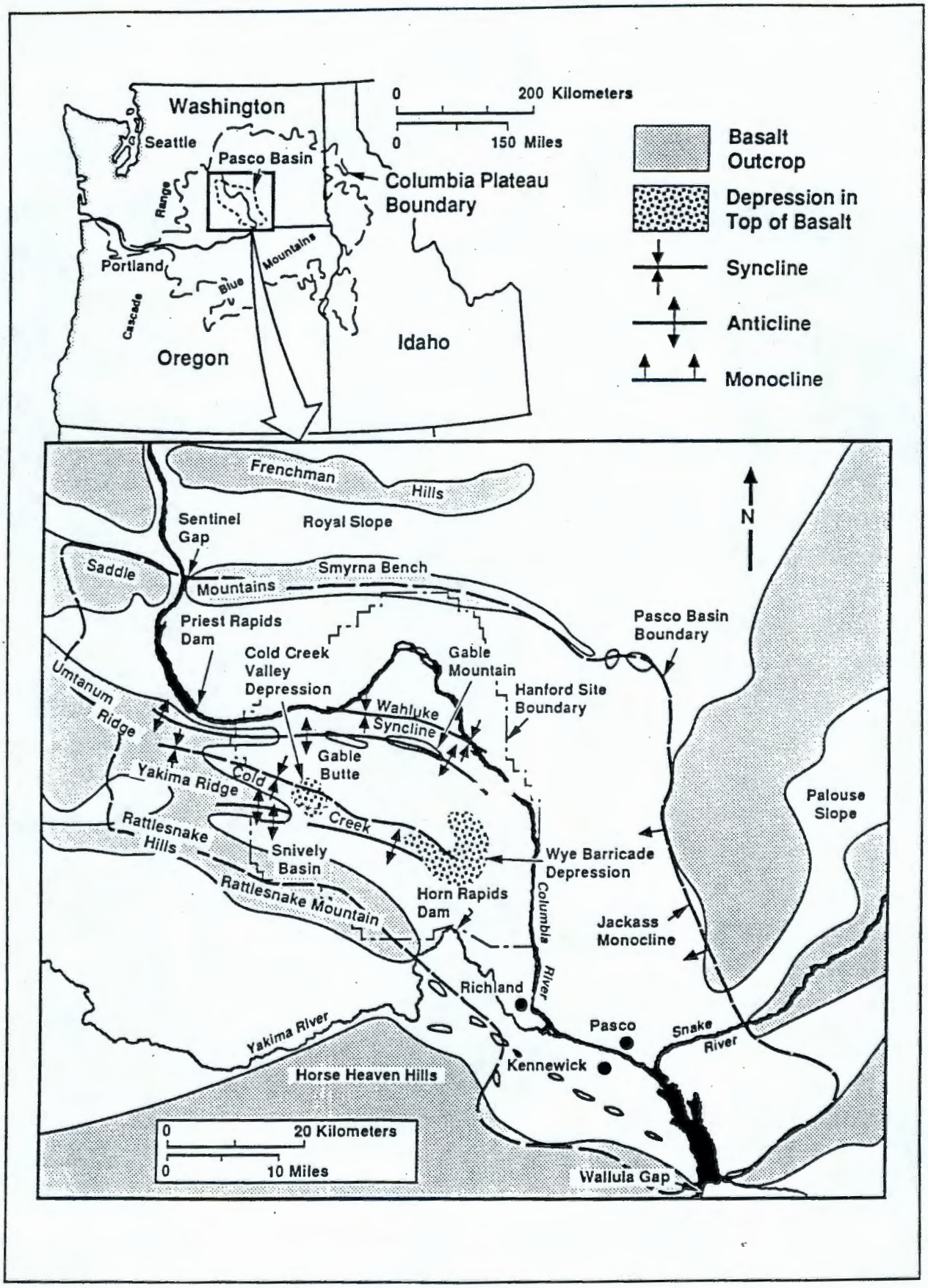

Figure 3-11. Geologic Structures of the Pasco Basin and the Hanford Site (Reidel et al. 1989).

9 2 1 2 6 1 0 2 7 5

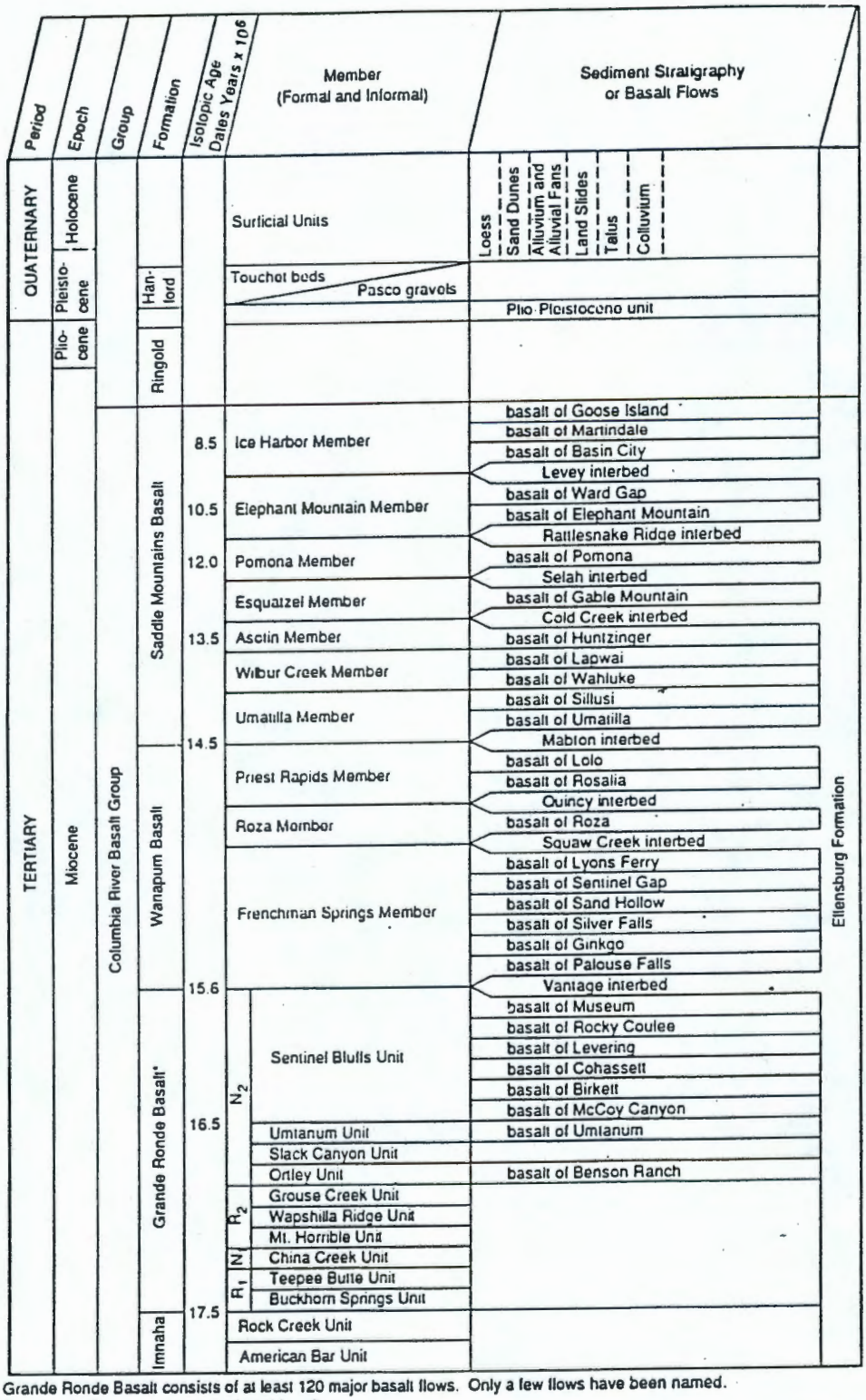

Figure 3-12. Generalized Stratigraphy of the Hanford Site.

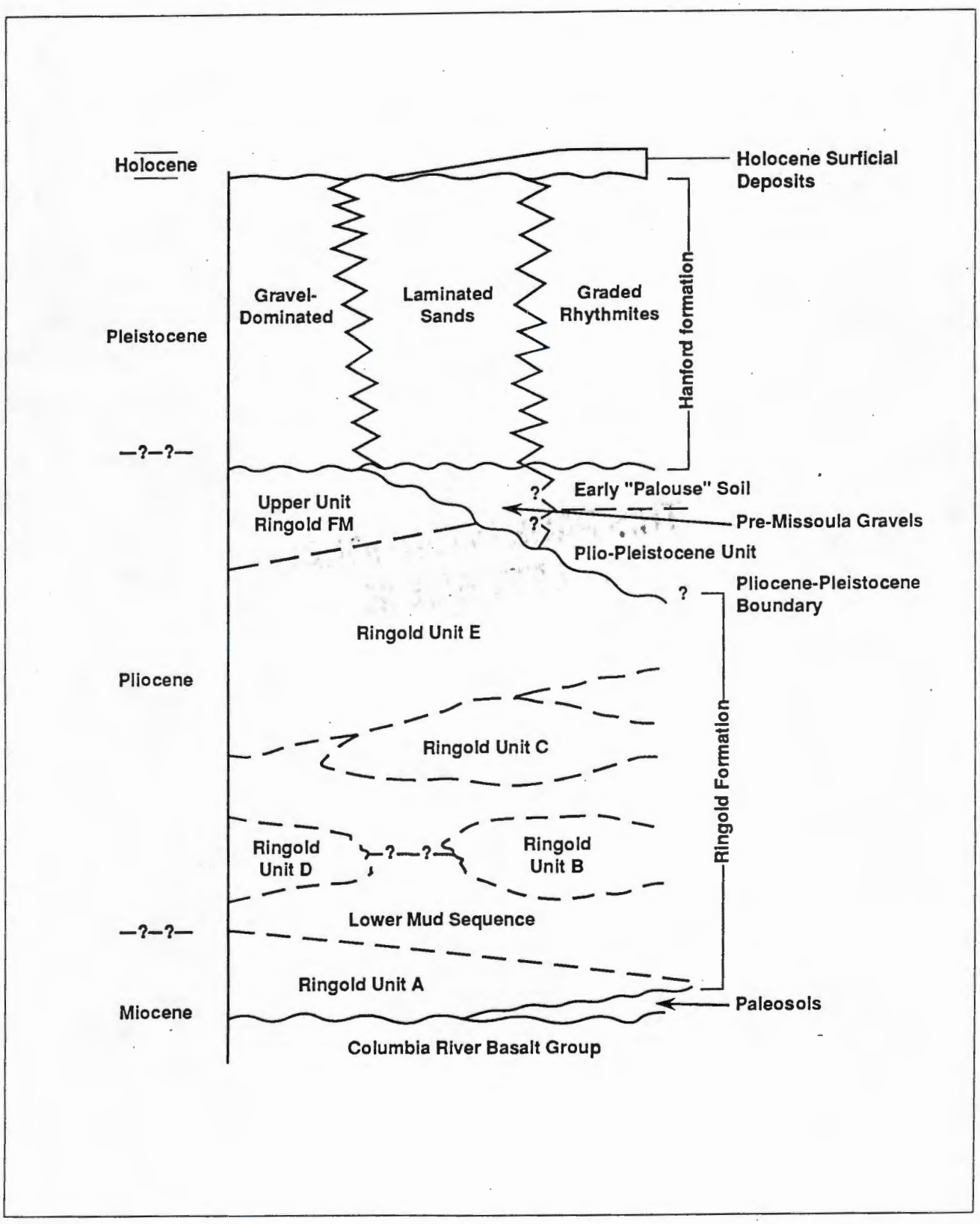

Figure 3-13. Generalized Stratigraphy of the Suprabasalt Sediments Beneath the Hanford Site (Lindsey et al. 1989).

9 2 1 2 6 1 0 2 7 7

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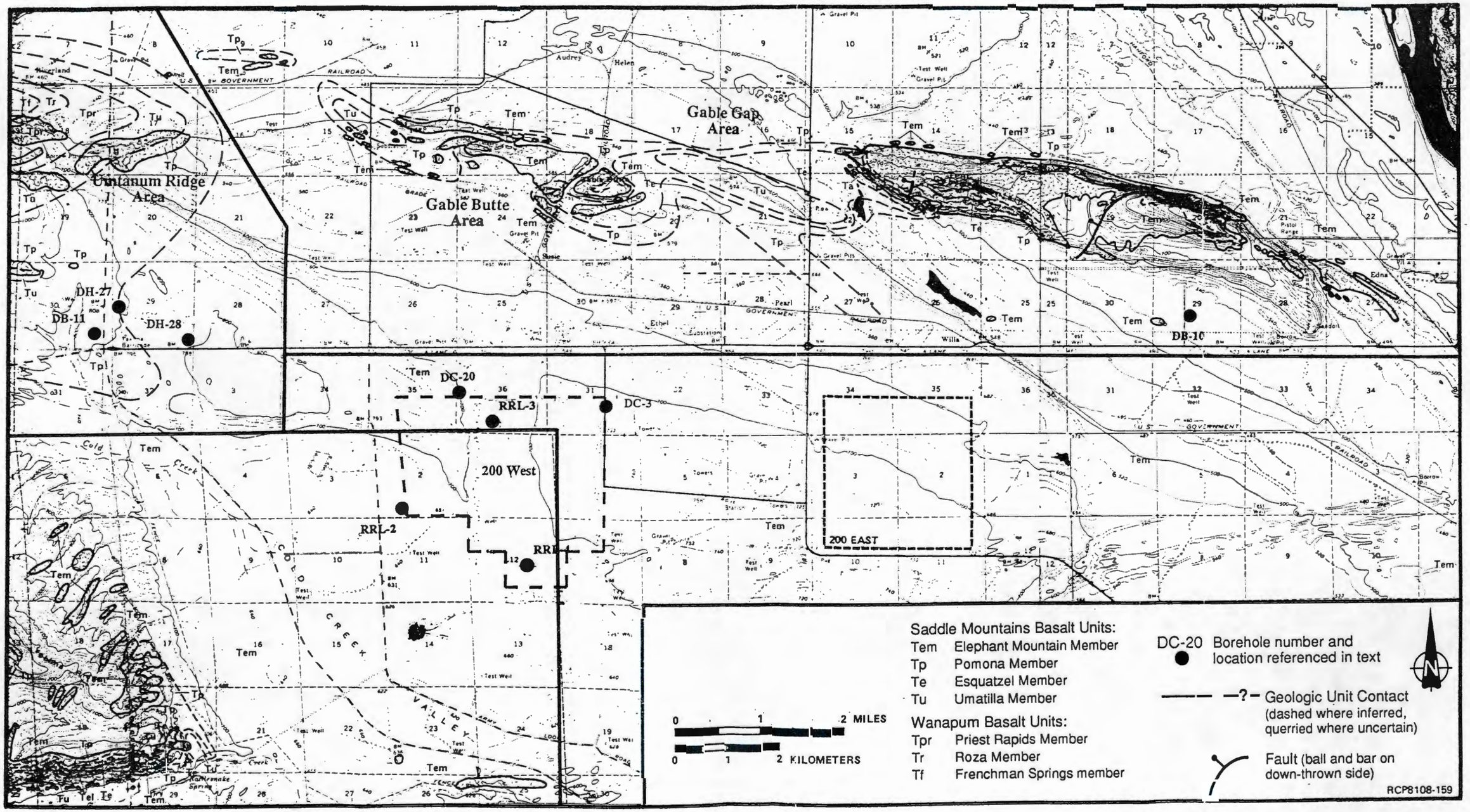

Figure 3-14. Bedrock Geology Map for the West-Central Part of the Hanford Site (Myers and Price 1981).

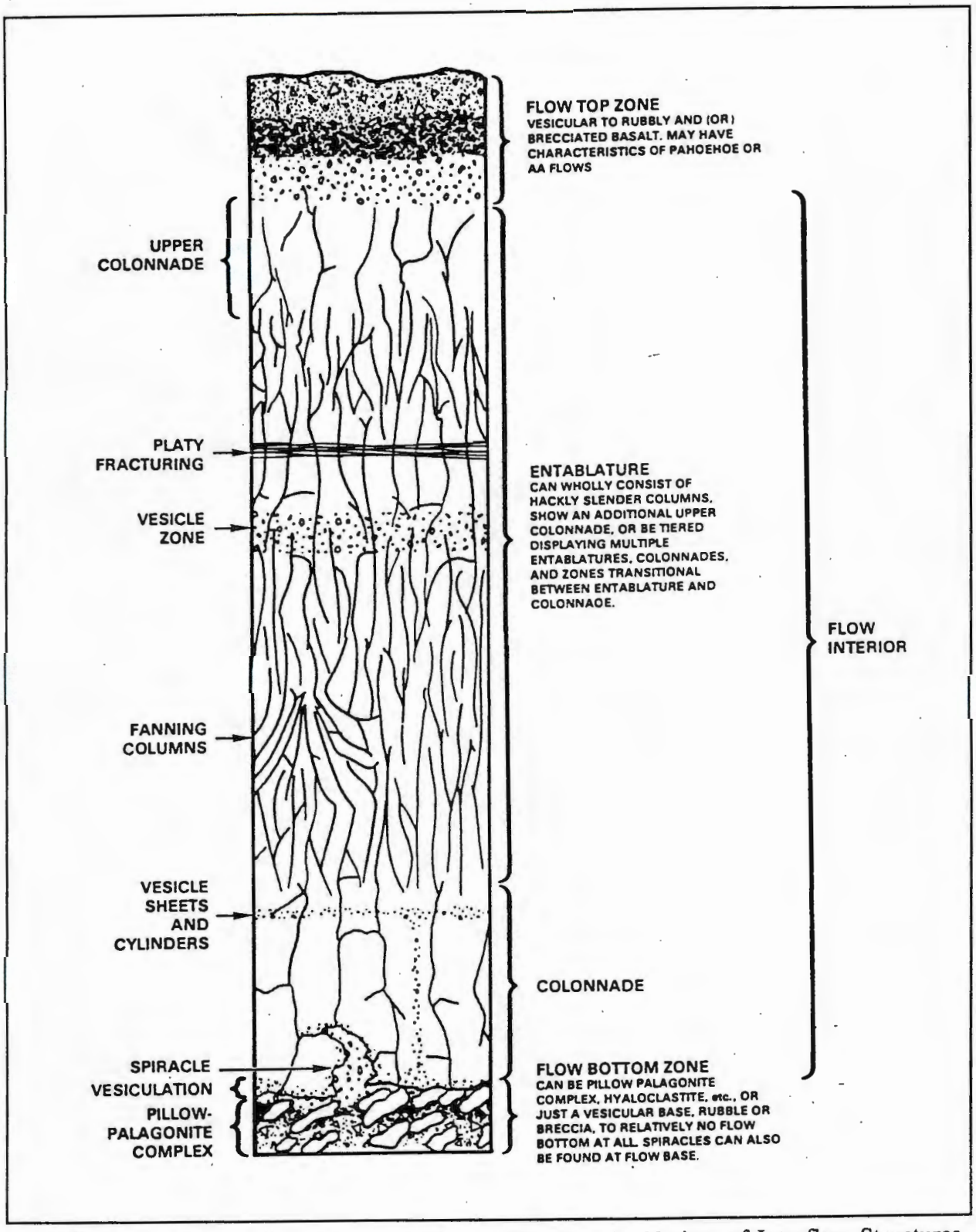

Figure 3-15. Idealized Columnar Section Showing the Variety of Intraflow Structures Possible in Columbia River Basalt Group Flows (Swanson et al. 1979).

9 2 1 2 6 1 0 2 7 9

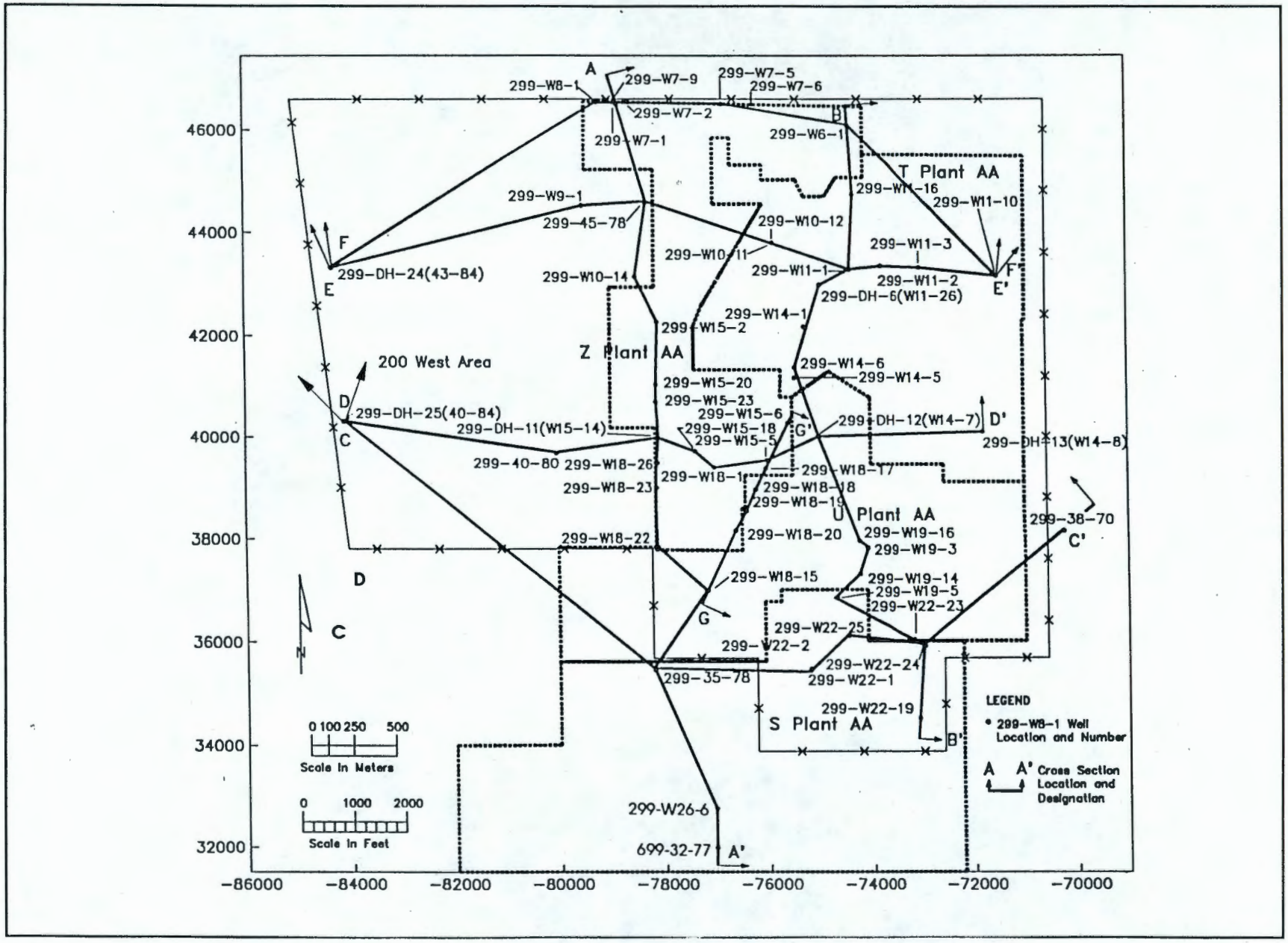

Figure 3-16. Location of 200 West Area Geologic Cross Sections. (Modified from Lindsey et al. 1991).

Explanation

Grain Size Scale, Indicates Dominant Grain Size in an Interval

- Cobble–boulder Gravel
- Pebble Gravel
- Sand
- Clay/Silt

Additional Lithologic Symbols Includes Subordinate Lithologies

- Pedogenic Calcium Carbonate
- Paleosols
- Ringold Clast Supported Gravels
- Open Framework Hanford Gravels
- Laminated Muds
- Basalt

Other Symbols

- ——?—— Formational contact, ? where inferred
- ····?···· Unit contact, ? where inferred
- Water Table Elevation (December 1991)

Unit Abbreviations

Hc – Upper Coarse Unit, Hanford formation
Hf – Lower Fine Unit, Hanford formation
EP – Early "Palouse" Soil
PP – Plio–Pleistocene Unit
UR – Upper Unit, Ringold Formation
E – Gravel Unit E, Ringold Formation
LM – Lower Mud Sequence, Ringold Formation
A – Gravel Unit A, Ringold Formation

Blank portions of cross section well logs represent sediments (dominantly sand) which do not fit into sediment categories depicted by symbols listed above.

NOTE:

1. Refer to Figure 3–16 for cross section locations and designation. Cross sections presented on Figures 3–18 through 3–24.
2. Figures based on Lindsey et al. 1991.

200west/west3–17

Figure 3-17. Legend for Cross Sections.

9 2 1 2 5 1 0 2 8 1

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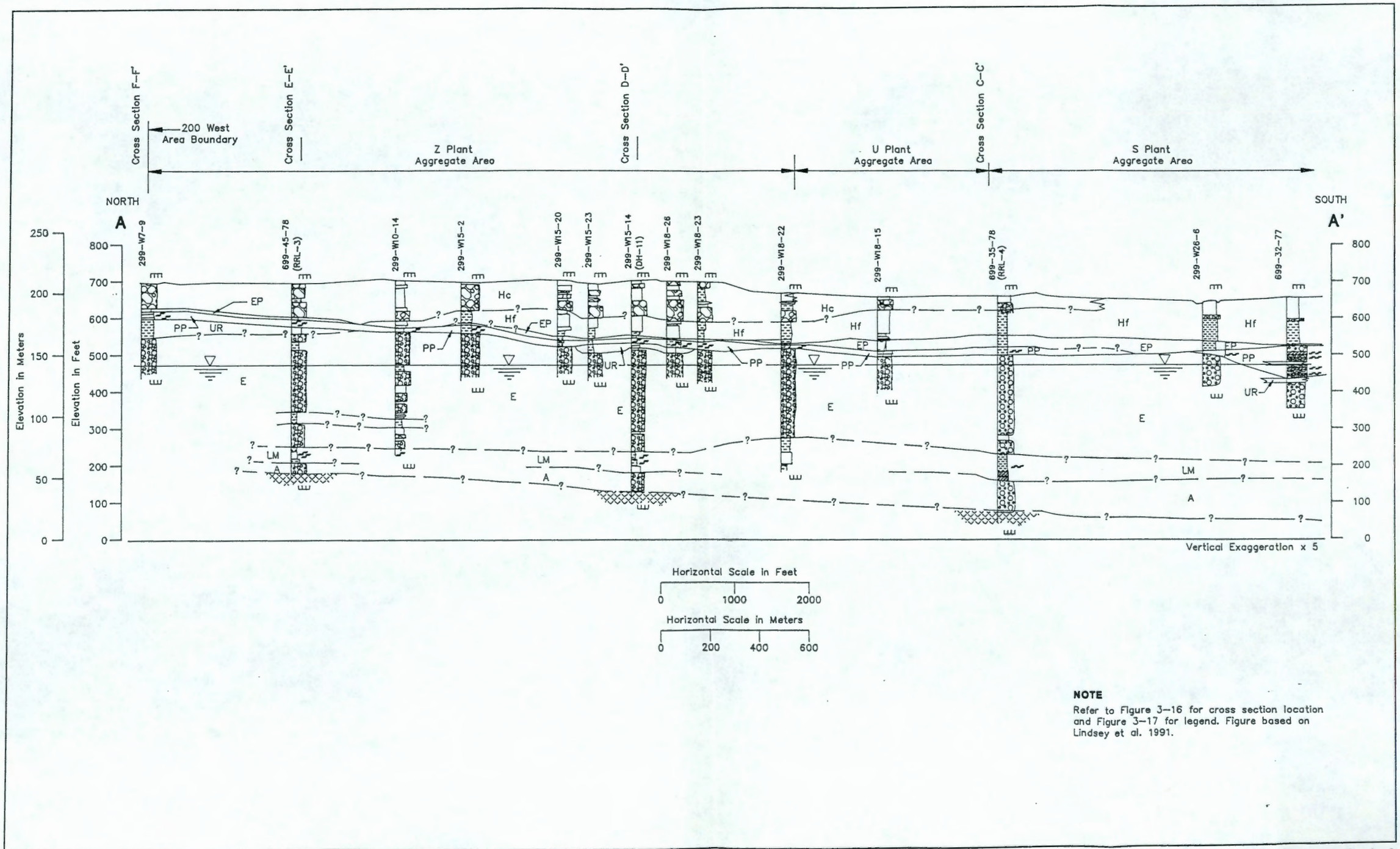
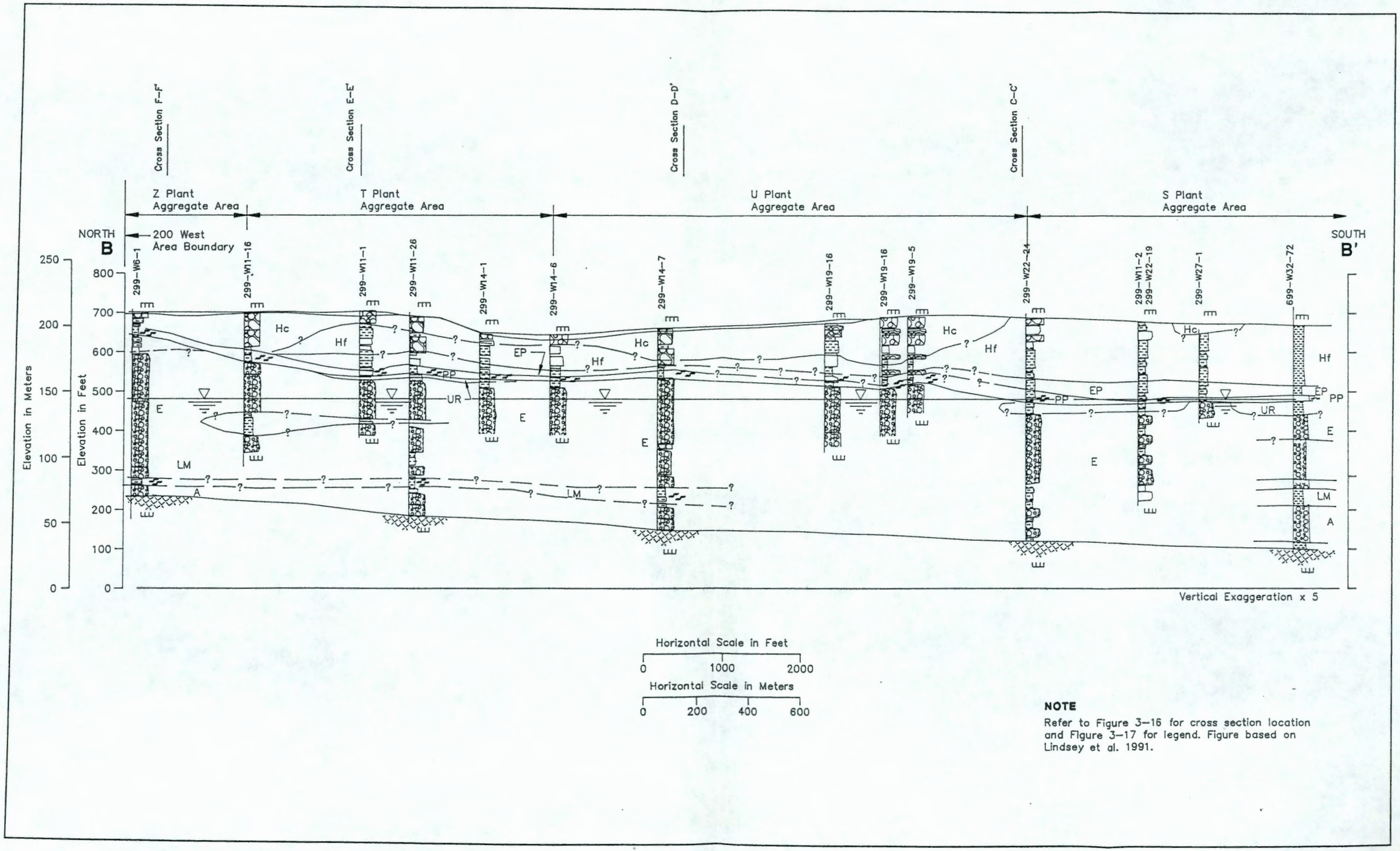


NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1991.

Figure 3-18. 200 West Area Geologic Cross Section A-A'.

9 2 1 2 6 6 1 0 2 8 2



NOTE

Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1991.

Figure 3-19. 200 West Area Geologic Cross Section B-B'.

9 2 1 2 6 5 1 0 2 8 3

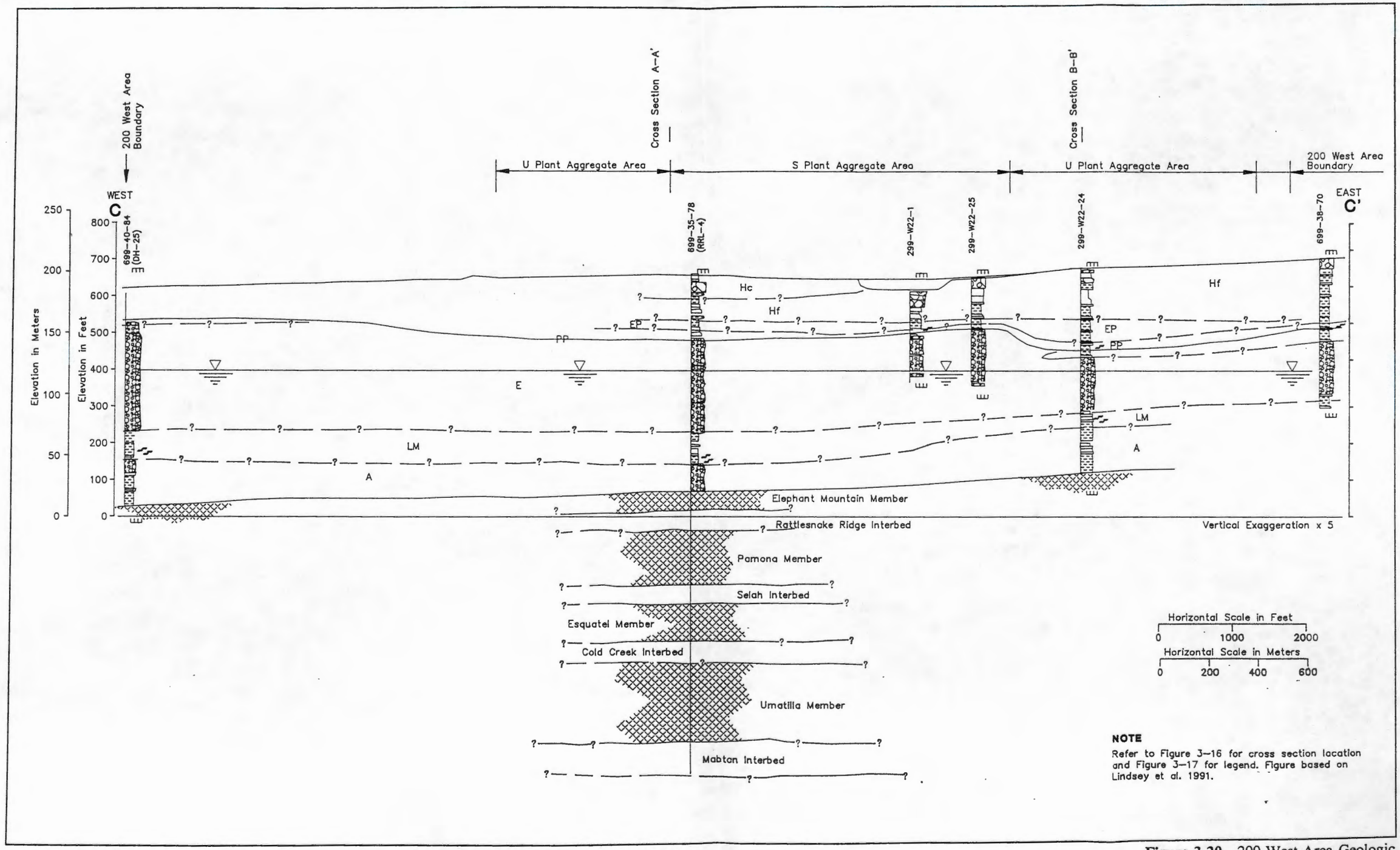
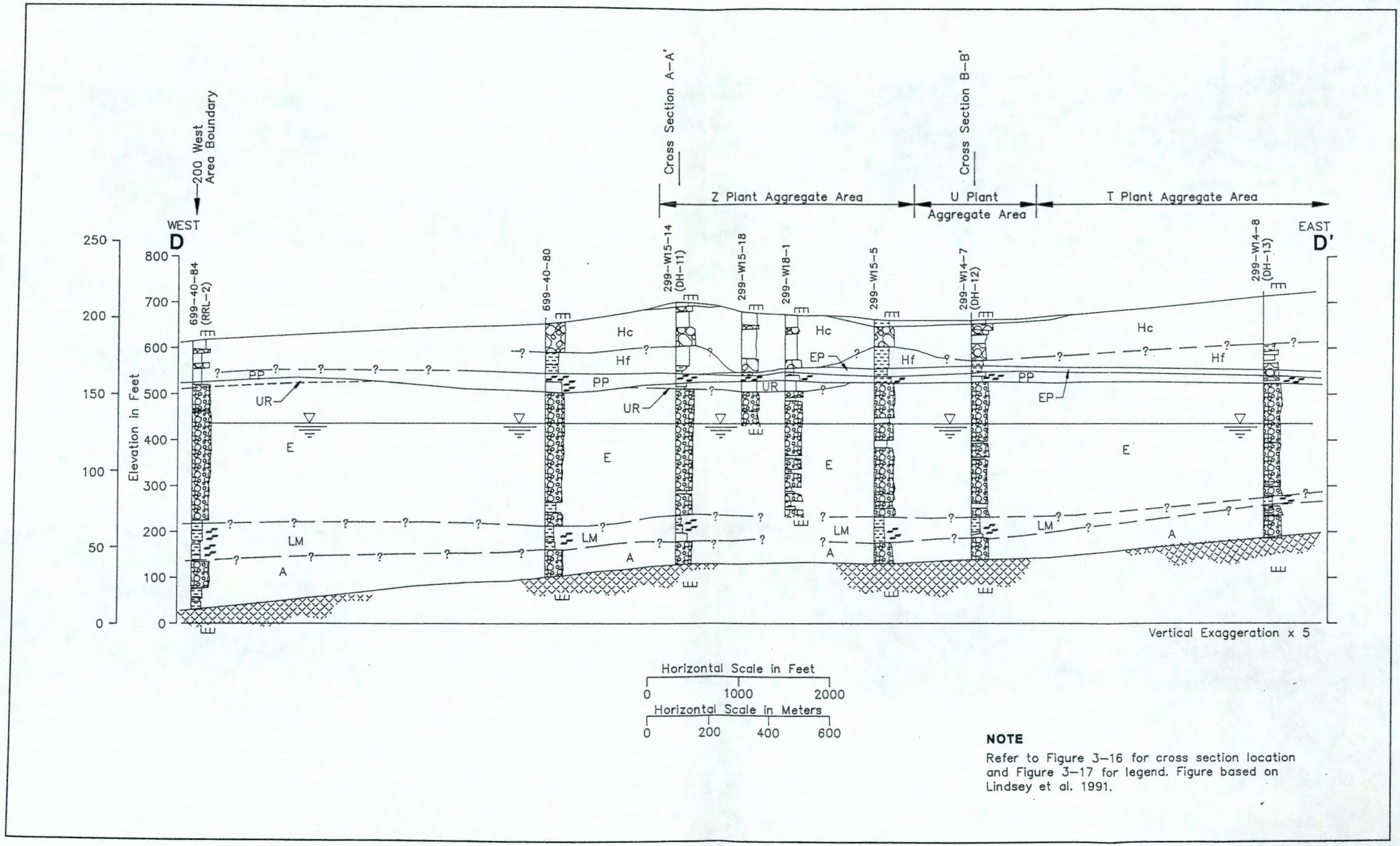


Figure 3-20. 200 West Area Geologic Cross Section C-C'.

9 2 1 2 6 6 1 0 2 8 4



NOTE

Refer to Figure 3–16 for cross section location and Figure 3–17 for legend. Figure based on Lindsey et al. 1991.

Figure 3-21. 200 West Area Geologic Cross Section D-D'.

9 2 1 2 6 5 1 0 2 3 5

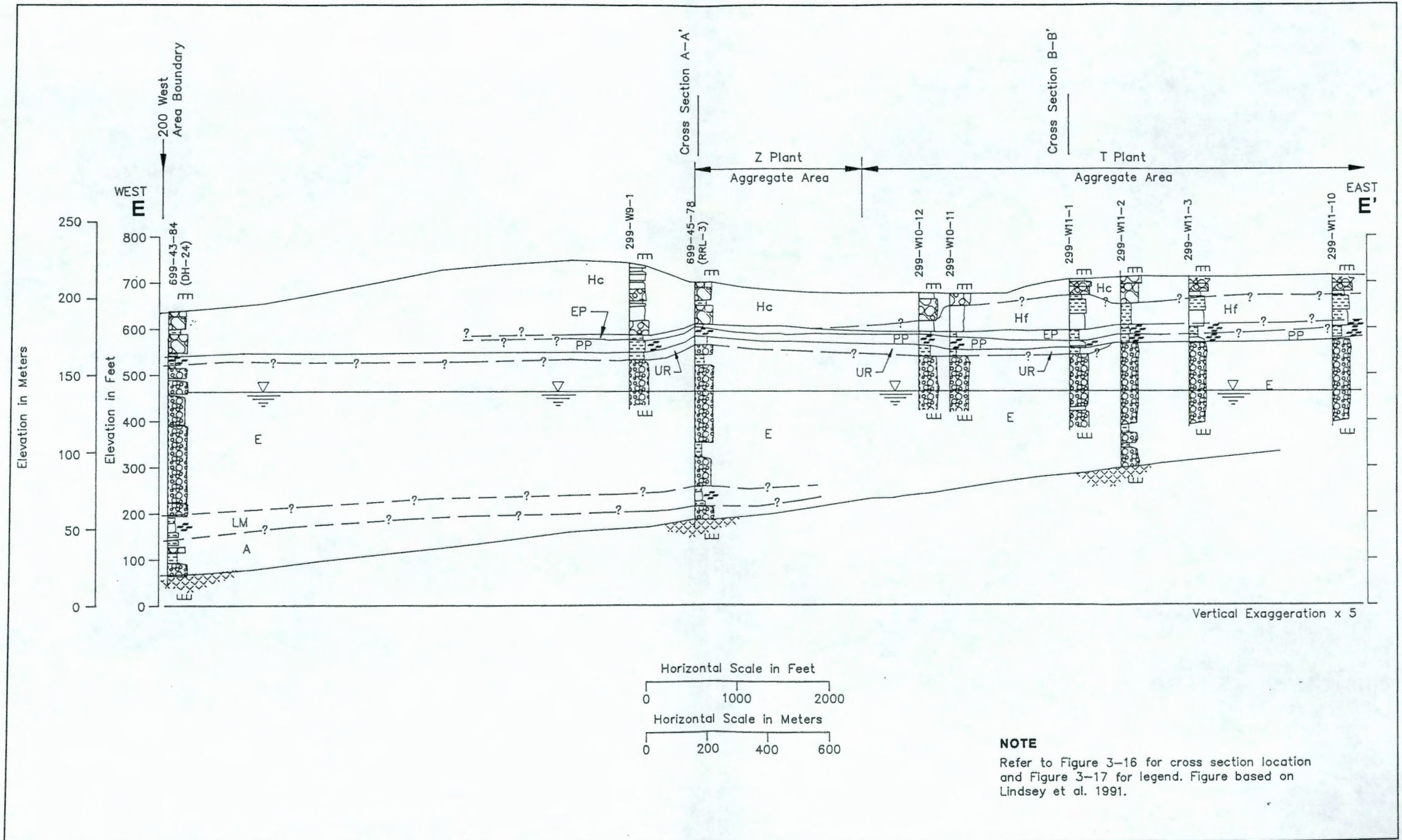
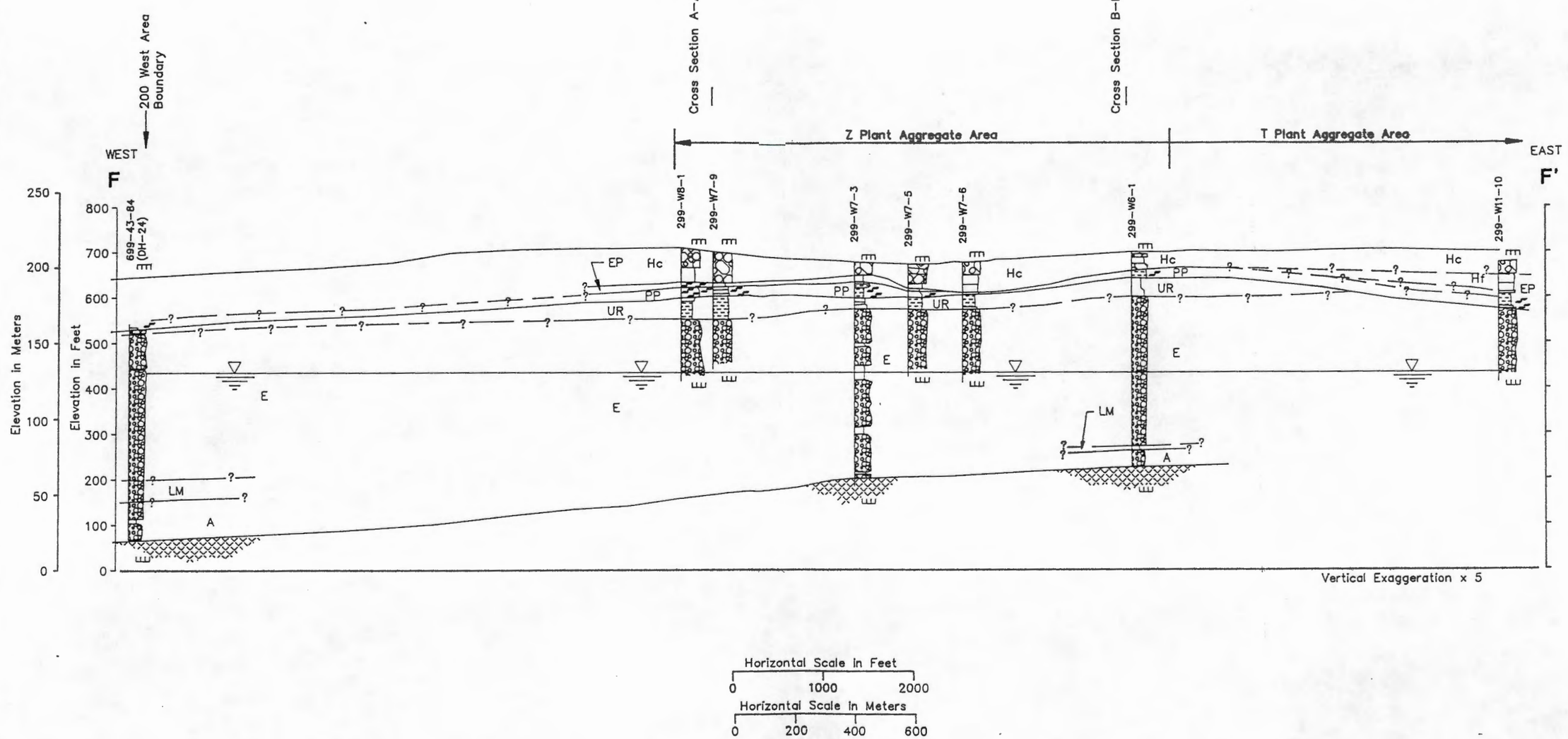


Figure 3-22. 200 West Area Geologic Cross Section E-E'.

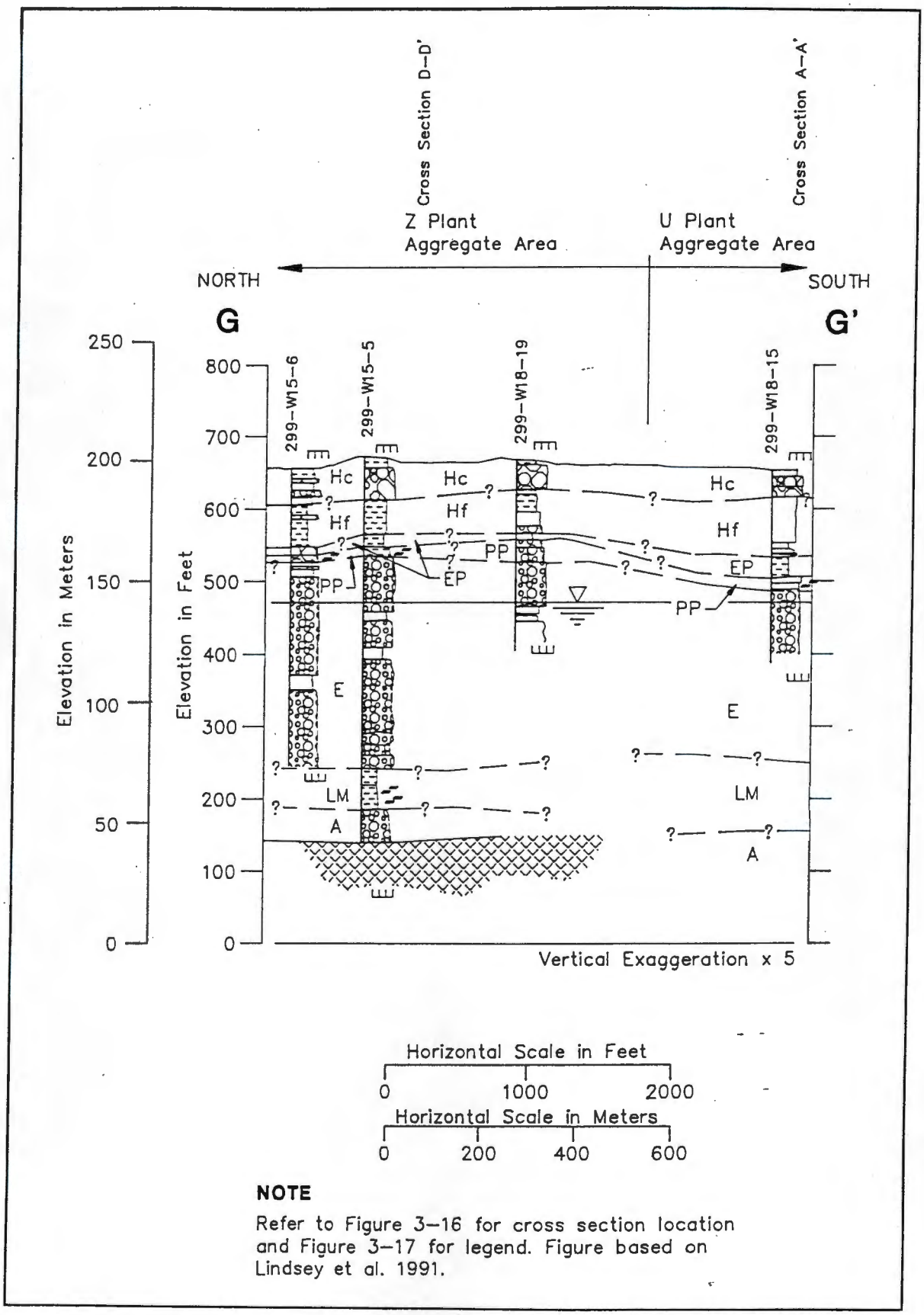
9 2 1 2 6 5 1 0 2 8 6



NOTE
Refer to Figure 3–16 for cross section location and Figure 3–17 for legend. Figure based on Lindsey et al. 1991.

Figure 3-23. 200 West Area Geologic Cross Section F-F'.

9 2 1 2 6 6 5 1 0 2 8 7



NOTE

Refer to Figure 3–16 for cross section location and Figure 3–17 for legend. Figure based on Lindsey et al. 1991.

Figure 3-24. 200 West Area Geologic Cross Section G-G'.

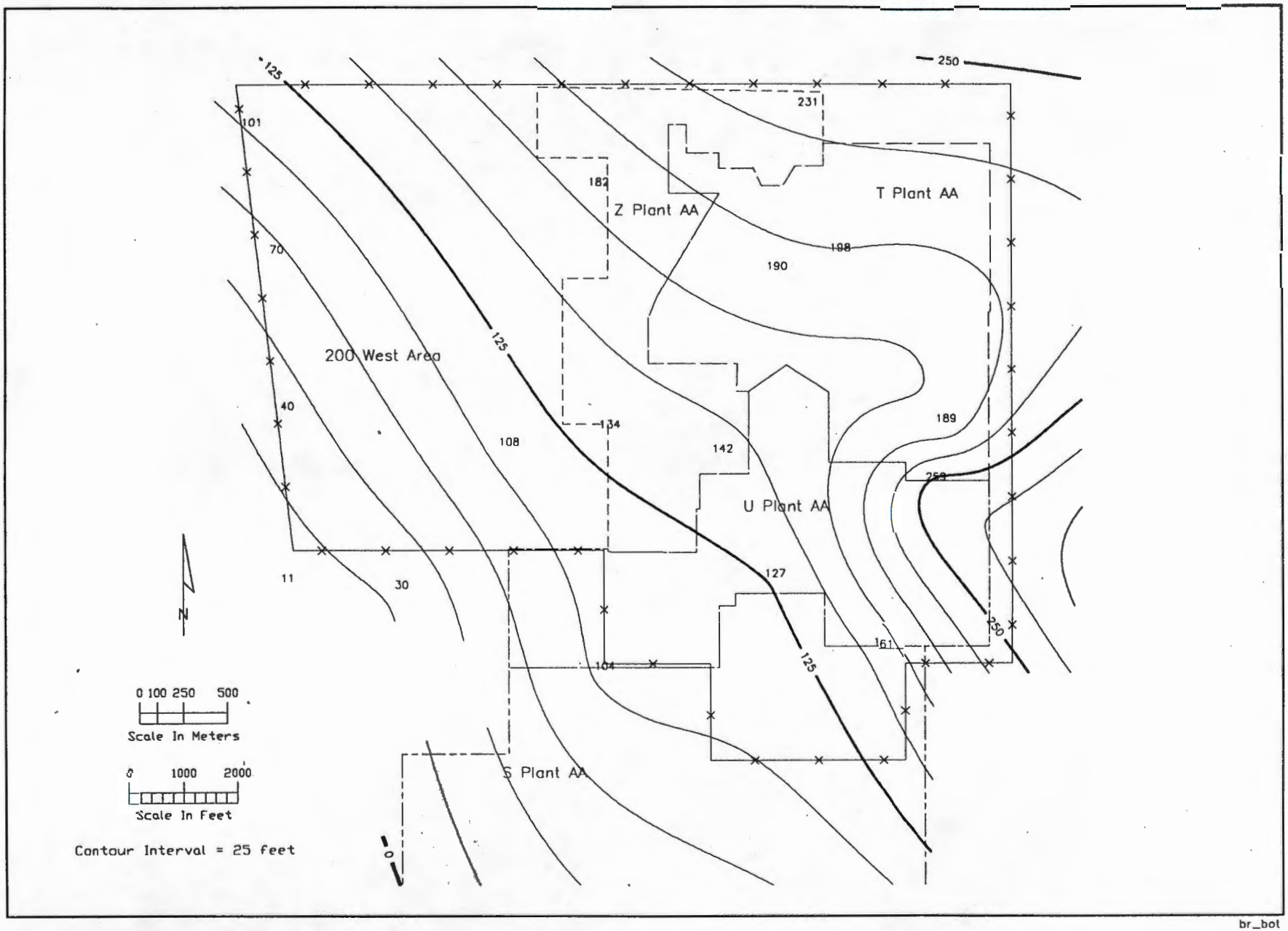


Figure 3-25. Top of the Elephant Mountain Member of the Saddle Mountains Basalt (Connelly et al. 1992).

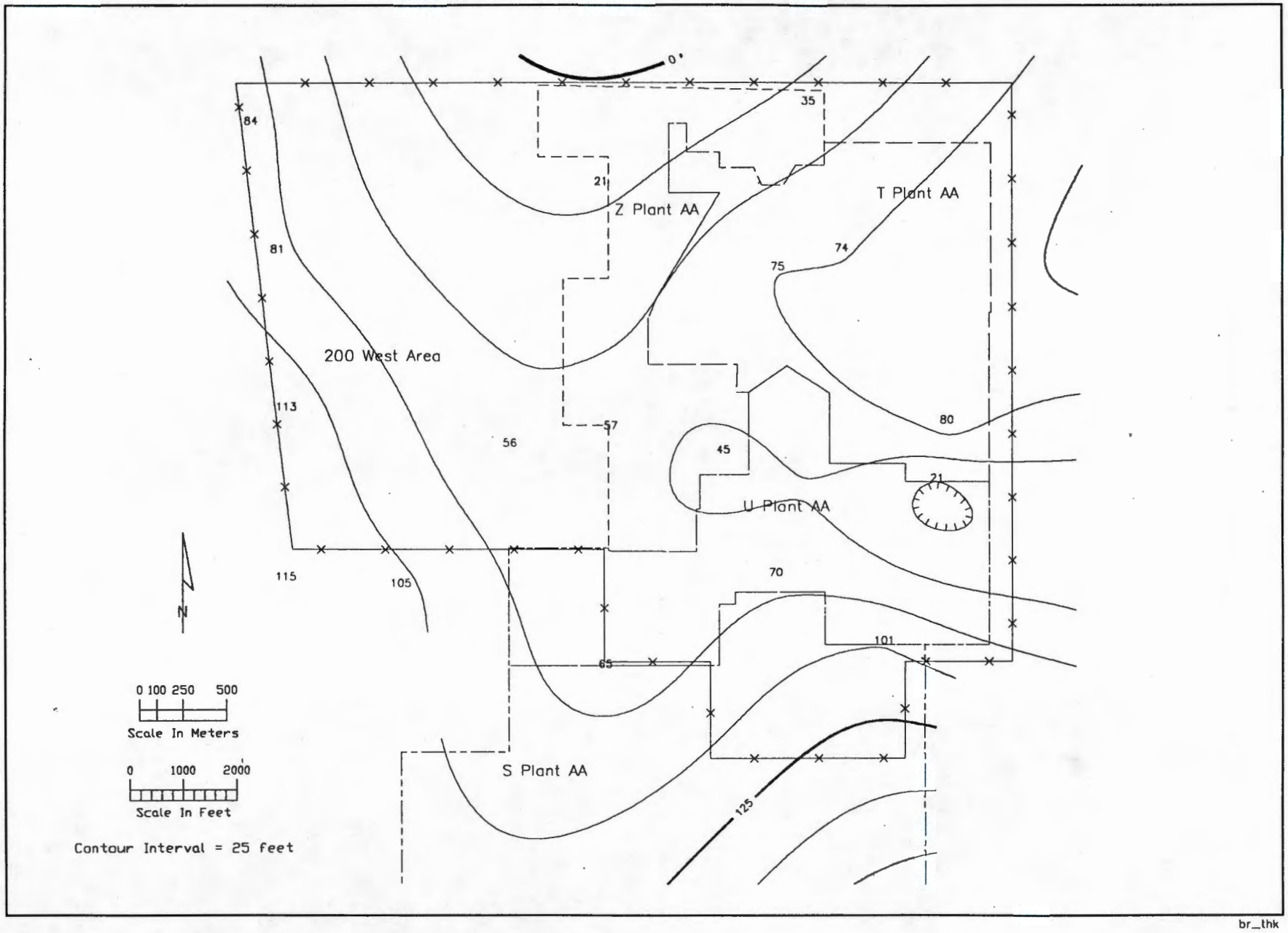


Figure 3-26. Isopach Map of the Ringold Formation Gravel Unit A (Connelly et al. 1992).

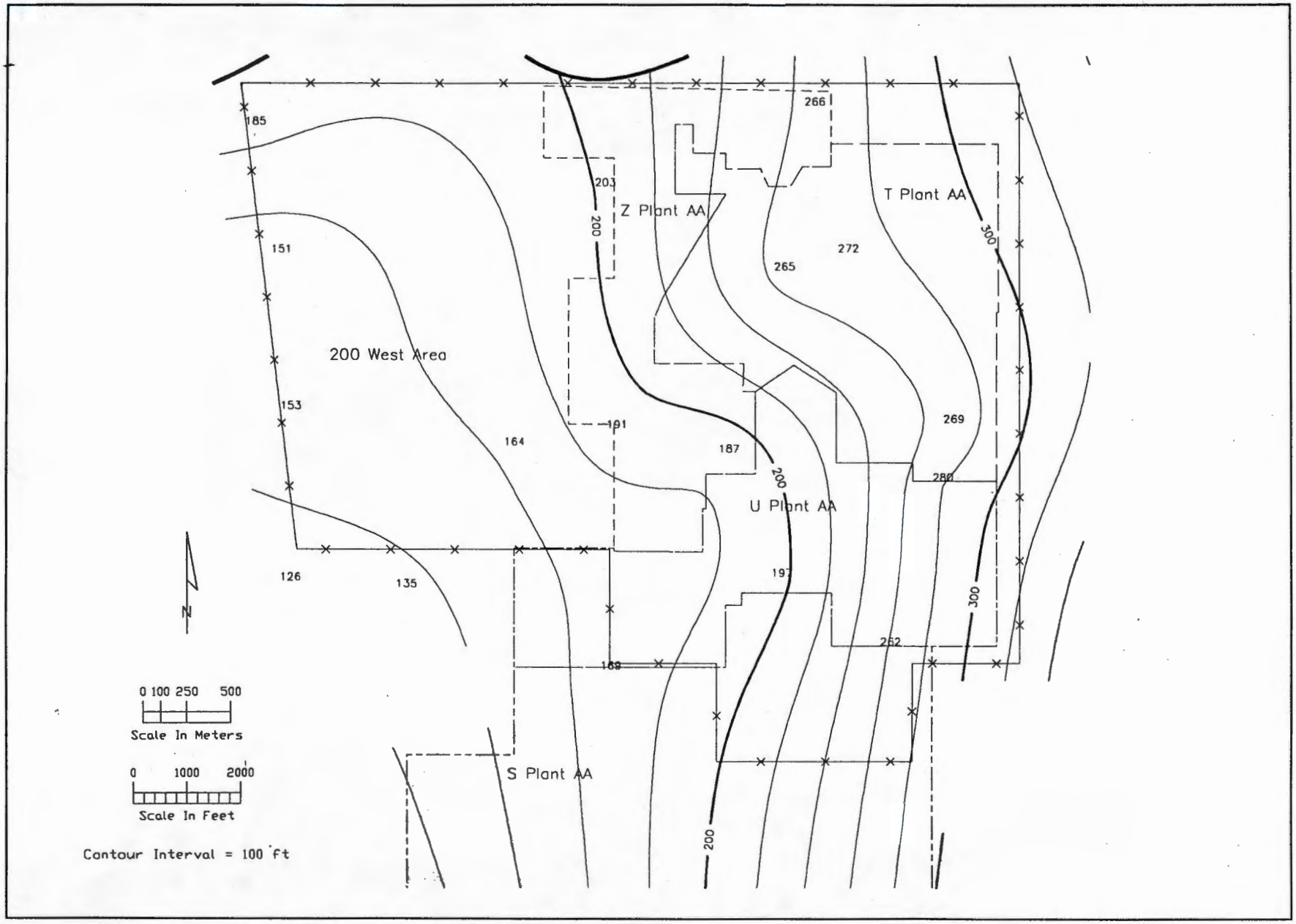


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Figure 3-27. Structure Contour Map of the Ringold Formation Gravel Unit A (Connelly et al. 1992).

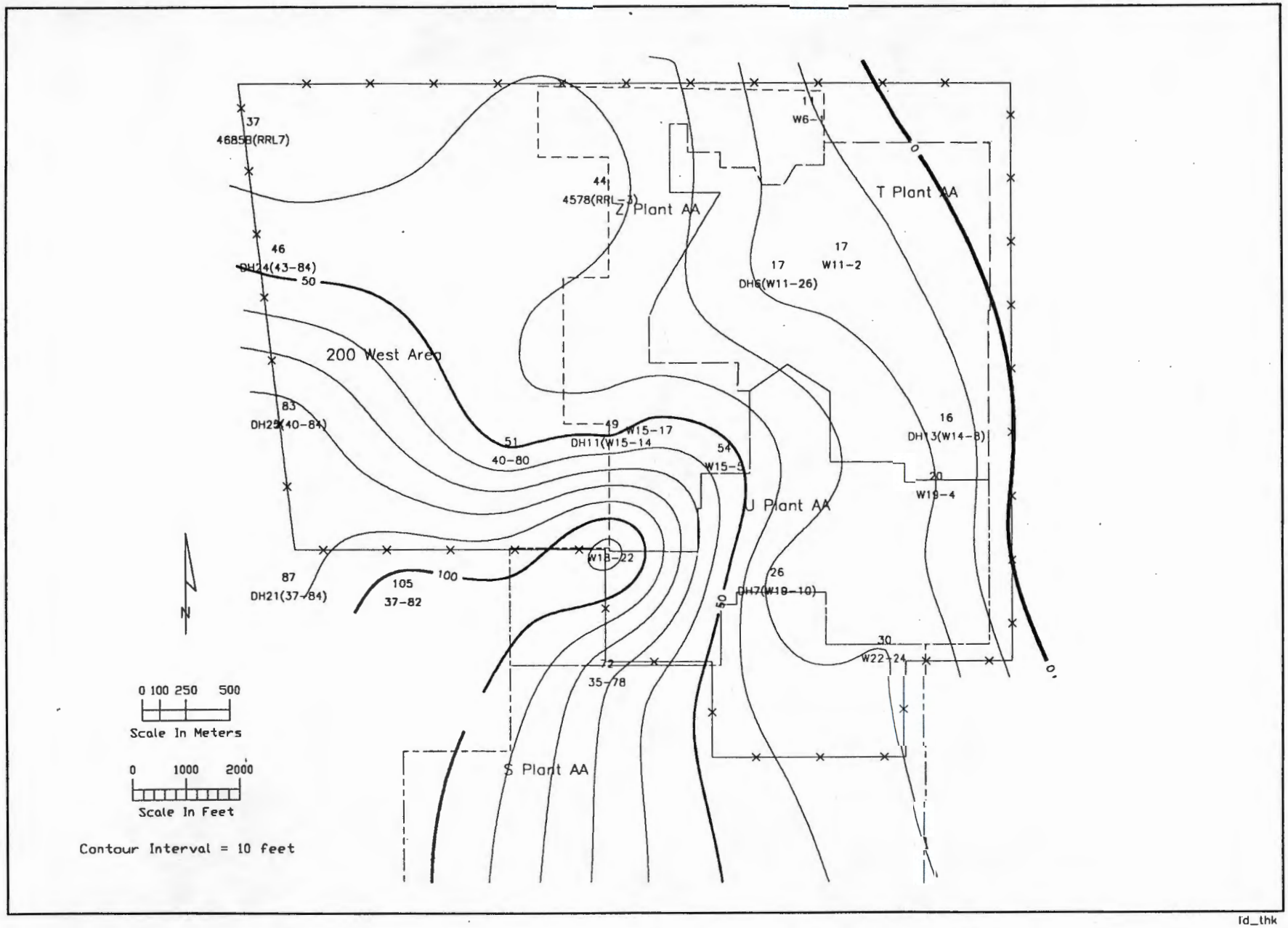

Figure 3-28. Isopach Map of the Ringold Formation Lower Mud Unit (Connelly et al. 1992).

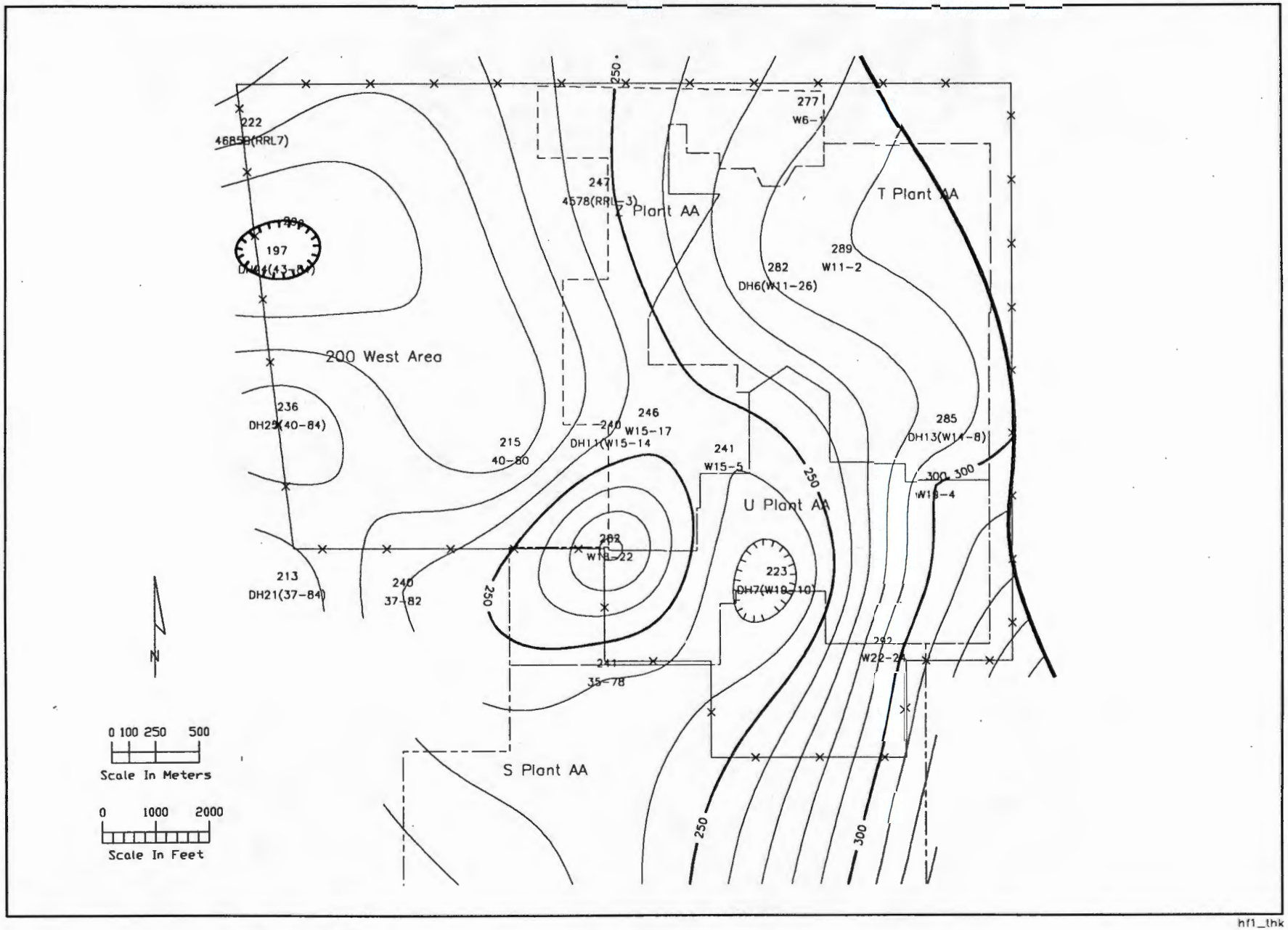

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Figure 3-29. Structure Contour Map of the Ringold Formation Lower Mud Unit (Connelly et al. 1992).

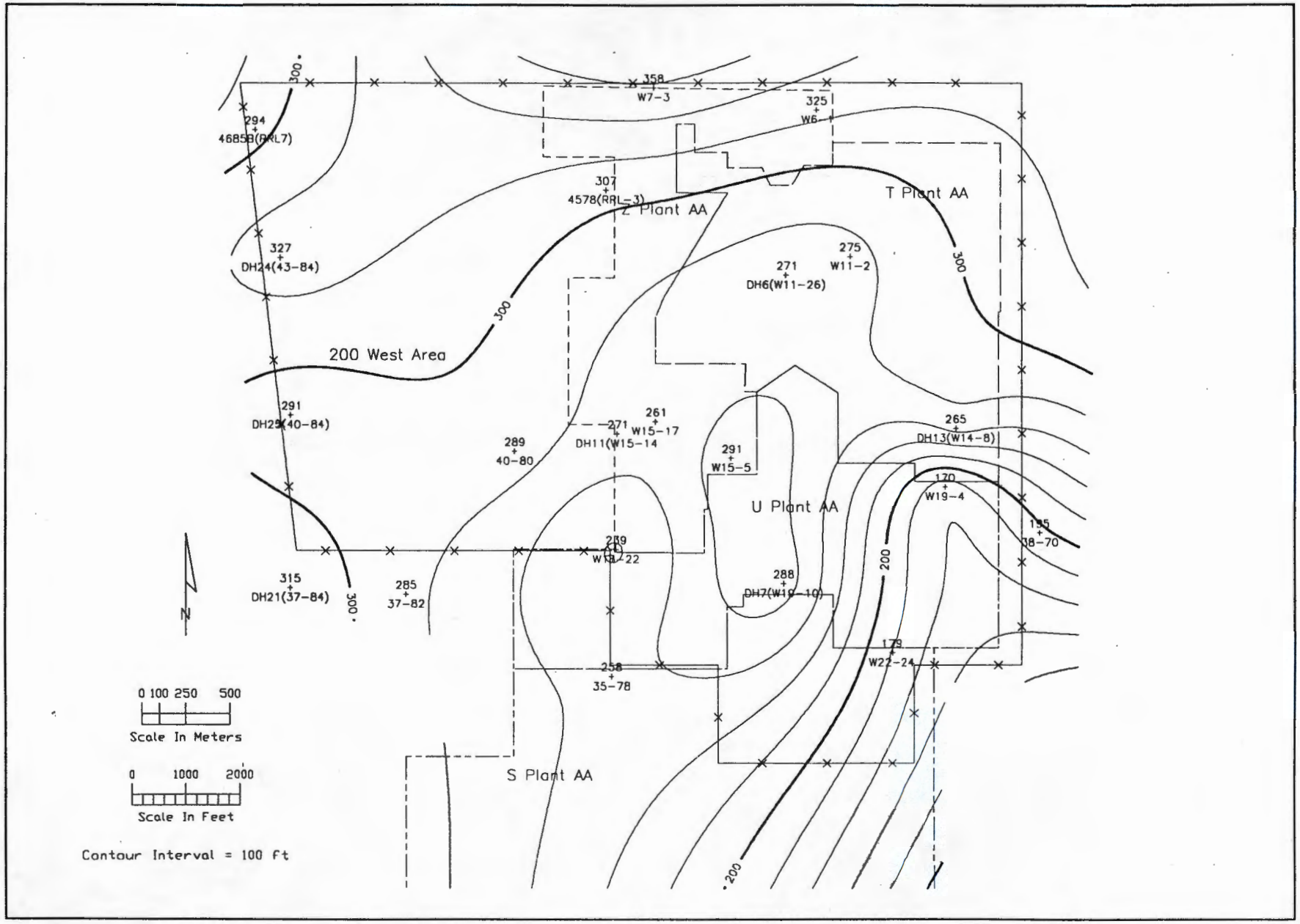

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Figure 3-30. Isopach Map of the Ringold Formation Gravel Unit E (Connelly et al. 1992).

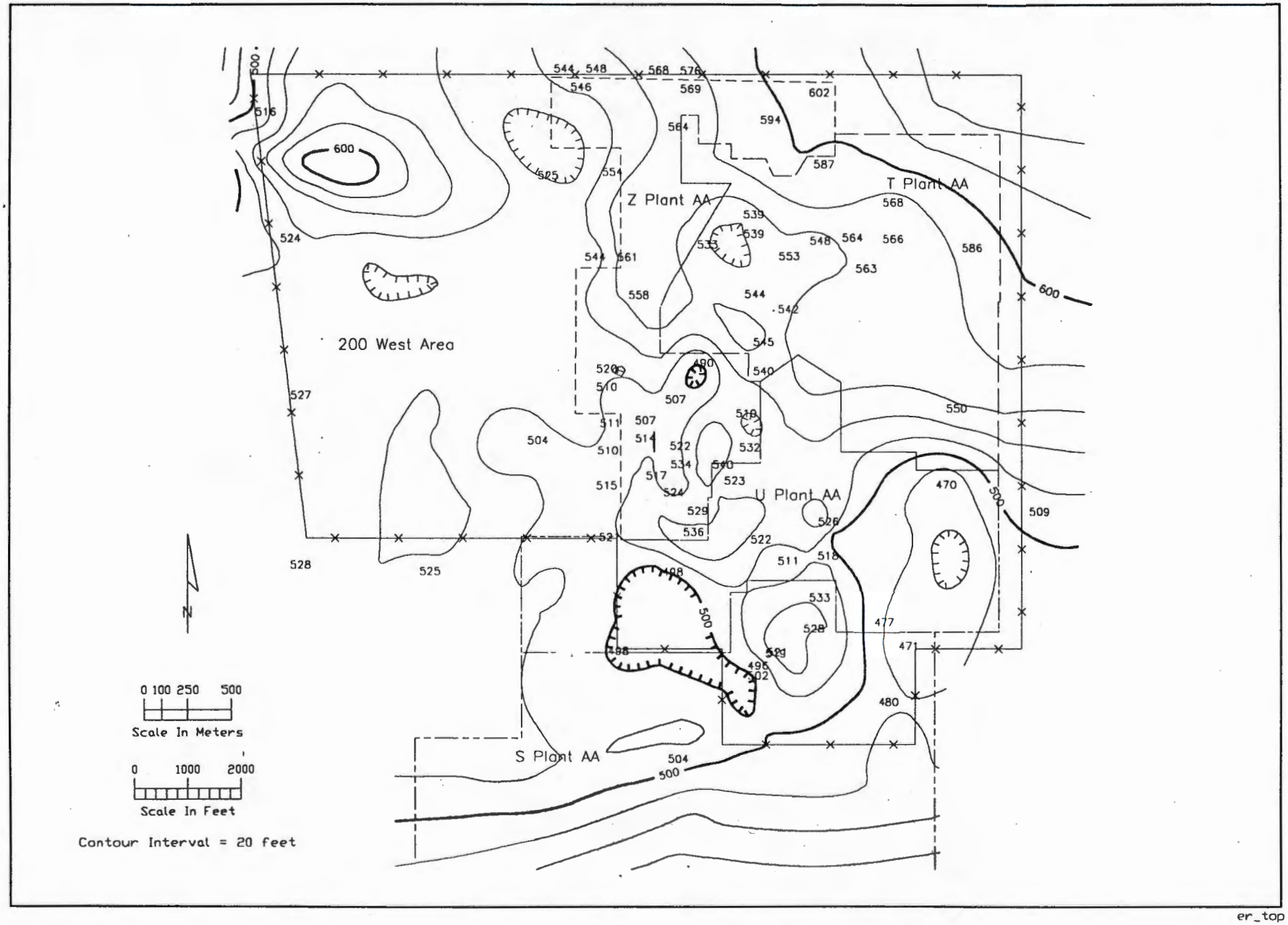

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Figure 3-31. Structure Contour Map of the Ringold Formation Gravel Unit E (Connelly et al. 1992).

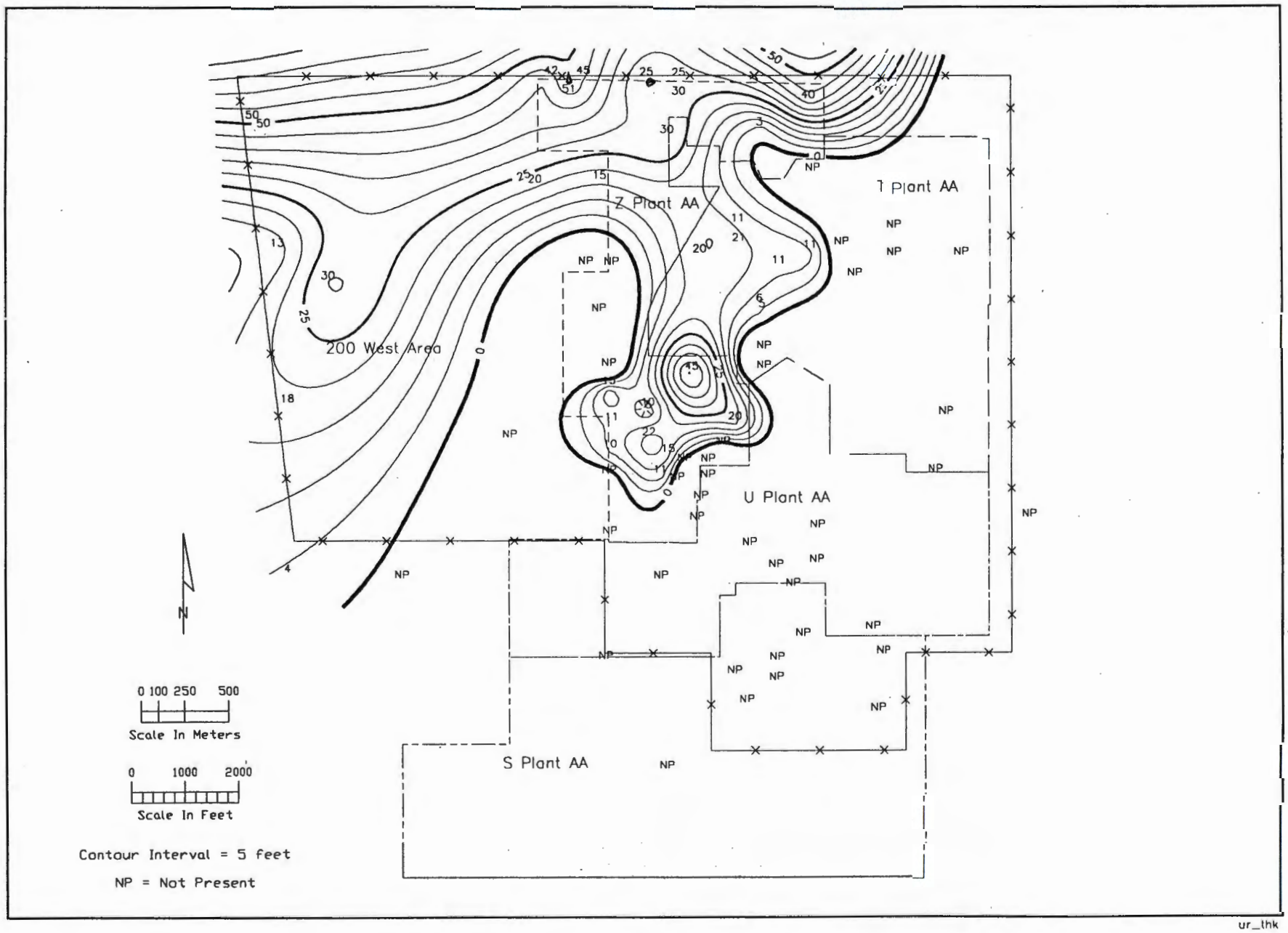

Figure 3-32. Isopach Map of the Ringold Formation Upper Unit (Connelly et al. 1992).

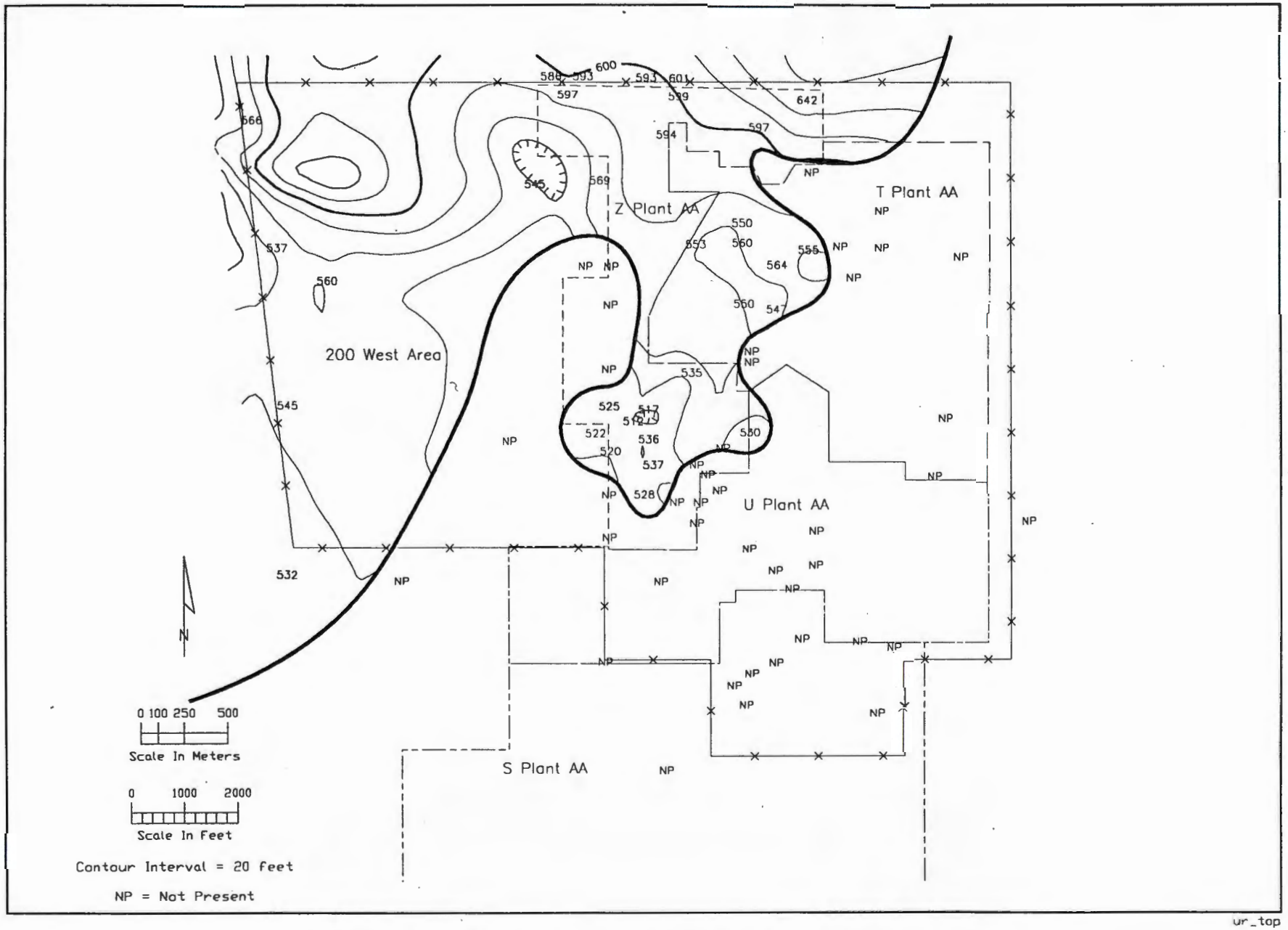

Figure 3-33. Structure Contour Map of the Ringold Formation Upper Unit (Connelly et al. 1992).

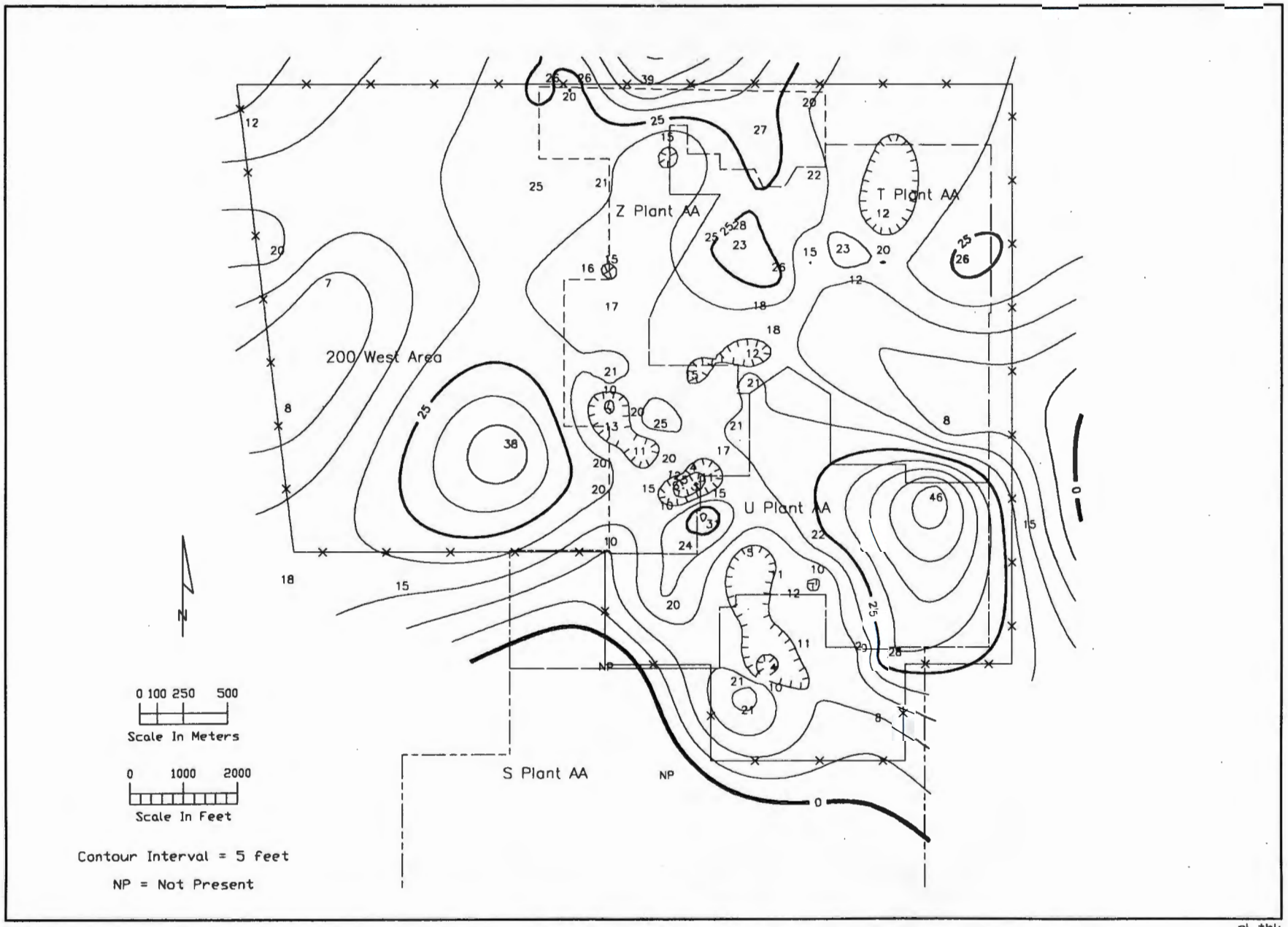

Figure 3-34. Isopach Map of the Plio-Pleistocene Unit (Connelly et al. 1992).

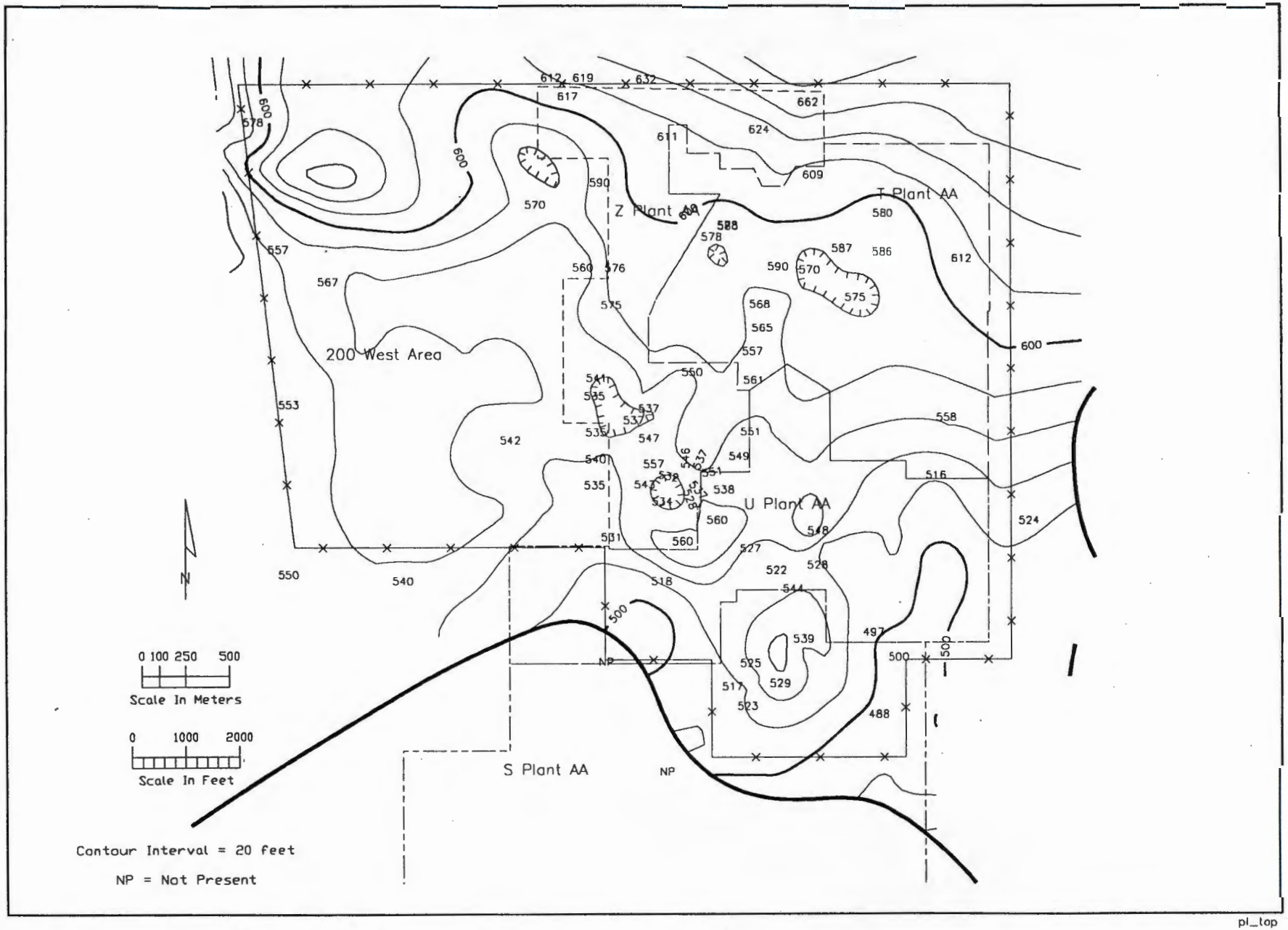

Figure 3-35. Structure Contour Map of the Plio-Pleistocene Unit (Connelly et al. 1992).

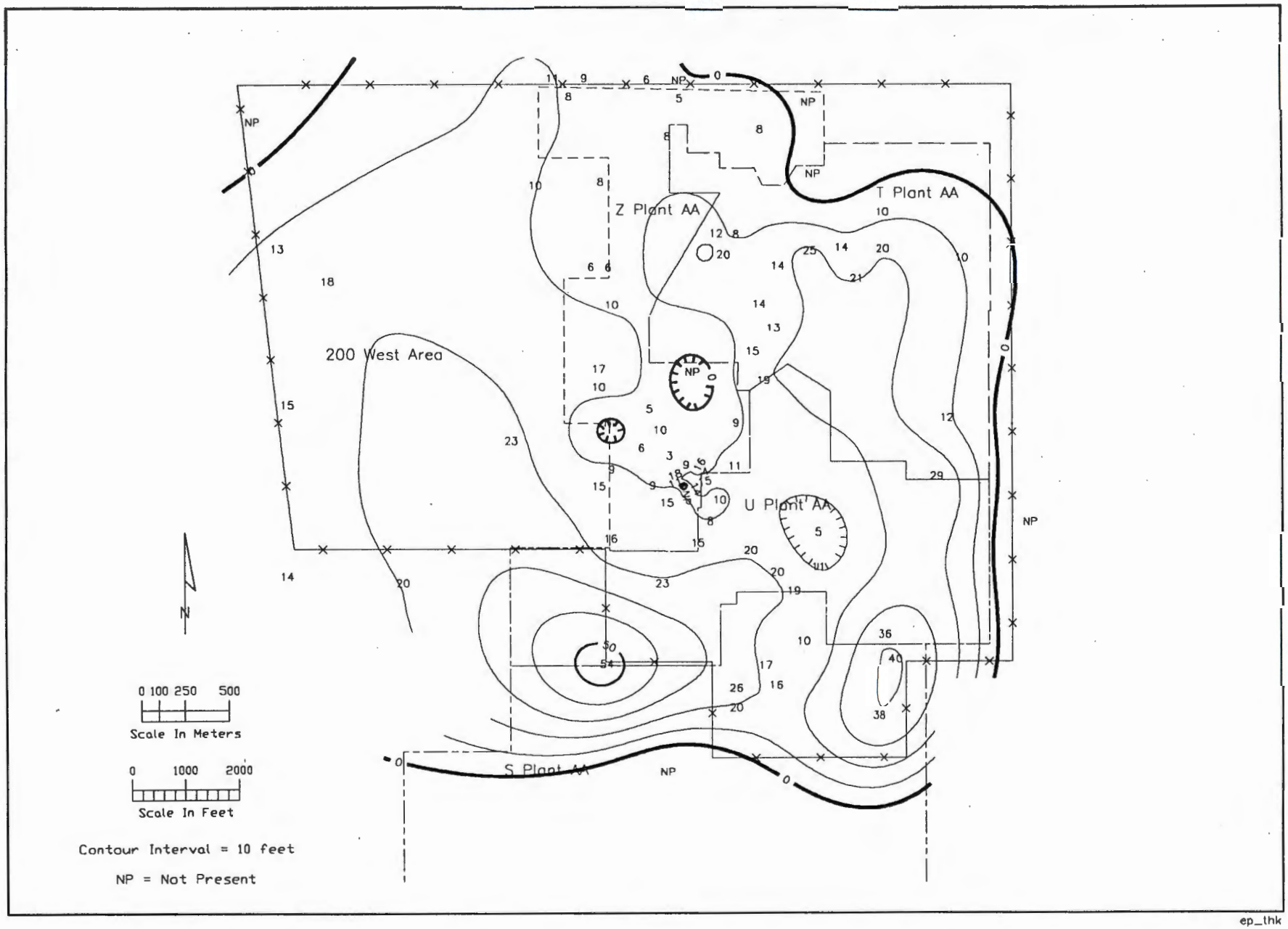

Figure 3-36. Isopach Map of the Early "Palouse" Soil (Connelly et al. 1992).

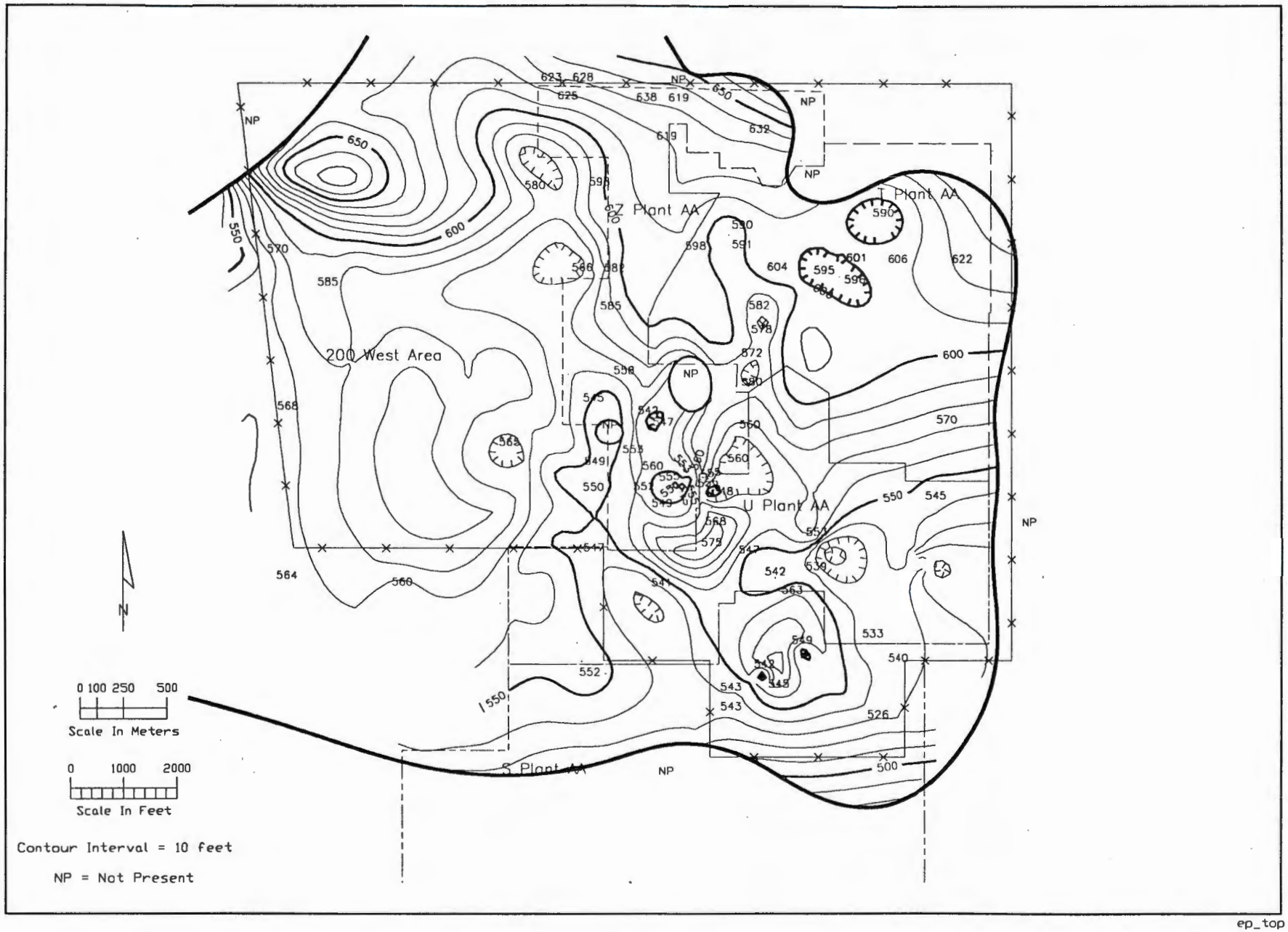

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Figure 3-37. Structure Contour Map of the Early "Palouse" Soil (Connelly et al. 1992).

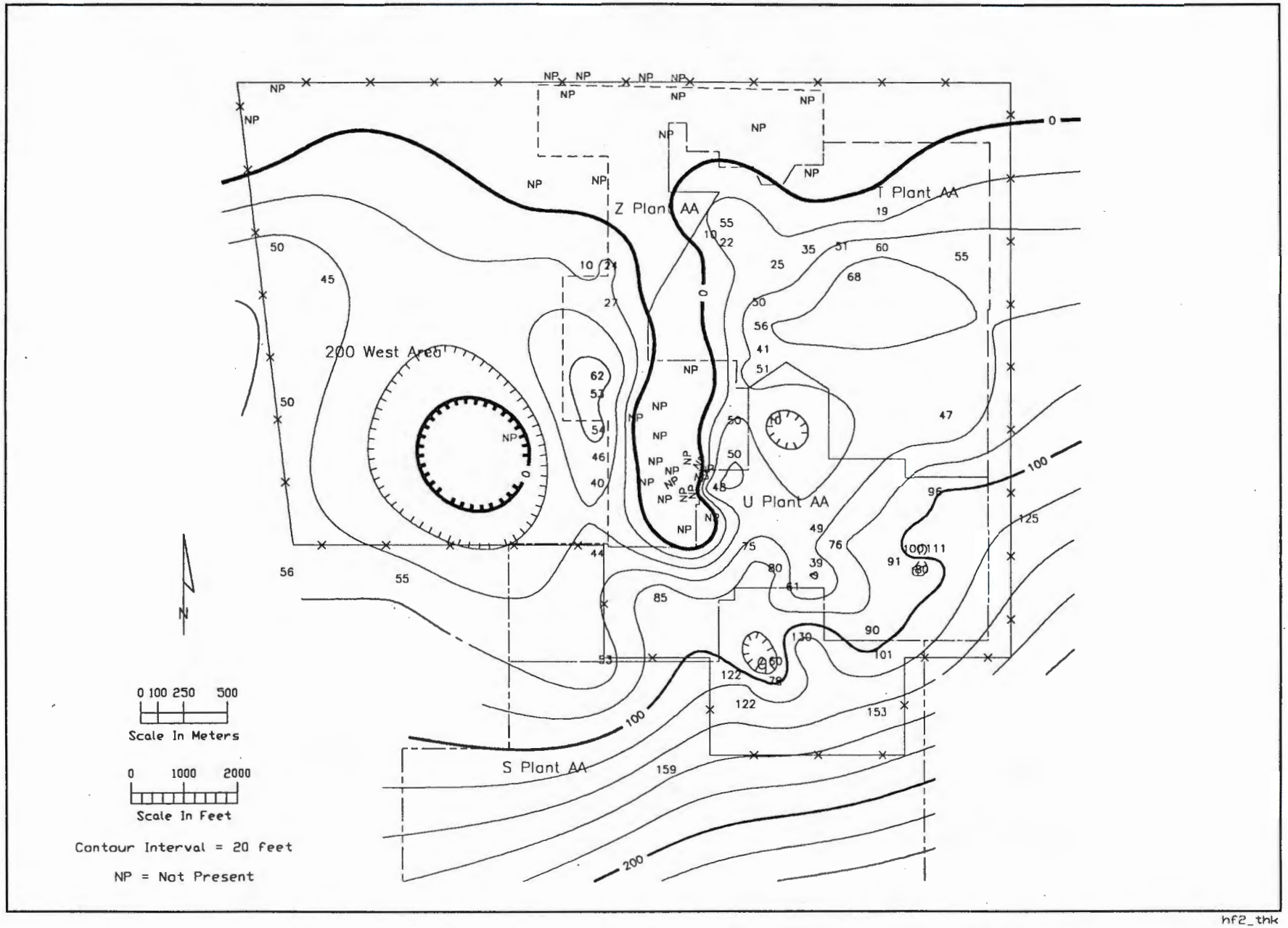

Figure 3-38. Isopach Map of the Hanford Formation Lower Fine Unit (Connelly et al. 1992).

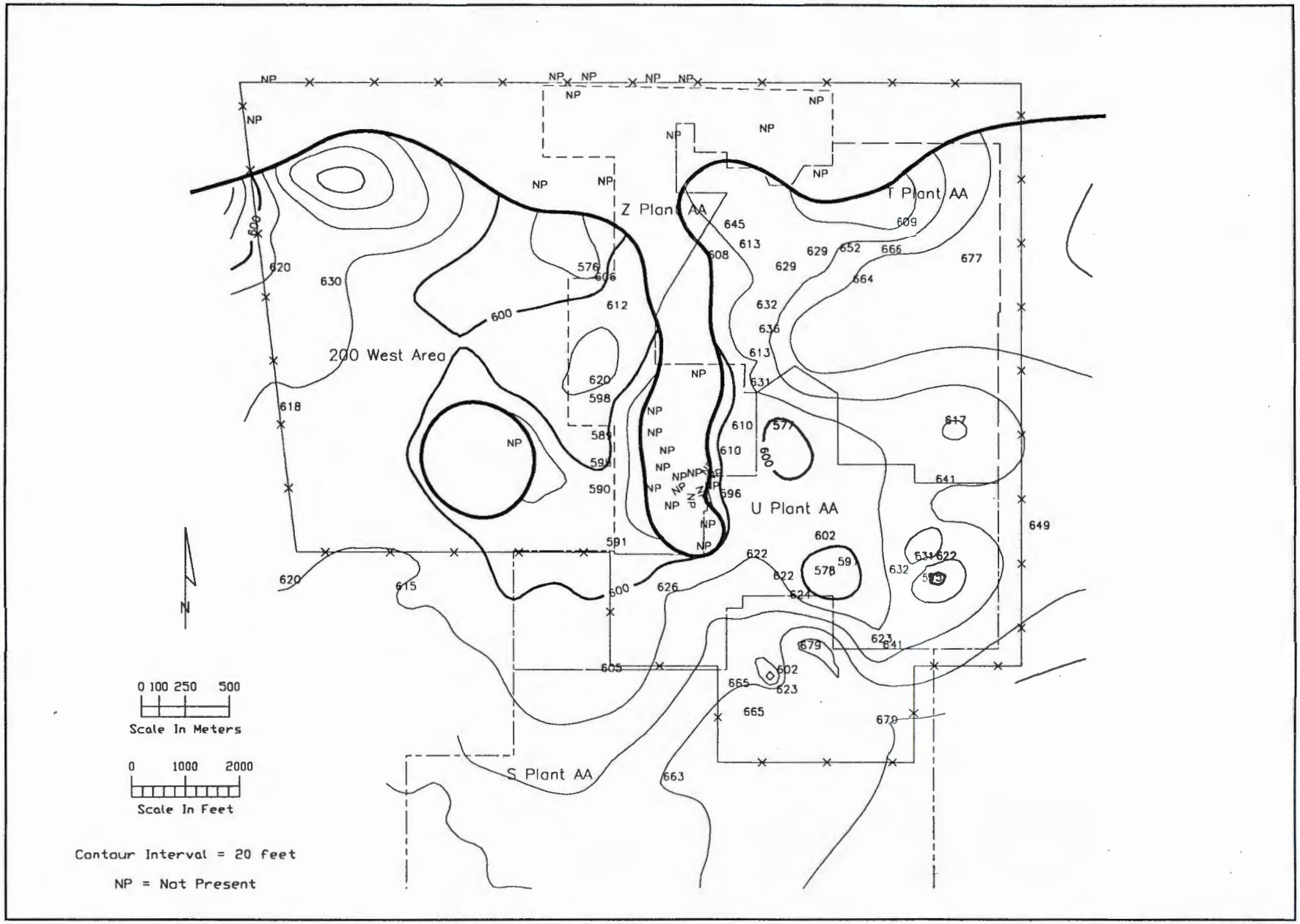

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Figure 3-39. Structure Contour Map of the Hanford Formation Lower Fine Unit (Connelly et al. 1992).

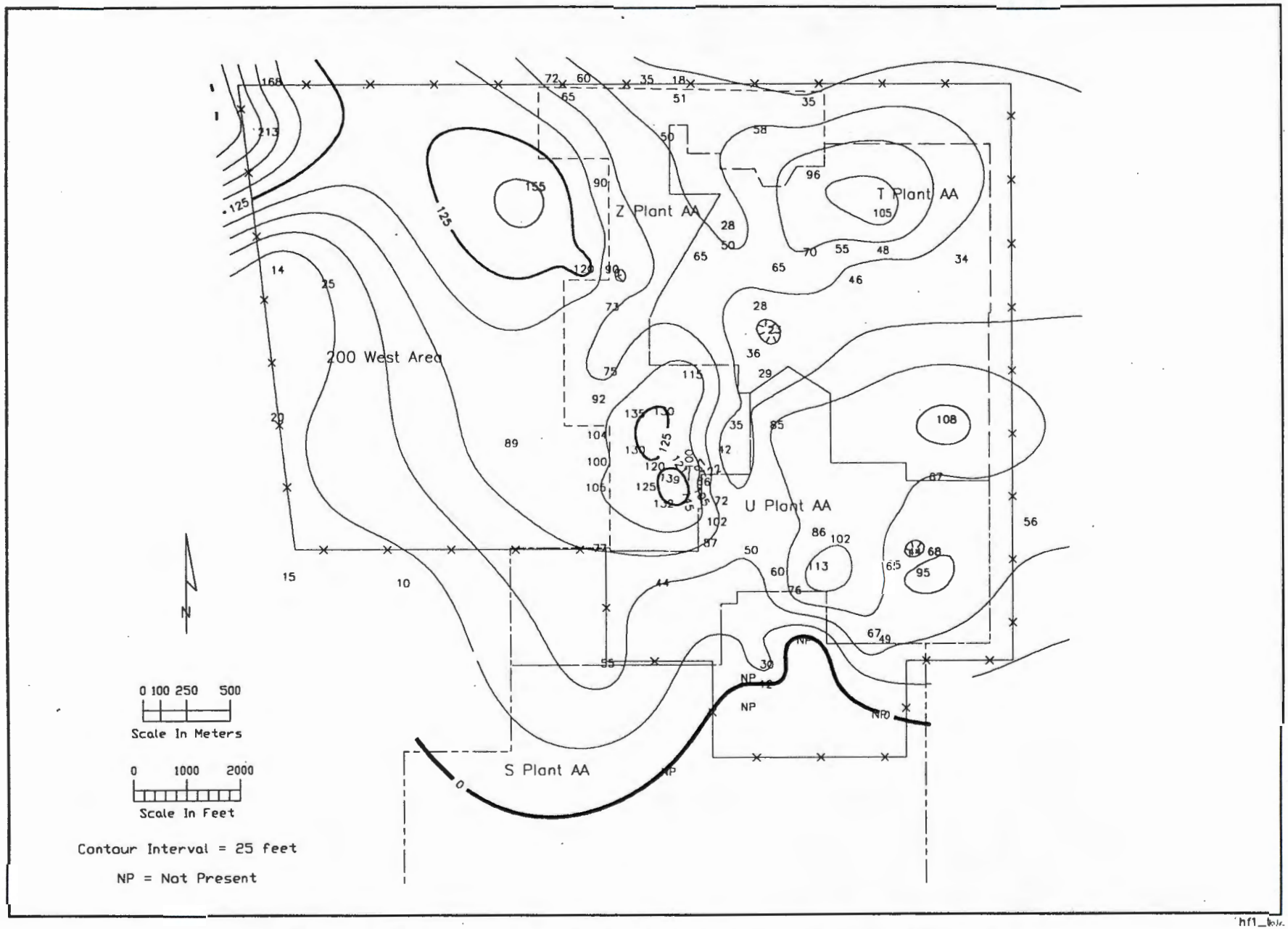


Figure 3-40. Isopach Map of the Hanford Formation Upper Coarse Unit (Connelly et al. 1992).

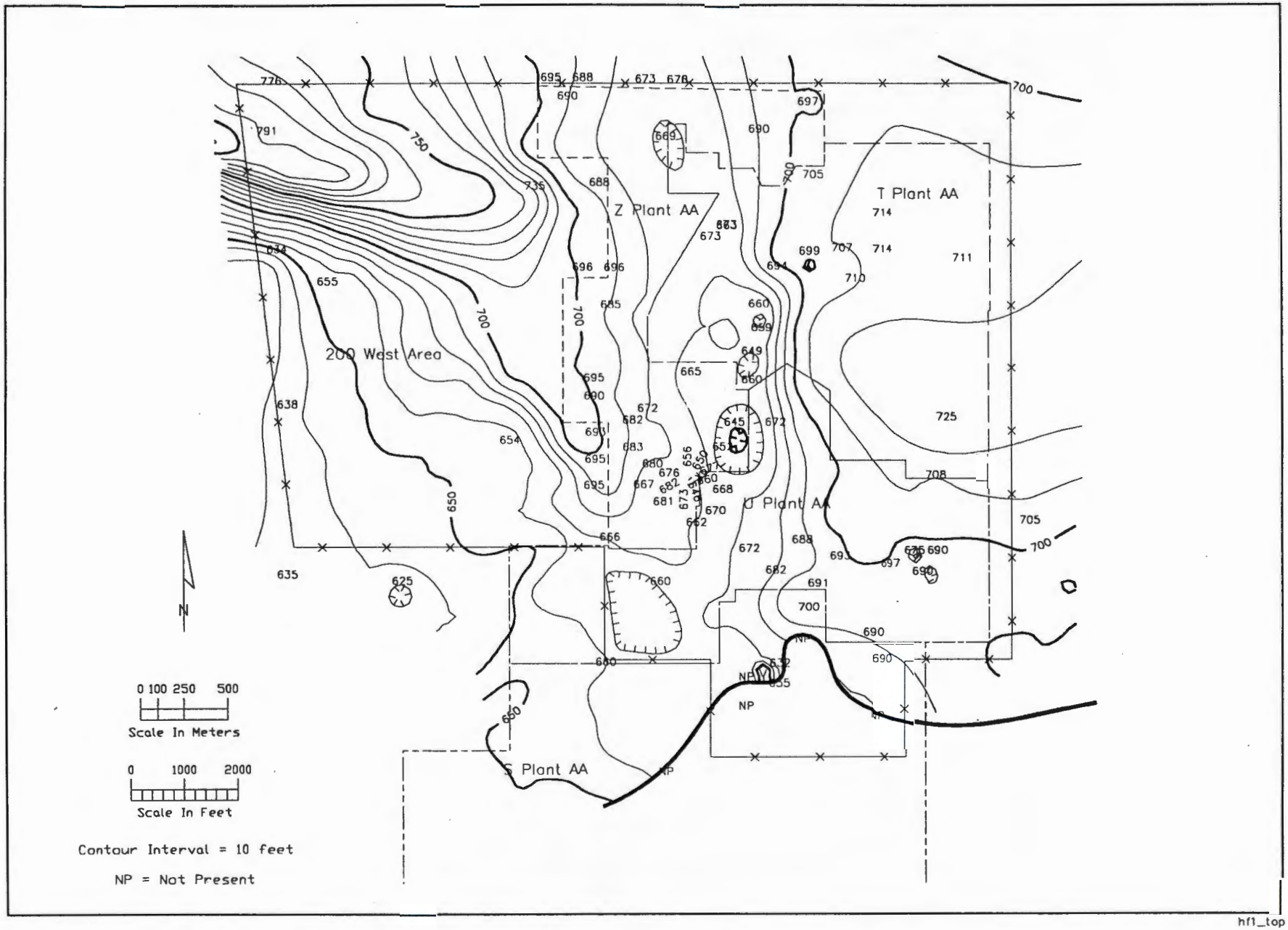


Figure 3-41. Structure Contour Map of the Hanford Formation Upper Coarse Unit (Connelly et al. 1992).

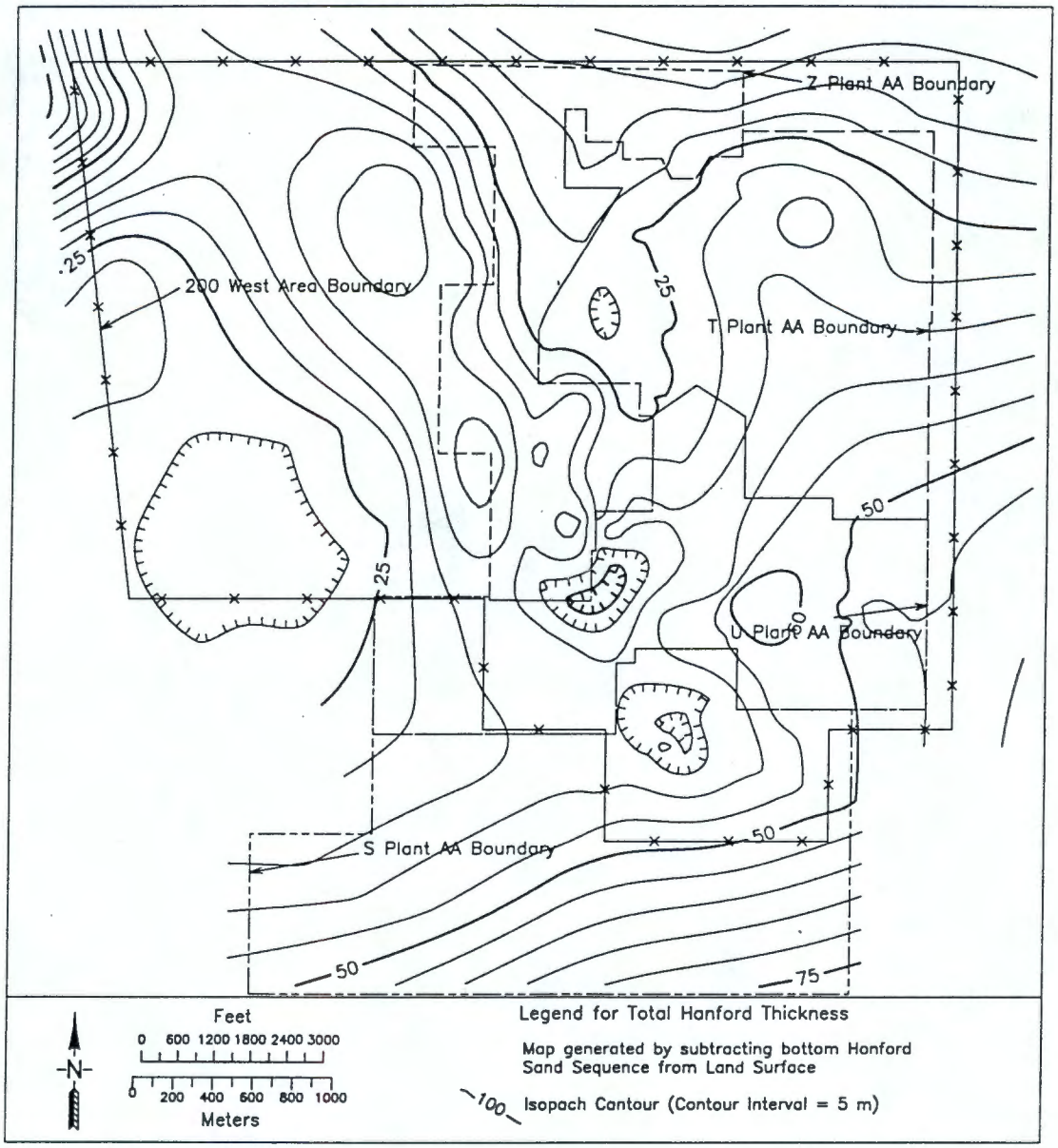


Figure 3-42. Isopach Map of the Entire Hanford Formation.

9 2 1 2 6 7 1 0 3 0 5

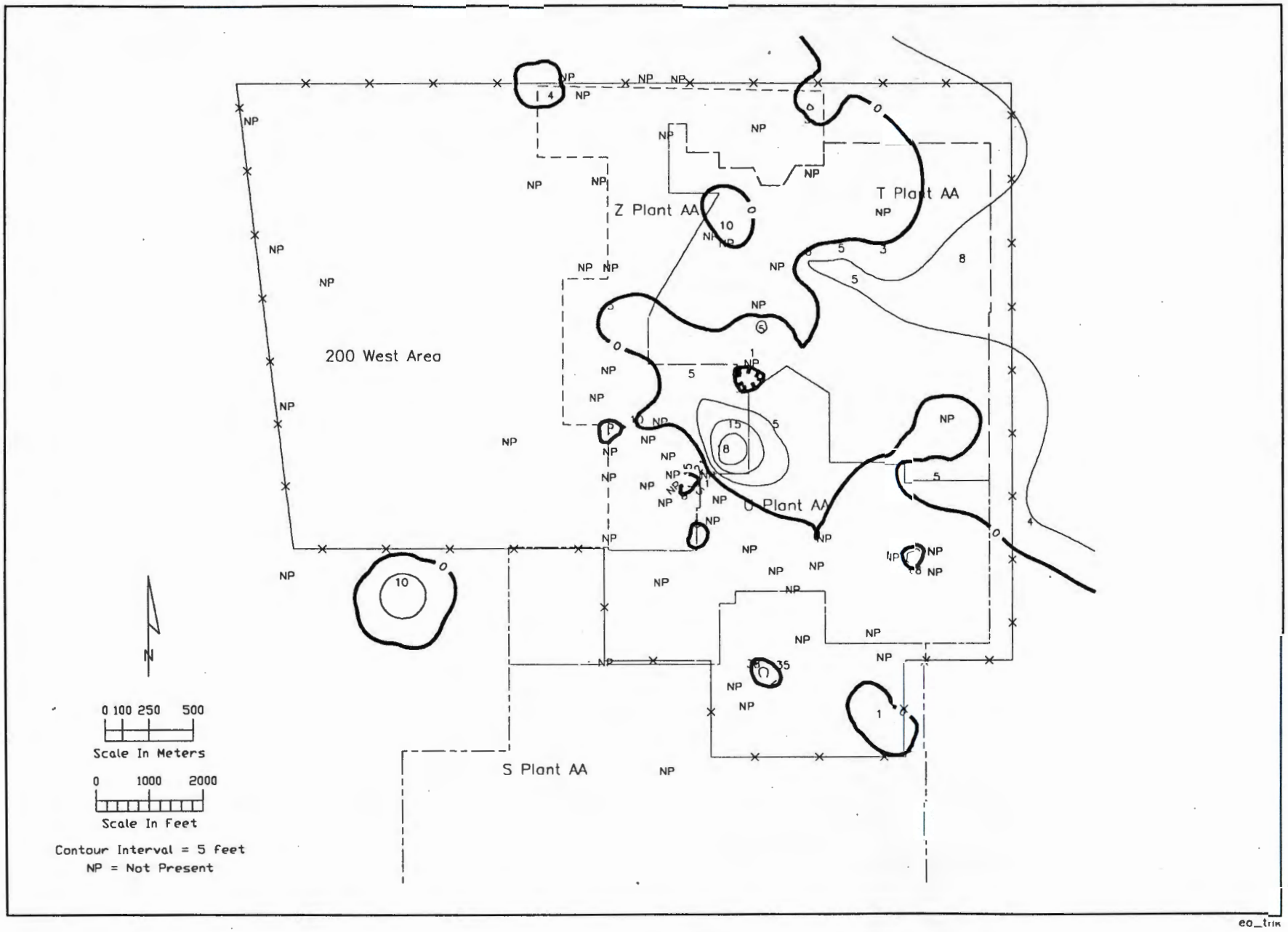


Figure 3-43. Isopach Map of the Backfilled Gravels and Eolian Sands.

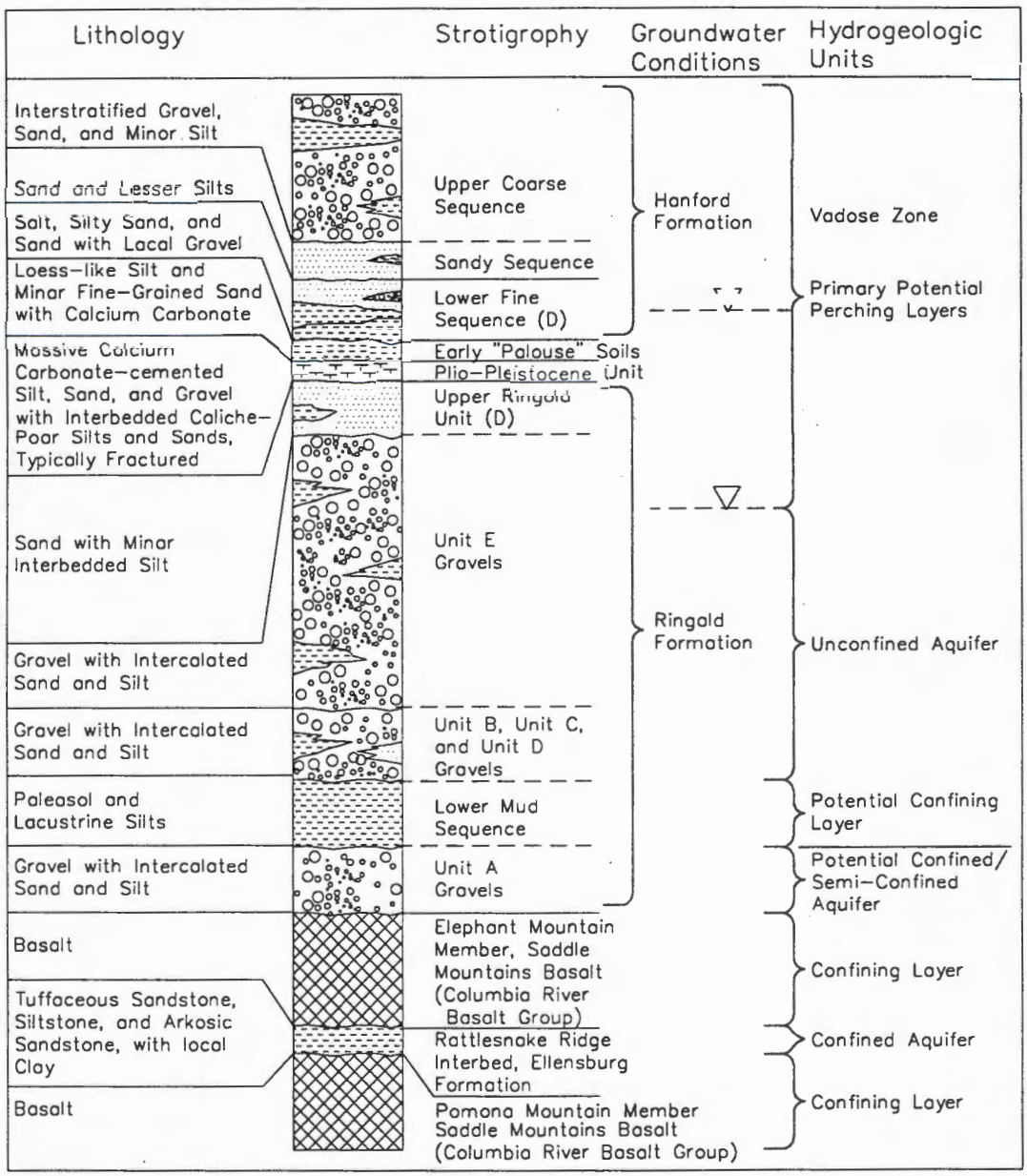
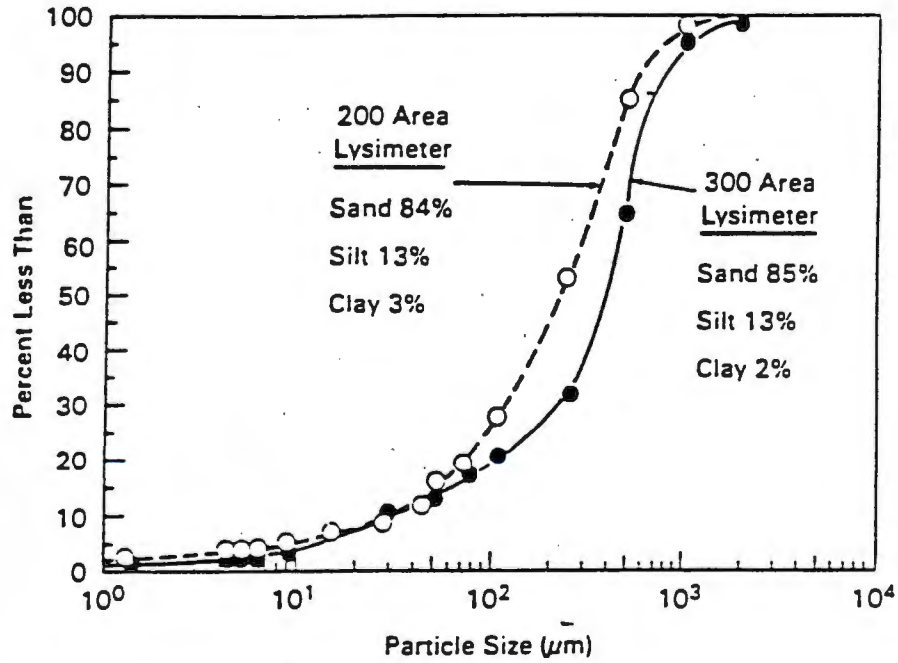
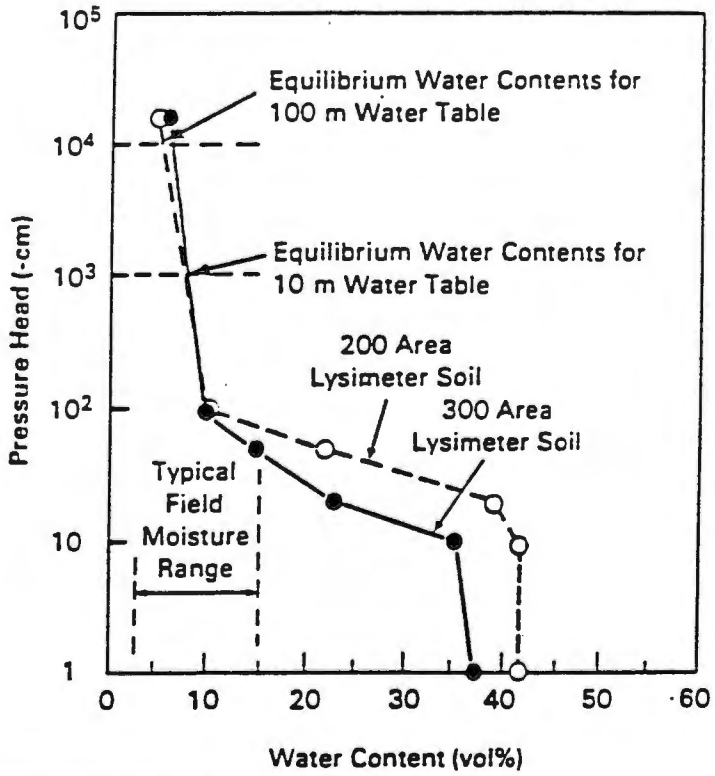


Figure 3-44. Conceptual Hydrogeologic Column for the Hanford Site.



a. Particle-Size Distribution



b. Water Retention Characteristics

Figure 3-45. Particle-Size Distribution and Water Retention Characteristics of Soils from Hanford Site Lysimeters (Gee and Heller 1985).

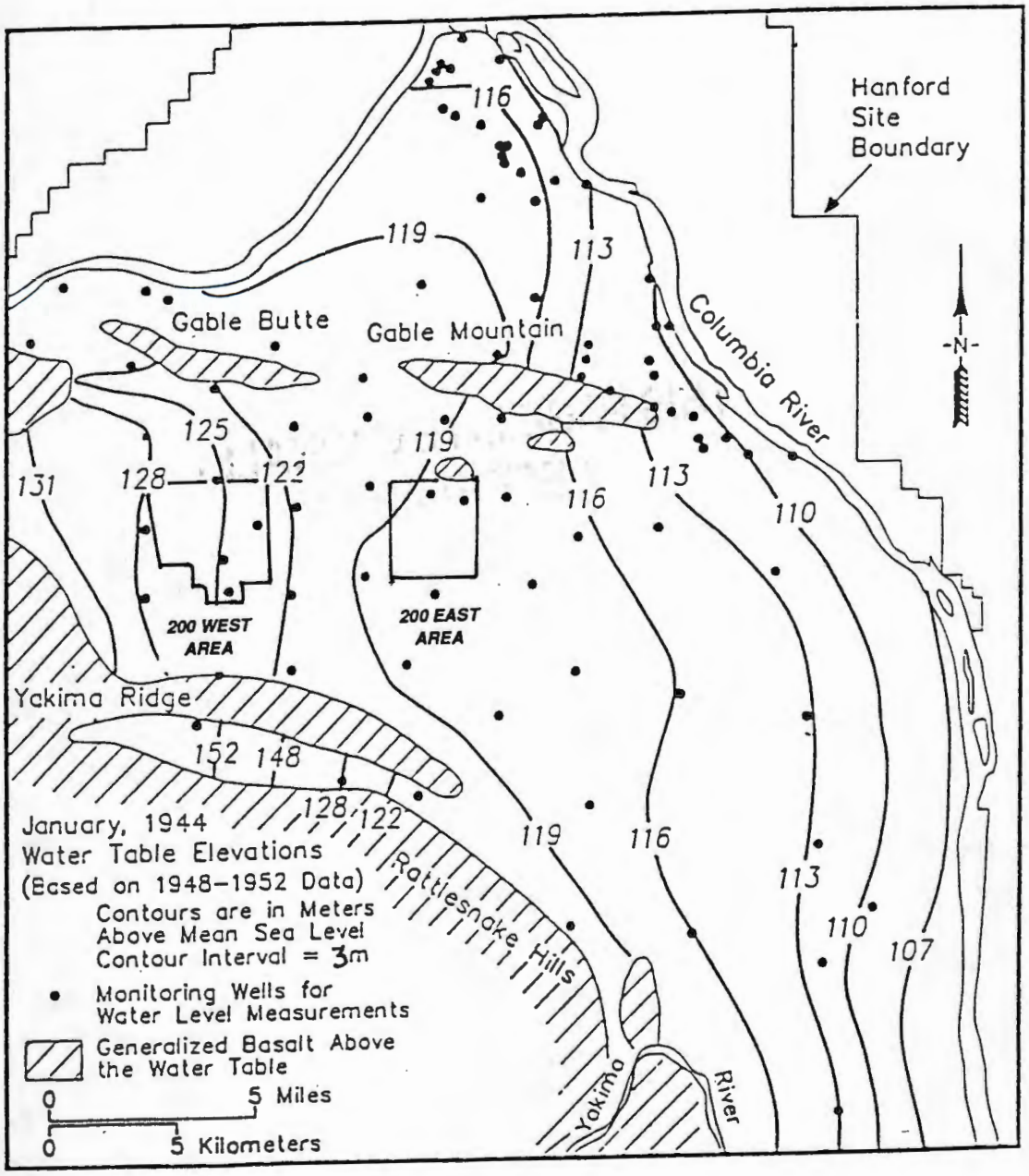


Figure 3-46. Hindcast Water Table Map of the Hanford Site, January 1944 (ERDA 1975).

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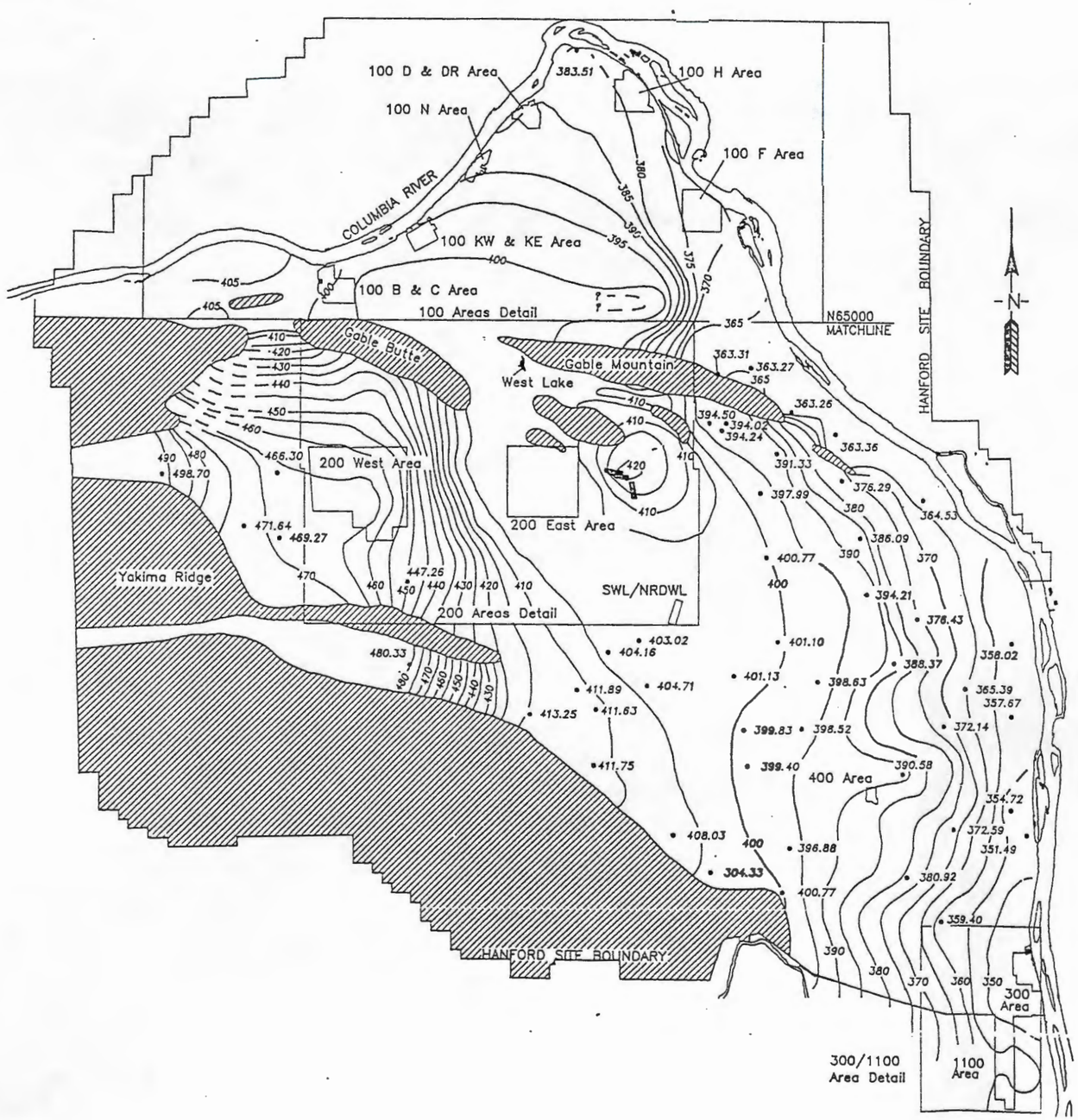


411.49 • Water table elevation (feet above mean sea level)

400 Water table contours in feet above mean sea level Contour Interval = 10 ft

Ponds

Areas where the basalt surface is generally above the water table

The Hanford Site water table map has been prepared by the Geosciences Group, Environmental Division, of Westinghouse Hanford Company.

Note: To convert to metric, multiply elevation (ft) by 0.3048 to obtain elevation (m).

0 1 Mile
0 1 Kilometer

Figure 3-47. Hanford Site Water Table Map, June 1991.

(source: Kasza et al. 1991)

9 2 1 2 6 5 1 0 3 1 0

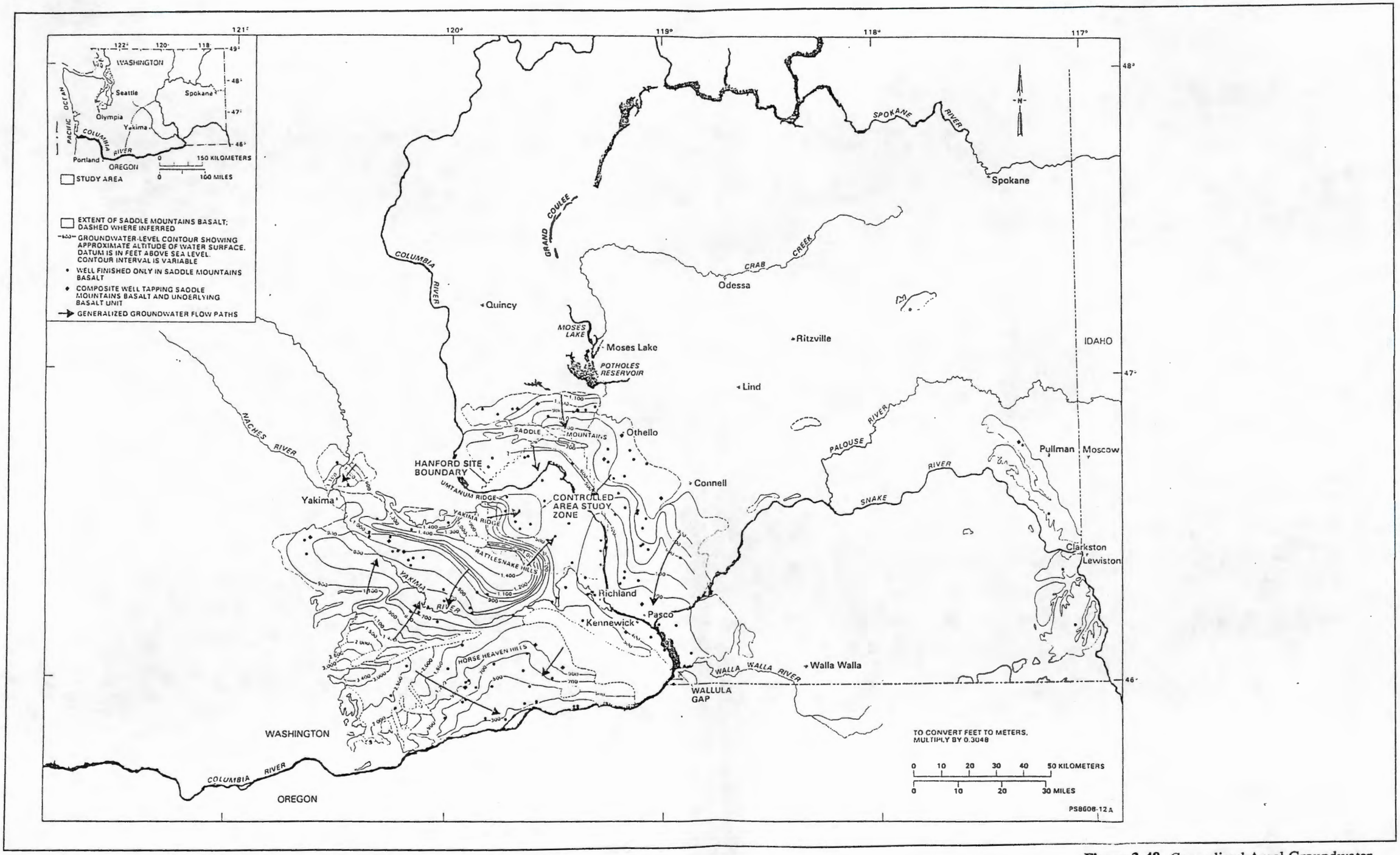
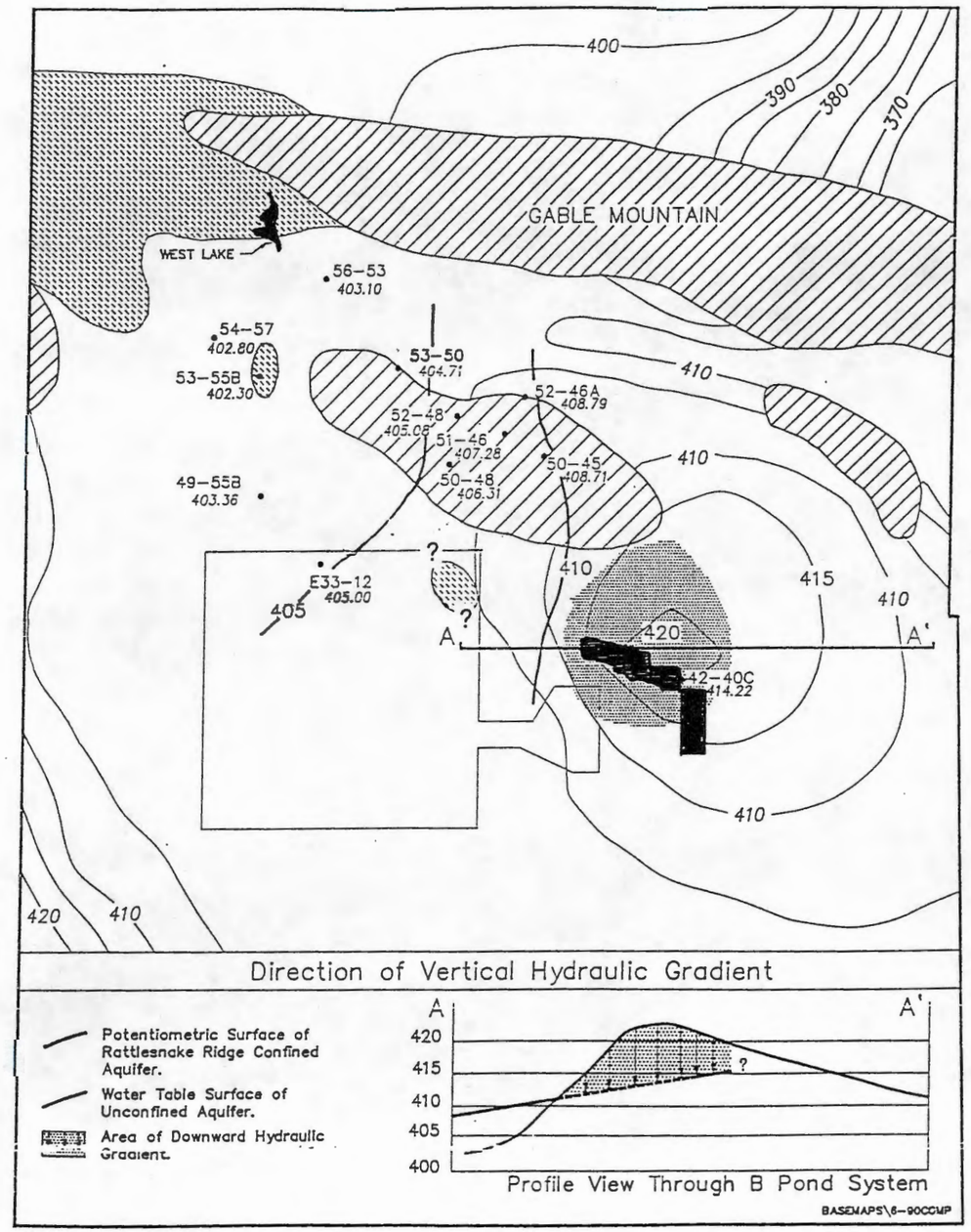


Figure 3-48. Generalized Areal Groundwater Flow Patterns in the Saddle Mountains Basalt within the Columbia Plateau (DOE 1988)

9 2 1 2 6 5 1 0 3 1 1



Potentiometric surface of the Rattlesnake Ridge confined aquifer in feet above mean sea level

Water table contours in feet above mean sea level

Areas of complete erosion of the Elephant Mountain Member (from RHO-RE-ST-12)

Area of downward hydraulic gradient

50-45 405 Wells in confined aquifer used to prepare map

Pond

Areas where the basalt surface is generally above the water table

The Rattlesnake Ridge aquifer, which is confined by the Elephant Mountain Member, is monitored quarterly in the eastern portion of 200 East Area. The June 1991 water level measurements in 12 wells completed in the Rattlesnake Ridge interbed were used to contour the potentiometric surface of the aquifer. Areal extent of downward hydraulic gradient from the unconfined aquifer to this confined aquifer is inferred from the water-table map and the contours of the potentiometric surface of the Rattlesnake Ridge. This area represents the zone in which downward flow might occur if a pathway is available due to complete erosion of the Elephant Mountain Member or sufficiently high hydraulic conductivity in the basalt. A profile view through the B Pond system shows the relationship between the unconfined water table and the potentiometric surface of the Rattlesnake Ridge confined aquifer.

The potentiometric surface of the Rattlesnake Ridge confined aquifer map has been prepared by the Geosciences Group, Environmental Division, Westinghouse Hanford Company.

Note: To convert to metric, multiply elevation (ft) by 0.3048 to obtain elevation (m).

-N-

0 1 Mile

0 1 Kilometer

Figure 3-49. Comparison of Potentiometric Surface of the Rattlesnake Ridge Confined Aquifer with the Water Table of the Unconfined Aquifer June 1991. (source: Kasza et al. 1991)

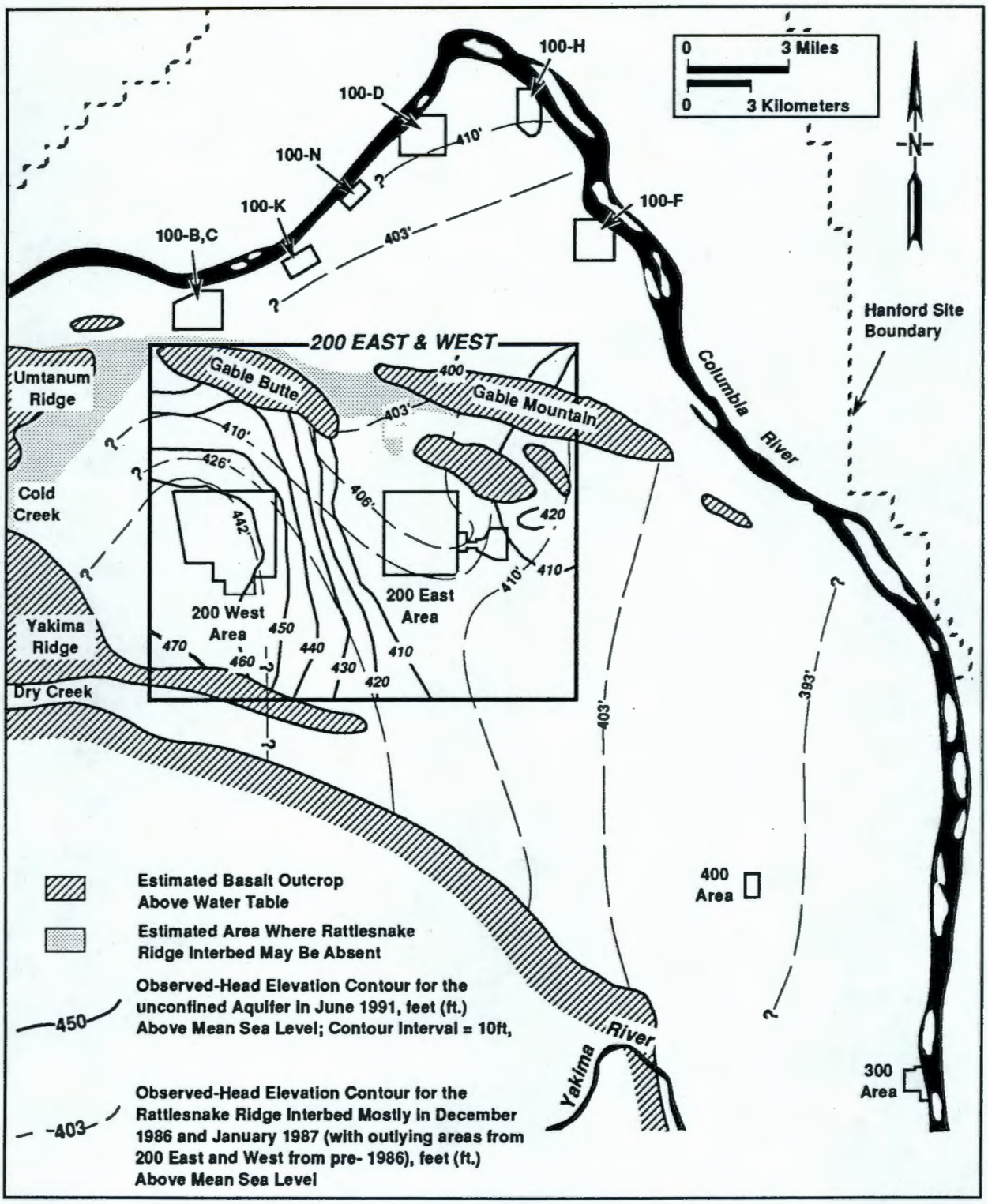


Figure 3-50. Potentiometric Surface Contour Map for the Unconfined and Rattlesnake Ridge Aquifers (Adapted from Kasza et al. 1991 and Jackson 1992)

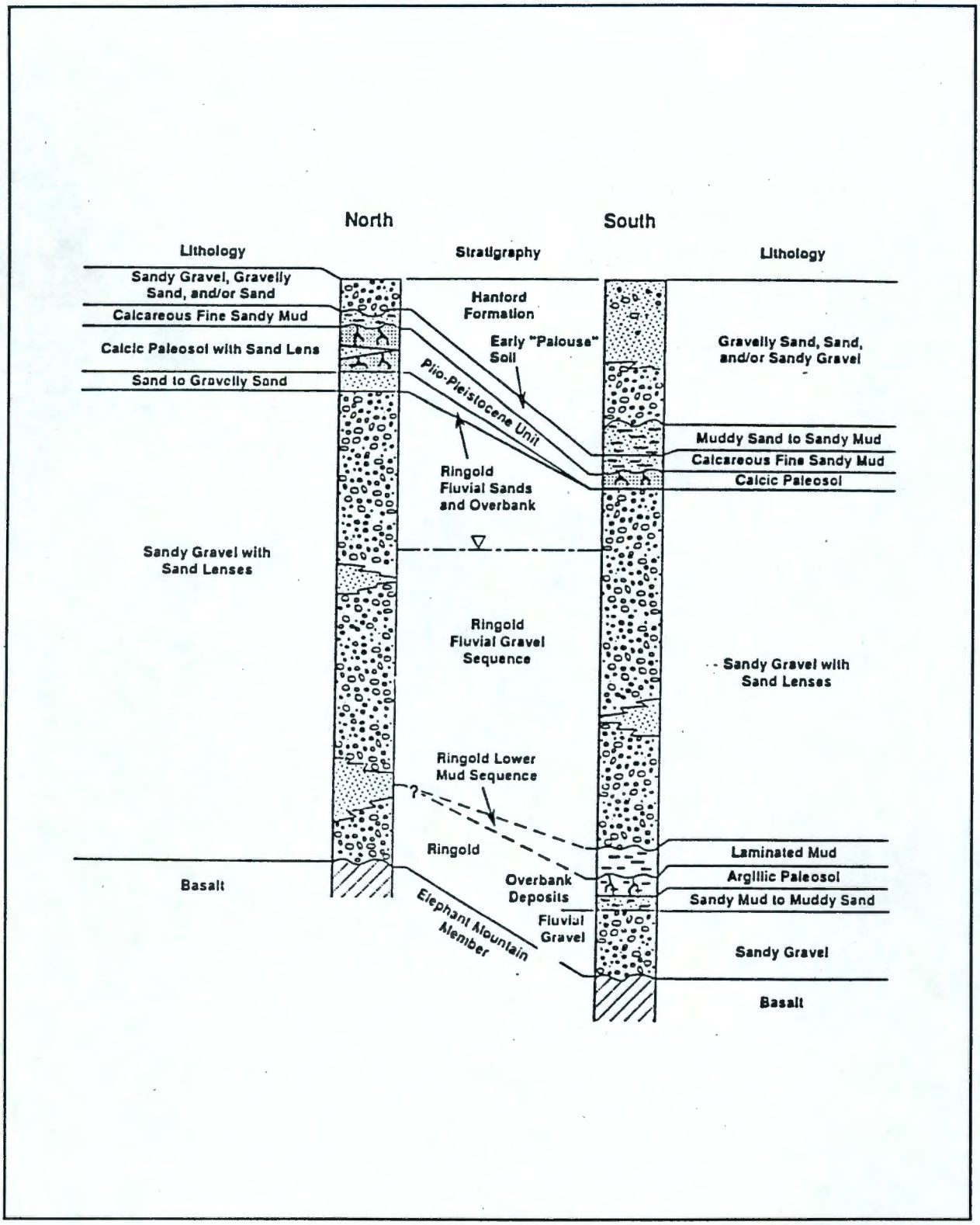


Figure 3-51. Conceptual Geologic and Hydrogeologic Column for the 200 West Area (Last et al. 1989).

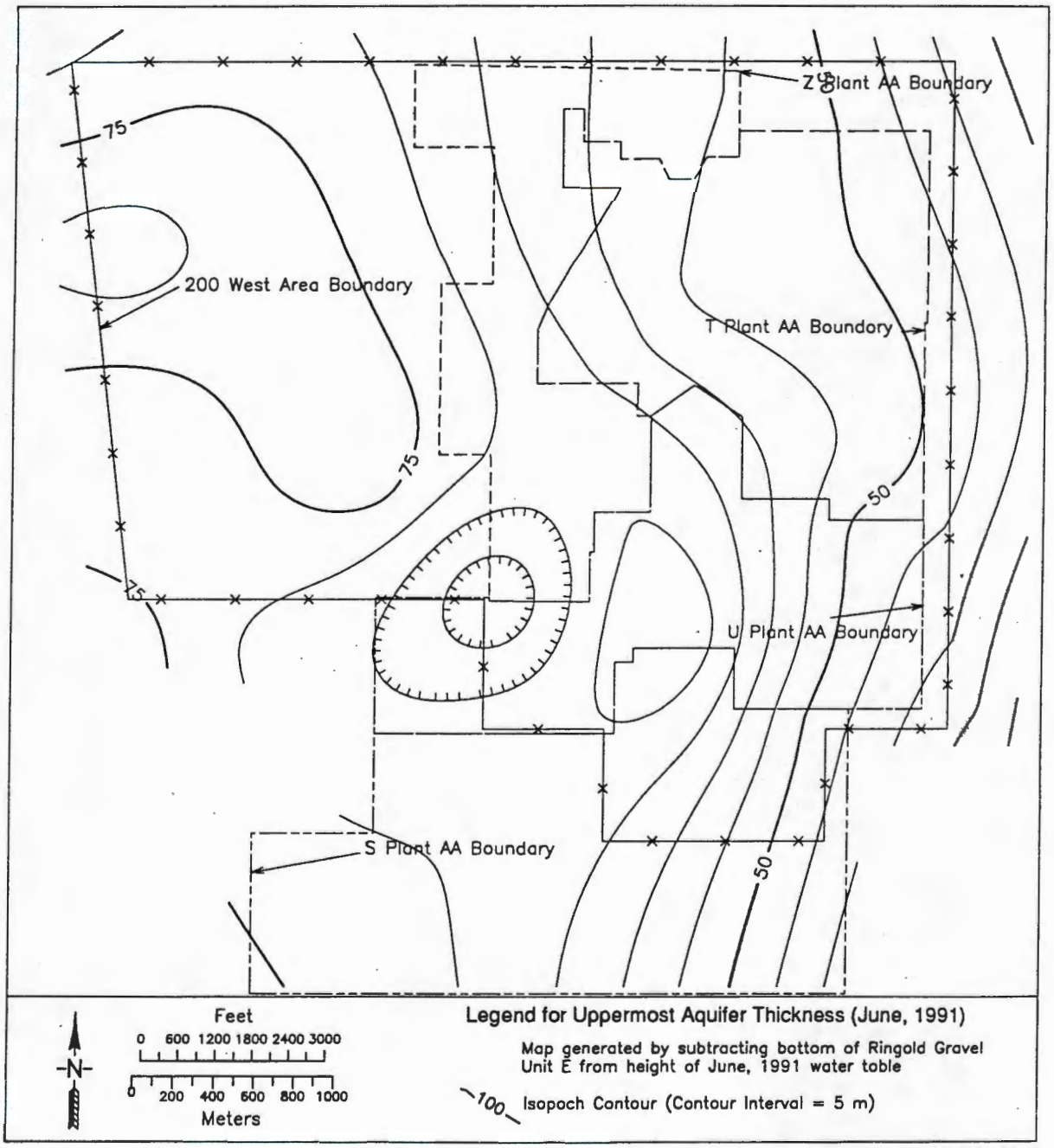


Figure 3-52. Isopach Map of the Uppermost Aquifer System in the 200 West Area.

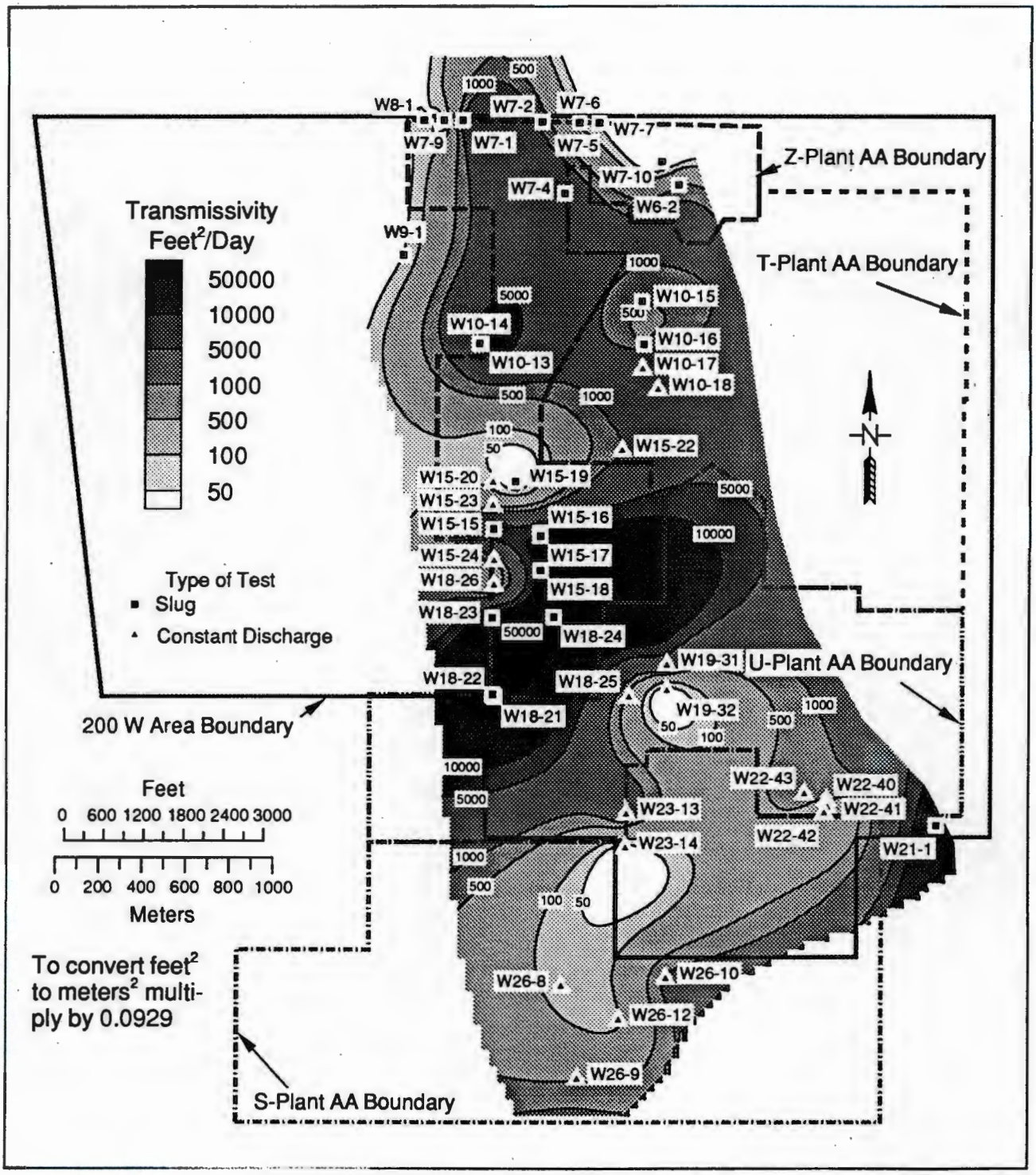


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Figure 3-53. Transmissivity Map for the Uppermost Aquifer in the 200 West Area (source: Connelly et al. 1992).

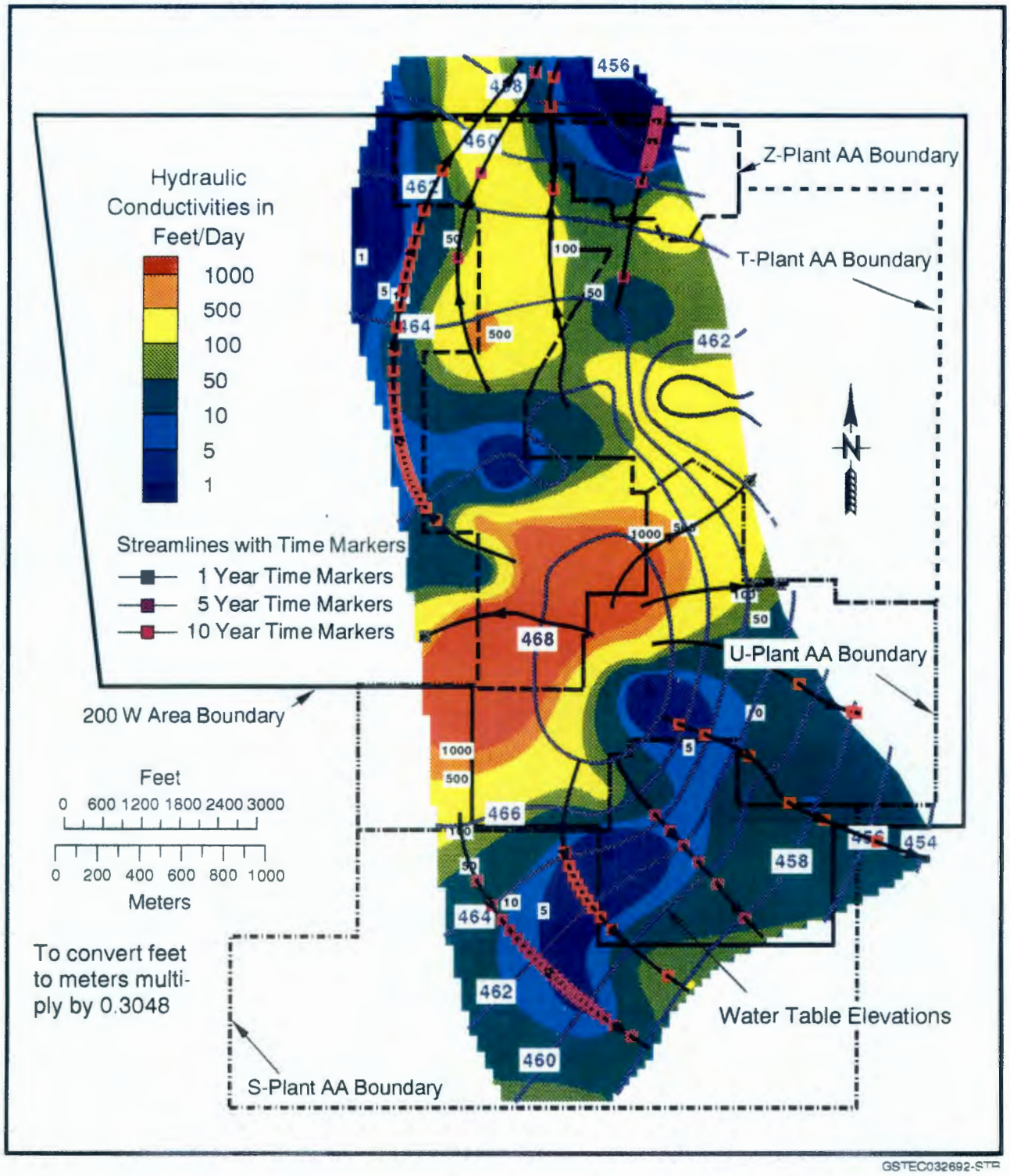

Figure 3-54. Hydraulic Conductivity Map for the 200 West Area.
(source: Connelly et al. 1992)

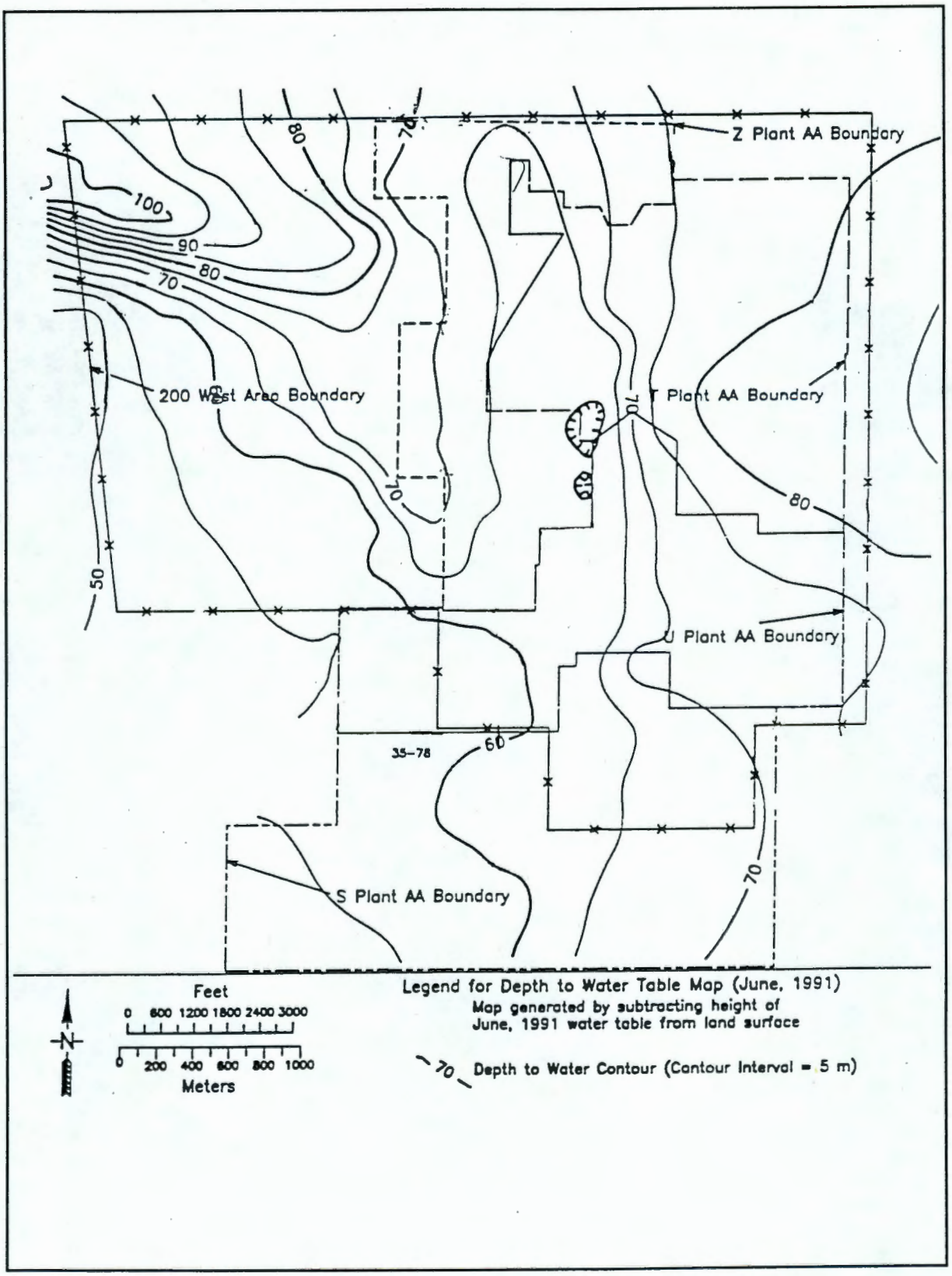

Figure 3-55. Isopach Map of the Vadose Zone in the 200 West Area.

9 2 1 2 6 1 0 3 1 8

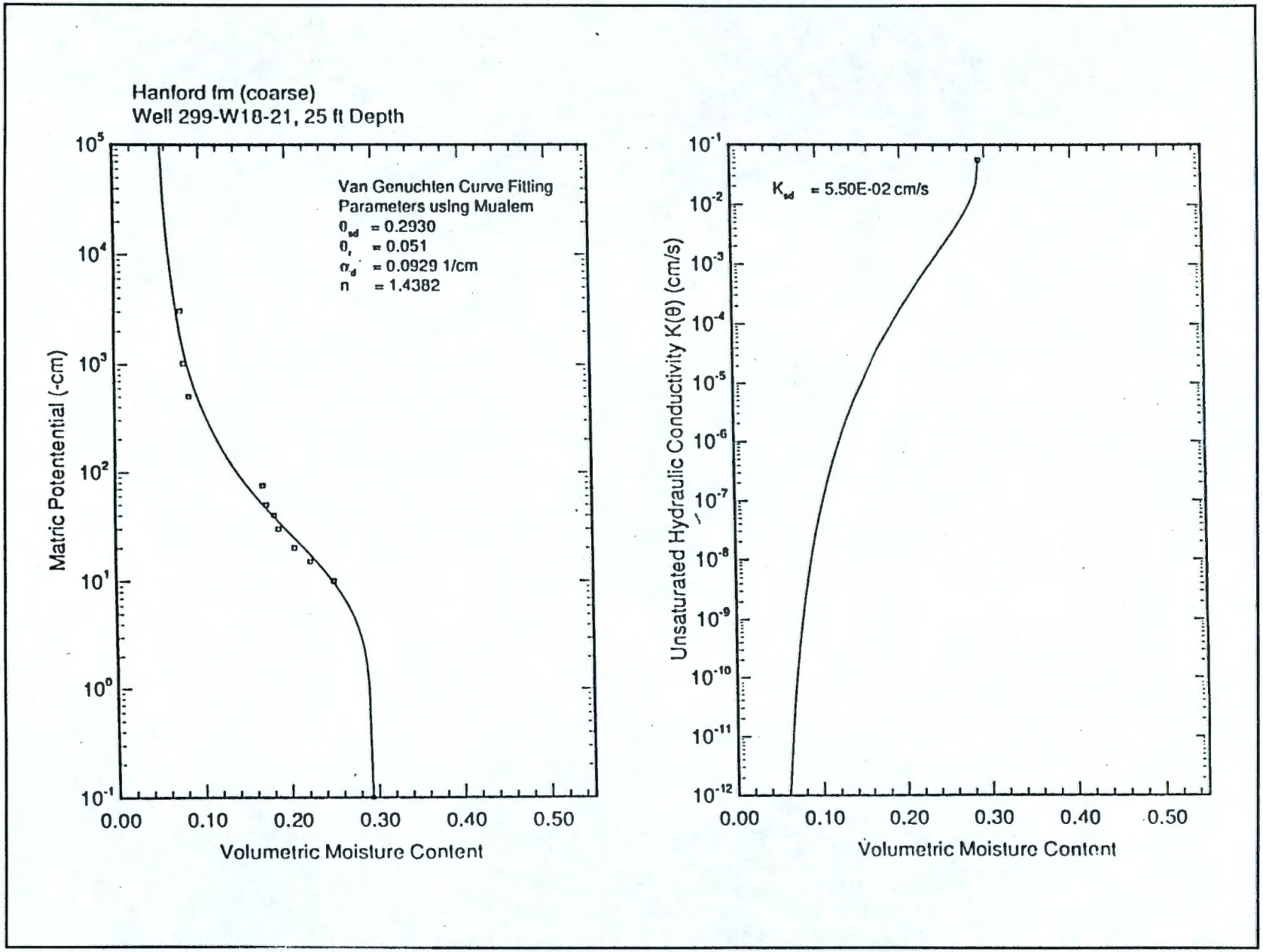

Figure 3-56. Wetting and Drying Curves for Well 299-W18-21.

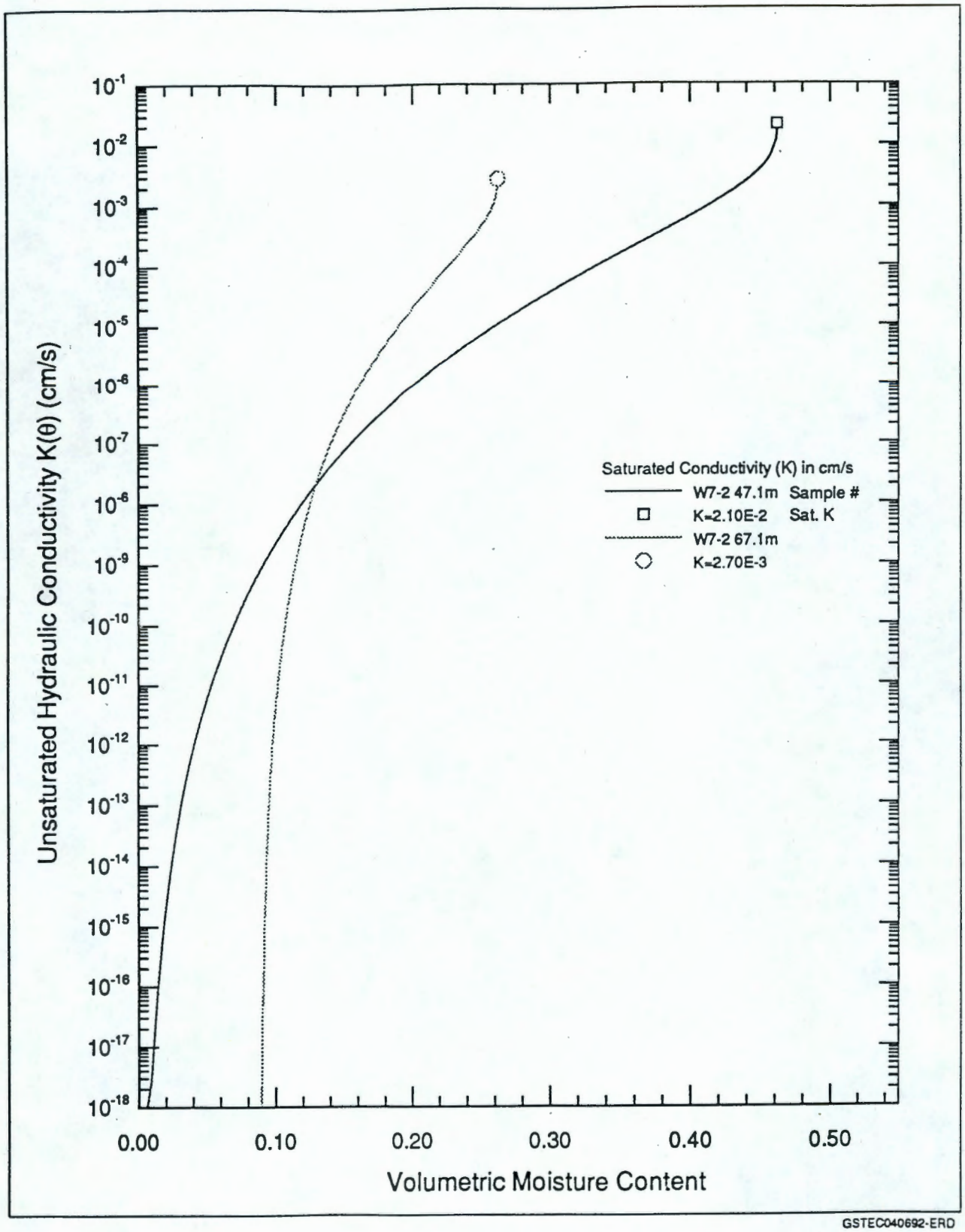

Figure 3-57. Ringold Unit E Unsaturated Hydraulic Conductivity Curves for Drying Conditions (Connelly et al. 1992).

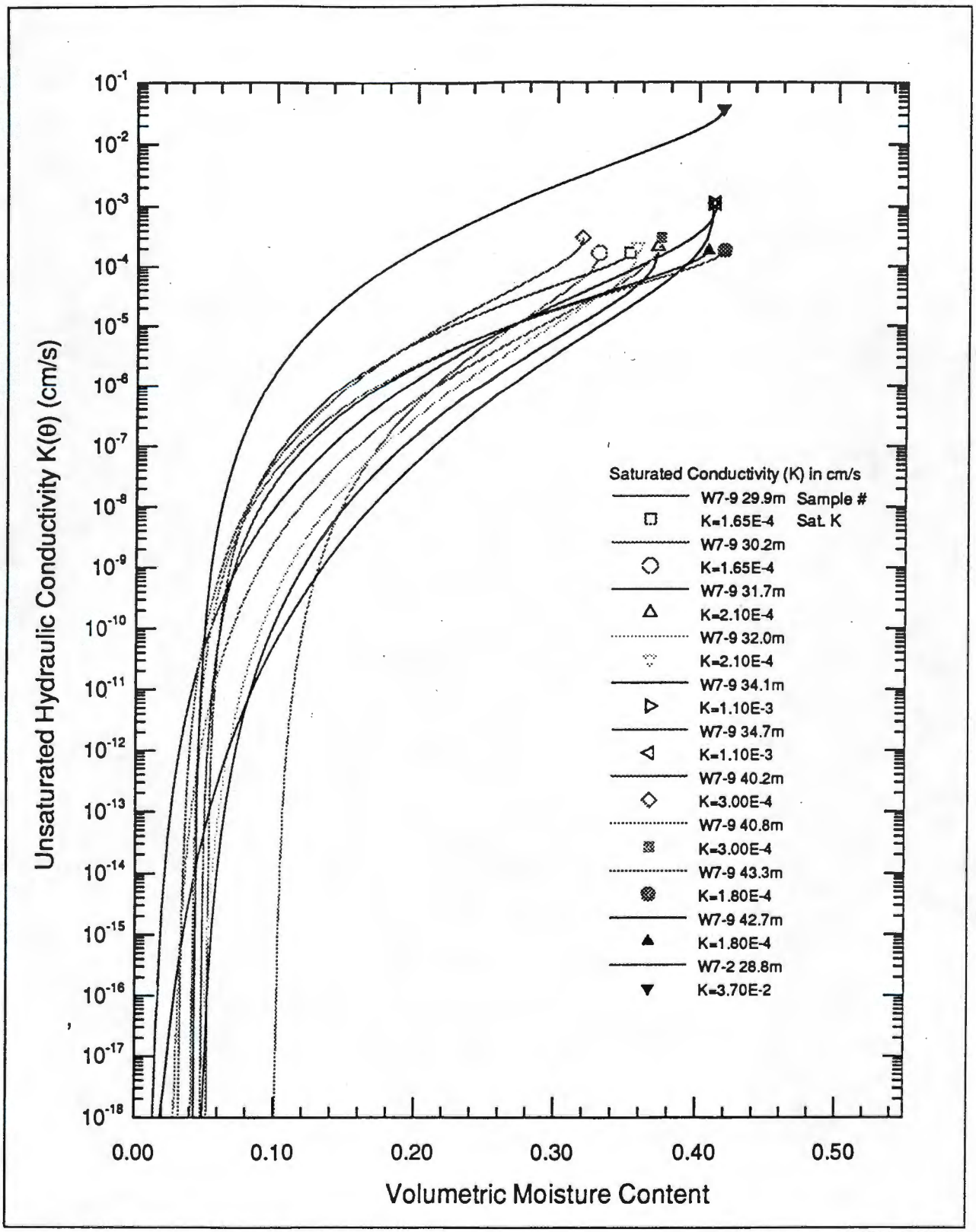

Figure 3-58. Upper Ringold Unsaturated Hydraulic Conductivity Curves for Drying Conditions (Connelly et al. 1992).

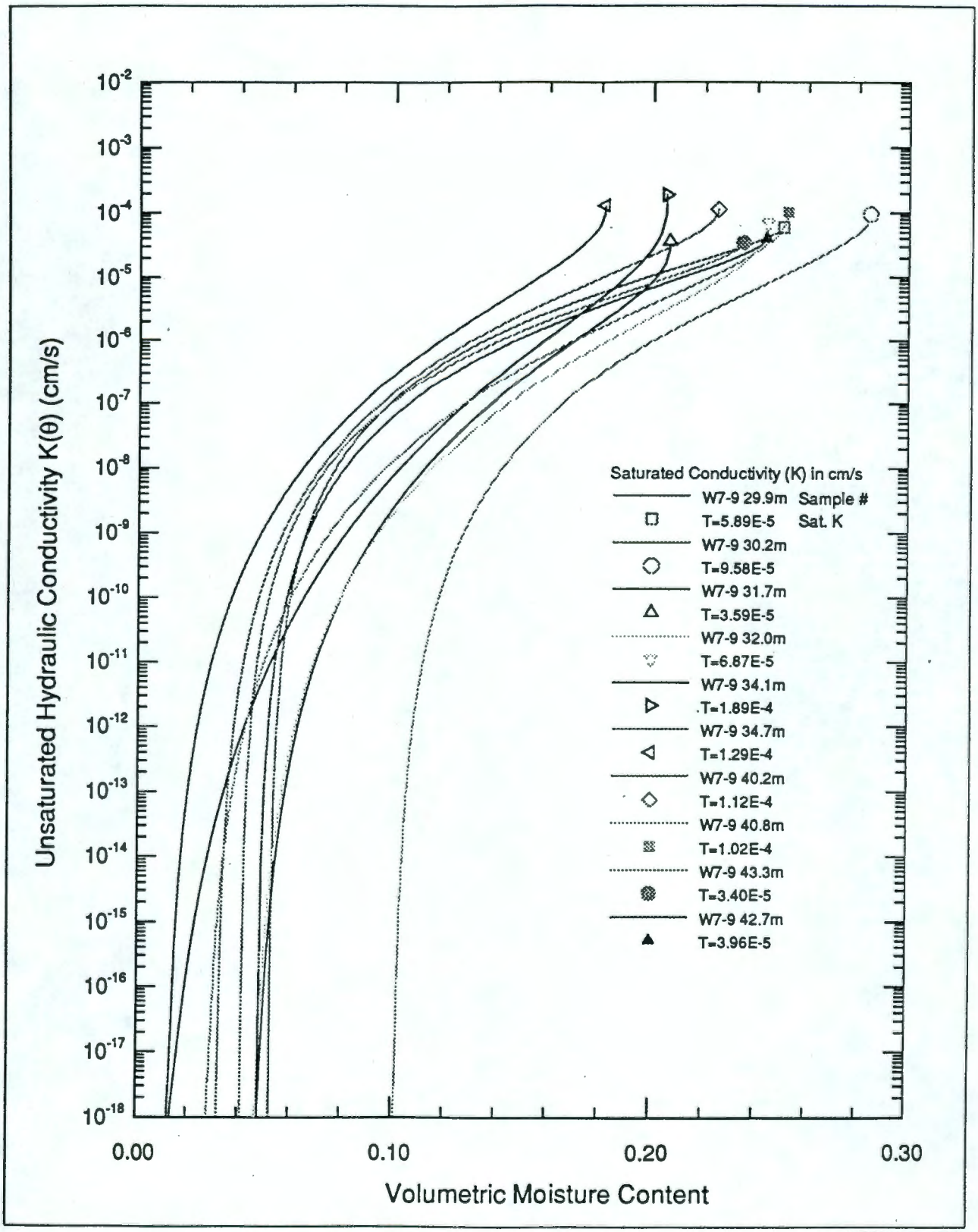

Figure 3-59. Upper Ringold Unsaturated Hydraulic Conductivity Curves for Wetting Conditions (Connelly et al. 1992).

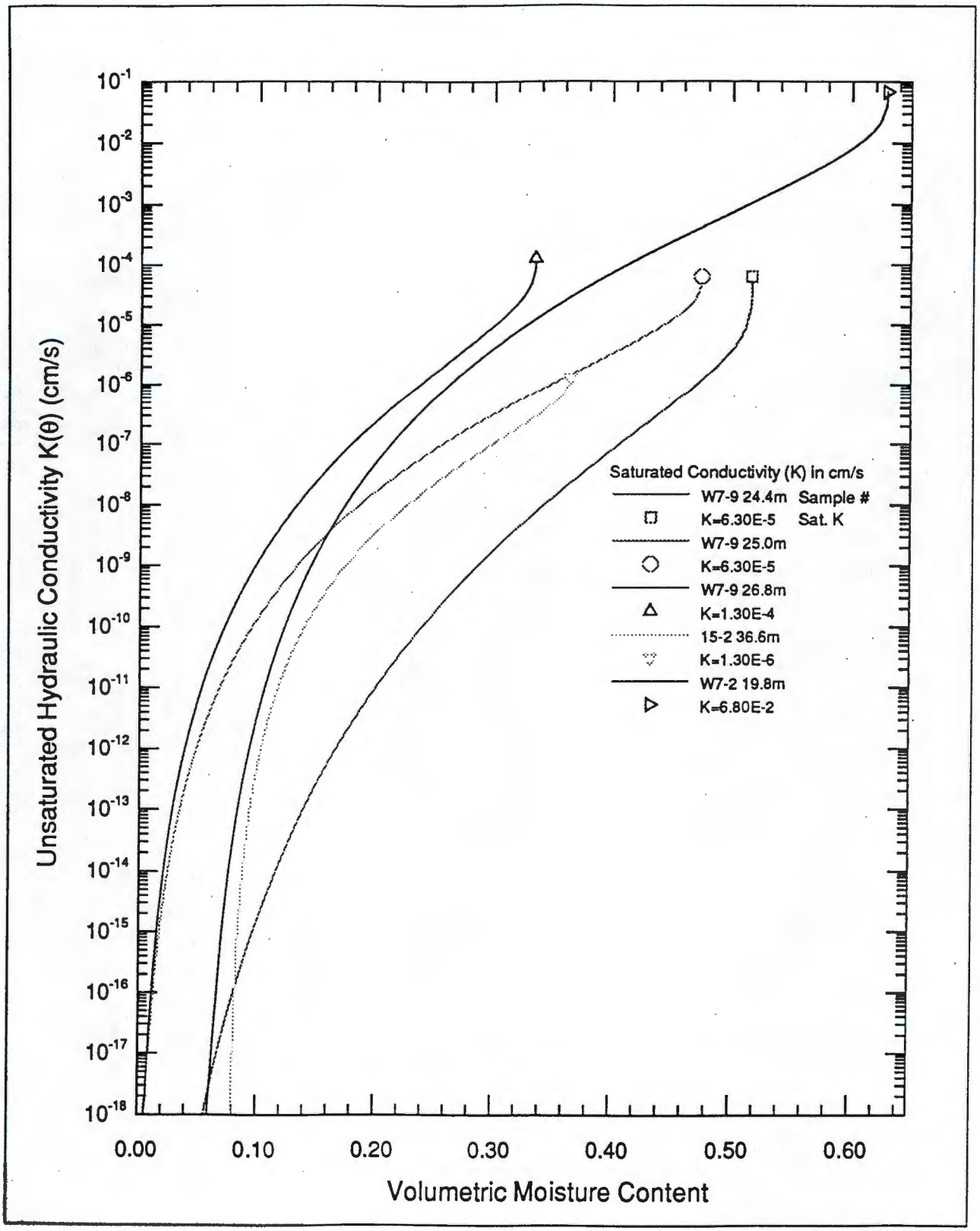

Figure 3-60. Plio-Pleistocene Unsaturated Hydraulic Conductivity Curves for Drying Conditions (Connelly et al. 1992).

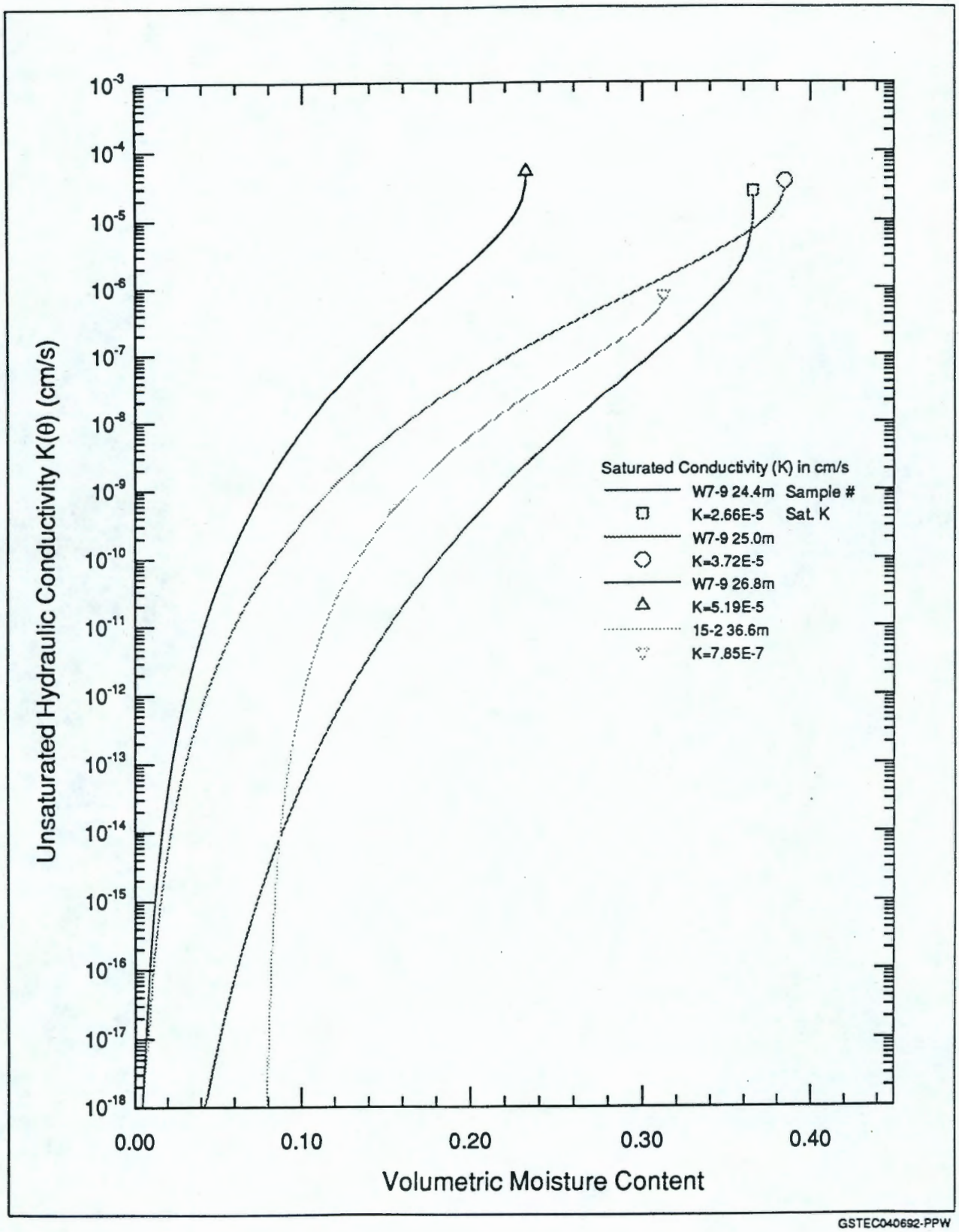

Figure 3-61. Plio-Pleistocene Unsaturated Hydraulic Conductivity Curves for Wetting Conditions (Connelly et al. 1992).

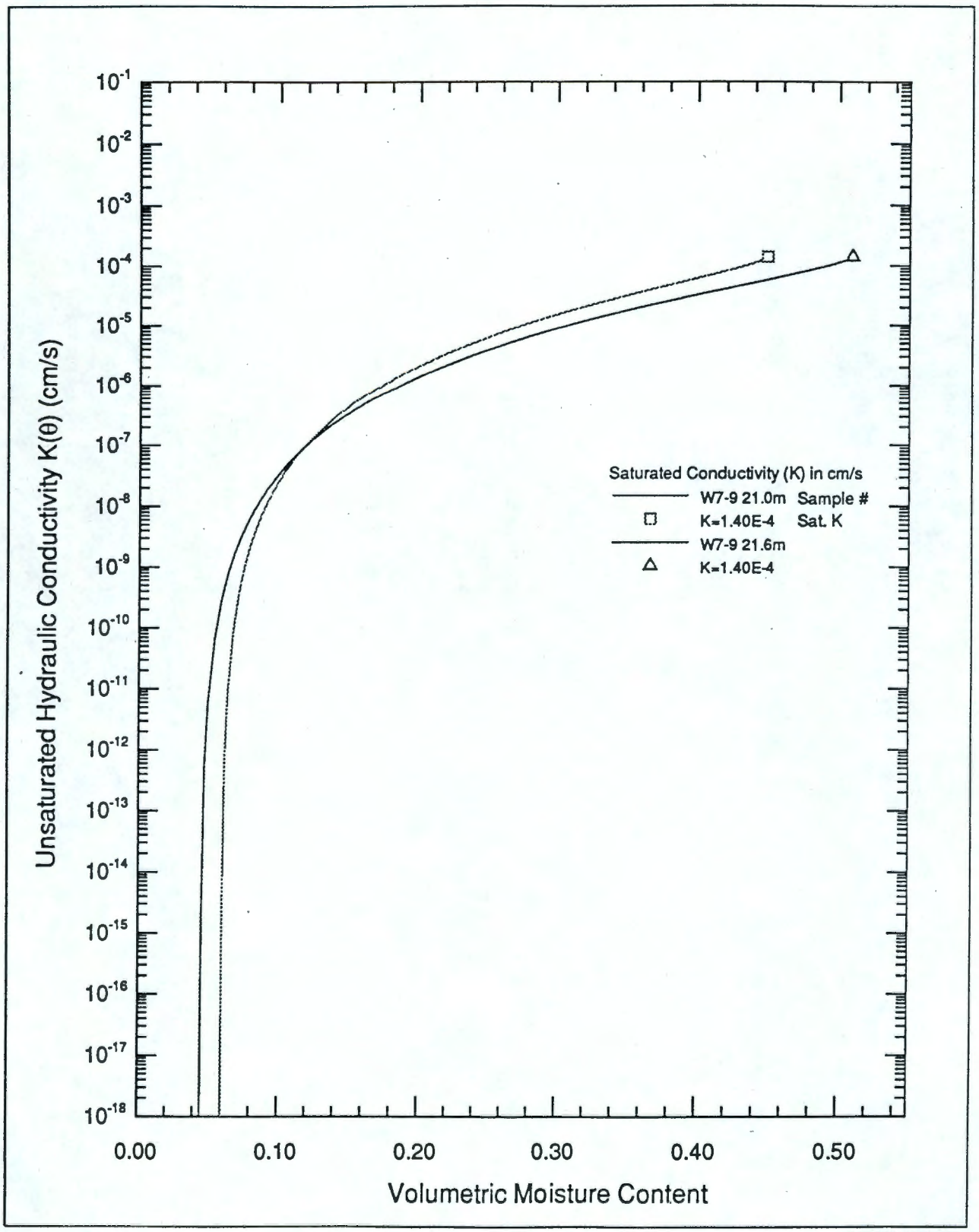

Figure 3-62. Early "Palouse" Soil Unsaturated Hydraulic Conductivity Curves for Drying Conditions (Connelly et al. 1992).

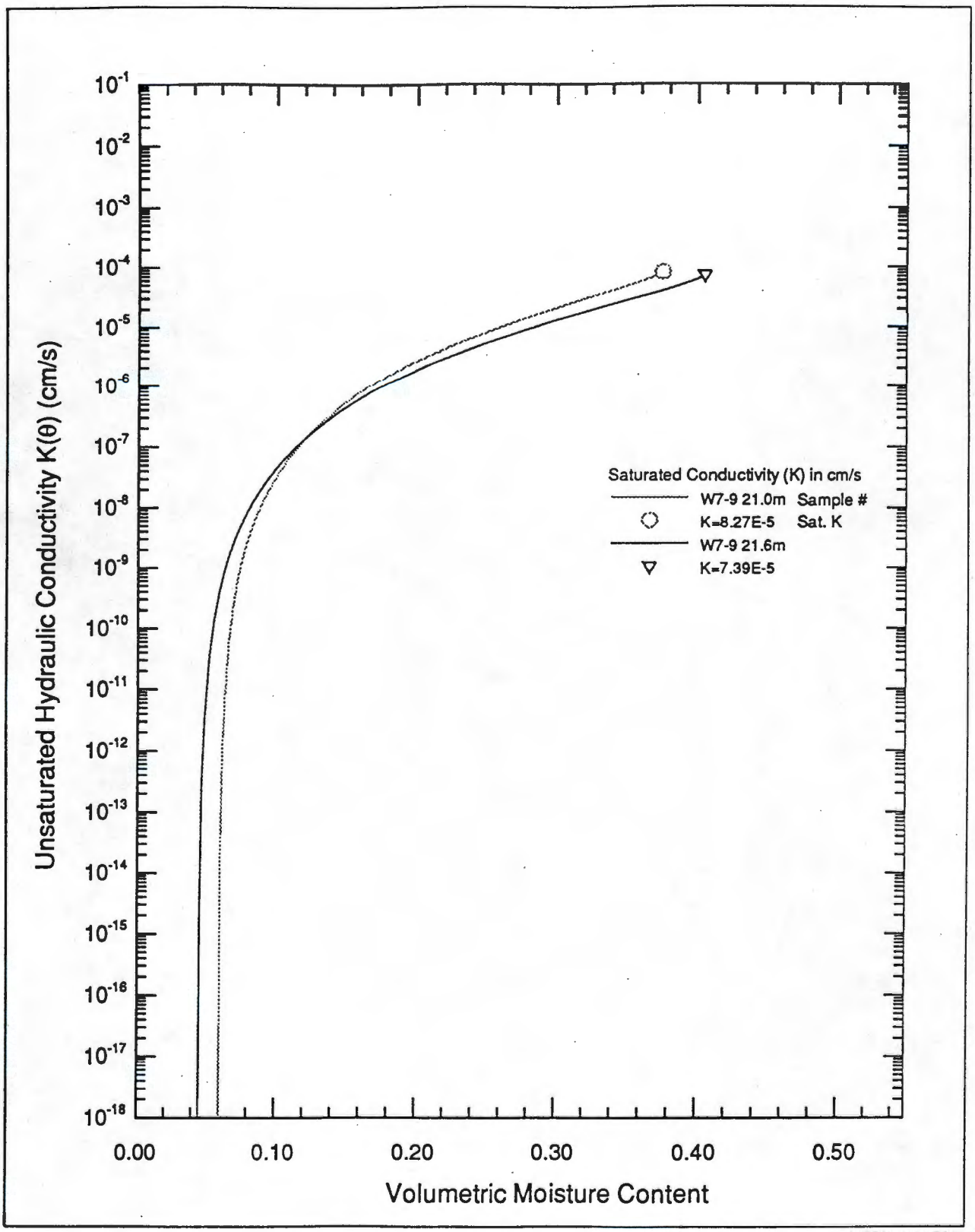

Figure 3-63. Early "Palouse" Soil Unsaturated Hydraulic Conductivity Curves for Wetting Conditions (Connelly et al. 1992).

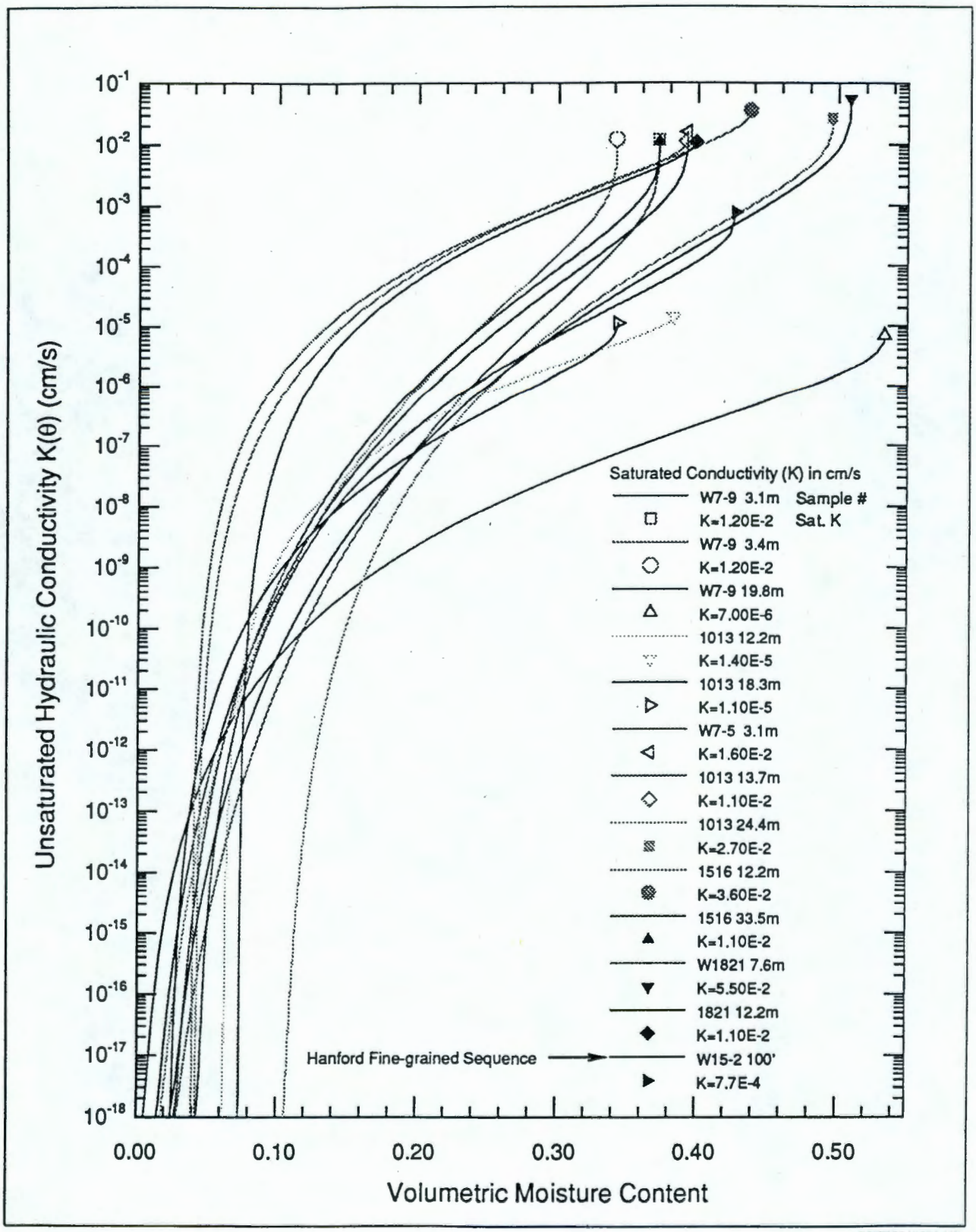

Figure 3-64. Hanford Formation Unsaturated Hydraulic Conductivity Curves for Drying Conditions (Connelly et al. 1992).

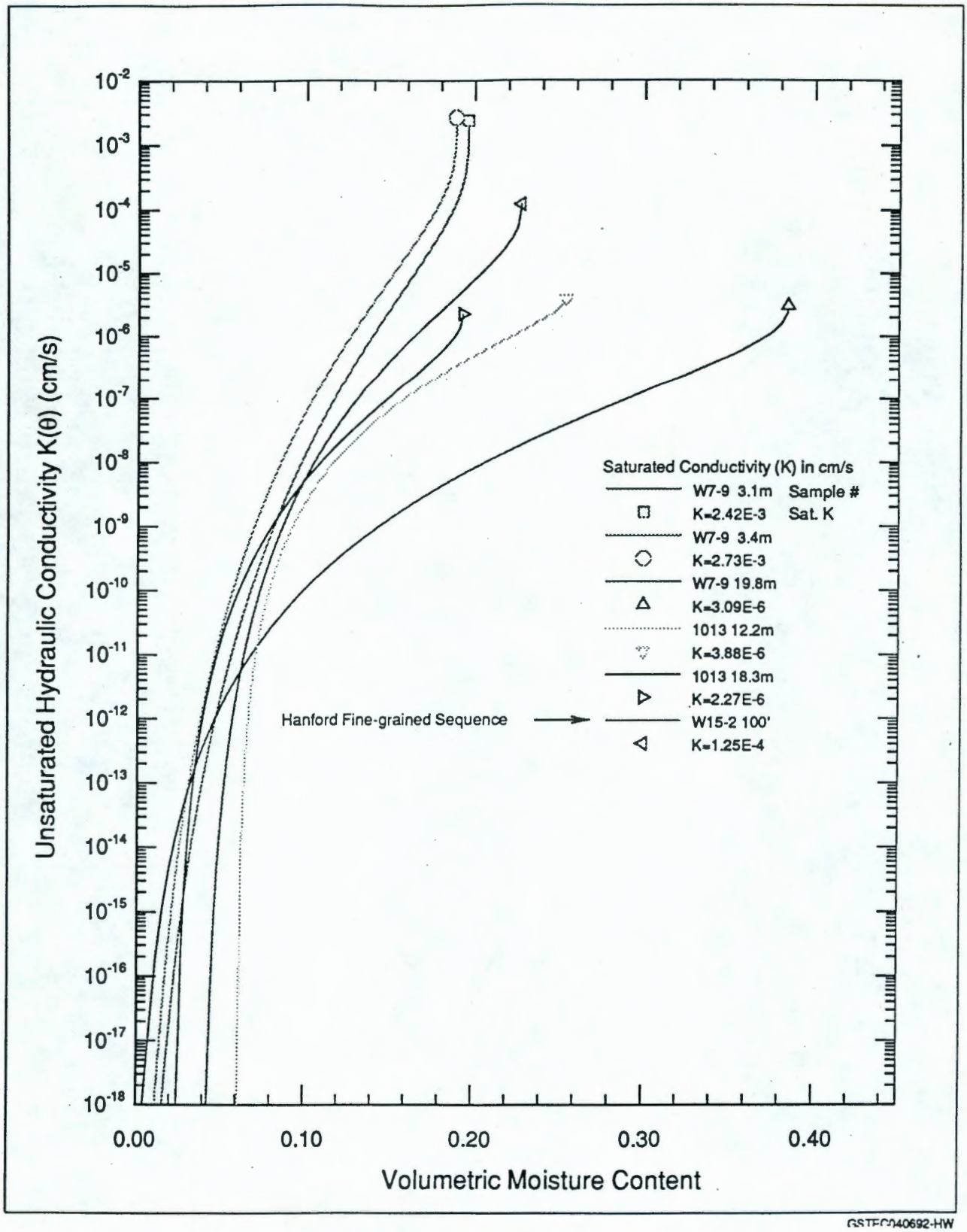

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Figure 3-65. Hanford Formation Unsaturated Hydraulic Conductivity Curves for Wetting Conditions (Connelly et al. 1992).

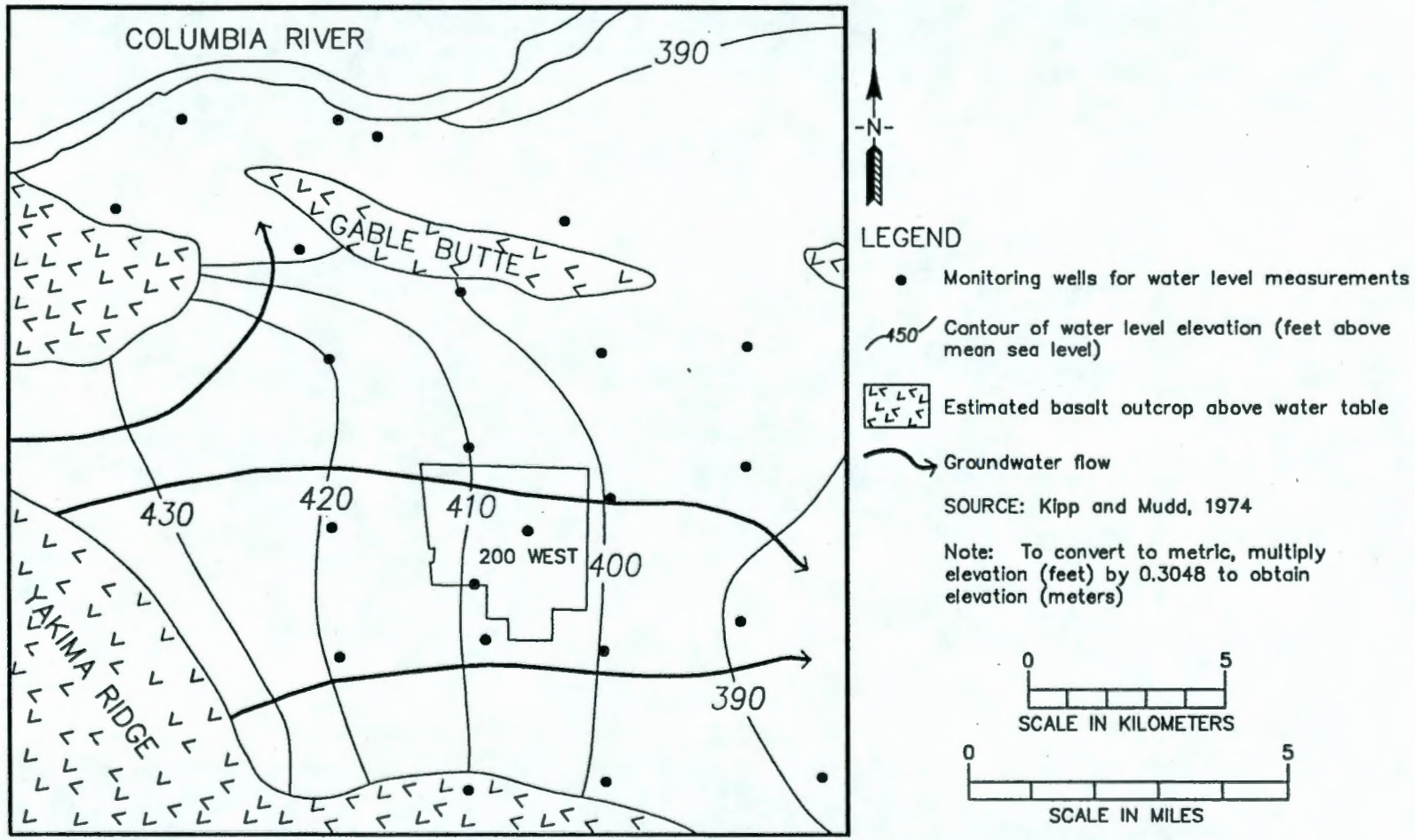

Figure 3-66. Water Table and Groundwater Flow in the Region of the 200 West Area for 1944.

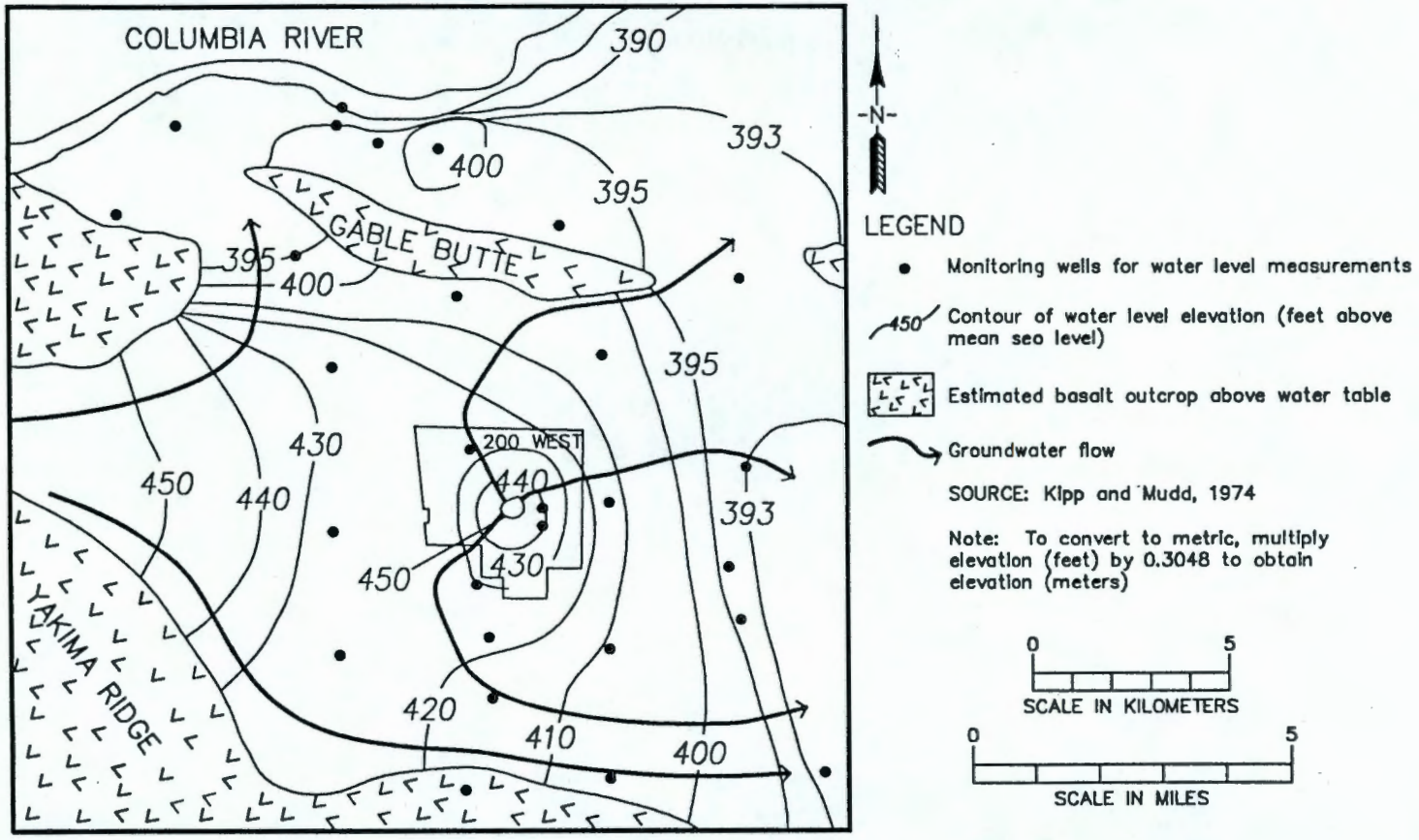

Figure 3-67. Water Table and Groundwater Flow in the Region of the 200 West Area for 1951.

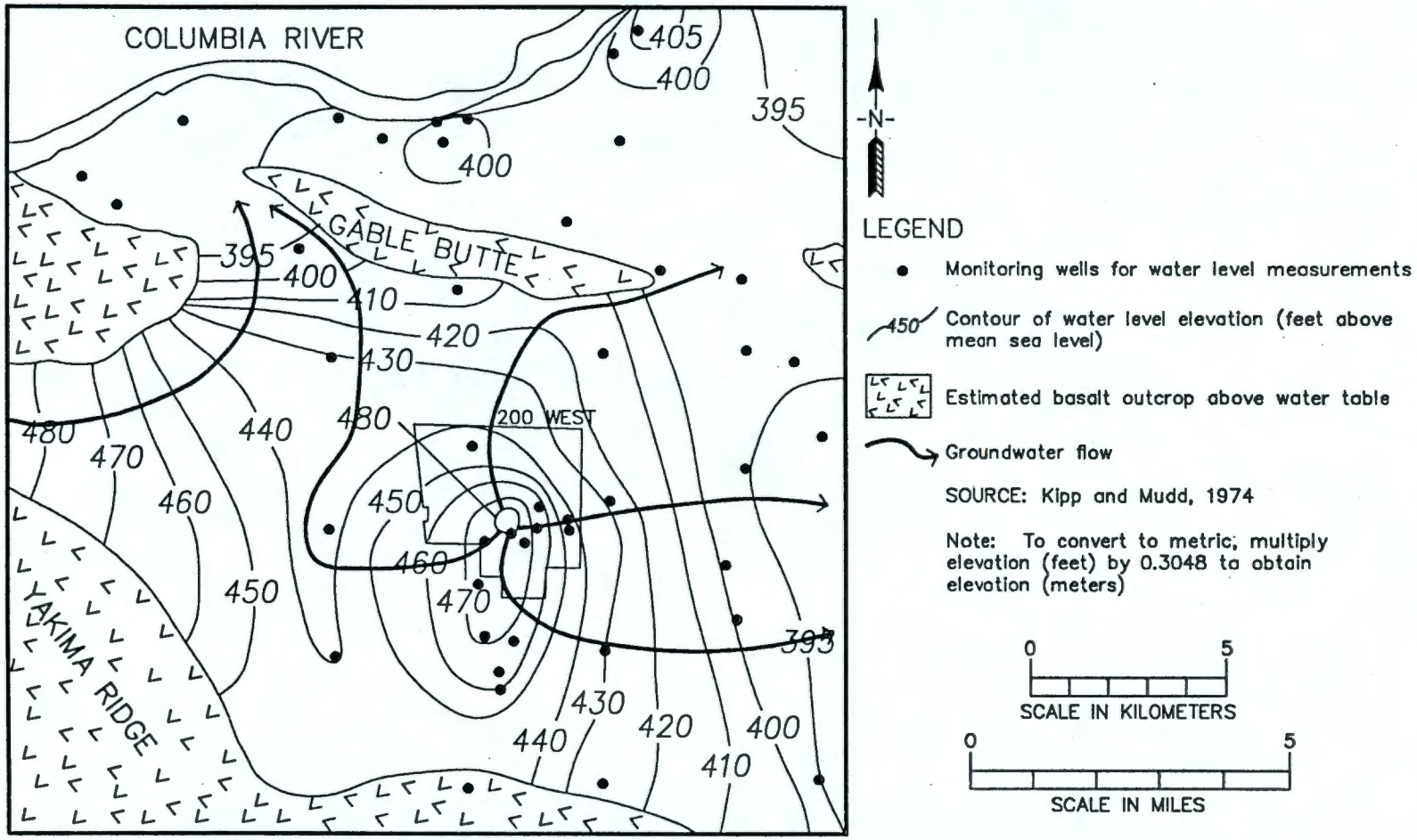

Figure 3-68. Water Table and Groundwater Flow in the Region of the 200 West Area for 1955.

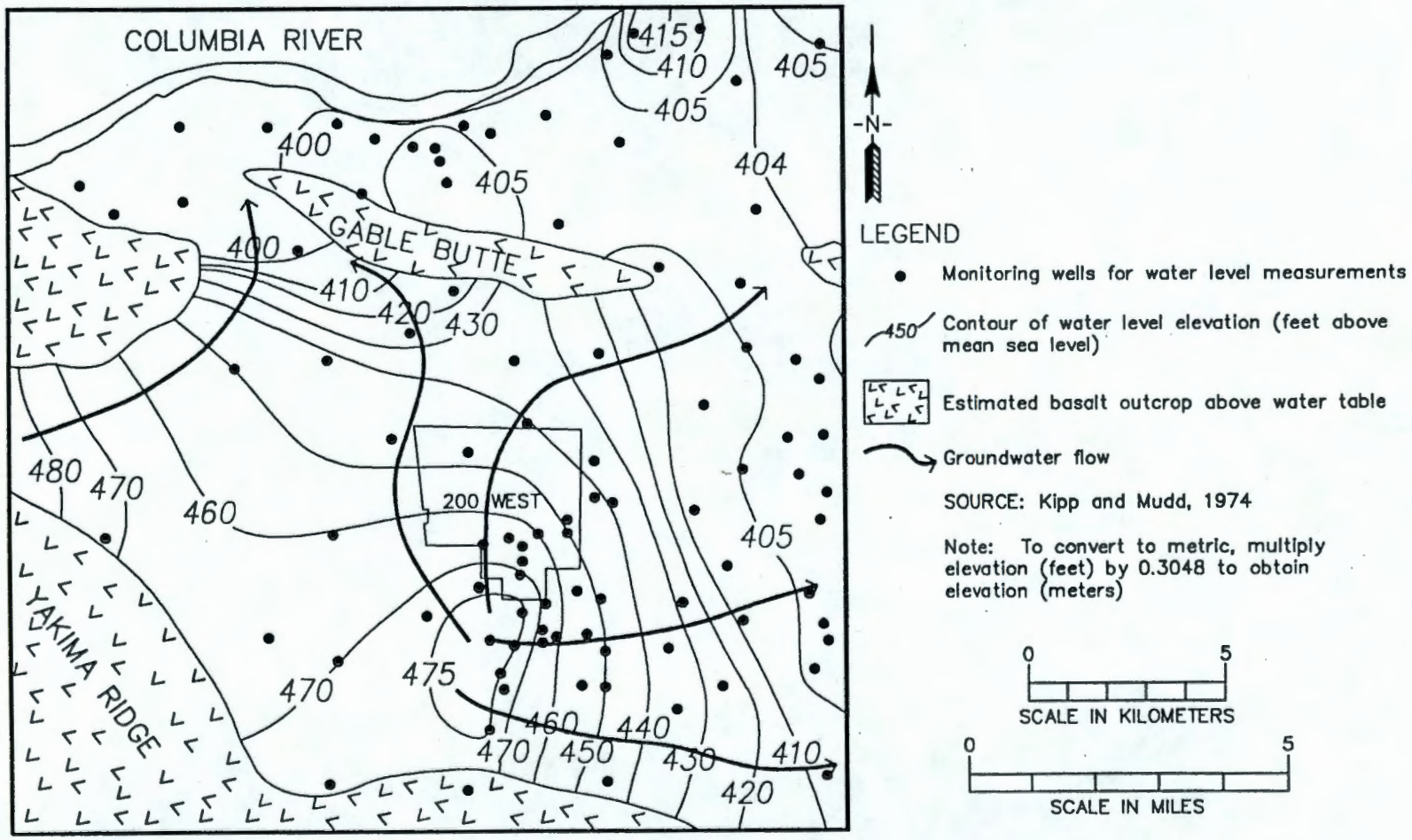

Figure 3-69. Water Table and Groundwater Flow in the Region of the 200 West Area for 1965.

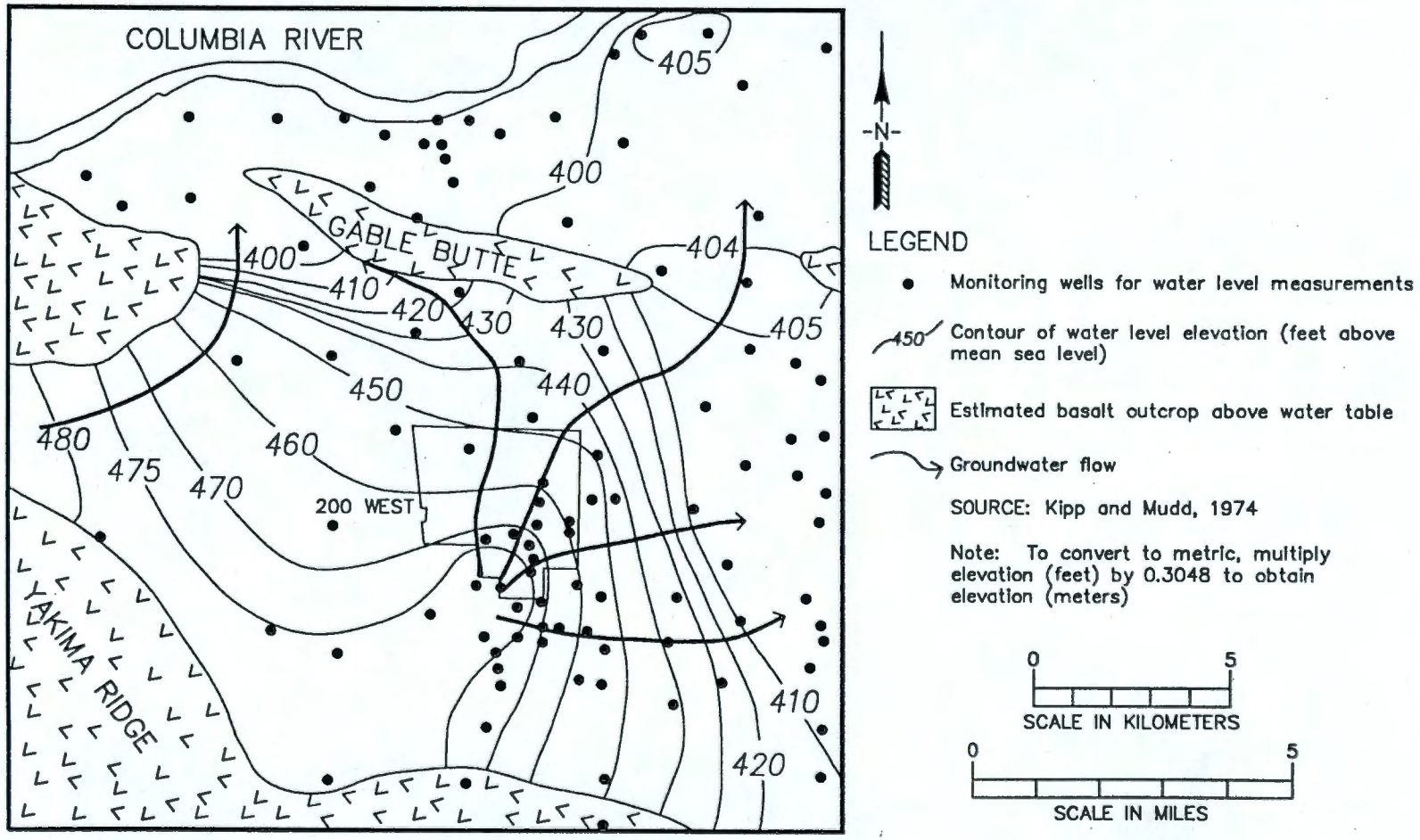

Figure 3-70. Water Table and Groundwater Flow in the Region of the 200 West Area for 1970.

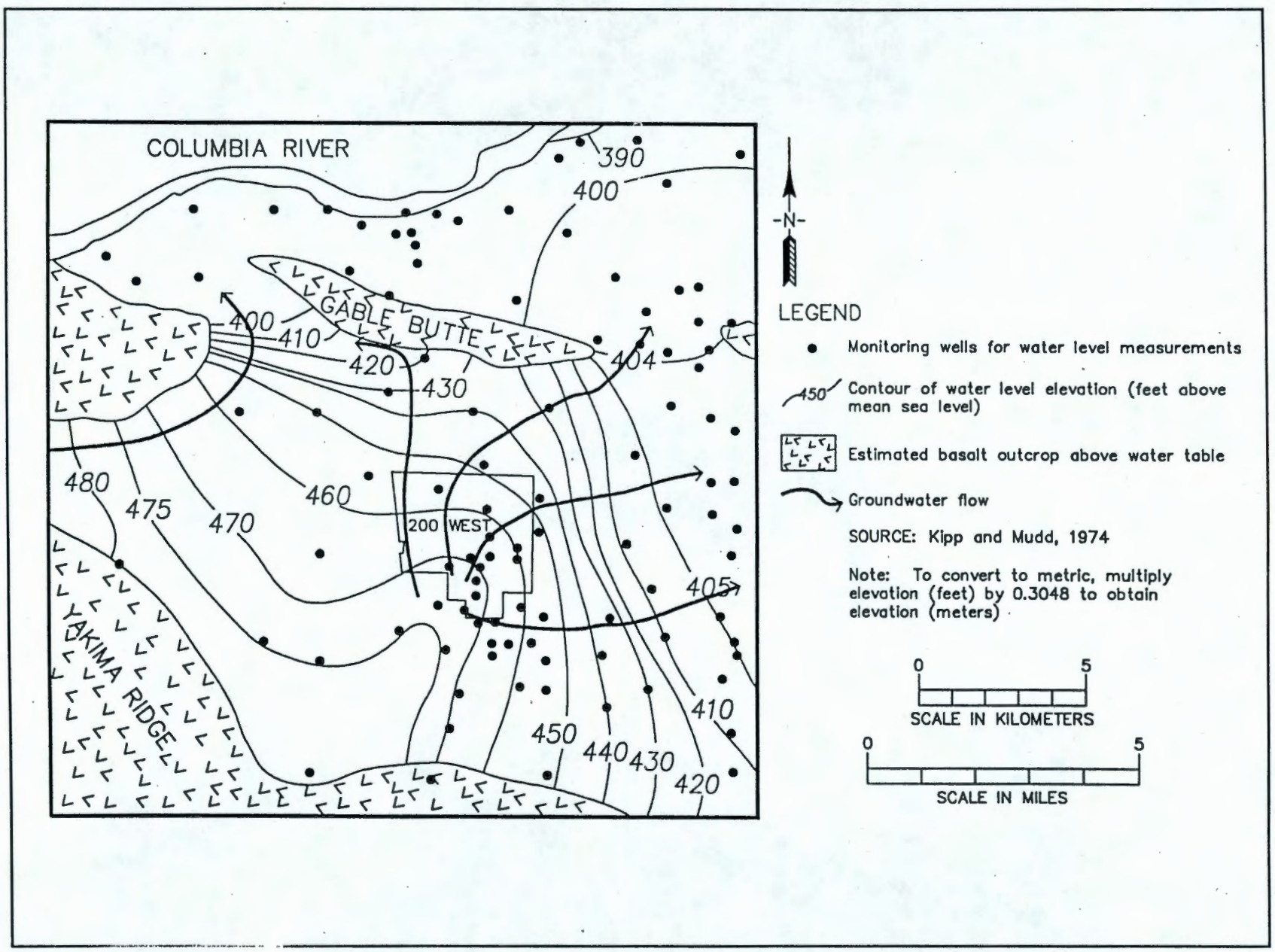

Figure 3-71. Water Table and Groundwater Flow in the Region of the 200 West Area for 1973.

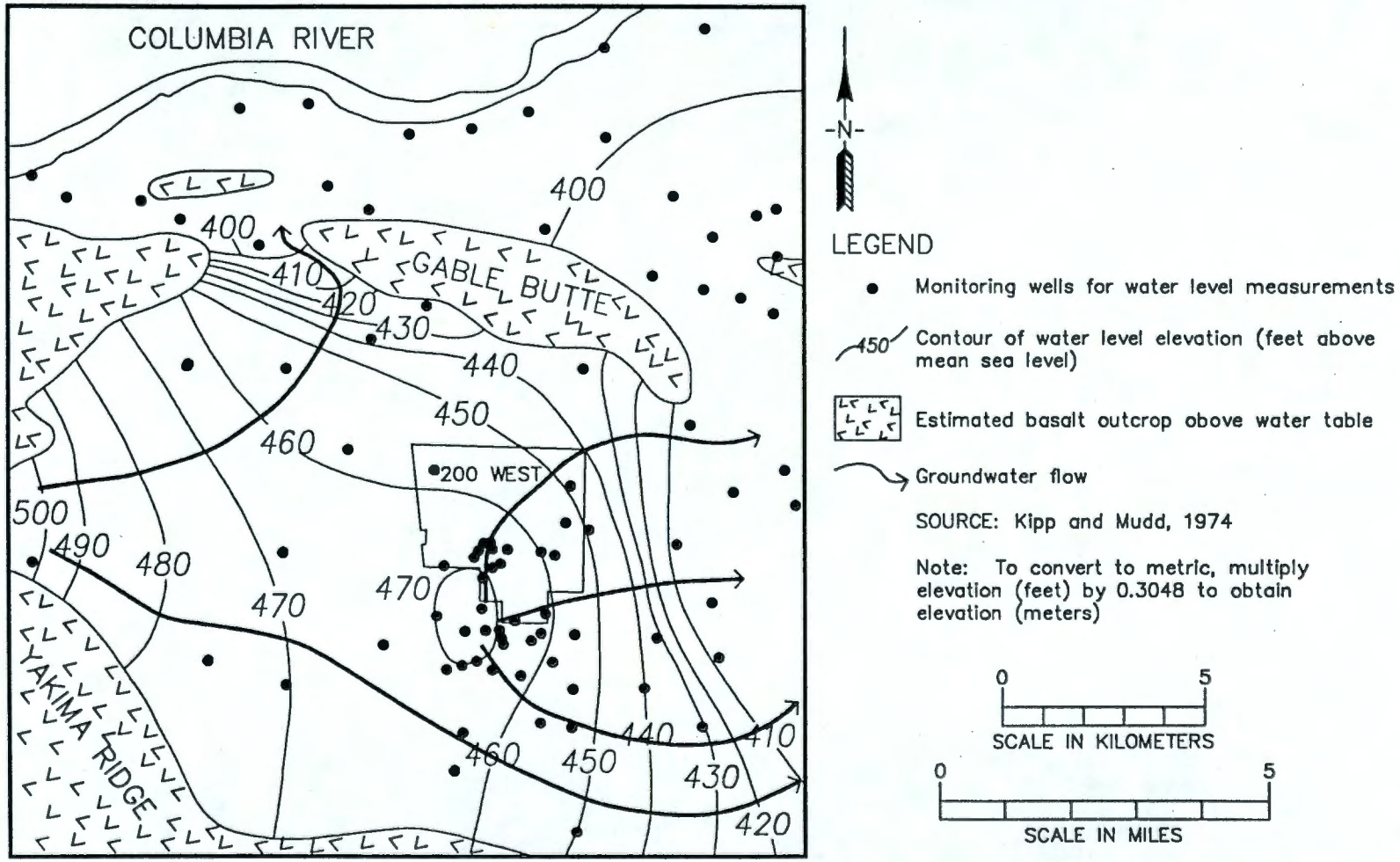

Figure 3-72. Water Table and Groundwater Flow in the Region of the 200 West Area for 1987.

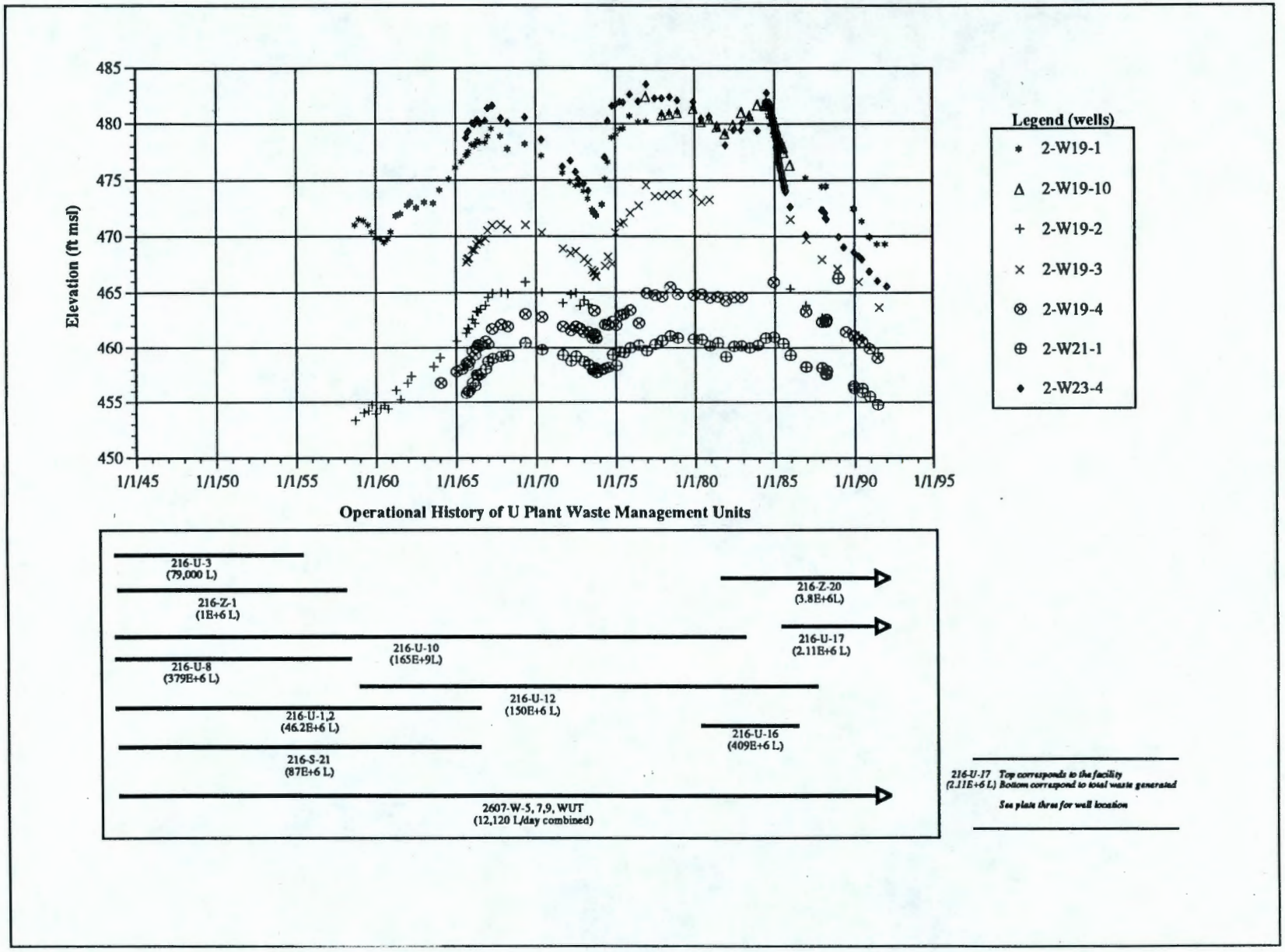

Figure 3-73. Well Hydrographs for the U Plant Aggregate Area.

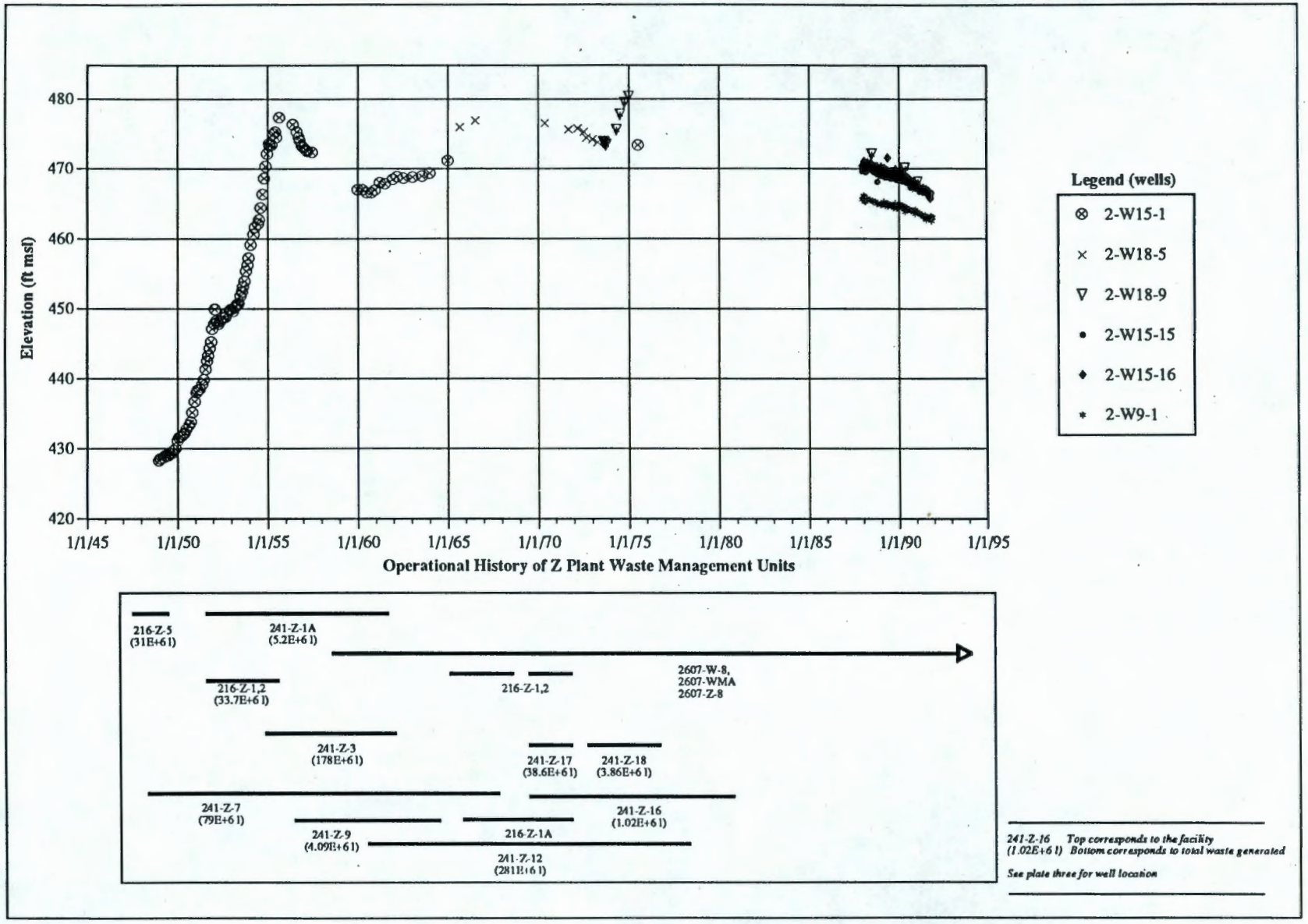

Figure 3-74. Well Hydrographs for the Z Plant Aggregate Area.

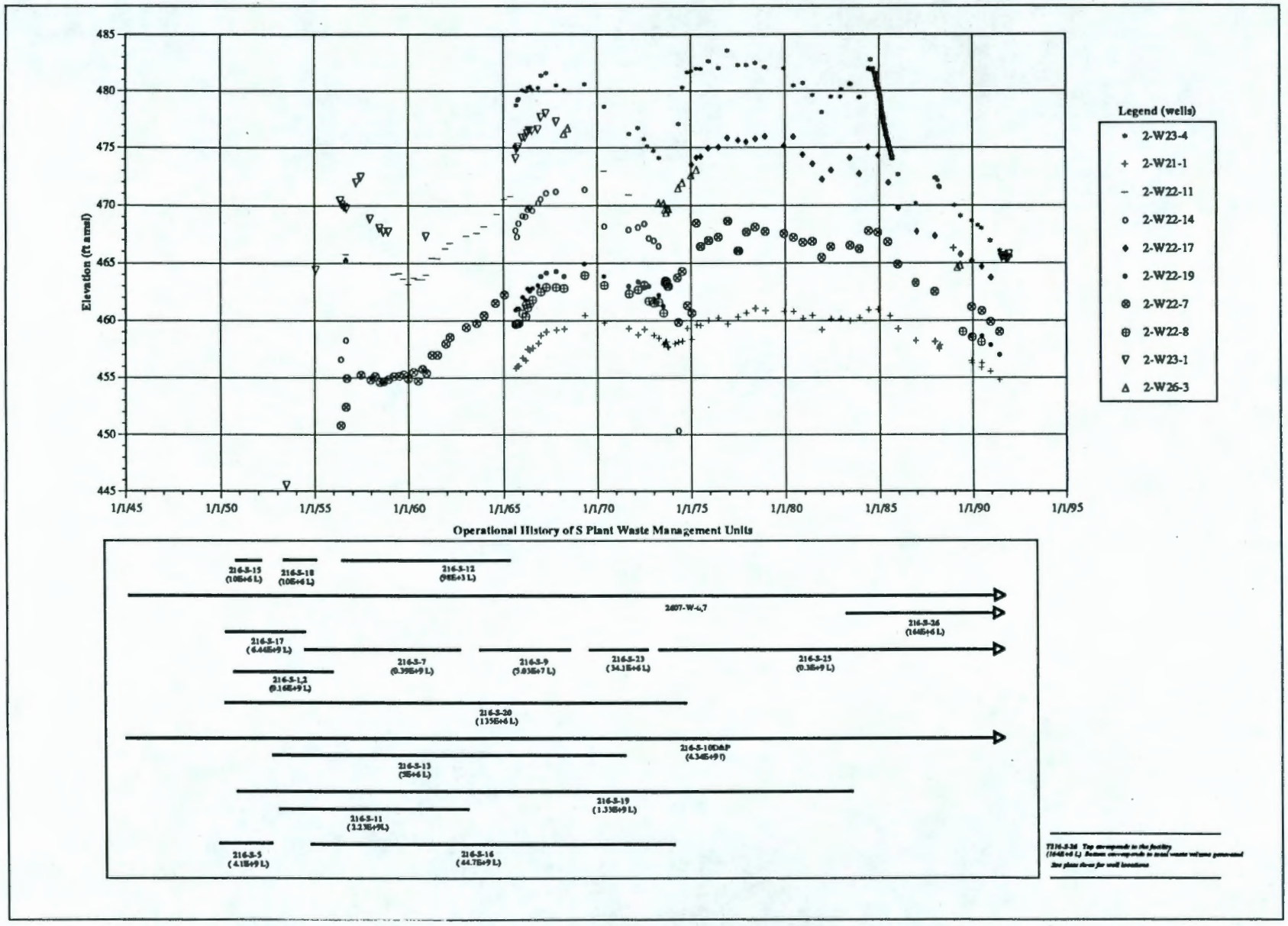

Figure 3-75. Well Hydrographs for the S Plant Aggregate Area.

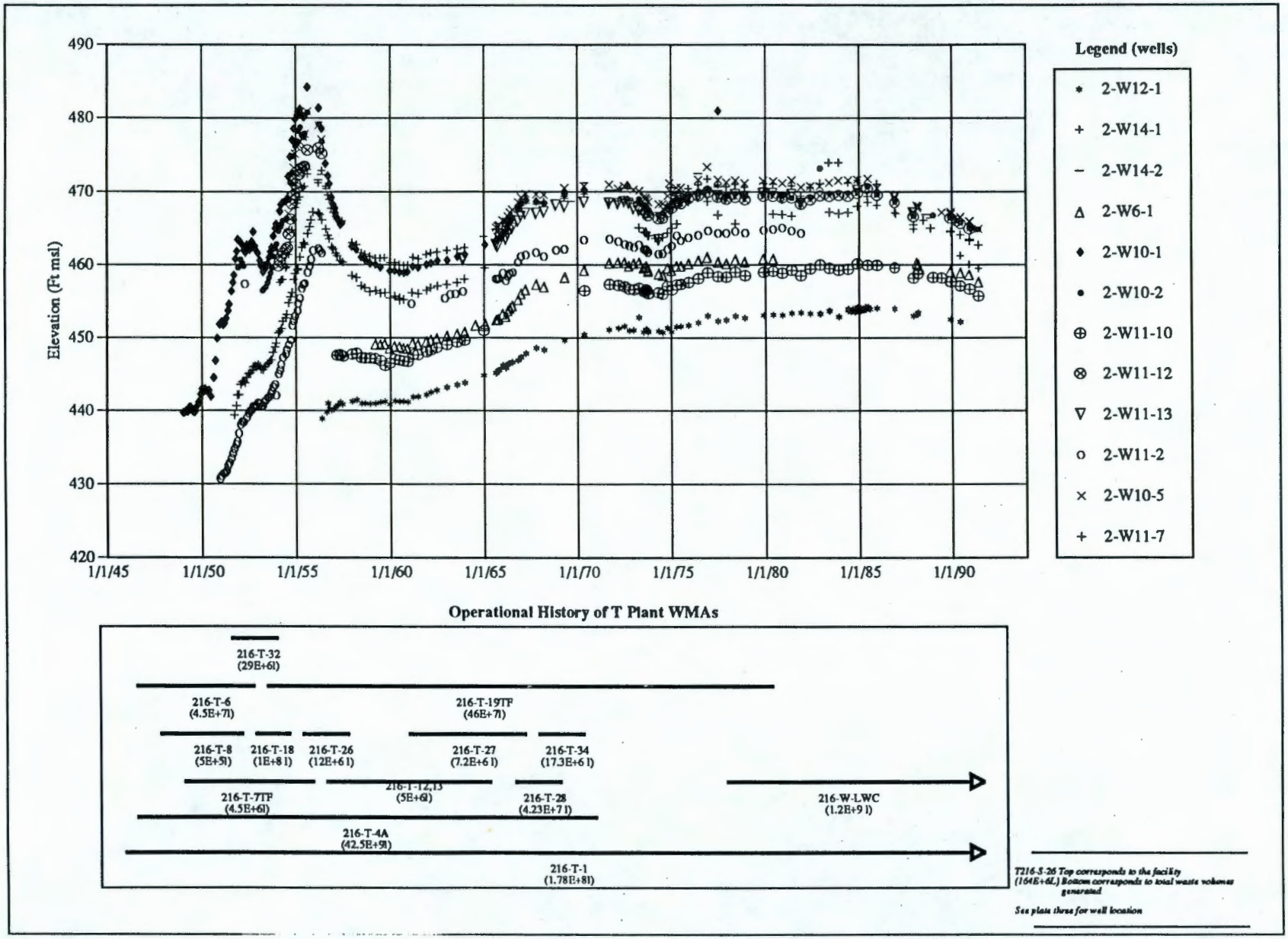

Figure 3-76. Well Hydrographs for the T Plant Aggregate Area.

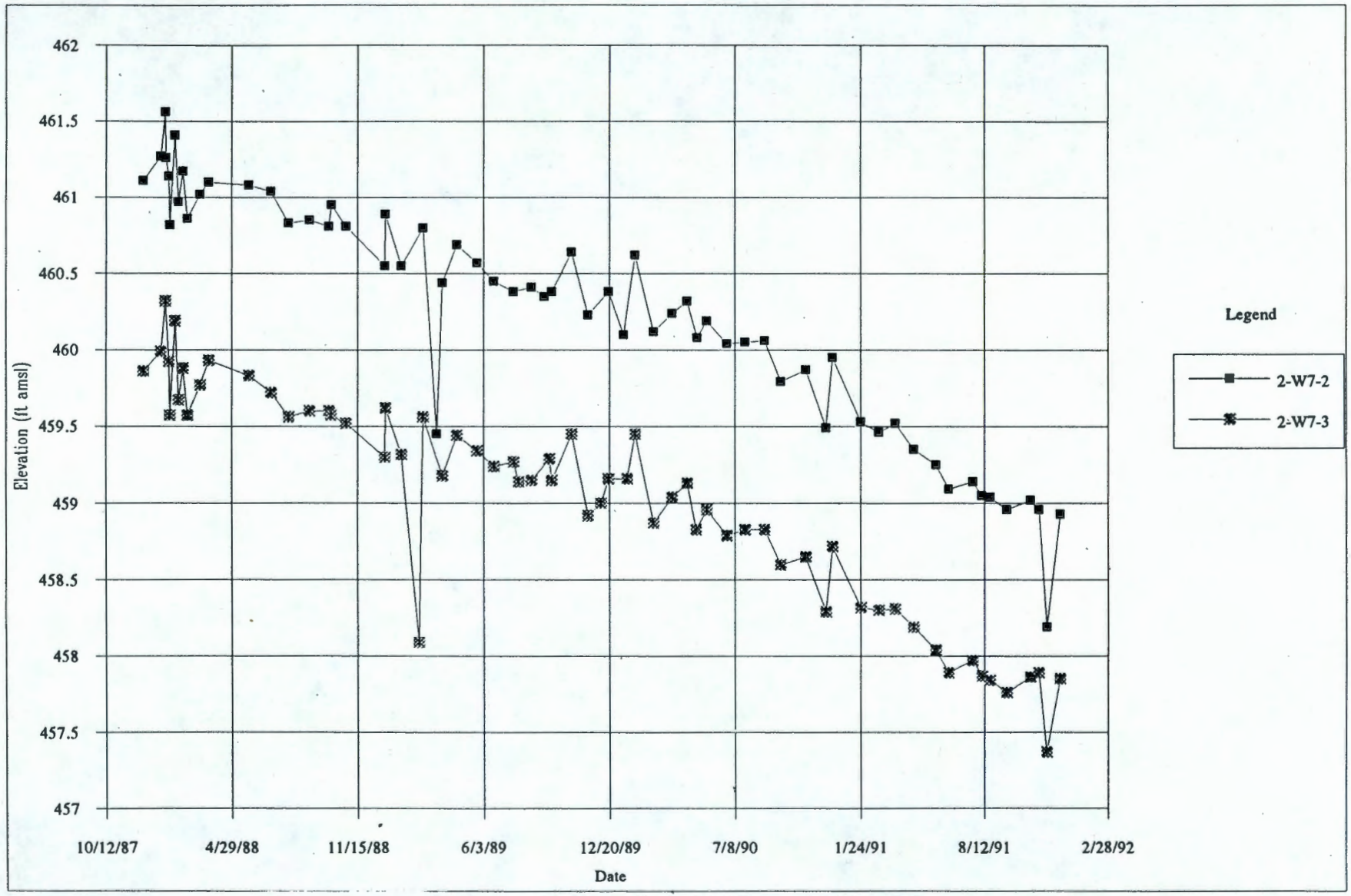

Figure 3-77. Hydrographs of Wells 299-W7-2 and 299-W7-3.

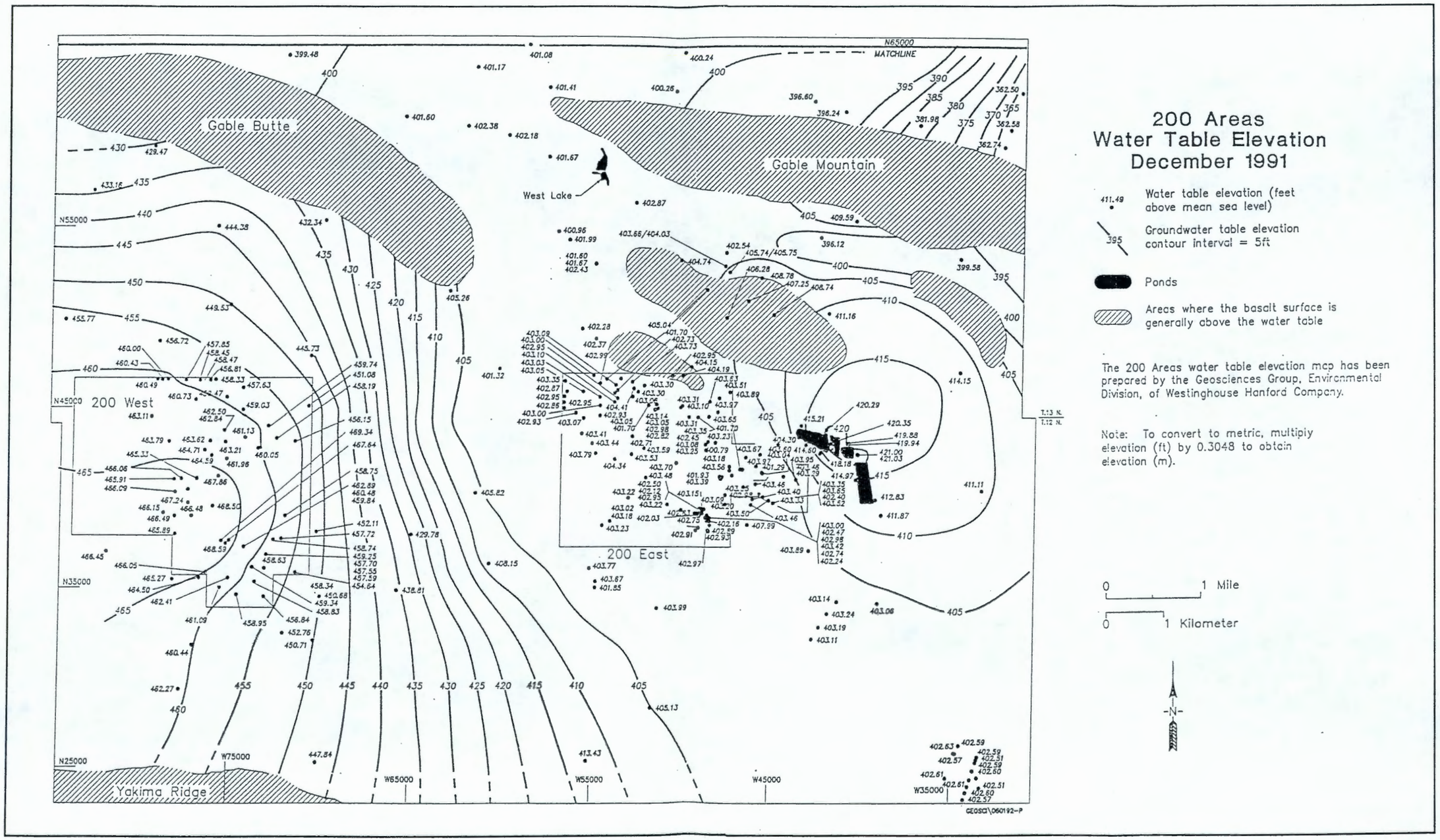

Figure 3-78. Water Table Elevation from December 1991 for the 200 Areas (Kasza et al. 1992).

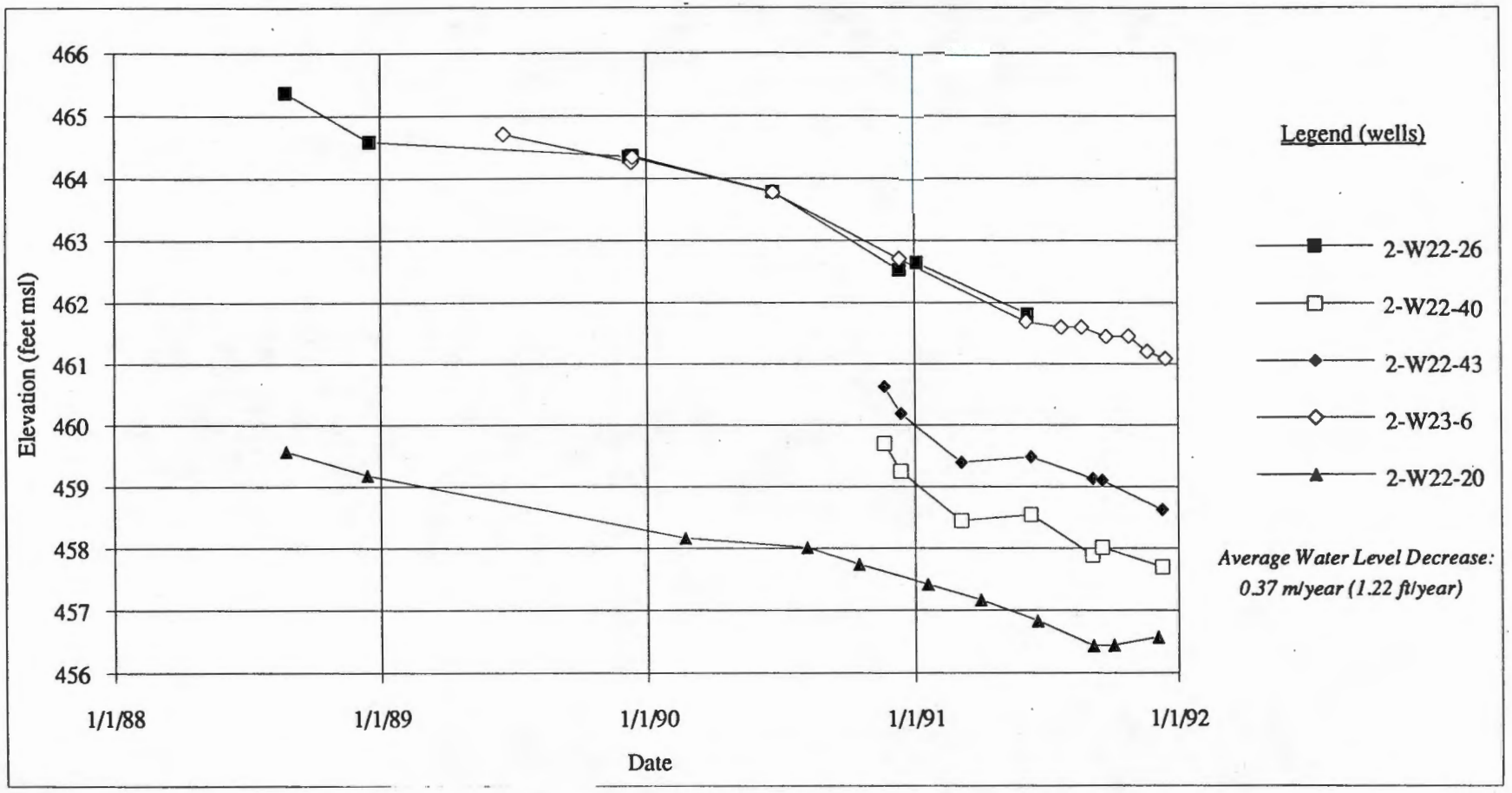

Figure 3-79. S Plant Hydrographs Showing Declining Water Levels.

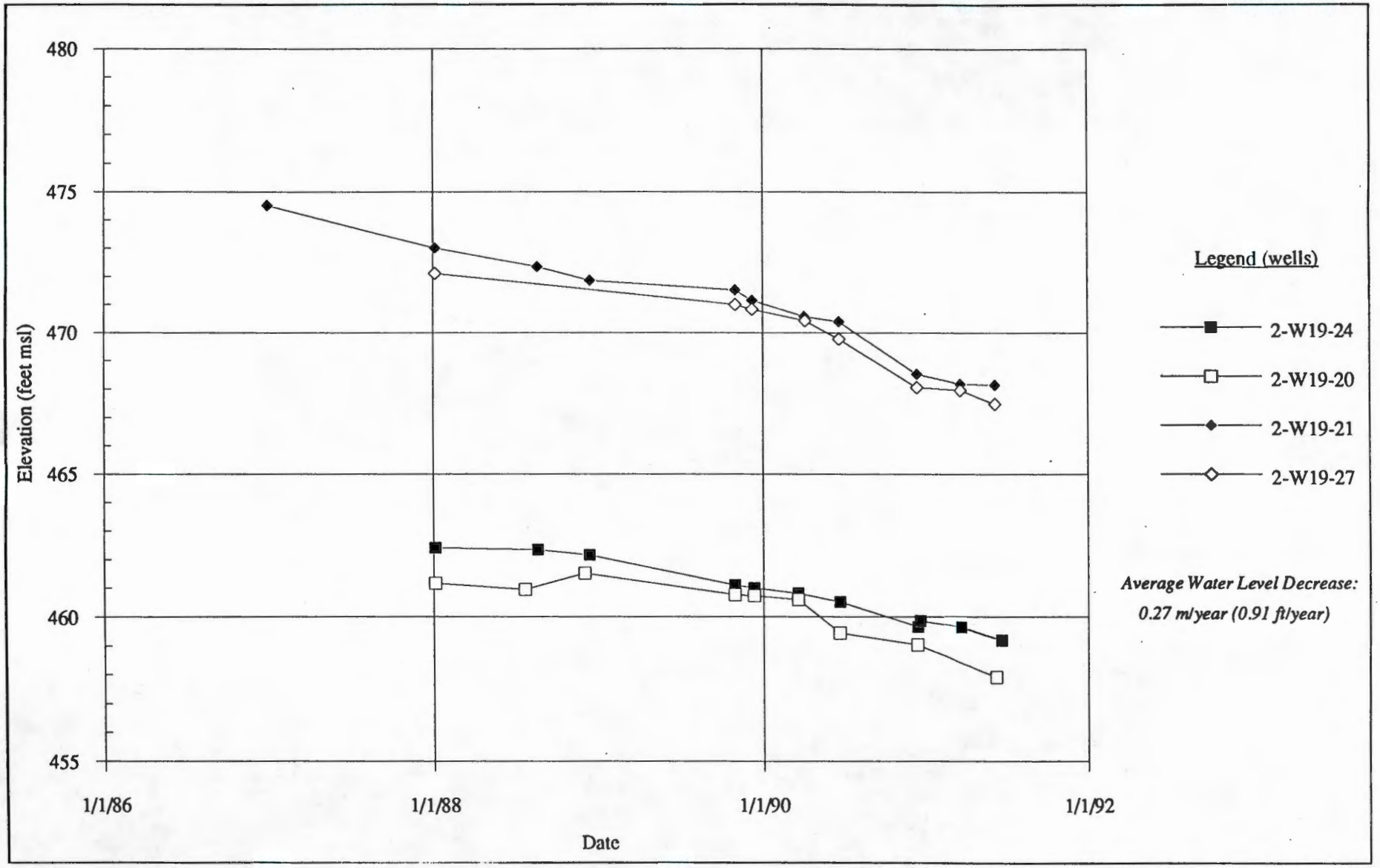

Figure 3-80. U Plant Hydrographs Showing Declining Water Levels.

4.0 PRELIMINARY CONCEPTUAL SITE MODEL

Section 4.1 presents the chemical and radiological data that are available for the groundwater in the 200 West Groundwater Aggregate Area. These chemical and radiological data are evaluated in Sections 4.2 and 5.0 in order to qualitatively assess the potential impacts of the contamination to human health and to the environment. The quality and sufficiency of the existing data are assessed in Section 8.0. This information is also used to identify applicable or relevant and appropriate requirements (ARARs) (Section 6.0). Contaminant information is assessed in Section 7.0 to provide a basis for selecting technologies that can be implemented at the site.

Contaminants that are released into the environment at a waste management unit or unplanned release site may migrate from the point of release into other types of media. The potentially affected media in the 200 West Groundwater Aggregate Area include vadose zone soil, vadose zone moisture, vadose zone vapor, perched groundwater, perched zone soils, groundwater, aquifer materials, potable water supplies, surface water, sediment, surface soil, and vegetation. While the focus of this evaluation is groundwater quality, other media are included that potentially affect or contribute to groundwater contamination. The media that are affected at a specific site will depend upon the quantities, chemical and physical properties of the material that was released, and the subsequent contaminant migration history.

4.1 KNOWN AND SUSPECTED CONTAMINATION

Contaminants are identified in the groundwater underlying the 200 West Groundwater Aggregate Area. This section presents the nature and extent of groundwater contaminants, probable sources of these contaminants, and potential future migration. Section 4.1.1 discusses the areal distribution of each contaminant plume and identifies waste management units and other facilities the plume underlies. The intent is to identify those areas that may potentially contribute to the underlying and nearby groundwater contamination. Other potential upgradient historical source areas may have contributed to existing plumes, but need to be further evaluated with regard to historical groundwater flow conditions. Waste inventories associated with 200 West Groundwater Aggregate Area facilities are discussed in Section 2.0.

4.1.1 Results of Groundwater Quality Monitoring

The distribution of elevated chemical compounds in the groundwater at the 200 West Groundwater Aggregate Area is evaluated by groundwater monitoring. The five groundwater

quality monitoring programs (Operational Groundwater Monitoring Network [OGWMN], Resource Conservation and Recovery Act [RCRA], Comprehensive Environmental Response, Compensation and Liability Act [CERCLA], Pacific Northwest Laboratory [PNL] and Hanford Environmental Health Foundation [HEHF]) currently in operation at the Hanford Site collect the data used to evaluate the distribution of chemical compounds. These monitoring programs evaluate the groundwater quality by sampling selected wells for a variety of chemical compounds. Section 2.8 summarizes the monitoring well network and the chemical compounds analyzed for in each of these monitoring programs. Wells monitored in the network are identified in Tables 2-8, 2-9, 2-14, and 2-16. These tables identify each monitoring well, its screened interval, and the formation being monitored for each program.

Groundwater quality data collected for these monitoring programs are summarized in reports prepared by Connelly et al. (1992); Last et al. (1991); Evans et al. (1990); DOE/RL (1991a); Serkowski and Jordan (1989); Schmidt et al. (1991); DOE/RL (1991b); Hoover and LeGore (1991); Evans et al. (1989); and Elder et al. (1989).

4.1.1.1 Groundwater Monitoring Data. The bulk of the groundwater quality data reported herein for the 200 West Groundwater Aggregate Area were compiled by Connelly et al. (1992) from monitoring well samplings conducted under the auspices of the five programs identified above between January 1, 1988 and April 1992. Due to a lack of laboratory capacity, chemical data for most chemical compounds and selected radionuclides were not collected between June 1990 and May 1991. Also included is additional groundwater sampling data for carbon tetrachloride and other selected volatile organic compounds collected for the Carbon Tetrachloride ERA Program (DOE/RL 1991a) between January 1991 and May 1991. Chemical and radionuclide data collected after April 1992 was not available from Westinghouse Hanford Company at the time this report was prepared. Groundwater contaminant plume maps were prepared by Connelly et al. (1992) using sampling from January 1988 to December 1991 as discussed in Section 4.1.1.2.

As shown on Tables 2-8, 2-9, 2-14, and 2-16, the majority of the monitoring wells sampled during this time are screened in the upper 12 m (39 ft) of the unconfined aquifer within the Ringold unit E gravels. However, five of the monitoring wells (299-W7-3, 299-W10-14, 299-W15-6, 299-W15-17, and 299-W18-22) are screened near the base of the Ringold unit E. Two additional monitoring wells, 299-W26-11 and 299-W18-29, are screened within a perched horizon near the base of the Hanford formation. All RCRA wells are screened in the upper 6 m (20 ft) of the unconfined aquifer according to the Tri-Party Agreement.

For the purposes of this report, selected wells were evaluated using available information and cross sections to identify the aquifer that these wells were screened in (Connelly et al. 1992; Lindsey et al. 1991). Wells selected for evaluation were chosen for

availability of chemical information, spatial distribution, and reliability of the well construction information.

Due to poor recovery, Well 299-W27-11 was removed from the monitoring network. Also, groundwater sampling results from Well 299-W15-6 cannot be directly compared to the other sampling data because the well is screened across the entire saturated thickness of the Ringold unit E. At best, groundwater sampling results from Well 299-W15-6 represent average groundwater quality conditions across the entire unconfined aquifer. This well may also provide a preferential pathway for vertical migration of contaminants from the upper part of the Ringold unit E to the base of the unit.

Chemical compounds detected in the groundwater within the 200 West Groundwater Aggregate Area (January 1988 to April 1992) are listed on Table 4-1. This list was generated from data provided by Westinghouse Hanford and used by Connelly et al. (1992) by searching the Hanford Site Groundwater Database for all contaminants detected within the 200 West Groundwater Aggregate Area wells from 1988 to 1992. For each constituent listed, this table identifies the well with the maximum average reported concentration and the maximum and minimum concentrations over this same period. The number of detections and the number of samples less than the detection limit for this well are also listed. Table 4-1 also identifies for all monitoring wells the minimum reported detection limit, the total number of analyses conducted, and the total number of wells with detections.

Chemical data collected from the deeper wells (screened near the base of the unconfined portion of the uppermost aquifer in Ringold unit E) are summarized in Table 4-2. This table compares chemical data collected from adjacent shallow wells screened in the middle Ringold Formation. In general, concentrations for chemical compounds in the shallow zone are higher than those in the deeper zone. Exceptions to this pattern are chromium and iron, where concentrations in the deeper aquifer zone are higher than the shallow aquifer zone.

The criteria used to evaluate the groundwater quality data collected by the groundwater monitoring programs are based on maximum contaminant levels (MCLs) established by the U.S. Environmental Protection Agency (EPA) under the Safe Drinking Water Act; 4% of the derived concentration guide (DCG) which complies with DOE Order 5400.5 II.ld(2); Washington State Groundwater Quality Standards (WAC 133-200) and the Washington State Model Toxics Control Act (WAC 173-340). Contaminant plume maps were drawn for all contaminants detected in the 200 West Groundwater Aggregate Area since January 1, 1988 that exceeded at least one of these groundwater quality criteria (Connelly et al. 1992).

4.1.1.2 Basis for Plume Evaluation. Groundwater contaminant plume maps were prepared by Connelly et al. (1992) for 14 individual constituents using groundwater quality data from January 1988 to December 1991 (Figures 4-1 through 4-14). A compilation plume map is

shown for inorganic and organic compounds in Figure 4-15 and for radionuclides in 4-16. The plume maps were developed by averaging detected concentration values at each well for chemical compounds identified in Table 4-1 and identifying those that exceeded groundwater quality criteria. This approach provides a gross indication of the extent of contamination for each constituent and sufficient data for contouring. Some of the plumes have areal extents that are indeterminant because they are essentially based on one well and surrounding well coverage is inadequate to delineate the plume boundaries. The interpolation of these plume boundaries could be changed markedly with additional data. Additionally, the areal plume distributions shown on the maps are based predominantly on wells screened in the upper 6 m (20 ft) of the unconfined aquifer. Samples collected at these shallow depths may not be representative of concentrations at greater depths.

Interpretations of the groundwater contaminant plume configurations are dependent on the quality of the data. Limitations associated with the data used to compile contaminant plume maps are as follows:

- Monitoring well construction variations
- Differences in groundwater sampling and analyses procedures and methodologies (e.g., use of bailer rather than submersible pump)
- Monitoring well coverage variations and limitations
- Computer contouring routines groundwater model interpretations.

These items may result in a change in the interpreted configuration of the plume map. In some cases the estimated areal extent of the plume may either be reduced or increased.

4.1.1.3 Chemical Compound Plume Evaluation. Fourteen individual plumes of chemical compounds were identified in the groundwater of the 200 West Groundwater Aggregate Area. Of these plumes, four (arsenic, fluoride, uranium, and $^{239,240}Pu$) are contained within the 200 West Area fence boundary, and ten plumes (chromium, nitrate, carbon tetrachloride, chloroform, trichloroethylene, gross alpha, gross beta, tritium, ^{99}Tc, ^{129}I) extend beyond the boundary of the 200 West Groundwater Aggregate Area. The extents of the 14 plumes are discussed in this section. Section 4.1.2 discusses the various potential sources for these plumes.

The 1991 groundwater table map of the unconfined aquifer was used to evaluate the migration patterns of these plumes (DOE/RL 1991b and Kasza et al. 1991). Figure 3-78 provides the 1991 groundwater map from Kasza et al. (1992).

4.1.1.4 Estimates of Areal Distribution of Contaminant Plumes. Estimates of areal extent for the 14 chemical compounds found at the 200 West Groundwater Aggregate Area were made from contaminant plume maps generated by Connelly et al. (1992). As discussed by Connelly et al. (1992), the plumes delineated represent areas which must be addressed when considering the lowest regulatory cleanup levels. In some cases the detection limit is above the lowest regulatory levels; when this occurs, the contour was set at or slightly above the detection limit. In these cases, areas of contamination, when compared to the most stringent standard available, may be much larger.

Table 4-3 provides the areal estimates for each plume. For the plume maps generated by Connelly et al. (1992), a computer interpolated grid of concentration levels was obtained from the authors, and the areas and total mass were obtained by integration of the values. This integration assumes a plume thickness of 10 m (33 ft.). This 10 m value was chosen to be consistent with previous investigations that selected this arbitrary depth (Evans et al. 1990; Connelly et al. 1992; Last el al. 1991; and DOE/RL 1991a). As discussed in Section 4.1.1.3, the areal distributions of plumes with limited well coverage were calculated by interpolating the chemical data between monitoring wells. These areas include plumes defined by a positive detection in a single well and nondetects in adjacent wells. This calculation therefore represents an estimate of the actual extent of the plumes, and provides for a consistent basis for analysis. Multiple plumes or plumes with complex geometries are divided in the discussion by individual plumes or lobes.

4.1.1.5 Vertical Extent of Contamination. Limited data are available regarding the vertical extent of chemical and radionuclide contamination (Last et al. 1991; Connelly et al. 1992; DOE/RL 1991a). Two studies that evaluated the vertical extent are Eddy et al. (1978) and DOE/RL 1991a. In 1976 Eddy et al. investigated the vertical extent of selected radionuclides in the unconfined portion of the uppermost aquifer. The bulk of this study was conducted east of the 200 West Groundwater Aggregate Area on selected 600 Area wells. Eddy et al. (1976) conclude that some contamination in the lower portion of the unconfined aquifer had occurred; however, concentrations of individual constituents appeared higher near the water table. Samples collected from Monitoring Well 699-31-31 contained concentrations of ^{106}Rb, tritium, and ^{60}Co at depths of up to 182 m (597 ft).

For each of the 14 contaminant plumes being evaluated, a nominal value of 10 m (33 ft) was chosen for the vertical extent of dissolved chemical constituents in groundwater (Connelly et al. 1992). Table 4-3 provides volume estimates for the quantity of contaminated water by each of the chemical compounds based on this nominal thickness. Although this 10 m thickness does not account for the chemical constituents identified at greater depths, this depth was selected to provide a preliminary estimate for the potential volume of the compound in the groundwater. Further characterization of the vertical extent of chemical constituents will be required to refine this thickness estimate.

The vertical extent and distribution of contaminants in 200 West Groundwater Aggregate Area groundwater has not been fully assessed. For example, volatile organic compounds are present at the site in high concentrations, may spread to deeper portions of the aquifer, and are simple to analyze; however, the vertical extent is not well understood. Rohay and Johnson (DOE/RL 1991a) investigated volatile organic concentrations in groundwater beneath several Plutonium Finishing Plant (PFP) cribs used to dispose of wastewater containing carbon tetrachloride to the soil column. They reported carbon tetrachloride concentrations of 5,770 μg/L in a groundwater sample collected from the top of the water column in Well 299-W15-6 and concentrations of 2,651 and 3,784 μg/L in groundwater samples collected from the bottom of the well. Because Well 299-W15-6 screens the entire saturated portion of the unconfined aquifer, it is unclear whether these sampling results reflect conditions in the surrounding formation or whether they reflect concentration differences between the top [62 m (203 ft) below ground surface] and the bottom [132 m (433 ft) below ground surface] of the water column in the well.

Well 299-W15-6 is located approximately 20 m (61 ft) northeast of the 216-Z-9 Trench, which disposed spent solvent and aqueous wastes from the RECUPLEX process line (Section 2.4.2.3). Well 299-W15-6 is also generally downgradient of the 216-Z-9 Trench.

Carbon tetrachloride was not detected in groundwater samples collected from deep Monitoring Well 299-W18-22, located approximately 500 m (1,640 ft) southwest of the 216-Z-18 Crib (another Z Plant Aggregate Area carbon tetrachloride disposal site) or from deep Well 299-W15-17, located approximately 500 m (1,640 ft) west and 100 m (328 ft) north of the 216-Z-9 Trench (DOE/RL 1991a). The 1 ft screened interval in Well 299-W18-22 is located within the Ringold lower mud sequence below a structural highpoint. The 10 ft screened interval in Well 299-W15-17 is located at the base of the Ringold unit E (Table 2-9). Due to their distance from the carbon tetrachloride source areas (e.g., the 216-Z-9 Trench and the 216-Z-18 Crib), sampling results from these two wells can probably only be used to infer that dissolved and dense, nonaqueous phase liquid (DNAPL) contamination near the base of the Ringold unit E probably does not extend as far as 500 m (1,640 ft) west the source areas. Conditions beneath the source areas are still indeterminate due to the lack of data.

The following discussion describes a potential mechanism for vertical migration of carbon tetrachloride through the soil column as a high density liquid or vapor phase. As discussed in Section 2.0, carbon tetrachloride was used during processing operations. Density differences with water would be expected to promote vertical migration of the compound. Following discharge, carbon tetrachloride could retain this high density characteristic, possibly as a DNAPL "slug." Subsequent aqueous discharges to waste management units could serve as an additional driving force to promote vertical migration. Due to the immiscible nature of carbon tetrachloride, it is possible that only minimal mixing/dilution would occur during vertical migration, with the DNAPL characteristics

retained. Carbon tetrachloride would also be expected to migrate vertically downward as a vapor phase in the vadose zone due to the dense nature of the compound.

The extent of vertical migration of carbon tetrachloride in the liquid state in the vadose zone depends on a number of factors including the volume of carbon tetrachloride present, the input of carbon tetrachloride/water ratio, migration rates, and the sediments encountered. Lateral spreading could potentially occur where sediments with sufficiently low permeability are present. Preferential spreading would presumably be expected along the down-dip direction of the sediment horizons. Potential low-permeability horizons include the early "Palouse" soil, Plio-Pleistocene unit, upper Ringold unit, and fine-grained sand and silt layers/lenses in the Hanford formation and Ringold Formation. Even where low-permeability sediments are encountered, carbon tetrachloride present in high concentrations (e.g., as a DNAPL phase) exceeding the residual saturation of the lithology could potentially promote renewed vertical migration. Stratigraphic discontinuities and fractures would also provide conduits for continued vertical migration.

In the vadose zone, vapor phase carbon tetrachloride may potentially migrate along the Plio-Pleistocene unit (DOE/RL 1991b), as well as along other low-permeability sedimentary layers. Potential down-dip transport of vapors along the surface of these sediments could result in contaminant migration in a direction opposite of the regional groundwater flow.

Upon reaching the water table, much of the carbon tetrachloride would dissolve and concentrate in the shallow portion of the unconfined aquifer. Deeper migration through groundwater of some proportion of the carbon tetrachloride is also possible due to the density difference with water and the two thirds' relative immiscibility. As discussed above, deeper migration in the unconfined aquifer is not well documented in the 200 West Groundwater Aggregate Area.

4.1.1.6 Plumes of Chemical and Radionuclide Constituents. Fourteen chemical constituent plumes are presented for this investigation. The areal distribution and migration patterns of these plumes are discussed separately below.

4.1.1.6.1 Arsenic. Three distinct plumes of dissolved arsenic (plumes A, B, and C) have been identified in the 200 West Area (Figure 4-1). These plumes cover a combined area of approximately 330,000 m^2 (3,500,000 ft^2). The areal estimate is based on total (not filtered) arsenic levels equal to or greater than 10 μg/L. This bounding contour was not dictated by regulatory considerations, but rather was required because of the high detection limit. Therefore, the areas of contamination indicated in Figure 4-1 are contoured to the minimum level supported by the data. Areas of contamination, when compared to the most stringent standard available, i.e., the WWQC standard of 0.05 μg/L, may be much larger but could not be estimated because of interferences from the detection limit of 5 μg/L. Table 4-3 provides the areal distribution for plumes A, B, and C based on 10 μg/L. Concentrations

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of arsenic range from below the detection limit (5 μg/L) to 101 μg/L (Monitoring Well 299-W10-8). Dissolved arsenic (filtered) ranges only up to 24 μg/L. Except for the one unfiltered sample, the MCL of 50 μg/L was not exceeded in the 200 West Groundwater Aggregate Area.

The highest average concentration of dissolved arsenic was found in the northernmost plume (plume A). This plume is centered beneath the northern end of the 241-T Tank Farm and the 216-T-4-2 Ditch. The western edge of the plume underlies the eastern end of the 218-W-2A Burial Grounds. Nine wells were used to roughly define the areal extent of this plume, although the size indicated by the 10 μg/L contour is controlled primarily by the one high value. The overall shape and orientation of this plume are poorly defined on the south due to sparse well coverage. Additional data may greatly alter the plume's size and shape. The 1991 groundwater map indicates northeasterly horizontal flow with a semiradial pattern that may result in some spreading of the plume (Figure 3-78).

One higher average concentration value of 20 μg/L dominates plume B (Figure 4-1). This plume is located beneath the southern end of the 241-TX Tank Farm and west of the 216-T-19 Crib. Seven wells were used to delimit the areal distribution of plume B. According to the groundwater flow map for 1991, groundwater is flowing predominantly to the north with slight northwest and northeast components. Because the elevated concentration is defined by one well, plume B cannot be said to be elongated in any direction, except that plumes A and B loosely define elevated concentrations on a north-south direction (Figure 4-1). If plumes A and B are interconnected, this may indicate that arsenic migration may be corresponding to a zone of higher transmissivity [1.1×10^{-3} m^2/s (1,000 ft^2/day), see Section 3.5.2.1.3].

Concentrations within the southern plume (plume C) did not exceed 16 μg/L. Plume C is located beneath the northeastern end of 216-U-10 Pond, along the 216-U-14 Ditch and in the area of 207-U. Plume C is roughly defined by ten wells and consists of two areas with elevated concentrations that may be interconnected. If the two areas are connected, then plume C appears to be migrating to the east, which corresponds to groundwater flow.

As shown in Table 4-2, information regarding the vertical distribution of arsenic is unavailable. None of the five wells screened at the base of Ringold unit E had analytical data for arsenic.

The mass of arsenic in groundwater within the 10 ppb contour line is estimated at approximately 9 kg (20 lb). This estimate is based on a vertical extent of 10 m (33 ft) a porosity of 0.2, and the computer interpolation of well averages.

4.1.1.6.2 Chromium. Two areas of elevated concentrations of chromium within the 200 West Area are identified as plumes A and B (Figure 4-2). These plumes are distributed over an area of 490,000 m^2 (5,300,000 ft^2), based on chromium concentrations greater than or equal to the MCL of 50 μg/L. The maximum concentration measured in groundwater for unfiltered (total) chromium was 6,180 μg/L in Monitoring Well 299-W10-8 and for filtered chromium was 322 μg/L in Well 299-W22-20 (Table 4-1). Well 299-W10-8 is located north of 241-T Tank Farm (plume A) and Well 299-W22-20 is south of 216-S-20 (plume B). Chromium concentrations shown in Figure 4-2 ranged from 10 to 316 μg/L. Chromium concentrations in plumes A and B exceeded the MCL and WWQS.

Plume A is centered beneath the areas of 241-T Tank Farm, 218-W-2A Burial Ground and 216-T-4-2 Ditch (Figure 4-2). Chemical data collected from eleven monitoring wells were used to depict this plume, although the plume is dominated by elevated concentrations in four wells. Plume A is elongated in a northerly direction. The northern trend of the plume corresponds to the groundwater flow direction and may reflect northerly transport.

Plume B is centered near the southeast corner of the 200 West Groundwater Aggregate Area, near Cribs 216-S-20 and 216-S-22. Just south of this plume is the 216-S-26 Septic Tank and Drain Field. The overall shape and extent of plume B are poorly defined on the east, south, and west due to sparse well coverage. Additional data may greatly alter the size and shape of this plume. Groundwater flow is oriented east-southeast in this area.

Thornton (1992) identified a reasonably good correlation between dissolved chromium concentrations and nitrate plumes in the 200 West Groundwater Aggregate Area. Large concentrations of nitrate increase the oxidation potential of the groundwater. Chromium, which is more soluble in a higher oxidation state (hexavalent chromium), would therefore be more mobile. Thornton (1992) suggests that the chromium present beneath the 200 West Groundwater Aggregate Area was introduced primarily as hexavalent chromium. Much of the hexavalent chromium would be expected to complex with organic carbon, however, decreasing its overall dissolved concentration. Specific chemical data to evaluate the distribution of individual chromium valence species in 200 West Groundwater Aggregate Area groundwater were not found, and represent an analytical data gap.

The vertical extent of chromium concentrations in the unconfined aquifer has not been established; however, Table 4-2 indicates that chromium concentrations were measured in both the deep and shallow wells of the Ringold Formation unit E. This table provides unfiltered and filtered chromium concentrations. Unfiltered analyses detected chromium in excess of the MCL of 50 μg/L in deep Wells 299-W7-3 (76.5 μg/L), 299-W10-14 (76 μg/L), 299-W15-17 (161.11 μg/L), and 299-W18-22 (74.13 μg/L) (Table 4-2). Concentrations of chromium in adjacent shallow wells were lower than those found in the deep wells, except in shallow Well 299-W18-21 (88.78 μg/L). None of these deep wells were located within the areal extent of plume A or B. Filtered analyses for chromium appear to have had detections

in two deep wells, 299-W10-14 (13.56 μg/L) and 299-W15-17 (18.40 μg/L). The concentrations measured in 299-W10-14 are slightly higher than those encountered in shallow Well 299-W10-13. Deep Well 299-W15-17 had higher concentrations of filtered chromium than adjacent shallow Well 299-W15-16 (13.22 μg/L). This information is insufficient to make an assessment on filtered chromium analyses.

The mass of dissolved chromium in the 200 West Groundwater Aggregate Area is estimated at 102 kg (225 lb). (Table 4-3). This mass is based on the total areal distribution of plumes A and B as interpolated for the contour lines, a 10 m (33 ft) vertical extent, and a porosity of 20%.

4.1.1.6.3 Fluoride. Two plumes of fluoride, plumes A and B, occur within the 200 West Groundwater Aggregate Area (Figure 4-3). The combined area of these plumes is approximately 83,000 m^2 (890,000 ft^2). This estimate is based on the area having fluoride concentrations greater than or equal to the MCL of 4 mg/L. Concentrations of fluoride range from nondetect (<0.5 mg/L) to 11.5 mg/L (identified in Monitoring Well 299-W15-4, Table 4-1).

Chemical data collected from 16 wells were used to define plumes A and B. Plume A is located beneath the 218-W-2A Burial Grounds and the northwest corner of 241-T Tank Farm. The highest concentration of fluoride in this area is 5 mg/L. Plume B is located under the area of 241-TX Tank Farm and the 216-T-19 Crib. The high concentration of fluoride for this plume is 12 mg/L. The shape of plume A as shown in Figure 4-3 makes it difficult to determine a transport direction due to the wide well spacing, although the small eastern lobe may represent northeastern transport from the southern lobe sources. Groundwater in this area is flowing in a northern to northeastern direction (Figure 3-78). An area of lower transmissivity [5.3 x 10^{-4} m^2/s (495 ft^2/day)] may cause the plume to deflect from a northern flow direction to a northeastern direction. The plume appears to follow a path of slightly more permeable sediments, with a transmissivity of 1.2 x 10^{-3} m^2/s (1,000 ft^2/day).

Another area with slightly elevated fluoride values is located east of U Plant by the burial grounds and the 216-U-17 Crib. Six wells identify the areal extent of this plume. Lower concentrations of fluoride are found here (1 to 2 mg/L). The flow of groundwater in this area is toward the east.

The vertical extent of fluoride concentrations in the unconfined aquifer was examined by comparing monitoring wells screened in the upper unit E and the base of unit E. Five monitoring wells were identified as being located in the base of unit E. Fluoride concentrations were identified in all five deep wells. Concentrations ranged from 0.473 to 0.510 mg/L. Fluoride concentrations were higher in shallow wells (Table 4-2) than in deeper wells, except in Well 299-W10-13 (0.494 mg/L).

The total mass of fluoride in the 200 West Groundwater Aggregate Area was estimated at 880 kg (1,940 lb, Table 4-3). This estimate is based on the areal extent of the plume with an average concentration of 6,965 μg/L, and assumes a porosity of 20% and a depth of 10 m (33 ft).

4.1.1.6.4 Nitrate. Elevated nitrate concentrations are widespread across the 200 West Groundwater Aggregate Area. A variety of interpretations have been made as to the areal distribution of nitrate within the 200 West Groundwater Aggregate Area (Connelly et al. 1992; Harris and Delaney 1991; Evans et al. 1990; Evans et al. 1989). Based on Figure 4-4, the areal distribution of nitrate for concentrations greater than or equal to 45 mg/L is estimated at 12,000,000 m^2 (129,120,000 ft^2). Concentrations of nitrate (as nitrate) within the plume range from 45 to 1,265 mg/L. The maximum sample concentration of nitrate identified within the 200 West Groundwater Aggregate Area is 2,810 mg/L at Well 299-W18-17 in June 1988. The maximum average concentration for nitrate was identified in Well 299-W19-19 (1,322 mg/L, Table 4-1). The MCL for nitrate is 45 mg/L (as nitrate, consistent with the data used here, rather than as nitrogen).

The nitrate plume can be differentiated into five source areas. The highest concentration (1,265 mg/L) is found in the area south of the U Plant beneath the 216-U-17 Crib. Evans et al. (1989) indicate that the 216-U-1 and 216-U-2 Cribs are believed to be the source of nitrate at the 216-U-17 Crib. The areal extent of the nitrate plume is defined by 53 wells, of which 40 wells have concentrations greater than or equal to 45 mg/L. Available monitoring well coverage is insufficient to sharply define the eastern portion of the plume.

The second highest concentration of nitrate (563 mg/L) is located underlying the northern end of the 216-Z-20 Ditch and the southern end of the 216-Z-9 Trench. The third highest concentration of nitrate (529 mg/L) is located beneath the area of 241-TX Tank Farm. The fourth highest nitrate concentration is located under the northwest end of 241-T Tank Farm and the 218-W-2A Burial Ground. Evans et. al. (1989) indicate that early T Plant waste was discharged into disposal facilities which appear to be contributing to the nitrate plume. Nitrate concentrations (151 mg/L) in the area southeast of the REDOX Plant are centered in the area beneath the 216-S-20 Crib and 216-S-26 Crib.

The overall direction of groundwater flow in the area of the nitrate plume appears to agree with nitrate plume configuration. Groundwater in this area flows to the east and northeast. Varying transmissivities in the area of the nitrate plume (Figure 3-53) influence the overall configuration of the plume.

According to Thornton (1992) nitrate discharges associated with waste effluent appear to have significantly disturbed local reduction/oxidation (redox) conditions in the unconfined aquifer. The addition of large amounts of nitrate has resulted in the increased oxidation potential of the system. As a result, constituents that are more mobile under oxidizing

conditions will be found dissolved in the groundwater. Uranium and hexavalent chromium are examples of these constituents.

The vertical extent of nitrate in the groundwater was evaluated by comparing chemical data obtained for deep and shallow wells (Table 4-2). These data suggest that nitrate can be found in the lower part of Ringold unit E and the upper part of unit E. Nitrate concentrations are elevated in both the deep and shallow wells. In addition, nitrate concentrations in shallow wells are not necessarily higher. For example, nitrate concentrations in deep Well 299-W10-14 (19.1 mg/L) are higher than those identified in adjacent shallow Well 299-W10-13 (13.0 mg/L). On the other hand, the nitrate concentration for shallow Well 299-W15-4 (539.3 mg/L) are higher than those found in the deeper Well 299-W15-6 (6.5 mg/L).

The mass of dissolved nitrate in the groundwater is estimated at 3,200,000 kg (7,100,000 lb). This estimate is based on the computer integration of the distribution, a vertical extent of 10 m (33 ft), and a porosity of 20%.

4.1.1.6.5 Carbon Tetrachloride. Elevated concentrations of dissolved carbon tetrachloride are found underlying over three-fourths of the 200 West Groundwater Aggregate Area. Estimated areal distribution of carbon tetrachloride is 12,700,000 m^2 (140,000,000 ft^2) (Last et al. 1991). This areal extent is based on the 10 μg/L contour, as required by the method detection limit. Three centers of high concentrations (plume centers A, B, and C) are found within the plume (Figure 4-5). Average concentrations of carbon tetrachloride from 200 West Groundwater Aggregate Area wells between 1988 and 1991 ranged from <5 μg/L to 7,867 μg/L. The single highest concentration measured for carbon tetrachloride is 8,700 μg/L at Well 299-W15-16 in March 1990 (Table 4-1). The maximum average concentration for this well is 6,559 μg/L (Table 4-1). The MCL for carbon tetrachloride (5 μg/L) has been exceeded over the entire area of the plume.

Center A has the second highest carbon tetrachloride concentrations (2,663 μg/L) within the 200 West Groundwater Aggregate Area and is centered beneath the area of 241-T Tank Farm and 216-T-7, 216-T-5, 216-T-3, 216-T-6, 216-T-12 and 216-T-14 through 216-T-17 Cribs (Figure 4-5). This lobe of the plume is oriented in an east to west direction. Groundwater flow in this area is moving in a semiradial direction to the west, north and east. Transmissivities in the area of the 241-T Tank Farm (Figure 3-53) range from $\leq 5.8 \times 10^{-4}$ to 1.2×10^{-3} m^2/s (500 to 1,000 ft^2/day).

Center B has the highest carbon tetrachloride concentrations (7,867 μg/L) within the 200 West Groundwater Aggregate Area and is the center of the entire carbon tetrachloride plume (Figure 4-5). The plume is centered under the PFP, just northwest of the 216-Z-9 Crib, 216-Z-1A Tile Field and the 216-Z-18 Crib. The carbon tetrachloride plume extends from this area to the northeast, southeast, and southwest (Figure 4-5). Groundwater flow in

this area is influenced by the groundwater mound and heterogeneities in the stratigraphy. Flow in this area is toward the northwest, north and northeast to east (Figure 3-78). Transmissivities shown on Figure 3-53 in this area range from $\geq 5.8 \times 10^{-3}$ to 5.8×10^{-2} m^2/s (5,000 to 50,000 ft^2/day).

Plume center C is located and west of the Z Plant Aggregate Area's 218-W-4C Burial Ground. The highest carbon tetrachloride concentrations at this center is 768 μg/L at Well 699-39-79. This well defines the westernmost extent of the carbon tetrachloride concentrations identified by this plume center. Although contours of lower concentrations are shown west of Well 699-39-79, wells located to the west were not sampled. Therefore, the westernmost extent of the carbon tetrachloride plume is poorly defined due to very sparse well coverage. Additional data may alter the size and shape of the western side of the plume.

Plume center C appears to be a distinct entity from plume center B to the northeast, and is well defined in sampling data from several wells between the two plumes. Potential sources of carbon tetrachloride contributing to either plume from the 218-W-4C Burial Ground are undocumented. If plume center C originated from similar liquid discharge sources as those contributing to plume center B, then the current separation of the two plumes could be the result of historical changes in groundwater flow patterns. Plume center C is currently associated with an area of where the groundwater table is relatively flat (Figure 3-78). Changes in groundwater flow have occurred in this area however, since the decommissioning of the U Pond and dissipation of the U Pond groundwater mound in the late 1980's. Since that time the primary area of groundwater mounding in the 200 West Groundwater Aggregate Area has been located in the southeastern portion of the Z Plant Aggregate Area, near the boundary of the U Plant Aggregate Area. The current mound is related to active wastewater discharges in these areas, and could potentially promote continued separation of the plumes. The transmissivity values in the area of plume center C range from 5.8×10^{-5} to 5.8×10^{-4} m^2/s (50 to 500 ft^2/day).

Additional water quality data collected at Well 299-W18-17 near the 216-Z-20 Crib also indicate that carbon tetrachloride is present at 6 to 9 m (20 to 30 ft) below ground surface. Rohay and Johnson did not detect carbon tetrachloride in the two deep wells (299-W15-17 and 299-W18-22) located west of the 216-Z-9 Trench and 216-Z-20 Crib (DOE/RL 1991a). Well 299-W18-22 is screened in the Ringold lower mud sequence. Well 299-W15-17 is screened in the unit E gravels and is located in the area of plume center B.

The mass of dissolved carbon tetrachloride in the groundwater was estimated by using the computer interpolated grid and a vertical extent of 10 m (33 ft). By using a 20% porosity, the mass of carbon tetrachloride is estimated at 8,800 kg (19,400 lb) (Table 4-3). Rohay and Johnson (DOE/RL 1991a) calculated a carbon tetrachloride mass ranging from 5,250 to 15,740 kg (11,574 to 34,700 lb) using a porosity range of 10 to 30%. They

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estimated that this mass represented roughly 2% of all carbon tetrachloride discharged to the trench and cribs.

4.1.1.6.6 Chloroform. The chloroform plume appears to be associated with the carbon tetrachloride plume and may be a degradation product (Last et al. 1991). Reportedly, this chemical constituent has not been used directly during processing activities in the 200 West Groundwater Aggregate Area. Other potential sources of chloroform include effluent discharged to the 200 West Powerhouse pond (in the northern portion of the U Plant Aggregate Area-Plate 1) which received water with high concentrations of chlorine, although this area is characterized by low chloroform concentrations in groundwater as discussed below.

Sources of chloroform, such as chlorination of drinking water, would be expected to contribute relatively low concentrations (on the order of 15 μg/L) to groundwater. Contribution from chlorinated compounds in petroleum waste is also unlikely, since disposal of petroleum products has not been documented in quantities sufficient to affect groundwater. The highest concentrations for chloroform appear to be shifted slightly eastward from those identified for carbon tetrachloride. This shift in concentration highs between these plumes could be potentially related to the degradation of carbon tetrachloride to chloroform. It is unknown why further degradation of these compounds does not appear to occur (e.g., in dichloromethane). It may be that it is occurring but the resulting levels are too low to measure. Data from additional groundwater wells are needed to further refine these issues.

The plume can be divided into two plumes (plumes A and B, Figure 4-6). The combined areal extent for these plumes is 3,500,000 m^2 (38,000,000 ft^2, Table 4-3). This area is defined by concentrations of chloroform that are $\geq$ 7 μg/L, which is higher than the strictest standard but was dictated by detection limits. The maximum average concentration identified by these plumes is 1,595 μg/L at Well 299-W15-8. This well is located at the southern end of 216-Z-9 Trench and was the only well at the site identified as having concentrations of ^{239,240}Pu. Well 299-W15-8 may have acted as a preferential pathway for the vertical migration of plutonium, and thus could also allow migration of chloroform. The highest individually measured concentration of chloroform found in the 200 West Groundwater Aggregate Area was 1,650 μg/L in the same Well 299-W15-8. The MCL (100 μg/L) and WWQS (7 μg/L) were exceeded for chloroform. The maximum concentration of the chloroform for one well is larger than the maximum concentration shown for the contaminant plume. The concentrations reported for the one well represent a single sampling event, whereas the concentrations on the plume map represent an average concentration identified for 1988 and 1990.

The larger chloroform plume (plume A) is located beneath the PFP and its associated facilities (216-Z-9, 216-Z-18, 216-Z-1A, and 216-Z-20) (Plate 1). The highest concentrations of this plume are found near the 216-Z-9 Trench (1,595 μg/L), 216-Z-12 Crib

(521 μg/L), and the 218-W-2 and 218-W-48 (176 μg/L) Burial Grounds. The chloroform plume may be absent (< 7 μg/L) in the area of the 200 West Powerhouse pond in the northernmost portion of the U Plant Aggregrate Area (see Plate 1), although this finding is based on limited sampling data in this area (Figure 4-6). The pond receives water from the powerhouse (Serkowski et al. 1988). The chloroform plume may have been diverted or otherwise modified in this area of water recharge near the pond. No additional information was found during review of documents for this report to indicate that the chloroform plume is being affected at this location from other sources such as leaking chlorinated water.

The areal distribution of chloroform at plume A appears as an amorphous shape without a definite orientation, although it does correspond to the same general area as the carbon tetrachloride plume. This distribution in part may be associated with the lack of well coverage on the eastern and western ends of this plume. About 37 wells are used to characterize this plume; however the majority of these wells are located in the area of the PFP. Transmissivity values in the area of the 216-Z-9 Trench range from 1.2×10^{-2} to 5.8×10^{-2} m^2/s (10,000 and 50,000 ft^2/day) (Figure 3-53).

Plume B is situated in the area southeast of the REDOX Plant, beneath cribs 216-S-20, 216-S-26, and 216-S-7 (Figure 4-6). The highest concentration identified at this plume is 9 μg/L. Groundwater in the area of this plume is moving toward the southeast and east. Transmissivities shown on Figure 3-53 in this area appear to be $\geq 1.2 \times 10^{-3}$ m^2/s (1,000 ft^2/day).

The vertical extent of chloroform is poorly defined. Rohay and Johnson (Appendix B, DOE/RL 1991a) attempted to examine the vertical distribution of carbon tetrachloride within Monitoring Well 299-W15-6. Water samples were collected from packed off, depth specific zones. Chloroform concentrations at roughly 50 m (164 ft) below the water table were 64 and 22 μg/L. As discussed in Section 4.1.1.5, Well 299-W15-6 screens the entire saturated portion of the unconfined aquifer. Sampling results may therefore reflect concentration differences between the upper and lower parts of the water column, and likely do not represent an accurate estimate of the concentration over the saturated thickness of the aquifer. Chloroform was identified in two other deep wells, 299-W10-14 (5.20 μg/L) and 299-W15-17 (4.35 μg/L). The adjacent shallow well to 299-W10-14 was not analyzed for chloroform (Table 4-2). The adjacent shallow well (299-W15-16, 44.67 μg/L) and deep well 299-W15-17 had higher concentrations of chloroform (Table 4-2).

The mass of dissolved chloroform is estimated at 240 kg (530 lb) (Table 4-3), about 5% of the mass of carbon tetrachloride. This estimate is based on the computer interpolated grid values of concentrations, a depth of 10 m (33 ft), and a porosity of 20%.

4.1.1.6.7 Trichloroethylene. Two distinct plumes of dissolved trichloroethylene (plumes A and B) were identified as originating in the 200 West Groundwater Aggregate Area (Figure 4-7). The estimated combined areal extent of these plumes is 2,200,000 m^3 (24,000,000 ft^2) (Table 4-3). This estimate is based on that area comprised by the 6 μg/L contour which is based on the detection limit rather than any regulatory limit. Trichloroethylene concentrations at the site ranged from less than or equal to 6 to 32 μg/L, with the maximum single detection measured in Well 299-W22-20 at 41 μg/L. Well 299-W15-16 was sampled in December 1988 with a trichloroethylene concentration of 50 μg/L; however, the average level in this well is 13 μg/L. The MCL for trichloroethylene (5 μg/L) has been exceeded for the entire areas of both plumes A and B.

The highest concentrations for plume A are located in the area beneath the T Plant Tank Farms (241-T Tank Farm, 241-TY Tank Farm, 244-TX, 2724-TXB, and 241-TX Tank Farm) and the 218-W2A Burial Ground. Twenty-three wells were used to define this plume. Of these wells, 11 contain concentrations that were greater than or equal to 6 μg/L. Plume A is oriented in a northern to southern direction with some slight deviation to the east (Figure 4-7). This plume orientation is created by the heterogeneities of the stratigraphy and the varying transmissivities. Groundwater in this area flows toward the north and the east, with preferential flow in those areas where the transmissivity is greatest [$\geq 1.2 \times 10^{-3}$ m^2/s (1,000 ft^2 day)], such as to the east (Figure 3-53).

Plume B is located in the southeast corner of the 200 West Groundwater Aggregate Area (Figure 4-7). This plume is southwest of the REDOX Plant beneath the area of cribs 216-S-20, 216-S-21, 216-S-22, and 216-S-7. Seven monitoring wells define the areal extent of this plume, one of which has a trichloroethylene concentration above 6 μg/L. This plume is primarily defined by the value of 32 μg/L and is poorly constrained by the sparse well coverage. Groundwater in the area of plume B is flowing predominantly toward the east to southeast. The transmissivity in this area is $\geq 1.1 \times 10^{-3}$ m^2/s (1,000 ft^2/day).

The vertical extent of trichloroethylene in the unconfined aquifer has not been defined. Chemical data for monitoring wells screened at the lower end of the unit E, Ringold Formation and adjacent shallow wells screened near the water table were examined (Table 4-2). Information was insufficient to make vertical extent estimates for this plume.

The mass of trichloroethylene in the groundwater is estimated at 44 kg (162 lb, Table 4-3). This volume is based on the computer interpolation of plume concentrations a depth of 10 m (33 ft), and a porosity of 20%.

4.1.1.6.8 Gross Alpha. Gross alpha measurements detected in the groundwater can be attributed to the presence of uranium and other high atomic number radionuclides such as plutonium and americium. Gross alpha analyses are run as a screening method for these isotopes. If elevated activity of gross alpha is measured, a more specific analysis can be

conducted to identify the source for the gross alpha activity. Not all gross alpha contamination can be accounted for by specific radioisotopes due to the varying sensitivities of the analyses to specific radionuclides.

The gross alpha detections in the 200 West Groundwater Aggregate Area are divided into four plumes (plumes A, B, C, and D, Figure 4-8). The areal extent estimated for these plumes combined is 3,800,000 m^2 (41,000,000 ft^2, Table 4-3) and is based on gross alpha concentrations greater than the MCL of 15 pCi/L. Average well concentrations for this plume range from nondetect to 2,554 pCi/L. The maximum single detection (individual analysis) identified for gross alpha was 48,700 pCi/L in Well 299-W19-11 in April 1985 at a time when contamination apparently first entered the groundwater and did not have the time to dilute. The maximum alpha concentration identified more recently was measured in Well 299-W19-18 at 3,710 pCi/L. The maximum average concentration for Well 299-W19-18 is 2,209 pCi/L (Table 4-1). The MCL for gross alpha of 15 pCi/L is exceeded by all four plumes.

Plume A is located at the northernmost boundary of the 200 West Groundwater Aggregate Area. This plume is defined by one well, 299-W7-6. This well is located beneath a portion of the railroad tracks that lead to the T Plant. The activity level at this well is 19 pCi/L. Neither uranium nor plutonium plumes are associated with this area. Groundwater in the area of this gross alpha activity is moving in a northeastern direction.

Plume B is located in the area beneath T Plant where cribs 216-T-2, 216-T-30 and 216-T-29 are present. The alpha activity at this plume is characterized by one well, 299-W11-14. Activity levels in this well measured at 240 pCi/L. A uranium plume is present in this location (see Section 4.1.1.6.13). Groundwater in the area of plume B is moving toward the east.

Plume C is located in the area beneath 216-U-10 Pond. Eight wells define the areal extent of this plume. The maximum activity identified at this well is 40 pCi/L. Groundwater in the area of the U Pond is moving toward the west and south.

Plume D is located in the area of the U Plant, where a burial ground and cribs 216-U-17, 222-U, 270-W, 2715-UA, 252-U, 271-U, 271-U, 203-W, and 241-WR are located. The highest gross alpha levels measured at this plume are associated with the inactive 216-U-1 and 216-U-2 Cribs (Evans et al. 1989). The maximum activity identified in this area is 2,554 pCi/L. A uranium plume is present in this location (see Section 4.1.1.6.13).

Nineteen wells characterize this plume. Of these 19 wells, 13 have activity at levels greater than or equal to 15 pCi/L. The majority of these wells are grouped in the southwestern portion of the plume. Better well definition is needed to the north and east.

The vertical extent of gross alpha activity in the unconfined aquifer was examined by comparing sampling results from shallow monitoring wells with wells screened near the base of the unconfined aquifer (Ringold unit E gravels). Gross alpha activity was measured in the five deep wells. Concentrations in these wells ranged from 1.05 to 1.39 pCi/L. Gross alpha concentrations in most of these wells were higher in the shallow wells than in the deeper wells, except at Well 299-W10-14 (Table 4-2). Gross alpha activity was not measured in the shallow wells adjacent to Well 299-W15-6 (Table 4-2).

The activity of gross alpha was estimated at 1.3 Ci (Table 4-3). This estimate is based on the computer interpolated grid values, a 10 m (33 ft) vertical extent, and a porosity of 20%.

4.1.1.6.9 Gross Beta. Gross beta levels can commonly be attributed to the presence of one or more of the following radionuclides in the groundwater: ^{60}Co, ^{90}Sr, ^{99}Tc, ^{106}Ru, ^{125}Sb, ^{137}Cs, ^{234}Th, ^{234}Pa, and ^{129}I. The gross beta activity in most cases in the plumes in the 200 West Groundwater Aggregate Area is derived from ^{99}Tc activity. Beta measurements are used as a screening tool. If activity is identified, then a more specific analysis can be conducted to identify the sources. As discussed for gross alpha contamination in Section 4.1.1.6.8, not all gross beta contamination can be accounted for by specific radioisotopes due to varying sensitivities of the analyses to specific radionuclides.

The gross beta plume detections in the 200 West Groundwater Aggregate Area form essentially three plumes (plumes A, B, and C, Figure 4-9). The combined areal extent for these plumes is 3,400,000 m^2 (37,000,000 ft^2). Gross beta levels used to define the areal extent of these plumes range from greater than or equal to 50 to 3,254 pCi/L. The maximum gross beta activity measured at the site is 80,000,000 pCi/L at Well 299-W22-26 in March 1967. Table 4-1 includes more recent beta activity (1988 to 1991), during which time the maximum activity listed for gross beta was 5,100 pCi/L in Well 299-W19-25. The maximum average activity in this well was 3,272 pCi/L (Table 4-2).

Plume A consists of an area of elevated beta levels beneath the T Plant Aggregate Area that has two closely spaced portions enclosed by the 50 pCi/L contours. The eastern portion of the plume underlies T Plant. Its maximum gross beta activity associated is 126 pCi/L in Well 299-W11-14, which is located in the area of crib 216-T-33. The western portion of plume A is located in the area of tank farms 241-T, 241-TY, and 241-TX and cribs 216-T-16, 216-T-26, 216-T-27, and 216-T-28. The maximum activity level of the western portion of the plume is 97 pCi/L. Another very small area with gross beta in excess of 50 pCi/L occurs to the north beneath 216-T-35 Crib in which one well indicates a value of 67 pCi/L. Thirteen monitoring wells define the areal extent of this plume. Groundwater flow in this area is toward the north and east (Figure 3-78). Transmissivity values for the area (Figure 3-53) with the highest gross beta activity range from 5.8×10^{-4} to 1.2×10^{-3} m^2/s (495 to 1,000 ft^2/day).

Plume B is located in the area of the U Plant. The highest beta activity is found in the area of the 216-U-17 Crib (3,272 pCi/L) and the 216-U-1 and 216-U-2 Cribs (3,254 pCi/L). Nineteen wells delineate the area of this plume as defined by gross beta activity greater than or equal to 50 pCi/L. The majority of these wells are located on the southwest end of the plume, resulting in poor definition of the plume to the east and to the north. Groundwater flow in this area is toward the east and southeast. Transmissivity values in this area (Figure 3-53) range from 5.8×10^{-4} to 1.2×10^{-3} m^2/s (495 to 1,000 ft^2/day).

Plume C is located west of the REDOX facility, in the area of cribs 216-S-15, 216-S-1, 216-S-2, and 216-S-6. The highest beta activity in this area is 2,148 pCi/L. Fifteen monitoring wells define the areal extent of this plume. Of these wells, six wells indicate beta activity greater than or equal to 50 pCi/L. The plume is poorly defined toward the south. Groundwater flow in this area is toward the south and east (Figure 3-74). Transmissivity values range from $\geq 5.8 \times 10^{-5}$ to 1.2×10^{-3} m^2/s (50 to 1,000 ft^2/day) (Figure 3-53).

The vertical extent of gross beta activity in the unconfined aquifer was examined by comparing the chemical data collected for monitoring wells screened in the upper unit E and the base of unit E (Table 4-2). Gross beta activity was found in both shallow and deep wells. Gross beta activity in deep wells ranged from 4.49 to 7.6 pCi/L (Table 4-2). Gross beta activity in deep Wells 299-W7-3 and 299-W15-17 was higher than adjacent shallow wells (Table 4-2).

The activity of gross beta is estimated at 2.1 Ci (Table 4-3). This estimate is based on the computer-interpolated grid values, a vertical extent of 10 m (33 ft), and a porosity range of 20%.

4.1.1.6.10 Tritium. Elevated tritium concentrations have been observed in groundwater in two areas within and adjacent to the 200 West Groundwater Aggregate Area. The two areas with elevated tritium concentrations appear to be present as separate plumes since numerous wells exist between the two plumes where tritium levels are much lower or even not detected. The two plumes are likely the result of contribution from several source areas. Also, groundwater dilution in this area could conceivably be occurring due to current discharges to the 216-Z-20 Crib, the 216-Z-21 Seepage Basin, and active U Plant liquid disposal waste management units. The current MCL for tritium is 20,000 pCi/L. The area bounded by the 20,000 pCi/L tritium contour lines totals approximately 11,200,000 m^2 (120,000,000 ft^2). The maximum average tritium concentration was identified in Well 299-W22-9 at 5,080 nCi/L.

The most northerly plume (plume A, Figure 4-10) appears to originate beneath the 241-TX, 241-TY, and 241-T Tank Farms in the T Plant Aggregate Area. Average tritium concentrations in groundwater monitoring wells within the plume range from 1 to 178 nCi/L. The center of mass of plume A trends northeast away from the T Tank Farms apparently

following the prevailing northeasterly groundwater gradient. For the purposes of this discussion, Plume A also includes the small plume northeast of the main Plume A (Figure 4-10). The northernmost plume is defined by a detection in one well that is greater than 20 nCi/L. Since no well sampling data were reported for the area between the plumes, their lateral extent in this area is uncertain. The separation of these plumes may therefore be an artifact of the computer contour program but has not been verified.

A second tritium plume (plume B, Figure 4-10) appears to originate beneath the 216-S-20 and 216-S-22 Cribs in the eastern portion of the S Plant Aggregate Area with possible lesser sources beneath the 216-S-4, 216-S-21, and 216-S-25 Cribs in the central portion of the S Plant Aggregate Area. The elevated tritium concentrations trend east-west beneath the REDOX facility and extend approximately 3,000 m (10,000 ft) beyond the eastern boundary of the 200 West Groundwater Aggregate Area to within approximately 1,000 m (3,000 ft) of the western boundary of the 200 East Area in a broad sweeping northeast trending plume. Consequently, the bulk of plume B lies east of U and S Plant. The maximum average tritium concentration, reported in Monitoring Well 299-W22-9, is 6,773 nCi/L (Table 4-1).

The center of mass of plume B forms an arc trending east to northeast away from the 200 West Groundwater Aggregate Area. Due to the relatively large size of this plume, the shape of the plume may be affected by historic changes in groundwater gradients, by aquifer inhomogeneities, and or contouring through areas with sparse data.

Data tabulated in Table 4-2 suggest no particular trend with respect to vertical concentration gradients for tritium. Average tritium concentrations in groundwater samples collected from Wells 299-W15-16 and 299-W15-17 (4,353 and 60.38 pCi/L, respectively), screened near the water table and the base of the Ringold unit E, respectively, indicate decreasing concentrations with depth. However, average tritium concentrations in Monitoring Wells 299-W18-21 and 299-W18-22 (245 and 275 pCi/L, respectively), also screened near the water table and the base of the Ringold unit E, respectively, indicate increasing concentrations with depth. Wells 299-W15-16 and 299-W15-17 are located near the east side of the northern portion of the 218-W-4C Burial Ground in the Z Plant Aggregate Area. Wells 299-W18-21 and 299-W18-22 are located near the southwest corner of the 218-W-4C Burial Ground in the Z Plant Aggregate Area.

Routine tritium analyses of groundwater samples collected at the Hanford Site began in the early 1960's. Results of sampling (including the 200 West Groundwater Aggregate Area) were presented in annual reports for the site and on tritium plume maps. Examples of tritium plume maps include those prepared for 1973 (ERDA 1975) and 1982 (Eddy et al. 1983). These were reviewed to compare historical plume extents to the present. The 1973 plume map shows a single extensive plume of tritium (>1,000 pCi/L) underlying almost the entire 200 West Groundwater Aggregate Area and extending approximately 1 km (0.6 mi) to

the east and south beyond the 200 West Groundwater Aggregate Area fence line. The eastern limit of the plume appears to be less than half of the distance beyond the 200 West Groundwater Aggregate Area fence line as observed under present day conditions for comparable concentrations (20,000 pCi/L). Three areas with values greater than 3,000,000 pCi/L were present under the general areas of U, S, and Z Plants in 1973. By 1982, the majority of the tritium plume is shown to be located underneath S and U Plants and extending eastward, with just a small plume identified under T Plant. The eastern limit of the plume for the 30,000 pCi/L contour appears similar to present day conditions, although the southern extent of the plume is shown greater than present. The origin of the 1982 plume appears to underlie S Plant, with an area exceeding 300,000 pCi/L extending over 2 km (1.2 mi) to the east, much like the present. Maximum concentrations appear to have been greater in 1973, although the areal extent was less than in 1982. The plume for 1982 is comparable to the present day plume with the exception that the plume currently extends slightly more eastward (perhaps 0.5 km), which shows some continued migration.

The total activity of tritium present in the groundwater plumes is estimated at 7,300 Ci (Table 4-3). This estimate is based on the computer-interpolation of the plumes, an assumed 10 m (33 ft) depth, the computer-interpolation on a grid and a porosity of 20%.

4.1.1.6.11 Technetium-99. Two distinct plumes of ^{99}Tc (plumes A and B) have been identified in the 200 West Groundwater Aggregate Area (Figure 4-11). The estimated combined areal extent of these plumes is 1,320,000 m^2 (14,200,000 ft^2, Table 4-3). This estimate is based on the areas delimited by ^{99}Tc concentrations greater than or equal to 900 pCi/L. Technetium-99 concentrations at the site range from nondetections to 26,975 pCi/L. The maximum single detection of ^{99}Tc identified at the site was measured at 41,000 pCi/L in October 1989 at Well 299-W19-24 (Table 4-1). The average maximum ^{99}Tc concentration in this well was 26,601 pCi/L.

The highest concentrations of ^{99}Tc are found in plume B, which is located beneath the U Plant. The western end of the plume is located beneath the 216-U-1 and 216-U-2 Cribs and 2607-W Septic Tank, with an extension separated to the west beneath 207-U Retention Basin (Figure 4-11). Concentrations in this area range from 545 to 4,800 pCi/L. The eastern end of the ^{99}Tc plume is beneath the 216-U-16 Crib, and concentrations range from 12,703 to 26,975 pCi/L. Seventeen wells define the areal extent of plume B. Monitoring well coverage on the southern and eastern end of this plume is poor. Groundwater flow in this area is toward the east as indicated by the east to west orientation of the plume. Transmissivities in this area range from $\geq 5.8 \times 10^{-4}$ to 1.2×10^{-2} m^2/s (500 to 10,000 ft^2/day).

Plume A is located beneath the 241-S and 241-SX Tank Farms. Concentrations for this plume range from $\geq$900 to 2,761 pCi/L. Six monitoring wells define the areal extent of this plume. Groundwater flow in this area is toward the south and southeast (Figure 3-78).

9 2 1 2 6 1 0 3 6 4

Transmissivity values in this area (Figure 3-53) range from 5.8×10^{-5} to 1.2×10^{-3} m^2/s (50 to 1,000 ft^2/day).

Elevated concentrations of ^{99}Tc were identified in three areas within the T Plant Aggregate Area (Figure 4-11). Concentrations in these areas ranged from 287 to 507 pCi/L, below the 900 pCi/L contour lower limit for the ^{99}Tc plume.

The vertical extent of ^{99}Tc concentrations in the unconfined aquifer was examined by comparing monitoring wells screened in the upper unit E and the base of unit E. Five monitoring wells were identified in the base of the unit E. Table 4-1 compares these wells with adjacent shallow wells. Deep Well 299-W15-17 measured 10.95 pCi/L of ^{99}Tc; whereas shallow Well 299-W15-16 measured 11.97 pCi/L of ^{99}Tc. These concentrations suggest that ^{99}Tc has traveled vertically in the aquifer. Wells 299-W15-17 and 299-W15-16 are at the northern end of the U Pond groundwater mound.

The activity of ^{99}Tc is estimated at 9.1 Ci (Table 4-3). This estimate is based on computer-interpolation of well values to a grid, an assumed vertical extent of 10 m (33 ft), and a porosity of 20%.

4.1.1.6.12 Iodine-129. Two distinct plumes (plumes A and B) of ^{129}I are identified in the 200 West Groundwater Aggregate Area (Figure 4-12). These plumes cover a combined area of approximately 6,200,000 m^2 (67,000,000 ft^2, Table 4-3). This areal estimate is based on dissolved ^{129}I concentrations ≥ 1 pCi/L. Concentrations of ^{129}I range from nondetections to 27 pCi/L. The maximum activity level identified for ^{129}I was 87.8 pCi/L in Well 699-35-70 in April 1988 (Table 4-1). Concentrations in this well dropped in 1989 to 11.1 pCi/L (Evans et al. 1990). The maximum average concentration in this well is 29.49 pCi/L (Table 4-1).

Plume A is located beneath T Plant near the 216-T-33 Crib. The highest concentration of ^{129}I in this area is 2 pCi/L (Well 299-W11-14). Only two wells define the areal extent of this plume. Groundwater in this area flows toward the east and northeast (Figure 3-78). Transmissivity values for this area (Figure 3-53) range from 46 to 93 m^2/day (500 to 10,000 ft^2/day).

Plume B is located in the area beneath the U Plant and east of the REDOX Plant. The highest concentrations of the plume are located in the area of cribs 216-S-22 and 216-S-12 and at Monitoring Well 699-35-70 (Figure 4-13). The direction of groundwater flow is toward the west and southwest (Figure 3-74). Transmissivity values for this area (Figure 3-60) range from 5.8×10^{-4} to 1.2×10^{-3} m^2/s (500 to 1,000 ft^2/day).

Table 4-2 indicates that information on the vertical distribution of ^{129}I is unavailable. The total activity of ^{129}I in the groundwater is estimated at 0.080 Ci. This estimate is based on the computer-interpolation onto a grid, a vertical extent of 10 m (33 ft), and a porosity range of 20%.

4.1.1.6.13 Uranium. Two areas, plumes A and B, of elevated concentrations of uranium can be identified within the 200 West Area boundaries (Figure 4-13). These plumes cover an approximate area of 670,000 m^2 (7,200,000 ft^2). This areal estimate is based on the area where concentrations are greater than or equal to 40 pCi/L. The highest concentration identified for these plumes is 1,130 pCi/L at Well 299-W19-18, which is located by the 216-U-1 and 216-U-2 Cribs (Figure 4-13).

Uranium concentrations reported during the mid-1980's have been considerably higher. Concentrations for uranium adjacent to the 216-U-1 and 216-U-2 Cribs increased from 200 to 72,000 pCi/L in February 1985 (Evans et al. 1988). Three monitoring wells and possibly a reverse well with improper annular seals were identified as providing vertical conduits for the uranium to reach the groundwater. Perched water resulting from the discharge of liquid waste into the 216-U-16 Crib was identified as the driving force for the vertical migration of the uranium. Shortly thereafter, discharges to the 216-U-16 Crib were terminated, the leaky wells were sealed, and a groundwater extraction and treatment program was instituted at the site (Serkowski and Jordan 1989).

Before the 1985 investigation, large quantities of uranium and nitrate were discharged into the 216-U-1 and 216-U-2 Cribs. Nitrate concentrations associated with the uranium plume in 1985 ranged from 6 to 1,500 mg/L (Evans et al. 1988). Nitrate is an oxidizing agent which elevates the Eh (oxidation potential) of the groundwater. Uranium under oxidizing conditions is present as hexavalent uranium, its very mobile state (Thornton 1992). The presence of the nitrate and uranium together enhanced the mobility of uranium.

Plume A is centered in the area of T Plant. Concentrations of this plume range from 40 to 399 pCi/L. Three wells appear to characterize this plume (Figure 4-13). Groundwater in the area of this plume flows toward the east (Figure 3-78). Perhaps due to the poor well coverage in this area the plume does not appear to reflect groundwater flow conditions. Transmissivity data were not available for this area.

Plume B is located in the central and southeastern portions of the U Plant Aggregate Area, and in the area to the east. Concentrations at this plume range from > 40 to 1,130 pCi/L. Two concentration highs are associated with this plume. One concentration high of 1,130 pCi/L underlies the 216-U-1 and 216-U-2 cribs, and the other of 547 pCi/L underlies the 216-U-17 crib. The uranium plume is elongated in an east to west direction with a slight trend toward the southeast. Groundwater in this area flows toward the east (Figure 3-78). The slight southeasterly bend of the plume may represent shifts in the location of the

groundwater mound. The transmissivity in this area ranges from 1.2×10^{-4} to 1.2×10^{-3} m^2/s (100 to 1,000 ft^2/day) (Figure 3-60).

Although the vertical extent of contamination for uranium has not been established, well data of Table 4-2 indicate that both deep (screened at the base of unit E) and shallow wells contain low levels of uranium. Uranium was measured in four deep wells; levels ranged from 0.51 to 0.99 pCi/L. Uranium levels in shallow wells were higher than levels in the deep wells, except in deep Well 299-W7-3 (Table 4-2).

The total activity of uranium in the groundwater at the 200 West Groundwater Aggregate Area is estimated at 0.24 Ci (Table 4-3). This volume is estimated on the computer-interpolated grid values, a porosity of 20%, and a 10 m (33 ft) vertical extent.

4.1.1.6.14 Plutonium-239/240. Plutonium-239/240 in the 200 West Groundwater Aggregate Area was detected in only Monitoring Well 299-W15-8. This well is located at the southern end of the 216-Z-9 Crib. Insufficient analytical coverage prevents a better definition of this plume. For the purpose of this report this detection will be considered as indicative of an actual plume. The areal distribution of this plume is based on two wells (Well 299-W15-8 and the nearest well with nondetect; Figure 4-14). The areal extent of this plume is estimated at 160,000 m^2 (1,710,000 ft^2) and is based on concentrations that are equal to or greater than 1 pCi/L. The maximum concentration identified for Monitoring Well 299-W15-8 is 8.3 pCi/L. The maximum average concentration for this well is 5.1 pCi/L.

The plume is located at the northern end of the groundwater mound in an area with a high transmissivity [$\geq 1.1 \times 10^{-2}$ m^2/s (10,000 ft^2/day)]. Groundwater flow in this area appears to be eastward. Water quality data collected from deeper wells (screened at the base of unit E) indicate that plutonium is present at concentrations ranging from 0.0022 to 0.0136 pCi/L (Wells 299-W7-3 and 299-W15-17) (Table 4-2). These levels are below the MCL of 1 pCi/L.

The total activity of $^{239,240}Pu$ is estimated at 2.6×10^{-3} Ci (Table 4-3). This estimate is based on an average concentration of 8.3 pCi/L (the one well with data), a porosity of 20%, and a depth of 10 m (33 ft).

4.1.2 Known Releases from 200 West Area Facilities

This section correlates contaminants identified in the groundwater to known releases from waste management units in the 200 West Groundwater Aggregate Area. The discussion is divided into identification of the factors that have contributed to the presence of contaminants in the groundwater followed by a discussion of individual contaminants.

4.1.2.1 Factors Contributing to Groundwater Contamination. Factors that have led to the observed groundwater contamination include: operation processes at the four plants in 200 West Groundwater Aggregate Area that generated waste streams; content, quantity, and areal extent of disposed wastes; and mobility of each contaminant in the vadose zone. This list is not intended to be exhaustive.

4.1.2.1.1 Plant Operations and Waste Generation. Table 4-4 summarizes the waste streams from the various plant operations in the 200 West Groundwater Aggregate Area which were disposed to waste management units that potentially contributed contaminants to groundwater. It also indicates the period of disposal. Operations and waste generation for each of the plants in the 200 West Groundwater Aggregate Area is described in Section 2.4. That discussion includes a summary of the waste-producing processes (Table 2-6) and identification of waste-management units where process wastes were disposed.

4.1.2.1.2 Sources of Groundwater Contaminants. Disposal of waste to waste management units potentially contributing contaminants to groundwater is identified below for the primary contaminants of concern in the groundwater. Waste disposal and storage is discussed in Section 2.3 by waste management unit. Tables 2-5 and 2-6 identify known inventories for specific waste management units that potentially have contributed contaminants to groundwater. Inventories are presented as a general guide to contaminants present, although the data presented in these tables must be viewed as incomplete. The dates of operation for these waste management units are shown in Table 2-4. This information is reformatted in this section to help identify potential sources for contaminant plumes identified in the groundwater. Where possible, contaminant plumes are related back to probable release sources in Sections 4.1.2.2 and 4.1.2.3.

4.1.2.1.3 Mobility of Contaminants Released to the Vadose Zone. Calculations were performed for waste management units in all of the 200 West Groundwater Aggregate Area source reports based on liquid waste discharge volumes and soil pore capacities. Waste management units receiving sufficient discharge for liquids to reach the water table by this calculation are identified in Section 2.3 as potentially contributing contaminants to the groundwater. This section discusses the potential for contaminants in these units to migrate to the uppermost aquifer.

The major processes affecting transport of chemicals discharged to the vadose zone include: precipitation/dissolution, adsorption/desorption, filtration of colloids and suspended particles, and diffusion into micropores within mineral grains (Serne and Wood 1990). The precipitation/dissolution and adsorption/desorption are considered the most important. Factors that affect the migration of contaminants in the vadose zone are summarized below:

- Ionic state--cations are more strongly sorbed than anions and nonionized solutions are more weakly sorbed.

- Valence state--generally, multivalent ions are more strongly sorbed than univalent ions.

- Particle size of contaminant--deposition of the contamination increases with increasing particle size.

- Soil grain size--sorption increases as soil (sorbent) particle size decreases. Filtration and ion exchange also increase with decreased soil grain size.

- pH and redox potential--the chemical species of a contaminant is dependent on these conditions, both in the waste and in the soil.

- Soil mineralogy--mineralogy affects the abundance of sorption sites as well as the availability of ions for precipitation.

- Waste stream constituents--sorption may be decreased if competing chemicals in the waste interfere, and complexing of inorganics with organics in the waste stream may increase the mobility of inorganics.

- Volume of discharge--hydrostatic forces are the primary driving force for contaminant migration, so that discharges that maintain saturated conditions in the vadose zone result in more rapid downward migration.

- Lithology--variations of the soil stratigraphy with depth, such as the presence of low-permeability layers, may increase the flowpath length of contaminant migration and slow its rate of descent.

- Monitoring wells--poorly sealed monitoring wells may provide a conduit by which contaminants may flow through the vadose zone to the groundwater.

Further discussion of contaminant mobility and transport is contained in Section 4.2.2 below. The potential for migration to the unconfined aquifer for each contaminant detected in the groundwater is discussed below in Sections 4.1.2.2 and 4.1.2.3.

4.1.2.2 Source and Mobility of Chemicals Released to Vadose Zone. Groundwater monitoring has detected numerous chemicals present in the groundwater of the 200 West Groundwater Aggregate Area (Table 4-1). Section 4.1.1 describes the plumes for the chemicals with the most significant concentrations. The probable source and mobility in the vadose zone of each of these chemicals with identified groundwater plumes are discussed below, beginning with inorganic and then organic compounds. Other inorganic and organic compounds detected in groundwater but not shown on plume maps are also discussed.

4.1.2.2.1 Inorganic Compounds. Inorganic compounds for which plumes in the groundwater are described include: arsenic, chromium, cyanide, fluoride, and nitrate. Other inorganic compounds detected include: aluminum, barium, cadmium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc.

Arsenic. Arsenic was not reported in inventories of chemical wastes discharged to waste management units for disposal, as presented in Table 2-6. Even so, arsenic may be associated with some of the process waste streams discharged to these units. Alternatively, lowering of the vadose zone pH and groundwater pH through release of acidic waste may alter iron oxide (e.g., iron hydroxide) to ionic iron (ferric iron), thereby mobilizing other metal ions such as arsenic that were adsorbed to the iron oxide. In addition, a lower pH may reduce arsenic to a lower valence state, thus making it less likely to adsorb to iron oxide.

Plume A (Figure 4-1) underlies the western portion of the T Plant Aggregate Area where 216-T-7F Tile Field and 216-T-32 Crib may have been the greatest contributors to the plume. Plume B would appear to have been formed by discharges to 216-T-19F Tile Field. Plume C may be the result of discharges to 216-U-1 and 216-U-2 Cribs and 216-U-1 Pond.

Arsenic exists as a negative ion in most soil conditions or as an oxide in slightly oxidizing to slightly reducing conditions (Dragun 1988). It is expected that arsenic in Hanford soils is a monovalent or divalent anion under most site conditions and therefore has a moderate to high mobility (Dragun 1988).

Chromium. Chromium was not reported in inventories of chemical wastes discharged to waste management units for disposal, but sodium dichromate is reported at T Plant as 10 kg (22 lb) released to 216-T-8 Crib and 200 kg (441 lb) released to 216-T-2 Reverse Well (Table 2-6). Sodium dichromate and chromic nitrate both were used in the feed preparation at S Plant, from which waste was stored in the 241-S Tank Farm. For comparison, approximately 102 kg (225 lb) comprise the chromium plume on groundwater (Section 4.1.1.6.2). It does appear that chromium may be associated with some of the process waste streams discharged to other units. This is supported by correlating plumes of nitrate and chromium in the Hanford Site (Thornton 1992). Chromium is mobile under oxidizing conditions (in its hexavalent state), but relatively immobile under more reducing conditions. Similar nitrate plumes are observed for the 200 West and 200 East Areas, which indicate oxidizing conditions, but a chromium plume is observed only in the 200 West Groundwater Aggregate Area (Evans et al. 1990). This indicates that the plume originates from waste disposal rather than mobilization of native chromium. Besides release as sodium dichromate, chromium in the waste stream may have originated as a byproduct of the separation processes or through dissolution of the walls of stainless steel process equipment by the strong acid solutions. Chromium was present in waste from the PFP in Z Plant, which was discharged to the 216-Z-3 and 216-Z-12 Cribs.

Plume A (Figure 4-2) may be associated, at least in part, with discharges from the 216-T-7F Tile Field, which has a record of sodium dichromate discharge (Table 2-6). No wells are positioned to monitor for discharge from the 216-T-8 Crib and the 216-T-2 Reverse Well. Plume B appears associated with cribs 216-S-20, 216-S-22, and 216-S-26, although inventories do not record chromium discharge to these units.

Chromium is mobile under oxidizing conditions (in its hexavalent state), but is relatively immobile under more reducing conditions. Hexavalent chromium exists as a monovalent anion at pH <6 and as a divalent anion at pH >6, and thus forms more mobile complexes at neutral to high pH values. Chromium has a high mobility in soil types such as those present at the site, while trivalent chromium has low mobility (Dragun 1988).

Fluoride. Inventories (Table 2-6) indicate that fluoride was disposed in cribs at Z Plant and T Plant. Hydrofluoric acid was used at the Plutonium Finishing Plant and RECUPLEX in Z Plant. A total of 491,000 kg (1,082,460 lb) is indicated for the units at Z Plant, with the greatest amounts disposed of to 216-Z-3 and 216-Z-12 Cribs; and 489,000 kg (1,078,000 lb) for the units at T Plant, with the greatest amounts disposed to units 216-T-7TF Tile Field and 216-T-32 Crib. Aluminum fluoride nitrate [210,000 kg, (463,000 lb)] also was discharged to 216-Z-9 Trench at Z Plant. The fluoride plume on groundwater represents approximately 1,400 kg (3,086 lb, Section 4.1.1.6.4).

Plume A (Figure 4-3) corresponds well with hydrofluoric acid disposal to 216-T-7F Tile Field and 216-T-32 Crib. Plume B underlies the 216-T-19F Tile Field, but no inventory records are shown for disposal of fluoride at this unit.

Fluoride is a common minor constituent in groundwater that typically occurs within the range of 0.01 to 10.0 mg/L (Freeze and Cherry 1979). Fluoride, which as a monovalent anion, is very mobile and would be expected to essentially travel unretarded with water through the vadose zone. Naturally occurring sources of fluoride include minerals that contain fluorides, such as apatite which is an accessory mineral in basalt. Aquifers that are naturally high in fluoride, such as the Grande Ronde Basalt, may also contribute fluoride if mixing occurs.

Nitrate. The chemical waste inventory (Table 2-6) indicates that nitrate was discharged in many forms to waste management units that potentially contributed contaminants to groundwater, but the primary form was nitric acid. Release of nitrate to these units is reported at 10,400,000 kg [22,927,800 lb], with the largest component discharged at T Plant and significant amounts at U and Z Plants, but with only minor amounts at S Plant (S Plant used nitric acid, sodium nitrate, and chromic nitrate in its processes). Other forms of nitrate discharged include aluminum fluoride nitrate [210,000 kg (463,000 lb)], aluminum nitrate [290,000 kg (639,300 lb)], calcium nitrate [130,000 kg (286,600 lb)], ferric nitrate [40,000 kg (88,200 lb)], HNO_3 [426,000 kg (939,200 lb)], and

magnesium nitrate [180,000 kg (396,800 lb)]. Nitrate discharge is associated with almost every unit on Table 2-6. The nitrate plume in groundwater is estimated to represent some 3,200,000 kg (7,050,000 lb, Section 4.1.1.6.5).

Disposal of nitrate has been widespread, and the plume reflects contributors of nitrate from many sources (Figure 4-4).

Nitrate exists as a negative ion and is readily soluble in water, so virtually no sorption is expected to occur in Hanford soils (Serne and Wood 1990; Evans et al. 1990). Nitrate degrades through natural (biological) processes to ammonia, thereby resulting in reduced concentrations with time.

Other Metals. Other metals detected in groundwater monitoring include aluminum, barium, cadmium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc. Chemical inventories (Table 2-6) include records for discharge of some of these metals as compounds, although this record is not considered to be complete. Aluminum was disposed in the form of aluminum fluoride nitrate and aluminum nitrate to the 216-Z-9 Trench in Z Plant. A total of 400,000 kg (881,880 lb) of these aluminum compounds were discharged to this unit. Aluminum discharge at T Plant also is reported in the form of sodium aluminate to cribs and trenches at a quantity of 280,000 kg (617,300 lb). Iron was discharged in the form of ferric nitrate to the 216-Z-9 Trench [40,000 kg (88,200 lb)] and ferrocyanide to the 216-T-26 Crib [6,000 kg (13,200 lb)]. Magnesium in the form of nitrate is reported to have been discharged to the 216-Z-9 Trench at a quantity of 180,000 kg (396,800 lb) (Table 2-6). Process wastes from the PFP at Z Plant included aluminum fluoride, chromium, lead, and other trace metal ions. Impurities in uranium present in small quantities in S Plant feed preparation waste include iron, zinc, copper, aluminum, and cadmium. Aluminum alloy jackets removed from uranium slugs at S Plant contained aluminum, iron, copper, and manganese, which were disposed of at the 241-S Tank Farm. Silver nitrate was used at S Plant to scrub ^{131}I from gaseous effluent. Potassium permanganate was used to remove ruthenium, with manganese later precipitated as manganese oxide. Aluminum nitrate also was used in the first extraction cycle at S Plant.

The cation exchange capacity of the Hanford Site soils is low due to its coarse nature and low clay and organic content. Thus, sorption through cation exchange of ionic metals is expected to be relatively low. The complex chemistry of the waste discharged at 200 West Groundwater Aggregate Area included many metal compounds and many other elements and compounds that likely altered the mobility of each metal. In general, the soil types present in the vadose zone at the site and natural soil conditions suggest that metals with anticipated high mobilities include selenium, metals with anticipated moderate or moderate to high mobilities include barium, cadmium, copper, iron, manganese, silver, and zinc, and metals with anticipated low mobilities include aluminum and mercury (Krauskopf 1979; Matthess

9 2 1 2 5 1 0 3 7 2

1982; Dragun 1988). However, changes to the pH and redox potential, as happened in many cases, and the very complex chemistry of the waste could greatly affect predicted mobilities.

4.1.2.2.2 Organic Compounds. Organic compounds for which plumes in the groundwater are described include: carbon tetrachloride, chloroform, and trichloroethylene. Other organic compounds detected include: 1,2-dichloroethane, 1,1,1-trichloroethylene, tetrachloroethylene, toluene, xylene-o,p, bis(2-ethylhexyl)phthalate, DDT, and N-nitrosodimethylamine.

Carbon Tetrachloride (CCl_4). Carbon tetrachloride was the organic diluent used in Z Plant processes. Inventories (Table 2-6) indicate that carbon tetrachloride was disposed in a tile field and crib at Z Plant. A total of 870,000 kg (1,918,000 lb) was discharged to the ground through the 216-Z-1A Tile Field, the 216-Z-18 Crib, and the 216-Z-9 Trench, with the majority disposed to the latter. Last et al. (1991) indicate that liquid wastes from the PFP contained an estimated 363,000 to 580,000 L (96,000 to 150,000 gal) of carbon tetrachloride which were discharged to these waste management units. Approximately 8,800 kg (19,400 lb) of carbon tetrachloride are present in the groundwater, as defined by the contaminant plume (Section 4.1.1.6.7).

As expected from the disposal record, the carbon tetrachloride plume is centered about disposal units in Z Plant, particularly the 216-Z-9 Trench (Figure 4-5). Other apparent source areas may be due to subsurface migration from the source area, as discussed below.

Carbon tetrachloride is a DNAPL, meaning that it sinks in water and has a low solubility. Mechanisms for transport through the vadose zone to the unconfined aquifer include gravity-driven liquid phase descent, aqueous phase transport (dissolved or as an emulsion in water), and density-driven vapor phase flow (Last et al. 1991). Measurements of the 200 West Groundwater Aggregate Area vadose zone indicate carbon tetrachloride vapor is present, with the highest concentrations detected below the caliche layer and just above the water table (Last et al. 1991). If carbon tetrachloride has been present at the water table in sufficient quantity, then it may have continued to sink through the aquifer as a separate phase until it reached a low permeability zone. In addition, because carbon tetrachloride has a low dielectric constant, it can increase the permeability of subsurface materials through reducing soil particle repulsion forces and thereby allowing a decrease in interparticle space that can result in the formation of cracks and fissures (Dragun 1988). If such cracks and fissures are formed, carbon tetrachloride may be permitted to migrate vertically, thus strongly influencing its migration pathways.

Chloroform. Chloroform is not included in the inventory for chemical waste (Table 2-6). Chloroform in the groundwater probably is a degradation product of carbon tetrachloride either through radiolytic processes prior to disposal or through natural

transformation processes, such as microbial degradation, in the subsurface (Evans et al. 1990).

The chloroform plume appears in general to have originated in the Z Plant Aggregate Area. As noted in Section 4.1.1.6.8, the chloroform plume fairly closely mimics the carbon tetrachloride plume.

Chloroform is probably a degradation product of carbon tetrachloride either through radiolytic processes prior to disposal or through natural transformation processes (i.e., microbial degradation) in the subsurface (Evans et al. 1990). Chloroform is a DNAPL and, as such, is expected to migrate by similar means as described for carbon tetrachloride.

Trichloroethylene. Trichloroethylene is not included in the inventory for chemical waste discharged to waste management units potentially contributing contaminants to groundwater (Table 2-6). Trichloroethylene is not mentioned in the AAMS source area reports for any processes of the plant operations in the 200 West Groundwater Aggregate Area, although its common use is as a cleaning solvent and it is mentioned as a chemical disposed to waste management units for Z Plant.

Trichloroethylene is a DNAPL and, as such, is expected to migrate by similar means as described for carbon tetrachloride if disposed in sufficient quantities.

Other Organic Compounds. Other organic compounds detected in groundwater, as discussed in Section 4.1.1, include 1,2-dichloroethane, 1,1,1-trichloroethane, tetrachloroethylene, toluene, xylene-o,p, bis(2-ethylhexyl)phthalate, DDT, and N-nitrosodimethylamine. These compounds likely were included in the waste discharged to the waste management units from peripheral activities to the main process operations. The compounds 1,2-dichloroethane, 1,1,1-trichloroethane, tetrachloroethylene, and bis(2-ethylhexyl)phthalate are all DNAPLs and, as such, are expected to migrate by similar means as described for carbon tetrachloride. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant and may be a spurious detection. Toluene and xylene-o,p are light nonaqueous phase liquids with low solubilities in water that may be transported by gravity-driven liquid phase descent or by aqueous phase transport (dissolved or as an emulsion in water). If liquid-phase descent has occurred, these compounds will pool above the water table. DDT is practically insoluble in water, but may be dissolved in another solvent that has migrated to the groundwater. N-nitrosodimethylamine is soluble in water. These last two compounds were detected only once, and only in one well each, and so are suspicious until their detection can be verified.

4.1.2.3 Source and Mobility of Radionuclides Released to Groundwater. Groundwater monitoring also has detected numerous radionuclides present in the groundwater of the 200 West Groundwater Aggregate Area (Table 4-1). Section 4.1.1 describes the plumes for the

radionuclides with the most significant concentrations. Plume maps include gross alpha, gross beta, tritium, ^{99}Tc, ^{129}I, uranium, and $^{239,240}Pu$. The probable source and mobility in the vadose zone of each of these radionuclides chemicals with identified groundwater plumes are discussed below. Other radionuclides detected in groundwater but not shown on plume maps are also discussed. These include: ^{14}C, ^{60}Co, ^{63}Ni, ^{90}Sr, ^{106}Ru, ^{137}Cs, radium, and ^{241}Am.

Operations at U, Z, S, and T Plants all involved process streams and waste streams that included uranium, plutonium, fission products, and TRU elements. Besides sources noted below for individual radionuclides, the following summarizes the potential sources of release for these elements.

At U Plant, fission products and transuranic (TRU) elements were associated with evaporator condensate for the uranium recovery process at 221-U Building released to cribs and ponds (216-U-1,-2,-7,-8,-10,-14, and -16); condensate recovered from the calcining process at 224-U Building released to 216-U-10 Pond and various cribs (216-U-1,-2,-8,-12, -14,-16, and -17); and 241-U Tank Farm condensate waste released to 216-U-3 French Drain. At Z Plant, fission products and TRU elements were associated with Plutonium Isolation Facility (PIF) process waste released to trenches, cribs, reverse wells (216-Z-4,-5,-6,-7, and -10); PFP process wastes and condensates discharged before 1973 to 216-Z-3 and 216-Z-12 Cribs and after 1973 to tanks; and RECUPLEX and Plutonium Reclamation Facility (PRF) spent solvent (carbon tetrachloride/tributylphosphate) released to the 216-Z-9 Trench, 216-Z-1A Tile Field, 216-Z-1 & 216-Z-2 Cribs, and the 216-Z-18 Crib. At S Plant, fission products and TRU elements were included in process waste stored in the 241-S Tank Farm. Condensate from the waste concentrator and from the uranium and plutonium concentrators were released to various 216-S cribs. At T Plant, fission products and TRU elements were associated with second cycle wastes (1948 to 1966), cell drainage waste (1951 to 1956), first-cycle wastes (scavenged for cesium beginning in 1955), and decontamination waste released to cribs, including the 216-T-28 Crib which received fission products totalling 594 Ci between 1959 and 1966 (Waite 1991).

4.1.2.3.1 Gross Alpha. The radiological waste inventory (Table 2-5) includes gross alpha values as an indicator of radionuclide releases. Alpha is reported on the table only for U Plant waste management units that potentially contributed contaminants to groundwater. The total alpha for U Plant units is 510 Ci, with 505 Ci attributed to the 216-U-10 Pond. This is associated with the greatest release of uranium, which is reported for the 216-U-10 Pond. The contaminant plume described in Section 4.1.1.6.9 represents roughly 1.3 Ci alpha in groundwater.

Plume A (Figure 4-8) is located north of T Plant and could represent migration of alpha-emitting sources from any of several waste management units. Plume B could be associated with alpha emitters released to various units in the northeast part of T Plant such

as the 216-T-8 Crib or 216-T-33 Crib. Plume C appears related to releases to the 216-U-10 Pond. Plume D is related to releases to units at U Plant, especially the 216-U-1 and 216-U-2 Cribs.

Gross alpha primarily is an indicator of uranium and other high atomic number radionuclides such as plutonium and americium. Thus, alpha detections primarily are dependent on the migration potential and concentrations of uranium, plutonium, and americium.

4.1.2.3.2 Gross Beta. The radiological waste inventory (Table 2-5) includes gross beta values as an indicator of radionuclide releases. Beta is reported on the table only for U Plant waste management units that potentially contributed contaminants to groundwater. The total beta for U Plant units is 337 Ci, with 208 Ci attributed to the 216-S-21 Crib and 112 Ci attributed to 216-U-12 Crib. Beta levels can be attributed to uranium fission products including ^{60}Co, ^{90}Sr, ^{99}Tc, ^{106}Ru, ^{125}Sb, ^{137}Cs, ^{234}Th, and ^{234}Pa, and to a lesser extent, ^{129}I. Some shorter-lived beta emitters, such as ^{131}I, may also have contributed initially, but have since decayed significantly. The contaminant plume described in Section 4.1.1.6.10 represents roughly 2.1 Ci beta present in groundwater.

Plume A (Figure 4-9) appears associated with several waste management units at T Plant, especially 216-T-21 to 25 Trenches and 216-T-26 to 28 and 216-T-33 Cribs. Plume B is centered beneath U Plant, especially 216-U-1 and 216-U-2 Cribs. Plume C appears to be related at least in part to discharges to 216-S-1, 216-S-2, and 216-S-7.

Gross beta is an indicator of many radionuclides and does not have a migration potential of its own.

4.1.2.3.3 Tritium. Tritium (^{3}H) is reported in the radiological inventory for waste management units for all but Z Plant (Table 2-5). Tritium was present in many of the waste streams discharged to the soil column in 200 West Groundwater Aggregate Area (Evans et al. 1990). A total of 355 Ci is reported in Table 2-5, with by far the greatest amounts released to the 216-U-10 Pond at U Plant (196 Ci) and to the 216-S-25 Crib at S Plant (148 Ci). Concentrations of tritium detected in groundwater indicate roughly 7,300 Ci, which far exceeds the reported inventory.

Plume A (Figure 4-10) underlies the southeast portion of T Plant Aggregate Area and could be attributed to a number of waste management units. Plume B appears to originate beneath S Plant, and may be attributed in part to the 216-S-25 Crib. Plume B also likely represents tritium discharged to waste management units at U Plant.

Tritium (^{3}H), as a constituent of tritiated water, closely resembles ordinary water in its structure (although is 11% heavier) and it travels unretarded along with water.

4.1.2.3.4 Carbon-14. Carbon-14 is not included in the inventory for radiological waste (Table 2-5). Carbon-14 is a fission product and likely was associated with process waste from reactor fuel reprocessing. Carbon is listed as an impurity in uranium metal that may have been present in small quantities throughout the separation precesses. Carbon exists primarily in the form of carbon dioxide, which is readily soluble in water. Thus, carbon migrates unretarded with water.

4.1.2.3.5 Cobalt-60. Cobalt-60 is reported in the radiological inventory for waste management units for all but S Plant (Table 2-5), although cobalt is presumed to have been present in the processes at S Plant due to the presence of irradiated uranium. Cobalt-60 is a fission product and likely was associated with process waste from reactor fuel reprocessing. Cobalt is listed as an impurity in uranium metal that may have been present in small quantities throughout the separation processes. The inventory in Table 2-5 shows a total of 2.4 Ci released to the soil at U, S, and T Plants, of which 1.9 Ci is reported for T Plant. The cribs at T Plant with the greatest releases include 216-T-34, 216-T-28, 216-T-35, and 216-T-14 with values of 0.2 to 0.6 Ci. Crib 216-U-21 at U Plant also received 0.3 Ci.

Cobalt exists primarily as a divalent cation up to a pH of approximately 9.5 that forms complexes with common anions (chloride, nitrate, hydroxide, and sulfate) to form mostly neutral or anionic species (Serne and Wood 1990). At a pH of 9 or less, which includes conditions present in the vadose zone, cobalt should sorb via cation exchange if it does not react with other anions to form anionic or neutral species. The formation of anionic and neutral complexes, as well as the formation of colloids, can result in a moderate to high mobility for cobalt (Serne and Wood 1990). Thus, some cobalt is expected to have sorbed to vadose zone soil through cation exchange, but that anionic and neutral species have allowed some migration to the uppermost aquifer.

4.1.2.3.6 Nickel-63. Nickel-63 is not included in the inventory for radiological waste (Table 2-5). Nickel-63 is a fission product and likely was associated with process waste from reactor fuel reprocessing. The PFP at Z Plant included coating plutonium cast forms with nickel to provide protection, a process that may have contributed to nickel released to the soil.

Nickel mobility exists primarily as a cation in the soil types at the site and is expected to have a high mobility due to the low cation exchange capacity. Nickel may have formed complexes in the waste stream that are less mobile.

4.1.2.3.7 Strontium-90. Strontium-90 is reported in the radiological inventory of Table 2-5 for almost every waste management unit. The inventory in Table 2-5 shows a total of 4,260 Ci released to the soil, of which 3,040 Ci was at S Plant and 920 Ci at T Plant. The greatest discharges by far occurred to the 216-S-7 Crib and 216-S-1 & 216-S-2 Cribs. Discharges at T Plant were distributed fairly evenly.

Strontium exists as a divalent cation throughout the potential range of groundwater pH in the absence of complexing anions and organic ligands. Strontium sorbs by ion exchange as a cation, with the degree of sorption in Hanford soil dependent on the types and concentrations of other cations in solution that can compete successfully for sorption sites (Serne and Wood 1990). Strontium may also precipitate as phosphate complexes. However, numerous organic anions react with strontium to form soluble organic complexes, which increases strontium mobility when present in the waste stream, and strontium is very mobile under acid conditions (Serne and Wood 1990). Thus, strontium commonly will be moderately sorbed or precipitated, but may be much more mobile in soil and groundwater where significant cationic competition for sorption sites occurs (e.g., high calcium conditions or high salt wastes), where significant organics are present in the waste, or where conditions are highly acidic.

4.1.2.3.8 Technetium-99. Technetium-99 is not included in the inventory for radiological waste (Table 2-5). Technetium-99 is a fission product and likely was associated with process waste from reactor fuel reprocessing. Fission products are associated with numerous operations processes. Approximately 9.1 Ci of ^{99}Tc are present in groundwater (Section 4.1.1.6.12).

Plume A (Figure 4-11) appears to originate from the 216-S-1 and 216-S-2 Cribs. Plume B underlies much of U Plant and may originate from the 216-U-1 and 216-U-2 Cribs.

Technetium exists as a negative ion in oxidizing environments and in soil types present at Hanford, and thereby, does not readily complex with other chemical species (Serne and Wood 1990). Consequently, technetium is considered nonsorbing in the Hanford soil environment. These conditions result in a high mobility for technetium in Hanford soils. Sorption may occur in soils that contain considerable organic matter, which tends to sorb anionic species, and the valence state may be reduced to the +4 state, causing precipitation or sorption. However, organic soils are not present at the site.

4.1.2.3.9 Ruthenium-106. Ruthenium is not included in the inventory for radiological waste (Table 2-5). Ruthenium-106 is a fission product and likely was associated with process waste from reactor fuel reprocessing. Ruthenium, which is the primary contaminant in purified plutonium and uranium streams, was removed from plutonium in the feed preparation process at S Plant and disposed with other wastes in the 241-S Tank Farm.

Ruthenium exists primarily in the +3 and +4 oxidation states and complexes readily with common anions to form a variety of anions or cations, depending on chemical conditions (Serne and Wood 1990). Mobility of ruthenium is greatly increased in the presence of nitrite and nitrate (Serne and Wood 1990), which results in a generally high mobility in the 200 West Groundwater Aggregate Area.

4.1.2.3.10 Iodine-129. Iodine-129 is not included in the inventory for radiological waste (Table 2-5). Iodine-129 is a fission product and likely was associated with process waste from fuel reprocessing. The groundwater plume represents roughly 0.08 Ci of ^{129}I (Section 4.1.1.6.13).

Plume A (Figure 4-12) may originate from 216-T-8 Crib or another unit nearby. Plume B originates underneath both U and S Plants. At U Plant, the plume appears to have been created by discharges to the 216-U-1 and 216-U-2 Cribs, and possibly 216-U-4 Reverse Well. At S Plant, both the 216-S-20 and 216-S-22 Cribs may have contributed to the plume.

Iodine exists as a negative ion in oxidizing environments and in soil types present at Hanford, and thereby, does not readily complex with other chemical species (Serne and Wood 1990). Consequently, iodine is considered nonsorbing in the Hanford soil environment. Sorption may occur in soils that contain considerable organic matter, which tends to sorb anionic species, but such soils are not present at the site.

4.1.2.3.11 Cesium-137. Cesium-137 is reported in the radiological inventory of Table 2-5 for almost every waste management unit. The inventory in Table 2-5 shows a total of 9,310 Ci released to the soil, of which nearly 6,800 Ci is reported for T Plant and 2,265 Ci for S Plant. The waste management units with the greatest releases include the 216-T-25, 216-T-22, and 216-T-24 Trenches at T Plant and the 216-S-1 & 216-S-2 and 216-S-7 Cribs.

Cesium exists as a monovalent cation within the range of soil and groundwater pH at Hanford and shows no tendency to complex with inorganic or organic ligands, no tendency to polymerize, nor a tendency to form colloids (Serne and Wood 1990). Consequently, cesium is expected to sorb primarily by ion exchange, with the degree of sorption dependent on the concentrations of other cations that can compete for sorption sites. Cesium is very mobile under acid conditions (pH <3).

4.1.2.3.12 Radium. Radium is not included in the inventory for radiological waste (Table 2-5). Radium is a decay product of uranium and likely was associated with waste for which uranium was identified.

4.1.2.3.13 Uranium. Uranium (^{238}U) is reported in the radiological inventory for waste management units for all but S Plant (Table 2-5), although uranium was also present in the processes at S Plant. A total of 4.0 Ci of uranium is reported in Table 2-5, of which 3.3 Ci is attributed to units at U Plant. At U Plant, the 216-U-10 Pond received the greatest amount at 1.9 Ci, followed by 0.7 Ci for both the 216-U-1 & 216-U-2 Cribs and the 216-U-12 Crib. The groundwater plume for uranium represents roughly 0.24 Ci (Section 4.1.1.6.14).

Plume A (Figure 4-13) appears to have originated from either the 216-T-8 or 216-T-33 Cribs. Plume B clearly is associated with the 216-U-1 and 216-U-2 Cribs. Only moderate levels of uranium are detected in the area of the 216-U-10 Pond.

Serne and Wood (1990) report that under oxidizing conditions that exist at Hanford, dissolved uranium is predicted to exist as a cation up to a pH of approximately 6, as a neutral hydroxide species from a pH of approximately 6 to 8, and as an anionic carbonate above a pH of 8. This suggests that uranium would sorb via cation exchange under acid conditions and sorb very poorly under neutral and basic conditions. However, strong evidence suggests that a uranium phosphate has precipitated beneath the cribs because of the high phosphate content in the waste streams (Serne and Wood 1990). Data compiled in the U Plant AAMSR indicate that uranium (^{238}U) has reacted with the soil where it has been discharged to form carbonate-phosphate compounds in the upper portions of the vadose zone, with little uranium normally reaching the uppermost aquifer.

Remobilization of uranium through acidic discharge is shown by events related to the 216-U-1 and 216-U-2 Cribs (Baker et al. 1988), which had received some 0.7 Ci of uranium between 1951 and 1967 that apparently precipitated in the soil. Acidic decontamination wastes, which were discharged to the cribs toward the end of their service life, had partially dissolved the sorbed uranium beneath the cribs but was of insufficient volume to transport the dissolved uranium to the groundwater. In 1984, a new crib (216-U-16) was installed south of the 216-U-1 and 216-U-2 Cribs. Liquid discharges to the 216-U-16 Crib were sufficient to form a perched zone above a caliche layer that by 1985 migrated under the 216-U-1 and 216-U-2 Cribs. This additional discharge mixed with the uranium-bearing fluid and uranium migrated downward with the liquid discharge to the uppermost aquifer. This was observed in a nearby monitoring well, as uranium concentrations rose from 166 pCi/L to about 72,000 pCi/L over a short period. A pump-and-treat remediation of the groundwater followed.

4.1.2.3.14 Plutonium-239/240. Plutonium-239 is reported in the radiological inventory for units at all four 200 West Groundwater Aggregate Area plants and ^{240}Pu at all but S Plant (Table 2-5). A total of 7,260 Ci of ^{239}Pu was discharged to the 200 West Groundwater Aggregate Area waste management units potentially contributing contaminants to groundwater. The greatest amount was discharged at Z Plant (6,910 Ci), especially at the 216-Z-1 & 216-Z-2 Cribs, 216-Z-7 Cribs, and 216-Z-9 Trench. A total of 2,310 Ci of ^{240}Pu was discharged to the 200 West Groundwater Aggregate Area units, with 2,130 Ci at Z Plant. Again, the greatest amount was discharged to 216-Z-1 & 216-Z-2 Cribs, 216-Z-7 Cribs, and 216-Z-9 Trench. Groundwater detections indicate the presence at only 0.0026 Ci plutonium (Section 4.1.1.6.15).

The plume indicated in Figure 4-14 appears to be related to discharges to 216-Z-9 Trench.

As described by Nishita et al. (1979), sorption of ^{239}Pu (and ^{241}Am) is greatest is calcareous soils between pH of 2 and 8, with high solubility below pH 2 and low to moderate solubility above pH 8. Below pH 2, TRUs are primarily in the ionic forms. Between a pH 2 and 8, low solubility indicates rapid hydrolysis, polymerization, and colloid and aggregate formation of TRUs. The solubilities mimic the pH solubility curves for aluminum, iron, and manganese, indicating that the insoluble hydrous oxides of these metals provide sorption sites for the TRUs. Nishita et al. (1979) also note that the presence of complexing or chelating agents, such as nitrate and organics (both of which are present in 200 West Groundwater Aggregate Area liquid discharges), increase the solubility of TRUs and are the likely mechanism for some transport of TRUs to the groundwater. Serne and Wood (1990) indicate that the maximum ^{239}Pu sorption occurs at the site in the pH range of 4 to 8.5. Price et al. (1979) indicate that most of the ^{239}Pu is retained in the top 15 m (49 ft) of the vadose zone beneath the 216-Z-1A Crib, with a maximum depth penetration of 30 m (98 ft), due to silicate hydrolysis reactions between the acidic waste liquid and the sediments and precipitation by plutonium-carbonate complexes. Price and Ames (1975) also show that ^{239}Pu at the 216-U-9 and 216-Z-1A Cribs decreases sharply in concentration in the top 9 m (30 ft), including apparent filtering of small plutonium oxide particles in the soil close to the discharge outlet.

4.1.2.3.15 Americium-241. Americium-241 is reported in the radiological inventory for waste management units for all but S Plant (Table 2-5), although americium is presumed to have been present in the processes at all four 200 West Groundwater Aggregate Area plants due to the presence of irradiated uranium. The americium recovery process occurred in the 242-Z Building of Z Plant, and americium also was recovered in the PRF of Z Plant. The values presented in Table 2-5 indicate a total of 13,400 Ci of americium for units at U, Z, and T Plants, although essentially 100% of this discharge occurred at the 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-8 French Drain.

Sorption of americium through ion exchange and physical sorption (polymerization and precipitation) to the soil is favored because the predicted ionic state of americium is cationic within the normal soil pH range (Serne and Wood 1990). Numerous organic anions react with americium to form soluble organic complexes, which increases americium mobility when present in the waste stream (Serne and Wood 1990). Americium is very mobile under acid conditions (pH of 1 to 3) and, thus, may be remobilized by acidic releases (Nishita et al. 1979). Price et al. (1979) observed that americium has the same distribution pattern as plutonium in the soil beneath the 216-Z-1A Crib and concluded that americium likely behaves the same as plutonium in the vadose zone.

4.1.3 Potential Future Contaminant Plumes

4.1.3.1 Anticipated Changes in Groundwater Flow. Artificial recharge to the unconfined aquifer in the separation areas has dramatically altered flow in the unconfined aquifer. Prior to 1944, groundwater within the uppermost aquifer system flowed generally in a west to east trend across the Hanford Site and the 200 West Groundwater Aggregate Area, as discussed in Section 3.5.2. Local groundwater mounding due to artificial recharge, primarily in the vicinity of the 216-U-10 and 216-T-4A Ponds (within the 200 West Groundwater Aggregate Area) and the 216-B-3 Pond (within the 200 East Area), has significantly altered the dynamics of this system. Mounding of the water table has caused local radial horizontal flow, steepened horizontal hydraulic gradients, and localized downward vertical gradients. As the patterns of artificial recharge have changed, so have the patterns of groundwater flow. This section addresses future groundwater flow patterns that may occur based on anticipated artificial recharge and its overprint on the natural flow regime.

4.1.3.1.1 Existing Conditions. Currently, groundwater flow within the 200 West Groundwater Aggregate Area trends northeast and east towards the 200 East Area and Gable Gap, with a small component trending to the northwest and the gap west of Gable Butte (Section 3.5.2). Groundwater flow within the 200 East Area radiates away from 216-B-3 Pond initially, then trends primarily to the southeast toward the Columbia River, with a smaller portion directed to the northeast and Gable Gap. Eastward flow from 200 West Groundwater Aggregate Area and westward flow from B Pond converge at the 200 East Area and divide into northern and southern components of flow. The flow ridgeline that divides north from south approximately bisects the fence line of the 200 East Area in an east-west direction. Groundwater north of this flow divide flows north to Gable Gap, and groundwater south of this flow divide flows southeastward toward the Columbia River.

The configuration of past and present contaminant plumes discussed in Section 4.1.2 provides insight on flow paths from the 200 West Groundwater Aggregate Area. Tritium and nitrate, both common components of the waste streams contributing to artificial recharge, are good tracers for defining groundwater flow directions. A tritium plume, which lies primarily to the east of the 200 West Groundwater Aggregate Area, extends from S Plant along a trend initially to the east-southeast and then curving to the northeast (Figure 4-10). This trend agrees with the flow paths indicated by historical and present potentiometric surfaces (Figures 3-67 to 3-72 and 3-78), with the northern extent of the plume possibly reflective of a more northeasterly flow trend that existed in the mid-1960's (Figure 3-69). Nitrate has a similarly shaped plume that originates from the U Plant area and shows flow to the east and northeast, also in agreement with historical and present potentiometric surfaces (Figure 3-65). Nitrate also has plumes to the north associated with T Plant and Z Plant, with trends to the north and northeast.

4.1.3.1.2 Future Artificial Recharge. Artificial recharge in the 200 West Groundwater Aggregate Area peaked in the 1950's and 1960's. Discharge to waste management units within the 200 West Groundwater Aggregate Area decreased dramatically following the decommissioning of the 216-U-10 Pond in 1985. This decrease has caused water table levels in the vicinity of the U Pond to drop an average of about 0.3 m/yr (1 ft/yr) since 1984. Almost all artificial recharge in the 200 West Groundwater Aggregate Area is expected to halt by 1995, with discharges to the SALDS facility just north of the 200 West Area and to the septic systems likely to continue for a short while, as well as the continued decline of the mounded water table. At the current rate, the 200 West mound will have dissipated nearly completely by about the year 2020, with the greatest loss in head from current levels occurring in the next 10 years. Hall (1981) projected the decline of the water table mound underlying 216-U-10 Pond for a 7-year period following cessation of discharge. The modeling projected a 10-m (33-ft) decline and virtual elimination of the mound after 7 years. Actual declines in 7 years since ceasing discharge to the pond have been much less than projected and the general form of the mound has been retained (Figure 3-78). Current water table elevations (Figure 3-78) at the eastern site boundary are about 3 m (10 ft) higher than projected, and levels in the mound area about 6 m (20 ft) higher than projected. This shows that the modeling either did not account for all of artificial recharge to the site following closure of the pond or overestimated the transmissivity of the aquifer.

A new area of mounding of the water table will be created when the State Approved Land Disposal Structure (SALDS) facility (Project C-018H: 242-A Evaporator/PUREX Plant Condensate Treatment Facility) is constructed to the north of the 200 West Groundwater Aggregate Area (see Section 2.7.3). This shift in discharge areas will affect future groundwater flow underlying the 200 West Groundwater Aggregate Area, with the magnitude of this influence dependent on the proximity of such a facility and its rate of discharge. Tri-Party Agreement milestone M-17-14 (Ecology et al. 1992) indicates that discharge of treated effluent to the soil column will be initiated in October 1994. Another SALDS facility (Project W-049H: 200 Area Treated Effluent Disposal Facility) to be located to the east or north of 216-B-3 Pond will also contribute to a new area of mounding that will affect groundwater flow in the 200 East Area. Tri-Party Agreement milestone M-17-08 indicates that this second SALDS will be initiated in June 1995. Discharge to the two SALDS will continue for an indefinite period, but eventually all artificial recharge will be discontinued and the area will revert to essentially natural flow conditions.

4.1.3.1.3 Anticipated Gradient and Flow Changes. Projections made through review of past and present data indicate that the anticipated decrease in artificial recharge to the 200 West Groundwater Aggregate Area and its ultimate termination will alter current groundwater flow directions and gradients. Current groundwater flow directions are shown on Figure 4-17, as based on the December 1991 water table contour map (Figure 3-78). A shift from current discharge to the SALDS facilities should have the following anticipated effects on groundwater flow and contaminant transport in the near future:

- The water table underlying the 200 West Groundwater Aggregate Area can be expected to lower by approximately 9 m (30 ft) as mounding continues to dissipate, if other conditions remain the same. Recharge from irrigation has caused groundwater levels to rise approximately 15 m (50 ft) within the upper Cold Creek valley west of the 200 West Groundwater Aggregate Area since 1944 (Graham et al. 1981). Groundwater levels across the 200 Areas Plateau have also risen in response to this recharge and will remain at elevated levels compared to pre-Hanford site activity as long as the groundwater recharge to the west is maintained.

- Mounding created by recharge to the Project C-018H SALDS, just north of the 200 West Groundwater Aggregate Area, will have only a minor effect on groundwater flow underlying the northern part of the site due to the low rate of discharge. Golder Associates (1990) modeled the impact of this SALDS and determined an anticipated mounding of the water table of only 1.5 m (5 ft).

- Horizontal groundwater gradients are expected to decrease significantly in the vicinity of the 200 West Groundwater Aggregate Area as mounding of the water table continues to dissipate. Current gradients are directed north, east, and southeast and average about 0.004. As the groundwater levels decrease the gradient will approach a more natural easterly direction and a value of about 0.002. A small component of flow to the north will be maintained by northerly gradients extending from the SALDS. Ultimately, the gradient should approach the pre-Hanford Site activity value of 0.001, although increased recharge from the Cold Creek valley has resulted in an overall gradient increase for the area.

- Horizontal groundwater flow leaving the 200 West Groundwater Aggregate Area will become oriented more uniformly in an easterly direction, losing most of its current northern component created by the mounding. The easterly flow will still meet westerly flow originating from the Project W-049H SALDS east of the 200 East Area and divide itself into southeasterly and northerly components, as shown on Figure 4-18. Groundwater flow originating from the 200 West Groundwater Aggregate Area that is directed to the north from this divide towards Gable Gap is expected to be reduced proportionally with the flow directed to the southeast. This change in proportional flow from the divide is anticipated due to the loss of the northerly flow component of flow from the 200 West Groundwater Aggregate Area. The small component of flow from the 200 West Groundwater Aggregate Area currently trending to the northwest toward gap west of Gable Butte will be greatly reduced. A smaller component of flow than present will be directed toward Gable Gap, and thus a greater component of the 200 West Groundwater Aggregate Area groundwater will exit to the east and then be directed south and east of the 200 East Area.

- The reduction of the horizontal gradient from 0.004 to 0.002 will decrease the horizontal groundwater flow velocity roughly by a factor of two over the present, which will slow horizontal contaminant migration by about one half.

- The downward vertical hydraulic gradient that exists within the uppermost aquifer system in the vicinity of the 216-U-10 Pond will diminish as the mounding dissipates. Currently, the downward gradient is approximately 0.004, which will likely be reduced to less than 0.001 when the water table mound completely dissipates. The downward vertical gradient between the uppermost aquifer system and the confined basalt aquifers likely will not revert to pre-Hanford Site conditions of an upward vertical gradient once mounding is gone, but rather will remain slightly downward due to the higher water table that will be maintained by greater recharge to the west in upper Cold Creek valley.

- The reduced vertical gradient from the current 0.004 to less than 0.001 will result in reducing the downward flow within the uppermost aquifer system by a factor of at least four. This decrease will reduce the rate of downward vertical migration of contaminants within the uppermost aquifer system by the same magnitude. The reduced downward vertical gradient between the unconfined aquifer and the confined basalt aquifers will reduce the potential for the migration of contaminants downward into the basalt aquifers.

Eventually, all wastewater discharges to waste management units within both the 200 West and 200 East Areas will be eliminated. This elimination of wastewater recharge to the uppermost aquifer will cause the dynamics of the uppermost aquifer to approach pre-Hanford Site conditions, albeit with a higher water table, as discussed above. Termination of all artificial recharge in the 200 Areas at some point in the future will likely result in the following additional changes:

- The dominant horizontal flow direction will remain west to east across the 200 West Groundwater Aggregate Area and turn southeastward near the 200 East Area, while horizontal flow across 200 East Area will revert to the east-southeast (Figure 4-19). No groundwater from the 200 West Groundwater Aggregate Area is anticipated to flow through Gable Gap once mounding in the 200 East Area dissipates, although some flow of groundwater through the gap (originating to the north) likely will continue at a reduced rate.

- Horizontal hydraulic gradients may steepen slightly with elimination of mounding at SALDS east of the 200 East Area, but are not expected to exceed an overall value much above 0.002 from the 200 West Groundwater Aggregate Area.

- The increase in horizontal gradient will result in a proportional increase in the rate of groundwater flow (and contaminant transport) from the 200 West Groundwater Aggregate Area.

4.1.3.2 Anticipated Releases from Vadose Zone. Potential future releases to the groundwater from the vadose zone include continued downward migration of previously released contaminants, leaching of sorbed or precipitated contaminants from the soil by water discharged through active units or by infiltrating precipitation, and contaminants entrained in discharge to currently active waste management units. It is possible that none of these modes present the potential for greatly affecting present contaminant plumes, although some additional contribution of contaminants to the unconfined aquifer can be expected.

Gross gamma geophysical logging has not provided evidence that downward migration of radionuclides is ongoing in the vadose zone (spectral gross gamma logging may provide more definitive data in the future). However, slow draining of soil underlying waste management units that were recently closed may contribute some small amount of additional contaminants to the groundwater. One recognized probable source of continued downward migration is reported for carbon tetrachloride, which appears to be migrating from areas of soil contamination to groundwater through the vapor phase transport (Last et al. 1991), although the planned ERA for carbon tetrachloride may halt this migration. A similar mode of transport may be occurring for other DNAPL compounds detected in the groundwater.

Leaching of sorbed or precipitated contaminants may occur at locations where water flows through contaminated soil zones. Such occurrences due to natural infiltration are probably negligible due to the very low recharge rate for the site. Leaching of contaminants from the soil may occur in areas of continued artificial recharge. For example, the 216-U-14 Ditch continues to discharge wastewater through a contaminated zone created by earlier discharges. Remobilization of contaminants in a situation like that of the 216-U-14 Ditch is not likely to be significant unless the waste discharged significantly alters the chemical conditions (e.g., a significant change to the pH).

The *Liquid Effluent Study Final Project Report* (WHC 1990b) documents the history and characteristics of current liquid discharges. The report includes discussion of nine waste management units in the 200 West Groundwater Aggregate Area: 216-S-10 Ditch, 216-S-26 Ditch, 216-T-1 Ditch, 216-T-4-2 Ditch, 216-U-14 Ditch, 216-U-17 Crib, 216-W-LC Crib, 216-Z-20 Crib, and 200-W-Powerhouse Pond. Discharges for these units are listed in a range of 874 m^3/month (216-T-1 Ditch) to 40,300 m^3/month (216-S-10 Ditch). Calculated travel times for liquid discharge to reach the groundwater range from 79 days (216-U-14 Ditch) to 794 days (216-U-17 Crib). Most of these current discharges contain low concentrations of metals and radionuclides, with some containing organic compounds such as acetone. WHC (1990b) states that in most cases a negligible impact to the groundwater is expected from future discharges, with the following exceptions. Uranium in low

concentrations with nitric acid are discharged to 216-U-14 Ditch and some breakthrough to the groundwater by uranium is expected. Mobile constituents such as nitrate, tritium, fluoride, and chromium (hexavalent) are expected to reach the groundwater from 216-U-17 Crib, but that other radionuclides should remain in the soil column. Chloride and aluminum contained in the 200-W Powerhouse Pond effluent have the potential to impact groundwater.

4.1.3.3 Projected Contaminant Plumes. Projected groundwater flow paths are presented in Section 4.1.3.1 for periods following cessation of artificial recharge to the 200 West Groundwater Aggregate Area and 200 East Area (Figures 4-18 and 4-19). These flow paths can be used for estimating the trend of future contaminant plume migration. Section 4.1.3.2 indicates that no significant sources are anticipated for contaminants in the groundwater that will significantly affect the contaminant plumes presented in Section 4.1. Therefore, groundwater flow paths presented in Figures 4-18 and 4-19 can be applied to present contaminant plumes to project future trends in migration.

In general, the most significant change to contaminant migration will occur when the water table mound underlying 200 West Groundwater Aggregate Area has dissipated. When that has occurred, contaminant transport by advection will occur along a generally eastern trend (Figure 4-18), with rates approximately one half of present rates. Only highly mobile contaminants with plumes that extend far beyond the boundary of the 200 West Groundwater Aggregate Area, such as nitrate and tritium, will continue to be significantly impacted by mounding in the 200 West Groundwater Aggregate Area. This mounding to the east will result in contaminant advection that divides near the 200 East Area into northerly and southeasterly components in which contaminants will migrate toward Gable Gap or the Columbia River, respectively. Cessation of all artificial recharge at some point in the future will allow dissipation of the mounding in the 200 East Area, at which time the groundwater flow dynamics of the uppermost aquifer system will again approach the pre-Hanford Site conditions (Figure 4-19). All contaminant transport by advection at that time will trend approximately east to southeast. Flow path lengths from sources to the Columbia River at that time will be very slightly shortened with respect to present path lengths, although reduced gradients will more than compensate the savings in travel time.

The projected effect of future contaminant transport by advection with groundwater flow is discussed below for each contaminant plume presented in Section 4.1.1 (Figures 4-1 to 4-14).

4.1.3.3.1 Arsenic. The arsenic plumes represent relatively small areas of elevated contamination and without clear evidence of current plume migration. These areas of elevated concentrations can be expected to shift slightly eastward due to eastward groundwater flow.

4.1.3.3.2 Chromium. Like arsenic, chromium values show limited areas of elevated concentrations (above 50 ppb), which will show shifts to the east with establishment of eastward groundwater flow. If groundwater conditions become more reducing with contaminant migration, then hexavalent chromium may be reduced to its trivalent (and less mobile) state, thereby lowering its concentration.

4.1.3.3.3 Fluoride. Fluoride detections indicate elevated concentrations over limited areas and without clear evidence of current plume migration. Establishment of eastward flow likely will result in an eastward shift in location of elevated concentrations.

4.1.3.3.4 Nitrate. The large plume of elevated concentrations that extends from T Plant to S Plant will shift eastward with continued eastward flow. As shown by more dilute concentrations, groundwater flow bearing elevated nitrate levels will meet flow from the 200 East Area and divide into northward flow towards Gable Gap and southeastward flow towards the Columbia River. More dilute concentrations of nitrate that have migrated to the north of 200 West Groundwater Aggregate Area will shift in transport direction to the east. Natural degradation of nitrate will contribute to reducing concentrations with time.

4.1.3.3.5 Carbon Tetrachloride. The carbon tetrachloride plume shows evidence of having migrated from the source area to the north-northeast, as well as to the southeast and southwest. The large plume to the north-northeast likely is due primarily to advection on the groundwater, while the other plume trends likely represent vadose zone vapor migration. It is anticipated that the expedited response action planned for carbon tetrachloride will eliminate most of the vadose zone vapor migration. Future eastward groundwater flow will result in a shift of the present plume to the east. If pooled, DNAPL exists in the aquifer, then the source area of high concentrations will be maintained. Natural degradation of carbon tetrachloride to chloroform and other products will result in reduced concentrations over time.

4.1.3.3.6 Chloroform. The chloroform plume, which closely mimics the carbon tetrachloride plume, likely exists as a degradation product of carbon tetrachloride. It is expected that the chloroform plume will remain associated with carbon tetrachloride. Chloroform also degrades through natural biological processes, which will help restrict the rate of migration.

4.1.3.3.7 Trichloroethylene. Trichloroethylene is expected to behave similarly to carbon tetrachloride, except that the southern plume (plume B) extends eastward from the 200 West Groundwater Aggregate Area boundary. Further eastward migration of this plume likely will result in flow that is directed to the southeast (south of 200 East Area) toward the Columbia River. Trichloroethylene degrades through microbial processes to other chlorinated compounds, thereby potentially reducing plume concentrations.

4.1.3.3.8 Gross Alpha. Gross alpha is an indicator of uranium, plutonium, americium, and other high atomic number radionuclides. As such, it will follow the migration patterns of these radionuclides.

4.1.3.3.9 Gross Beta. Gross beta is an indicator of many of the fission product radionuclides. As such, it will follow the migration patterns of those radionuclides.

4.1.3.3.10 Tritium. The tritium plume will likely continue to extend eastward, and then divide itself between flow to the north and to the southeast as long as the 200 East Area mound remains, with the largest component to the southeast.

4.1.3.3.11 Technetium-99. The primary ^{99}Tc plume will continue eastward migration. If this plume reaches the convergence zone with flow from the 200 East Area while mounding remains in that area, then the technetium plume is expected to be directed primarily to the southeast due to its southern position respective to the north-south flow divide.

4.1.3.3.12 Iodine-129. The primary ^{129}I plume will continue eastward migration. If this plume reaches the convergence area with the 200 East Area, then the plume is expected to be directed primarily to the southeast due to its souther location respective to the flow divide.

4.1.3.3.13 Uranium. The uranium plume will continue its eastern migration. Elevated levels indicated in the area at U Plant likely would be directed to the southeast from the flow divided while mounding at 200 East Area remains, while elevated levels at T Plant likely would be directed to the north from the flow divide.

4.1.3.3.14 Plutonium. Plutonium presently has detection in groundwater at one well location. It is not expected that a significant plume migration will develop from this limited area of groundwater contamination.

4.1.4 Interactions of Study Area Groundwater with Other Areas

As discussed above, groundwater flow from the 200 West Groundwater Aggregate Area has resulted in contaminant transport through advection in the uppermost aquifer. The transport has occurred primarily to the east-southeast and to the northeast, with a small component to the northwest. Nitrate and tritium, which have been discharged in large quantities and also are very mobile in groundwater, form the largest plumes and have traveled the longest distance. Nitrate in at least low concentrations likely has been advected to the area of convergence of groundwater flow between the 200 West and 200 East Areas. From this convergence area, flow is divided to the north and southeast, transporting nitrate in

both directions. Nitrate may have been transported from the 200 West Groundwater Aggregate Area through Gable Gap to the north in low concentrations, but this and other contaminants are unlikely to have impacted groundwater in the 100 Area or the Columbia River. Nitrate also extends to the north of the 200 West Groundwater Aggregate Area in low concentrations, from which a small component of the plume appears trend to the northwest toward the gap west of Gable Butte. Tritium also extends far to the east, but it is unclear whether low concentrations of tritium have reached the area of convergence with groundwater flow from the 200 East Area. The decay of tritium appears to have limited the extent of its plume.

Figure 4-17 illustrates flowpaths for present conditions. The flowpaths indicate that migration of mobile contaminants primarily occurs eastward or northeastward to the 200 East Area, with subsequent transport divided into northerly and southeasterly trends. Transport also occurs from the western portion of the area to the north and northwest.

Qualitatively estimated near-future migration during operation of the SALDS (following closure of all existing 200 Areas liquid waste disposal units) indicates that these contaminants will continue along similar migration paths to present, but with primarily eastward transport from the 200 West Groundwater Aggregate Area and with a reduced gradient (Figure 4-16). The eastward contaminant transport during this period will occur to the 200 East Area and again separate at a convergence area (with flow from the mound underlying W-049H SALDS) into southeastern and northern components. A small component may be directed toward the gap west of Gable Butte due to flow to the northwest (Figure 4-18).

Estimated groundwater flow in the future (also qualitative), when all artificial recharge has ceased and related mounding has dissipated, will result in flow from both 200 Areas to trend east and southeast (Figure 4-19). At such a time, mobile contaminants advected from the 200 West Groundwater Aggregate Area will be transported eastward and southeastward in the uppermost aquifer system toward the Columbia River, commingling with contaminants from the 200 East Area. Contaminant transport to the northeast and northwest will have ceased.

4.2 POTENTIAL IMPACTS TO HUMAN HEALTH

This preliminary assessment is intended to provide a qualitative evaluation of potential human health and environmental hazards associated with the known and suspected contaminants in the 200 West Groundwater Aggregate Area. The assessment includes a discussion of potential transport pathways, develops a conceptual model of human exposure based on these pathways, and presents the physical, radiological, and toxicological characteristics of the known or suspected contaminants.

The primary transport pathway addressed in this section is migration of contaminants from waste management units and unplanned releases to groundwater, transport within groundwater, and transport from groundwater to surface water. Other transport pathways that could potentially lead to exposures to human or environmental receptors (e.g., airborne dust transport) were discussed in the AAMSRs for the individual source areas within the 200 West Groundwater Aggregate Area boundary.

It is important to note that these evaluations do not attempt to quantify potential human health risks associated with exposure to 200 West Groundwater Aggregate Area contaminants. Such a risk assessment cannot be performed until additional characterization data are acquired. Risk assessments will be performed in accordance with the *Hanford Site Baseline Risk Assessment Methodology* document (DOE/RL 1991c) which was prepared in response to the M-29 milestone. This document incorporates requirements established in the *Risk Assessment Guidance for Superfund* (EPA 1989b) and the *EPA Region 10 Supplemental Risk Assessment Guidance for Superfund* (EPA 1991).

4.2.1 Release Mechanisms

Waste management units and unplanned releases can be divided into two general categories based on the nature of the waste release: (1) units where waste was discharged directly to the environment; and (2) units where waste was disposed of inside a containment structure and must bypass an engineered barrier to reach the environment.

In the first group are those waste management units where release of wastes to the soil column was an integral part of the waste disposal strategy. Included in this group are tile fields, ditches, french drains, seepage basins, cribs, reverse wells, septic system drain fields, and some disposal trenches. Also in this group are unplanned releases that involved waste material contacting soil. For these types of waste management units, if discharges to the unit contained chemicals of concern, it can be assumed that soils underlying the waste management unit are contaminated. The first task in developing a conceptual model for these units is to determine whether chemicals of concern are retained in soil near the waste management unit, or are likely to migrate to the underlying aquifer and then to receptor points such as drinking water wells or surface water bodies. Factors affecting migration of chemicals away from the point of release will be discussed in the following section.

In the second group are waste management units that were intended to act as a barrier to environmental releases. Included in this group are burial grounds containing drums or other containers, vaults and caissons, storage and treatment tanks, cribs with membrane liners, retention basins, waste transfer facilities, and unplanned releases that occurred within containment structures. Waste management units that received only dry waste can also be included in this category, since the potential for wastes to migrate to soils outside of the unit

is low due to the negligible natural recharge rate at the Hanford Site. However, early disposal records (prior to about 1968) are incomplete; therefore, it is possible that some liquid wastes may have been disposed to these units. For these waste management units, the first consideration to be addressed in developing a conceptual model is the integrity of the containment structure.

The ability of this report to evaluate the efficacy of engineered barriers is limited by the lack of vadose zone and subsurface soil sampling data for many waste management units. Indication of radioactive waste releases is provided by gamma logging of boreholes; however, the usefulness of these data is limited by methodological problems, and this information also is not available for all waste management units. Available sampling information and gamma logs for the waste management units and unplanned releases are summarized in Section 4.1 of each individual source AAMSR.

The efficacy and integrity of concrete liners (e.g., retention basins), and concrete and steel tanks and vaults have not been determined for all units of this type. Certain single-shell tanks within the 200 West Groundwater Aggregate Area have been classified as assumed or confirmed leakers based on historical inventory information and/or the results of gamma logging boreholes. The potential for releases to groundwater is expected to be low for waste management units that received only dry wastes such as contaminated dirt, decommissioning wastes, and process equipment.

4.2.2 Transport Pathways

Transport pathways expected to affect contaminants in the 200 West Groundwater Aggregate Area are summarized in this section, including the following:

- Drainage and leaching of bulk fluids and dissolved contaminants from soil to perched water and groundwater
- Transport in the groundwater
- Vapor transport in the subsurface
- Migration between groundwater and surface water.

4.2.2.1 Transport from Soils to Perched Water and Groundwater. Soil is the initial receiving medium for waste discharges in the 200 West Groundwater Aggregate Area, whether the release is directly to soil or through failure of a containment system. Several factors determine whether chemicals that are introduced into the vadose zone will reach a perched water zone or the unconfined portion of the uppermost aquifer, which lies at depths approximately 55 to 80 m (180 to 260 ft) below ground surface in the vicinity of 200 West

Area liquid disposal sites (December 1991 groundwater elevation data, Figure 3-78). These factors are discussed in the following sections.

4.2.2.1.1 Depth of Release. Waste management units that released wastes at a greater depth below the surface are more likely to contaminate groundwater than waste management units where the release was shallow. Reverse wells located in the Z Plant, U Plant, and T Plant Aggregate Areas discharged liquid wastes to the vadose zone at depths of 45 m (150 ft), 23 m (75 ft) and 62 m (204 ft) below the surface, or approximately 15 m (50 ft), 37 m (125 ft) and 14 m (45 ft) above the water table, respectively. Because of this proximity to the water table, reverse wells are presumed to have contributed contaminants to the groundwater.

4.2.2.1.2 Liquid Volume or Recharge Rate. The primary mechanism leading to migration of waste constituents to the water table is dissolution in infiltrating soil pore water. In the 200 West Groundwater Aggregate Area, the primary sources of recharge are the waste management units that discharge liquid waste to the soil column, although infiltration of precipitation probably contributes a small component. As discussed in Section 3.5.1.5, estimates of natural precipitation recharge range from zero to 10 cm/yr (zero to 4 in./yr), primarily depending on surface soil type, vegetation, and topography. Gravelly surface soils with no or minor shallow-rooted vegetation appear to facilitate precipitation recharge. One modeling study (Smoot et al. 1989) indicated that some radionuclide (^{137}Cs and ^{106}Ru) transport can occur with as little as 5 cm/yr (2 in./yr) of natural recharge. However, other researchers (Routson and Johnson 1990) conclude that no net precipitation recharge occurs in the 200 Areas, particularly at waste management units that are capped with fine-grained soils or impermeable covers.

With respect to artificial recharge, as discussed in Section 2.3, waste management units (e.g., the 216-Z-12 Crib) were identified in which the known volume of liquid waste discharged exceeded the total estimated soil pore volume present below the footprint of the facility. In these cases, the potential for contaminant migration was assumed to be greater than those units where the liquid volume did not exceed the pore volume.

Contaminants that are not initially transported to the water table by downward water flow may be mobilized at a later date if an additional large volume of liquid is added to the waste management unit. In addition, liquids discharged to one unit could mobilize wastes discharged to an adjacent unit if lateral migration takes place within the vadose zone. An example of this process occurred at the 216-U-16 Crib where lateral migration of waste above a caliche layer mixed with and transported acidic waste beneath the 216-U-1 and 216-U-2 Cribs that had remobilized previously sorbed or precipitated radionuclides. At present, artificial recharge within the 200 West Groundwater Aggregate Area is limited to septic wastewaters, cooling waters, and other noncontact wastewaters. The potential interactions

between these discharges and adjacent waste management units generally have not been characterized.

4.2.2.1.3 Soil Moisture Transport Properties. As discussed in Section 3.5.2, moisture flux in the vadose zone is dependent on hydraulic conductivity as well as gradients of moisture content or matrix suction. Higher unsaturated hydraulic conductivities are associated with higher moisture contents. However, higher unsaturated hydraulic conductivities may be associated with fine-grained soils compared to coarse-grained soils at low moisture contents. Because of the highly stratified nature of Hanford Site vadose zone soils and the moisture content dependence of unsaturated hydraulic conductivity, substantial vertical anisotropy is expected. In other words, vadose zone soils are likely more permeable in the horizontal direction than in the vertical. Lateral spreading commonly occurs at any interface within the vadose zone between fine- and coarse-grained soils. This vertical anisotropy may substantially retard downward contaminant migration to the uppermost aquifer but increase horizontal spreading in the vadose zone.

Conditions leading to the accumulation of soil moisture or liquid waste in soil zones above the water table (perched water zones) are discussed in Section 3.5.4. The presence of perching layers beneath waste management units where liquid wastes were released may have led to lateral migration of contaminants away from the point of release.

Rapid transport of contaminants to the subsurface may occur if contaminants are able to migrate along the casing of a monitoring well or borehole. For example, monitoring wells adjacent to the 216-S-1, 216-S-2, 216-A-8, and 216-A-24 Cribs apparently created such a transport pathway to the water table.

4.2.2.1.4 Retardation. The rate at which contaminants will be transported through unsaturated soils depends on a number of characteristics of the chemical, the waste, and the soil matrix. In general, chemicals that have low solubilities in the leaching fluid or strongly sorb to soils will be retarded in their migration velocity compared to the movement of soil pore water. Studies have been conducted of soil parameters affecting waste migration at the Hanford Site to attempt to identify the factors that control migration of radionuclides and other chemicals. Recent studies of soil sorption applicable to the Hanford Site are summarized by Ames and Serne (1991) and Serne and Wood (1990). Some of the processes that have been shown to control the rate of transport are the following:

- **Adsorption to Soils.** Most contaminants are chemically attracted to some degree to the solid components of the soil matrix. For organic compounds, the adsorption is generally to the organic fraction of the soil, although in extremely low-organic soils adsorption to inorganic components may be of greater importance. Soil components contributing to adsorption of inorganic compounds include clay, organic matter, and iron and aluminum oxyhydroxides. In general,

surface and Hanford formation soils are characterized as sandy or gravelly with very low organic content (<0.1%) and low clay content (<12%) (Tallman et al. 1981). Thus, site-specific adsorption factors are likely to be lower, and rate of transport higher, than the average for soils nationwide.

- **Filtration.** Filtration of suspended particulates by fine-grained sediments was suggested as a mechanism for concentration of plutonium in certain sedimentary layers at the 216-Z-1A Tile Field. This finding suggests that migration of suspended particulates may be an important mechanism of transport for chemicals of low solubility. Particulates in the colloid size range may pass through even fine-grained soils.

- **Solubility.** The migration of some chemicals from the point of release is controlled by the rate of dissolution of the chemical from a separate phase. The concentration of such chemicals in the pore water will be extremely low, even if they are poorly sorbed to soils. An example cited by Serne and Wood (1990) is the low rate dissolution of plutonium oxide, which appears to be the limiting factor controlling the release of plutonium from waste materials at neutral and basic pH.

- **Organic Content of Waste.** Waste liquids containing high concentrations of certain organic compounds can alter the rate of transport of the waste constituents through soils. A liquid with a low dielectric constant, such as carbon tetrachloride, can cause clays within the soil to shrink, which will increase the permeability of the soil by creating cracks and fissures (DOE/RL 1991b). In addition, the complexing of many inorganic compounds with organic compounds in the waste stream can greatly increase the mobility of the compounds (see Section 4.2.2.1.5).

- **Ionic Strength of Waste.** For some inorganics, the dominant mechanism leading to desorption from the soil matrix is ion exchange. Leachant having high ionic strength (high salt content) can bias the sorption equilibrium toward desorption, leading to higher concentrations of the chemical in the soil pore water. Wastes within the 200 West Groundwater Aggregate Area that can be considered of high ionic strength include PFP process wastes, RECUPLEX and PRF aqueous wastes, and single-shell tank aqueous wastes.

- **Waste pH.** The pH of a leachant has a strong effect on inorganic contaminant transport. Acidic leachates tend to increase migration both by increasing the solubility of precipitates and by changing the distribution of charged species in solution. The exact impact of acidic or basic wastes will depend on whether the chemical is normally in cationic, anionic, or neutral form, and the form that it

takes at the new pH. Cationic species tend to be more strongly adsorbed to soils than neutral or anionic species. The extent to which addition of acidic leachate will cause a contaminant to migrate will also depend on the buffering or neutralizing capacity of the soil, which is correlated with the calcium carbonate ($CaCO_3$) content of the soil and the extent of reaction of acidic wastes with soil silicates (Price et al. 1979). The soils in the Hanford formation generally have carbonate contents in the range of 0.1 to 5%. Higher carbonate contents (20 to 30%) are observed within the Plio-Pleistocene caliche layer. Once a waste liquid has been neutralized, the dissolved constituents may reprecipitate or become readsorbed to the soil.

Observations of pH impacts on waste transport at the Hanford Site include the following:

- Mobilization of plutonium and americium isotopes beneath the 216-Z-1A Tile Field by acid liquid waste depends on a combination of pH effects and complexation by organic components of the waste. These processes were implicated in migration of the radionuclides to a depth of 30 m (100 ft) below the bottom of the crib.

- Leaching of americium from 216-Z-9 Trench sediments was found to be solubility controlled and correlated to solution pH (Rai et al. 1981).

4.2.2.1.5 Complexation and Cosolvation. Certain materials disposed of within the 200 West Groundwater Aggregate Area are known to form complexes with inorganic ions, which can enhance the solubility and mobility of the inorganic species. Tributyl phosphate, dibutyl phosphate, and dibutyl butyl phosphonate are the primary organic complexing agents disposed of in the 200 West Groundwater Aggregate Area. However, these compounds were not detected in groundwater at the Hanford Site, perhaps due to biodegradation or immobilization in the vadose zone. Cyanide ions can form complexes with many metal cations. Formation of such complexes reduces the mobility of the cyanide compared to that of the free ion, but often increases the mobility of the metal.

The presence in leachate of high levels of water-miscible organic solvents can mobilize strongly sorbed organic compounds by the process of cosolvation, and may also impact mobility of inorganic contaminants. Laboratory studies cited by Price et al. (1979) indicate that the presence of organic wastes reduced sorption of ^{239}Pu to Hanford Site soils. Although water-miscible solvents such as acetone were detected in 200 West Groundwater Aggregate Area groundwater, there is no indication that sufficient volumes were disposed of in waste management units to lead to significant cosolvent effects. Large volumes of carbon tetrachloride in a free phase (not dissolved in water) released to Z Plant waste management units potentially could have had such an effect.

4.2.2.1.6 Contaminant Loss Mechanisms. Processes that can lead to loss of chemicals from soils and thus decrease the amount of chemical available for leaching to groundwater include the following:

- **Radioactive Decay.** Radioactivity of radionuclides decays over time and generally decreases the quantities and impacts from radioactive isotopes, such as for tritium. However, for some radioactive decay chains, in-growth of daughter products can lead to a net increase in radioactive emissions over time.

- **Biotransformation.** Microorganisms in the soil may degrade organic chemicals such as carbon tetrachloride and inorganic chemicals such as nitrate.

- **Chemical Transformation.** Hydrolysis, oxidation, reduction, radiolytic degradation, and other chemical reactions are possible degradation mechanisms for contaminants.

- **Vegetative Uptake.** Vegetation may remove chemicals from the soil, bring them to the surface, and thereby introduce them to the food web.

- **Volatilization.** Organic chemicals and volatile radionuclides can partition into the soil vapor phase. Losses to the atmosphere can occur for vapors that are lighter than the soil vapors. Some elements (mainly fission products such as iodine, ruthenium, cerium, and antimony) are referred to as "semivolatiles" because they have a lesser tendency to volatilize.

4.2.2.2 Transport in Groundwater. The primary modes of contaminant migration in the 200 West Groundwater Aggregate Area groundwater are advective transport and dispersion of dissolved chemicals. Other processes that could lead to migration of contaminants in groundwater include transport of suspended particulates, diffusion, density-driven flow of high-salt liquids, and bulk flow of DNAPLs. The presence of fine-grained silt layers in the unsaturated zone will generally prevent particulates larger than colloidal size from reaching groundwater. In low hydraulic conductivity materials (e.g., clays), diffusion may be the primary transport mechanism. A DNAPL may persist in pockets in the saturated zone or above a perching layer and potentially promote continued contamination of groundwater by dissolution. The presence of a carbon tetrachloride DNAPL atop perching layers or at the base of the unconfined aquifer was hypothesized (DOE/RL 1991b), but the existence of such DNAPLs has not been confirmed (see Section 4.1.1.6.6).

The transport of dissolved contaminants in the saturated zone is affected by the groundwater flow rates and flow paths, retardation of contaminants, and contaminant loss mechanisms. The impact of each of these factors is discussed below.

4.2.2.2.1 Hydrologic Factors. Local and regional flow patterns at the 200 West Groundwater Aggregate Area and Hanford Site are described in Section 3.5. Based on this information and the plume distributions described in Section 4.1, the primary direction of transport from the 200 West Groundwater Aggregate Area is east to southeast, toward the Columbia River. However, artificial recharge from disposal of liquid wastes and reactor cooling waters has led to mounding of groundwater beneath the 200 Areas. The effect of the mounding is that an increased fraction of the groundwater flow from the 200 West Groundwater Aggregate Area is diverted northward toward Gable Gap. As discussed in Section 4.1.3, contaminants originating from the northern half of the 200 West Groundwater Aggregate Area currently follow flow paths that pass through the gap.

Variations in horizontal hydraulic conductivity across the Hanford Site impact the travel time of contaminants to off-site receptors. As discussed in Section 3.5, the uppermost aquifer in the 200 West Groundwater Aggregate Area lies within the generally less permeable Ringold Formation, while in the 200 East Area, the uppermost aquifer lies partially within the more permeable Hanford formation. Thus, the rate of contaminant transport in groundwater is generally slower under the 200 West Groundwater Aggregate Area than in the 200 East Area (Freshley and Graham 1988).

The potential for transport of contaminants from the unconfined portions of the uppermost aquifer to the confined portions of the uppermost aquifer and to the basalt aquifers depends on the existence of downward vertical gradients. As discussed in Section 3.5, hydrologic studies suggest that downward gradients are present in some areas of the Hanford Site due to groundwater mounding beneath wastewater disposal facilities. Few monitoring wells are screened in the deeper zones; thus, the vertical hydraulic gradient is poorly defined and the vertical extent of contamination in most areas of the site has not been determined.

4.2.2.2.2 Retardation in Groundwater. Mechanisms leading to retardation of contaminants on aquifer solid materials are generally the same as those occurring in the unsaturated zone, which are described in Section 4.2.2.1.4. Physical/chemical mechanisms causing a contaminant to be retarded in its migration relative to the groundwater include adsorption, ion exchange, precipitation, and chemical reaction with aquifer solids.

The geochemical environment of the saturated zone may differ from that of the vadose zone particularly in terms of its redox potential, pH, and soil-water ionic composition. In addition, introduction of concentrated waste solutions into the saturated zone may alter significantly the rate of transport of contaminants compared to their behavior in dilute solutions. Potential impacts of concentrated wastes on contaminant mobility include the following:

- Bacterial metabolism of waste materials that can act as substrates for microbial growth (e.g., biodegradable organic compounds, nitrate, sulfate) can create localized areas of anoxic, low Eh conditions in the groundwater. Some inorganic species (e.g., arsenic, heavy metals) are more mobile under these conditions. Ames and Serne (1991) concluded, however, that the persistence of nitrate in Hanford Site groundwater indicates that biotransformation of nitrate is not currently a significant process. Biotransformation potential for other constituents (and for nitrate in the future) is also expected to be minor, but site specific data are not currently available.

- High concentrations of chloride or other ionic species can affect the binding properties of clay surfaces and metal hydroxides, altering the sorption of contaminants to soil materials.

- Anionic contaminants (e.g., chloride (Cl^-), fluoride (Fl^-) can migrate through clay soils at a velocity greater than the average rate of groundwater movement. This phenomenon, known as anion exclusion, is due to repulsion between the contaminant anions and the negatively charged soil surfaces (Dragun 1988).

- Alteration in groundwater pH due to introduction of acidic or basic wastes into the aquifer can modify contaminant mobility both by affecting the ionic form of the contaminant and by changing the binding characteristics of soil adsorptive surfaces (i.e., metal oxides, clay minerals, and soil organic matter) (Dragun 1988).

4.2.2.2.3 Contaminant Loss Mechanisms. Processes leading to loss of contaminants from groundwater are generally the same as those affecting contaminants in the vadose zone: radioactive, chemical, and biological decay. Contaminant losses from volatilization are expected to occur primarily in near-surface soils, and this loss mechanism is likely to be less important once contaminants reach the water table.

4.2.2.4 Vapor Transport in the Subsurface. Migration of chemical vapors in the unsaturated zone pore spaces is suggested as an important transport pathway in the 200 West Groundwater Aggregate Area for volatile organic compounds such as carbon tetrachloride (DOE/RL 1991b). Possible sources of organic vapors are residual chemicals in the unsaturated soil column, liquid phase chemical present in perched zones, and dissolved chemicals that have reached the unconfined aquifer. Lateral migration of carbon tetrachloride vapors above or below the Plio-Pleistocene unit due to density-driven migration and diffusion was proposed as a potential explanation for detection of this chemical at locations distant from known disposal locations. The calcic paleosol facies of the Plio-Pleistocene unit (caliche) layer may serve as a cap for these vapors, leading to enhanced lateral transport. Carbon tetrachloride vapors were observed primarily below the unit in the

far field soil boring reported by DOE/RL (1991b). Equilibration of these vapors with infiltrating wastewater or natural recharge can then provide a source of contamination of perched water or groundwater. Because of the slope of the Plio-Pleistocene unit, vapor transport can lead to migration of contaminants in directions opposite to the regional groundwater flow direction (DOE/RL 1991b). Additional data on the vertical distribution of carbon tetrachloride in 200 West Groundwater Aggregate Area groundwater is required to verify this conceptual model of vapor transport (DOE/RL 1991b).

4.2.2.5 Transport from Groundwater to Surface Water. There are no naturally occurring surface water bodies within the 200 West Groundwater Aggregate Area. Artificial surface water bodies, (e.g., ditches and seepage basins) are present, but these are not in hydraulic contact with the underlying aquifer. Thus, no transport of contaminants from groundwater to these surface waters is anticipated.

Transport of contaminants to surface water bodies outside of the 200 West Groundwater Aggregate Area via groundwater discharge is the primary pathway of potential concern for 200 West Groundwater Aggregate Area. Discharge from the unconfined portions of the uppermost aquifer is to the Columbia River, either via springs near the river or by direct flow into the river. Although contaminants in the Rattlesnake Ridge aquifer are not documented in the vicinity of the 200 West Area, these contaminants, if present, may also discharge to the Columbia River along with documented contaminants from the 200 East Groundwater Aggregate Area. As discussed above, groundwater from these aquifers may discharge to the river either to the north, via Gable Gap, or to the east and southeast. Based on the current plume configurations of tritium, the most mobile contaminant present in the 200 West Groundwater Aggregate Area groundwater, groundwater contamination from waste disposal in the 200 West Groundwater Aggregate Area, has not yet reached the river in either the northerly or southeasterly directions.

A number of studies have attempted to estimate the time required for contaminants to travel in groundwater from the 200 Areas to the Columbia River. Freshley and Graham (1988) summarize the results of many of these studies as well as the methodology and assumptions used to obtain the estimates. Methods used to derive time of travel estimates include use of plume monitoring data, flow tracer studies, extrapolation of local hydrologic measurements, and groundwater modeling. Estimates of the time required for tritium in 200 West Groundwater Aggregate Area groundwater to reach the river range from 43 to 190 years. The predicted time of travel depends on the starting location and the flow path that the contaminant takes to the river. For estimates obtained from modeling, time of travel depends on assumptions incorporated into the model about future hydrologic gradients and recharge conditions.

4.2.3 Conceptual Model

Figure 4-20 presents a graphical summary of the contaminant sources, release mechanisms, and 200 West Groundwater Aggregate Area/Hanford Site physical characteristics that could potentially affect the generation, transport, and impact of contaminants in the 200 West Groundwater Aggregate Area groundwater on humans and biota (conceptual model).

The sources of contamination include process wastes (condensates, cooling water, sewage) from U Plant, the Plutonium Finishing Plant (Z Plant), T Plant, and S Plant; unirradiated uranium wastes from the cold startup of U Plant ("interface crud"); condensate and supernatant from Tank Farms; laboratory wastes; drainage from diversion boxes; sanitary wastes; process feed materials; materials from outside the aggregate area (e.g., laundry water and powerhouse wastewater); and contaminated equipment or waste material that was spilled during transit or disposed of in the Burial Ground/Burning Pit, or Construction Surface Laydown Area.

Contaminants from these sources have been disposed of at the U, Z, T, and S Plant waste management units that have been discussed in the AAMSRs for the individual source areas. These include ponds, ditches, retention basins, settling tanks, trenches, cribs, french drains, reverse wells, catch tanks, septic tanks and drain fields, single-shell tanks, vaults, and the various unplanned releases that have occurred within the 200 West Groundwater Aggregate Area. Releases from these disposal activities and resulting contamination of the uppermost aquifer beneath the 200 West Groundwater Aggregate Area are described in Sections 2.0 and 4.1.

The focus of the 200 West Groundwater Aggregate Area conceptual model is on the migration of contaminants from the waste management units and unplanned releases to groundwater, transport within the groundwater, and transport from groundwater to surface water. Other release mechanisms that may have transported contamination to potentially affected surface media are addressed in the source area AAMSRs.

Many waste management units discharge their waste effluents directly to the near surface (vadose zone) soils. The trenches are potential release points via leaching or drainage of the liquid portion of the disposed materials. The cribs provide seepage discharge and similarly the french drains, reverse wells, and septic system drain fields directly inject their effluents into the subsurface sediments. The unplanned releases have mainly impacted surface soils, with the exception of tank leaks, which generally release wastes to the shallow subsurface.

The primary mechanism of vertical contaminant migration is the downward movement of water from the surface through the vadose zone to the unconfined aquifer. The

contaminants generally move as a dissolved phase in the water, and their rate of migration is controlled both by water movement rates and by adsorption and desorption reactions involving the surrounding sediments. Other transport pathways which may be significant are vapor transport (for volatile organics) and diffusion (for fine-grained soils). Some contaminants are strongly sorbed on sediments and their downward movement through the stratigraphic column is greatly retarded. Significant lateral migration of contaminants can occur within perched water zones or along the contact of finer sediments over sediments of higher hydraulic conductivity and other horizontal bedding features. Lateral transport also occurs in the unconfined aquifer. Again adsorption and desorption reactions may greatly retard lateral contaminant migration. Contaminants that were introduced to the soil column outside of the aggregate area may migrate into the area in the aquifer through advection by groundwater flow. As another potential mechanism of vertical contaminant migration, bad well seals or wells screened over relatively large intervals may promote downward movement of chemical constituents within the uppermost aquifer. As discussed in Section 4.1.1.5, Well 299-W15-6 is screened across the entire portion of the uppermost aquifer and may have promoted vertical migration of carbon tetrachloride.

Once contaminants reach the uppermost aquifer, their primary mode of continued migration is by advective transport as dissolved chemicals. The possibility of a carbon tetrachloride DNAPL migrating via bulk flow has been suggested based on the significant levels of carbon tetrachloride soil vapors. However, additional data are required to verify the vapor transport conceptual model.

Humans (offsite and onsite) and other biota (plants and animals) can be exposed to groundwater contaminants as a result of withdrawal and use of contaminated groundwater obtained from wells, or as a result of withdrawal and use of surface water that has been contaminated by groundwater migration and discharge to surface water. There are four general routes by which direct or indirect exposure to contaminants in groundwater can occur at a waste site:

- Inhalation of airborne volatiles or fugitive dusts from surface soils contaminated through irrigation with ground or surface water

- Ingestion of water, fugitive dust, surface soils, agricultural products, or other biota (either directly or through the food chain)

- Direct contact with waterborne contaminants or contaminated surface soils

- External exposure from radionuclides in water, surface soils, or fugitive dusts.

4.2.4 Characteristics of Contaminants

Table 4-5 is a list of radioactive and nonradioactive chemical substances that represent candidate contaminants of potential concern for the 200 West Groundwater Aggregate Area. Chemicals on this list were identified from the following sources:

- Chemicals detected in the 200 West Groundwater Aggregate Area, as reported in Connelly et al. (1992).

- Chemicals reported in waste disposal inventories for those U, Z, T, and S Plant Aggregate Area waste management units that were determined to be potential sources of release to groundwater, based on release volume and soil pore water capacity

- Chemicals reported in the TRAC inventory system for those single-shell tanks that were determined to be assumed leakers based on evaluation of gamma logs or other data.

This table also includes daughters of long-lived parent radionuclides, whether or not the daughter species have been detected or reported.

Given the large number of candidate chemicals of concern identified from the above sources, it is appropriate to focus this assessment on those contaminants that pose the greatest risk to human health or the environment. Table 4-6 lists the contaminants of concern for the 200 West Groundwater Aggregate Area. This list was developed from Table 4-5 and includes only those contaminants which meet the following criteria:

- Radionuclide with a half-life greater than one year

- Radionuclide with a half-life of less than one year and is part of a long-lived decay chain that would result in the building up of the short-lived radionuclide activity to a level of 1% or greater of the parent radionuclide's activity within the time period of interest

- Chemical is a known or suspected chemical carcinogen or has a U.S. Environmental Protection Agency (EPA) noncarcinogenic toxicity factor.

Chemicals for which no EPA toxicity criteria are available were included as chemicals of potential concern only if they have known chronic toxic effects and are known to have been released in large quantities to the environment. Chemicals included in this group are the following:

- Lead
- Dibutyl phosphate
- Tributyl phosphate
- Uranium.

The following characteristics will be discussed for the contaminants listed in Table 4-5:

- Detection of contaminants in environmental media
- Historical association with plant activities
- Mobility
- Persistence
- Toxicity
- Bioaccumulation.

4.2.4.1 Detection of Contaminants in Environmental Media. Chemicals detected in groundwater samples collected from 200 West Groundwater Aggregate Area monitoring wells between 1988 and 1991 are summarized in Table 4-1. A list of chemicals that are routinely tested for in these wells is provided in Tables 2-7, 2-10 to 2-13, 2-15, and 2-17. It should be noted that groundwater is routinely tested for only a limited number of radionuclides; this limitation is discussed as a data gap in Section 8.0.

4.2.4.2 Historical Association with Source Area Activities. Potential sources of contamination to the 200 West Groundwater Aggregate Area groundwater were identified in Section 2.0, including waste management units used for disposal of liquid waste (cribs, trenches, tile fields, septic fields, reverse wells), leaking tanks, and other unplanned releases. Chemicals that were known or suspected components of the waste streams entering these units are potential groundwater contaminants. Known or suspected constituents of the waste streams were identified in the U, Z, S, and T Plant AAMS based on waste inventories and process information. Waste inventories are summarized in Tables 2-5 and 2-6 for those waste management units that are considered likely to have impacted groundwater, based on the volume of liquid waste released to the subsurface. Constituents of single-shell tanks that are assumed or suspected leakers and thus are potential contributors to groundwater contamination are summarized in Tables 2-2, 2-3, and 2-4.

It should be noted that the WIDS does not report all TRU elements and fission products that are likely to occur in radioactive waste streams within the 200 West Groundwater Aggregate Area. Thus, it is likely that additional radionuclides were disposed to 200 West Groundwater Aggregate Areas that are not included in the waste inventories. Additionally, only those nonradioactive chemicals that were present in large quantities in the waste were reported (e.g., nitrates, carbon tetrachloride).

Nonradioactive chemicals reportedly released into the 200 West Groundwater Aggregate Area waste management units in large quantities include nitric acid, nitrates, sodium, phosphate, sodium hydroxide, uranium, fluorides, ferrocyanide, sulfate, tributyl phosphate, carbon tetrachloride, dibutyl phosphate, hexone, calcium, potassium, magnesium, aluminum, and iron.

4.2.4.3 Mobility. Since most wastes within the 200 West Groundwater Aggregate Area were released directly to subsurface soils via injection, infiltration, or burial, the mobility of wastes in the subsurface will determine the potential for future exposures. The mobility in the subsurface of the chemicals listed in Table 4-5 varies widely and depends on site-specific factors as well as the intrinsic properties of the chemical. Much of the site-specific information needed to characterize mobility is not available and must be obtained during the RI/FS process. However, it is possible to make general statements about the relative mobility of the candidate chemicals of concern.

The mobility of radionuclides and other inorganic elements in groundwater depends on the chemical form and charge of the element or molecule, which in turn depends on site-related factors such as the pH, redox potential state, and ionic composition of the groundwater. Cationic species (e.g., Cd^{2+}, Pu^{4+}) generally are retarded in their migration relative to groundwater to a greater extent than anionic species such as nitrate (NO_3^-). The presence in groundwater of complexing or chelating agents can increase the mobility of metals by forming neutral or negatively charged compounds.

The chemical properties of radionuclides are essentially identical to the nonradioactive form of the element; thus, discussions of the chemical properties affecting the transport of contaminants can apply to both radionuclides and nonradioactive chemicals.

A soil-water distribution coefficient (K_d) can be used to predict mobility of inorganic chemicals in the subsurface. Table 4-7 summarizes soil-water distribution coefficients that have been developed for many of the candidate inorganic chemicals of concern. As discussed above, the pH and ionic strength of the leaching medium have an impact on the adsorption of inorganics to soil; thus, the listed K_ds are valid only for a limited range of pH and waste composition. In addition, soil sorption of inorganics is highly dependent on the mineral composition of the soil, the ionic composition of the soil pore water, and other site-

specific factors. Thus, a high degree of uncertainty is involved with use of K_ds that have not been verified by experimentation with site soils.

Serne and Wood (1990) recommended K_d values for use with Hanford waste assessments for a limited number of important radionuclides (Am, Cs, Co, Cu, I, Pu, Ru, Sr, and tritium) based on soil column or batch desorption studies, and have proposed conservative average values for a more extensive list of elements based on a review of the literature. A K_d of <1 is recommended for Am, Cs, Pu, and Sr under acidic conditions. A more recent literature review was performed by Cantrell and Serne (1992) for use in the 200-BP-1 Operable Unit investigation at the Hanford Site. Probable K_d values and ranges of K_d values cited by Cantrell and Serne for ambient conditions at the Hanford Site are shown in the first and second columns of Table 4-7, respectively. Where no value was cited by Cantrell and Serne, conservative default values cited by Serne and Wood (1990) are shown in brackets.

Strenge and Peterson (1989) developed default K_d values for a large number of elements for use in the Multimedia Environmental Pollution Assessment System (MEPAS), a computerized waste management unit evaluation system. The K_d values were based on findings in the scientific literature, and include non-site-specific as well as Hanford Site values. Values are provided for nine sets of environmental conditions: three ranges of waste pH and three ranges of soil adsorbent material (sum of percent clay, organic material, and metal hydrous oxides). The values presented in Table 4-7 are for conditions of neutral waste pH and less than 10% adsorbent material, which is likely to be most representative of Hanford Site soils.

The mobility of inorganic species in soil can be divided roughly into three classes, using site-specific values (Serne and Wood 1990) where available and conservative default values otherwise: highly mobile ($K_d<5$), moderately mobile ($5<K_d<100$), and low mobility ($K_d>100$). The mobility classes for the candidate chemicals of concern are as follows:

High mobility (K_d < 5)

Antimony	Iodine	Silica
Arsenic	Krypton	Sodium
Boron	Lithium	Sulfate
Carbon (as ^{14}C)	Neptunium	Technetium
Chloride	Nitrate	Thallium
Chromium (VI)	Potassium	Tritium
Cyanide (free ion)	Protactinium	Uranium
Fluoride	Selenium	

Moderate Mobility ($5 < K_d < 100$)

Barium	Lead	Samarium
Beryllium	Magnesium	Silver
Bismuth	Manganese	Strontium
Cadmium	Nickel	Thorium
Calcium	Niobium	Vanadium
Copper	Phosphate	Zinc
Europium	Radium	Zirconium
Iron	Ruthenium	

Low Mobility ($K_d > 100$)

Actinium	Bismuth	Curium
Aluminum	Cesium	Mercury
Americium	Cobalt	Plutonium
		Yttrium

Note that the environmental mobility of radionuclides may be determined by the adsorption characteristics of either the parent or daughter species in a decay chain. For example, a contaminant that is itself immobile in the subsurface could be detected at some distance from the source due to its production from a mobile parent species.

The tendency of organic compounds to adsorb to the organic fraction of soils is indicated by the soil organic matter partition coefficient, K_{oc}. Partition coefficients for the candidate organic chemicals of potential concern are listed in Table 4-8. Chemicals with low K_{oc} values are weakly adsorbed by soils and will tend to migrate in the subsurface, although their rate of travel will be retarded somewhat relative to the pore water or groundwater flow. Soils at the Hanford Site have very little organic carbon content and thus sorption to the inorganic fraction of soils may dominate over sorption to soil organic matter. Mobility of organic chemicals in the subsurface can be roughly estimated by the equation:

$$K_d = K_{oc} * f_{oc}$$

where f_{oc} is the organic carbon content of the aquifer solids, which is generally less than 0.1% in Hanford soils.

4.2.4.4 Persistence. Once released to environmental media, the concentration of a chemical may decrease because of biological or chemical transformation, radioactive decay, or the intermediate transfer processes discussed above that remove the chemical from the medium (e.g., volatilization to air). Radiological, chemical, and biological decay processes affecting the persistence of the candidate contaminants of potential concern are discussed below.

The persistence of radionuclides depends primarily on their half-lives. A comparison of the half-lives and specific activities for the candidate radionuclides of potential concern is presented in Table 4-9. The specific activity is the decay rate per unit mass, and is inversely proportional to the half-life of the radionuclide. Half-lives for the radionuclides listed in Table 4-9 range from fractions of a second to over one billion years. Also listed are the decay mechanisms of primary concern for the radionuclide. Note that radionuclides often undergo several decay steps in quick succession, (e.g., an alpha decay followed by release of one or more gamma rays). The daughter products of these decays are often themselves radioactive.

Nonradioactive inorganic chemicals detected at the site are generally persistent in the environment, although they may decline in concentration due to transport processes or change their chemical form due to chemical or biological reactions. Nitrate and sulfate undergo chemical and biological transformations that may lead to their loss to the atmosphere (as N_2 and H_2S) or incorporation into living organisms, depending on the redox potential of the environment and microbiological communities present in the medium.

Biotransformation rates for organics vary widely and are highly dependent on site-specific factors such as soil moisture, redox conditions, and the presence of nutrients and of organisms capable of degrading the compound. Ketones, such as acetone and MIBK, are easily degraded by microorganisms in soil and thus would tend not to persist. Chlorinated solvents (e.g., carbon tetrachloride) may undergo slow biotransformation in the subsurface under appropriate conditions of soil redox state and nutrient availability. Tetrachloroethylene and trichloroethylene may be converted to the more toxic compound vinyl chloride under some redox conditions. Volatile aromatics such as toluene are generally intermediate in their biodegradability between these two example groups.

4.2.4.5 Toxicity. Contaminants may be of potential concern for impacts to human health if they are known or suspected to have carcinogenic properties, or if they have adverse noncarcinogenic human health effects. The toxicity characteristics of the candidate contaminants of potential concern are summarized below.

4.2.4.5.1 Radionuclides. All radionuclides are classified by the EPA as known human carcinogens based on their property of emitting ionizing radiation and on the evidence provided by epidemiological studies of radiation-induced cancers in humans. Noncarcinogenic health effects associated with radiation exposure include genetic and teratogenic effects; however, these effects generally occur at higher exposure levels than those required to induce cancer. Thus, the carcinogenic effect of radionuclides is the primary identified health concern for these chemicals.

Risks associated with radionuclides differ for various routes of exposure depending on the type of ionizing radiation emitted. Nuclides that emit alpha or beta particles are

hazardous primarily if the materials are inhaled or ingested, since these particles expend their energy within a short distance after penetrating body tissues. Gamma-emitting radioisotopes are of concern as both external and internal hazards. A fourth mode of radioactive decay, neutron emission, is generally not of major health concern, since this mode of decay is much less frequent than other decay processes. In addition to the mode of radioactive decay, the degree of hazard from a particular radionuclide depends on the rate at which particles or gamma radiation are released from the material.

Excess cancer risks for exposure to radionuclides by inhaling air, drinking water, ingesting soil, and by external irradiation are shown in Table 4-10 for the radionuclides of potential concern. The unit risk values represent the increase in probability of cancer to an individual exposed for a lifetime to a radionuclide at a level of 1 pCi/m^3 in air, 1 pCi/L in drinking water, 1 pCi/g in ingested soil, or to external radiation from soil having a radionuclide content of 1 pCi/g.

For those radionuclides without slope factors, the *Hanford Baseline Risk Assessment Methodology* (DOE/RL 1991c) proposes to use the dose conversion factors developed by the International Commission on Radiological Protection to calculate a risk value.

The unit risk factors for different radionuclides are roughly proportional to their specific activities, but also incorporate factors to account for distribution of each radionuclide within various body organs, the type of radiation emitted, and the length of time that the nuclide is retained in the organs.

Based on the factors listed in Table 4-10 the highest risk for ingestion of water containing 1 pCi/L of a radionuclide is from the TRU isotopes ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am, ^{243}Am, and ^{237}Np, and the fission products ^{210}Po, ^{210}Pb, and ^{227}Ac. The highest risk from inhalation of 1 pCi/m^3 in air is from uranium isotopes, TRUs, and fission products which are alpha emitters (e.g., ^{238}U, ^{241}Am, ^{238}Pu, ^{227}Ac). The highest risks from ingestion of soil at 1 pCi/g are for ^{227}Ac, ^{241}Am, ^{243}Am, ^{238}Pu, ^{244}Cm, and ^{243}Cm. The highest risk from external exposure to a soil surface contaminated at 1 pCi/g is from ^{60}Co, ^{137m}Ba (a daughter product of ^{137}Cs), ^{134}Cs, ^{214}Bi, ^{214}Pb, and ^{154}Eu.

The standard EPA risk assessment methodology assumes that the probability of a carcinogenic effect increases linearly with dose at low dose levels, i.e., there is no threshold for carcinogenic response. The EPA methodology also assumes that the combined effect of exposure to multiple carcinogens is additive without regard to target organ or cancer mechanism.

4.2.4.5.2 Hazardous Chemicals. Carcinogenic and noncarcinogenic health effects associated with the candidate chemicals of potential concern are summarized in Table 4-11. EPA has not derived toxicity criteria for many of these chemicals. Many of the chemicals

that lack toxicity criteria have negligible toxicity or are necessary nutrients in the human diet. However; several of the chemicals have known toxic effects but no toxicity criterion is presently available. In some instances the criteria have been withdrawn by EPA pending review of the toxicological data and will be reissued at a future date. Chemicals with known toxicity for which toxicity factors are presently not available include the following:

- Lead
- Selenium
- Uranium
- Tributyl phosphate.

4.2.4.6 Bioaccumulation potential. Contaminants may be of concern for exposure if they have a tendency to accumulate in plant or animal tissues at levels higher than those in the surrounding medium (bioaccumulation) or if their levels increase at higher trophic levels in the food chain (biomagnification). Contaminants may be bioaccumulated because of element-specific uptake mechanisms (e.g., incorporation of strontium into bone) or by passive partitioning into body tissue (e.g., concentration of organic chemicals in fatty tissues). Ecological risk assessment issues, including potential uptake in off site receptors (e.g., Columbia River biota) would be considered where applicable during anticipated future site assessment activities.

9 2 1 2 6 1 0 4 1 0

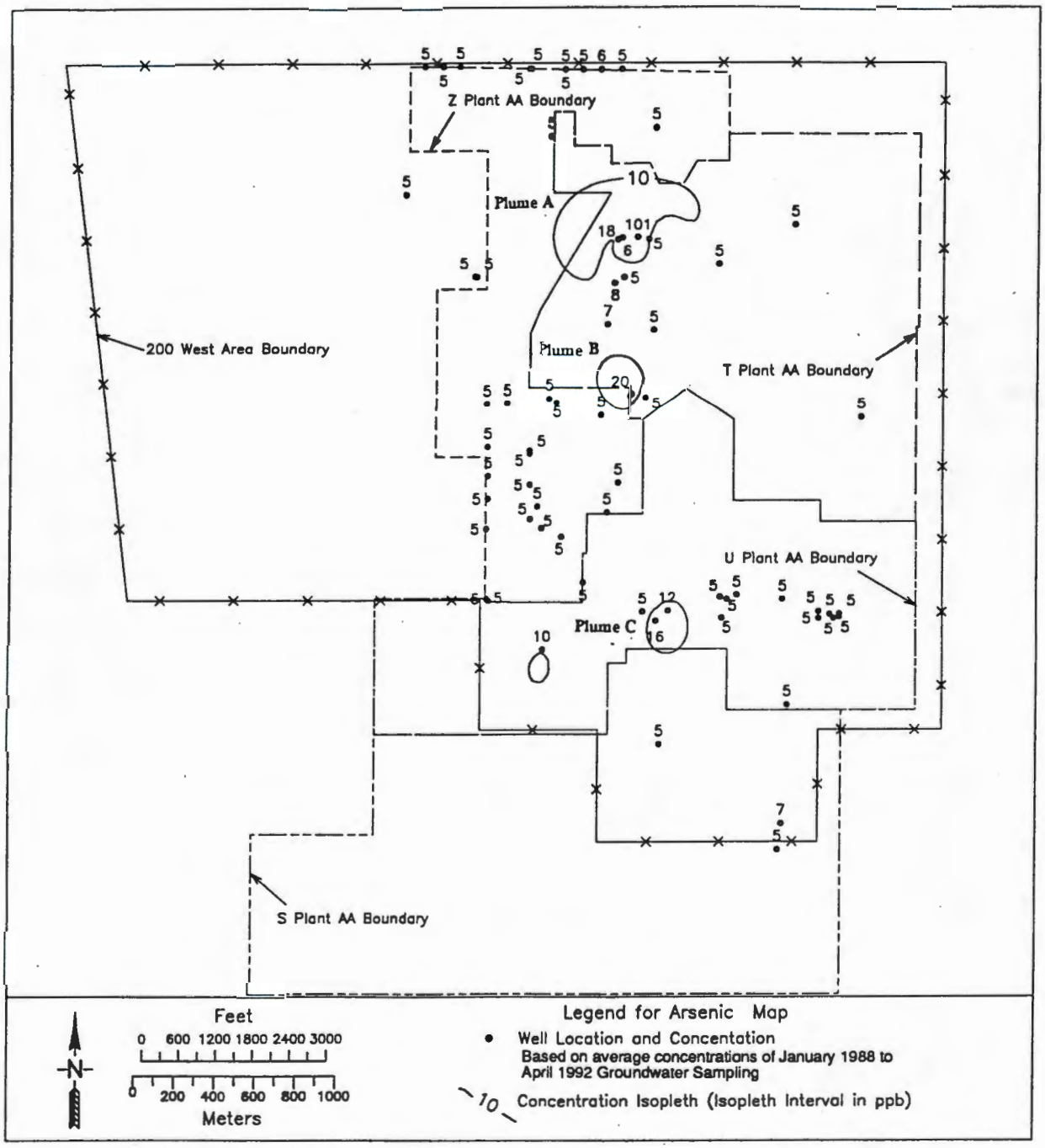

Figure 4-1. Arsenic Groundwater Plume Map (Connelly et al. 1992).

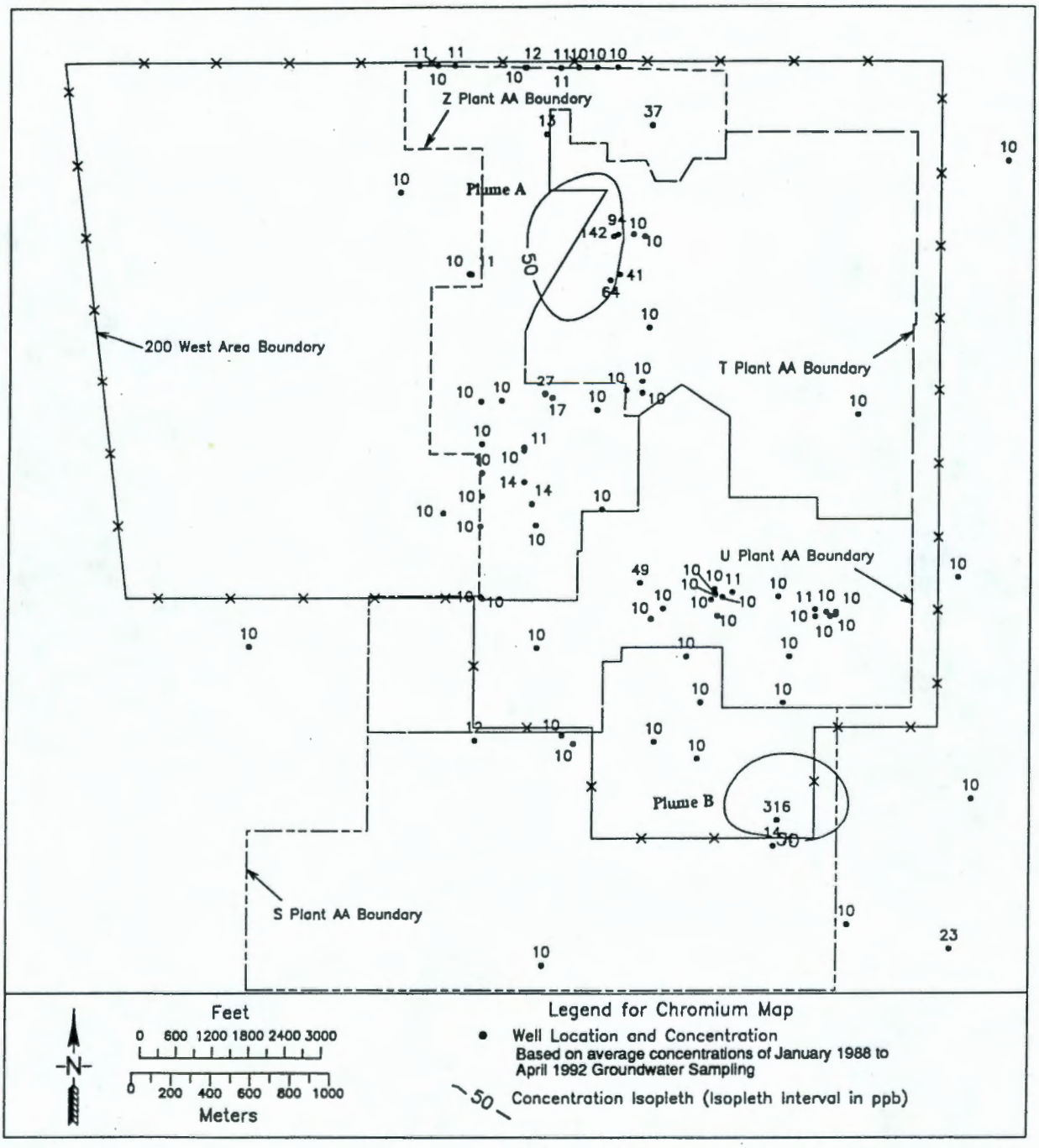

Figure 4-2. Chromium Groundwater Plume Map (Connelly et al. 1992).

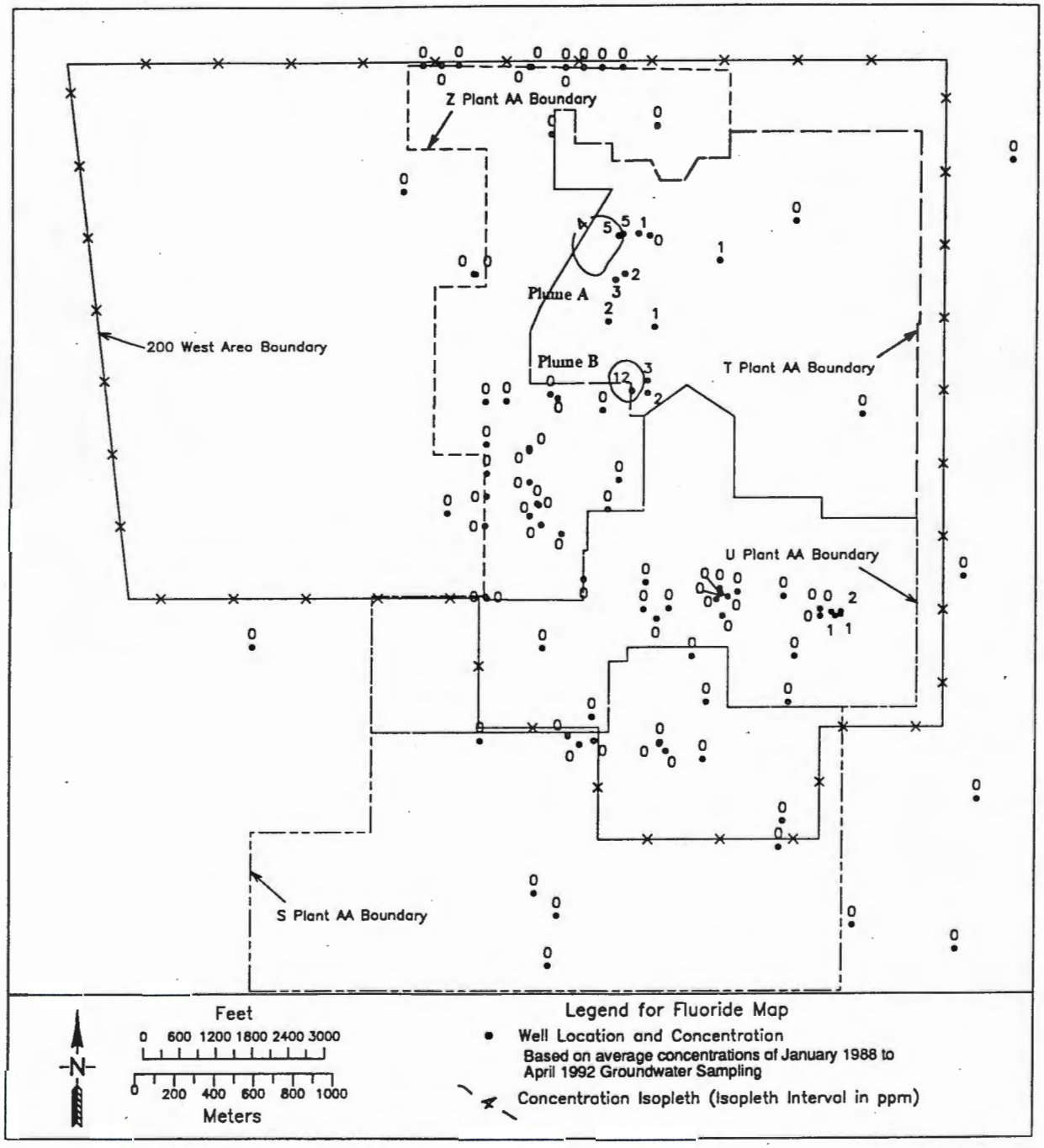

Figure 4-3. Fluoride Groundwater Plume Map (Connelly et al. 1992).

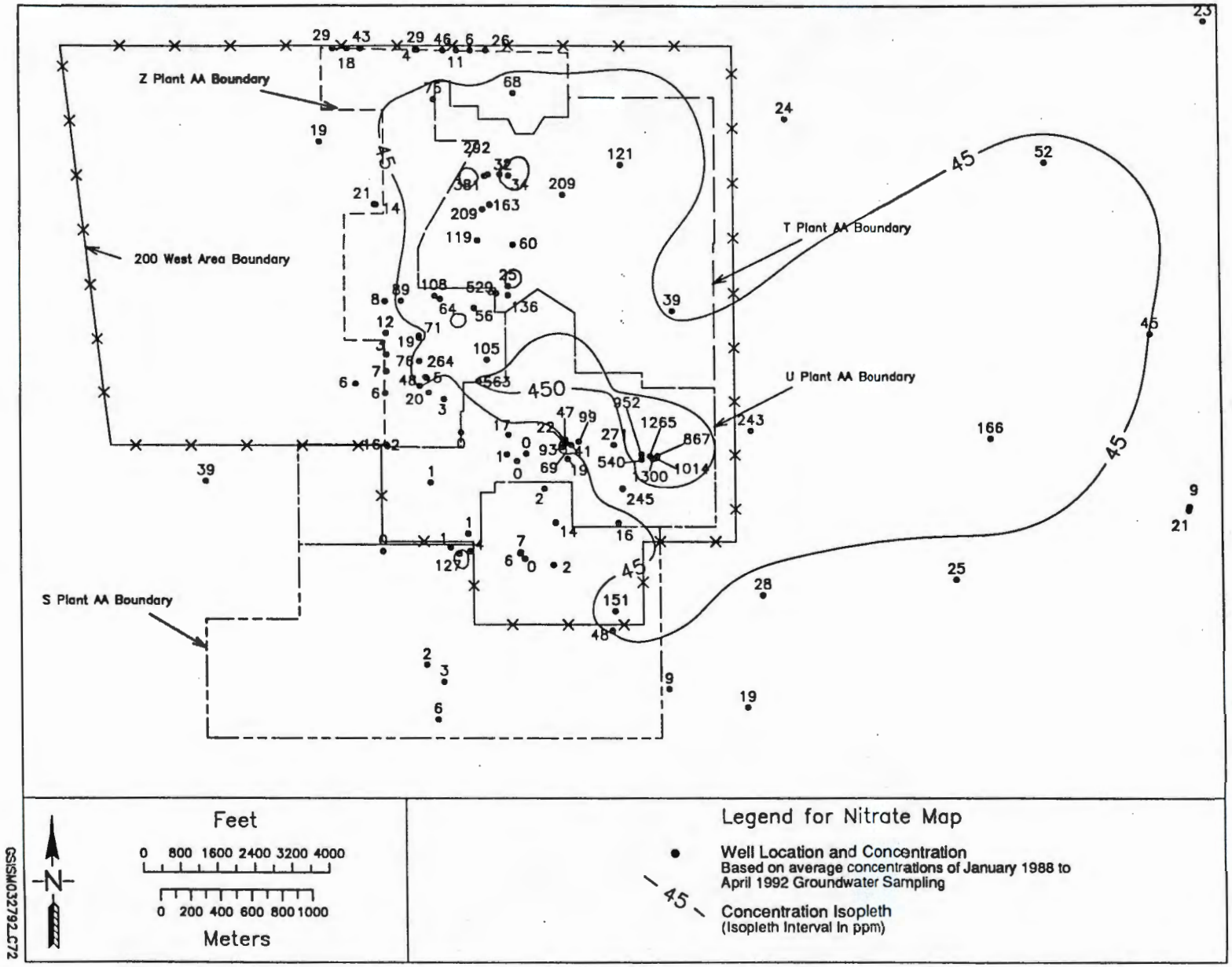

Figure 4-4. Nitrate Groundwater Plume Map (Connelly et al. 1992).).

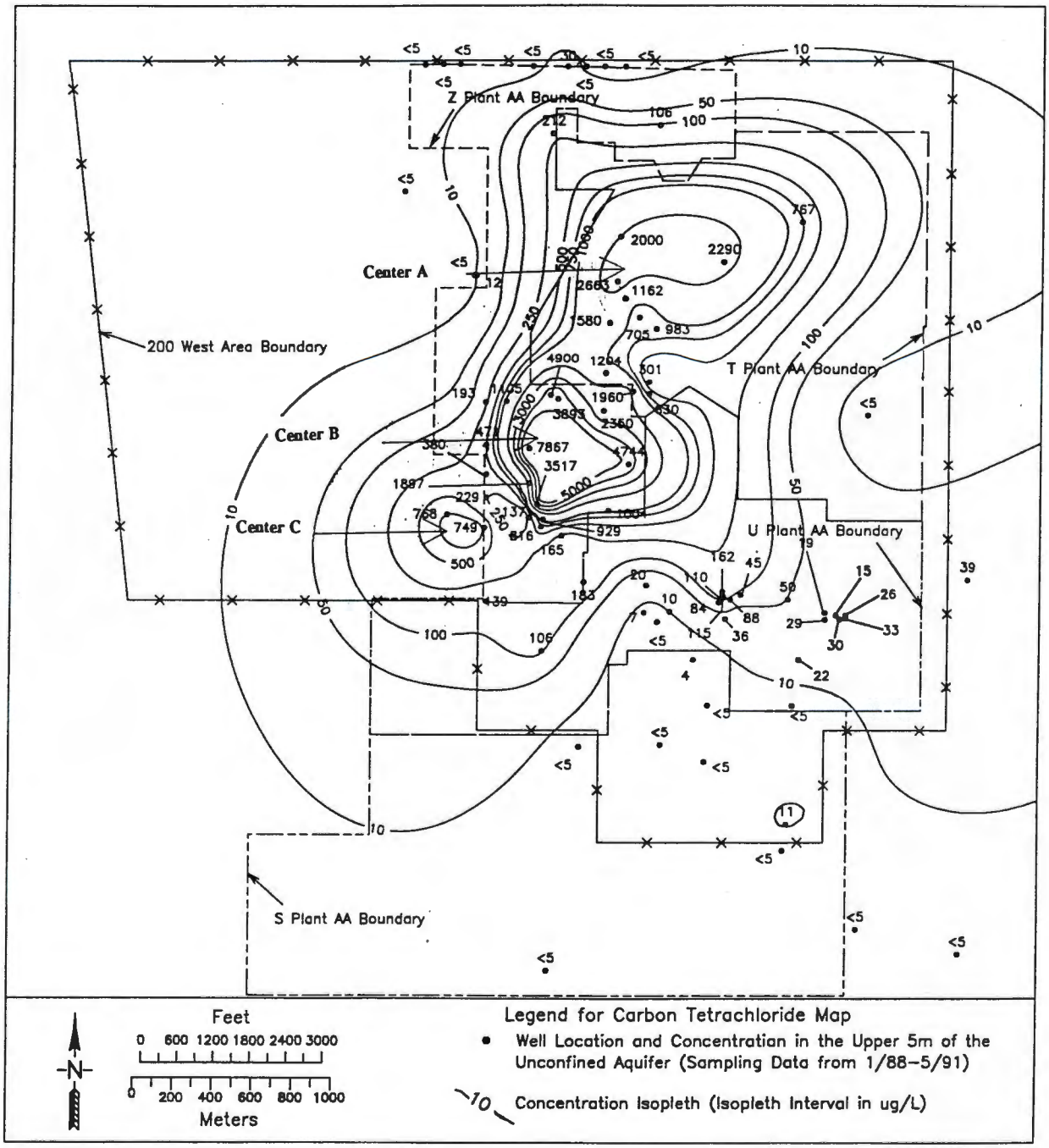

Figure 4-5. Carbon Tetrachloride Groundwater Plume Map (Connelly et al. 1992).

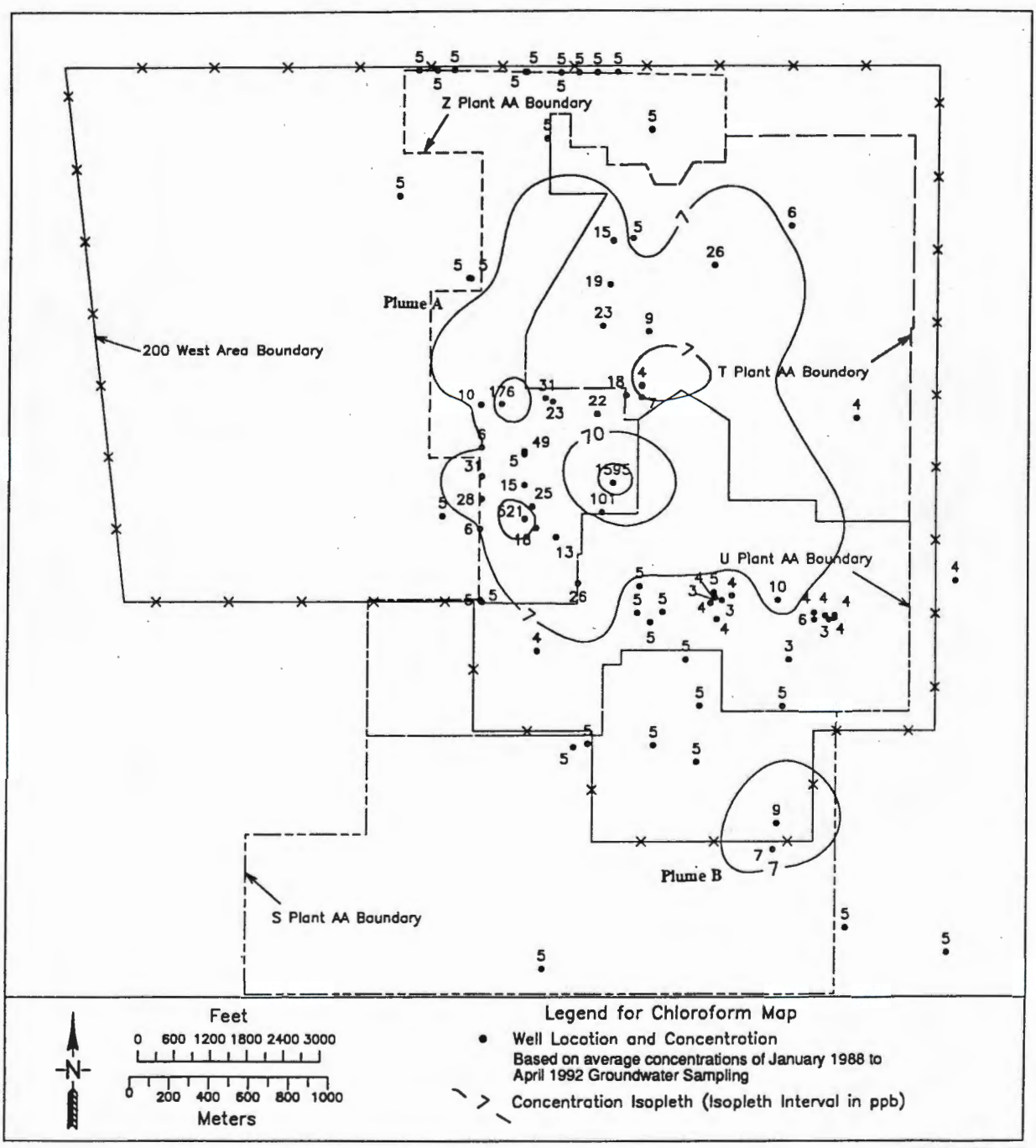

Figure 4-6. Chloroform Groundwater Plume Map (Connelly et al. 1992).

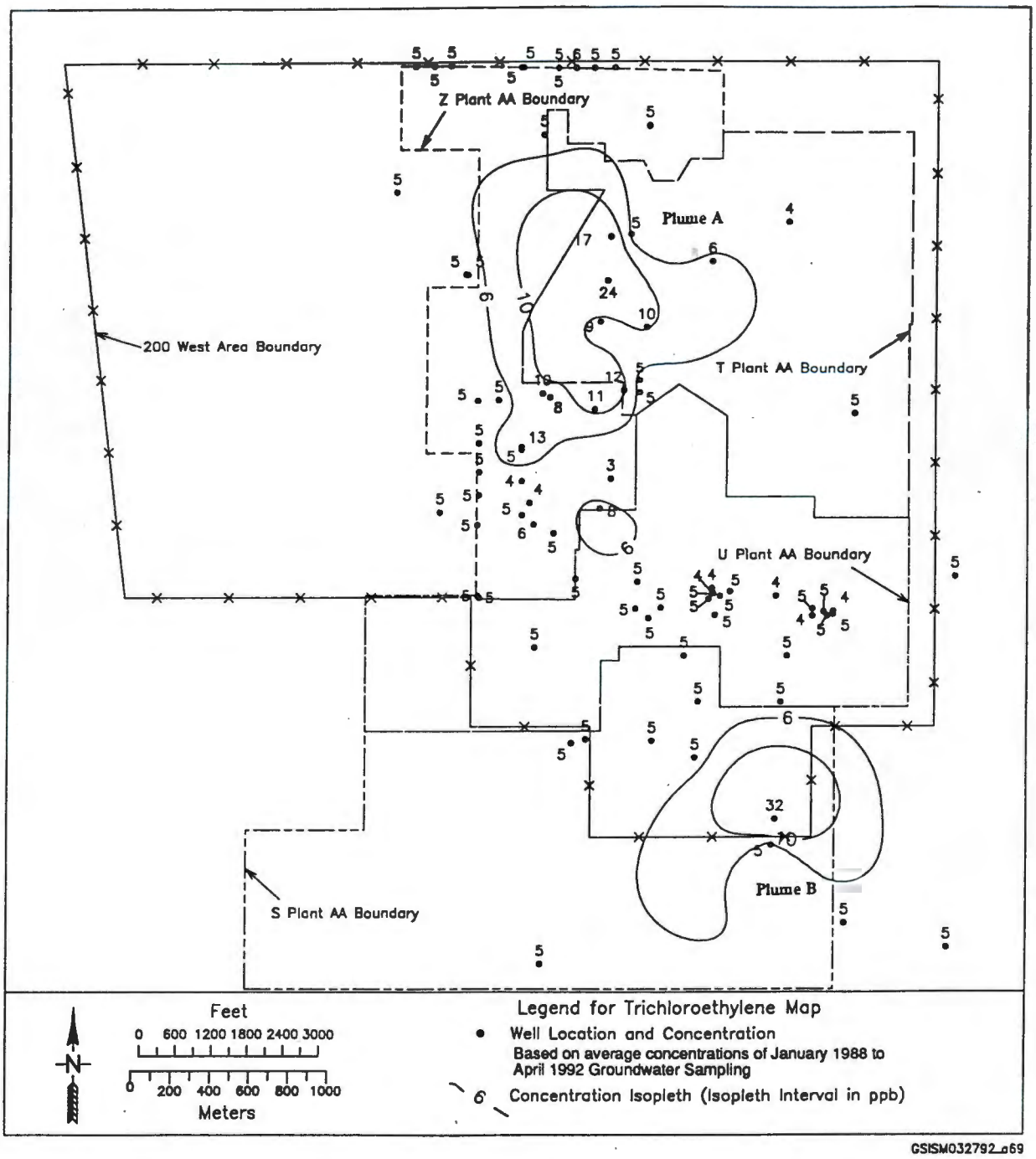

Figure 4-7. Trichloroethylene Groundwater Plume Map (Connelly et al. 1992).

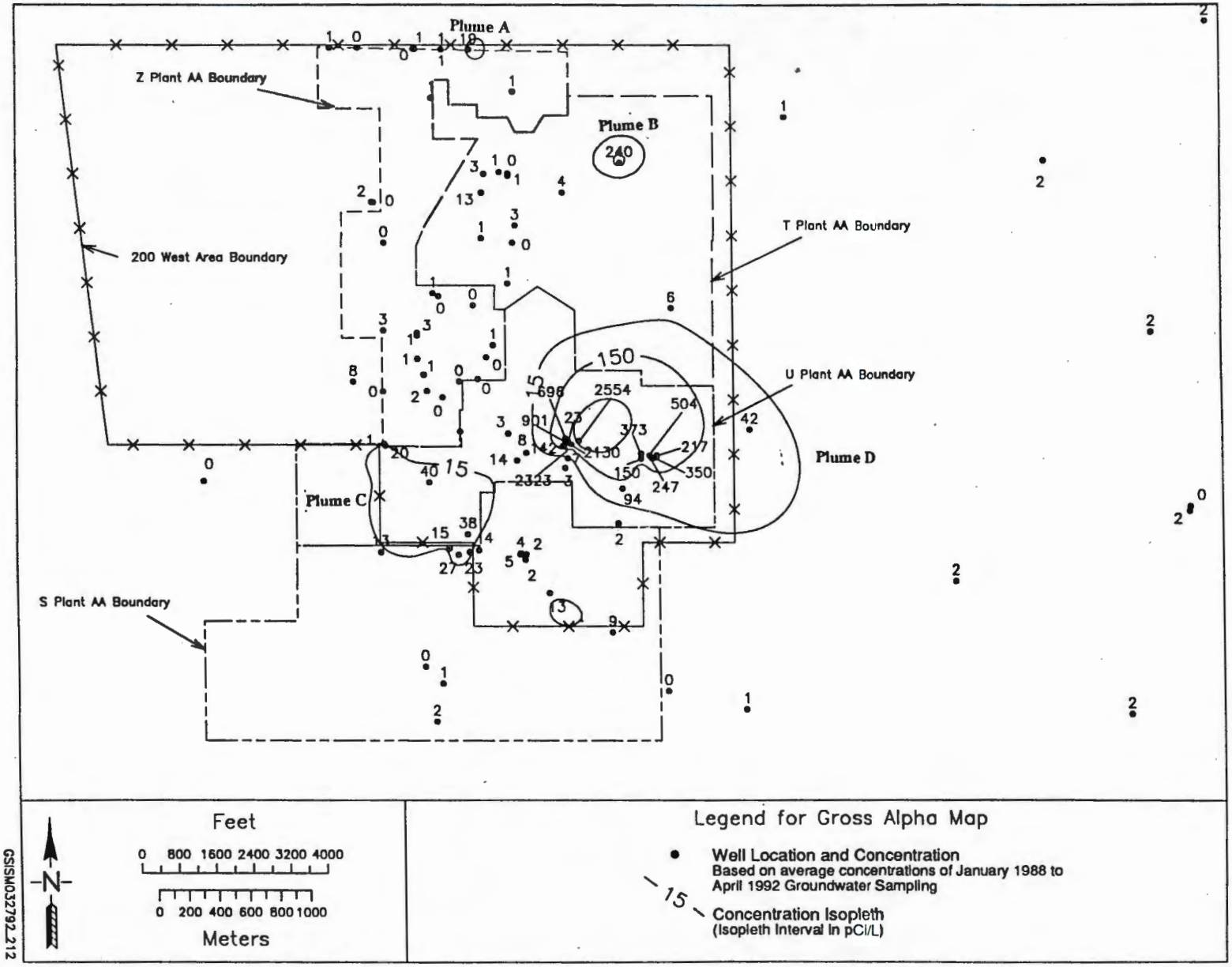

Figure 4-8. Gross Alpha Groundwater Plume Map (Connelly et al. 1992).

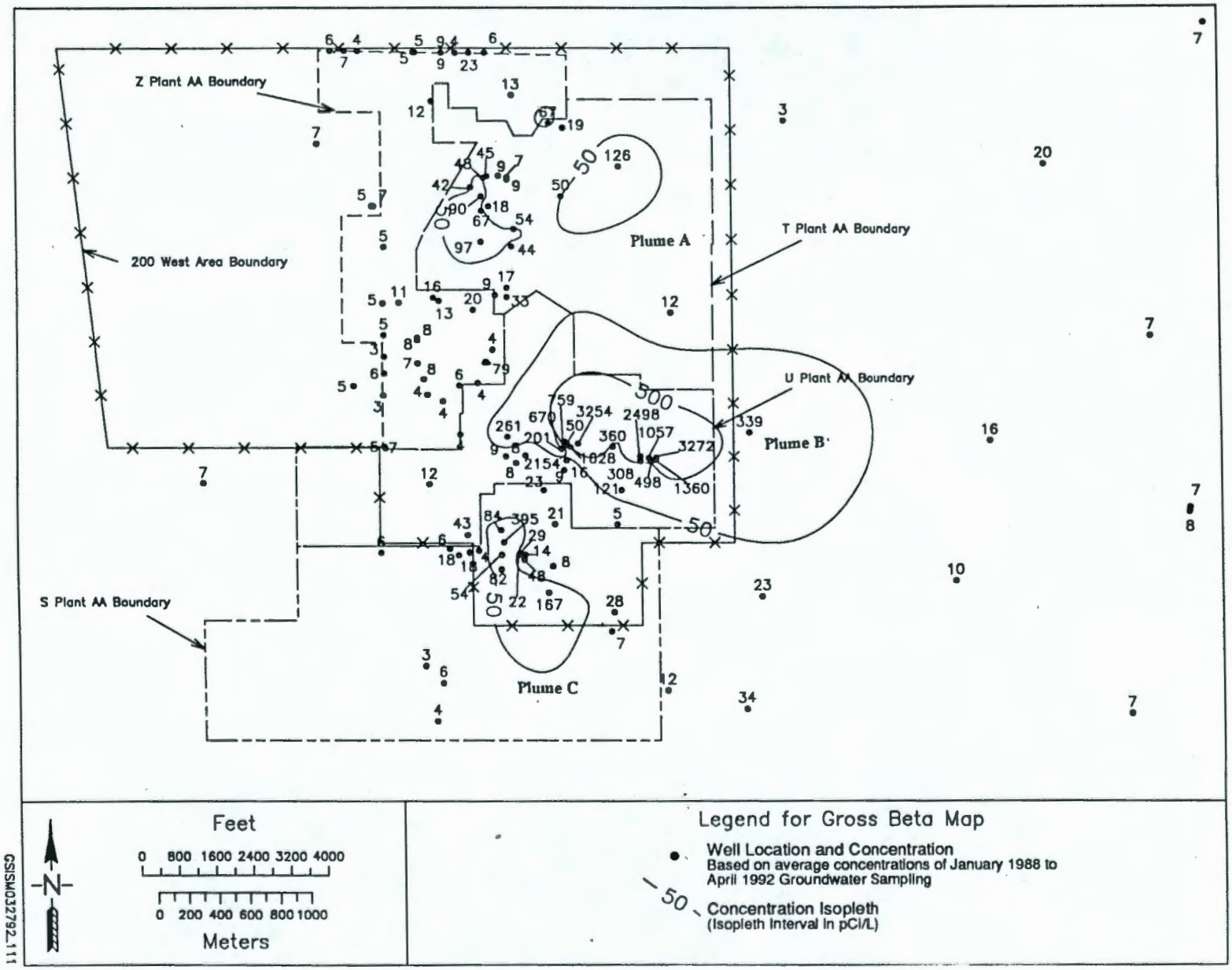

Figure 4-9. Gross Beta Groundwater Plume Map (Connelly et al. 1992).

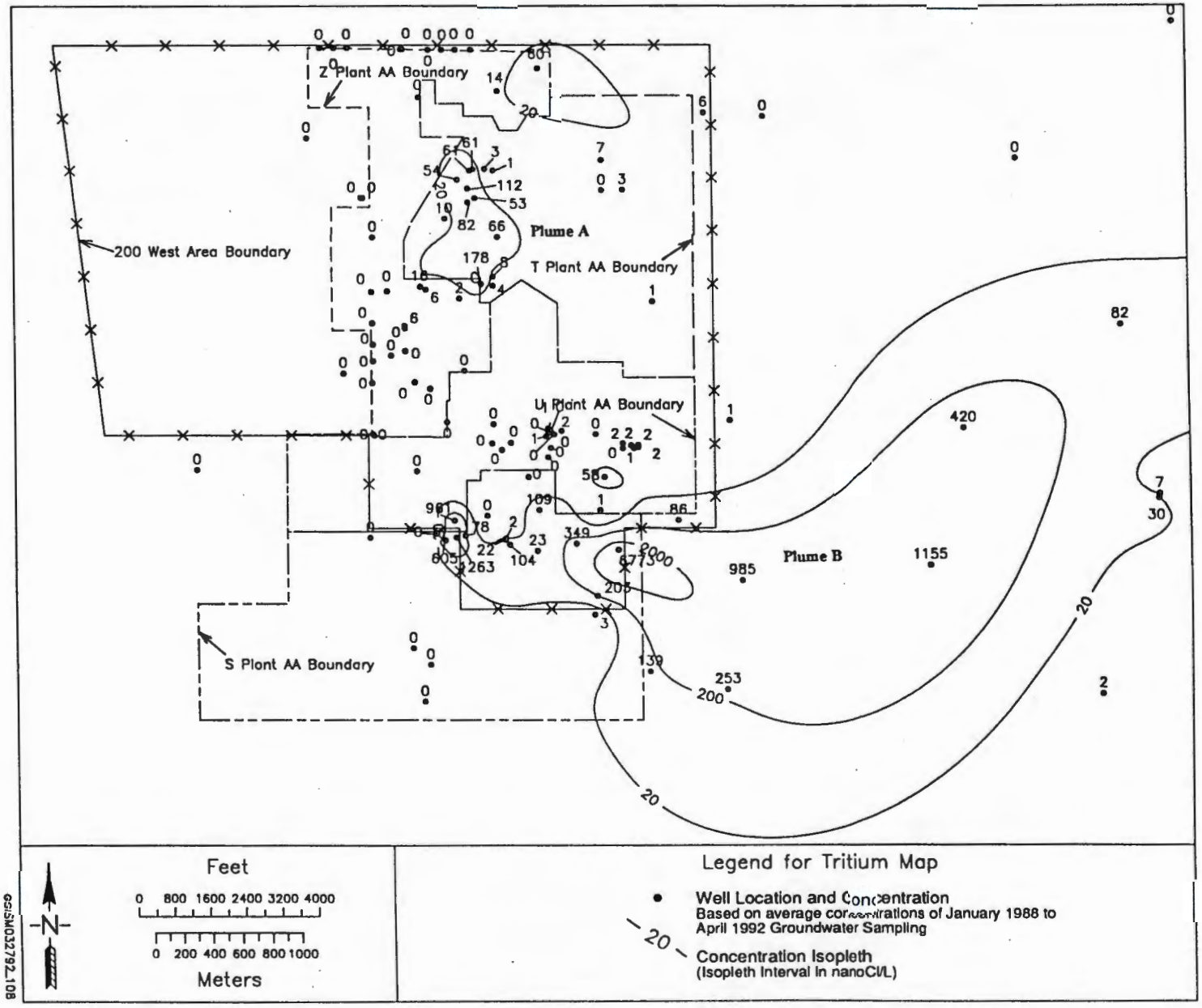

Figure 4-10. Tritium Groundwater Plume Map (Connelly et al. 1992).

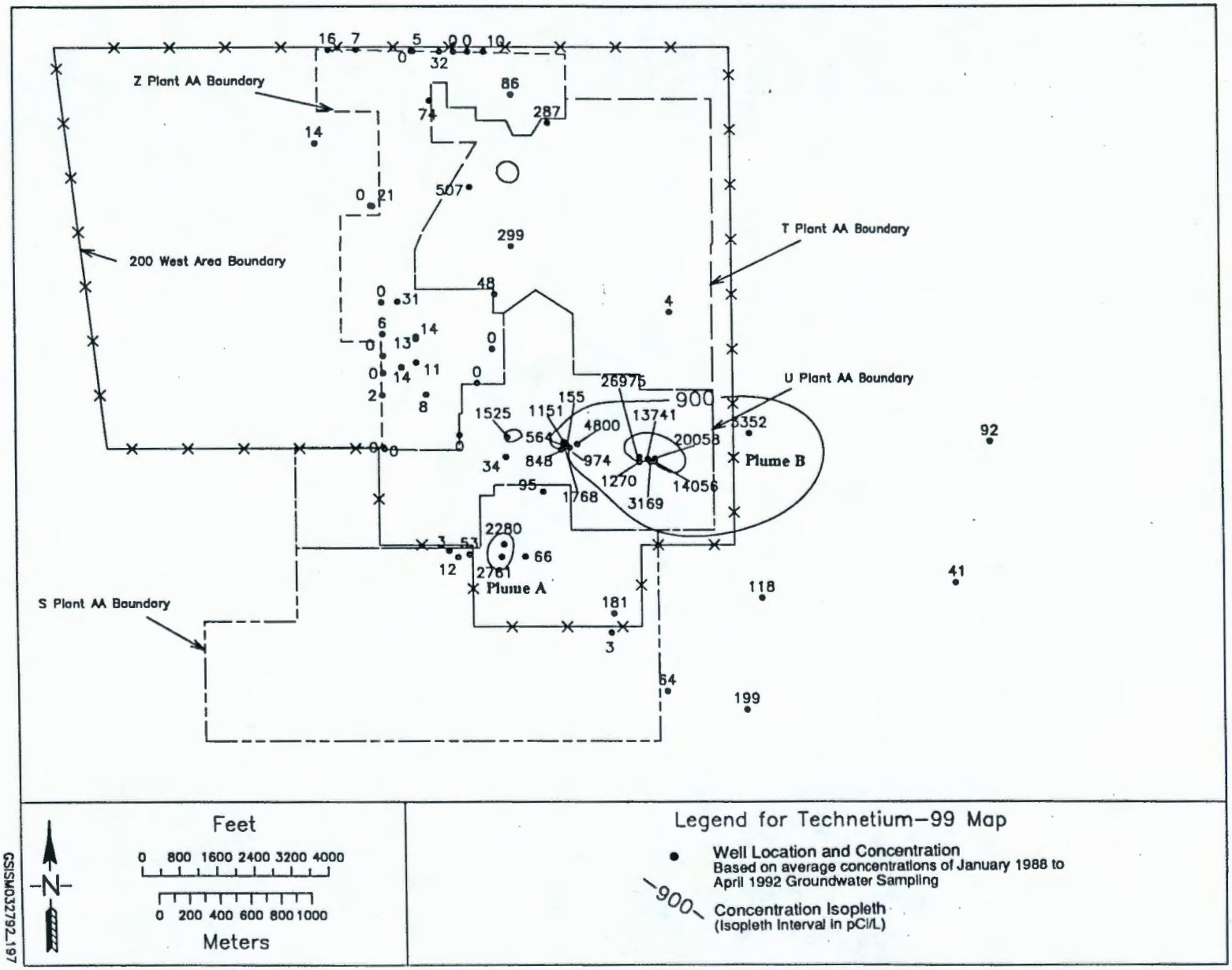

Figure 4-11. Technetium-99 Groundwater Plume Map (Connelly et al. 1992).

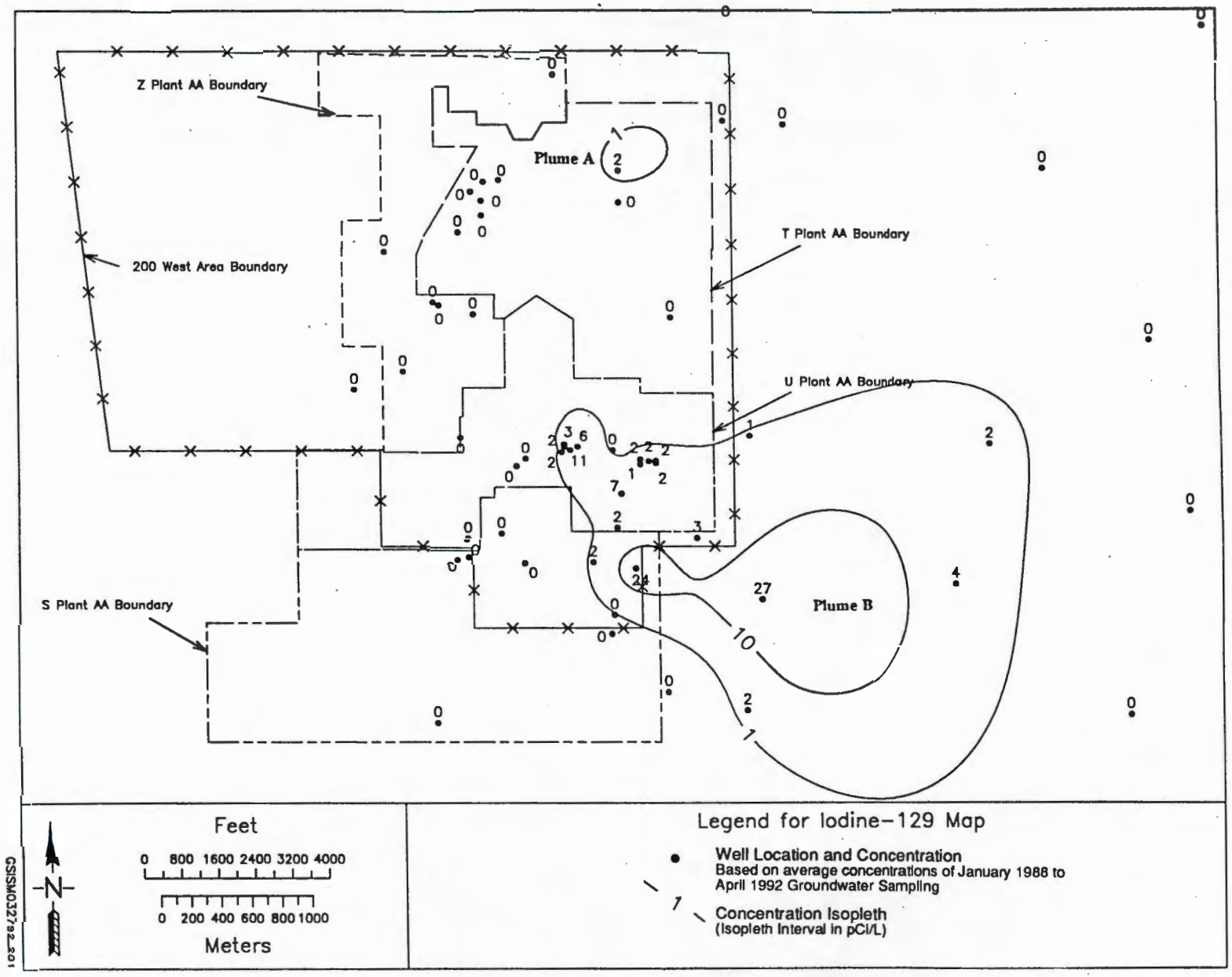

Figure 4-12. Iodine-129 Groundwater Plume Map (Connelly et al. 1992).

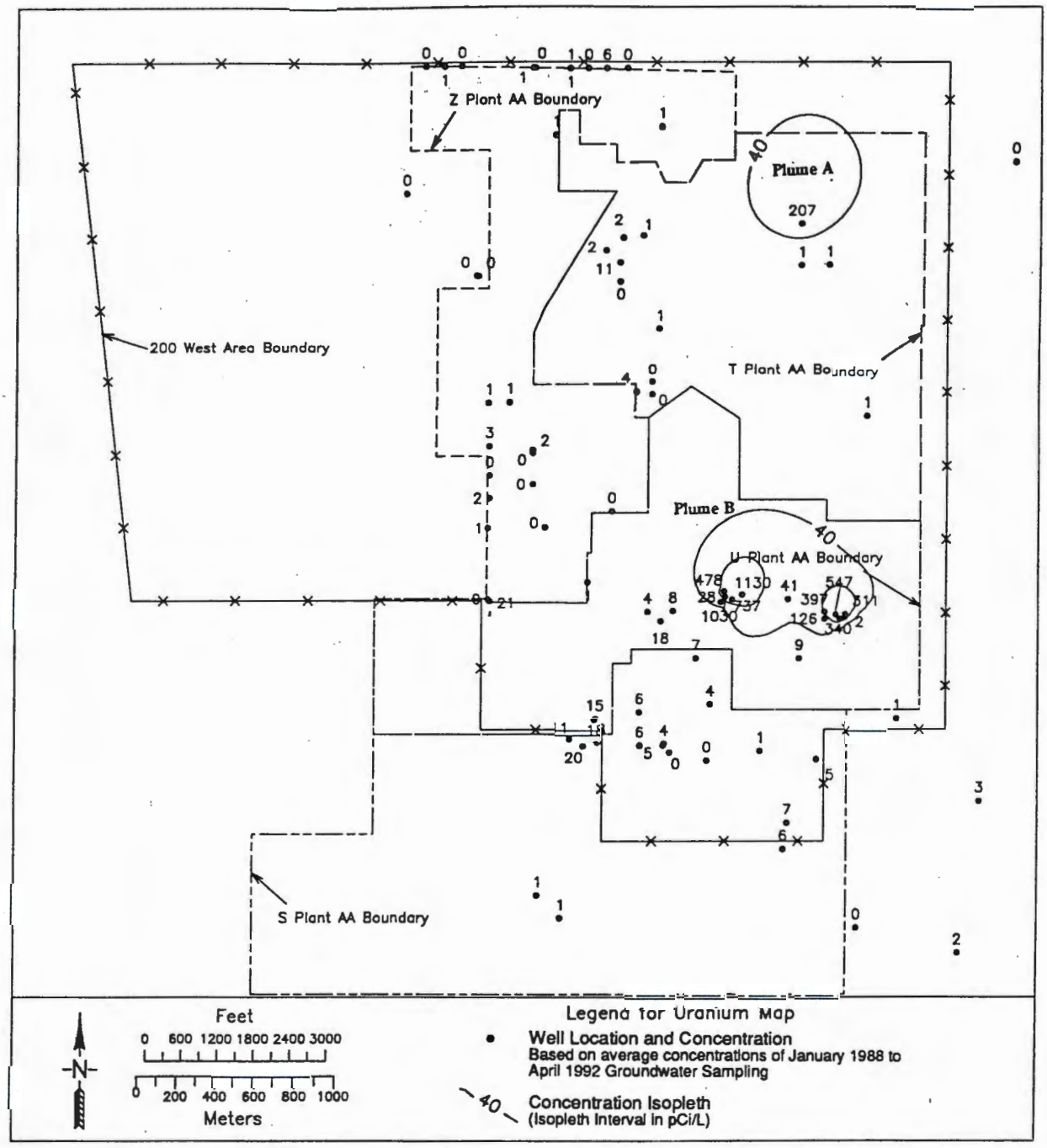

Figure 4-13. Uranium Groundwater Plume Map (Connelly et al. 1992).

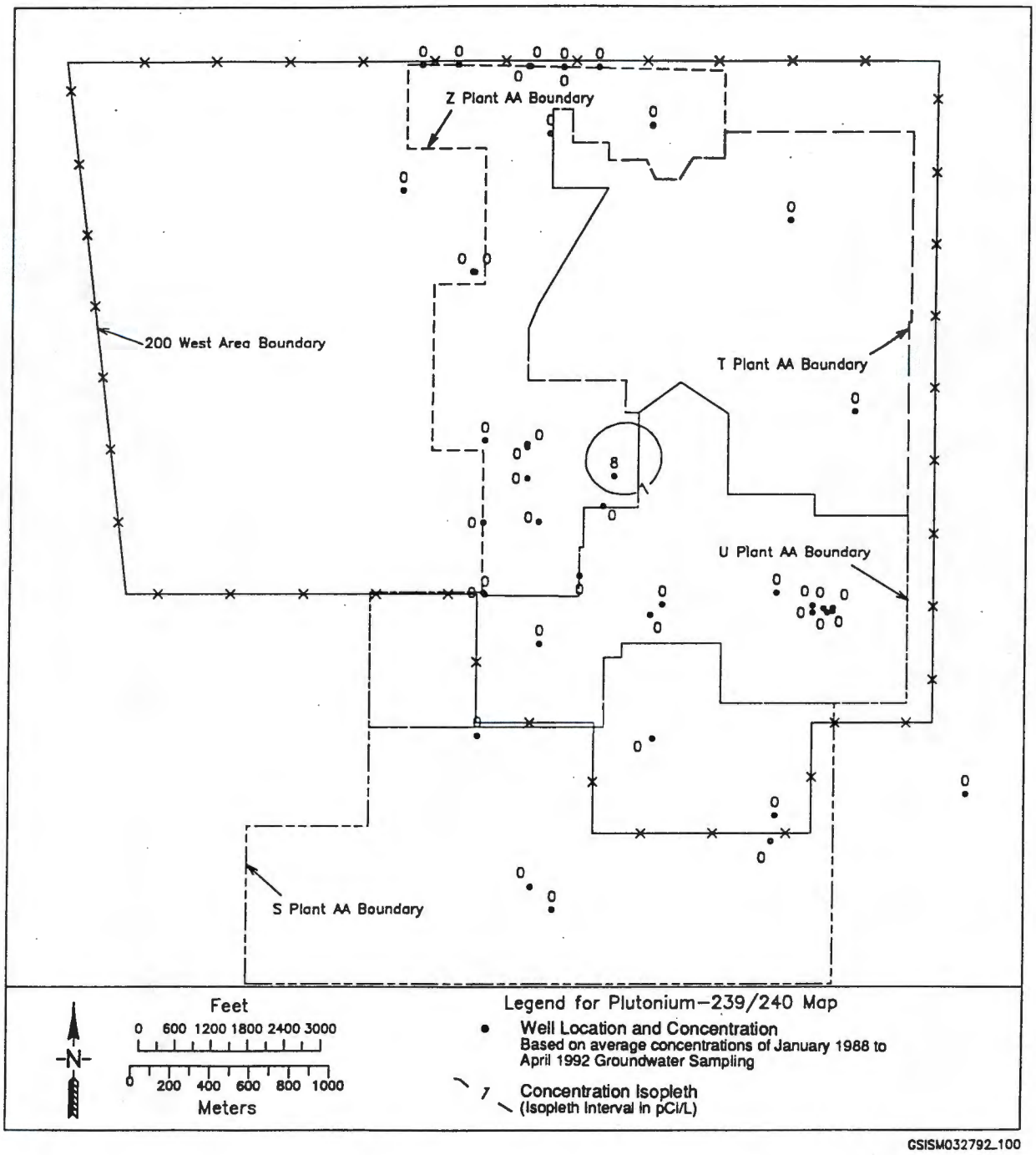

Figure 4-14. Plutonium-239/240 Groundwater Plume Map (Connelly et al. 1992).

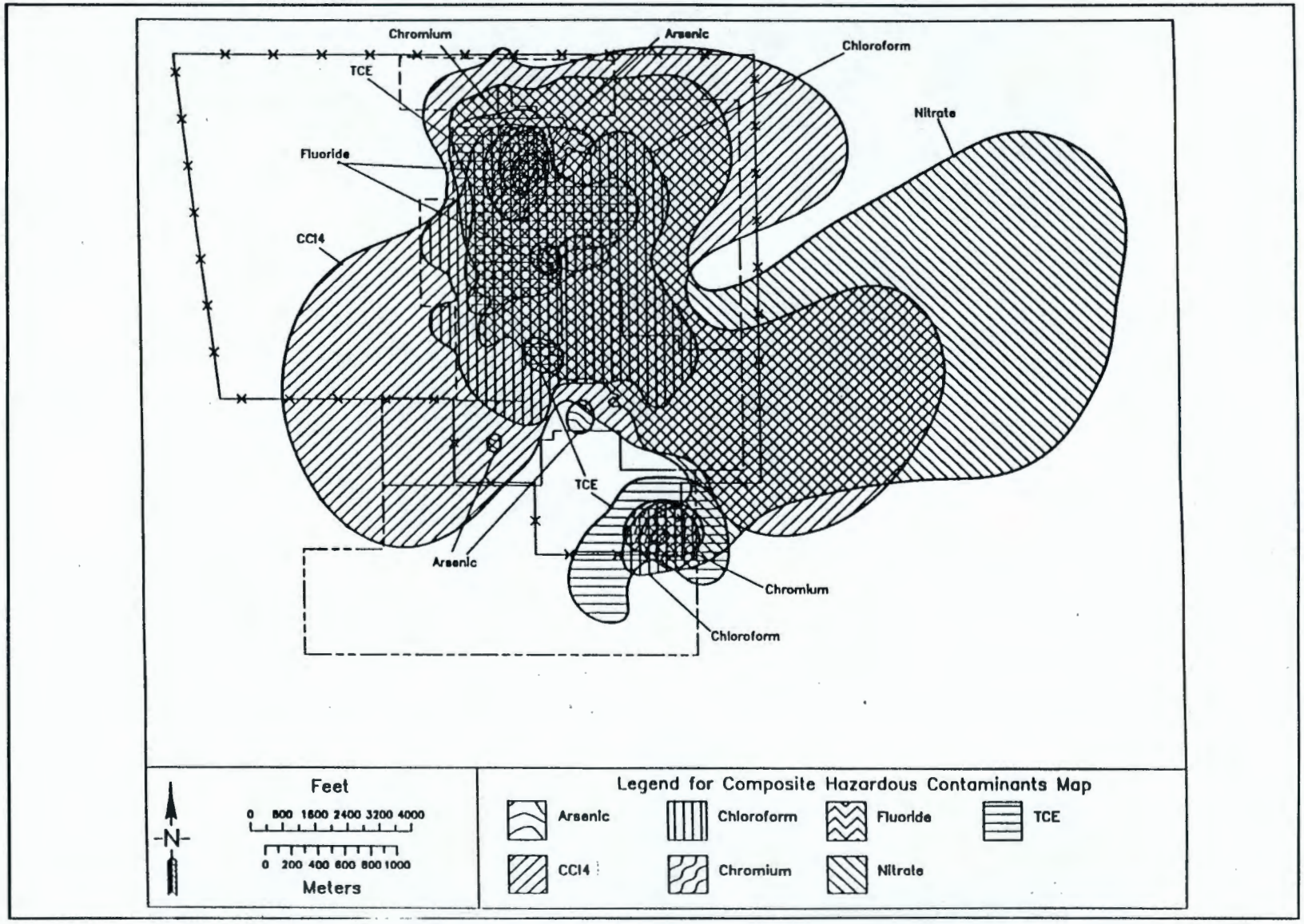

Figure 4-15. Composite Contaminant Plume Map for Inorganic and Organic Compounds (Connelly et al. 1992).

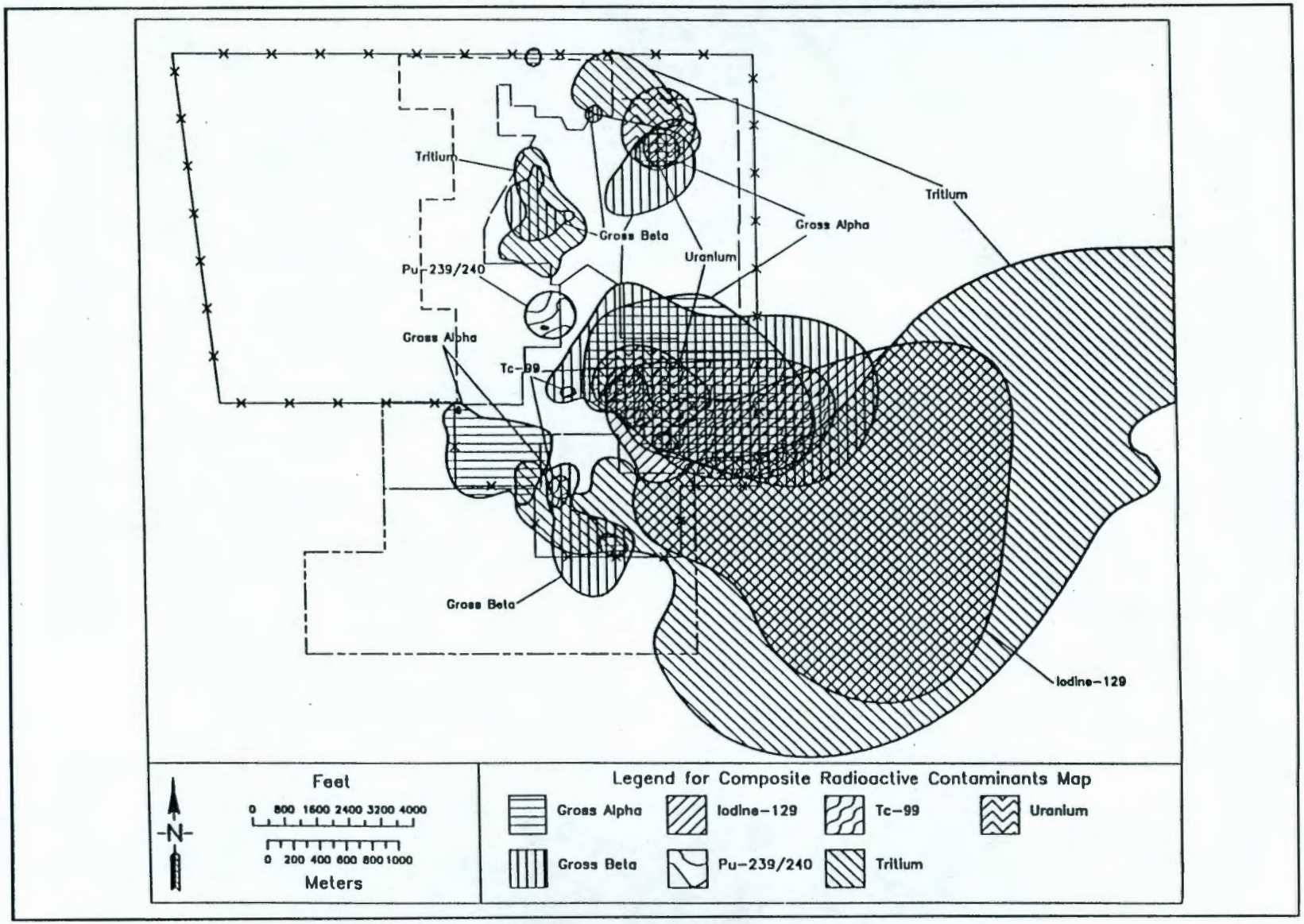

Figure 4-16. Composite Contaminant Plume Map for Radionuclides (Connelly et al. 1992).

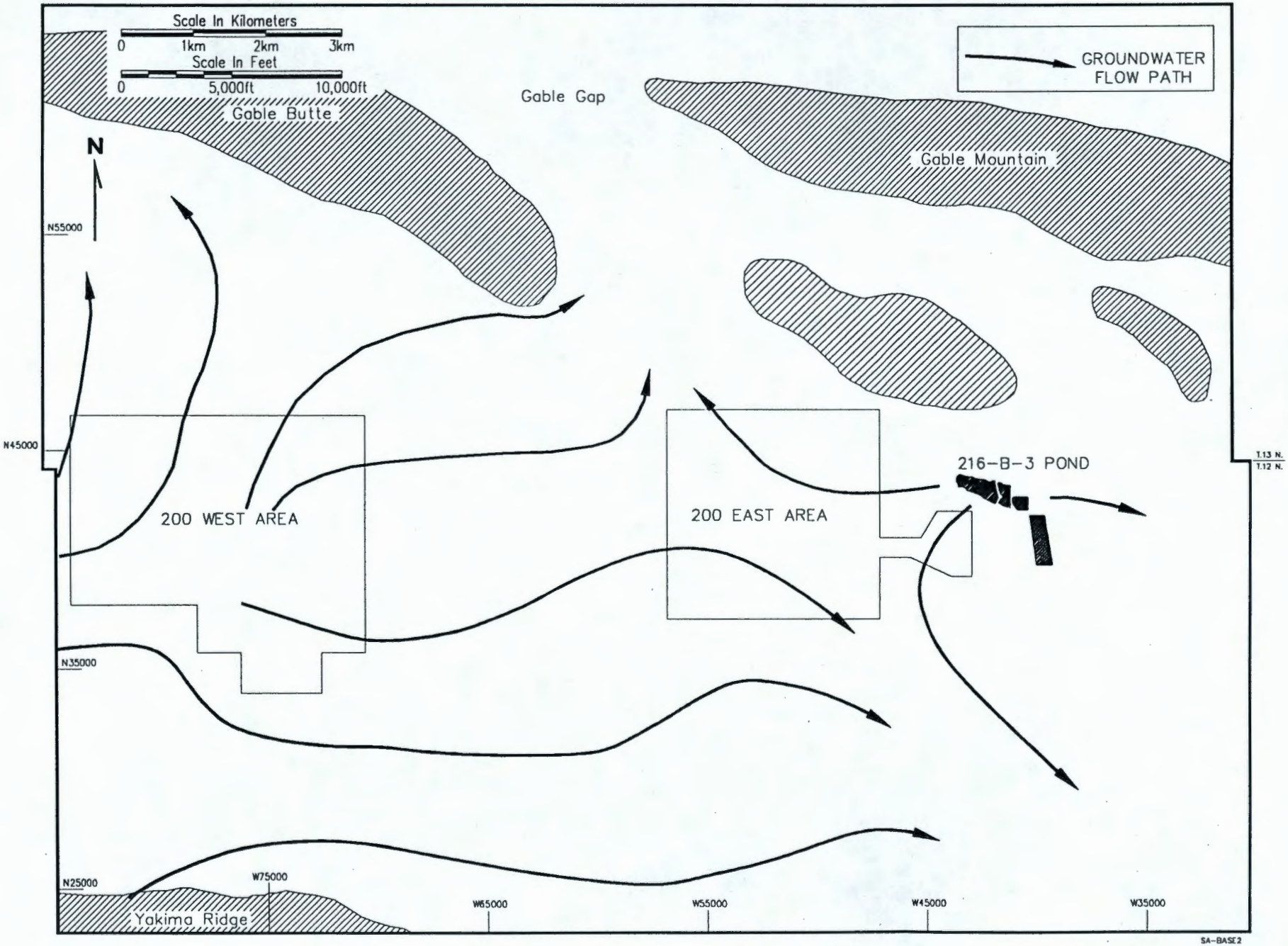

Figure 4-17. Schematic Present (1991) Horizontal Groundwater Flow Paths for the 200 Areas.

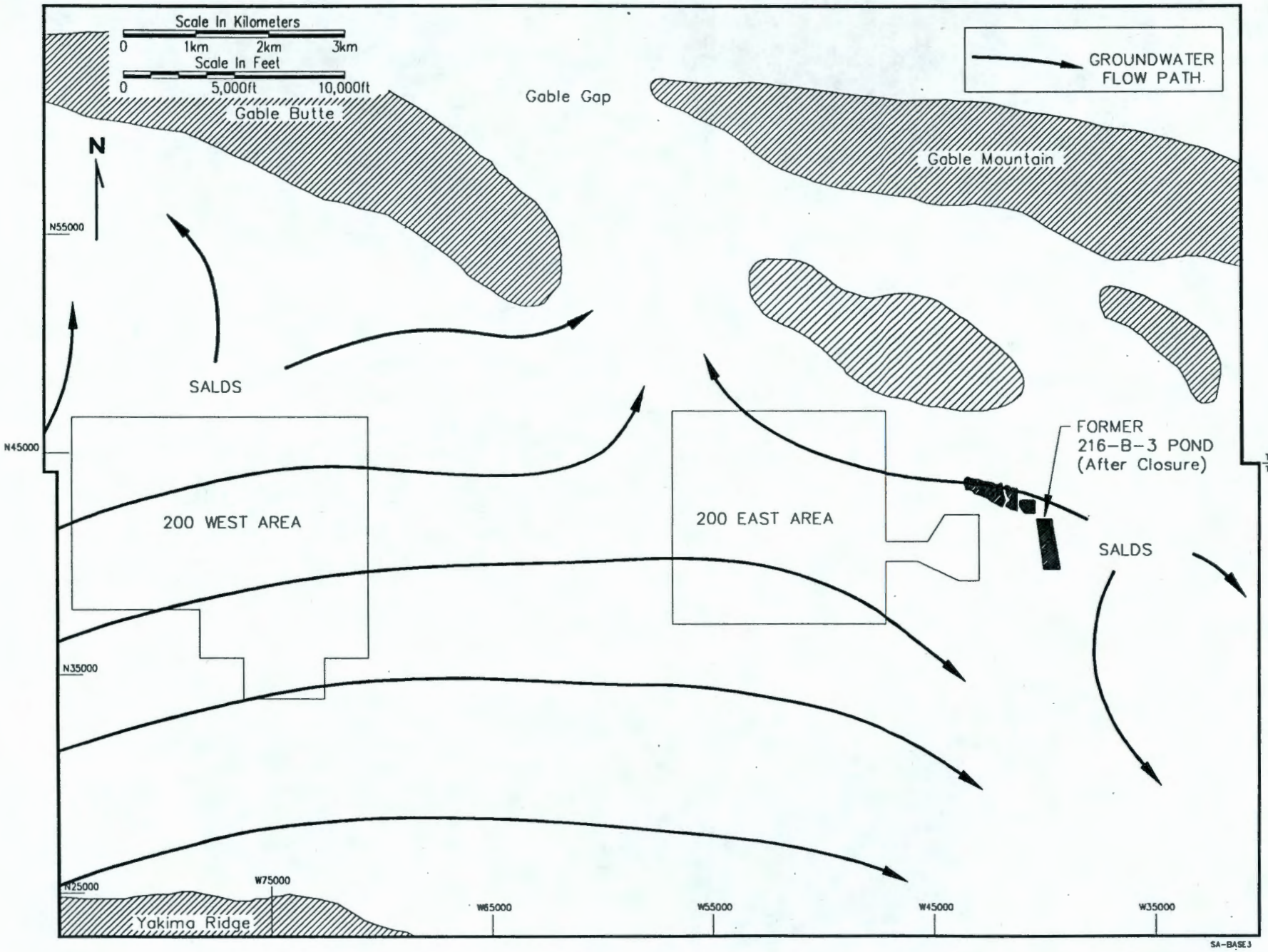

Figure 4-18. Estimate Near-Future Groundwater Flow Paths for the 200 Areas.

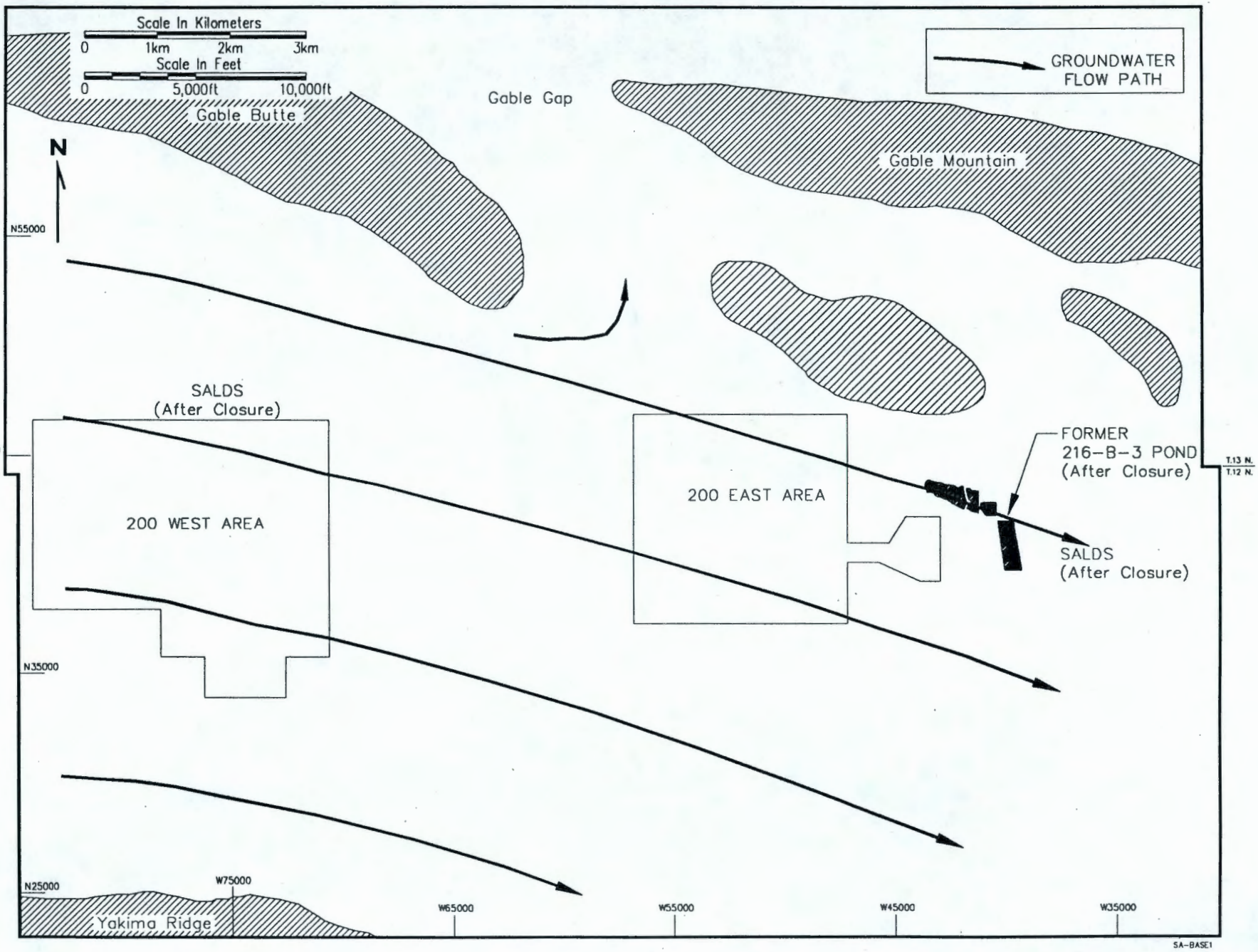

Figure 4-19. Estimated Futre Groundwater Flow Paths for the 200 Areas.

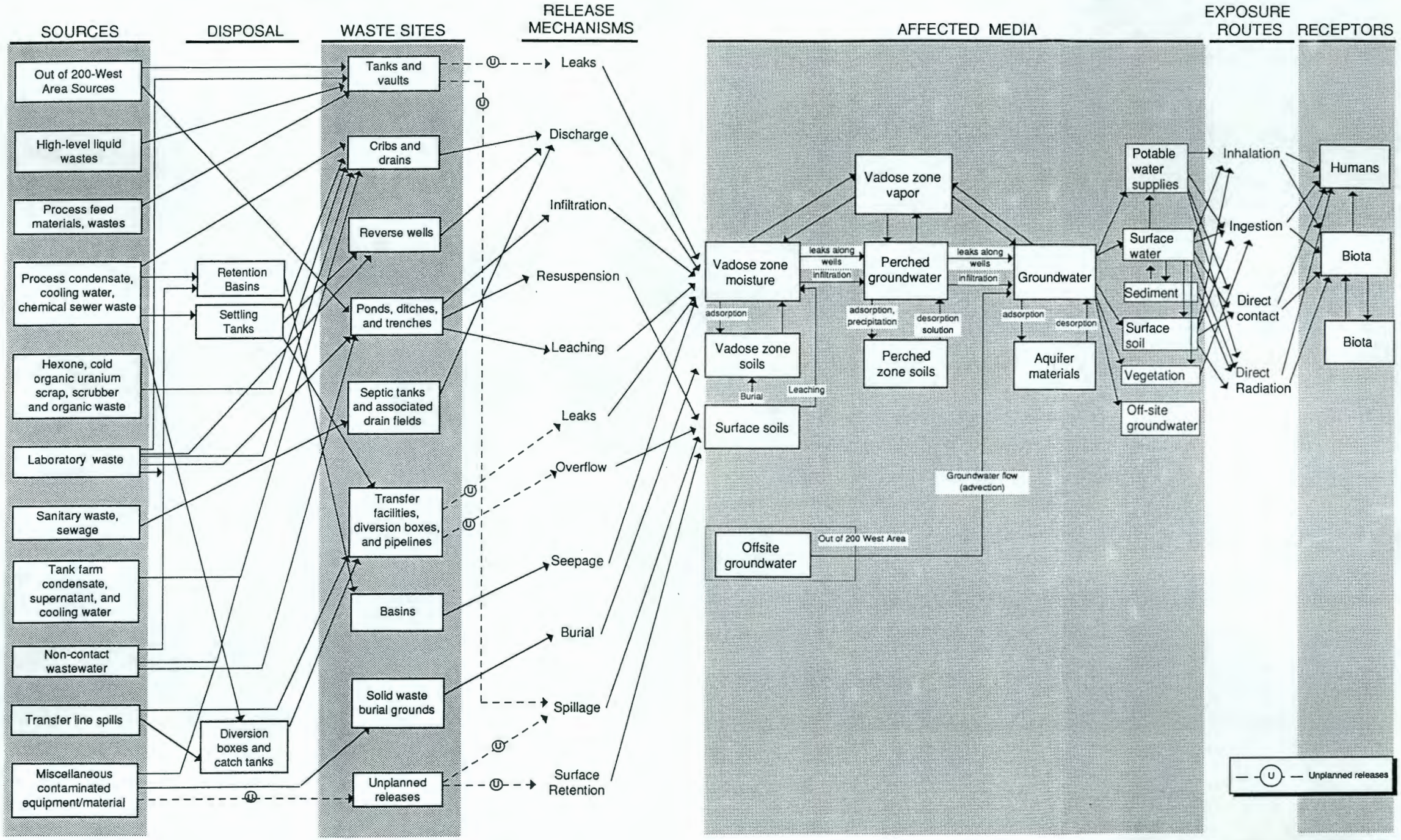

Figure 4-20. Conceptual Model of the 200 West Groundwater Aggregate Area.

Table 4-1. Average Reported Constituent Concentrations/Maximums and Minimums --200 West Groundwater Aggregate Area (January 1988 to April 1992).

		Well-Specific Data						All Wells			
Constituent		Well Number	Average of Reported Values	Maximum of Detections	Minimum of Detections	Number of Detections	Number < D.L.	Min Reported D.L.	Min mark	Total Number of Analyses	Total Number of Wells with Detections
ORGANIC COMPOUNDS (ug/L)											
Methylene Chloride	@	2-W15-8	562	980	144	2	0	0.34		469	19
Chloroform	@	2-W15-8	1595	1650	1540	2	0	0.72		469	48
Carbon Tetrachloride	@	2-W15-16	6558.89	8700	1780	9	0	1.2		469	71
1,2-dichloroethane	@	2-W22-20	7.75	6	5	2	2	5		419	1
1,1-dichloroethylene		2-W22-20	8.57	5.7	5.7	1	2	5		172	1
1,1,1-trichloroethane	@	2-W18-21	5.33	8	8	1	8	0.5		469	3
1,1,2-trichloroethane											
Trichloroethylene	@	2-W22-20	32.2	41	25	5	0	1		469	16
Tetrachloroethylene	@	2-W15-8	5	7	7	1	1	0.5		469	1
Toluene		2-W19-1	9	13	13	1	1	0.6		419	1
Xylene-o,p		2-W15-18	5.17	6	6	1	5	5		351	2
Phenol	@	2-W7-10	11.67	10	10	1	2	1		452	10
Bisphenol A		2-W14-10	42	42	42	1	0		&	1	1
2-chlorophenol		2-W7-6	22.5	35	35	1	1	5		140	1
2,4-dichlorophenol		2-W15-24	17.5	30	30	1	1	5		140	2
2,6-dichlorophenol		2-W7-6	23	36	36	1	1	5		140	1
2,4,5-Trichlorophenol		2-W22-39	5	5	5	1	2	5		141	1
Pentachlorophenol		2-W15-19	75	50	50	1	1	50		203	6
2,4-dimethylphenol		2-W10-18	26	47	47	1	1	5		126	3
2,6-Bis(1,1-Dimethylethyl)-4-Methyl Phenol		2-W19-27	20	20	20	1	0		&	2	2
o-Nitrophenol		2-W7-6	7	7	7	1	0	5		93	1
2,4-dinitrophenol											
2-sec-butyl-4,6-dinitrophenol		2-W18-24	5.33	5	5	1	2	1		201	6
Acetone		2-W15-17	57.17	23	23	1	5	3		307	8
Methyl ethyl ketone		2-W15-18	33.25	16	16	1	7	5		468	2
4-Methyl-2-Pentanone		2-W19-18	6	6	6	1	0	50		139	1
Aldrin		2-W15-8	1.8	1.8	1.8	1	0	0.05		378	3
Aldrin		2-W19-18	1.8	1.8	1.8	1	0	0.05		378	3
DDD		2-W15-8	0.33	0.33	0.33	1	0	0.1		189	3
DDT		2-W15-8	4.3	4.3	4.3	1	0	0.1		189	4
Dieldrin		2-W15-8	3.9	3.9	3.9	1	0	0.05		189	3
Endrin		2-W15-8	4.6	4.6	4.6	1	0	0.1		306	3
Endrin Aldehyde		2-W14-2	0.7	0.7	0.7	1	0	0.2		152	3
Gamma-BHC		2-W14-2	1.7	1.7	1.7	1	0	0.05		918	3
Gamma-BHC		2-W15-8	1.7	1.7	1.7	1	0	0.05		918	3
Gamma-BHC		2-W19-18	1.7	1.7	1.7	1	0	0.05		918	3
Heptachlor		2-W14-2	1.7	1.7	1.7	1	0	0.05		567	3
Heptachlor		2-W15-8	1.7	1.7	1.7	1	0	0.05		567	3
Heptachlor		2-W19-18	1.7	1.7	1.7	1	0	0.05		567	3
Bis(2-ethylhexyl) phthalate		2-W7-10	64	64	64	1	0	10		63	2

Table 4-1. Average Reported Constituent Concentrations/Maximums and Minimums --200 West Groundwater Aggregate Area (January 1988 to April 1992).

	Well-Specific Data						All Wells			
Constituent	Well Number	Average of Reported Values	Maximum of Detections	Minimum of Detections	Number of Detections	Number < D.L.	Min Reported D.L.	Min mark	Total Number of Analyses	Total Number of Wells with Detections
1,2-Propanediol	2-W19-15	48	48	48	1	0			1	1
Carbon Disulfide	2-W22-40	39	39	39	1	0	5		138	2
Citrus Red	2-W7-6	2492.5	6940	1030	2	2	1000		98	1
Cresols	2-W7-6	15.5	21	21	1	1	10		144	1
N-nitrosodimethylamine	2-W23-10	27	27	27	1	0	10		63	1
Unknown	2W7-7	43	43	43	1	0			27	26
RADIONUCLIDES (pCi/L)										
Gross alpha	@ 2-W19-18	2208.61	3710	515	18	0	-0.357		916	130
Gross beta	2-W19-25	3271.88	5110	1910	16	0	-6.31		1026	147
Tritium	2-W22-9	5080001.11	7560000	5880000	3	1	-923		849	122
Beryllium-7	2-W6-2	17.65	57.7	57.7	1	1	-86.5		65	1
Carbon-14	6-35-70	12.49	19.6	4.08	5	1	-0.856		25	2
Potassium-40	2-W10-18	476	476	476	1	0	6.31		66	47
Cobalt-60	2-W15-7	12.57	14	13	2	1	-13.8		640	37
Nickel-63	6-43-88	9.18	9.18	9.18	1	0		&	4	2
Zinc-65	2-W18-26	10.4	10.4	10.4	1	0	-23.6		65	5
Strontium-90	2-W22-10	21.95	29.8	13.1	6	0	-1.66		445	19
Zirconium/Niobium-95	2-W23-13	24.3	24.3	24.3	1	0	-26.8		65	4
Technetium-99	2-W19-24	26601.6	41000	27.2	17	0	-13.7		536	91
Ruthenium-106	2-W22-39	35.53	57.7	57.7	1	2	-102		637	26
Silver-110 Metastable	2-W14-10	5.38	5.38	5.38	1	0	-6.81		4	1
Antimony-125	2-W7-9	9.51	20.8	20.8	1	2	-21.9		159	6
Iodine-129	@ 6-35-70	29.49	87.8	10.3	6	0	-0.547		146	40
Cesium-137	2-W15-8	5.215	6.94	6.94	1	1	-10.2		640	22
Cerium/Praeseodymium-144	2-W15-20	31	31	31	1	0	-67.2		65	2
Europium-154	2-W19-31	24.9	24.9	24.9	1	0	-15.5		66	4
Lead-212	2-W7-7	6.28	6.28	6.28	1	0		&	3	3
Radium	2-W10-8	6.42	6.42	6.42	1	0	-0.108		318	53
Uranium	2-W19-18	1130	1130	1130	1	0	0.0407		249	86
Uranium-234	2-W19-18	1605	1890	1320	2	0		&	123	22
Uranium-235	2-W19-11	102	102	102	1	0	0.199		123	22
Uranium-238	2-W19-18	1730	2040	1420	2	0		&	123	22
Plutonium-238	2-W22-21	8.97	8.9706	8.9706	1	0	-5.5906		292	6
Plutonium-239/40	2-W15-8	5.09	8.27	1.9	2	0	-0.0947		292	13
Americium-241	2-W15-8	5.9	5.9	5.9	1	0	-0.113		170	11

Table 4-1. Average Reported Constituent Concentrations/Maximums and Minimums --200 West Groundwater Aggregate Area (January 1988 to April 1992).

	Well-Specific Data						All Wells			
Constituent	Well Number	Average of Reported Values	Maximum of Detections	Minimum of Detections	Number of Detections	Number < D.L.	Min Reported D.L.	Min mark	Total Number of Analyses	Total Number of Wells with Detections
INORGANIC COMPOUNDS (ug/L)										
Aluminum	2-W7-6	17675	38700	1060	6	0	150		180	25
Aluminum, filtered	2-W7-6	233.5	328	306	2	2	150		312	2
Ammonium ion	2-W15-8	44000	44000	44000	1	0	20		406	23
Arsenic	2-W10-8	101	101	101	1	0	5		344	24
Arsenic, filtered	2-W15-4	24	24	24	1	0	5		362	17
Barium	2-W10-8	732	732	732	1	0	20		344	99
Barium, filtered	2-W15-8	410	410	410	1	0	20		475	113
Beryllium	2-W7-6	4.64	6	4.8	2	7	3		336	2
Beryllium, filtered	2-W7-6	4.67	6.7	6.7	1	6	3		475	4
Boron	2-W14-10	587	587	587	1	0	10		116	45
Boron, filtered	2-W22-20	73	73	73	1	0	10		145	63
Cadmium	2-W19-1	94	94	94	1	0	2		344	16
Cadmium, filtered	2-W8-1	4.89	4	4	1	8	2		475	6
Calcium	2-W19-19	308000	308000	308000	1	0		&	344	99
Calcium, filtered	2-W19-19	304500	325000	284000	2	0		&	475	113
Total carbon	2-W19-18	40533.33	43200	36100	3	0	27000		405	112
Chloride	2-W11-14	63933.33	66900	59400	3	0		&	576	130
Chromium	2-W10-8	6180	6180	6180	1	0	10		344	71
Chromium, filtered	2-W22-20	322.6	350	296	5	0	10		475	47
Cobalt, filtered	2-W22-43	21.5	26	26	1	3	20		308	1
Copper	2-W19-26	126	232	232	1	1	10		344	46
Copper, filtered	2-W26-9	25.33	36	36	1	2	10		475	33
Cyanide	2-W14-2	49.5	70	26	4	1	10		416	8
Fluoride	@ 2-W15-4	11500	12800	10200	2	0	500		670	124
Iron	2-W10-8	328000	328000	328000	1	0	20		344	98
Iron, filtered	2-W22-43	9593	38000	62	4	0	20		475	80
Lead	2-W10-8	340	340	340	1	0	5		336	40
Lead, filtered	2-W15-24	11.5	31	31	1	3	5		378	16
Lithium	2-W7-6	24.75	37	20	3	1	10		116	5
Lithium, filtered	2-W19-26	12	12	12	1	0	10		145	4
Magnesium	2-W19-19	108000	108000	108000	1	0		&	344	99
Magnesium, filtered	2-W19-19	105650	114000	97300	2	0		&	475	113
Manganese	2-W19-1	3010	3010	3010	1	0	5		344	76
Manganese, filtered	2-W15-8	680	680	680	1	0	5		475	46
Mercury	2-W11-7	0.54	0.54	0.54	1	0	0.1		342	3
Nickel	2-W7-9	311.75	880	49	4	0	10		344	57
Nickel, filtered	2-W9-1	85.67	330	15	7	2	10		474	19
Nitrate	@ 2-W19-19	1321666.67	1450000	1220000	18	0	200		1079	149
Nitrite	2-W23-9	1700	2400	1000	2	0	200		334	6
Phosphate	2-W19-24	7350	39700	39700	1	5	400		575	6
Potassium	2-W15-8	18500	25000	12000	2	0	300		344	99
Potassium, filtered	2-W15-8	12000	12000	12000	1	0		&	475	113

Table 4-1. Average Reported Constituent Concentrations/Maximums and Minimums --200 West Groundwater Aggregate Area (January 1988 to April 1992).

	Well-Specific Data						All Wells			
Constituent	Well Number	Average of Reported Values	Maximum of Detections	Minimum of Detections	Number of Detections	Number < D.L.	Min Reported D.L.	Min mark	Total Number of Analyses	Total Number of Wells with Detections
Selenium	2-W27-1	22	35	21	2	1	5		341	17
Selenium, filtered	2-W27-1	22.33	33	24	2	1	5		363	9
Silicon	2-W10-8	83100	83100	83100	1	0		&	116	45
Silicon, filtered	2-W19-24	25300	28500	22100	2	0		&	145	63
Silver, filtered	2-W18-22	14.375	25	25	1	7	10		475	1
Sodium	2-W15-4	258000	258000	258000	1	0		&	344	99
Sodium, filtered	2-W15-4	320500	372000	269000	2	0		&	475	113
Strontium	2-W19-26	1630	1630	1630	1	0		&	172	64
Strontium, filtered	2-W19-26	1690	1690	1690	1	0		&	312	90
Sulfate	2-W22-9	3500000	3500000	3500000	1	0	500		576	129
Titanium	2-W19-1	1370	1370	1370	1	0	60		116	7
Uranium, chemical	2-W19-18	3417.44	5760	814	18	0		&	468	105
Vanadium	2-W10-8	1140	1140	1140	1	0	5		344	80
Vanadium, filtered	2-W15-4	221	269	173	2	0	5		475	93
Zinc	2-W18-9	7380	7380	7380	1	0	5		344	83
Zinc, filtered	2-W19-25	298	429	167	2	0	5		475	80
MISCELLANEOUS CONSTITUENTS (ug/L) AND PARAMETERS										
Total dissolved solids	2-W19-26	1880000	1880000	1880000	1	0		&	30	29
Total organic carbon	2-W19-15	7736.25	27300	2310	2	2	100		1091	14
Total Organic Halogen, Low Det. Level	2-W15-16	4317.45	6870	96	33	0	-2		1073	88
Alkalinity	2-W10-9	167000	169000	165000	2	0		&	168	64
pH, Field Measurement	6-37-82A	9.89	9.98	9.8	2	0		&	1195	126
Conductivity, Laboratory	2-W19-20	2303.33	2310	2300	3	0		&	685	74
Specific conductance	2-W10-9	3659.4	13296	923	10	0		&	1189	126
Turbidity	2-W7-6	216.67	380	120	6	0		&	235	64
Coliform (Membrane Filter)	2-W8-1	42.5	84	84	1	1	1		44	4
Coliform bacteria	2-W15-15	4.3	16	16	1	5	1		219	5

Table 4-2. Comparison of Average Reported Concentrations of Selected Chemical Constituents for Shallow And Deep Portions of the Unconfined Aquifer.

Monitoring Well	2-W7-3	2-W7-1	2-W7-2	2-W10-14	2-W10-13	2-W15-6	2-W15-4	2-W14-5
Constituent	Deep	Shallow	Shallow	Deep	Shallow	Deep	Shallow	Shallow
ORGANIC COMPOUNDS (ug/l)								
Carbon Tetrachloride by GC					12.83		1960.00	630.00
Chloroform				5.20			17.50	6.67
1,1,1-trichloroethane					5.25			
Trichloroethylene							11.50	
RADIONUCLIDES (pCi/l)								
Gross alpha	1.16	0.89	1.20	1.13	0.55	1.05		
Zirconium/Nubidium-95								
Gross beta	5.59	4.44	4.51	4.48	6.41	4.33	9.34	32.75
Tritium					281.00		178500.00	4030.00
Potassium-40	155.00	144.00	230.00	188.00	158.00			
Cobalt-60	2.24	-0.37		-0.24	0.01			
Zinc-65								
Strontium-90						0.35		
Technetium-99		6.33	4.00		14.98		47.60	
Ruthenium-106				25.98	12.45			
Cesium-137					1.04			
Cerium/Promethium-144	29.30							
Radium	0.16	0.15	0.22	0.28	0.20			0.26
Uranium	0.99	0.51	0.72	0.62	0.71		3.61	0.59
Plutonium-239/40	0.00				0.01			
Americium-241		0.01						
INORGANIC COMPOUNDS (ug/l)								
Aluminum	194.43							266.00
Arsenic							20.00	
Arsenic, filtered							24.00	
Barium	39.20	30.22	32.67	67.78	30.30		39.00	43.00
Barium, filtered	37.20	30.33	31.56	65.67	29.80	42.00	53.00	63.67
Cadmium								
Chloride	4240.91	9327.00	4408.00	9024.00	24218.18	7400.00	16150.00	32113.33
Chromium	76.50	55.89	51.89	76.00	50.40			
Chromium, filtered		14.00	14.89	13.56	13.50			
Copper	14.20	14.00	15.67	16.00	15.30			
Copper, filtered	14.80	14.78		17.67	14.90			
Fluoride	510.00	502.00	516.00	507.00	493.64	500.00	11500.00	1877.50
Iron	816.70	244.22	376.11	342.22	275.30		112.00	1240.00
Iron, filtered	156.70	41.33	55.89	44.22	43.30	110.00	44.50	
Lead (graphite furnace)	5.40		5.25	5.56	5.73			
Lead, filtered								
Magnesium	11610.00	14566.67	14077.78	12255.56	12540.00		6680.00	8740.00
Magnesium, filtered	11590.00	14677.78	14166.67	12366.67	12290.00	8000.00	9825.00	16486.67
Manganese	142.20	15.44	13.11	12.78	10.30		11.00	17.00
Manganese, filtered	127.80	10.89		8.44	7.40	18.00	19.50	5.67
Nitrate	3441.82	39800.00	26110.00	19090.00	14985.45	6533.33	539250.00	107780.00
Selenium		6.70	6.22	6.50	6.45			
Selenium, filtered					6.45			
Silver, filtered								
Sulfate	24354.55	50000.00	28860.00	24790.00	27509.09	19000.00	38350.00	72766.67
Uranium, chemical	1.66	0.79	1.06	0.95	0.83	1.24		
Zinc	264.80	18.22	23.22	32.00	13.30			
Zinc, filtered	24.40	14.00	8.56	19.44	92.90			
MISCELLANEOUS PARAMETERS								
Coliform bacteria								

Table 4-3. Estimated Area and Mass of Plumes, 200 West Groundwater Aggregate Area. Page 1 of 2

INORGANIC AND ORGANIC COMPOUNDS:					Groundwater Volume (m^3)			
					Porosity (n) =			
Chemical Compound	Maximum Concentration (μg/L)	Monitoring Well	Bounding Contour Interval (μg/L)	Area (m^2)	n=0.1	n=0.2	n=0.3	Mass (kg)[a/]
Arsenic			10	330,000	330,000	650,000	980,000	8.9
Plume A	101	299-W10-8						
Plume B	20	299-W15-4						
Plume C	16	299-W19-21						
Chromium			0	490,000	490,000	980,000	1,470,000	102
Plume A	316	299-W22-20						
Plume B	142	299-W10-9						
Fluoride			4,000	83,000	83,000	166,000	250,000	880
Plume A	4,795	299-W10-9						
Plume B	11,500	299-W15-14						
Nitrate			45,000	12,000,000	12,000,000	2,300,000	3,500,000	3,200,000
Plume A	1,321,666	299-W19-19						
Carbon Tetrachloride			10	13,000,000	13,000,000	2,500,000	38,000,000	8,800
Plume A	6,997	299-W15-16						
Chloroform			7	3,500,000	3,500,000	7,100,000	10,600,000	240
Plume A	1,595	299-W15-8						
Plume B	9	299-W22-20						
Trichloroethylene			6	2,200,000	2,200,000	4,500,000	6,700,000	44
Plume A	32	299-W22-20						
Plume B	24	299-W10-4						

Table 4-3. Estimated Area and Mass of Plumes, 200 West Groundwater Aggregate Area. Page 2 of 2

RADIONUCLIDES: Chemical Compound	Maximum Activity (pCi/L)	Monitoring Well	Bounding Contour Interval pCi/L)	Area (m^2)	Groundwater Volume (m^3) Porosity (n) = n=0.1	n=0.2	n=0.3	Activity (Ci)[a/]
Gross Alpha			15	3,800,000	3,800,000	7,600,000	11,500,000	1.3
Plume A	50	299-W7-6						
Plume B	232	299-W11-14						
Plume C	40	299-W18-15						
Plume D	2,308	299-W19-18						
Gross Beta			50	3,400,000	3,400,000	6,900,000	10,300,000	2.1
Plume A	126	299-W11-14						
Plume B	3,272	299-W19-25						
Plume C	395	299-W23-7						
Tritium			20,000	11,200,000	11,200,000	22,000,000	34,000,000	7,300
Plume A	6,773,333	299-W22-9						
Plume B	178,000	299-W23-8						
Tc-99			900	1,320,000	1,320,000	2,600,000	4,000,000	9.1
Plume A	26,975	299-W23-2						
Plume B	2,761	299-W19-24						
I-129			1	6,200,000	6,200,000	12,400,000	18,600,000	0.080
Plume A	27	699-35-70						
Plume B	2	299-W11-14						
Uranium	1,130		40	670,000	670,000	1,340,000	2,000,000	0.24
Plume A	207	299-W19-18						
Plume B		299-W11-14						
Pu 239/240			1	160,000	160,000	320,000	480,000	
Plume A	8	299-W15-8						2.6E-03[b/]

a/ Mass is generally calculated by integrating the groundwater volume (n=0.2) times the concentration on a computer-interpolated grid and dividing by a conversion factor.

b/ Where computer-interpolated grids were not available, area is estimated graphically on maps, and mass calculated from area and average well concentration within plume.

WHC(200W-3)/8-19-92/03100T

Table 4-4. Summary of Waste-Producing Processes Potentially Contributing Contaminants to Groundwater Beneath the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Waste Disposal Methods	Waste Management Units Potentially Affecting Groundwater	Years In Service
U Plant Aggregate Area					
Uranium recovery	Process waste	Nitric acid, bismuth phosphate, NAOH	Crib, french drain, pond, ditch	216-U-1, 216-U-2, 216-U-10	1952 - 1958
	Wastewater	Nitrates	Crib, french drain, pond, ditch	216-U-1, 216-U-2, 216-U-10	1952 - 1958
UO_3 conversion	Wastewater	Nitrates	Pond, crib, ditch	216-U-10, 216-U-1, 216-U-2, 216-U-12	1944 - present
Solvent treatment	Spent solvents	Tributyl phosphate, normal paraffin hydrocarbons	Crib	various	1952 - 1958
	Carbonate scrub solution	Carbonate, tributyl phosphate, normal paraffin hydrocarbons	Crib	various	1952 - 1958
Analytical laboratory	Laboratory process waste	Unknown	Reverse well, french drain	216-U-4	1947 - 1972
	Used or discarded reagents	Unknown	Reverse well, french drain	216-U-4	1947 - 1972
	Wastewater	Unknown	Reverse well, french drain	216-U-4	1947 - 1972

Table 4-4. Summary of Waste-Producing Processes Potentially Contributing Contaminants to Groundwater Beneath the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Waste Disposal Methods	Waste Management Units Potentially Affecting Groundwater	Years In Service
Tank farm condensate	Wastewater	Unknown	French drain	None	1954 - 1957
		Z Plant Aggregate Area			
Plutonium Finishing Plant (PFP)	Process waste	Nitric acid, nitrate salts, fluoride	Cribs until 1973, tanks after 1973	216-Z-3, 216-Z-12	1949 - 1973 1985 - 1988
	Wastewater	Sodium, fluoride, sulfate	Ponds, ditches, seepage basin	216-U-10, 216-Z-21	1949 - 1973 1985 - 1988
RECUPLEX	Aqueous process waste	Nitric acid, fluorides, nitrates, phosphate	Ditch, pond	216-U-10	1955 - 1962
	Organic solvent waste	CCl_4, TBP, DBBP	Trench	216-Z-9	1955 - 1962
	Spent silica gel	Silica gel, Pu	French drain	216-Z-8	1955 - 1962
Plutonium Reclamation Facility (PRF)	Aqueous process waste	Nitric acid, fluorides, nitrates, phosphate	Crib, tile field	216-Z-1, 216-Z-2, 216-Z-1A, 216-Z-18	1964 - 1978 1984 - 1987
	Organic process waste	CCl_4, TBP, DBBP	Crib, tile field	216-Z-1, 216-Z-2, 216-Z-1A, 216-Z-18	1964 - 1978 1984 - 1987
Americium recovery	Spent ion exchange resin	^{241}Am, resin	Ditches, pond	216-U-10	1949 - 1959 1964 - 1976

Table 4-4. Summary of Waste-Producing Processes Potentially Contributing Contaminants to Groundwater Beneath the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Waste Disposal Methods	Waste Management Units Potentially Affecting Groundwater	Years In Service
Analytical laboratory	Laboratory process wastes	Unknown	Crib	216-Z-3, 216-Z-12	1955? - present
	Used or discarded reagents	Unknown	Crib	216-Z-3, 216-Z-12	1955 - present
	Wastewater	Sanitary and lab water	Crib	216-Z-3, 216-Z-12	1955 - present
Plutonium Isolation Facility (PIF)	Process waste	Nitric acid	Trench, crib, reverse well	216-Z-5, 216-Z-7 216-Z-10	1945 - 1949
	Wastewater	Unknown			
S Plant Aggregate Area					
Feed preparation	Jacket dissolution	Fission products, jacket constituents (alloy) sodium hydroxide, sodium aluminate	Tank	None	1951 - 1967
	Slug dissolution	Sodium hydroxide, ferrous sulfamate, zirconium, niobium	Tank	None	1951 - 1967
Extraction cycles	Aqueous process waste	Sodium aluminate, fission products, sodium hydroxide	Crib	Various	1951 - 1967
	Organic process waste	Hexone	Crib	Various	1951 - 1967
Solvent recovery	Aqueous waste	Sodium hydroxide, sodium carbonate	Crib	Various	1951 - 1967

Table 4-4. Summary of Waste-Producing Processes Potentially Contributing Contaminants to Groundwater Beneath the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Waste Disposal Methods	Waste Management Units Potentially Affecting Groundwater	Years In Service
Analytical laboratory	Laboratory waste	Sodium hydroxide, organics, fission products	Tank	None	1951 - present
		T Plant Aggregate Area			
Bismuth phosphate	Process waste	Nitric acid	Tank, crib, trench	Various	1944 - 1956
	Aqueous process waste	Phosphoric acid, nitrate solution, uranium, plutonium	Tank, crib, trench	Various	1944 - 1956
Lanthanum fluoride	Process waste	Plutonium, sodium bismuthate, phosphoric acid, nitric acid, hydrogen fluoride, lanthanum salts	Tank, crib, trench	Various	1944 - 1956
	Aqueous process waste	Plutonium, sodium bismuthate, phosphoric acid, nitric acid, hydrogen fluoride, lanthanum salts	Tank, crib, trench	Various	1944 - 1956
"Hot" Semi-Works	Aqueous process waste	Ammonium silico-fluoride	Tank, crib, trench	Various	1944 - 1956
Decontamination and equipment refurbishment	Wastewater	Bismuth phosphate	Crib	216-T-28	1944 - 1956

Table 4-4. Summary of Waste-Producing Processes Potentially Contributing Contaminants to Groundwater Beneath the 200 West Area.

Process	Waste Generated	Major Chemical Constituents	Waste Disposal Methods	Waste Management Units Potentially Affecting Groundwater	Years In Service
Containment Systems Test Facility (CSTF)	NA	NA	NA	NA	1964 - 1990
Analytical laboratory	Aqueous process waste	Sodium, lithium, sodium iodine	Crib	216-T-28	1944 - 1956
Analytical laboratory	Aqueous process waste	Cesium, manganese, zinc, lithium, sulfate, iodine and hydrogen iodine	Crib	216-T-28	1944 - 1956

NA = No information available.

Table 4-5. Candidate Contaminants of Potential Concern for the 200 West Groundwater Aggregate Area.

TRANSURANICS

Americium-241
Americium-242*
Americium-242m
Americium-243
Curium-242*
Curium-244
Curium-245
Neptunium-237
Neptunium-239
Plutonium-238
Plutonium-239
Plutonium-240
Plutonium-241

URANIUM

Uranium (total)
Uranium-233
Uranium-234
Uranium-235
Uranium-236
Uranium-238

FISSION PRODUCTS

Actinium-225
Actinium-227
Antimony-125
Antimony-126
Antimony-126m
Astatine-217*
Barium-133
Barium-137m
Beryllium-7*
Bismuth-210
Bismuth-211
Bismuth-213
Bismuth-214
Carbon-14
Cerium-144*
Cesium-134
Cesium-135
Cesium-137
Cobalt-60
Europium-154
Francium-221
Francium-223*
Iodine-129
Krypton-85
Lead-209
Lead-210
Lead-211
Lead-212
Lead-214
Nickel-59
Nickel-63
Polonium-214
Polonium-215*
Polonium-218
Potassium-40
Protactinium-231
Protactinium-233*
Protactinium-234*
Promethium-144*
Niobium-93m
Niobium-95*
Niobium-95m*
Palladium-107*
Polonium-210
Polonium-211*
Polonium-213*
Protactinium-234m*
Radium-223
Radium-225
Radium-226
Radium-228
Radon-219*
Radon-222
Rhodium-106
Ruthenium-106
Samarium-151
Selenium-79
Silver-110*
Silver-110m*
Strontium-89*
Strontium-90
Technetium-99
Thallium-207
Thorium-227
Thorium-229
Thorium-230
Thorium-231
Thorium-232
Thorium-234
Tin-126*
Tritium
Yttrium-90
Zinc-65*
Zirconium-93
Zirconium-95*

METALS

Aluminum
Barium
Beryllium
Cadmium
Chromium
Copper
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Nickel
Radium
Silver
Strontium
Titanium
Uranium
Vanadium
Zinc

OTHER INORGANICS

Ammonia
Ammonium nitrate
Arsenic
Boron
Calcium
Chloride
Cobalt
Cyanide
Ferrocyanide
Fluoride
Hydrofluoric acid
Nitrate
Nitrite
Nitric acid
Phosphate
Potassium
Selenium
Silica
Sodium
Sodium nitrite
Sodium aluminate
Sodium dichromate
Sodium metasilicate
Sodium hydroxide
Sodium nitrate
Sulfate
Sulfuric acid

9 2 1 2 6 1 0 4 4 3

Table 4-5. Candidate Contaminants of Potential Concern for the 200 West Groundwater Aggregate Area.

VOLATILE ORGANICS	SEMIVOLATILE ORGANICS	
Acetone	Aldrin	n-Nitrosodimethylamine
Carbon tetrachloride	gamma-BHC	Pentachlorophenol
Chloroform	Bis(2-ethylhexyl)phthalate	Phenol
Carbon disulfide	Bisphenol A	1,2-Propanediol
Dibutyl phosphate	2-Chlorophenol	Sodium oxalate
1,1-Dichloroethene	Cresols	2,4,5-Trichlorophenol
1,2-Dichloroethane	DDD	
Hexone (MIBK)	DDT	
Methylene chloride	Dibutyl butyl phosphonate	
Methyl isopropyl ketone	2,4-Dichlorophenol	
Tetrachloroethene	Dieldrin	
Toluene	2,4-Dimethylphenol	
Tributyl phosphate	Endrin	
1,1,1-Trichloroethane	Heptachlor	
Trichloroethene	Methyl isobutyl carbinol	
Xylenes		

* The radionuclide has a half-life of <1 year and, if it is a daughter product, the parent has a half-life of <1 year, and the buildup of the short-lived daughter would result in an activity of <1% of the parent radionuclide's initial activity.

9 2 1 2 6 0 1 0 4 4 4

Table 4-6. Contaminants of Potential Concern for the 200 West Groundwater Aggregate Area.

TRANSURANICS

Americium-241
Americium-242m
Americium-243
Curium-244
Curium-245
Neptunium-237
Neptunium-239
Plutonium-238
Plutonium-239
Plutonium-240
Plutonium-241

URANIUM

Uranium (total)
Uranium-233
Uranium-234
Uranium-235
Uranium-236
Uranium-238

FISSION PRODUCTS

Actinium-225
Actinium-227
Antimony-125
Antimony-126
Antimony-126m
Barium-133
Barium-137m
Bismuth-210
Bismuth-211
Bismuth-213
Bismuth-214
Carbon-14
Cesium-134
Cesium-135
Cesium-137
Cobalt-60
Europium-154
Francium-221
Iodine-129
Krypton-85
Lead-209
Lead-210
Lead-211
Lead-214
Nickel-59
Nickel-63
Niobium-93m
Polonium-210
Polonium-214
Polonium-218
Potassium-40
Protactinium-231
Radium-223
Radium-225
Radium-226
Radium-228
Radon-222
Rhodium-106
Ruthenium-106
Samarium-151
Selenium-79
Strontium-90
Technetium-99
Thallium-207
Thorium-227
Thorium-229
Thorium-230
Thorium-231
Thorium-232
Thorium-234
Tritium
Yttrium-90
Zirconium-93

METALS

Barium
Beryllium
Cadmium
Chromium
Copper
Lead
Manganese
Mercury
Nickel
Silver
Uranium
Vanadium
Zinc

OTHER INORGANICS

Ammonia
Ammonium nitrate
Arsenic
Boron
Cyanide
Ferrocyanide
Fluoride
Nitrate/Nitrite
Sulfuric acid

VOLATILE ORGANICS

Acetone
Carbon disulfide
Carbon tetrachloride
Chloroform
1,1-Dichloroethene
1,2-Dichloroethane
Hexone (MIBK)
Methylene chloride
Tetrachloroethene
Toluene
Tributyl phosphate
1,1,1-Trichloroethane
Trichloroethlene
Xylenes

SEMIVOLATILE ORGANICS

Aldrin
gamma-BHC
Bisphenol A
Bis(2-ethylhexyl)phthalate
2-Chlorophenol
Cresols
DDD
DDT
2,4-Dichlorophenol
Dieldrin
2,4-Dimethylphenol
Endrin
Heptachlor
n-Nitrosodimethylamine
Pentachlorophenol
Phenol
1,2-Propanediol
2,4,5-Trichlorophenol

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Table 4-7. Soil-Water Distribution Coefficients (K_d) for Candidate Radionuclides[a] and Inorganics of Potential Concern for the 200 West Groundwater Aggregate Area.

Element or Chemical	Range of K_d for Hanford Site Cantrell and Serne 1992 (Serne and Wood 1990) in mL/g	Probable K_d[b] Cantrell and Serne 1992 (Serne and Wood 1990) in mL/g	MEPAS Default K_d pH 6-9[c] (Strenge and Peterson 1989) in mL/g	Mobility Class
Actinium	–	–	228	Low
Aluminum	–	–	35,300	Low
Americium	(100 to 1,000) (<1 at pH 1-3)	(100)	82	Low
Ammonia	–	–	–	NA
Antimony	–	–	2	High
Arsenic	–	(0)	5.86	High
Barium	–	(50)	530	Moderate
Beryllium	–	–	70	Moderate
Bismuth	500-19,000	1,000	–	Low
Boron	–	–	0.19	High
Cadmium	–	(15)	14.9	Moderate
Calcium	–	(10)	70	Moderate
Carbon (^{14}C)	–	–	0	High
Cesium	500 to 1,000 (1 to 200 (acidic waste))	500	51	Low
Chloride	<1	0	–	High
Chromium (VI)	–	0	16.8	Moderate-High
Cobalt	1,000 to 10,000	2,000	1.9	Low
Copper	–	(15)	41.9	Moderate
Cyanide ion[d]	–	0.1	–	High[d]
Curium	(100 to >2,000)	(100)	82	Low
Fluoride	–	–	0	High
Francium	–	–	–	NA
Iodine	(<1)	0	0	High
Iron	–	(20)	15	Moderate
Krypton	–	–	0	High

9 2 1 2 6 1 0 4 4 6

Table 4-7. Soil-Water Distribution Coefficients (K_d) for Candidate Radionuclides[a/] and Inorganics of Potential Concern for the 200 West Groundwater Aggregate Area.

Element or Chemical	Range of K_{ds} for Hanford Site Cantrell and Serne 1992 (Serne and Wood 1990) in mL/g	Probable K_d[b/] Cantrell and Serne 1992 (Serne and Wood 1990) in mL/g	MEPAS Default K_d pH 6-9[c/] (Strenge and Peterson 1989) in mL/g	Mobility Class
Lead	–	(30)	234	Moderate
Lithium	–	–	0	High
Magnesium	–	–	70	Moderate
Manganese	–	(20)	16.5	Moderate
Mercury	–	–	322	Low
Neptunium	(<1 to 5)	(3)	3	High
Nickel	–	(15)	12.2	Moderate
Nitrate/nitric acid	–	–	0	High
Phosphate	20 to 100	50	50	Moderate
Plutonium	(100 to 1,000) (< 1 at pH 1 to 3)	(100)	10	Low
Polonium	–	–	5.9	Moderate
Potassium	–	–	0	High
Protactinium	–	–	0	High
Radium	–	(20)	24.3	Moderate
Radon	–	–	–	NA
Ruthenium	(20 to 700) (<2 at >1 M nitrate)	–	274	Low-Moderate
Samarium	–	(50)	228	Moderate
Selenium	–	(0)	5.91	High
Silica	–	–	5.0	High
Silver	–	(20)	0.4	Moderate
Strontium	5 to 100 0 to 20 (acidic conditions) (200 to 500 (w/phosphate or oxalate))	20	24.3	Moderate
Sulfate	–	(0)	0	High
Technetium	0 to 1	0	3	High
Thallium	–	–	0	High

9 2 1 2 6 7 1 0 4 4 7

Table 4-7. Soil-Water Distribution Coefficients (K_d) for Candidate Radionuclides[a] and Inorganics of Potential Concern for the 200 West Groundwater Aggregate Area.

Element or Chemical	Range of K_ds for Hanford Site Cantrell and Serne 1992 (Serne and Wood 1990) in mL/g	Probable K_d[b] Cantrell and Serne 1992 (Serne and Wood 1990) in mL/g	MEPAS Default K_d pH 6-9[c] (Strenge and Peterson 1989) in mL/g	Mobility Class
Thorium	–	(50)	100	Moderate
Titanium	–	–	–	NA
Tritium	0	0	0	High
Uranium	0 to 3	1	0	High
Yttrium	–	–	278	Low
Zinc	–	(15)	12.7	Moderate
Zirconium	–	(30)	50	Moderate

a/ Radionuclides with half-lives of greater than one year or short-lived products of long-lived precursors.
b/ Average K_ds for low salt and organic solutions with neutral pH.
c/ Default values for pH 6-9 and soil content of [clay + organic matter + metal oxyhydroxides] < 10% (Strenge and Peterson 1989).
d/ Cyanide mobility is highly dependent on identity of complexing agent. Simple cyanides (e.g., HCN) are more mobile than complex (e.g., metallic) cyanides.
– Value was not provided for this element in this reference.
NA K_d value was not provided from sources cited in this table.

Table 4-8. Physical/Chemical Properties of Candidate Organic Compounds of Potential Concern for the 200 West Groundwater Aggregate Area.

Compound	Molecular Weight in g/mole	Water Solubility in mg/L	Vapor Pressure in mm Hg	Henry's Law Constant in atm-m^3/mole	Soil/Organic Matter Partition Coef. K_{oc} in mL/g
Acetone	58	miscible	270	2.1×10^{-5}	2.2
Aldrin	365.0	0.18	6.0×10^{-6}	1.6×10^{-5}	9.6×10^{-4}
gamma-BHC (lindane)	290.8	7.8	1.6×10^{-4}	7.8×10^{-6}	1,100
Bis(2-ethylhexyl)phthalate	391	0.4	2.0×10^{-7}	4.4×10^{-7}	8.7×10^{4}
Bisphenol A	228.3	"insoluble" [a]	4.0×10^{-8} [a]	1.0×10^{-10} [a]	1,524 [a]
2-sec-Butyl-4,6-dinitrophenol (Dinoseb)	240.2	1.7	0.085[a]	5.0×10^{-4} [a]	124 [a]
2,6-Bis (1,1-dimethylethyl)-4-Methylphenol (BHT)	220.3	"insoluble" [a]	NA	NA	NA
Carbon disulfide	76.1	2,900	360	1.2×10^{-2}	5.4
Carbon tetrachloride	154.0	758	90	2.4×10^{-2}	110
Chloroform (trichloromethane)	119	8,200	150	2.9×10^{-3}	31
2-Chlorophenol	128.56	29,000	1.8	1.0×10^{-5}	73
Citrus red	308.34	NA	NA	NA	NA
Cresols (o-cresol)	108.15	31,000	0.24	1.1×10^{-6}	15
DDD	320	0.10	1.9×10^{-6}	8.0×10^{-6}	7.7×10^{5}
DDT	354.5	0.005	5.5×10^{-6}	5.1×10^{-4}	2.4×10^{5}
Dibutyl butyl phosphonate	250.36	"insoluble"[a]	8.6[a]	NA	NA
Dibutyl phosphate	210.21	"insoluble"[a]	1[a]	NA	NA
1,1-Dichloroethene	96.94	2,300	600	3.4×10^{-2}	65
1,2-Dichloroethane	98.96	8,500	64	9.8×10^{-4}	14
2,4-Dichlorophenol	163.0	4,600	0.059	2.8×10^{-6}	380
2,6-Dichlorophenol	163.0	320	0.090	6.6×10^{-5}	270
Dieldrin	380.95	0.19	1.8×10^{-7}	4.6×10^{-7}	1,700

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Table 4-8. Physical/Chemical Properties of Candidate Organic Compounds of Potential Concern for the 200 West Groundwater Aggregate Area.

Compound	Molecular Weight in g/mole	Water Solubility in mg/L	Vapor Pressure in mm Hg	Henry's Law Constant in atm-m^3/mole	Soil/Organic Matter Partition Coef. K_{oc} in mL/g
2,4-Dimethylphenol	122.16	590	0.026	1.8×10^{-5}	96
Endrin	380.89	0.2	2.7×10^{-7}	1.0×10^{-6}	11,000
Endrin aldehyde	380.89	0.25 a/	2.0×10^{-7} a/	2.9×10^{-9} a/	45,000 a/
Heptachlor	373.5	0.056	3.0×10^{-4}	2.9×10^{-3}	6,000
Hexone (4-methyl-2-pentanone,MIBK)	100.16	19,000	6	4.2×10^{-5}	19
Methylene chloride	84.9	20,000	360	2×10^{-3}	8.8
Methyl isobutyl carbinol	102.18	3,100 a/	1.1 a/	NA	NA
Methyl isopropyl ketone	86.1	NA	NA	NA	NA
o-Nitrophenol	139.11	10,800 a/	1.0	3.5×10^{-6}	65
n-Nitrosodimethylamine	102.14	93,000	5	7.9×10^{-6}	1.9
Pentachlorophenol	266.0	14	1.1×10^{-4}	2.8×10^{-6}	53,000
Phenol	94.11	93,000	0.34	4.5×10^{-7}	14
1,2-Propanediol	76.11	miscible a/	0.07 a/	1.2×10^{-8} a/	-0.92 a/
Sodium oxalate	134.01	NA	NA	NA	NA
Toluene	92.2	1,550 b/	28.4	6.4×10^{-3}	300
Tributyl phosphate	266.3	280	15	1.9×10^{-2}	6,000
1,1,1-Trichloroethane	133.41	1,500	120	1.4×10^{-2}	150
Trichloroethene	131.3	1,100	58	9.1×10^{-3}	130
2,4,5-Trichlorophenol	197.4	1,200	1.0	2.2×10^{-4}	89
Xylenes	106.2	200	10	7×10^{-3}	240

Sources: Strenge and Peterson 1989, except as noted in footnotes below.
a/ Values listed in Hazardous Substance Data Base (HSDB), National Library of Medicine database (HSDB 1991).
b/ Value from Banerjee et al. 1980
NA Value not available from above sources.

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Table 4-9. Radiological Properties of Candidate Radionuclides of Potential Concern for the 200 West Groundwater Aggregate Area. Page 1 of 3

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Radiation of Concern[b]
^{225}Ac	10 day	5.8×10^{4}	α
^{227}Ac	21.8 yr	7.2×10^{1}	β, α
^{110}Ag	24.6 sec	4.2×10^{9}	β
^{110m}Ag	249.85 day	4.7×10^{3}	β, γ
^{241}Am	432 yr	3.4×10^{0}	α
^{242}Am	16 hr	8.1×10^{5}	β
^{242m}Am	152 yr	9.7×10^{0}	α
^{243}Am	7,380 yr	2.0×10^{-1}	α
^{217}At	0.032 sec	1.6×10^{12}	α
^{133}Ba	10.5 yr	2.5×10^{2}	γ [c]
^{137m}Ba	53.4 day	3.5×10^{-5}	γ
^{7}Be	2.6 min	5.3×10^{8}	γ
^{210}Bi	5.01 day	1.2×10^{5}	β
^{211}Bi	2.13 min	4.2×10^{8}	α, β
^{213}Bi	45.6 min	1.9×10^{7}	β, α
^{214}Bi	19.9 min	4.4×10^{7}	β, γ
^{14}C	5,730 yr	4.5×10^{0}	β
^{144}Ce	284.9 day	3.2×10^{3}	β, γ[c]
^{242}Cm	163.2 day	3.3×10^{3}	α
^{244}Cm	18.1 yr	8.1×10^{1}	α
^{245}Cm	8,500 yr	1.7×10^{-1}	α, γ
^{60}Co	5.3 yr	1.1×10^{3}	γ
^{134}Cs	2.06 yr	1.3×10^{3}	γ
^{135}Cs	2.3×10^{6} yr	1.2×10^{-3}	β
^{137}Cs	30 yr	8.7×10^{1}	γ [c]
^{154}Eu	8.8 yr	2.7×10^{2}	β, γ [c]
^{221}Fr	4.8 min	1.8×10^{8}	α
^{223}Fr	21.8 min	3.9×10^{7}	β
^{3}H	12.3 yr	9.7×10^{3}	β
^{129}I	1.6×10^{7} yr	1.7×10^{-4}	β
^{40}K	1.3×10^{9} yr	6.7×10^{-6}	β, γ [c]
^{85}Kr	10.7 yr	3.9×10^{2}	β
^{93m}Nb	14.6 yr	2.8×10^{2}	γ [c]
^{95}Nb	34.97 day	3.9×10^{4}	β, γ
^{95m}Nb	90 hr	3.7×10^{5}	γ[c]
^{59}Ni	75,000 yr	7.6×10^{4}	γ [c]
^{63}Ni	100.1 yr	6.2×10^{1}	β
^{237}Np	2.14×10^{6} yr	7.0×10^{-4}	α, γ

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9 2 1 2 6 1 0 4 5 1

Table 4-9. Radiological Properties of Candidate Radionuclides of Potential Concern for the 200 West Groundwater Aggregate Area. Page 2 of 3

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Radiation of Concern[b]
^{239}Np	2.35 day	2.3×10^{5}	β
^{231}Pa	32,800 yr	4.7×10^{-2}	α
^{233}Pa	27 day	2.1×10^{4}	β, γ^{a}
^{234}Pa	6.8 hr	2.0×10^{-6}	β
^{234m}Pa	1.17 min	6.9×10^{8}	β
^{209}Pb	3.25 hr	4.5×10^{6}	β
^{210}Pb	22.3 yr	7.6×10^{1}	β
^{211}Pb	36.1 min	2.5×10^{7}	β
^{212}Pb	10.6 hr	1.4×10^{6}	β, γ^{a}
^{214}Pb	26.8 min	3.3×10^{7}	β, γ^{a}
^{107}Pd	6.5×10^{6} yr	5.1×10^{-4}	β
^{144}Pm	363 day	2.5×10^{3}	γ
^{210}Po	128 day	4.9×10^{3}	α
^{211}Po	0.52 sec	1.0×10^{11}	α, γ
^{213}Po	4.2×10^{-6} sec	1.3×10^{16}	α
^{214}Po	6×10^{-5} sec	8.8×10^{14}	α
^{215}Po	7.8×10^{-4} sec	2.9×10^{13}	α
^{218}Po	3.05 min	2.8×10^{8}	α
^{238}Pu	87.7 yr	1.7×10^{1}	α
^{239}Pu	24,400 yr	6.2×10^{-2}	α
^{240}Pu	6,560 yr	2.3×10^{-1}	α
^{241}Pu	14.4 yr	1.0×10^{2}	β
^{223}Ra	11.43 day	5.1×10^{4}	α
^{225}Ra	14.8 day	3.9×10^{4}	β
^{226}Ra	1,600 yr	9.9×10^{-1}	α
^{228}Ra	5.75 yr	2.3×10^{2}	β
^{187}Re	5×10^{10} yr	3.8×10^{8}	β
^{106}Rh	30 sec	3.5×10^{9}	β, γ
^{219}Rn	4.0 sec	1.3×10^{10}	α
^{222}Rn	3.8 day	1.5×10^{5}	α, γ
^{106}Ru	1.0 yr	3.4×10^{3}	β, γ^{a}
^{125}Sb	2.73 yr	1.0×10^{3}	β, γ^{a}
^{126}Sb	12.4 day	8.4×10^{4}	β, γ^{a}
^{126m}Sb	19 min	7.85×10^{7}	β, γ^{a}
^{79}Se	<65,000 yr	7.0×10^{-2}	β
^{151}Sm	90 yr	2.6×10^{1}	β
^{126}Sn	1×10^{5} yr	2.8×10^{-2}	γ
^{89}Sr	50.55 day	2.9×10^{4}	β, γ^{a}
^{90}Sr	28.5 yr	1.4×10^{2}	β

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9 2 1 2 6 1 0 4 5 2

Table 4-9. Radiological Properties of Candidate Radionuclides of Potential Concern for the 200 West Groundwater Aggregate Area. Page 3 of 3

Radionuclide	Half-Life	Specific Activity[a/] in Ci/g	Radiation of Concern[b/]
^{99}Tc	213,000 yr	1.7×10^{-2}	β
^{227}Th	18.7 day	3.1×10^{4}	α
^{229}Th	7,340 yr	2.1×10^{-1}	α
^{230}Th	77,000 yr	2.1×10^{-2}	α
^{231}Th	25.5 hr	5.3×10^{5}	β
^{232}Th	1.4×10^{10} yr	1.1×10^{-7}	α
^{234}Th	24.1 day	2.3×10^{-4}	β
^{207}Tl	4.77 min	1.9×10^{8}	β, γ
^{233}U	159,000 yr	9.7×10^{-3}	α
^{234}U	244,500 yr	6.2×10^{-3}	α
^{235}U	7.0×10^{8} yr	2.2×10^{-6}	α, γ
^{236}U	2.3×10^{7} yr	6.5×10^{-5}	α
^{238}U	4.5×10^{9} yr	3.4×10^{-7}	α
^{90}Y	6.41 hr	5.4×10^{5}	β
^{65}Zn	244 day	8.2×10^{3}	γ[c/]
^{95}Zr	64 day	2.1×10^{4}	β

a/ Source: DOE 1990.
b/ α - alpha decay; β - negative beta decay; γ - release of gamma rays.
c/ Gamma radiation due to daughter product activity.

Table 4-10. Relative Risks for Radionuclides of Potential Concern for the 200 West Groundwater Aggregate Area.

Radionuclide	Half-Life[a]	Air Unit Risk[b] in $(pCi/m^3)^{-1}$	Drinking Water Unit Risk[c] in $(pCi/L)^{-1}$	Soil Ingestion Unit Risk[d] in $(pCi/g)^{-1}$	External Exposure Unit Risk[e] in $(pCi/g)^{-1}$
^{225}Ac	10 day	1.2×10^{-3}	8.7×10^{-7}	4.6×10^{-8}	9.4×10^{-6}
^{227}Ac	21.8 yr	4.2×10^{-2}	1.8×10^{-5}	9.5×10^{-7}	1.3×10^{-7}
^{241}Am	433 yr	2.1×10^{-2}	1.6×10^{-5}	8.4×10^{-7}	1.6×10^{-5}
^{242m}Am	152 yr	NA	NA	NA	NA
^{243}Am	7,380 yr	2.1×10^{-2}	1.5×10^{-5}	8.1×10^{-7}	3.6×10^{-5}
^{133}Ba	10.5 yr	NA	NA	NA	NA
^{137m}Ba	2.6 min	3×10^{-10}	1.2×10^{-10}	6.5×10^{-12}	3.4×10^{-4}
^{210}Bi	5.01 day	4.1×10^{-5}	9.7×10^{-8}	5.1×10^{-9}	0
^{211}Bi	2.13 min	9.7×10^{-8}	6.1×10^{-10}	3.2×10^{-11}	2.8×10^{-5}
^{213}Bi	45.6 min	1.6×10^{-7}	1.2×10^{-8}	6.2×10^{-10}	8.1×10^{-5}
^{214}Bi	19.9 min	1.1×10^{-6}	7.2×10^{-9}	3.8×10^{-10}	8.0×10^{-4}
^{14}C	5,730 yr	3.2×10^{-9}	4.7×10^{-8}	2.5×10^{-9}	0
^{244}Cm	18.1 yr	1.4×10^{-2}	1.0×10^{-5}	5.4×10^{-7}	5.9×10^{-7}
^{245}Cm	8,500 yr	NA	NA	NA	NA
^{60}Co	5.3 yr	8.1×10^{-5}	7.8×10^{-7}	4.1×10^{-8}	1.3×10^{-3}
^{134}Cs	2.06 yr	1.4×10^{-5}	2.1×10^{-6}	1.1×10^{-7}	8.9×10^{-4}
^{135}Cs	2.3×10^{6} yr	1.4×10^{-6}	2.1×10^{-7}	1.1×10^{-8}	0
^{137}Cs	30 yr	9.6×10^{-6}	1.4×10^{-6}	7.6×10^{-8}	0
^{154}Eu	8.8 yr	7.2×10^{-5}	1.5×10^{-7}	8.1×10^{-9}	6.8×10^{-4}
^{221}Fr	4.8 min	4.7×10^{-7}	3.0×10^{-9}	1.6×10^{-10}	1.9×10^{-5}
^{3}H	12.3 yr	4.0×10^{-8}	2.8×10^{-9}	1.5×10^{-10}	0
^{129}I	1.6×10^{7} yr	6.1×10^{-5}	9.6×10^{-6}	5.1×10^{-7}	1.5×10^{-5}
^{40}K	1.3×10^{9} yr	4.0×10^{-6}	5.7×10^{-7}	3.0×10^{-8}	7.8×10^{-5}
^{85}Kr	10.7 yr	NA	NA	NA	NA
^{93m}Nb	14.6 yr	NA	NA	NA	NA
^{59}Ni	75,000 yr	3.5×10^{-7}	4.4×10^{-9}	2.3×10^{-10}	3.4×10^{-7}
^{63}Ni	100.1 yr	8.7×10^{-7}	1.2×10^{-8}	6.2×10^{-10}	0
^{237}Np	2.14×10^{6} yr	1.8×10^{-2}	1.4×10^{-5}	7.3×10^{-7}	1.8×10^{-5}

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Table 4-10. Relative Risks for Radionuclides of Potential Concern for the 200 West Groundwater Aggregate Area.

Radionuclide	Half-Life[a/]	Air Unit Risk[b/] in $(pCi/m^3)^{-1}$	Drinking Water Unit Risk[c/] in $(pCi/L)^{-1}$	Soil Ingestion Unit Risk[d/] in $(pCi/g)^{-1}$	External Exposure Unit Risk[e/] in $(pCi/g)^{-1}$
^{239}Np	2.35 day	7.7×10^{-7}	4.8×10^{-8}	2.5×10^{-9}	1.1×10^{-4}
^{231}Pa	32,800 yr	2.0×10^{-2}	9.7×10^{-6}	5.1×10^{-7}	2.0×10^{-5}
^{209}Pb	3.25 hr	3.6×10^{-8}	4.3×10^{-9}	2.3×10^{-10}	0
^{210}Pb	22.3 yr	8.7×10^{-4}	3.4×10^{-5}	1.8×10^{-6}	1.8×10^{-6}
^{211}Pb	36.1 min	1.5×10^{-6}	9.2×10^{-9}	4.9×10^{-10}	2.9×10^{-5}
^{214}Pb	26.8 min	1.5×10^{-6}	9.2×10^{-9}	4.9×10^{-10}	1.5×10^{-4}
^{210}Po	128 day	8.7×10^{-4}	3.4×10^{-5}	1.8×10^{-6}	1.8×10^{-6}
^{214}Po	6×10^{-5} sec	1.4×10^{-13}	5.1×10^{-16}	2.7×10^{-17}	4.7×10^{-8}
^{215}Po	7.8×10^{-4} sec	2.9×10^{-12}	1.4×10^{-14}	7.6×10^{-16}	8.7×10^{-8}
^{218}Po	3.05 min	3.0×10^{-7}	1.4×10^{-9}	7.6×10^{-11}	0
^{238}Pu	87.7 yr	2.1×10^{-2}	1.4×10^{-5}	7.6×10^{-7}	5.9×10^{-7}
^{239}Pu	24,400 yr	2.6×10^{-2}	1.6×10^{-5}	8.4×10^{-8}	2.6×10^{-7}
^{239}Pu oxide	24,400 yr	2.6×10^{-2}	1.6×10^{-6}	8.4×10^{-8}	2.6×10^{-7}
^{240}Pu	6,560 yr	2.1×10^{-2}	1.6×10^{-5}	8.4×10^{-8}	5.9×10^{-7}
^{240}Pu oxide	6,560 yr	2.1×10^{-2}	1.6×10^{-6}	8.4×10^{-8}	5.9×10^{-7}
^{241}Pu	14.4 yr	1.5×10^{-4}	2.5×10^{-7}	1.3×10^{-8}	0
^{223}Ra	11.4 day	1.6×10^{-3}	4.1×10^{-6}	2.2×10^{-7}	8.4×10^{-5}
^{225}Ra	14.8 day	8.2×10^{-4}	3.4×10^{-6}	1.8×10^{-7}	8.0×10^{-6}
^{226}Ra	1,600 yr	1.5×10^{-3}	6.1×10^{-6}	3.2×10^{-7}	4.1×10^{-6}
^{228}Ra	5.75 yr	3.4×10^{-4}	5.1×10^{-6}	2.7×10^{-7}	5.6×10^{-13}
^{106}Rh	30 sec	NA	NA	NA	NA
^{222}Rn	3.8 day	3.7×10^{-7}	NA	NA	2.2×10^{-7}
^{106}Ru	1.0 yr	2.3×10^{-4}	4.9×10^{-7}	2.6×10^{-8}	0
^{125}Sb	2.73 yr	NA	NA	NA	NA
^{126m}Sb	19 min	NA	NA	NA	NA
^{79}Se	<65,000 yr	NA	NA	NA	NA
^{151}Sm	90 yr	NA	NA	NA	NA
^{90}Sr	28.5 yr	2.8×10^{-5}	1.7×10^{-6}	8.9×10^{-8}	0

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Table 4-10. Relative Risks for Radionuclides of Potential Concern for the 200 West Groundwater Aggregate Area.

Radionuclide	Half-Life[a/]	Air Unit Risk[b/] in $(pCi/m^3)^{-1}$	Drinking Water Unit Risk[c/] in $(pCi/L)^{-1}$	Soil Ingestion Unit Risk[d/] in $(pCi/g)^{-1}$	External Exposure Unit Risk[e/] in $(pCi/g)^{-1}$
^{99}Tc	213,000 yr	4.2×10^{-6}	6.6×10^{-8}	3.5×10^{-9}	3.4×10^{-10}
^{227}Th	18.72 day	2.5×10^{-3}	2.5×10^{-7}	1.3×10^{-8}	6.6×10^{-6}
^{229}Th	7,340 yr	3.9×10^{-2}	2.0×10^{-6}	1.1×10^{-7}	5.8×10^{-5}
^{230}Th	77,000 yr	1.6×10^{-2}	1.2×10^{-6}	6.5×10^{-8}	5.9×10^{-7}
^{231}Th	25.5 hr	2.5×10^{-7}	2.0×10^{-8}	1.1×10^{-9}	1.1×10^{-5}
^{232}Th	1.4×10^{10} yr	1.6×10^{-2}	1.1×10^{-6}	5.9×10^{-8}	4.5×10^{-7}
^{234}Th	24.1 day	1.6×10^{-5}	2.0×10^{-7}	1.1×10^{-8}	5.6×10^{-6}
^{207}Tl	4.77 min	2.3×10^{-9}	6.6×10^{-10}	3.5×10^{-11}	1.2×10^{-6}
^{233}U	159,000 yr	1.4×10^{-2}	7.2×10^{-6}	3.8×10^{-7}	3.2×10^{-7}
^{234}U	244,500 yr	1.4×10^{-2}	7.2×10^{-6}	3.8×10^{-7}	5.6×10^{-7}
^{235}U	7.0×10^{8} yr	1.3×10^{-2}	6.6×10^{-6}	3.5×10^{-7}	9.7×10^{-5}
^{236}U	2.3×10^{7} yr	NA	NA	NA	NA
^{238}U	4.5×10^{9} yr	1.2×10^{-2}	6.6×10^{-6}	3.5×10^{-7}	4.5×10^{-7}
^{90}Y	64.1 hr	2.8×10^{-6}	1.6×10^{-7}	8.6×10^{-9}	0
^{93}Zr	1.53×10^{6} yr	NA	NA	NA	NA

a/ Source: DOE 1990
b/ Excess cancer risk associated with lifetime exposure to 1 pCi/m^3 (10^{-12} curies) per day in air (EPA 1991a).
c/ Excess cancer risk associated with lifetime exposure to 1 pCi (10^{-12} curies) per day in drinking water (EPA 1991a).
d/ Excess cancer risk associated with lifetime exposure to 1 pCi/g (10^{-12} curies/g) per day in soil (EPA 1991a).
e/ Excess cancer risk associated with lifetime exposure to surface soils containing 1 pCi/g of gamma-emitting radionuclides (EPA 1991a).

NA No information available.

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Table 4-11. Potential Chronic Health Effects on Candidate Chemicals of Potential Concern for the 200 West Groundwater Aggregate Area. Page 1 or 4

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a/]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route
INORGANIC CHEMICALS		
Aluminum	--	--
Ammonia	--	decreased pulmonary function; degrades odor; taste of water
Ammonium nitrate	(see ammonia and nitrate)	(see ammonia and nitrate)
Arsenic	respiratory tract [A]; skin [A]	--; keratosis, hyperpigmentation
Barium	--	fetotoxicity; increased blood pressure
Beryllium	lung [B2]; total tumors [B2]	none observed
Boron	--	--; testicular lesions
Cadmium	respiratory tract [B1]; --	cancer; renal damage
Calcium	--	--
Chloride	--	--
Chromium	lung [A] - Cr(VI) only; --	Nasal mucosa atrophy (Cr(III) and (VI)); hepatotoxicity (Cr (III)
Cobalt	--	--
Copper	--	--; gastrointestinal irritation
Cyanide	--	--; weight loss, thyroid effects, myelin degeneration
Ferrocyanide	(see cyanide)	(see cyanide)
Fluoride	--	--; dental fluorosis at high levels
Iron	--	--
Lead	[B2][c/]; [B2]	central nervous system (CNS) effects[c/]; CNS effects
Lithium	--	--
Magnesium	--	--
Manganese	--	respiratory, psychomotor symptoms; no effect
Mercury	--	neurotoxicity; kidney effects

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Table 4-11. Potential Chronic Health Effects on Candidate Chemicals of Potential Concern for the 200 West Groundwater Aggregate Area. Page 2 or 4

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a/]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route
Nickel	respiratory tract [A]; --	cancer; reduced weight gain
Nitrate/Nitrite	--	--; methemoglobinemia in infants[d/]
Nitric acid	(see nitrate)	(see nitrate)
Phosphate	--	--
Potassium	--	--
Selenium	--	--
Silica	--	--
Silver	--	--; argyria
Sodium	--	--
Sodium aluminate	(see sodium and aluminum)	(see sodium and aluminum)
Sodium dichromate	(see sodium and chromium(VI))	(see sodium and chromium(VI))
Sodium metasilicate	(see sodium and silica)	(see sodium and silica)
Sodium hydroxide	--	--
Sodium nitrate	(see sodium and nitrate)	(see sodium and nitrate)
Sodium nitrite	(see sodium and nitrite)	(see sodium and nitrite)
Sulfate	--	--
Sulfuric acid	--	respiratory; --
Strontium	--	--
Titanium	--	--
Uranium (soluble salts)	--	--; body weight loss, nephrotoxicity
Vanadium	--	--; none observed
Zinc	--	--; anemia
ORGANIC CHEMICALS		
Acetone	--	--; kidney and liver effects
Aldrin	liver [B2]; liver [B2]	--; liver toxicity

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Table 4-11. Potential Chronic Health Effects on Candidate Chemicals of Potential Concern for the 200 West Groundwater Aggregate Area. Page 3 or 4

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route
gamma-BHC	--; liver [B2]	--; liver, kidney toxicity
Bis(2-ethylhexyl)phthalate	-- [B2]; liver [B2]	--; increased liver weight
Bisphenol A	--	--; reduced body weight
Carbon disulfide	--	fetal toxicity; fetal toxicity
Carbon tetrachloride	liver [B2]; liver [B2]	--; liver lesions
Chloroform	liver [B2]; kidney [B2]	--; liver lesions
2-Chlorophenol	--	--; reproductive effects
Citrus red	--	--
Cresols	[C] [c]	--; lowered body weight, neurotoxicity
DDD	[B2]; liver [B2]	--
DDT	liver [B2]; liver [B2]	--; liver lesions
Dibutyl butyl phosphonate	--	--
Dibutyl phosphate	--	--; respiratory irritation[b]
1,2-Dichloroethane	circulatory system [B2]; circulatory system [B2]	--
1,1-Dichloroethene	kidney [C]; adrenal pheochromocytoma [C]	--; liver lesions
2,6-Dichlorophenol	--	--
2,4-Dichlorophenol	--	--; delayed hypersensitivity response
Dieldrin	liver [B2]; liver [B2]	--; liver lesions
2,4-Dimethylphenol	--	--; behavioral, blood changes
Endrin	--	--; liver effects, convulsions
Endrin aldehyde	--	--
Heptachlor	liver [B2]; liver[B2]	--; increased liver weight
Hexone (4-methyl-2-pentanone, MIBK)	--	liver, kidney effects; liver, kidney effects
Methylene chloride	lung, liver [B2]; liver [B2]	--; liver toxicity

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Table 4-11. Potential Chronic Health Effects on Candidate Chemicals of Potential Concern for the 200 West Groundwater Aggregate Area. Page 4 or 4

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route
Methyl isobutyl carbinol	--	--
Methyl isopropyl ketone	--	--
o-nitrophenol	--	--
n-Nitrosodimethylamine	liver [B2]; liver [B2]	--
Pentachlorophenol	--; hemangiosarcoma, liver [B2]	--; liver, kidney effects
Phenol	--	--; fetal body weight
1,2-Propanediol	--	central nervous system; liver, kidney effects
Sodium oxalate	--	--
Tetrachloroethene	leukemia, liver [B2]; liver [B2]	--; hepatotoxicity
Toluene	--	CNS effects, eye irritation; change in liver and kidney weights
Tributyl phosphate	--	respiratory irritant; kidney damage[b]
1,1,1-Trichloroethane	--	liver toxicity; liver toxicity
Trichloroethylene	lung [B2]; liver [B2]	--
2,4,5-Trichlorophenol	--	--; liver, kidney effects
Xylenes	--	liver effects; hyperactivity, lowered body weight, increased mortality

[a] Weight of Evidence Groups for carcinogens: A - Human carcinogen (sufficient evidence of carcinogenicity in humans); B -Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of data in humans); C - Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data); D - Not Classifiable as to Human Carcinogenicity (inadequate or no evidence).

[b] Verified toxicity information was not available from EPA 1991 or 1992. Toxicity information was obtained from EPA Registry of Toxic Effects of Chemical Systems (RTECS). A blank space means that no information was available from the above sources.

[c] Lead is considered by EPA to have both neurotoxic and carcinogenic effects; however, no toxicity criteria are available for lead at the present time.

[d] Toxic effect is considered to occur from exposure to nitrite; nitrate can be converted to nitrite in the body by intestinal bacteria.

[e] Carcinogenicity evaluation has been withdrawn by EPA 1992 for review.

-- No information available.

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5.0 GROUNDWATER CONTAMINANT SCREENING AND PRIORITIZATION

This preliminary qualitative evaluation of groundwater contaminants is intended to provide input to the 200 West Area recommendation process (Section 9.0). That process requires evaluation of groundwater contaminants and contaminant plumes in the context of their near and long-term significance to human health and the environment.

The approach that has been taken in this evaluation of 200 West Area groundwater contaminants is as follows:

- Contaminants of potential concern are identified within the 200 West Area. As discussed in Section 4.2, contaminants of potential concern were selected from the list of candidate contaminants of potential concern presented in Table 4-6. The subset of those contaminants that were detected in the unconfined aquifer beneath the 200 West Area during 1989 and 1990 are listed in Table 5-1.

- Relative-significance rankings are developed for the currently measured groundwater contaminant concentrations, and the contaminant concentrations projected to occur offsite following transport within the Hanford unconfined aquifer.

- The relative-significance rankings for collocated contaminants are combined, as appropriate, to construct overall significance rankings for contaminant plumes or portions of plumes within the groundwater. These overall rankings are used, in conjunction with other factors, to identify regions of the contaminated aquifer for the review and possible redefinition of groundwater operable units.

In the data evaluation process presented in Section 9.0, "higher" priority sites are evaluated for the potential implementation of an interim remedial measure (IRM). "Lower" priority sites are evaluated to determine what type of additional investigation is necessary to establish a final remedy. Further detail is presented in Section 9.0.

The data used for this evaluation of contaminant significance based on human health considerations are presented in the earlier sections of this report. The types of data that have been assessed include site histories and physical descriptions (Section 2.0), descriptions of the physical environment of the study area (Section 3.0) and a summary of the available chemical and radiological data for the 200 West Area aquifer (Section 4.0).

The quality and sufficiency of these data are assessed in Section 8.0. This information is also used to identify applicable or relevant and appropriate requirements (ARARs) (Section 6.0).

5.1 CONCEPTUAL FRAMEWORK FOR RISK-BASED SCREENING

The range of potential human health exposure pathways associated with the 200 West Area groundwater was summarized in Section 4.2. The U.S. Environmental Protection Agency (EPA; 1989b) considers a human exposure pathway to consist of four elements: (1) a source and mechanism for contaminant release; (2) a retention or transport medium (or media); (3) a point of potential human contact; and (4) an exposure route (e.g., ingestion) at the contact point. The probability of the existence of a particular pathway is dependent upon the physical and institutional controls affecting site access and use. In the absence of site access controls and other land use restrictions, the identified potential exposure pathways can all occur. For example, it can be hypothesized that an individual may establish a residence within the boundaries of the Hanford Site, drill a well and withdraw contaminated water for drinking water and crop irrigation. However, within the five- to ten-year period of interest associated with identification and prioritization of remedial actions associated with the 200 West Area, unrestricted access and ability to drill a well have a negligible probability of occurrence. Until future land use of the Hanford Site is defined, U.S. Department of Energy (DOE) policy is that the Hanford Site will remain under DOE management, which includes control over beneficial use of the land and any uses of groundwater at least until the year 2018 as agreed upon in the Tri-Party Agreement.

Public exposure to groundwater contaminants can also occur following contaminant transport through the unconfined aquifer to offsite locations. The distances separating current 200 West Area groundwater plumes from offsite locations are significant.

To provide input to the prioritization of remediation actions for the 200 West Area, groundwater contaminants were evaluated on the basis of: (1) their currently measured levels and; (2) their theoretical levels estimated to occur offsite following transport through the unconfined aquifer. It is important to note that this contaminant screening process does not evaluate potential risks associated with the Hanford Site and potential exposure to contaminated groundwater. Rather, the screening, on a consistent semiquantitative basis, evaluates the various contaminants in the aquifer and potential future contaminant concentrations offsite, for their relative intrinsic significance to human health. This screening process does not consider, nor suggest for consideration, any specific scenario for exposure to groundwater contaminants. Formal quantitative evaluations of potential human health risks will ultimately be conducted in accordance with the M-29 milestone report, *Hanford Site Baseline Risk Assessment Methodology* (DOE/RL 1991c).

5.2 SCREENING PROCESS

The objective of the 200 West Area groundwater contaminant screening process is to provide risk-based input to the process of: (1) establishing groundwater remedial action priorities; and (2) defining groundwater "operable units" that focus and ensure the

effectiveness of remedial actions. This risk-based input consists of relative-significance rankings developed for the currently measured groundwater contaminant concentrations, and the contaminant concentrations projected to occur offsite following transport within the Hanford unconfined aquifer.

The Multimedia Environmental Pollutant Assessment System (MEPAS), developed by the Pacific Northwest Laboratory (PNL), was used to calculate semiquantitative indices of contaminant relative-risk significance. These relative-risk indices integrate the various contaminant characteristics (toxicity, mobility, persistence, quantity, etc.) into a single prioritization value, thereby providing comprehensive input to the recommendation process. The MEPAS computer software is an enhanced version of the Remedial Action Priority System (RAPS) (Whelan et al. 1987).

5.2.1 Multimedia Environmental Pollutant Assessment System

The MEPAS is a computer-based system developed for the U.S. Department of Energy's Office of Environmental, Safety and Health to provide a management tool for assistance in prioritizing environmental restoration funding and resource allocations. It uses empirical, analytical, and semi-analytical mathematical algorithms and pathway analyses to estimate the following processes:

- Potential release of contaminants into the environment
- Transport of contaminants through and between four major environmental transport elements: groundwater, surface water, overland flow, and atmosphere
- Exposure to surrounding human populations (i.e., food chain considerations, inhalation, ingestion, dermal contact, and external dose)
- Human health effects associated with exposure to chemicals and radionuclides.

Detailed descriptions of the MEPAS formulations are given in Droppo et al. (1989) and Whelan et al. (1987) as well as comparisons with the EPA's HRS, and the MHRS developed by PNL. MEPAS was developed to calculate semiquantitative indices of health risks associated with long-term (hundreds to thousands of years) environmental conditions resulting from the release of contaminants from a hazardous waste site. Potential health impacts are evaluated for multiple, sequential 70-yr exposure increments, with average concentrations defined for each increment.

The MEPAS groundwater component computes (or takes as input) contaminant concentrations at wells and calculates solute fluxes from the groundwater environment to the

surface water environment. The groundwater pathway solution algorithms are based on Green's functions (Whelan et al. 1987).

The MEPAS is capable of addressing nontidal rivers and wetlands. A three-dimensional, steady-state, vertically integrated mass balance equation for contaminant transport in a river environment (where longitudinal advection dominates longitudinal dispersion) forms the basis for the river water solution algorithm (Codell et al. 1982). Contaminants released into a river are transported through the system by the processes of advection and dispersion, with dispersion being considered in both the lateral and vertical directions.

Overland flow is that portion of precipitation that ultimately appears as flowing water on the ground surface. The driving mechanism transporting contaminants through the overland pathway is this overland flow. Estimation techniques for the overland pathway are based on the curve number technique of the U.S. Department of Agriculture's Soil Conservation Service (SCS 1972, 1982). The overland transport pathway can interact with the surface water pathway or directly supply the exposure component with contaminant levels.

The MEPAS atmospheric component considers release mechanisms and characteristics, dilution and transport, washout by cloud droplets and precipitation, and deposition on the underlying surface cover. The prediction of contaminant movement through the atmospheric pathway therefore involves modeling components that address atmospheric suspension/emission, transport, diffusion, and deposition. Contaminant transport is assumed to occur fast enough to allow chemical transformations to be neglected. Atmospheric transport and dispersion are computed in terms of sector-averaged values using Gaussian dispersion principles. Deposition is calculated as the sum of wet and dry deposition.

The results from each of the four transport pathways are used in the exposure assessment component of MEPAS to calculate the hazard potential for each contaminant. The exposure assessment component considers potential exposure of the surrounding population through the following exposure routes:

- Dermal contact with chemicals
- External dose from radiation
- Inhalation of airborne contaminants
- Ingestion of contaminated drinking water, soil, crops, animal products, and aquatic foods.

Based on the air, water, and soil contaminant levels provided by the transport pathway analyses, an estimate is made of the average daily human exposure to each contaminant. The daily exposure rate is next converted to an average individual relative health risk index (RRI) using mathematical models for radionuclides, carcinogenic chemicals, and noncarcinogenic chemicals. Some chemicals have both carcinogenic and toxic effects and are therefore considered in both categories. The RRI indicates the level of potential health impact to an average member of the exposed population. For radionuclides, the RRI is based on cancer risk estimates of the National Academy of Sciences Committee on Biological Effects of Ionizing Radiation (NAS 1980). The risks from chemical carcinogens are based on cancer potency factors defined by the EPA (1982). For noncarcinogens, RRIs represent the ratio of estimated dose to reference dose multiplied by 1×10^{-6}. Due to their chemical nature, constituents such as 1,1-dichloroethane, beryllium, cadmium, chromium, and nickel are considered both as carcinogens and toxic noncarcinogens.

The MEPAS also provides a database of standardized values for many nonsite-specific parameters, including all chemical-specific values and the soil-water distribution coefficient (K_d) (Strenge and Peterson 1989). The values contained in this database were used in the relative-risk computations, with a few exceptions. The Cancer Potency Factors (CPF) for carcinogenic chemicals and the Reference Doses (RfD) for noncarcinogenic chemicals are often updated by EPA. Due to these updates, the values in the MEPAS database were reviewed and the following changes were made:

- **1,1,1-Trichloroethane.** The MEPAS database classifies this chemical as a carcinogen, however, EPA does not. Therefore, the chemical was flagged as a noncarcinogen in the MEPAS database.

- **Trichloroethylene.** The EPA retracted the oral CPF, so the MEPAS database does not present a value for this parameter. However, the Health Effects and Assessment Summary Tables (HEAST) provide a value of 1.7E-02 $(mg/kg/day)^{-1}$, which was entered into the database.

- **Lead.** The EPA has retracted the RfDs for lead which, therefore, should not be used in this assessment. While the MEPAS database currently includes the old values, the relative risk from this chemical is discussed qualitatively.

- **Uranium.** The oral and inhalation RfDs in MEPAS are based on an inhalation Threshold Limit Value (TLV) based on negative findings in an occupational study. This value is questionable and was not used. However, a proposed maximum contaminant level (MCL) has been derived, based on an RfD of 3.0E-03 mg/kg/day (Federal Register, Vol 56, No 138, Thursday July 18, 1991). This value has instead been used for the oral toxicity value of uranium.

- **Aluminum, boron, cobalt, magnesium, sulfate, and zinc.** The oral and inhalation RfDs in MEPAS are based on an inhalation TLV, based on negative findings in an occupational study. Since the EPA has not developed exposure criteria for the chemicals, the relative risk will not be quantified.

As described in Section 4.2.4.3, the soil-water distribution coefficient, K_d, is used to predict the mobility of inorganic contaminants in groundwater. The default K_d values contained in the MEPAS data libraries were not used in the ranking of groundwater contaminants. Instead, the values for K_d contained in column three of Table 4-7 were used with preference given to values provided by Cantrell and Serne (1992) when available.

5.2.2 Evaluation of Current Plumes

For the evaluation of current concentrations of groundwater contaminants, unit concentrations (i.e., 1 pCi/L, 1 μg/L) of the contaminants listed in Table 5-1 were input to MEPAS. The constituents evaluated represent the subset of contaminants of potential concern from Table 4-6 that were detected in samples of 200 West Area groundwater collected during January 1988 through April 1992. Contaminants of potential concern that were not detected, or were only detected in a single sample during this period, are not included. For each of the contaminant unit concentrations, MEPAS calculated unit RRI values to allow the MEPAS computer evaluation to be run only once, rather than separately for each well with detections. Because there are no interactions among the effects of the various contaminants in the MEPAS model, it was possible to combine their impacts mathematically for each well using unit RRI values multiplied by the concentrations at the well and summed for all the constituents detected at that well. The unit RRI values represent semiquantitative measures of relative human health risk, with carcinogenic risk normalized to a level of 10^{-6}.

The calculated unit RRI values are combined with the database of measured 200 West Area groundwater concentrations for the individual contaminants, resulting in a GIS database of contaminant RRI values. Contaminant RRI data for both chemical and radiological carcinogens are combined to produce total RRI values for the unconfined aquifer and plotted to allow visual identification and ranking. Noncarcinogenic contaminant RRI values are summed and plotted separately.

5.2.3 Potential Future Offsite Contaminant Levels

The second screening evaluation examined potential future offsite concentrations of contaminants that may result from 200 West Area groundwater contaminant transport and discharge into the Columbia River. The calculations were based on present measured concentrations and plume volumes that were combined to estimate the inventory of

contaminants within the unconfined aquifer. These calculations could only be performed for contaminants with sufficient detection data to enable estimation of plume volume and contaminant inventory. The contaminants addressed in this second screening evaluation were ^{129}I, $^{239/240}Pu$, ^{99}Tc, ^{3}H (tritium), arsenic, carbon tetrachloride, chloroform, trichloroethylene, chromium, fluoride, nitrate, and total elemental uranium (^{234}U, ^{235}U, and ^{238}U).

The MEPAS was used to calculate contaminant transport within the aquifer and discharge into the river, as described in Section 5.2.1. The resulting RRI values, based on potential offsite concentrations, provide a secondary relative ranking of 200 West Area groundwater contaminants.

5.3 SUMMARY OF SCREENING RESULTS

As described in the preceding sections, the MEPAS computer code was used to evaluate the contaminants detected in groundwater beneath the 200 West Area, and generate relative significance rankings for (1) the currently measured contaminant concentrations; and (2) contaminant concentrations projected to occur offsite following transport within the Hanford unconfined aquifer. While these relative significance rankings are based on human health risk considerations, the screening process did not evaluate potential risks associated with the Hanford Site or potential exposure to contaminated groundwater. Rather, the screening process provided a consistent semiquantitative evaluation of the various contaminants for their relative intrinsic significance to human health.

The ranking values described in the sections that follow provide risk-related bases for prioritizing plume-specific or contaminant-specific remedial actions. The role of these risk-related values in the overall recommendation process is described in Section 9.0.

5.3.1 Current Plumes

The unit RRI values for the evaluation of current plumes, calculated as described in Section 5.2.2, are listed in Table 5-2. The unit RRI values were multiplied by the concentration in the groundwater at a well (and by a constant to adjust units) to give the RRI for that constituent at that point. The maximum value of this constituent RRI value in the 200 West Area is also shown in Table 5-2. The RRI values are also serially ranked in Table 5-2 from 1 (for highest RRI) to 25 (for lowest), with 23 as the maximum rank (lowest RRI) for noncarcinogens. Some ranks were repeated because of ties, where RRI values are essentially the same (differences of less than 5%). Also, some detections were considered questionable and were therefore not ranked, as indicated on Table 5-2 by the notation "NR."

The calculated constituent RRI values have been combined for chemical and radiological carcinogens and separately for chemical noncarcinogens to produce a total

The calculated constituent RRI values have been combined for chemical and radiological carcinogens and separately for chemical noncarcinogens to produce a total carcinogenic contaminant RRI and a total noncarcinogenic contaminant RRI for each well. The total RRI values were then contoured and plotted to allow visual identification and ranking. Plates 4 and 5 depict contours of the carcinogenic RRI and the noncarcinogenic RRI for the 200 West Area, respectively.

The carcinogenic RRI plume depicted in Plate 4 exhibits a central region of RRIs with values of 1,000 and greater. The RRI values in this region, which covers the north-central and west-central portions of the 200 West Area and extends toward the southeast, are mainly attributable to a limited number of groundwater contaminants. This area central to the 200 West Area is directly attributable to the carbon tetrachloride plume (Figure 4-5) with secondary, but very localized, contributions from arsenic (Plumes A and B), chloroform, and ^{99}Tc (Figures 4-4, 4-6 and 4-11). This area has several portions of even higher (> 10,000) values.

The region of high RRI values (greater than 1,000) also extends (across a narrow isthmus in the vicinity of the U Tank Farm) eastward into the vicinity of U Plant and further, beyond the eastern boundary of 200 West Area. Here the RRI is attributable to the uranium plume shown in Figure 4-13. The ^{99}Tc plume (Figure 4-11) also contributes to the RRI values in this area, but to a lesser extent as well as some isolated carbon tetrachloride values. The portions of the region of RRI value greater than 1,000 shown in the vicinity of the REDOX (S) Plant and directly east across the 200 West Area boundary are directly attributable to the tritium plume (Figure 4-10). Another branch, centered over the 216-U-10 Pond, is mainly associated with arsenic.

The noncarcinogenic RRI plume depicted in Plate 5 exhibits two large regions of RRI values greater than 10. The first, located in the north-central region of the 200 West Area at the western extent of the T Plant Aggregate Area, is primarily attributable to the fluoride plume (Figure 4-3) with a lesser contribution from the nitrate plume (Figure 4-4) and isolated detections of chromium, cyanide, and TCA. The second region with RRI values greater than 10 covers the eastern third of the U Plant Aggregate Area, and extends to the east beyond the 200 West Area boundary. The RRI in this region is attributable to both the nitrate and uranium (chemical) plumes (Figures 4-4 and 4-13 respectively) with contributions from isolated detections of fluoride, cyanide, chromium, cadmium, and strontium.

5.3.2 Potential Future Offsite Contaminant Levels

The RRI values for the evaluation of potential future offsite contaminant levels were calculated as described in Section 5.2.3. The input parameters used for the evaluation are provided in Appendix A. The results of these computations are listed in Table 5-3 for each contaminant of concern evaluated. The RRIs were only computed for contaminants of

noncarcinogens). Several contaminants resulted in RRI values of zero, based on their low mobility characteristics (these are noted in Table 5-3 by a ranking of "L"). The RRI values for the remaining contaminants ranged from 6E-26 to 2E-06, with nitrate, fluoride, and chromium ranking the highest.

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Table 5-1. Contaminants Evaluated Based on Current Plume Contaminant Levels.

Organics
Methylene Chloride
Chloroform
Carbon Tetrachloride (CCl4)
1,2-dichloroethane (DCA)
1,1-dichloroethylene (DCE)
1,1,1-trichloroethane (TCA)
Trichloroethylene (TCE)
Tetrachloroethylene (PCE)
Toluene
Xylene-o,p
Phenol
2-chlorophenol
2,4-dichlorophenol
2,6-dichlorophenol
2,4,5-Trichlorophenol
Pentachlorophenol (PCP)
2,4-dimethylphenol
2-sec-butyl-4,6-dinitrophenol
Acetone
Methyl ethyl ketone (MEK)
4-Methyl-2-Pentanone
Aldrin
DDD
DDT
Dieldrin
Endrin
Gamma-BHC
Heptachlor
Bis(2-ethylhexyl) phthalate
Carbon disulfide
Cresols
N-nitrosodimethylamine

Radionuclides
Tritium (H-3)
Beryllium-7
Carbon-14
Potassium-40
Cobalt-60
Nickel-63
Zinc-65
Strontium-90
Zirconium/Niobium-95
Technetium-99
Ruthenium-106
Antimony-125
Iodine-129
Cesium-137
Cerium/Praseodymium-144
Europium-154
Lead-212
Radium
Uranium-234
Uranium-235
Uranium-238
Plutonium-238
Plutonium-239/40
Americium-241

Inorganics
Aluminum
Arsenic
Barium
Beryllium
Boron
Cadmium
Chromium
Cobalt
Copper
Cyanide
Fluoride
Iron
Lithium
Magnesium
Manganese
Mercury
Nickel
Nitrate
Potassium
Selenium
Silver
Sodium
Strontium
Sulfate
Uranium, chemical
Vanadium
Zinc

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Table 5-2. Unit RRIs Computed for Current Plume Contaminant Levels.

Constituents	Unit RRI	Maximum Groundwater Concentration	Maximum RRI	Ranking
Radionuclides		(pCi/L)		
Tritium (H-3)	1.3E-03	5080001	6600	5
Beryllium-7	2.4E-03	17.65	0.042	NR[b/]
Carbon-14	5.5E-01	12.4883	6.9	21
Potassium-40	2.0E+00	476	950	8
Cobalt-60	6.4E-01	12.5667	8.0	20
Nickel-63	1.8E-02	9.18	0.17	23
Zinc-65	1.7E+00	10.4	18	NR[b/]
Strontium-90	7.0E+00	21.95	150	15
Zirconium/Niobium-95	5.1E-02	24.3	1.2	NR[b/]
Technetium-99	5.8E-01	26601.6	15400	2
Ruthenium-106	5.9E-01	35.5333	21	18
Silver-110 Metastable	NA	5.38	NA	NR[b/]
Antimony-125	7.0E-02	9.50667	0.67	NR[b/]
Iodine-129	1.5E+01	29.4933	440	12
Cesium-137	2.1E+00	5.215	11	19
Cerium/Praseodymium-144	4.4E-01	31	14	NR[b/]
Europium-154	2.2E-01	24.9	5.5	NR[b/]
Lead-212	2.9E-01	6.28	1.8	22
Radium (as Ra-226)	3.6E+01	6.42	230	13
Uranium-234	6.1E+00	1605	9800	3[a/]
Uranium-235	5.9E+00	102	600	9[a/]
Uranium-238	5.6E+00	1730	9700	3[a/]
Plutonium-238	8.7E+01	8.9706	780	NR[b/]
Plutonium-239/240	9.8E+01	5.085	500	11
Americium-241	1.0E+02	5.9	590	9[a]

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Table 5-2. Unit RRIs Computed for Current Plume Contaminant Levels.

Constituents	Unit RRI	Maximum Groundwater Concentration	Maximum RRI	Ranking
Chemical Carcinogens		ug/L		
Methylene Chloride	3.8E-01	562	210	14
Chloroform	1.1E+00	1595	1800	7
Carbon Tetrachloride	8.0E+00	6559	52500	1
1,2-dichloroethane	1.0E+01	7.75	78	16
1,1-dichloroethylene	3.7E+01	8.6	320	NR[b/]
Trichloroethylene	8.4E-01	32.2	27	17
Tetrachloroethylene	3.8E-01	5	1.9	NR[b/]
Aldrin	3.7E+03	1.8	6700	NR[b/]
DDD	1.7E+01	0.33	5.6	NR[b/]
DDT	3.9E+01	4.3	170	NR[b/]
Dieldrin	2.1E+03	3.9	8200	NR[b/]
Heptachlor	3.6E+02	1.7	610	NR[b/]
Bis(2-ethylhexyl) phthalate	3.1E+03	64	200000	NR[b/]
N-nitrosodimethylamine	2.5E+05	27	6.8E+06	NR[b/]
Arsenic, filtered	9.3E+01	24	2200	6
Chemical Noncarcinogens				
1,1,1-trichloroethane	3.4E+00	5.3	1.8E+01	4[a/]
Toluene	3.8E-04	9	3.4E-03	NR[b/]
Xylene-o,p	1.4E-04	5.2	7.2E-04	NR[b/]
Phenol	6.4E-04	11.7	7.5E-03	23
2-chlorophenol	3.4E-02	22.5	7.7E-01	NR[b/]
2,4-dichlorophenol	3.2E-02	17.5	5.6E-01	NR[b/]
2,6-dichlorophenol	1.1E-02	23	2.5E-01	NR[b/]
2,4,5-Trichlorophenol	6.2E-04	5	3.1E-03	NR[b/]
Pentachlorophenol	6.3E+00	75	4.7E+02	NR[b/]
2,4-dimethylphenol	5.1E-03	26	1.3E-01	NR[b/]

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Table 5-2. Unit RRIs Computed for Current Plume Contaminant Levels.

Constituents	Unit RRI	Maximum Groundwater Concentration	Maximum RRI	Ranking
2-sec-butyl-4,6-dinitrophenol	4.9E-02	5.3	2.6E-01	18
Aceton	1.1E-03	57.2	6.3E-02	22
Methyl ethyl ketone	6.4E-03	33.2	2.1E-01	NR[b/]
4-Methyl-2-Pentanone	1.7E-02	6	1.0E-01	NR[b/]
Endrin	1.2E-01	4.6	5.5E-01	NR[b/]
Gamma-BHC	2.8E-01	1.7	4.8E-01	NR[b/]
Carbon disulfide	1.7E-02	39	6.6E-01	NR[b/]
Cresols	4.7E-03	15.5	7.3E-02	NR[b/]
Aluminum	3.4E-02	233.5	7.9E+00	7
Barium	9.3E-04	410	3.8E-01	14
Beryllium	1.9E+02	4.7	8.9E+02	NR[b/]
Boron	9.9E-04	73	7.2E-02	21
Cadmium	3.0E-01	4.9	1.5E+00	NR[b/]
Chromium	1.0E-02	322.6	3.2E+00	8
Cobalt	6.1E-03	21.5	1.3E-01	NR[b/]
Copper	3.4E-03	25.3	8.6E-02	20
Cyanide	1.7E-01	49.5	8.4E+00	6
Fluoride	1.6E-03	11500	1.8E+01	4[a/]
Iron	4.6E-05	9593	4.4E-01	13
Lithium	4.7E-05	12	5.6E-04	25
Magnesium	2.7E-06	105650	2.9E-01	16[a/]
Manganese	2.5E-04	680	1.7E-01	19
Mercury	1.6E+00	0.54	8.6E-01	NR[b/]
Nickel	3.3E-03	85.7	2.8E-01	16[a/]
Nitrate	4.4E-05	1321667	5.8E+01	1
Potassium	4.3E-07	12000	5.2E-03	24
Selenium	2.0E+00	22.3	4.5E+01	3

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Table 5-2. Unit RRIs Computed for Current Plume Contaminant Levels.

Constituents	Unit RRI	Maximum Groundwater Concentration	Maximum RRI	Ranking
Silver	7.7E-2	14.4	1.1E+00	NR[b/]
Strontium	6.3E-04	1690	1.1E+00	12
Sulfate	6.2E-07	3500000	2.2E+00	9
Uranium, chemical	1.5E-02	3417	5.1E+01	2
Vanadium	7.2E-03	221	1.6E+00	11
Zinc	5.8E-03	298	1.7E+00	10

a/ Same rankings are repeated due to a tie in maximum relative risk index.
b/ NR = not ranked because of questionable detection.

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Table 5-3. Contaminants Evaluated for Future Offsite Plume Contaminant Levels.

Constituent	RRI	Ranking[a/]
Radionuclides		**Carcinogens**
Iodine-129	1.1E-11	3
Plutonium-239/240	0.0E+00	L
Technetium-99	9.5E-11	1
Tritium	2.4E-12	4
Uranium-234	0.0E+00	L
Uranium-235	0.0E+00	L
Uranium-238	0.0E+00	L
Chemical Carcinogens		
Arsenic	1.6E-11	2
Carbon tetrachloride	6.9E-21	6
Chloroform	9.3E-18	5
Trichloroethylene	5.9E-26	7
Chemical Noncarcinogens		**Noncarcinogens**
Chromium	3.1E-08	3
Fluoride	3.3E-08	2
Nitrate	2.0E-06	1
Uranium	0.0E+00	L

a/ Ranking is from 1 for the highest to 7 (carcinogens) or 4 (noncarcinogens) for the lowest RRIs that could be calculated. L=lower than was calculable by MEPAS.

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6.0 POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

6.1 INTRODUCTION

The Superfund Amendments and Reauthorization Act (SARA) of 1986 amended the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to require that all applicable or relevant and appropriate requirements (ARARs) be employed during implementation of a hazardous waste site cleanup. "Applicable" requirements are defined by the U.S. Environmental Protection Agency (EPA) in "CERCLA Compliance with Other Laws Manual" (OSWER Directive 9234.1-01, August 8, 1988) as:

> cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

A separate set of "relevant and appropriate" requirements that must be evaluated include:

> cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

"To-be-Considered Materials" (TBCs) are nonpromulgated advisories or guidance issued by federal or state governments that are not legally binding and do not have the status of potential ARARs. However, in many circumstances, TBCs will be considered along with potential ARARs and may be used in determining the necessary level of cleanup for protection of health or the environment.

The following sections identify potential ARARs to be used in developing and assessing various remedial action alternatives at the 200 West Groundwater Aggregate Area. Specific requirements pertaining to hazardous and radiological waste management, remediation of contaminated soils, surface water protection, and air quality will be discussed.

The potential ARARs focus on federal or state statutes, regulations, criteria, and guidelines. The specific types of potential ARARs evaluated include the following:

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- Contaminant-specific
- Location-specific
- Action-specific.

Potential contaminant-specific ARARs are usually health or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical contaminant values that are generally recognized by the regulatory agencies as allowable to protect human health and the environment. In the case of the 200 West Groundwater Aggregate Area, potential contaminant-specific ARARs address chemical constituents and/or radionuclides. The potential contaminant-specific ARARs that were evaluated for the 200 West Groundwater Aggregate Area are discussed in Section 6.2.

Potential location-specific ARARs are restrictions placed on the concentration of hazardous substances, or the conduct of activities, solely because they occur in specific locations. The potential location-specific ARARs that were evaluated for the 200 West Groundwater Aggregate Area are discussed in Section 6.3.

Potential action-specific ARARs apply to particular remediation methods and technologies, and are evaluated during the detailed screening and evaluation of remediation alternatives. The potential action-specific ARARs that were evaluated for the 200 West Groundwater Aggregate Area are discussed in Section 6.4.

The TBC requirements are other federal and state criteria, advisories, and regulatory guidance that are not promulgated regulations, but are to be considered in evaluating alternatives. Potential TBCs include U.S. Department of Energy (DOE) Orders that carry out authority granted under the Atomic Energy Act. All DOE Orders are potentially applicable to operations at the 200 West Groundwater Aggregate Area. Specific potential TBC requirements are discussed in Section 6.5.

Potential contaminant- and location-specific ARARs will be refined during the aggregate area management study (AAMS) process. Potential action-specific ARARs are briefly discussed in this section, and will be further evaluated upon final selection of remedial alternatives. The points at which these potential ARARs must be achieved and the timing of the ARARs evaluations are discussed in Sections 6.6 and 6.7, respectively.

6.2 CONTAMINANT-SPECIFIC REQUIREMENTS

A contaminant-specific requirement sets concentration limits in various environmental media for specific hazardous substances, pollutants, or contaminants. Based on available

information, some of the currently known or suspected contaminants that may be present in the 200 West Groundwater Aggregate Area are outlined in Table 4-6. The currently identified potential federal and state contaminant-specific ARARs are summarized below.

6.2.1 Federal Requirements

Federal contaminant-specific requirements are specified in several statutes, codified in the U.S. Code (USC), and promulgated in the Code of Federal Regulations (CFR), as follows:

- **Safe Drinking Water Act (42 U.S.C. 30.0 (f)).** Drinking water criteria are established by EPA pursuant to the federal Safe Drinking Water Act (SDWA) (42 U.S.C. 30.0 (f)) and are promulgated in 40 CFR Parts 141 and 143. These regulations present water quality standards (contaminant levels) for water used for drinking, cooking, bathing, and similar uses. Maximum contaminant levels (MCLs) are enforceable for public water systems, usually at the point of water usage. Secondary maximum contaminant levels (SMCLs) are established for contaminants in drinking water that may adversely affect odor, color, or public welfare. Maximum contaminant level goals (MCLGs) are non-enforceable, health-based goals that do not take cost or feasibility into account. The EPA may consider MCLGs where multiple exposure pathways exist, highly sensitive populations are involved, or a greater degree of protection is otherwise required.

  Currently, the EPA applies MCLs as potential ARARs for groundwater contaminants at CERCLA sites where groundwater could be used as a drinking water source. The federal MCLs and SMCLs are presented in Table 6-1 for the potential contaminants of interest. The MCLGs have not been included as potential ARARs because they are not enforceable, their application would be subject to negotiation with the agencies, and their application would depend on the remedial alternatives being considered.

- **Resource Conservation and Recovery Act (42 U.S.C. 6901, 40 CFR 260 to 271).** The Resource Conservation and Recovery Act (RCRA) addresses the generation and transportation of hazardous waste, and waste management activities at facilities that treat, store, or dispose of hazardous wastes. Subtitle C of RCRA (Hazardous Waste Management) mandates the creation of a cradle-to-grave management and permitting system for hazardous wastes. The RCRA defines hazardous wastes (40 CFR 261) as "solid wastes" (even though the waste is often liquid in physical form) that may cause or significantly contribute to an increase in mortality or serious illness; or that

poses a substantial hazard to human health or the environment when improperly managed. In Washington State, RCRA is implemented by EPA and the authorized state agency, the Washington State Department of Ecology (Ecology).

The CERCLA sections 121 (d) and 121 (e) respectively require that CERCLA activities, including remedial actions, comply with substantive requirements and not administrative requirements such as permitting. Therefore, hazardous waste activities conducted on site at the 200 West Groundwater Aggregate Area will comply with the substantive requirements of RCRA, and not the permitting requirements of RCRA, which are deemed to be potential ARARs.

Two key potential contaminant-specific ARARs have been adopted under the federal hazardous waste regulations: the Toxicity Characteristic Leaching Procedure (TCLP) designation limits promulgated under 40 CFR Part 261; and the hazardous waste land disposal restrictions (LDRs) for constituent concentrations promulgated under 40 CFR Part 268.

The TCLP designation limits define when a waste is hazardous, and are used to determine when more stringent management standards apply than would be applied to typical solid wastes. Thus, the TCLP potential contaminant-specific ARARs can be used to determine when RCRA waste management standards may be required. The TCLP limits are presented in Table 6-1.

The LDRs are numerical limits derived by EPA by reviewing available technologies for treating hazardous wastes. Until a prohibited waste can meet the numerical limits, it can be prohibited from land disposal. Two sets of limits have been promulgated: limits for constituent concentrations in waste extract, which use the TCLP test to obtain a leached sample of the waste; and limits for constituent concentrations in waste, which address the total contaminant concentration in the waste. The latter concentrations are generally applied to wastewaters (e.g., groundwater, leachate). Applicability to CERCLA actions is based on determinations of waste "placement/disposal" during a remediation action. According to OSWER Directive 9347.3-05FS, EPA concludes that Congress did not intend in situ consolidation, remediations, or improvement of structural stability to constitute placement or disposal. The land disposal numerical limits can be used to determine if generated cleanup wastes can be redisposed of onsite without further treatment, or must be subject to certain treatment practices prior to land disposal. The LDR limits are presented in Table 6-1 (see Section 6.4.1 for a further discussion on applying the land disposal restriction limits).

- **Clean Air Act (42 U.S.C. 7401).** The Clean Air Act (42 U.S.C. 7401) establishes National Primary and Secondary Ambient Air Quality Standards (NAAQS) (40 CFR Part 50), National Emission Standards for Hazardous Air Pollutants (NESHAP)(40 CFR Part 61), and New Source Performance Standards (NSPS)(40 CFR Part 60). These standards would not, in most cases, be potential contaminant-specific ARARs for the 200 West Groundwater Aggregate Area. However, it is possible that unique circumstances, or instances where groundwater remediation alternatives result in emissions to air, could require consideration of air quality standards as potential contaminant-specific ARARs. The applicability or relevance and appropriateness of potential air quality ARARs in such situations would be subject to negotiation with the agencies and may depend on the remedial alternatives being considered.

  In general, new and modified stationary sources of air emissions must undergo a pre-construction review to determine whether the construction or modification of any source, such as a CERCLA remedial program, would interfere with attaining or maintaining NAAQS or fail to meet other new source review requirements including NESHAP and NSPS. However, the process applies only to "major" sources of air emissions (defined as emissions of 250 tons/yr). The 200 West Groundwater Aggregate Area would not constitute a major source.

  Section 112 of the Clean Air Act directs EPA to establish standards at the level that provides an ample margin of safety to protect the public health from hazardous air pollutants. The NESHAP standards for radionuclides are directly applicable to DOE facilities under Subpart H of Section 112 that establishes a 10 mrem/yr standard for total exposure to an offsite receptor. Further, if the maximum individual dose during remediation exceeds 1% of the NESHAP standard (0.1 mrem/yr), a report meeting the substantive requirements of an application for approval of construction must be prepared.

6.2.2 State of Washington Requirements

Potential state contaminant-specific requirements are specified in several statutes, codified in the Revised Code of Washington (RCW) and promulgated in the Washington Administrative Code (WAC).

- **Water Quality Standards.** Washington State has adopted various numerical standards under the state Water Pollution Control Act (Chapter 90.48 RCW)

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related to surface and groundwater contaminants. These are included principally in the following regulations:

- **Public Water Supplies (Chapter 248-54 WAC).** This regulation establishes drinking water standards for public water supplies. The standards essentially parallel the federal drinking water standards (40 CFR Parts 141 and 143).

- **Water Quality Standards for Ground Waters of the State of Washington (RCW 90.44, Chapter 173-200 WAC).** This regulation establishes contaminant standards for protecting existing and future beneficial uses of groundwater through the reduction or elimination of the discharge of contaminants to the state's groundwater.

The state drinking water quality standards would be evaluated as potential ARARs in essentially the same manner as the federal drinking water standards would be considered. Because the numerical standards are identical for both federal and state contaminants, the state drinking water standards are already addressed in Table 6-1 under the federal MCL and SMCL columns.

The state groundwater standards are not applicable to cleanup actions approved by Ecology under Washington's Model Toxics Control Act (MTCA) or by EPA under CERCLA [(WAC 173-200-010(3)(c)]. Groundwater cleanup standards are to be developed under MTCA procedures (see Section 6.2.2.2 for a discussion of these procedures). Nevertheless, the state groundwater standards may be considered relevant and appropriate as potential ARARs for contaminants in groundwater (e.g., where no other potential ARARs exist for particular constituents) and for selected remedial actions that could result in discharges to groundwater (e.g., if treated wastewaters are discharged to the soil column). Determining ARARs for treated discharges would depend on the type of remediation performed and would have to be established on a case-by-case basis as remedial actions are defined.

- **Model Toxics Control Act (RCW 70.105D, Chapter 173-340 WAC).** The MTCA (RCW 70.105D, Chapter 173-340 WAC) (Ecology 1991) authorized Ecology to adopt cleanup standards for remedial actions at hazardous waste sites. These regulations are considered potential ARARs for soil, groundwater, and surface water cleanup actions. The processes for identifying, investigating, and cleaning up hazardous waste sites are defined and cleanup standards are set for groundwater, soil, surface water, and air in Chapter 173-340 WAC.

Under MTCA regulations, cleanup standards may be established by one of three methods:

- Method A may be used if a routine cleanup action, as defined in WAC 173-340-200, is being conducted at the site or relatively few hazardous substances are involved for which cleanup standards have been specified by Tables 1, 2, or 3 of WAC 173-340-720 through 173-340-745.

- Under Method B, a risk level of 10^{-6} is established and a risk calculation based on contaminants present is determined.

- Method C cleanup standards represent concentrations that are protective of human health and the environment for specified site uses. Method C cleanup standards may be established where it can be demonstrated that such standards comply with applicable state and federal laws, that all practical methods of treatment are used, that institutional controls are implemented, and that one of the following conditions exist: (1) Method A or Method B standards are below background concentrations; (2) Method A or Method B results in a significantly greater threat to human health or the environment; (3) Method A or Method B standards are below technically possible concentrations; or (4) the site is defined as an industrial site for purposes of remediation.

Table 1 of Method A addresses groundwater and is considered to be a potential ARAR for the 200 West Groundwater Aggregate Area. Table 2 of Method A is intended for nonindustrial site soil cleanups and Table 3 of Method A is intended for industrial site soil cleanups. Since soil cleanup is being addressed in other source unit aggregate area management study reports (AAMSRs), Table 6-1 presents as potential ARARs only the cleanup standards from Table 1 of Method A for preliminary contaminants of concern.

In addition to Method A, Method B and Method C cleanup standards may also be considered potential ARARs for the 200 West Groundwater Aggregate Area. Method B and Method C cleanup standards can be calculated on a case-by-case basis in concert with Ecology. Method B and Method C should be used where Method A standards do not exist or cannot be met, or where routine cleanup actions cannot be implemented at a specific contaminated site.

- **State Hazardous Waste Management Act and Dangerous Waste Regulations (Chapter 173-303 WAC).** The state of Washington is a RCRA-authorized state for hazardous waste management, and has developed state-

specific hazardous waste regulations under the authority of the State Hazardous Waste Management Act. Generally, state hazardous waste regulations (WAC 173-303) parallel the federal regulations. The state definition of a hazardous waste incorporates the EPA designation of hazardous waste that is based on the compound being specifically listed as hazardous, or on the waste exhibiting the properties of reactivity, ignitability, corrosivity, or toxicity as determined by the TCLP.

In addition, Washington State identifies other waste as hazardous. Three unique criteria are established: toxic dangerous waste; persistent dangerous waste; and carcinogenic dangerous waste. These additional designation criteria may be identified by Ecology as potential ARARs, for purposes of determining acceptable cleanup standards and appropriate waste management standards.

- **Washington State Air Quality Requirements.** Washington State air quality standards would not, in most cases, be potential contaminant-specific ARARs for the 200 West Groundwater Aggregate Area. However, it is possible that unique circumstances, or instances where groundwater remediation alternatives result in emissions to air, could require consideration of air quality standards as potential contaminant-specific ARARs. The applicability or relevance and appropriateness of potential air quality ARARs in such situations would be subject to negotiation with the agencies and may depend on the remedial alternatives being considered.

  Ambient Air Quality Standards and Emission Limits for Radionuclides (Chapter 173-480 WAC), implemented by Ecology, specify maximum accumulated dose limits to members of the public. Monitoring and Enforcement of Air Quality and Emission Standards for Radionuclides (WAC 246-247), implemented by the Washington Department of Health (Health), adopt the Ecology standards for maximum accumulated dose limits to members of the public. Controls for New Sources of Toxic Air Pollutants (Chapter 173-460 WAC), implemented by Ecology, establish allowable acceptable source impact levels (ASILs) for hundreds of organic and inorganic compounds. Ecology's ASILs may be potential ARARs for cleanup activities that could affect air, but they would have to be established on a case-by-case basis as remedial actions are defined.

6.2.3 Surface Water Quality Standards

This section describes federal and state contaminant-specific requirements that generally apply only to surface water contaminants. These standards are discussed because the agencies may rely on them as potential ARARs if the following:

- 200 West Groundwater Aggregate Area groundwater is discharging or will be discharged to surface waters (e.g., Columbia River)

- No other potential contaminant-specific ARARs for protection of human consumption are readily identifiable from groundwater requirements for particular contaminants.

The applicability or relevance and appropriateness of potential surface water ARARs will be subject to negotiation with the agencies and may depend on the remedial alternatives being considered.

- **Clean Water Act.** Federal Water Quality Criteria (FWQC) are developed under the authority of the Clean Water Act to assist the states in protecting surface water quality. Different FWQC are derived for protection of human health and protection of aquatic life. The human health FWQC are subdivided according to how people are expected to use the water: drinking the water and consuming aquatic organisms (e.g., fish, clams) living in the water; or consuming the organisms and not drinking the water. The aquatic life FWQC are subdivided into saltwater and freshwater, and further subdivided into criteria for protecting against acute and chronic effects in aquatic organisms.

  Section 121(d)(2)(B)(i) of SARA states that the designated or potential use of the surface or groundwater, the environmental media affected, the purposes for which the criteria were developed, and the latest available information must be considered when determining whether or not water quality criteria under the Clean Water Act are relevant and appropriate under the circumstances of a release or threatened release. Thus, although the FWQC may be considered as potential ARARs at the 200 West Groundwater Aggregate Area, they will likely be subject to negotiation with the agencies and may depend on the remedial alternatives being considered.

- **National Pollutant Discharge Elimination System and Water Quality Standards (RCW 90.48, WAC 173-220, and 40 CFR 122).** National Pollutant Discharge Elimination System (NPDES) regulations govern point source discharges into navigable waters. Limits on the concentrations of contaminants and volumetric flowrates that may be discharged are determined

on a case-by-case basis and permitted under this program. In addition, NPDES regulations establish water quality standards for discharges from various industrial classifications. The EPA currently implements this program in Washington State for federal facilities; however, assumption of the NPDES program by the state is likely within five years. Although no point source discharges have been identified for 200 West Groundwater Aggregate Area remedial actions at this time, the agencies may evaluate contaminant-specific limits under the NPDES program as potential ARARs when remediation alternatives are developed. These potential ARARs will have to be negotiated on a case-by-case basis.

- **Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201 WAC and Proposed Chapter 173-201A WAC).** Ecology has adopted numerical ambient water quality criteria for six conventional pollutant parameters (defined at WAC 173-201-025): (1) fecal coliform bacteria; (2) dissolved oxygen; (3) total dissolved gas; (4) temperature; (5) pH; and (6) turbidity. In addition, toxic, radioactive, or deleterious material concentrations are required to be below those of public health significance or which may cause acute or chronic toxic conditions to the aquatic environment or which may adversely affect any water use. The current Chapter 173-201 WAC has promulgated numerical water quality criteria for a limited number of compounds; these criteria generally are identical to the FWQC. Ecology has initiated rulemaking to expand and incorporate the remaining FWQC numerical criteria for toxic chemicals. Currently, only the current Chapter 173-201 WAC could be considered a potential ARAR; the proposed Chapter 173-201A WAC could only be a potential TBC. Since the FWQC and promulgated state water quality criteria are essentially identical, the state standards are already addressed by the FWQC.

  Under the state Water Quality Standards, the criteria and classifications do not apply inside an authorized mixing zone surrounding a wastewater discharge. Ecology is presently developing additional guidance and regulations for defining mixing zones; in the past, Ecology has generally followed guidelines contained in "Criteria for Sewage Works Design." Although water quality standards can be exceeded inside a mixing zone, state regulations will not permit discharges that cause mortalities of fish or shellfish within the zone or that diminish aesthetic values.

6.3 LOCATION-SPECIFIC REQUIREMENTS

Potential location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations.

Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats.

Table 6-2 lists various location-specific standards and indicates which of these may be potential ARARs. Potential ARARs have been identified as follows:

- **Floodplains.** Requirements for protecting floodplains are not necessarily potential ARARs for the 200 West Groundwater Aggregate Area as there are none in the 200 West Area or vicinity (see Section 3.3.3). However, remedial actions selected for cleanup may require projects in or near floodplains (e.g., construction of a treatment facility outfall at the Columbia River). In such cases, location-specific floodplain requirements may be potential ARARs.

- **Wetlands, Shorelines, and Rivers and Streams.** Requirements related to wetlands, shorelines, and rivers and streams are not necessarily potential ARARs for the 200 West Groundwater Aggregate Area. However, remedial actions selected for cleanup may require projects on a shoreline or wetland, or discharges to wetlands, rivers, or streams (e.g., construction of a treatment facility outfall at the Columbia River). In such cases, location-specific shoreline and wetlands requirements may be potential ARARs.

- **Threatened and Endangered Species Habitats.** As discussed in Section 3.6, various threatened and endangered species (e.g., American peregrine falcon, bald eagle, white pelican, and sandhill crane) inhabit portions of the Hanford Site and may occur in the 200 West Groundwater Aggregate Area. Therefore, critical habitat protection for these species may constitute potential ARARs.

- **Wild and Scenic Rivers.** The Columbia River Hanford Reach is currently undergoing study pursuant to the federal Wild and Scenic Rivers Act. Pending results of this study, actions that may impact the Hanford Reach may be restricted. This requirement would not necessarily be an ARAR for the 200 West Groundwater Aggregate Area. However, Wild and Scenic Rivers Act requirements may be ARARs for actions taken as a result of 200 West Groundwater Aggregate Area cleanup efforts that could affect the Hanford Reach.

6.4 ACTION-SPECIFIC REQUIREMENTS

Potential action-specific ARARs are requirements that are triggered by specific remedial actions at the site. These remedial actions will not be fully defined until a remedial approach has been selected. However, the universe of potential action-specific ARARs

defined by a preliminary screening of potential remedial action alternatives will help focus the selection process. Potential action-specific ARARs are outlined below. (Note that potential contaminant- and location-specific ARARs discussed above will also include provisions for potential action-specific ARARs to be applied once the remedial action is selected.)

6.4.1 Federal Requirements

- **Comprehensive Environmental Response, Compensation, and Liability Act (40 CFR 300).** The CERCLA (including SARA) and regulations adopted pursuant to CERCLA, as contained in the National Contingency Plan (40 CFR 300), include selection criteria for remedial actions. Under the criteria, onsite treatment options are more highly favored when available. Emphasis is placed on alternatives that permanently treat or immobilize contamination. Selected alternatives must be protective of human health and the environment, which implies that federal and state ARARs be met. However, a remedy may be selected that does not meet all ARARs if the requirement is technically impractical, if its implementation would produce a greater risk to human health or the environment, if an equivalent level of protection can otherwise be provided, if state standards are inconsistently applied, or if the remedy is only part of a complete remedial action which attains potential ARARs.

  The CERCLA gives state cleanup standards essentially equal importance as federal standards in guiding cleanup measures in cases where state standards are more stringent. State standards pertain only if they are generally applicable, passed through formal means, adopted on the basis of hydrologic, geologic, or other pertinent considerations, and do not preclude the option of land disposal by a state-wide ban. Most importantly, CERCLA provides that cleanup of a site must ensure that public health and the environment are protected. Selected remedies should meet all ARARs, but issues such as cost-effectiveness must be weighed in the selection process.

- **Resource Conservation and Recovery Act (42 U.S.C. 6901, 40 CFR 260 to 271).** The RCRA (42 U.S.C. 6901), and regulations adopted pursuant to RCRA, describe numerous action-specific requirements that may be potential ARARs for cleanup activities. The primary regulations are promulgated under 40 CFR Parts 262 (standards for generators), 264, and 265 (standards for owners and operators of hazardous waste treatment, storage, and disposal facilities), and include such action-specific requirements as follows:

- Packaging, labeling, placarding, and manifesting of offsite waste shipments

- Inspecting waste management areas to ensure proper performance and safe conditions

- Preparation of plans and procedures to train personnel and respond to emergencies

- Management standards for containers, tanks, incinerators, and treatment units

- Design and performance standards for land disposal facilities

- Groundwater monitoring system design and performance.

Many of these requirements will depend on the particular remediation activity undertaken, and will have to be identified as remediation proceeds.

One key area of potential action-specific RCRA ARARs are the 40 CFR Part 268 LDRs. In addition to the contaminant-specific constituent concentration limits established in the LDRs (as previously discussed in Section 6.2.1), EPA has identified best demonstrated available treatment technologies (BDATs) for various waste streams. The EPA could require the use of BDATs prior to allowing land disposal of wastes generated during remediation of the 200 West Groundwater Aggregate Area. The EPA's imposition of the LDRs and BDAT requirements will depend on various factors.

Applicability to CERCLA actions is based on determinations of waste "placement/disposal" during a remediation action. According to OSWER Directive 9347.3-05FS, EPA concludes that Congress did not intend in situ consolidation, remediations, or improvement of structural stability to constitute placement or disposal. Placement or disposal would be considered to occur if the following:

- Wastes from different units are consolidated into one unit (other than a land disposal unit within an area of contamination)

- Waste is removed and treated outside a unit and redeposited into the same or another unit (other than a land disposal unit within an area of contamination)

- Waste is picked up from a unit and treated within the area of contamination in an incinerator, surface impoundment, or tank and then redeposited into the unit (except for in situ treatment).

Consequently, the requirement to use BDAT would not apply under the land disposal restrictions standards unless placement or disposal had occurred. However, remediation actions involving excavation, groundwater extraction, and/or treatment could trigger the requirements to use BDAT for wastes subject to the LDR standards. In addition, the agencies could consider BDAT technologies to be relevant and appropriate when developing and evaluating potential remediation technologies.

Two additional components of the LDR program should be considered with regard to an excavate and treat remedial action. First, a national capacity variance was issued by EPA for contaminated soil and debris for a two-year period ending May 8, 1992 (54 FR 26640). The agency extended that variance for an additional year through May 8, 1993. The EPA recently issued proposed rules on January 9, 1992 (57 FR 958) for LDR on contaminated debris for review and comment. Second, a series of variances and exemptions may be applied under an excavate and treat scenario. These include the following:

- A no-migration petition

- A case-by-case extension to an effective date

- A treatability variance

- Mixed waste provisions of a federal Facilities Compliance Act (when enacted).

The applicability and relevance of each of these options will vary based on the specific details of 200 West Groundwater Aggregate Area remedial actions. An analysis of these variances can be developed once engineering data on remedial options becomes available.

The effect of the LDR program on mixed waste management is significant. Currently, limited technologies are available for effective treatment of these waste streams and no commercially available treatment facilities exist except for liquid scintillation counting fluids used for laboratory analysis and testing. The EPA recognized that inadequate capacity exists and issued a national capacity variance until May 8, 1992, to allow for the development of such

treatment capacity. The agency is considering extension of that variance for an additional year, and in the interim, will apply the mixed waste storage enforcement policy described below.

Lack of treatment and disposal capacity also presents implications for storage of these materials. Under 40 CFR 268.50, mixed wastes subject to LDRs may be stored for up to one year. Beyond one year, the owner/operator has the burden of proving such storage is for accumulating sufficient quantities for treatment. On August 29, 1991, EPA issued a mixed waste storage enforcement policy providing some relief from this provision for generators of small volumes of mixed wastes. However, the policy was limited to facilities generating less than 28 m^3 (1,000 ft^3) of land disposal-prohibited waste per year. Congress is considering amendments to RCRA postponing the storage prohibition for another five years; however, final action on these amendments has not occurred.

- **Clean Water Act (40 CFR 122).** Regulations adopted pursuant to the Clean Water Act (40 CFR 122) under the NPDES mandate use of best available treatment technologies (BAT) prior to discharging contaminants to surface waters. The NPDES requirements for use of BAT would not be ARARs for actions conducted only within the 200 West Groundwater Aggregate Area. However, these requirements could constitute potential ARARs for cleanup actions which would result in discharge of treated wastewaters to the Columbia River, and associated treatment systems could be required to utilize BAT.

- **Department of Transportation Standards (40 CFR 171 to 177).** The Department of Transportation standards contained in 40 CFR 171-177 specify the requirements for packaging, labeling, and placarding for offsite transport of hazardous materials. These standards ensure that hazardous substances and wastes are safely transported using adequate means of transport and with proper documentation.

- **Occupational Health and Safety Administration Standards (29 CFR 1910).** The Occupational Health and Safety Administration requirements contained in 29 CFR 1910 outline standards for provision of safe and healthful places of employment for workers. Section 1910.120 specifically addresses standards for workers engaged in hazardous waste operations and emergency response, and includes detailed standards on the procedures and equipment required.

6.4.2 State of Washington Requirements

- **Hazardous Waste Management (WAC 173-303).** As discussed in Section 6.4.1, there are various requirements addressing the management of hazardous wastes that may be potential action-specific ARARs. Pertinent Washington regulations appear in Chapter 173-303 WAC (under the authority of RCW 70.105) and generally parallel federal management standards. Determination of potential ARARs will be on a case-by-case basis as cleanup actions proceed.

- **Solid Waste Management (WAC 173-304).** Washington State regulations describe management standards for solid waste in Chapter 173-304 WAC (under the authority of RCW 70.95). Some of these management standards may be potential ARARs for disposal of cleanup wastes within the 200 West Groundwater Aggregate Area. Solid waste standards include such requirements as the following:

  - Inspecting waste management areas to ensure proper performance and safe conditions

  - Management standards for incinerators and treatment units

  - Design and performance standards for landfills

  - Groundwater monitoring system design and performance.

  Many of these requirements will depend on the particular remediation activity undertaken, and will have to be identified as remediation proceeds.

- **Water Quality Management.** Chapter 90.48 RCW, the Washington State Water Pollution Control Act (WPCA), requires use of all known, available, and reasonable treatment technologies (AKART) for treating contaminants prior to discharge to waters of the state. Implementing regulations appear principally at Chapters 173-216, 173-220, and 173-240 WAC.

  The WPCA requirements for groundwater could be potential ARARs for actions conducted within the 200 West Groundwater Aggregate Area if such actions would result in discharge of liquid contaminants to the soil column, reinjection of withdrawn groundwater, or other actions that could introduce or return contaminants to the groundwater. In this event, Ecology would require use of AKART to treat the liquid discharges prior to soil disposal.

The WPCA requirements for surface water would not necessarily be potential ARARs for the 200 West Groundwater Aggregate Area. However, these requirements could constitute potential ARARs for cleanup actions which would result in discharge of treated wastewaters to the Columbia River and associated treatment systems could be required to demonstrate they meet AKART.

- **Air Quality Management (RCW 70.94).** Under the authority of the Washington Clean Air Act (RCW 70.94) the Toxic Air Pollutant regulations for new air emission sources, promulgated in Chapter 173-460 WAC, require use of best available control technology for air toxics (T-BACT). The Toxic Air Pollutant regulations may be potential ARARs for cleanup actions at the 200 West Groundwater Aggregate Area that could result in emissions of toxic contaminants to the air. Ecology may require the use of T-BACT to treat such air emissions.

- **Water Well Construction (RCW 18.104).** This regulation establishes authority for Ecology to require the licensing of water well contractors and operators and for the regulation of water well construction.

- **Nuclear Energy and Radiation (RCW 70.98).** Chapter 70.98 RCW establishes a program to establish procedures for assumption and performance of certain regulatory responsibilities with respect to byproduct, source, and special nuclear materials.

- **Pollution Disclosure Act (RCW 90.52).** Chapter 90.52 RCW describes the authority of the state to regulate reports for any commercial or industrial discharge, other than sanitary sewage, into waters of the state.

- **Water Resources Act (RCW 90.54).** Chapter 90.54 RCW gives the state authority to implement water related resources programs.

- **Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 WAC).** Well construction regulations establish minimum standards for water well construction and require the preparation of construction reports.

- **Rules and Regulations Governing the Licensing of Well Contractors and Operators (Chapter 173-162 WAC).** Chapter 173-162 WAC establishes requirements for licensing of well drillers.

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- **State Waste Discharge Permit Program (Chapter 173-216 WAC).** Chapters 173-216 WAC establishes a permit system for discharges of wastewater to groundwater and surface water via the municipal sewage system.

- **Underground Injection Control Program (Chapter 173-218 WAC).** Chapter 173-218 WAC pertains to the injection of wastes into aquifers that are used for drinking water.

- **Incinerators (Chapter 173-303-670 WAC).** If incinerators are used for a remedial technology this regulation would be applicable.

6.5 OTHER CRITERIA AND GUIDANCE TO BE CONSIDERED

In addition to the potential ARARs presented, other federal and state criteria, advisories, guidance, and similar materials are TBC in determining the appropriate degree of remediation for the 200 West Groundwater Aggregate Area. A myriad of resources may be potentially evaluated. The following represents an initial assessment of pertinent potential TBC provisions.

6.5.1 Health Advisories

The EPA Office of Drinking Water publishes advisories identifying contaminants for which health advisories have been issued.

6.5.2 International Commission of Radiation Protection/National Council on Radiation Protection

The International Commission of Radiation Protection and the National Council on Radiation Protection have a guidance standard of 100 mrem/yr whole body dose of gamma radiation. These organizations also issue recommendations on other areas of interest regarding radiation protection.

6.5.3 Environmental Protection Agency Proposed Corrective Actions for Solid Waste Management Units

In the July 27, 1990, Federal Register (55 FR 30798), EPA published proposed regulations for performing corrective actions (cleanup activities) at solid waste management units associated with RCRA facilities. The proposed 40 CFR Part 264 Subpart S includes

requirements that would be potential TBCs for determining an appropriate level of cleanup at the 200 West Groundwater Aggregate Area. In particular, EPA included an appendix, "Appendix A - Examples of Concentrations Meeting Criteria for Action Levels," which presented recommended contaminant concentrations warranting corrective action. These contaminant-specific TBCs for water are included in Table 6-1 for the preliminary contaminants of concern.

6.5.4 Department of Energy Standards for Radiation Protection

A number of DOE Orders exist which could be TBCs. The DOE Orders that establish potential contaminant-specific or action-specific standards for the remediation of radioactive wastes and materials are discussed below.

- **DOE Order 5400.5 - DOE Standards for Radiation Protection of the Public and Environment.** The DOE Order 5400.5 establishes the requirements for DOE facilities to protect the environment and human health from radiation including soil and air contamination. The purpose of the Order is to establish standards and requirements for operations of the DOE and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation.

  The Order mandates that the exposure to members of the public from a radiation source as a consequence of routine activities shall not exceed 100 mrem from all exposure sources due to routine DOE activities. In accordance with the Clean Air Act, exposures resulting from airborne emissions shall not exceed 10 mrem to the maximally exposed individual at the facility boundary. The DOE Order 5400.5 provides Derived Concentration Guide values for releases of radionuclides into the air or water. Derived Concentration Guide values are calculated so that, under conditions of continuous exposure, an individual would receive an effective dose equivalent of 100 mrem/yr. Because dispersion in air or water is not accounted for in the Derived Concentration Guide, actual exposures of maximally exposed individuals in unrestricted areas are considerably below the 100 mrem/yr level.

  The DOE Order 5400.5 also provides for establishment of soil cleanup levels through a site-specific pathway analysis such as the allowable residual contamination level method. The calculation of allowable residual contamination level values for radionuclides is dependent on the physical characteristics of the site, the radiation dose limit determined to be acceptable, and the scenarios of human exposure judged to be possible and to result in the upper-bound exposure.

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- **DOE Order 5820.2A - Radioactive Waste Management.** The DOE Order 5820.2A applies to all DOE contractors and subcontractors performing work that involves management of waste containing radioactivity. This Order requires that wastes be managed in a manner that assures protection of the health and safety of the public, operating personnel, and the environment. The DOE Order 5820.2A establishes requirements for management of high-level, transuranic (TRU), and low-level wastes as well as wastes containing naturally occurring or accelerator produced radioactive material, and for decommissioning of facilities. The requirements applicable to the 200 West Groundwater Aggregate Area remediation activities include those related to TRU waste and low-level radioactive waste. These are summarized below.

  - **Management of Transuranic Waste.** The TRU waste resulting from the 200 West Groundwater Aggregate Area remedial action must be managed to protect the public and worker health and safety, and the environment, and performed in compliance with applicable radiation protection standards and environmental regulations. Practical and cost-effective methods must be used to reduce the volume and toxicity of TRU waste.

    The TRU waste must be certified in compliance with the Waste Isolation Pilot Plant (WIPP) Acceptance Criteria, placed in interim storage, if required, and sent to the WIPP. Any TRU waste that the DOE has determined, with the concurrence of the EPA Administrator, does not need the degree of isolation provided by a geologic repository or TRU waste that cannot be certified or otherwise approved for acceptance at the WIPP must be disposed of by alternative methods. Alternative disposal methods must be approved by DOE Headquarters and comply with NEPA requirements and EPA/state regulations.

  - **Management of Low-Level Radioactive Waste.** The requirements for management of low-level radioactive waste presented in DOE Order 5820.2A are relevant to the remedial alternative of removal and disposal of 200 West Groundwater Aggregate Area wastes. Performance objectives for this option shall ensure that external exposure to the radioactive material released into surface water, groundwater, soil, plants, and animals does not result in an effective dose greater than 25 mrem/yr to the public. Releases to the environment shall be at levels as low as reasonably achievable. An inadvertent intruder after the institutional control period of 100 years is not to exceed 100 mrem/yr for continuous exposure or 500 mrem for a

single acute exposure. A performance assessment is to be prepared to demonstrate compliance with the above performance objectives.

Other requirements under DOE Order 5820.2A which may affect remediation of the 200 West Groundwater Aggregate Area include waste volume minimization, waste characterization, waste acceptance criteria, waste treatment, and shipment. The low-level radioactive waste may be stored by appropriate methods prior to disposal to achieve the performance objectives discussed above. Disposal site selection, closure/post-closure, and monitoring requirements are also discussed in this Order.

6.6 POINT OF APPLICABILITY

A significant factor in the evaluation of remedial alternatives for the 200 West Groundwater Aggregate Area will be the determination of the point at which compliance with identified ARARs must be achieved (i.e., the point of a specific ARAR's applicability). These points of applicability are the boundaries at which the effectiveness of a particular remedial alternative will be assessed.

For most individual radioactive species transported by either water or air, Ecology and Health standards generally require compliance at the boundaries of the Hanford Site (e.g., Clean Air Act, Section 6.2.1). The assumed point of compliance for radioactive species is the point where a member of the public would have unrestricted access to live and conduct business, and, consequently, to be maximally exposed. Although Health is responsible for monitoring and enforcing the air standards promulgated by Ecology, and generally recognizes the site boundary as the point of applicability, Ecology has recently indicated that compliance may be required at the point of emission.

The point at which compliance with identified ARARs must be achieved will be a significant factor in evaluating appropriate remedial alternatives in the 200 West Groundwater Aggregate Area. Applicability of ARARs at the point of discharge, at the boundary of the disposal unit, at the boundary of the AAMS, at the boundary of the Hanford Site, and/or at the point of maximum exposure will need to be determined.

6.7 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS EVALUATION

Evaluation of ARARs is an iterative process that will be conducted at multiple points throughout the remedial process:

9 2 1 2 6 1 0 4 9 6

- When the public health evaluation is conducted to assess risks at the 200 West Groundwater Aggregate Area, the potential contaminant-specific ARARs and the potential location-specific ARARs will be identified more comprehensively and used to help determine the cleanup goals

- During detailed analysis of alternatives, all the potential ARARs for each alternative will be examined to determine what is needed to comply with other laws and to be protective of public health and the environment.

Following completion of the investigation, the remedial alternative selected must be able to attain all ARARs unless one of the six statutory waivers provided in Section 121 (d)(4)(A) through (F) of CERCLA is invoked. Finally, during remedial design, the technical specifications of construction must ensure attainment of ARARs. The six reasons ARARs can be waived are as follows:

- The remedial action is an interim measure, where the final remedy will attain ARARs upon completion

- Compliance will result in greater risk to human health and the environment than will other options

- Compliance is technically impracticable

- An alternative remedial action will attain the equivalent performance of the ARAR

- For state ARARs, the state has not consistently applied (or demonstrated the intention to consistently apply) the requirements in similar circumstances

- For CERCLA-financed actions under Section 104, compliance with the ARAR will not provide a balance between the need for protecting public health, welfare, and the environment at the facility, and the need for fund money to respond to other sites (this waiver is not applicable at the Hanford Site).

Once investigations have been completed and final remedies have been selected, the ARARs that must be met will be formally identified in the Record of Decision (ROD). Compliance with those ARARs specified in the ROD will be achieved through the remedial action. The ARARs may need to be reevaluated if unanticipated circumstances are encountered during remediation which prevent the ability to satisfy the identified ARARs.

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic Organic, and Radionuclides of Concern.

	SDWA		RCRA	RCRA	MTCA	RCRA	DOE Order 5400.5	DOE Order 5400.5
	Drinking Water Standards		TCLP Designation Limit	LDR Limits For Wastewaters	Groundwater Cleanup Levels	Proposed Corrective Action Levels	Ingested Water	4% Ingested Water[b]
	MCL in mg/L	SMCL in mg/L	in mg/L	CCW in mg/L	Method A µg/L	Water in mg/L	DCG pCi/L	DCG pCi/L
INORGANIC COMPOUNDS								
Aluminum	–	–	–	–	–	–	–	–
Antimony	0.006[a]	–	–	–	–	–	–	–
Arsenic	0.05	–	5	5	2	–	–	–
Barium	2[b]	–	100	100	–	1	–	–
Beryllium	0.004[a]	–	–	0.82	–	0.000008	–	–
Boron	–	–	–	–	–	–	–	–
Cadmium	0.005[a]	–	1	1	2	0.01	–	–
Calcium	–	–	–	–	–	–	–	–
Chromium	0.1	–	5	5	50	0.1[a]	–	–
Cobalt	–	–	–	–	–	–	–	–
Copper	TT[d]	1	–	1.3	1000	–	–	–
Cyanide	0.2[a]	0.3	–	1.9	–	0.7	–	–
Iron	–	–	–	–	–	–	–	–
Lead	0.05/TT[d]	–	5	5	5	0.05	–	–
Lithium	–	–	–	–	–	–	–	–
Magnesium	–	–	–	–	–	–	–	–
Manganese	–	0.05	–	–	–	–	–	–
Mercury	0.002	–	0.2	0.2	2	0.002	–	–
Nickel	0.1[a]	–	–	0.55	–	0.7	–	–
Potassium	–	–	–	–	–	–	–	–

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic Organic, and Radionuclides of Concern.

	SDWA		RCRA	RCRA	MTCA	RCRA	DOE Order 5400.5	DOE Order 5400.5
	Drinking Water Standards		TCLP Designation Limit	LDR Limits For Wastewaters	Groundwater Cleanup Levels	Proposed Corrective Action Levels	Ingested Water	4% Ingested Water[k]
	MCL in mg/L	SMCL in mg/L	in mg/L	CCW in mg/L	Method A µg/L	Water in mg/L	DCG pCi/L	DCG pCi/L
Selenium	0.05	–	1	1	–	–	–	–
Silicon	–	–	–	–	–	–	–	–
Silver	–	0.1	5	5	–	0.05	–	–
Sodium	–	–	–	–	–	–	–	–
Strontium	–	–	–	–	–	–	–	–
Thallium	0.002[a]	–	–	–	–	–	–	–
Titanium	–	–	–	–	–	–	–	–
Uranium	–	–	–	–	–	–	–	–
Vanadium	–	–	–	0.042	–	–	–	–
Zinc	–	5	–	1	5000	–	–	–
ORGANIC COMPOUNDS								
Chloroform	0.1 (THM)	–	6	0.046[e]	–	0.006	–	–
Carbon Tetrachloride	0.005	–	0.5	0.057[e]	–	0.0003	–	–
Methylene Chloride	0.005[a]	–	–	0.44	5	0.005	–	–
1,1-Dichloroethane	–	–	–	0.059[e]	–	–	–	–
1,2-Dichloroethane	0.005	–	0.5	0.21[e]	1	0.005	–	–
Cis-1,2-Dichloroethylene	0.07	–	–	–	–	–	–	–
Trans-1,2 Dichloroethylene	0.1	–	–	–	–	–	–	–
1,1,1-Trichloroethane	0.2	–	–	0.054[e]	200	3	–	–
1,1,2-Trichloroethane	0.005[a]	–	–	0.03	–	–	–	–

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic Organic, and Radionuclides of Concern.

	SDWA		RCRA	RCRA	MTCA	RCRA	DOE Order 5400.5	DOE Order 5400.5
	Drinking Water Standards		TCLP Designation Limit	LDR Limits For Wastewaters	Groundwater Cleanup Levels	Proposed Corrective Action Levels	Ingested Water	4% Ingested Water[k/]
	MCL in mg/L	SMCL in mg/L	in mg/L	CCW in mg/L	Method A µg/L	Water in mg/L	DCG pCi/L	DCG pCi/L
Trichloroethylene	0.005	–	0.5	0.54[e/]	5	0.005	–	–
Tetrachloroethylene	0.005	–	0.4	0.56[e/]	1	0.0007	–	–
Pyrene	–	–	–	–	–	–	–	–
Styrene	0.1	–	–	–	–	–	–	–
Toluene	1	–	–	0.08[e/]	40	10	–	–
2,4-Dinitrotoluene	–	–	0.13	0.32[e/]	–	–	–	–
Phenol	–	–	–	0.039	–	–	–	–
2,3,4,6-Tetrachlorophenol	–	–	–	–	–	–	–	–
2,4-Dichlorophenol	–	–	–	0.044[e/]	–	0.1	–	–
2,4-Dimethylphenol	–	–	–	–	–	–	–	–
2,4-Dinitrophenol	–	–	–	0.12[e/]	–	0.07	–	–
2-Chlorophenol	–	–	–	0.044[e/]	–	0.2	–	–
o-Nitrophenol	–	–	–	–	–	–	–	–
Acetone	–	–	–	–	–	–	–	–
Methyl Ethyl Ketone	–	–	200	0.28	–	2	–	–
4-Methyl-2-Pentanone	–	–	–	–	–	–	–	–
Cyclohexanone	–	–	–	–	–	–	–	–
Aldrin	–	–	–	0.21[e/]	–	–	–	–

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic Organic, and Radionuclides of Concern.

	SDWA		RCRA	RCRA	MTCA	RCRA	DOE Order 5400.5	DOE Order 5400.5
	Drinking Water Standards		TCLP Designation Limit	LDR Limits For Wastewaters	Groundwater Cleanup Levels	Proposed Corrective Action Levels	Ingested Water	4% Ingested Water[k]
	MCL in mg/L	SMCL in mg/L	in mg/L	CCW in mg/L	Method A µg/L	Water in mg/L	DCG pCi/L	DCG pCi/L
DDD	–	–	–	0.023	–	0.0001	–	–
DDT	–	–	–	0.0039[e]	0.12	0.0001	–	–
Dieldrin	–	–	–	0.017[e]	–	0.000002	–	–
Endrin	.0002/0.002[f]	–	0.02	0.0028[e]	–	0.0002	–	–
Endrin Aldehyde	–	–	–	–	–	–	–	–
Gamma-BHC	–	–	–	–	–	–	–	–
Heptachlor	0.0004	–	0.003	0.0012[e]	–	0.000008	–	–
Bis(2-ethylhexyl) phthalate	0.006	–	–	0.54[g]	–	–	–	–
Diethyl Ether	–	–	–	–	–	–	–	–
Dimethoate	–	–	–	–	–	0.7	–	–
Ethyl Cyanide	–	–	–	0.24[e]	–	–	–	–
Hydrazine	–	–	–	–	–	–	–	–
P-chloro-m-cresol	–	–	–	–	–	–	–	–
Phorate	–	–	–	–	–	–	–	–
Trichloromonofluoromethane	–	–	–	0.02[e]	–	–	–	–
Triethylene Glycol	–	–	–	–	–	–	–	–
CONVENTIONAL CONSTITUENTS								
Ammonium Ion	–	–	–	–	–	–	–	–
Bromide	–	–	–	–	–	–	–	–

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic Organic, and Radionuclides of Concern.

	SDWA		RCRA	RCRA	MTCA	RCRA	DOE Order 5400.5	DOE Order 5400.5
	Drinking Water Standards		TCLP Designation Limit	LDR Limits For Wastewaters	Groundwater Cleanup Levels	Proposed Corrective Action Levels	Ingested Water	4% Ingested Water[k]
	MCL in mg/L	SMCL in mg/L	in mg/L	CCW in mg/L	Method A µg/L	Water in mg/L	DCG pCi/L	DCG pCi/L
Chloride	–	250	–	–	–	–	–	–
Fluoride	4	2	–	35	–	–	–	–
Nitrate (as N)	10	–	–	–	–	–	–	–
Nitrite (as N)	1[c]	–	–	–	–	–	–	–
Phosphate	–	–	–	–	–	–	–	–
Sulfate	–[h]	250	–	–	–	–	–	–
Total Dissolved Solids	–	500	–	–	–	–	–	–
Coliform Bacteria	–	–	–	–	–	–	–	–
RADIONUCLIDES								
Gross Alpha	15 pCi/L[i]	–	–	–	–		NS	NS
Gross Beta	4 mrem/yr[j]	–	–	–	–	–	NS	NS
Tritium	20,000 pCi/L[i]	–	–	–	–	–	2,000,00	80,000
Beryllium-7	–	–	–	–	–	–	1,000,00	40,000
Carbon-14	–	–	–	–	–	–	70,000	2,800
Potassium-40	–	–	–	–	–	–	7,000	280
Cobalt-60	–	–	–	–	–	–	5,000	200
Zinc-65	–	–	–	–	–	–	9,000	360
Strontium-90	8 pCi/L[i]	–	–	–	–	–	1,000	40
Zirconium/Niobium-95	–	–	–	–	–	–	40,000	1,600
Technetium-99	–	–	–	–	–	–	100,000	4,000

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic Organic, and Radionuclides of Concern.

	SDWA		RCRA	RCRA	MTCA	RCRA	DOE Order 5400.5	DOE Order 5400.5
	Drinking Water Standards		TCLP Designation Limit	LDR Limits For Wastewaters	Groundwater Cleanup Levels	Proposed Corrective Action Levels	Ingested Water	4% Ingested Water[k]
	MCL in mg/L	SMCL in mg/L	in mg/L	CCW in mg/L	Method A µg/L	Water in mg/L	DCG pCi/L	DCG pCi/L
Ruthenium-106	–	–	–	–	–	–	6,000	240
Antimony-125	–	–	–	–	–	–	50,000	2,000
Iodine-129	–	–	–	–	–	–	500	20
Cesium-134	–	–	–	–	–	–	2,000	80
Cesium-137	–	–	–	–	–	–	3,000	120
Cerium/Praesodymium-144	–	–	–	–	–	–	7,000	280
Europium-154	–	–	–	–	–	–	20,000	800
Europium-155	–	–	–	–	–	–	100,000	4,000
Lead-212	–	–	–	–	–	–	3,000	120
Radium	5 pCi/L[j]	–	–	–	–	–	100	4
Uranium	–	–	–	–	–	–	NS	NS
Uranium-234	–	–	–	–	–	–	500	20
Uranium-235	–	–	–	–	–	–	600	24
Uranium-238	–	–	–	–	–	–	600	24

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic Organic, and Radionuclides of Concern.

	SDWA		RCRA	RCRA	MTCA	RCRA	DOE Order 5400.5	DOE Order 5400.5
	Drinking Water Standards		TCLP Designation Limit	LDR Limits For Wastewaters	Groundwater Cleanup Levels	Proposed Corrective Action Levels	Ingested Water	4% Ingested Water[j/]
	MCL in mg/L	SMCL in mg/L	in mg/L	CCW in mg/L	Method A µg/L	Water in mg/L	DCG pCi/L	DCG pCi/L
Plutonium-239/40	–	–	–	–	–	–	30	1.2
Americium-241	–	–	–	–	–	–	30	1.2

a/ = Effective Date January 17, 1994.
b/ = Effective Date - January 1, 1993, current MCL = 1.0 mg/L.
c/ = Effective Date - July 30, 1992.
d/ = Treatment technique requirement in effect. Effective Date - December 7, 1992.
e/ = Based on analysis of composite samples.
f/ = Revised MCL effective January 17, 1994.
g/ = Treatment standards based upon incineration in units operated in accordance with the technical requirements of 40 CFR Part 264 Subpart 0, or based upon combustion in fuel substitution units operating in accordance with applicable technical requirements.
h/ = Sulfate was proposed for an MCL of 400-500 mg/L, but this regulation has been deferred (57 FR 31776, July 17, 1992).
i/ = "Picocurie (pCi)" means the quantity of radioactive material producing 2.22 nuclear transformations per minute.
j/ = To use the DCGs for comparison with the DOE drinking water systems criterion of 4 mrem/yr, use the 4 percent DCG values for ingestion.
k/ = "Rem" means the unit of dose equivalent from ionizing radiation to the total body of any internal organ or organ system. A "millirem (mrem)" is 1/1000 of a rem.

Abbreviations:

CCW = Constituent Concentration in Waste
DCG = Derived Concentration Guide
DOE = Department of Energy
LDR = Land Disposal Restrictions
MCL = Maximum Contaminant Level
MTCA = Washington State Model Toxic Control Act
NS = Not Specified
RCRA = Federal Resource Conservation and Recovery Act
SDWA = Federal Safe Drinking Water Act
SMCL = Secondary Maximum Contaminant Level
TCLP = Toxicity Characteristics Leaching Procedure
THM = Trihalomethanes

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation	ARAR
GEOLOGICAL:				
Within 200 feet of a fault displaced in Holocene time.	New treatment, storage or disposal of hazardous waste prohibited.	Hazardous waste management near Holocene fault.	40 CFR 264.18; WAC 173-303-420	Not ARAR. No Holocene fault.
Holocene faults and subsidence areas.	New solid waste disposal facilities prohibited over faults with displacement in Holocene time, and in subsidence areas.	New solid waste management activities near Holocene fault.	WAC 173-304-130	Not ARAR. No Holocene fault.
Unstable slopes.	New solid waste disposal areas prohibited from hills with unstable slopes.	New solid waste disposal on an unstable slope.	WAC 173-304-130	Not ARAR. No unstable slope.
100-year floodplains.	Solid and hazardous waste disposal facilities must be designed, built, operated, and maintained to prevent washout.	Solid or hazardous waste disposal in a 100-year floodplain.	40 CFR 264.18; WAC 173-303-420; WAC 173-304-460	Potential ARAR.
	Avoid adverse effects, minimize potential harm, restore/preserve natural and beneficial values in floodplains.	Actions occurring in a floodplain.	40 CFR Part 6 Subpart A; 16 USC 661 et seq; 40 CFR 6.302	Potential ARAR.
Salt dome and salt bed formations, underground mines, and caves.	Placement of non-containerized or bulk liquid hazardous wastes is prohibited.	Hazardous waste placement in salt dome, salt bed, mine, or cave.	40 CFR 264.18	Not ARAR. None of these units.

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation	ARAR
SURFACE WATER:				
Wetlands.	New hazardous waste disposal facilities prohibited in wetlands (including within 200 feet of shoreline).	Hazardous waste disposal within 200 feet of surface water.	WAC 173-303-420	Potential ARAR.
	New solid waste disposal facilities prohibited within 200 feet of surface water (stream, lake, pond, river, salt water body).	Solid waste disposal within 200 feet of surface water.	WAC 173-304-130	Potential ARAR.
	New solid waste disposal facilities prohibited in wetlands (swamps, marshes, bogs, estuaries, and similar areas).	Solid waste disposal in a wetland (swamp, marsh, bog, estuary, etc.).	WAC 173-304-130	Not ARAR. No wetlands present.
	Discharge of dredged or fill materials into wetlands prohibited without a permit.	Discharges to wetlands and navigable waters.	40 CFR Part 230; 33 CFR Parts 303, and 320 to 330	Potential ARAR.
	Minimize potential harm, avoid adverse effects, preserve and enhance wetlands.	Construction or management of property in wetlands.	40 CFR Part 6 Appendix A	Not ARAR. No wetlands present.
Shorelines.	Actions prohibited within 200 feet of shorelines of statewide significance unless permitted.	Actions near shorelines.	Chapter 90.58 RCW; Chapter 173-14 WAC.	Potential ARAR.

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation	ARAR
Rivers and streams.	Avoid diversion, channeling or other actions that modify streams or rivers, or adversely affect fish or wildlife habitats and water resources.	Actions modifying a stream or river and affecting fish or wildlife.	40 CFR 6.302	Potential ARAR.
GROUNDWATER:				
Sole source aquifer.	New solid and hazardous waste land disposal facilities prohibited over a sole source aquifer.	Disposal over a sole source aquifer.	WAC 173-303-402; WAC 173-304-130	Not ARAR. No sole source aquifer.
Uppermost aquifer.	Bottom of lowest liner of new solid waste disposal facility must be at least 10 feet above seasonal high water in uppermost aquifer (5 feet if hydraulic gradient controls installed).	New solid waste disposal.	WAC 173-304-130	Not ARAR. Groundwater is deeper than 10 feet.
Aquifer Protection Areas.	Activities restricted within designated Aquifer Protection Areas.	Activities within an Aquifer Protection Area.	Chapter 36.36 RCW.	Not ARAR. Not an Aquifer Protection Area.
Groundwater Management Areas.	Activities restricted within Ground Water Management Areas.	Activities within a Groundwater Management Area.	Chapter 90.44 RCW; Chapter 173-100 WAC	Not ARAR. Not a Groundwater Management Area.

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation	ARAR
DRINKING WATER SUPPLY:				
Drinking water supply well.	New solid waste disposal areas prohibited within 1,000 feet upgradient, or 90 days travel time, of drinking water supply well.	New solid waste disposal within 1,000 feet of drinking water supply well.	WAC 173-304-130	Not ARAR. No drinking water supply wells.
Watershed.	New solid waste disposal areas prohibited within a watershed used by a public water supply system for municipal drinking water.	New solid waste disposal in a public watershed.	WAC 173-304-130	Not ARAR. Not a public watershed.
AIR:				
Non-attainment areas.	Restrictions on air emissions in areas designated as non-attainment areas under state and federal air quality programs.	Activities in a designated non-attainment area.	Chapter 70.94 RCW; Chapters 173-400 and 173-403 WAC.	Not ARAR. Not a non-attainment area.
SENSITIVE ENVIRONMENTS:				
Endangered/threatened species habitats.	New solid waste disposal prohibited from areas designated by US Fish and Wildlife Service as critical habitats for endangered/ threatened species.	New solid waste disposal in critical habitats.	WAC 173-304-130	Not ARAR. Not a critical habitat.
	Actions within critical habitats must conserve endangered/threatened species.	Activities where endangered or threatened species exist.	50 CFR Parts 200 and 402.	Potential ARAR.

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation	ARAR
Parks.	No new solid waste disposal areas within 1,000 feet of state or national park.	New solid waste disposal near state/national park.	WAC 173-304-130	Not ARAR. No state/national park.
	Restrictions on activities in areas that are designated state parks, or recreation/ conservation areas.	Activities in state parks or recreation/conservation areas.	Chapter 43.51 RCW; Chapter 352.32 WAC	Not ARAR. None of these state areas.
Wilderness areas.	Actions within designated wilderness areas must ensure area is preserved and not impaired.	Activities within designated wilderness areas.	16 USC 1131 et seq; 50 CFR 35.1 et seq	Not ARAR. Not a wilderness area.
Wildlife refuge.	Restrictions on actions in areas that are part of the National Wildlife Refuge System.	Activities within designated wildlife refuges.	16 USC 668dd et seq; 50 CFR Part 27	Not ARAR. Not a wildlife refuge.
Natural areas preserves.	Activities restricted in areas designated as having special habitat value (Natural Heritage Resources).	Activities within identified Natural Area Preserves.	Chapter 79.70 RCW; Chapter 332-650 WAC	Not ARAR. Not a Natural Area Preserve.
Wild, scenic, or recreational rivers.	Avoid actions that would have adverse effects on designated wild, scenic, or recreational rivers.	Activities near wild, scenic, and recreational rivers.	16 USC 1271 et seq; 40 CFR 6.302; Chapter 79.72 RCW	Potential ARAR.
Columbia River Gorge	Restrictions on activities that could affect resources in the Columbia River Gorge.	Activities within the Columbia River Gorge.	Chapter 43.97 RCW	Not ARAR. Not in Columbia River Gorge.

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation	ARAR
UNIQUE LANDS AND PROPERTIES:				
Natural resource conservation areas.	Restrictions on activities within designated Conservation Areas.	Activities within designated Conservation Areas.	Chapter 79.71 RCW	Not ARAR. Not a Conservation Area.
Forest lands.	Activities restricted within state forest lands to minimize fire hazards and other adverse impacts.	Activities within state forest lands.	Chapter 76.04 RCW; Chapter 332-24 WAC	Not ARAR. Not a forest land.
	Restrictions on activities in state and federal forest lands.	Activities within state and federal forest lands.	16 USC 1601; Chapter 76.09 RCW	Not ARAR. Not a forest land.
Public lands.	Activities on public lands are restricted, regulated, or proscribed.	Activities on state-owned lands	Chapter 79.01 RCW	Not ARAR. Not a state land.
Scenic vistas.	Restrictions on activities that can occur in designated scenic areas.	Activities in designated scenic vista areas.	Chapter 47.42 RCW	Not ARAR. Not a scenic area.
Historic areas.	Actions must be taken to preserve and recover significant artifacts, preserve historic and archaeologic properties and resources, and minimize harm to national landmarks.	Activities that could affect historic or archaeologic sites or artifacts.	16 UST 469, 470 et seq; 36 CFR Parts 65 and 800; Chapters 27.34, 27.53, and 27.58 RCW.	Not ARAR. No historic or archaeologic sites.

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation	ARAR
LAND USE:				
Neighboring properties.	No new solid waste disposal areas within 100 feet of the facility's property line.	New solid waste disposal within 100 feet of facility property line.	WAC 173-304-130	Not ARAR. Not near facility boundary.
	No new solid waste disposal areas within 250 feet of property line of residential zone properties.	New solid waste disposal within 250 feet of property line of residential property.	WAC 173-304-130	Not ARAR. No residential property near.
Proximity to airports.	Disposal of garbage that could attract birds prohibited within 10,000 feet (turbojet aircraft)/5,000 feet (piston-type aircraft) of airport runways.	Garbage disposal near airport.	WAC 173-304-130	Not ARAR. No airports near.

7.0 PRELIMINARY REMEDIAL ACTION TECHNOLOGIES

Previous sections identified contaminants of concern in the 200 West Groundwater Aggregate Area, potential routes of exposure, and potentially applicable or relevant and appropriate requirements (ARARs). Section 7.0 identifies preliminary remedial action objectives (RAOs) and develops preliminary remedial action alternatives consistent with reducing the potential hazards of this contamination and satisfying ARARs. The overall objective of this section is to identify viable and innovative remedial action alternatives for groundwater in the 200 West Groundwater Aggregate Area.

The process of identifying remedial action alternatives consists of several steps. In Section 7.1, RAOs are identified. Next, in Section 7.2, general response actions are identified along with general treatment, resource recovery, and containment technologies applicable to each general response action. Specific process options belonging to each technology are identified, and these process options are subsequently screened based on their effectiveness, implementability, and relative cost (Section 7.3). Process options are combined into alternatives in Section 7.4, which also includes descriptions and diagrams for the alternatives. Section 7.5 provides a brief discussion of the integration of innovative technologies into the process for selecting remedial action alternatives. Criteria are then identified in Section 7.6 for preliminary screening of alternatives that may be applicable to groundwater operable units identified in the 200 West Groundwater Aggregate Area. Figure 7-1 is a flowchart diagramming the development of the remedial action alternatives starting with media-specific RAOs.

Because of uncertainty regarding the nature and extent of contamination at the 200 West Groundwater Aggregate Area, recommendations for remedial alternatives are general and cover a broad range of actions. Remedial action alternatives will be considered and more fully developed in future focused feasibility studies. The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) is used to focus the range of remedial action alternatives that will be evaluated in future studies. The *Hanford Site Past-Practice Strategy* implements the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). Remedial Investigations (RIs)/Feasibility Studies (FSs) and RCRA Facility Investigation (RFI)/Corrective Measures Studies (CMS) are components of this strategy and are implemented through a combination of interim remedial measures (IRMs), limited field investigations (LFIs) for final remedy selection where interim actions are not clearly justified, and focused or aggregate area feasibility/treatability studies for further evaluation of treatment alternatives. After completion of an IRM, data will be evaluated including concurrent characterization and data monitoring to determine if a final remedy can be selected directly, without additional characterization.

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With respect to evaluating remedial alternatives for the 200 West Groundwater Aggregate Area, it should be noted that several of the groundwater contamination problems are similar to engineering problems that have been encountered in previous Hanford Site facility effluent wastewater treatment and disposal studies. In particular, treatment of extracted groundwater may be similar in concept to Hanford Site wastewater treatment projects (C-018H Facility, N-Reactor Effluent, Project L-045H 300 Area Treated Effluent Disposal Facility) conducted under the guidance for *Best Available Technology (BAT) Guidance Document for the Hanford Site* (WHC 1988b). The general response action of containment of contaminated groundwater was evaluated in *Engineering Evaluation of Containment Alternatives for N-Springs Releases* (WHC 1991b). In another example, the *Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume* (DOE/RL 1991a) describes a feasible approach for disposal of secondary wastes generated during the potential air stripping of groundwater. These documents are recognized as important tools to guide both this initial screening and future selection of remedial alternatives.

A secondary purpose of the evaluation of preliminary remedial action alternatives is to identify additional information needed to complete the evaluation. This information may include field data needs, review of literature, validation of existing data, focused feasibility studies, or treatability tests of selected technologies. Alternatives involving proven technologies, identified in Sections 7.3 and 7.4, typically require detailed data delineating site conditions, as well as bench-scale and pilot-scale treatability studies. Innovative technologies, discussed in Section 7.5, are expected to require additional literature searches, research and development, and other studies. Thus, another purpose of this evaluation is to identify the treatability studies required to fully evaluate proven technologies and to scope the research necessary to evaluate promising technologies. Additional data will be developed for most sites or waste groups during future data gathering activities (e.g., LFIs, ERAs, or treatability studies). Data needs are summarized in Section 8.0. New data will be used to refine and supplement the RAOs and the proposed alternatives identified in this initial study. Conclusions regarding the feasibility of some individual technologies may change after new data become available.

The bias-for-action philosophy of addressing contamination at the Hanford Site requires an expedited process for implementing remedial actions. Implementation of general response actions may be accomplished using an observational approach in which the implementation is redirected as information is obtained. This observational approach is an iterative process of data acquisition and refinement of the conceptual model. Data needs are determined by the model, and data collected to fulfill these needs are used as additional input to the model. Use of the observational approach while conducting response actions in the source aggregate areas within the 200 West Area will allow integration of these actions with longer-range objectives of final remediation of similar areas and the entire 200 West Groundwater

Aggregate Area. Site characterization and remediation data will be collected concurrently with the use of LFIs, ERAs, and treatability testing. The knowledge gained through these different activities will be applied to similar areas. The overall goal of this approach is convergence on an appropriate response action as early as possible while continuing to obtain valuable characterization information during remediation phases.

7.1 PRELIMINARY REMEDIAL ACTION OBJECTIVES

The RAOs are remediation goals for protection of human health and the environment that specify the contaminants and media of concern, exposure pathways, and allowable contaminant levels. The RAOs discussed in this section are considered to be preliminary and may change or be refined as new data are acquired and evaluated.

The fundamental objective of the corrective action process at the 200 West Groundwater Aggregate Area is to protect environmental resources and human receptors from the potential threats that may exist because of known or suspected contamination in the groundwater. Specific interim and final RAOs will depend in part on current and reasonable potential future groundwater use in the 200 West Groundwater Aggregate Area. The RAOs account for CERCLA preference for permanent isolation and permanent reduction in the mobility and toxicity of the contaminants.

Potential future groundwater use affects the risk-based cleanup objectives, potential ARARs, and point of compliance. The RAOs for protecting human health would be based on risk assessment exposure scenarios. In addition, due to the potential for groundwater migration toward the Columbia River, RAOs based on risk assessment exposure scenarios for protection of surface water may be an added factor. It is important that potential future groundwater use and the RAOs be clearly defined and agreed upon by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) before further and more detailed evaluation of remedial actions. Until future land use of the Hanford Site is defined, DOE policy is that the Hanford Site will remain under DOE management, which includes control over beneficial use of the land and any uses of groundwater at least until the year 2018 as agreed upon in the Tri-Party Agreement. The Hanford Site remedial action environmental impact statement is intended to resolve the groundwater use issues. A Record of Decision for this environmental impact statement is expected in the spring of 1994.

To focus the corrective actions with a bias for action through implementing IRMs and ERAs, preliminary RAOs based on current use are identified for the 200 West Groundwater Aggregate Area. The potential final RAO and interim action objective is as follows:

Reduce the risk of harmful effects to the environment and human users of the area by isolating and permanently reducing the toxicity, mobility, or volume of contaminants from the source areas to meet ARARs or risk-based levels that will allow industrial use of the area.

The RAOs are further developed in Table 7-1 for groundwater and applicable exposure pathways (see Sections 4.1 and 4.2) for the 200 West Groundwater Aggregate Area. The potential exposure pathways include the following:

- Contaminated water supplies, the use of which could result in inhalation, ingestion, direct contact, and/or direct radiation exposure to humans

- Contaminated groundwater that could migrate to surface waters (i.e., the Columbia River, Yakima River, or West Lake) resulting in inhalation, ingestion, direct contact, and/or direct radiation exposure to humans

- Biota uptake of contaminated groundwater

- Release of groundwater contaminants to soil and vadose zone via vadose zone vapors and offgassing into the air pathway.

The two pathways of biota uptake and soils/vadose zone vapors as an exposure medium are not addressed in this 200 West Groundwater Aggregate Area Management Study Report (AAMSR), but are addressed in each of the four source 200 West Area AAMSRs.

Preliminary contaminant concentration standards that are to be applied to media-specific RAOs are developed from the preliminary identification of potential ARARs in Section 6.0 or by numerical assessment of the expected exposures and associated risks for each contaminant.

RAOs are likely to differ based upon the proposed remedial action. Short-term actions (defined as ERAs and IRMs in Section 9.0) may have different goals than actions which focus on long-term solutions (defined as the final remedy in Section 9.0). Short-term RAOs will likely focus primarily on risk reduction to meet a stopping point based on either a concentration threshold (which is a multiple higher than a final threshold) or on reaching an asymptote on the remediation production curve (the point of diminishing returns).

7.2 PRELIMINARY GENERAL RESPONSE ACTIONS

General response actions represent broad classes of remedial measures that may be appropriate to achieve both interim and final RAOs at the 200 West Groundwater Aggregate Area, and are presented in Table 7-2. The following are the general response actions for the 200 West Groundwater Aggregate Area followed by general discussions of applicability:

- No action
- Institutional controls
- Groundwater removal, treatment, and disposal
- Groundwater containment
- In situ groundwater treatment
- Point-of-use treatment
- Point-of-discharge treatment
- Combinations of the above actions.

7.2.1 No Action and Institutional Control

No action is included for evaluations as required by the National Environmental Policy Act (NEPA) and National Contingency Plan (NCP) [40 CFR 300.68 (f)(l)(v)] to provide a baseline for comparison with other response actions. The no action alternative may be appropriate for some facilities and sources of contamination if risk assessments determine that acceptable natural resource or human health risks are posed by those sources or facilities and that no exceedances of contaminant-specific ARARs occur.

The general response actions focus on permanently reducing the volume, mobility, and toxicity of the contaminants. Active remedial measures to achieve these goals will be supplemented by institutional controls in many cases. Institutional controls involve the use of above-ground physical barriers, plume monitoring, well closures, and a variety of groundwater use restrictions to reduce or eliminate public exposure to contaminated groundwater. Considering the nature of the 200 Areas as a whole, institutional controls will likely be an integral component of all interim remedial alternatives and will be combined with active groundwater treatment steps. Many groundwater use restrictions are currently in

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place at the Hanford Site and will remain in place during implementation of interim remedial measures. The decision regarding future long-term groundwater use at the 200 Areas will be important in determining whether institutional controls will be part of the remedial measure alternatives and the type of controls required.

Application of institutional control and no action alternatives to 200 West Groundwater Aggregate Area cleanup will be affected by many factors. For example, the substantial quantity of groundwater potentially requiring treatment and/or containment may make timely treatment actions prohibitively costly. Risk and groundwater migration studies may conclude that natural attenuation, accompanied by appropriate institutional controls combined with, for example, point-of-use treatment is preferred over the adverse consequences of large-scale source treatment alternatives. Such adverse consequences include increased risks to human health and the environment due to construction activities, disposal of secondary wastes, increased disruption of existing groundwater use, and potential generation of large quantities of radiation-contaminated remediation equipment requiring offsite burial. Evaluation of potential adverse effects will play a vital role in establishing the appropriateness of institutional control and no action alternatives.

7.2.2 Extraction and Treatment (Pump and Treat) Technologies

Groundwater removal and treatment or disposal, commonly known as "pump and treat," involves the extraction of contaminated groundwater and above-ground treatment. Once extracted and treated, it is anticipated that the groundwater would be reinjected into the ground or disposed of to land or surface waters. Extraction, treatment, and reinjection options can be varied to achieve a variety of RAOs. For example, the large-scale extraction of groundwater, followed by treatment of contaminants and disposal of the groundwater to nonhydrogeologically related surface waters, treats the groundwater and hydraulically contains contaminated groundwater remaining in the aquifer. A second possible approach is small-scale extraction of isolated contamination plumes followed by removal of high risk contaminants and reinjection near the area of extraction, achieving a net reduction of risk without requiring offsite disposal of groundwater. Pump and treat actions can be used to achieve a wide variety of goals, but may not be needed, or may only be required on a small scale, to protect human health and the environment for the industrial uses of the 200 West Area.

Pump and treat technologies begin with groundwater extraction using techniques including extraction wells, drains, and trenches. Subsurface sediments at the 200 West Area consisting of mostly sand and gravel are well suited to efficient groundwater extraction using extraction wells. Before initiating pumping (especially large-scale pumping), a detailed understanding of the site's groundwater system including the presence of confined and

unconfined aquifers, radius-of-influence, permeability, recharge rates, and preferential flow paths, is used to predict how pumping will alter system hydraulics to move and potentially mix contaminant plumes. Based on these site-specific conditions, a network of extraction wells is installed to effect the desired removal of groundwater.

Following extraction, treatment of extracted groundwater will vary in scope and complexity according to the variety of chemical constituents present in the groundwater and level of removal required by applicable ARARs and RAOs. Because 200 West Area groundwater contains a variety of chemical constituents, treatment of extracted groundwater may involve the use of a combination of biological, physical, or chemical technologies to achieve treatment goals. Typical options for treatment of extracted contaminants likely to be present in 200 Areas groundwater include air stripping, UV oxidation, reverse osmosis, chemical precipitation, and ion exchange. For some constituents such as hexavalent chromium, treatment via chemical precipitation would include an initial reduction step. For the unique radiochemical tritium, treatment options are limited because of tritiated water's near chemical identity to water.

It is expected that a treatment system for extracted groundwater will be designed in accordance with Hanford BAT guidance (WHC 1988b) to facilitate the beneficial transfer of prior experience with potentially applicable technologies acquired on other similar projects (such as C-018H Facility, N-Reactor Effluent, and 300 Area Treated Effluent Disposal Basin). Interaction with innovative technology development programs at the Hanford Site (see Section 7.5) may also play a viable role in design of the treatment process. Because of the wide variety of chemicals present (both introduced and natural) in 200 Areas groundwater, bench and possibly pilot treatability tests are likely to be required to obtain critical design and proof-of-principal information for applicable technologies. These tests will be critical to fully evaluate feasible approaches for groundwater treatment in the 200 West Area.

Once treated, the groundwater must be disposed of in accordance with applicable regulations. Disposal may include discharge to uncontaminated soils and water. Disposal may alternatively include reinjection of the treated groundwater into the contaminated source from which it came, or introduction of chemical nutrients to promote in situ biotreatment. In all cases, determination of applicable regulations and standards will be necessary.

A limitation of the groundwater pump-and-treat alternative is that its success may require years to decades of operation and treatment of voluminous quantities of water. Key factors in evaluating the time to completion are the site-specific mobility of chemicals detected in groundwater, soil characteristics, and hydrogeologic conditions. Chemicals such as some metals and radionuclides, which adsorb strongly to soil, are more difficult to extract by pumping groundwater. Site-specific mobility is a result of partitioning between dissolved

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and adsorbed phases of chemicals. The DNAPLs can adsorb to soils or be held in residual saturation forming long-term sources that may dissolve into groundwater for a long time. Silts and fine sands may adsorb many chemicals more readily and also have a low permeability, thereby increasing the time and effort required to remove contaminants. Hydrogeologic characteristics like fissures, lenses, confining layers, and preferential flow paths can divert groundwater and inhibit the uniform extraction of constituents from target zones.

In many cases, groundwater pump and treat programs have reported a significant decrease in contaminant concentrations after only a short operating period, particularly when the initial contaminant concentrations are relatively high. However, the reduction of chemical concentrations with time tends to follow an asymptotic function, with low concentrations of contaminants persisting over a very long time. Further operations result in the extraction of large volumes of water which must be treated to remove increasingly smaller amounts of contaminants. Thus, the efficiency of the pump and treat operation continues to decrease. Because the 200 West Groundwater Aggregate Area is characterized as containing large volumes of water with relatively low levels of many chemical and radionuclide contaminants, operations are not expected to achieve dramatic reductions initially, and the achievement of specified cleanup levels will likely require a lengthy operation during which the rate of contaminant reductions are expected to be low.

During the extended operating period, using the pump and treat system for plumes in the 200 West Area (estimated 160,000 to 38,000,000 m^3 for contaminant plumes identified in Table 4-3) would result in treating millions of gallons of water. If long-term success of the groundwater treatment is potentially questionable, secondary effects such as by-product wastes and economic considerations may overshadow the benefits of installing a pump and treat system.

Even with the limitations discussed, pump-and-treat technologies are considered the primary, proven technology available to remove and treat contaminants in groundwater. Detailed knowledge of the extractability of target chemicals, groundwater treatability RAOs applicable to discharges, and potentially adverse secondary effects are keys to understanding the applicability of pump-and-treat systems in 200 West Groundwater Aggregate Area remedial actions.

7.2.3 Containment Technologies

Groundwater containment includes the use of technologies to minimize, divert, or prevent the movement of contaminated groundwater. Containment technologies can be used to reach RAOs for groundwater remediation in a variety of ways. Containment can be

implemented to stop groundwater flow and hence isolate contaminants. Alternatively, containment can be used to divert groundwater, increasing migration time before it reaches a receptor, and hence allow for increased natural attenuation. Typically, containment is achieved by installing either impermeable barriers (either vertical or horizontal) or by using dynamic hydraulic pumping and/or injection systems. Impermeable barriers (cutoff walls) can be constructed with metal, grouts, or soil freezing. Dynamic systems are based on the removal or injection of sufficient quantities of water to affect groundwater flow.

The 200 West Groundwater Aggregate Area consists of large volumes of groundwater located about 55 to 130 m (180 to 425 ft) below ground surface. These depths will pose new challenges for the implementation of containment technologies. For example, cutoff walls are typically a moderate cost option. However, when installed at the depth required, relative costs may rise disproportionately compared to other alternatives. Monitoring the effectiveness of cutoff walls at these depths requires innovative solutions.

Similarly, dynamic hydraulic systems can often be straightforward and efficient to implement, but the operation of a containment system may be complicated in the 200 West Groundwater Aggregate Area because of the large volumes of water involved. Management options for the large volumes of extracted water will present technical treatment challenges and regulatory complications. Furthermore, pumping and/or injection may change overall groundwater flow directions and gradients, which requires that the changes be considered and monitored.

Containment technologies have proven effective in groundwater remediation. Because they are based on physical installation, they achieve the desired goal relatively quickly. They can be used to achieve isolation of groundwater, or partial hydrogeologic flow modification, and with proper evaluation, could be a valuable tool in designing remedial alternatives for the 200 West Groundwater Aggregate Area.

7.2.4 In Situ Groundwater Technologies

In situ groundwater technologies include chemical, physical, and biological treatments to remove, immobilize, or destroy groundwater contaminants in the subsurface. Examples of process options include chemical additions to pump-and-treat systems to assist flushing or precipitation of contaminants, oxygenating groundwater to enhance natural biological degradation, or sparging to strip chemical contaminants from groundwater.

In situ technologies may be low cost or may have minimal adverse effects, but their dependencies on geological conditions, site-specific chemical/biological background conditions, and time are not well known. Successful in situ treatment has been simulated in

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the laboratory and tested in the field for a few chemicals in a limited range of site-specific conditions. These studies have demonstrated the potential benefits of in situ treatment. However, they have also revealed that improved understanding of subsurface mixing, effects of existing background conditions, hazards associated with by-product production, and other failure/success modes is needed before in situ technologies can be recommended and implemented successfully.

The relatively high permeability of much of the saturated subsurface soil column in the 200 West Area fulfills a key prerequisite for successful in situ remediation. High permeability soils help overcome the poor mixing and reagent delivery which typically hamper in situ treatments. The effectiveness and implementability of in situ technologies to the range of chemicals and site conditions at the Hanford Site is currently the subject of research and development through innovative technology development programs. The role of in situ treatment technology in the 200 West Groundwater Aggregate Area will depend on the outcome of these programs.

7.2.5 Treatment at Point-of-Use and Point-of-Discharge Locations

Groundwater treatment at point-of-use and point-of-discharge locations is a variation of pump-and-treat technologies that attempt to mitigate groundwater problems by treating only the portion of groundwater directly associated with an exposure pathway. These technologies address the limitations of general pump and treat and containment technologies by treating only the groundwater extracted to which humans or environmental receptors may be exposed, rather than all contaminated groundwater regardless of its potential use or discharge. Point-of-use and point-of-discharge response actions are applicable to sites where use and discharge points of the groundwater are limited and can be effectively controlled. In the case of the 200 West Groundwater Aggregate Area, future use and discharge points will likely continue to consist of a few wells and discharge points along the Columbia River.

Several advantages are gained by this approach. First, only contaminants present in the groundwater at the point of use or discharge must be treated. By limiting treatment to those contaminants associated with actual exposure pathways, less treatment is necessary. Allowing groundwater to remain in the ground during its migration from the source to the receptor allows time for natural decay of radionuclides, natural precipitation and adsorption of inorganic metals, and natural biodegradation of organic chemicals before its discharge or use. The natural loss mechanisms potentially simplify treatment and minimize adverse impacts. A second advantage is that if natural attenuation is effective, the volume of water requiring treatment is significantly reduced, which improves the economics and efficiency of treatment. The third advantage is that remedial action alternatives can be customized for the

known human or environmental exposure at each point of use or point of discharge. This allows flexibility in the goals of the treatment train design based on actual exposure.

Remedial actions that rely on treatment at the point of use or point of discharge have several potential limitations. These actions only address exposure pathways concerning human use, and may have to be combined with other remedial technologies to be acceptable. If natural attenuation is ineffective, allowing the groundwater to migrate to the point of discharge may result in an increase in the volume of groundwater which requires treatment. It may also be impractical to build the required treatment facilities at the point of discharge or point of use due to physical, legal, or political restrictions. For example, if the point of use is a relatively small private well, and the groundwater contains a recalcitrant chemical, it may be physically difficult to build a suitably small treatment unit. In another example, if the point of discharge occurs in near a community, the regional politics may prevent the construction of a large-scale treatment plant to treat groundwater.

Like the other alternatives, remedial actions that rely on treatment at the point of use or point of discharge have specific advantages and limitations. Because of the size and complexity of the 200 West Groundwater Aggregate Area, point-of-use and point-of-discharge alternatives that take advantage of natural attenuation processes to reduce contaminant concentrations in situ may play a role in the final remedy.

7.2.6 Combinations of General Response Actions

The above broad classes of response actions may be combined into additional remedial alternatives. As discussed in the above sections, each general response action has particular advantages and disadvantages when applied to the site-specific conditions located at a 200 West Area location. No single action may be able to achieve all RAOs, but a combination of actions may be successful.

For example, containment actions which mitigate hazards resulting from groundwater movement, but are limited in implementability due to the large size of the 200 West Groundwater Aggregate Area and the great depth to groundwater, could be used in combination with pump-and-treat actions to effectively control a highly contaminated source area. In situ treatment may be combined with pump-and-treat actions to decrease the time required to achieve cleanup goals. Containment could be combined with in situ treatment to contain and reduce contamination. In all cases, institutional controls (i.e., fences and deed restrictions) may be a required component to prevent disruption of the containment system and reduce the risk to human health and the environment until other classes of response actions are effective.

In the next section, specific process options within each general response action are evaluated.

7.3 TECHNOLOGY SCREENING

In this section, potentially applicable technology types and process options for each general response action are identified. These process options are then screened using effectiveness, implementability, and relative cost as criteria to eliminate those process options that would not be feasible at the site. Consideration of innovative technologies is maintained throughout the screening process. When applicable, technologies that have high potential benefits, but failed screening due to lack of development, are retained as innovative technologies. The selected process options are then grouped into viable remedial alternatives in Section 7.4. A limited discussion of innovative technologies is presented in Section 7.5.

7.3.1 Screening Criteria

The effectiveness criterion focuses on: (1) the potential effectiveness of process options in handling the estimated areas or volume of groundwater and meeting the RAOs; (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 the contaminants and conditions at the site. This criterion is applied based on the ability of a process option to treat a contaminant type (organic, inorganic, metals, radionuclides, etc.) rather than a specific contaminant (nitrate, cyanide, chromium, plutonium, etc.).

The implementability criterion places 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. This 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. At this stage in the process, the cost analysis is made on the basis of engineering judgment, and 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 media required, if it does not adversely 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 at the site. Also, a process option is considered more effective if it treats a wide range of contaminants rather than a specific contaminant.

An easily implemented process option 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 also given to lower cost options, but a process option is not eliminated based on cost alone.

7.3.2 Screening of Technologies

Technologies are identified, organized by general response actions, and presented in Table 7-2. Results of the screening process for each identified technology are then shown in Table 7-3. To help clarify the numerous variety of pump-and-treat groundwater technologies identified, a summary of retained groundwater technologies is presented in Table 7-4.

Results of the screening process are shown in Table 7-3. Brief descriptions of the process options are given, followed by comments regarding the three evaluation criteria defined in Section 7.3.1. The effectiveness and implementability criteria comments formed the primary basis for evaluating each option. Cost criteria comments are very general and did not play a primary role in evaluating options. The last column of the table indicates whether the process option is rejected, retained but recognized as an innovative technology, or carried forward for possible alternative formation. Each of the technologies presented in the table addresses RAOs for both surface water and groundwater exposure routes discussed previously in this groundwater.

The "conclusions" column of Table 7-3 indicates that in addition to no action and monitoring, 22 process options were retained as potentially applicable. Of these, five were classified as innovative (for separate discussion); the remaining 16 options were retained for further development of alternatives. These options are carried forward into the development of preliminary alternatives.

Table 7-4 summarizes the 22 technologies retained from the screening process for use as a quick reference. Footnotes are provided on the table to highlight specific aspects of each technology.

7.4 PRELIMINARY REMEDIAL ACTION ALTERNATIVES

This section develops and describes several remedial alternatives applicable to 200 West Groundwater Aggregate Area radionuclides and hazardous organic and inorganic contaminants of concern (Sections 4.0 and 5.0). These alternatives are not intended as recommended actions for any particular contaminant, but are intended only to provide potential options. Selection of the actual remedial alternatives would be partly based on future expedited or interim actions and limited field investigations, as recommended in Section 9.0 of this report. Selection of final alternatives would be conducted within the framework of the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a), and the strategy outlined in Section 9.4.

The remedial alternatives are developed in Section 7.4.1. In Sections 7.4.2 through 7.4.7, the remedial action alternatives are described. Detailed evaluations and costs are not provided because site-specific conditions must be further investigated before meaningful technical and cost evaluations can be conducted.

7.4.1 Development of Remedial Alternatives

Potentially feasible remedial technologies were described and screened in Section 7.3. Some of those technologies were found to be proven, effective, and constructible, while other technologies are in the development or "innovative" stages. EPA guidance on feasibility studies (EPA 1989a) for uncontrolled waste management units recommends that a limited number of candidate technologies be grouped into "Remedial Alternatives." For this study, technologies were combined to develop remedial alternatives and provide at least one alternative for each of the general response actions previously discussed:

- No action
- Institutional controls
- Groundwater removal, above-ground treatment, and disposal (i.e., pump and treat)
- Containment of groundwater
- In situ treatment of groundwater
- Point-of-use treatment

- Point-of-discharge treatment

- Combination of the above actions.

The alternatives are intended to treat all or the highest risk portion of contaminants of the 200 West Groundwater Aggregate Area groundwater plumes. Consistent with the development of RAOs and technologies, alternatives were initially developed based on treating classes of compounds (radionuclides, heavy metals, inorganic, and organic) rather than specific contaminants. At a minimum, the alternative must be a complete package. For example, extraction of groundwater followed by treatment must be combined with either reinjection or disposal of the groundwater and treatment of secondary wastes.

Both no action and institutional control alternatives are evaluated as required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RI/FS guidance. The purpose of including these alternatives is to provide decision-makers with information on the entire range of available remedial actions. For the containment alternative, engineered frozen barriers and slurry walls are presented. Two alternatives are presented for pump-and-treat strategies. One alternative proposes large-scale extraction of groundwater followed by comprehensive treatment and disposal. The second alternative addresses limited-scale groundwater extraction followed by treatment for high-priority compounds. Finally, one example of point-of-use and one example of point-of-discharge options are presented. In situ technologies are addressed in the innovative technologies sections.

This evaluation does not include an exhaustive list of all possible combination of process options. However, the alternatives presented provide a reasonable range of remedial actions that are likely to be evaluated in future feasibility studies. The remedial alternatives presented in this report are summarized as follows:

- No action

- Institutional controls

- Containment barriers engineered from freeze or grout technologies

- Extraction of groundwater, comprehensive treatment, and disposal

- Limited extraction of groundwater, treatment of high priority compounds, and reinjection in zone of extraction

- Treatment at point of use

- Treatment at point of discharge, followed by reinjection.

These alternatives, with the exception of no action and institutional controls, were created to satisfy a number of RAOs simultaneously and use technologies that are appropriate for a wide range of contaminant types. For example, installation of a comprehensive pump-and-treat system can effectively treat radionuclides, heavy metals, inorganic compounds, and organic compounds and provide a measure of hydraulic containment simultaneously. It satisfies the RAO of protecting human health and the environment from exposures to contaminated groundwater as well as reducing migration of contaminated groundwater to the Columbia River.

It is likely that groundwater will require a combination of treatment technologies to completely address all contaminants. Air stripping is highly effective for removing volatile organics present in groundwater, but has little effect on metals. Ion exchange is highly effective on most metals but is typically ineffective in treating volatile organics. Tritium, because of its near chemical identity to water, can currently only be treated by natural attenuation. Because groundwater is likely to contain multiple classes of chemicals, and because it is likely that extraction well drawdown will enhance the mixing of contaminants from operable units, final alternatives will probably require a combination of treatment technologies.

The use of contaminant-specific remedial technologies was avoided because there appear to be few, if any, groundwater plumes where a single contaminant appears alone. It is possible to construct alternatives that include several contaminant-specific technologies, but the number of combinations of technologies required to address the contaminant mixtures would result in an unmanageable number of alternatives. Moreover, the possible presence of unidentified contaminants may render specific alternatives unusable. Alternatives can be refined as more contamination data are acquired. For now, the alternatives will be directed at remediating the major classes of compounds (radionuclides, heavy metals, inorganics, and organics).

In all action alternatives it is assumed that monitoring and institutional controls are required, although they may be temporary. These features are not explicitly mentioned, and details on monitoring programs and institutional controls are purposely omitted until a more detailed evaluation is performed in subsequent studies.

In the next sections, the preliminary remedial action alternatives (exclusive of the no action and institutional controls alternatives) are described in more detail.

7.4.2 Alternative 1--Engineered Vertical Barriers

Alternative 1 consists of containment of contaminated groundwater. Screening of potential containment technologies indicated that containment of groundwater at the depth occurring at 200 West Groundwater Aggregate Area can be achieved by two methods--subsurface freezing and grouting. Figure 7-2 shows schematic examples of these technologies. Both barriers achieve the same goal, but have unique cost and implementability factors. Installation of either type of barrier to the depth of groundwater present at the site (over 200 ft) will challenge existing applications of these techniques. The feasibility of these two technologies for unconfined aquifers at depth was previously evaluated in the *Engineering Evaluation of Containment Alternatives for N-Springs Releases* (WHC 1991b). Although not directly analogous to the 200 West Groundwater Aggregate Area, the analyses presented in the report suggest that physical barriers may be successfully installed at great depths.

Subsurface freezing and grouting could be designed to achieve a variety of goals within the 200 West Area such as:

- Mitigate/delay flow of contaminated groundwater to the Columbia River
- Segregate operable units for treatment
- Block natural recharge pathways which accentuate mobility of contaminated groundwater.

Because of the large size of the 200 West Groundwater Aggregate Area, and the fact that no contaminant destruction occurs, engineered vertical barriers are not likely to be used as a single permanent solution, but will likely be included as a key component in a combined technology solution. Detailed evaluation of site hydrogeology, costs, feasibility, and adverse consequences is required to determine the best use of containment alternatives in remediation of 200 West Groundwater Aggregate Area groundwater.

7.4.3 Alternative 2--Groundwater Extraction, Comprehensive Treatment, and Disposal

Alternative 2, a pump-and-treat option, consists of extraction of groundwater, comprehensive treatment, and disposal. In this alternative, groundwater contaminated with one or more chemicals is treated using multiple treatment technologies to meet long-term RAOs established for the site. The treated groundwater is discharged to surface water, groundwater, or soil column. Additionally, extraction of groundwater followed by offsite

discharge is assumed to result in a reversal of the groundwater flow gradient, resulting in hydraulic containment of the contaminant plume.

Figure 7-3 shows a schematic diagram of this alternative. Extraction wells would be installed and operated near the center of contamination within identified contaminant plumes. Pump tests on existing wells, aquifer characterization, analysis of sorption, and exchange properties of contaminants detected in groundwater and adsorbed in soils would be used to predict the spacing for new extraction wells, pumping rates, and operating time necessary to effect the desired hydraulic containment and treatment.

A multi-technology wastewater treatment train would be employed to treat the groundwater to meet discharge limits. Depending on the contaminants located in the target plume, the treatment train would consist of one or more of treatment technologies such as chemical precipitation, filtration, coagulation, reverse osmosis, air stripping, ultraviolet (UV) oxidation, and/or ion exchange. Table 7-4 provides a preliminary screening of treatment technologies applicable to the chemicals detected in the 200 West Area groundwater. Technologies would be selected and combined in accordance with Hanford BAT guidance to create a reliable, effective, comprehensive treatment train. All secondary waste generated by the comprehensive treatment train would have to be disposed of or treated accordingly. Detailed understanding of the variability in groundwater to be extracted, potential new chemicals introduced during future plume mixing caused by groundwater extraction, as well as effects of site-specific background chemicals (such as iron) would be required to design an effective treatment system. Some chemicals, such as tritium, have no known treatment, and therefore could not be addressed by this alternative. For other chemicals, the known removal technology might not be able to achieve cleanup standards determined by potential ARARs and RAOs without additional research and development.

An appropriately permitted discharge site likely to be similar to the SALDS proposed for the C-018H and -049H effluents would be required to dispose of the groundwater. This site would be evaluated to ensure that hydrogeologic effects of the discharge on existing groundwater would be negligible. Discharge water could be potentially beneficial by providing an introduced gradient that enhances the containment of existing contaminated groundwater.

Alternative 2 would provide a combination of complete treatment of all contaminants and mitigation of groundwater movement, thus successfully addressing the most stringent RAOs. However, the alternative is limited by the inability of pump-and-treat systems to quickly achieve cleanup goals and potentially require treatment of excessive quantities of water. A detailed feasibility study is needed to evaluate the performance, costs, and potential adverse effects associated with this alternative. Other recognized limitations of the pump-and-treat system should be evaluated in the feasibility study, such as remediation of plumes

where chemicals have adsorbed to soils, or where DNAPLs or zones of low hydraulic conductivity are present.

7.4.4 Alternative 3--Limited Extraction of Groundwater, Treatment of High Priority Compounds, and Reinjection in Zone of Extraction

Under Alternative 3, groundwater would be extracted from a contaminant plume, and partially treated to remove the compounds which represent the highest risk to human health. After treatment, the groundwater would be reinjected to the same groundwater regime for management by other technologies (such as containment or institutional controls). The treatment technology selected would depend on the contaminants identified as posing the highest risk in the operable unit. The reinjected groundwater could be used to hydraulically contain and enhance the removal of the target high-risk contaminants. Discharge of the treated groundwater to surface water, as in Alternative 2, would not be possible due to the presence of trace nontarget chemicals.

The partial treatment of groundwater described in this alternative (rather than the comprehensive treatment described in Alternative 2) may be appropriate because plume definition and technology screening indicate that groundwater contains a sufficient variety of chemicals to potentially mandate the use of multiple, linked, treatment technologies (see Table 7-4). This multiplicity could lead to the delay, or possible prevention, of the implementation of both short-term and long-term remedies. For example, the treatability programs required to effectively link several technologies may be long when compared to the treatability program required for the single technology that addresses the highest risk chemical. It also may be found that the groundwater contains isolated chemical(s) for which treatment is not available in the near future (such as tritium). To allow the timely implementation of existing, effective technologies, partial treatment of extracted groundwater may be recognized as a viable option.

A key issue raised by Alternative 3 is the feasibility and/or regulatory acceptability of reinjecting groundwater that still contains untreated or partially treated chemical groups. Although the groundwater is being reinjected into the area from which it originated, thereby reducing the risk and improving local groundwater quality, long-term ARARs or RAOs for groundwater quality may not be met. As a result, Alternative 3 may require that location-specific reinjection standards be developed recognizing that the reinjected contaminants will be managed by alternative methods.

For example, Figure 7-4 shows a schematic of this alternative applied to removing volatile organics from groundwater that also contains chemicals such as tritium for which treatment is not effective. Technology screening indicates that air stripping is an effective

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technology for removing volatile organics identified in the 200 West Groundwater Aggregate Area, including the chlorinated solvent chemicals (trichloroethylene, trichloroethane, tetrachloroethylene, etc.). Extraction wells and reinjection wells are placed to effect the desired groundwater removal and containment. An appropriately sized air stripping unit, with off-gas treatment potentially based on experience being gained in the *Expedited Response Action Proposal for the 200 West Area Carbon Tetrachloride Plume* (DOE/RL 1991a), would be installed. Its design would consider potential side effects associated with the contaminant plume. Quantities of tritium and ^{129}I, both of which have significant vapor pressures, would be evaluated to determine if they would co-strip with the volatile organics. Iron and other metals, occurring naturally, would be evaluated to determine pretreatment required to avoid fouling the stripping unit. Other recognized limitations of the pump and treat systems, such as adsorption of chemicals to soils or the presence of DNAPLs, should be evaluated to determine the ability of Alternative 3 to effectively remove the target volatile organic chemicals.

In another example, Figure 7-5 shows a schematic of this alternative as applied to groundwater which has a variety of inorganic metals, as well as trace organic chemicals for which natural biodegradation has been determined to be effective. Technology screening indicates that chemical precipitation is an effective technology to remove many inorganic metals identified in the 200 West Groundwater Aggregate Area *(Project L-045H 300 Area TEDF,* WHC 1991c). As in the previous example, extraction and reinjection wells are designed and installed to effect the desired extraction, hydraulically contain the contaminant plume, and potentially assist in the removal of metal ions remaining in the groundwater. The side effects of all trace, nontarget chemicals on chemical precipitation would be evaluated before implementing the system. All secondary waste would be evaluated and disposed of properly. Once treated the groundwater would be returned to the plume where the trace organics would biodegrade at their natural rate.

Similar systems could be devised for other technologies such as ion exchange, reverse osmosis, UV oxidation, and other process options identified in Table 7-4. Several technologies could be combined if required. It is important to recognize that the selectivity of available technologies is likely to be limited to chemical groups rather than specific chemicals; however, some chemical-specific technologies may be identified in future work. As with the previous two examples, bench-scale testing should be performed to ensure compatibility with other trace, nontarget chemicals contained in groundwater plumes being treated. For each class of chemical contaminant, treatability studies with extracted groundwater should be conducted to evaluate potential interference reactions and pretreatment requirements. Secondary wastes must also be evaluated and secondary treatment tested. The recognized limitations of pump and treat systems, such as the potentially long time to completion and the cost and secondary waste production associated with long-term operation of treatment facilities may limit the net effectiveness of Alternative 3.

Identification of target high priority classes of chemicals that would warrant use of this alternative should be based on evaluation of plume maps, risk analysis, the selectivity of available treatment technologies, and application of ARARs and RAOs.

7.4.5 Alternative 4--Treatment of Groundwater at the Point of Use

This alternative proposes remediation of only the portion of groundwater that actually will be used. Because of the depth of the groundwater on the site and the lack of natural surface connections such as springs or seeps, present or future points of use would likely be defined by the presence of a water supply well.

Figure 7-6 shows a schematic of this alternative. Depending on the location of the point of use, a different range of contaminants would be present. Low mobility contaminants would not migrate far from their source, whereas high mobility contaminants could affect wells located downgradient. As the groundwater travels from sources to the point of use, natural attenuation through decay of radionuclides, precipitation and adsorption of metals, and possible biodegradation of organic compounds can reduce contaminant levels. Point-of-use treatment has the significant advantage of focusing on only those contaminants that pose risks to receptors.

During installation of a water supply well at the point of use, a treatment train would be installed. The treatment train would be designed in accordance with Hanford BAT to meet the required water quality standards for consumer use. Because natural attenuation can reduce the number and concentration of contaminants at the point of use, the treatment train design may be a simplified version of those proposed in source-related alternatives (Alternatives 2 and 3). The treatment train would be properly maintained to ensure sufficient quality and quantity of water for the duration of end-user needs.

The point-of-use remedial alternative has two important disadvantages. First, point-of-use treatment will only address the potential routes of groundwater exposure to humans. Alone, it is not likely to achieve RAOs. Many regulatory programs reflected in the RAOs require protection of the environment and other factors in addition to protection of human consumption. Point of use may not effectively address these other regulatory concerns. Second, point-of-use treatment requires that a water treatment system be constructed relatively near the point of use. Depending on the chemical composition of groundwater at the point of use, the water quality required, and the volume of water being treated, construction of a treatment system adjacent to the point of use may not be practical. Point-of-use treatment may be a viable alternative for certain limited operable units, but prior to its use, chemical characteristics and potential volumes need to be thoroughly evaluated.

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7.4.6 Alternative 5--Treatment of Groundwater at Point of Discharge

Alternative 5 proposes treatment of only the portion of groundwater that is discharged. Because of the hydrogeology at the 200 West Groundwater Aggregate Area, points of discharge are expected to include the Columbia River, West Lake, or the Yakima River. As with the point-of-use alternative, the chemical composition of groundwater at the point of discharge will be substantially different than the chemical composition of groundwater near the source. Various mechanisms associated with natural decay of radionuclides, precipitation and adsorption of metals, and biological decay of organics will alter the composition of groundwater as it travels from the source to the point of discharge. Point-of-discharge treatment has the significant advantage of focusing on only those contaminants that pose a significant risk to receptors. In addition, because point of discharge exploits natural attenuation, it may be the only viable alternative for tritium.

The treatment of groundwater recovered at the point of discharge would be designed in accordance with Hanford BAT to meet the standards required to protect the discharge receptor. As discussed in Section 7.4.5, the treatment train at the point of discharge may be a modified version of the treatment train proposed in the other source-related treatment alternatives (Alternatives 2 and 3). Figure 7-7 depicts an example of this alternative.

The point-of-discharge remedial alternative has a number of disadvantages. First, point-of-discharge treatment focuses on protecting the discharge receptors' water quality standards (such as the Columbia River surface water quality) and therefore is not likely to be acceptable alone in achieving site-wide RAOs. Many regulatory programs reflected in the RAOs require protection of the environment and other factors in addition to protection of discharge receptors. Point of discharge may not effectively address these other regulatory concerns. Second, if natural attenuation is insufficient in reducing contaminant levels, contamination may be diluted and spread over a considerable length of the Columbia River, factors that may make extraction and treatment more difficult and costly.

If available treatment technologies are unable to treat groundwater at the point of discharge to meet standards for the discharge receptor, it may be possible to discharge treated groundwater to an alternative location. Once reinjected, the groundwater would begin a second migration towards the point of discharge. This second migration would increase the time allowed for natural attenuation. For chemicals such as tritium, whose only known treatment is natural attenuation, this second migration may enable groundwater to meet treatment standards established at the point of discharge.

7.5 INNOVATIVE TECHNOLOGIES

All remedial alternatives presented in the previous section were composed of proven process options that passed the required screening criteria for effectiveness, implementability, and cost. Some technologies that did not meet these criteria were retained and identified as innovative technologies. Innovative technologies recognized to potentially play a key role in 200 West Groundwater Aggregate Area remediation are discussed in this section. Technology screening in Section 7.4 identified three types of innovative technologies applicable to groundwater.

First, in situ treatments may be especially suited for treatment of groundwater contamination in the 200 Areas. In situ treatments use the soil/groundwater matrix as a treatment bed and are facilitated by the potential for good mixing offered by the high permeability of the 200 Areas soils. Because in situ treatment conducts the treatment in soil/groundwater matrix, secondary waste generation can be minimized, adverse affects are diminished, and treatment costs are potentially reduced. In addition, for groundwater which cannot be successfully remediated by conventional technologies, in situ treatment may be the only viable solution. For example, low mobility compounds such as plutonium are not amenable to remediation through pump and treat technologies, since extraction of groundwater cannot completely remove the plutonium. In situ precipitation of the plutonium could render the plutonium essentially immobile. Alternatively, in situ solubilization could increase plutonium's mobility to allow pump and treat to effectively remove the plutonium in an acceptable time frame. Of course, increasing the mobility of toxic chemicals in groundwater would be performed only after evaluating the potential benefits and adverse effects.

In another example of in situ technologies, air sparging may effectively remove volatile organics from groundwater. Sparging air is pumped into an injection well and released into groundwater. As the air expands and rises through the groundwater, small bubbles extract and transport volatile chemicals upward to the soil in the vadose zone. Once the bubbles reach the vadose zone, vacuum extraction wells would remove the air. The air would then be treated and either discharged or recycled for additional reinjection/extraction cycles. Air sparging can also be used to enhance natural degradation by adding oxygen, or if steam is used for sparging, by adding heat and increasing the speed of naturally occurring biodegradation.

A second area of innovative technologies to be explored is in wastewater treatment. Currently, each chemical class in the wide range of chemicals found in Hanford Site groundwater (organics, radionuclides, and metals) requires unique treatment technologies. These technologies must be linked to provide a successful comprehensive treatment. Additionally, although many of these technologies are effective in producing an effluent that

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meets cleanup standards, many produce large volumes of secondary waste. Innovative technologies such as supercritical extraction, oxidation, freeze crystallization, and membrane separation may be able to treat broader classes of compounds while providing low cost, effective secondary waste treatment. An example of this is that membrane fouling problems have traditionally prevented reverse osmosis' use for wastewater treatment including organic and inorganic classes of chemical compounds. However, if new anti-fouling, multi-chemical class membranes can be identified, membrane separation has the potential to treat the full range of chemicals in 200 Areas groundwater, simplifying the current multi-technology treatment trains that are required.

In another example of innovative wastewater treatments, freeze technologies may provide an energy efficient way to concentrate secondary waste generated from membrane technologies or ion exchange. These secondary wastes comprise up to 10% of influents entering these processes and can be a major impediment to their implementation. Freeze technologies can potentially concentrate the volumes of these secondary wastes, replacing the traditional method of evaporation, at a potential cost savings with fewer adverse effects.

The third area of innovative technologies which would warrant development is the installation of horizontal barriers at the depths of groundwater encountered in the 200 Areas. Because vertical flows of contaminants may further degrade groundwater quality, barriers that prevent vertical flows may be desired. However, large-scale installation of deep horizontal barriers is a developmental procedure, so technologies in grouting and freezing need to be evaluated to determine if blockage of vertical flows is possible. Application of these technologies would likely include right angle drilling and/or sophisticated grouting techniques which have not been proven for remediation applications.

A final area of innovative technology concerns the treatment of tritium. Because the structures of are tritated water and nontritated water nearly identical, no removal treatments that achieve levels lower than those present in groundwater are known. Soil columns and retention systems that retain tritium for sufficient periods to allow natural decay may be effective implementable options which need only to be proven through testing.

To encourage research and development of innovative technologies, the AAMS program personnel interface regularly with the DOE Office of Technology Development.

7.6 PRELIMINARY REMEDIAL ACTION ALTERNATIVES APPLICABLE TO GROUNDWATER OPERABLE UNITS

The purpose of this section is to discuss how preliminary remedial action alternatives could be used to remediate specific situations identified in 200 West Groundwater Aggregate Area operable units. The decision criteria are as follows:

- **Alternative 1--Physical Containment.** Alternative 1 could be used on any chemical contaminant plume where restriction of groundwater flow is required to stop migration or to support the effectiveness of another alternative.

- **Alternative 2--Groundwater Extraction, Treatment with a Comprehensive System, and Disposal.** Alternative 2 could be used on any plume where all the contaminants identified could be extracted and treated with known technologies. The plume would have to be sufficiently large to justify the substantial cost associated with comprehensive treatment.

- **Alternative 3--Groundwater Extraction with Treatment to Remove a Single Chemical Class, and Reinjection.** Alternative 3 could be used on any operable unit for which a single class of contaminants poses significantly more risk than other classes and is amendable to pump and treat technologies. It can also be used on a plume that contains isolated chemical(s) for which pump and treat is not effective, but is required for treating the remaining chemicals. The more disproportionate the risk or treatment practicality between chemical groups in a contaminant plume, the more advantageous is Alternative 3. However, the technology required to remove the target chemical group must be carefully evaluated for nontarget chemicals which could interfere with treatment or trigger regulatory reinjection hurdles. Additionally, this evaluation should determine if it is economically efficient to remove the target group selectively, rather than with the comprehensive treatment proposed in Alternative 2.

- **Alternative 4--Treatment at Point of Use.** Alternative 4 could be used for a contaminant plume where the RAOs can be focused on the groundwater ingestion exposure pathways alone. Because one of the primary benefits of point-of-use treatment is the natural attenuation time, contaminant plumes that benefit from natural attenuation are more appropriate candidates for Alternative 4.

- **Alternative 5--Treatment at Point of Discharge.** Alternative 5 could be used for contaminant plumes where the RAOs can be focused on exposure pathways associated with surface water alone. Since one of the primary benefits of point-of-discharge treatment is the large natural attenuation time allowed, contaminant

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plumes with chemicals such as tritium that will benefit from natural attenuation are candidates for Alternative 5.

Using these criteria, Table 7-5 was created showing possible preliminary action alternatives that could be used to remediate each of the contaminant plumes identified in Section 4.1. These criteria are not meant to be exclusive. The criteria and preliminary remedial alternatives are presented as an initial screening only. Operable units which may contain one or more contaminant plumes, may use one or several of these alternatives to achieve applicable RAOs. Also, more specific waste treatment alternatives could be identified and evaluated as more information concerning innovative technologies is acquired. Since the primary mechanism for groundwater treatment involves various forms of pump and treat, many alternatives overlap.

As mentioned previously, the selection of the treatment technologies for Alternatives 2 through 5, which involve treatment of extracted groundwater, is not straightforward. After using Table 7-5 to identify the appropriate remedial alternative, Table 7-4 should be used to identify the required treatment technologies, potential interferences, and limitations. However, Table 7-4 is not a complete reference nor is it completely accurate in cases where multiple contaminants are present. Interferences between chemical classes is common and often unpredictable. Treatments that are effective for one chemical may not work when a second chemical is present. Final treatment technologies for use in alternatives that depend on extraction and treatment of groundwater should be selected according to the Hanford BAT document (which seeks to facilitate technology transfer) to ensure reliable success in designs for water treatment.

Before selecting a remedial alternative for an operable unit, detailed feasibility studies, bench-scale, and pilot-scale treatment tests must be performed. These studies and tests should develop a better understanding of groundwater hydrogeology and chemical mobilities to successfully implement extraction alternatives. A more complete identification of RAOs is required to determine the applicability of point-of-use and point-of-discharge alternatives. Completion of these studies and the acquisition of additional site characterization data will focus the remedial action model and begin to narrow the range of potentially applicable technologies and alternatives. Finally, continuing efforts by the DOE Office of Technology Development, Westinghouse Integrated Programs and Demonstrations programs, and Battelle Pacific Northwest Laboratory to evaluate in situ treatments, advanced wastewater treatment, and the treatment of tritium will be important in arriving at remedial alternatives for the 200 West Groundwater Aggregate Area.

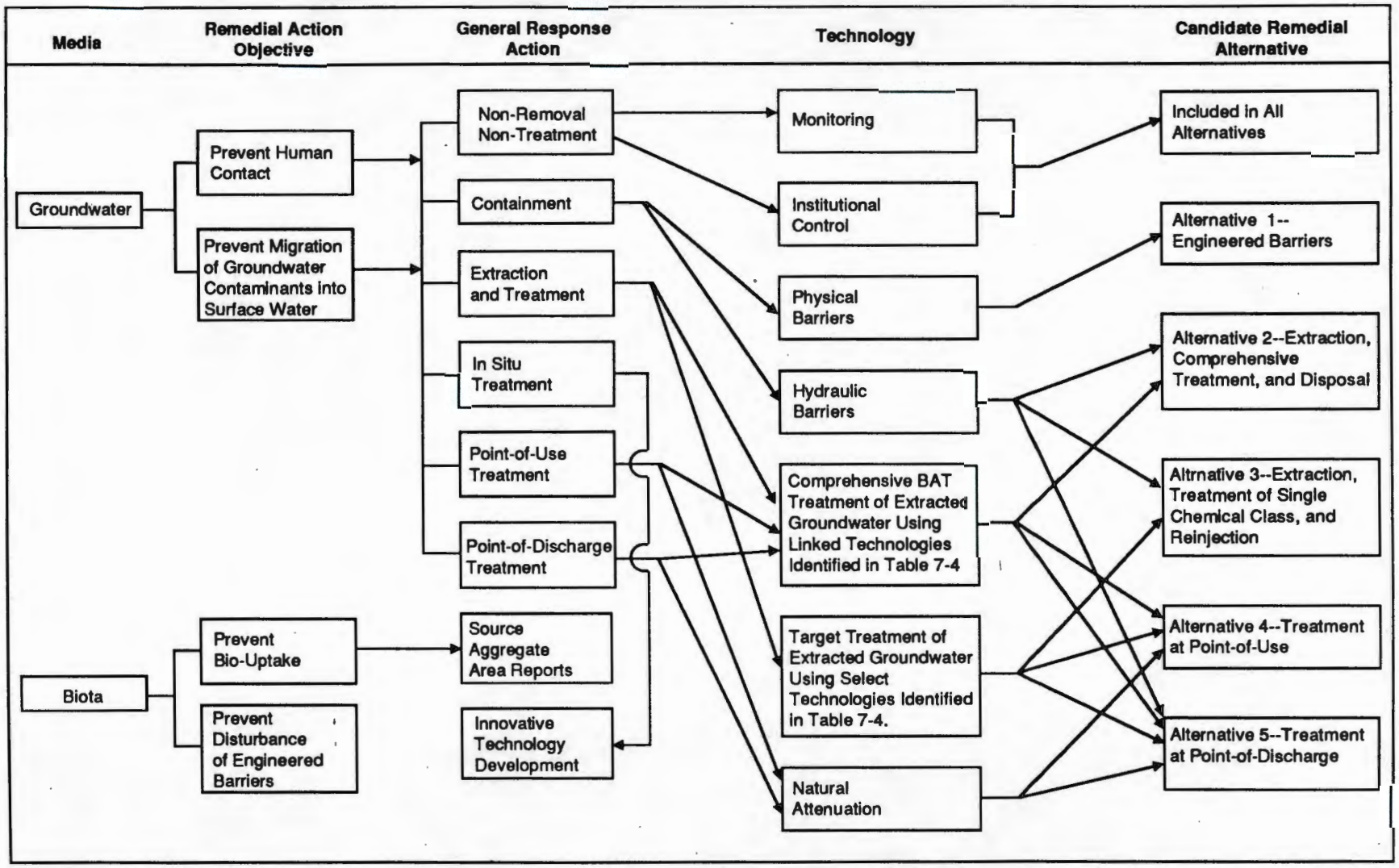

Figure 7-1. Development of Candidate Remedial Alternatives for 200 West Groundwater Aggregate Area.

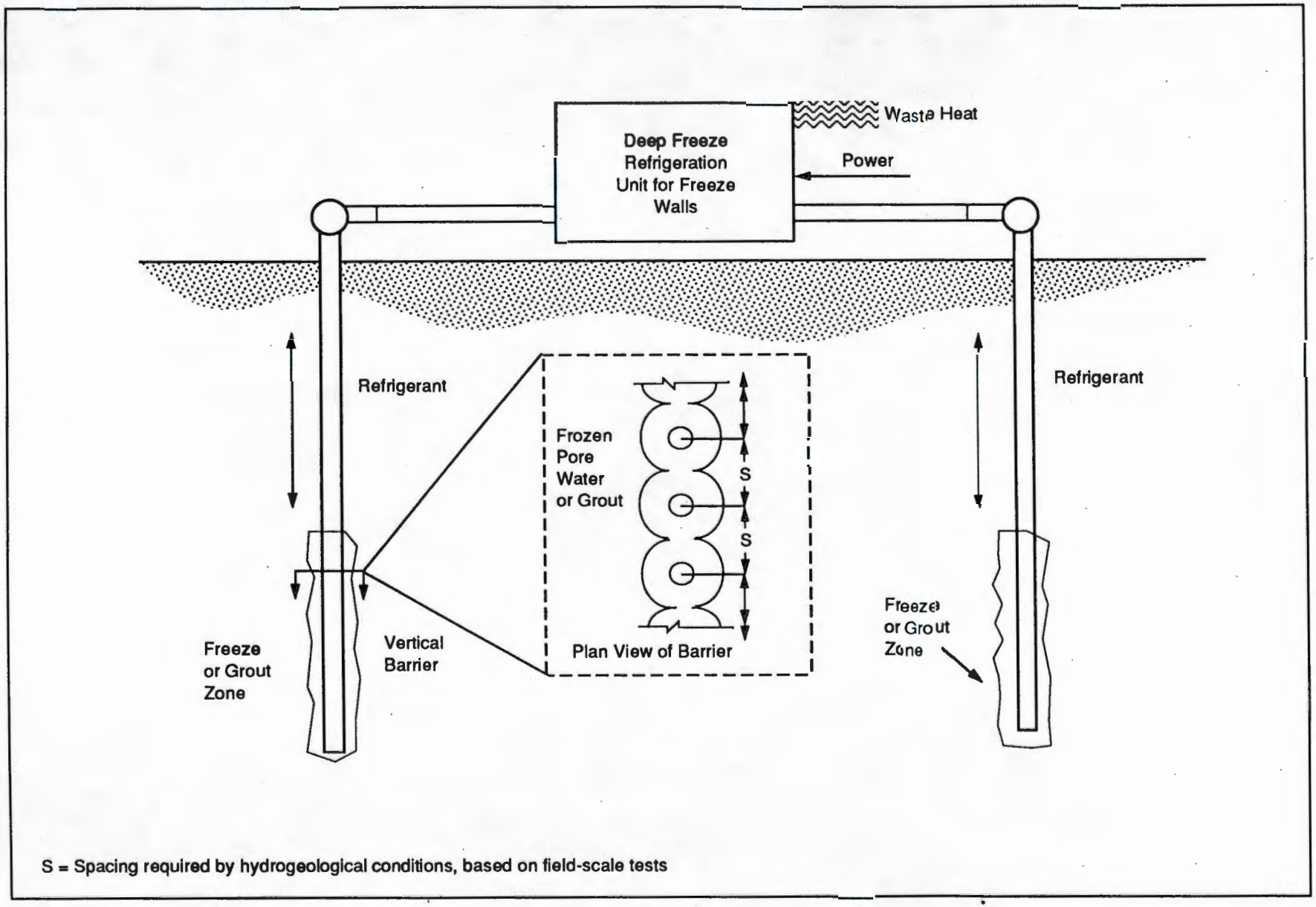

Figure 7-2. Alternative 1—Engineered Vertical and/or Horizontal Barriers.

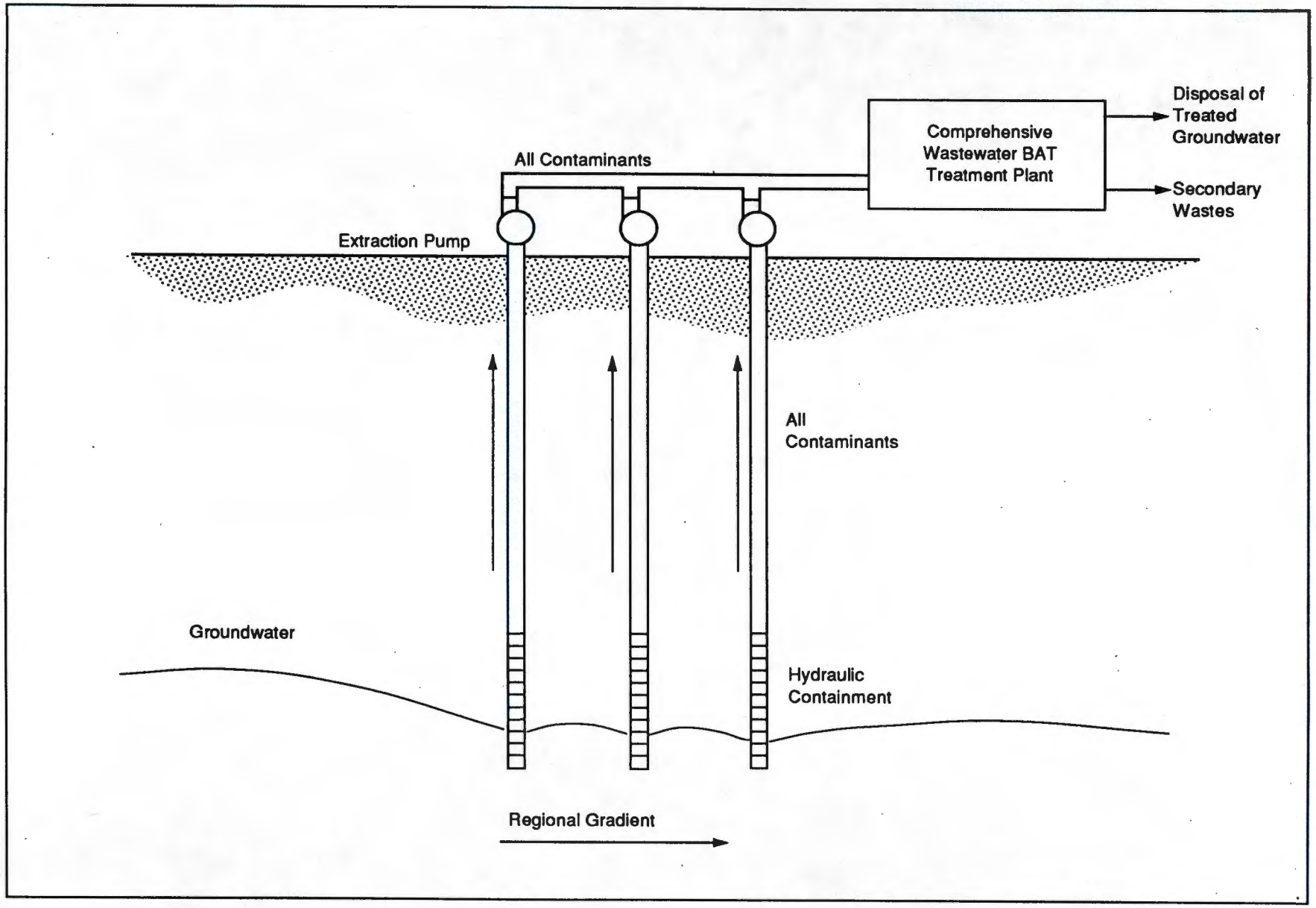

Figure 7-3. Alternative 2—Groundwater Extraction, Comprehensive Treatment, and Disposal.

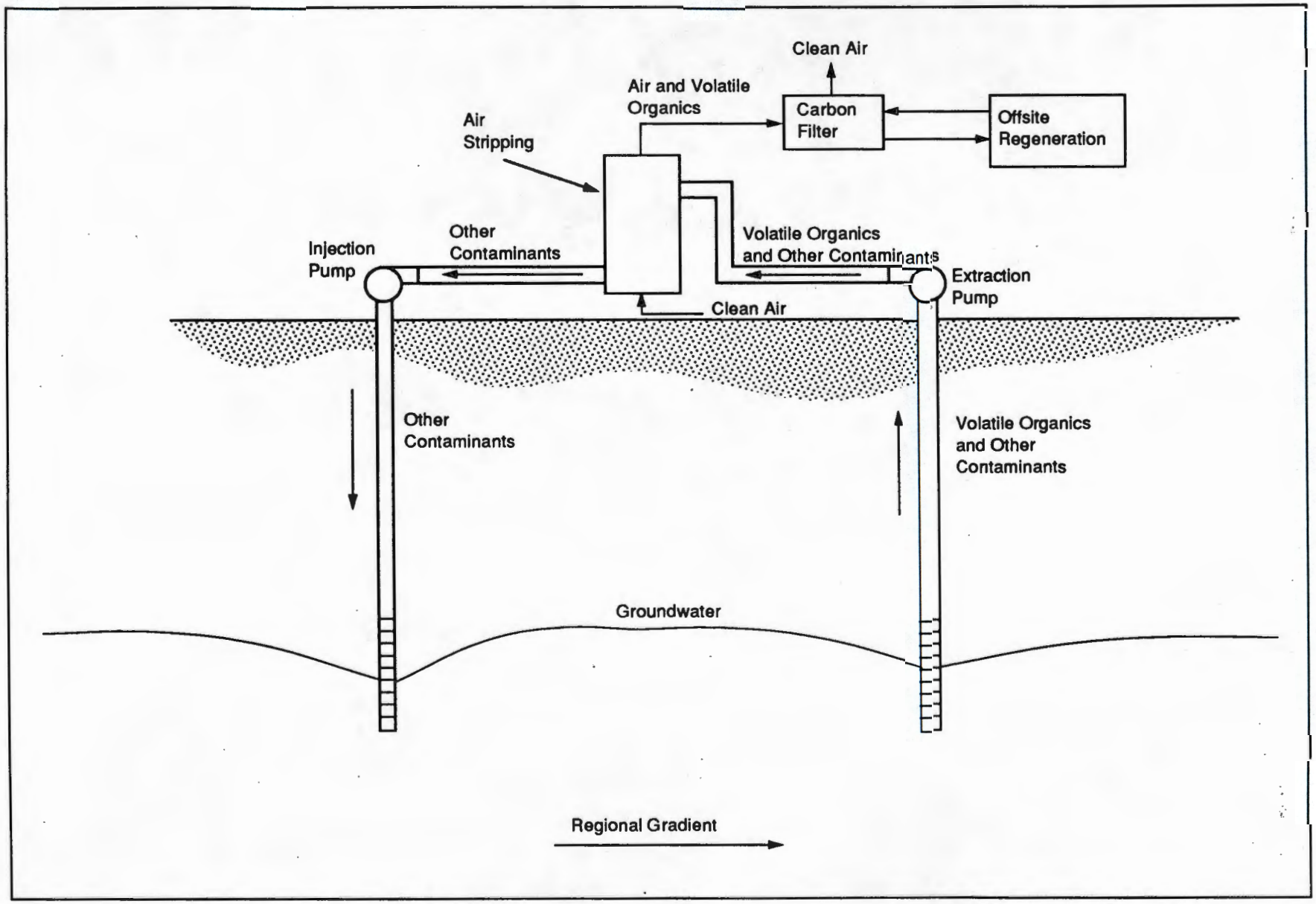

Figure 7-4. Alternative 3—Extraction of Groundwater, Treatment of Single Class of Compounds (Volatile Organics), and Reinjection in Zone of Extraction.

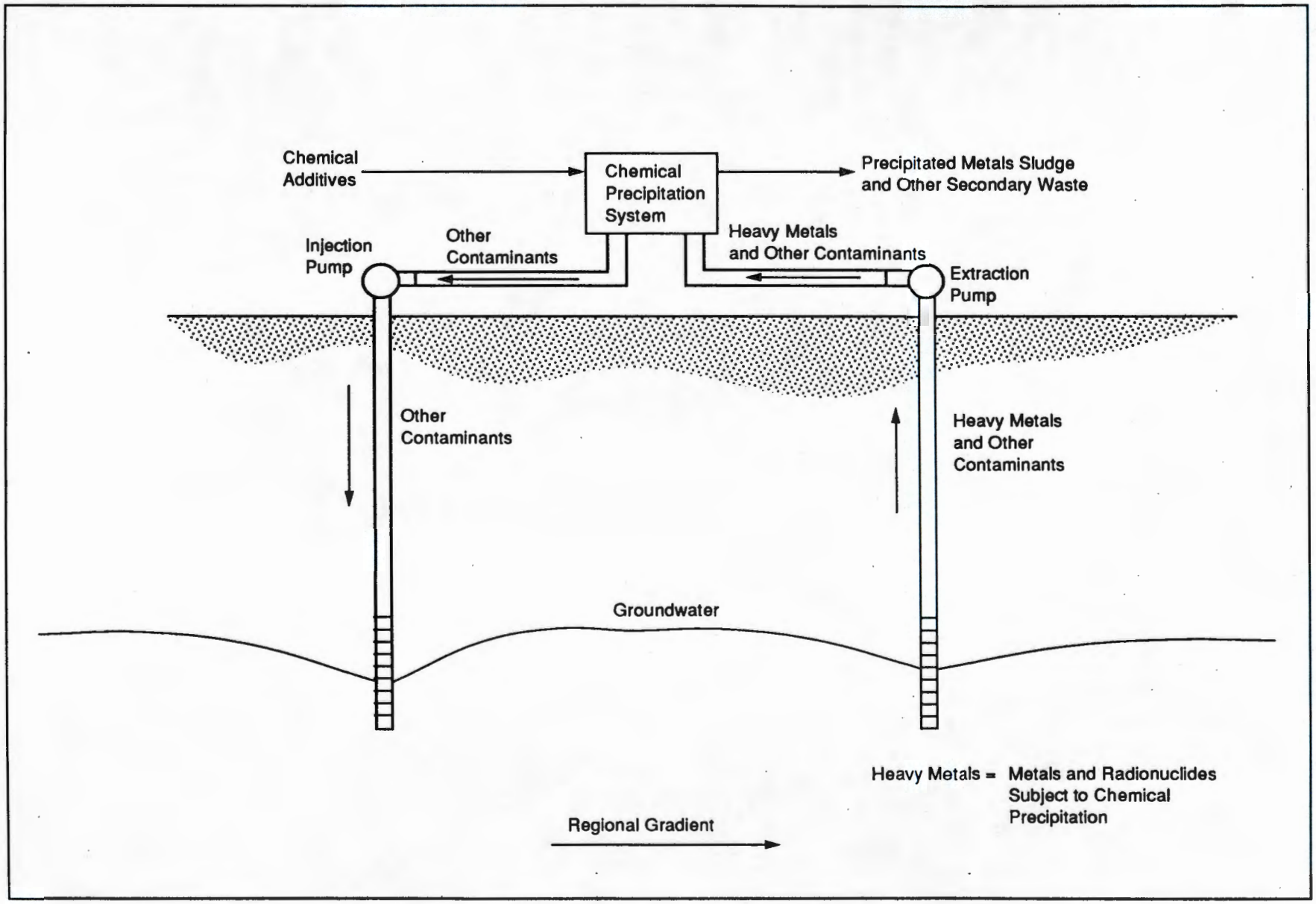

Figure 7-5. Alternative 3—Extraction of Groundwater, Treatment of Single Class of Compounds (Inorganic Heavy Metals), and Reinjection in Zone of Extraction.

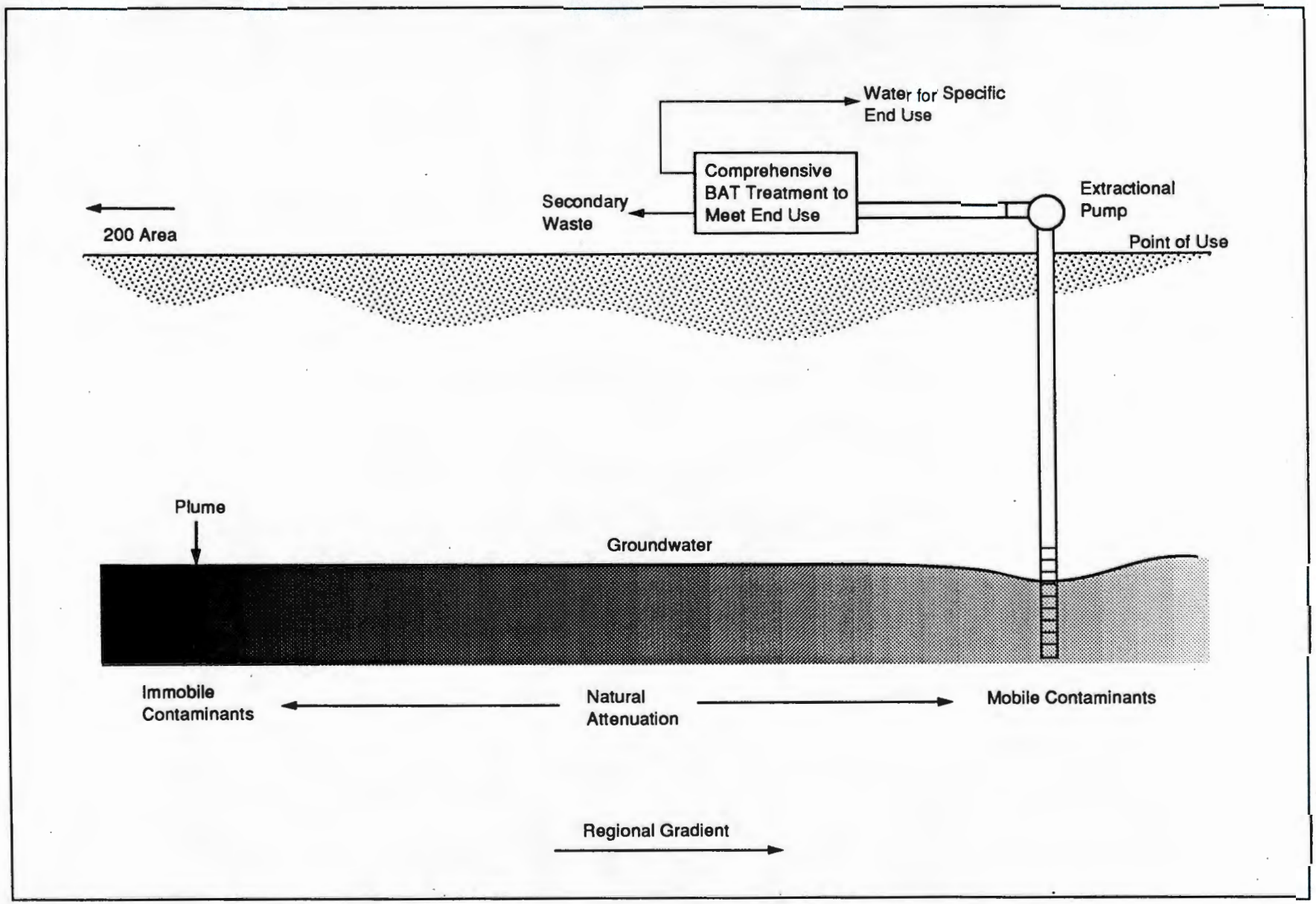

Figure 7-6. Alternative 4—Treatment of Groundwater at Point of Use.

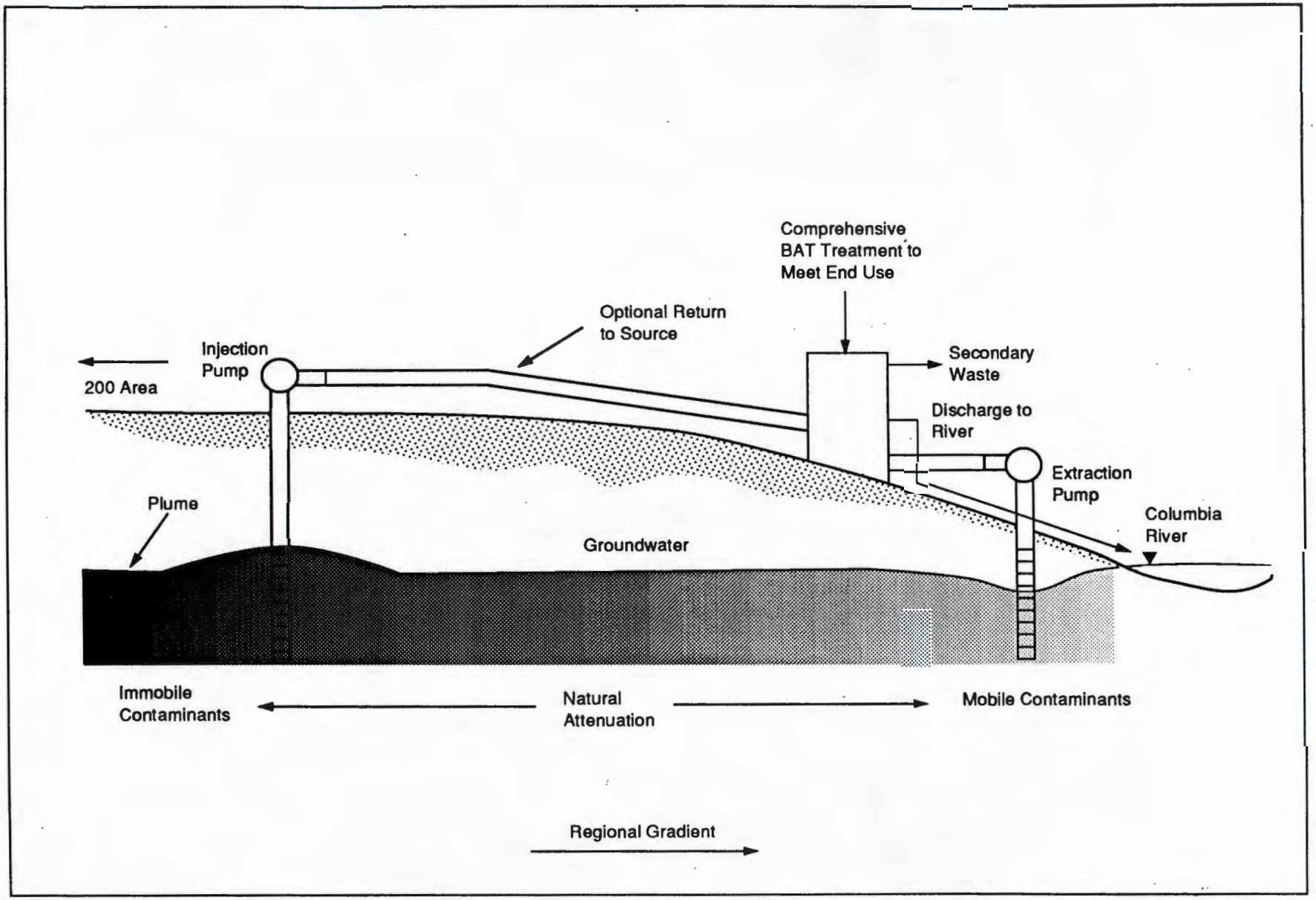

Figure 7-7. Alternative 5—Treatment of Groundwater at Point of Discharge.

Table 7-1. Preliminary Remedial Action Objectives and General Response Actions.

Remedial Action Objectives			
Environmental Media	Human Health	Environmental Protection	General Response Actions
Groundwater	• Prevent ingestion, inhalation, or direct contact with groundwater containing radioactive and/or hazardous constituents present at concentrations above MTCA and DOE standards for industrial sites (or subsequent risk-based standards). • Prevent discharge of groundwater to surface water or transmission of contaminants from groundwater to surface water that would cause surface water to exceed MTCA and DOE standards at the compliance point location	• Prevent migration of radionuclides and hazardous constituents that would result in surface water, air, or biota contamination with constituents at concentrations exceeding ARARs.	• No Action • Institutional Controls/Monitoring • Containment • Groundwater Removal and Treatment • In Situ Groundwater Treatment • Point-of-Use Treatment • Point-of-Discharge Treatment

Table 7-2. Preliminary Remedial Action Technologies for Groundwater.

General Response Action	Technology Type	Process Option	Contaminants Treated*
No Action	No Action	No Action	None
Institutional Controls	Groundwater Use Restrictions	Deed Restrictions	None
	Access Controls	Well Prohibitions Closures and Controls	None
		General Area Access Control	None
	Monitoring	Monitoring	None
Containment	Vertical Physical Barriers	Freeze Walls	I,M,R,O,V,S,T
		Slurry Walls	I,M,R,O,V,S,T
		Grout Curtains	I,M,R,O,V,S,T
		Sheet Piles	I,M,R,O,V,S,T
		Membrane installation	I,M,R,O,V,S,T
	Horizontal Physical Barriers	Block Displacement	I,M,R,O,V,S,T
		Capping	I,M,R,O,V,S,T
		Grouting	I,M,R,O,V,S,T

Table 7-2. Preliminary Remedial Action Technologies for Groundwater.

General Response Action	Technology Type	Process Option	Contaminants Treated*
		Horizontal/Right Angle drilling with Freeze technologies	I,M,R,O,V,S,T
		Horizontal/Right Angle Drilling with Grout Curtains	I,M,R,O,V,S,T
	Hydraulic Containment	Trenching	I,M,R,O,V,S,T
		Injection Wells	I,M,R,O,V,S,T
		Extraction Wells	I,M,R,O,V,S,T
		Drains	I,M,R,O,V,S,T
Extract and Treat	Chemical Treatment	Reduction	M
		Chemical Oxidation	O,V
		Supercritical Oxidation	O,V
		UV Oxidation	O,V
		Hydrolysis	I
		Precipitation	I,M,R
		Dechlorination	O,V (chlorinated only)
		Neutralization	I,M,R

Table 7-2. Preliminary Remedial Action Technologies for Groundwater.

General Response Action	Technology Type	Process Option	Contaminants Treated*
Extract and Treat	Physical Treatment	Air Stripping	V
		Steam Stripping	V,O
		Filtration	R,S,M
		Ion Exchange	I,M,R,O,V,S
		Reverse Osmosis	I,M,R,O,V,S
		Solvent Extraction	I,M,R,O,V
		Supercritical Fluid Extraction	I,M,R,O,V
		Gravity Separation	R,S,O
		Alumina Adsorption	R,S,M
		Carbon Adsorption	O,V,M
		Flocculation	R,S,M
		Filtration	R,S,M
Extract and Treat	Biological Treatment	Aerobic	O,V
		Anaerobic	O,V
Extract and Treat	Thermal Treatments	Solar Evaporation	I,M,R,O,S
		Distillation	I,M,R,O,S
		Destructive Incineration	I,M,R,O,V,S
		Wet Air Oxidation	O,V

Table 7-2. Preliminary Remedial Action Technologies for Groundwater.

General Response Action	Technology Type	Process Option	Contaminants Treated*
In Situ Treatment	Physical	Sparging	V
		Vapor Extraction	V
In Situ Treatment	Chemical	Precipitation	I,M,R
		Solubilization	I,M,R,O,V
		Degradation	O,V
In Situ Treatment	Biological	Aerobic	O,V
		Anaerobic	O,V

Target Chemical Code
I = Other Inorganics contaminants applicability
M = Heavy Metals contaminants applicability
R = Radionuclide contaminants applicability
O = Organic contaminants applicability
V = Volatile Organic contaminants applicability
S = Suspended Solid
T = Tritium
NA = Not Applicable
* Tritium is classified as a single chemical due to its unique chemical treatability characteristics

Table 7-3. Technology Screenings.

Technology			Evaluation Criteria			
Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Conclusions
No Action	None	Does nothing to cleanup 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"
Groundwater Use Restrictions	Deed Restrictions	Identify contaminated areas and prohibit groundwater usage though restriction of deed	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	Well Prohibitions Closures and Controls	Close all wells in area and prohibit installation by general ordinance	Effective if closure controls are maintained	Easily implemented. Restrictions of well installation and use	Low	Retained to be used in conjunction with other process options
	General Area Access Control	Restrict access to all land which may allow access to groundwater	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 groundwater to monitor movement of contamination	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
Vertical Physical Barriers	Freeze Walls	Circulate refrigerant in pipes surrounding groundwater to create a frozen curtain of pore water	Effective in blocking lateral movement of all types of groundwater contamination. May be difficult to monitor effectiveness for deep contamination	Specialized engineering design required. Requires ongoing freezing	Medium	Retained because of effectiveness and implementability
	Slurry Walls	Trench around areas of groundwater and fill with soil/cement/bentonite slurry which solidifies to form impermeable barriers	Effective in blocking lateral movement of all types of groundwater contamination. May be difficult to monitor effectiveness for deep contamination	Commonly used practice but difficult to install at depth	Medium	Rejected due to implementability problems at depth
	Grout Curtains	Pressure inject grout in regular pattern of drilled holes	Effective in blocking lateral movement of all types of groundwater contamination. May be difficult to monitor effectiveness for deep contamination	Commonly used practice and easily implemented but depends on soil type. May be difficult to ensure continuous wall	Medium	Retained because of effectiveness and implementability
	Sheet Piles	Physically drive sheets of steel to form impermeable barriers	Effective in blocking lateral movement of all types of groundwater contamination	Commonly used practice but difficult to install at depth	Low	Rejected due to implementability problems at depth
	Impermeable Membrane installation	Trench around areas of groundwater contamination and install impermeable membranes prior to backfilling.	Effective in blocking lateral movement of all types of groundwater contamination	Difficult to install at depth	Medium	Rejected due to implementability problems at depth

Table 7-3. Technology Screenings.

Technology			Evaluation Criteria			
Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Conclusions
Horizontal Physical Barriers	Capping	Construct impermeable cover over surfaces known to provide recharge to groundwater	Combined with proper runoff control, effective in preventing rainwater recharge to groundwater	Easily implemented. Restriction of future land use will be necessary	Low	Rejected because of limited applicability and/or implementability problems
	Block Displacement	Inject in multiple subsurface mono-planer locations, high pressure grout. Hydraulic pressure will lift soil, and form horizontal barrier of grout	Effective in restricting vertical movement of groundwater contamination. May not be effective for deep groundwater	Difficult to install at depth	Medium	Rejected because of limited applicability and/or implementability problems
	Grouting	Pressure inject grout at screened depths in regular pattern of drilled holes	Effective in restricting vertical movement of groundwater contamination. May not be effective for deep groundwater	Difficult to install at depth	Medium	Rejected because of limited applicability and/or implementability problems
	Horizontal/Right Angle Drilling with Freeze Technologies	Circulated refrigerant in pipes installed both horizontally and vertically	Effective in restricting vertical movement of groundwater contamination	Specialized right angle drilling and freeze engineering required	High	Retained as innovative technology
	Horizontal/Right Angle Drilling with Grout Curtains	Pressure inject grout in regular pattern of drilled holes installed both horizontally and vertically	Effective in restricting vertical movement of groundwater contamination	Specialized right angle drilling required	Medium	Retained as innovative technology
Hydraulic Containment	Trenching	Dig subsurface trenches to capture and divert groundwater flow	Effective in diverting near-surface groundwater flow. May not be effective for deep groundwater	Easily implemented for shallow groundwater. Difficult to implement for deep groundwater	Medium	Rejected due to implementability problems at depth
	Injection Wells	Inject water to alter gradient of groundwater	Effective if hydrogeology is known. Requires source of water to inject	Easy to implement providing adequate source of water is available	Medium	Retained because of effectiveness and implementability
	Extraction Wells	Extract water from deep wells to alter gradient of groundwater	Effective if hydrogeology is known	Easy to implement providing disposal options for extracted water are available	Medium	Retained because of effectiveness and implementability

Table 7-3. Technology Screenings.

Technology			Evaluation Criteria			
Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Conclusions
Extraction & Chemical Treatment	Reduction	Use Redox reactions to alter chemical form of contaminants	May be effective in treating some heavy metal groundwater contamination. Radioactivity will not be reduced	Implementable. Treatability tests are necessary. Well developed technology and commercially available	Medium	Retained for combination with chemical precipitation re: hexavalent chromium
	Chemical Oxidation	Use oxygenating chemicals such as peroxide to destroy chemicals through oxidation	May be effective in treating organic groundwater contaminants. Can be highly chemical matrix specific	Implementable. Treatability tests are necessary. Well developed technology and commercially available	Medium	Rejected because similar technologies have broader effectiveness
	Supercritical Oxidation	Use of supercritical fluids to destroy chemicals through oxidation	May be effective in treating organic groundwater contaminants. May be applicable to broad range of chemicals	May be implementable. Treatability tests are necessary. Relatively new technology, but commercially available	High	Rejected because similar technologies have broader effectiveness
	UV Oxidation	Use of ultraviolet light and appropriate catalysts to destroy chemicals through oxidation	May be effective in treating organic groundwater contaminants. May be applicable to broad range of chemicals	Implementable. Treatability tests are necessary. Well developed technology and commercially available	Medium	Retained because of effectiveness and implementability
	Hydrolysis	Use of water to destroy water reactive chemicals	Not effective on groundwater contaminants because of aqueous state	Not implementable on aqueous solution	Low	Rejected because of limited applicability and/or implementability problems
	Precipitation	Use of chemical additives to alter the solubility of chemicals, and cause their precipitation from solution	May be effective in treating inorganic groundwater contaminants. Applicable to a broad range of metals and radionuclides	Implementable. Treatability tests are necessary. Common technology, commercially available	Medium	Retained because of effectiveness and implementability
	Dechlorination	Use of strong reducing agents to remove chlorine from chemical and hence reduce their toxicity	May be effective on chlorinated organic contaminants in groundwater	May be difficult to implement. Most often used on organic matrixes. Treatability tests for aqueous matrixes required	Medium	Rejected because similar technologies have broader effectiveness
	Neutralization	Use of acids or bases to remove corrosivity from groundwater	Not applicable to chemicals identified in groundwater. May be effective as pretreatment for other options	Implementable. Common industrial practice. Commercially available	Low	Retained to be used in conjunction with other process options

Table 7-3. Technology Screenings.

Technology			Evaluation Criteria			
Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Conclusions
Extraction & Physical Treatment	Air Stripping	Use of air to remove chemicals from groundwater. Chemical must be volatile. Subsequent air containing chemicals must be treated.	Effective in removing many volatile organic groundwater contaminants. Ineffective for inorganics and radionuclides	Implementable. Requires emission treatment for organics and capture system for radionuclide and volatilized metals	Low	Retained because of effectiveness and implementability
	Steam Stripping	Use of steam to remove chemicals from groundwater. Chemical must be semivolatile or volatile. Subsequent steam containing chemicals must be treated.	Effective in removing many volatile, and some semivolatile organic groundwater contaminants. Ineffective for inorganics and radionuclides	Implementable. Requires emission treatment for organics and capture system for radionuclide and volatilized metals	Medium	Retained because of effectiveness and implementability
	Filtration	Use of sand or filters to separate chemical by particle size.	May be effective in removing groundwater contaminants absorbed to suspended solids. Not effective on dissolved chemicals	Implementable. Requires treatability study to determine specific filtration equipment. Commercially available	Low	Retained to be used in conjunction with other process options
	Ion Exchange	Use of special resin to exchange ionic chemical between groundwater and resin. Regeneration solution containing exchanged chemical must be treated.	Effective in removing ionic inorganic groundwater contaminants. Requires treatment of regeneration solutions	Implementable. Treatability studies required to determine specific resin required. Fouling by organic contaminants likely	Medium	Retained because of effectiveness and implementability
	Reverse Osmosis	Use of molecular size membranes and osmotic pressure to separate chemical from groundwater. Concentrated solution with chemical must be treated.	Effective in removing suspended soils, metals, and radionuclides from groundwater. Requires treatment of concentrated reject streams	Implementable. Treatability studies required to determine membranes required. Fouling by organic contaminants likely	High	Retained because of effectiveness and implementability
	Solvent Extraction	Use of special solvents to extract chemical from groundwater. Contaminated solvents must be treated.	May be effective in removing specific groundwater chemicals (such as plutonium or organics). Requires treatment of solvents	May be implementable. Treatability studies to determine suitable solvent. Target chemicals must be identified. Secondary solvents must be treated	Medium	Rejected because of limited applicability and/or implementability problems
	Gravity Separation	Use of differences in chemical density to separate chemical from groundwater. Includes settling, DAF, and centrifuging.	May be effective in removing groundwater contaminants absorbed to suspended solids. Not effective on dissolved chemicals	Implementable. Requires treatability study to determine which specific separation equipment will be most effective. Commercially available	Low	Retained to be used in conjunction with other process options
	Activated Alumina	Use of activated alumina to absorb chemical from groundwater. Contaminated alumina must be disposed of.	May be effective for removing some radionuclides and suspended solids. Requires regeneration of alumina	Implementable. Commercially available data for effectiveness for many chemicals. Treatability tests will be required for other chemicals	Low	Rejected because similar technologies have broader effectiveness

Table 7-3. Technology Screenings.

Technology			Evaluation Criteria			
Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Conclusions
	Coagulation/ Flocculation	Use of colloidal interactions to remove suspended solids and some dissolved phase chemicals.	May be effective for removing chemicals associated with suspended solids	Implementable. Commercial systems readily avaialable	Low	Retained for use with other options
	Carbon Absorption	Use of activated carbon to absorb chemicals from groundwater. Contaminated carbon must be disposed of.	Effective in removing organic and some inorganic groundwater contaminants. Treatment of spent carbon required	Implementable. Well documented effectiveness for many chemicals. Evaluation of treatment of spent carbon required	Medium	Retained because of effectiveness and implementability
	Freeze Separation	Use of liquid/solid	May be effective to remove most groundwater contaminants	May be implementable at this time. Occasionally used in other industries. Media-specific treatability tests required	Medium	Retained as innovative technology because of potential high benefits
Extraction & Biological Treatment	Aerobic	Use of oxygen breathing biological organisms to destroy chemicals	Effectiveness is very contaminant and concentration specific. Treatment has been identified for a variety of organic compounds. Not effective on inorganics or radionuclides	Potentially implementable. Various options are commercially available to produce contaminant degradation. Treatability tests required to determine site-specific conditions	Low	Rejected because of limited applicability and/or implementability problems
	Anaerobic	Use of nonoxygen breathing biological organisms to destroy chemicals	Effectiveness is very contaminant- and concentration-specific. Treatment has been identified for a variety of organic compounds. Not effective on inorganics or radionuclides	Potentially implementable. Various options are commercially available to produce contaminant degradation. Treatability tests required to determine site-specific conditions	n/a	Rejected because of limited applicability and/or implementability problems
Extraction & Thermal Treatments	Solar Evaporation	Use of solar energy to evaporate groundwater to air, leaving non-volatile chemical behind	Effective in concentrating non-volatile groundwater contaminants. Requires large spaces. May be difficult to control radionuclide trace emissions	Difficult to implement. Requires large spaces. Air emission controls difficult to implement over the large space. Air pollution permitting required	Low	Rejected because of limited applicability and/or implementability problems
	Distillation	Use of thermal energy to separate groundwater from chemical by differing vapor pressures	Effective for non-volatile groundwater contaminants. Energy intensive. Concentrated distillation bottoms require treatment	Implementable. Technology is well developed. Energy requirements and disposal of distillation bottoms should be addressed	High	Retained to be used in conjunction with other process options
	Destructive Incineration	Use of thermal energy and oxidation to distil groundwater from nonvolatile chemical and oxidize at high temperature all remaining chemicals.	Effective in destroying organic groundwater contaminants, and concentration non-volatile groundwater contaminants. Air emissions and ash likely to require further treatment	Implementable. Technology is well developed. Mobile units are available for small volumes. Energy requirements and disposal of distillation bottoms should be addressed	High	Rejected because of limited applicability and/or implementability problems
	Wet Air Oxidation	Use of thermal energy and oxidation to force destruction of organic chemical while in aqueous phase.	Effective for organic groundwater contaminants. Applicable to broad range of organic chemicals	Implementable. Specialized industrial process. Commercially available. Treatability test required to determine media-specific effectiveness	High	Rejected because similar technologies have broader effectiveness

Table 7-3. Technology Screenings.

Technology			Evaluation Criteria			
Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Conclusions
In Situ Physical Treatment	Sparging	Injection of air into groundwater zone to distribute chemicals or effect a stripping operation	May be effective in removing volatile organic chemicals or dispersing other in situ treatment chemicals	May be implementable. Detailed permeability of soil must be known. Treatability studies must be performed to evaluate site-specific effects	Low	Retained as innovative technology because of potential high benefits
In Situ Chemical Treatment	Precipitation	Injection of chemical designed to reduce mobility of contaminants in groundwater	May be effective in reducing mobility of metals and radionuclides	May be implementable. Techniques to enhance mixing of chemical additives and groundwater must be developed	Low	Retained as innovative technology because of potential high benefits
	Solubilization	Injection of chemical designed to increase mobility of contaminants in groundwater	May be effective in increasing mobility of metals and radionuclides. The increased mobility would enhance performance of pump and treat technologies	May be implementable. Techniques to enhance mixing of chemical additives and groundwater must be developed	Low	Retained as innovative technology because of potential high benefits
	Destruction	Injection of chemical designed to destroy contaminants in groundwater	May be effective in destroying organic chemical. Secondary by-products may be generated	Difficult to implement. Chemical with destructive potential, such as oxidizers, are affected by sand media. Techniques to enhance mixing required	Low	Retained as innovative technology because of potential high benefits
In Situ Biological Treatment	Aerobic	Use of oxygen breathing biological organisms to destroy chemicals	Effective for organic compounds under proper chemical conditions. Ineffective for inorganics and radionuclides	Difficult to implement. Treatability studies and thorough subsurface characterization required	Low	Retained as innovative technology because of potential high benefits
	Anaerobic	Use of non-oxygen breathing biological organisms to destroy chemicals	Effective for some volatile and complex organics. Not effective for inorganics and radionuclides	Difficult to implement. Anoxic groundwater conditions required. Treatability studies and thorough subsurface characterization required	Low	Retained as innovative technology because of potential high benefits

Table 7-4. Summary of Retained Groundwater Technologies.

Chemical Class	Proven Technologies											Innovative Technologies				
	Containment		Groundwater Treatments									Groundwater Treatments		In Situ		Containment
	Grout wall	Freeze wall	UV Oxidation	Precipitation and Reduction**	Air Stripping	Steam Stripping	Coagulation and Filtration	Reverse Osmosis	Carbon Absorbtion	Evaporation	Ion Exchange	Freezing	Supercritical extraction	Air Sparging and/or biodegradation	Flushing and/or precipitation	Horizontal Grout and/or Freeze walls
Organics	A	A	A	D	D	C	C	X,I	B	E	X	I,C	I	E,I	I	I
Volatile Organics	A	A	A	D	B	B	D	X,I	B	C,X	X	I,B	I	I	I	I
Inorganics	A	A	D,X	C	D,X	D,X	D	B,I	C	B,X	B	I,B	I	E,I	I	I
Metals	A	A	D,X	A	D,X	D,X	C	A	C	A	A	I,A	I	E,I	I	I
Radionuclides	A	A	D	A	D,X	D,X	C	A	C,X	A	A	I,A	I	E,I	I	I
Suspended Solids	A	A	X	E	X	X	A	A	X	A	X	I,A	I	E,I	I	I
Tritium*	A	A	E	E	E	E	E	E	E	E	E	E	I	E,I	E,I	I

A= Applicable to most chemicals in class.
B= Applicable to many chemicals in class.
C= Applicable to some chemicals in class.
D= Applicable to few chemicals in class.
E= Not specifically applicable to chemicals in class.
X= Known to be susceptible to interference due to fouling, media contamination, or other uncontrollable effects.
I= Potential innovative application.
* Tritium is classified as a single chemical group due to its unique chemical characteristics
** Reduction required for hexavalent chromium prior to chemical precipitation.

Table 7-5. Preliminary Remedial Action Alternatives Applicable to Defined Chemical Plumes.

Chemical Plume	Alternative 1 Containment	Alternative 2 Groundwater Extractions and Comprehensive Treatment	Alternative 3 Groundwater Extraction, Treatment of Single Chemical, and Reinjection	Alternative 4 Treatment at Point-of-Use	Alternative 5 Treatment at Point-of-Discharge
Arsenic	A	B	B	E	E
Chromium	A	B	B	E	E
Cyanide	A	B	B	E	E
Fluoride	A	B	B	E	E
Nitrate	A	B	B	E	E
Carbon Tetrachloride	A	BC	BC	E	E
Chloroform	A	BC	BC	E	E
Trichloroethylene	A	BC	BC	E	E
Gross Alpha	A	F	F	FD	FD
Gross Beta	A	F	F	FD	FD
Tritium	A	X	X	D	D
Technetium-99	A	B	B	E	E
Plutonium	A	B	B	E	E
Iodine-129	A	B	B	E	E
Uranium	A	B	B	E	E

A= Possible applicability.
B= Possible applicability but treatment interferences may be encountered if plumes overlap and long-term performance may be hampered by absorbed chemicals.
C= Long-term performance may be additionally hampered by presence of DNAPLS.
D= Possible applicability if natural attenuation time is sufficiently long.
E= Possible applicability.
F= Applicability depends on which chemicals are emitting alpha or beta.
X= Not likely to be effective.

8.0 DATA QUALITY OBJECTIVES

As described in Section 1.2.2, this aggregate area management study (AAMS) process, as part of the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a), is designed to focus the remedial investigation (RI)/feasibility study (FS) process toward comprehensive cleanup or closure of all contaminated areas at the earliest possible date and in the most effective manner. The fundamental principle of the *Hanford Site Past-Practice Strategy* is a "bias for action" which emphasizes the maximum use of existing data to expedite the RI/FS process as well as allow decisions about work that can be done at the site early in the process, such as expedited response actions (ERAs), interim remedial measures (IRMs), limited field investigations (LFIs), and focused feasibility studies (FFSs). The data have already been described in previous sections (2.0, 3.0, and 4.0). Remediation alternatives are described in Section 7.0. However, data, whether existing or newly acquired, can only be used for these purposes if it meets the requirements of data quality as defined by the data quality objective (DQO) process developed by the U.S. Environmental Protection Agency (EPA) for use at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites (EPA 1987). This section implements the DQO process for this, the scoping phase in the 200 West Groundwater Aggregate Area.

In the guidance document for DQO development (EPA 1987), the process is described as involving three stages which have been used in the organization of the following sections:

- Stage 1--Identify decision types (Section 8.1)
- Stage 2--Identify data uses and needs (Section 8.2)
- Stage 3--Design a data collection program (Section 8.3).

8.1 DECISION TYPES (STAGE 1 OF THE DQO PROCESS)

Stage 1 of the DQO process is undertaken to identify:

- The decision makers (thus the most important data users) relying on the data to be developed (Section 8.1.1)
- The data available to make these decisions (Section 8.1.2)
- The quality of these available data (Section 8.1.3)
- The conceptual model into which these data must be incorporated (Section 8.1.4)

- The objectives and decisions that must evolve from the data (Section 8.1.5).

These issues serve to define, from various sides, the types of decisions that will be made on the basis of the 200 West Groundwater AAMS.

8.1.1 Data Users

The data users for the 200 West Groundwater AAMS and subsequent investigations such as LFIs, RI/FSs, and Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFIs)/Corrective Measures Studies (CMSs) are the following:

- The decision makers for policies and strategies on remedial action at the Hanford Site. These are the signatories of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) including the U.S. Department of Energy (DOE), EPA, and the Washington State Department of Ecology (Ecology).

Nominally these responsibilities are assigned to the heads of these agencies (the Secretary of Energy for DOE, the Administrator of EPA, and the Director of Ecology). However, the political process requires that more local policy-makers [e.g., the Regional Administrator of EPA and the head of the U.S. Department of Energy, Richland Operations Office (DOE/RL)] or technical and policy-assessment staff of these agencies to be involved in the decision-making process.

- Unit managers of Westinghouse Hanford and potentially other Hanford Site contractors who will implement remedial activities for the 200 West Groundwater Aggregate Area. Staff of these contractors will have to make the lower level (tactical) decisions about appropriate scheduling of activities and allocation of funding, personnel, and equipment to accomplish the recommendations of the AAMS.

- Concerned members of the wide community involved with the Hanford Site. These may include:

  - Other state (Washington, Oregon, and other states) and federal agencies
  - Affected Indian tribes
  - Special interest groups
  - The general public.

These groups will be involved in the decision process through the implementation of the Community Relations Plan (CRP) (Ecology et al. 1989), and will apply their concerns through the "primary" data users, the signatories of the Tri-Party Agreement.

The needs of these users will have a pivotal role in issues of data quality. Some of this influence is already imposed by the guidance of the Tri-Party Agreement.

8.1.2 Available Information

The *Hanford Site Past-Practice Strategy* specifies a "bias for action" which intends to maximize use of existing data for initial decisions about remediation. This emphasis can only be implemented if the existing data are adequate for the purpose.

Available data for the 200 West Groundwater Aggregate Area are presented in Sections 2.0, 3.0, and 4.0 and in topical reports prepared for this study. The available data for this 200 West Groundwater Aggregate Area Management Study Report (AAMSR) are slightly different from those presented in the U Plant, Z Plant, S Plant, and T Plant AAMSRs for waste management units in the 200 West Area. For many aspects of the site data, the source AAMSRs are given primacy and the 200 West Groundwater AAMSR simply summarizes the data developed in those studies. Only in regard to data about groundwater, the deeper geologic layers in which it is found, and the monitoring of this medium, does the 200 West Groundwater AAMSR present separately developed data. As described in Section 1.2.2, these data should address several issues:

- Issue 1: Facility and process descriptions and operational histories for waste sources (mainly in source AAMSRs, but summarized here in Sections 2.2, 2.3, and 2.4)

- Issue 2: Waste disposal records defining dates of disposal, waste types and waste quantities (also mainly in source AAMSRs, but again summarized here in Section 2.4)

- Issue 3: Sampling events of waste effluents and affected media (left strictly to the source AAMSRs)

- Issue 4: Site conditions including the site physiography, topography, geology, hydrology, meteorology, ecology, demography, and archaeology (Section 3.0)

- Issue 5: Environmental monitoring data for affected media--for this groundwater AAMSR, this is specifically groundwater (Section 4.1).

For the purposes of the 200 West Groundwater AAMSR, the most relevant data pertain to issues 4 and 5 and will be discussed further in the following paragraphs. Results of groundwater sampling and analysis (issue 5) reveal the nature and extent of groundwater contamination. Site characterization data (issue 4) on the other hand indicate the dynamics of the situation: where the contamination is likely to migrate, how it might be transformed in the process, and where potential receptors may be located.

Nature and Extent of Contamination. The data available about nature and extent (detections and concentrations) of contaminants in groundwater (Section 4.1.1) are relatively extensive and comprehensive, especially when compared to the data available for the waste management units in the individual source AAMSRs. There are gaps (particularly in the front end of plumes which have migrated into the 600 Areas where there are fewer wells but also in the east-northeast and southwestern quadrants of the 200 West Area) but the lateral extent of the plumes (and their constituents) appear to be well defined although there is a deficiency of data on the vertical extent of contamination. This AAMSR emphasizes the most recent data (1988 to 1991) because they are more complete than any earlier data set: more wells were sampled (including newer wells) at greater frequency and consistency, more constituents analyzed, and better methodology was used for both field procedures and laboratory methods (e.g., detection limits). While these data are not perfect, they provide a fairly consistent basis to compare concentrations across the site, and thereby delineate plumes. While the data base is adequate for this purpose, earlier data across the Hanford Site (including in the 200 West Area) have been deficient in analyzing groundwater samples for a wide enough range of constituents and at detection levels sensitive enough to delineate plumes in areas where they must have been present.

To a limited extent, these data are supported by the data regarding the sources of these plumes: contaminant releases from waste management units (Sections 2.3 and 4.1.2). These data include inventory (liquid waste volumes and contaminant quantities), and results of borehole logging for gross gamma radiation. The extent and limitations of this information are discussed more fully in the individual AAMSRs and are only summarized in this report. However, some inconsistencies between the reported releases and known groundwater contaminant plumes indicate that the inventories may be incomplete.

The inventory data are supplemented by the results of geophysical gross gamma logging in boreholes near the waste management units that indicate the depth to which gamma-emitting radionuclides have penetrated the subsurface. These data are limited in two ways: the boreholes are generally some distance away from the unit and thus may not observe contamination directly beneath the unit; and the method does not differentiate what radionuclide species are actually present. These limitations may be removed with further field investigations in the source areas and the use of the Radionuclide Logging System (RLS), which can differentiate different radionuclides. Additional information on previous geophysical logging is given in the topical reports for the source aggregate areas (U Plant, Z Plant, S Plant, and T Plant) (Chamness et al. 1992a, Chamness et al. 1991, Teel 1992,

Chamness et al. 1992b). Further information on the RLS program will be presented in a 200 West Area borehole geophysics field characterization topical report.

Contaminant Transport Potential. Besides knowing the type and location of the contamination, it is also necessary to know its direction. In this respect the data for the 200 West Groundwater Aggregate Area are again fairly comprehensive.

Site characterization data relating to contaminant transport potential vary more than those on nature and extent. The stratigraphic constraints on groundwater flow (Section 3.5.2.1) are well known on a broad scale, and are limited mainly by the spacing of wells that have been drilled and the quality of the geologic logging; most of the earlier logs were compiled by the driller rather than a geologist, and generally display a limited understanding of important depositional and textural features. Stratigraphic data from the wells can be interpolated relatively inexpensively across the large spaces without wells by using seismic reflection or refraction geophysical surveys. However, the applications have been limited in the past. The main use of surface geophysics on the Hanford Site was for the Basalt Waste Isolation Project (BWIP), where features in the basalt were more important than those in the "suprabasalt" sediments. The results of the investigation reflect this need (DOE 1988).

Other data for understanding the potential for contaminant migration in groundwater include those describing the geohydrology of the aquifer(s) of concern. These data include information on recharge and discharge from the aquifer (Section 3.5.2.2); mappings of the potentiometric surface across the Hanford Site to determine groundwater flow directions and gradients (Section 3.5.2.3); and aquifer and vadose zone properties such as hydraulic conductivity (saturated and unsaturated), transmissivity, matric potential (capillary pressure/moisture relation), porosity, and storativity/specific yield (Sections 3.5.1 and 3.5.2). In addition to the data summarized in these sections, the topical report *Unconfined Aquifer Hydrologic Test Data Package for the 200 West Area* (Newcomer et al. 1992) contains more information. In spite of the complexity of the flow system and the uncertainties of future recharge to the aquifer, all these parameters are known to a reasonable degree of accuracy, which allows groundwater models to estimate the likely flow patterns and the advective component of contaminant transport which they determine.

Even to the extent that groundwater flow is known, however, contaminant-specific factors can cause the different constituents to move at different rates in relation to the groundwater and to change in concentration, phenomena known as retardation and attenuation. Because of the complexity of some of the potential chemical interactions, retardation is not as well understood as the groundwater flow system. Some aspects of attenuation such as radionuclide half-life are well understood while others, such as dispersion, are not. However, here again reasonable approximations to the parameters are possible (Section 4.2). In addition, the modeling process of calibration, i.e., fitting the model results to the known history of a physical process, can allow these parameters to be

corrected to the conditions actually found in the aquifer. The main limitation to accomplishing such a calibration process is the long time frame during which these changes occur, usually requiring a longer record of data than is generally available. The errors in estimating retardation are multiplicative to those for groundwater advection, and the problem of other errors adds to the noise in the observed data being fitted.

Receptors. In assessing the significance of the groundwater contaminant concentrations and their likely transport, the final stage in the development of data is at the point of impact: are there receptors who may be affected by this contamination? This question is generally not a data issue, but rather a regulatory one. Because no one can predict future land use at the Hanford Site, a conservative approach may be required that specifies the point of compliance for applicable or relevant and appropriate requirements (ARARs) and the exposure point for risk assessment to be established on the site. Nevertheless, the data for present day land/water use, ecology, and demography are available (Sections 3.6, 3.7, and 3.8) and are reasonably complete.

Therefore, the data described above appears to be sufficient to carry out risk assessment and ARARs assessment for the 200 West Groundwater Aggregate Area.

8.1.3 Evaluation of Available Data

EPA (1987) has specified indicators of data quality, the five "PARCC" parameters (precision, accuracy, representativeness, completeness, and comparability), which can be used to evaluate the existing data and to specify requirements for future data collection.

- Precision--the reproducibility of the data

- Accuracy--the lack of a bias in the data.

  Much of the existing data appears to be acceptably accurate and precise. The contamination concentration data were checked by comparing the range of the detected concentrations (c_{max} : c_{min}) of a given constituent in a well. The range is a similar measure to other statistical estimates of accuracy, such as relative percent difference or relative standard deviation, which are used for comparison of laboratory duplicate samples. Because the samples in this test are not exact duplicates but simply other samples from the same well taken at another time, this measurement would be expected to be much higher than would be allowed in assessing quality assurance (QA) for an analytical lab. For example, the steep front-end part of the contaminant plume may have passed through the well location during the period of record, at which time the concentration would have gone up by a large factor, possibly by several orders of magnitude.

Nevertheless, for most of the analyses checked, the range was less than an order of magnitude for more than 90% of the wells (with two or more detections). This indicates that these concentration values can be considered to be accurate to about half an order of magnitude (i.e., plus or minus half the range). Some cases with ranges larger than this level appeared to be caused by isolated "outlier" data, caused perhaps by errors in transcription (some appeared to be off by three orders of magnitude, as if the results were thought to be in mg/L rather than μg/L). These data have generally not been checked thoroughly against lab documentation to assure that such errors have not occurred, but this is apparently only an occasional problem.

Accuracy is normally assured through the use of field and trip blanks and (in the laboratory) through matrix spikes which give estimates of percent recovery. These methods are becoming common for analyses of samples from the site.

Earlier groundwater contaminant data may be more suspect (the earlier they are the more suspect), because of the subsequent improvement in analytical methodologies and QA procedures since the time these samples were collected.

Other data for groundwater which mainly involve site characterization issues (e.g., aquifer properties and other parameters to predict transport of water and contaminants) also have some questions about precision and accuracy. Slug tests may not be accurate for highly transmissive aquifers such as the uppermost aquifer at the Hanford Site and may depend on factors of well construction such as filter pack grain size and screen slot size. This is also in part an issue of representativeness, see below. Even pump tests have been criticized because the well construction as partially penetrating the aquifer does not satisfy the assumptions of the most common analysis methods.

There is also an issue of accuracy in regard to aspects which are derived from boreholes (such as stratigraphic logging, grain size distribution, carbonate content, porosity, and other material properties). These data are interpolated among a limited and widely spaced set of sampling locations.

The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) recommends that existing data be used to the maximum extent possible, at two levels: first to formulate the conceptual model, conduct a qualitative risk assessment, and prepare work plans, but also as an initial data set that can be the basis for a fully-qualified data set through a process of review, evaluation, and confirmation. The recently collected data, although not fully-qualified, appear to be acceptable to be such an initial data set.

- Representativeness--the degree to which the appropriate environmental parameters or media have been sampled.

  In most cases the data regarding groundwater meet the criterion of representativeness because the groundwater has been sampled directly. It is this groundwater that is transporting contamination toward potential offsite receptors. Well tests stress the aquifer zones where much of the contamination has been detected and where pump-and-treat remediation can be applied.

  Limitations of the data in regard to representativeness are generally minor. For example, slug tests sample the hydraulic conductivity in only a narrow zone around the well being tested, perhaps only the gravel pack. For this reason, the slug test data were excluded from recent hydraulic conductivity assessment for the uppermost aquifer (Connelly et al. 1992), as discussed in Section 3.5. Also, wells are not always located exactly where they can give the most representative information--this is particularly true of the lack of wells at the down-gradient portions of the plumes and in some portions (in the east-northeast and southwest quadrants) of the 200 West Area. Even in regard to groundwater elevations, the location of wells near waste disposal facilities may result in unrepresentative sampling. Finally, soil moisture retention data for modeling moisture transport through the vadose zone may be a very important feature of the contaminant transport regime to be assessed, but these data have been obtained only in samples from very few boreholes (Connelly et al. 1992), and none of them at sites where large quantities of contaminated vadose zone water may yet drain into the aquifer. For vadose zone transport modeling, the sampling methods used for the soil samples could be critical to maintaining the structure of the soil to assure that the sample is really representative of the soils in situ.

  In many cases it is necessary to use nonsite-specific data (i.e., from the vicinity of the 200 Areas or even elsewhere on the Hanford Site) rather than data specific to the 200 West Area. For most purposes of characterization for transport mechanisms, this procedure is acceptable given the screening level of the present study.

- Completeness--the fraction of samples whose measurements are considered "valid."

  Only a small fraction of the previously gathered data on groundwater concentrations in the 200 West Groundwater Aggregate Area has been "validated" in the EPA Contract Laboratory Program (CLP) sense, although varying levels of quality control have been applied to the sampling and analysis procedures. The data are generally adequate for characterization purposes, but may not be suitable

for use in a formal risk assessment. The best indication of the validity of the data is the reproducibility of the results, and this indicates that validity (completeness) is one of the less significant problems with the data.

- Comparability--the confidence that can be placed in the comparison to two data sets (e.g., separate samplings).

  Although varying levels of quality control and varying procedures for sample acquisition and analysis may have limited the comparability of early groundwater data, this problem has generally been eliminated for most recent data.

While these limitations cannot in most cases be quantified (and some such as representativeness are specifically only qualitative), most of the data gathered in the 200 West Groundwater Aggregate Area can be seen to satisfy the PARCC parameters to a reasonable degree. These data can be used for preliminary risk assessments (human health and ecological) planning of additional characterization studies and FFSs for groundwater remediation.

In addition to these site-specific data, there are also a limited number of nonsite-specific sampling programs that are being developed to determine background levels of naturally occurring constituents (Hoover and LeGore 1991, DOE/RL 1992c). These data can be used to differentiate the effect of the environmental releases from naturally occurring background levels.

8.1.4 Conceptual Models

The initial conceptual model of the sites in the 200 West Groundwater Aggregate Area is presented and described in Section 4.2 (Figure 4-18). The model is based on best estimates of where contaminants were discharged and their potential for migration from release points. The conceptual model is designed to be conservatively inclusive in the face of a lack of data. This migration pathway was included if there is any possibility of contamination travelling on it, historically or at present. In most cases there may not be a significant flux of such contamination for many of the pathways shown on the figure.

The one pathway on Figure 4-18 that has undoubtedly transported the largest amount of water through vadose zone soils to the uppermost aquifer is associated with releases from surface water bodies at the various ponds, ditches, and trenches in the 200 West Area. Contamination can be demonstrated to have been present in some of these waste management units based on results of sediment sampling. If significant levels of dissolved constituents were present in the surface water bodies, the large quantities of water would have contributed to their mobilization and transport through the vadose zone. However, there is little information confirming that large amounts of contamination actually have been transported

along this pathway. The pathway from cribs, trenches and reverse wells to groundwater is possibly more significant since many of the waste streams discharged to cribs, trenches and reverse wells are known to be contaminated. Most of the plumes that have been delineated in the uppermost aquifer can be traced back to releases from cribs (Section 4.1). These and other pathways can be traced on the conceptual model. All are possible; only a few are likely because of the conservatism inherent in including all conceivable pathways. More importantly, even if a pathway carries significant levels of a contaminant, it still may not have carried contamination to the ultimate receptors, human or ecological. This can only be assessed by sampling at the exposure point on this pathway, or sampling at some other point and extrapolation to the exposure point, to indicate the dosage to the receptors. To a great extent this can be demonstrated for groundwater contamination in the 200 West Area, as only tritium and nitrate plumes are known to have reached the Columbia River, and no plumes are known to have migrated to any water supply wells. For this area the conceptual model can best be used to estimate likely future impacts.

8.1.5 Aggregate Area Management Study Objectives and Decisions

The specific objectives of the 200 West Groundwater AAMS are listed in Section 1.3. They include the following:

- Assemble site data (as described in Section 8.1.2)
- Describe site conditions (see Section 3.0)
- Conduct limited new site characterization work (see separate topical reports)
- Develop a preliminary site conceptual model (see Section 8.1.4)
- Identify contaminants of concern and their distribution (Section 4.0)
- Identify potential ARARs (Section 6.0)
- Define preliminary remedial action objectives and screen potential remedial technologies to prepare preliminary remedial action alternatives (Section 7.0) and provide recommendations for focussed FS (Section 9.4.1) and treatability studies (Section 9.5)
- Define data needs, establish general DQOs, and set priorities
- Recommend ERA, IRM, LFI, or other actions (Section 9.0)

- Redefine and prioritize, as data allow, operable units, their boundaries, and work plan activities with emphasis on supporting early cleanup actions and a Record of Decision (ROD)

- Integrate RCRA TSD closure activities with past practices activities.

The decisions that will have to be made on the basis of this AAMS can best be described according to the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) flow chart (Figure 1-2 in Section 1.0) that must be conducted on a site-by-site basis. Decisions are shown on the flow chart as diamond-shaped boxes, and include the following:

- Is an ERA justified?

- Is less than six months' response needed (is the ERA time critical)?

- Are data sufficient to formulate the conceptual model and perform a qualitative risk assessment?

- Is an IRM justified?

- Can the remedy be selected?

- Can additional required data be obtained by LFI?

- Are data (from field investigations) sufficient to perform risk assessment?

- Can an operable unit/aggregate area ROD be issued?

The last two questions will only be asked after additional data are obtained through field investigations, and so are DQO issues only in assessing scoping for those investigations.

Most of these decisions are actually a complicated mix of many smaller questions, and will be addressed in Section 9.0 in a more detailed flowchart for assessing the need for remediation or investigation.

Similarly, the tasks to be performed after the AAMS that will drive the data needs for the study are found in the rectangular boxes on the flow chart. These include the following:

- ERA (if justified)

- Definition of threshold contamination levels, and formulation of a conceptual model, performance of qualitative risk assessment and FS screening (IRM preliminaries)

- FFS for IRM selection

- Determination of minimum data requirements for IRM path

- Negotiation of Scope of Work, relative priority, and incorporation into integrated schedule, performance of LFI

- Determination of minimum data needs for risk assessment and final remedy selection (preparation of RI/FS pathway).

These stages of the investigation must be considered in assessing data needs (Section 8.2.1).

8.2 DATA USES AND NEEDS (STAGE 2 OF THE DQO PROCESS)

Stage 2 of the DQO development process (EPA 1987) defines data uses and specifies the types of data needed to meet the project objectives. These data uses and needs are based on the Stage 1 results, but must be more specific. The elements of this stage of the DQO process include:

- Identifying data uses (Section 8.2.1)

- Identifying data types (Section 8.2.2.1)

- Identifying data quality needs (Section 8.2.2.2)

- Identifying data quantity needs (Section 8.2.2.3)

- Evaluating sampling/analysis options (Section 8.2.2.4)

- Reviewing data quality parameters (Section 8.2.2.5)

- Summarizing data gaps (Section 8.2.3).

Stage 2 is developed on the basis of the conceptual model and the project objectives. The following sections discuss these issues in greater detail.

8.2.1 Data Uses

For the purposes of the remediation of 200 West Area groundwater, most data uses fall into one or more of four general categories:

- Site characterization
- Public health evaluation and human health and ecological risk assessments
- Evaluation of remedial action alternatives
- Worker health and safety.

Site characterization refers to a process that includes determination and evaluation of the physical and chemical properties of any wastes and contaminated media present at a site, and an evaluation of the nature and extent of contamination. This process normally involves the collection of basic geologic, hydrologic, and meteorologic data and data on specific contaminants and sources that can be incorporated into the conceptual model to indicate the relative significance of the various pathways. Site characterization is not an end in itself, as stressed in the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a), but rather the data must ultimately assess the need for remediation (according to risk assessment methods, either qualitative or quantitative, or compliance with ARARs) and provide appropriate means of remediation (through an FFS, FS, or CMS). A primary set of tools for assessing these issues is the group of groundwater models selected for use at the Hanford Site: UNSAT-H, PORFLO-3, VAM3D, and CFEST. These models in turn impose additional data requirements. The understanding of the site characterization, based on existing data, is presented in Sections 2.0, 3.0, and 4.0, and summarized in the conceptual model (Section 4.2).

Data required to conduct a public health evaluation, and human health and ecological risk assessments for groundwater in the 200 West Groundwater Aggregate Area include the following: input parameters for various performance assessment models (e.g., the Multimedia Environmental Pollutant Assessment System); site characteristics; and contaminant data required to evaluate the threat to public and environmental health and welfare through exposure to the various media. These needs usually overlap with site characterization needs. An extensive discussion of risk assessment data uses and needs is presented in the *Risk Assessment Guidance for Superfund Vol. I* (EPA 1989a) and *EPA Region 10 Supplemental Risk Assessment Guidance for Superfund dated August 16, 1991* (EPA 1991). The risk assessments will follow the guidance outlined in the M-29-03 milestone document, *Hanford Site Baseline Risk Assessment Methodology* (DOE/RL 1991c). The present understanding of site risks is presented in the selection of constituents of concern

(Section 5.0). The data needs for quantitative risk assessments will be considered in developing sampling and analysis plans according to the *Hanford Site Past-Practice strategy*.

Data collected to evaluate remedial action alternatives for ERAs, IRMs, FFSs, or the full RI/FS, include site screening of alternatives, feasibility-level design, and preliminary cost estimates. Once an alternative is selected, much of the data collected from field site investigations (LFI or RI) can also be used for the final engineering design. Generally, collection of data during the investigations specifically for use in the final design is not cost effective because many issues must be decided about appropriate technologies before effective data gathering can be undertaken. It is preferable to gather such specific information during a separate predesign investigation or at the time of remediation [i.e., the "observational approach" of the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a)]. Based on the existing data, broad remedial action technologies and objectives have been identified in Section 7.0.

The worker health and safety category includes data collected to establish the required level of protection for workers during various investigation activities. These data are used to determine if there is concern for the personnel working in the vicinity of the aggregate area. The results of these assessments are also used in the development of the various safety documents required for field work (see Health and Safety Plan, Appendix B).

It should be noted that each of these data use categories (site characterization, risk assessment needs, remedial actions, and health and safety) will be required at each decision point on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) flow chart, as discussed at the end of Section 8.1.5. Areas are prioritized and not all areas of possible contamination will be investigated to the same degree. In general, the existing data for groundwater are adequate to initiate efforts to all these uses.

8.2.2 Data Needs

The data needs for the 200 West Groundwater Aggregate Area are discussed in the following sections according to the categories of data type (Section 8.2.2.1), data quality needs (8.2.2.2), data quantity needs (8.2.2.3), sampling and analysis options (8.2.2.4), and data quality parameters (8.2.2.5).

8.2.2.1 Data Types. Data use categories described in Section 8.2.1 define the general purpose of collecting additional data. Based on the intended uses, a concise statement regarding the data types needed can be developed. Types of data needed for characterization purposes in regard to the 200 West Groundwater Aggregate Area are quite varied. A major consideration is that the most important tools for characterization are models to address groundwater and vadose zone flow and contaminant transport. The data requirements for

such models have been described (DOE/RL 1991e) to include climatic data, plant and vegetation data, precipitation recharge, flow domain characteristics, soil characteristics (the critical hydrologic parameters), contaminant distribution/transport parameters, and contaminant source characteristics (Table 8-1).

Risk assessment is supported by these same models, and so has the same needs, but adds other types of data required to determine exposure and impact (e.g., toxicity). Much of the latter data is imposed by regulatory agencies rather than being acquired by site investigation. Toxicity data are generally supplied from standardized databases such as IRIS and HEAST.

The data type requirements for the preliminary remedial action alternatives developed in Section 7.4 are summarized in Table 8-2. In addition, the same groundwater models discussed in regard to characterization and risk assessment uses will also be vital to the assessment of remedial alternatives. Capabilities of features such as barriers, pumping, and recharge, possible technologies used in remediation of the groundwater, should be built-in to the model in its development so that the success or failure of these remedial actions can be readily predicted.

Types of data required for human health and safety involve contaminant concentrations and radioactivities in site media (groundwater and soils) that could cause exposures to personnel conducting intrusive investigation work, and parameters to predict transport, exposure, and toxicity. These data include volatilization partial pressures, vapor density, explosivity, corrosivity, and acceptable levels of chemicals in breathing zones. These parameters are spelled out in health and safety guidance documents.

8.2.2.2 Data Quality Needs. The various tasks and phases of a CERCLA investigation may require different levels of data quality. Important factors in defining data quality include selecting appropriate analytical levels and validating and identifying contaminant levels of concern as described below. The Westinghouse Hanford document, *A Proposed Data Quality Strategy for Hanford Site Characterization,* will be used to help define these levels (McCain and Johnson 1990). The Data Quality Objectives (DQOs) will also be developed and defined on an operable unit basis in the work plans and specifically in the Quality Assurance Project Plans (QAPjPs) which will guide investigation activities.

Chemical and radionuclide laboratory analysis will be one of the most important data types for many groundwater samples with various levels of contamination. In general, increased accuracy, precision, and lower detection limits are obtained with increased cost and time. Therefore, the analytical level used to obtain data should be commensurate with the intended use. Table 8-3 defines five analytical levels associated with different types of characterization efforts. While the bulk of the analysis during LFIs/RIs will be at the screening level (DQO Level I or II), these data will require confirmatory sampling and

analysis to allow final remedial decisions through quantitative risk assessment methods. Individual DQO analytical PARCC parameters for Level III or IV analytical data associated with each contaminant anticipated in the 200 West Groundwater Aggregate Area (as developed in Section 5.0) are given in Table 8-4. These parameters will be used to develop site-specific sampling and analysis plans and quality assurance plans for investigations and remediations in the aggregate area.

Before laboratory or even field data can be used in the selection of the final remedial action, they must first be validated. Validation involves determining the usability and quality of the data. Exceptions are made for initial evaluations of the sites using existing data, which may not be appropriate for validation but will be used on a screening basis based on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a). Other screening data (e.g., estimates of contaminant concentration inferred from field analyses) may also be excepted.

Once data are validated, they can be used to successfully complete the remedial action selection process. Activities involved in the data validation process include the following:

- Verification of chain-of-custody and sample holding times
- Confirmation that laboratory data meet Quality Assurance/Quality Control (QA/QC) criteria
- Confirmation of the usability and quality of field data, which includes geological logs, hydrologic data, and geophysical surveys
- Proper documentation and management of data so that they are usable.

Validation may be performed by qualified Westinghouse Hanford personnel from the Office of Sample Management (OSM), other Westinghouse Hanford organizations, or a qualified independent participant subcontractor. Data validation of laboratory analyses will be performed in accordance with *A Proposed Data Quality Strategy for Hanford Site Characterization* (McCain and Johnson 1990) and standards set forth by Westinghouse Hanford.

To accomplish the second point, all laboratory data must meet the requirements of the specific QA/QC parameters as set up in the QAPjP for the project before it can be considered usable. The QA/QC parameters address laboratory precision and accuracy, method blanks, instrument calibration, and holding times.

The usability of field data must be assessed by a trained and qualified person. The project geohydrologist/geophysicists will review the geologic logs, hydrologic data,

geophysical surveys, and results of physical testing, and senior technical reviews will be conducted periodically throughout the project.

Data management procedures are also necessary for validation. Data management includes proper documentation of field activities, sample management and tracking, and document and inventory control. Specific consistent procedures are discussed in the Information Management Overview (Appendix D).

8.2.2.3 Data Quantity Needs. The number of samples that need to be collected during an investigation can be determined by using several approaches. In instances where data are lacking or are limited, a phased sampling approach may be appropriate. However, this approach is difficult for groundwater because of the expense in installing the sampling access (wells). In the absence of any available data, an approach or rationale must be developed to justify the sampling locations (wells), the number of them to be installed and sampled, and at what frequency. This will be accomplished and documented by Westinghouse Hanford in the production of work plans and field sampling plans, under the guidance and review of the Tri-Party Agreement participants. Specific locations for wells and numbers (frequency) of sampling will be determined based on data collected up to the time for the well placement. In situations where and when available data are more complete, geostatistical techniques may be useful in determining the additional data required.

Some locations are obvious as sites for proposed installation and sampling of new wells as indicated by the plume maps (Figures 4-1 to 4-14). For example, data for trichloroethylene is very sparse downgradient of its detection in Well 299-W22-20, in the southeasternmost corner of the S Plant Aggregate Area and the 200 West Area; the plume's extent in the 600 Area beyond the fenceline is very uncertain because of the limited number of wells found in this part of the site. Other examples are easy to find, since many plumes are heading out of the 200 West Area. There are statistical packages available that not only interpolate the plume concentration in such areas, but also estimate the errors associated with this interpolation. One such package is Geostatistical Environmental Assessment Software (GEO-EAS) (Englund and Sparks 1988). The relative risk interpretation methods discussed in Section 5.0 can be used in this method so that the placement of new wells can at the highest priority resolve the most significant issues regarding the risks associated with groundwater contamination.

8.2.2.4 Sampling and Analysis Options. Data collection activities are structured to obtain the needed data in a cost-effective manner. Developing a sampling and analysis approach that ensures that appropriate data quality and quantity are obtained with the resources available may be accomplished by using field screening techniques and focusing the higher DQO level analyses on a limited set of samples at each site. The groundwater investigations should take advantage of this approach for a comprehensive characterization of the site in a cost-effective manner.

A combination of lower level (Levels I and II) and higher level analytical data (Levels III and IV) should be collected. For instance, at least one of the samples collected from each well should be analyzed at DQO Level IV and validated to provide high quality data to confirm the less expensive but more extensive lower level analyses. This approach would provide the certainty necessary to determine contaminants present in plumes. Samples collected will be analyzed by *Test Methods for Evaluating Solid Wastes*, ("SW-846," EPA 1986b), CLP (EPA 1988a, EPA 1989a), *Methods for Chemical Analysis of Water and Wastes* (EPA 1983), or *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA 1980) or other standard methods.

8.2.2.5 Data Quality Parameters. The PARCC parameters indicate data quality. Ideally, the end use of the data collected should define the necessary PARCC parameters. Once the PARCC requirements have been identified, then appropriate analytical methods can be chosen to meet established goals and requirements. Definitions of the PARCC parameters are presented in Section 8.1.2.

In general the precision and accuracy objectives are governed by the capabilities of the available methodologies and in most cases these are more than adequate for the needs of the investigations. Chemical analyses can usually attain parts per billion detection range in soils and water, and this level is adequate to the needs of the risk assessment for most analytes. Radiological analyses can similarly reach levels of pCi/L. Table 8-4 shows detection levels, generally obtained from the method description or from experience with laboratory analysis. Some constituents (e.g., arsenic) would require analysis to much lower levels, but this is generally impossible because of the limitations of analytical methods and the effects of natural background levels of the analyte. In some cases, special analytical methods can be developed to obtain lower detection limits. In addition, risk assessment is conventionally computed only to a single digit of precision and uses conservative assumptions, which reduce the impact of measurements with lower accuracy.

For other measurements, such as physical parameters, the precision and accuracy capabilities of existing measurement technologies are sufficient for the evaluation methods used to produce characterization data, so the objectives are usually based on the limitations of the analysis methodologies.

Representativeness is maintained by fitting the sampling program to the governing aspects of the sources and transport processes of the site, as demonstrated in the site conceptual model (Section 4.2). Sampling for groundwater should concentrate on representative locations of all anticipated transport mechanisms. Moisture and contaminant transport through the vadose zone are especially poorly understood and are as such good candidates for sampling (this is more appropriately done during source investigations). If necessary, the following activities can focus on aspects or locations that were not anticipated but were demonstrated by the more general results.

Completeness is generally attained by specifying redundancy on critical samples and maintaining quality control on their acquisition and analysis. As with representativeness, the initial sampling program may lead to modifications of which samples should be considered critical during subsequent sampling activities.

Comparability will be met through the use of Westinghouse Hanford standard procedures generally incorporated into the *Environmental Investigation and Site Characterization Manual* (WHC 1988c).

8.2.3 Data Gaps

Considering the data needs developed in Section 8.2.2, and the data available to meet these needs as presented in Section 8.1.2, it is apparent that a number of data gaps can be identified. These should be the focus of LFIs conducted for groundwater. The data gaps have been gathered from the assessment of the data and a review of previous assessments of groundwater data needs (DOE/RL 1991e). These data gaps include the following:

- **Gaps in Plume Extents**--the extent of some plumes, especially those which have exited the 200 West Area, is not well defined. New wells will have to be placed in these areas which will better delineate the actual extents of contamination. Some wells (e.g., in the east-northeast and southwest portions of the 200 West Area) will be required to fill in gaps in the network.

- **Confined Aquifers**--the lower portion of the uppermost aquifer (Ringold gravel unit A) becomes locally confined by the Ringold lower mud sequence in the northwestern part of the 200 West Area (See Section 3.5.2.1.3 and Figures 3-28 and 3-29). To date very few wells have been screened in the confined portion of this zone, and so neither flow directions nor the presence or absence of contamination is known of this zone. It will be necessary to construct new wells into this zone that are sufficient in number to determine gradients and possibly complicated groundwater flow patterns and to allow for sampling and analysis.

  Although the confined aquifers located in interbeds of the basalt are possible routes of contaminant migration from the unconfined portions of the uppermost aquifer, they have also been underrepresented in sampling and water level measurements in the 200 West Area since the time of the Basalt Waste Isolation Project (DOE 1988). Existing wells should be checked for suitability, and additional wells should be installed to provide at least screening coverage of the uppermost (Rattlesnake Ridge) aquifer.

- **Analytical Data Limitations**--historic groundwater concentrations data vary in quality from very questionable to adequate. Different analytical methods and detection limits

plus poor quality control compromise the results. Sampling methods, such as the use of a bailer instead of a pump, can affect the quality of the samples obtained.

Some data in the present data set appear erroneous such as reports of concentrations three orders of magnitude different from other values in the same well; this may indicate a confusion between ppb and ppm units. Other values are simply suspicious, such as reports of plutonium in deeper wells but not shallow ones adjacent. Situations like these should be checked and wells resampled if necessary.

The historical data should be reviewed in light of these issues, and compared to each other to limit the likelihood of erroneous results.

- **Background Concentrations of Inorganic Constituents**--while this data gap is already being addressed (Hoover and LeGore 1991, DOE/RL 1992c), it still impedes proper interpretation of the concentrations of inorganics being observed in sampling.

- **Missing Chemical Constituents**--some chemicals that were used in very large quantities in the chemical separations processes are not found in the groundwater. These include the butyl phosphates which formed the basis of the TBP, DBP, and MBP processes used in several of the plants in the 200 West Area. These chemicals have been detected in groundwater, but not as frequently as would be expected from the quantities used. It is possible that these constituents were not disposed of in large quantities, perhaps due to process reasons, or that they have been adsorbed onto sediments, or have biologically degraded in the environment since disposal (DOE/RL 1991a). These questions should be investigated.

- **Detection Limits**--Some contaminants which may be present at low concentrations have toxicities high enough to render these concentrations important to health and environment concerns. These include N-nitrosodimethylamine, bis(2-ethylhexyl) phthalate, arsenic, 1,1-dichloroethylene (DCE), pesticides, beryllium, pentachlorophenol (PCP), and selenium. Methods may have to be developed to obtain lower detection limits to adequately delineate these possibly important plumes.

- **Single Detections of Chemicals**--some of the chemicals included in the list of detections (Table 4-1) were detected only once in a well and only in one well. These chemicals include 1,1-dichloroethylene (DCE), tetrachloroethylene (PCE), toluene, bis(2-ethylhexyl)phthalate, N-nitrosodimethylamine, Silver-110 (metastable isotope), and cobalt. A wider list of chemicals was detected in more than one well, without any of the detections being confirmed by a repeated detection. These detections should be reviewed and validated, and the well resampled and reanalyzed to confirm or refute these potentially spurious results. Particularly when only one member of a chemical family requires analysis, the cost of the analysis goes up significantly. To continue

analyzing throughout the site for chemicals that were misreported in the first place is a misallocation of scarce resources.

- **Plumes at Only One Well**--it is difficult to assess the significance of a plume that is found only in one well, but has been confirmed by repeated sampling. It is possible that this contamination is due to some local conditions, such as transport along the well casing, and that the contamination is not as high elsewhere, but if the level is high enough to be of regulatory concern, the potential for a plume should be checked with other wells located immediately down-gradient. These chemicals include 1,2-Dichloroethane (DCA) in 299-W22-20 (the same well has the highest detection of trichloroethylene), and citrus red in 299-W7-6.

- **Well Construction Data**--some wells may be appropriate or inappropriate for particular uses (sampling, aquifer tests, geophysical logging) but this cannot be determined because of inconsistencies in the recorded information on their construction (especially screened depths) as well as their current condition (e.g., screen clogging). The depth of the wells could be especially significant in cases where the declining water table could leave a well dry; this could result in a loss of data until a new well can be installed. These issues could easily be resolved to a considerable degree by television logging and other simple methods.

- **Well Locations and Elevations**--a more precise accounting of well locations and elevations is becoming increasingly important to the investigation. The locations of wells are important to allow development of detailed geologic models (cross sections) for field sampling plans, and the elevations are needed to provide the basis for calculating groundwater gradients. The gradients are so low in an area between the 200 East and West Areas that errors of less than 15 cm (6 in.) are significant, and distances between wells in this area are far enough that ordinary (third order) surveying techniques may not be sufficient.

- **Aquifer Properties**--aquifer properties such as hydraulic conductivity, transmissivity, storage coefficient, and porosity are not well determined. To date, aquifer testing has consisted of slug testing and some poorly designed pump tests. Pump testing has been difficult to carry out due to problems disposing of fluids. This issue could be negotiated and solved, and properly designed pump tests carried out.

- **Potential for Continuing Releases from the Vadose Zone**--many source waste management units have been inactive for years and so have not added moisture to the soil column during this time. It is unknown how long after shutdown the soil under such a unit will continue to drain, and to transport contamination down to the groundwater. Since such a process, if it is occurring, would constitute a continuing source of groundwater contamination, it is important to predict when it will occur.

This also applies to dry sites that have never received free liquids but through which wastes could be leached by precipitation recharge or by continuing discharges of clean water to soils (via septic drain fields). Modeling efforts for transport through the vadose zone are ongoing, using models such as UNSAT-H, PORFLO-3, and VAM3D-CG, and so specific data requirements of these models will be included in the field investigation programs. A generic list of these data needs is presented in Table 8-2. It is also vital to obtain better data on the levels and depths of chemical and radiologic constituents in the soil column which are available for transport. This last issue is the responsibility of source investigations.

Another alternative in this regard is to monitor the transport of contaminants through the soil using borehole geophysical logging like the RLS program. This has the advantages of monitoring actual rather than theoretical migration rates of the contaminants of concern directly and cuts through the multitude of assumptions and approximations inherent in such modeling. It has the major disadvantage of requiring a much longer program to come up with results and the interpretation of the results may not allow extrapolation to other sites. In addition, many radionuclides do not have sufficient gamma emissions to allow detection of their migration.

There is also a potential problem with the well installation methods presently employed. The use of annular seals (clay-based grout) compromises the detection capability of the logging by attenuating radiation from beyond the borehole and introducing other radionuclides in the grout.

- **Estimation of Recharge Rates**--available data from previous studies (such as lysimeter studies, see Section 3.5.1.2.1) indicate a wide range of estimates of recharge through natural or disturbed Hanford Site soils. Since this could affect both the transport from dry or inactive sites as well as changes in concentration in the saturated zone during transport, it is potentially very important. Freshley and Graham (1988) indicate that the range of possible recharge rates lead to predictions of very different flow patterns in the unconfined aquifer, including opposite directions of flow through Gable Gap.

- **Hydraulic Interconnections with Basalt Aquifers**--the effect of connections with basalt aquifers, particularly the Rattlesnake Ridge interbed, can be of significant concern, mainly for the potential for allowing further spread of contamination but also as affecting flows in the uppermost aquifer. This is especially a potential in areas where the interbed sediments are exposed to overlying sediments through erosion of the basalt, such as in the Gable Gap area. While this area is not included in the extent of the 200 West Groundwater Aggregate Area, it is a region where contamination is headed from the 200 West Area, and so is of concern.

- **Groundwater Inflows from Off-Hanford Site**--the quantity of flow entering the Hanford Site from upgradient (from the west), particularly from the Cold Creek and Dry Creek basins, is not well understood, and will affect the modeling by imposing important boundary conditions on the model. The sources could be natural infiltration of runoff or recharge from irrigation.

- **Contaminant Travel Time to the Columbia River**--this issue addresses the degree to which degradation can be anticipated to affect contaminant concentrations. If the travel time is known, then the decay of radioactive constituents can be accurately determined. This travel time can be obtained from groundwater modeling, and so interacts with a great many other factors with their own data needs, particularly hydraulic conductivity, porosity, gradients, and retardation parameters. It is significant to note that for the purposes of modeling these data are required for the entire area of potential migration across the Hanford Site to the Columbia River.

- **Soil Vapor Phase Transport**--there is a consideration that some volatile organic compounds, primarily carbon tetrachloride, are being transported from water phase near the source disposal areas to locations hydrologically upgradient via the soil vapor phase. If this is occurring then control of this contaminant is becoming more difficult, and the situation will require a more rapid response than otherwise warranted by the materials present extent.

- **Dense Non-aqueous Phase Liquids (DNAPLs)**--some liquid chemicals that are denser than water, low in viscosity, and relatively insoluble in water can form deposits of relatively pure chemicals in zones at the bottom of an aquifer, if disposed originally in sufficient quantity. This could be the situation at the carbon tetrachloride plume. If these deposits are present, they could act as "secondary sources" and continue to feed groundwater contamination even after the vadose zone is cleaned up (e.g., via vapor extraction). They also have an influence on the nature of the plume, making it more concentrated near the bottom of the aquifer than at the top (the case with vadose-zone sources). Dense high-salt wastes could have a similar effect and are known to result from uranium scavenging operations. These waste materials are probably less likely to lodge in the aquifer and travel by density gradient because of their solubility and high viscosity.

- **Enhancement of Contaminant Transport by Complexing**--some chemicals can help transport other possibly more toxic chemicals by forming complexes with them. At many sites a great variety of chemicals were potentially disposed, including some that were selected for the processes in which they were used to form such complexes.

- **Dispersivity**--this parameter is difficult to estimate in situ or from physical properties of the soils and is impossible to duplicate at laboratory scale. The best methods are by

calibration to the behavior of plumes that have been tracked over time (mainly tritium and nitrate). The value of these parameters will significantly affect the changes in concentration as the plumes transit the site.

- **Vertical Extent of Plumes**--there are very few well groups that can assess the thickness of the contaminant plumes. Most of the newer wells are screened just across the water table at the top of the saturated zone; some of the old wells have very long screened sections. Neither of these will give information about the depth to which contamination can be found in the plume. The data would assist evaluation of dispersivity and would assist in the screening of remedial technologies. These data are especially important for chemical constituents which can form DNAPLs such as carbon tetrachloride, chloroform, and trichloroethylene.

- **Vertical Gradients**--even within the uppermost aquifer vertical gradients are possible, especially in areas of recharge as near the ponds. However, there are no well clusters situated that would allow this information to be obtained. Vertical components can result in thicker plumes (based solely on advection, not dispersion) and thus will have to be taken into account.

- **Effects of Old Monitoring Well Construction**--wells constructed before the late 1980's were generally constructed of mild carbon steel rather than stainless steel. This construction is thought to affect the measured concentrations of both radioactive and hazardous constituents by adsorbing them. This can also have an effect on the use of the wells for gamma ray logging. It will be very expensive to replace these wells, and so some level of study should be put into determining if this is really a problem.

- **Focussed Feasibility Studies of Remedial Technologies**--some of the technologies suggested for use on groundwater should be assessed at various scales for their applicability in the 200 West Area groundwater environment. In part this investigation should include a comprehensive best available technology (BAT) assessment of applicable technologies, and should consider costs (per unit volume), secondary wastes, and adverse effects. Various properties for contaminant treatability should also be obtained through treatability testing; these include strippability, adsorbability, biodegradability (natural biodegradation), heavy metal properties, and natural degradability for radionuclides.

- **Innovative Technologies**--these state-of-the-art technologies for cleaning up groundwater should be assessed in a separate program which is linked to the AAMS studies by providing data requirements to field programs, and treatability studies (at various scales) to develop needed parameters and to preliminarily assess their applicability to site conditions.

8.3 DATA COLLECTION PROGRAM (STAGE 3 OF THE DQO PROCESS)

The data collection program is Stage 3 of the process to develop DQOs. Conducting an investigation by a sequentially-adapted process that uses the data as it comes in is a common method for optimizing the quantity and quality of the data collected. It would be very inefficient and overly expensive to specify beforehand all the well location depths sampling schedules, and analyses that will yield the most complete and accurate understanding of the contamination and physical behavior of the site. Data adequate to achieve the goals and objectives for remedial action decisions are obtained at a lower cost by using the information obtained in the field to focus the ongoing investigation and remediation process.

Initial sampling should collect new data believed most necessary to confirm and refine the conceptual model particularly along transport pathways with priority constituents or quantities of flow. Sampling may then be extended to further reduce uncertainty, to fill in remaining data gaps, to collect more detailed information for certain points where such information is required, or to conduct any needed treatability studies or otherwise support the data needs of the remedial action selection process. The need for subsequent investigation phases will be assessed throughout the investigation and remediation activities as data become available. Assessing completeness of the investigation data through a formal statistical procedure is not possible, given the complexity and uncertainty of the parameters required to describe the site and the time to make decisions. Rather, the use of engineering judgment is considered sufficient to the decision process.

8.3.1 General Rationale

The general rationale for the investigation of groundwater contamination in the 200 West Groundwater Aggregate Area is to collect needed data that are not available. Because of the size of the aggregate area, the complexity of past operations, and the number of potential sources and plumes, a large amount of new information will be required such as the specific radionuclides and chemicals present, their spatial distribution and form, and the presence of special migration pathways such as potential (localized) perched groundwater systems.

The following work plan approach will be used for LFIs and RI/FS in the 200 West Groundwater Aggregate Area. The results are described in Sections 8.3.2 and 8.3.3 in a general form.

- Existing data as described in Sections 2.0, 3.0, and 4.0 should be used to the maximum extent possible. Although existing data are not validated fully, the data are still useful in developing a preliminary conceptual model (Section 4.2) and in helping to focus and guide the planning of investigations, expedited actions, and interim measures. The data as is are sufficient for preliminary risk assessment purposes.

- Additional data at validated and screening levels should be collected to obtain the maximum amount of useful information for the amount of time and resources invested in the investigation.

- Data should be collected to support the intended data uses identified in Section 8.2.1.

- Data collected from initial investigation activities should be used to confirm and refine the conceptual model (Section 4.2), refine the analyte constituents of concern, adjust the locations for subsequently installed monitoring wells, and provide information to conduct interim response actions or risk assessment activities.

- Additional investigation activities are proposed to support quantitative baseline risk assessments for final cleanup actions and further refine the conceptual model.

- Field investigation techniques should be used to minimize the amount of hazardous or mixed waste generated. Any waste generated will be in accordance with EII 4.2, "Interim Control of Unknown Suspected Hazardous and Mixed Waste " (WHC 1988c).

8.3.2 General Strategy

The overall objective of any field investigation (LFI, IRM, or RI) of the groundwater in the 200 West Groundwater Aggregate Area will be to gather additional information to support risk assessment and remedial action selection according to the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) flow chart discussed in Section 8.1.5. The general approach or strategy for obtaining this additional information is presented below.

- The investigations should interface closely with the source operable unit field investigations to achieve data goals of both projects with a minimal field program. For example, if geologic assessment is required in a particular source area, the data should be shared with the groundwater operable units, to allow refinement of the

hydrogeological model. When samples are to be taken in saturated zones (for other reasons) they should also allow testing of parameters required for groundwater models.

- New wells should be situated according to the most recent data about plume extents and locations, to reduce uncertainty most efficiently. Thus, as data become available regarding groundwater concentrations, they should be incorporated in the model of plume distributions and the locations of subsequent wells to be reviewed according to this most recent information. Existing wells should be evaluated, and those which may be providing pathways for contaminant transport to deeper strata should be abandoned or remediated (this is a continuation of an already on-going program).

- Specification of analytical parameters should start with the long list of potential contaminants of concern and be narrowed to a shorter list as quickly as possible, perhaps with different lists in different areas limited to those of concern at the specific area. Increased use of field screening methods at the well head may also reduce the cost of analysis and increase the amount of meaningful data obtained for the cost expanded by allowing submittal of only those samples most likely to be contaminated. Occasional samples should continue to be analyzed for the long list, but the best allocation of resources is to analyze for those constituents which will give the most information. Nondetects, if highly predictable, do not convey much additional information.

8.3.3 Investigation Methodology

Initial field investigations (mainly LFIs, but also associated with IRMs for appropriate plumes and possibly some RIs) may include some or all of the following integrated methodologies:

- Plume Nature and Extent Investigation (Section 8.3.3.1)
- Groundwater Transport Investigation (Section 8.3.3.2)
- Source Release Investigation (Section 8.3.3.3)
- Geologic Investigation (Section 8.3.3.4)
- Geodetic Survey (Section 8.3.3.5)

Each investigation methodology is briefly outlined in the following sections. Specific field methods such as well construction methods have not been recommended to allow flexibility in the development of field sampling plans which can be sensitive to very local conditions. Some of the data needs are very local especially for specific limited plumes,

others must be addressed on an area-wide basis (e.g., stratigraphy interpretation). More detailed descriptions and specific methods and instrumentation will be included in site-specific work plans, sampling and analysis plans, and field sampling plans for LFIs/IRMs for plumes that require these investigations.

These investigations are presented in the approximate priority of their need, with the plume, nature and extent investigation first because of its importance to the decisions about remedial action on a site-by-site basis. The other investigations are of lower priority, and will be conducted according to the availability of resources.

8.3.3.1 Plume Nature and Extent Investigation. The purpose of the plume investigation is to confirm the characteristics and locations of the plumes in the 200 West Groundwater Aggregate Area. "Nature" encompasses the contaminants present in the plume as well as their concentrations and interrelations. "Extent" involves the areal bounds of the plumes but also their thicknesses (vertical extent). This investigation will address data gaps (Section 8.2.3) relating to the limitations in well coverage of plumes including single-well plumes, missing or unusual chemical constituents, confirmation or refutation of single detection chemicals, and the issue of vertical extent. Activities for this investigation methodology may include the following:

- **Installation of New Monitoring Wells**--this will allow gaps in the coverage of known plumes to be filled in. In particular, new wells should be situated just downgradient from single-well plumes (those with repeated confirmations of the presence of a chemical but only in one well), in areas with the greatest uncertainty about the location of existing plumes (e.g., in parts of the 200 West Area and 600 Area where wells are sparse and the plumes have moved beyond monitoring control in the 200 West Area), at lower portions of the uppermost aquifer, in the zone where the Ringold A becomes a confined aquifer and in the uppermost confined basalt aquifers. Locations of these wells will be derived for priority plumes of concern in separate field sampling plans to be developed by Westinghouse Hanford. Some wells may be required on an aggregate area basis rather than at an operable unit scale.

- **Sampling and Analysis**--sampling of some existing wells that have not been adequately covered in the past and new wells should include analyses of constituents that have been reported or can reasonably be expected to be released in some of the waste streams going to cribs or other liquid waste disposal facilities. Appendix A includes Tables A-1 and A-2 that list the chemicals and radionuclides detected in samplings of wells and their maximum detections. Table A-3 lists constituents that have not been detected in any of these wells, including the number of times the constituent was analyzed for and the analysis detection limit. Table A-4 lists all wells where chemical constituents have been detected. These tables, in conjunction with the table of contaminants of concern (Table 4-5) can allow for selection of target analyte lists in the

vicinity of specific plumes. To some extent, the ongoing groundwater sampling in support of the 200 Areas AAMS will address these issues.

For the case of single-detection plumes where the compound in question is of concern at low concentrations, analysis at the well with the detection, as well as other nearby wells which may also be affected, should employ special analytical methods with lower detection limits. This will help delineate the actual extent of a plume with lower concentrations, and get a better estimate of the concentration even in the well with the detection. Wells with elevated gross alpha and/or gross beta should include tests for specific radionuclides which may be causing the indicator parameter.

Some potentially highly toxic constituents may require method development to give suitably low detection limits.

Determination of background levels (Hoover and LeGore 1991) will also be supported by analysis of groundwater samples.

The proposed investigation will also include reviewing and television logging of wells to determine their suitability for sampling.

8.3.3.2 Groundwater Transport Investigation. The purpose of the groundwater transport investigation is to gather additional information about groundwater transport to determine future plume directions, changes in concentration, and potential impacts. To a great extent, this investigation will be interdependent on the development of groundwater models for the Hanford Site which are already under way under a separate Tri-Party Agreement milestone (M29-00), which is developing more detailed data requirements for the models.

Data gaps that this investigation will address include recharge rates both at former disposal sites as well as generally across the site, the potential for interconnections with other aquifers (also addressed by new wells listed in the plume investigation, Section 8.3.3.1), groundwater inflows from Cold Creek and Dry Creek valleys, dispersivity, vertical gradients (also to be addressed with additional wells), and travel time issues. Data needs for contaminant mobilization and transport will also be developed, such as K_d, Eh, and/or pH measurements for speciation, solubility and mobility of inorganics, and organic carbon contents for transport of organics.

8.3.3.3 Source Release Investigation. A very significant data gap is whether former liquid disposal sites continue to release contamination to groundwater after disposal is terminated. This issue can be addressed in two ways, each of which may be confirmatory of the other. First, models should be calibrated using available data that will predict the flows in these unsaturated systems. This also may involve obtaining additional data to supply parameters for these models through field investigation, as determined by the model developers.

Second, an investigation should be carried out to track levels of contamination beneath these facilities to see if there is a net movement of the contamination. This latter investigation will probably use radioactive contaminants such as tracers for contamination, and detect their levels and depths through spectral gamma logging, such as the RLS surveys being conducted in support of the AAMS study. Both studies should coordinate with field investigations being conducted for the source operable units to assure proper parameters are collected for the vadose zone transport models and that permanent logging wells are to be installed through representative facilities. Another aspect of the confirmatory field studies is to track groundwater concentrations at the tail end of plumes to determine from the groundwater side the possibility of continuing releases.

8.3.3.4 Geologic Investigation. The purpose of the geologic investigation is to clarify the stratigraphic constraints on groundwater flow. This may utilize geophysical methods in conjunction with geologic and geophysical logging in boreholes. It is essential that this investigation be coordinated with the field investigations at the various source operable units. This would minimize the drilling cost by drilling characterization wells once rather than twice (once for vadose zone properties then a separate boring for the saturated zone).

8.3.3.5 Geodetic Survey. Geodetic surveys will be conducted after the installation and completion of each investigation activity. Horizontal and vertical locations of all wells will be surveyed. The survey should also include existing wells with known or suspected erroneous reference elevations. The geodetic survey should be conducted by a professional surveyor licensed in the state of Washington and should be referenced to both historic (e.g., Hanford coordinates) and current coordinate datums (e.g., North American Datum of 1983 - NAD-83), both vertical and horizontal.

8.3.4 Data Evaluation and Decision Making

Data will be evaluated as soon as results (e.g., soil gas, radiation screening, drilling results) become available for use in restructuring and focusing the investigation activities. Data reports will be developed that summarize and interpret new data. This includes the ongoing groundwater sampling and RLS borehole logging as part of the AAMS and the results of the source investigations under the various source AAMS. Data will be used to refine the conceptual model, further assess potential contaminant-specific ARARs, develop the quantitative risk assessment, and assess remedial action alternatives.

The objectives of data evaluation are:

- To reduce and integrate data to ensure that data gaps are identified and that the goals and objectives of the 200 West Groundwater AAMS are met

- To confirm that data are representative of the media sampled and that other QA/QC criteria have been met.

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Table 8-1. Data Requirements for Modeling Flow and Transport in the Vadose Zone.

C.1 CLIMATIC DATA

- 1.1 Precipitation Data (from Meteorological Measurements)
  - 1.1.1 Rainfall
  - 1.1.2 Snowmelt
  - 1.1.3 Runoff from Precipitation Events (Field-Measured)
- 1.2 Potential Evapotranspiration Data (From Meteorological Measurements)
  - 1.2.1 Air Temperature
  - 1.2.2 Relative Humidity (Wet and Dry Bulk)
  - 1.2.3 Wind Speed
  - 1.2.4 Solar Radiation

C.2 PLANT AND VEGETATION DATA

- 2.1 Transpiration Function (Field-Measured)
  - 2.1.1 Plant Type and Depth of Root System
  - 2.1.2 Plant Density
- 2.2 Plant Cover
  - 2.2.1 Leaf Area Index (Field-Measured)

C.3 FLOW DOMAIN CHARACTERISTICS

- 3.1 Size of Flow Domain (Based on Field Data)
  - 3.1.1 Spatial Discretization (Numerical Input)
  - 3.1.2 Temporal Discretization (Numerical Input)
- 3.2 Boundary Conditions
  - 3.2.1 Flow (Field-Measured Moisture Contents of Fluxes)
  - 3.2.2 Contaminant Transport (Field-Measured Concentration or Mass Fluxes for Various Species)
- 3.3 Initial Conditions
  - 3.3.1 Flow (Field-Measured Moisture Contents or Pressure Potentials)
  - 3.3.2 Contaminant Transport (Field-Measured Concentrations for Various Contaminant Species)
- 3.4 Depth to Water Table (Field-Measured)
- 3.5 Thickness and Hydraulic Properties of the Unconfined Aquifer (Field-Measured)
- 3.6 Location and Rates of Pumping/Injection Wells (Field Data)

C.4 SOIL CHARACTERISTICS (These are considered to be the critical hydrologic parameters)

- 4.1 Heterogeneity and Anisotrophy (Field-Measured)
  - 4.1.1 Layering (Thickness and Continuity of Various Layers)
  - 4.1.2 Anisotropic Characteristics of Various Layers

Table 8-1. Data Requirements for Modeling Flow and Transport in the Vadose Zone.

4.2 Moisture Characteristic Curves for Each Layer
- 4.2.1 Moisture Content Versus Pressure Potential Curves (Field or Laboratory Measured)
- 4.2.2 Hydraulic Conductivity Versus Moisture Content Curves (Field- or Laboratory-Measured or Derived From Moisture Content Versus Pressure Potential Curves)
- 4.2.3 Hysteresis Data for Wetting and Drying Cycles (Field- or Laboratory-Measured)

4.3 Soil Bulk Density and Porosity for Each layer (Field- or Laboratory-Measured)

C.5 CONTAMINANT TRANSPORT PARAMETERS

5.1 Diffusion Coefficients (Laboratory-Measured or Obtained From Literature)
5.2 Hydrodynamic Dispersion Coefficients (Laboratory-Measured or Obtained from Literature)
5.3 Retardation Coefficients (Laboratory-Measured or Obtained From Literature)
5.4 Radioactive Decay Constants (Laboratory-Measured or Obtained From Literature)

C.6 CONTAMINANT SOURCE CHARACTERISTICS

6.1 Major Radionuclides and Their Concentrations
6.2 Mass Source Loading Rate for Radionuclide

Source: DOE/RL 1991d

Table 8-2. Data Needs for Preliminary Remedial Action Technologies for 200 West Groundwater Aggregate Area Operable Units. Page 1 of 2

Technology Group	Physical Attribute	Chemical Attribute
Physical Containment Examples: • Freeze walls • Grout curtains	• Areal extent • Depth • Hydrogeologic conditions • Geologic conditions • Potential siting for operational refrigeration units • Surface access along corridor of installation	• Radioactivity
Hydraulic Containment Examples: • Injection wells • Extraction wells	• Areal extent • Depth • Hydrogeologic conditions • Potential water disposal sites • Sources of water for injection	• Chemical contaminants which affect disposal of extracted water
Pump and Treat Examples: • Comprehensive BAT treatment • Target treatment of single chemical class Treatment options • Ion exchange • Chemical precipitation • Air stripping • Carbon absorption • Reverse osmosis • Evaporation • UV oxidation • Filtration	• Areal extent • Vertical extent • Hydrogeologic conditions • Geologic conditions • Potential water disposal/ reinjection sites • Siting for potential treatment facilities	• Applicable treatment options depend on complex, interrelated contaminant matrix • Contaminant variability • Geochemistry of saturated soils
Natural Attenuation Examples: • Point of use • Point of discharge	• Areal extent • Migration pathways • Geologic conditions between source and point of use • Hydrogeologic conditions between source and point of use • Siting conditions for treatment facility at point of use	• Chemical matrix at point of use • Applicable treatment options depend on complex, interrelated contaminant matrix • Geochemistry between source and point of use • Natural attenuation potential of contaminant

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Table 8-2. Data Needs for Preliminary Remedial Action Technologies for 200 West Groundwater Aggregate Area Operable Units. Page 2 of 2

Technology Group	Physical Attribute	Chemical Attribute
In Situ Treatment Examples: • Air sparging • In situ precipitation • In situ destruction • In situ mobilization • In situ natural attenuation	• Areal extent • Vertical extent • Hydrogeologic conditions • Geologic conditions	• Specific treatment is contaminant dependent • Geochemistry of saturated soils • Contaminant heterogeneity

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Table 8-3. Analytical Levels for the 200 West Groundwater Aggregate Area.

Level	Description
LEVEL I	Field screening. This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.
LEVEL II	Field analysis. This level is characterized by the use of portable analytical instruments which can be used onsite, or in mobile laboratories stationed near a site (close-support laboratories). Depending on the types of contaminants, sample matrix, and personnel skill, qualitative and quantitative data can be obtained.
LEVEL III	Laboratory analysis using methods other than the Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is used primarily in support of engineering studies using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS without the CLP requirements for documentation.
LEVEL IV	Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is characterized by rigorous QA/QC protocols and documentation and provides qualitative and quantitative analytical data. Some regions have obtained similar support via their own regional laboratories, university laboratories, or other commercial laboratories.
LEVEL V	Nonstandard methods. Analyses which may require method modification and/or development are considered Level V by CLP Special Analytical Services (SAS).

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Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit (pCi/g)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit (pCi/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES								
Gross Alpha	900.0 M	TBD	±30	±25	900.0	10	±25	±25
Gross Beta	900.0 M	TBD	±30	±25	900.0	5	±25	±25
Gamma Scan	D3699 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Actinium-225	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Actinium-227	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-241	Am-01	TBD	±30	±25	Am-03	TBD	±25	±25
Americium-242	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-242m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-243	Am-01	TBD	±30	±25	Am-03	TBD	±25	±25
Antimomy-126	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Antimony-126m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Barium-137m	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Bismuth-210	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-211	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-213	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Carbon-14	C-01 M	TBD	±30	±25	TBD	TBD	±25	±25
Cesium-134	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Cesium-135	901.0 M	TBD	±30	±25	901.0	TBD	±25	±25
Cesium-137	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Cobalt-60	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Curium-242	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Curium-244	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Curium-245	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Europium-152	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Europium-154	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit (pCi/g)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit (pCi/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
Europium-155	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Francium-221	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Iodine-129	902.0 M	TBD	±30	±25	902.0	TBD	±25	±25
Lead-209	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-210	Pb-01 M	TBD	±30	±25	Pb-01	TBD	±25	±25
Lead-211	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-212	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Neptunium-237	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Neptunium-239	D35649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Nickel-59	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Nickel-63	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Niobium-93m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Plutonium	Pu-02	TBD	±30	±25	Pu-10	TBD	±25	±25
Plutonium-238	Pu-02	TBD	±30	±25	Pu-10	TBD	±25	±25
Plutonium-239/240	Pu-02	TBD	±30	±25	Pu-10	TBD	±25	±25
Plutonium-241	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Polonium-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Polonium-215	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Polonium-218	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Potassium-40	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Protactinium-231	TBD	TBD	±30	±25	TBD	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit (pCi/g)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit (pCi/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
Protactinium-234m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Radium	Ra-04	TBD	±30	±25	Ra-05	TBD	±25	±25
Radium-225	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Radium-226	Ra-04	TBD	±30	±25	Ra-05	TBD	±25	±25
Ruthenium-106	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Samarium-151	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Selenium-79	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Sodium-22	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Strontium-90	Sr-02	TBD	±30	±25	Sr-02	TBD	±25	±25
Technetium-99	Tc-01 M	TBD	±30	±25	Tc-01	TBD	±25	±25
Thallium-207	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Thorium-227	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-229	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-230	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-231	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Tritium	906.0 M	TBD	±30	±25	906.0	300	±25	±25
Uranium	U-04	TBD	±30	±25	U-04	TBD	±25	±25
Uranium-233	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-234	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-235	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-238	U	TBD	±30	±25	908.0	TBD	±25	±25
Yttrium-90	Sr-02	TBD	±30	±25	Sr-02	TBD	±25	±25
Zirconium-93	TBD	TBD	±30	±25	TBD	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit (mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit (μg/L)	Precision (RPD)	Accuracy (%)
INORGANICS								
Arsenic	7061	0.02	±25	±30	7061	10	±20	±25
Barium	6010	0.02	±25	±30	6010	20	±20	±25
Boron	6010	TBD	±25	±30	6010	TBD	±20	±25
Cadmium	6010	0.09	±25	±30	6010	1	±20	±25
Chromium	6010	0.07	±25	±30	6010	10	±20	±25
Copper	6010	0.06	±25	±30	220.2	10	±20	±25
Cyanide	9010	TBD	±25	±30	335.3	50	±20	±25
Fluoride	300 M	TBD	±25	±30	300	50	±20	±25
Iron	6010	20	±25	±30	6010	70	±20	±25
Lead	6010	0.45	±25	±30	6010	450	±20	±25
Manganese	6010	0.02	±25	±30	6010	20	±20	±25
Mercury	7471	0.02	±25	±30	245.2	2	±20	±25
Nickel	6010	1.5	±25	±30	6010	50	±20	±25
Nitrate	300 M	TBD	±25	±30	300	130	±20	±25
Nitrite	300 M	TBD	±25	±30	300	40	±20	±25
Selenium	6010	0.75	±25	±30	270.2	20	±20	±25
Silver	6010	2	±25	±30	272.2	10	±20	±25
Titanium	6010	TBD	±25	±30	6010	TBD	±20	±25
Vanadium	6010	0.08	±25	±30	286.2	40	±20	±25
Zinc	6010	0.02	±25	±30	6010	20	±20	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit (mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit (μg/L)	Precision (RPD)	Accuracy (%)
ORGANICS								
Acetone	8240	0.1	±25	±30	8240	100	±20	±25
Carbon tetrachloride	8240	0.005	±25	±30	8240	1	±20	±25
Chloroform	8240	0.005	±25	±30	8240	5	±20	±25
Kerosene	8015 M	20	±35	±30	8015 M	500	±35	±25
Methylene chloride	8240	0.005	±25	±30	8240	5	±20	±25
MIBK	8240	0.5	±25	±30	8240	5	±20	±25
1,1,1-Trichloroethane	8240	0.005	±25	±30	8240	5	±20	±25
Toluene	8240	0.005	±25	±30	8240	5	±20	±25
Tributyl phosphate	TBD	TBD	±25	±30	TBD	TBD	±30	±25

TBD = To Be Determined
M = method modified, generally, to include extraction from the solid medium, extraction method is matrix and laboratory-specific
RPD = Relative Percent Difference
Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA 1980)
Test Methods for Evaluating Solid Wastes (EPA 1986b)
Methods for Chemical Analysis of Water and Wastes (EPA 1983)
Eastern Environmental Radiation Facility Radiochemistry Procedures Manual (EPA 1984)
Precision and accuracy are goals. Since these parameters are highly matrix dependent they could vary greatly from the goals listed.

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9.0 RECOMMENDATIONS

The purpose of the aggregate area management study (AAMS) is to compile and evaluate the existing body of knowledge to support the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) decision making process. A primary task in achieving this purpose is to assess each contaminant within the groundwater aggregate area to determine the most expeditious path for remediation within the statutory requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) and Resource Conservation and Recovery Act (RCRA). The existing body of pertinent knowledge regarding the 200 West Groundwater Aggregate Area was summarized and evaluated in the previous sections of this study. A data evaluation process has been established that uses the existing data to develop preliminary recommendations on the appropriate remediation path for each contaminant detected in groundwater monitoring wells. This data evaluation process is a refinement of the *Hanford Site Past-Practice Strategy* (Figure 1-2) and establishes criteria for selecting appropriate *Hanford Site Past-Practice Strategy* paths [expedited response action (ERA), interim remedial measure (IRM), limited field investigation (LFI), and final remedy selection] for contaminant releases within the 200 West Groundwater Aggregate Area. The process is an extension of, and is consistent with, the process used in source AAMS to plan remediation for waste management units and unplanned releases. A discussion of the criteria for path selection and the results of the data evaluation process are provided in Sections 9.1 and 9.2, respectively. Figure 9-1 provides a flowchart of the data evaluation process that will be discussed. Table 9-1 provides a summary of the results of the data evaluation assessment of each constituent. Table 9-2 provides the decisional matrix patterns followed for each constituent.

This section presents recommended assessment paths for the contaminants in the 200 West Groundwater Aggregate Area. These recommendations are only proposed at this time and are subject to adjustment and change. Factors that may affect development of final recommendations include, but are not limited to, comments and advice from the U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), or U.S. Department of Energy (DOE); identification and development of new information; and modification of the criteria used in the assessment path decision-making process. The data evaluation process depicted on Figure 9-1 and discussed in Section 9.1 was developed to facilitate only the technical data evaluation step shown on the *Hanford Site Past-Practice Strategy* (Figure 1-2). Procedural and administrative requirements to implement the recommendations provided in this AAMS will be performed in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) and the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a). Changes in recommendations will be addressed, and more detail on recommended assessment

paths for groundwater contamination will be included in work plans for the actual investigation and remediation activities as they are developed.

Many of the distinct contaminant plumes in the 200 West Groundwater Aggregate Area with the highest rankings have enough information on the nature and extent of contamination for at least preliminary risk assessments based on their present day concentrations and distribution of contaminants. Some constituents with lower concentrations or poorly defined plumes will require an LFI or remedial investigation (RI) to verify that contamination is present, or to assess the extent of contamination to support IRM path decisions.

ERAs. The data evaluation process recommends that an ERA be initiated for the highest concentration portion [(greater than 500 μg/L, 100 times the maximum contaminant level (MCL) standard)] of the carbon tetrachloride plume centered near the Z Plant source aggregate area. This ERA could use any of a variety of remedial technologies such as in situ sparging or a combination of extraction, treatment (by air stripping and/or carbon adsorption), and disposal of the effluent by reinjection into the aquifer for gradient modification. The actual remediation will be chosen through the Engineering Evaluation/Cost Analysis (EE/CA) process required for ERAs.

The carbon tetrachloride plume recommended for an ERA overlaps plumes of arsenic, fluoride, chloroform, trichloroethylene (TCE) and ^{239,240}Pu that are proposed for other remediation paths. Nonetheless, the ERA will focus on removing the carbon tetrachloride. Because chloroform and other volatile contaminants will behave similarly to carbon tetrachloride, they will also likely be removed during the ERA.

The carbon tetrachloride plume represents the highest contribution to the maximum carcinogenic relative risk both at present and in the future projection according to the Multimedia Environmental Pollutant Assessment System (MEPAS) model (Section 5.0), with only the unconfirmed detections of N-nitrosodimethylamine and bis(2-ethylhexyl)phthalate as possibly higher in present carcinogenic relative risk.

IRMs. The second highest contributor to the present carcinogenic relative risk, and the highest contributor to future carcinogenic relative risk, is ^{99}Tc, which is proposed for IRM activities and was associated in the separations processing with uranium. Uranium, consisting mainly of three different isotopes (^{234}U, ^{235}U, and ^{238}U), contributes significantly to both carcinogenic and noncarcinogenic relative risks, and is recommended for an IRM. Nitrate, the highest noncarcinogenic relative risk plume (both present and future), falls slightly short of 100 times the drinking water standard, and will be included as an IRM. Because the nitrate, ^{99}Tc, and uranium plumes overlap, they should be addressed collectively under a single multicontaminant IRM.

Chloroform and trichloroethylene (plume A) are also proposed for IRM activities. However, both constituents coincide with the carbon tetrachloride plume, for which an ERA is recommended. As a result, both the chloroform and trichloroethylene plumes should be addressed by the proposed ERA.

LFIs/RI. Inorganic constituents, including arsenic, beryllium, cadmium, chromium, fluoride, nitrate (lower concentration portions), and selenium, will generally require an LFI assessment of background levels to confirm risk or exceedance before IRMs are initiated. Similar studies will be necessary (under the RI rather than an LFI) before a risk assessment can be completed for aluminum, ammonium, barium, cobalt, copper, cyanide, iron, lead, lithium, magnesium, manganese, mercury, nickel, nitrite, potassium, silver, sodium, strontium, sulfate, vanadium, and zinc. Some studies may also be necessary to better determine the extent of the plumes. Lead lacks an EPA-approved toxicity value; therefore, risk-related action for this constituent may not be possible to determine.

Recommended LFI activities in support of possible IRMs for organic constituents include verification and/or plume delineation of methylene chloride, bis(2-ethylhexyl) phthalate, 1,1-dichloroethylene, 1,2-dichloroethane, pentachlorophenol, N-nitrosodimethylamine and trichloroethylene (plume B). In addition, a number of pesticides (aldrin, DDD, DDT, endrin, endrin aldehyde, gamma-BHC, and heptachlor) were detected a single time in three isolated wells--this will also require confirmatory LFI sampling. Additional sampling to determine the presence and/or extent of plumes of 1,1,1-trichloroethane, tetrachloroethylene (PCE), toluene, xylenes, various phenolic compounds, acetone and two other ketones, carbon disulfide, and cresols, should be studied during the RI in support of final risk assessments.

Among radionuclides, tritium (^{3}H) is proposed for inclusion in the final remedy risk assessment; ^{40}K, ^{90}Sr, ^{129}I, radium, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am are proposed for LFIs to support decisions on whether an IRM is justified. The LFI should mainly be scoped to better delineate the nature and extent of these plumes. It should also determine natural background levels of the naturally-occurring ^{40}K and uranium. Finally, ^{7}Be, ^{14}C, ^{60}Co, ^{63}Ni, ^{65}Zn, $^{95}Zr/Nb$, ^{106}Ru, ^{110m}Ag, ^{125}Sb, ^{137}Cs, $^{144}Ce/Pr$, ^{154}Eu, and ^{212}Pb are proposed for the RI to support final remedy risk assessment.

In some cases various separate geographic portions of the plumes, as shown in the plume maps (Figures 4-1 through 4-15), are recommended for LFI or RI investigations while the higher priority portion is recommended for IRM activities.

A discussion of the four decision-making paths shown on Figure 9-1 (ERA, IRM, LFI, and final remedy selection) is provided in Section 9.1. Section 9.2 provides a discussion of the contaminants categorized under each of these paths. A discussion of regrouping and

prioritization of the contaminants is provided in Section 9.3. Recommendations for defining and prioritizing groundwater operable units within the 200 West Groundwater Aggregate Area are provided in Section 9.3. All recommendations for future characterization needs (see Section 8.0) will be more fully developed and implemented through work plans. Plan development and submittal will be accomplished in accordance with requirements of the *Hanford Site Past-Practice Strategy* and the Tri-Party Agreement (Ecology et al. 1990) and could include RI/FS or LFI work plans. Sections 9.4 and 9.5 provide recommendations for focused feasibility and treatability studies, respectively. Section 9.6 discusses recommendations for site characterization on an aggregate-area scale.

9.1 DECISION MAKING CRITERIA

The criteria used to assess the most appropriate and expeditious remediation process path are based primarily on urgency for action and whether data are adequate to proceed along a given path (Figure 9-1). Chemical-specific contaminant plumes [i.e., contaminants detected, as developed by Connelly et al. (1992) and checked by a direct access of the Westinghouse Hanford groundwater contamination data base] in 200 West Area groundwater are considered evidence of a release and are thus initially evaluated in the data evaluation process as candidates for an ERA. However, gross alpha and beta are considered indicator parameters and are not developed as distinct constituents. Conditions that might trigger an ERA are the determination of an unacceptable health or environmental risk or that minimal time is available to mitigate the problem (DOE/RL 1992a). As a result, candidate ERA constituents were evaluated against a set of criteria to determine whether potential for exposure to unacceptable health or environmental risks currently exists. Despite the fact that there presently are no receptors (e.g., no drinking water wells in the vicinity), and thus no present risk from the groundwater, the presence of high levels of contaminants in groundwater could be considered an unacceptable release. Contaminants recommended for ERAs will undergo a formal evaluation following the selection process outlined in WHC (1991b).

Constituents that are not recommended for an ERA continue through the data evaluation process. Contaminants continuing through the process that potentially pose a high relative risk (refer to Section 5.0) become candidates for an IRM. The criteria used to determine a high risk potential, thereby indicating a high priority, include relative risk and/or exceedance of standards. The candidate IRM contaminants are identified in Table 9-2 with "Y" in the IRM section. Candidate IRM contaminants were then further evaluated to determine if an IRM is appropriate. Candidate IRM contaminants that did not meet the IRM criteria were placed into the final remedy selection path.

Specific criteria used to develop initial recommendations for ERAs, LFIs, and IRMs for constituents detected within the 200 West Groundwater Aggregate Area are provided in Sections 9.1.1 and 9.1.2. Constituents not initially addressed under an ERA, LFI or IRM will be evaluated under the final remedy selection path discussed in Section 9.1.3.

9.1.1 Expedited Response Action Path

All detected constituents are assessed against the ERA criteria to determine if they pose an unacceptable health or environmental risk. Again, in the absence of receptors, this must be considered a theoretical health or environmental risk. The *Hanford Site Past-Practice Strategy* describes conditions that might trigger abatement under an ERA. Generally, these conditions would rely on a determination of, or suspicion of, existing or future unacceptable health or environmental risks, and a short time-frame available to mitigate the problem. Conditions include, but are not limited to:

- Actual or potential exposure to nearby human populations, biota, or the food chain from hazardous substances and radioactive or mixed waste contaminants
- Actual or potential contamination of drinking water supplies or sensitive ecosystems
- Threats of release of hazardous substances and radioactive or mixed waste contaminants
- High levels of hazardous substances and radioactive or mixed waste contaminants in soils that pose or may pose a threat to human health or the environment, or have the potential for migration
- Weather conditions that may increase the potential for release or migration of hazardous substances and radioactive or mixed waste contaminants
- The availability of other appropriate federal or state response mechanisms to respond to the release
- Time required to develop and implement a final remedy
- Further degradation of the medium which may occur if a response action is not expeditiously initiated

- Risks of fire or explosion or potential for exposure as a result of an accident or failure of a container or handling system

- Other situations or factors that may pose threats to human health, welfare, or the environment.

These conditions were used as the initial screening criteria to identify candidate contaminants for ERAs. Candidate contaminants that did not meet these conditions were not assessed through the ERA evaluation path. Contaminants were eliminated if they were not hazardous, i.e., if they did not have EPA risk parameters. Additional criteria for further, detailed screening of ERA candidates were developed based on the conditions outlined in the *Hanford Site Past-Practice Strategy*. These additional screening criteria are shown in Figure 9-1 and are described below.

Constituents were first assessed to determine if they pose unacceptable (theoretical) health or environmental risks. The criteria used to determine "unacceptable" are based on the maximum concentration detected (averaged for all samples collected in a well during 1989 through April 1992). For hazardous or radioactive constituents at concentrations that are 100 times the applicable standard (" > 100*Std?" on Table 9-2), the contaminant continues to be considered for an ERA. Application of the criterion of 100 times applicable standards is for quantification of the strategy criteria which addresses "high levels of hazardous substances and radioactive or mixed waste contaminants ...." The factor of 100 is based on engineering judgment of what constitutes a high level of contamination warranting expedited action. Standards applied include MCLs under the Safe Drinking Water Act and 4% of DOE Derived Concentration Guides (DCGs) as prescribed by DOE Order 5400.5, Section II.1.d(2), for radionuclides which do not have promulgated MCLs. The application of these standards does not imply they are recognized as applicable or relevant and appropriate requirements (ARARs). Final promulgation of the most recent MCLs was considered an adequate basis for their use in this screening; their effective dates were not considered because of the long-term nature of the remediation process.

The ERA screening criteria, in addition to those presented in the *Hanford Site Past-Practice Strategy*, were applied to provide a consistent quantitative basis for making recommendations in this AAMS. Final decisions to implement the recommendations developed in this AAMS will be made collectively between DOE, EPA, and Ecology.

If a groundwater contaminant concentration is unacceptable with respect to health or environmental risk according to these criteria, it may still be necessary to verify if the contamination level is real. It is possible that some detections are spurious, due to either laboratory error or a transcription error in conveying the laboratory results to the data base

used in this analysis. Thus, an ERA should not be initiated on the basis of single isolated analytical results. Only if the concentration is confirmed (abbreviated "Conf?" on Table 9-2), and is based on more than one analytical result will the constituent continue to be considered for an ERA. The other constituents will drop down for consideration on the IRM path. Even in a worst-case scenario (e.g., a newly detected true high-concentration plume is dropped from the ERA path), LFI confirmation studies will be initiated to support an IRM and the situation would be controlled.

At the next decision step, even if a contaminant concentration is a true high priority, a technology must be readily available to control the contaminant plume for it to be considered for an ERA. An example that would require substantial technology development before implementation of cleanup is a tritium plume since no established treatment technology is available to separate low concentrations of tritium from water. This is referred to on Figure 9-1 and Table 9-2 as best demonstrated available technology (BDAT). The availability of funds to develop technology for these contaminants is beyond the scope of this AAMS.

The next step in the ERA evaluation path involves determining whether implementation of the available technology would have adverse consequences that would offset the benefits of an ERA. Examples of adverse consequences (abbreviated "adv cnsq" on Table 9-2) include: (1) use of technologies that result in risks to cleanup personnel or the public that are much greater than the risks of the contaminant; (2) the ERA would preclude future remedial actions; and (3) the ERA would prevent or greatly hinder future data collection activities. If adverse consequences are not expected, the constituent remains in consideration for an ERA. At this point, because all criteria are satisfied, the recommendation for an ERA is made.

The final decision regarding whether ERAs are pursued in groundwater aggregate areas will be made among DOE, EPA, and Ecology based, at least in part, on the recommendations provided in this section, results of the final selection process outlined in WHC (1991b), and availability of resources.

9.1.2 Limited Field Investigation and Interim Remedial Measure Paths

An IRM is desired for high priority contaminants/plumes where extensive characterization is not necessary to reach defensible cleanup decisions. The first step, therefore, in the IRM evaluation path is a screening based on (1) exceedance of MCLs provided in applicable standards, e.g., drinking water standards (40 CFR 141) or 4% of the DCGs (DOE Order 5400.5), and (2) semiquantitative relative risk indices (RRIs) developed in Section 5.0. Both of these numerical criteria are presented in Table 9-2.

Comparison of the maximum contaminant concentrations in groundwater to the MCLs and DCGs identified those contaminants that would be considered for an IRM. The RRI values provided a supplementary basis for prioritizing potential IRMs for contaminants that do not have an MCL. These high priority contaminants were considered in the IRM path.

High priority contaminants were then evaluated to determine if sufficient need and information exists such that an IRM could be pursued. Implementation of IRMs for a contaminant with minimal characterization may rely on observational data acquired during remedial activities, including full-scale treatability studies, pump tests to determine aquifer properties, and confirmatory sampling using existing wells. Successful execution of this strategy is expected to reduce both time and cost for cleanup of the site groundwater without impacting the effectiveness of the implemented action.

The next step in the IRM evaluation path is to assess data adequacy. The existing data are evaluated to determine if: (1) existing data are sufficient to develop a conceptual model and perform a qualitative risk assessment; (2) the IRM will work for the contaminant/pathway of concern; (3) implementing the IRM will have adverse impacts on the environment, future remediation activities or data collection efforts; (4) the benefits of implementing the IRM are greater than the costs. If data are not adequate, an assessment will be made to determine if an LFI might provide enough data to perform an IRM. If an LFI is not expected to collect sufficient data to perform an IRM, the contaminant will be addressed in the final remedy selection path.

The final step in the IRM evaluation process is to assess if the IRM will work without significant adverse consequences. This includes: will the IRM be successful? will it create significant adverse environmental impacts (e.g., environmental releases)? will the costs outweigh the benefits? will it preclude future cleanup or data collection efforts? and will the risks of the cleanup be greater than the risks of no action? Units are recommended for IRMs where remediation is considered to be possible without adverse consequences outweighing benefits of the remediation.

Final decisions will be made between DOE, EPA, and Ecology on whether particular IRMs are pursued based, at least in part, on the recommendation provided in this AAMSR, results of any supporting LFI, and the availability of resources.

9.1.3 Final Remedy Selection Path

Contaminants recommended for initial consideration in the final remedy selection path are low priority contaminants not previously recommended for IRMs, LFIs, or ERAs. It is recognized that all contaminants of concern within the aggregate area will eventually be

addressed collectively under the final remedy path to support a final Record of Decision (ROD).

The initial step in the final remedy selection process path is to assess whether the combined data from the AAMS, and any completed ERAs, IRMs, and LFIs, are adequate for performing a risk assessment and selecting a final remedy. Whereas the scope of an ERA or IRM is limited to an individual contaminant or a single multicontaminant plume, the final remedy selection path will likely address all contaminants and plumes within the operable unit or aggregate area.

If the data are collectively sufficient, an operable unit or aggregate area risk assessment will be performed. If sufficient data are not available, additional needs will be identified and collected.

9.2 PATH RECOMMENDATIONS

Initial recommendations for ERA, IRM, and LFI are discussed in Sections 9.2.1 through 9.2.3, respectively. Contaminants proposed for initial consideration under the final remedy selection path are discussed in Section 9.2.4. Table 9-1 provides a summary of the data evaluation process path assessment. A summary of the responses to the decision points on the flowchart that led to the recommendations is provided in Table 9-2. Following approval by DOE, EPA, and Ecology, these recommendations will be further developed and implemented in work plans.

9.2.1 Proposed Contaminants for Expedited Response Actions

The carbon tetrachloride plume is proposed for an ERA. The following section describes the selection of this plume and the likely ERA activity. Implementing an ERA now may reduce further spread of contaminant plumes in advance of a potentially lengthy RI/FS process, will extract high levels of contamination, and is expected to provide significant progress toward remediation. Remedial technologies are suggested in the following descriptions, although final selection of the appropriate means will require completion of an EE/CA.

Remedial actions under ERAs should be scoped as a containment/control program or a limited cleanup with a stopping point based on either a concentration threshold (such as the 100 times standards used in the selection criteria) or on reaching an asymptote on the remediation production curve (the point of diminishing returns). The objective is to provide substantial risk reduction within a short time frame, not to complete cleanup of groundwater

contamination over the entire extent of the plume geometry. As there are no present day receptors for this groundwater contamination, there are also presently no immediate health and safety concerns.

9.2.1.1 Carbon Tetrachloride ERA Selection. The drinking water standard MCL for carbon tetrachloride is 5 ppb (μg/L). The highest concentrations found in the groundwater, nearly 7,000 ppb, are almost 1,400 times higher than the MCL. The area in which carbon tetrachloride exceeds 500 ppb (100 times MCL) is a large portion of the 200 West Area over most of the Z Plant source aggregate area (Figure 4-6). Carbon tetrachloride probably contributes a majority of the carcinogenic risk present at the 200 West Groundwater Aggregate Area, despite the presence of many radionuclides.

The location of the carbon tetrachloride ERA plume also contains high concentrations (above MCL or other standard) of other contaminants, including chloroform, TCE, arsenic, fluoride, and possibly $^{239,240}Pu$. If the appropriate technology specifically treats carbon tetrachloride, or only a limited group of chemicals similar to it, other contaminants co-existing with the plume would continue as candidates for future IRMs.

This ERA addresses what is clearly the most critical and complicated groundwater contamination issue in the 200 West Groundwater Aggregate Area.

9.2.1.2 ERA Remediation Alternatives. Remedial alternatives which may be suitable for the proposed ERA on the carbon tetrachloride plume include:

- In situ sparging--injection of gases into the groundwater via wells to strip the volatile organics, mainly carbon tetrachloride but also TCE and chloroform, and transfer them to the ground surface, where they can be captured through carbon adsorption. A vacuum extraction system is being tested in the vicinity of Z Plant as a remedial measure for carbon-tetrachloride contaminated soil, and the in situ sparging system complements this technology. This system would not significantly treat other major contaminants which may be present in the groundwater except TCE, chloroform, and other volatile contaminants.

- Pump and treat--extraction of the contaminated groundwater and treatment by any of several systems which would remove the carbon tetrachloride. Suitable candidate technologies include air stripping, carbon adsorption, and UV/chemical oxidation. Other treatment systems can be added to a pump-and-treat system to treat other contaminants. Some technologies include chemical precipitation and/or ion exchange for arsenic, fluoride, and possibly $^{239,240}Pu$.

9.2.2 Proposed Contaminants for Interim Remedial Measures

Five contaminants are proposed for direct application of IRMs: nitrate, uranium, ^{99}Tc, chloroform, and TCE. These are discussed in the following sections.

Like ERAs, IRMs should not be designed to specifically meet ARARs (e.g., MCLs), but should be based on risk reduction. Groundwater remediation should proceed until the response objective (e.g., reduction in RRI or containment) is met or until contaminant concentrations reach an asymptote, beyond which the returns on a treatment effort diminish or natural attenuation exceeds active treatment. After the response objective is met or the concentration asymptote is reached, the IRM should be discontinued and any residual contamination be addressed in the final remedy selection path.

9.2.2.1 Nitrate. The highest concentration of nitrate within the 200 West Groundwater Aggregate Area is 1,322 mg/L (ppm, as nitrate), almost 30 times the MCL of 45 mg/L. This plume had the highest noncarcinogenic risk, both currently (except for questionable levels of beryllium and pentachlorophenol) and in the future projection. The area of highest concentrations (> 1000 mg/L) are located near Well 299-W19-19, a short distance southeast of the 221-U Building (U Plant) (Figure 4-5). This is also an area of high gross alpha, gross beta, uranium and ^{99}Tc activity. While the IRM for nitrate could be instituted without additional data collection, LFI activities are also proposed to determine better background concentrations, particularly from offsite.

9.2.2.2 Uranium. Uranium in a chemical form is second to nitrate in presenting the highest current noncarcinogenic risk on the site (the two RRI levels are so close they are considered tied for first place), and as a radionuclide its isotopes are tied for third (^{234}U and ^{238}U) and ninth (^{235}U) in carcinogenic risk (combined, the three isotopes would be second, ahead of ^{99}Tc). The maximum total uranium analysis (Well 299-W19-18) is 1130 pCi/L, about 50 times the required 4% of the DCG limit (24 pCi/L). In addition, the uranium probably also contributes the bulk of the gross alpha activity. Plume B of uranium (Figure 4-14) corresponds to plume D of the gross alpha. The other geographic area of uranium, plume A, is recommended for inclusion as an LFI to delineate its actual extent.

9.2.2.3 Technetium-99. Technetium-99 presents the second highest current carcinogenic relative risk and the highest future relative risk. The highest concentration (about 27,000 pCi/L in Well 299-W19-24) is more than six times the 4% DCG concentration of 4,000 pCi/L. Only plume B (Figure 4-12) will require IRM activities, and this location is near the uranium plume B. The lower concentration plume A of ^{99}Tc is recommended for inclusion in the final remedy RI.

9.2.2.4 Chloroform. Chloroform is seventh highest current carcinogenic relative risk, and fifth highest future carcinogenic risk. The highest level (about 1,600 μg/L in Well 299-W15-8) is almost 16 times the MCL (100 μg/L). Plume A (Figure 4-7) contains these highest levels and is the area proposed for the IRM. Plume B is lower in concentration and less well defined and can thus be considered by the final remedy RI.

9.2.2.5 Trichloroethylene. Plume A (Figure 4-8) represents the largest area where TCE is above MCLs in the 200 West Area. Plume A is nearly coincident with the carbon tetrachloride plume and is sufficiently delineated for an IRM. Trichloroethylene is one of the lowest in terms of current and future relative risk. Trichloroethylene at its highest average concentration (in Well 299-W22-20) of 32 μg/L within plume B is more than six times the MCL (5 μg/L). The extent of plume B, however, is considered to be indefinite and is recommended for an LFI initially.

9.2.3 Proposed Contaminants for Limited Field Investigation

Twenty-seven contaminants appear to be eligible for IRMs but data were insufficient to determine whether an IRM is justified. It is recommended that these constituents first undergo LFI to supply additional data required to support the conceptual model and a qualitative risk assessment. Another purpose of the data acquisition would be to delineate the vertical and horizontal extent of their plumes. These constituents include the following:

- Methylene Chloride
- 1,2-Dichloroethane (DCA)
- 1,1-Dichloroethylene (DCE)
- Pentachlorophenol (PCP)
- Pesticides (aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC, and heptachlor)
- Bis(2-ethylhexyl)phthalate
- N-Nitrosodimethylamine
- Potassium-40
- Strontium-90

- Iodine-129
- Radium
- Plutonium-238
- Plutonium-239,240
- Americium-241
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Fluoride
- Selenium.

The two radioactivity indicator parameters, gross alpha and gross beta, should also be investigated in the course of the LFI activities to determine the actual radionuclides which constitute the highest levels in these plumes.

In addition to these constituents, some contaminant plumes for which an ERA or IRM is recommended also have portions where an LFI is recommended. These secondary plumes (e.g., trichloroethylene plume B and uranium plume A) are classified differently to avoid confusion in identifying contaminant plumes. These secondary plumes typically require better delineation of extent before an IRM can be initiated.

The rationale and scope for the IRMs and LFIs will be more completely developed in work plans; however, the following address possible considerations during work plan development:

- Confirm contamination to be present in well(s) and determine average levels of that contamination. Some contaminants designated for LFIs consist of a single detection or only one at a level of concern. Plumes with less than three wells delineating the extent of concentrations over MCL or risk levels are not adequately defined for risk assessment or remediation decision making. Lower

detection limit analyses may be required for some contaminants with very low action levels.

- Background concentrations of inorganics must be determined to gauge the significance of the detected levels. Arsenic and fluoride, for example, were detected at elevated levels only in a limited number of wells and could be present in background groundwater. A program is presently underway to determine site background levels (Hoover and LeGore 1991; DOE/RL 1992c) which may be sufficient to answer this data gap.

- The nature of the radionuclides making up the beta radiation must be determined. Much may be ^{99}Tc, but other fission products may be contributing. The same study requirement may be applicable to portions of the gross alpha plume, which is well above the 15 pCi/L MCL, although this can generally be attributed to isotopes of uranium.

- Toxicity data may be required for some constituents, although these data must be sanctioned by EPA before final risk assessment is possible. This includes lead and uranium (for its chemical toxicity), as well as some of the lesser-known organics which were detected.

- Remediation methods will require data gathering, and may lead into treatability testing.

- Some of the plumes proposed for LFIs/IRMs are located within the boundaries of the carbon tetrachloride ERA. The ERA will likely remediate select IRM constituents of concern such as chloroform. This would still leave an LFI necessary to evaluate the effectiveness of the ERA as a final remediation of the IRM constituents. At a minimum, it will be necessary for the ERA to consider the presence of these other contaminants in regard to remediation and disposal options.

- Well-designed pump tests should be conducted to determine geohydrological properties such as hydraulic conductivity, transmissivity, and storage coefficients and thus help estimate flow rates in areas considered for groundwater extraction.

9.2.4 Proposed Contaminants for Final Remedy Selection

Several of the low priority contaminants have been proposed for the final remedy selection path. Section 9.2.4.2 discusses those proposed for direct inclusion in the final

remedy selection risk assessment. An RI is recommended for the remainder of the contaminants due to the lack of information to support a final risk assessment and select a final remedy(ies). These are discussed in Section 9.2.4.1.

9.2.4.1 Proposed Contaminants for Remedial Investigation. An RI should be conducted for several contaminants of apparent low priority, poor definition, and uncertain verification. These include:

- Organics: 1,1,1-trichloroethane (TCA), tetrachloroethylene (PCE), toluene, xylenes, several phenolic compounds (phenol, bisphenol A, 2-chlorophenol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4,5-trichlorophenol, 2,4-dimethylphenol, o-nitrophenol, 2-sec-butyl-4,6-dinitrophenol), acetone and two other ketones [methyl ethyl ketone (MEK) and 4-methyl-2-pentanone], 1,2-propandiol, carbon disulfide, citrus red, and cresols. These require confirmation and development of lower detection limits.

- Radionuclides: ^{7}Be, ^{14}C, ^{60}Co, ^{63}Ni, ^{65}Zn, $^{95}Zr/Nb$, ^{106}Ru, ^{110m}Ag, ^{125}Sb, ^{137}Cs, $^{144}Ce/Pr$, ^{154}Eu, and ^{212}Pb. These share the need for verification and even any indication that there is contamination. Background levels of uranium and ^{40}K will also be required.

- Inorganics: aluminum, barium, boron, cobalt, copper, cyanide, iron, lead, lithium, magnesium, manganese, mercury, nickel, nitrite, potassium, silver, sodium, strontium, sulfate, vanadium, and zinc. These contaminants generally require confirmation, better delineation (if actually at levels of concern), and sampling and analysis of background levels.

- Miscellaneous parameters / constituents: other parameters will also be considered during the RI although they are not constituents of concern or identifiable contaminant plumes. These include total carbon and total organic carbon, total dissolved solids, total organic halogens, alkalinity, pH, conductivity, turbidity, and coliform bacteria. Their investigation will be mainly for the purposes of characterization of the aquifer geochemical environment but some may assist in the identification of hazardous constituents (consideration of turbidity may help determine the effects of filtering on inorganic contaminant levels, for example).

In addition, the geographic portion (plume B) of chloroform, plume A of ^{99}Tc, and plume A of ^{129}I will require consideration under the RI phase, even though other parts of these contaminant plumes are addressed by IRM or LFI activities. Residual contamination after ERA/IRM completion will also be included in the RI scope if necessary.

9.2.4.2 Proposed Contaminants for Risk Assessment. The tritium plume presents a high risk level and exceeds standards: 6,800,000 pCi/L at Well 299-W22-9 is more than 300 times the standard (MCL) of 20,000 pCi/L. It also has the fifth highest current carcinogenic RRI, and fourth highest future RRI level. Nevertheless, because of its chemical similarity with water, there is presently no commercially viable treatment systems to remove tritiated water from the groundwater. No ERA could therefore be proposed. One possible strategy would be to extract tritium-contaminated groundwater and reinject it upgradient to increase the groundwater travel time, thereby increasing the time for natural decay before a receptor is reached.

The tritium plume is well enough defined to proceed directly into risk assessment without attempting any further investigation. If the risk assessment confirms the need for remediation, then the RI/FS process will investigate further remedial alternatives.

9.3 GROUNDWATER OPERABLE UNIT DEFINITION AND PRIORITIZATION

The investigation process can be made more efficient if plumes with multiple contaminants in the same general vicinity can be studied together. The data needs and remedial actions required for many of the contaminants are frequently the same. It is much easier to ensure a consistent level of effort, investigation methodology, prioritization, funding, and regulatory oversight if associated plumes are grouped together. Economies of scale also make the investigation process more cost effective if larger areas are studied together.

9.3.1 Groundwater Operable Unit Definition

An objective of the 200 West Groundwater AAMS is to define appropriate groundwater-specific operable units. A groundwater operable unit is a portion or aspect of a remedial action site which can best be planned and remediated as a single entity. At the Hanford Site, a source area operable unit is usually a group of waste management units which are spatially close to each other and generally shared a similar disposal history. Prior to the aggregate area management study process, 9 of the 17 operable units in the 200 West Area were designated as combination source and groundwater contamination. These include the following:

- 200-UP-1
- 200-UP-2

- 200-ZP-1
- 200-ZP-2
- 200-RO-1
- 200-RO-2
- 200-RO-3
- 200-TP-2
- 200-TP-4.

To maximize the efficiency of the investigation of groundwater flow and contamination, it is recommended that separate groundwater operable units be defined for the 200 West Area and vicinity on the basis of flow patterns and plume distributions, both of which are hydrologic in nature and do not respect the geographic boundaries established for the source operable units. In addition, the groundwater plumes as discussed in previous sections frequently overlap or coincide, and so the groundwater at a point may have several contaminants at significant concentrations from different sources and source operable units. For these reasons, each of the 200 West source AAMS recommends that groundwater be deleted from the source operable units and be placed in a groundwater-specific operable unit.

Because of the interrelations of the contaminant plumes in the 200 West Area, it is considered best to have a relatively small number of groundwater-specific operable units. It is also important, however, to keep the size and complexity of groundwater operable units small enough so that each can handle all groundwater issues in that portion of the 200 West Area.

With these considerations, two operable units were developed for the 200 West Groundwater Aggregate Area. These would be divided on the basis of the hydrologic flow system which is present under the aggregate area. Two parallel hydrologic regimes can be defined, both emanating from the groundwater mound found beneath the location of the former U Pond (216-U-10). Groundwater flow on the north and northeast sides of the mound generally flows north-northeast towards Gable Gap. Groundwater south and east of the mound generally flows east-southeast towards a point south of the 200 East Area. The distributions of the contaminant plumes in the 200 West Groundwater Aggregate Area reflect these flow conditions. Contaminant plumes in the one regime or the other generally do not mix. These two groundwater flow regimes can therefore be the basis of the two groundwater operable units. The line of their division runs approximately along the northern edge of the

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U Plant Source Aggregate Area (Figure 9-2), as derived from groundwater potentiometric maps (e.g., Figure 3-78) and the extent of the various known plumes (Figures 4-1 to 4-16).

The south groundwater operable unit, tentatively called GW-OU-1, could be identified with U Plant and the plumes originating in that area, including the uranium, nitrate (mostly), and ^{99}Tc plumes. There are also some plumes (e.g., tritium) emanating from the S Plant source aggregate area that would be encompassed by this GW-OU-1. The northerly groundwater operable unit, tentatively GW-OU-2, includes those plumes in the Z Plant and T Plant source aggregate areas. This includes the carbon tetrachloride, chloroform, TCE, fluoride, arsenic, and $^{239,240}Pu$ plumes.

To keep the number of operable units constant over the 200 Areas, including both source and groundwater, it is advisable to combine source operable units, so that new groundwater specific operable units can be created. Two candidates are apparent in the source AAMSRs: 200-UP-1 could release its source waste management units to 200-UP-2 and can then be used for the groundwater operable unit GW-OU-1, and 200-ZP-1 could release its source waste management units to 200-ZP-2 and be used for GW-OU-2. In both cases the source operable units have a limited number of waste management units, dominantly liquid disposal facilities, and share similar characteristics. Efficiencies should be obtained by developing groundwater specific operable units.

9.3.2 Investigation Prioritization

Although contaminants have been individually recommended for an ERA or IRM, the scope of a remediation activity will likely address multiple contaminants because many of the priority groundwater contaminants in the 200 West Area are colocated. Implementing ERAs and IRMs may also result in addressing contaminants of lower priority. As a result, recommendations for functionally grouping contaminants and their relative priority are provided below.

The carbon tetrachloride ERA plume coincides with the chloroform and trichoroethylene IRM plumes. Because of similarities in chemical and physical properties between carbon tetrachloride, chloroform and TCE, it is reasonable to expect that they can be coremediated. As a result, it is recommended that the ERA activity at least address chloroform and trichoroethylene in addition to carbon tetrachloride. Although chloroform and other compounds may be treated as part of the ERA, carbon tetrachloride concentrations should specifically determine the starting and stopping points for the ERA. That is, when the carbon tetrachloride concentration decreases to levels that satisfy the ERA objective, the ERA should be discontinued. This ERA addresses what is clearly the most critical

groundwater contamination issue in the 200 West Groundwater Aggregate Area and should receive the highest priority.

The overlapping nitrate, uranium, and ^{99}Tc should be coremediated under a single multicontaminant IRM to the extent the technology is available. This IRM should receive priority relative to other IRMs due to the high carcinogenic and noncarcinogenic risk associated with this multicontaminant plume. Chloroform should initially be remediated in conjunction with the carbon tetrachloride ERA activities. The last IRM, TCE, ranked lowest according to its RRI score, should have the lowest priority.

To summarize, remedial actions or investigations in cases of overlapping plumes should normally be driven by the highest priority activity. For example, if an ERA plume overlaps an IRM plume, the overlapping areas should first be addressed by the ERA activities which are higher in priority. The ERA will dictate the extent of treatment, such that when the ERA goals are satisfied, the ERA activities will be discontinued in the region of overlap. The overlapping area, if necessary, can then be addressed more completely under an IRM. In the case of overlapping plumes that require IRMs, LFIs, and RIs, the work plans and other planning and implementation activities should address the overlapping plumes on a case-by-case basis.

Although ERAs and IRMs will likely be implemented based on multicontaminant plumes, LFIs should be implemented based on the operable unit work plan framework. As a result, chromium (plume B), and ^{129}I should be addressed under an LFI work plan for GW-OU-1, and arsenic, chromium (plume A), fluoride, uranium (plume A), and $^{239,240}Pu$ should be addressed under an LFI work plan for GW-OU-2. Priority should be given to GW-OU-2.

Individually (i.e., outside the operable unit work plan framework), LFIs would be prioritized in the following order: n-nitrosodimethylamine, bis(2-ethylhexyl)phthalate, beryllium, pentachlorophenol (PCP), methylene chloride, pesticides (aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC, and heptachlor), arsenic, ^{40}K, ^{238}Pu, ^{241}Am, $^{239,240}Pu$, selenium, fluoride, chromium, cadmium, ^{129}I, 1,1-dichloroethylene (DCE), radium, ^{90}Sr, and 1,2-dichloroethane.

Tritium is the only plume for direct risk assessment, and does not require prioritization.

RI activities should be performed simultaneously on the following contaminants: TCA, PCE, toluene, xylenes, several phenolic compounds (phenol, bisphenol A, 2-chlorophenol, 2,4-dichlorophenol, 2,6-dichlorophenol, 2,4,5-trichlorophenol, 2,4-dimethylphenol, o-nitrophenol, 2-sec-butyl-4,6-dinitrophenol), acetone and two other ketones (MEK and 4-methyl-2-pentanone), 1,2-propandiol, carbon disulfide, citrus red, and cresols; ^{7}Be, ^{14}C,

^{60}Co, ^{63}Ni, ^{65}Zn, $^{95}Zr/Nb$, ^{106}Ru, ^{110m}Ag, ^{125}Sb, ^{137}Cs, $^{144}Ce/Pr$, ^{154}Eu, and ^{212}Pb; aluminum, barium, boron, cobalt, copper, cyanide, iron, lead, lithium, magnesium, manganese, mercury, nickel, nitrite, potassium, silver, sodium, strontium, sulfate, vanadium, and zinc. The miscellaneous parameters/constituents described in Section 9.2.4.1 should also be investigated at the same time.

9.3.3 RCRA Facility Interface

As discussed in Section 2.8, groundwater monitoring programs are underway at several RCRA facilities in the 200 West Groundwater Aggregate Area. If these monitoring programs indicate that groundwater contamination is originating from a RCRA treatment, storage, or disposal (TSD) unit, it is likely that groundwater remediation will need to be integrated with the overall CERCLA remediation program for the 200 Areas. It is recommended that groundwater remediation activities associated with RCRA TSD unit be fully integrated with the past practice program. Even though efforts have been made by the regulators to integrate the RCRA and CERCLA programs, further site specific integration decisions will be required at the NPL site- or waste management unit-level.

Section 2.6 described the RCRA TSD groundwater monitoring programs in the 200 West Area. RCRA facilities with groundwater monitoring programs in the 200 West Area are listed below along with the planned actions (e.g., closure under interim status, final facility operating permit):

TSD Unit	Planned Action
216-S-10 Pond and Ditch	Closure
216-U-12 Crib	Closure
Low-Level Burial Grounds (includes 218-W-3A, -3AE,-4B, -4C, -5 and -6)	Landfill Operating Permit
Single-Shell Tanks (includes 241-S, -SX, -T, -TX, -TY, and -U Farms)	Closure

Closure of the single-shell tanks will be addressed under RCRA by the Single-Shell Tank Program (see Section 2.7.1), which presently incorporates groundwater. After closure of the surface facilities, however, it is likely that any groundwater contamination will be remediated under the CERCLA program. Sections 9.3.3.1 through 9.3.3.3 discuss CERCLA/RCRA integration considerations for the remaining RCRA TSD units within the 200 West Groundwater Aggregate Area in terms of:

- Common, baseline activities which must be integrated;

- The approach used to recommend whether groundwater monitoring and remediation activities should be addressed under CERCLA or RCRA for RCRA TSD facilities within the groundwater aggregate area; and

- Considerations which must be addressed to ensure RCRA conformance under CERCLA activities.

Section 2.7 discussed interactions with other site programs. Coordination with the Emergency Response Action Program will be required for the proposed ERAs and for any IRMs which interact with these ERAs.

The Effluent Treatment Program is developing treatment and disposal facilities for remaining site effluent streams. Such a facility (such as the SALDS, see Section 2.7.3) could potentially be used for treatment and disposal of extracted groundwater under either an ERA or IRM.

Finally, the Remedial Technology Development Program could have a significant role in the development of appropriate remedial alternatives for the mixtures of contaminants which may be found in groundwater at the site of an ERA or IRM.

9.3.3.1 Common RCRA/CERCLA Integration Considerations. Regardless of the program chosen for groundwater characterization and remediation activities at individual units, the needs and requirements of both programs must be considered during the planning and execution of the various project phases. Integration of the requirements of both RCRA and CERCLA into these activities will accomplish several goals, including:

- Coordinate document preparation, investigation and remediation efforts

- Maximize use of existing and collected data

- Minimize amount of additional/duplicative data collection

- More efficient use of resources

- Ensure compatibility of selected remedial measures

- Provide consistency of cleanup action levels.

The needs of both the CERCLA and RCRA programs in the groundwater aggregate area should be considered when planning monitoring well installations. The numbers and locations of the wells, the type and depth of well screening, and the type of well installation

(e.g., single, nested) should be determined in such a manner as to ensure that both CERCLA and RCRA program needs are served to the maximum extent possible.

Sampling frequencies, and the monitoring parameters and constituents that the samples will be analyzed for, in all monitoring wells in the groundwater aggregate area should be selected to ensure that data necessary to support both the RCRA and CERCLA programs are collected while minimizing sampling efforts.

Analytical methods and quality assurance/quality control protocols should be chosen carefully during the preparation of workplans or groundwater monitoring plans to ensure that sample analytical requirements for both the CERCLA and RCRA programs will be met to the maximum extent possible. For example, groundwater activities under RCRA generally rely upon the use of methods from *Test Methods for Evaluating Solid Wastes* (EPA 1986b), while definitive CERCLA activities are generally performed using CLP analytical methods and quality assurance protocols. Specific quantitation limit requirements, such as those established in 40 CFR Part 264 Appendix IX, may also need to be met. The methods used for interpretation and statistical analysis of the data collected must also be chosen to ensure both RCRA and CERCLA program requirements will be met.

A single, consistent approach should be used to establish Health Based Levels (HBLs) for RCRA groundwater monitoring programs and cleanup limits for CERCLA groundwater remediation efforts within the groundwater aggregate area. This approach should ensure that common risk levels, compound toxicity factors, and uptake/transport assumptions are used for both programs to the maximum extent possible.

Preparation of the documents necessary to plan and execute characterization and remediation activities (e.g., work plans, closure plans) should be coordinated to ensure that all documentation is available in the time frames necessary to support integrated actions. Time constraints, including Tri-Party Agreement commitments, may dictate whether actions at individual RCRA TSD units are taken under the RCRA or CERCLA programs.

9.3.3.2 RCRA Facility Interface Strategy. Groundwater programs exist for a number of RCRA TSD units. Although the source AAMS reports have provided recommendations for integrating past practice and TSD waste management unit activities with respect to vadose zone contamination, some of the TSD units may have contributed, or are recognized as potential contributors, to groundwater contamination. Thus, it is necessary to have a strategy for deciding if groundwater contamination associated with a TSD unit (or group of TSD units) would best be addressed under the RCRA or CERCLA program. Such a strategy has been developed to facilitate CERCLA/RCRA groundwater integration decisions, and is outlined in this section.

The acceptability of a strategy which allows the use of past practice programs to remediate groundwater contamination at TSD units scheduled for either permitting or closure is discussed in the Tri-Party Agreement (Ecology et al. 1991). Part One, Article III, Section 14A of the Tri-Party Agreement notes that one purpose of the agreement is to:

> *... promote an orderly, effective investigation and cleanup of contamination at the Hanford Site* [Section 13B] *... and coordinate* [RCRA TSD unit] *closure with any interconnected remedial action at the Hanford Site ....*

To ensure that this objective is achieved, integration of CERCLA and RCRA groundwater remediation activities is specifically addressed in Part One, Article IV, Sections 17 and 18 of the Tri-Party Agreement, which state in part that:

> *...the Parties agree that past practice authority may provide the most efficient means for addressing groundwater contamination plumes originating from both TSD and past practice units ... remedial actions that address TSD groundwater contamination, excluding situations where there is an imminent threat to the public health or environment, will meet or exceed the substantive requirements of RCRA* [Section 17] *...the Parties recognize and agree that remediation of groundwater contamination from TSD units at the Hanford Site may be managed either under Part Three of this Agreement* [Remedial and Corrective Actions], *or under Part Two of this Agreement* [Permitting/Closure of TSD Facilities]....

In keeping with the principles outlined above, groundwater contamination associated with a RCRA TSD unit should be investigated/remediated under CERCLA if any one of the following criteria are met:

- There is minimal contribution from the TSD unit to a major, overall CERCLA groundwater unit. For example, if the TSD unit represents a small "island" contributing minimally to the larger past-practice derived contamination which will be dealt with under the CERCLA program.

- If the TSD unit has been closed and the interim status or final permit has been terminated or nearly terminated (e.g., public notice has been issued).

- If a planned CERCLA ERA or IRM would result in completely or substantially remediating any groundwater releases from the TSD unit.

- If the source TSD unit is addressed under CERCLA as part of an analogous group as a part of a source aggregate area.

For TSD units meeting the following criteria, groundwater activities should remain under the RCRA Program:

- There is no evidence of groundwater contamination at an active or closed TSD unit. Where applicable, active TSD units or TSD units closed as landfills would maintain established detection monitoring programs.

- Groundwater contamination is clearly dominated by contributions from a RCRA TSD unit and any CERCLA contaminants present would be adequately addressed under a RCRA corrective action.

- Groundwater associated with the TSD unit is hydrologically isolated and has little or no interaction with established groundwater operable units addressed under CERCLA.

Using this strategy, the unit-specific integration recommendations outlined in Sections 9.3.3.2.1 through 9.3.3.2.5 have been developed for the RCRA TSD units currently involved in a groundwater monitoring program.

9.3.3.2.1 216-U-12 Crib and 216-S-10 Pond and Ditch. As of the close of 1991, background monitoring programs were underway at the 216-S-10 Pond and Ditch and the 216-U-12 Crib; it is anticipated that these units will begin a detection monitoring program for indicator parameters before the close of 1992. The source TSD units are scheduled to undergo closure as a landfill, with the closure plan for the 216-U-12 Crib to be submitted in 1994 and the closure plan for the 216-S-10 Pond and Ditch to be submitted in 1996. It has been recommended that an LFI and IRM be performed at the source units under the CERCLA program as a part of activities to characterize and remediate several similar waste management units in the S Plant and U Plant source aggregate areas. An LFI has been recommended to further investigate the extent and magnitude of Iodine-129 groundwater contamination in the 200 West Area in the vicinity of the 216-U-12 Crib (see Section 9.2.3).

Groundwater at these TSD units is not hydrologically isolated, and interacts with groundwater from other locations in the 200 West Area. There is currently no evidence that groundwater has been contaminated by releases associated with these TSD units. It is recommended that groundwater monitoring activities continue under the RCRA program, integrating CERCLA program needs as described in Section 9.3.3.1. Once detection monitoring begins for the 216-U-12 Crib and the 216-S-10 Ditch and Pond, it can be determined if releases from these units have contaminated groundwater. If it is determined that groundwater has been contaminated, it may be necessary to re-evaluate the status of groundwater activities at these TSD units for possible inclusion in the CERCLA program.

9.3.3.2.2 218-W-3A, 218-W-3AE, and 218-W-5 Burial Grounds. The 218-W-3A, 218-W-3AE, and 218-W-5 Burial Grounds are a part of the Low Level Waste Management Area 3 (LLWMA 3) groundwater monitoring unit. The LLWMA-3 unit is currently undergoing a groundwater quality assessment due to elevated total organic halogen levels in samples collected in December 1989. Carbon tetrachloride has been noted in samples collected in 1991 at concentrations above EPA drinking water standards (DOE/RL 1992b). Elevated turbidity readings were also noted in 1991. Groundwater at the LLWMA 3 unit is not hydrologically isolated, and interacts with groundwater from other locations in the 200 West Area. Nitrate is also known to be present at concentrations above drinking water standards in the groundwater beneath LLWMA 3 (see Figure 4-5). It is likely that these contaminants originated from past practice units to the south of these TSD units. The RCRA final facility permit applications were submitted for these units in 1989, and are currently under agency review. An ERA was recommended to address carbon tetrachloride contamination in groundwater in the 200 West Area (DOE/RL 1991a); an ERA is currently underway to address vadose zone carbon tetrachloride contamination.

Based upon the contaminants currently known to be present in the groundwater, it would appear the groundwater contamination does not originate from the TSD but is a part of the larger, overall past-practice contamination which will be dealt with by the CERCLA program in the 200 West Area. Therefore, it is recommended that groundwater contamination beneath these burial grounds be investigated and, if necessary, remediated under the CERCLA program (e.g., as a part of proposed groundwater operable unit GW-OU-2 as defined in Section 9.3.1), integrating RCRA program needs as described in Sections 9.3.3.1 and 9.3.3.3.

9.3.3.2.4 218-W-4B and 218-W-4C Burial Grounds. The 218-W-4B and 218-W-4C Burial Grounds are part of the Low Level Waste Management Area 4 (LLWMA 4) groundwater monitoring unit. The LLWMA 4 unit is currently undergoing detection monitoring for indicator parameters, with no indication of contamination in the groundwater associated with the TSD units. The RCRA final facility permit application was submitted for these burial grounds in 1989, and is currently under agency review. Actions at the burial ground source units as analogous units under CERCLA have not been recommended. Groundwater at the 218-W-4B Burial Ground is not hydrologically isolated, and interacts with groundwater at other locations in the 200 West Area.

It is recommended that groundwater at the LLWMA 4 unit continue to be monitored under the RCRA program, integrating CERCLA program needs as described in Section 9.3.3.1. If it is determined that groundwater has been contaminated, it may be necessary to re-evaluate the status of the LLWMA 4 groundwater activities for possible inclusion in the CERCLA program.

9.3.3.2.5 218-W-6 Burial Ground. The 218-W-6 Burial Ground is a part of the Low Level Waste Management Area 5 (LLWMA 5) groundwater monitoring unit. As of the close of 1991, a background monitoring program was underway at the 218-W-5 Burial Ground (DOE/RL 1992b); it is anticipated that this unit will begin a detection monitoring program for indicator parameters by the close of 1992. The RCRA final facility permit application was submitted for the 218-W-6 Burial Ground in 1989, and is currently undergoing agency review. Actions at the burial ground source units as analogous units under CERCLA have not been recommended.

It is recommended that groundwater at the 218-W-6 Burial Ground continue to be monitored under the RCRA program, integrating CERCLA program needs as described in Section 9.3.3.1. Once detection monitoring begins for the 218-W-6 Burial Ground, it can be determined if releases from this unit have contaminated groundwater. If it is determined that groundwater has been contaminated, it may be necessary to re-evaluate the status of the 218-W-6 groundwater activities for possible inclusion in the CERCLA program.

9.3.3.3 Ensuring RCRA Conformance Under CERCLA Activities. In order to close or permit a RCRA TSD unit, it will be necessary to gather certain information and make certain demonstrations. In the event that groundwater associated with a TSD unit is investigated or remediated under CERCLA, the CERCLA activities should be performed in a manner that will support final RCRA actions. The goals of integrating RCRA requirements into CERCLA actions are:

- To ensure that cleanup and closure are performed <u>once</u>, in a single action
- To demonstrate that the substantive requirements of RCRA have been satisfied
- To support final permitting or closure of the TSD unit
- To minimize the need for post-closure care.

CERCLA activities will affect site conditions at neighboring and included RCRA TSD units. The potential impact that these affects may have on the data collected or the demonstrations being performed to achieve conformance with RCRA standards must be accounted for when planning CERCLA groundwater activities. An example where careful planning and integration would be necessary would be the case where groundwater extraction and treatment are being performed at a CERCLA operable unit, altering groundwater flow patterns and contaminant transport characteristics within groundwater monitoring networks which have been established to conform to RCRA requirements.

Investigation and remediation activities performed under CERCLA at RCRA TSD units must supply the data necessary to support RCRA TSD unit permit or demonstration needs. Examples would be ensuring that groundwater characterization data necessary to support a petition for exemption from dangerous waste tank release standards, or to demonstrate clean closure of a RCRA TSD unit, are collected.

CERCLA groundwater activities must ensure that RCRA groundwater closure requirements are met. For example, groundwater monitoring at RCRA TSD units closed through a CERCLA remedial action may be required to continue for as long as 30 years after completion of the remedial action. When possible, CERCLA groundwater remediation activities should be performed in such a manner as to ensure that only detection monitoring will be required for active or closed RCRA TSD units within the 200 West Groundwater Aggregate Area. When practical, CERCLA activities should be performed in such a manner as to demonstrate clean closure of the RCRA TSD unit. An example of such a case would be a RCRA TSD unit within a CERCLA operable unit where cleanup of the groundwater to RCRA cleanup criteria for the constituents of concern at the RCRA TSD unit is achievable.

9.3.4 Integration of Ongoing CERCLA Activities

Planning for CERCLA activities has begun only at Operable Unit 200-UP-2 in the 200 West Area. Through coordination of this planning with the AAMS process, the draft work plan for this operable unit already take into account the proposed incorporation of 200-UP-1 waste management units into the operable unit and the removal of groundwater investigation activities. It also anticipates coordination of the investigation activities with the pending groundwater investigation (proposed for 200-UP-1) through, for example, joint use of boring locations for collection of soil samples and installation of additional monitoring wells. This coordination and integration process should continue.

9.4 FEASIBILITY STUDY

Two types of FS will be conducted to support remediation in the 200 Areas including focuses and the final FS. Focused feasibility studies (FFSs) are studies in which a limited number of contaminants or remedial alternatives are considered. A final FS will be prepared to provide the data necessary to support the preparation of final ROD. Data are insufficient to prepare either a focused or final FS for any contaminants in the 200 West Groundwater Aggregate Area. Sufficient data are considered available to prepare a FFS on selected remedial alternatives.

9.4.1 Focused Feasibility Study

IRMs are planned for the 200 West Groundwater Aggregate Area for various contaminants or groups of contaminants and will need to be supported by FFSs. The FFS applied in this manner is intended to examine a limited number of alternatives for a specific contaminant or groups of contaminants. The FFS supporting IRMs will be based on the technology screening process applied in Section 7.0, engineering judgment, and/or new characterization data such as that generated by an LFI.

In most cases, LFIs will be conducted at plumes initially identified for IRMs. The information gathered is considered necessary prior to making a final determination whether an IRM is actually necessary or whether a remedy can be selected.

Rather than being driven by an IRM, the FFS will also be prepared to evaluate select remedial alternatives. In this case the FFS focuses on technologies or alternatives that are considered to be viable based on their implementability, cost, and effectiveness and broad application to a variety of sites. The following recommendations are made for FS that focus on a particular technology or alternative:

- Pump and treat
- Barriers
- Gradient modification.

These recommendations reflect select technologies developed in Section 7.0 of this aggregate area management study report.

The FFS is intended to provide a detailed analysis of select remedial alternatives. The results of the detailed analysis provide the basis for identifying preferred alternatives. The detailed analysis for alternatives consists of the following components:

- Further definition of each alternative, if appropriate, with respect to the volumes or areas of contaminated environmental media to be addressed, the technologies to be used, and any performance requirements associated with those technologies. Remedial investigations and treatability studies, if conducted, will also be used to further define applicable alternatives.
- An assessment and summary of each alternative against evaluation criteria specified in EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988b).

- A comparative analysis of the alternatives that will facilitate the selection of a remedial action.

9.4.2 Final Feasibility Study

To complete the remediation process for an aggregate area, a final or summary FS will be prepared. This study will address those contaminants not previously evaluated and will summarize the results of preceding evaluations. The overall study and evaluation process for an aggregate area will consist of a number of FFSs, field investigations, and interim RODs. All of this study information will be summarized in one final FS to provide the data necessary for the final ROD. The summary FS will likely be conducted on an aggregate area basis.

9.5 TREATABILITY STUDIES

In accordance with EPA RI/FS guidance (EPA 1988b), treatability studies will be conducted when existing data is insufficient to provide required design values, practical cost ranges, or proof-of-principle for technologies identified in the feasibility study process. Treatability studies involve bench-scale testing, analysis of existing information and, in a few situations, pilot-scale proof-of-principle studies. It is important to conduct both treatability tests and pilot-scale tests at the earliest stages of the remediation process to allow overall schedules to be maintained.

The preliminary screening of technologies conducted in Section 7.0 identified several technologies that could play a key role in 200 West Area groundwater feasibility studies, but currently have insufficient data to establish engineering design values, functional cost estimates, or proof-of-principle. Therefore the following treatability studies are recommended.

9.5.1 Treatment of Extracted Groundwater

Treatment of extracted groundwater is likely to play an important role in 200 West Area groundwater remediation. The performance of even proven treatment technologies cannot sufficiently be predicted because of the numerous contaminants present in groundwater, the high level of performance required by potential RAOs, and the presence of interfering background chemicals common to groundwater (such as reduced iron). To establish the viability and practically of these proven technologies, treatability tests are required.

Key technologies identified in Section 7.0 include reverse osmosis, coagulation/filtration, chemical precipitation, ion exchange, and UV/oxidation. Treatability testing should include, at a minimum, an evaluation of fouling problems associated with background groundwater contaminants (such as reduced iron); technologies that have the widest range of applicability to contaminants identified in 200 West Area groundwater; interferences of these contaminants; secondary waste quantities (see Section 9.5.2); and other potential adverse effects. Most of these technologies are currently under evaluation for the C-018H and W-049H Projects. These programs should be used as models for a groundwater treatability program. A key consideration will be establishing which technologies are capable of meeting the potentially stringent standards anticipated in final RAOs.

9.5.2 Treatment of Secondary Waste

Ion exchange, chemical precipitation, and reverse osmosis are candidate technologies for removing inorganics and radionuclides from groundwater; however the production of secondary waste in these technologies is an adverse effect. For ion exchange and reverse osmosis, the volume of secondary waste can exceed 10% of the influent mass. Typically at the Hanford Site, secondary waste is solidified and landfilled, or placed in double-shell tanks for later volume reduction by evaporation. Because these practices are increasingly undesirable, alternative secondary waste concentration technologies should be evaluated on a bench scale. Innovative technologies that might be evaluated include freeze crystallization and supercritical extraction.

9.5.3 Pilot Testing of Containment Technologies

Section 7.0 identified engineered barriers (i.e., containment) technologies including grout injection and freeze technologies as important in the final remedy for 200 West Area groundwater. Containment technologies are not believed to be a sole solution, but their unique qualities make them mandatory components of a final solution. Preliminary screening indicated that due to the depth of groundwater in the 200 Areas, implementation costs and effectiveness need to be established prior to their consideration.

Small-scale pilot tests (or other means) should be conducted to assess this uncertainty. Pilot-scale testing should be conducted to determine required grout injection point or freezing equipment spacing to identify special installation techniques needed, and to better understand potential cost ranges.

9.5.4 Pilot Testing of In Situ Air Sparging

Air sparging is a relatively new technology that can be used to selectively remediate volatile constituents in multicontaminant plumes. As a result, this technology may be viable for the volatile organic compounds detected in the 200 West Area. A pilot test of this technology is recommended and discussed in Section 9.2.1.

9.6 AGGREGATE AREA-SCALE CHARACTERIZATION RECOMMENDATIONS

The analysis of data needs (Section 8.2.3) and resulting investigation strategy (Section 8.3.3) pointed out a number of issues which should be addressed in investigations subsequent to the AAMS process. Some of these issues will be addressed as part of the LFIs and the RI, but some are not plume specific and would be better investigated on an aggregate area basis. These issues include:

- **Installation of additional monitoring wells**, mainly in areas where historically few wells have been located. These include the northeast portion of T Plant Aggregate Area, and the western portions of U Plant and S Plant Aggregate Areas. In addition, many of the plumes have migrated into the 600 Area (i.e,, outside the 200 West Area fenceline) and the number of wells is few here as well. While some of the wells required in this area will be installed in the course of the investigation of these plumes, it may be necessary to install others in the 600 Areas to provide sufficient coverage. An approximate number of about ten wells should be sufficient as an initial investigation. This process will also provide data to bridge gaps in the geologic understanding of this area.

- **Continued groundwater monitoring** is necessary to continue to augment the analytical data base. To some extent this will be supplied by other programs (especially the programs by the Westinghouse Hanford Operational Groundwater Monitoring Network and the Pacific Northwest Laboratory), but the coverage obtained by the AAMS sampling should also be continued and expanded. As the data base is checked, specific questions can be addressed in this program which can be configured to be flexible in such matters as which analytes and wells are to be included.

- **Interpretation of the geochemical environment** of the uppermost aquifer should be improved through appropriate sampling and analysis (or in situ analysis) of groundwater in both uncontaminated areas and in the midst of representative plumes. Analyses should be oriented toward the development of stability diagrams which will help determine the speciation and redox conditions of the

constituents in the groundwater, such as pH-Eh and pH-pO_2. The investigation should also allow prediction of some kinds of complexation and chelation, and should enhance understanding of transport mechanisms, and aid feasibility studies of in situ groundwater remedial alternatives.

- **Computer modeling capabilities** should be enhanced and developed. This is necessary at three levels: at the source unit level, where vadose zone models must be calibrated and applied to determine the potential for continuing releases; at the aggregate area level to show the details of the groundwater flow system and the effects of various remedial alternatives; and at the Hanford Site level, which will estimate the long term effects of groundwater flow systems and contaminant plumes on receptors beyond the extent of the 200 West Groundwater Aggregate Area. The models for these purposes have been chosen, only their development on a site-specific basis and calibration remain.

9 2 1 2 6 5 1 0 6 3

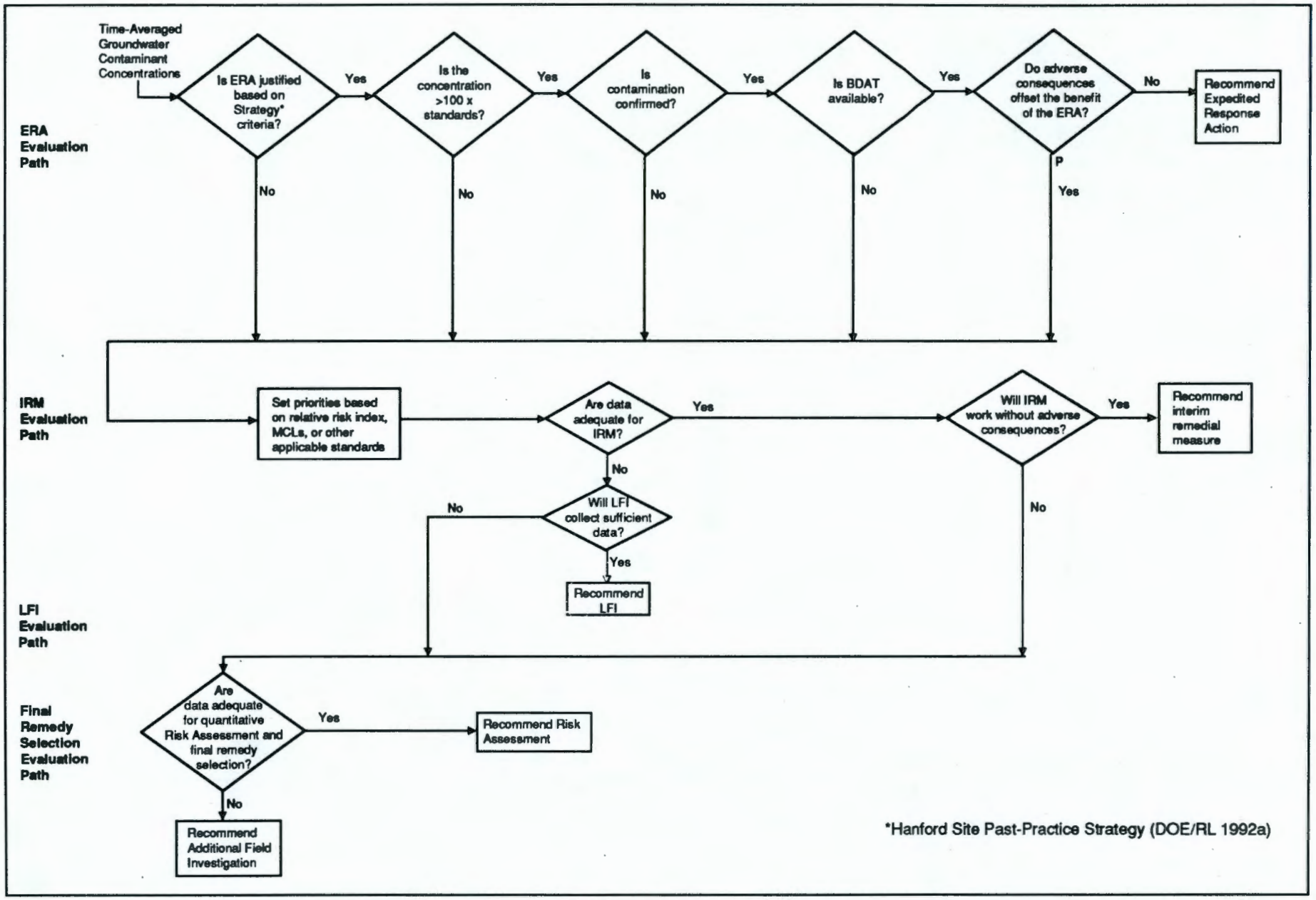

Figure 9-1. Groundwater Aggregate Area Management Study Data Evaluation Process.

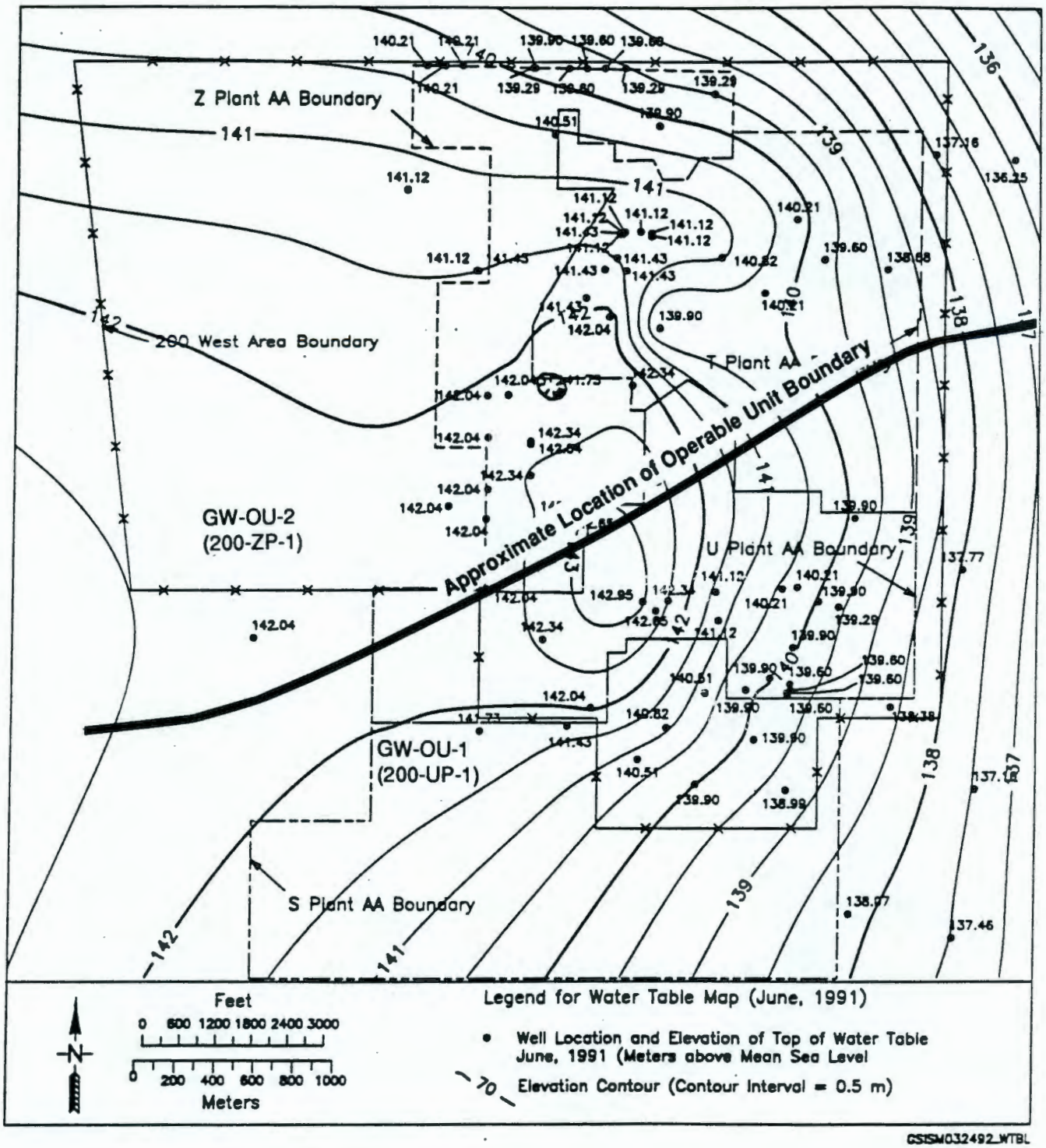

Figure 9-2. Water Table Map With Recommended Groundwater Operable Units for the 200 West Area (base map from Connelly et al., 1992).

Table 9-1. Summary of the Results of the Data Evaluation Process Path Assessment.

Detected Constituent	ERA	IRM	LFI	RA	RI	Remarks
ORGANIC COMPOUNDS (μg/L)						
Chlorinated Aliphatics						
Chloroform (CHCl3)	–	X	–	–	–	Overlaps with CCl_4 (ERA) plume
Carbon Tetrachloride (CCl4)	X	–	–	–	–	
Methylene Chloride	–	–	X	–	–	
1,1-dichloroethylene (DCE)	–	–	X	–	–	Single detection, not confirmed
1,2-dichloroethane (DCA)	–	–	X	–	–	Detected in one well only
1,1,1-trichloroethane (TCA)	–	–	–	–	X	
Trichloroethylene (TCE)	–	X	–	–	–	Overlaps with CCl_4 (ERA) plume
Tetrachloroethylene (PCE)	–	–	–	–	X	Single detection, not confirmed
Aromatics						
Toluene	–	–	–	–	X	Single detection, not confirmed
Xylene	–	–	–	–	X	Neither detection (of 2) confirmed
Phenols						
Phenol	–	–	–	–	X	
o-Nitrophenol	–	–	–	–	X	Single detection, not confirmed
2-chlorophenol	–	–	–	–	X	Single detection, not confirmed
2,4-dichlorophenol	–	–	–	–	X	Neither detection (of 2) confirmed
Pentachlorophenol (PCP)	–	–	X	–	–	Not confirmed in any well detected (of 6)
2,4-dimethylphenol	–	–	–	–	X	Not confirmed in any well detected (of 3)
Bisphenol A	–	–	–	–	X	Single detection, not confirmed
2,6-dichlorophenol	–	–	–	–	X	Single detection, not confirmed
2,4,5-trichlorophenol	–	–	–	–	X	Single detection, not confirmed
2,6-Bis(1,1-Dimethylethyl)-4 methyl-phenol	–	–	–	–	X	Not confirmed in any well detected (of 2)
2-sec-butyl-4,6-dinitrophenol	–	–	–	–	X	
Ketones						
Acetone	–	–	–	–	X	
Methyl ethyl ketone (MEK)	–	–	–	–	X	Not confirmed in any well detected (of 2)
4-Methyl-2-Pentanone	–	–	–	–	X	Single detection, not confirmed
Pesticides						All pesticide detections colocated.
Aldrin	–	–	X	–	–	Not confirmed in any well detected (of 3)
DDD	–	–	X	–	–	Not confirmed in any well detected (of 3)
DDT	–	–	X	–	–	Not confirmed in any well detected (of 4)
Dieldrin	–	–	X	–	–	Not confirmed in any well detected (of 3)
Endrin	–	–	X	–	–	Not confirmed in any well detected (of 3)
Endrin Aldehyde	–	–	X	–	–	Not confirmed in any well detected (of 3)
Gamma-BHC	–	–	X	–	–	Not confirmed in any well detected (of 3)
Heptachlor	–	–	X	–	–	Not confirmed in any well detected (of 3)

9 2 1 2 6 . 1 0 6 3 3

Table 9-1. Summary of the Results of the Data Evaluation Process Path Assessment.

Detected Constituent	ERA	IRM	LFI	RA	RI	Remarks
Miscellaneous Organics						
Bis(2-ethylhexyl) phthalate	–	–	X	–	–	Not confirmed in any well detected (of 2)
1,2 Propandiol	–	–	–	–	X	Single detection, not confirmed
Carbon disulfide	–	–	–	–	X	Not confirmed in any well detected (of 2)
Citrus Red	–	–	–	–	X	Detected in one well only
Cresols	–	–	–	–	X	Single detection, not confirmed
N-nitrosodimethylamine	–	–	X	–	–	Single detection, not confirmed
RADIONUCLIDES (pCi/L)						
Gross alpha	–	–	X	–	–	Indicator parameter
Gross beta	–	–	X	–	–	Indicator parameter
Tritium (H-3)	–	–	–	X	–	Treatment technology not available
Beryllium(Be)-7	–	–	–	–	X	Single detection, not confirmed
Carbon(C)-14	–	–	–	–	X	
Potassium(K)-40	–	–	X	–	–	
Cobalt(Co)-60	–	–	–	–	X	
Nickel(Ni)-63	–	–	–	–	X	
Zinc(Zn)-65	–	–	–	–	X	Not confirmed in any well detected (of 5)
Strontium(Sr)-90	–	–	X	–	–	
Zirconium/Niobium(Zr/Nb)-95	–	–	–	–	X	Not confirmed in any well detected (of 4)
Technetium(Tc)-99	–	X	–	–	–	Associated with uranium
Silver(Ag)-110 Metastable	–	–	–	–	X	Single detection, not confirmed
Ruthenium(Ru)-106	–	–	–	–	X	
Antimony(Sb)-125	–	–	–	–	X	Not confirmed in any well detected (of 6)
Iodine(I)-129	–	–	X	–	–	
Cesium(Cs)-137	–	–	–	–	X	
Cerium/Praseodymium(Ce/Pr)-144	–	–	–	–	X	Not confirmed in any well detected (of 2)
Europium(Eu)-154	–	–	–	–	X	Not confirmed in any well detected (of 4)
Lead(Pb)-212	–	–	–	–	X	
Radium (Ra)	–	–	X	–	–	
Uranium (U)	–	X	–	–	–	
Uranium(U)-234	–	X	–	–	–	
Uranium(U)-235	–	X	–	–	–	
Uranium(U)-238	–	X	–	–	–	
Plutonium(Pu)-238	–	–	X	–	–	Not confirmed in any well detected (of 6)
Plutonium(Pu)-239/40	–	–	X	–	–	
Americium(Am)-241	–	–	X	–	–	

9 2 1 2 6 1 0 6 3 4

Table 9-1. Summary of the Results of the Data Evaluation Process Path Assessment.

Detected Constituent	ERA	IRM	LFI	RA	RI	Remarks
INORGANIC COMPOUNDS (μg/L)						Most inorganics require determination of background determination
Aluminum (Al)	–	–	–	–	X	
Ammonium ion (NH4)	–	–	–	–	X	
Arsenic (As)	–	–	X	–	–	Overlaps partially with CCl_4 (ERA) plume
Barium (Ba)	–	–	–	–	X	
Beryllium (Be)	–	–	X	–	–	Not confirmed in any well detected (of 4)
Boron (B)	–	–	–	–	X	
Cadmium (Cd)	–	–	X	–	–	Not confirmed in any well detected (of 6)
Chromium (Cr)	–	–	X	–	–	
Cobalt (Co)	–	–	–	–	X	Single detection, not confirmed
Copper (Cu)	–	–	–	–	X	
Cyanide (CN)	–	–	–	–	X	
Fluoride (F)	–	–	X	–	–	Colocated with CCl_4 (ERA) plume
Iron (Fe)	–	–	–	–	X	
Lead (Pb)	–	–	–	–	X	Toxicity value also needed
Lithium (Li)	–	–	–	–	X	
Magnesium (Mg)	–	–	–	–	X	
Manganese (Mn)	–	–	–	–	X	
Mercury (Hg)	–	–	–	–	X	Not confirmed in any well detected (of 3)
Nickel (Ni)	–	–	–	–	X	
Nitrate (NO3)	–	X	–	–	–	
Nitrite (NO2)	–	–	–	–	X	
Potassium (K)	–	–	–	–	X	
Selenium (Se)	–	–	X	–	–	
Silver (Ag)	–	–	–	–	X	Single detection, not confirmed
Sodium (Na)	–	–	–	–	X	
Strontium (Sr)	–	–	–	–	X	
Sulfate (SO4)	–	–	–	–	X	
Uranium (U), chemical	–	X	–	–	–	
Vanadium (V)	–	–	–	–	X	
Zinc (Zn)	–	–	–	–	X	

9 2 1 2 6 1 0 6 3 5

Table 9-2. 200 West Groundwater Aggregate Area Data Evaluation Decision Matrix.

	ERA Evaluation Path								RRI Rank				IRM Path				Final Remedy Path		
									Current		Future								
Detected Constituent	Max Conc	HSPPS justfd?	GW Std	>100 *Std?	conf?	BDAT avail?	Adv Cnsq?	ERA?	C	NC	C	NC	Data Adeq?	LFI?	Adv Cnsq?	IRM?	Data Adeq?	RA?	RI?
ORGANIC COMPOUNDS (μg/L)																			
Chlorinated Aliphatics																			
Chloroform ($CHCl_3$)	1,595	Y	100	N	–	–	–	N	7	–	5	–	Y	N	N	Y	–	–	–
Carbon Tetrachloride (CCl_4)	6,559	Y	5	Y	Y	Y	N	Y	1	–	6	–	–	–	–	–	–	–	–
Methylene Chloride	562	Y	5	Y	N	–	–	N	14	–	–	–	N	Y	–	–	–	–	–
1,1-dichloroethylene (DCE)	8.6	Y	7	N	–	–	–	N	NR	–	–	–	N	Y	–	–	–	–	–
1,2-dichloroethane (DCA)	7.8	Y	5	N	–	–	–	N	16	–	–	–	N	Y	–	–	–	–	–
1,1,1-trichloroethane (TCA)	5.3	Y	200	N	–	–	–	N	–	4	–	–	N	N	–	–	N	–	Y
Trichloroethylene (TCE)	32.2	Y	5	N	–	–	–	N	17	–	7	–	N	N	N	Y	–	–	–
Tetrachloroethylene (PCE)	5	Y	5	N	–	–	–	N	NR	–	–	–	N	N	–	–	N	–	Y
Aromatics																			
Toluene	9	Y	1,000	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
Xylene	5.2	Y	10,000	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
Phenols																			
Phenol	11.7	Y	NA	N	–	–	–	N	–	23	–	–	N	N	–	–	N	–	Y
o-Nitrophenol	7	Y	NA	N	–	–	–	N	–	–	–	–	N	N	–	–	N	–	Y
2-chlorophenol	22.5	Y	NA	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
2,4-dichlorophenol	17.5	Y	NA	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
Pentachlorophenol	75	Y	1	Y	–	–	–	N	–	NR	–	–	N	Y	–	–	–	–	–

Table 9-2. 200 West Groundwater Aggregate Area Data Evaluation Decision Matrix.

	ERA Evaluation Path								RRI Rank				IRM Path				Final Remedy Path		
									Current		Future								
Detected Constituent	Max Conc	HSPPS justfd?	GW Std	>100 *Std?	conf?	BDAT avail?	Adv Cnsq?	ERA?	C	NC	C	NC	Data Adeq?	LTH?	Adv Cnsq?	IRM?	Data Adeq?	RA?	RI?
Phenols (continued)																			
2,4-dimethyl-phenol	26	Y	NA	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
2,6-Bis(1,1-Dimethylethyl)-4 methyl-phenol	20	Y	NA	N	–	–	–	N	–	–	–	–	N	N	–	–	N	–	Y
2-sec-butyl-4, 6-dinitrophenol	5.3	Y	NA	N	–	–	–	N	–	18	–	–	N	N	–	–	N	–	Y
Bisphenol A	42	Y	NA	N	–	–	–	N	–	–	–	–	N	N	–	–	N	–	Y
2,6-dichloro-phenol	23	Y	NA	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
2,4,5-trichloro-phenol	5	Y	NA	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
Ketones																			
Acetone	57	Y	NA	N	–	–	–	N	–	22	–	–	N	N	–	–	N	–	Y
Methyl ethyl ketone (MEK)	33	Y	NA	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
4-Methyl-2-Pentanone	6	Y	NA	N	–	–	–	N	–	NR	–	–	N	N	–	–	N	–	Y
Pesticides																			
Aldrin	1.8	Y	NA	N	–	–	–	N	NR	–	–	–	N	Y	–	–	–	–	–
DDD	0.3	Y	NA	N	–	–	–	N	NR	–	–	–	N	Y	–	–	–	–	–
DDT	4.3	Y	NA	N	–	–	–	N	NR	–	–	–	N	Y	–	–	–	–	–
Dieldrin	3.9	Y	NA	N	–	–	–	N	NR	–	–	–	N	Y	–	–	–	–	–
Endrin	4.6	Y	2	N	–	–	–	N	–	NR	–	–	N	Y	–	–	–	–	–
Endrin Aldehyde	0.7	Y	NA	N	–	–	–	N	–	–	–	–	N	Y	–	–	–	–	–
Gamma-BHC	1.7	Y	NA	N	–	–	–	N	–	NR	–	–	N	Y	–	–	–	–	–
Heptachlor	1.7	Y	0.4	N	–	–	–	N	NR	–	–	–	N	Y	–	–	–	–	–

Table 9-2. 200 West Groundwater Aggregate Area Data Evaluation Decision Matrix.

	ERA Evaluation Path								RRI Rank				IRM Path				Final Remedy Path		
									Current		Future								
Detected Constituent	Max Conc	HSPPS justfd?	GW Std	>100 *Std?	conf?	BDAT avail?	Adv Cnsq?	ERA?	C	NC	C	NC	Data Adeq?	LFI?	Adv Cnsq?	IRM?	Data Adeq?	RA?	RI?
Miscellaneous Organics																			
Bis(2-ethylhexyl) phthalate	64	Y	6	N	--	--	--	N	NR	--	--	--	N	Y	--	--	--	--	--
Miscellaneous Organics (continued)																			
1,2-Propandiol	48	Y	NA	N	--	--	--	N	--	--	--	--	N	N	--	--	N	--	Y
Carbon disulfide	39	Y	NA	N	--	--	--	N	--	--	--	--	N	N	--	--	N	--	Y
Citrus Red	2,493	Y	NA	N	--	--	--	N	--	--	--	--	N	N	--	--	N	--	Y
Cresols	15.5	Y	NA	N	--	--	--	N	--	--	--	--	N	N	--	--	N	--	Y
N-nitrosodi-methylamine	27	Y	NA	N	--	--	--	N	NR	--	--	--	N	Y	--	--	--	--	--
RADIONUCLIDES (pCi/L)																			
Gross alpha	2,209	Y	15	Y	Y	N	--	N	--	--	--	--	N	Y	--	--	--	--	--
Gross beta	3,272	Y	50	Y	Y	N	--	N	--	--	--	--	N	Y	--	--	--	--	--
Tritium (H-3)	5,080,000	Y	20,000	Y	Y	N	--	N	5	--	4	--	Y	N	Y	N	Y	Y	--
Beryllium(Be)-7	18	Y	40,000	N	--	--	--	N	NR	--	--	--	N	N	--	--	N	--	Y
Carbon(C)-14	12	Y	2,800	N	--	--	--	N	21	--	--	--	N	N	--	--	N	--	Y
Potassium(K)-40	476	Y	280	N	--	--	--	N	8	--	--	--	N	Y	--	--	--	--	--
Cobalt(Co)-60	13	Y	200	N	--	--	--	N	20	--	--	--	N	N	--	--	N	--	Y
Nickel(Ni)-63	9.18	Y	1,200	N	--	--	--	N	23	--	--	--	N	N	--	--	N	--	Y
Zinc(Zn)-65	10.4	Y	360	N	--	--	--	N	NR	--	--	--	N	N	--	--	N	--	Y
Strontium(Sr)-90	22	Y	8	N	--	--	--	N	15	--	--	--	N	Y	--	--	--	--	--
Zirconium/Niobium (Zr/Nb)-95	24.3	Y	1,600	N	--	--	--	N	NR	--	--	--	N	N	--	--	N	--	Y
Technetium(Tc)-99	26,600	Y	4,000	N	--	--	--	N	2	--	1	--	Y	N	N	Y	--	--	--
Ruthenium (Ru)-106	36	Y	240	N	--	--	--	N	18	--	--	--	N	N	--	--	N	--	Y
Silver-110 Metastable	5	Y	400	N	--	--	--	N	--	--	--	--	N	N	--	--	N	--	Y

Table 9-2. 200 West Groundwater Aggregate Area Data Evaluation Decision Matrix.

	ERA Evaluation Path								RRI Rank				IRM Path				Final Remedy Path		
									Current		Future								
Detected Constituent	Max Conc	HSPPS justfd?	GW Std	>100 *Std?	conf?	BDAT avail?	Adv Cnsq?	ERA?	C	NC	C	NC	Data Adeq?	LFI?	Adv Cnsq?	IRM?	Data Adeq?	RA?	RI?
RADIONUCLIDES (pCi/L) (continued)																			
Antimony(Sb)-125	9.5	Y	2,000	N	--	--	--	N	NR	--	--	--	N	N	--	--	N	--	Y
Iodine(I)-129	29	Y	20	N	--	--	--	N	12	--	3	--	N	Y	--	--	--	--	--
Cesium(Cs)-137	5.2	Y	120	N	--	--	--	N	19	--	--	--	N	N	--	--	N	--	Y
Cerium/Praseodymium(Ce/Pr)-144	31	Y	280	N	--	--	--	N	NR	--	--	--	N	N	--	--	N	--	Y
Europium(Eu)-154	25	Y	800	N	--	--	--	N	NR	--	--	--	N	N	--	--	N	--	Y
Lead(Pb)-212	6.3	Y	120	N	--	--	--	N	22	--	--	--	N	N	--	--	N	--	Y
Radium (Ra)	6.4	Y	5	N	--	--	--	N	13	--	--	--	N	Y	--	--	--	--	--
Uranium (U)	1,130	Y	24	N	--	--	--	N	--	--	L	--	Y	N	N	Y	--	--	--
Uranium(U)-234	1,605	Y	20	N	--	--	--	N	3	--	L	--	Y	N	N	Y	--	--	--
Uranium(U)-235	102	Y	24	N	--	--	--	N	9	--	L	--	Y	N	N	Y	--	--	--
Uranium(U)-238	1,730	Y	24	N	--	--	--	N	3	--	L	--	Y	N	N	Y	--	--	--
Plutonium(Pu)-238	8.97	Y	1.6	N	--	--	--	N	NR	--	--	--	N	Y	--	--	--	--	--
Plutonium (Pu)-239/40	5.1	Y	1.2	N	--	--	--	N	11	--	L	--	N	Y	--	--	--	--	--
Americium(Am)-241	5.9	Y	1.2	N	--	--	--	N	9	--	--	--	N	Y	--	--	--	--	--
INORGANIC COMPOUNDS (µg/L)																			
Aluminum (Al), filtered	234	Y	NA	N	--	--	--	N	--	7	--	--	N	N	--	--	N	--	Y
Ammonium ion (NH_4)	44,000	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N	--	Y
Arsenic (As), filtered	24	Y	50	N	--	--	--	N	6	--	2	--	N	Y	--	--	--	--	--
Barium (Ba), filtered	410	Y	2,000	N	--	--	--	N	--	14	--	--	N	N	--	--	N	--	Y
Beryllium (Be), filtered	4.7	Y	4	N	--	--	--	N	--	NR	--	--	N	Y	--	--	--	--	--
Boron (B), filtered	73	Y	NA	N	--	--	--	N	--	21	--	--	N	N	--	--	N	--	Y
Cadmium (Cd), filtered	4.9	Y	5	N	--	--	--	N	--	NR	--	--	N	Y	--	--	--	--	--

Table 9-2. 200 West Groundwater Aggregate Area Data Evaluation Decision Matrix.

	ERA Evaluation Path								RRI Rank				IRM Path				Final Remedy Path		
									Current		Future								
Detected Constituent	Max Conc	HSPPS justfd?	GW Std	>100 *Std?	conf?	BDAT avail?	Adv Cnsq?	ERA?	C	NC	C	NC	Data Adeq?	LFI?	Adv Cnsq?	IRM?	Data Adeq?	RA?	RI?
INORGANIC COMPOUNDS (μg/L) (continued)																			
Calcium (Ca), filtered	304,500	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Carbon	40,533	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chloride (Cl)	64,000	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chromium (Cr), filtered	323	Y	100	N	--	--	--	N	--	8	--	3	N	Y	--	--	--	--	--
Cobalt (Co), filtered	22	Y	NA	N	--	--	--	N	--	NR	--	--	N	N	--	--	N	--	Y
Copper (Cu), filtered	25	Y	NA	N	--	--	--	N	--	20	--	--	N	N	--	--	N	--	Y
Cyanide (CN)	49.5	Y	200	N	--	--	--	N	--	6	--	--	Y	N	--	--	N	--	Y
Fluoride (F)	11,500	Y	4,000	N	--	--	--	N	--	4	--	2	N	Y	--	--	--	--	--
Iron (Fe), filtered	9,593	Y	NA	N	--	--	--	N	--	13	--	--	N	N	--	--	N	--	Y
Lead (Pb), filtered	11.5	Y	50	N	--	--	--	N	--	--	--	--	N	N	--	--	N	--	Y
Lithium (Li), filtered	12	Y	NA	N	--	--	--	N	--	25	--	--	N	N	--	--	N	--	Y
Magnesium (Mg), filtered	106,000	Y	NA	N	--	--	--	N	--	16	--	--	N	N	--	--	N	--	Y
Manganese (Mn), filtered	680	Y	NA	N	--	--	--	N	--	19	--	--	N	N	--	--	N	--	Y
Mercury (Hg)	0.54	Y	2	N	--	--	--	N	--	NR	--	--	N	N	--	--	N	--	Y
Nickel (Ni), filtered	86	Y	100	N	--	--	--	N	L	16	--	--	N	N	--	--	N	--	Y
Nitrate (NO_3)	1,322,000	Y	45,000	N	--	--	--	N	--	1	--	1	Y	N	N	Y	--	--	--
Nitrite (NO_2)	1,700	Y	3,300	N	--	--	--	N	--	--	--	--	N	N	--	--	N	--	Y
Phosphate (PO_4)	7,350	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Potassium (K), filtered	12,000	Y	NA	N	--	--	--	N	--	24	--	--	N	N	--	--	N	--	Y
Selenium (Se), filtered	22	Y	50	N	--	--	--	N	--	3	--	--	N	Y	--	--	--	--	--
Silicon (Si), filtered	25,300	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Silver (Ag), filtered	14	Y	50	N	--	--	--	N	--	NR	--	--	N	N	--	--	N	--	Y

Table 9-2. 200 West Groundwater Aggregate Area Data Evaluation Decision Matrix.

	ERA Evaluation Path								RRI Rank				IRM Path				Final Remedy Path		
									Current		Future								
Detected Constituent	Max Conc	HSPPS justfd?	GW Std	>100 *Std?	conf?	BDAT avail?	Adv Cnsq?	ERA?	C	NC	C	NC	Data Adeq?	LFI?	Adv Cnsq?	IRM?	Data Adeq?	RA?	RI?
INORGANIC COMPOUNDS (μg/L) (continued)																			
Sodium (Na), filtered	320,500	Y	NA	N	–	–	–	N	–	15	–	–	N	N	–	–	N	–	Y
Strontium (Sr), filtered	1,690	Y	NA	N	–	–	–	N	–	12	–	–	N	N	–	–	N	–	Y
Sulfate (SO_4)	3,500,000	Y	NA	N	–	–	–	N	–	9	–	–	N	N	–	–	N	–	Y
Titanium (Ti)	1,370	N	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Uranium (U), chemical	3,417	Y	NA	N	–	–	–	N	–	2	–	L	Y	N	N	Y	–	–	–
Vanadium (V)	221	Y	NA	N	–	–	–	N	–	11	–	–	N	N	–	–	N	–	Y
Zinc (Zn)	298	Y	NA	N	–	–	–	N	–	10	–	–	N	N	–	–	N	–	Y

Y = Yes (decision)
N = No (decision)
NA = not available
NR = not ranked
L = low ranked (below MEPAS computation capability)

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APPENDIX A

SUPPLEMENTAL DATA

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CONTENTS

TABLES:

A-1 Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992)

A-2 Maximum Detections in 200 West Groundwater (October 1951 - April 1992)

A-3 Summary of Reported Results Below Analytical Detection Limits

A-4 Summary of Wells with Detected Compounds (January 1988 - April 1992)

A-5 Input Parameters for Exposure to Future Offsite Contaminant Levels

A-6 Chemical Specific Exposure Input Parameters

A-7 Unconfined Aquifer Hydrologic Test Data for the 200 West Area

A-8 Transmissivity and Hydraulic Conductivity Values for the Unconfined Aquifer--200 West Area

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For Table A-1, organic and inorganic constituent concentrations are in μg/L. Radionuclide concentrations are in pCi/L.

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Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992). Page 1

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a 1,1,1-trichloroethane							
	2-W18-21	5.333	8.000	8.000	1	8	9
	2-W7-4	5.273	8.000	5.000	2	9	11
	2-W10-13	5.250	8.000	8.000	1	11	12
1,1-dichloroethylene							
	2-W22-20	8.567	5.700	5.700	1	2	3
a 1,2-dichloroethene							
	2-W22-20	7.750	6.000	5.000	2	2	4
12-PROPANEDIOL							
	2-W19-15	48.000	48.000	48.000	1	0	1
2,4,5-Trichlorophenol							
	2-W22-39	5.000	5.000	5.000	1	2	3
2,4-dichlorophenol							
	2-W15-24	17.500	30.000	30.000	1	1	2
	2-W7-6	11.000	12.000	12.000	1	1	2
2,4-dimethylphenol							
	2-W10-18	26.000	47.000	47.000	1	1	2
	2-W15-22	6.000	7.000	7.000	1	1	2
	2-W23-14	5.500	6.000	6.000	1	1	2
2,6-Bis(1,1-Dimethylethyl)-4-Methyl Ph							
	2-W19-27	20.000	20.000	20.000	1	0	1
	2-W8-1	9.000	9.000	9.000	1	0	1
2,6-dichlorophenol							
	2-W7-6	23.000	36.000	36.000	1	1	2
2-chlorophenol							
	2-W7-6	22.500	35.000	35.000	1	1	2
2-sec-butyl-4,6-dinitrophenol							
	2-W18-24	5.333	5.000	5.000	1	2	3
	2-W7-8	4.667	8.000	8.000	1	2	3
	2-W15-24	4.000	6.000	6.000	1	2	3
	2-W15-19	3.000	5.000	1.000	2	0	2
	2-W7-10	2.333	1.000	1.000	1	2	3
	2-W10-18	2.000	1.000	1.000	1	3	4
4-Methyl-2-Pentanone							
	2-W19-18	6.000	6.000	6.000	1	0	1
Acetone by VOA							
	2-W15-17	57.167	23.000	23.000	1	5	6
	2-W15-18	42.000	22.000	22.000	1	5	6
	2-W18-24	41.250	70.000	20.000	2	6	8
	2-W7-4	32.500	11.000	11.000	1	7	8
	2-W22-26	12.000	12.000	12.000	1	0	1
	2-W18-17	9.333	8.000	8.000	1	2	3
	2-W19-13	5.000	5.000	5.000	1	0	1
	2-W22-1	5.000	5.000	5.000	1	0	1
Aldrin							
	2-W15-8	1.800	1.800	1.800	1	0	1
	2-W19-18	1.800	1.800	1.800	1	0	1
	2-W14-2	1.700	1.700	1.700	1	0	1
Alkalinity							
	2-W10-9	167000.000	169000.000	165000.000	2	0	2
	2-W15-4	160000.000	173000.000	147000.000	2	0	2
	2-W14-10	159000.000	159000.000	159000.000	1	0	1
	2-W19-18	157666.667	189000.000	126000.000	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992). Page 2

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Alkalinity							
	2-W10-4	157000.000	157000.000	157000.000	3	0	3
	6-35-66	155500.000	157000.000	153000.000	4	0	4
	6-36-61B	154000.000	154000.000	154000.000	1	0	1
	2-W19-3	149333.333	157000.000	140000.000	3	0	3
	6-36-61A	148666.667	149000.000	148000.000	3	0	3
	2-W15-16	145000.000	145000.000	145000.000	1	0	1
	2-W19-11	145000.000	145000.000	145000.000	1	0	1
	2-W19-15	144500.000	156000.000	131000.000	4	0	4
	2-W27-1	144333.333	148000.000	139000.000	3	0	3
	2-W19-20	141000.000	161000.000	125000.000	3	0	3
	6-40-62	139333.333	140000.000	139000.000	3	0	3
	2-W19-24	137666.667	145000.000	128000.000	3	0	3
	2-W19-13	135666.667	137000.000	135000.000	3	0	3
	2-W22-20	135666.667	138000.000	134000.000	3	0	3
	6-35-70	132500.000	134000.000	131000.000	2	0	2
	6-38-65	128000.000	128000.000	128000.000	1	0	1
	6-38-70	126500.000	127000.000	126000.000	4	0	4
	6-32-70B	126000.000	130000.000	119000.000	4	0	4
	2-W14-2	123333.333	127000.000	121000.000	3	0	3
	2-W14-5	122333.333	125000.000	119000.000	3	0	3
	6-45-69A	122000.000	122000.000	122000.000	1	0	1
	2-W15-[illegible]	121333.333	123000.000	119000.000	3	0	3
	6-50-85	121333.333	122000.000	121000.000	3	0	3
	2-W19-28	121000.000	121000.000	121000.000	1	0	1
	2-W19-9	119250.000	127000.000	115000.000	4	0	4
	6-47-60	118666.667	120000.000	118000.000	3	0	3
	2-W19-16	118000.000	126000.000	113000.000	4	0	4
	2-W22-12	117500.000	119000.000	116000.000	2	0	2
	6-44-64	117500.000	118000.000	117000.000	4	0	4
	2-W23-10	116250.000	119000.000	114000.000	4	0	4
	6-32-72	115000.000	117000.000	112000.000	3	0	3
	2-W11-7	114000.000	117000.000	111000.000	2	0	2
	2-W6-2	113000.000	113000.000	113000.000	2	0	2
	2-W14-6	112125.000	115000.000	110000.000	8	0	8
	2-W15-12	111666.667	116000.000	103000.000	3	0	3
	2-W15-10	111500.000	113000.000	111000.000	4	0	4
	2-W15-8	108000.000	108000.000	108000.000	1	0	1
	2-W18-5	107000.000	108000.000	106000.000	3	0	3
	6-48-71	107000.000	107000.000	107000.000	1	0	1
	2-W10-8	105000.000	105000.000	105000.000	1	0	1
	6-39-79	102250.000	105000.000	101000.000	4	0	4
	2-W15-7	101000.000	101000.000	101000.000	2	0	2
	2-W19-5	100300.000	101000.000	99600.000	2	0	2
	6-29-78	100233.333	103000.000	98800.000	3	0	3
	2-W22-22	99300.000	103000.000	96600.000	3	0	3
	6-49-79	99175.000	99900.000	98400.000	4	0	4
	2-W22-26	96150.000	96600.000	95700.000	2	0	2
	6-35-78A	96100.000	96200.000	96000.000	2	0	2
	2-W18-15	95500.000	96000.000	95200.000	3	0	3
	2-W22-1	95200.000	96100.000	94600.000	3	0	3
	2-W18-24	88000.000	88000.000	88000.000	1	0	1
	2-W19-21	86533.333	88700.000	84200.000	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Alkalinity							
	2-W11-14	85600.000	111000.000	60200.000	2	0	2
	2-W18-4	81400.000	109000.000	59700.000	3	0	3
	6-32-77	81275.000	109000.000	100.000	4	0	4
	6-43-88	77600.000	77600.000	77600.000	1	0	1
	2-W18-17	67900.000	73700.000	57600.000	3	0	3
	2-W18-9	67700.000	67700.000	67700.000	1	0	1
	6-37-82A	32900.000	32900.000	32900.000	1	0	1
	6-51-75	120.000	120.000	120.000	1	0	1
Aluminum							
	2-W7-6	17675.000	38700.000	1060.000	6	0	6
	2-W19-1	14700.000	14700.000	14700.000	1	0	1
	2-W15-8	9690.000	9690.000	9690.000	1	0	1
	2-W15-24	7920.000	7920.000	7920.000	1	0	1
	2-W22-20	2800.000	2800.000	2800.000	1	0	1
	2-W14-2	1620.000	1620.000	1620.000	1	0	1
	2-W10-8	1550.000	1550.000	1550.000	1	0	1
	2-W14-10	1090.000	2030.000	2030.000	1	1	2
	2-W7-9	919.000	919.000	919.000	1	0	1
	2-W18-9	839.000	839.000	839.000	1	0	1
	2-W18-20	676.000	676.000	676.000	1	0	1
	2-W15-17	669.000	2950.000	278.000	3	3	6
	2-W18-4	555.000	555.000	555.000	1	0	1
	2-W15-12	524.000	524.000	524.000	1	0	1
	2-W7-8	496.000	496.000	496.000	1	0	1
	2-W15-20	312.000	312.000	312.000	1	0	1
	2-W18-17	302.714	589.000	185.000	5	2	7
	2-W14-5	266.000	266.000	266.000	1	0	1
	2-W18-21	245.857	657.000	314.000	2	5	7
	2-W9-1	236.667	518.000	224.000	3	3	6
	2-W7-3	194.429	461.000	461.000	1	6	7
	2-W18-23	181.000	352.000	165.000	2	5	7
	2-W10-16	175.000	175.000	175.000	1	0	1
	2-W18-22	158.667	202.000	202.000	1	5	6
	2-W7-5	152.167	163.000	163.000	1	5	6
Aluminum, filtered							
	2-W7-6	233.500	328.000	306.000	2	2	4
	2-W7-5	152.667	166.000	166.000	1	5	6
Americium-241							
	2-W15-8	5.900	5.900	5.900	1	0	1
	2-W19-1	.770	.770	.770	1	0	1
	2-W18-17	.061	.120	.120	1	1	2
	2-W15-23	.017	.030	.030	1	1	2
	2-W7-6	.015	.027	.027	1	6	7
	2-W7-1	.012	.056	.014	2	5	7
	2-W7-5	.004	.021	.021	1	7	8
	2-W15-15	.004	.014	.014	1	4	5
	2-W15-16	.003	.019	.019	1	5	6
	2-W18-21	.003	.030	.030	1	5	6
	2-W7-4	.001	.013	.013	1	6	7
Ammonium ion							
	2-W15-8	44000.000	44000.000	44000.000	1	0	1
	2-W18-4	13800.000	15000.000	12600.000	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Ammonium ion							
	2-W18-5	301.667	420.000	215.000	3	0	3
	2-W15-19	293.500	551.000	423.000	2	2	4
	2-W18-17	212.250	342.000	120.000	4	0	4
	2-W7-9	188.200	341.000	140.000	3	2	5
	2-W15-4	157.000	166.000	148.000	2	0	2
	2-W18-26	91.000	81.000	74.000	2	3	5
	2-W19-1	79.000	79.000	79.000	1	0	1
	2-W14-10	72.000	94.000	94.000	1	1	2
	2-W7-3	68.182	90.000	50.000	3	8	11
	2-W9-1	67.000	120.000	120.000	1	9	10
	2-W7-6	65.500	55.000	55.000	1	9	10
	2-W19-11	60.000	60.000	60.000	1	0	1
	2-W18-23	59.909	59.000	59.000	1	10	11
	2-W18-9	58.000	58.000	58.000	1	0	1
	6-44-64	56.000	62.000	62.000	1	1	2
	2-W19-15	53.250	63.000	63.000	1	3	4
	6-47-60	53.000	56.000	56.000	1	1	2
	2-W23-10	51.000	54.000	54.000	1	3	4
	6-38-70	50.333	52.000	52.000	1	5	6
	2-W22-12	50.000	50.000	50.000	1	1	2
	6-35-66	50.000	50.000	50.000	1	1	2
Antimony-125							
	2-W7-9	9.507	20.800	20.800	1	2	3
	2-W22-40	9.106	17.500	17.500	1	1	2
	2-W7-10	7.533	25.100	25.100	1	2	3
	2-W15-16	3.700	7.880	7.880	1	1	2
	2-W7-3	3.670	20.200	20.200	1	2	3
	2-W15-20	2.730	15.000	15.000	1	2	3
Arsenic							
	2-W10-8	101.000	101.000	101.000	1	0	1
	2-W15-4	20.000	20.000	20.000	1	0	1
	2-W10-9	18.000	20.000	16.000	4	0	4
	2-W19-21	16.000	18.000	14.000	2	0	2
	2-W23-13	15.333	17.000	14.000	3	0	3
	2-W23-11	14.000	14.000	14.000	1	0	1
	2-W19-27	12.000	12.000	12.000	1	0	1
	2-W10-17	10.450	11.000	9.800	4	0	4
	2-W18-15	10.000	10.000	10.000	1	0	1
	2-W18-25	8.833	9.200	8.300	3	0	3
	2-W10-4	8.000	8.000	8.000	1	0	1
	2-W19-31	7.767	13.000	5.300	2	1	3
	2-W26-9	7.300	9.000	7.900	2	1	3
	2-W15-12	7.000	7.000	7.000	1	0	1
	2-W7-6	6.400	10.000	5.600	5	4	9
	2-W22-20	6.000	7.000	7.000	1	1	2
	2-W10-15	5.983	7.000	5.100	6	0	6
	2-W23-14	5.933	7.000	5.200	3	0	3
	2-W22-39	5.400	5.800	5.100	3	0	3
	2-W22-40	5.225	5.900	5.900	1	3	4
	2-W22-43	5.200	5.800	5.800	1	3	4
	2-W10-16	5.120	5.600	5.000	2	3	5
	2-W15-15	5.000	5.000	5.000	1	6	7

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Arsenic							
	2-W18-21	5.000	5.000	5.000	1	8	9
Arsenic, filtered							
	2-W15-4	24.000	24.000	24.000	1	0	1
	2-W10-9	16.000	17.000	15.000	4	0	4
	2-W23-13	14.333	17.000	13.000	3	0	3
	2-W19-21	13.500	14.000	13.000	2	0	2
	2-W18-15	12.000	12.000	12.000	1	0	1
	2-W19-27	12.000	12.000	12.000	1	0	1
	2-W23-11	12.000	12.000	12.000	1	0	1
	2-W10-17	11.500	12.000	11.000	4	0	4
	2-W18-25	8.700	10.000	7.100	3	0	3
	2-W26-9	7.500	9.000	8.500	2	1	3
	2-W23-14	6.367	7.700	5.400	3	0	3
	2-W10-4	6.000	6.000	6.000	1	0	1
	6-47-60	6.000	7.000	7.000	1	1	2
	2-W10-15	5.733	6.000	5.000	6	0	6
	2-W22-39	5.667	6.500	5.500	2	1	3
	2-W10-18	5.525	7.100	7.100	1	3	4
	2-W18-21	5.000	5.000	5.000	1	8	9
Barium							
	2-W10-8	732.000	732.000	732.000	1	0	1
	2-W15-8	444.000	660.000	228.000	2	0	2
	2-W14-2	273.000	400.000	146.000	2	0	2
	2-W19-19	270.000	270.000	270.000	1	0	1
	2-W19-26	245.000	290.000	200.000	2	0	2
	2-W7-6	238.889	507.000	47.000	9	0	9
	2-W19-1	222.000	222.000	222.000	1	0	1
	2-W19-20	216.000	233.000	205.000	3	0	3
	2-W15-12	210.000	210.000	210.000	1	0	1
	2-W19-24	197.500	213.000	182.000	2	0	2
	2-W19-25	193.000	193.000	193.000	1	0	1
	2-W19-30	190.000	190.000	190.000	1	0	1
	2-W19-23	124.000	124.000	124.000	1	0	1
	6-38-70	100.000	100.000	100.000	1	0	1
	2-W11-14	99.000	99.000	99.000	1	0	1
	2-W22-20	93.667	130.000	48.000	3	0	3
	2-W19-29	92.000	110.000	74.000	2	0	2
	2-W15-17	84.111	118.000	70.000	9	0	9
	2-W19-28	84.000	84.000	84.000	1	0	1
	2-W11-7	79.000	79.000	79.000	1	0	1
	2-W18-5	75.000	75.000	75.000	1	0	1
	2-W22-42	75.000	84.000	67.000	3	0	3
	2-W19-32	72.500	76.000	69.000	2	0	2
	2-W10-15	71.429	80.000	49.000	7	0	7
	2-W15-11	71.000	71.000	71.000	1	0	1
	2-W15-24	70.750	121.000	53.000	4	0	4
	2-W22-41	69.333	77.000	64.000	3	0	3
	2-W10-9	67.800	78.000	55.000	5	0	5
	2-W10-14	67.778	76.000	56.000	9	0	9
	2-W15-16	66.750	75.000	60.000	8	0	8
	2-W15-10	64.000	64.000	64.000	1	0	1
	2-W10-18	63.750	67.000	61.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Barium							
	2-W15-19	60.000	61.000	59.000	3	0	3
	6-36-61A	60.000	60.000	60.000	1	0	1
	6-40-62	59.000	59.000	59.000	1	0	1
	2-W19-18	57.000	77.000	37.000	2	0	2
	2-W15-22	56.333	58.000	55.000	3	0	3
	2-W11-23	51.000	51.000	51.000	1	0	1
	2-W18-22	50.875	64.000	52.000	7	1	8
	2-W7-9	48.500	54.000	43.000	4	0	4
	2-W23-11	48.000	48.000	48.000	1	0	1
	2-W15-18	45.750	54.000	42.000	8	0	8
	2-W14-10	45.500	49.000	42.000	2	0	2
	2-W18-26	45.250	58.000	37.000	4	0	4
	2-W10-16	44.200	47.000	40.000	5	0	5
	2-W22-21	44.000	44.000	44.000	1	0	1
	2-W15-7	43.500	50.000	37.000	2	0	2
	2-W14-5	43.000	43.000	43.000	1	0	1
	2-W15-20	43.000	50.000	38.000	4	0	4
	2-W19-11	43.000	43.000	43.000	1	0	1
	2-W26-8	40.250	48.000	25.000	4	0	4
	2-W19-13	40.000	40.000	40.000	1	0	1
	6-35-70	40.000	40.000	40.000	1	0	1
	2-W7-3	39.200	50.000	34.000	10	0	10
	2-W15-4	39.000	39.000	39.000	1	0	1
	2-W19-3	39.000	39.000	39.000	1	0	1
	2-W22-40	39.000	40.000	38.000	4	0	4
	2-W6-2	38.667	43.000	35.000	12	0	12
	2-W27-1	38.500	40.000	37.000	2	0	2
	2-W7-10	37.333	38.000	36.000	3	0	3
	2-W19-31	36.667	38.000	34.000	3	0	3
	2-W9-1	36.000	44.000	29.000	9	0	9
	2-W7-4	34.700	38.000	31.000	10	0	10
	2-W18-17	34.571	56.000	25.000	7	0	7
	2-W8-1	34.111	43.000	26.000	9	0	9
	2-W10-4	34.000	34.000	34.000	1	0	1
	2-W18-4	34.000	34.000	34.000	1	0	1
	2-W7-5	33.000	36.000	29.000	9	0	9
	2-W7-8	33.000	41.000	28.000	4	0	4
	2-W7-2	32.667	39.000	24.000	9	0	9
	2-W22-43	32.250	35.000	30.000	4	0	4
	2-W7-7	32.250	38.000	25.000	4	0	4
	2-W23-14	31.000	41.000	26.000	3	0	3
	2-W18-24	30.333	46.000	24.000	9	0	9
	2-W10-13	30.300	34.000	27.000	10	0	10
	2-W10-17	30.250	33.000	27.000	4	0	4
	2-W7-1	30.222	35.000	24.000	9	0	9
	2-W15-15	29.857	36.000	26.000	7	0	7
	2-W23-13	29.333	41.000	23.000	3	0	3
	2-W15-23	28.667	30.000	28.000	3	0	3
	2-W18-20	28.000	28.000	28.000	1	0	1
	2-W18-9	28.000	28.000	28.000	1	0	1
	2-W22-39	28.000	31.000	26.000	3	0	3
	6-45-69A	28.000	28.000	28.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Barium							
	6-49-79	28.000	28.000	28.000	1	0	1
	2-W18-23	27.667	37.000	24.000	9	0	9
	2-W26-6	27.000	27.000	27.000	1	0	1
	2-W19-12	25.000	25.000	25.000	1	0	1
	2-W18-21	24.667	35.000	21.000	9	0	9
	6-37-82A	23.000	23.000	23.000	1	0	1
	2-W26-9	22.667	26.000	22.000	2	1	3
	6-32-77	22.000	22.000	22.000	1	0	1
	2-W18-15	21.000	21.000	21.000	1	0	1
	2-W19-27	21.000	21.000	21.000	1	0	1
	6-48-71	21.000	21.000	21.000	1	0	1
	2-W18-25	20.000	20.000	20.000	1	2	3
	2-W22-1	20.000	20.000	20.000	1	0	1
	2-W19-21	19.500	23.000	16.000	2	0	2
	2-W22-22	13.000	13.000	13.000	1	0	1
Barium, filtered							
	2-W15-8	410.000	410.000	410.000	1	0	1
	2-W19-19	262.000	275.000	249.000	2	0	2
	2-W19-26	234.500	279.000	190.000	2	0	2
	2-W19-20	220.333	238.000	203.000	6	0	6
	2-W19-24	198.000	230.000	161.000	5	0	5
	2-W19-25	197.500	201.000	194.000	2	0	2
	2-W19-23	129.000	135.000	123.000	2	0	2
	2-W22-43	129.000	420.000	31.000	4	0	4
	2-W7-6	105.000	510.000	24.000	7	0	7
	6-38-65	86.000	89.000	83.000	2	0	2
	6-38-70	85.500	99.000	72.000	6	0	6
	2-W19-29	81.333	98.000	72.000	3	0	3
	2-W14-2	80.750	93.000	74.000	4	0	4
	2-W19-28	77.250	130.000	22.000	4	0	4
	2-W19-2	77.000	77.000	77.000	1	0	1
	2-W15-17	76.800	85.000	71.000	5	0	5
	2-W22-41	69.667	76.000	66.000	3	0	3
	2-W10-15	68.800	81.000	48.000	5	0	5
	2-W18-5	67.000	71.000	61.000	3	0	3
	2-W10-14	65.667	73.000	57.000	9	0	9
	2-W14-5	63.667	98.000	40.000	3	0	3
	2-W15-16	63.667	68.000	60.000	9	0	9
	6-40-62	63.000	67.000	57.000	4	0	4
	6-36-61A	61.800	65.000	57.000	5	0	5
	2-W15-19	61.333	63.000	60.000	3	0	3
	2-W15-10	60.333	67.000	54.000	3	0	3
	2-W15-11	60.000	69.000	51.000	3	0	3
	2-W19-18	58.600	73.000	40.000	5	0	5
	2-W10-9	58.500	67.000	52.000	4	0	4
	2-W22-42	58.333	76.000	32.000	3	0	3
	2-W10-18	56.750	58.000	54.000	4	0	4
	2-W19-32	54.000	56.000	52.000	2	0	2
	2-W18-22	53.375	58.000	48.000	8	0	8
	2-W15-4	53.000	67.000	39.000	2	0	2
	2-W11-23	51.000	51.000	51.000	1	0	1
	2-W22-20	50.800	55.000	43.000	5	0	5

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Barium, filtered							
	2-W23-10	50.800	57.000	47.000	5	0	5
	6-44-64	49.800	54.000	46.000	5	0	5
	2-W15-22	48.333	52.000	43.000	3	0	3
	2-W14-6	48.000	50.000	46.000	6	0	6
	2-W15-24	46.500	50.000	43.000	4	0	4
	6-35-66	44.750	47.000	44.000	4	0	4
	2-W18-26	44.500	59.000	37.000	4	0	4
	2-W7-9	44.500	50.000	40.000	4	0	4
	2-W19-9	44.250	49.000	37.000	4	0	4
	2-W15-18	43.500	51.000	38.000	8	0	8
	2-W15-20	43.000	48.000	36.000	4	0	4
	2-W10-16	42.800	46.000	41.000	5	0	5
	2-W15-6	42.000	42.000	42.000	1	0	1
	2-W19-15	41.400	49.000	32.000	5	0	5
	2-W14-10	40.000	40.000	40.000	1	0	1
	2-W22-40	40.000	43.000	37.000	4	0	4
	6-35-70	39.500	41.000	38.000	4	0	4
	2-W26-8	39.250	49.000	27.000	4	0	4
	2-W6-2	37.286	39.000	35.000	14	0	14
	2-W7-3	37.200	46.000	33.000	10	0	10
	6-32-70B	37.000	39.000	35.000	4	0	4
	6-47-60	36.667	39.000	34.000	3	0	3
	2-W7-10	36.333	39.000	34.000	3	0	3
	2-W19-16	36.200	39.000	29.000	5	0	5
	2-W19-31	36.000	38.000	33.000	3	0	3
	2-W9-1	35.667	46.000	27.000	9	0	9
	2-W19-11	35.500	42.000	29.000	2	0	2
	2-W7-4	35.100	38.000	31.000	10	0	10
	6-43-88	35.000	35.000	35.000	1	0	1
	2-W19-13	34.667	37.000	32.000	3	0	3
	2-W19-12	34.000	34.000	34.000	1	0	1
	2-W7-5	33.333	40.000	27.000	9	0	9
	2-W8-1	33.111	37.000	25.000	9	0	9
	2-W10-4	32.667	35.000	31.000	3	0	3
	6-32-72	32.667	37.000	28.000	3	0	3
	2-W22-12	32.500	34.000	31.000	2	0	2
	2-W7-2	31.556	39.000	25.000	9	0	9
	2-W7-7	31.500	39.000	24.000	4	0	4
	2-W7-8	30.750	36.000	25.000	4	0	4
	2-W15-7	30.333	33.000	28.000	3	0	3
	2-W7-1	30.333	34.000	25.000	9	0	9
	2-W10-17	30.000	31.000	29.000	4	0	4
	6-50-85	30.000	31.000	29.000	3	0	3
	2-W10-13	29.800	36.000	25.000	10	0	10
	2-W27-1	29.625	40.000	20.000	7	1	8
	2-W15-15	29.500	35.000	25.000	8	0	8
	2-W19-3	29.250	38.000	24.000	4	0	4
	6-49-79	28.600	31.000	27.000	5	0	5
	2-W15-23	28.333	29.000	27.000	3	0	3
	2-W22-21	27.000	27.000	27.000	1	0	1
	2-W22-39	27.000	28.000	26.000	3	0	3
	2-W18-24	26.800	32.000	22.000	10	0	10

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Barium, filtered							
	2-W18-23	26.556	30.000	24.000	9	0	9
	6-37-82A	26.500	31.000	22.000	2	0	2
	2-W22-22	26.200	32.000	15.000	5	0	5
	6-51-75	26.000	26.000	26.000	1	0	1
	6-29-78	24.333	26.000	23.000	3	0	3
	2-W10-8	24.000	24.000	24.000	1	0	1
	2-W26-6	24.000	24.000	24.000	1	0	1
	2-W18-21	23.000	26.000	20.000	9	0	9
	6-39-79	23.000	24.000	22.000	4	0	4
	6-48-71	23.000	25.000	21.000	2	0	2
	6-45-69A	22.667	23.000	22.000	3	0	3
	2-W18-17	22.500	23.000	22.000	2	0	2
	2-W26-9	22.333	25.000	22.000	2	1	3
	2-W18-15	21.000	23.000	20.000	3	0	3
	2-W23-13	21.000	22.000	21.000	2	1	3
	2-W18-25	20.667	22.000	22.000	1	2	3
	2-W22-1	20.000	21.000	18.000	3	0	3
	2-W23-11	20.000	20.000	20.000	1	1	2
	2-W23-14	20.000	20.000	20.000	1	2	3
	2-W22-26	19.000	21.000	17.000	2	0	2
	2-W19-21	18.200	20.000	16.000	5	0	5
	6-32-77	17.667	24.000	7.000	3	0	3
	2-W19-27	17.000	18.000	16.000	2	0	2
	2-W19-5	17.000	18.000	16.000	2	0	2
	6-35-78A	15.000	16.000	14.000	2	0	2
Beryllium							
	2-W7-6	4.644	6.000	4.800	2	7	9
	2-W9-1	4.444	6.000	6.000	1	8	9
Beryllium, filtered							
	2-W7-6	4.671	6.700	6.700	1	6	7
	2-W15-18	4.625	6.000	6.000	1	7	8
	2-W6-2	4.429	7.000	7.000	1	13	14
	2-W10-14	4.333	5.000	5.000	1	8	9
Beryllium-7							
	2-W6-2	17.650	57.700	57.700	1	1	2
Bis(2-ethylhexyl) phthalate							
	2-W7-10	64.000	64.000	64.000	1	0	1
	2-W14-10	12.500	15.000	15.000	1	1	2
Bisphenol A							
	2-W14-10	42.000	42.000	42.000	1	0	1
Boron							
	2-W14-10	587.000	587.000	587.000	1	0	1
	2-W10-8	86.000	86.000	86.000	1	0	1
	2-W15-24	61.000	61.000	61.000	1	0	1
	2-W10-9	55.000	55.000	55.000	1	0	1
	2-W10-16	52.000	52.000	52.000	1	0	1
	2-W7-9	52.000	52.000	52.000	1	0	1
	2-W19-26	43.000	43.000	43.000	1	0	1
	2-W19-1	40.000	40.000	40.000	1	0	1
	2-W15-17	39.000	44.000	30.000	3	0	3
	2-W19-28	38.000	38.000	38.000	1	0	1
	2-W19-27	36.000	36.000	36.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Boron							
	2-W19-23	35.000	35.000	35.000	1	0	1
	2-W19-25	35.000	35.000	35.000	1	0	1
	2-W7-7	35.000	35.000	35.000	1	0	1
	2-W7-6	34.500	51.000	20.000	4	0	4
	2-W11-23	34.000	34.000	34.000	1	0	1
	2-W15-16	32.750	49.000	22.000	4	0	4
	2-W15-15	31.750	40.000	23.000	4	0	4
	2-W19-30	31.000	31.000	31.000	1	0	1
	2-W19-24	31.000	31.000	31.000	1	0	1
	2-W27-1	30.000	30.000	30.000	1	0	1
	2-W19-19	29.000	29.000	29.000	1	0	1
	2-W15-18	27.500	50.000	17.000	4	0	4
	2-W18-21	27.400	38.000	23.000	5	0	5
	2-W18-23	26.500	32.000	21.000	6	0	6
	2-W18-24	25.000	45.000	16.000	5	0	5
	2-W7-8	25.000	25.000	25.000	1	0	1
	2-W18-26	23.000	23.000	23.000	1	0	1
	2-W18-17	22.333	28.000	17.000	6	0	6
	2-W10-15	21.000	21.000	21.000	1	0	1
	2-W15-19	21.000	21.000	21.000	1	0	1
	2-W15-20	20.000	20.000	20.000	1	0	1
	2-W19-21	20.000	20.000	20.000	1	0	1
	2-W18-22	19.250	31.000	13.000	4	0	4
	2-W18-20	19.000	19.000	19.000	1	0	1
	2-W9-1	18.750	25.000	12.000	4	0	4
	2-W7-1	17.000	24.000	12.000	4	0	4
	2-W8-1	16.750	20.000	15.000	4	0	4
	2-W7-3	16.600	20.000	14.000	5	0	5
	2-W10-14	14.200	19.000	10.000	5	0	5
	2-W10-13	13.833	19.000	11.000	6	0	6
	2-W6-2	13.667	16.000	13.000	5	1	6
	2-W7-4	12.250	14.000	11.000	3	1	4
	2-W7-2	11.750	14.000	11.000	3	1	4
	2-W7-5	10.750	13.000	13.000	1	3	4
Boron, filtered							
	2-W22-20	73.000	73.000	73.000	1	0	1
	2-W19-18	62.000	62.000	62.000	1	0	1
	2-W19-3	58.000	58.000	58.000	1	0	1
	2-W19-11	57.000	57.000	57.000	1	0	1
	2-W19-24	49.000	58.000	40.000	2	0	2
	2-W19-16	48.000	48.000	48.000	1	0	1
	2-W19-2	46.000	46.000	46.000	1	0	1
	2-W19-12	45.000	45.000	45.000	1	0	1
	2-W19-15	41.000	41.000	41.000	1	0	1
	2-W19-28	40.500	44.000	37.000	2	0	2
	2-W19-20	40.000	40.000	40.000	2	0	2
	2-W22-22	40.000	42.000	38.000	2	0	2
	2-W15-24	39.000	39.000	39.000	1	0	1
	2-W19-27	38.000	43.000	33.000	2	0	2
	2-W10-9	37.000	37.000	37.000	1	0	1
	6-38-70	36.500	42.000	31.000	2	0	2
	2-W7-9	36.000	36.000	36.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Boron, filtered							
	2-W19-25	35.500	38.000	33.000	2	0	2
	2-W27-1	34.333	37.000	32.000	3	0	3
	2-W10-16	34.000	34.000	34.000	1	0	1
	2-W11-23	34.000	34.000	34.000	1	0	1
	2-W19-26	34.000	34.000	34.000	1	0	1
	2-W19-19	33.500	34.000	33.000	2	0	2
	2-W19-23	33.500	35.000	32.000	2	0	2
	2-W18-26	33.000	33.000	33.000	1	0	1
	6-38-65	32.000	32.000	32.000	1	0	1
	2-W7-7	31.000	31.000	31.000	1	0	1
	6-35-70	30.500	36.000	25.000	2	0	2
	2-W15-17	29.000	29.000	29.000	1	0	1
	2-W18-21	28.200	41.000	23.000	5	0	5
	2-W15-15	28.000	35.000	22.000	4	0	4
	2-W15-16	28.000	39.000	22.000	5	0	5
	6-36-61A	28.000	28.000	28.000	1	0	1
	2-W15-18	27.750	52.000	19.000	4	0	4
	2-W10-15	27.000	27.000	27.000	1	0	1
	2-W7-8	27.000	27.000	27.000	1	0	1
	2-W23-11	26.000	26.000	26.000	1	0	1
	2-W18-23	24.833	33.000	19.000	6	0	6
	2-W18-22	24.750	50.000	14.000	4	0	4
	2-W23-10	24.000	24.000	24.000	1	0	1
	2-W18-24	23.167	39.000	14.000	6	0	6
	2-W15-19	23.000	23.000	23.000	1	0	1
	2-W15-20	23.000	23.000	23.000	1	0	1
	6-39-79	23.000	23.000	23.000	1	0	1
	2-W19-21	21.500	23.000	20.000	2	0	2
	6-32-70B	21.000	21.000	21.000	1	0	1
	6-35-66	21.000	21.000	21.000	1	0	1
	6-35-78A	21.000	21.000	21.000	1	0	1
	2-W9-1	18.500	24.000	15.000	4	0	4
	6-44-64	18.500	19.000	18.000	2	0	2
	2-W18-17	18.000	18.000	18.000	2	0	2
	2-W7-6	18.000	21.000	13.000	3	0	3
	2-W7-1	17.500	21.000	14.000	4	0	4
	2-W10-14	17.400	21.000	15.000	5	0	5
	2-W10-13	17.333	21.000	13.000	6	0	6
	2-W7-3	17.000	21.000	13.000	5	0	5
	6-45-69A	17.000	17.000	17.000	1	0	1
	2-W8-1	16.250	17.000	15.000	4	0	4
	2-W7-2	15.000	19.000	13.000	4	0	4
	2-W6-2	13.000	19.000	11.000	6	2	8
	2-W7-5	12.750	18.000	10.000	4	0	4
	2-W7-4	12.500	14.000	11.000	4	0	4
	6-49-79	11.000	11.000	11.000	1	0	1
Cadmium							
	2-W19-1	94.000	94.000	94.000	1	0	1
	2-W10-8	93.000	93.000	93.000	1	0	1
	2-W18-20	22.000	22.000	22.000	1	0	1
	2-W15-17	18.778	55.000	15.000	4	5	9
	2-W15-24	8.750	5.000	5.000	1	3	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Cadmium							
	2-W14-10	7.500	13.000	13.000	1	1	2
	2-W7-6	6.444	10.000	4.000	3	6	9
	2-W19-26	6.000	2.000	2.000	1	1	2
	2-W18-9	5.000	5.000	5.000	1	0	1
	2-W7-5	4.889	4.000	4.000	1	8	9
	2-W9-1	4.778	3.000	3.000	1	8	9
	2-W7-4	4.500	3.000	3.000	1	9	10
	2-W18-17	4.143	16.000	3.000	2	5	7
	2-W11-14	4.000	4.000	4.000	1	0	1
	2-W18-23	3.889	3.000	3.000	1	8	9
	2-W18-4	3.000	3.000	3.000	1	0	1
Cadmium, filtered							
	2-W8-1	4.889	4.000	4.000	1	8	9
	2-W18-24	4.600	4.000	4.000	1	9	10
	2-W27-1	4.000	2.000	2.000	1	7	8
	2-W22-20	3.800	3.000	3.000	1	4	5
	6-38-70	3.333	2.000	2.000	1	5	6
	2-W22-26	2.000	2.000	2.000	1	1	2
Calcium							
	2-W19-19	308000.000	308000.000	308000.000	1	0	1
	2-W19-24	273500.000	297000.000	250000.000	2	0	2
	2-W19-30	260000.000	260000.000	260000.000	1	0	1
	2-W19-26	259500.000	289000.000	230000.000	2	0	2
	2-W19-20	247666.667	257000.000	240000.000	3	0	3
	2-W19-25	236000.000	236000.000	236000.000	1	0	1
	2-W15-8	180500.000	250000.000	111000.000	2	0	2
	2-W19-23	139000.000	139000.000	139000.000	1	0	1
	2-W19-29	120000.000	140000.000	100000.000	2	0	2
	2-W19-28	108000.000	108000.000	108000.000	1	0	1
	6-38-70	100000.000	100000.000	100000.000	1	0	1
	2-W11-7	97800.000	97800.000	97800.000	1	0	1
	2-W22-20	87733.333	92000.000	83000.000	3	0	3
	2-W11-14	83400.000	83400.000	83400.000	1	0	1
	2-W22-42	80000.000	88000.000	68000.000	3	0	3
	2-W22-41	78666.667	90000.000	67000.000	3	0	3
	2-W15-11	70800.000	70800.000	70800.000	1	0	1
	2-W15-12	70400.000	70400.000	70400.000	1	0	1
	2-W11-23	64700.000	64700.000	64700.000	1	0	1
	2-W18-5	63300.000	63300.000	63300.000	1	0	1
	2-W15-16	62287.500	72400.000	56000.000	8	0	8
	2-W14-2	60100.000	63200.000	57000.000	2	0	2
	2-W19-18	59100.000	82200.000	36000.000	2	0	2
	2-W15-10	56000.000	56000.000	56000.000	1	0	1
	2-W7-4	55350.000	63900.000	52300.000	10	0	10
	2-W10-18	55000.000	57000.000	51000.000	4	0	4
	2-W14-10	51800.000	82100.000	21500.000	2	0	2
	2-W10-9	51320.000	60000.000	40100.000	5	0	5
	2-W27-1	51200.000	52600.000	49800.000	2	0	2
	2-W15-22	47333.333	52000.000	41000.000	3	0	3
	6-40-62	47000.000	47000.000	47000.000	1	0	1
	2-W7-1	46600.000	50700.000	42000.000	9	0	9
	2-W8-1	46255.556	52400.000	42000.000	9	0	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Calcium							
	2-W15-19	45400.000	49000.000	39200.000	3	0	3
	2-W10-8	45100.000	45100.000	45100.000	1	0	1
	6-49-79	45000.000	45000.000	45000.000	1	0	1
	2-W10-15	43971.429	48000.000	33800.000	7	0	7
	2-W19-11	43900.000	43900.000	43900.000	1	0	1
	6-36-61A	43000.000	43000.000	43000.000	1	0	1
	2-W6-2	42233.333	46100.000	38000.000	12	0	12
	2-W9-1	42033.333	45300.000	37000.000	9	0	9
	6-35-70	42000.000	42000.000	42000.000	1	0	1
	6-45-69A	42000.000	42000.000	42000.000	1	0	1
	2-W19-13	41400.000	41400.000	41400.000	1	0	1
	2-W7-5	40277.778	44800.000	38400.000	9	0	9
	2-W10-13	40140.000	44000.000	37000.000	10	0	10
	2-W22-40	38750.000	40000.000	37000.000	4	0	4
	2-W15-17	38544.444	42800.000	35200.000	9	0	9
	2-W19-31	37333.333	38000.000	37000.000	3	0	3
	2-W15-18	36387.500	41600.000	32900.000	8	0	8
	2-W19-3	36100.000	36100.000	36100.000	1	0	1
	2-W10-16	35760.000	38000.000	29800.000	5	0	5
	2-W10-14	34811.111	37200.000	32000.000	9	0	9
	2-W7-9	34500.000	37000.000	30000.000	4	0	4
	2-W7-8	33150.000	36000.000	31600.000	4	0	4
	6-48-71	33000.000	33000.000	33000.000	1	0	1
	2-W15-7	32950.000	34000.000	31900.000	2	0	2
	2-W22-43	32750.000	34000.000	31000.000	4	0	4
	2-W19-32	32500.000	34000.000	31000.000	2	0	2
	2-W22-21	32000.000	32000.000	32000.000	1	0	1
	2-W18-22	31925.000	40100.000	2200.000	8	0	8
	2-W7-10	31000.000	31000.000	31000.000	3	0	3
	6-37-82A	31000.000	31000.000	31000.000	1	0	1
	2-W7-2	30711.111	35900.000	26000.000	9	0	9
	2-W7-7	29425.000	31000.000	27700.000	4	0	4
	2-W7-3	29320.000	32000.000	28400.000	10	0	10
	2-W15-23	28666.667	29000.000	28000.000	3	0	3
	2-W7-6	28244.444	47900.000	12000.000	9	0	9
	2-W22-22	27900.000	27900.000	27900.000	1	0	1
	2-W15-20	27450.000	28000.000	26000.000	4	0	4
	2-W18-26	27325.000	29000.000	26300.000	4	0	4
	6-32-77	27000.000	27000.000	27000.000	1	0	1
	2-W14-5	26300.000	26300.000	26300.000	1	0	1
	2-W10-17	26250.000	28000.000	24000.000	4	0	4
	2-W15-15	26128.571	35000.000	21900.000	7	0	7
	2-W26-6	26000.000	26000.000	26000.000	1	0	1
	2-W18-23	25922.222	29200.000	24000.000	9	0	9
	2-W15-24	25600.000	28000.000	24000.000	4	0	4
	2-W18-24	24200.000	27400.000	21000.000	9	0	9
	2-W18-17	24014.286	26600.000	18900.000	7	0	7
	2-W23-11	24000.000	24000.000	24000.000	1	0	1
	2-W23-13	23666.667	25000.000	22000.000	3	0	3
	2-W10-4	23600.000	23600.000	23600.000	1	0	1
	2-W18-15	23500.000	23500.000	23500.000	1	0	1
	2-W15-4	22800.000	22800.000	22800.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Calcium							
	2-W19-1	22600.000	22600.000	22600.000	1	0	1
	2-W22-39	22000.000	24000.000	21000.000	3	0	3
	2-W18-21	21577.778	23900.000	20200.000	9	0	9
	2-W19-12	21000.000	21000.000	21000.000	1	0	1
	2-W26-9	21000.000	21000.000	21000.000	3	0	3
	2-W26-8	18750.000	22000.000	12000.000	4	0	4
	2-W18-9	18300.000	18300.000	18300.000	1	0	1
	2-W19-21	17350.000	17900.000	16800.000	2	0	2
	2-W18-4	17200.000	17200.000	17200.000	1	0	1
	2-W18-25	17000.000	18000.000	16000.000	3	0	3
	2-W19-27	16700.000	16700.000	16700.000	1	0	1
	2-W22-1	16100.000	16100.000	16100.000	1	0	1
	2-W18-20	16000.000	16000.000	16000.000	1	0	1
	2-W23-14	15333.333	16000.000	15000.000	3	0	3
Calcium, filtered							
	2-W19-19	304500.000	325000.000	284000.000	2	0	2
	2-W19-24	271800.000	315000.000	244000.000	5	0	5
	2-W19-26	266000.000	312000.000	220000.000	2	0	2
	2-W19-20	252500.000	276000.000	232000.000	6	0	6
	2-W15-8	240000.000	240000.000	240000.000	1	0	1
	2-W19-25	236000.000	250000.000	222000.000	2	0	2
	2-W19-23	149500.000	152000.000	147000.000	2	0	2
	2-W19-29	110000.000	130000.000	100000.000	3	0	3
	2-W19-28	106275.000	180000.000	24200.000	4	0	4
	6-38-70	96200.000	101000.000	91800.000	6	0	6
	2-W19-2	92600.000	92600.000	92600.000	1	0	1
	2-W22-20	88100.000	97600.000	76300.000	5	0	5
	2-W22-41	80333.333	88000.000	73000.000	3	0	3
	2-W14-10	76600.000	76600.000	76600.000	1	0	1
	2-W11-23	65100.000	65100.000	65100.000	1	0	1
	6-38-65	65100.000	65700.000	64500.000	2	0	2
	2-W15-11	64066.667	75000.000	57800.000	3	0	3
	2-W22-42	62666.667	84000.000	33000.000	3	0	3
	2-W15-16	58877.778	65000.000	55400.000	9	0	9
	2-W18-5	58200.000	64300.000	54200.000	3	0	3
	2-W15-10	57666.667	59400.000	56000.000	3	0	3
	2-W19-18	57580.000	79800.000	37000.000	5	0	5
	2-W14-2	56550.000	63700.000	51000.000	4	0	4
	2-W19-15	54980.000	69200.000	37800.000	5	0	5
	2-W10-18	54500.000	57000.000	49000.000	4	0	4
	2-W7-4	53900.000	64600.000	48900.000	10	0	10
	2-W14-5	50200.000	84300.000	26700.000	3	0	3
	2-W15-22	49333.333	53000.000	46000.000	3	0	3
	6-40-62	48275.000	49400.000	47000.000	4	0	4
	6-35-66	48075.000	51900.000	44700.000	4	0	4
	2-W15-19	46466.667	49000.000	41400.000	3	0	3
	6-49-79	45420.000	49900.000	43400.000	5	0	5
	2-W10-9	45400.000	55000.000	39000.000	4	0	4
	2-W8-1	45300.000	51900.000	42000.000	9	0	9
	2-W23-10	45280.000	52200.000	40100.000	5	0	5
	2-W7-1	45222.222	48400.000	40100.000	9	0	9
	6-44-64	43860.000	46000.000	40800.000	5	0	5

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Calcium, filtered							
	2-W7-5	43566.667	62600.000	38300.000	9	0	9
	2-W10-15	43100.000	51000.000	33500.000	5	0	5
	6-36-61A	42460.000	45900.000	38900.000	5	0	5
	6-35-70	42400.000	45300.000	41000.000	4	0	4
	2-W27-1	41700.000	52300.000	30000.000	8	0	8
	2-W6-2	41650.000	45700.000	38800.000	14	0	14
	6-45-69A	41633.333	43900.000	40000.000	3	0	3
	2-W9-1	41122.222	44600.000	37000.000	9	0	9
	2-W14-6	40866.667	45500.000	38400.000	6	0	6
	2-W19-13	39800.000	41300.000	37300.000	3	0	3
	2-W15-17	39700.000	42000.000	37700.000	5	0	5
	2-W10-13	39520.000	45000.000	35500.000	10	0	10
	6-47-60	38500.000	41800.000	36400.000	3	0	3
	6-50-85	38300.000	39600.000	36900.000	3	0	3
	2-W22-40	38250.000	39000.000	37000.000	4	0	4
	6-43-88	37900.000	37900.000	37900.000	1	0	1
	2-W19-31	37666.667	38000.000	37000.000	3	0	3
	2-W19-11	37650.000	45200.000	30100.000	2	0	2
	6-32-70B	36525.000	37800.000	35500.000	4	0	4
	6-48-71	36500.000	39000.000	34000.000	2	0	2
	2-W10-16	35880.000	39000.000	29400.000	5	0	5
	2-W15-18	35875.000	42000.000	31800.000	8	0	8
	2-W18-22	35775.000	38500.000	33900.000	8	0	8
	6-32-72	35766.667	37400.000	33000.000	3	0	3
	2-W10-14	34400.000	36400.000	32000.000	9	0	9
	2-W7-9	34050.000	38000.000	28200.000	4	0	4
	2-W15-7	33733.333	35900.000	32300.000	3	0	3
	2-W7-8	33550.000	36000.000	31200.000	4	0	4
	2-W15-4	33350.000	42200.000	24500.000	2	0	2
	2-W22-22	33340.000	38100.000	27300.000	5	0	5
	2-W22-43	32750.000	34000.000	32000.000	4	0	4
	2-W19-16	32560.000	34600.000	30600.000	5	0	5
	6-37-82A	31800.000	32600.000	31000.000	2	0	2
	2-W19-32	31500.000	32000.000	31000.000	2	0	2
	2-W7-10	31333.333	32000.000	31000.000	3	0	3
	2-W19-3	30725.000	34900.000	24700.000	4	0	4
	2-W19-9	30600.000	33200.000	27600.000	4	0	4
	2-W22-21	30000.000	30000.000	30000.000	1	0	1
	6-51-75	30000.000	30000.000	30000.000	1	0	1
	2-W7-2	29488.889	33900.000	27000.000	9	0	9
	2-W7-7	29475.000	31000.000	27900.000	4	0	4
	2-W15-23	29333.333	31000.000	28000.000	3	0	3
	2-W15-20	29150.000	36000.000	25000.000	4	0	4
	2-W7-3	28800.000	30500.000	25000.000	10	0	10
	2-W10-8	28400.000	28400.000	28400.000	1	0	1
	2-W18-26	27150.000	29000.000	26000.000	4	0	4
	2-W15-6	27000.000	27000.000	27000.000	1	0	1
	2-W19-12	26700.000	26700.000	26700.000	1	0	1
	2-W22-12	26550.000	28000.000	25100.000	2	0	2
	6-32-77	26266.667	27400.000	25200.000	3	0	3
	2-W26-6	26000.000	26000.000	26000.000	1	0	1
	2-W18-23	25866.667	28700.000	24000.000	9	0	9

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Calcium, filtered							
	6-29-78	25733.333	27700.000	24200.000	3	0	3
	2-W15-15	25437.500	35000.000	22300.000	8	0	8
	2-W10-17	25250.000	26000.000	23000.000	4	0	4
	2-W18-17	24000.000	24200.000	23800.000	2	0	2
	2-W15-24	23875.000	26000.000	20500.000	4	0	4
	2-W18-24	23870.000	27700.000	21000.000	10	0	10
	2-W10-4	23800.000	24900.000	22800.000	3	0	3
	2-W18-15	22700.000	23600.000	21000.000	3	0	3
	2-W22-39	22000.000	24000.000	20000.000	3	0	3
	2-W23-13	22000.000	23000.000	21000.000	3	0	3
	6-39-79	21600.000	23700.000	20200.000	4	0	4
	2-W26-9	21333.333	22000.000	21000.000	3	0	3
	2-W23-11	21300.000	21600.000	21000.000	2	0	2
	2-W18-21	21222.222	23000.000	18000.000	9	0	9
	2-W22-26	20850.000	21800.000	19900.000	2	0	2
	2-W19-5	19050.000	19900.000	18200.000	2	0	2
	2-W7-6	18714.286	41000.000	10000.000	7	0	7
	2-W18-25	18000.000	19000.000	17000.000	3	0	3
	2-W26-8	18000.000	21000.000	12000.000	4	0	4
	2-W19-21	17600.000	20200.000	15700.000	5	0	5
	2-W22-1	17566.667	19200.000	16500.000	3	0	3
	6-35-78A	16750.000	17100.000	16400.000	2	0	2
	2-W19-27	16000.000	16400.000	15600.000	2	0	2
	2-W23-14	15333.333	16000.000	15000.000	3	0	3
a Carbon Tetrachloride by GC							
	2-W15-16	6558.889	8700.000	1780.000	9	0	9
	2-W15-11	4900.000	5550.000	4350.000	3	0	3
	2-W15-10	3620.000	4200.000	2800.000	4	0	4
	2-W18-5	3516.667	3640.000	3310.000	3	0	3
	2-W10-4	2643.333	2800.000	2590.000	3	0	3
	2-W11-7	2290.000	2500.000	2080.000	2	0	2
	2-W15-7	2133.333	2390.000	1700.000	3	0	3
	2-W10-9	2000.000	2300.000	1700.000	2	0	2
	2-W15-4	1960.000	2090.000	1830.000	2	0	2
	2-W15-12	1580.000	1920.000	1320.000	3	0	3
	2-W15-18	1367.875	2600.000	14.000	8	0	8
	2-W15-22	1230.000	1600.000	860.000	2	0	2
	2-W15-19	1227.500	1500.000	710.000	4	0	4
	2-W10-18	1100.000	1100.000	1100.000	1	0	1
	2-W14-2	857.500	1050.000	480.000	4	0	4
	2-W18-24	786.333	1400.000	575.000	9	0	9
	6-39-79	767.500	990.000	430.000	8	0	8
	2-W11-14	766.667	860.000	650.000	3	0	3
	2-W10-16	690.000	690.000	690.000	1	0	1
	2-W18-23	667.600	928.000	195.000	10	0	10
	2-W14-5	630.000	860.000	300.000	3	0	3
	2-W15-8	620.000	1110.000	130.000	2	0	2
	2-W15-15	562.125	1200.000	264.000	8	0	8
	2-W18-17	553.500	2000.000	12.000	4	0	4
	2-W15-23	425.000	690.000	100.000	3	0	3
	2-W14-6	300.000	320.000	280.000	10	0	10
	2-W15-24	262.500	380.000	130.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Carbon Tetrachloride by GC							
	2-W15-20	205.000	230.000	180.000	5	0	5
	2-W7-4	194.273	360.000	158.000	9	2	11
	2-W18-26	191.600	250.000	140.000	5	0	5
	2-W10-17	170.000	170.000	170.000	1	0	1
	2-W18-21	166.444	325.000	92.000	9	0	9
	2-W18-9	165.500	210.000	121.000	2	0	2
	2-W19-16	162.400	209.000	120.000	5	0	5
	2-W18-4	137.333	194.000	98.000	3	0	3
	2-W19-31	130.000	130.000	130.000	1	0	1
	2-W19-11	115.000	115.000	115.000	1	0	1
	2-W19-9	110.250	120.000	99.000	4	0	4
	2-W18-15	106.333	120.000	89.000	3	0	3
	2-W6-2	101.643	132.000	84.000	14	0	14
	2-W19-3	87.667	120.000	49.000	3	0	3
	2-W19-29	86.333	130.000	19.000	3	0	3
	2-W19-15	84.200	127.000	63.000	5	0	5
	2-W19-28	65.750	82.000	50.000	4	0	4
	2-W10-8	49.000	49.000	49.000	1	0	1
	2-W19-18	44.500	89.000	9.000	4	0	4
	6-38-70	37.000	58.000	29.000	5	0	5
	2-W19-13	36.000	39.000	33.000	3	0	3
	2-W7-5	34.818	56.000	23.000	11	0	11
	2-W19-26	31.667	33.000	30.000	3	0	3
	2-W19-20	29.429	42.000	17.000	7	0	7
	2-W19-23	28.500	37.000	20.000	2	0	2
	2-W19-25	26.000	31.000	21.000	2	0	2
	2-W19-2	22.000	22.000	22.000	1	0	1
	2-W19-12	20.000	20.000	20.000	1	0	1
	2-W19-24	19.833	24.000	14.000	6	0	6
	2-W19-30	18.000	18.000	18.000	1	0	1
	2-W19-19	15.000	20.000	10.000	2	0	2
	2-W10-13	12.833	18.000	7.000	12	0	12
	2-W19-27	12.000	17.000	7.000	4	0	4
	2-W22-20	10.160	13.000	7.800	5	0	5
	2-W11-23	9.700	9.700	9.700	1	0	1
	2-W18-20	9.500	14.000	14.000	1	1	2
	2-W22-40	7.750	9.000	7.000	4	0	4
	2-W22-43	7.167	8.800	6.000	3	0	3
	2-W22-41	6.167	6.900	5.000	3	0	3
	2-W7-8	6.140	9.800	5.000	4	1	5
	2-W19-1	6.000	7.000	7.000	1	1	2
	2-W18-25	5.700	5.700	5.700	1	0	1
	2-W22-42	5.000	6.300	4.000	2	1	3
	2-W19-21	3.657	2.700	2.700	1	6	7
Carbon disulfide							
	2-W22-40	39.000	39.000	39.000	1	0	1
	2-W22-41	20.000	20.000	20.000	1	0	1
Carbon-14							
	6-35-70	12.488	19.600	4.080	5	1	6
	2-W19-3	2.216	4.660	4.660	1	3	4
Cerium/Promethium-144							
	2-W15-20	31.000	31.000	31.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Cerium/Promethium-144							
	2-W7-3	29.300	29.300	29.300	1	0	1
Cesium-137							
	2-W15-8	5.215	6.940	6.940	1	1	2
	2-W22-2	4.415	17.200	7.430	2	4	6
	2-W10-18	3.783	8.910	8.910	1	3	4
	2-W22-39	3.733	5.880	5.880	1	2	3
	2-W15-11	3.390	5.070	5.070	1	1	2
	6-55-89	3.020	4.790	4.790	1	2	3
	2-W19-20	2.474	5.390	5.390	1	6	7
	2-W18-24	2.138	4.420	4.420	1	7	8
	2-W6-2	1.985	7.360	7.360	1	12	13
	2-W7-7	1.936	3.570	3.570	1	4	5
	2-W7-4	1.633	4.590	4.590	1	10	11
	2-W15-7	1.183	7.890	7.890	1	2	3
	6-35-70	1.038	3.700	3.700	1	7	8
	2-W10-13	1.037	8.500	3.000	2	8	10
	2-W22-18	.934	4.560	4.560	1	4	5
	2-W14-10	.795	6.010	6.010	1	2	3
	2-W23-1	.644	8.270	8.270	1	5	6
	2-W22-40	.640	4.960	4.960	1	1	2
	2-W15-17	.614	8.240	8.240	1	7	8
	6-38-65	.210	6.710	6.710	1	11	12
	2-W15-24	.078	7.110	7.110	1	3	4
	2-W19-3	-.006	6.140	6.140	1	16	17
Chloride							
	2-W11-14	63933.333	66900.000	59400.000	3	0	3
	2-W14-2	53200.000	62000.000	45800.000	5	0	5
	2-W11-7	49300.000	52700.000	45900.000	2	0	2
	2-W14-6	46800.000	55500.000	5100.000	10	0	10
	2-W15-12	37340.000	49000.000	31000.000	5	0	5
	2-W10-18	35500.000	37000.000	34000.000	2	0	2
	2-W15-8	32820.000	45000.000	23500.000	5	0	5
	2-W14-5	32113.333	48000.000	6940.000	3	0	3
	2-W10-16	30925.000	34000.000	23700.000	4	0	4
	2-W19-2	30400.000	30400.000	30400.000	1	0	1
	2-W10-17	29666.667	30000.000	29000.000	3	0	3
	2-W19-19	29250.000	36500.000	22000.000	2	0	2
	2-W10-8	27700.000	27700.000	27700.000	1	0	1
	2-W22-20	27228.571	33200.000	24000.000	7	0	7
	2-W19-26	27000.000	27000.000	27000.000	3	0	3
	6-38-70	26712.500	32200.000	23000.000	8	0	8
	2-W19-28	26475.000	33000.000	22700.000	4	0	4
	2-W19-30	26000.000	26000.000	26000.000	1	0	1
	2-W19-23	25350.000	26000.000	24700.000	2	0	2
	2-W14-10	24666.667	29100.000	22400.000	3	0	3
	2-W19-15	24220.000	28600.000	18300.000	5	0	5
	2-W10-13	24218.182	32100.000	20600.000	11	0	11
	2-W22-40	22750.000	23000.000	22000.000	4	0	4
	2-W19-20	22657.143	28700.000	18000.000	7	0	7
	2-W10-9	22480.000	25000.000	20600.000	5	0	5
	6-35-70	22433.333	24000.000	21000.000	6	0	6
	2-W10-15	22280.000	27000.000	19400.000	5	0	5

9 2 1 2 6 6 1 0 6 7 1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Chloride							
	2-W15-10	21940.000	22600.000	21400.000	5	0	5
	2-W19-25	21800.000	22900.000	20700.000	2	0	2
	2-W15-16	21466.667	24000.000	17600.000	9	0	9
	2-W19-24	21350.000	25500.000	16000.000	6	0	6
	2-W15-22	20500.000	21000.000	20000.000	2	0	2
	2-W22-43	19500.000	20000.000	18000.000	4	0	4
	2-W15-11	19466.667	23100.000	17500.000	3	0	3
	2-W19-18	19320.000	21900.000	15000.000	5	0	5
	2-W9-1	18730.000	20600.000	17000.000	10	0	10
	2-W19-29	18333.333	19000.000	18000.000	3	0	3
	6-35-66	18060.000	21000.000	16300.000	5	0	5
	2-W22-41	18000.000	19000.000	17000.000	3	0	3
	2-W7-4	17920.000	19300.000	15800.000	10	0	10
	2-W10-4	17133.333	17400.000	16900.000	3	0	3
	2-W15-7	16900.000	30000.000	8000.000	3	0	3
	2-W19-12	16850.000	19700.000	14000.000	2	0	2
	2-W15-4	16150.000	16700.000	15600.000	2	0	2
	2-W22-22	15920.000	16500.000	15500.000	5	0	5
	6-32-72	15850.000	16900.000	14700.000	4	0	4
	2-W8-1	15710.000	17200.000	13400.000	10	0	10
	6-37-82A	15533.333	16000.000	14600.000	3	0	3
	2-W19-3	15325.000	18600.000	11800.000	4	0	4
	2-W15-17	15200.000	16000.000	13700.000	8	0	8
	6-43-88	15100.000	15100.000	15100.000	1	0	1
	2-W22-42	15000.000	15000.000	15000.000	3	0	3
	2-W7-9	14760.000	16000.000	14000.000	5	0	5
	2-W7-5	14170.000	16000.000	12200.000	10	0	10
	6-38-65	14050.000	15000.000	12300.000	4	0	4
	2-W19-11	13900.000	16000.000	11800.000	2	0	2
	2-W15-19	13550.000	15000.000	12000.000	4	0	4
	2-W19-16	13520.000	14500.000	12000.000	5	0	5
	2-W19-9	13475.000	15600.000	12000.000	4	0	4
	2-W22-10	13200.000	13200.000	13200.000	1	0	1
	2-W19-32	13000.000	13000.000	13000.000	1	0	1
	2-W18-8	12200.000	12200.000	12200.000	1	0	1
	6-32-70B	12033.333	12700.000	11700.000	6	0	6
	2-W19-13	12000.000	14400.000	10600.000	3	0	3
	2-W22-9	12000.000	12000.000	12000.000	1	0	1
	6-44-64	11850.000	14000.000	9800.000	6	0	6
	6-47-60	9553.333	10400.000	8610.000	3	0	3
	2-W18-22	9461.250	11000.000	8600.000	8	0	8
	2-W7-1	9327.000	11000.000	7250.000	10	0	10
	2-W18-26	9320.000	12000.000	7800.000	5	0	5
	6-40-62	9141.429	9650.000	8620.000	7	0	7
	2-W18-4	9070.000	9800.000	8300.000	4	0	4
	2-W10-14	9024.000	10000.000	7640.000	10	0	10
	6-50-85	8970.000	9960.000	7620.000	3	0	3
	2-W15-18	8700.000	38300.000	3700.000	8	0	8
	6-36-61A	8363.333	9400.000	7060.000	6	0	6
	2-W23-1	8100.000	8100.000	8100.000	1	0	1
	6-49-79	7920.000	10000.000	1000.000	6	0	6
	6-45-69A	7872.500	8100.000	7500.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Chloride							
	2-W15-6	7400.000	7400.000	7400.000	1	0	1
	2-W19-31	6850.000	6900.000	6800.000	2	0	2
	6-32-77	6765.000	8130.000	5810.000	4	0	4
	2-W27-1	6711.250	9700.000	5200.000	8	0	8
	2-W26-6	6700.000	7200.000	6200.000	2	0	2
	6-36-61B	6700.000	6700.000	6700.000	1	0	1
	2-W7-8	6360.000	6900.000	6000.000	5	0	5
	6-48-71	5903.333	6210.000	5700.000	3	0	3
	2-W23-13	5900.000	6400.000	5400.000	2	0	2
	2-W7-6	5855.000	6400.000	5100.000	10	0	10
	2-W19-1	5833.333	7300.000	4800.000	3	0	3
	2-W22-12	5820.000	6180.000	5600.000	4	0	4
	2-W15-23	5600.000	5800.000	5400.000	3	0	3
	2-W22-21	5600.000	5600.000	5600.000	1	0	1
	2-W22-39	5600.000	6100.000	5100.000	2	0	2
	2-W26-9	5566.667	7000.000	3000.000	3	0	3
	2-W6-2	5428.667	6800.000	3500.000	15	0	15
	2-W11-23	5400.000	6400.000	4400.000	2	0	2
	6-29-78	5207.500	5790.000	4000.000	4	0	4
	2-W15-20	4820.000	5000.000	4700.000	5	0	5
	2-W18-5	4720.000	4970.000	4400.000	3	0	3
	2-W7-10	4566.667	4700.000	4400.000	3	0	3
	2-W18-9	4555.000	4700.000	4410.000	2	0	2
	2-W26-3	4500.000	4500.000	4500.000	1	0	1
	2-W7-2	4408.000	9000.000	3000.000	10	0	10
	2-W7-3	4240.909	4600.000	3650.000	11	0	11
	2-W7-7	4140.000	4500.000	3900.000	5	0	5
	2-W18-24	4038.889	4900.000	3450.000	9	0	9
	2-W18-20	4033.333	4200.000	3900.000	3	0	3
	2-W15-24	4025.000	4700.000	3300.000	4	0	4
	2-W23-10	3966.000	4300.000	3530.000	5	0	5
	2-W22-26	3785.000	3870.000	3700.000	2	0	2
	6-39-79	3715.556	4010.000	3400.000	9	0	9
	2-W15-15	3662.500	5400.000	2940.000	8	0	8
	2-W18-17	3464.000	3800.000	3100.000	5	0	5
	2-W22-1	3403.333	3420.000	3390.000	3	0	3
	2-W18-15	3376.667	3760.000	3100.000	3	0	3
	2-W26-8	3375.000	3500.000	3300.000	4	0	4
	2-W18-23	3252.727	3900.000	2800.000	11	0	11
	2-W18-21	3150.000	3700.000	2800.000	9	0	9
	6-35-78A	3033.333	3100.000	3000.000	3	0	3
	2-W23-9	3000.000	3300.000	2700.000	2	0	2
	2-W22-2	2750.000	3300.000	2200.000	2	0	2
	6-51-75	2700.000	2700.000	2700.000	1	0	1
	2-W19-5	2380.000	2560.000	2200.000	2	0	2
	2-W23-11	2350.000	2700.000	2000.000	2	0	2
	2-W23-14	1850.000	2000.000	1700.000	2	0	2
	2-W23-4	1800.000	1800.000	1800.000	1	0	1
	2-W18-25	1300.000	1300.000	1300.000	2	0	2
	2-W19-27	1200.000	1300.000	1100.000	3	0	3
	2-W19-21	1097.167	1400.000	873.000	6	0	6

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Chloroform							
	2-W15-8	1595.000	1650.000	1540.000	2	0	2
	2-W18-4	520.667	632.000	420.000	3	0	3
	2-W15-19	158.000	179.000	110.000	4	0	4
	2-W18-17	100.750	204.000	13.000	4	0	4
	2-W15-16	44.667	71.000	33.000	7	2	9
	2-W15-24	44.500	60.000	31.000	4	0	4
	2-W15-11	31.333	40.000	21.000	3	0	3
	2-W11-7	26.000	37.000	15.000	2	0	2
	2-W18-20	25.500	26.000	25.000	2	0	2
	2-W18-5	24.667	28.000	19.000	3	0	3
	2-W15-12	23.000	26.000	20.000	3	0	3
	2-W18-26	21.200	38.000	14.000	5	0	5
	2-W15-10	20.750	27.000	13.000	4	0	4
	2-W10-4	19.000	21.000	16.000	3	0	3
	2-W18-24	18.667	23.000	13.000	9	0	9
	2-W15-22	18.500	19.000	18.000	2	0	2
	2-W15-4	17.500	19.000	16.000	2	0	2
	2-W15-18	16.500	28.000	12.000	6	2	8
	2-W15-7	16.000	24.000	19.000	2	1	3
	2-W10-9	15.000	16.000	14.000	2	0	2
	2-W10-18	13.000	13.000	13.000	1	0	1
	2-W18-9	13.000	19.000	7.000	2	0	2
	2-W22-20	9.400	12.000	8.000	5	0	5
	2-W27-1	8.857	14.000	6.000	6	1	7
	2-W15-20	8.820	11.000	6.400	5	0	5
	2-W14-2	8.450	12.000	5.800	4	0	4
	2-W10-16	7.900	7.900	7.900	1	0	1
	2-W19-28	7.375	10.000	5.200	4	0	4
	2-W14-5	6.667	12.000	12.000	1	2	3
	2-W18-23	6.520	12.000	5.000	9	1	10
	2-W11-14	6.000	10.000	10.000	1	2	3
	2-W19-29	5.833	6.300	6.200	2	1	3
	2-W15-15	5.750	10.000	5.000	4	4	8
	2-W19-23	5.500	7.000	7.000	1	1	2
	6-39-79	5.500	6.000	5.000	7	1	8
	2-W15-23	5.433	6.000	5.300	2	1	3
	2-W7-4	5.427	6.400	5.000	11	0	11
	2-W10-14	5.200	7.000	7.000	1	9	10
	2-W18-21	4.878	7.000	3.900	3	6	9
	2-W19-20	4.600	6.000	5.400	2	5	7
	2-W19-16	4.600	5.000	5.000	3	2	5
	2-W19-24	4.483	6.000	5.900	2	4	6
	2-W15-17	4.350	1.800	1.800	1	7	8
	2-W19-25	4.000	5.000	5.000	1	1	2
	2-W19-9	3.750	5.000	5.000	1	3	4
	2-W14-6	3.300	6.000	6.000	1	9	10
	2-W22-42	2.353	.860	.860	1	2	3
	2-W22-40	2.150	1.100	1.100	1	3	4
Chromium							
	2-W10-8	6180.000	6180.000	6180.000	1	0	1
	2-W7-9	603.250	1700.000	100.000	4	0	4
	2-W14-2	574.000	850.000	298.000	2	0	2

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Chromium							
	2-W22-20	375.333	500.000	310.000	3	0	3
	2-W7-10	370.000	500.000	210.000	3	0	3
	2-W19-32	260.000	360.000	160.000	2	0	2
	2-W7-8	246.750	300.000	147.000	4	0	4
	2-W10-16	235.600	360.000	100.000	5	0	5
	2-W15-8	194.000	340.000	48.000	2	0	2
	2-W10-15	190.571	230.000	140.000	7	0	7
	2-W10-9	187.600	220.000	157.000	5	0	5
	2-W10-18	176.000	270.000	44.000	4	0	4
	2-W15-17	161.111	577.000	29.000	9	0	9
	2-W19-1	149.000	149.000	149.000	1	0	1
	2-W23-14	126.667	160.000	90.000	3	0	3
	2-W26-8	123.500	150.000	94.000	4	0	4
	2-W7-7	107.500	150.000	64.000	4	0	4
	2-W15-22	102.333	130.000	47.000	3	0	3
	2-W19-29	100.000	180.000	180.000	1	1	2
	2-W15-24	98.500	170.000	25.000	4	0	4
	2-W26-9	96.333	220.000	32.000	3	0	3
	2-W6-2	90.250	170.000	44.000	12	0	12
	2-W18-21	88.778	280.000	30.000	9	0	9
	2-W22-42	83.333	130.000	100.000	2	1	3
	2-W7-3	76.500	150.000	25.000	10	0	10
	2-W10-14	76.000	140.000	34.000	9	0	9
	2-W7-4	75.300	144.000	23.000	10	0	10
	2-W10-17	74.750	110.000	52.000	4	0	4
	2-W18-22	74.125	107.000	29.000	8	0	8
	2-W15-16	71.250	142.000	44.000	8	0	8
	2-W11-18	69.125	129.000	36.000	8	0	8
	2-W22-40	69.000	100.000	23.000	4	0	4
	2-W18-24	68.778	140.000	22.000	9	0	9
	2-W10-4	66.000	66.000	66.000	1	0	1
	2-W18-26	65.250	140.000	18.000	4	0	4
	2-W15-12	65.000	65.000	65.000	1	0	1
	2-W7-5	64.222	180.000	23.000	9	0	9
	2-W19-31	64.000	110.000	37.000	3	0	3
	2-W7-6	60.778	230.000	16.000	8	1	9
	2-W22-39	58.333	83.000	32.000	3	0	3
	2-W6-5	58.333	186.000	18.000	9	0	9
	2-W8-1	57.556	160.000	23.000	9	0	9
	2-W7-1	55.889	130.000	29.000	9	0	9
	2-W18-25	55.333	78.000	38.000	3	0	3
	2-W22-43	55.250	81.000	60.000	3	1	4
	2-W23-13	54.333	71.000	24.000	3	0	3
	2-W15-20	53.250	130.000	22.000	3	1	4
	2-W22-21	52.000	52.000	52.000	1	0	1
	2-W7-2	51.889	190.000	20.000	9	0	9
	2-W18-20	51.000	51.000	51.000	1	0	1
	2-W10-13	50.400	89.000	24.000	10	0	10
	2-W18-23	47.111	68.000	24.000	9	0	9
	2-W11-7	47.000	47.000	47.000	1	0	1
	2-W19-28	47.000	47.000	47.000	1	0	1
	2-W15-15	46.714	108.000	13.000	6	1	7

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Chromium							
	2-W11-14	46.000	46.000	46.000	1	0	1
	2-W15-19	43.000	74.000	20.000	3	0	3
	2-W22-41	36.000	61.000	27.000	2	1	3
	2-W19-12	35.000	35.000	35.000	1	0	1
	2-W15-11	31.000	31.000	31.000	1	0	1
	2-W15-23	28.000	44.000	44.000	1	2	3
	2-W18-9	28.000	28.000	28.000	1	0	1
	2-W18-17	23.714	85.000	13.000	4	3	7
	2-W18-4	22.000	22.000	22.000	1	0	1
	2-W18-5	21.000	21.000	21.000	1	0	1
	2-W27-1	17.000	21.000	13.000	2	0	2
	2-W15-10	14.000	14.000	14.000	1	0	1
	2-W14-10	13.000	16.000	16.000	1	1	2
	2-W19-19	11.000	11.000	11.000	1	0	1
	2-W19-3	11.000	11.000	11.000	1	0	1
	2-W19-23	10.000	10.000	10.000	1	0	1
Chromium, filtered							
	2-W22-20	322.600	350.000	296.000	5	0	5
	2-W10-9	149.250	170.000	135.000	4	0	4
	2-W10-15	136.800	170.000	94.000	5	0	5
	2-W7-9	83.000	280.000	22.000	2	2	4
	2-W10-4	64.333	65.000	63.000	3	0	3
	2-W19-12	49.000	49.000	49.000	1	0	1
	2-W7-6	43.286	220.000	23.000	2	5	7
	2-W22-21	40.000	40.000	40.000	1	0	1
	2-W10-16	34.200	41.000	27.000	5	0	5
	2-W19-32	34.000	34.000	34.000	2	0	2
	2-W26-9	33.667	61.000	61.000	1	2	3
	2-W6-2	33.500	59.000	24.000	14	0	14
	2-W10-18	32.500	54.000	22.000	3	1	4
	2-W10-17	27.500	30.000	24.000	4	0	4
	2-W15-11	27.333	33.000	22.000	3	0	3
	6-32-70B	22.750	25.000	20.000	4	0	4
	6-35-66	22.750	26.000	20.000	4	0	4
	2-W22-43	21.750	27.000	27.000	1	3	4
	2-W22-40	21.000	24.000	24.000	1	3	4
	2-W22-42	21.000	23.000	23.000	1	2	3
	2-W15-18	20.000	58.000	13.000	4	4	8
	2-W19-31	20.000	20.000	20.000	1	2	3
	2-W7-8	18.500	24.000	24.000	1	3	4
	2-W15-17	18.400	32.000	32.000	1	4	5
	2-W18-26	18.250	23.000	23.000	1	3	4
	2-W15-10	17.333	21.000	15.000	3	0	3
	2-W27-1	15.750	24.000	11.000	5	3	8
	2-W18-23	15.333	48.000	48.000	1	8	9
	2-W7-2	14.889	17.000	11.000	5	4	9
	2-W7-4	14.800	18.000	11.000	4	6	10
	2-W7-5	14.222	15.000	10.000	5	4	9
	6-36-61A	14.200	15.000	13.000	3	2	5
	2-W7-1	14.000	16.000	16.000	1	8	9
	2-W8-1	14.000	14.000	12.000	2	7	9
	2-W18-21	13.778	29.000	10.000	3	6	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Chromium, filtered							
	2-W18-5	13.667	14.000	13.000	3	0	3
	2-W10-14	13.556	12.000	12.000	[illegible]	8	9
	2-W9-1	13.556	11.000	10.000	3	6	9
	2-W10-13	13.500	15.000	15.000	1	9	10
	2-W15-16	13.222	12.000	11.000	5	4	9
	2-W19-18	12.800	12.000	12.000	2	3	5
	2-W14-2	12.500	10.000	10.000	1	3	4
	6-35-78A	11.500	13.000	13.000	1	1	2
	2-W19-24	11.000	15.000	15.000	1	4	5
	2-W14-6	10.167	11.000	11.000	1	5	6
	2-W10-8	10.000	10.000	10.000	1	0	1
	2-W19-3	10.000	10.000	10.000	1	3	4
Citrus red							
	2-W7-6	2492.500	6940.000	1030.000	2	2	4
Cobalt, filtered							
	2-W22-43	21.500	26.000	26.000	1	3	4
Cobalt-60							
	2-W15-7	12.567	14.000	13.000	2	1	3
	2-W10-3	8.565	16.600	5.890	4	2	6
	2-W19-18	7.801	77.800	52.900	2	15	17
	2-W19-32	5.760	5.590	5.590	1	1	2
	2-W10-1	5.085	11.400	8.400	3	3	6
	6-55-89	4.830	7.370	5.050	2	1	3
	2-W22-20	4.178	13.100	5.220	3	5	8
	2-W15-22	3.581	11.600	11.600	1	2	3
	2-W15-3	3.063	9.920	4.310	2	2	4
	2-W19-11	3.012	7.480	7.480	1	2	3
	2-W22-41	2.970	2.970	2.970	1	0	1
	2-W18-15	2.912	6.830	6.830	1	4	5
	2-W7-5	2.244	6.140	6.140	1	9	10
	2-W10-4	2.235	6.430	6.430	1	1	2
	2-W14-10	2.087	6.790	6.790	1	2	3
	2-W15-23	1.927	7.490	3.090	2	1	3
	6-47-60	1.327	5.690	5.690	1	5	6
	2-W19-13	1.212	9.910	9.910	1	4	5
	2-W19-16	1.192	3.980	3.980	1	4	5
	2-W9-1	1.007	8.280	8.280	1	9	10
	6-35-78A	.970	5.060	5.060	1	6	7
	2-W23-10	.959	6.760	6.760	1	4	5
	2-W19-19	.845	5.070	3.380	2	8	10
	6-38-65	.680	8.890	5.470	2	10	12
	6-32-77	.662	9.930	5.000	2	3	5
	2-W15-17	.660	3.650	3.650	1	7	8
	2-W19-20	.651	7.570	7.570	1	6	7
	2-W7-4	.481	10.000	[illegible]	2	9	11
	2-W22-1	.425	0.000	0.000	1	3	4
	2-W18-24	.328	7.290	7.290	1	7	8
	2-W10-13	.005	7.290	0.000	2	8	10
	2-W10-14	-.237	6.200	6.140	2	8	10
	2-W15-15	-.316	10.300	10.300	1	6	7
	2-W7-1	-.369	3.520	3.520	1	10	11
	2-W7-6	-.786	8.590	8.590	1	9	10

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Cobalt-60							
	2-W18-17	-.792	16.800	16.800	1	8	9
	2-W27-1	-1.340	0.000	0.000	1	6	7
Coliform (Membrane Filter)							
	2-W8-1	42.500	84.000	84.000	1	1	2
	2-W6-2	14.250	30.000	25.000	2	2	4
	2-W11-23	6.000	6.000	6.000	1	0	1
	2-W7-7	1.000	1.000	1.000	1	0	1
Coliform bacteria							
	2-W15-15	4.300	16.000	16.000	1	5	6
	2-W19-20	4.000	4.000	4.000	1	0	1
	2-W18-21	2.029	2.200	2.200	1	6	7
	2-W15-19	1.400	1.000	1.000	1	2	3
	2-W22-39	1.333	2.000	2.000	1	2	3
Conductivity, Laboratory							
	2-W19-20	2303.333	2310.000	2300.000	3	0	3
	2-W19-26	2200.000	2300.000	2100.000	2	0	2
	2-W19-24	2190.000	2200.000	2180.000	2	0	2
	2-W19-30	2100.000	2100.000	2100.000	1	0	1
	2-W19-25	2080.000	2080.000	2080.000	1	0	1
	2-W19-19	2060.000	2060.000	2060.000	1	0	1
	2-W19-23	1500.000	1500.000	1500.000	1	0	1
	2-W10-9	1282.000	1400.000	1110.000	5	0	5
	2-W19-28	1179.750	1600.000	955.000	4	0	4
	2-W10-15	1162.000	1200.000	1010.000	5	0	5
	2-W19-29	1116.667	1200.000	950.000	3	0	3
	6-38-70	973.000	973.000	973.000	1	0	1
	2-W22-20	860.500	880.000	841.000	2	0	2
	2-W10-16	832.800	860.000	764.000	5	0	5
	2-W11-14	826.000	826.000	826.000	1	0	1
	2-W19-2	814.000	814.000	814.000	1	0	1
	2-W15-16	606.724	680.000	542.000	29	0	29
	2-W11-23	605.000	605.000	605.000	1	0	1
	2-W15-8	555.000	555.000	555.000	1	0	1
	2-W23-10	521.000	521.000	521.000	1	0	1
	2-W15-19	488.375	520.000	459.000	8	0	8
	2-W19-15	464.000	464.000	464.000	1	0	1
	2-W7-4	448.036	485.000	405.000	28	0	28
	2-W19-18	445.000	445.000	445.000	1	0	1
	2-W15-10	444.000	445.000	443.000	2	0	2
	2-W7-9	431.778	448.000	400.000	9	0	9
	2-W27-1	429.000	544.000	360.000	4	0	4
	2-W19-16	418.000	418.000	418.000	1	0	1
	2-W19-11	417.000	417.000	417.000	1	0	1
	2-W6-2	412.188	456.000	310.000	32	0	32
	2-W15-17	402.875	452.000	380.000	24	0	24
	2-W8-1	396.069	419.000	356.000	29	0	29
	2-W7-1	392.276	417.000	354.000	29	0	29
	2-W9-1	389.759	429.000	353.000	29	0	29
	2-W14-10	384.500	409.000	360.000	2	0	2
	2-W15-18	383.200	440.000	340.000	25	0	25
	2-W19-3	379.000	379.000	379.000	1	0	1
	2-W18-8	376.000	376.000	376.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Conductivity, Laboratory							
	2-W22-22	376.000	376.000	376.000	1	0	1
	2-W7-5	369.448	410.000	327.000	29	0	29
	2-W19-13	362.069	495.000	309.000	29	0	29
	2-W19-12	350.000	350.000	350.000	1	0	1
	2-W18-22	341.500	357.000	321.000	28	0	28
	2-W16-14	339.103	371.000	288.000	29	0	29
	2-W7-6	337.483	450.000	296.000	29	0	29
	2-W7-8	317.000	326.000	305.000	9	0	9
	2-W18-26	307.833	320.000	300.000	12	0	12
	2-W7-3	300.267	323.000	275.000	29	0	29
	2-W15-23	300.000	300.000	300.000	4	0	4
	2-W22-12	298.000	298.000	298.000	1	0	1
	2-W7-2	292.034	320.000	252.000	29	0	29
	2-W7-10	290.000	290.000	290.000	1	0	1
	6-51-75	290.000	290.000	290.000	1	0	1
	2-W7-7	276.222	286.000	265.000	9	0	9
	2-W26-6	271.000	271.000	271.000	1	0	1
	2-W19-1	270.500	290.000	251.000	2	0	2
	2-W18-24	269.885	297.000	235.000	26	0	26
	2-W15-20	266.750	277.000	260.000	12	0	12
	2-W15-15	261.826	316.000	238.000	23	0	23
	2-W15-24	251.625	260.000	242.000	8	0	8
	2-W18-23	250.448	276.000	204.000	29	0	29
	2-W22-2	246.000	246.000	246.000	1	0	1
	2-W26-3	244.000	244.000	244.000	1	0	1
	2-W18-21	238.143	340.000	218.000	28	0	28
	2-W23-11	234.000	234.000	234.000	1	0	1
	6-35-78A	230.000	230.000	230.000	1	0	1
	2-W19-27	213.667	231.000	200.000	3	0	3
	2-W23-9	212.000	212.000	212.000	1	0	1
	2-W23-4	202.000	202.000	202.000	1	0	1
	2-W19-21	195.667	200.000	190.000	3	0	3
	2-W18-9	194.000	194.000	194.000	1	0	1
	2-W18-17	189.500	241.000	138.000	2	0	2
	2-W22-10	177.000	177.000	177.000	1	0	1
	2-W18-20	164.500	167.000	162.000	2	0	2
Copper							
	2-W19-26	126.000	232.000	232.000	1	1	2
	2-W15-8	91.500	100.000	83.000	2	0	2
	2-W10-8	53.000	53.000	53.000	1	0	1
	2-W26-8	47.500	130.000	130.000	1	3	4
	2-W14-10	45.500	78.000	13.000	2	0	2
	2-W7-10	39.667	44.000	31.000	3	0	3
	2-W19-1	38.000	38.000	38.000	1	0	1
	2-W19-32	34.000	35.000	33.000	2	0	2
	2-W15-17	32.889	127.000	12.000	4	5	9
	2-W15-22	29.000	37.000	30.000	2	1	3
	2-W7-9	28.500	47.000	27.000	3	1	4
	2-W15-24	27.500	47.000	23.000	2	2	4
	2-W22-39	26.000	38.000	38.000	1	2	3
	2-W23-14	26.000	38.000	38.000	1	2	3
	2-W7-7	25.750	45.000	28.000	2	2	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Copper							
	2-W18-26	25.500	37.000	35.000	2	2	4
	2-W22-43	25.250	41.000	41.000	1	3	4
	2-W10-18	24.250	30.000	21.000	3	1	4
	2-W19-29	23.500	27.000	27.000	1	1	2
	2-W7-6	23.444	69.000	11.000	6	3	9
	2-W10-16	23.200	36.000	10.000	4	1	5
	2-W22-42	22.667	28.000	28.000	1	2	3
	2-W18-20	21.000	21.000	21.000	1	0	1
	2-W22-41	21.000	22.000	21.000	2	1	3
	2-W26-9	21.000	23.000	23.000	1	2	3
	2-W7-8	21.000	33.000	11.000	2	2	4
	2-W10-15	20.571	29.000	25.000	2	5	7
	2-W18-25	20.000	20.000	20.000	1	2	3
	2-W15-20	18.500	24.000	24.000	1	3	4
	2-W6-2	18.167	53.000	35.000	2	10	12
	2-W14-2	17.000	24.000	24.000	1	1	2
	2-W15-19	16.667	20.000	20.000	1	2	3
	2-W10-14	16.000	33.000	19.000	3	6	9
	2-W7-2	15.667	32.000	29.000	2	7	9
	2-W10-13	15.300	27.000	21.000	3	7	10
	2-W7-4	14.500	35.000	35.000	1	9	10
	2-W7-3	14.200	32.000	32.000	1	9	10
	2-W9-1	14.111	17.000	10.000	2	7	9
	2-W18-9	14.000	14.000	14.000	1	0	1
	2-W7-1	14.000	26.000	26.000	1	8	9
	2-W8-1	14.000	26.000	26.000	1	8	9
	2-W7-5	13.889	25.000	25.000	1	8	9
	2-W18-21	13.556	32.000	32.000	1	8	9
	2-W15-15	11.857	13.000	13.000	1	6	7
	2-W18-17	10.143	11.000	11.000	1	6	7
	2-W19-24	10.000	10.000	10.000	1	1	2
Copper, filtered							
	2-W26-9	25.333	36.000	36.000	1	2	3
	2-W22-39	24.000	32.000	32.000	1	2	3
	2-W22-43	24.000	29.000	27.000	2	2	4
	2-W7-8	23.750	45.000	45.000	1	3	4
	2-W18-26	23.000	42.000	42.000	1	3	4
	2-W26-8	23.000	32.000	32.000	1	3	4
	2-W7-10	21.667	25.000	25.000	1	2	3
	2-W7-9	21.500	36.000	36.000	1	3	4
	2-W22-41	21.000	23.000	23.000	1	2	3
	2-W15-22	20.333	21.000	21.000	1	2	3
	2-W15-20	20.250	31.000	31.000	1	3	4
	2-W22-40	20.000	20.000	20.000	1	3	4
	2-W7-7	19.500	28.000	28.000	1	3	4
	2-W10-16	18.600	23.000	23.000	1	4	5
	2-W10-15	18.400	22.000	22.000	1	4	5
	2-W7-6	17.714	43.000	21.000	2	5	7
	2-W10-14	17.667	53.000	26.000	2	7	9
	2-W9-1	17.444	41.000	36.000	2	7	9
	2-W19-26	17.000	14.000	14.000	1	1	2
	2-W7-5	16.000	30.000	26.000	3	6	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Copper, filtered							
	2-W18-24	15.300	43.000	43.000	1	9	10
	2-W10-13	14.900	39.000	20.000	2	8	10
	2-W7-4	14.900	30.000	29.000	2	8	10
	2-W7-3	14.800	38.000	38.000	1	9	10
	2-W7-1	14.778	33.000	33.000	1	8	9
	2-W6-2	14.357	31.000	31.000	1	13	14
	2-W18-21	14.333	24.000	15.000	2	7	9
	2-W8-1	13.667	23.000	23.000	1	8	9
	2-W15-18	12.500	10.000	10.000	1	7	8
	2-W15-16	12.333	21.000	21.000	1	8	9
	6-29-78	11.667	15.000	15.000	1	2	3
	2-W18-5	10.000	10.000	10.000	1	2	3
	2-W19-24	10.000	10.000	10.000	1	4	5
Cresols							
	2-W7-6	15.500	21.000	21.000	1	1	2
Cyanide							
	2-W14-2	49.500	70.000	26.000	4	1	5
	2-W15-8	25.333	36.400	19.600	2	1	3
	2-W18-5	25.000	70.000	70.000	1	3	4
	6-38-70	17.243	27.900	20.000	3	4	7
	2-W19-28	16.025	12.400	11.700	2	2	4
	6-44-64	15.250	20.100	11.000	4	2	6
	6-49-79	12.200	11.000	11.000	1	4	5
	2-W19-25	10.100	10.100	10.100	1	0	1
DDD							
	2-W15-8	.330	.330	.330	1	0	1
	2-W14-2	.320	.320	.320	1	0	1
	2-W19-18	.320	.320	.320	1	0	1
DDT							
	2-W15-8	4.300	4.300	4.300	1	0	1
	2-W19-18	4.200	4.200	4.200	1	0	1
	2-W14-2	3.500	3.500	3.500	1	0	1
	2-W14-10	.100	.100	.100	1	0	1
Dieldrin							
	2-W15-8	3.900	3.900	3.900	1	0	1
	2-W19-18	3.800	3.800	3.800	1	0	1
	2-W14-2	3.700	3.700	3.700	1	0	1
Endrin							
	2-W15-8	4.600	4.600	4.600	1	0	1
	2-W19-18	4.400	4.400	4.400	1	0	1
	2-W14-2	4.000	4.000	4.000	1	0	1
Endrin Aldehyde							
	2-W14-2	.700	.700	.700	1	0	1
	2-W19-18	.670	.670	.670	1	0	1
	2-W15-8	.420	.420	.420	1	0	1
Europium-154							
	2-W19-31	24.900	24.900	24.900	1	0	1
	2-W7-7	11.000	11.000	11.000	1	0	1
	2-W10-13	5.980	5.980	5.980	1	0	1
	2-W9-1	5.980	5.980	5.980	1	0	1
a Fluoride							
	2-W15-4	11500.000	12800.000	10200.000	2	0	2

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Fluoride							
	2-W10-9	4613.333	5200.000	4200.000	6	0	6
	2-W10-15	4260.000	4600.000	4100.000	5	0	5
	2-W19-30	4000.000	4000.000	4000.000	1	0	1
	2-W22-9	3600.000	3600.000	3600.000	1	0	1
	2-W10-4	3042.500	3270.000	2830.000	4	0	4
	2-W14-6	2854.737	3620.000	2470.000	19	0	19
	2-W10-16	1975.000	2100.000	1800.000	4	0	4
	2-W14-5	1877.500	2260.000	1600.000	4	0	4
	2-W10-17	1800.000	1900.000	1700.000	3	0	3
	2-W15-12	1794.000	2100.000	1600.000	5	0	5
	2-W15-8	1458.400	2500.000	592.000	4	1	5
	2-W10-18	1250.000	1400.000	1100.000	2	0	2
	2-W11-7	1250.000	1300.000	1200.000	2	0	2
	2-W19-26	1219.000	1800.000	376.000	3	1	4
	2-W10-8	1200.000	1200.000	1200.000	1	0	1
	2-W19-25	1190.000	1700.000	370.000	3	0	3
	2-W19-29	1166.667	2100.000	600.000	3	0	3
	2-W19-20	1047.222	1900.000	272.000	7	2	9
	2-W14-2	1045.667	1110.000	900.000	6	0	6
	2-W23-1	1000.000	1000.000	1000.000	1	0	1
	2-W19-24	854.875	1850.000	322.000	4	4	8
	2-W18-4	775.000	1600.000	500.000	2	2	4
	2-W22-41	766.667	1000.000	600.000	3	0	3
	2-W19-28	750.000	1400.000	600.000	2	2	4
	2-W11-14	720.667	962.000	700.000	2	1	3
	2-W19-13	706.250	900.000	595.000	3	1	4
	2-W15-24	680.000	1100.000	400.000	4	0	4
	2-W22-43	677.500	810.000	600.000	4	0	4
	2-W15-16	671.444	880.000	600.000	9	0	9
	2-W22-2	650.000	800.000	800.000	1	1	2
	2-W18-26	646.000	1000.000	500.000	4	1	5
	2-W18-24	641.889	800.000	577.000	9	0	9
	2-W18-5	640.000	700.000	589.000	4	0	4
	2-W7-6	640.000	1200.000	500.000	5	5	10
	2-W19-23	639.333	418.000	418.000	1	2	3
	2-W15-18	634.500	780.000	596.000	7	1	8
	2-W19-9	632.571	756.000	574.000	6	1	7
	2-W22-42	626.667	880.000	500.000	3	0	3
	2-W19-19	613.667	341.000	341.000	1	2	3
	2-W15-23	600.000	1000.000	400.000	3	0	3
	2-W19-12	600.000	600.000	600.000	2	0	2
	2-W23-13	600.000	600.000	600.000	2	0	2
	6-47-60	598.200	744.000	559.000	4	1	5
	2-W19-32	590.000	590.000	590.000	1	0	1
	2-W19-16	584.875	892.000	500.000	6	2	8
	2-W19-11	583.500	667.000	500.000	2	0	2
	6-32-77	580.714	676.000	487.000	6	1	7
	6-38-70	570.182	800.000	326.000	9	2	11
	2-W19-3	564.800	600.000	524.000	5	0	5
	2-W7-8	564.000	900.000	400.000	3	2	5
	2-W7-9	564.000	1000.000	300.000	3	2	5
	2-W22-40	562.500	750.000	500.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Fluoride							
	2-W15-20	562.000	1000.000	300.000	3	2	5
	2-W7-7	562.000	900.000	400.000	3	2	5
	2-W22-39	550.000	600.000	500.000	2	0	2
	2-W23-9	550.000	600.000	600.000	1	1	2
	2-W26-8	547.500	720.000	300.000	4	0	4
	2-W14-10	546.667	640.000	640.000	1	2	3
	2-W22-12	545.600	600.000	500.000	4	1	5
	2-W15-7	542.333	600.000	527.000	2	1	3
	2-W7-5	540.000	1000.000	400.000	3	7	10
	2-W19-1	533.333	800.000	300.000	2	1	3
	2-W22-20	520.875	1100.000	217.000	4	4	8
	2-W7-4	520.000	900.000	300.000	2	8	10
	2-W26-9	516.667	750.000	200.000	3	0	3
	2-W19-15	516.500	705.000	390.000	5	3	8
	2-W6-2	516.000	900.000	400.000	5	10	15
	2-W7-2	516.000	900.000	300.000	3	7	10
	2-W9-1	513.000	900.000	300.000	3	7	10
	2-W19-18	510.833	655.000	410.000	4	2	6
	6-29-78	510.143	625.000	433.000	6	1	7
	2-W7-3	510.000	900.000	300.000	3	8	11
	2-W10-14	507.000	800.000	300.000	3	7	10
	2-W18-25	505.000	510.000	500.000	2	0	2
	2-W19-31	505.000	510.000	500.000	2	0	2
	2-W23-14	505.000	510.000	500.000	2	0	2
	2-W7-1	502.000	800.000	300.000	3	7	10
	2-W8-1	501.000	800.000	300.000	3	7	10
	2-W11-23	500.000	500.000	500.000	1	1	2
	2-W15-19	500.000	500.000	500.000	2	2	4
	2-W15-6	500.000	500.000	500.000	1	0	1
	2-W18-8	500.000	500.000	500.000	1	0	1
	2-W18-9	500.000	500.000	500.000	1	1	2
	2-W19-2	500.000	500.000	500.000	1	0	1
	2-W22-21	500.000	500.000	500.000	1	0	1
	6-51-75	500.000	500.000	500.000	1	0	1
	2-W15-11	496.000	484.000	484.000	1	3	4
	2-W11-21	495.556	560.000	400.000	2	7	9
	2-W22-22	495.167	504.000	467.000	2	4	6
	2-W10-13	493.636	700.000	300.000	3	8	11
	6-35-70	493.286	800.000	353.000	4	3	7
	2-W22-1	492.750	471.000	471.000	1	3	4
	2-W18-23	492.727	520.000	400.000	2	9	11
	2-W19-5	489.667	469.000	469.000	1	2	3
	2-W22-26	489.667	469.000	469.000	1	2	3
	6-44-64	488.667	745.000	348.000	5	4	9
	2-W15-15	487.500	400.000	400.000	1	7	8
	2-W15-10	480.500	383.000	383.000	1	5	6
	2-W15-17	475.000	510.000	300.000	3	5	8
	2-W18-22	473.750	490.000	300.000	2	6	8
	6-38-65	472.400	800.000	262.000	3	2	5
	6-35-78A	467.000	368.000	368.000	1	3	4
	2-W19-27	466.667	500.000	400.000	2	1	3
	6-39-79	464.417	400.000	384.000	4	8	12

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Fluoride							
	2-W7-10	463.333	590.000	400.000	3	0	3
	2-W15-22	455.000	500.000	410.000	2	0	2
	6-45-69A	451.800	600.000	300.000	3	2	5
	6-32-72	450.000	560.000	356.000	6	1	7
	6-32-70B	448.667	509.000	393.000	6	3	9
	2-W18-15	444.750	279.000	279.000	1	3	4
	6-48-71	432.500	430.000	400.000	3	1	4
	2-W27-1	429.667	300.000	267.000	3	6	9
	6-35-66	427.625	521.000	309.000	5	3	8
	6-36-61A	422.111	400.000	315.000	5	4	9
	2-W23-10	409.500	283.000	240.000	3	5	8
	2-W26-6	400.000	300.000	300.000	1	1	2
	2-W19-21	392.000	231.000	200.000	3	5	8
	6-40-62	390.400	547.000	300.000	9	1	10
	6-49-79	381.222	300.000	262.000	5	4	9
	6-50-85	369.833	256.000	224.000	3	3	6
	6-43-88	352.000	204.000	204.000	1	1	2
	6-37-82A	304.750	300.000	200.000	3	1	4
	2-W23-11	300.000	100.000	100.000	1	1	2
Gamma-BHC							
	2-W14-2	1.700	1.700	1.700	1	0	1
	2-W15-8	1.700	1.700	1.700	1	0	1
	2-W19-18	1.700	1.700	1.700	1	0	1
a Gross alpha							
	2-W19-18	2208.611	3710.000	515.000	18	0	18
	2-W19-3	1968.389	3100.000	811.000	18	0	18
	2-W19-11	1959.250	2570.000	867.000	4	0	4
	2-W19-29	1359.333	2120.000	928.000	3	0	3
	2-W19-9	900.571	1360.000	613.000	7	0	7
	2-W19-16	675.417	989.000	407.000	12	0	12
	2-W19-19	453.429	594.000	170.000	21	0	21
	2-W19-24	338.737	489.000	189.000	19	0	19
	2-W19-20	319.550	452.000	157.000	20	0	20
	2-W11-14	232.286	273.000	173.000	7	0	7
	2-W19-26	221.364	315.000	100.000	11	0	11
	2-W19-25	206.250	285.000	154.000	16	0	16
	2-W19-23	149.624	208.000	94.600	17	0	17
	2-W19-15	127.463	235.000	24.800	8	0	8
	2-W19-2	79.400	114.000	10.200	17	0	17
	2-W7-6	45.509	143.000	4.210	10	0	10
	6-38-70	41.645	52.200	19.600	20	0	20
	2-W18-15	40.480	49.200	30.800	5	0	5
	2-W23-4	39.908	64.200	15.700	13	0	13
	2-W15-8	37.758	226.000	226.000	1	5	6
	2-W19-28	32.000	38.500	25.000	4	0	4
	2-W23-10	26.408	39.500	14.700	12	0	12
	2-W10-3	25.842	92.400	9.250	6	0	6
	2-W23-9	25.171	56.500	17.500	17	0	17
	2-W19-17	22.925	36.100	17.100	4	0	4
	2-W18-21	16.671	24.800	5.730	9	0	9
	2-W22-21	15.233	20.500	11.600	3	0	3
	2-W19-21	14.088	18.200	11.500	8	0	8

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Gross alpha							
	2-W23-11	13.929	17.200	10.400	7	0	7
	6-35-78A	13.019	15.400	9.730	7	0	7
	2-W26-8	10.285	15.700	6.630	4	0	4
	2-W19-27	9.167	14.900	4.250	9	0	9
	2-W23-14	9.020	10.400	8.120	3	0	3
	2-W23-13	8.660	9.340	7.960	3	0	3
	6-39-79	8.087	10.100	6.500	6	0	6
	2-W22-20	7.172	11.700	2.830	6	0	6
	2-W27-1	7.170	13.000	4.240	10	0	10
	2-W19-13	6.552	8.480	3.110	5	0	5
	2-W19-1	6.185	6.260	6.110	2	0	2
	2-W22-2	6.123	9.940	4.930	6	0	6
	2-W22-39	5.203	7.550	3.660	3	0	3
	2-W10-8	4.414	11.300	.533	3	0	3
	2-W22-1	4.025	5.780	1.740	4	0	4
	2-W23-8	3.780	3.780	3.780	1	0	1
	2-W22-40	3.680	4.790	2.340	4	0	4
	2-W14-10	3.666	5.760	2.770	3	1	4
	2-W18-25	3.433	4.160	2.850	4	0	4
	2-W22-41	3.217	4.970	3.400	2	1	3
	2-W19-14	3.102	4.370	2.390	4	1	5
	2-W19-12	3.087	3.500	2.770	3	0	3
	2-W14-2	3.081	7.370	.712	3	0	3
	2-W11-7	3.076	13.200	.866	5	1	6
	2-W15-15	2.889	4.600	2.090	7	1	8
	2-W15-16	2.842	5.340	1.740	7	1	8
	2-W22-42	2.783	3.740	1.710	3	0	3
	2-W10-16	2.685	9.840	1.600	2	3	5
	2-W11-11	2.625	3.160	2.090	2	0	2
	2-W22-43	2.613	3.890	1.440	4	0	4
	2-W19-30	2.550	2.550	2.550	1	0	1
	2-W7-9	2.502	5.080	1.660	5	0	5
	2-W10-9	2.459	4.680	1.430	4	1	5
	2-W18-26	2.388	3.370	1.550	4	1	5
	2-W19-31	2.180	2.600	1.710	3	0	3
	6-35-70	2.154	3.550	2.140	5	2	7
	2-W18-7	2.114	9.590	.478	2	3	5
	6-40-62	2.089	3.680	1.560	8	1	9
	2-W22-18	2.048	5.710	1.020	5	0	5
	2-W10-15	1.980	5.030	1.680	4	2	6
	6-32-62	1.938	2.490	1.700	5	0	5
	2-W7-10	1.900	3.130	1.260	3	0	3
	6-44-64	1.890	3.000	1.330	8	0	8
	2-W22-12	1.885	1.960	1.810	2	0	2
	6-47-60	1.780	2.140	1.420	2	0	2
	6-38-65	1.774	2.530	1.910	4	2	6
	2-W22-22	1.760	6.360	.684	6	1	7
	2-W6-2	1.756	2.690	1.260	10	3	13
	2-W15-19	1.755	2.110	1.400	4	0	4
	6-35-66	1.737	2.400	1.390	3	0	3
	2-W15-3	1.707	3.120	1.020	5	1	6
	6-48-71	1.620	2.700	.716	7	0	7

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Gross alpha							
	2-W18-2	1.610	1.610	1.610	1	0	1
	2-W9-1	1.599	3.850	1.150	6	4	10
	2-W7-5	1.582	3.600	1.180	8	2	10
	6-45-69A	1.574	2.060	1.090	7	0	7
	2-W7-8	1.562	2.100	1.310	4	1	5
	6-32-77	1.556	2.160	.877	6	1	7
	2-W26-3	1.554	2.760	.763	3	0	3
	2-W19-32	1.535	1.550	1.520	2	0	2
	2-W18-20	1.488	9.420	.558	10	7	17
	2-W22-10	1.438	7.710	.469	2	4	6
	6-32-70B	1.428	2.170	2.170	1	1	2
	2-W7-7	1.412	2.240	1.160	3	2	5
	2-W15-17	1.392	2.640	1.280	4	4	8
	2-W14-6	1.361	2.450	2.450	1	3	4
	2-W15-11	1.360	1.640	1.080	2	0	2
	2-W7-4	1.351	2.650	1.120	7	4	11
	6-29-78	1.336	2.000	.921	6	2	8
	6-36-61A	1.325	1.750	1.430	2	1	3
	2-W18-24	1.218	1.940	1.040	5	3	8
	6-25-70	1.206	1.360	.768	5	1	6
	2-W18-23	1.202	2.590	1.100	5	6	11
	2-W7-2	1.201	2.240	1.100	6	4	10
	2-W10-18	1.186	1.480	1.480	1	3	4
	2-W7-3	1.155	2.570	1.160	5	6	11
	2-W18-17	1.155	12.400	.785	5	15	20
	2-W10-14	1.133	2.580	1.350	6	4	10
	2-W18-5	1.080	1.140	1.020	2	0	2
	2-W18-22	1.072	1.710	1.020	2	6	8
	2-W15-6	1.046	1.430	.687	4	1	5
	2-W11-23	1.036	1.290	1.060	2	1	3
	2-W10-17	.986	2.190	2.190	1	3	4
	6-51-75	.958	2.550	.497	5	1	6
	2-W15-2	.938	2.800	.340	4	2	6
	2-W8-1	.931	2.090	1.810	3	7	10
	2-W15-10	.904	1.030	.777	2	0	2
	2-W15-24	.902	1.340	.961	2	2	4
	2-W15-18	.902	1.760	1.260	3	5	8
	2-W7-1	.891	2.100	1.720	3	7	10
	2-W15-7	.852	1.620	.460	3	0	3
	2-W26-6	.851	1.330	.954	3	1	4
	6-49-79	.851	1.680	.455	6	3	9
	2-W15-20	.811	1.330	1.330	1	4	5
	6-36-61B	.786	2.640	.449	2	3	5
	6-50-85	.697	1.090	.535	5	3	8
	2-W10-13	.551	1.570	1.130	3	8	11
	2-W18-9	.457	1.630	1.630	1	6	7
	2-W11-24	.444	.655	.655	1	1	2
	6-43-88	.341	.394	.394	1	5	6
	6-32-72	.291	.993	.993	1	7	8
	6-37-82A	.078	1.150	1.150	1	6	7
Gross beta							
	2-W19-25	3271.875	5110.000	1910.000	16	0	16

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Gross beta							
	2-W19-18	3078.067	6180.000	86.200	18	0	18
	2-W19-24	2526.316	3900.000	1640.000	19	0	19
	2-W19-11	2154.500	3160.000	278.000	4	0	4
	2-W19-29	1940.000	2230.000	1480.000	3	0	3
	2-W19-3	1627.778	2870.000	239.000	18	0	18
	2-W19-20	1569.100	3690.000	753.000	20	0	20
	2-W19-19	1057.048	1750.000	533.000	21	0	21
	2-W19-28	900.000	2150.000	328.000	4	0	4
	2-W19-16	758.667	1540.000	286.000	12	0	12
	2-W19-9	669.714	1100.000	353.000	7	0	7
	2-W19-26	564.273	909.000	222.000	11	0	11
	2-W23-2	541.412	1180.000	102.000	17	0	17
	2-W23-7	394.882	1200.000	187.000	17	0	17
	6-38-70	340.200	437.000	252.000	20	0	20
	2-W19-23	308.176	632.000	134.000	17	0	17
	2-W19-12	261.333	339.000	108.000	3	0	3
	2-W19-15	201.475	325.000	78.200	8	0	8
	2-W19-30	157.000	157.000	157.000	1	0	1
	2-W22-21	155.000	170.000	131.000	3	0	3
	2-W11-14	125.529	193.000	72.800	7	0	7
	2-W19-2	120.900	163.000	66.500	17	0	17
	2-W19-32	117.000	127.000	107.000	2	0	2
	2-W22-39	99.000	107.000	92.400	3	0	3
	2-W15-5	96.750	128.000	77.200	6	0	6
	2-W10-3	90.333	163.000	28.700	6	0	6
	2-W23-1	84.367	404.000	11.400	6	0	6
	2-W23-3	82.450	131.000	33.700	6	0	6
	2-W14-2	80.967	154.000	34.500	3	0	3
	2-W15-8	79.217	336.000	18.800	6	0	6
	2-W11-18	67.400	70.100	64.700	2	0	2
	2-W10-4	67.000	79.900	54.100	2	0	2
	2-W11-11	53.800	54.400	53.200	2	0	2
	2-W10-15	53.000	75.000	40.200	6	0	6
	2-W11-7	50.283	66.000	22.000	6	0	6
	2-W19-17	50.250	63.600	45.700	4	0	4
	2-W19-31	49.500	51.800	46.000	3	0	3
	2-W22-10	48.217	64.800	32.800	6	0	6
	2-W10-9	47.720	54.400	39.600	5	0	5
	2-W23-4	43.246	77.700	7.500	13	0	13
	2-W10-1	41.800	49.300	32.100	6	0	6
	2-W15-22	34.933	39.100	31.900	3	0	3
	6-32-70B	33.575	40.000	23.800	8	0	8
	2-W14-5	32.750	39.900	25.600	2	0	2
	2-W22-41	30.000	48.500	19.300	3	0	3
	2-W22-1	29.150	30.800	27.800	4	0	4
	2-W10-17	29.075	34.500	25.200	4	0	4
	2-W22-42	27.433	39.300	18.600	3	0	3
	2-W22-20	25.661	37.400	19.700	7	1	8
	2-W7-6	24.768	55.200	7.630	10	0	10
	2-W19-5	22.600	27.300	17.900	2	0	2
	2-W22-2	22.417	40.000	15.400	6	0	6
	2-W22-26	21.050	23.300	18.800	2	0	2

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Gross beta							
	6-44-64	19.875	21.400	18.300	8	0	8
	2-W10-16	19.500	21.800	17.800	5	0	5
	6-35-70	19.055	32.800	11.700	11	0	11
	2-W11-15	18.750	22.900	14.400	4	0	4
	2-W23-9	18.006	51.100	10.100	17	0	17
	2-W23-10	17.977	44.100	8.450	11	0	11
	2-W14-6	17.188	40.600	9.790	9	0	9
	2-W15-7	16.373	20.300	9.120	3	0	3
	6-38-65	16.270	20.000	13.700	10	0	10
	2-W19-13	15.820	18.700	12.900	5	0	5
	2-W15-11	15.650	16.300	15.000	2	0	2
	2-W22-18	14.400	18.500	12.400	5	0	5
	2-W19-1	13.845	19.000	8.690	2	0	2
	2-W15-10	13.350	14.000	12.700	2	0	2
	2-W14-10	12.090	20.300	5.780	4	0	4
	6-32-72	12.044	18.700	2.510	8	0	8
	2-W18-15	12.016	16.600	7.160	5	0	5
	2-W7-4	11.648	15.700	7.790	11	0	11
	2-W6-2	11.392	16.400	6.500	13	0	13
	2-W10-18	11.235	13.500	8.840	4	0	4
	6-35-66	10.278	12.200	7.240	8	0	8
	6-51-63	10.202	36.200	3.140	6	0	6
	2-W15-19	9.703	11.600	8.330	4	0	4
	2-W15-4	9.335	10.100	8.570	2	0	2
	2-W26-8	9.240	14.200	6.680	4	0	4
	2-W11-23	9.207	13.300	3.820	3	0	3
	2-W19-14	8.976	11.500	6.320	5	0	5
	2-W10-8	8.863	17.500	2.790	3	0	3
	2-W7-5	8.610	15.400	4.440	10	0	10
	2-W22-12	7.950	9.610	5.170	4	0	4
	2-W23-14	7.810	11.100	3.750	3	0	3
	6-36-61A	7.660	9.800	6.140	3	0	3
	6-40-62	7.614	11.900	4.380	9	0	9
	2-W15-17	7.609	10.600	3.430	8	0	8
	2-W18-5	7.540	8.130	6.950	2	0	2
	2-W11-24	7.445	8.900	5.990	2	0	2
	6-36-61B	7.412	9.750	5.150	5	0	5
	6-32-62	7.280	9.020	6.040	5	0	5
	2-W15-16	7.189	11.300	2.560	8	0	8
	2-W19-27	7.084	13.600	3.710	8	1	9
	2-W19-21	6.995	11.600	3.320	8	0	8
	2-W22-43	6.995	9.040	3.900	4	0	4
	2-W27-1	6.977	9.710	4.960	9	1	10
	6-37-82A	6.959	8.710	5.910	7	0	7
	2-W23-11	6.691	8.590	4.100	7	0	7
	2-W7-8	6.532	9.020	3.960	5	0	5
	6-47-60	6.518	7.960	5.730	8	0	8
	2-W15-18	6.516	8.820	4.520	8	0	8
	2-W8-1	6.504	8.270	4.240	10	0	10
	2-W18-21	6.462	9.250	3.390	9	0	9
	2-W10-13	6.405	10.200	4.050	11	0	11
	2-W18-7	6.286	10.900	3.160	5	0	5

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Gross beta							
	2-W23-13	6.223	10.500	3.790	3	0	3
	2-W18-26	6.214	7.080	4.940	5	0	5
	2-W9-1	6.181	10.900	3.130	9	1	10
	2-W22-40	6.145	8.520	2.830	4	0	4
	6-35-78A	6.046	9.880	4.240	7	0	7
	2-W7-9	5.900	7.840	4.320	5	0	5
	2-W18-25	5.628	8.030	3.700	4	0	4
	2-W7-3	5.588	8.750	4.260	9	2	11
	2-W26-6	5.460	6.560	4.410	4	0	4
	2-W22-22	5.307	7.640	3.410	7	0	7
	2-W15-20	5.232	7.570	2.850	5	0	5
	2-W18-2	5.210	5.210	5.210	1	0	1
	2-W15-15	5.146	7.150	3.030	8	0	8
	6-39-79	4.970	6.090	3.670	6	0	6
	2-W15-2	4.908	6.820	3.410	6	0	6
	6-51-75	4.907	8.630	3.320	6	0	6
	6-49-79	4.533	6.850	3.400	8	1	9
	2-W7-2	4.512	6.790	2.310	10	0	10
	2-W10-14	4.483	7.500	4.070	7	3	10
	2-W18-22	4.444	6.460	2.290	7	1	8
	2-W7-1	4.440	7.120	2.650	9	1	10
	2-W18-20	4.380	9.780	3.130	15	2	17
	2-W15-6	4.326	4.950	3.680	5	0	5
	2-W18-9	4.306	9.820	3.020	5	2	7
	2-W15-23	4.237	7.030	3.970	2	1	3
	6-25-70	4.230	4.880	2.470	6	0	6
	6-48-71	4.164	9.010	2.440	6	1	7
	2-W15-24	4.075	4.970	2.540	4	0	4
	6-32-77	4.064	5.110	3.060	7	0	7
	6-55-89	3.987	4.730	3.180	3	0	3
	2-W18-17	3.912	24.600	.678	19	1	20
	6-50-85	3.899	5.250	3.150	7	1	8
	6-43-88	3.880	6.650	3.320	5	1	6
	6-45-69A	3.784	5.640	3.240	7	0	7
	2-W23-8	3.780	3.780	3.780	1	0	1
	2-W18-24	3.720	7.370	2.560	8	0	8
	2-W7-10	3.580	5.500	3.430	2	1	3
	2-W7-7	3.522	4.680	2.670	4	1	5
	2-W18-23	3.237	4.710	2.980	8	3	11
	2-W26-9	3.030	3.650	2.320	3	0	3
	2-W26-3	3.003	3.320	2.790	3	0	3
	6-29-78	2.801	4.750	1.930	5	3	8
Heptachlor							
	2-W14-2	1.700	1.700	1.700	1	0	1
	2-W15-8	1.700	1.700	1.700	1	0	1
	2-W19-18	1.700	1.700	1.700	1	0	1
a Iodine-129							
	6-35-70	29.493	87.800	10.300	6	0	6
	2-W22-9	23.900	23.900	23.900	1	0	1
	2-W19-3	10.540	15.500	5.580	2	0	2
	2-W19-2	7.100	7.100	7.100	1	0	1
	6-35-66	5.257	7.720	1.490	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Iodine-129							
	2-W19-18	5.125	6.120	4.130	2	0	2
	2-W22-12	3.870	3.870	3.870	1	0	1
	2-W19-16	3.405	4.560	2.250	2	0	2
	2-W21-1	3.370	3.370	3.370	1	0	1
	6-32-70B	2.559	3.570	.856	3	0	3
	2-W19-20	2.330	2.330	2.330	1	0	1
	2-W11-14	2.240	2.240	2.240	1	0	1
	2-W19-25	2.220	2.220	2.220	1	0	1
	2-W22-22	2.110	2.180	2.040	2	0	2
	2-W19-15	1.985	2.680	1.290	2	0	2
	6-38-65	1.808	3.510	.920	3	0	3
	2-W19-19	1.770	1.770	1.770	1	0	1
	2-W19-24	1.745	1.970	1.520	2	0	2
	2-W22-7	1.630	1.630	1.630	1	0	1
	6-38-70	1.545	1.990	.319	3	1	4
	2-W19-9	1.540	1.540	1.540	1	0	1
	2-W19-23	1.290	1.290	1.290	1	0	1
	2-W22-20	1.145	2.020	.339	4	0	4
	2-W19-29	.733	.733	.733	1	0	1
	2-W19-28	.729	.889	.569	2	0	2
	2-W19-30	.593	.593	.593	1	0	1
	2-W23-9	.406	.406	.406	1	0	1
	6-50-85	.307	.307	.307	1	0	1
	2-W18-5	.279	.279	.279	1	0	1
	2-W12-1	.235	.235	.235	1	0	1
	2-W10-18	.213	.477	.477	1	3	4
	2-W10-17	.207	.232	.232	1	2	3
	2-W10-15	.180	.765	.198	3	2	5
	2-W10-3	.174	.174	.174	1	0	1
	2-W10-16	.170	.398	.398	1	3	4
	2-W27-1	.167	.336	.336	1	1	2
	6-40-62	.147	.266	.266	1	1	2
	2-W11-3	.101	.101	.101	1	0	1
	2-W15-7	.100	.100	.100	1	0	1
	6-32-62	.038	.058	.058	1	1	2
Iron							
	2-W10-8	328000.000	328000.000	328000.000	1	0	1
	2-W19-1	276000.000	276000.000	276000.000	1	0	1
	2-W15-8	166000.000	222000.000	110000.000	2	0	2
	2-W15-12	72100.000	72100.000	72100.000	1	0	1
	2-W18-20	48700.000	48700.000	48700.000	1	0	1
	2-W14-2	30250.000	48000.000	12500.000	2	0	2
	2-W18-9	27300.000	27300.000	27300.000	1	0	1
	2-W11-14	26300.000	26300.000	26300.000	1	0	1
	2-W14-10	19268.000	37700.000	836.000	2	0	2
	2-W18-17	16698.571	53600.000	810.000	7	0	7
	2-W7-6	16278.889	32500.000	1040.000	9	0	9
	2-W18-4	7350.000	7350.000	7350.000	1	0	1
	2-W23-11	6700.000	6700.000	6700.000	1	0	1
	2-W22-20	5786.667	12000.000	5340.000	2	1	3
	2-W15-17	4962.222	31100.000	377.000	9	0	9
	2-W15-24	4950.000	14800.000	700.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Iron							
	2-W19-23	4400.000	4400.000	4400.000	1	0	1
	6-45-69A	4300.000	4300.000	4300.000	1	0	1
	2-W19-26	4100.000	7770.000	430.000	2	0	2
	2-W22-21	3800.000	3800.000	3800.000	1	0	1
	2-W19-32	3700.000	5300.000	2100.000	2	0	2
	2-W15-22	3300.000	5600.000	1900.000	3	0	3
	2-W23-14	3300.000	4700.000	2500.000	3	0	3
	2-W7-9	3067.500	7000.000	690.000	4	0	4
	2-W11-7	2680.000	2680.000	2680.000	1	0	1
	2-W15-7	2329.000	4100.000	558.000	2	0	2
	2-W10-18	2227.500	4100.000	510.000	4	0	4
	2-W18-5	1970.000	1970.000	1970.000	1	0	1
	2-W10-9	1796.800	4200.000	164.000	4	1	5
	2-W19-24	1794.000	3060.000	528.000	2	0	2
	2-W7-10	1516.667	2000.000	850.000	3	0	3
	2-W9-1	1485.222	4520.000	221.000	9	0	9
	2-W7-8	1432.500	1930.000	1200.000	4	0	4
	2-W14-5	1240.000	1240.000	1240.000	1	0	1
	2-W10-16	1229.000	1800.000	610.000	5	0	5
	2-W19-25	993.000	993.000	993.000	1	0	1
	2-W18-21	892.111	2200.000	164.000	9	0	9
	2-W26-8	890.000	1300.000	430.000	4	0	4
	2-W19-20	843.667	1330.000	430.000	3	0	3
	2-W7-3	816.700	2780.000	280.000	10	0	10
	2-W19-28	752.000	752.000	752.000	1	0	1
	6-37-82A	730.000	730.000	730.000	1	0	1
	2-W22-22	728.000	728.000	728.000	1	0	1
	2-W26-9	723.333	1800.000	160.000	3	0	3
	2-W18-26	653.750	1200.000	315.000	4	0	4
	2-W7-7	599.000	830.000	380.000	4	0	4
	2-W19-31	590.000	840.000	240.000	3	0	3
	2-W23-13	563.333	890.000	350.000	3	0	3
	2-W22-39	533.333	890.000	210.000	3	0	3
	2-W15-20	528.000	760.000	300.000	4	0	4
	2-W18-22	498.625	905.000	210.000	8	0	8
	2-W18-23	471.556	1150.000	99.000	9	0	9
	2-W10-17	432.500	680.000	190.000	4	0	4
	2-W19-29	432.000	840.000	24.000	2	0	2
	6-36-61A	430.000	430.000	430.000	1	0	1
	2-W18-25	426.667	680.000	220.000	3	0	3
	2-W11-23	402.000	402.000	402.000	1	0	1
	2-W19-3	390.000	390.000	390.000	1	0	1
	2-W15-18	377.500	560.000	163.000	8	0	8
	2-W7-2	376.111	1300.000	97.000	9	0	9
	2-W18-24	366.333	1200.000	101.000	9	0	9
	2-W22-42	363.000	560.000	59.000	3	0	3
	2-W19-19	362.000	362.000	362.000	1	0	1
	2-W15-16	345.750	666.000	191.000	8	0	8
	2-W10-14	342.222	660.000	159.000	9	0	9
	2-W7-5	321.778	800.000	92.000	9	0	9
	2-W19-11	316.000	316.000	316.000	1	0	1
	2-W6-2	311.750	660.000	68.000	12	0	12

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Iron							
	2-W10-15	297.286	400.000	160.000	6	1	7
	2-W7-4	286.800	540.000	89.000	10	0	10
	2-W10-13	275.300	590.000	130.000	10	0	10
	2-W15-15	275.286	544.000	89.000	7	0	7
	2-W22-40	275.250	420.000	91.000	4	0	4
	2-W26-6	260.000	260.000	260.000	1	0	1
	2-W8-1	257.333	680.000	108.000	9	0	9
	2-W22-43	249.500	430.000	28.000	4	0	4
	2-W7-1	244.222	570.000	110.000	9	0	9
	6-38-70	210.000	210.000	210.000	1	0	1
	2-W15-19	197.000	300.000	131.000	3	0	3
	6-48-71	180.000	180.000	180.000	1	0	1
	2-W15-23	146.667	180.000	130.000	3	0	3
	2-W27-1	141.500	177.000	106.000	2	0	2
	6-35-70	140.000	140.000	140.000	1	0	1
	2-W22-41	132.000	250.000	53.000	3	0	3
	2-W19-12	130.000	130.000	130.000	1	0	1
	2-W15-10	113.000	113.000	113.000	1	0	1
	2-W15-4	112.000	112.000	112.000	1	0	1
	2-W19-18	108.500	133.000	84.000	2	0	2
	2-W18-15	91.000	91.000	91.000	1	0	1
	6-40-62	83.000	83.000	83.000	1	0	1
	2-W19-21	78.500	91.000	66.000	2	0	2
	6-49-79	73.000	73.000	73.000	1	0	1
	2-W19-30	55.000	55.000	55.000	1	0	1
	2-W10-4	44.000	44.000	44.000	1	0	1
	2-W15-11	39.000	39.000	39.000	1	0	1
	2-W19-27	36.000	36.000	36.000	1	0	1
	2-W19-13	34.000	34.000	34.000	1	0	1
	6-32-77	34.000	34.000	34.000	1	0	1
Iron, filtered							
	2-W22-43	9593.000	38000.000	62.000	4	0	4
	2-W7-6	9238.857	57000.000	44.000	6	1	7
	6-51-75	460.000	460.000	460.000	1	0	1
	2-W7-9	452.500	1200.000	210.000	3	1	4
	2-W26-9	277.333	790.000	22.000	2	1	3
	2-W10-18	262.500	420.000	80.000	4	0	4
	2-W19-20	233.167	350.000	160.000	6	0	6
	2-W15-22	197.000	290.000	81.000	3	0	3
	2-W18-26	183.500	456.000	38.000	3	1	4
	2-W10-8	169.000	169.000	169.000	1	0	1
	2-W19-32	164.500	230.000	99.000	2	0	2
	2-W7-3	156.700	250.000	96.000	9	1	10
	2-W14-6	140.333	487.000	31.000	5	1	6
	2-W15-8	140.000	140.000	140.000	1	0	1
	2-W23-14	134.333	340.000	43.000	2	1	3
	2-W15-17	123.000	410.000	53.000	3	2	5
	2-W19-23	115.500	201.000	201.000	1	1	2
	2-W15-6	110.000	110.000	110.000	1	0	1
	2-W18-21	106.222	300.000	32.000	5	4	9
	2-W19-31	100.667	220.000	36.000	3	0	3
	2-W18-23	99.778	630.000	29.000	6	3	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Iron, filtered							
	2-W15-18	90.500	370.000	48.000	3	5	8
	2-W19-26	79.500	121.000	38.000	2	0	2
	2-W15-24	78.500	180.000	26.000	4	0	4
	2-W27-1	69.000	248.000	24.000	3	5	8
	2-W19-5	65.000	100.000	100.000	1	1	2
	2-W9-1	64.778	130.000	49.000	5	4	9
	2-W22-42	64.000	120.000	52.000	2	1	3
	2-W22-12	61.500	85.000	38.000	2	0	2
	2-W7-8	61.500	91.000	38.000	4	0	4
	2-W15-20	60.750	73.000	50.000	4	0	4
	2-W10-16	60.200	86.000	39.000	4	1	5
	2-W22-39	57.000	110.000	24.000	3	0	3
	2-W7-2	55.889	75.000	31.000	8	1	9
	2-W18-25	49.333	69.000	29.000	3	0	3
	2-W19-29	48.333	81.000	31.000	3	0	3
	2-W7-5	48.111	125.000	34.000	5	4	9
	2-W18-24	46.500	96.000	32.000	7	3	10
	2-W7-10	46.333	80.000	20.000	3	0	3
	2-W15-4	44.500	59.000	59.000	1	1	2
	2-W10-14	44.222	66.000	34.000	9	0	9
	2-W6-2	44.143	157.000	30.000	8	6	14
	2-W22-40	43.500	76.000	28.000	3	1	4
	2-W10-13	43.300	61.000	35.000	8	2	10
	2-W14-2	43.000	70.000	42.000	2	2	4
	2-W7-1	41.333	80.000	30.000	6	3	9
	2-W22-22	40.800	65.000	30.000	3	2	5
	2-W19-9	40.750	58.000	35.000	3	1	4
	2-W8-1	39.778	69.000	31.000	5	4	9
	2-W23-13	39.667	55.000	31.000	3	0	3
	2-W19-25	39.500	42.000	37.000	2	0	2
	2-W18-5	39.333	54.000	34.000	2	1	3
	2-W18-22	38.500	61.000	33.000	5	3	8
	6-35-78A	37.500	45.000	45.000	1	1	2
	6-38-70	37.167	73.000	73.000	1	5	6
	2-W7-4	37.100	72.000	24.000	4	6	10
	2-W15-11	36.667	50.000	50.000	1	2	3
	2-W19-11	36.000	42.000	42.000	1	1	2
	6-48-71	36.000	42.000	42.000	1	1	2
	2-W15-23	35.667	44.000	27.000	3	0	3
	2-W22-41	35.333	52.000	34.000	2	1	3
	2-W10-9	34.500	49.000	21.000	4	0	4
	2-W19-15	34.200	51.000	51.000	1	4	5
	6-39-70	33.750	39.000	36.000	2	2	4
	2-W26-8	33.500	36.000	33.000	3	1	4
	2-W15-16	33.444	42.000	32.000	4	5	9
	6-36-61A	32.200	41.000	41.000	1	4	5
	2-W15-10	32.000	36.000	36.000	1	2	3
	2-W19-21	31.800	39.000	39.000	1	4	5
	6-37-82A	31.500	33.000	33.000	1	1	2
	6-35-70	30.750	33.000	33.000	1	3	4
	2-W19-24	30.400	32.000	32.000	1	4	5
	2-W15-15	30.125	38.000	33.000	2	6	8

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Iron, filtered							
	2-W7-7	30.000	37.000	24.000	3	1	4
	2-W15-19	29.333	38.000	38.000	1	2	3
	2-W10-17	29.000	40.000	23.000	3	1	4
	2-W10-15	28.800	32.000	31.000	3	2	5
	2-W15-7	28.667	36.000	36.000	1	2	3
	2-W19-18	28.600	23.000	23.000	1	4	5
	2-W19-28	27.500	30.000	30.000	1	3	4
Lead (graphite furnace)							
	2-W10-8	340.000	340.000	340.000	1	0	1
	2-W15-17	126.000	1000.000	13.000	4	5	9
	2-W15-8	74.500	132.000	17.000	2	0	2
	2-W7-6	53.222	127.000	7.000	9	0	9
	2-W18-4	32.600	32.600	32.600	1	0	1
	2-W19-1	25.000	25.000	25.000	1	0	1
	2-W14-10	19.000	33.000	33.000	1	1	2
	2-W18-9	18.900	18.900	18.900	1	0	1
	2-W19-26	16.000	16.000	16.000	1	0	1
	2-W18-20	12.000	12.000	12.000	1	0	1
	2-W19-32	12.000	19.000	19.000	1	1	2
	2-W10-9	8.250	17.000	6.000	2	2	4
	2-W18-26	7.500	15.000	7.500	2	3	5
	2-W26-8	7.000	11.000	7.000	2	2	4
	6-45-69A	7.000	7.000	7.000	1	0	1
	2-W14-2	6.800	8.600	8.600	1	1	2
	2-W18-25	6.667	10.000	10.000	1	2	3
	2-W23-13	6.600	9.800	9.800	1	2	3
	2-W23-11	6.500	6.500	6.500	1	0	1
	2-W11-7	6.300	6.300	6.300	1	0	1
	2-W18-17	6.000	7.000	7.000	1	1	2
	2-W7-10	5.900	7.700	7.700	1	2	3
	2-W7-8	5.880	9.400	9.400	1	4	5
	2-W15-24	5.750	8.000	8.000	1	3	4
	2-W10-13	5.727	13.000	13.000	1	10	11
	2-W10-14	5.556	9.000	6.000	2	7	9
	2-W10-17	5.550	6.300	5.900	2	2	4
	2-W26-9	5.500	6.500	5.000	2	1	3
	2-W8-1	5.433	8.900	8.900	1	8	9
	2-W7-3	5.400	9.000	9.000	1	9	10
	2-W15-7	5.350	5.700	5.700	1	1	2
	2-W22-42	5.267	5.800	5.800	1	2	3
	2-W7-2	5.250	7.000	7.000	1	7	8
	2-W15-22	5.233	5.700	5.700	1	2	3
	2-W7-9	5.200	6.000	6.000	1	4	5
	2-W22-43	5.150	5.600	5.600	1	3	4
	2-W10-15	5.033	5.200	5.200	1	5	6
	2-W7-4	5.033	5.300	5.300	1	8	9
	2-W10-16	5.000	5.000	5.000	1	4	5
	2-W22-20	5.000	5.000	5.000	1	1	2
Lead, filtered							
	2-W15-24	11.500	31.000	31.000	1	3	4
	2-W22-40	7.250	13.000	6.000	2	2	4
	2-W7-6	6.333	11.000	7.000	2	4	6

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Lead, filtered							
	2-W26-8	6.150	7.000	5.500	4	0	4
	2-W22-43	5.725	7.900	7.900	1	3	4
	2-W18-25	5.400	6.200	6.200	1	2	3
	2-W7-10	5.367	6.100	6.100	1	2	3
	2-W10-15	5.333	7.000	5.000	2	4	6
	2-W15-23	5.333	6.000	6.000	1	2	3
	2-W22-39	5.300	5.900	5.900	1	2	3
	2-W7-9	5.240	6.200	5.000	2	3	5
	2-W15-7	5.233	5.700	5.700	1	2	3
	2-W15-18	5.125	6.000	6.000	1	7	8
	2-W7-4	5.111	6.000	6.000	1	8	9
	2-W18-21	5.056	5.500	5.000	2	7	9
	2-W18-22	5.000	5.000	5.000	1	7	8
Lead-212							
	2-W7-7	6.280	6.280	6.280	1	0	1
	2-W18-17	5.470	5.470	5.470	1	0	1
	2-W22-20	4.020	4.020	4.020	1	0	1
Lithium							
	2-W7-6	24.750	37.000	20.000	3	1	4
	2-W19-1	17.000	17.000	17.000	1	0	1
	2-W15-17	11.000	13.000	13.000	1	2	3
	2-W19-26	11.000	11.000	11.000	1	0	1
	2-W19-19	10.000	10.000	10.000	1	0	1
Lithium, filtered							
	2-W19-26	12.000	12.000	12.000	1	0	1
	2-W19-19	11.000	12.000	10.000	2	0	2
	2-W19-24	10.500	11.000	10.000	2	0	2
	2-W19-20	10.000	10.000	10.000	2	0	2
Magnesium							
	2-W19-19	108000.000	108000.000	108000.000	1	0	1
	2-W19-26	93000.000	105000.000	81000.000	2	0	2
	2-W19-20	87033.333	91400.000	84000.000	3	0	3
	2-W19-24	86900.000	93800.000	80000.000	2	0	2
	2-W19-30	84000.000	84000.000	84000.000	1	0	1
	2-W19-25	76500.000	76500.000	76500.000	1	0	1
	2-W19-23	50600.000	50600.000	50600.000	1	0	1
	2-W15-8	46400.000	72000.000	20800.000	2	0	2
	6-38-70	36000.000	36000.000	36000.000	1	0	1
	2-W19-29	35500.000	41000.000	30000.000	2	0	2
	2-W11-7	32400.000	32400.000	32400.000	1	0	1
	2-W19-28	32100.000	32100.000	32100.000	1	0	1
	2-W11-14	28100.000	28100.000	28100.000	1	0	1
	2-W22-42	27666.667	31000.000	23000.000	3	0	3
	2-W22-41	26000.000	29000.000	22000.000	3	0	3
	2-W22-20	24500.000	26000.000	22000.000	3	0	3
	2-W15-12	23100.000	23100.000	23100.000	1	0	1
	2-W11-23	22900.000	22900.000	22900.000	1	0	1
	2-W14-2	22600.000	23200.000	22000.000	2	0	2
	2-W14-10	21700.000	26100.000	17300.000	2	0	2
	2-W15-11	21600.000	21600.000	21600.000	1	0	1
	2-W18-5	19200.000	19200.000	19200.000	1	0	1
	2-W10-18	19000.000	20000.000	18000.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Magnesium							
	2-W15-10	18400.000	18400.000	18400.000	1	0	1
	2-W19-18	18200.000	25400.000	11000.000	2	0	2
	2-W7-4	17490.000	19600.000	16500.000	10	0	10
	2-W6-2	17100.000	19400.000	15000.000	12	0	12
	2-W10-9	17000.000	20000.000	13300.000	5	0	5
	2-W15-16	16537.500	17400.000	15000.000	8	0	8
	6-40-62	16000.000	16000.000	16000.000	1	0	1
	6-45-69A	16000.000	16000.000	16000.000	1	0	1
	2-W10-15	15371.429	17000.000	10600.000	7	0	7
	2-W9-1	14877.778	16000.000	13200.000	9	0	9
	2-W7-1	14566.667	15600.000	12200.000	9	0	9
	2-W15-22	14333.333	16000.000	13000.000	3	0	3
	2-W8-1	14300.000	16300.000	13000.000	9	0	9
	2-W7-2	14077.778	17100.000	12000.000	9	0	9
	2-W7-5	14000.000	15500.000	13400.000	9	0	9
	6-49-79	14000.000	14000.000	14000.000	1	0	1
	2-W15-17	13911.111	15200.000	13000.000	9	0	9
	2-W19-11	13800.000	13800.000	13800.000	1	0	1
	2-W22-40	13750.000	14000.000	13000.000	4	0	4
	2-W15-19	13500.000	15000.000	11500.000	3	0	3
	2-W7-6	13500.000	22200.000	8610.000	9	0	9
	2-W27-1	13250.000	13400.000	13100.000	2	0	2
	6-35-70	13000.000	13000.000	13000.000	1	0	1
	6-36-61A	13000.000	13000.000	13000.000	1	0	1
	2-W19-13	12800.000	12800.000	12800.000	1	0	1
	2-W7-10	12666.667	13000.000	12000.000	3	0	3
	2-W10-13	12540.000	15000.000	11600.000	10	0	10
	2-W10-14	12255.556	13200.000	11000.000	9	0	9
	2-W22-43	12000.000	12000.000	12000.000	4	0	4
	6-48-71	12000.000	12000.000	12000.000	1	0	1
	2-W7-3	11610.000	12900.000	10900.000	10	0	10
	2-W7-8	11350.000	12000.000	11000.000	4	0	4
	2-W10-8	11200.000	11200.000	11200.000	1	0	1
	2-W18-22	11112.500	13700.000	2200.000	8	0	8
	2-W15-18	11100.000	12700.000	10100.000	8	0	8
	2-W19-31	11000.000	11000.000	11000.000	3	0	3
	2-W22-21	11000.000	11000.000	11000.000	1	0	1
	2-W10-16	10860.000	12000.000	9300.000	5	0	5
	2-W15-7	10550.000	11000.000	10100.000	2	0	2
	2-W19-3	10500.000	10500.000	10500.000	1	0	1
	2-W19-1	10200.000	10200.000	10200.000	1	0	1
	2-W19-12	10000.000	10000.000	10000.000	1	0	1
	2-W7-9	9997.500	11000.000	8990.000	4	0	4
	2-W7-7	9875.000	10000.000	9700.000	4	0	4
	2-W22-22	9670.000	9670.000	9670.000	1	0	1
	2-W19-32	9450.000	9800.000	9100.000	2	0	2
	2-W14-5	8740.000	8740.000	8740.000	1	0	1
	2-W18-15	8630.000	8630.000	8630.000	1	0	1
	2-W10-17	8375.000	8800.000	7600.000	4	0	4
	6-32-77	8100.000	8100.000	8100.000	1	0	1
	2-W18-17	8052.857	9420.000	6440.000	7	0	7
	2-W15-15	7880.000	11000.000	6470.000	7	0	7

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Magnesium							
	2-W18-4	7880.000	7880.000	7880.000	1	0	1
	2-W15-23	7800.000	8000.000	7600.000	3	0	3
	2-W15-20	7762.500	8200.000	7500.000	4	0	4
	2-W23-11	7700.000	7700.000	7700.000	1	0	1
	2-W23-13	7500.000	8100.000	6700.000	3	0	3
	2-W18-24	7418.889	8830.000	6600.000	9	0	9
	2-W18-23	7307.778	8360.000	6800.000	9	0	9
	2-W10-4	7200.000	7200.000	7200.000	1	0	1
	2-W26-6	7200.000	7200.000	7200.000	1	0	1
	2-W15-24	7135.000	8540.000	6300.000	4	0	4
	2-W22-39	7133.333	7900.000	6700.000	3	0	3
	2-W18-26	6937.500	7400.000	6600.000	4	0	4
	2-W15-4	6680.000	6680.000	6680.000	1	0	1
	2-W18-21	6676.667	7570.000	5990.000	9	0	9
	2-W18-9	6080.000	6080.000	6080.000	1	0	1
	2-W26-9	6066.667	6300.000	5700.000	3	0	3
	2-W19-21	5905.000	6260.000	5550.000	2	0	2
	2-W18-20	5730.000	5730.000	5730.000	1	0	1
	2-W19-27	5440.000	5440.000	5440.000	1	0	1
	2-W18-25	5166.667	5500.000	4800.000	3	0	3
	2-W26-8	5075.000	5900.000	3200.000	4	0	4
	2-W22-1	5070.000	5070.000	5070.000	1	0	1
	2-W23-14	4966.667	5200.000	4700.000	3	0	3
	6-37-82A	150.000	150.000	150.000	1	0	1
Magnesium, filtered							
	2-W19-19	105650.000	114000.000	97300.000	2	0	2
	2-W19-26	95000.000	112000.000	78000.000	2	0	2
	2-W19-20	88833.333	96800.000	82000.000	6	0	6
	2-W19-24	87240.000	103000.000	78800.000	5	0	5
	2-W19-25	76700.000	79800.000	73600.000	2	0	2
	2-W15-8	66000.000	66000.000	66000.000	1	0	1
	2-W19-23	54500.000	55000.000	54000.000	2	0	2
	2-W19-29	33000.000	39000.000	30000.000	3	0	3
	6-38-70	32516.667	36000.000	29400.000	6	0	6
	2-W19-28	31322.500	53000.000	6590.000	4	0	4
	2-W22-41	26666.667	29000.000	24000.000	3	0	3
	2-W19-2	25600.000	25600.000	25600.000	1	0	1
	2-W14-10	25100.000	25100.000	25100.000	1	0	1
	2-W22-20	23780.000	24600.000	22300.000	5	0	5
	2-W11-23	22900.000	22900.000	22900.000	1	0	1
	6-38-65	22050.000	22500.000	21600.000	2	0	2
	2-W22-42	21666.667	23000.000	12000.000	3	0	3
	2-W14-2	19875.000	21600.000	18900.000	4	0	4
	2-W15-11	19633.333	22400.000	18200.000	3	0	3
	2-W15-10	18900.000	19500.000	18500.000	3	0	3
	2-W19-15	18780.000	23600.000	13300.000	5	0	5
	2-W10-18	18750.000	20000.000	17000.000	4	0	4
	2-W18-5	18533.333	18900.000	18100.000	3	0	3
	2-W19-18	17640.000	25100.000	11000.000	5	0	5
	2-W7-4	17630.000	22100.000	16000.000	10	0	10
	2-W6-2	17185.714	19200.000	16000.000	14	0	14
	2-W14-5	16486.667	27200.000	8960.000	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Magnesium, filtered							
	6-40-62	16475.000	16900.000	16000.000	4	0	4
	6-44-64	16300.000	17600.000	15200.000	5	0	5
	2-W15-16	16122.222	18200.000	15000.000	9	0	9
	6-45-69A	15700.000	16300.000	15000.000	3	0	3
	2-W10-9	15425.000	19000.000	13600.000	4	0	4
	2-W23-10	15340.000	17700.000	14000.000	5	0	5
	2-W10-15	15300.000	19000.000	10500.000	5	0	5
	2-W9-1	15088.889	17000.000	13700.000	9	0	9
	2-W7-1	14677.778	16500.000	13200.000	9	0	9
	2-W15-22	14666.667	16000.000	14000.000	3	0	3
	2-W7-5	14422.222	16400.000	13400.000	9	0	9
	6-49-79	14300.000	15200.000	13000.000	5	0	5
	2-W7-2	14166.667	15300.000	13000.000	9	0	9
	2-W8-1	14155.556	17100.000	13000.000	9	0	9
	2-W15-17	14040.000	15000.000	13000.000	5	0	5
	2-W14-6	13650.000	14700.000	12900.000	6	0	6
	6-35-66	13650.000	14200.000	12700.000	4	0	4
	6-36-61A	13600.000	14200.000	13000.000	5	0	5
	2-W15-19	13366.667	14000.000	12100.000	3	0	3
	2-W22-40	13250.000	14000.000	13000.000	4	0	4
	6-50-85	13133.333	13400.000	12900.000	3	0	3
	6-35-70	13100.000	13600.000	12900.000	4	0	4
	2-W7-10	13000.000	13000.000	13000.000	3	0	3
	6-48-71	12750.000	13500.000	12000.000	2	0	2
	6-32-72	12533.333	12800.000	12300.000	3	0	3
	2-W19-13	12433.333	12900.000	11600.000	3	0	3
	2-W10-14	12366.667	13400.000	11700.000	9	0	9
	2-W18-22	12350.000	13100.000	11700.000	8	0	8
	2-W10-13	12290.000	15000.000	10800.000	10	0	10
	2-W22-43	12250.000	13000.000	12000.000	4	0	4
	6-47-60	12133.333	12800.000	11700.000	3	0	3
	2-W19-12	12100.000	12100.000	12100.000	1	0	1
	6-51-75	12000.000	12000.000	12000.000	1	0	1
	2-W7-3	11590.000	12700.000	10900.000	10	0	10
	2-W7-8	11550.000	12000.000	11000.000	4	0	4
	6-32-70B	11475.000	12000.000	10900.000	4	0	4
	2-W19-11	11250.000	13600.000	8900.000	2	0	2
	2-W15-7	11233.333	12200.000	10500.000	3	0	3
	2-W22-22	11222.000	12900.000	9760.000	5	0	5
	2-W19-31	11000.000	11000.000	11000.000	3	0	3
	2-W15-18	10943.750	12100.000	9450.000	8	0	8
	2-W27-1	10861.250	13400.000	7500.000	8	0	8
	2-W10-16	10776.000	12000.000	8880.000	5	0	5
	2-W10-8	10700.000	10700.000	10700.000	1	0	1
	2-W19-16	10660.000	11200.000	10000.000	5	0	5
	2-W7-7	9877.500	10000.000	9800.000	4	0	4
	2-W7-9	9842.500	11000.000	8370.000	4	0	4
	2-W15-4	9825.000	12600.000	7050.000	2	0	2
	2-W22-12	9540.000	9670.000	9410.000	2	0	2
	2-W22-21	9500.000	9500.000	9500.000	1	0	1
	2-W19-9	9462.500	10500.000	8520.000	4	0	4
	2-W7-6	9341.429	32000.000	3300.000	7	0	7

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Magnesium, filtered							
	2-W19-3	9197.500	10400.000	7520.000	4	0	4
	2-W19-32	9100.000	9200.000	9000.000	2	0	2
	6-43-88	8810.000	8810.000	8810.000	1	0	1
	6-29-78	8770.000	9070.000	8610.000	3	0	3
	2-W18-15	8570.000	8850.000	8070.000	3	0	3
	2-W15-20	8335.000	11000.000	7100.000	4	0	4
	2-W10-17	8325.000	8600.000	8100.000	4	0	4
	2-W15-6	8000.000	8000.000	8000.000	1	0	1
	6-32-77	7956.667	8060.000	7890.000	3	0	3
	2-W15-23	7900.000	8500.000	7500.000	3	0	3
	2-W15-15	7791.250	11000.000	6710.000	8	0	8
	2-W18-17	7745.000	7930.000	7560.000	2	0	2
	2-W10-4	7550.000	7950.000	7340.000	3	0	3
	2-W18-24	7348.000	8720.000	6700.000	10	0	10
	2-W18-23	7288.889	7620.000	6600.000	9	0	9
	2-W22-39	7100.000	7900.000	6500.000	3	0	3
	2-W26-6	7000.000	7000.000	7000.000	1	0	1
	2-W23-13	6966.667	7400.000	6700.000	3	0	3
	2-W22-26	6935.000	7340.000	6530.000	2	0	2
	2-W18-26	6912.500	7200.000	6600.000	4	0	4
	2-W23-11	6575.000	6650.000	6500.000	2	0	2
	2-W18-21	6522.222	6970.000	6030.000	9	0	9
	2-W15-24	6222.500	6900.000	5790.000	4	0	4
	2-W26-9	6033.333	6200.000	5800.000	3	0	3
	2-W19-21	5960.000	6400.000	5390.000	5	0	5
	6-39-79	5825.000	6130.000	5560.000	4	0	4
	6-35-78A	5765.000	6050.000	5480.000	2	0	2
	2-W22-1	5726.667	6160.000	5320.000	3	0	3
	2-W19-5	5615.000	5830.000	5400.000	2	0	2
	2-W18-25	5333.333	5800.000	4800.000	3	0	3
	2-W19-27	5120.000	5290.000	4950.000	2	0	2
	2-W26-8	4925.000	5700.000	3100.000	4	0	4
	2-W23-14	4833.333	4900.000	4700.000	3	0	3
	6-37-82A	478.500	777.000	180.000	2	0	2
Manganese							
	2-W19-1	3010.000	3010.000	3010.000	1	0	1
	2-W10-8	2320.000	2320.000	2320.000	1	0	1
	2-W15-8	1980.000	2160.000	1800.000	2	0	2
	2-W15-12	1960.000	1960.000	1960.000	1	0	1
	2-W11-14	766.000	766.000	766.000	1	0	1
	2-W22-20	723.333	1900.000	260.000	2	1	3
	2-W18-20	556.000	556.000	556.000	1	0	1
	2-W18-9	379.000	379.000	379.000	1	0	1
	2-W14-2	364.500	640.000	89.000	2	0	2
	2-W18-4	309.000	309.000	309.000	1	0	1
	2-W18-17	308.571	732.000	29.000	7	0	7
	2-W15-7	299.500	570.000	29.000	2	0	2
	2-W7-6	292.111	560.000	43.000	9	0	9
	2-W14-10	225.000	432.000	18.000	2	0	2
	2-W15-24	151.000	398.000	43.000	4	0	4
	2-W7-3	142.200	266.000	64.000	10	0	10
	2-W22-21	140.000	140.000	140.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Manganese							
	2-W23-11	140.000	140.000	140.000	1	0	1
	2-W7-9	137.250	265.000	32.000	4	0	4
	2-W19-32	125.000	130.000	120.000	2	0	2
	2-W15-17	101.111	470.000	17.000	9	0	9
	2-W11-7	91.000	91.000	91.000	1	0	1
	2-W15-22	85.333	110.000	48.000	3	0	3
	2-W18-5	68.000	68.000	68.000	1	0	1
	2-W23-14	65.000	100.000	46.000	3	0	3
	2-W22-22	56.000	56.000	56.000	1	0	1
	6-43-69A	56.000	56.000	56.000	1	0	1
	2-W10-18	40.000	60.000	21.000	4	0	4
	2-W18-26	38.250	91.000	16.000	4	0	4
	2-W26-8	34.750	54.000	13.000	4	0	4
	2-W7-8	34.500	46.000	27.000	4	0	4
	2-W19-12	34.000	34.000	34.000	1	0	1
	2-W7-10	34.000	44.000	21.000	3	0	3
	2-W9-1	32.000	62.000	10.000	9	0	9
	2-W10-9	27.000	49.000	34.000	3	2	5
	2-W10-16	22.400	34.000	18.000	4	1	5
	2-W15-20	22.000	42.000	10.000	4	0	4
	2-W18-24	19.556	55.000	6.000	9	0	9
	2-W22-39	19.000	34.000	13.000	2	1	3
	2-W18-21	18.667	39.000	8.000	8	1	9
	2-W26-9	18.333	35.000	35.000	1	2	3
	6-37-82A	18.000	18.000	18.000	1	0	1
	2-W15-18	17.500	24.000	7.000	8	0	8
	2-W14-5	17.000	17.000	17.000	1	0	1
	2-W26-6	17.000	17.000	17.000	1	0	1
	2-W19-29	15.500	21.000	21.000	1	1	2
	2-W7-7	15.500	20.000	11.000	4	0	4
	2-W7-1	15.444	20.000	10.000	8	1	9
	2-W19-20	14.667	21.000	13.000	2	1	3
	2-W18-25	14.000	20.000	12.000	2	1	3
	2-W22-43	14.000	17.000	13.000	3	1	4
	2-W19-31	13.667	16.000	15.000	2	1	3
	2-W7-2	13.111	40.000	7.000	6	3	9
	2-W10-14	12.778	25.000	6.000	8	1	9
	2-W23-13	12.667	18.000	18.000	1	2	3
	2-W19-28	12.000	12.000	12.000	1	0	1
	2-W19-3	12.000	12.000	12.000	1	0	1
	2-W10-15	11.286	14.000	11.000	4	3	7
	2-W18-22	11.250	17.000	7.000	6	2	8
	2-W15-15	11.143	19.000	5.000	6	1	7
	2-W15-4	11.000	11.000	11.000	1	0	1
	2-W18-23	11.000	21.000	6.000	8	1	9
	2-W10-17	10.750	12.000	11.000	2	2	4
	2-W22-42	10.667	12.000	12.000	1	2	3
	2-W7-5	10.556	22.000	6.000	6	3	9
	2-W22-40	10.500	12.000	12.000	1	3	4
	2-W10-13	10.300	18.000	6.000	8	2	10
	2-W19-18	10.000	10.000	10.000	1	1	2
	6-38-70	10.000	10.000	10.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Manganese							
	2-W11-23	9.000	9.000	9.000	1	0	1
	2-W15-16	8.750	15.000	5.000	4	4	8
	2-W7-4	8.500	13.000	6.000	6	4	10
	2-W6-2	8.417	13.000	6.000	5	7	12
	2-W8-1	8.000	14.000	5.000	5	4	9
	2-W19-21	7.000	9.000	9.000	1	1	2
	2-W19-23	6.000	6.000	6.000	1	0	1
Manganese, filtered							
	2-W15-8	680.000	680.000	680.000	1	0	1
	2-W22-43	484.750	1900.000	14.000	3	1	4
	2-W7-3	127.800	233.000	55.000	10	0	10
	2-W7-6	117.429	710.000	6.000	5	2	7
	2-W7-9	80.750	192.000	18.000	4	0	4
	2-W15-24	53.250	124.000	26.000	4	0	4
	6-51-75	47.000	47.000	47.000	1	0	1
	2-W19-2	39.000	39.000	39.000	1	0	1
	2-W19-32	37.500	53.000	22.000	2	0	2
	2-W18-26	30.500	92.000	92.000	1	3	4
	2-W19-15	27.200	70.000	51.000	2	3	5
	2-W22-12	26.500	27.000	26.000	2	0	2
	2-W15-22	26.333	36.000	21.000	3	0	3
	2-W26-8	20.250	34.000	15.000	3	1	4
	2-W15-4	19.500	29.000	10.000	2	0	2
	2-W22-22	18.800	37.000	10.000	5	0	5
	2-W15-6	18.000	18.000	18.000	1	0	1
	2-W9-1	17.000	61.000	5.000	7	2	9
	6-43-88	16.000	16.000	16.000	1	0	1
	2-W19-12	15.000	15.000	15.000	1	0	1
	2-W15-20	13.750	25.000	25.000	1	3	4
	2-W26-9	12.333	17.000	17.000	1	2	3
	6-32-72	12.000	14.000	10.000	3	0	3
	2-W10-18	11.750	14.000	11.000	3	1	4
	2-W14-2	11.000	24.000	6.000	3	1	4
	2-W7-1	10.889	13.000	8.000	7	2	9
	2-W19-20	10.667	17.000	7.000	5	1	6
	2-W23-14	10.667	12.000	12.000	1	2	3
	2-W18-25	10.000	10.000	10.000	1	2	3
	2-W7-8	9.500	8.000	8.000	1	3	4
	2-W10-15	9.400	7.000	7.000	1	4	5
	2-W15-17	8.600	12.000	6.000	2	3	5
	2-W19-16	8.600	19.000	9.000	2	3	5
	2-W10-14	8.444	14.000	6.000	3	6	9
	2-W19-9	8.000	14.000	8.000	2	2	4
	2-W7-5	8.000	17.000	17.000	1	8	9
	2-W15-18	7.875	10.000	5.000	2	6	8
	2-W10-13	7.400	8.000	7.000	4	6	10
	2-W18-21	7.111	14.000	7.000	3	6	9
	2-W14-6	7.000	11.000	6.000	4	2	6
	2-W18-23	6.778	13.000	8.000	2	7	9
	2-W19-18	6.600	8.000	8.000	1	4	5
	2-W27-1	6.375	6.000	6.000	1	7	8
	2-W22-20	6.000	10.000	10.000	1	4	5

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Manganese, filtered							
	2-W14-5	5.667	6.000	6.000	2	1	3
	2-W10-8	5.000	5.000	5.000	1	0	1
Mercury							
	2-W11-7	.540	.540	.540	1	0	1
	2-W10-18	.235	.340	.340	1	3	4
	2-W14-2	.165	.230	.230	1	1	2
Methyl ethyl ketone							
	2-W15-18	33.250	16.000	16.000	1	7	8
	2-W18-22	32.625	11.000	11.000	1	7	8
a Methylene Chloride							
	2-W15-8	562.000	980.000	144.000	2	0	2
	2-W15-15	518.125	4100.000	4100.000	1	7	8
	2-W18-4	77.667	90.000	67.000	3	0	3
	2-W7-1	10.100	51.000	51.000	1	9	10
	2-W10-13	9.250	51.000	51.000	1	11	12
	2-W18-24	7.667	16.000	13.000	2	7	9
	2-W7-6	7.300	18.000	18.000	1	9	10
	2-W15-18	7.250	17.000	8.000	2	6	8
	2-W18-23	6.800	18.000	18.000	1	9	10
	2-W15-17	6.750	7.000	7.000	2	6	8
	2-W6-2	6.741	18.000	16.000	2	12	14
	2-W18-17	6.500	7.000	7.000	1	3	4
	2-W10-14	6.200	12.000	12.000	1	9	10
	2-W18-22	5.500	7.000	7.000	1	7	8
	2-W15-20	5.140	8.000	8.000	1	4	5
	2-W15-24	4.850	8.000	8.000	1	3	4
	2-W22-40	4.500	3.000	3.000	1	3	4
	2-W22-42	4.333	3.000	3.000	1	2	3
	2-W22-41	4.000	2.000	2.000	1	2	3
N-nitrosodimethylamine							
	2-W23-10	27.000	27.000	27.000	1	0	1
Nickel							
	2-W7-9	311.750	880.000	49.000	4	0	4
	2-W7-10	167.333	240.000	82.000	3	0	3
	2-W10-18	150.000	180.000	110.000	4	0	4
	2-W15-8	139.500	230.000	49.000	2	0	2
	2-W7-8	128.500	190.000	79.000	4	0	4
	2-W19-32	117.500	170.000	65.000	2	0	2
	2-W15-15	99.714	518.000	17.000	5	2	7
	2-W10-16	96.200	180.000	49.000	4	1	5
	2-W15-17	91.000	269.000	13.000	9	0	9
	2-W9-1	88.556	210.000	17.000	9	0	9
	2-W10-8	87.000	87.000	87.000	1	0	1
	2-W15-22	81.667	110.000	40.000	3	0	3
	2-W19-1	78.000	78.000	78.000	1	0	1
	2-W26-8	72.250	110.000	56.000	4	0	4
	2-W22-43	70.250	95.000	47.000	4	0	4
	2-W23-14	68.667	72.000	65.000	3	0	3
	2-W26-9	60.000	120.000	120.000	1	2	3
	2-W15-24	55.000	89.000	25.000	3	1	4
	2-W19-29	53.500	77.000	77.000	1	1	2
	2-W22-42	50.000	62.000	58.000	2	1	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Nickel							
	2-W7-7	48.250	64.000	36.000	4	0	4
	2-W7-2	48.000	198.000	13.000	6	3	9
	2-W23-13	47.000	63.000	48.000	2	1	3
	2-W18-21	45.333	140.000	13.000	9	0	9
	2-W[illegible]-13	43.500	71.000	25.000	10	0	10
	2-W18-22	43.375	61.000	25.000	7	1	8
	2-W7-6	43.222	120.000	12.000	7	2	9
	2-W19-31	40.000	57.000	33.000	2	1	3
	2-W10-14	39.556	72.000	19.000	9	0	9
	2-W22-40	39.250	49.000	36.000	3	1	4
	2-W7-3	38.400	64.000	16.000	9	1	10
	2-W[illegible]	36.750	44.000	43.000	2	2	4
	2-W7-1	36.667	80.000	19.000	9	0	9
	2-W7-5	36.111	110.000	14.000	8	1	9
	2-W15-20	35.500	56.000	26.000	2	2	4
	2-W7-4	35.100	69.000	12.000	9	1	10
	2-W15-16	34.750	68.000	21.000	8	0	8
	2-W18-25	34.000	42.000	42.000	1	2	3
	2-W18-26	34.000	59.000	13.000	3	1	4
	2-W10-15	33.714	48.000	38.000	2	5	7
	2-W6-2	33.000	72.000	12.000	8	4	12
	2-W15-18	31.375	61.000	12.000	8	0	8
	2-W18-24	31.333	59.000	13.000	8	1	9
	2-W18-20	31.000	31.000	31.000	1	0	1
	2-W22-39	30.667	32.000	32.000	1	2	3
	2-W18-23	29.111	38.000	20.000	7	2	9
	2-W8-1	28.667	88.000	13.000	7	2	9
	2-W19-28	27.000	27.000	27.000	1	0	1
	2-W15-19	26.333	39.000	39.000	1	2	3
	2-W22-20	24.000	12.000	12.000	1	2	3
	2-W14-[illegible]	21.000	32.000	32.000	1	1	2
	2-W15-12	21.000	21.000	21.000	1	0	1
	2-W18-17	20.429	47.000	15.000	3	4	7
	2-W18-9	19.000	19.000	19.000	1	0	1
	2-W19-20	18.667	16.000	16.000	1	2	3
	2-W14-10	14.500	19.000	19.000	1	1	2
	2-W16-[illegible]	12.000	12.000	12.000	1	0	1
Nickel, filtered							
	2-W9-1	85.667	330.000	15.000	7	2	9
	2-W10-18	80.750	100.000	57.000	4	0	4
	2-W7-[illegible]	59.250	160.000	17.000	2	2	4
	2-W22-43	54.750	75.000	37.000	4	0	4
	2-W15-[illegible]	49.667	62.000	57.000	2	1	3
	2-W22-42	40.333	61.000	61.000	1	2	3
	2-W15-[illegible]	32.000	32.000	32.000	1	0	1
	2-W15-17	31.600	49.000	18.000	4	1	5
	2-W7-6	30.000	110.000	110.000	1	6	7
	2-W10-15	29.800	49.000	49.000	1	4	5
	2-W19-13	26.900	70.000	11.000	6	4	10
	2-W15-[illegible]	23.333	10.000	10.000	1	2	3
	2-W18-21	22.333	73.000	11.000	4	5	9
	2-W7-1	18.778	34.000	22.000	3	6	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Nickel, filtered							
	2-W6-2	17.929	17.000	10.000	3	11	14
	2-W7-2	17.556	18.000	18.000	1	8	9
	2-W7-5	16.889	12.000	12.000	1	8	9
	2-W15-18	16.250	37.000	13.000	2	6	8
	2-W19-20	15.167	17.000	12.000	3	3	6
Nickel-63							
	6-43-88	9.180	9.180	9.180	1	0	1
	6-38-70	7.937	18.300	2.390	3	0	3
a Nitrate							
	2-W19-19	1321666.667	1450000.000	1220000.000	18	0	18
	2-W19-26	1120000.000	1360000.000	850000.000	11	0	11
	2-W19-24	1024571.429	1270000.000	584000.000	21	0	21
	2-W19-20	1024347.826	1110000.000	827000.000	23	0	23
	2-W19-25	805750.000	960000.000	588000.000	16	0	16
	2-W10-3	793500.000	926000.000	661000.000	2	0	2
	2-W15-4	539250.000	699000.000	397000.000	4	0	4
	2-W10-1	503000.000	550000.000	456000.000	2	0	2
	2-W19-23	418941.176	586000.000	330000.000	17	0	17
	2-W10-9	398333.333	480000.000	356000.000	6	0	6
	2-W10-15	379750.000	426000.000	292000.000	4	0	4
	2-W12-1	354000.000	377000.000	331000.000	2	0	2
	2-W19-28	322673.600	620000.000	368.000	5	0	5
	2-W18-5	263666.667	277000.000	255000.000	3	0	3
	2-W22-42	260000.000	290000.000	220000.000	3	0	3
	2-W19-2	250705.882	340000.000	101000.000	17	0	17
	2-W18-17	236223.333	2810000.000	1100.000	5	7	12
	6-38-70	234333.333	330000.000	69000.000	12	0	12
	2-W22-41	230000.000	300000.000	190000.000	3	0	3
	2-W19-29	229000.000	390000.000	68000.000	2	0	2
	2-W11-23	227775.000	757000.000	7100.000	4	0	4
	2-W6-1	225000.000	226000.000	224000.000	2	0	2
	2-W15-8	212020.000	340000.000	71100.000	5	0	5
	2-W10-4	209800.000	222000.000	194000.000	5	0	5
	2-W11-7	209000.000	215000.000	203000.000	2	0	2
	2-W10-16	176333.333	196000.000	163000.000	3	0	3
	2-W11-24	155500.000	163000.000	148000.000	2	0	2
	2-W15-3	133166.667	140000.000	127000.000	6	0	6
	6-38-65	123906.545	171000.000	172.000	11	0	11
	2-W11-14	121333.333	125000.000	116000.000	3	0	3
	2-W18-3	114000.000	115000.000	113000.000	2	0	2
	2-W23-10	113990.000	158000.000	87100.000	10	0	10
	2-W15-11	110200.000	131000.000	95000.000	5	0	5
	2-W14-5	107780.000	290000.000	41400.000	5	0	5
	2-W22-20	105613.600	199000.000	136.000	10	0	10
	2-W19-18	101819.048	146000.000	7400.000	21	0	21
	2-W10-5	98700.000	104000.000	93400.000	2	0	2
	2-W15-12	95400.000	124000.000	22000.000	5	0	5
	2-W19-15	88600.000	109000.000	68600.000	10	0	10
	2-W11-3	84300.000	85900.000	82700.000	2	0	2
	2-W15-18	82262.500	114000.000	68900.000	8	0	8
	2-W23-9	81229.412	223000.000	1700.000	17	0	17
	2-W19-11	80720.000	93100.000	44800.000	5	0	5

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Nitrate							
	2-W15-10	73471.429	114000.000	38800.000	7	0	7
	2-W15-19	72450.000	95400.000	21000.000	4	0	4
	2-W7-4	72390.909	91000.000	21000.000	11	0	11
	2-W15-16	69866.667	76900.000	60000.000	9	0	9
	2-W15-22	67650.000	74300.000	61000.000	2	0	2
	2-W10-18	64000.000	70000.000	58000.000	2	0	2
	2-W10-17	62666.667	131000.000	28000.000	3	0	3
	2-W6-2	61006.667	80700.000	12000.000	15	0	15
	2-W14-10	56520.000	101000.000	14300.000	4	1	5
	2-W11-9	56400.000	56400.000	56400.000	1	0	1
	6-44-64	50966.667	65200.000	18000.000	12	0	12
	2-W14-2	47128.571	74500.000	12000.000	7	0	7
	2-W19-16	46440.000	53600.000	39100.000	10	0	10
	2-W15-7	46380.000	60000.000	5200.000	5	0	5
	2-W27-1	45415.385	96900.000	17000.000	13	0	13
	2-W7-5	42880.000	51600.000	11000.000	10	0	10
	2-W19-3	41772.222	60300.000	21900.000	18	0	18
	6-40-62	41561.538	52000.000	11000.000	13	0	13
	2-W7-1	39800.000	45100.000	9900.000	10	0	10
	2-W21-1	39700.000	40700.000	38700.000	2	0	2
	2-W18-4	36300.000	65300.000	1600.000	4	0	4
	6-49-79	34800.000	41800.000	9300.000	12	0	12
	6-37-82A	32767.655	46700.000	44.200	11	0	11
	2-W10-8	31273.333	58900.000	2720.000	3	0	3
	2-W14-6	30366.667	114000.000	14500.000	15	0	15
	2-W23-2	30342.857	33000.000	27700.000	7	0	7
	2-W8-1	26790.000	30400.000	6700.000	10	0	10
	6-32-62	26450.000	27100.000	25900.000	4	0	4
	2-W7-2	26110.000	42000.000	6600.000	10	0	10
	2-W22-40	25500.000	26000.000	25000.000	4	0	4
	2-W7-8	25160.000	33600.000	7300.000	5	0	5
	6-50-85	24511.111	25800.000	22000.000	9	0	9
	2-W19-9	22711.111	36000.000	16200.000	9	0	9
	6-35-70	21901.969	29200.000	25.600	13	0	13
	6-35-66	21718.583	28500.000	23.000	12	0	12
	6-47-60	20222.470	23500.000	24.700	10	0	10
	2-W9-1	20040.000	32900.000	5700.000	10	0	10
	2-W15-23	19300.000	27000.000	6000.000	3	0	3
	6-48-71	19155.556	25100.000	6100.000	9	0	9
	2-W10-14	19090.000	22200.000	4500.000	10	0	10
	2-W7-9	19040.000	27000.000	6900.000	5	0	5
	6-45-69A	18740.000	25600.000	6100.000	10	0	10
	2-W15-17	18550.000	23200.000	16700.000	8	0	8
	2-W19-13	18487.500	21000.000	15900.000	8	0	8
	2-W18-24	17944.444	23700.000	9700.000	9	0	9
	2-W15-15	17716.250	61000.000	4490.000	8	0	8
	2-W22-21	17333.333	35300.000	4000.000	3	0	3
	2-W22-43	17250.000	20000.000	15000.000	4	0	4
	6-32-70B	17216.667	22000.000	4600.000	12	0	12
	6-51-63	17050.000	18900.000	14700.000	6	0	6
	6-36-61A	16601.654	21600.000	21.500	13	0	13
	2-W18-22	16250.000	18000.000	13800.000	8	0	8

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Nitrate							
	2-W23-3	15568.333	21500.000	8410.000	6	0	6
	2-W22-26	15000.000	18700.000	12800.000	4	0	4
	2-W10-13	14985.455	51000.000	6100.000	11	0	11
	2-W22-22	13875.000	24900.000	2810.000	9	1	10
	2-W7-10	12833.333	17700.000	3800.000	3	0	3
	6-25-70	12350.000	13500.000	11700.000	6	0	6
	2-W19-12	11025.000	16700.000	7100.000	4	0	4
	2-W15-24	10925.000	24000.000	2800.000	4	0	4
	2-W7-7	10740.000	14100.000	3400.000	5	0	5
	2-W22-39	10550.000	17000.000	4100.000	2	0	2
	2-W23-1	10448.571	58800.000	830.000	4	3	7
	6-43-88	10262.857	19200.000	7500.000	7	0	7
	6-36-61B	9978.750	26100.000	20.000	6	2	8
	2-W19-17	9807.500	10000.000	9660.000	4	0	4
	2-W19-31	9750.000	16000.000	3500.000	2	0	2
	2-W19-14	8838.000	11700.000	3540.000	5	0	5
	2-W23-13	8450.000	9200.000	7700.000	2	0	2
	6-55-89	7793.333	17500.000	3380.000	2	1	3
	6-29-78	7684.000	8660.000	7200.000	10	0	10
	6-32-72	7474.444	10600.000	5970.000	8	1	9
	2-W15-20	6786.000	9000.000	2000.000	5	0	5
	6-39-79	6587.692	13000.000	4000.000	13	0	13
	2-W15-6	6533.333	9320.000	1700.000	6	0	6
	2-W22-1	6415.714	12400.000	3830.000	7	0	7
	2-W18-23	6117.273	6800.000	5600.000	11	0	11
	6-32-77	5681.111	6400.000	5200.000	9	0	9
	2-W22-9	5595.000	12000.000	5380.000	2	2	4
	2-W19-32	5500.000	5500.000	5500.000	1	0	1
	2-W7-6	5470.000	8400.000	1200.000	10	0	10
	2-W23-4	5355.385	9730.000	1000.000	12	1	13
	2-W22-2	5078.571	7400.000	900.000	7	0	7
	2-W18-8	5000.000	5000.000	5000.000	1	0	1
	2-W18-26	4296.000	8600.000	1000.000	5	0	5
	2-W15-2	3985.000	4320.000	3650.000	2	0	2
	2-W26-9	3816.667	5500.000	550.000	3	0	3
	2-W7-3	3441.818	8800.000	920.000	11	0	11
	2-W18-9	3237.500	6060.000	1400.000	4	4	8
	2-W23-14	3000.000	3200.000	2800.000	2	0	2
	2-W19-5	2812.500	4220.000	2100.000	3	1	4
	2-W18-21	2615.556	3210.000	2200.000	9	0	9
	6-26-89	2576.667	2730.000	2730.000	1	2	3
	2-W26-6	2520.000	3400.000	870.000	3	1	4
	2-W26-3	2266.667	1800.000	1800.000	1	2	3
	6-51-75	2258.571	2700.000	480.000	3	4	7
	2-W22-12	2108.333	2770.000	1300.000	5	1	6
	2-W18-15	2086.250	1570.000	1200.000	3	5	8
	2-W23-11	2002.857	1200.000	320.000	2	5	7
	6-35-78A	1916.333	1100.000	500.000	3	6	9
	2-W19-27	1825.714	2580.000	900.000	4	3	7
	2-W18-20	1762.500	600.000	600.000	1	7	8
	2-W19-21	1310.000	700.000	300.000	3	7	10
	2-W19-1	766.667	1300.000	800.000	2	1	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
a Nitrate							
	2-W18-25	750.000	800.000	700.000	2	0	2
	2-W26-8	737.500	990.000	200.000	4	0	4
Nitrite							
	2-W23-9	1700.000	2400.000	1000.000	2	0	2
	2-W14-10	1100.000	1200.000	1200.000	1	1	2
	2-W7-9	925.000	1400.000	800.000	3	1	4
	2-W18-4	765.000	530.000	530.000	1	1	2
	2-W22-9	400.000	400.000	400.000	1	0	1
	2-W19-29	360.000	520.000	520.000	1	1	2
Pentachlorophenol							
	2-W15-19	75.000	50.000	50.000	1	1	2
	2-W7-9	66.667	50.000	50.000	1	2	3
	2-W7-6	62.500	50.000	50.000	1	3	4
	2-W7-1	50.000	50.000	50.000	1	3	4
	2-W7-10	50.000	50.000	50.000	1	2	3
	2-W7-7	50.000	50.000	50.000	1	2	3
a Phenol							
	2-W7-10	11.667	10.000	10.000	1	2	3
	2-W15-17	11.500	10.000	10.000	1	9	10
	2-W7-7	10.714	10.000	10.000	1	6	7
	2-W7-6	10.417	10.000	10.000	2	10	12
	2-W15-24	10.100	10.000	10.000	1	4	5
	2-W15-19	10.000	10.000	10.000	1	5	6
	2-W7-1	9.692	10.000	10.000	1	12	13
	2-W7-9	9.429	10.000	10.000	1	6	7
	2-W26-9	7.333	1.000	1.000	1	2	3
	2-W10-17	5.750	1.000	1.000	2	2	4
Phosphate							
	2-W19-24	7350.000	39700.000	39700.000	1	5	6
	2-W19-20	5428.571	33200.000	33200.000	1	6	7
	6-38-70	1798.750	9190.000	9190.000	1	7	8
	2-W19-18	1712.000	5160.000	5160.000	1	4	5
	2-W15-17	787.500	1100.000	1100.000	1	7	8
	2-W22-20	742.857	400.000	400.000	1	6	7
Plutonium-238							
	2-W22-21	8.971	8.971	8.971	1	0	1
	2-W15-8	.083	.139	.139	1	1	2
	2-W19-24	.024	.170	.170	1	6	7
	2-W19-26	.010	.070	.070	1	5	6
	2-W19-23	.006	.049	.049	1	6	7
	2-W19-25	.003	.021	.021	1	6	7
Plutonium-239/40							
	2-W15-8	5.085	8.270	1.900	2	0	2
	2-W22-2	.115	.115	.115	1	0	1
	2-W15-7	.091	.091	.091	1	0	1
	2-W23-13	.085	.258	.258	1	2	3
	2-W18-17	.053	.432	.015	2	7	9
	2-W19-31	.043	.133	.133	1	2	3
	2-W19-24	.018	.117	.117	1	6	7
	2-W19-23	.014	.064	.039	2	5	7
	2-W10-13	.008	.045	.045	1	6	7
	2-W19-25	.007	.050	.018	2	5	7

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Plutonium-239/40							
	2-W19-26	.007	.018	.018	1	5	6
	2-W15-17	.007	.041	.041	1	5	6
	2-W7-3	.002	.009	.009	1	6	7
Potassium							
	2-W15-8	18500.000	25000.000	12000.000	2	0	2
	2-W19-19	11100.000	11100.000	11100.000	1	0	1
	2-W19-24	10280.000	10700.000	9860.000	2	0	2
	2-W19-20	10170.000	10900.000	9800.000	3	0	3
	2-W19-26	9900.000	10700.000	9100.000	2	0	2
	2-W19-30	9800.000	9800.000	9800.000	1	0	1
	2-W19-25	9680.000	9680.000	9680.000	1	0	1
	2-W22-20	8083.333	8600.000	7500.000	3	0	3
	2-W14-10	7500.000	9290.000	5710.000	2	0	2
	2-W19-23	7350.000	7350.000	7350.000	1	0	1
	6-38-70	7300.000	7300.000	7300.000	1	0	1
	2-W19-1	6670.000	6670.000	6670.000	1	0	1
	2-W19-28	6470.000	6470.000	6470.000	1	0	1
	6-35-70	6300.000	6300.000	6300.000	1	0	1
	2-W27-1	6235.000	6460.000	6010.000	2	0	2
	6-37-82A	6200.000	6200.000	6200.000	1	0	1
	2-W18-4	6100.000	6100.000	6100.000	1	0	1
	2-W19-29	6050.000	6900.000	5200.000	2	0	2
	2-W22-42	6000.000	6400.000	5200.000	3	0	3
	2-W11-7	5840.000	5840.000	5840.000	1	0	1
	2-W15-4	5590.000	5590.000	5590.000	1	0	1
	2-W11-14	5420.000	5420.000	5420.000	1	0	1
	6-40-62	5400.000	5400.000	5400.000	1	0	1
	2-W10-9	5330.000	6100.000	4530.000	5	0	5
	2-W14-2	5270.000	5400.000	5140.000	2	0	2
	2-W15-11	5270.000	5270.000	5270.000	1	0	1
	2-W15-17	5201.111	5970.000	4200.000	9	0	9
	6-36-61A	5200.000	5200.000	5200.000	1	0	1
	2-W15-16	5198.750	5770.000	4400.000	8	0	8
	2-W10-15	5087.143	5500.000	4600.000	7	0	7
	2-W15-12	5070.000	5070.000	5070.000	1	0	1
	2-W15-19	4970.000	5300.000	4600.000	3	0	3
	2-W19-11	4970.000	4970.000	4970.000	1	0	1
	2-W7-3	4935.000	5900.000	3900.000	10	0	10
	2-W10-18	4850.000	5200.000	4200.000	4	0	4
	2-W22-41	4833.333	5400.000	4400.000	3	0	3
	2-W10-14	4793.333	5030.000	4550.000	9	0	9
	2-W15-22	4766.667	5000.000	4300.000	3	0	3
	2-W15-10	4750.000	4750.000	4750.000	1	0	1
	2-W7-9	4715.000	5000.000	4500.000	4	0	4
	2-W22-40	4650.000	4800.000	4400.000	4	0	4
	2-W9-1	4641.111	5010.000	4130.000	9	0	9
	2-W19-18	4625.000	5550.000	3700.000	2	0	2
	2-W18-26	4510.000	5100.000	4000.000	4	0	4
	2-W23-13	4500.000	5300.000	4000.000	3	0	3
	2-W7-6	4447.778	5970.000	3030.000	9	0	9
	2-W15-7	4440.000	4900.000	3980.000	2	0	2
	2-W15-24	4400.000	4700.000	3800.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Potassium							
	2-W19-13	4400.000	4400.000	4400.000	1	0	1
	2-W19-32	4400.000	4900.000	3900.000	2	0	2
	2-W18-5	4330.000	4330.000	4330.000	1	0	1
	2-W19-12	4300.000	4300.000	4300.000	1	0	1
	2-W22-21	4300.000	4300.000	4300.000	1	0	1
	2-W22-43	4300.000	5100.000	3800.000	4	0	4
	2-W14-5	4290.000	4290.000	4290.000	1	0	1
	2-W11-23	4110.000	4110.000	4110.000	1	0	1
	2-W15-18	4096.250	4610.000	3700.000	8	0	8
	2-W26-8	4075.000	4700.000	2400.000	4	0	4
	2-W19-3	4050.000	4050.000	4050.000	1	0	1
	2-W10-16	4044.000	4200.000	3800.000	5	0	5
	2-W22-39	4000.000	4500.000	3600.000	3	0	3
	6-32-77	4000.000	4000.000	4000.000	1	0	1
	2-W8-1	3998.889	4800.000	3100.000	9	0	9
	2-W15-23	3866.667	5000.000	3000.000	3	0	3
	2-W26-9	3866.667	5000.000	3100.000	3	0	3
	2-W18-22	3843.750	4650.000	4040.000	7	1	8
	2-W7-1	3823.333	4400.000	3200.000	9	0	9
	6-48-71	3800.000	3800.000	3800.000	1	0	1
	2-W19-31	3766.667	4200.000	3500.000	3	0	3
	2-W10-13	3747.000	4180.000	2800.000	10	0	10
	2-W7-4	3717.000	4500.000	3490.000	10	0	10
	2-W15-20	3645.000	4300.000	2900.000	4	0	4
	2-W7-8	3635.000	4100.000	3000.000	4	0	4
	2-W22-22	3600.000	3600.000	3600.000	1	0	1
	2-W10-17	3550.000	4000.000	3300.000	4	0	4
	2-W18-15	3550.000	3550.000	3550.000	1	0	1
	2-W23-11	3500.000	3500.000	3500.000	1	0	1
	6-45-69A	3500.000	3500.000	3500.000	1	0	1
	2-W7-5	3474.444	4000.000	3200.000	9	0	9
	2-W18-9	3460.000	3460.000	3460.000	1	0	1
	2-W6-2	3435.000	4000.000	2900.000	12	0	12
	2-W26-6	3400.000	3400.000	3400.000	1	0	1
	6-49-79	3400.000	3400.000	3400.000	1	0	1
	2-W18-20	3330.000	3330.000	3330.000	1	0	1
	2-W19-27	3260.000	3260.000	3260.000	1	0	1
	2-W15-15	3254.286	3600.000	2740.000	7	0	7
	2-W7-10	3233.333	3400.000	3100.000	3	0	3
	2-W18-23	3231.111	3570.000	2940.000	9	0	9
	2-W10-8	3210.000	3210.000	3210.000	1	0	1
	2-W23-14	3166.667	3700.000	2700.000	3	0	3
	2-W7-7	3160.000	3400.000	3000.000	4	0	4
	2-W18-24	3116.667	3600.000	2500.000	9	0	9
	2-W10-4	3060.000	3060.000	3060.000	1	0	1
	2-W18-17	3052.857	3640.000	2830.000	7	0	7
	2-W19-21	2955.000	3040.000	2870.000	2	0	2
	2-W18-21	2880.000	3310.000	2570.000	9	0	9
	2-W22-1	2870.000	2870.000	2870.000	1	0	1
	2-W7-2	2590.000	3180.000	2300.000	9	0	9
	2-W18-25	2433.333	3100.000	1800.000	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Potassium, filtered							
	2-W15-8	12000.000	12000.000	12000.000	1	0	1
	2-W19-19	11000.000	11500.000	10500.000	2	0	2
	2-W19-20	10600.000	11700.000	9900.000	6	0	6
	2-W19-24	10520.000	11900.000	9480.000	5	0	5
	2-W19-26	10200.000	11200.000	9200.000	2	0	2
	2-W19-25	9540.000	9690.000	9390.000	2	0	2
	2-W22-20	8012.000	8270.000	7670.000	5	0	5
	2-W19-23	7640.000	7670.000	7610.000	2	0	2
	2-W15-4	6935.000	7920.000	5950.000	2	0	2
	6-38-65	6885.000	7070.000	6700.000	2	0	2
	6-37-82A	6805.000	7000.000	6610.000	2	0	2
	2-W19-28	6567.500	7690.000	5680.000	4	0	4
	6-38-70	6481.667	7080.000	5910.000	6	0	6
	2-W19-2	6100.000	6100.000	6100.000	1	0	1
	6-47-60	6023.333	6390.000	5540.000	3	0	3
	2-W14-5	5856.667	7630.000	4370.000	3	0	3
	2-W22-43	5775.000	10000.000	3900.000	4	0	4
	2-W22-42	5666.667	6400.000	4200.000	3	0	3
	6-40-62	5625.000	5890.000	5420.000	4	0	4
	2-W27-1	5595.000	6300.000	4500.000	8	0	8
	2-W19-29	5566.667	6200.000	5000.000	3	0	3
	6-35-66	5482.500	5780.000	5220.000	4	0	4
	6-35-70	5400.000	5990.000	4700.000	4	0	4
	6-36-61A	5378.000	5840.000	4980.000	5	0	5
	2-W10-15	5370.000	5600.000	4950.000	5	0	5
	2-W14-10	5370.000	5370.000	5370.000	1	0	1
	2-W15-11	5316.667	5540.000	4930.000	3	0	3
	2-W15-10	5150.000	5710.000	4790.000	3	0	3
	2-W15-16	5073.333	5580.000	4500.000	9	0	9
	6-44-64	5068.000	5650.000	4710.000	5	0	5
	2-W10-9	4995.000	5600.000	4550.000	4	0	4
	2-W15-19	4993.333	5400.000	4400.000	3	0	3
	2-W15-17	4990.000	5500.000	4400.000	5	0	5
	2-W14-6	4976.667	5290.000	4690.000	6	0	6
	2-W18-5	4973.333	5250.000	4820.000	3	0	3
	2-W19-15	4942.000	5530.000	4170.000	5	0	5
	2-W7-3	4938.000	5620.000	4440.000	10	0	10
	2-W22-41	4900.000	5000.000	4700.000	3	0	3
	2-W7-9	4815.000	5400.000	4260.000	4	0	4
	2-W10-14	4733.333	5070.000	4300.000	9	0	9
	2-W9-1	4728.889	5220.000	4260.000	9	0	9
	2-W10-18	4725.000	5100.000	4200.000	4	0	4
	2-W14-2	4605.000	4950.000	4000.000	4	0	4
	2-W15-22	4566.667	5100.000	4200.000	3	0	3
	2-W19-13	4476.667	4670.000	4160.000	3	0	3
	2-W19-18	4408.000	5510.000	2500.000	5	0	5
	2-W23-10	4378.000	4900.000	4060.000	5	0	5
	2-W15-7	4340.000	4600.000	4040.000	3	0	3
	6-32-70B	4330.000	4480.000	4190.000	4	0	4
	2-W22-40	4325.000	4700.000	3600.000	4	0	4
	2-W18-26	4300.000	4400.000	4100.000	4	0	4
	2-W22-39	4233.333	4600.000	3900.000	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Potassium, filtered							
	2-W18-22	4205.000	4620.000	3300.000	8	0	8
	2-W22-21	4200.000	4200.000	4200.000	1	0	1
	2-W26-8	4175.000	5300.000	2400.000	4	0	4
	2-W10-16	4158.000	4700.000	3400.000	5	0	5
	2-W23-13	4133.333	4300.000	3800.000	3	0	3
	2-W19-16	4106.000	4330.000	3840.000	5	0	5
	2-W19-32	4100.000	4600.000	3600.000	2	0	2
	2-W15-18	4066.250	4400.000	3640.000	8	0	8
	2-W11-23	4040.000	4040.000	4040.000	1	0	1
	2-W19-12	4040.000	4040.000	4040.000	1	0	1
	6-43-88	4010.000	4010.000	4010.000	1	0	1
	2-W8-1	4001.111	4900.000	3100.000	9	0	9
	2-W19-11	3995.000	4410.000	3580.000	2	0	2
	2-W15-24	3955.000	4300.000	3720.000	4	0	4
	6-32-72	3913.333	4090.000	3660.000	3	0	3
	2-W22-12	3860.000	4010.000	3710.000	2	0	2
	2-W26-9	3833.333	5200.000	3000.000	3	0	3
	6-50-85	3813.333	3990.000	3690.000	3	0	3
	2-W7-1	3795.556	4400.000	3400.000	9	0	9
	2-W7-4	3776.000	4300.000	3300.000	10	0	10
	2-W22-22	3734.000	4050.000	3380.000	5	0	5
	6-49-79	3732.000	4020.000	3480.000	5	0	5
	6-48-71	3730.000	3760.000	3700.000	2	0	2
	2-W10-13	3719.000	4070.000	3000.000	10	0	10
	2-W15-20	3710.000	4300.000	3100.000	4	0	4
	2-W26-6	3700.000	3700.000	3700.000	1	0	1
	2-W19-3	3692.500	4010.000	3250.000	4	0	4
	6-45-69A	3623.333	4000.000	3380.000	3	0	3
	2-W7-8	3607.500	4300.000	2800.000	4	0	4
	2-W18-15	3583.333	3800.000	3400.000	3	0	3
	2-W7-6	3547.143	7200.000	2660.000	7	0	7
	2-W7-5	3535.556	4000.000	3100.000	9	0	9
	2-W19-9	3530.000	3820.000	3320.000	4	0	4
	2-W15-23	3500.000	4200.000	2800.000	3	0	3
	2-W10-8	3460.000	3460.000	3460.000	1	0	1
	6-29-78	3403.333	3530.000	3260.000	3	0	3
	2-W19-31	3400.000	4100.000	2900.000	3	0	3
	2-W6-2	3390.000	4000.000	3200.000	14	0	14
	6-32-77	3336.667	3520.000	3070.000	3	0	3
	2-W10-17	3325.000	3800.000	3000.000	4	0	4
	6-51-75	3300.000	3300.000	3300.000	1	0	1
	2-W7-7	3297.500	3500.000	3090.000	4	0	4
	2-W22-26	3285.000	3570.000	3000.000	2	0	2
	2-W22-1	3253.333	3360.000	3050.000	3	0	3
	2-W15-15	3226.250	3600.000	3030.000	8	0	8
	2-W18-23	3198.889	3380.000	2900.000	9	0	9
	2-W18-24	3177.000	4000.000	2800.000	10	0	10
	2-W10-4	3116.667	3210.000	2950.000	3	0	3
	2-W15-6	3100.000	3100.000	3100.000	1	0	1
	2-W7-10	3066.667	3400.000	2600.000	3	0	3
	2-W19-27	3015.000	3150.000	2880.000	2	0	2
	2-W19-21	2918.000	3070.000	2620.000	5	0	5

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Potassium, filtered							
	6-39-79	2905.000	3040.000	2770.000	4	0	4
	2-W18-25	2866.667	3000.000	2700.000	3	0	3
	2-W23-14	2833.333	3100.000	2700.000	3	0	3
	2-W18-17	2815.000	2860.000	2770.000	2	0	2
	2-W18-21	2814.444	3230.000	2400.000	9	0	9
	2-W23-11	2800.000	2900.000	2700.000	2	0	2
	2-W19-5	2750.000	2800.000	2700.000	2	0	2
	6-35-78A	2625.000	2820.000	2430.000	2	0	2
	2-W7-2	2624.444	3100.000	2300.000	9	0	9
Potassium-40							
	2-W10-18	476.000	476.000	476.000	1	0	1
	2-W19-32	373.000	373.000	373.000	1	0	1
	2-W10-9	359.000	359.000	359.000	1	0	1
	6-48-71	268.000	268.000	268.000	1	0	1
	2-W10-15	259.500	353.000	166.000	2	0	2
	2-W15-22	244.000	244.000	244.000	1	0	1
	2-W7-2	230.000	230.000	230.000	1	0	1
	2-W23-13	207.000	207.000	207.000	1	0	1
	2-W15-20	199.000	199.000	199.000	1	0	1
	2-W15-18	194.000	194.000	194.000	1	0	1
	2-W10-14	188.000	188.000	188.000	1	0	1
	2-W7-5	174.000	174.000	174.000	1	0	1
	2-W10-13	158.000	158.000	158.000	1	0	1
	2-W18-21	155.000	155.000	155.000	1	0	1
	2-W7-3	155.000	155.000	155.000	1	0	1
	2-W15-17	152.500	192.000	113.000	2	0	2
	2-W22-42	146.000	146.000	146.000	1	0	1
	2-W18-17	144.000	144.000	144.000	1	0	1
	2-W7-1	144.000	144.000	144.000	1	0	1
	2-W18-24	142.000	142.000	142.000	1	0	1
	2-W19-29	140.000	140.000	140.000	1	0	1
	2-W9-1	139.000	139.000	139.000	1	0	1
	2-W18-22	131.000	131.000	131.000	1	0	1
	2-W6-2	127.250	204.000	50.500	2	0	2
	2-W18-5	127.000	127.000	127.000	1	0	1
	2-W19-31	126.000	126.000	126.000	1	0	1
	2-W22-43	123.500	124.000	123.000	2	0	2
	2-W7-9	121.000	121.000	121.000	1	0	1
	6-49-79	113.000	113.000	113.000	1	0	1
	2-W15-16	112.000	112.000	112.000	1	0	1
	6-32-72	111.000	111.000	111.000	1	0	1
	2-W7-10	107.000	107.000	107.000	1	0	1
	6-35-70	106.575	149.000	125.000	3	1	4
	2-W19-30	97.800	97.800	97.800	1	0	1
	2-W7-7	91.200	91.200	91.200	1	0	1
	2-W7-6	88.500	88.500	88.500	1	0	1
	2-W15-23	84.900	84.900	84.900	1	0	1
	2-W7-4	76.200	76.200	76.200	1	0	1
	6-38-70	74.500	74.500	74.500	1	0	1
	6-38-65	72.175	118.000	105.000	2	2	4
	2-W18-20	66.600	66.600	66.600	1	0	1
	2-W22-40	66.600	66.600	66.600	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Potassium-40							
	2-W22-20	65.233	84.900	55.900	2	1	3
	2-W18-23	55.900	55.900	55.900	1	0	1
	2-W18-26	54.200	54.200	54.200	1	0	1
	2-W22-12	53.600	53.600	53.600	1	0	1
	2-W8-1	45.400	45.400	45.400	1	0	1
Radium							
	2-W10-8	6.420	6.420	6.420	1	0	1
	2-W7-6	4.038	10.100	.825	9	0	9
	2-W15-12	2.440	2.440	2.440	1	0	1
	2-W22-20	1.530	1.530	1.530	1	0	1
	2-W15-8	1.480	1.480	1.480	1	0	1
	2-W19-1	1.010	1.010	1.010	1	0	1
	2-W11-14	.881	.881	.881	1	0	1
	2-W19-23	.712	.712	.712	1	0	1
	2-W10-15	.591	1.840	.168	6	0	6
	2-W19-24	.521	.709	.332	2	0	2
	2-W15-19	.498	.629	.366	4	0	4
	2-W10-16	.473	1.960	.208	2	3	5
	2-W22-41	.472	.559	.334	3	0	3
	2-W19-26	.455	.455	.455	1	0	1
	2-W19-20	.449	.876	.876	1	1	2
	2-W7-9	.334	.512	.180	5	0	5
	2-W10-14	.275	.446	.194	8	2	10
	2-W14-5	.258	.258	.258	1	0	1
	2-W7-10	.258	.297	.210	3	0	3
	2-W14-10	.249	.442	.442	1	1	2
	2-W9-1	.241	.580	.158	7	3	10
	2-W15-20	.238	.576	.181	3	2	5
	2-W8-1	.235	.574	.182	7	3	10
	2-W7-8	.227	.444	.249	3	2	5
	2-W18-26	.222	.313	.156	4	1	5
	2-W7-2	.218	.529	.174	8	2	10
	2-W15-16	.216	.619	.228	5	3	8
	2-W18-22	.215	.497	.331	4	4	8
	2-W7-7	.213	.290	.268	3	2	5
	2-W22-43	.199	.295	.203	3	1	4
	2-W10-13	.196	.415	.241	6	5	11
	2-W19-32	.196	.228	.163	2	0	2
	2-W19-25	.195	.195	.195	1	0	1
	2-W26-8	.188	.223	.161	3	1	4
	2-W15-7	.176	.176	.176	1	0	1
	2-W19-19	.163	.163	.163	1	0	1
	2-W7-5	.156	.446	.208	3	7	10
	2-W15-18	.156	.335	.225	3	5	8
	2-W7-1	.153	.640	.191	4	6	10
	2-W7-4	.148	.363	.191	4	6	10
	2-W15-17	.141	.360	.164	3	5	8
	2-W15-24	.130	.386	.386	1	3	4
	2-W15-22	.128	.197	.197	1	2	3
	2-W6-2	.121	.299	.148	5	7	12
	2-W18-21	.119	.256	.203	2	7	9
	2-W18-23	.115	.265	.256	2	6	8

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Radium							
	2-W7-5	.107	.271	.234	3	7	10
	2-W23-14	.101	.156	.156	1	1	2
	2-W22-40	.089	.203	.203	1	3	4
	2-W22-42	.087	.167	.167	1	2	3
	2-W10-9	.085	.204	.204	1	3	4
	2-W18-24	.079	.228	.156	2	6	8
	2-W15-15	.072	.177	.156	2	5	7
Ruthenium-106							
	2-W22-39	35.533	57.700	57.700	1	2	3
	2-W19-29	35.150	45.000	45.000	1	1	2
	2-W18-15	31.440	48.200	48.200	1	4	5
	2-W10-14	25.975	65.000	39.900	2	8	10
	2-W22-43	19.890	34.800	34.800	1	1	2
	2-W19-19	15.381	42.000	37.800	2	8	10
	2-W15-15	15.146	58.200	58.200	1	6	7
	6-47-60	13.202	52.200	41.300	2	4	6
	2-W10-13	12.449	47.200	47.200	1	9	10
	2-W22-2	10.725	71.400	71.400	1	5	6
	6-35-70	10.643	46.500	46.500	1	7	8
	2-W19-23	10.277	44.500	44.500	1	6	7
	2-W23-1	8.937	43.400	40.400	2	4	6
	2-W7-8	6.872	71.900	71.900	1	4	5
	2-W23-9	6.669	51.700	45.900	2	14	16
	2-W9-1	6.506	44.400	44.400	1	8	9
	2-W15-20	6.160	47.000	47.000	1	4	5
	6-35-78A	5.994	60.600	60.600	1	6	7
	2-W15-3	4.925	47.300	47.300	1	3	4
	2-W19-24	3.203	34.200	34.200	1	7	8
	2-W27-1	1.047	40.700	40.700	1	6	7
	2-W19-25	.276	42.400	42.400	1	6	7
	2-W10-18	-2.280	45.200	45.200	1	3	4
	2-W15-17	-6.808	35.100	35.100	1	7	8
	2-W7-5	-7.697	53.200	45.600	2	9	11
	2-W19-16	-8.164	45.800	45.800	1	4	5
Selenium							
	2-W27-1	22.000	35.000	21.000	2	1	3
	2-W22-20	12.000	14.000	14.000	1	1	2
	2-W19-23	10.000	10.000	10.000	1	0	1
	2-W10-16	9.200	6.000	6.000	1	4	5
	2-W11-14	7.100	7.100	7.100	1	0	1
	2-W15-17	7.000	7.000	5.000	3	6	9
	2-W19-28	7.000	7.000	7.000	1	0	1
	2-W7-1	6.700	7.000	7.000	1	9	10
	2-W8-1	6.700	7.000	7.000	1	9	10
	2-W9-1	6.667	5.000	5.000	1	8	9
	2-W10-14	6.500	5.000	5.000	1	9	10
	2-W10-13	6.455	6.000	6.000	1	10	11
	2-W15-16	6.250	5.000	5.000	1	7	8
	2-W7-2	6.222	6.000	6.000	1	8	9
	2-W7-4	6.111	5.000	5.000	1	8	9
	2-W19-26	6.000	6.000	6.000	1	0	1
	2-W19-20	5.500	6.000	6.000	1	1	2

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Selenium, filtered							
	2-W27-1	22.333	33.000	24.000	2	1	3
	2-W10-15	9.333	6.000	6.000	1	5	6
	2-W19-23	9.000	9.000	9.000	1	0	1
	2-W22-20	9.000	8.000	8.000	1	1	2
	2-W19-28	7.000	7.000	7.000	1	0	1
	6-36-61A	6.667	5.000	5.000	1	2	3
	2-W19-15	6.500	8.000	8.000	1	1	2
	2-W10-13	6.455	6.000	6.000	1	10	11
	2-W19-20	5.500	6.000	6.000	1	1	2
Silicon							
	2-W10-8	83100.000	83100.000	83100.000	1	0	1
	2-W7-6	36500.000	59500.000	14800.000	4	0	4
	2-W19-1	35900.000	35900.000	35900.000	1	0	1
	2-W15-24	25500.000	25500.000	25500.000	1	0	1
	2-W19-19	25400.000	25400.000	25400.000	1	0	1
	2-W19-24	25100.000	25100.000	25100.000	1	0	1
	2-W19-20	24800.000	24800.000	24800.000	1	0	1
	2-W19-26	24100.000	24100.000	24100.000	1	0	1
	2-W19-23	23600.000	23600.000	23600.000	1	0	1
	2-W15-16	22850.000	24400.000	21900.000	4	0	4
	2-W18-17	22666.667	24800.000	17700.000	6	0	6
	2-W19-28	22000.000	22000.000	22000.000	1	0	1
	2-W10-13	21866.667	23000.000	20800.000	6	0	6
	2-W19-25	21500.000	21500.000	21500.000	1	0	1
	2-W18-22	21475.000	22400.000	19900.000	4	0	4
	2-W15-18	21400.000	22000.000	20700.000	4	0	4
	2-W18-24	21300.000	22200.000	20300.000	5	0	5
	2-W10-14	21220.000	22200.000	19600.000	5	0	5
	2-W10-9	21100.000	21100.000	21100.000	1	0	1
	2-W11-23	20800.000	20800.000	20800.000	1	0	1
	2-W10-16	20100.000	20100.000	20100.000	1	0	1
	2-W7-1	19950.000	21700.000	17600.000	4	0	4
	2-W15-17	19800.000	21500.000	17800.000	3	0	3
	2-W8-1	19500.000	20700.000	18200.000	4	0	4
	2-W10-15	19400.000	19400.000	19400.000	1	0	1
	2-W7-3	19380.000	20100.000	18700.000	5	0	5
	2-W15-15	19275.000	20300.000	17600.000	4	0	4
	2-W18-23	19150.000	20400.000	18400.000	6	0	6
	2-W19-27	19100.000	19100.000	19100.000	1	0	1
	2-W6-2	19050.000	20100.000	16100.000	6	0	6
	2-W7-8	19000.000	19000.000	19000.000	1	0	1
	2-W7-2	18550.000	19100.000	17900.000	4	0	4
	2-W18-21	18420.000	19000.000	17200.000	5	0	5
	2-W15-20	17600.000	17600.000	17600.000	1	0	1
	2-W9-1	17600.000	18300.000	16700.000	4	0	4
	2-W7-7	16900.000	16900.000	16900.000	1	0	1
	2-W7-5	16875.000	17300.000	16500.000	4	0	4
	2-W7-4	16750.000	17400.000	16000.000	4	0	4
	2-W19-21	14700.000	14700.000	14700.000	1	0	1
	2-W27-1	14300.000	14300.000	14300.000	1	0	1
	2-W18-20	12900.000	12900.000	12900.000	1	0	1
	2-W15-19	12700.000	12700.000	12700.000	1	0	1

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Silicon							
	2-W7-9	12200.000	12200.000	12200.000	1	0	1
	2-W14-10	11300.000	11300.000	11300.000	1	0	1
	2-W18-26	11000.000	11000.000	11000.000	1	0	1
Silicon, filtered							
	2-W19-24	25300.000	28500.000	22100.000	2	0	2
	2-W19-26	24900.000	24900.000	24900.000	1	0	1
	2-W19-28	23750.000	27500.000	20000.000	2	0	2
	2-W19-19	23700.000	26800.000	20600.000	2	0	2
	2-W19-2	23200.000	23200.000	23200.000	1	0	1
	2-W18-17	22800.000	23000.000	22600.000	2	0	2
	2-W19-20	22700.000	24400.000	21000.000	2	0	2
	2-W19-23	22600.000	24100.000	21100.000	2	0	2
	6-44-64	22350.000	23200.000	21500.000	2	0	2
	6-36-61A	22300.000	22300.000	22300.000	1	0	1
	6-38-70	22200.000	22300.000	22100.000	2	0	2
	2-W15-16	22040.000	22800.000	21400.000	5	0	5
	2-W19-18	21900.000	21900.000	21900.000	1	0	1
	2-W18-22	21700.000	23200.000	20800.000	4	0	4
	2-W19-25	21600.000	21900.000	21300.000	2	0	2
	2-W15-17	21300.000	21300.000	21300.000	1	0	1
	2-W10-13	21250.000	22900.000	19500.000	6	0	6
	2-W10-14	21140.000	22200.000	19100.000	5	0	5
	2-W18-24	21116.667	22900.000	20400.000	6	0	6
	6-45-69A	21100.000	21100.000	21100.000	1	0	1
	2-W10-9	20900.000	20900.000	20900.000	1	0	1
	2-W11-23	20700.000	20700.000	20700.000	1	0	1
	2-W15-18	20525.000	22700.000	16600.000	4	0	4
	2-W19-11	20500.000	20500.000	20500.000	1	0	1
	2-W19-16	20500.000	20500.000	20500.000	1	0	1
	2-W19-3	20400.000	20400.000	20400.000	1	0	1
	6-38-65	20300.000	20300.000	20300.000	1	0	1
	6-32-70B	20000.000	20000.000	20000.000	1	0	1
	2-W8-1	19800.000	21000.000	18600.000	4	0	4
	2-W18-23	19750.000	20900.000	18600.000	6	0	6
	2-W19-15	19600.000	19600.000	19600.000	1	0	1
	6-35-70	19600.000	19800.000	19400.000	2	0	2
	2-W15-15	19550.000	20800.000	19000.000	4	0	4
	2-W10-16	19500.000	19500.000	19500.000	1	0	1
	2-W6-2	19112.500	19900.000	18200.000	8	0	8
	2-W10-15	19100.000	19100.000	19100.000	1	0	1
	2-W22-22	19000.000	19100.000	18900.000	2	0	2
	6-35-66	19000.000	19000.000	19000.000	1	0	1
	2-W7-3	18840.000	20400.000	16800.000	5	0	5
	2-W7-2	18825.000	20800.000	17400.000	4	0	4
	6-49-79	18700.000	18700.000	18700.000	1	0	1
	2-W19-12	18300.000	18300.000	18300.000	1	0	1
	2-W19-27	18250.000	18700.000	17800.000	2	0	2
	2-W18-21	17940.000	19600.000	15800.000	5	0	5
	2-W7-1	17875.000	19800.000	14600.000	4	0	4
	2-W9-1	17700.000	18600.000	17200.000	4	0	4
	2-W15-20	17500.000	17500.000	17500.000	1	0	1
	2-W7-5	17375.000	17800.000	16900.000	4	0	4

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Silicon, filtered							
	2-W7-8	17200.000	17200.000	17200.000	1	0	1
	2-W23-10	17100.000	17100.000	17100.000	1	0	1
	6-39-79	17100.000	17100.000	17100.000	1	0	1
	2-W7-7	17000.000	17000.000	17000.000	1	0	1
	2-W7-6	16500.000	17600.000	15300.000	3	0	3
	2-W23-11	16300.000	16300.000	16300.000	1	0	1
	2-W7-4	16275.000	17200.000	15700.000	4	0	4
	2-W15-24	15700.000	15700.000	15700.000	1	0	1
	2-W19-21	14800.000	15000.000	14600.000	2	0	2
	6-35-78A	14500.000	14500.000	14500.000	1	0	1
	2-W22-20	14200.000	14200.000	14200.000	1	0	1
	2-W27-1	14066.667	14400.000	13800.000	3	0	3
	2-W15-19	13900.000	13900.000	13900.000	1	0	1
	2-W18-26	11400.000	11400.000	11400.000	1	0	1
	2-W7-9	10300.000	10300.000	10300.000	1	0	1
Silver, filtered							
	2-W18-22	14.375	25.000	25.000	1	7	8
Silver-110 Metastable							
	2-W14-10	5.380	5.380	5.380	1	0	1
Sodium							
	2-W15-4	258000.000	258000.000	258000.000	1	0	1
	2-W10-9	190200.000	200000.000	170000.000	5	0	5
	2-W10-15	186857.143	200000.000	178000.000	7	0	7
	2-W10-4	155000.000	155000.000	155000.000	1	0	1
	2-W10-16	117800.000	120000.000	110000.000	5	0	5
	2-W10-17	117500.000	120000.000	110000.000	4	0	4
	2-W15-8	114500.000	190000.000	39000.000	2	0	2
	2-W14-5	88700.000	88700.000	88700.000	1	0	1
	2-W19-3	63400.000	63400.000	63400.000	1	0	1
	2-W7-6	59266.667	85500.000	29400.000	9	0	9
	2-W22-20	54200.000	56000.000	52000.000	3	0	3
	2-W19-11	53000.000	53000.000	53000.000	1	0	1
	2-W19-19	52100.000	52100.000	52100.000	1	0	1
	2-W18-5	48400.000	48400.000	48400.000	1	0	1
	2-W19-24	46900.000	49700.000	44100.000	2	0	2
	2-W15-12	46400.000	46400.000	46400.000	1	0	1
	2-W19-30	44000.000	44000.000	44000.000	1	0	1
	2-W15-16	43275.000	50100.000	37000.000	8	0	8
	2-W19-26	42050.000	44100.000	40000.000	2	0	2
	2-W19-20	41233.333	43300.000	38400.000	3	0	3
	2-W19-18	40400.000	46800.000	34000.000	2	0	2
	2-W19-1	39900.000	39900.000	39900.000	1	0	1
	2-W19-25	39800.000	39800.000	39800.000	1	0	1
	2-W11-14	36500.000	36500.000	36500.000	1	0	1
	2-W27-1	36400.000	38000.000	34800.000	2	0	2
	2-W10-18	35750.000	39000.000	34000.000	4	0	4
	2-W10-8	34800.000	34800.000	34800.000	1	0	1
	2-W19-29	32500.000	35000.000	30000.000	2	0	2
	2-W7-9	30775.000	38100.000	23000.000	4	0	4
	2-W22-42	30333.333	31000.000	29000.000	3	0	3
	2-W18-4	29800.000	29800.000	29800.000	1	0	1
	2-W19-28	29800.000	29800.000	29800.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Sodium							
	2-W23-13	29000.000	30000.000	28000.000	3	0	3
	2-W19-23	28000.000	28000.000	28000.000	1	0	1
	2-W22-21	28000.000	28000.000	28000.000	1	0	1
	2-W22-39	28000.000	29000.000	26000.000	3	0	3
	2-W14-2	27850.000	28700.000	27000.000	2	0	2
	2-W11-7	27400.000	27400.000	27400.000	1	0	1
	2-W14-10	26850.000	32500.000	21200.000	2	0	2
	2-W15-19	25700.000	26000.000	25100.000	3	0	3
	2-W19-13	25600.000	25600.000	25600.000	1	0	1
	2-W15-11	25300.000	25300.000	25300.000	1	0	1
	2-W15-7	25050.000	26100.000	24000.000	2	0	2
	2-W22-41	25000.000	27000.000	22000.000	3	0	3
	6-37-82A	24000.000	24000.000	24000.000	1	0	1
	2-W22-43	23250.000	24000.000	22000.000	4	0	4
	6-38-70	23000.000	23000.000	23000.000	1	0	1
	2-W15-18	22312.500	29700.000	2400.000	8	0	8
	2-W19-27	22300.000	22300.000	22300.000	1	0	1
	2-W22-40	21750.000	22000.000	21000.000	4	0	4
	2-W18-26	21550.000	25000.000	19000.000	4	0	4
	2-W22-1	20900.000	20900.000	20900.000	1	0	1
	2-W26-8	20750.000	24000.000	13000.000	4	0	4
	2-W26-9	20666.667	24000.000	15000.000	3	0	3
	2-W11-23	20500.000	20500.000	20500.000	1	0	1
	2-W23-14	20333.333	21000.000	20000.000	3	0	3
	2-W15-17	20077.778	25700.000	16000.000	9	0	9
	6-35-70	20000.000	20000.000	20000.000	1	0	1
	2-W15-23	19333.333	20000.000	19000.000	3	0	3
	2-W15-15	19285.714	21000.000	17000.000	7	0	7
	2-W19-32	19000.000	19000.000	19000.000	2	0	2
	2-W15-22	18666.667	21000.000	16000.000	3	0	3
	2-W7-3	18420.000	22000.000	16000.000	10	0	10
	2-W15-24	18350.000	19400.000	17000.000	4	0	4
	2-W19-31	18333.333	19000.000	18000.000	3	0	3
	2-W18-21	18022.222	21100.000	15000.000	9	0	9
	2-W19-12	18000.000	18000.000	18000.000	1	0	1
	2-W15-10	17600.000	17600.000	17600.000	1	0	1
	2-W18-24	17166.667	20000.000	15000.000	9	0	9
	2-W26-6	17000.000	17000.000	17000.000	1	0	1
	6-32-77	17000.000	17000.000	17000.000	1	0	1
	6-36-61A	17000.000	17000.000	17000.000	1	0	1
	6-40-62	17000.000	17000.000	17000.000	1	0	1
	2-W10-14	16711.111	17900.000	14000.000	9	0	9
	2-W18-9	15300.000	15300.000	15300.000	1	0	1
	2-W18-25	14333.333	15000.000	14000.000	3	0	3
	2-W18-23	14022.222	15900.000	13000.000	9	0	9
	2-W15-20	13850.000	14400.000	13000.000	4	0	4
	2-W19-21	13850.000	15100.000	12600.000	2	0	2
	2-W22-22	13100.000	13100.000	13100.000	1	0	1
	2-W18-22	12687.500	16000.000	400.000	8	0	8
	2-W18-15	12000.000	12000.000	12000.000	1	0	1
	2-W9-1	11171.111	12000.000	9140.000	9	0	9
	2-W10-13	11070.000	12000.000	10000.000	10	0	10

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Sodium							
	2-W23-11	11000.000	11000.000	11000.000	1	0	1
	6-45-69A	11000.000	11000.000	11000.000	1	0	1
	2-W6-2	10410.000	11500.000	9600.000	12	0	12
	6-48-71	10000.000	10000.000	10000.000	1	0	1
	2-W8-1	9923.333	11400.000	8500.000	9	0	9
	2-W7-5	9478.889	9930.000	8900.000	9	0	9
	2-W7-1	9117.778	9900.000	7480.000	9	0	9
	2-W7-4	8804.000	9600.000	8360.000	10	0	10
	6-49-79	8800.000	8800.000	8800.000	1	0	1
	2-W7-2	8708.889	10900.000	7300.000	9	0	9
	2-W18-20	8490.000	8490.000	8490.000	1	0	1
	2-W7-10	8400.000	8600.000	8300.000	3	0	3
	2-W7-8	8387.500	9000.000	7600.000	4	0	4
	2-W7-7	8235.000	9000.000	7400.000	4	0	4
	2-W18-17	6837.143	8730.000	5890.000	7	0	7
Sodium, filtered							
	2-W15-4	320500.000	372000.000	269000.000	2	0	2
	2-W15-8	190000.000	190000.000	190000.000	1	0	1
	2-W19-15	185400.000	200000.000	177000.000	5	0	5
	2-W16-9	182500.000	200000.000	171000.000	4	0	4
	2-W19-4	148666.667	152000.000	145000.000	3	0	3
	2-W19-17	122500.000	130000.000	120000.000	4	0	4
	2-W16-10	116600.000	120000.000	110000.000	5	0	5
	2-W14-5	86566.667	90900.000	80900.000	3	0	3
	2-W19-8	84800.000	84800.000	84800.000	1	0	1
	2-W22-20	53280.000	55600.000	48900.000	5	0	5
	2-W19-10	52550.000	55100.000	50000.000	2	0	2
	2-W18-5	50966.667	51300.000	50500.000	3	0	3
	2-W19-3	50700.000	62900.000	39700.000	4	0	4
	2-W7-6	49128.571	65000.000	25600.000	7	0	7
	2-W19-24	48980.000	55600.000	45200.000	5	0	5
	2-W14-6	44833.333	48600.000	38600.000	6	0	6
	2-W19-18	43160.000	48100.000	35000.000	5	0	5
	2-W19-20	42600.000	45700.000	40000.000	6	0	6
	2-W19-26	42600.000	46200.000	39000.000	2	0	2
	2-W19-30	41850.000	48100.000	35600.000	2	0	2
	2-W15-16	41355.556	44500.000	38000.000	9	0	9
	2-W19-25	40150.000	40200.000	40100.000	2	0	2
	2-W19-16	37340.000	41700.000	27300.000	5	0	5
	2-W18-18	33750.000	35000.000	33000.000	4	0	4
	2-W21-1	31775.000	35600.000	26000.000	8	0	8
	2-W19-29	31333.333	32000.000	31000.000	3	0	3
	2-W15-28	30950.000	36100.000	26700.000	4	0	4
	2-W19-12	30140.000	34300.000	27900.000	5	0	5
	2-W19-9	30075.000	35000.000	26300.000	4	0	4
	2-W19-23	29650.000	30400.000	28900.000	2	0	2
	2-W22-39	28666.667	31000.000	26000.000	3	0	3
	2-W7-9	28650.000	34600.000	23000.000	4	0	4
	2-W22-42	27666.667	31000.000	23000.000	3	0	3
	2-W22-43	27250.000	38000.000	23000.000	4	0	4
	2-W14-2	27150.000	28100.000	26700.000	4	0	4
	2-W22-21	27000.000	27000.000	27000.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Sodium, filtered							
	2-W15-7	26900.000	29300.000	24000.000	3	0	3
	2-W23-13	26666.667	28000.000	26000.000	3	0	3
	2-W19-2	26500.000	26500.000	26500.000	1	0	1
	6-38-65	25900.000	26400.000	25400.000	2	0	2
	2-W15-19	25633.333	26000.000	25000.000	3	0	3
	6-47-60	25433.333	27300.000	24100.000	3	0	3
	2-W22-41	25333.333	26000.000	24000.000	3	0	3
	2-W19-13	25166.667	26400.000	23400.000	3	0	3
	2-W15-18	24937.500	27100.000	22900.000	8	0	8
	2-W15-11	24600.000	25700.000	23200.000	3	0	3
	6-37-82A	23400.000	24000.000	22800.000	2	0	2
	2-W22-1	23333.333	23800.000	22800.000	3	0	3
	6-38-70	22116.667	24000.000	20000.000	6	0	6
	2-W19-27	21300.000	21700.000	20900.000	2	0	2
	6-39-79	21275.000	22400.000	19900.000	4	0	4
	2-W22-40	21250.000	22000.000	20000.000	4	0	4
	2-W18-26	21150.000	25000.000	18000.000	4	0	4
	2-W26-8	21000.000	25000.000	14000.000	4	0	4
	6-35-66	21000.000	21800.000	20200.000	4	0	4
	6-35-70	20925.000	22300.000	20000.000	4	0	4
	2-W14-10	20900.000	20900.000	20900.000	1	0	1
	2-W19-5	20700.000	21400.000	20000.000	2	0	2
	2-W26-9	20666.667	24000.000	15000.000	3	0	3
	2-W19-12	20500.000	20500.000	20500.000	1	0	1
	2-W11-23	20400.000	20400.000	20400.000	1	0	1
	2-W22-26	20350.000	21900.000	18800.000	2	0	2
	2-W23-14	20333.333	21000.000	20000.000	3	0	3
	2-W23-10	20300.000	23000.000	17900.000	5	0	5
	2-W15-23	20000.000	21000.000	19000.000	3	0	3
	2-W15-22	19333.333	21000.000	18000.000	3	0	3
	2-W22-12	19200.000	19900.000	18500.000	2	0	2
	6-32-70B	19075.000	19500.000	18400.000	4	0	4
	6-32-77	19000.000	19800.000	17700.000	3	0	3
	2-W15-15	18850.000	20000.000	17500.000	8	0	8
	2-W15-10	18800.000	20600.000	17100.000	3	0	3
	6-40-62	18500.000	19500.000	17000.000	4	0	4
	2-W19-31	18333.333	19000.000	18000.000	3	0	3
	6-36-61A	18200.000	20100.000	17000.000	5	0	5
	6-35-78A	17900.000	19100.000	16700.000	2	0	2
	2-W18-21	17777.778	19300.000	16000.000	9	0	9
	2-W15-24	17750.000	18000.000	17000.000	4	0	4
	2-W15-17	17500.000	18000.000	16000.000	5	0	5
	2-W19-32	17500.000	18000.000	17000.000	2	0	2
	2-W26-6	17000.000	17000.000	17000.000	1	0	1
	2-W7-3	16940.000	22500.000	1700.000	10	0	10
	2-W18-24	16860.000	20000.000	15000.000	10	0	10
	2-W10-14	16311.111	17600.000	14000.000	9	0	9
	6-44-64	15640.000	17300.000	14800.000	5	0	5
	6-29-78	15200.000	15700.000	14800.000	3	0	3
	6-32-72	14833.333	15300.000	14300.000	3	0	3
	2-W15-20	14575.000	17000.000	13000.000	4	0	4
	2-W18-22	14337.500	15700.000	13000.000	8	0	8

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Sodium, filtered							
	2-W18-23	14111.111	14800.000	13000.000	9	0	9
	2-W15-6	14000.000	14000.000	14000.000	1	0	1
	2-W18-25	14000.000	14000.000	14000.000	3	0	3
	6-43-88	13800.000	13800.000	13800.000	1	0	1
	2-W22-22	13720.000	14600.000	12200.000	5	0	5
	2-W19-21	13600.000	15200.000	12100.000	5	0	5
	6-45-69A	11566.667	12100.000	11000.000	3	0	3
	2-W18-15	11400.000	11900.000	11000.000	3	0	3
	2-W9-1	11044.444	11700.000	10300.000	9	0	9
	2-W10-13	10840.000	12000.000	9600.000	10	0	10
	2-W6-2	10564.286	11200.000	10000.000	14	0	14
	6-48-71	10550.000	11100.000	10000.000	2	0	2
	2-W23-11	10350.000	10700.000	10000.000	2	0	2
	6-50-85	10300.000	10300.000	10300.000	3	0	3
	2-W8-1	9945.556	11500.000	8400.000	9	0	9
	2-W7-5	9732.222	10800.000	8800.000	9	0	9
	2-W7-1	9343.333	10500.000	8470.000	9	0	9
	2-W7-4	8842.000	10000.000	8080.000	10	0	10
	2-W7-2	8801.111	9700.000	7500.000	9	0	9
	6-49-79	8794.000	9390.000	8340.000	5	0	5
	6-51-75	8500.000	8500.000	8500.000	1	0	1
	2-W7-8	8410.000	8840.000	7700.000	4	0	4
	2-W7-7	8300.000	9200.000	7400.000	4	0	4
	2-W7-10	8233.333	8300.000	8200.000	3	0	3
	2-W18-17	6205.000	6440.000	5970.000	2	0	2
Specific conductance							
	2-W10-9	3659.400	13296.000	923.000	10	0	10
	2-W19-19	2615.000	2640.000	2590.000	2	0	2
	2-W19-30	2310.000	2310.000	2310.000	1	0	1
	2-W19-24	2176.750	2650.000	1716.000	8	0	8
	2-W19-20	2127.857	2630.000	1800.000	7	0	7
	2-W15-8	2110.400	3720.000	543.000	5	0	5
	2-W19-25	2053.500	2170.000	1937.000	2	0	2
	2-W19-26	1758.250	2350.000	283.000	4	0	4
	2-W19-28	1504.250	1966.000	965.000	4	0	4
	2-W19-23	1395.000	1464.000	1326.000	2	0	2
	2-W10-15	1188.563	1299.000	1030.000	16	0	16
	2-W19-29	1156.750	1402.000	965.000	4	0	4
	2-W22-20	961.000	1815.000	659.000	6	0	6
	2-W15-4	920.000	1635.000	205.000	2	0	2
	2-W10-16	859.554	888.000	823.000	14	0	14
	6-38-70	845.833	966.000	679.000	6	0	6
	2-W22-42	801.167	881.000	698.000	12	0	12
	2-W11-14	771.000	813.000	742.000	3	0	3
	2-W10-17	768.523	795.000	753.000	11	0	11
	2-W14-5	761.667	1052.000	568.000	3	0	3
	2-W11-7	756.000	774.000	738.000	2	0	2
	2-W19-2	745.000	745.000	745.000	1	0	1
	2-W22-41	724.583	861.000	389.000	12	0	12
	2-W18-5	721.000	760.000	666.000	3	0	3
	2-W10-4	711.000	804.000	648.000	3	0	3
	2-W15-12	642.333	668.000	620.000	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Specific conductance							
	2-W15-11	609.000	693.000	565.000	3	0	3
	2-W10-18	595.675	632.000	585.000	10	0	10
	2-W22-12	582.667	1208.000	228.000	3	0	3
	2-W14-2	570.000	622.000	503.000	5	0	5
	2-W15-16	569.234	652.000	417.000	31	0	31
	6-38-65	553.500	585.000	522.000	2	0	2
	2-W19-15	540.600	720.000	407.000	5	0	5
	2-W15-10	538.750	669.000	455.000	4	0	4
	2-W19-18	536.833	683.000	458.000	6	0	6
	2-W14-6	531.750	600.000	474.000	4	0	4
	2-W10-8	506.500	623.000	390.000	2	0	2
	2-W15-22	475.725	538.000	449.000	10	0	10
	2-W23-10	459.000	582.000	370.000	4	0	4
	2-W19-11	449.500	492.000	407.000	2	0	2
	2-W7-4	442.175	510.000	277.000	40	0	40
	2-W15-19	425.118	485.000	287.000	17	0	17
	2-W27-1	416.429	501.000	310.000	7	0	7
	2-W19-16	413.200	429.000	373.000	5	0	5
	2-W14-10	411.000	471.000	351.000	2	0	2
	2-W7-9	408.909	414.000	401.000	11	0	11
	6-44-64	407.800	462.000	358.000	5	0	5
	2-W22-40	406.917	414.000	401.000	12	0	12
	6-35-66	404.750	432.000	384.000	4	0	4
	2-W19-3	401.250	432.000	367.000	4	0	4
	6-40-62	393.333	417.000	368.000	3	0	3
	6-35-70	393.250	434.000	357.000	4	0	4
	6-49-79	392.333	416.000	345.000	6	0	6
	6-36-61A	385.500	465.000	335.000	4	0	4
	6-36-61B	384.500	392.000	377.000	2	0	2
	2-W6-2	384.032	423.000	332.000	31	0	31
	2-W15-18	376.386	471.000	281.000	33	0	33
	2-W22-43	375.833	384.000	371.000	12	0	12
	2-W8-1	375.333	438.000	278.000	39	0	39
	2-W22-9	375.000	375.000	375.000	1	0	1
	2-W15-7	374.750	435.000	296.000	4	0	4
	2-W15-17	374.475	437.000	298.000	20	0	20
	6-45-69A	373.000	392.000	354.000	2	0	2
	2-W15-6	367.000	375.000	351.000	3	0	3
	2-W7-1	366.536	406.000	321.000	28	0	28
	2-W19-31	363.200	386.000	353.000	10	0	10
	2-W19-12	360.000	360.000	360.000	1	0	1
	2-W22-21	360.000	360.000	360.000	2	0	2
	6-32-70B	358.500	419.000	286.000	4	0	4
	2-W7-6	356.774	440.000	211.000	31	0	31
	2-W9-1	354.000	421.000	263.000	31	0	31
	2-W10-13	353.694	474.000	271.000	36	0	36
	2-W7-5	353.368	392.000	256.000	38	0	38
	2-W19-13	352.333	399.000	293.000	3	0	3
	6-47-60	342.333	375.000	313.000	3	0	3
	2-W18-2	337.000	436.000	312.000	5	0	5
	2-W19-21	333.667	1040.000	178.000	6	0	6
	2-W19-32	326.875	329.000	324.000	6	0	6

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Specific conductance							
	2-W10-14	326.321	380.000	286.000	28	0	28
	2-W18-26	320.900	431.000	287.000	20	0	20
	6-37-82A	318.500	373.000	264.000	2	0	2
	2-W19-9	318.250	381.000	189.000	4	0	4
	2-W18-4	311.000	347.000	263.000	3	0	3
	6-50-85	310.000	316.000	304.000	2	0	2
	2-W18-22	305.515	356.000	245.000	33	0	33
	2-W15-23	294.917	305.000	279.000	12	0	12
	2-W7-10	290.333	300.000	284.000	3	0	3
	2-W22-22	287.250	326.000	266.000	4	0	4
	2-W23-13	286.667	298.000	274.000	9	0	9
	2-W7-3	284.750	315.000	243.000	28	0	28
	2-W22-39	283.625	288.000	282.000	8	0	8
	2-W26-6	279.000	293.000	251.000	3	0	3
	2-W7-2	276.929	292.000	235.000	28	0	28
	2-W19-1	273.667	297.000	227.000	3	0	3
	6-48-71	272.000	272.000	272.000	1	0	1
	6-32-72	270.333	296.000	256.000	3	0	3
	6-39-79	270.333	400.000	189.000	3	0	3
	2-W15-20	263.150	272.000	250.000	20	0	20
	2-W7-7	262.167	274.000	258.000	12	0	12
	2-W7-8	261.462	323.000	155.000	13	0	13
	2-W15-24	260.824	280.000	240.000	17	0	17
	2-W26-9	255.000	279.000	222.000	12	0	12
	2-W18-24	250.728	279.000	216.000	34	0	34
	6-32-77	249.000	260.000	228.000	3	0	3
	2-W15-15	245.060	368.000	177.000	29	0	29
	6-43-88	244.000	244.000	244.000	1	0	1
	2-W18-23	243.750	296.000	179.000	41	0	41
	2-W19-27	240.750	270.000	230.000	4	0	4
	2-W26-8	237.000	240.000	234.000	8	0	8
	6-29-78	233.000	275.000	191.000	2	0	2
	2-W22-2	231.000	231.000	231.000	1	0	1
	2-W19-5	223.500	245.000	202.000	2	0	2
	2-W18-21	215.400	241.000	172.000	30	0	30
	2-W23-14	206.500	211.000	202.000	9	0	9
	2-W22-26	206.000	224.000	188.000	2	0	2
	2-W23-11	202.333	203.000	201.000	3	0	3
	2-W18-17	201.000	229.000	111.000	9	0	9
	2-W22-10	194.000	194.000	194.000	1	0	1
	2-W23-4	194.000	194.000	194.000	1	0	1
	2-W18-25	192.773	224.500	184.000	11	0	11
	2-W22-1	192.667	213.000	179.000	3	0	3
	6-35-78A	191.667	212.000	179.000	3	0	3
	2-W18-15	189.000	203.000	175.000	2	0	2
	2-W18-20	181.250	207.000	115.000	4	0	4
	2-W18-9	175.000	179.000	171.000	2	0	2
	2-W23-9	149.000	149.000	149.000	1	0	1
Strontium							
	2-W19-26	1630.000	1630.000	1630.000	1	0	1
	2-W19-19	1530.000	1530.000	1530.000	1	0	1
	2-W19-24	1320.000	1320.000	1320.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Strontium							
	2-W19-20	1250.000	1250.000	1250.000	1	0	1
	2-W19-25	1110.000	1110.000	1110.000	1	0	1
	2-W19-23	785.000	785.000	785.000	1	0	1
	2-W19-28	483.000	483.000	483.000	1	0	1
	2-W11-7	436.000	436.000	436.000	1	0	1
	2-W11-14	431.000	431.000	431.000	1	0	1
	2-W10-8	419.000	419.000	419.000	1	0	1
	2-W22-20	402.000	402.000	402.000	1	0	1
	2-W11-23	381.000	381.000	381.000	1	0	1
	2-W15-12	319.000	319.000	319.000	1	0	1
	2-W7-6	313.333	483.000	152.000	6	0	6
	2-W15-11	302.000	302.000	302.000	1	0	1
	2-W14-2	293.000	293.000	293.000	1	0	1
	2-W15-8	268.000	268.000	268.000	1	0	1
	2-W15-16	266.500	280.000	251.000	6	0	6
	2-W27-1	264.000	264.000	264.000	1	0	1
	2-W18-5	251.000	251.000	251.000	1	0	1
	2-W6-2	250.000	275.000	225.000	7	0	7
	2-W15-10	248.000	248.000	248.000	1	0	1
	2-W7-4	243.857	255.000	235.000	7	0	7
	2-W10-9	239.500	245.000	234.000	2	0	2
	2-W10-15	212.000	212.000	212.000	1	0	1
	2-W15-17	205.667	222.000	196.000	6	0	6
	2-W19-11	194.000	194.000	194.000	1	0	1
	2-W8-1	189.000	215.000	150.000	6	0	6
	2-W10-14	184.667	195.000	174.000	6	0	6
	2-W15-19	181.000	181.000	181.000	1	0	1
	2-W19-13	179.000	179.000	179.000	1	0	1
	2-W9-1	177.667	191.000	158.000	6	0	6
	2-W10-16	175.000	175.000	175.000	1	0	1
	2-W7-1	174.333	190.000	144.000	6	0	6
	2-W18-22	171.833	191.000	161.000	6	0	6
	2-W7-5	171.500	178.000	164.000	6	0	6
	2-W7-9	166.000	166.000	166.000	1	0	1
	2-W10-13	165.714	173.000	162.000	7	0	7
	2-W7-2	161.500	189.000	145.000	6	0	6
	2-W15-18	154.500	183.000	125.000	6	0	6
	2-W7-3	153.000	169.000	145.000	7	0	7
	2-W15-7	151.000	151.000	151.000	1	0	1
	2-W19-3	151.000	151.000	151.000	1	0	1
	2-W7-8	139.000	139.000	139.000	1	0	1
	2-W15-24	134.000	134.000	134.000	1	0	1
	2-W10-4	128.000	128.000	128.000	1	0	1
	2-W18-26	128.000	128.000	128.000	1	0	1
	2-W15-20	123.000	123.000	123.000	1	0	1
	2-W14-5	117.000	117.000	117.000	1	0	1
	2-W15-4	117.000	117.000	117.000	1	0	1
	2-W7-7	114.000	114.000	114.000	1	0	1
	2-W18-4	111.000	111.000	111.000	1	0	1
	2-W18-17	107.571	127.000	77.000	7	0	7
	2-W18-23	107.000	123.000	102.000	7	0	7
	2-W18-24	105.833	118.000	97.000	6	0	6

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Strontium							
	2-W19-1	101.000	101.000	101.000	1	0	1
	2-W15-15	98.000	110.000	85.000	6	0	6
	2-W14-10	93.000	93.000	93.000	1	0	1
	2-W18-9	93.000	93.000	93.000	1	0	1
	2-W18-21	88.571	100.000	81.000	7	0	7
	2-W19-21	86.000	86.000	86.000	1	0	1
	2-W22-1	74.000	74.000	74.000	1	0	1
	2-W19-27	73.000	73.000	73.000	1	0	1
	2-W18-20	59.000	59.000	59.000	1	0	1
Strontium, filtered							
	2-W19-26	1690.000	1690.000	1690.000	1	0	1
	2-W19-19	1505.000	1570.000	1440.000	2	0	2
	2-W19-24	1438.000	1600.000	1250.000	5	0	5
	2-W19-20	1208.000	1270.000	1120.000	5	0	5
	2-W19-25	1155.000	1160.000	1150.000	2	0	2
	2-W19-23	835.500	858.000	813.000	2	0	2
	2-W19-2	560.000	560.000	560.000	1	0	1
	6-38-70	466.400	508.000	428.000	5	0	5
	2-W22-20	400.750	420.000	390.000	4	0	4
	2-W11-23	382.000	382.000	382.000	1	0	1
	2-W14-10	342.000	342.000	342.000	1	0	1
	6-38-65	333.000	338.000	328.000	2	0	2
	2-W15-11	283.000	314.000	259.000	3	0	3
	6-45-69A	271.500	273.000	270.000	2	0	2
	2-W14-2	268.000	285.000	259.000	3	0	3
	2-W19-28	264.000	391.000	137.000	2	0	2
	2-W19-18	263.750	345.000	173.000	4	0	4
	6-37-82A	260.000	260.000	260.000	1	0	1
	2-W15-10	257.667	278.000	245.000	3	0	3
	2-W15-16	256.857	265.000	241.000	7	0	7
	2-W7-4	247.000	273.000	229.000	7	0	7
	2-W6-2	243.778	258.000	227.000	9	0	9
	2-W10-9	240.333	249.000	233.000	3	0	3
	2-W18-5	237.333	243.000	230.000	3	0	3
	2-W19-15	235.600	293.000	175.000	5	0	5
	2-W27-1	231.000	263.000	188.000	6	0	6
	2-W14-5	219.333	353.000	120.000	3	0	3
	6-40-62	216.667	226.000	207.000	3	0	3
	6-47-60	208.667	226.000	196.000	3	0	3
	6-35-66	208.500	211.000	207.000	4	0	4
	2-W10-15	208.000	208.000	208.000	1	0	1
	2-W15-17	207.000	208.000	206.000	2	0	2
	6-44-64	203.600	218.000	[illegible]	5	0	5
	2-W15-19	201.000	201.000	201.000	1	0	1
	6-35-70	192.000	194.000	188.000	3	0	3
	2-W23-10	191.400	217.000	166.000	5	0	5
	6-36-61A	189.250	197.000	173.000	4	0	4
	2-W8-1	187.000	207.000	155.000	6	0	6
	2-W10-14	183.167	194.000	173.000	6	0	6
	2-W7-5	180.167	203.000	171.000	6	0	6
	6-49-79	178.250	193.000	168.000	4	0	4
	2-W9-1	177.500	196.000	158.000	6	0	6

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Strontium, filtered							
	2-W19-13	175.667	182.000	170.000	3	0	3
	2-W7-1	174.333	181.000	163.000	6	0	6
	2-W14-6	173.167	183.000	162.000	6	0	6
	2-W19-12	171.000	171.000	171.000	1	0	1
	2-W18-22	170.333	185.000	158.000	6	0	6
	2-W15-4	169.500	217.000	122.000	2	0	2
	2-W10-16	169.000	169.000	169.000	1	0	1
	2-W10-8	167.000	167.000	167.000	1	0	1
	2-W10-13	162.571	170.000	146.000	7	0	7
	2-W15-7	162.000	171.000	153.000	2	0	2
	2-W19-11	161.500	188.000	135.000	2	0	2
	6-32-70B	159.750	163.000	156.000	4	0	4
	2-W7-2	159.333	174.000	145.000	6	0	6
	2-W19-16	156.400	164.000	152.000	5	0	5
	2-W7-9	153.000	153.000	153.000	1	0	1
	2-W7-3	151.571	164.000	144.000	7	0	7
	6-48-71	151.000	151.000	151.000	1	0	1
	2-W15-18	149.000	165.000	117.000	6	0	6
	2-W22-22	145.800	162.000	119.000	5	0	5
	6-32-72	143.667	147.000	141.000	3	0	3
	6-50-85	139.667	142.000	135.000	3	0	3
	2-W18-26	137.000	137.000	137.000	1	0	1
	2-W7-8	137.000	137.000	137.000	1	0	1
	6-43-88	134.000	134.000	134.000	1	0	1
	2-W19-9	131.750	148.000	113.000	4	0	4
	2-W22-12	131.000	136.000	126.000	2	0	2
	2-W10-4	130.667	134.000	126.000	3	0	3
	2-W19-3	128.500	145.000	107.000	4	0	4
	2-W7-6	124.500	133.000	111.000	4	0	4
	2-W15-20	123.000	123.000	123.000	1	0	1
	6-29-78	119.000	122.000	115.000	3	0	3
	2-W7-7	116.000	116.000	116.000	1	0	1
	6-32-77	112.000	117.000	107.000	3	0	3
	2-W18-23	106.714	116.000	103.000	7	0	7
	2-W18-17	106.000	108.000	104.000	2	0	2
	2-W15-24	103.000	103.000	103.000	1	0	1
	2-W18-24	102.429	116.000	94.000	7	0	7
	2-W18-15	98.000	105.000	92.000	3	0	3
	2-W22-26	97.000	107.000	87.000	2	0	2
	2-W15-15	96.714	108.000	84.000	7	0	7
	2-W23-11	90.000	90.000	90.000	1	0	1
	6-39-79	88.500	96.000	82.000	4	0	4
	2-W18-21	86.571	95.000	79.000	7	0	7
	2-W22-1	81.000	85.000	77.000	3	0	3
	2-W19-21	79.400	84.000	72.000	5	0	5
	2-W19-5	78.000	79.000	77.000	2	0	2
	2-W19-27	70.000	72.000	68.000	2	0	2
	6-35-78A	69.500	71.000	68.000	2	0	2
Strontium-90							
	2-W22-10	21.950	29.800	13.100	6	0	6
	2-W22-1	7.588	8.040	6.910	4	0	4
	2-W19-2	4.865	8.240	2.020	6	0	6

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Strontium-90							
	2-W19-24	2.028	4.310	1.430	5	1	6
	2-W19-18	1.375	2.150	2.150	1	1	2
	2-W22-2	1.344	1.890	1.100	5	0	5
	2-W19-3	1.256	3.460	1.330	2	3	5
	2-W14-2	.783	1.180	1.180	1	1	2
	2-W19-26	.660	1.880	1.880	1	4	5
	2-W15-19	.555	1.430	1.430	1	1	2
	2-W22-7	.416	.899	.899	1	1	2
	2-W10-9	.402	1.490	1.490	1	2	3
	2-W19-19	.363	1.010	1.010	1	6	7
	2-W15-6	.354	.354	.354	1	0	1
	2-W10-3	.288	.862	.862	1	5	6
	2-W19-20	.279	1.200	1.200	1	5	6
	2-W27-1	.005	.883	.883	1	6	7
	2-W7-8	-.016	.699	.699	1	2	3
	2-W18-21	-.090	.933	.933	1	6	7
Sulfate							
	2-W22-9	3500000.000	3500000.000	3500000.000	1	0	1
	2-W18-17	261220.000	1280000.000	1300.000	5	0	5
	2-W22-20	145714.286	151000.000	139000.000	7	0	7
	2-W10-8	120000.000	120000.000	120000.000	1	0	1
	2-W11-23	111500.000	142000.000	81000.000	2	0	2
	2-W19-19	93000.000	121000.000	65000.000	2	0	2
	2-W19-28	77200.000	81000.000	75000.000	4	0	4
	2-W19-30	77000.000	77000.000	77000.000	1	0	1
	2-W14-5	72766.667	88700.000	61500.000	3	0	3
	2-W11-14	71733.333	76100.000	64900.000	3	0	3
	2-W15-8	71600.000	100000.000	40700.000	5	0	5
	2-W19-23	71200.000	71400.000	71000.000	2	0	2
	2-W14-10	68033.333	79300.000	60900.000	3	0	3
	2-W15-16	67833.333	74600.000	60000.000	9	0	9
	2-W19-25	67550.000	69800.000	65300.000	2	0	2
	2-W10-17	65333.333	68000.000	64000.000	3	0	3
	2-W19-24	65000.000	71800.000	57000.000	6	0	6
	2-W10-15	63860.000	69000.000	61000.000	5	0	5
	2-W18-8	62600.000	62600.000	62600.000	1	0	1
	2-W19-20	62385.714	66200.000	52800.000	7	0	7
	2-W10-9	61380.000	65600.000	59000.000	5	0	5
	2-W10-16	61375.000	67000.000	56500.000	4	0	4
	2-W19-26	60666.667	62000.000	59000.000	3	0	3
	2-W19-15	59360.000	71200.000	42500.000	5	0	5
	2-W19-29	59333.333	62000.000	57000.000	3	0	3
	6-[illegible]	59033.333	65000.000	51100.000	3	0	3
	2-W15-12	58000.000	67000.000	49000.000	5	0	5
	2-W10-18	56500.000	58000.000	55000.000	2	0	2
	2-W15-11	54133.333	60800.000	50500.000	3	0	3
	2-W10-4	53733.333	54200.000	53200.000	3	0	3
	2-W[illegible]	52520.000	64000.000	48000.000	10	0	10
	6-38-70	52200.000	58000.000	45700.000	8	0	8
	2-W[illegible]	50000.000	52300.000	48000.000	10	0	10
	2-W7-9	49900.000	52700.000	48000.000	5	0	5
	6-49-79	47933.333	56000.000	42200.000	6	0	6

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Sulfate							
	2-W11-7	46800.000	47300.000	46300.000	2	0	2
	2-W8-1	45940.000	49000.000	42000.000	10	0	10
	6-47-60	44666.667	46300.000	42400.000	3	0	3
	2-W15-10	44400.000	49200.000	41400.000	5	0	5
	2-W14-2	44240.000	51000.000	37000.000	5	0	5
	2-W19-18	42180.000	50600.000	32000.000	5	0	5
	2-W27-1	40675.000	58700.000	28000.000	8	0	8
	2-W19-2	40000.000	40000.000	40000.000	1	0	1
	2-W19-13	38800.000	40400.000	37200.000	3	0	3
	6-40-62	38385.714	44200.000	35000.000	7	0	7
	2-W15-4	38350.000	38900.000	37800.000	2	0	2
	2-W14-6	38260.000	42500.000	35200.000	10	0	10
	6-43-88	37900.000	37900.000	37900.000	1	0	1
	2-W19-3	35300.000	42000.000	29100.000	4	0	4
	6-45-69A	34825.000	41500.000	31000.000	4	0	4
	2-W7-6	34750.000	46000.000	27700.000	10	0	10
	2-W15-22	34500.000	35000.000	34000.000	2	0	2
	2-W19-11	34450.000	38400.000	30500.000	2	0	2
	2-W22-41	33666.667	35000.000	32000.000	3	0	3
	2-W15-7	33266.667	41000.000	26400.000	3	0	3
	2-W15-17	33112.500	41500.000	28000.000	8	0	8
	2-W19-16	32440.000	35100.000	29400.000	5	0	5
	2-W7-4	31770.000	33800.000	30300.000	10	0	10
	2-W22-42	31666.667	33000.000	31000.000	3	0	3
	2-W15-19	31350.000	32100.000	30300.000	4	0	4
	6-44-64	31083.333	35200.000	27700.000	6	0	6
	2-W19-1	31066.667	39200.000	20000.000	3	0	3
	2-W19-31	31000.000	31000.000	31000.000	2	0	2
	2-W22-40	30750.000	33000.000	27000.000	4	0	4
	6-36-61A	30566.667	32000.000	29200.000	6	0	6
	6-48-71	30533.333	31000.000	29600.000	3	0	3
	6-38-65	30450.000	32000.000	28000.000	4	0	4
	2-W7-2	28860.000	50000.000	24400.000	10	0	10
	2-W22-22	28340.000	33900.000	17900.000	5	0	5
	2-W22-43	28000.000	31000.000	25000.000	4	0	4
	6-36-61B	27900.000	27900.000	27900.000	1	0	1
	2-W7-5	27790.000	29600.000	26000.000	10	0	10
	2-W10-13	27509.091	42900.000	22200.000	11	0	11
	6-35-70	27466.667	29200.000	23000.000	6	0	6
	6-35-66	27360.000	29700.000	25700.000	5	0	5
	2-W19-9	26775.000	28400.000	25600.000	4	0	4
	2-W6-2	26446.667	28300.000	24000.000	15	0	15
	2-W19-12	25650.000	27300.000	24000.000	2	0	2
	2-W10-14	24790.000	26400.000	23000.000	10	0	10
	2-W7-3	24354.545	26000.000	22000.000	11	0	11
	6-51-75	24000.000	24000.000	24000.000	1	0	1
	6-32-70B	23866.667	25000.000	22300.000	6	0	6
	2-W7-8	23520.000	24000.000	23000.000	5	0	5
	2-W23-13	23500.000	24000.000	23000.000	2	0	2
	2-W19-32	23000.000	23000.000	23000.000	1	0	1
	2-W18-5	22866.667	23300.000	22500.000	3	0	3
	2-W18-4	22850.000	23400.000	22000.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Sulfate							
	2-W15-18	21125.000	23000.000	19000.000	8	0	8
	2-W22-21	21000.000	21000.000	21000.000	1	0	1
	2-W7-10	21000.000	22000.000	20000.000	3	0	3
	6-29-78	20475.000	21900.000	19600.000	4	0	4
	6-50-85	20300.000	20800.000	19600.000	3	0	3
	2-W22-39	20000.000	20000.000	20000.000	2	0	2
	2-W26-9	20000.000	27000.000	15000.000	3	0	3
	2-W18-24	19855.556	21800.000	18000.000	9	0	9
	6-32-77	19525.000	20000.000	18600.000	4	0	4
	2-W7-7	19280.000	20000.000	18000.000	5	0	5
	2-W22-12	19100.000	21600.000	18000.000	4	0	4
	2-W15-6	19000.000	19000.000	19000.000	1	0	1
	2-W23-1	19000.000	19000.000	19000.000	1	0	1
	2-W18-22	18762.500	20100.000	17000.000	8	0	8
	6-32-72	18625.000	20300.000	17900.000	4	0	4
	2-W18-26	18620.000	22100.000	14000.000	5	0	5
	2-W22-26	17750.000	20300.000	15200.000	2	0	2
	2-W18-9	17550.000	18100.000	17000.000	2	0	2
	2-W15-23	16666.667	17000.000	16000.000	3	0	3
	6-39-79	16033.333	17000.000	15300.000	9	0	9
	2-W15-24	15975.000	20000.000	12900.000	4	0	4
	2-W18-23	15945.455	17000.000	14800.000	11	0	11
	2-W15-20	15740.000	16000.000	15000.000	5	0	5
	2-W26-6	15700.000	16000.000	15400.000	2	0	2
	2-W19-5	15650.000	16200.000	15100.000	2	0	2
	2-W15-15	15325.000	17300.000	14300.000	8	0	8
	2-W22-1	15066.667	15200.000	15000.000	3	0	3
	2-W18-21	14666.667	15200.000	14000.000	9	0	9
	2-W22-2	14500.000	17000.000	12000.000	2	0	2
	2-W23-4	13500.000	13500.000	13500.000	1	0	1
	2-W26-3	13400.000	13400.000	13400.000	1	0	1
	2-W23-9	13200.000	13400.000	13000.000	2	0	2
	2-W23-10	13160.000	13500.000	12400.000	5	0	5
	2-W18-15	12733.333	12900.000	12500.000	3	0	3
	2-W23-11	12050.000	13100.000	11000.000	2	0	2
	2-W23-14	12000.000	12000.000	12000.000	2	0	2
	2-W19-21	11200.000	13200.000	9600.000	6	0	6
	2-W18-25	11000.000	11000.000	11000.000	2	0	2
	2-W19-27	10833.333	11500.000	9600.000	3	0	3
	6-35-78A	10550.000	11300.000	9250.000	3	0	3
	2-W26-8	9650.000	10000.000	9500.000	4	0	4
	2-W18-20	4900.000	8500.000	3100.000	3	0	3
Technetium-99							
	2-W19-24	26601.600	41000.000	27.200	17	0	17
	2-W19-25	20057.857	33000.000	8810.000	14	0	14
	2-W19-20	13947.059	25400.000	10600.000	17	0	17
	2-W19-19	13741.250	24600.000	8530.000	16	0	16
	2-W19-28	7315.000	8450.000	6180.000	2	0	2
	2-W19-29	5330.000	10000.000	2520.000	3	0	3
	2-W19-18	4279.922	9200.000	91.600	18	0	18
	6-38-70	3231.111	4230.000	1940.000	18	0	18
	2-W19-26	3077.778	7290.000	1040.000	9	0	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Technetium-99							
	2-W19-30	2800.000	2800.000	2800.000	1	0	1
	2-W23-2	2760.824	5150.000	103.000	17	0	17
	2-W23-7	2279.824	7830.000	117.000	17	0	17
	2-W19-11	1768.333	2870.000	355.000	3	0	3
	2-W19-23	1270.267	1850.000	907.000	15	0	15
	2-W19-12	1117.667	2350.000	302.000	3	0	3
	2-W19-16	976.550	1720.000	105.000	5	1	6
	2-W19-3	927.307	1280.000	323.000	13	1	14
	2-W19-15	713.133	1030.000	36.800	6	0	6
	2-W22-21	637.000	637.000	637.000	1	0	1
	2-W19-9	511.000	1020.000	247.000	6	0	6
	2-W10-1	507.000	514.000	500.000	2	0	2
	2-W14-2	483.333	852.000	247.000	3	0	3
	2-W19-32	459.000	521.000	397.000	2	0	2
	2-W22-39	408.333	453.000	359.000	3	0	3
	2-W15-8	406.000	406.000	406.000	1	0	1
	2-W10-15	311.800	395.000	278.000	5	0	5
	2-W10-9	309.500	310.000	309.000	2	0	2
	2-W11-18	220.633	558.000	15.400	3	0	3
	2-W19-31	211.333	297.000	152.000	3	0	3
	6-32-708	172.775	210.000	93.100	4	0	4
	2-W22-20	162.000	184.000	124.000	3	0	3
	2-W19-17	155.500	178.000	115.000	4	0	4
	2-W22-42	131.000	137.000	125.000	2	0	2
	2-W10-17	119.475	136.000	92.900	4	0	4
	2-W10-16	111.025	131.000	96.000	4	0	4
	2-W19-13	110.000	110.000	110.000	1	0	1
	6-44-64	109.000	109.000	109.000	1	0	1
	2-W22-41	104.050	117.000	91.100	2	0	2
	2-W15-22	98.567	137.000	38.700	3	0	3
	2-W19-5	94.950	117.000	72.900	2	0	2
	6-35-70	89.700	135.000	26.800	6	0	6
	2-W22-18	65.950	69.400	62.500	2	0	2
	2-W7-4	63.960	81.200	38.000	10	0	10
	2-W6-2	62.258	107.000	6.590	12	0	12
	2-W23-9	53.350	81.200	25.500	2	0	2
	6-32-72	51.850	86.400	15.000	4	0	4
	2-W15-4	47.600	49.200	46.000	2	0	2
	6-38-65	40.633	92.400	40.700	2	1	3
	2-W10-18	40.475	43.200	35.500	4	0	4
	2-W19-14	38.700	38.700	38.700	1	0	1
	2-W19-1	33.667	46.700	24.400	3	0	3
	6-35-66	32.113	44.700	5.850	4	0	4
	2-W7-5	26.933	39.400	14.800	9	0	9
	2-W15-19	22.933	31.400	14.200	3	0	3
	2-W22-43	17.650	27.400	7.900	2	0	2
	2-W22-40	16.667	23.400	12.600	3	0	3
	2-W10-13	14.977	24.900	8.250	8	1	9
	2-W22-12	14.500	14.500	14.500	1	0	1
	2-W23-10	14.500	19.800	19.000	2	1	3
	2-W18-3	13.775	20.400	20.400	1	1	2
	2-W8-1	12.937	18.100	6.390	9	0	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Technetium-99							
	2-W9-1	12.429	19.200	5.120	8	1	9
	2-W15-16	11.468	18.700	4.600	8	0	8
	2-W15-17	10.949	17.000	7.950	8	0	8
	2-W15-7	10.720	12.900	8.540	2	0	2
	2-W15-18	9.726	27.400	6.590	7	1	8
	2-W7-8	8.320	9.860	7.670	4	0	4
	2-W23-14	8.283	11.800	4.140	3	0	3
	2-W15-15	7.469	17.200	12.600	2	5	7
	2-W18-24	6.497	46.000	46.000	1	7	8
	2-W7-1	6.331	8.220	3.870	6	3	9
	6-48-71	6.190	12.200	12.200	1	1	2
	6-40-62	5.310	5.310	5.310	1	0	1
	2-W23-13	5.221	13.700	13.700	1	2	3
	2-W7-9	4.293	5.690	3.220	3	0	3
	2-W7-2	4.002	8.170	3.600	2	7	9
	6-36-61A	3.705	6.080	6.080	1	1	2
	2-W7-10	3.573	9.360	3.810	2	1	3
	2-W22-22	3.560	3.560	3.560	1	0	1
	2-W15-23	3.467	4.710	2.630	3	0	3
	2-W23-11	3.281	6.830	6.830	1	3	4
	2-W15-24	3.183	5.170	4.190	2	1	3
	6-49-79	3.150	3.150	3.150	1	0	1
	6-25-70	3.100	3.100	3.100	1	0	1
	6-39-79	2.360	2.360	2.360	1	0	1
	2-W7-7	2.220	4.760	4.760	1	3	4
	2-W18-25	2.133	4.070	2.760	2	2	4
	2-W18-23	1.700	2.970	2.970	1	6	7
	2-W15-20	1.331	2.420	2.420	1	3	4
	2-W18-21	.930	1.790	1.790	1	7	8
	2-W18-26	.313	2.230	2.230	1	3	4
a Tetrachloroethylene							
	2-W15-8	5.000	7.000	7.000	1	1	2
Titanium							
	2-W19-1	1370.000	1370.000	1370.000	1	0	1
	2-W15-24	997.000	997.000	997.000	1	0	1
	2-W14-10	193.000	193.000	193.000	1	0	1
	2-W10-8	169.000	169.000	169.000	1	0	1
	2-W7-6	146.250	263.000	202.000	2	2	4
	2-W15-17	94.333	163.000	163.000	1	2	3
	2-W18-20	70.000	70.000	70.000	1	0	1
Toluene							
	2-W19-1	9.000	13.000	13.000	1	1	2
Total Organic Halogen, Low Det. Level							
	2-W15-16	4317.455	6870.000	96.000	33	0	33
	2-W15-6	2900.000	2900.000	2900.000	1	0	1
	2-W15-11	2870.000	2870.000	2870.000	1	0	1
	2-W15-10	2010.000	2030.000	1990.000	2	0	2
	2-W18-5	1970.000	1970.000	1970.000	1	0	1
	2-W15-18	1225.517	1770.000	650.000	29	0	29
	2-W10-4	1200.000	1200.000	1200.000	1	0	1
	2-W10-17	1189.167	3200.000	730.000	12	0	12
	2-W10-9	991.923	1510.000	695.000	13	0	13

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Total Organic Halogen, Low Det. Level							
	2-W15-15	963.786	5550.000	201.000	28	0	28
	2-W15-7	953.000	953.000	953.000	1	0	1
	2-W15-4	915.000	915.000	915.000	1	0	1
	2-W15-19	861.000	1300.000	648.000	16	0	16
	2-W14-2	788.000	788.000	788.000	1	0	1
	2-W15-22	777.917	1400.000	320.000	12	0	12
	2-W10-15	731.619	1600.000	200.000	21	0	21
	2-W10-16	714.100	1100.000	280.000	20	0	20
	2-W10-18	652.083	875.000	470.000	12	0	12
	2-W18-24	535.467	843.000	28.000	30	0	30
	2-W18-23	535.091	898.000	171.000	33	0	33
	6-39-79	474.000	660.000	288.000	2	0	2
	2-W18-17	466.667	1170.000	32.000	3	0	3
	2-W18-4	438.000	438.000	438.000	1	0	1
	2-W11-14	354.500	561.000	148.000	2	0	2
	2-W15-23	343.333	435.000	40.000	12	0	12
	2-W7-4	261.500	1540.000	118.000	34	0	34
	2-W14-5	232.000	232.000	232.000	1	0	1
	2-W14-6	208.000	234.000	182.000	2	0	2
	2-W15-24	205.063	390.000	120.000	16	0	16
	2-W18-26	171.000	253.000	125.000	20	0	20
	2-W15-20	155.100	196.000	110.000	20	0	20
	2-W7-3	136.345	1740.000	197.000	4	25	29
	2-W18-21	132.719	250.000	39.000	31	1	32
	2-W19-11	123.000	136.000	110.000	2	0	2
	2-W7-2	121.034	1670.000	10.000	6	24	30
	2-W19-31	108.750	130.000	100.000	12	0	12
	2-W19-16	93.800	136.000	70.000	3	0	3
	2-W19-3	88.800	111.000	66.600	2	0	2
	2-W18-15	84.200	84.200	84.200	1	0	1
	2-W6-2	78.009	96.000	60.000	35	0	35
	2-W19-29	76.833	100.000	60.000	3	0	3
	2-W22-20	63.100	82.000	46.800	3	0	3
	2-W19-15	61.933	86.000	40.800	3	0	3
	2-W19-9	61.150	81.100	41.200	2	0	2
	2-W19-28	53.000	70.000	40.000	4	0	4
	2-W19-18	52.650	77.000	28.300	2	0	2
	2-W19-30	45.000	45.000	45.000	1	0	1
	6-38-70	39.133	42.400	37.000	3	0	3
	2-W18-20	39.000	40.000	38.000	2	0	2
	2-W19-20	32.500	55.500	20.000	5	0	5
	2-W7-5	29.823	50.000	21.000	30	1	31
	2-W19-26	29.500	39.000	20.000	2	0	2
	2-W19-23	25.500	26.000	25.000	2	0	2
	2-W7-1	23.581	163.000	148.000	4	27	31
	2-W10-14	23.259	487.000	12.000	3	28	31
	2-W19-12	23.000	23.000	23.000	1	0	1
	2-W19-2	23.000	23.000	23.000	1	0	1
	2-W19-19	22.500	25.000	20.000	2	0	2
	2-W19-25	22.500	23.000	22.000	2	0	2
	2-W10-13	22.352	60.000	11.500	23	8	31
	2-W19-24	21.800	26.200	20.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Total Organic Halogen, Low Det. Level							
	2-W14-10	19.600	26.000	20.000	2	1	3
	2-W22-43	16.958	34.000	10.000	8	4	12
	2-W19-1	16.500	20.000	13.000	2	0	2
	2-W11-23	16.250	18.000	13.000	4	0	4
	2-W19-27	14.750	20.000	11.000	3	1	4
	2-W22-41	14.458	20.000	10.000	8	4	12
	2-W22-40	13.458	30.000	10.000	8	4	12
	2-W23-13	13.333	50.000	50.000	1	11	12
	2-W10-8	13.000	15.000	11.000	4	0	4
	2-W22-42	11.583	20.000	10.000	7	5	12
	6-32-77	11.067	10.000	10.000	1	2	3
	2-W27-1	11.040	12.000	10.000	3	2	5
	2-W19-32	11.000	14.500	10.000	8	0	8
	2-W15-17	10.893	30.000	12.000	10	18	28
	2-W18-25	10.833	20.000	10.000	3	9	12
	2-W22-39	10.833	20.000	10.000	2	10	12
	2-W23-14	10.458	14.500	11.000	2	10	12
	2-W26-9	10.083	11.000	11.000	1	11	12
	2-W26-8	10.000	10.000	10.000	2	10	12
	2-W7-10	10.000	10.000	10.000	1	1	2
	2-W7-9	9.545	12.000	10.000	3	8	11
	2-W19-21	8.020	10.000	10.000	3	2	5
	2-W7-8	7.391	12.500	10.000	2	9	11
	2-W9-1	7.032	14.000	14.000	1	30	31
	2-W8-1	6.613	12.000	10.000	2	29	31
	2-W7-6	6.307	33.000	14.500	2	29	31
	2-W18-22	5.157	12.000	12.000	1	31	32
Total carbon							
	2-W19-18	40533.333	43200.000	36100.000	3	0	3
	2-W10-9	40200.000	43000.000	38000.000	5	0	5
	2-W10-15	39916.667	42000.000	38000.000	6	0	6
	2-W15-4	38550.000	42600.000	34500.000	2	0	2
	2-W10-4	37633.333	39600.000	36100.000	3	0	3
	6-35-66	35925.000	37300.000	33800.000	4	0	4
	2-W19-3	35633.333	39000.000	32000.000	3	0	3
	2-W10-16	35240.000	36000.000	34000.000	5	0	5
	2-W10-17	35000.000	38000.000	33000.000	3	0	3
	6-36-61A	34533.333	35100.000	33800.000	3	0	3
	2-W19-15	34350.000	38000.000	30100.000	4	0	4
	2-W19-19	33900.000	33900.000	33900.000	1	0	1
	2-W19-11	33400.000	33400.000	33400.000	1	0	1
	2-W22-20	33233.333	35200.000	32200.000	3	0	3
	6-36-61B	33100.000	33100.000	33100.000	1	0	1
	2-W19-24	33025.000	34600.000	30300.000	4	0	4
	2-W27-1	32775.000	33400.000	32200.000	4	0	4
	2-W19-20	32325.000	34700.000	29800.000	4	0	4
	2-W19-25	32200.000	32200.000	32200.000	1	0	1
	6-40-62	32066.667	33000.000	31600.000	3	0	3
	2-W19-31	32000.000	34000.000	30000.000	2	0	2
	2-W11-23	31800.000	31800.000	31800.000	1	0	1
	2-W19-13	31800.000	32300.000	31300.000	3	0	3
	2-W22-43	31000.000	33000.000	29000.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Total carbon							
	2-W19-26	30900.000	30900.000	30900.000	1	0	1
	2-W19-23	29800.000	29800.000	29800.000	1	0	1
	2-W7-6	29775.000	39000.000	23700.000	8	0	8
	2-W7-3	29350.000	33000.000	23800.000	8	0	8
	2-W15-11	29300.000	30900.000	28200.000	3	0	3
	6-32-70B	29275.000	30700.000	26400.000	4	0	4
	2-W22-40	29250.000	30000.000	29000.000	4	0	4
	6-35-70	29250.000	30200.000	28300.000	2	0	2
	2-W18-26	29200.000	31000.000	27400.000	5	0	5
	6-38-65	29100.000	29100.000	29100.000	1	0	1
	2-W15-16	29055.167	42000.000	31.000	6	0	6
	6-38-70	28850.000	30300.000	27200.000	4	0	4
	2-W14-5	28766.667	31400.000	26500.000	3	0	3
	2-W22-41	28666.667	29000.000	28000.000	3	0	3
	2-W14-2	28166.667	29100.000	27100.000	3	0	3
	2-W11-7	28100.000	30200.000	26000.000	2	0	2
	2-W14-10	27900.000	35400.000	20400.000	2	0	2
	2-W6-2	27880.000	30000.000	24000.000	10	0	10
	2-W22-42	27666.667	29000.000	27000.000	3	0	3
	2-W19-9	27650.000	29200.000	26700.000	4	0	4
	2-W10-14	27500.000	31000.000	25200.000	8	0	8
	2-W22-12	27500.000	28600.000	26400.000	2	0	2
	2-W23-13	27500.000	30000.000	25000.000	2	0	2
	6-45-69A	27500.000	27500.000	27500.000	1	0	1
	2-W15-23	27333.333	28000.000	27000.000	3	0	3
	6-47-60	27333.333	27900.000	26700.000	3	0	3
	6-50-85	27300.000	28600.000	25500.000	3	0	3
	2-W15-10	27266.667	28300.000	26700.000	3	0	3
	2-W15-12	27233.333	29000.000	25900.000	3	0	3
	2-W19-16	27025.000	28100.000	26000.000	4	0	4
	2-W15-22	27000.000	28000.000	26000.000	3	0	3
	2-W11-14	26850.000	28600.000	25100.000	2	0	2
	2-W23-10	26775.000	27600.000	26300.000	4	0	4
	2-W7-10	26666.667	27000.000	26000.000	3	0	3
	2-W15-20	26560.000	28000.000	24700.000	5	0	5
	2-W14-6	26425.000	29300.000	24800.000	4	0	4
	6-44-64	26350.000	28200.000	24500.000	4	0	4
	2-W15-17	26332.571	34000.000	28.000	7	0	7
	6-32-72	26266.667	26500.000	26100.000	3	0	3
	2-W22-39	26000.000	26000.000	26000.000	2	0	2
	2-W7-9	25920.000	28000.000	23000.000	5	0	5
	2-W18-5	25466.667	25800.000	25100.000	3	0	3
	2-W18-22	25054.500	35000.000	27.000	6	0	6
	2-W10-8	24650.000	24900.000	24400.000	2	0	2
	2-W15-7	24650.000	25200.000	24100.000	2	0	2
	6-32-77	24533.333	25100.000	24200.000	3	0	3
	2-W10-18	24507.250	34000.000	29.000	4	0	4
	2-W18-23	24385.714	26600.000	22600.000	6	1	7
	6-48-71	24300.000	24300.000	24300.000	1	0	1
	2-W7-7	24260.000	26000.000	22000.000	5	0	5
	2-W15-24	23925.000	26000.000	21000.000	4	0	4
	2-W19-27	23900.000	23900.000	23900.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Total carbon							
	6-29-78	23733.333	24700.000	22700.000	3	0	3
	2-W7-8	23660.000	26000.000	20000.000	5	0	5
	2-W18-25	23500.000	24000.000	23000.000	2	0	2
	2-W19-5	23500.000	23800.000	23200.000	2	0	2
	2-W8-1	23437.500	26000.000	21000.000	8	0	8
	2-W22-22	23166.667	24400.000	21900.000	3	0	3
	2-W10-13	23137.500	25200.000	22000.000	8	0	8
	2-W7-4	23062.500	26000.000	21600.000	8	0	8
	6-37-82A	23000.000	23000.000	23000.000	1	0	1
	6-39-79	22975.000	23500.000	22100.000	4	0	4
	2-W22-26	22550.000	22900.000	22200.000	2	0	2
	2-W7-2	22275.000	24000.000	20300.000	8	0	8
	6-49-79	22275.000	23600.000	20500.000	4	0	4
	2-W18-15	22233.333	23200.000	21200.000	3	0	3
	2-W7-5	22225.000	25000.000	19000.000	8	0	8
	2-W23-14	22000.000	24000.000	20000.000	2	0	2
	2-W7-1	21825.000	24000.000	19700.000	8	0	8
	2-W22-1	21633.333	23700.000	20000.000	3	0	3
	6-35-78A	21250.000	22300.000	20200.000	2	0	2
	2-W9-1	21062.500	22600.000	18000.000	8	0	8
	2-W19-21	20575.000	21400.000	20100.000	4	0	4
	2-W26-8	20505.750	28000.000	23.000	4	0	4
	2-W15-19	20131.500	29000.000	26.000	4	0	4
	2-W15-18	19570.167	25000.000	21.000	6	0	6
	2-W18-21	19120.333	25000.000	22.000	6	0	6
	2-W18-9	19100.000	19100.000	19100.000	1	0	1
	2-W15-15	18524.400	24000.000	22.000	5	0	5
	6-43-88	18100.000	18100.000	18100.000	1	0	1
	2-W18-24	17653.167	22000.000	19.000	6	0	6
	2-W18-4	16633.333	18000.000	15000.000	3	0	3
	2-W18-17	16350.000	21200.000	14100.000	4	0	4
	2-W19-1	15800.000	15800.000	15800.000	1	0	1
	2-W26-9	15674.000	27000.000	22.000	3	0	3
	2-W18-20	15600.000	15600.000	15600.000	1	0	1
	2-W15-8	9970.000	9970.000	9970.000	1	0	1
	2-W19-32	3000.000	3000.000	3000.000	1	0	1
Total dissolved solids							
	2-W19-26	1880000.000	1880000.000	1880000.000	1	0	1
	2-W19-19	1810000.000	1810000.000	1810000.000	1	0	1
	2-W19-20	1550000.000	1550000.000	1550000.000	1	0	1
	2-W19-24	1510000.000	1510000.000	1510000.000	1	0	1
	2-W19-25	1370000.000	1370000.000	1370000.000	1	0	1
	2-W19-23	904000.000	904000.000	904000.000	1	0	1
	2-W19-28	609000.000	609000.000	609000.000	1	0	1
	2-W19-27	123000.000	123000.000	123000.000	1	0	1
	2-W19-21	110000.000	110000.000	110000.000	1	0	1
	2-W15-8	2100.000	2100.000	2100.000	1	0	1
	2-W19-30	2100.000	2100.000	2100.000	1	0	1
	2-W19-29	805.000	870.000	740.000	2	0	2
	6-38-70	680.000	680.000	680.000	1	0	1
	2-W22-20	630.000	630.000	630.000	1	0	1
	2-W7-6	420.000	420.000	420.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Total dissolved solids							
	2-W15-19	360.000	360.000	360.000	1	0	1
	6-40-62	310.000	310.000	310.000	1	0	1
	6-35-70	300.000	300.000	300.000	1	0	1
	6-49-79	290.000	290.000	290.000	1	0	1
	2-W6-2	280.000	280.000	280.000	1	0	1
	2-W15-7	270.000	270.000	270.000	1	0	1
	2-W22-40	270.000	270.000	270.000	1	0	1
	6-36-61A	270.000	270.000	270.000	1	0	1
	6-45-69A	260.000	260.000	260.000	1	0	1
	2-W22-21	230.000	230.000	230.000	1	0	1
	6-48-71	220.000	220.000	220.000	1	0	1
	2-W15-24	210.000	210.000	210.000	1	0	1
	6-37-82A	200.000	200.000	200.000	1	0	1
	2-W26-6	190.000	190.000	190.000	1	0	1
Total organic carbon							
	2-W19-15	7736.250	27300.000	2310.000	2	2	4
	2-W15-8	2740.000	2740.000	2740.000	1	0	1
	2-W14-10	1851.500	2800.000	2800.000	1	1	2
	2-W18-25	1162,500	1600.000	1000.000	6	2	8
	2-W22-43	1083.333	2000.000	2000.000	1	11	12
	2-W15-17	946.429	2100.000	2100.000	1	27	28
	2-W22-12	906.000	1100.000	1100.000	1	1	2
	2-W15-12	756.667	1170.000	1170.000	1	2	3
	2-W15-19	737.500	1000.000	1000.000	1	15	16
	2-W15-10	683.333	1030.000	1030.000	1	2	3
	2-W14-6	592.250	1000.000	1000.000	1	3	4
	2-W10-13	588.571	3500.000	2500.000	2	33	35
	2-W19-29	500.500	1.000	1.000	1	1	2
	2-W7-3	456.667	1100.000	1000.000	2	28	30
a Trichloroethylene							
	2-W22-20	32.200	41.000	25.000	5	0	5
	2-W10-4	24.333	28.000	22.000	3	0	3
	2-W10-9	17.000	19.000	15.000	2	0	2
	2-W15-4	11.500	12.000	11.000	2	0	2
	2-W15-16	11.222	9.000	5.000	7	2	9
	2-W15-11	10.000	11.000	9.000	3	0	3
	2-W14-2	9.000	12.000	8.000	3	1	4
	2-W15-7	9.000	12.000	10.000	2	1	3
	2-W15-12	8.667	10.000	8.000	3	0	3
	2-W10-16	8.200	8.200	8.200	1	0	1
	2-W15-10	7.500	8.000	7.000	4	0	4
	2-W18-17	7.500	15.000	15.000	1	3	4
	2-W11-7	6.500	7.000	6.000	2	0	2
	2-W19-29	5.567	6.200	5.500	2	1	3
	2-W7-7	5.200	6.000	6.000	1	4	5
	6-38-70	4.200	8.000	8.000	1	4	5
Tritium							
	2-W22-9	5080001.113	7560000.000	5880000.000	3	1	4
	2-W23-9	1217722.222	1520000.000	215000.000	18	0	18
	6-35-66	1127714.286	1210000.000	964000.000	7	0	7
	2-W23-4	892762.143	5450000.000	3660.000	14	0	14
	6-35-70	795254.833	1180000.000	620000.000	11	1	12

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Tritium							
	2-W23-10	605000.000	687000.000	553000.000	6	0	6
	6-38-65	434750.000	472000.000	397000.000	12	0	12
	2-W22-7	349500.000	364000.000	335000.000	2	0	2
	2-W22-20	255250.000	310000.000	193000.000	8	0	8
	6-32-708	237250.000	269000.000	183000.000	8	0	8
	2-W23-14	212666.667	224000.000	206000.000	3	0	3
	2-W15-4	178500.000	202000.000	155000.000	2	0	2
	2-W23-8	178000.000	178000.000	178000.000	1	0	1
	6-32-72	136500.000	146000.000	123000.000	6	0	6
	2-W10-3	112500.000	118000.000	107000.000	2	0	2
	2-W22-26	109250.000	132000.000	86500.000	2	0	2
	2-W22-10	103700.000	121000.000	93700.000	3	0	3
	2-W21-1	86250.000	90400.000	82100.000	2	0	2
	2-W10-4	82400.000	88500.000	76300.000	2	0	2
	6-40-62	78042.857	88100.000	55700.000	7	0	7
	2-W22-21	76000.000	76000.000	76000.000	1	0	1
	2-W14-2	67833.333	80300.000	51200.000	3	0	3
	2-W6-1	59650.000	59700.000	59600.000	2	0	2
	2-W19-2	58242.857	77400.000	24700.000	7	0	7
	2-W10-1	54250.000	54800.000	53700.000	2	0	2
	2-W10-9	53780.000	65000.000	42000.000	5	0	5
	2-W15-12	51066.667	56400.000	47600.000	3	0	3
	2-W10-16	46880.000	53200.000	44000.000	5	0	5
	2-W15-3	45000.000	45000.000	45000.000	1	0	1
	2-W10-15	44866.667	60600.000	38900.000	6	0	6
	2-W10-17	44125.000	46300.000	43400.000	4	0	4
	2-W11-7	41700.000	41700.000	41700.000	1	0	1
	2-W10-18	36050.000	38700.000	34400.000	4	0	4
	6-36-61A	30666.667	31400.000	29500.000	3	0	3
	2-W22-12	19766.667	25200.000	14000.000	3	0	3
	2-W22-2	19508.571	67300.000	4160.000	7	0	7
	6-36-61B	16769.829	41900.000	1340.000	5	2	7
	2-W15-11	16400.000	18100.000	14700.000	2	0	2
	2-W6-2	13261.538	15800.000	10500.000	13	0	13
	2-W22-42	11430.000	13200.000	8690.000	3	0	3
	2-W10-5	9560.000	9810.000	9310.000	2	0	2
	2-W15-22	7640.000	9290.000	4730.000	3	0	3
	2-W14-6	7030.000	11400.000	1170.000	6	0	6
	2-W11-14	6810.000	6890.000	6730.000	2	0	2
	2-W12-1	6190.000	6730.000	5650.000	2	0	2
	2-W15-10	5975.000	7110.000	4840.000	2	0	2
	2-W15-16	4352.713	33700.000	297.000	2	6	8
	2-W22-40	4245.000	4370.000	3980.000	4	0	4
	2-W19-29	4113.333	4670.000	3360.000	3	0	3
	2-W14-5	4030.000	6280.000	1780.000	2	0	2
	2-W23-3	3480.000	3480.000	3480.000	1	0	1
	2-W10-8	3353.333	4090.000	2730.000	3	0	3
	2-W22-41	2810.000	3070.000	2630.000	3	0	3
	2-W27-1	2698.900	5760.000	342.000	9	1	10
	6-32-62	2383.333	3680.000	1990.000	6	0	6
	2-W19-20	2083.684	3760.000	1350.000	19	0	19
	2-W19-25	2020.000	3010.000	1350.000	16	0	16

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Tritium							
	2-W22-43	1920.000	2490.000	1270.000	4	0	4
	2-W19-24	1828.053	2820.000	943.000	19	0	19
	2-W22-1	1683.000	2960.000	792.000	4	0	4
	2-W19-19	1676.667	3190.000	1060.000	21	0	21
	2-W11-9	1618.500	2740.000	497.000	2	0	2
	2-W19-18	1516.333	4960.000	422.000	8	1	9
	2-W15-7	1398.667	2040.000	976.000	3	0	3
	2-W14-10	1352.500	1700.000	1090.000	4	0	4
	2-W19-26	1271.273	2090.000	1040.000	10	1	11
	2-W19-15	1266.000	2770.000	779.000	6	0	6
	2-W22-22	1160.429	1810.000	1040.000	6	1	7
	2-W11-23	1080.000	1080.000	1080.000	1	0	1
	2-W19-32	1076.500	1550.000	603.000	2	0	2
	6-38-70	1068.833	1460.000	849.000	6	0	6
	2-W19-16	971.500	2200.000	395.000	4	2	6
	2-W19-23	874.938	1990.000	456.000	16	0	16
	2-W23-11	841.714	1240.000	629.000	6	1	7
	6-25-70	817.286	969.000	692.000	7	0	7
	2-W19-30	817.000	817.000	817.000	1	0	1
	2-W19-31	783.667	865.000	637.000	3	0	3
	2-W19-11	783.000	886.000	680.000	2	0	2
	2-W7-6	773.000	1050.000	478.000	9	0	9
	6-44-64	725.375	1150.000	511.000	8	0	8
	2-W22-39	650.667	731.000	592.000	3	0	3
	2-W19-5	597.500	826.000	826.000	1	1	2
	2-W18-17	580.078	3300.000	265.000	4	5	9
	2-W19-3	535.444	950.000	383.000	7	2	9
	2-W7-10	523.333	546.000	487.000	3	0	3
	2-W15-2	502.000	1190.000	1190.000	1	2	3
	2-W19-9	490.100	1500.000	430.000	3	3	6
	2-W19-12	488.500	816.000	546.000	2	2	4
	2-W7-8	471.600	517.000	366.000	5	0	5
	2-W7-4	452.200	850.000	283.000	9	1	10
	2-W11-3	401.000	560.000	560.000	1	1	2
	2-W26-6	380.960	1450.000	1450.000	1	3	4
	2-W15-15	355.986	680.000	267.000	5	2	7
	2-W18-5	342.000	342.000	342.000	1	0	1
	2-W7-7	329.600	411.000	243.000	5	0	5
	2-W22-18	328.000	328.000	328.000	1	0	1
	2-W7-5	286.830	886.000	277.000	4	6	10
	2-W19-28	282.200	411.000	235.000	4	1	5
	2-W10-13	281.000	421.000	257.000	6	4	10
	6-29-78	275.500	498.000	228.000	3	3	6
	2-W18-22	274.730	1150.000	1090.000	2	6	8
	6-32-77	246.443	567.000	360.000	2	5	7
	2-W18-21	244.989	734.000	309.000	3	5	8
	2-W15-8	212.600	405.000	405.000	1	1	2
	2-W18-2	210.000	210.000	210.000	1	0	1
	6-45-69A	201.863	341.000	341.000	1	7	8
	2-W15-19	201.250	301.000	301.000	1	3	4
	2-W18-26	201.040	257.000	256.000	2	3	5
	2-W18-15	192.440	484.000	484.000	1	4	5

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Tritium							
	2-W15-23	191.333	293.000	293.000	1	2	3
	2-W18-20	187.222	521.000	407.000	2	7	9
	2-W18-23	186.070	615.000	327.000	2	8	10
	2-W19-13	169.320	593.000	593.000	1	4	5
	2-W15-24	164.000	252.000	252.000	1	3	4
	2-W18-25	163.600	617.000	223.000	2	2	4
	2-W15-18	161.613	472.000	472.000	2	6	8
	2-W19-1	146.167	330.000	330.000	1	2	3
	2-W11-20	134.580	246.000	246.000	1	4	5
	2-W16-4	124.000	214.000	214.000	1	1	2
	2-W9-1	103.878	265.000	265.000	1	8	9
	6-39-79	62.550	232.000	232.000	1	5	6
	2-W15-17	60.375	261.000	261.000	1	7	8
Turbidity							
	2-W7-6	216.667	380.000	120.000	6	0	6
	2-W18-8	200.000	200.000	200.000	1	0	1
	2-W19-1	200.000	200.000	200.000	1	0	1
	2-W19-26	185.000	185.000	185.000	1	0	1
	2-W18-17	108.000	108.000	108.000	1	0	1
	2-W18-20	94.000	94.000	94.000	1	0	1
	2-W15-24	60.025	200.000	5.100	4	0	4
	2-W19-23	45.000	45.000	45.000	1	0	1
	2-W14-10	33.000	33.000	33.000	1	0	1
	2-W15-22	25.333	44.000	11.000	3	0	3
	2-W23-14	25.333	30.000	17.000	3	0	3
	2-W10-18	15.300	32.000	6.200	4	0	4
	2-W7-5	10.820	34.000	2.000	5	0	5
	2-W15-20	9.640	25.000	2.100	5	0	5
	2-W10-9	9.533	13.600	6.400	3	0	3
	2-W9-1	9.486	19.300	1.500	7	0	7
	2-W19-25	8.800	8.800	8.800	1	0	1
	2-W15-17	7.740	27.000	.400	5	0	5
	2-W18-26	7.180	19.500	2.700	5	0	5
	2-W19-24	5.100	5.100	5.100	1	0	1
	2-W19-32	4.150	7.000	1.300	2	0	2
	2-W19-20	4.100	4.100	4.100	1	0	1
	2-W22-39	3.433	7.000	1.200	3	0	3
	2-W19-19	3.200	3.200	3.200	1	0	1
	2-W7-8	3.120	8.800	.800	5	0	5
	2-W10-16	2.960	4.900	1.900	5	0	5
	2-W18-21	2.925	6.900	1.200	4	0	4
	2-W19-31	2.633	3.400	1.200	3	0	3
	2-W19-30	2.600	2.600	2.600	1	0	1
	2-W18-25	2.433	4.200	1.000	3	0	3
	2-W18-23	2.433	6.200	.500	6	0	6
	2-W7-7	2.320	2.800	1.600	5	0	5
	2-W23-13	2.300	4.200	1.200	3	0	3
	2-W19-28	2.300	2.300	2.300	1	0	1
	2-W7-2	2.071	3.500	.900	7	0	7
	2-W11-23	1.600	1.600	1.600	1	0	1
	2-W15-19	1.525	2.500	.500	4	0	4
	2-W10-15	1.500	3.300	.700	6	0	6

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Turbidity							
	2-W18-22	1.340	3.600	.400	5	0	5
	2-W15-18	1.320	3.200	.500	5	0	5
	2-W19-29	1.300	1.300	1.300	1	0	1
	2-W26-9	1.233	2.900	.200	3	0	3
	2-W8-1	1.214	2.100	.600	7	0	7
	2-W7-10	1.200	1.400	1.000	3	0	3
	2-W10-17	1.125	2.000	.700	4	0	4
	2-W7-3	1.114	2.000	.600	7	0	7
	2-W7-5	1.100	4.600	.200	7	0	7
	2-W15-15	1.050	2.100	.500	4	0	4
	2-W7-1	.971	2.200	.400	7	0	7
	2-W10-13	.900	1.600	.400	6	0	6
	2-W6-2	.876	3.000	.500	10	0	10
	2-W15-16	.820	1.700	.300	5	0	5
	2-W27-1	.800	.800	.800	1	0	1
	2-W26-8	.725	1.000	.300	4	0	4
	2-W10-14	.700	.900	.400	7	0	7
	2-W19-21	.600	.600	.600	1	0	1
	2-W22-43	.600	1.000	.300	4	0	4
	2-W7-4	.600	.900	.300	5	0	5
	2-W22-42	.533	.800	.400	3	0	3
	2-W18-24	.520	.600	.400	5	0	5
	2-W22-40	.450	.600	.400	4	0	4
	2-W22-41	.367	.600	.200	3	0	3
	2-W15-23	.333	.400	.300	3	0	3
	2-W19-27	.200	.200	.200	1	0	1
Unknown							
	2-W7-7	43.000	43.000	43.000	1	0	1
	2-W8-1	42.000	42.000	42.000	1	0	1
	2-W7-10	41.000	41.000	41.000	1	0	1
	2-W18-21	39.000	39.000	39.000	1	0	1
	2-W7-3	38.000	38.000	38.000	1	0	1
	2-W18-23	32.000	32.000	32.000	1	0	1
	2-W15-24	31.000	31.000	31.000	1	0	1
	2-W7-6	30.000	30.000	30.000	1	0	1
	2-W15-23	29.000	29.000	29.000	1	0	1
	2-W18-22	28.000	28.000	28.000	1	0	1
	2-W7-5	25.000	25.000	25.000	1	0	1
	2-W6-2	24.500	32.000	17.000	2	0	2
	2-W7-8	19.500	19.500	19.500	1	0	1
	2-W10-13	18.000	18.000	18.000	1	0	1
	2-W9-1	18.000	18.000	18.000	1	0	1
	2-W7-1	16.000	16.000	16.000	1	0	1
	2-W7-2	16.000	16.000	16.000	1	0	1
	2-W15-17	14.000	14.000	14.000	1	0	1
	2-W15-16	12.000	12.000	12.000	1	0	1
	2-W15-20	12.000	12.000	12.000	1	0	1
	2-W18-24	11.000	11.000	11.000	1	0	1
	2-W7-9	11.000	11.000	11.000	1	0	1
	2-W15-18	10.000	10.000	10.000	1	0	1
	2-W10-14	8.000	8.000	8.000	1	0	1
	2-W18-26	8.000	8.000	8.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Unknown							
	2-W26-9	8.000	8.000	8.000	1	0	1
Uranium							
	2-W19-18	1130.000	1130.000	1130.000	1	0	1
	2-W19-11	1030.000	1030.000	1030.000	1	0	1
	2-W19-3	737.000	737.000	737.000	1	0	1
	2-W19-19	547.000	547.000	547.000	1	0	1
	2-W19-16	478.000	478.000	478.000	1	0	1
	2-W19-24	397.000	397.000	397.000	1	0	1
	2-W19-26	340.000	340.000	340.000	1	0	1
	2-W19-25	311.000	311.000	311.000	1	0	1
	2-W11-14	207.000	207.000	207.000	1	0	1
	2-W19-23	126.000	126.000	126.000	1	0	1
	2-W19-28	40.850	53.300	28.400	2	0	2
	2-W19-15	27.700	27.700	27.700	1	0	1
	2-W18-21	20.860	24.000	14.200	5	0	5
	2-W23-10	19.500	19.500	19.500	1	0	1
	2-W19-21	18.000	20.900	15.100	2	0	2
	2-W23-9	17.800	17.800	17.800	1	0	1
	2-W23-4	14.700	14.700	14.700	1	0	1
	2-W23-11	11.400	11.400	11.400	1	0	1
	2-W10-3	11.090	14.800	7.380	2	0	2
	2-W19-2	8.800	8.800	8.800	1	0	1
	2-W19-27	8.455	8.570	8.340	2	0	2
	2-W19-5	7.020	7.340	6.700	2	0	2
	2-W22-20	6.508	6.900	5.920	4	0	4
	2-W7-6	5.893	10.100	1.860	5	1	6
	2-W23-1	5.850	6.280	5.420	2	0	2
	2-W27-1	5.550	5.550	5.550	1	0	1
	2-W23-2	5.505	5.970	4.760	4	0	4
	2-W22-2	5.097	6.250	4.470	3	0	3
	2-W22-9	4.775	5.360	4.190	2	0	2
	2-W19-1	4.390	4.390	4.390	1	0	1
	2-W22-26	4.305	4.710	3.900	2	0	2
	2-W22-1	4.285	5.150	3.420	2	0	2
	2-W15-4	3.605	4.510	2.700	2	0	2
	2-W15-15	3.098	3.640	2.330	5	0	5
	6-35-70	2.541	3.950	1.750	7	0	7
	2-W15-16	2.234	3.520	1.410	5	0	5
	2-W10-9	2.160	2.380	1.940	2	0	2
	6-35-66	2.103	2.390	1.840	6	0	6
	6-51-63	2.093	5.900	1.120	6	0	6
	2-W19-20	2.040	2.040	2.040	1	0	1
	2-W10-1	2.010	2.180	1.840	2	0	2
	6-47-60	1.883	2.280	1.440	6	0	6
	2-W18-26	1.770	2.130	1.410	2	0	2
	6-38-65	1.714	2.180	1.460	5	0	5
	6-32-708	1.645	3.250	1.080	6	0	6
	2-W21-1	1.465	1.470	1.460	2	0	2
	2-W7-5	1.459	3.450	.912	6	0	6
	2-W26-6	1.430	1.430	1.430	1	0	1
	2-W7-4	1.379	1.610	1.020	7	0	7
	6-36-61A	1.260	1.260	1.260	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Uranium							
	2-W7-9	1.191	1.600	.782	2	0	2
	2-W18-23	1.150	2.110	.607	8	0	8
	2-W18-20	1.110	1.110	1.110	1	0	1
	2-W6-2	1.109	1.500	.833	6	0	6
	2-W22-7	1.106	1.480	.731	2	0	2
	2-W14-10	1.100	1.100	1.100	1	0	1
	2-W10-8	1.095	1.150	1.040	2	0	2
	2-W15-20	1.089	1.650	.528	2	0	2
	2-W11-9	1.080	1.080	1.080	1	0	1
	2-W26-3	1.080	1.080	1.080	1	0	1
	2-W14-2	1.008	1.070	.946	2	0	2
	2-W11-3	1.004	1.290	.717	2	0	2
	2-W15-19	1.001	1.390	.612	2	0	2
	2-W7-3	.991	1.520	.676	7	0	7
	6-55-89	.961	1.260	.793	3	0	3
	6-44-64	.956	.956	.956	1	0	1
	2-W7-8	.910	1.050	.770	2	0	2
	2-W9-1	.903	1.080	.624	5	0	5
	2-W22-12	.895	1.040	.749	2	0	2
	2-W10-4	.862	.985	.739	2	0	2
	2-W18-24	.817	1.100	.636	5	0	5
	2-W8-1	.800	1.440	.567	6	0	6
	2-W7-2	.718	.900	.562	6	0	6
	2-W10-13	.707	1.220	.486	7	0	7
	2-W15-18	.703	.795	.575	4	0	4
	2-W7-7	.694	.744	.643	2	0	2
	6-45-69A	.691	.691	.691	1	0	1
	2-W14-6	.678	.724	.632	2	0	2
	2-W15-24	.668	.668	.668	1	0	1
	2-W18-22	.628	.875	.512	5	0	5
	2-W10-14	.624	.794	.357	6	0	6
	2-W14-5	.594	.705	.483	2	0	2
	2-W15-17	.587	.693	.454	4	0	4
	2-W7-1	.507	.621	.448	6	0	6
	2-W18-17	.433	.433	.433	1	0	1
	6-32-72	.297	.419	.263	4	1	5
Uranium, chemical							
	2-W19-18	3417.444	5760.000	814.000	18	0	18
	2-W19-11	3243.333	3920.000	2610.000	3	0	3
	2-W19-3	2904.286	5150.000	1650.000	14	0	14
	2-W19-29	2262.000	3250.000	416.000	3	0	3
	2-W19-9	1344.667	2140.000	508.000	6	0	6
	2-W19-16	987.000	1540.000	641.000	5	0	5
	2-W19-19	793.625	2900.000	506.000	16	0	16
	2-W19-24	560.833	803.000	411.000	18	0	18
	2-W19-20	491.778	665.000	389.000	18	0	18
	2-W19-25	311.643	390.000	260.000	14	0	14
	2-W19-26	244.629	479.000	8.120	11	0	11
	2-W19-23	202.667	248.000	157.000	15	0	15
	2-W19-15	154.160	336.000	45.800	5	0	5
	2-W19-2	104.675	149.000	23.300	16	0	16
	2-W23-4	93.458	372.000	26.300	12	0	12

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Uranium, chemical							
	2-W19-30	78.700	78.700	78.700	1	0	1
	6-38-70	62.972	93.900	41.700	18	0	18
	2-W18-15	56.240	63.200	46.800	5	0	5
	2-W23-10	49.760	61.600	44.200	5	0	5
	2-W19-28	45.933	50.100	40.100	3	0	3
	2-W23-9	36.531	73.300	19.700	16	0	16
	2-W22-21	30.200	30.200	30.200	1	0	1
	2-W19-17	27.650	49.800	18.000	4	0	4
	6-35-70A	22.783	28.100	16.800	6	0	6
	2-W19-21	22.167	27.000	14.600	6	0	6
	2-W26-8	21.650	27.300	14.800	4	0	4
	2-W23-11	20.717	28.700	15.000	6	0	6
	2-W18-21	20.675	31.900	15.500	4	0	4
	6-32-77	16.000	16.000	16.000	1	0	1
	2-W19-27	14.690	23.300	9.000	7	0	7
	2-W23-14	11.927	13.600	8.880	3	0	3
	2-W23-13	11.663	17.200	.889	3	0	3
	2-W7-6	10.373	21.600	4.530	4	0	4
	2-W27-1	10.346	14.000	6.590	7	0	7
	2-W18-25	10.263	11.600	9.070	4	0	4
	2-W19-13	9.534	10.300	8.940	5	0	5
	2-W22-20	8.753	12.400	5.700	4	0	4
	6-39-79	8.140	8.140	8.140	1	0	1
	2-W22-39	8.057	9.770	5.290	3	0	3
	2-W15-8	7.680	7.680	7.680	1	0	1
	2-W23-8	4.650	4.650	4.650	1	0	1
	2-W13-15	4.250	4.750	3.380	3	0	3
	2-W19-22	4.020	4.300	3.540	3	0	3
	2-W19-14	4.004	4.590	3.200	5	0	5
	2-W22-43	3.920	4.730	3.100	4	0	4
	2-W19-12	3.535	3.740	3.330	2	0	2
	2-W10-9	3.250	3.410	3.090	2	0	2
	2-W10-15	3.170	3.820	2.370	5	0	5
	2-W22-42	3.150	3.640	2.730	3	0	3
	2-W22-40	3.113	3.840	2.270	4	0	4
	6-35-70	2.970	3.020	2.920	2	0	2
	2-W19-32	2.895	3.110	2.680	2	0	2
	2-W15-19	2.760	3.290	2.230	2	0	2
	2-W19-1	2.420	2.420	2.420	1	0	1
	2-W7-9	2.420	2.720	2.090	3	0	3
	6-38-65	2.400	2.400	2.400	1	0	1
	2-W7-4	2.385	4.110	1.140	4	0	4
	2-W10-18	2.370	2.780	2.030	4	0	4
	2-W15-16	2.350	2.770	1.630	3	0	3
	2-W22-41	2.317	2.750	2.020	3	0	3
	2-W18-26	2.307	3.170	1.350	3	0	3
	2-W18-20	2.250	2.250	2.250	1	0	1
	2-W22-22	2.221	6.230	.748	5	0	5
	6-36-61A	2.060	2.060	2.060	1	0	1
	2-W26-7	2.000	2.490	1.240	3	0	3
	2-W10-16	1.983	2.490	1.800	4	0	4
	6-45-69A	1.920	1.920	1.920	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Uranium, chemical							
	6-40-62	1.860	1.860	1.860	1	0	1
	2-W15-22	1.817	2.140	1.290	3	0	3
	2-W15-24	1.780	2.820	1.250	3	0	3
	2-W6-2	1.765	2.490	1.270	6	0	6
	6-32-70B	1.700	1.700	1.700	1	0	1
	2-W7-10	1.670	1.970	1.510	3	0	3
	2-W7-3	1.655	2.050	1.180	4	0	4
	2-W7-5	1.648	1.810	1.460	4	0	4
	2-W7-8	1.480	1.720	1.330	3	0	3
	2-W10-17	1.473	1.720	1.230	4	0	4
	2-W18-23	1.460	1.790	1.180	3	0	3
	6-51-75	1.430	1.430	1.430	1	0	1
	2-W26-6	1.390	1.390	1.390	1	0	1
	2-W15-17	1.358	2.550	.783	4	0	4
	2-W15-7	1.330	1.330	1.330	1	0	1
	2-W18-17	1.310	1.310	1.310	1	0	1
	2-W15-20	1.290	1.480	1.010	3	0	3
	2-W15-23	1.277	1.400	1.100	3	0	3
	2-W15-6	1.240	1.240	1.240	1	0	1
	2-W9-1	1.189	1.810	.734	4	0	4
	2-W14-2	1.140	1.140	1.140	1	0	1
	2-W22-12	1.140	1.140	1.140	1	0	1
	2-W7-7	1.130	1.440	.831	3	0	3
	6-25-70	1.130	1.130	1.130	1	0	1
	2-W7-2	1.063	1.390	.849	4	0	4
	2-W18-24	1.045	1.280	.776	3	0	3
	6-49-79	.966	1.030	.901	2	0	2
	2-W18-5	.964	.964	.964	1	0	1
	2-W10-14	.953	1.060	.846	4	0	4
	2-W18-22	.911	1.130	.544	3	0	3
	2-W8-1	.891	1.010	.740	4	0	4
	2-W10-13	.835	.885	.772	4	0	4
	2-W7-1	.793	1.010	.603	4	0	4
	6-50-85	.766	.766	.766	1	0	1
	2-W15-18	.746	.955	.533	3	0	3
	6-48-71	.568	1.020	.116	2	0	2
	6-32-72	.206	.206	.206	1	0	1
	6-37-82A	.126	.126	.126	1	0	1
Uranium-234							
	2-W19-18	1605.000	1890.000	1320.000	2	0	2
	2-W19-11	1360.000	1360.000	1360.000	1	0	1
	2-W19-3	1172.667	1860.000	608.000	3	0	3
	2-W19-9	643.667	903.000	473.000	3	0	3
	2-W19-16	424.667	609.000	248.000	3	0	3
	2-W19-19	273.167	465.000	220.000	6	0	6
	2-W19-24	180.193	217.000	85.900	15	0	15
	2-W19-20	168.167	186.000	136.000	6	0	6
	2-W19-26	123.075	207.000	83.600	8	0	8
	2-W19-25	116.857	134.000	106.000	14	0	14
	2-W19-23	73.780	82.600	67.500	15	0	15
	2-W19-15	56.000	114.000	19.700	3	0	3
	2-W23-4	33.600	61.300	17.800	3	0	3

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Uranium-234							
	2-W18-15	20.733	22.900	17.800	3	0	3
	2-W23-10	15.404	22.300	1.320	5	0	5
	2-W19-17	13.990	18.300	9.680	2	0	2
	2-W23-9	12.457	30.100	3.860	6	0	6
	6-35-78A	8.447	10.700	6.280	6	0	6
	2-W19-21	7.428	7.850	7.000	4	0	4
	2-W23-11	6.550	8.290	1.460	5	0	5
	2-W27-1	4.568	5.090	3.750	5	0	5
	2-W19-27	4.094	4.410	3.660	5	0	5
Uranium-235							
	2-W19-11	102.000	102.000	102.000	1	0	1
	2-W19-18	89.600	116.000	63.200	2	0	2
	2-W19-3	65.500	110.000	31.100	3	0	3
	2-W19-9	61.633	131.000	18.900	3	0	3
	2-W19-16	34.300	46.800	24.500	3	0	3
	2-W19-19	17.600	29.300	12.900	6	0	6
	2-W19-24	9.890	13.800	3.710	15	0	15
	2-W19-20	9.280	13.400	6.410	6	0	6
	2-W19-25	6.306	8.050	3.670	14	0	14
	2-W19-26	5.418	7.110	3.530	8	0	8
	2-W19-23	3.912	5.920	1.920	15	0	15
	2-W19-15	3.020	5.630	1.330	3	0	3
	2-W23-4	2.320	4.420	1.100	3	0	3
	2-W18-15	1.427	2.750	.731	3	0	3
	2-W19-17	.682	.891	.472	2	0	2
	2-W23-9	.638	1.690	.293	6	0	6
	2-W23-10	.504	.947	.068	4	1	5
	6-35-78A	.418	.515	.341	6	0	6
	2-W19-27	.344	.963	.147	5	0	5
	2-W19-21	.316	.343	.283	4	0	4
	2-W23-11	.273	.486	.072	5	0	5
	2-W27-1	.177	.258	.131	5	0	5
Uranium-238							
	2-W19-18	1730.000	2040.000	1420.000	2	0	2
	2-W19-11	1490.000	1490.000	1490.000	1	0	1
	2-W19-3	1209.000	1910.000	627.000	3	0	3
	2-W19-9	689.000	1000.000	505.000	3	0	3
	2-W19-16	425.000	595.000	276.000	3	0	3
	2-W19-19	281.500	484.000	227.000	6	0	6
	2-W19-24	184.840	223.000	88.600	15	0	15
	2-W19-20	173.500	191.000	141.000	6	0	6
	2-W19-26	123.425	209.000	82.600	8	0	8
	2-W19-25	119.857	138.000	110.000	14	0	14
	2-W19-23	74.160	83.600	64.400	15	0	15
	2-W19-15	54.600	117.000	19.800	3	0	3
	2-W23-4	33.633	60.600	18.100	3	0	3
	2-W18-15	21.567	24.500	17.900	3	0	3
	2-W23-10	15.684	22.800	1.520	5	0	5
	2-W19-17	13.480	17.900	9.060	2	0	2
	2-W23-9	12.713	30.000	4.050	6	0	6
	6-35-78A	8.442	10.200	4.150	6	0	6
	2-W19-21	7.633	7.820	[illegible]	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Uranium-238							
	2-W23-11	6.588	8.660	1.530	5	0	5
	2-W19-27	4.096	5.700	3.410	5	0	5
	2-W27-1	4.024	4.630	3.130	5	0	5
Vanadium							
	2-W10-8	1140.000	1140.000	1140.000	1	0	1
	2-W15-4	259.000	259.000	259.000	1	0	1
	2-W19-1	145.000	145.000	145.000	1	0	1
	2-W14-5	86.000	86.000	86.000	1	0	1
	2-W15-12	84.000	84.000	84.000	1	0	1
	2-W14-2	72.500	100.000	45.000	2	0	2
	2-W10-9	66.000	74.000	58.000	5	0	5
	2-W11-14	57.000	57.000	57.000	1	0	1
	2-W15-8	54.000	56.000	52.000	2	0	2
	2-W10-4	51.000	51.000	51.000	1	0	1
	2-W18-17	51.000	100.000	39.000	7	0	7
	2-W10-17	48.750	54.000	43.000	4	0	4
	2-W23-11	44.000	44.000	44.000	1	0	1
	2-W18-20	43.000	43.000	43.000	1	0	1
	2-W26-9	40.333	53.000	38.000	2	1	3
	2-W19-27	39.000	39.000	39.000	1	0	1
	2-W22-21	38.000	38.000	38.000	1	0	1
	2-W10-15	37.143	41.000	32.000	7	0	7
	2-W10-16	36.400	44.000	27.000	5	0	5
	2-W26-6	36.000	36.000	36.000	1	0	1
	2-W22-39	34.333	37.000	32.000	3	0	3
	2-W18-9	34.000	34.000	34.000	1	0	1
	2-W7-6	33.778	54.000	24.000	8	1	9
	2-W23-13	33.333	35.000	35.000	2	1	3
	6-45-69A	33.000	33.000	33.000	1	0	1
	2-W10-14	32.444	35.000	28.000	9	0	9
	2-W18-24	32.222	39.000	29.000	7	2	9
	2-W15-24	32.000	38.000	38.000	1	3	4
	2-W18-5	32.000	32.000	32.000	1	0	1
	6-32-77	32.000	32.000	32.000	1	0	1
	6-35-70	32.000	32.000	32.000	1	0	1
	6-49-79	32.000	32.000	32.000	1	0	1
	2-W15-23	31.333	34.000	34.000	1	2	3
	2-W22-40	31.250	34.000	31.000	2	2	4
	2-W15-7	30.500	36.000	25.000	2	0	2
	2-W18-25	30.000	30.000	30.000	1	2	3
	2-W19-26	30.000	30.000	30.000	1	1	2
	2-W22-20	30.000	39.000	21.000	2	1	3
	2-W23-14	30.000	30.000	30.000	1	2	3
	2-W15-15	29.571	37.000	24.000	6	1	7
	2-W10-13	29.500	34.000	25.000	7	3	10
	2-W7-1	29.333	32.000	25.000	6	3	9
	2-W15-16	29.000	32.000	25.000	6	2	8
	2-W18-21	29.000	35.000	25.000	8	1	9
	2-W6-2	28.917	37.000	21.000	9	3	12
	2-W15-18	28.625	31.000	24.000	7	1	8
	2-W18-23	28.111	31.000	25.000	7	2	9
	2-W22-1	28.000	28.000	28.000	1	0	1

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Vanadium							
	2-W7-8	27.750	21.000	21.000	1	3	4
	2-W8-1	27.667	33.000	21.000	7	2	9
	2-W18-22	27.250	33.000	21.000	6	2	8
	2-W15-20	26.750	17.000	17.000	1	3	4
	2-W7-7	26.250	15.000	15.000	1	3	4
	2-W7-2	26.111	30.000	20.000	7	2	9
	2-W7-4	24.900	28.000	19.000	7	3	10
	2-W7-5	24.444	24.000	20.000	6	3	9
	2-W15-17	24.333	34.000	9.000	9	0	9
	2-W11-23	24.000	24.000	24.000	1	0	1
	2-W15-10	24.000	24.000	24.000	1	0	1
	2-W15-11	24.000	24.000	24.000	1	0	1
	2-W7-9	24.000	6.000	6.000	1	3	4
	2-W19-21	23.500	27.000	20.000	2	0	2
	2-W11-7	23.000	23.000	23.000	1	0	1
	2-W19-23	23.000	23.000	23.000	1	0	1
	2-W15-19	22.000	6.000	6.000	1	2	3
	2-W18-15	21.000	21.000	21.000	1	0	1
	2-W7-3	20.900	21.000	13.000	7	3	10
	2-W9-1	20.889	19.000	12.000	6	3	9
	2-W27-1	17.500	19.000	16.000	2	0	2
	2-W19-20	16.000	13.000	13.000	1	2	3
	2-W19-28	16.000	16.000	16.000	1	0	1
	2-W19-3	16.000	16.000	16.000	1	0	1
	2-W14-10	13.000	17.000	9.000	2	0	2
	2-W19-13	13.000	13.000	13.000	1	0	1
	2-W19-19	12.000	12.000	12.000	1	0	1
	2-W19-11	11.000	11.000	11.000	1	0	1
	2-W18-4	10.000	10.000	10.000	1	0	1
	2-W19-25	10.000	10.000	10.000	1	0	1
	2-W19-24	9.500	14.000	14.000	1	1	2
	2-W22-22	6.000	6.000	6.000	1	0	1
Vanadium, filtered							
	2-W15-4	221.000	269.000	173.000	2	0	2
	2-W10-9	65.500	71.000	61.000	4	0	4
	2-W14-5	65.000	88.000	38.000	3	0	3
	2-W10-17	50.750	58.000	41.000	4	0	4
	2-W10-4	48.667	52.000	42.000	3	0	3
	2-W10-8	40.000	40.000	40.000	1	0	1
	2-W18-17	38.500	39.000	38.000	2	0	2
	2-W10-15	37.000	41.000	30.000	5	0	5
	2-W19-28	36.250	70.000	15.000	2	2	4
	2-W26-6	36.000	36.000	36.000	1	0	1
	2-W22-43	35.750	50.000	33.000	2	2	4
	2-W19-27	35.000	36.000	34.000	2	0	2
	2-W22-1	35.000	37.000	34.000	3	0	3
	2-W26-9	34.667	39.000	35.000	2	1	3
	2-W19-5	34.000	36.000	32.000	2	0	2
	2-W14-6	33.667	37.000	28.000	6	0	6
	6-29-78	32.333	34.000	30.000	3	0	3
	2-W18-24	32.200	37.000	30.000	9	1	10
	2-W10-14	31.778	39.000	21.000	8	1	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Vanadium, filtered							
	2-W22-39	31.667	33.000	32.000	2	1	3
	2-W7-6	31.429	64.000	20.000	5	2	7
	2-W10-16	31.000	39.000	24.000	4	1	5
	2-W22-26	31.000	36.000	26.000	2	0	2
	2-W22-40	31.000	33.000	31.000	2	2	4
	6-35-66	30.750	31.000	30.000	4	0	4
	2-W23-11	30.500	34.000	27.000	2	0	2
	2-W15-17	30.200	33.000	24.000	4	1	5
	6-32-70B	29.250	34.000	25.000	4	0	4
	2-W10-13	29.100	30.000	26.000	7	3	10
	6-48-71	29.000	28.000	28.000	1	1	2
	2-W15-7	28.667	30.000	26.000	2	1	3
	2-W18-21	28.667	30.000	25.000	7	2	9
	2-W7-1	28.333	30.000	25.000	6	3	9
	6-45-69A	28.333	29.000	26.000	2	1	3
	2-W18-23	28.222	33.000	25.000	8	1	9
	2-W15-15	28.000	30.000	24.000	7	1	8
	6-32-77	28.000	40.000	39.000	2	1	3
	6-40-62	28.000	29.000	26.000	3	1	4
	6-44-64	27.600	33.000	24.000	5	0	5
	2-W18-22	27.500	31.000	24.000	6	2	8
	2-W6-2	27.357	31.000	22.000	9	5	14
	2-W19-13	27.333	29.000	26.000	3	0	3
	2-W15-18	27.250	28.000	24.000	6	2	8
	2-W15-20	27.000	18.000	18.000	1	3	4
	6-37-82A	27.000	24.000	24.000	1	1	2
	2-W7-8	26.750	17.000	17.000	1	3	4
	6-35-70	26.750	27.000	25.000	3	1	4
	6-36-61A	26.600	26.000	25.000	4	1	5
	2-W15-16	26.556	28.000	24.000	7	2	9
	6-49-79	26.400	27.000	23.000	4	1	5
	2-W7-2	26.333	28.000	20.000	6	3	9
	2-W7-7	26.250	15.000	15.000	1	3	4
	2-W7-4	26.000	27.000	22.000	7	3	10
	2-W8-1	25.667	28.000	20.000	6	3	9
	2-W15-24	25.500	12.000	12.000	1	3	4
	2-W7-5	25.222	26.000	20.000	6	3	9
	6-32-72	25.000	26.000	24.000	3	0	3
	6-38-65	25.000	26.000	24.000	2	0	2
	6-50-85	25.000	27.000	24.000	3	0	3
	2-W14-2	24.250	23.000	22.000	3	1	4
	2-W19-21	24.200	29.000	20.000	5	0	5
	2-W11-23	24.000	24.000	24.000	1	0	1
	2-W15-10	23.667	25.000	23.000	3	0	3
	2-W18-5	23.333	25.000	21.000	3	0	3
	2-W23-10	23.000	24.000	21.000	5	0	5
	2-W15-19	22.333	7.000	7.000	1	2	3
	2-W15-11	22.000	25.000	20.000	3	0	3
	2-W19-2	22.000	22.000	22.000	1	0	1
	2-W22-12	22.000	25.000	19.000	2	0	2
	2-W27-1	21.875	24.000	16.000	6	2	8
	6-35-78A	21.500	24.000	19.000	2	0	2

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Vanadium, filtered							
	2-W7-3	21.200	22.000	14.000	7	3	10
	2-W19-26	21.000	12.000	12.000	1	1	2
	6-38-70	20.667	23.000	11.000	5	1	6
	2-W19-9	20.250	25.000	16.000	4	0	4
	6-39-79	20.250	22.000	18.000	4	0	4
	2-W9-1	20.111	21.000	13.000	6	3	9
	2-W18-15	19.333	21.000	18.000	3	0	3
	2-W19-11	19.000	26.000	12.000	2	0	2
	6-47-60	18.667	21.000	17.000	3	0	3
	2-W19-16	18.600	26.000	16.000	4	1	5
	2-W19-12	18.000	18.000	18.000	1	0	1
	2-W19-15	17.800	24.000	9.000	5	0	5
	2-W19-3	17.750	29.000	9.000	4	0	4
	2-W22-20	17.000	19.000	8.000	4	1	5
	2-W19-18	16.800	25.000	10.000	3	2	5
	2-W22-22	16.000	19.000	11.000	5	0	5
	2-W14-10	15.000	15.000	15.000	1	0	1
	2-W19-20	12.500	12.000	5.000	5	1	6
	2-W19-23	11.500	12.000	11.000	2	0	2
	2-W19-19	10.500	11.000	10.000	2	0	2
	2-W19-24	10.200	16.000	12.000	3	2	5
	2-W19-25	9.000	9.000	9.000	2	0	2
Xylene-o,p							
	2-W15-18	5.167	6.000	6.000	1	5	6
	2-W15-8	5.000	5.000	5.000	1	1	2
Zinc							
	2-W18-9	7380.000	7380.000	7380.000	1	0	1
	2-W18-4	5610.000	5610.000	5610.000	1	0	1
	2-W15-8	755.000	1300.000	210.000	2	0	2
	2-W15-17	618.556	1940.000	27.000	8	1	9
	2-W19-25	542.000	542.000	542.000	1	0	1
	2-W10-8	525.000	525.000	525.000	1	0	1
	2-W7-3	264.800	1090.000	15.000	10	0	10
	2-W14-10	208.500	404.000	13.000	2	0	2
	6-40-62	180.000	180.000	180.000	1	0	1
	2-W10-9	159.000	739.000	11.000	4	1	5
	2-W19-24	146.000	213.000	79.000	2	0	2
	2-W19-23	133.000	133.000	133.000	1	0	1
	2-W19-1	127.000	127.000	127.000	1	0	1
	2-W7-6	124.111	205.000	23.000	9	0	9
	2-W19-26	76.000	131.000	21.000	2	0	2
	2-W7-9	75.750	130.000	24.000	4	0	4
	2-W19-32	65.500	76.000	55.000	2	0	2
	2-W15-12	65.000	65.000	65.000	1	0	1
	2-W19-19	61.000	61.000	61.000	1	0	1
	2-W23-14	58.667	110.000	25.000	3	0	3
	6-36-61A	55.000	55.000	55.000	1	0	1
	2-W18-26	52.250	101.000	49.000	3	1	4
	2-W18-22	52.000	143.000	16.000	6	2	8
	2-W11-14	41.000	41.000	41.000	1	0	1
	2-W11-7	36.000	36.000	36.000	1	0	1
	2-W10-14	32.000	110.000	7.000	8	1	9

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Zinc							
	2-W15-19	31.667	65.000	14.000	3	0	3
	2-W19-20	31.333	43.000	20.000	3	0	3
	2-W23-13	31.000	73.000	73.000	1	2	3
	2-W15-22	29.333	59.000	19.000	2	1	3
	2-W7-5	28.222	90.000	10.000	7	2	9
	2-W15-18	27.250	108.000	6.000	7	1	8
	2-W9-1	26.333	94.000	9.000	8	1	9
	2-W7-4	25.100	105.000	11.000	5	5	10
	2-W19-18	25.000	33.000	17.000	2	0	2
	2-W22-20	25.000	54.000	11.000	2	1	3
	2-W7-2	23.222	76.000	10.000	7	2	9
	2-W14-2	23.000	31.000	15.000	2	0	2
	2-W10-18	22.750	33.000	15.000	4	0	4
	2-W15-15	22.714	52.000	12.000	6	1	7
	2-W18-21	22.556	107.000	6.000	5	4	9
	2-W19-11	21.000	21.000	21.000	1	0	1
	2-W22-39	20.000	40.000	40.000	1	2	3
	2-W15-24	19.000	44.000	12.000	2	2	4
	2-W10-15	18.571	57.000	13.000	3	4	7
	2-W7-8	18.500	37.000	17.000	2	2	4
	2-W26-8	18.250	25.000	16.000	3	1	4
	2-W7-1	18.222	75.000	6.000	5	4	9
	2-W19-3	18.000	18.000	18.000	1	0	1
	2-W19-30	18.000	18.000	18.000	1	0	1
	2-W27-1	18.000	31.000	31.000	1	1	2
	2-W18-23	17.889	55.000	6.000	9	0	9
	2-W18-17	17.429	42.000	6.000	7	0	7
	2-W19-13	17.000	17.000	17.000	1	0	1
	2-W10-16	16.800	43.000	11.000	2	3	5
	2-W6-2	15.417	60.000	9.000	4	8	12
	2-W19-31	15.333	25.000	11.000	2	1	3
	2-W18-20	15.000	15.000	15.000	1	0	1
	2-W19-27	14.000	14.000	14.000	1	0	1
	2-W7-10	14.000	17.000	15.000	2	1	3
	2-W8-1	13.778	45.000	8.000	5	4	9
	2-W10-13	13.300	36.000	7.000	6	4	10
	2-W22-21	13.000	13.000	13.000	1	0	1
	2-W26-9	13.000	19.000	19.000	1	2	3
	6-49-79	13.000	13.000	13.000	1	0	1
	2-W22-43	11.750	16.000	11.000	2	2	4
	2-W22-42	11.667	14.000	11.000	2	1	3
	2-W18-24	11.444	29.000	5.000	5	4	9
	2-W15-23	11.333	14.000	10.000	2	1	3
	2-W15-16	11.125	30.000	6.000	5	3	8
	2-W10-17	11.000	14.000	14.000	1	3	4
	2-W19-21	11.000	11.000	11.000	2	0	2
	6-32-77	11.000	11.000	11.000	1	0	1
	2-W22-40	10.750	13.000	13.000	1	3	4
	2-W22-41	10.667	12.000	12.000	1	2	3
	2-W15-7	10.000	14.000	6.000	2	0	2
	2-W18-25	10.000	10.000	10.000	1	2	3
	2-W7-7	9.500	8.000	8.000	1	3	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Zinc							
	2-W18-5	9.000	9.000	9.000	1	0	1
	2-W15-20	8.750	5.000	5.000	1	3	4
	2-W19-28	8.000	8.000	8.000	1	0	1
	2-W11-23	6.000	6.000	6.000	1	0	1
	2-W22-22	5.000	5.000	5.000	1	0	1
Zinc, filtered							
	2-W19-25	298.000	429.000	167.000	2	0	2
	2-W10-13	92.900	839.000	9.000	4	6	10
	2-W26-8	87.500	320.000	320.000	1	3	4
	2-W19-24	63.400	140.000	31.000	5	0	5
	2-W7-5	63.333	407.000	8.000	6	3	9
	2-W7-9	60.500	160.000	14.000	3	1	4
	2-W22-43	50.500	160.000	14.000	3	1	4
	2-W7-6	41.286	210.000	23.000	3	4	7
	2-W19-23	40.500	41.000	40.000	2	0	2
	2-W19-9	37.000	44.000	30.000	4	0	4
	2-W18-26	35.750	101.000	22.000	2	2	4
	2-W19-19	34.500	47.000	22.000	2	0	2
	2-W18-22	31.250	99.000	10.000	6	2	8
	2-W10-18	26.000	69.000	12.000	3	1	4
	2-W15-19	26.000	54.000	14.000	2	1	3
	2-W19-15	25.200	53.000	10.000	5	0	5
	2-W22-12	25.000	45.000	45.000	1	1	2
	2-W7-3	24.400	115.000	10.000	8	2	10
	2-W15-22	22.000	46.000	46.000	1	2	3
	2-W19-26	22.000	34.000	34.000	1	1	2
	2-W19-18	19.800	27.000	11.000	5	0	5
	2-W10-14	19.444	59.000	6.000	8	1	9
	2-W7-4	19.200	92.000	11.000	5	5	10
	2-W19-20	19.167	24.000	12.000	6	0	6
	2-W27-1	19.000	37.000	8.000	5	3	8
	2-W15-17	16.600	32.000	10.000	4	1	5
	2-W15-18	16.500	63.000	7.000	5	3	8
	2-W15-15	16.250	34.000	5.000	6	2	8
	2-W22-42	15.000	18.000	17.000	2	1	3
	6-49-79	14.600	27.000	6.000	5	0	5
	2-W19-3	14.250	30.000	8.000	4	0	4
	2-W19-21	14.200	46.000	6.000	4	1	5
	2-W14-10	14.000	14.000	14.000	1	0	1
	2-W7-1	14.000	59.000	10.000	4	5	9
	2-W18-21	13.444	50.000	12.000	3	6	9
	2-W22-41	13.000	17.000	12.000	2	1	3
	2-W7-10	13.000	19.000	19.000	1	2	3
	2-W18-23	12.444	34.000	10.000	6	3	9
	2-W22-20	12.400	31.000	8.000	3	2	5
	2-W10-16	12.200	19.000	12.000	2	3	5
	2-W19-2	12.000	12.000	12.000	1	0	1
	2-W7-8	12.000	18.000	18.000	1	3	4
	2-W8-1	11.556	30.000	10.000	4	5	9
	6-38-70	11.000	16.000	10.000	4	2	6
	2-W19-32	10.500	11.000	11.000	1	1	2
	6-35-66	10.250	12.000	8.000	4	0	4

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
Zinc, filtered							
	2-W10-15	10.000	10.000	10.000	1	4	5
	2-W19-31	10.000	10.000	10.000	1	2	3
	2-W22-39	10.000	10.000	10.000	1	2	3
	2-W10-9	9.250	17.000	17.000	1	3	4
	2-W18-24	9.000	24.000	11.000	2	8	10
	6-32-77	9.000	12.000	10.000	2	1	3
	2-W9-1	8.667	14.000	7.000	5	4	9
	2-W7-2	8.556	18.000	9.000	2	7	9
	2-W19-27	8.500	9.000	8.000	2	0	2
	2-W19-28	8.250	7.000	6.000	2	2	4
	6-32-70B	8.250	11.000	6.000	4	0	4
	2-W6-2	8.214	24.000	5.000	3	11	14
	2-W19-16	8.200	12.000	6.000	4	1	5
	6-35-78A	8.000	11.000	5.000	2	0	2
	6-35-70	7.500	7.000	6.000	3	1	4
	6-36-61A	7.200	11.000	11.000	1	4	5
	2-W19-11	7.000	9.000	5.000	2	0	2
	6-29-78	7.000	11.000	11.000	1	2	3
	2-W22-22	6.800	14.000	5.000	2	3	5
	2-W15-16	6.667	8.000	5.000	4	5	9
	2-W15-7	6.667	5.000	5.000	1	2	3
	6-38-65	6.500	7.000	6.000	2	0	2
	2-W18-15	6.000	7.000	6.000	2	1	3
	2-W18-5	6.000	7.000	6.000	2	1	3
	2-W23-10	5.800	9.000	9.000	1	4	5
	2-W10-4	5.667	7.000	7.000	1	2	3
	2-W19-13	5.667	7.000	5.000	2	1	3
	2-W22-1	5.667	7.000	7.000	1	2	3
	6-44-64	5.400	6.000	6.000	2	3	5
	6-32-72	5.333	6.000	6.000	1	2	3
	2-W11-23	5.000	5.000	5.000	1	0	1
	2-W15-10	5.000	5.000	5.000	1	2	3
	2-W15-11	5.000	5.000	5.000	2	1	3
	2-W19-5	5.000	5.000	5.000	1	1	2
Zinc-65							
	2-W18-26	10.400	10.400	10.400	1	0	1
	2-W7-7	8.710	8.710	8.710	1	0	1
	2-W7-10	7.860	7.860	7.860	1	0	1
	2-W7-8	7.420	7.420	7.420	1	0	1
	2-W15-17	5.720	8.360	8.360	1	1	2
Zirconium/Niobium-95							
	2-W23-13	24.300	24.300	24.300	1	0	1
	2-W18-22	11.700	11.700	11.700	1	0	1
	2-W19-24	7.970	7.970	7.970	1	0	1
	2-W22-20	3.970	1.840	5.840	1	2	3
o-Nitrophenol							
	2-W7-6	7.000	7.000	7.000	1	0	1
pH, Field Measurement							
	6-37-82A	9.890	9.980	9.800	2	0	2
	2-W19-1	9.307	9.390	9.140	3	0	3
	2-W23-9	9.190	9.190	9.190	1	0	1
	2-W7-6	8.966	9.330	8.300	31	0	31

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
pH, Field Measurement							
	2-W14-10	8.493	9.000	8.200	3	0	3
	2-W10-8	8.460	8.720	8.200	2	0	2
	6-39-79	8.375	8.700	8.100	4	0	4
	2-W19-12	8.290	8.290	8.290	1	0	1
	2-W7-3	8.284	9.500	7.800	28	0	28
	2-W22-10	8.270	8.270	8.270	1	0	1
	2-W19-21	8.268	8.400	8.100	6	0	6
	2-W22-9	8.260	8.260	8.260	1	0	1
	2-W26-6	8.230	8.240	8.210	3	0	3
	2-W7-2	8.171	8.780	7.889	28	0	28
	2-W22-39	8.156	8.350	7.930	8	0	8
	2-W23-4	8.150	8.150	8.150	1	0	1
	2-W23-13	8.138	8.580	7.760	9	0	9
	2-W15-24	8.111	8.390	7.740	17	0	17
	2-W11-7	8.100	8.100	8.100	2	0	2
	2-W18-15	8.100	8.400	7.900	3	0	3
	2-W26-9	8.100	8.440	7.830	12	0	12
	2-W15-7	8.095	8.400	7.790	4	0	4
	2-W10-15	8.093	8.450	7.750	16	0	16
	2-W27-1	8.081	8.570	7.800	7	0	7
	2-W15-19	8.069	8.420	7.670	17	0	17
	2-W15-8	8.042	9.420	7.070	5	0	5
	6-35-78A	8.030	8.990	7.500	3	0	3
	2-W26-8	8.016	8.270	7.660	8	0	8
	2-W7-5	8.005	8.330	7.680	38	0	38
	2-W9-1	8.002	8.500	7.500	31	0	31
	2-W19-5	8.000	8.100	7.900	2	0	2
	6-47-60	8.000	8.400	7.500	3	0	3
	6-50-85	8.000	8.300	7.700	2	0	2
	2-W10-13	7.999	8.620	7.500	36	0	36
	2-W22-22	7.998	8.200	7.900	4	0	4
	2-W18-26	7.989	8.240	7.590	20	0	20
	2-W10-17	7.985	8.130	7.870	11	0	11
	2-W7-4	7.985	8.600	7.260	40	0	40
	2-W18-4	7.983	8.250	7.700	3	0	3
	6-45-69A	7.980	8.000	7.960	2	0	2
	2-W19-9	7.975	8.500	7.700	4	0	4
	2-W22-2	7.970	7.970	7.970	1	0	1
	2-W22-1	7.967	8.300	7.500	3	0	3
	2-W18-2	7.964	8.120	7.350	5	0	5
	6-49-79	7.957	8.100	7.800	6	0	6
	2-W18-25	7.947	8.210	7.708	11	0	11
	2-W6-2	7.913	8.080	7.650	31	0	31
	2-W19-27	7.907	8.370	7.420	4	0	4
	2-W22-12	7.887	8.060	7.600	3	0	3
	2-W7-8	7.886	8.060	7.330	13	0	13
	2-W15-22	7.884	8.320	7.450	10	0	10
	2-W23-11	7.857	7.930	7.820	3	0	3
	2-W19-18	7.852	8.400	7.600	6	0	6
	2-W7-9	7.850	8.710	7.260	11	0	11
	2-W23-10	7.842	8.200	7.610	5	0	5
	2-W15-23	7.838	8.080	7.710	12	0	12

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
pH, Field Measurement							
	2-W18-21	7.837	8.410	7.360	30	0	30
	2-W7-10	7.837	8.100	7.570	3	0	3
	2-W8-1	7.827	8.500	6.920	39	0	39
	2-W18-23	7.813	8.100	7.282	41	0	41
	2-W18-22	7.813	8.200	7.300	33	0	33
	6-38-70	7.809	7.900	7.400	7	0	7
	2-W22-43	7.803	7.870	7.710	12	0	12
	2-W15-15	7.801	8.000	7.100	29	0	29
	2-W19-13	7.800	8.000	7.600	3	0	3
	2-W22-26	7.800	8.200	7.400	2	0	2
	2-W18-24	7.793	8.070	7.600	34	0	34
	2-W18-20	7.788	8.170	7.490	4	0	4
	2-W18-17	7.787	8.800	7.170	9	0	9
	2-W15-18	7.782	8.000	7.630	33	0	33
	2-W7-1	7.766	8.490	7.230	28	0	28
	2-W10-14	7.760	8.140	6.980	28	0	28
	2-W22-40	7.756	7.880	7.690	12	0	12
	2-W19-11	7.755	8.010	7.500	2	0	2
	2-W10-18	7.752	7.850	7.630	10	0	10
	2-W19-16	7.738	7.900	7.600	5	0	5
	2-W10-16	7.706	8.010	7.330	14	0	14
	2-W19-3	7.705	8.000	7.000	4	0	4
	6-29-78	7.700	8.100	7.200	3	0	3
	6-48-71	7.700	7.700	7.700	1	0	1
	2-W18-9	7.695	7.790	7.600	2	0	2
	2-W15-17	7.686	8.010	6.400	20	0	20
	2-W19-25	7.680	7.690	7.670	2	0	2
	6-35-66	7.675	7.900	7.500	4	0	4
	2-W15-16	7.671	7.940	7.000	31	0	31
	6-44-64	7.668	7.840	7.400	5	0	5
	2-W19-31	7.665	8.040	7.270	10	0	10
	2-W22-42	7.665	7.790	7.440	12	0	12
	2-W15-10	7.655	8.200	6.900	4	0	4
	2-W14-2	7.648	7.820	7.400	5	0	5
	2-W15-20	7.638	8.060	7.060	20	0	20
	2-W10-4	7.633	7.800	7.400	3	0	3
	2-W14-5	7.633	7.700	7.600	3	0	3
	2-W19-20	7.629	8.500	7.390	7	0	7
	2-W7-7	7.622	8.190	7.010	12	0	12
	2-W19-15	7.602	7.810	7.400	5	0	5
	2-W14-6	7.600	7.800	7.500	4	0	4
	6-40-62	7.567	7.900	7.400	3	0	3
	6-35-70	7.558	7.780	7.300	4	0	4
	2-W18-5	7.533	7.900	7.000	3	0	3
	2-W15-12	7.523	7.670	7.300	3	0	3
	2-W19-32	7.521	7.935	7.330	6	0	6
	2-W22-41	7.518	7.860	6.900	12	0	12
	2-W22-21	7.510	7.510	7.510	2	0	2
	6-36-61B	7.500	7.600	7.400	2	0	2
	2-W19-28	7.498	8.040	7.210	4	0	4
	2-W19-24	7.494	8.100	7.180	8	0	8
	2-W19-23	7.475	7.500	7.450	2	0	2

Table A-1. Summary of Detections in 200 West Groundwater Aggregate Area (January 1988 - April 1992).

Constituent	Well	Average of Reported Values (Detections and Nondetections)	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number of < D.L. in Well	Total Number of Analyses
pH, Field Measurement							
	6-38-65	7.470	7.640	7.300	2	0	2
	2-W15-11	7.467	8.000	6.700	3	0	3
	6-36-61A	7.453	7.810	7.300	4	0	4
	2-W19-19	7.400	7.420	7.380	2	0	2
	2-W19-2	7.400	7.400	7.400	1	0	1
	6-43-88	7.400	7.400	7.400	1	0	1
	6-32-70B	7.375	7.900	6.900	4	0	4
	2-W11-14	7.367	7.800	7.100	3	0	3
	2-W22-20	7.363	7.600	6.800	6	0	6
	2-W19-29	7.285	7.360	7.250	4	0	4
	6-32-72	7.200	7.800	6.200	3	0	3
	2-W10-9	7.198	8.300	6.560	10	0	10
	6-32-77	7.167	7.700	6.300	3	0	3
	2-W19-26	7.075	7.330	6.880	4	0	4
	2-W19-30	6.950	6.950	6.950	1	0	1
	2-W15-6	6.930	7.870	6.460	3	0	3
	2-W15-4	6.900	7.000	6.800	2	0	2
	2-W23-14	6.863	7.798	5.770	9	0	9

Note: D.L. Detection limit

a Chemical data combined from two chemical constituent data codes or more thane one analytical method. Chemical constituent codes provided from Hanford Site Groundwater Chemical Database by WHC.

Units: All organic and inorganic compounds in micrograms per liter
All radionuclides in picocuries per liter

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Table A-2. Maximum Detections
in 200 West Groundwater (October 1951 - April 1992)

Constituent		Well	Maximum of Detections *	Date
1,1,1-trichloroethane	@	**	50	**
1,1-dichloroethylene		2-W22-20	5.7	10/03/91
1,2-dichloroethane	@	2-W22-20	6	12/14/88
12-Propanediol		2-W19-15	48	01/12/88
2,4,5-Trichlorophenol		**	50	**
2,4-Dichloropenthan		2-W15-4	180	12/09/87
2,4-dichlorophenol		2-W15-24	30	02/06/92
2,4-dimethylphenol		2-W10-18	47	04/20/92
2,6-Bis(1,1-Dimethylethyl)-4-Methyl Phenol		2-W19-27	20	11/02/89
2,6-dichlorophenol		2-W7-6	36	02/03/92
2-chlorophenol		2-W7-6	35	02/03/92
2-Hydroxy-2-Methylpropanoic Acid		2-W15-4	300	12/09/87
2-sec-butyl-4,6-dinitrophenol		2-W7-8	8	11/11/91
3-Bromocyclohexene		2-W15-4	11	08/14/87
4-Methyl-2-Pentanol		2-W15-4	300	12/09/87
4-Methyl-2-Pentanone		2-W19-18	6	07/22/88
5-Methyl-3-Hexanol		2-W15-4	240	12/09/87
Acetone by VOA		**	100	**
Aldrin		**	1	**
Alkalinity		2-W19-3	258000	03/11/87
Aluminum		6-51-75	77300	08/14/85
Aluminum, filtered		2-W14-2	516	12/06/87
Americium-241		2-W15-8	5.9	11/13/91
Ammonium ion		2-W15-8	44000	06/30/88
Antimony-125		2-W7-10	25.1	11/14/91
Arsenic		2-W10-8	101	03/16/90
Arsenic, filtered		2-W15-4	24	03/02/88
Barium		2-W10-8	732	03/16/90
Barium, filtered		2-W7-6	510	08/12/91
Beryllium		**	6	**
Beryllium, filtered		2-W6-2	7	09/07/89
Beryllium-7		2-W6-2	57.7	08/12/91
Bicarbonate		6-35-70	220	11/01/76
Bisphenol A		2-W14-10	42	01/30/90
Bis(2-ethylhexyl) phthalate		2-W7-10	64	08/09/91
Boron		2-W14-10	587	01/30/90
Boron, filtered		2-W22-20	73	02/21/90
Boron (Colorimetric by curcumin)		2-W23-5	0.66	12/19/77
Cadmium		2-W19-1	94	01/02/90
Cadmium, filtered		2-W14-5	6	07/22/87
Calcium		2-W19-24	321000	12/29/87
Calcium, filtered		2-W19-19	325000	10/31/89
Carbon disulfide		2-W22-40	39	09/03/91
Carbon Tetrachloride by GC	@	2-W15-16	8700	03/15/90

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Table A-2. Maximum Detections
in 200 West Groundwater (October 1951 - April 1992)

Constituent		Well	Maximum of Detections *	Date
Carbonate		6-25-70	3.6	01/06/77
Carbon-14		6-35-70	19.6	08/24/88
Cerium/Praseodymium-144		2-W15-20	31	08/05/91
Cesium-137		6-38-70	790000	01/19/60
Chemical calcium by AA		6-35-70	77	12/04/78
Chemical sodium by AA		2-W10-3	770	03/01/59
Chloride		2-W11-14	66900	04/13/90
Chloride by chemical analysis		6-38-70	32	11/01/76
Chloroform	@	2-W15-8	1650	06/30/88
Chromium		2-W10-8	6180	03/16/90
Chromium, filtered		2-W22-20	350	01/07/92
Chromium-6		6-32-72	0.0032	03/04/83
Citrus red		2-W7-6	6940	10/03/88
Cobalt, filtered		2-W22-43	26	04/09/92
Cobalt-60		2-W19-3	43000000	03/04/60
Coliform bacteria		6-47-60	2400	11/08/85
Coliform (Membrane Filter)		2-W8-1	84	09/12/89
Conductivity, Laboratory		2-W19-20	2310	03/20/90
Copper		2-W19-26	232	10/27/89
Copper, filtered		2-W10-14	53	08/14/91
Cresols		2-W7-6	21	02/03/92
Cyanide		2-W14-2	115	12/06/87
DDD		2-W15-8	0.33	01/13/92
DDT		2-W15-8	4.3	01/13/92
Dieldrin		2-W15-8	3.9	01/13/92
Endrin		2-W15-8	4.6	01/13/92
Endrin Aldehyde		2-W14-2	0.7	01/13/92
Europium-154		2-W19-31	24.9	10/01/91
Fluoride		**	0.5	**
Gamma-BHC		**	1	**
Gross alpha	@	2-W19-11	48700	05/23/85
Gross beta		2-W22-26	80000000	03/16/67
Hardness		6-38-70	350	11/01/76
Heptachlor		**	1	**
Iodine-129	@	6-35-70	87.8	04/18/88
Iron		2-W10-8	328000	03/16/90
Iron, filtered		2-W7-6	57000	08/12/91
Lead		6-51-75	276	08/14/85
Lead, filtered		2-W15-24	31	02/06/92
Lead (graphite furnace)		2-W15-17	1000	05/31/89
Lead-212		2-W7-7	6.28	08/09/91
Lithium		2-W7-6	37	01/11/90
Lithium, filtered		**	12	**
Magnesium		2-W19-19	108000	10/31/89

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Table A-2. Maximum Detections
in 200 West Groundwater (October 1951 - April 1992)

Constituent		Well	Maximum of Detections *	Date
Magnesium, filtered		2-W19-19	114000	10/31/89
Magnesium by chemical analysis		6-38-70	29	11/01/76
Manganese		2-W19-1	3010	01/02/90
Manganese, filtered		2-W22-43	1900	04/09/92
Mercury		6-38-70	1	08/12/85
Mercury, filtered		2-W23-7	0.16	06/09/87
Methyl ethyl ketone		2-W15-18	16	09/25/89
Methylene Chloride	@	6-38-65	33500	08/27/87
Nickel		2-W7-9	880	08/09/91
Nickel, filtered		2-W9-1	330	08/08/91
Nickel-63		6-38-70	18.3	11/10/88
Nitrate	@	2-W18-17	2810000	06/22/88
Nitrate, Phenodisulfonic Acid Method		2-W14-2	11000	03/25/58
Nitrate-Ion		2-W6-1	3200	09/07/85
Nitrite		2-W23-9	2400	04/06/90
N-nitrosodimethylamine		2-W15-4	40	05/28/87
ORGANIC		**	0.2	**
o-Nitrophenol		2-W7-6	7	02/03/92
Pentachlorophenol		**	111	**
pH, Field Measurement		6-37-82A	9.98	05/06/90
pH, Laboratory Measurement		6-37-82A	9.8	08/26/88
Phenol	@	**	222	**
Phosphate		2-W19-24	45900	12/29/87
Plutonium		**	220	**
Plutonium-238		2-W22-21	8.9706	01/09/92
Plutonium-239/40		2-W15-8	8.27	05/07/90
Potassium		2-W15-8	25000	06/30/88
Potassium, filtered		2-W15-8	12000	01/13/92
Potassium-40		2-W10-18	476	09/24/91
p-Dichlorobenzene	@	6-43-88	31.4	08/20/85
Radium		2-W7-6	10.1	01/11/90
Ruthenium-106		2-W22-26	130000	07/14/71
Selenium		2-W27-1	35	01/11/90
Selenium, filtered		**	54	**
Silicon		2-W10-8	83100	03/16/90
Silicon, filtered		2-W19-24	28500	10/30/89
Silver		6-26-89	34	05/14/86
Silver, filtered		2-W18-22	25	10/05/88
Silver-110 Metastable		2-W14-10	5.38	01/30/90
Sodium		2-W15-4	258000	03/02/88
Sodium, filtered		2-W10-4	386000	07/22/87
Specific conductance		2-W10-9	13296	10/03/91
Strontium		2-W19-26	1630	10/27/89
Strontium, filtered		2-W19-26	1690	10/27/89

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Table A-2. Maximum Detections
in 200 West Groundwater (October 1951 - April 1992)

Constituent		Well	Maximum of Detections *	Date
Strontium-90		2-W22-10	330000	04/23/57
Sulfate		2-W22-9	3500000	02/12/92
Sulphate		6-45-69A	65	12/12/83
Technetium-99		2-W19-24	41000	10/06/89
Temperature, field		2-W18-20	23.3	02/06/91
Tetrachloroethylene	@	2-W15-8	7	05/07/90
Titanium		2-W19-1	1370	01/02/90
Toluene		2-W19-1	13	01/02/90
Total carbon		2-W19-3	44800	10/15/87
Total dissolved solids		2-W19-26	1880000	10/27/89
Total dissolved solids		**	1,880,000	**
Total organic carbon		2-W19-15	27300	08/17/88
Total Organic Halogen, Low Det. Level		6-38-65	27500	08/27/87
Total potassium		6-35-70	6.4	12/27/83
Trichloroethylene	@	2-W22-20	41	02/21/90
Tritium		**	200,000,000	**
Turbidity		2-W7-6	380	08/12/91
Unknown		2-W15-4	1120	12/09/87
Uranium		2-W19-11	83000	03/08/85
Uranium, chemical		2-W19-11	24700	03/04/86
Uranium-234		2-W19-3	3430	07/22/87
Uranium-235		2-W19-11	573	03/04/86
Uranium-236		2-W19-3	55.4	09/15/87
Uranium-238		2-W19-3	3470	07/22/87
Vanadium		2-W10-8	1140	03/16/90
Vanadium, filtered		2-W15-4	269	03/02/88
Xylene-o,p		2-W15-18	6	09/25/89
Zinc		2-W18-9	7380	06/27/88
Zinc, filtered		2-W10-13	839	09/13/89
Zinc-65		2-W18-26	10.4	08/07/91
Zirconium/Niobium-95		2-W23-13	24.3	10/03/91

Notes:

* Units:

Organic and inorganic concentrations in micrograms per liter.
Radionuclide concentrations in picocuries per liter.

** Maximum detected concentration was reported for multiple wells, or multiple sampling events in a specific well. For this reason, these values are suspectd to be analytical detection limit concentrations although they were not specifically identified as such in the Hanford Site Groundwater Database.

@ Chemical data combined from two chemical constituent data codes or from more than one analytical method. Chemical constituent data codes from Hanford Site Groundwater Database provided by WHC.

Italicized constituents have been revised from Hanford Site Groundwater Database to present corrected spelling or name.

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Table A-3. Summary of reported results below analytical detection limits.

Constituent		Minimum of reported D.L.**	Maximum of reported D.L.**	Number of analyses < D.L.	Total number of analyses
1,1,1,2-tetrachlorethane	*	5.000	10.000	136	136
1,1,1-trichloroethane	@	.500	50.000	465	469
1,1,2,2-tetrachlorethane	*	5.000	10.000	136	136
1,1,2-trichloroethane	@ *	.500	50.000	469	469
1,1-dichloroethane	@ *	1.000	12.500	419	419
1,1-dichloroethylene		5.000	10.000	171	172
1,1-dimethylhydrazine	*	10.000	10.000	14	14
1,2,3,4-tetrachlorobenzene	*	10.000	22.200	165	165
1,2,3,5-tetrachlorobenzene	*	10.000	22.200	165	165
1,2,3-trichlorobenzene	*	10.000	22.200	165	165
1,2,3-trichloropropane	*	5.000	10.000	136	136
1,2,4,5-tetrachlorobenzene	*	10.000	22.200	165	165
1,2,4-trichlorobenzene	*	10.000	22.200	165	165
1,2-dibromo-3-chloropropane	*	10.000	10.000	134	134
1,2-dibromoethane	*	5.000	10.000	136	136
1,2-dichlorobenzene	*	10.000	22.200	165	165
1,2-dichloroethane	@	5.000	12.500	417	419
1,2-dichloropropane	*	5.000	10.000	136	136
1,2-dimethylhydrazine	*	10.000	10.000	14	14
1,2-diphenylhydrazine	*	10.000	10.000	62	62
1,3,5-trichlorobenzene	*	10.000	22.200	165	165
1,3-dichlorobenzene	*	10.000	22.200	165	165
1,3-dichloropropene	*	5.000	10.000	136	136
1,4-dichloro-2-butene	*	5.000	10.000	136	136
1,4-naphthoquinone	*	10.000	10.000	62	62
1-(o-chlorophenyl) thiourea	*	200.000	200.000	37	37
1-Butanol	*	1.000	10000.000	120	120
1-Butynol	*	10000.000	10000.000	18	18
1-Propanol	*	10000.000	10000.000	18	18
1-acetyl-2-thiourea	*	200.000	200.000	37	37
1-chloro-2,3-epoxypropane	*	10.000	10.000	62	62
1-naphthyl-2-thiourea	*	200.000	200.000	37	37
1-naphthylamine	*	10.000	10.000	62	62
2,3,4,6-tetrachlorophenol	*	10.000	10.000	141	141
2,3,7,8 TCDD	*	.010	.010	14	14
2,4,5-T	*	2.000	2.000	284	284
2,4,5-TP silvex	*	2.000	2.000	298	298
2,4,5-Trichlorophenol		5.000	50.000	140	141
2,4,6-trichlorophenol	*	5.000	10.000	141	141
2,4-D	*	2.000	10.000	298	298
2,4-dichlorophenol		5.000	10.000	138	140
2,4-dimethylphenol		5.000	10.000	123	126
2,4-dinitrophenol	*	10.000	150.000	140	140
2,4-dinitrotoluene	*	10.000	10.000	62	62
2,6-dichlorophenol		5.000	10.000	139	140
2,6-dinitrotoluene	*	10.000	10.000	62	62
2-Hexanone	*	50.000	50.000	16	16
2-Methylnaphthalene	*	10.000	10.000	14	14
2-Methylphenol	*	10.000	10.000	100	100
2-acetylaminofluorene	*	10.000	10.000	62	62
2-chloroethyl vinyl ether	*	5.000	10.000	134	134
2-chloronaphthalene	*	10.000	10.000	62	62
2-chlorophenol		5.000	10.000	139	140

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Constituent		Minimum of reported D.L.**	Maximum of reported D.L.**	Number of analyses < D.L.	Total number of analyses
2-cyclohexyl-4,6-dinitrophenol	*	10.000	10.000	62	62
2-methyl-2-(methylthio) propionaldehyde-	*	10.000	10.000	62	62
2-methylaziridine	*	10.000	10.000	62	62
2-methyllactonitrile	*	10.000	10.000	62	62
2-naphthylamine	*	10.000	10.000	62	62
2-picoline	*	10.000	10.000	62	62
2-propyn-1-ol	*	8000.000	10000.000	37	37
2-sec-butyl-4,6-dinitrophenol		1.000	10.000	194	201
3,3'-Dichlorobenzidine	*	10.000	20.000	62	62
3,3'-dimethoxybenzidine	*	10.000	10.000	62	62
3,3'-dimethylbenzidine	*	10.000	10.000	62	62
3-chloropropionitrile	*	4000.000	10000.000	37	37
3-methylcholanthrene	*	10.000	10.000	62	62
4,4'-methylenebis(2-chloroaniline)	*	10.000	10.000	62	62
4,6-Dinitro-2-methylphenol	*	200.000	200.000	78	78
4,6-dinitro-o-cresol and salts	*	10.000	10.000	62	62
4-Methyl-2-Pentanone		50.000	50.000	138	139
4-Methylphenol	*	10.000	10.000	100	100
4-Nitroquinoline 1-oxide	*	10.000	10.000	14	14
4-aminobyphenyl	*	10.000	10.000	62	62
4-bromophenyl phenyl ether	*	10.000	10.000	62	62
5-(aminomethyl)-3-isoxazolol	*	10.000	10.000	62	62
5-nitro-o-toluidine	*	10.000	10.000	62	62
7,12-dimethylbenz[a]anthracene	*	10.000	10.000	62	62
7H-dibenzo[c,g]carbazole	*	10.000	10.000	62	62
Acenaphthalene	*	10.000	10.000	14	14
Acenaphthene	*	10.000	10.000	14	14
Acetone - by ABN	*	10.000	10.000	14	14
Acetone by VOA		3.000	100.000	298	307
Acetonitrile	*	10.000	3000.000	136	136
Acetophenone	*	10.000	10.000	62	62
Acrolein	*	5.000	10.000	136	136
Acrylamide	*	10000.000	10000.000	37	37
Acrylonitrile	*	5.000	10.000	136	136
Aldrin		.050	.100	186	189
Allyl Chloride	*	100.000	100.000	16	16
Allyl alcohol	*	2500.000	10000.000	37	37
Alpha,alpha-dimethylphenethylamine	*	10.000	10.000	62	62
Alpha-BHC	*	.050	.100	306	306
Aluminum		150.000	150.000	140	180
Aluminum, filtered		150.000	150.000	309	312
Americium-241		-.113	.096	158	170
Amitrole	*	10.000	10.000	62	62
Ammonium ion		20.000	100.000	369	406
Aniline	*	10.000	10.000	62	62
Anthracene	*	10.000	10.000	14	14
Antimony	*	100.000	200.000	336	336
Antimony, filtered	*	100.000	200.000	475	475
Antimony-125		-21.900	13.100	153	159
Aramite	*	10.000	10.000	62	62
Arochlor 1016	*	1.000	1.000	37	37
Arochlor 1221	*	1.000	5.000	37	37
Arochlor 1232	*	1.000	1.000	37	37

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Constituent		Minimum of reported D.L.**	Maximum of reported D.L.**	Number of analyses analyses < D.L.	Total number of analyses
Arochlor 1242	*	1.000	1.000	37	37
Arochlor 1248	*	1.000	1.000	37	37
Arochlor 1254	*	1.000	1.000	37	37
Arochlor 1260	*	1.000	1.000	37	37
Arsenic		5.000	5.000	293	344
Arsenic, filtered		5.000	5.000	325	362
Auramine	*	10.000	10.000	62	62
Barium		20.000	20.000	4	344
Barium, filtered		20.000	20.000	8	475
Benz[a]anthracene	*	10.000	10.000	62	62
Benz[c]acridine	*	10.000	10.000	62	62
Benzene	*	2.000	12.500	419	419
Benzene, dichloromethyl	*	10.000	10.000	62	62
Benzenethoil	*	10.000	10.000	62	62
Benzidine	*	10.000	10.000	62	62
Benzo(ghi)perylene	*	10.000	10.000	14	14
Benzo(k)Fluoranthene	*	10.000	10.000	14	14
Benzo[a]pyrene	*	10.000	10.000	62	62
Benzo[b]fluoranthene	*	10.000	10.000	62	62
Benzo[j]fluoranthene	*	10.000	10.000	62	62
Benzyl Alcohol	*	10.000	10.000	14	14
Benzyl chloride	*	10.000	10.000	62	62
Beryllium		3.000	5.000	333	336
Beryllium, filtered		3.000	5.000	471	475
Beryllium-7		-86.500	617.000	64	65
Beta-BHC	*	.050	.100	306	306
Bis(2-chloro-1-methylethyl)ether	*	10.000	10.000	14	14
Bis(2-chloroethoxy) methane	*	10.000	10.000	62	62
Bis(2-chloroethyl) ether	*	10.000	10.000	62	62
Bis(2-chloroisopropyl)ether	*	10.000	10.000	62	62
Bis(2-ethylhexyl) phthalate		10.000	10.000	61	63
Bis(chloromethyl) ether	*	5.000	10.000	134	134
Boron		10.000	10.000	6	116
Boron, filtered		10.000	10.000	2	145
Bromide	*	100.000	40000.000	387	387
Bromoacetone	*	5.000	10.000	134	134
Bromodichloromethane	*	5.000	5.000	16	16
Bromoform	*	5.000	10.000	136	136
Butyl benzyl phthalate	*	10.000	10.000	62	62
Cadmium		2.000	10.000	322	344
Cadmium, filtered		2.000	10.000	469	475
Carbon Tetrachloride by GC	@	1.200	5.000	183	469
Carbon disulfide		5.000	10.000	136	138
Carbon-14		-.856	3.380	19	25
Carbophenothion	*	2.000	2.000	33	33
Cerium/Promethium-144		-67.200	63.500	63	65
Cesium-134	*	-12.400	4.090	67	67
Cesium-137		-10.200	8.930	616	640
Chlordane	*	.100	1.000	189	189
Chlornaphazine	*	10.000	10.000	62	62
Chloroacetaldehyde	*	16000.000	16000.000	19	19
Chloroalkyl ethers	*	10.000	10.000	62	62
Chlorobenzene	@ *	5.000	22.200	252	252

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Table A-3. Summary of reported results below analytical detection limits.

Constituent		Minimum of reported D.L.**	Maximum of reported D.L.**	Number of analyses < D.L.	Total number of analyses
Chlorobenzilate	*	30.000	300.000	37	37
Chloroethane	*	10.000	10.000	16	16
Chloroform	@	.720	40.000	314	469
Chloromethyl methyl ether	*	10.000	10.000	134	134
Chloroprene	*	5.000	5.000	2	2
Chromium		10.000	20.000	48	344
Chromium, filtered		10.000	20.000	348	475
Chrysene	*	10.000	10.000	62	62
Cis-1,2-Dichloroethene	*	1.000	1.000	1	1
Citrus red		1000.000	1000.000	96	98
Cobalt	*	20.000	20.000	280	280
Cobalt, filtered		20.000	20.000	307	308
Cobalt-60		-13.800	10.700	585	640
Coliform (Membrane Filter)		1.000	1.000	39	44
Coliform bacteria		1.000	2.200	214	219
Copper		10.000	20.000	264	344
Copper, filtered		10.000	20.000	433	475
Cresols		10.000	22.200	143	144
Crotonaldehyde	*	10.000	10.000	134	134
Cyanide		10.000	20.000	398	416
DDD		.100	.100	186	189
DDE	*	.050	.100	189	189
DDT		.100	.100	185	189
Decane	*	10.000	10.000	100	100
Delta-BHC	*	.100	.100	306	306
Di-n-butyl phthalate	*	10.000	10.000	62	62
Di-n-octyl phthalate	*	10.000	10.000	62	62
Di-n-propylnitrosamine	*	10.000	10.000	62	62
Diallate	*	10.000	10.000	14	14
Dibenz[a,h]acridine	*	10.000	10.000	62	62
Dibenz[a,h]anthracene	*	10.000	10.000	62	62
Dibenz[a,j]acridine	*	10.000	10.000	62	62
Dibenzo[a,e]pyrene	*	10.000	10.000	62	62
Dibenzo[a,h]pyrene	*	10.000	10.000	62	62
Dibenzo[a,i]pyrene	*	10.000	10.000	62	62
Dibenzofuran	*	10.000	10.000	14	14
Dibromomethane	*	5.000	10.000	136	136
Dibutyl Phosphate	*	10000.000	10000.000	18	18
Dichlorodifluoromethane	*	5.000	10.000	136	136
Dieldrin		.050	.100	186	189
Diethyl phthalate	*	10.000	10.000	62	62
Diethylarsine	*	10.000	10.000	120	120
Diethylstilbesterol	*	200.000	200.000	37	37
Dihydrosafrole	*	10.000	10.000	62	62
Dimethoate	*	2.000	2.000	33	33
Dimethyl phthalate	*	10.000	10.000	62	62
Dinitrobenzene	*	10.000	10.000	62	62
Dinoseb	*	10.000	10.000	14	14
Dioxane	*	500.000	1000.000	136	136
Dioxin	*	.100	.100	19	19
Diphenylamine	*	10.000	10.000	62	62
Disulfoton	*	2.000	2.000	33	33
Dodecane	*	10.000	10.000	100	100

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Constituent		Minimum of reported D.L.**	Maximum of reported D.L.**	Number of analyses < D.L.	Total number of analyses
Endosulfan I	*	.100	.100	189	189
Endosulfan II	*	.050	.100	189	189
Endosulfan Sulfate	*	.500	.500	170	170
Endrin		.100	.100	303	306
Endrin Aldehyde		.200	2.000	149	152
Ethanol	*	10000.000	10000.000	18	18
Ethyl benzene	*	2.000	5.000	17	17
Ethyl carbamate	*	5000.000	10000.000	37	37
Ethyl cyanide	*	5.000	10000.000	39	39
Ethyl methacrylate	*	10.000	10.000	134	134
Ethyl methanesulfonate	*	10.000	10.000	62	62
Ethylene glycol	@ *	10000.000	10000.000	18	18
Ethylene oxide	*	10.000	3000.000	134	134
Ethyleneimine	*	10.000	10.000	62	62
Ethylenethiourea	*	200.000	200.000	37	37
Europium-154		-15.500	9.270	62	66
Europium-155	*	-11.800	6.570	66	66
Fluoranthene	*	10.000	10.000	62	62
Fluorene	*	10.000	10.000	14	14
Fluoride	@	500.000	1050.000	268	670
Formalin	*	500.000	500.000	134	134
Gamma-BHC		.050	.100	303	306
Gross alpha	@	-.357	1.760	200	916
Gross beta		-6.310	3.290	29	1026
Heptachlor		.050	.150	186	189
Heptchlor epoxide	*	.100	1.000	189	189
Hexachlorobenzene	*	10.000	22.200	165	165
Hexachlorobutadiene	*	10.000	10.000	62	62
Hexachlorocyclopentadiene	*	10.000	10.000	62	62
Hexachloroethane	*	10.000	10.000	62	62
Hexachlorophene	*	10.000	22.200	165	165
Hexachloropropene	*	10.000	10.000	62	62
Hydrazine	@ *	3.000	3000.000	92	92
Hydrogen sulfide	*	10.000	10.000	120	120
Indeno(1,2,3-cd)pyrene	*	10.000	10.000	62	62
Iodine-129	@	-.547	2.450	81	146
Iodomethane	*	5.000	10.000	136	136
Iron		20.000	30.000	4	344
Iron, filtered		20.000	30.000	229	475
Isobutyl alcohol	*	1000.000	10000.000	39	39
Isodrin	*	10.000	10.000	14	14
Isophorone	*	10.000	10.000	14	14
Isosafrole	*	10.000	10.000	62	62
Kepone	*	1.000	1.000	18	18
Kerosene	*	10000.000	22200.000	165	165
Lead (graphite furnace)		5.000	5.000	278	336
Lead, filtered		5.000	5.000	354	378
Lithium		10.000	10.000	109	116
Lithium, filtered		10.000	10.000	138	145
Maleic hydrizide	*	500.000	1110.000	66	66
Malononitrile	*	10.000	10.000	62	62
Manganese		5.000	10.000	92	344
Manganese, filtered		5.000	10.000	358	475

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Constituent		Minimum of reported D.L.**	Maximum of reported D.L.**	Number of analyses analyses < D.L.	Total numbe of analyses
Manganese-54	*	2.680	2.680	1	1
Melphalan	*	10.000	10.000	62	62
Mercury		.100	.200	339	342
Mercury, filtered	*	.100	.200	357	357
Methacrylonitrile	*	5.000	10.000	136	136
Methanethiol	*	10.000	10.000	134	134
Methapyrilene	*	10.000	10.000	62	62
Metholonyl	*	10.000	10.000	62	62
Methoxychlor	*	2.000	3.000	306	306
Methyl Isobutyl Ketone	*	10.000	100.000	330	330
Methyl bromide	*	10.000	10.000	136	136
Methyl chloride	*	10.000	10.000	136	136
Methyl ethyl ketone		5.000	100.000	466	468
Methyl methacrylate	*	5.000	10.000	136	136
Methyl methanesulfonate	*	10.000	10.000	62	62
Methyl parathion	*	2.000	2.000	33	33
Methylene Chloride	@	.340	100.000	443	469
Methylthiouracil	*	10.000	10.000	62	62
Molybdenum	*	40.000	40.000	116	116
Molybdenum, filtered	*	40.000	40.000	145	145
Monobutyl Phosphate	*	10000.000	10000.000	18	18
N,N-diethylhydrazine	*	10.000	10.000	134	134
N-Nitrosodiphenylamine	*	10.000	10.000	14	14
N-nitroso-N-methylurethane	*	10.000	10.000	62	62
N-nitrosodi-n-butylamine	*	10.000	10.000	62	62
N-nitrosodiethanolamine	*	10.000	10.000	62	62
N-nitrosodiethylamine	*	10.000	10.000	62	62
N-nitrosodimethylamine		10.000	10.000	62	63
N-nitrosomethylethylamine	*	10.000	10.000	62	62
N-nitrosomethylvinylamine	*	10.000	10.000	62	62
N-nitrosomorpholine	*	10.000	10.000	62	62
N-nitrosonornicotine	*	10.000	10.000	62	62
N-nitrosopiperidine	*	10.000	10.000	62	62
N-phenylthiourea	*	500.000	500.000	37	37
N-propylamine	*	10000.000	10000.000	37	37
Naphthalene	*	10.000	22.200	265	265
Nickel		10.000	30.000	111	344
Nickel, filtered		10.000	30.000	423	474
Nicotinic acid	*	100.000	222.000	66	66
Nitrate	@	200.000	2500.000	72	1079
Nitrite		200.000	1000.000	325	334
Nitrobenzine	*	10.000	10.000	62	62
Nitrosopyrrolidine	*	10.000	10.000	62	62
O,O,O-triethyl phosphorothioate	*	10.000	10.000	62	62
O-toluidine hydrochloride	*	10.000	10.000	62	62
P benzoquinone	*	10.000	10.000	62	62
P-chloro-m-cresol	*	5.000	10.000	141	141
P-chloroaniline	*	10.000	10.000	62	62
P-dimethylaminoazobenzene	*	10.000	10.000	62	62
P-nitroaniline	*	10.000	50.000	62	62
Paraldehyde	*	2000.000	10000.000	37	37
Parathion	*	2.000	2.000	33	33
Pcdd's	*	.010	.010	14	14

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Constituent		Minimum of reported D.L.**	Maximum of reported D.L.**	Number of analyses < D.L.	Total number of analyses
Pcdf's	*	.010	.010	14	14
Pentachlorobenzene	*	10.000	22.200	165	165
Pentachloroethane	*	10.000	10.000	134	134
Pentachloronitrobenzene	*	10.000	10.000	62	62
Pentachlorophenol		50.000	111.000	197	203
Perchlorate	*	500.000	1000.000	62	62
Phenacetin	*	10.000	10.000	62	62
Phenanthrene	*	10.000	10.000	14	14
Phenol	a	1.000	22.200	440	452
Phenylenediamine	*	10.000	10.000	62	62
Phorate	*	2.000	2.000	14	14
Phosphate		400.000	40000.000	569	575
Phthalic acid esters	*	10.000	10.000	62	62
Plutonium-238		-5.591	.222	286	292
Plutonium-239/40		-.095	.268	275	292
Potassium		300.000	300.000	1	344
Potassium-40		6.310	58.600	11	66
Pronamide	*	10.000	10.000	62	62
Propionitrile	*	5.000	5.000	14	14
Pyrene	*	10.000	10.000	14	14
Pyridine	*	500.000	500.000	134	134
Radium		-.108	.160	165	318
Reserpine	*	10.000	10.000	62	62
Resorcinol	*	10.000	10.000	62	62
Ruthenium-103	*	-4.140	-.319	2	2
Ruthenium-106		-102.000	59.100	605	637
Safrol	*	10.000	10.000	62	62
Selenium		5.000	10.000	321	341
Selenium, filtered		5.000	10.000	353	363
Silver	*	10.000	20.000	344	344
Silver, filtered		10.000	20.000	474	475
Silver-110 Metastable		-6.810	4.690	3	4
Strontium-90		-1.660	1.080	404	445
Strychnine	*	50.000	111.000	66	66
Styrene	*	5.000	5.000	16	16
Sulfate		500.000	500.000	1	576
Sulfide	*	1000.000	10000.000	64	64
Sym-trinitrobenzene	*	10.000	10.000	62	62
Technetium-99		-13.700	14.300	114	536
Tetrachloroethylene	a	.500	50.000	468	469
Tetradecane	*	10.000	10.000	100	100
Tetraethylpyrophosphate	*	2.000	2.000	33	33
Tetrahydrofuran	*	10.000	25.000	296	296
Thallium	*	5.000	5.000	76	76
Thallium, filtered	*	5.000	5.000	71	71
Thiofanox	*	10.000	10.000	62	62
Thiourea	*	200.000	200.000	37	37
Thiuram	*	10.000	10.000	62	62
Tin	*	30.000	100.000	280	280
Tin, filtered	*	30.000	100.000	308	308
Titanium		60.000	60.000	108	116
Titanium, filtered	*	60.000	60.000	145	145
Toluene		.600	12.500	418	419

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Constituent		Minimum of reported D.L.**	Maximum of reported D.L.**	Number of analyses < D.L.	Total number of analyses
Toluenediamine	*	10.000	10.000	62	62
Total Organic Halogen, Low Det. Level		-2.000	3880.000	400	1073
Total carbon		27000.000	27000.000	1	405
Total organic carbon		100.000	1900.000	1069	1091
Toxaphene	*	1.000	2.000	306	306
Trans-1,2 Dichloroethylene	@ *	1.000	12.500	419	419
Tributyl Phosphate	*	10.000	10.000	100	100
Tributylphosphoric Acid	*	10.000	22.200	165	165
Trichloroethylene	@	1.000	50.000	427	469
Trichloromethanethiol	*	10.000	10.000	134	134
Trichloromonofluoromethane	*	5.000	10.000	136	136
Trichloropropane	*	10.000	10.000	120	120
Tris(2,3-dibromopropyl) phosphate	*	10.000	10.000	62	62
Tritium		-923.000	435.000	313	849
Uranium		.041	7.650	4	249
Uranium-235		.199	.199	1	123
Vanadium		5.000	30.000	113	344
Vanadium, filtered		5.000	30.000	141	475
Vinyl Acetate	*	5.000	5.000	16	16
Vinyl chloride	*	2.000	25.000	419	419
Warfarin	*	10.000	10.000	62	62
Xylene-m	*	5.000	50.000	351	351
Xylene-o,p		5.000	50.000	349	351
Xylenes (total)	*	5.000	5.000	118	118
Zinc		5.000	10.000	109	344
Zinc, filtered		5.000	10.000	250	475
Zinc-65		-23.600	6.960	60	65
Zirconium	*	50.000	50.000	116	116
Zirconium, filtered	*	50.000	50.000	145	145
Zirconium/Nubidium-95		-26.800	88.900	61	65
dibromochloromethane	*	5.000	5.000	16	16
m-Cresol	*	10.000	10.000	100	100
m-Nitroaniline	*	10.000	10.000	14	14
o,o-Diethyl-o,2-pyrazinyl phosphorothion	*	10.000	10.000	14	14
o-Nitroaniline	*	10.000	10.000	14	14
o-Nitrophenol		5.000	10.000	92	93
p-Dichlorobenzene	*	5.000	12.500	160	160
p-Dichlorobenzene	@ *	2.000	22.200	302	302
p-Nitrophenol	*	10.000	50.000	140	140

Note: D.L. Detection limit

* Designates constituents with all analyses below detection limit

@ Chemical data combined from two chemical constituent data codes or more than one analytical method. Chemical constituent data codes provided from Hanford Site Groundwater Chemical Database by WHC.

** Units: All organic and inorganic compounds in micrograms per liter
All radionuclides in picocuries per liter

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Table A-4. Input Parameters for Exposure to Current Groundwater Plumes.

Parameter	Description	Units	Value
WG-CONC	Conc. of contaminant in GW	g/mL	1
WB-DATE	Date of conc. measurement	unitless	1/1/91
EG-TWATER	Water distribution time from pump to use	days	0.5
EG-PRODLV	Leafy vegetable production rate	kg/yr	15
EG-PRODOV	Other vegetable production rate	kg/yr	140
EG-PRODMT	Meat production rate	kg/yr	70
EG-PRODMK	Milk production rate	kg/yr	230
EG-IRRATE	Irrigation rate	L/m2/month	100

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Table A-5. Input Parameters for Exposure to Future Offsite Contaminant Levels.

Parameter	Description	Units	Value
WS-DEPTH	Depth of release unit in saturated zone	ft	16
WS-DATE	Starting date of release unit	unitless	1/1/91
WS-LENGTH	Length of site in direction of GW flow	ft	*
WS-WIDTH	Width of site perpendicular to GW flow	ft	*
WS-LEACHV	Waste liquid infiltration rate	ft/day	0.018
WS-TLIFE	# of yrs contaminant was discharged to release unit	yr	1
WS-NUM	# of flux rates for contaminant	unitless	1
WS-CDATE	Date contaminant was first discharged to release unit	unitless	1/1/91
WS-FLUX	Flux rate for contaminant	g/yr or Ci/yr	*
WS-TIME	# of yrs contaminant was discharged to release unit at flux rate	yr	1
WZ-CLASS	Soil class in the saturated zone	unitless	Gravel
WZ-SAND	% sand in the saturated zone	%	81
WZ-SILT	% silt in the saturated zone	%	15
WZ-CLAY	% clay in the saturated zone	%	4
WZ-OMC	% organic matter content in the saturated zone	%	0.0004
WZ-IRON	% iron and aluminum in the saturated zone	%	2.7
WZ-PH	pH of the pore water in the saturated zone	unitless	7.86
WZ-TOTPOR	Total porosity of the saturated zone	%	0.3
WZ-EFFPOR	Effective porosity of the saturated zone	%	0.2
WZ-PVELOC	Pore water velocity of the saturated zone	ft/day	1.65
WZ-THICK	Thickness of the saturated zone	ft	300
WZ-BULKD	Bulk density of the saturated zone	g/cm3	1.62
WZ-DIST	Travel distance in saturated zone from source to receptor	ft	70000
WZ-LDISP	Longitudinal dispersivity	ft	7000
WZ-TDISP	Transverse dispersivity	ft	1400
WZ-VDISP	Vertical dispersivity	ft	8.12
WW-VELOC	River flow velocity	ft/s	5
WW-DEPTH	River depth	ft	15
WW-WIDTH	River width	ft	2000
WW-DIST	Distance to closest receptor	ft	1000

Table A-5. Input Parameters for Exposure to Future Offsite Contaminant Levels.

Parameter	Description	Units	Value
WW-DISCHG	Average annual discharge at receptor location	ft3/s	180000
WA-SUBKD	Subsurface absorption coefficient for contaminant in the saturated zone	ml/g	*
EW-TWATER	Water distribution time from pump to use	days	0.5
EG-PRODLV	Leafy vegetable production rate	kg/yr	15
EG-PRODOV	Other vegetable production rate	kg/yr	140
EG-PRODMT	Meat production rate	kg/yr	70
EG-PRODMK	Milk production rate	kg/yr	230
EG-IRRATE	Irrigation rate	L/m2/month	100
EW-PRODFF	Finfish production rate	kg/yr	6.9
EW-PRODSF	Shellfish production rate	kg/yr	0
EW-FDELAY	Finfish consumption delay	day	1
EW-SDELAY	Shellfish consumption delay	day	0

* Values are contaminant specific (see Table A-6).

Table A-6. Chemical Specific Exposure Input Parameters.

Contaminant	WS-LENGTH (ft)	WS-WIDTH (ft)	WS-FLUX (g/yr or Ci/yr)	WA-SUBKD (mL/g)
Inorganics:				
Arsenic	1,222.	3,426.	1.20E+04	0
Chromium	2,332.	3,228.	2.16E+05	0
Cyanide	3,672.	2,792.	6.10E+04	0.1
Fluoride	823.	1,312.	1.40E+06	0
Nitrate	11,303.	6,054.	3.30E+09	0
Uranium	2,572.	4,038.	1.57E+06	1
Organics:				
Carbon tetrachloride	7,541.	9,836.	5.75E+07	0.11
Chloroform	6,904.	9,788.	1.41E+06	0.031
Trichloroethylene	4,920.	6,058.	7.40E+04	0.13
Radionuclides:				
H-3	9,027.	7,367.	6.60E+03	0
Tc-99	3,641.	2,421.	1.15E+01	0
I-129	7,777.	6,862.	5.20E-02	0
U-234	2,572.	4,038.	8.61E-01	1
U-235	2,572.	4,038.	5.00E-02	1
U-238	2,572.	4,038.	8.75E-01	1
Pu-239/240	1,410.	1,210.	2.62E-03	100

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Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[a]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
299-W6-2	245	227-245	225-245	233	11/05/87	Constant Discharge	350	--	--
*	245	227-245	227-245	233	11/03/87	Recovery	500	--	--
299-W7-1	244	226-244	224-244	231	07/15/87	Constant Discharge	1000	--	--
*	244	226-244	224-244	231	07/15/87	Recovery	1400	--	--
299-W7-2	222	211-222	202-222	217	09/16/87	Constant Discharge	430	--	--
*	222	211-222	202-222	217	09/16/87	Recovery	740	--	--
299-W7-3	470	449-470	449-470	218	10/30-31/87	Constant Discharge	--	--	151 ft of Drawdown at 1680 min; 2.8 gpm
299-W7-4	233	205-233	203-233	211	11/12/87	Constant Discharge	3300	--	--
*	233	205-233	203-233	211	1/12/87	Recovery	2800	--	--
299-W7-5	228	208-228	208-228	214	11/21/87	Constant Discharge	170	--	--
299-W7-6	229	215-229	209-229	220	10/14/87	Constant Discharge	14	--	--
*	229	215-229	209-229	220	10/14/87	Recovery	40	--	--
299-W7-7	228	211-228	207-228	216	12/05/89	Slug Withdrawal	45[e]/	--	--
299-W7-9	241	228-241	220-241	232	03/01/90	Slug Withdrawal	26[e]/	--	--
299-W7-10	241	225-241	220-241	231	02/13/90	Slug Withdrawal	18[e]/	--	--
299-W8-1	256	236-256	236-256	241	07/11/87	Recovery	80	--	--
299-W9-1	286	269-286	266-286	275	10/23/87	Slug Withdrawal	43-65[e]/	--	--
*	286	269-286	266-286	275	10/23/87	Slug Injection	55[e]/	--	--
299-W10-13	247	229-247	227-247	235	09/14/87	Recovery	7000	--	--
299-W10-14	447	427-447	427-447	235	10/26/87	Recovery	900	--	--
*	447	240 (OH)	427-447	235	09/14/87	Recovery	3500	--	Pumping Well is 299-W10-13
299-W10-15	222	206-222	201-222	212	11/03/89	Slug Withdrawal	510[e]/	--	--

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Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[a]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
*	222	206-222	210-222	212	11/03/89	Slug Withdrawal	540[e]/	–	–
299-W10-16	220	203-219	198-219	209	10/30/89	Slug Injection	670[e]/	–	–
*	220	203-219	198-219	209	10/30/89	Slug Withdrawal	540[e]/	–	–
299-W11-2P	498	486-508	486-508	215	04/24/70	Recovery	104	–	–
								–	–
299-W15-5R	448	435-460	435-460	202	04/27/70	Constant Discharge	–	–	85 ft of drawdown; 2.7 gpm Pumped from Well 299-W15-5P
299-W15-5S	395	375-400	375-400	202	04/27/70	Constant Discharge	–	–	20 ft of drawdown; 2.7 gpm Pumped from Well 299-W15-5P
299-W15-15	253	243-253[b]/	223-253	231	08/21/87	Constant Discharge	10,000	–	–
299-W15-18	238	228-238	208-238	218	08/20/87	Constant Discharge	5000	–	–
*	238	228-238[b]/	208-238	218	08/20/87	Recovery	12,000	–	–
299-W15-17	432	422-432	422-432	218	09/28/87	Constant Discharge	–	–	19 ft of Drawdown at 360 min; 6 gpm
*	432	220 (OH)	422-432	218	08/20/87	Constant Discharge	12,000	–	Pumping Well is 299-W15-16
*	432	220 (OH)	422-432	218	08/20/87	Recovery	12,000	–	Pumping Well is 299-W15-16
299-W15-18	238	232-242[b]/	208-238	218	07/21/87	Recovery	14,000	–	–
299-W15-19	235	219-235	214-235	225	10/30/89	Slug Withdrawal	20[e]/	–	–
299-W15-20	241	226-241	220-241	232	11/03/89	Slug Withdrawal	75-250[e]/	–	2 Tests Conducted
299-W15-23	239	228-239	219-239	233	03/01/90	Slug Withdrawal	240-330[e]/	–	2 Tests Conducted
299-W15-24	241	230-241	222-241	233	12/18/89	Slug Withdrawal	600[e]/	–	–
299-W18-2	244	210-244	205-255	213	07/17/87	Recovery	17,000	–	Pumping Well is 299-W18-24

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Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[a]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
299-W18-21	225.5	215.5-225.5	215.5-225.5	202	07/14/87	Constant Discharge	1300	--	--
*	225.5	215.5-225.5	215.5-225.5	202	07/14/87	Recovery	51,000	--	--
299-W18-22	447.5	437.5-447.5	437.5-447.5	202	08/26/87	Recovery	420	--	--
299-W18-23	251	241-251	241-251	230	08/22/87	Constant Discharge	27,000	--	--
*	251	241-251	241-251	230	06/22/87	Recovery	23,000	--	--
299-W18-24	240	230-240	230-240	217	07/17/87	Recovery	44,000	--	--
299-W18-26	243	227-243	222-243	232	11/22/89	Slug Withdrawal	200[e]/	--	2 Tests Conducted
299-W21-1	253	239-2537	220-290	244	07/28/69	Constant Discharge	5400	--	--
*	253	239-2537	220-290	244	07/28/69	Recovery	29,000	--	--
299-W22-24Q	476	475-497	475-497	245	04/30/63	Development w/Air	--	--	186 ft of Drawdown at 80 min; 17 gpm
299-W22-40	244	228-244	224-244	234	04/23/90	Slug Withdrawal	600[e]/	--	--
299-W22-41	245	229-245	224-245	233	04/23/90	Slug Withdrawal	140[e]/	--	--
299-W22-42	243	228-243	223-243	233	04/30/90	Slug Withdrawal	190[e]/	--	--
299-W22-43	244	228-244	224-244	232	04/23/90	Slug Withdrawal	790[e]/	--	--
299-W26-8	219	200-219	199-219	205	05/31/90	Slug Withdrawal	--	--	Data Not Analyzed
299-W26-9	208	190-208	188-208	194	05/31/90	Slug Withdrawal	--	--	Data Not Analyzed
299-W26-11	139	123-139	119-139	123	05/31-06/01/90	Slug Withdrawal	--	--	Data Not Analyzed; Lack Recovery; Tested Perched Water
699-26-89	254	198-488 492-500[c]/*	165-488	181	06/27/69	Constant Discharge	620	--	Well Penetrates 3 Aquifers, Sand Filled in During Test
*	254	198-488 492-500[c]/*	165-488	181	06/27/69	Recovery	430	--	Well Penetrates 3 Aquifers, Sand Filled in During Test
699-32-70B	280	212-330	207-330	216	06/20/74	Constant Discharge	--	--	Data Not Analyzed; 3.17 ft of Drawdown at 180 min; 100 gpm

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Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[a]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
699-32-72Q	–	460-480	–	215	09/19/68	Constant Discharge	–	–	18 ft of Drawdown at >100 min; 5 gpm Pumped from Well 699-32-72P
699-32-77	220	179-220?	175-290	193	08/25/69	Constant Discharge	4500	–	–
*	220	179-220?	175-290	193	08/25/69	Recovery	57,000	–	–
699-34-88P	–	668-688	–	164	04/29/70	Recovery	1	–	2.5 gpm; Poor Test; U Bev
699-34-88Q	–	590-600	–	164	05/04/70	Recovery	4.3	–	8.5 gpm; 12.7 ft Drawdown in P Tube
*	–	590-600	–	164	05/11/70	Recovery	24	–	13 gpm
699-36-61A	363	358-389*	330-389	340	07/22/69	Step Drawdown and Recovery	2800	–	Average Transmissivity
*	363	358-389	330-389	340	07/22/69	Step Drawdown	970	–	–
*	363	358-389*	330-389	340	07/22/69	Step Drawdown	730	–	Data Reanalyzed
*	363	358-389*	330-389	340	07/22/69	Step Test Recovery	40,000	–	–
*	363	358-389*	330-389	340	07/22/69	Step Test Recovery	4300	–	Data Reanalyzed
699-36-61B	363	339-505?	330-505	340	07/22/69	Step Drawdown	400	–	Pumping Well is 699-36-61A
*	363	339-505?	330-505	340	07/22/69	Step Drawdown	5000	–	Data Reanalyzed
*	363	339-505?	330-505	340	07/22/69	Step Test Recovery	53,000	–	Pumping Well is 699-36-61A
*	363	339-505?	330-505	340	07/22/69	Step Test Recovery	4200	–	Data Reanalyzed
699-37-82A	175	163-175	155-410	170	08/15-17/79	Constant Discharge	T(early) = 270	0.02	Pumping Well is 699-37-82B
*	175	163-175	155-410	170	08/15-17/79	Constant Discharge	T(late) = 370	0.18[f]/	Pumping Well is 699-37-82B
*	175	163-175	155-410	170	08/15-17/79	Constant Discharge	T(early) = 350	0.018	Pumping Well is 699-37-82B
*	175	163-175	155-410	170	08/15-17/79	Constant Discharge	T(late) = 400	0.15[f]/	Pumping Well is 699-37-82B
699-43-88	191	178-198	177-198	170	09/10/69	Constant Discharge	2000	0.01-0.021	Pumping Well is 699-43-89

Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[a]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
*	191	178-198	177-198	170	09/10/69	Constant Discharge	1300	0.009	Data Reanalyzed
*	191	178-198	177-198	170	09/10-13/69	Recovery	19,000	--	--
*	191	178-198	177-198	170	09/10-13/69	Recovery	700	--	Data Reanalyzed
*	191	178-198	177-198	170	10/23/69	Constant Discharge	--	--	Data Not Analyzed; Pumping Well is 699-43-89
*	191	178-198	177-198	170	10/23/69	Recovery	--	--	Data Not Analyzed
*	191	178-198	177-198	170	10/28-29/69	Constant Discharge	--	--	Data Not Analyzed; Pumping Well is 699-43-89
*	191	178-198	177-198	170	10/29/69	Recovery	--	--	Data Not Analyzed
*	191	178-198	177-198	170	10/30/69	Constant Discharge	--	--	Data Not Analyzed; Pumping Well is 699-43-89
*	191	178-198	177-198	170	10/30-31/69	Recovery	--	--	Data Not Analyzed
*	191	177-198	177-198	170	11/06-07/69	Constant Discharge	--	--	Data Not Analyzed; Pumping Well is 699-43-89
*	191	177-198	177-198	170	11/07/69	Recovery	--	--	Data Not Analyzed
*	191	178-198	177-198	170	11/10-11/69	Constant Discharge	--	--	Data Not Analyzed; Pumping Well is 699-43-89
*	191	178-198	177-198	170	11/11/69	Recovery	--	--	Data Not Analyzed
*	191	178-198	177-198	170	11/13-14/69	Constant Discharge	--	--	Data Not Analyzed; Pumping Well is 699-43-89
*	191	178-198	177-198	170	11/14/69	Recovery	--	--	Data Not Analyzed
*	191	177-198	177-198	170	09/25/79	Constant Discharge	970	0.05	Pumping Well is 699-43-89
*	191	177-198	177-198	170	09/11/80	Constant Discharge	800	0.04	Pumping Well is 699-43-89
*	191	177-198	177-198	170	09/11/80	Constant Discharge	800	0.03	Pumping Well is 699-43-89
699-43-89	300	178-247	175-247	176	1969	Constant Discharge	1400	--	Exact Date of Test Unknown

Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[a]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
*	300	178-247	175-247	176	1969	Recovery	18,000	–	Exact Date of Test Unknown
*	300	178-247	175-247	176	09/10/69	Constant Discharge	850	–	10-hr Test
*	300	178-247	175-247	176	09/10-11/69	Recovery	1100	–	–
*	300	178-247	175-247	176	10/23/69	Constant Discharge	–	–	Data Not Analyzed; 14-hr Test
*	300	178-247	175-247	176	10/23/69	Recovery	–	–	Data Not Analyzed
*	300	178-247	175-247	178	10/28-29/69	Constant Discharge	–	–	Data Not Analyzed; 25-hr Test
*	300	178-247	175-247	176	10/29/69	Recovery	–	–	Data Not Analyzed
*	300	178-247	175-247	176	10/30/69	Constant Discharge	–	–	Data Not Analyzed; Test Stopped at 6.33 Hours Due to Engine Trouble
*	300	178-247	175-247	176	10/30-31/69	Recovery	–	–	Data Not Analyzed
*	300	178-247	175-247	176	11/06-07/69	Constant Discharge	–	–	Data Not Analyzed; 21-hr Test
*	300	178-247	175-247	176	11/07/69	Recovery	–	–	Data Not Analyzed
*	300	178-247	175-247	176	11/10-11/69	Constant Discharge	–	–	Data Not Analyzed; 24-hr Test
*	300	178-247	175-247	176	11/11/69	Recovery	–	–	Data Not Analyzed
*	300	178-247	175-247	176	11/13-14/69	Constant Discharge	–	–	Data Not Analyzed; 23-hr Test
*	300	178-247	175-247	176	11/14/69	Recovery	–	–	Data Not Analyzed
299-W11-2Q	434	409-434	409-434	215	04/24/70	Constant Discharge and Recovery	–	–	No Drawdown; Pumping Well is 299-W11-2P
299-W11-4	310	279-312	257-312	279	1950's	Ball Test	–	–	20 gpm
299-W11-13P	468	443-468	443-468	232	11/19/63	Development w/Air	–	–	250 Total Gallons Pumped

Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[a]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
299-W15-5P	418	524-594	524-594	202	04/27/70	Constant Discharge and Recovery	–	–	2.7 gpm; Pumping Well; Poor Test
299-W15-5Q	336	495-520	495-520	202	04/27/70	Constant Discharge	–	–	No Drawdown; 2.7 gpm Pumped from Well 299-W15-5P
*	336	495-520	495-520	202	04/27/70	Constant Discharge	–	–	No Drawdown; Poor Test; 5.5 gpm
299-W15-5R	448	435-460	435-460	202	04/27/70	Constant Discharge	–	–	No Drawdown; 5.5 gpm Pumped from Well 299-W15-5Q
299-W15-16	238	215-238	208-238	218	09/28/87	Constant Discharge	–	–	Pumping Well is 299-W15-17
299-W15-18	238	232-242[b]/	208-238	218	07/17/87	Constant Discharge	–	–	Pumping Well is 299-W18-24; No Drawdown
299-W15-19	235	219-235	214-235	225	10/30/89	Slug Injection	–	–	Poor Test
299-W18-4	246	212-246	194-254	212	07/21/87	Constant Discharge and Recovery	–	–	Pumping Well is 299-W15-18; Negligible Drawdown
299-W18-18	?	183?-204	183-204	188	1984	Constant Discharge	–	–	Sand Filled in During 2 Tests
299-W18-21	225.5	196-225.5	195.5-225.5	202	08/26/87	Constant Discharge	–	–	Pumping Well is 299-W18-22; No Drawdown
299-W18-22	205	205 (OH)	437.5-447.5	202	07/14/87	Constant Discharge	–	–	Pumping Well is 299-W18-21; No Drawdown
299-W19-9	284	268-302*	214-244	224	11/25/44	Injection Test	–	–	–
299-W22-14P	–	293-308	–	–	10/26/68	Development w/Air	–	–	No Drawdown at 150 min; 4 gpm
299-W22-24P	296	537-561	537-561	245	04/64, 09/68	Development w/Air	–	–	Flow Rate Not Sustained
299-W22-27P	240	550-570	550-570	230	10/23/64	Development w/Air	–	–	200 Total Gallons Pumped; 0.5 gpm

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Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[e]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
299-W22-27Q	451	470-490	470-490	218	10/23/64	Development w/Air	--	--	150 Total Gallons Pumped; 7 gpm
299-W22-27R	398	400-420	400-420	214	10/23/64	Development w/Air	--	--	--
299-W22-27S	356	330-350	330-350	214	10/23/64	Development w/Air	--	--	10 gpm for 20 min.
699-31-65P	353	410-430	410-430	242	06/24/64	Development w/Air	--	--	--
699-31-65Q	371	370-390	370-390	242	06/24/64	Development w/Air	--	--	--
699-31-65R	322	310-330	310-330	242	06/24/64	Development w/Air	--	--	--
699-32-72P	470	465-470	465-470	215	06/22/64	Development w/Air	--	--	50 Total Gallons Pumped; <0.5 gpm
*	470	465-470	465-470	215	09/19/68	Constant Discharge	--	--	>500 Gallons Pumped; 5 gpm
699-32-72Q	--	460-480	--	--	06/22/64	Development w/Air	--	--	250 Total Gallons Pumped; 6 gpm
699-32-72R	--	390-410	--	--	06/22/64	Development w/Air	--	--	50 Total Gallons Pumped; 5 gpm
699-32-72S	--	340-360	--	--	06/22/64	Development w/Air	--	--	200 Total Gallons Pumped; 4 gpm
699-34-88Q	--	590-600	--	--	05/14/70	Recovery	--	--	19 gpm; Poor Test
699-34-88R	--	510-520	--	--	05/12/70	Constant Discharge	--	--	10 gpm
699-34-88S	--	430-440	--	--	05/12/70	Constant Discharge	--	--	5 gpm
699-34-88T	--	350-360	--	--	05/12/70	Constant Discharge	--	--	7 gpm
699-37-82BP	344	540-560	540-560	170	11/02/64	Development w/Air	--	--	157 ft of Drawdown at 30 min
*	344	540-560	540-560	170	11/03/64	Development w/Air	--	--	49 ft of Drawdown; 1 gpm
699-37-82BS	414	230-250	230-250	170	10/16/64	Development w/Air	--	--	75 Total Gallons Pumped; 2 gpm
699-38-65	395	330-520	220-520	323	12/59	Ball Test?	--	--	Tested by Bach Drilling Co.
699-38-85P	510	500-510	500-510	323	10/27/64	Development w/Air	--	--	100 Total Gallons Pumped; 2 gpm

Table A-7. Unconfined Aquifer Hydrologic Test Data for the 200 West Area.

Hanford Well Designation	Current Depth[a]/ (ft)	Depth of Test Interval (ft)	Current Screen/ Perforation Interval[a]/ (ft)	Current Depth to Water[d]/ (ft)	Date of Test	Type of Hydrologic Test	Transmissivity (ft^2/day)	Storage Coefficient	Comment
699-38-70P	--	390-410	--	--	10/27/64	Development w/Air	--	--	200 Total Gallons Pumped; 4 gpm
699-40-62	384	359-374*	335-374	342	12/11/69	Constant Discharge	--	--	Poor Test
699-49-100B	?	326-401	?	316	06/15/77	Constant Discharge	--	--	380 gpm; No Water-Level Measurements
699-51-75P	375	370-375	370-375	192	09/04/63	Development w/Air	--	--	250 Total Gallons Pumped; 1 gpm
699-57-83AP	--	335-355	--	--	08/04/64	Development w/Air	--	--	200 Total Gallons Pumped; 7 gpm
699-57-83AQ	--	270-290	--	--	08/04/64	Development w/Air	--	--	200 Total Gallons Pumped; 6 gpm
699-57-83AR	--	210-230	--	--	08/04/64	Development w/Air	--	--	120 Total Gallons Pumped; 3 gpm

* Well Recompleted Since Test Was Conducted.
a/ Taken From Unpublished Update of McGhan (1989).
b/ Temporary Screen Installed Prior to Final Well Completion.
c/ Interval Completed in Confined Basalt Aquifer.
d/ Measured or Estimated As of June 1991.
e/ Transmissivity Calculated by Multiplying Equivalent Hydraulic Conductivity by Thickness of the Test Internal.
f/ Specific Yield.
OH = Open Hole.
Source: Newcomer et al. (1992).

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Table A-8. Transmissivity and Hydraulic Conductivity Values for the Unconfined Aquifer--200 West Area. Page 1 of 2

Well Number	Hanford Coordinates (ft) West	Hanford Coordinates (ft) North	Transmissivity (ft^2/day)	Hydraulic Conductivity (k) (ft/day)	Distance From Water Level to Bottom of Screen (ft)
W6-2	75302	45571	500	50	12
W7-1	78601	46551	1400	140	13
W7-2	77385	46519	740	74	5
W7-4	77040	45435	2800	95	2
W7-5	76816	46509	170	8.5	2
					14
W7-6	76816	46509	40	4	9
W7-7	76519	46509	45	5	17
W7-9	78889	46549	26	--	9
W7-10	75564	45921	18	1	10
W8-1	79200	46551	80	8	15
W9-1	79507	44508	50	2.5	11
W10-13	78297	43137	7000	700	12
W10-14	78330	43143	3500	350	5
W10-14[a/]	78330	43143	900	--	20
W10-15	75858	43791	540	33	10
W10-16	75825	43130	540	33	10
W10-17	75844	42751	5000	260	19
W10-18	75610	42439	2500	140	18
W15-15	78103	40330	10000	1000	22
W15-16	77387	40269	12000	1200	20
W15-17	77387	40221	12000	1200	--
W15-18	77383	39705	14000	1400	10
W15-19	77772	41041	20	1	10
W15-20	78120	41028	75	10	9
W15-22	76150	41504	1000	50	20
W15-23	78119	40680	300	20	6
W15-24	78096	39851	600	40	8
W18-21	78080	37794	51000	5100	10
W18-22[b/]	78109	37831	420	42	10
W18-23	78120	38987	23000	2300	21
W18-24	77180	38998	44000	4400	10

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Table A-8. Transmissivity and Hydraulic Conductivity Values for the Unconfined Aquifer--200 West Area. Page 2 of 2

Well Number	Hanford Coordinates (ft) West	Hanford Coordinates (ft) North	Transmissivity (ft^2/day)	Hydraulic Conductivity (k) (ft/day)	Distance From Water Level to Bottom of Screen (ft)
W18-25	76034	37786	400	20	20
W18-26	78097	39477	200	10	11
W19-31	75457	38275	2400	120	20
W19-32	75459	37887	20	1	20
W21-1	71382	35868	29000	--	9
W22-40	73041.7	36242.3	600	20	10
W22-41	73033.8	36242.1	140	8	12
W22-42	73079.6	36052.7	190	12	10
W22-43	73376.5	36339.1	790	20	12
W23-13	76067	36040	1800	90	20
W23-14	76082	35529	27	1.4	19
W26-8	77049	33441	80	5	16
W26-9	76801.1	32048.7	480	30	16
W26-10	75456	33557	1125	75	15
W26-11[c/]	75793	33526	--	0.006	15
W26-12	76172	32933	90	5	18

a/ At time of test well was completed in the bottom of the unconfined aquifer, values not used in maps.
b/ Well monitors the bottom of the unconfined, values not used in maps.
c/ Well monitors a perched zone, values not used in maps to convert from ft^2 to m^2 multiply by 0.0930 to convert from ft to m multiply by 0.3048.
Source: Connelly et al. (1992) - Table 3-2.

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APPENDIX B

HEALTH AND SAFETY PLAN

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ACRONYMS AND ABBREVIATIONS

AAMS	aggregate area management study
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EII	Environmental Investigations Instructions
HEHF	Hanford Environmental Health Foundation
HSP	health and safety plan
HWOP	Hazardous Waste Operations Permit
JSA	Job Safety Analysis
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
RCRA	Resource Conservation Recovery Act
RWP	Radiation Work Permit
SCBA	self-contained breathing apparatus
Westinghouse Hanford	Westinghouse Hanford Company
WISHA	Washington Industrial Safety and Health Act

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1.0 GENERAL CONSIDERATIONS AND REQUIREMENTS

1.1 INTRODUCTION

The purpose of this Health and Safety Plan (HSP) is to outline standard health and safety procedures for Westinghouse Hanford Company (Westinghouse Hanford) employees and contractors engaged in investigation activities in the 200 West Groundwater Aggregate Area Management Study (AAMS). These activities will include surface investigation, drilling and sampling boreholes, and environmental sampling in areas of known chemical and radiological contamination. Appropriate site-specific safety documents (e.g., Hazardous Waste Operations Permit [HWOP] or Job Safety Analysis [JSA]) will be written for each task or group of tasks. A more complete discussion of Westinghouse Hanford environmental safety procedures is presented in the Westinghouse Hanford manual *Health and Safety for Hazardous Waste Field Operations*, WHC-CM-4-3 vol. 4 (WHC 1992).

All employees of Westinghouse Hanford or any other contractors who are participating in onsite activities in the 200 West Groundwater AAMS shall read the site-specific safety document and attend a pre-job safety or tailgate meeting to review and discuss the task.

1.2 DESIGNATED SAFETY PERSONNEL

The field team leader and site safety officer are responsible for site safety and health. Specific individuals will be assigned on a task-by-task basis by project management, and their names will be properly recorded before the task is initiated.

All activities onsite must be cleared through the field team leader. The field team leader has responsibility for the following:

- Allocating and administering resources to successfully comply with all technical and health and safety requirements
- Verifying that all permits, supporting documentation, and clearances are in place (e.g., electrical outage requests, welding permits, excavation permits, HWOP or JSA, sampling plan, radiation work permits [RWP], and onsite/offsite radiation shipping records)
- Providing technical advice during routine operations and emergencies
- Informing the appropriate site management and safety personnel of the activities to be performed each day

- Coordinating resolution of any conflicts that may arise between RWPs and the implementation of the HWOP or JSA with health physics

- Handling emergency response situations as may be required

- Conducting pre-job and daily tailgate safety meetings

- Interacting with adjacent building occupants and/or inquisitive public.

The site safety officer is responsible for implementing the HWOP at the site. The site safety officer shall do the following.

- Monitor chemical, physical, and (in conjunction with the health physics technician) radiation hazards to assess the degree of hazard present; monitoring shall specifically include organic vapor detection, radiation screening, and confined space evaluation where appropriate.

- Determine protection levels, clothing, and equipment needed to ensure the safety of personnel in conjunction with the health physics department.

- Monitor the performance of all personnel to ensure that the required safety procedures are followed.

- Halt operations immediately, if necessary, due to safety or health concerns.

- Conduct safety briefings as necessary.

- Assist the field team leader in conducting safety briefings as necessary.

The health physics technician is responsible for ensuring that all radiological monitoring and protection procedures are being followed as specified in the Radiation Protection Manual and in the appropriate RWP. Westinghouse Hanford Industrial Safety and Fire Protection personnel will provide safety overview during drilling operations consistent with Westinghouse Hanford policy and, as requested, will provide technical advice. Also, downwind sampling for hazardous materials and radiological contaminants and other analyses may be requested from appropriate contractor personnel as required.

The ultimate responsibility and authority for employee's health and safety lies with the employee and the employee's colleagues. Each employee is responsible for exercising the utmost care and good judgment in protecting his or her personal health and safety and that of fellow employees. Should any employee observe a potentially unsafe condition or situation, it is the responsibility of that employee to immediately bring the observed condition to the

attention of the appropriate health and safety personnel, as designated previously. In the event of an immediately dangerous or life-threatening situation, the employee automatically has temporary "stop work" authority and the responsibility to immediately notify the field team leader or site safety officer. When work is temporarily halted because of a safety or health concern, personnel will exit the exclusion zone and meet at a predetermined place in the support zone. The field team leader, site safety officer, and health physics technician will determine the next course of action.

1.3 MEDICAL SURVEILLANCE

All field team members engaged in operable unit activities at sites governed by an HWOP must have baseline physical examinations and be participants in Westinghouse Hanford (or an equivalent) hazardous waste worker medical surveillance program.

Medical examinations will be designed to identify any pre-existing conditions that may place an employee at high risk, and will verify that each worker is physically able to perform the work required by this plan without undue risk to personal health. The physician shall determine the existence of conditions that may reduce the effectiveness or prevent the employee's use of respiratory protection. The physician shall also determine the presence of conditions that may pose undue risk to the employee while performing the physical tasks of this work plan using level B personal protection equipment. This would include any condition that increases the employee's susceptibility to heat stress.

The examining physician's report will not include any nonoccupational diagnoses unless directly applicable to the employee's fitness for the work required.

1.4 TRAINING

Before engaging in any onsite activities, each team member is required to have received 40 hours of health and safety training related to hazardous waste site operations and at least 8 hours of refresher training each year thereafter as specified in 29 Code of Federal Regulations (CFR) 1910.120. In addition, each inexperienced employee (never having performed site characterization) will be directly supervised by a trained/experienced person for a minimum of 24 hours of field experience.

The field team leader and the site safety officer shall receive an additional 8 hours of training (in addition to the refresher training previously discussed).

1.5 TRAINING FOR VISITORS

For the purposes of this plan, a visitor is defined as any person visiting the Hanford Site, who is not a Westinghouse Hanford employee or a Westinghouse Hanford contractor directly involved in the Resource Conservation and Recovery Act (RCRA)/Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) facility investigation activities, including but not limited to those engaged in surveillance, inspection, or observation activities.

Visitors who must, for whatever reason, enter a controlled (either contamination reduction or exclusion) zone, shall be subject to all of the applicable training, respirator fit testing, and medical surveillance requirements discussed in Westinghouse Hanford Environmental Investigations Instructions (EII) 1.1 and Appendix B to EII 1.1 (WHC 1991).

All visitors shall be informed of potential hazards and emergency procedures by their escorts and shall conform to EII 1.1 (WHC 1991).

1.6 RADIATION DOSIMETRY

All personnel engaged in onsite activities shall be assigned dosimeters according to the requirements of the RWP applicable to that activity. All visitors shall be assigned basic dosimeters, as a minimum, that will be exchanged annually.

1.7 REQUIREMENTS FOR THE USE OF RESPIRATORY PROTECTION

All employees of Westinghouse Hanford and subcontractors who may be required to use air-purifying or air-supplied respirators must be included in the medical surveillance program and be approved for the use of respiratory protection by the Hanford Environmental Health Foundation (HEHF) or other licensed physician. Each team member must be trained in the selection, limitations, and proper use and maintenance of respiratory protection (existing respiratory protection training may be applicable towards the 40-hour training requirement).

Before using a negative pressure respirator, each employee must have been fit-tested (within the previous year) for the specific make, model, and size according to Westinghouse Hanford fit-testing procedures. Beards (including a few days' growth), large sideburns, or moustaches that may interfere with a proper respirator seal are not permitted.

Subcontractors must provide evidence to Westinghouse Hanford that personnel are participants in a medical surveillance and respiratory protection program that complies with 29 CFR 1910.120 and 29 CFR 1910.134, respectively.

2.0 GENERAL PROCEDURES

The following personal hygiene and work practice guidelines are intended to prevent injuries and adverse health effects. A hazardous waste site poses a multitude of health and safety concerns because of the variety and number of hazardous substances present. These guidelines represent the minimum standard procedures for reducing potential risks associated with this project and are to be followed by all job-site employees at all times.

2.1 GENERAL WORK SAFETY PRACTICES

2.1.1 Work Practices

The following work practices must be observed.

- Eating, drinking, smoking, taking certain medications, chewing gum, and similar actions are prohibited within the exclusion zone. All sanitation facilities shall be located outside the exclusion zone; decontamination is required before using such facilities.

- Personnel shall avoid direct contact with contaminated materials unless necessary for sample collecting or required observation. Remote handling of such things as casings and auger flights will be practiced whenever practical.

- While operating in the controlled zone, personnel shall use the "buddy system" where appropriate, or be in visual contact with someone outside of the controlled zone.

- The buddy system will be used where appropriate for manual lifting.

- Requirements of Westinghouse Hanford radiation protection and RWP manuals shall be followed for all work involving radioactive materials or conducted within a radiologically controlled area.

- Onsite work operations shall only be carried out during daylight hours, unless the entire control zone is adequately illuminated with artificial lighting. A new tour (shift) will operate the drilling rig after completion of each shift.

- Do not handle soil, waste samples, or any other potentially contaminated items unless wearing the protective equipment specified in the HWOP or JSA.

- Whenever possible, stand upwind of excavations, boreholes, well casings, drilling spoils, and the like, as indicated by an onsite windsock.

- Stand clear of trenches during excavation. Always approach an excavation from upwind.

- Be alert to potentially changing exposure conditions as evidenced by such indications as perceptible odors, unusual appearance of excavated soils, or oily sheen on water.

- Do not enter any test pit or trench deeper than 1.2 m (4 ft) unless in accordance with procedures specified in the HWOP.

- Do not <u>under any circumstances</u> enter or ride in or on any backhoe bucket, materials hoist, or any other similar device not specifically designed for carrying passengers.

- All drilling team members must make a conscientious effort to remain aware of their own and others' positions in regards to rotating equipment, cat heads, or u-joints. Drilling operations members must be extremely careful when assembling, lifting, and carrying flights or pipe to avoid pinch-point injuries and collisions.

- Tools and equipment will be kept off the ground whenever possible to avoid tripping hazards and the spread of contamination.

- Personnel not involved in operation of the drill rig or monitoring activities shall remain a safe distance from the rig as indicated by the field team leader.

- Follow all provisions of each site-specific hazardous work permit as addressed in the HWOP, including cutting and welding, confined space entry, and excavation.

- Catalytic converters on the underside of vehicles are sufficiently hot to ignite dry prairie grass. Team members should not drive over dry grass that is higher than the ground clearance of the vehicle and should be aware of the potential fire hazard posed by catalytic converters at all times. Never allow a running or hot vehicle to sit in a stationary location over dry grass or other combustible materials.

- Follow all provisions of each site-specific RWP.

- Team members will attempt to minimize truck tire disturbance of all stabilized sites.

2.1.2 Personal Protective Equipment

- Personal protective equipment will be selected specifically for the hazards identified in the HWOP. The site safety officer in conjunction with Westinghouse Hanford Health Physics and Industrial Hygiene and Safety is responsible for choosing the appropriate type and level of protection required for different activities at the job site.

- Levels of protection shall be appropriate to the hazard to avoid either excessive exposure or additional hazards imposed by excessive levels of protection. The HWOP will contain provisions for adjusting the level of protection as necessary. These personal protective equipment specifications must be followed at all times, as directed by the field team leader, health physics technician, and site safety officer.

- Each employee must have a hard hat, safety glasses, and substantial protective footwear available to wear as specified in the HWOP or JSA.

- The exclusion zone around drilling or other noisy operations will be posted "Hearing Protection Required" and team members will have had noise control training.

- Personnel should maintain a high level of awareness of the limitations in mobility, dexterity, and visual impairment inherent in the use of level B and level C personal protective equipment.

- Personnel should be alert to the symptoms of fatigue, heat stress, and cold stress and their effects on the normal caution and judgment of personnel.

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- Rescue equipment as required by Occupational Safety and Health Administration (OSHA), Washington Industrial Safety and Health Act (WISHA), or standards for working over water will be available and used.

2.1.3 Personal Decontamination

- The HWOP will describe in detail methods of personnel decontamination, including the use of contamination control corridors and step-off pads when appropriate.

- Thoroughly wash hands and face before eating or putting anything in the mouth to avoid hand-to-mouth contamination.

- At the end of each work day or each job, disposable clothing shall be removed and placed in (chemical contamination) drums, plastic-lined boxes or other containers as appropriate. Clothing that can be cleaned may be sent to the Hanford Site laundry.

- Individuals are expected to thoroughly shower before leaving the work site or Hanford Site if directed to do so by the health physics technician, site safety officer, or field team leader.

2.1.4 Emergency Preparation

- A multipurpose dry chemical fire extinguisher, a fire shovel, a complete field first-aid kit, and a portable pressurized spray wash unit shall be available at every site where there is potential for personnel contamination.

- Prearranged hand signals or other means of emergency communication will be established when respiratory protection equipment is to be worn, because this equipment seriously impairs speech.

- The Hanford Fire Department shall be initially notified before the start of the site investigation project. This notification shall include the location and nature of the various types of field work activities as described in the work plan. A site location map shall be included in this notification.

2.2 CONFINED SPACE/TEST PIT ENTRY PROCEDURES

The following procedures apply to the entry of any confined space, which for the purpose of this document shall be defined as any space having limited egress (access to an exit) and the potential for the presence or accumulation of a toxic or explosive atmosphere. This includes manholes, certain trenches (particularly those through waste disposal areas), and all test pits greater than 1 m (4 ft) deep. If confined spaces are to be entered as part of the work operations, a hazardous work permit (filled out for confined space entry) must be obtained from Industrial Safety and Fire Protection.

The identified remedial investigation activities on the 200 West Groundwater AAMS should not require confined space entry. Nevertheless, the hazards associated with confined spaces are of such severity that all employees should be familiar with the safe work discussed in the following paragraphs.

No employee shall enter any test pit or trench deeper than 1 m (4 ft) unless the sides are shored or laid back to a stable slope as specified in OSHA 29 CFR 1926.652 or equivalent state occupational health and safety regulations.

When an employee is required to enter a pit or trench 1 m (4 ft) deep or more, an adequate means of access and egress, such as a slope of at least 2:1 to the bottom of the pit or a secure ladder or steps shall be provided.

Before entering any confined space, <u>including any test pit</u>, the atmosphere will be tested for flammable gases, oxygen deficiency, and organic vapors. If other specific contamination, such as radioactive materials or other gases and vapors may be present, additional testing for those substances shall be conducted. Depending on the situation, the space may require ventilation and retesting before entry.

An employee entering a confined or partially confined space must be equipped with an appropriate level of respiratory protection in keeping with the monitoring procedures discussed previously and the action levels for airborne contaminants (see "Warnings and Action Levels" in HWOP).

No employee shall enter any test pit requiring the use of level B protection, unless a backup person also equipped with a pressure-demand self-contained breathing apparatus (SCBA) is present. No backup person shall attempt any emergency rescue unless a second backup person equipped with an SCBA is present, or the appropriate emergency response authorities have been notified and additional help is on the way.

3.0 SITE BACKGROUND

Specific details on the 200 West Groundwater AAMS background and known and suspected contamination are described in Chapters 2.0 through 10.0 of the plan. The 200 West Groundwater Aggregate Area encompasses the 200 West Area and associated perimeter of the U.S. Department of Energy's (DOE) Hanford Site, in the south-central portion of the state of Washington. The 200 West Area is located in Benton County in the central portion of the Hanford Site. It is adjacent to the 200 East Area, located roughly 5 km to the west.

The 200 West Groundwater Aggregate Area at the Hanford Site was used by the U.S. Government as a chemical separations area in the process to produce plutonium for nuclear weapons. These operations resulted in the release of chemical and radioactive wastes into the soil, air, and water of the area. Each waste site in the aggregate area is described separately in this document. Close relationships between waste units, such as overflow from one to another, are also discussed.

4.0 SCOPE OF WORK AND POTENTIAL HAZARDS

While the information presented in Chapters 2.0 through 10.0 of the plan are believed to be representative of the constituents and quantities of wastes at the time of discharge, the present chemical nature, location, extent, and ultimate fate of these wastes in and around the liquid disposal facilities are largely unknown. The emphasis of the investigation in the 200 West Groundwater AAMS will be to characterize the nature and extent of contamination in the groundwater (saturated soil and rock) zone.

4.1 WORK TASKS

Work tasks are described in Chapter 5.0 of the plan.

4.2 POTENTIAL HAZARDS

Onsite tasks will involve noninvasive surface sampling procedures and invasive soil sampling either directly in or immediately adjacent to areas known or suspected to contain potentially hazardous chemical substances, toxic metals, and radioactive materials.

Surface radiological contamination and fugitive dust will be the potential hazards of primary concern during noninvasive mapping and sampling activities.

Existing data indicate that hazardous substances may be encountered during invasive sampling; these include radionuclides, heavy metals, and corrosives. In addition, volatile organics may also be associated with certain facilities such as the solvent storage buildings or underground storage tanks.

Potential hazards include the following:

- External radiation (gamma and to a lesser extract, beta) from radioactive materials in the soil
- Internal radiation resulting from radionuclides present in contaminated soil entering the body by ingestion or through open cuts and scratches
- Internal radiation resulting from inhalation of particulate (dust) contaminated with radioactive materials
- Inhalation of toxic vapors or gases such as volatile organics or ammonia
- Inhalation or ingestion of particulate (dust) contaminated with inorganic or organic chemicals, and toxic metals
- Dermal exposure to soil or groundwater contaminated with radionuclides
- Dermal exposure to soil or groundwater contaminated with inorganic or organic chemicals, and toxic metals
- Physical hazards such as noise, heat stress, and cold stress
- Slips, trips, falls, bumps, cuts, pinch points, falling objects, other overhead hazards, crushing injuries, and other hazards typical of a construction-related job site
- Unknown or unexpected underground utilities
- Biological hazards; snakes, spiders, etc.

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4.3 ASSESSMENT AND MITIGATION OF POTENTIAL HAZARDS

The likelihood of significant exposure (100 mR/h or greater) to external radiation is remote and can be readily monitored and controlled by limiting exposure time, increasing distance, and employing shielding as required.

Internal radiation by inhalation or inadvertent ingestion of contaminated dust is a realistic concern and must be continuously evaluated by the health physics technician. Appropriate respiratory protection, protective clothing, and decontamination procedures will be implemented as necessary to reduce potential inhalation, ingestion, and dermal exposure to acceptable levels.

Dermal exposure to toxic chemical substances is not expected to pose a significant problem for the identified tasks given the use of the designated protective clothing. The appropriate level of personal protective clothing and respiratory protection will vary from work site to work site.

5.0 ENVIRONMENTAL AND PERSONAL MONITORING

The site safety officer or authorized delegate shall be present at all times during work activities which require an HWOP, and shall be in charge of all environmental/personal monitoring equipment. Industrial Hygiene and Safety shall review all activities involving or potentially involving radiological exposure or contamination control and shall prescribe the appropriate level of technical support and/or monitoring requirements. Other equipment deemed necessary by the site safety officer or Industrial Hygiene and Safety shall be obtained at their direction; work will be initiated or continued until such equipment is in place. These instruments are to be used only by persons who are trained in their usage and who understand their limitations. No work shall be done unless instrumentation is available and in proper working order.

Air sampling may be required downwind of the referenced waste sites to monitor particulates and vapors before job startup. Siting of such sampling devices will be determined by Health Physics, the site safety officer, and HEHF, if appropriate. Any time personnel exposure monitoring, other than radiological, is required to determine exposure levels, it must be done by HEHF. Discrete sampling of ambient air within the work zone and breathing zones will be conducted using a direct-reading instrument, as specified in the site-specific safety document, and other methods as deemed appropriate (e.g., pumps with tubes, O_2 meters). The following standards will be used in determining critical levels:

- "Radionuclide Concentrations in Air," in Chapter XI, DOE Order 5480.1B (DOE 1986)

- "Air Contaminants - Permissible Exposure Limits," in 29 CFR 1910.1000

- *Threshold Limit Values and Biological Exposure Indices for 1990-1991* (ACGIH 1991)

- *Occupational Safety and Health Standards*, 29 CFR 1910.1000

- *Pocket Guide to Chemical Hazards* (NIOSH 1991), which provides National Institute for Occupational Safety and Health (NIOSH)-recommended exposure limits for substances that do not have either a threshold limit value or a permissible exposure limit.

5.1 AIRBORNE RADIOACTIVE AND RADIATION MONITORING

An onsite health physics technician will monitor airborne radioactive contamination levels and external radiation levels. Action levels will be consistent with derived air concentrations and applicable guidelines as specified in the radiation protection manual WHC-CM-4-10 (WHC 1988).

Appropriate respiratory protection shall be required when conditions are such that the airborne contamination levels may exceed an 8-hour derived air concentration (e.g., the presence of high levels of uncontained, loose contamination on exposed surfaces or operations that may raise excessive levels of dust contaminated with airborne radioactive materials, such as excavation or drilling under extremely dry conditions).

Specific conditions requiring the use of respiratory protection because of radioactive materials in air will be incorporated into the RWP. If, in the judgement of the health physics technician, any of these conditions arise, work shall cease until appropriate respiratory protection is provided.

6.0 PERSONAL PROTECTIVE EQUIPMENT

The level of personal protective equipment required initially at a site will be specified in the site-specific safety document for each task or group of tasks. Personal protective

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clothing and respiratory protection shall be selected to limit exposure to anticipated chemical and radiological hazards. Work practices and engineering controls may be used to control exposure.

7.0 SITE CONTROL

The field team leader, site safety officer, and health physics technician are designated to coordinate access control and security on the site. Special site control measures will be necessary to restrict public access. The zones will be clearly marked with rope and/or appropriate signs. The size and shape of the control zone will be dictated by the types of hazards expected, the climatic conditions, and specific operations required.

Control zone boundaries may be increased or decreased based on results of field monitoring, environmental changes, or work technique changes. The site RWP and the contractor's standard operating procedures for radiation protection may also dictate the boundary size and shape. All team members must be surveyed for radioactive contamination when leaving the controlled zone if in a radiation zone.

The onsite command post and staging area will be established near the upwind side of the control zone as determined by an onsite windsock. Exact location for the command post is to be determined just before start of work. Vehicle access, availability of utilities (power and telephone), wind direction, and proximity to sample locations should be considered in establishing a command post location.

8.0 DECONTAMINATION PROCEDURES

Remedial investigation activities will require entry into areas of known chemical and radiological contamination. Consequently, it is possible that personnel and equipment could be contaminated with hazardous chemical and radiological substances.

During site activities, potential sources of contamination may include airborne vapors, gases, dust, mists, and aerosols; splashes and spills; walking through contaminated areas; and handling contaminated equipment. Personnel who enter the exclusion zone will be required to go through the appropriate decontamination procedures on leaving the zone. Decontamination procedures shall be consistent with EII 5.4, "Field Decontamination of Drilling, Well Development, and Sampling Equipment," and EII 5.5, "Decontamination of

Equipment for RCRA/CERCLA Sampling" (WHC 1991), or other approved decontamination procedures.

9.0 CONTINGENCY AND EMERGENCY RESPONSE PLANS

As a general rule, in the event of an unanticipated, potentially hazardous situation indicated by instrument readings, visible contamination, unusual or excessive odors, or other indications, team members shall temporarily cease operations and move upwind to a predesignated safe area as specified in the site-specific safety documentation.

10.0 REFERENCES

ACGIH, 1991, *Threshold Limit Values and Biological Exposure Indices for 1990-1991*, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.

DOE, 1986, *Environment, Safety & Health Program for DOE Operations*, DOE Order 5480.1B, U.S. Department of Energy, Washington, D.C.

NIOSH, 1991, *Pocket Guide to Chemical Hazards, National Institute for Occupational Safety and Health*, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Washington, D.C.

WHC, 1988, *Radiation Protection*, WHC-CM-4-10, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992, *Health and Safety for Hazardous Waste Field Operations*, WHC-CM-4-3 Vol. 4, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX C

PROJECT MANAGEMENT PLAN

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ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
MCS	Management Control System
PMP	Project Management Plan
PNL	Pacific Northwest Laboratory
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order

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1.0 INTRODUCTION

This Project Management Plan (PMP) defines the administrative and institutional tasks necessary to support the 200 West Groundwater Aggregate Area investigations at the Hanford Site. Also, this PMP defines the responsibilities of the various participants, the organizational structure, and the project tracking and reporting procedures. This PMP is in accordance with the provisions of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) dated August 1990 (Ecology et al. 1990). Any revisions to the Tri-Party Agreement that would result in changes to the project management requirements would supersede the provisions of this chapter.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 INTERFACE OF REGULATORY AUTHORITIES AND THE U.S. DEPARTMENT OF ENERGY

The 200 West Groundwater Aggregate Area consists of active and inactive waste management units to be remedied under either the Resource Conservation and Recovery Act (RCRA) or the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The U.S. Department of Ecology (Ecology) has been designated as the lead regulatory agency, as defined in the Tri-Party Agreement. Accordingly, Ecology is responsible for overseeing remedial action activity at this aggregate area and ensuring that the applicable authorities of both the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) are applied. The specific responsibilities of EPA, Ecology, and DOE are detailed in the Tri-Party Agreement.

2.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The project organization for implementing remedial activities at the 200 West Groundwater Aggregate Area is shown in Figure C-1. The following sections describe the responsibilities of the individuals shown in Figure C-1.

2.2.1 Project Managers

The EPA, DOE, and Ecology have each designated one individual as project manager for remedial activities at the Hanford Site. These project managers will serve as the primary point of contact for all activities to be carried out under the Tri-Party Agreement. The responsibilities of the project managers are given in Section 4.1 of the Tri-Party Agreement.

2.2.2 Unit Managers

As shown in Figure C-1, EPA, DOE, and Ecology will each designate an individual as a unit manager for the 200 West Groundwater Aggregate Area.

The unit manager from Ecology will serve as the lead unit manager. The Ecology unit manager will be responsible for regulatory oversight of all activities required for the 200 West Groundwater Aggregate Area.

The unit manager from EPA will be responsible for making decisions related to issues for which the supporting regulatory agency maintains authority. All such decisions will be made in consideration of recommendations made by the Ecology unit manager.

The unit manager from DOE will be responsible for maintaining and controlling the schedule and budget and keeping the EPA and Ecology unit managers informed as to the status of the activities at the 200 West Groundwater Aggregate Area, particularly the status of agreements and commitments.

2.2.3 Quality Assurance Lead

The quality assurance lead will be a designated person within the Westinghouse Hanford Quality Assurance Organization. This designated person will be responsible for monitoring overall environmental restoration activities for this project. The designated personnel shall have the necessary organizational independence and authority to identify conditions adverse to quality and to systematically seek corrective action.

This individual is responsible for the preplanned survellance and audit activities for this project. A quality assurance report shall be provided to the technical lead, annually as a minimum, for inclusion in the project final report generated by the technical organization. The quality assurance report shall summarize the surveillance and audit activities as well as associated corrective actions that may have been taken during the interval.

2.2.4 Health and Safety Officer (Environmental Division/Environmental Field Services)

The health and safety officer is responsible for monitoring all potential health and safety hazards, including those associated with radioactive, volatile, and/or toxic compounds during sample handling and sampling decontamination activities. The health and safety officer has the responsibility and authority to halt field activities resulting from unacceptable health and safety hazards.

2.2.5 Technical Lead

The technical lead will be a designated person within the Westinghouse Hanford Environmental Engineering Group. The responsibilities of the technical lead will be to plan, authorize, and control work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound.

2.2.6 Remedial Investigation/Feasibility Study Coordinators

The remedial investigation (RI) and feasibility study (FS) coordinators will be responsible for coordinating all activities related to the RI and FS, respectively, including data collection, analysis, and reporting. The RI and FS coordinators will be responsible for keeping the technical lead informed as to the RI and FS work status and any problems that may arise.

2.2.7 Resource Conservation and Recovery Act Facility Investigation/Corrective Measures Study Contractor

Figure C-1 shows the organizational relationship of an offsite contractor. Assuming a contractor is used to perform the RI/FS for the 200 West Groundwater Aggregate Area, the contractor would assume responsibilities of the RI and FS coordinators, as described above. In this instance, the contractor will be directly responsible for planning data collection activities and for analyzing and reporting the results of the data-gathering in the RI and FS reports. However, the Westinghouse Hanford coordinator would retain the responsibility for securing and managing the field sampling efforts of the Hanford Site technical resource teams, described below. Figure C-2 shows a sample organizational structure for an RI/FS contractor team.

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2.2.8 Hanford Site Technical Resources

The various technical resources available on the Hanford Site for performing the field studies are shown in Table C-1. These resources will be responsible for performing data collection activities and analyses, and for reporting the results of specific technical activities. Figures C-3 through C-6 show the detailed organizational structure of specific technical teams. Internal and external work orders and subcontractor task orders will be written by the Westinghouse Hanford technical lead to use these technical resources, which are under the control of the technical lead. Statements of work will be provided to the technical teams and will include a discussion of authority and responsibility, a schedule with clearly defined milestones, and a task description including specific requirements. Each technical team will keep the coordinator informed of the work status performed by that group and any problems that may arise.

3.0 DOCUMENTATION AND RECORDS

All plans and reports will be categorized as either primary or secondary documents as described by Section 9.1 of the Tri-Party Agreement. The process for document review and comment will be as described in Section 9.2 of the Tri-Party Agreement. Revisions, should they become necessary after finalization of any document, will be in accordance with Section 9.3 of the Tri-Party Agreement. Changes in the work schedule, as well as minor field changes, can be made without having to process a formal revision. The process for making these changes will be as stated in Section 12.0 of the Tri-Party Agreement. Administrative records, which must be maintained to support the Hanford Site activities, will be in accordance with Section 9.4 of the Tri-Party Agreement.

4.0 FINANCIAL AND PROJECT TRACKING REQUIREMENTS

4.1 MANAGEMENT CONTROL

Westinghouse Hanford will have the overall responsibility for planning and controlling the investigation activities, and providing effective technical, cost, and schedule baseline management. If a contractor is used, the contractor will assume the direct day-to-day responsibilities for these management functions. The management control system used for this project must meet the requirements of DOE Order 4700.1, Project Management System

and DOE Order 2250.1C, Cost and Schedule Control Systems Criteria. The Westinghouse Hanford Management Control System (MCS) meets these requirements. The primary goals of the Westinghouse Hanford MCS are to provide methods for planning, authorizing, and controlling work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound and in conformance with management and quality requirements.

The schedule developed for the 200 West Groundwater Aggregate Area will be updated at least annually, to expand the new current fiscal year and the follow-on year. In addition, any approved schedule changes (see Section 12.0 of the Tri-Party Agreement for the formal change control system) would be incorporated at this time, if not previously incorporated. This update will be performed in the fourth quarter of the previous fiscal year (e.g., July to September) for the upcoming current fiscal year. The work schedule can be revised at any time during the year if the need arises, but the changes would be restricted to major changes that would not be suitable for the change control process.

4.2 MEETINGS AND PROGRESS REPORTS

Both project and unit managers must meet periodically to discuss progress, review plans, and address any issues that have arisen. The project managers' meeting will take place at least quarterly, and is discussed in Section 8.1 of the Tri-Party Agreement.

Unit managers shall meet monthly to discuss progress, address issues, and review near-term plans pertaining to their respective operable units and/or treatment, storage, and disposal groups/units. The meetings shall be technical in nature, with emphasis on technical issues and work progress. The assigned DOE unit manager for the 200 West Groundwater Aggregate Area will be responsible for preparing revisions to the aggregate area schedule prior to the meeting. The schedule shall address all ongoing activities associated with the 200 West Groundwater Aggregate Area, including actions on specific source units (e.g., sampling). This schedule will be provided to all parties and reviewed at the meeting. Any agreements and commitments (within the unit manager's level of authority) resulting from the meeting will be prepared and signed by all parties as soon as possible after the meeting. Meeting minutes will be issued by the DOE unit manager and will summarize the discussion at the meeting, with information copies given to the project managers. The minutes will be issued within five working days following the meeting. The minutes will include, at a minimum, the following information:

- Status of previous agreements and commitments
- Any new agreements and commitments

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- Schedules (with current status noted)

- Any approved changes signed off at the meeting in accordance with Section 12.1 of the Tri-Party Agreement.

Project coordinators for each operable unit also will meet on a monthly basis to share information and to discuss progress and problems.

The DOE shall issue a quarterly progress report for the Hanford Site within 45 days following the end of each quarter. Quarters end on March 31, June 30, September 30, and December 31. The quarterly progress reports will be placed in the public information repositories as discussed in Section 10.2 of the Tri-Party Agreement. The report shall include the following:

- Highlights of significant progress and problems.

- Technical progress with supporting information, as appropriate.

- Problem areas with recommended solutions. This will include any anticipated delays in meeting schedules, the reason(s) for the potential delay, and actions to prevent or minimize the delay.

- Significant activities planned for the next quarter.

- Work schedules (with current status noted).

5.0 REFERENCES

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, (First Amendment), 89-10, Rev.1, Olympia, Washington.

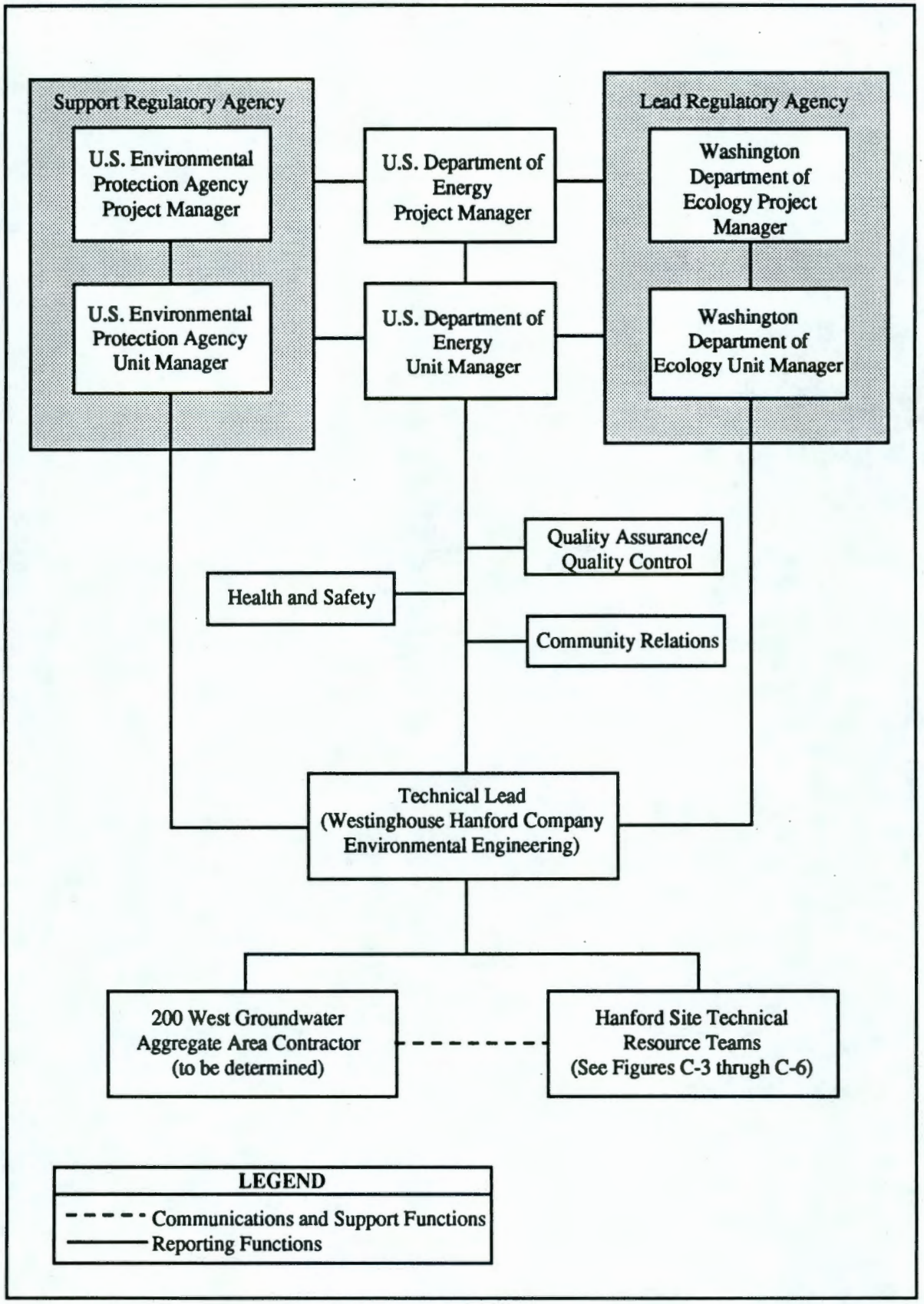

Figure C-1. Project Organization for the 200 West Groundwater Aggregate Area Project.

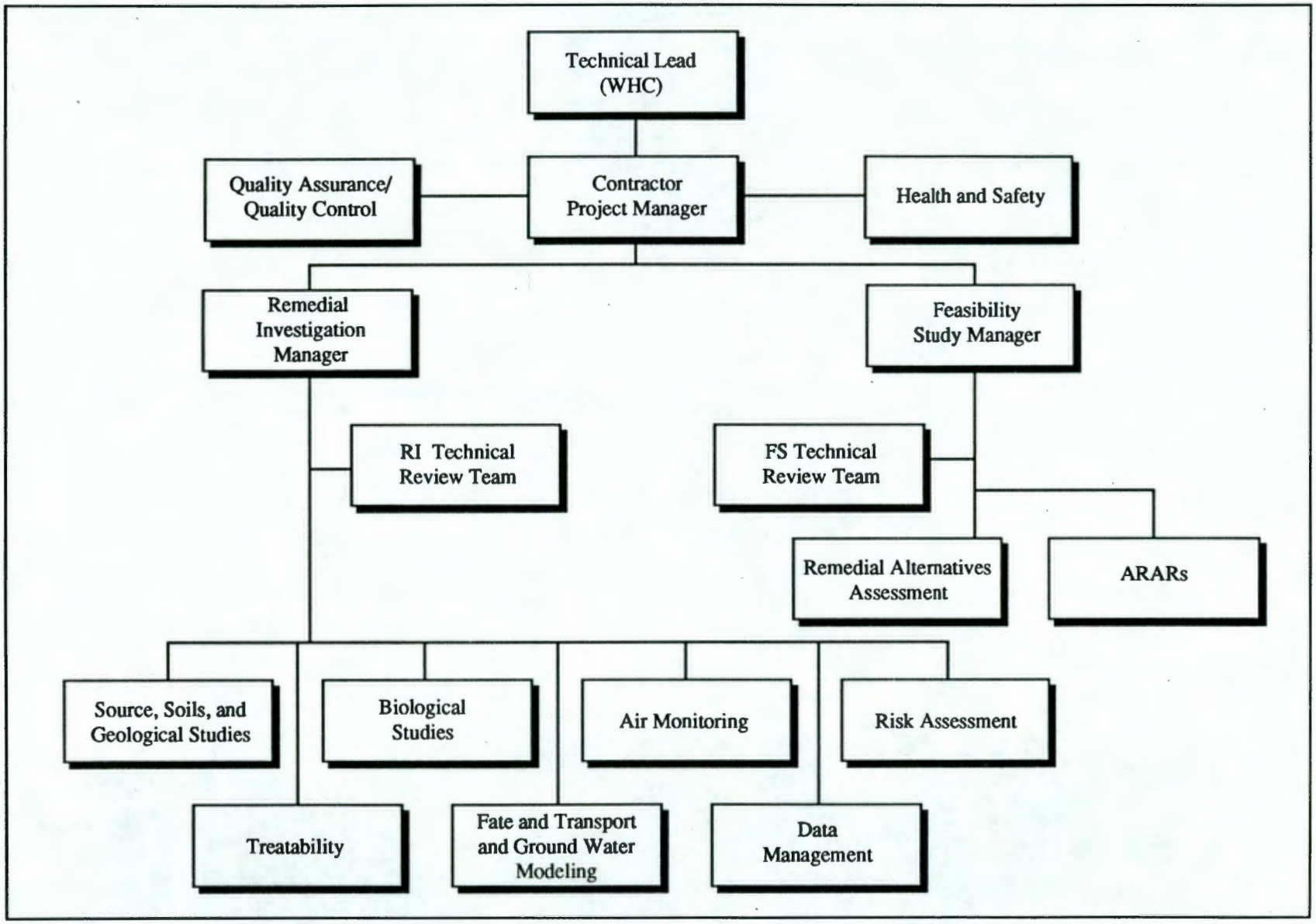

Figure C-2. Example Project Organization for the 200 West Groundwater Aggregate Area

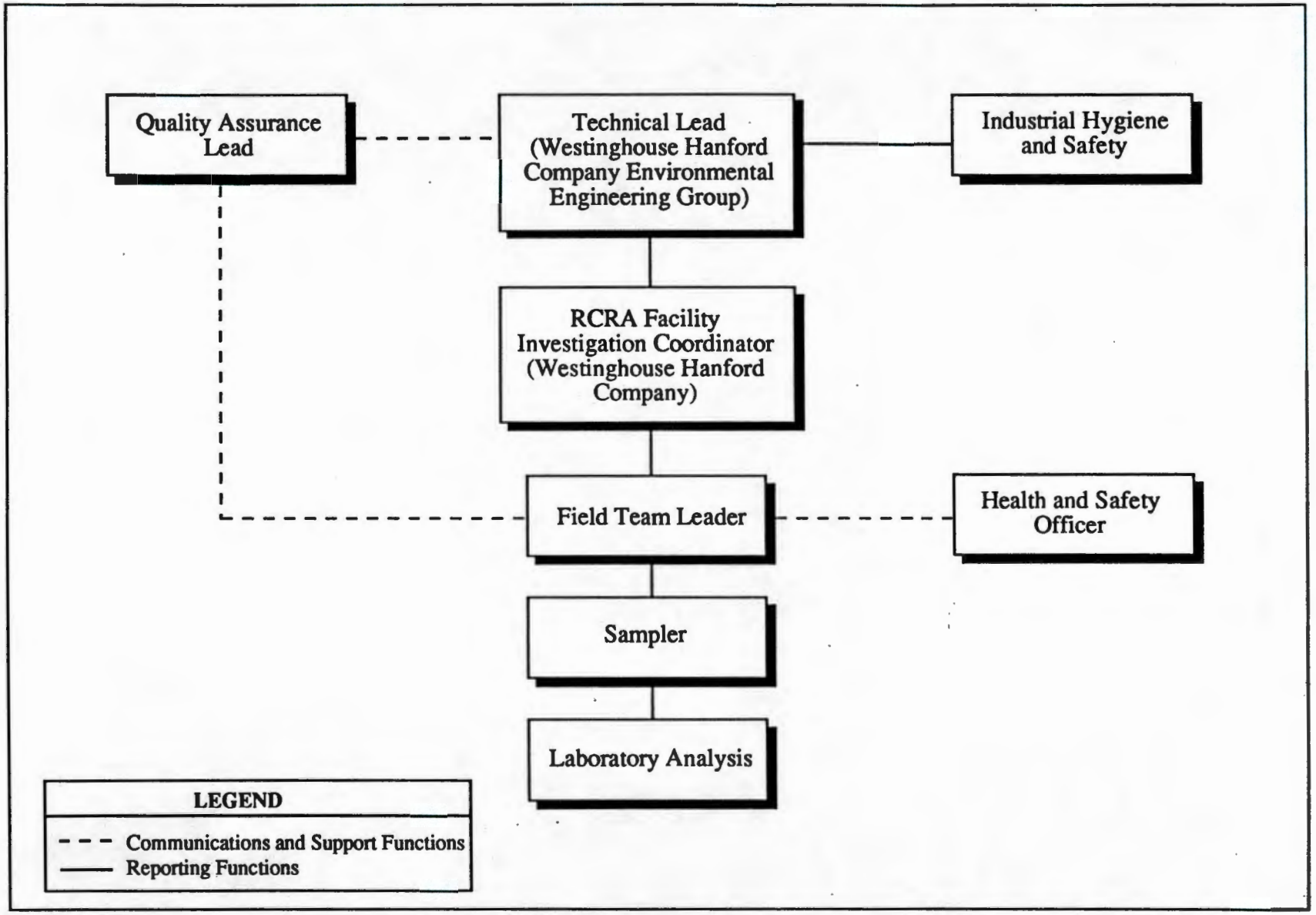

Figure C-3. The Hanford Site Soil Sampling Team.

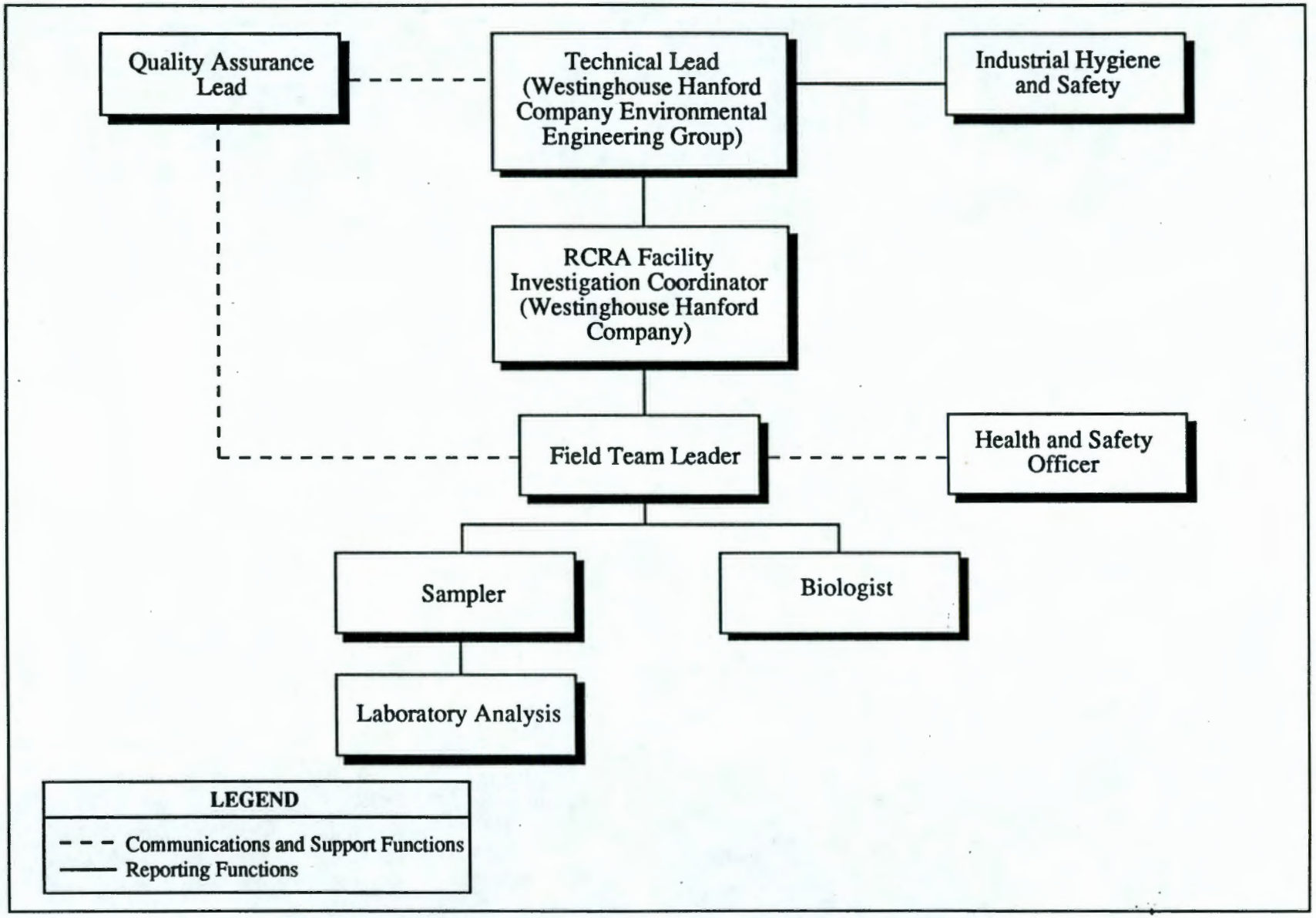

Figure C-4. The Hanford Site Biological Sampling Team.

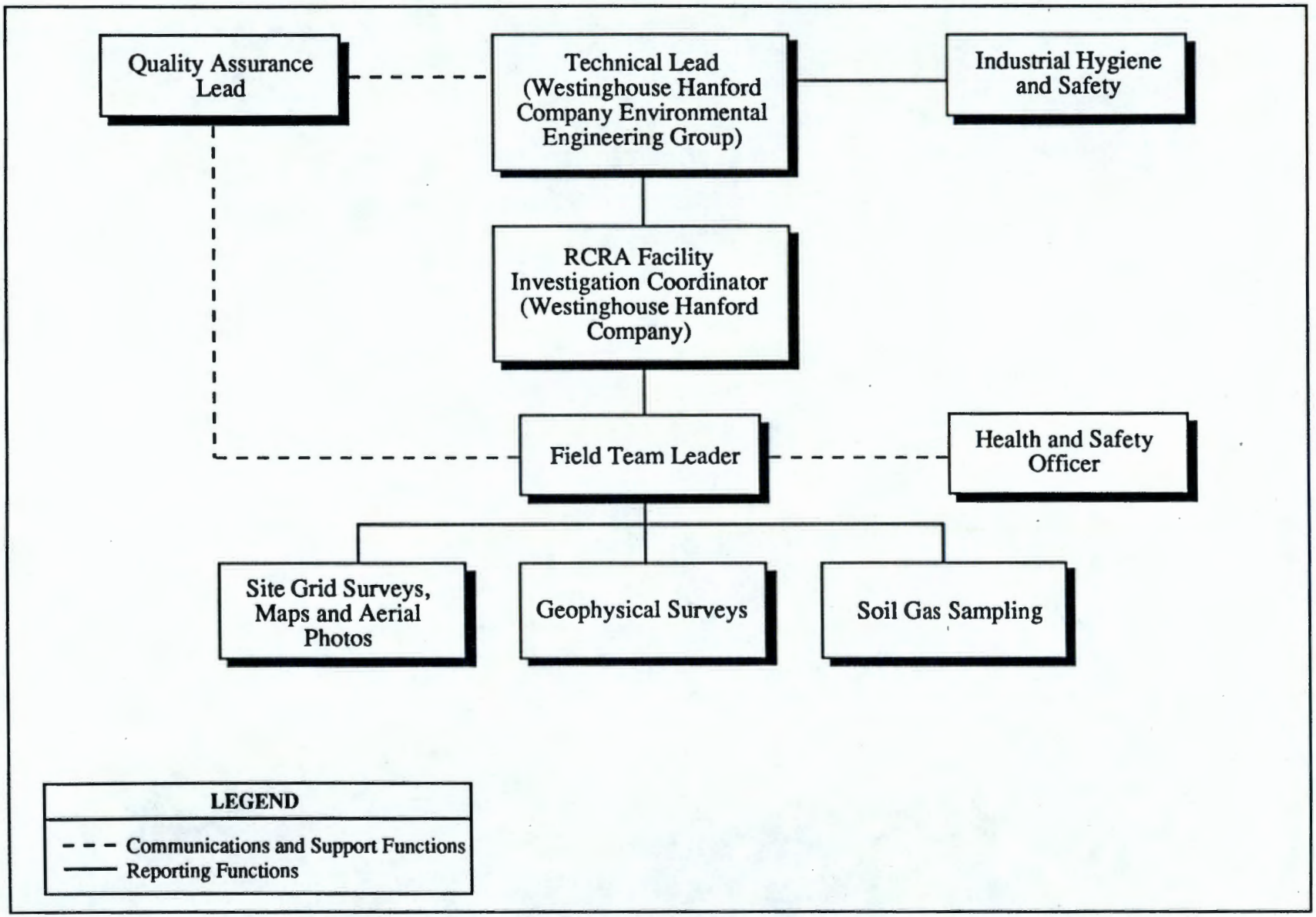

Figure C-5. The Hanford Site Physical and Geophysical Survey Team.

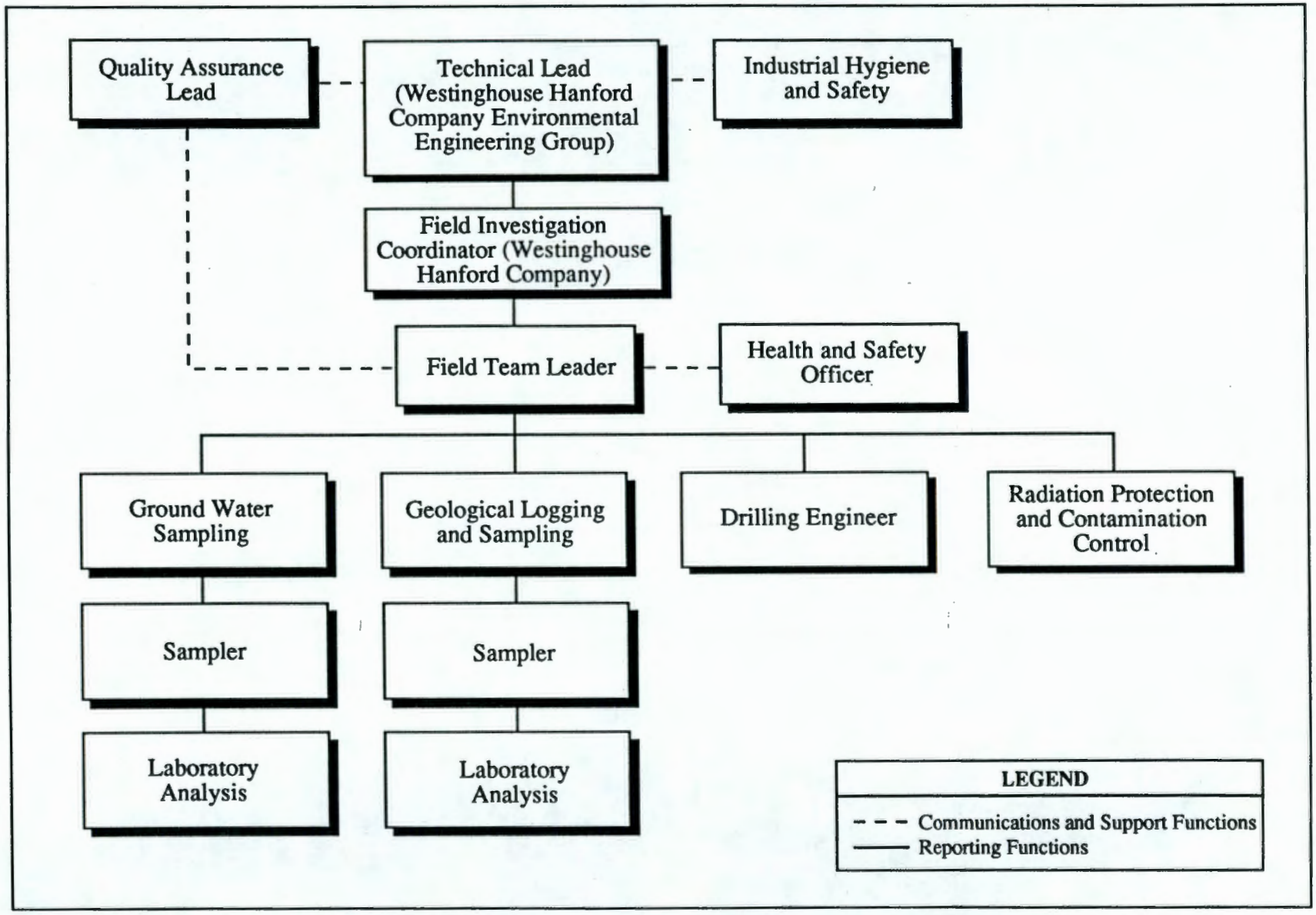

Figure C-6. Drilling, Sampling, and Well-Development Team.

Table C-1. Hanford Site RI/FS Technical Resources. Page 1 of 2

Subject/Activity	Technical Resources	
	RI	FS
Hydrology and geology	Westinghouse Hanford/Geosciences PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/Geosciences
Toxicology and risk/endangerment assessment	Westinghouse Hanford/Environmental Technology PNL/Earth and Environmental Sciences Center PNL/Life Sciences Center	Westinghouse Hanford/ Environmental Technology
Environmental chemistry	Westinghouse Hanford/Geosciences PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/Geosciences
Geotechnical and civil engineering	Westinghouse Hanford/Geosciences (Planning) Environmental Field Services	NA
Geotechnical and civil engineering	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Groundwater treatment engineering	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Waste stabilization and treatment	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Surveying	Kaiser Engineers Hanford	NA

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Table C-1. Hanford Site RI/FS Technical Resources. Page 2 of 2

Subject/Activity	Technical Resources	
	RI	FS
Soil and water sampling and analysis	Westinghouse Hanford/Environmental Engineering Westinghouse Office of Sampling Management PNL/Earth and Environmental Sciences Center PNL/Materials and Chemical Sciences Center	NA
Drilling and well installation	Westinghouse Hanford/Geosciences Environmental Field Services Kaiser Engineers	NA
Radiation monitoring	Westinghouse Hanford/Operational Health Physics	NA

NA = Not applicable.

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APPENDIX D

INFORMATION MANAGEMENT OVERVIEW

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ACRONYMS AND ABBREVIATIONS

AR	administrative record
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CMS	Corrective Measures Study
DOE	U.S. Department of Energy
DOE/RL	U.S. Department of Energy, Richland Operations Office
Ecology	Washington Department of Ecology
EDMC	Environmental Data Management Center
EHPSS	Environmental Health and Pesticide Services Section
EII	Environmental Investigations Instructions
EIMP	Environmental Information Management Plan
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERRA	Environmental Restoration Remedial Action
FOMP	Field Office Management Plan
FS	feasibility study
GIS	geographic information system
HEHF	Hanford Environmental Health Foundation
HEIS	Hanford Environmental Information System
HLAN	Hanford Local Area Network
HMS	Hanford Meteorological Station
IMO	Information Management Overview
KEH	Kaiser Engineers Hanford
OSM	Office of Sample Management
PNL	Pacific Northwest Laboratory
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RFI	RCRA Facility Investigation
RI	remedial investigation
ROD	record of decision
TR	training records
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TSD	treatment, storage, and disposal
Westinghouse Hanford	Westinghouse Hanford Company

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DEFINITIONS OF TERMS

Action Plan. Action plan for implementation of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990). A negotiation between the U.S. Environmental Protection (EPA), the U.S. Department of Energy (DOE), and the State of Washington Department of Ecology (Ecology). 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 (AR). In CERCLA, the official file that contains all information that was considered or relied on by the regulatory agency in arriving at a final remedial action decision, as well as all documentation of public participation throughout the process. In RCRA, the official file that contains all documents to support a final RCRA permit determination.

Administrative Record File. The assemblage of documents compiled and maintained by an agency pertaining to a proposed project of administrative action and designated as AR or that are candidates for inclusion in the AR once a record of decision (ROD) is attained.

Data Management. The planning and control of activities affecting data.

Data Quality. The totality of features and characteristics of data that bears on its ability to satisfy a given purpose. The characteristics of major importance are accuracy, precision, completeness, representativeness, and comparability.

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

ENCORE. The name given to the combination of hardware, software, and administrative subsystems that serve to integrate the management of the Hanford Site environmental data.

Environmental Data Management Center (EDMC). The central facility and services that provide a files management system for processing environmental information.

Environmental Information. Data related to the protection or improvement of the Hanford Site environment, including data required to satisfy environmental statutes, applicable DOE orders, or the Tri-Party Agreement.

Field File Custodian. An individual who is responsible for receipt, validation, storage, maintenance, control, and disposition of information or other records generated in support of Environmental Division activities.

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

Information System. Collection of components relate to the management of data and reporting of information. Information systems typically include computer hardware, computer software, operating systems, utilities, procedures, and data.

Lead Agency. The regulatory agency (EPA or Ecology) that is assigned the primary administrative and technical responsibility with respect to actions at a particular operable unit.

Nonrecord Material. Copies of material that are maintained for information, reference, and operating convenience and for which another office has primary responsibility.

Operable Unit. An operable unit at the Hanford Site is a group of land disposal and groundwater sites placed together for the purposes of doing a remedial investigation/ feasibility study. 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 on which key decisions are made with respect to the remedial action or permitting process. Primary documents are subject to dispute resolution and are part of the administrative record file.

Project Manager. The individual responsible for implementing the terms and conditions of the Action Plan on behalf of his respective party. The EPA, DOE, and Ecology will each designate one project manager.

Quality Affecting Record. Information contained on any media, including but not limited to, hard copy, sample material, photo copy, and electronic systems, that is complete in

terms of appropriate content and that furnishes evidence of the quality of items and/or activities affecting quality.

Quality Assurance. The systematic actions necessary to provide adequate confidence that a material, component, system, process, or facility performs satisfactorily or as planned in service.

Quality Assured Data. Data developed under an integrated program for assurance of the reliability of data.

Raw Data. Unprocessed or unanalyzed information.

Record Validation. A review to determine that records are complete, legible, and meet records requirements. Documents are considered valid records only after the validation process has been completed.

Retention Period. The length of time records must be held before they can be disposed of. The time is usually expressed in years from the date of the record, but may also be expressed as contingent on the occurrence of an event.

Secondary Document. A document providing information that does not, in itself, reflect or support key decisions. A secondary document is subject to review by the regulatory agencies and may be part of the administrative record field. It is not subject to dispute resolution.

Validated Data. Data that meet criteria contained in an approved company procedure.

Verified Data. Data that have been checked for accuracy and consistency following a transfer action (e.g., from manual log to computer, or from distributed database to centralized data repository).

1.0 INTRODUCTION AND OBJECTIVES

1.1 INTRODUCTION

An extensive amount of data will be generated over the next several years in connection with the activities planned for the 200 West Aggregate Area. The quality of these data are extremely important to the full remediation of the aggregate area as agreed on by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA) the Washington Department of Ecology (Ecology), and interested parties.

The Information Management Overview (IMO) provides an overview of the data management activities at the operable unit level. It identifies the type and quantity of data to be collected and references the procedures which control the collection and handling of data. It provides guidance for the data collector, aggregate area investigator, project manager, and reviewer to fulfill their respective roles.

This IMO addresses handling of data generated from activities associated with the aggregate area activities. All data collected will be in accordance with the Environmental Investigations Instructions (EII) contained in the Westinghouse Hanford Company's (Westinghouse Hanford) *Environmental Investigations and Site Characterization Manual* (WHC 1991a).

Development of a comprehensive plan for the management of all environmental data generated at the Hanford Site is under way. The *Environmental Information Management Plan* (EIMP) (Steward et al. 1989), released in March 1989, described activities in the Environmental Data Management Center (EDMC) and long-range goals for management of scientific and technical data. The scientific and technical data part of the EIMP was reviewed, revised, and expanded in fiscal year 1990 (Michael et al. 1990). An *Environmental Restoration Remedial Action Program Records Management Plan* (WHC 1991b) issued in July 1991, enables the program office to identify, control, and maintain the quality assurance (QA), decisional, or regulatory prescribed records generated and used in support of the Environmental Restoration Remedial Action (ERRA) Program.

1.2 OBJECTIVES

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

- Types of data to be collected

- Plans for managing data
- Organizations controlling data
- Databases used to store the data
- EIMP
- Hanford Environmental Information System (HEIS).

2.0 TYPES OF DATA

2.1 TYPES OF DATA

The general types of technical data to be collected and the associated controlling procedures are as follows:

Type of data	Procedure
Historical reports	EII 1.6
Aerial photos	EII 1.6
Chart recordings	EII 1.6
Technical memos	EII 1.6
Validated samples analyses	EII 1.6
Reports	EII 1.6
Logbooks	EII 1.5
Chain-of-custody forms	EII 5.1
Sample quality assurance/ quality control (QA/QC)	Office of Sample Management (OSM)

All such data are submitted to the EDMC for entry into the administrative record (AR).

General types of related administrative data is shown in Table D-1, which is organized in terms of general types of personnel and compliance/regulatory data. Table D-1 references the appropriate procedures and the record custodians. Data associated with aggregate area investigations will be submitted to the EDMC for entry into the AR, as appropriate.

2.2 DATA COLLECTION

Data will be collected according to the aggregate area sampling and analysis plans and the Quality Assurance Project Plan (QAPP). Section 2.1 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 the Westinghouse Hanford *Environmental Investigations and Site Characterization Manual* (WHC 1991a).

2.3 DATA STORAGE AND ACCESS

Data will be handled and stored according to procedures approved in compliance with applicable Westinghouse Hanford procedures (WHC 1988). The EDMC is the central files manager and process facility. All data entering the EDMC will be indexed, recorded, and placed into safe and secure storage. Data designated for placement into the AR will be copied, placed into the Hanford Site AR file, and distributed by the EDMC to the user community. The hard copy files are the primary sources of information; the various electronic data bases are secondary sources.

Normal access to data is through EDMC which is responsible for the AR. The Administrative Record Public Access Room is located in the 345 Hills Street Facility in Richland, Washington. This facility includes AR file documents (including identified guidance documents and technical literature).

Project participants may access data that are not in the AR by requesting it at the monthly unit managers' meeting for the operable unit of concern. As the project moves to completion, it is expected that all of the relevant data will be contained in the AR and the need to access data will be minimal.

The following types of data will be accessed from and reside in locations other than the EDMC:

Data Type	Data location
• QA/QC laboratory data	OSM (Westinghouse Hanford)
• Sample status	OSM (Westinghouse Hanford)
• Archived samples	Laboratory performing analyses
• Training records	Technical Training Support Section (Westinghouse Hanford)
• Meteorological data	Hanford Meteorological Station (HMS) (Pacific Northwest Laboratory [PNL])

• Health and safety records	Hanford Environmental Health Foundation (HEHF)
• Personal protective fitting	Environmental Health and Pesticide Services Section (Westinghouse Hanford)
• Radiological exposure	Pacific Northwest Laboratory.

2.4 DATA QUANTITY

Data quantities for the investigative activities will be estimated based on the sampling and analysis plans developed for investigation of sites within the aggregate area.

3.0 DATA MANAGEMENT

3.1 OBJECTIVE

A considerable amount of data will be generated through the implementation of the aggregate area sampling and analysis plans. The QAPP will provide the specific procedural direction and control for obtaining and analyzing samples in conformance with requirements to ensure quality data results. The sampling and analysis plans will provide the basis for selecting the location, depth, frequency of collection, etc., of media to be sampled and methods to be employed to obtain samples of selected media for cataloging, shipment, and analysis. Figure D-1 displays the general data management model for data generated through work plan activities.

3.2 ORGANIZATIONS CONTROLLING DATA

This section addresses the organizations that will receive data generated from aggregate area activities.

3.2.1 Environmental Engineering Group

The Westinghouse Hanford Environmental Engineering Group provides the operable unit technical coordinator. The technical coordinator is responsible for maintaining and transmitting data to the designated storage facility.

3.2.2 Office of Sample Management

The Westinghouse Hanford OSM will validate all analytical data packages received from the laboratory. Validated summary data (sample results and copies of chain-of-custody forms) will be forwarded to the technical coordinator. Nonvalidated data will be forwarded to the technical coordinator on request. Preliminary data will be clearly labeled as such. The OSM will maintain raw sample data, QA/QC laboratory data, and the archived sample index.

3.2.3 Environmental Data Management Center

The EDMC is the Westinghouse Hanford Environmental Division's central facility and service that provides a file management system for processing environmental information. The EDMC manages and controls the AR and Administrative Record Public Access Room at the Hanford Site. Part 1 of the EIMP (Michael et al. 1990) describes the central file system and services provided by the EDMC. The following procedures address data transmittal to the EDMC:

- EII 1.6, Records Management (WHC 1991a)
- EII 1.11, Technical Data Management (WHC 1991a)
- TPA-MP-02, Information Transmittals and Receipt Controls (DOE/RL 1990)
- TPA-MP-07, Administrative Record Collection and Management (DOE/RL 1990)

3.2.4 Information Resource Management

Information Resource Management is the designated records custodian (permanent storage) for Westinghouse Hanford. The procedural link from the EDMC to the Information Resource Management is currently under development.

3.2.5 Hanford Environmental Health Foundation

The HEHF performs the analyses on the nonradiological health and exposure data (Section 3.3.2) and forwards summary reports to the Fire and Protection Group and the Environmental Health and Pesticide Services Section within the Westinghouse Hanford Environmental Division. Nonradiological and health exposure data are maintained also for other Hanford Site contractors (PNL and Kaiser Engineers Hanford [KEH]) associated with aggregate area activities. The HEHF provides summary data to the appropriate site contractor. EII 2.1, Preparation of Hazardous Waste Operations Permits, and EII 2.2,

Occupational Health Monitoring (WHC 1991a) address the preparation of health and safety plans and occupational health monitoring, respectively.

3.2.6 Environmental Health and Pesticide Services Section

The Westinghouse Hanford Environmental Health and Pesticide Services Section maintains personal protective equipment fitting records and maintains nonradiological health field exposure and exposure summary reports provided by HEHF for Westinghouse Hanford Environmental Division and subcontractor personnel.

3.2.7 Technical Training Records and Scheduling Section

The Westinghouse Hanford Technical Training Records and Scheduling Section provides training and maintains training records (Section 3.3.4).

3.2.8 Pacific Northwest Laboratory

The PNL operates the HMS and collects and maintains meteorological data (Section 3.3.1). Data management is discussed in Andrews (1988).

The PNL collects and maintains radiation exposure data (Section 3.3.3).

3.3 DATABASES

This section addresses databases that will receive data generated from the aggregate area activities. These and other databases are described in the EIMP (Michael et al. 1990). All of these databases exist independently of this aggregate area and serve other site functions. Data pertinent to the operable unit, housed in these databases, will be submitted to the AR.

3.3.1 Meteorological Data

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

3.3.2 Nonradiological Exposure and Medical Records

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

3.3.3 Radiological Exposure Records

The PNL collects and maintains data on occupational radiation exposure. This database contains respiratory personal protective equipment fitting records, work restrictions, and radiation exposure information.

3.3.4 Training Records

Training records for Westinghouse Hanford and subcontractor personnel are managed by the Westinghouse Hanford Technical Training Support Section. Other Hanford Site contractors (PNL and KEH) maintain their own personnel training records. Training records for non-Westinghouse personnel are entered into the Westinghouse (soft reporting) database to document compliance.

Training records include:

- Initial 40-h hazardous waste worker training
- Annual 8-h 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.

3.3.5 Environmental Information/Administrative Record

Environmental information and the AR are managed by Westinghouse Hanford EDMC personnel. They provide an index and key information on all data transmitted to the EDMC. This database is used to assist in data retrieval and to produce index lists as required.

3.3.6 Sample Status Tracking

The OSM maintains the sample status tracking database. This database contains information about each sample. Information maintained includes sample number, ship date, receipt date, and laboratory identification.

4.0 ENVIRONMENTAL INFORMATION AND RECORDS MANAGEMENT PLAN

This section briefly discusses the EIMP (Michael et al. 1990) that was developed to provide an overview of an integrated approach to managing Hanford Site environmental data, and the *Environmental Restoration Remedial Action Program Records Management Plan* (WHC 1991b).

4.1 ENVIRONMENTAL INFORMATION MANAGEMENT PLAN

The EIMP provides an overview of how information is managed throughout the lifetime of Hanford Site environmental programs.

The Environmental Division of Westinghouse Hanford is responsible for the protection and improvement of the Hanford Site environment. To fulfill responsibility, the Environmental Division has assumed a management role with respect to Hanford Site environmental information. This management role includes (1) establishing standards for how data are validated and controlled, (2) developing and maintaining a supporting computer-based environment, and (3) sustaining a centralized file management system.

Hanford Site environmental information is defined as data related to the protection or improvement of the Hanford Site environment, including data required to satisfy environmental statutes, applicable DOE orders, or the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990), (Tri-Party Agreement).

Environmental information falls into several overlapping categories, such as administrative versus technical and electronic versus manual or hard copy. A considerable amount of data are recorded in documents, which are governed by company-wide document and records control practices. Other data are collected or generated by computer and, therefore, exist in electronic form. The name ENCORE has been given to the combination of administrative, hardware, and software systems that serve to integrate the management of this electronic data.

Administrative information (e.g., budgets and schedules) is subject to accounting and other standard business practices. Scientific and technical data are subject to a different set of legal, classification, release, and engineering requirements.

Superimposed over these categories is the files management system for environmental information. This management system, has been developed to meet a number of Environmental Division needs, including requirements for compilation of AR files. The AR files are compilations of all material related to environmental restoration and remedial action records of decision (ROD) for each operable unit and treatment, storage, and disposal (TSD) group described in the Tri-Party Agreement.

Data in electronic form flows from information systems in the ENCORE realm to both scientific/technical and administrative documents. Environmental documents distributed within the Hanford Site and from regulatory agencies are received by the EDMC for storage and future processing.

Part I of the EIMP describes the overall Westinghouse Hanford systems that are generally applied to documents and records. Part I also describes, in greater detail, the files management system developed to manage the AR file information. The EDMC compiles the AR files and provides controlled distribution of specified information to the AR files held by DOE, Ecology, and the EPA. The EDMC also provides controlled distribution of specified community relations information to regional information repositories.

Part II addresses computer-based information, with an emphasis on scientific and technical data. The long-term nature of environmental programs and the complex interrelationships of environmental data require that the data be preserved, retrievable, traceable, and sufficient for future use. To ensure data availability for response to regulatory and agency requirements, the plan is directed toward optimizing the use of automated techniques for managing data. The current processing environment and the proposed ENCORE realm are described, and the plans for implementation of ENCORE are addressed.

4.2 ENVIRONMENTAL RESTORATION REMEDIAL ACTION PROGRAM RECORDS MANAGEMENT PLAN

The ERRA Program records management plan was developed to fulfill the requirements of the U.S. Department of Energy, Richland Operations Office (DOE/RL) *Environmental Restoration Field Office Management Plan* (FOMP) (DOE/RL 1989). The FOMP describes the plans, organization, and control systems to be used for management of the Hanford Site ERRA Program. The Westinghouse Hanford ERRA Program Office has developed this ERRA Program records management plan to fulfill the requirements of the FOMP. This records management plan will enable the program office to identify, control,

and maintain the quality assurance, decisional, or regulatory prescribed records generated and used in support of the ERRA Program.

The ERRA Program records management plan describes how the applicable records management requirements will be implemented for the ERRA Program. The plan also develops the criteria for identifying the appropriate requirements for each individual piece of information related to ERRA work activities.

This records management plan applies to all ERRA Program records and documents generated, used, or maintained in support of ERRA-funded work activities on the Hanford Site. The terms, information, documents, nonrecord material, records, record material, and QA records used throughout the ERRA records management plan are interpreted as ERRA information, ERRA documents, ERRA nonrecord material, ERRA records, ERRA record material, and ERRA QA records.

5.0 HANFORD ENVIRONMENTAL INFORMATION SYSTEM

5.1 OBJECTIVE

The Hanford Environmental Information System (HEIS) has been developed by PNL for Westinghouse Hanford as a primary resource for computerized storage, retrieval, and analysis of quality-assured technical data associated with Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) remedial investigation/ feasibility study (RI/FS) activities and RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) activities being undertaken at the Hanford Site. The HEIS will provide a means of interactive access to data sets extracted from other databases relevant to implementation of the Tri-Party Agreement (Ecology et al. 1990). The HEIS will support graphics analysis, including a geographic information system. Implementation of HEIS will serve to ensure 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 proposed to be entered into HEIS:

- Geologic
- Geophysics
- Atmospheric
- Biotic
- Site characterization
- Soil gas

- Waste site information
- Surface monitoring
- Groundwater.

5.2 STATUS OF THE HANFORD ENVIRONMENTAL INFORMATION SYSTEM

The HEIS, a computerized database containing technical data and information used to support the Hanford environmental restoration (ER) activities, is operational. The data for the Hanford groundwater wells and groundwater samples is currently accessible via the Hanford Local Area Network (HLAN) to local users and to offsite users via a modem link to the HEIS database computer. Additional data, including geologic, biota, and other pertinent environmental sample results, are being entered into the HEIS database.

The *Hanford Environmental Information System (HEIS) User's Manual* (WHC 1990) was issued in October 1990. An operator manual is being prepared and is expected to be issued in 1992.

The HEIS geographic information system (GIS) will display detailed maps for the Hanford restoration sites including data from the HEIS database. Such spatially related data will be used to support analysis of waste site technical issues and restoration options. The combination of the HEIS for data and the GIS spatial displays offers some powerful tools for many users to analyze and collectively evaluate the environmental data from the ER and site-wide monitoring programs.

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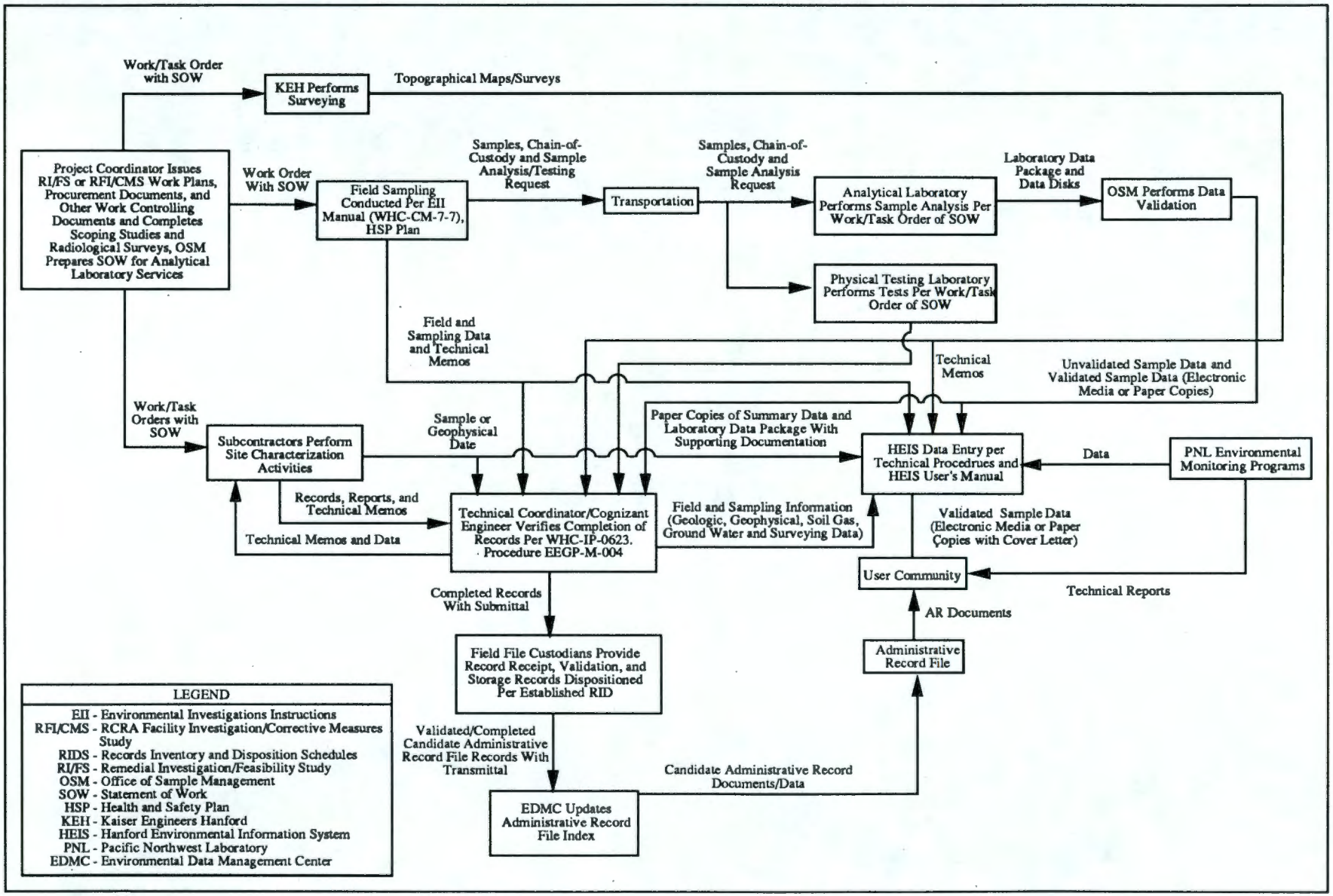

Figure D-1. Environmental Engineering, Technology and Permitting Data Management Model.

Table D-1. Types of Related Administrative Data.

Type of Data	Controlling document/procedure	Record Custodians				
		TR	HEHF	PNL	EDMC	EHPSS
Personnel						
Personnel training and qualifications	EII 1.7[a/]	X				
Occupational exposure records (nonradiological)	EII 2.2[a/]		X			X
Radiological exposure records				X		
Respiratory protection fitting						X
Personnel health and safety records	EII 2.1[a/]		X			X
Compliance/regulatory						
Action-specific requirements/screening levels	EII 1.6[a/]				X	
Guidance document tracking	EII 1.6[a/]				X	
Compliance issues	EII 1.6[a/]				X	
Problem resolution	EII 1.6[a/]				X	
Administrative record	TPA-MP-11[b/]				X	

[a/] WHC 1991a, *Environmental Investigations and Site Characterization Manual.*
[b/] DOE/RL 1990, *Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Handbook.*
EDMC = Environmental Data Management Center (Westinghouse Hanford Company).
EHPSS = Environmental Health and Pesticide Services Section (Westinghouse Hanford Company).
EII = Environmental Investigations Instructions.
HEHF = Hanford Environmental Health Foundation.
TR = training records (Westinghouse Hanford Company, Pacific Northwest Laboratory [PNL], Kaiser Engineers Hanford [KEH]).

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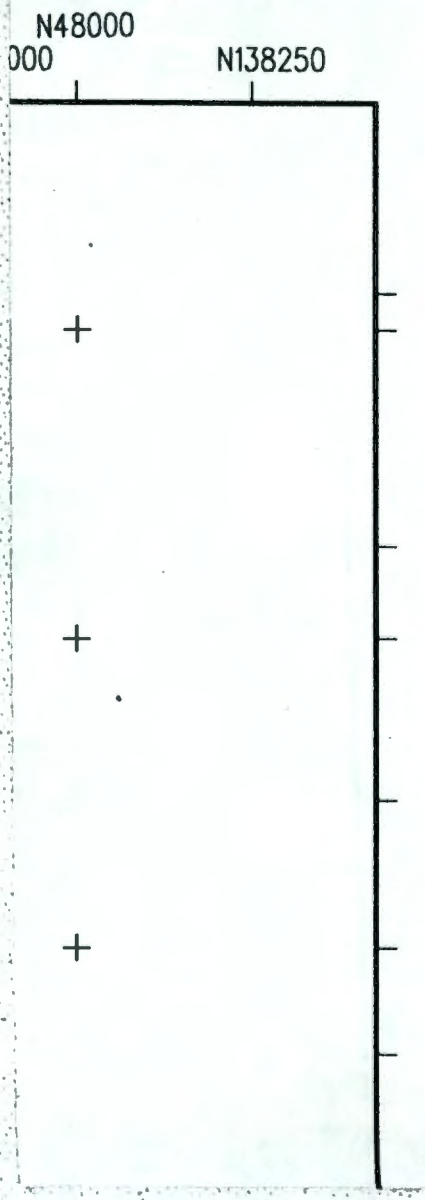

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Westinghouse Hanford Company
Aggregate Area Management Studies

200 WEST GROUNDWATER
PLATE 1 - Facilities & Sites

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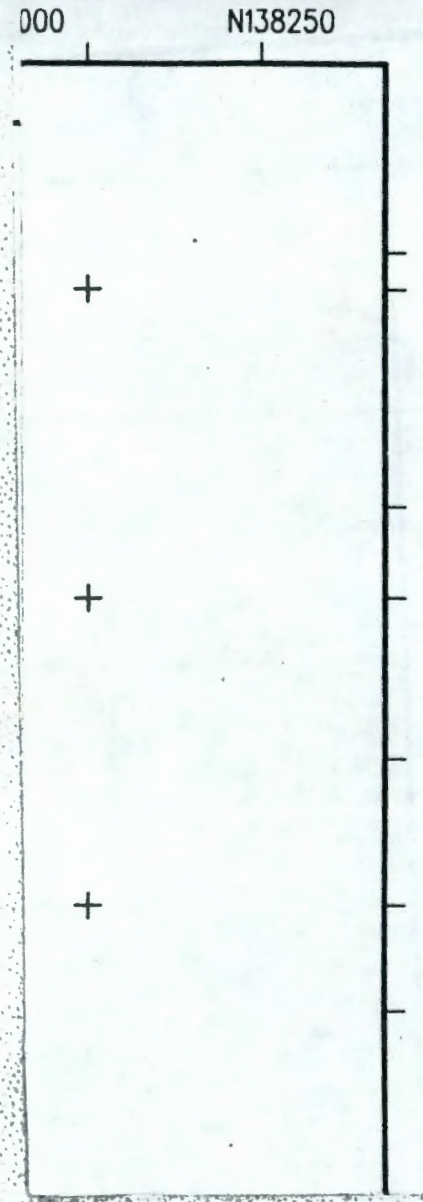

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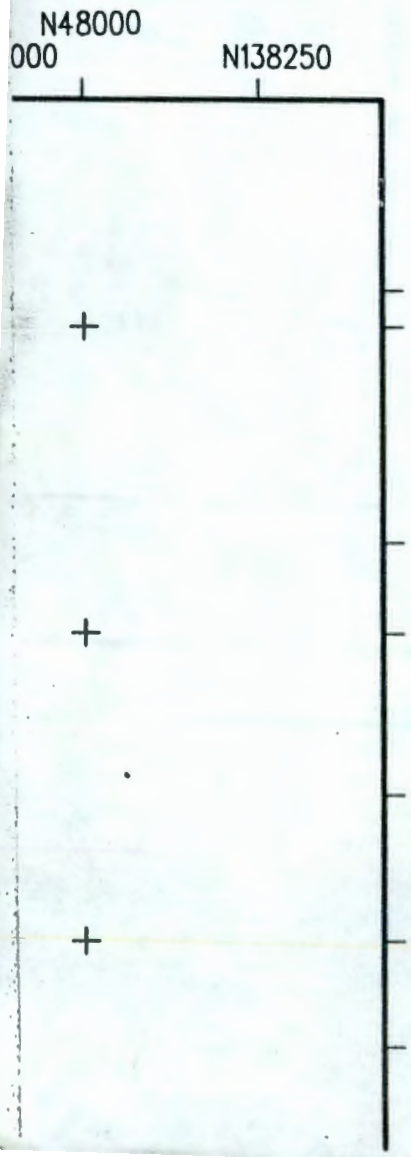
Westinghouse Hanford Company
Aggregate Area Management Studies

200 WEST GROUNDWATER
PLATE 2 - Topography

23057



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200 WEST GROUNDWATER
PLATE 3a - Monitor Wells

23057

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200 WEST GROUNDWATER
PLATE 3b - Monitor Wells

2305

RRI Contours at 0.1,0.3,1,3,10,30

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200 WEST GROUNDWATER
PLATE 4 - Total Relative Risk Index
(RRI) for Carcinogenic Detections

RRI Contours at 1,10,100,1000,10000

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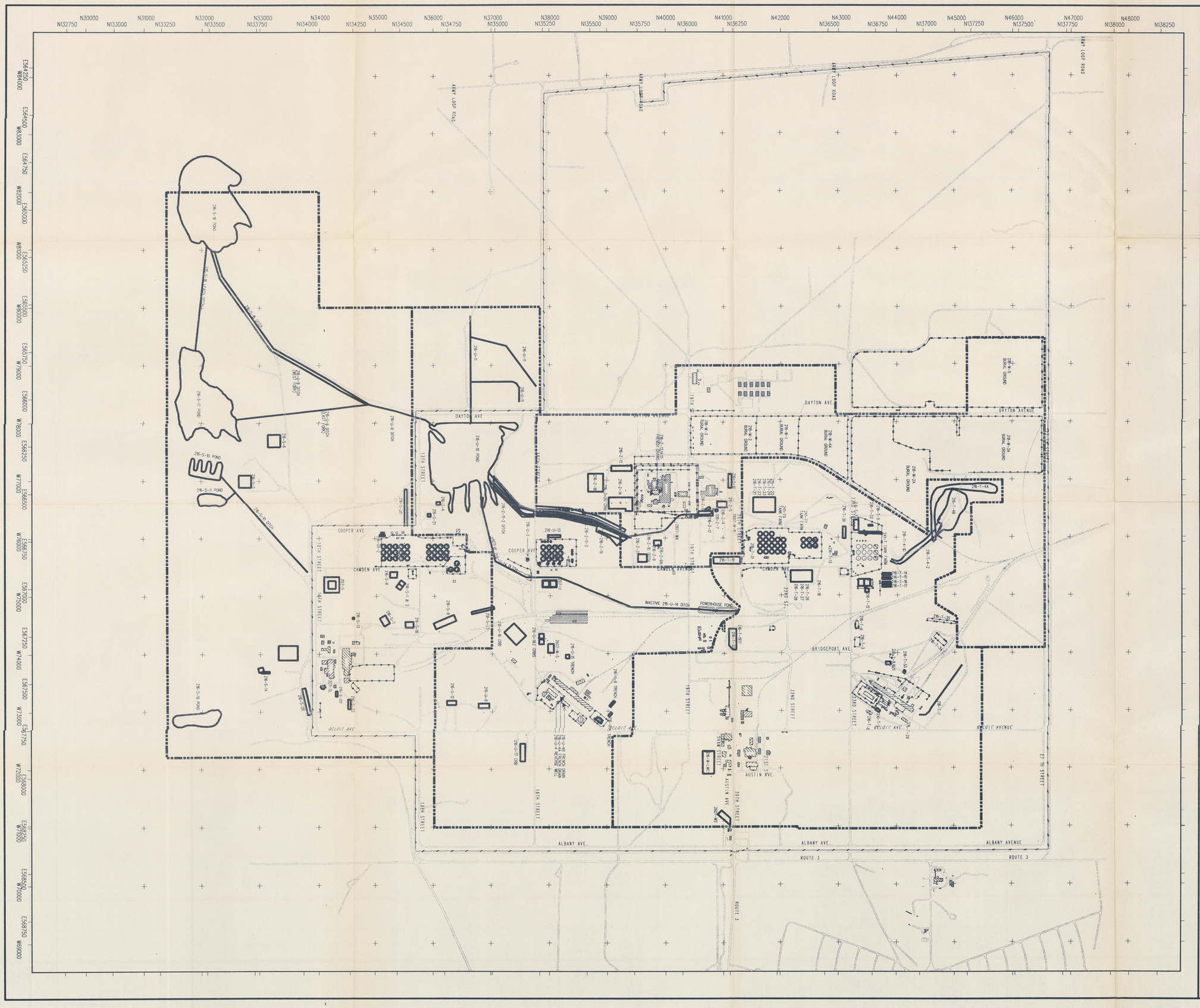
200 WEST GROUNDWATER
PLATE 5 – Total Relative Risk Index
(RRI) for Non-Carcinogenic Detections

6-51-63
8.7

2305



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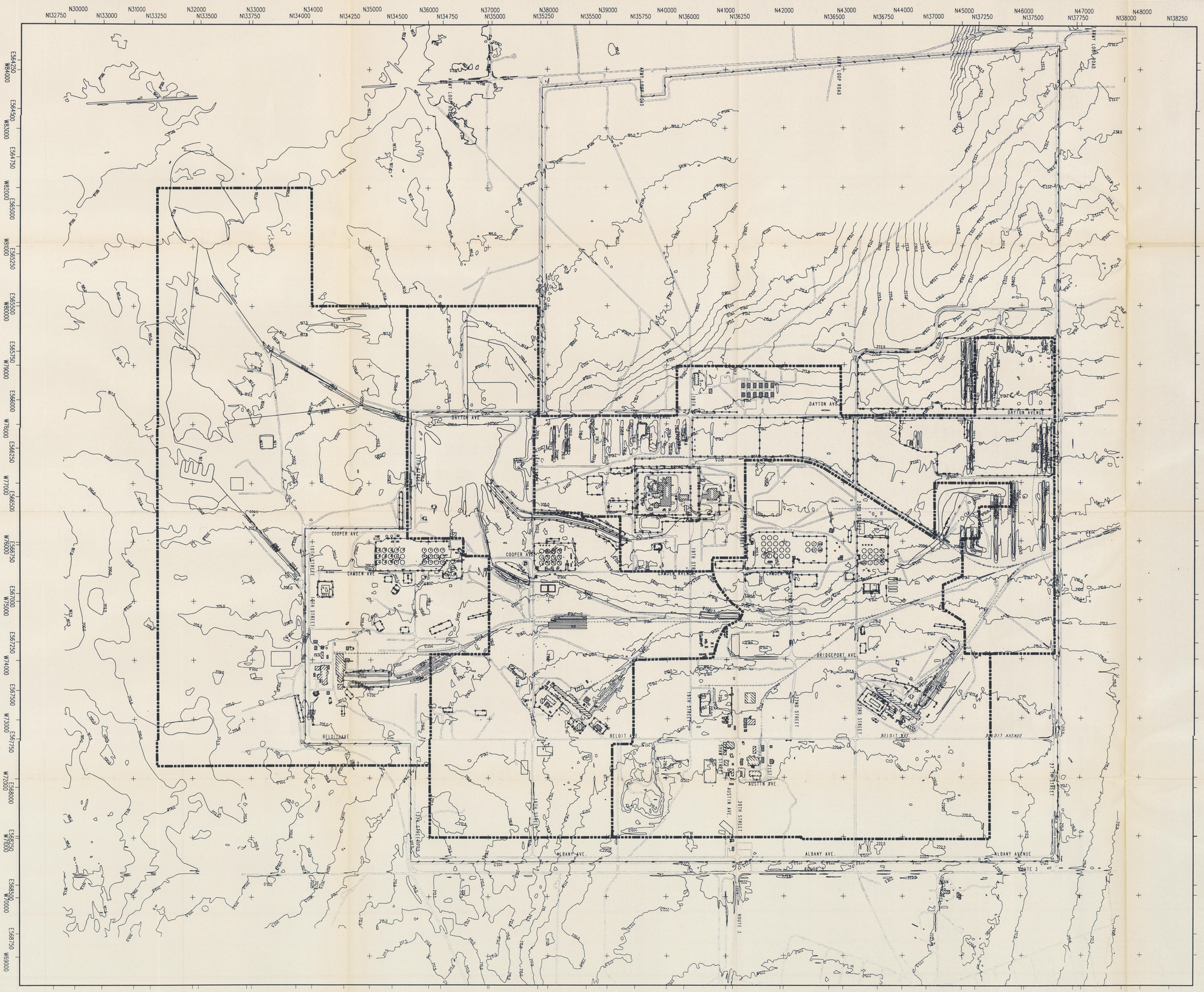
200 WEST GROUNDWATER
PLATE 1 – Facilities & Sites

LEGEND

- Aggregate Area Boundary
- Security Systems/Fences
- Perimeter Boundary
- Buildings
- Waste Management Units
- Other Waste Mgmt Units

23057



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200 WEST GROUNDWATER
PLATE 2 - Topography

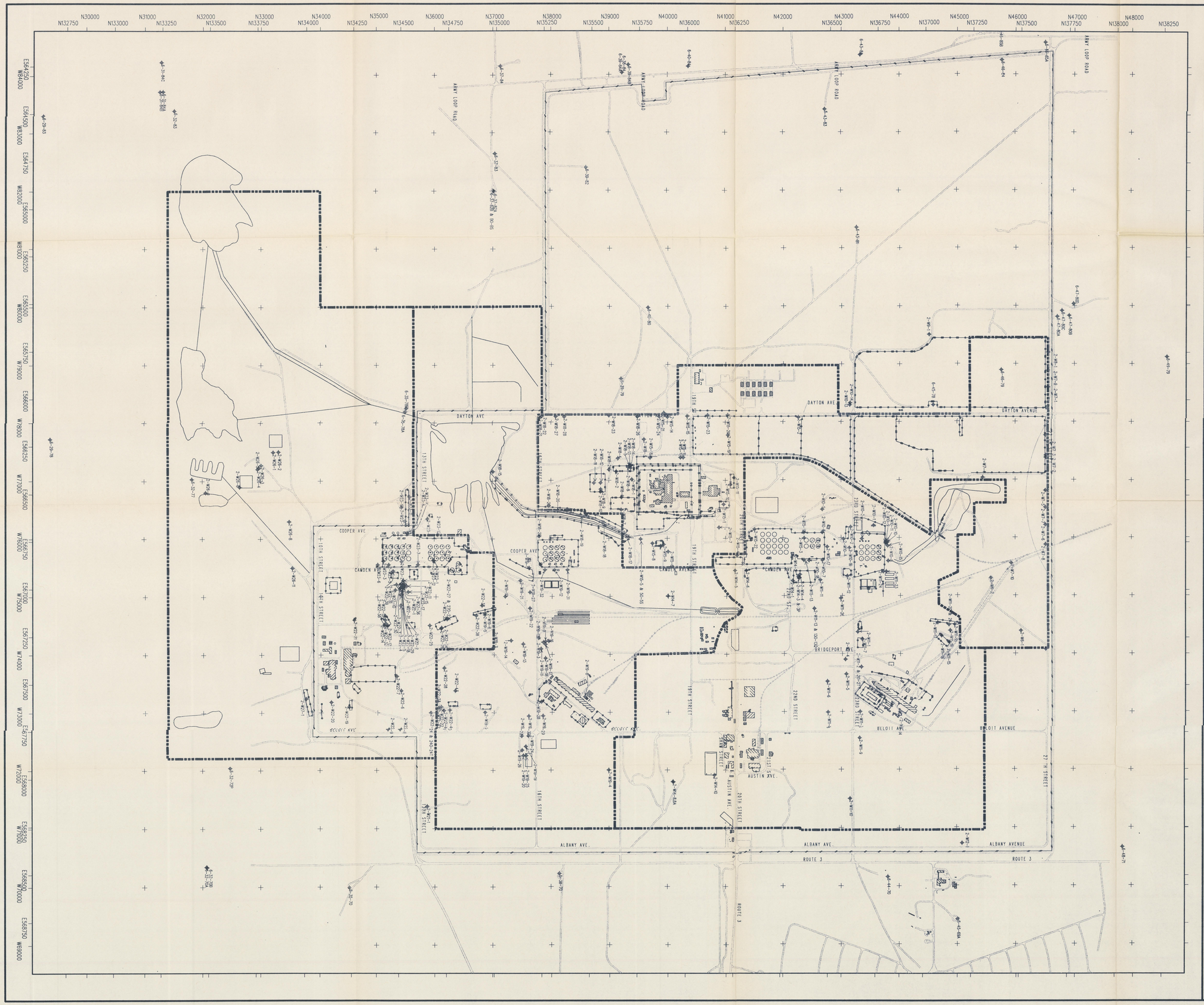
LEGEND

- Aggregate Area Boundary
- Security Systems/Fences
- Perimeter Boundary
- Buildings

Contour Interval 2.5 Meter

Scale in Feet
0 1000 2000

Scale in Meters
0 100 500



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Aggregate Area Management Studies

200 WEST GROUNDWATER
PLATE 3a - Monitor Wells

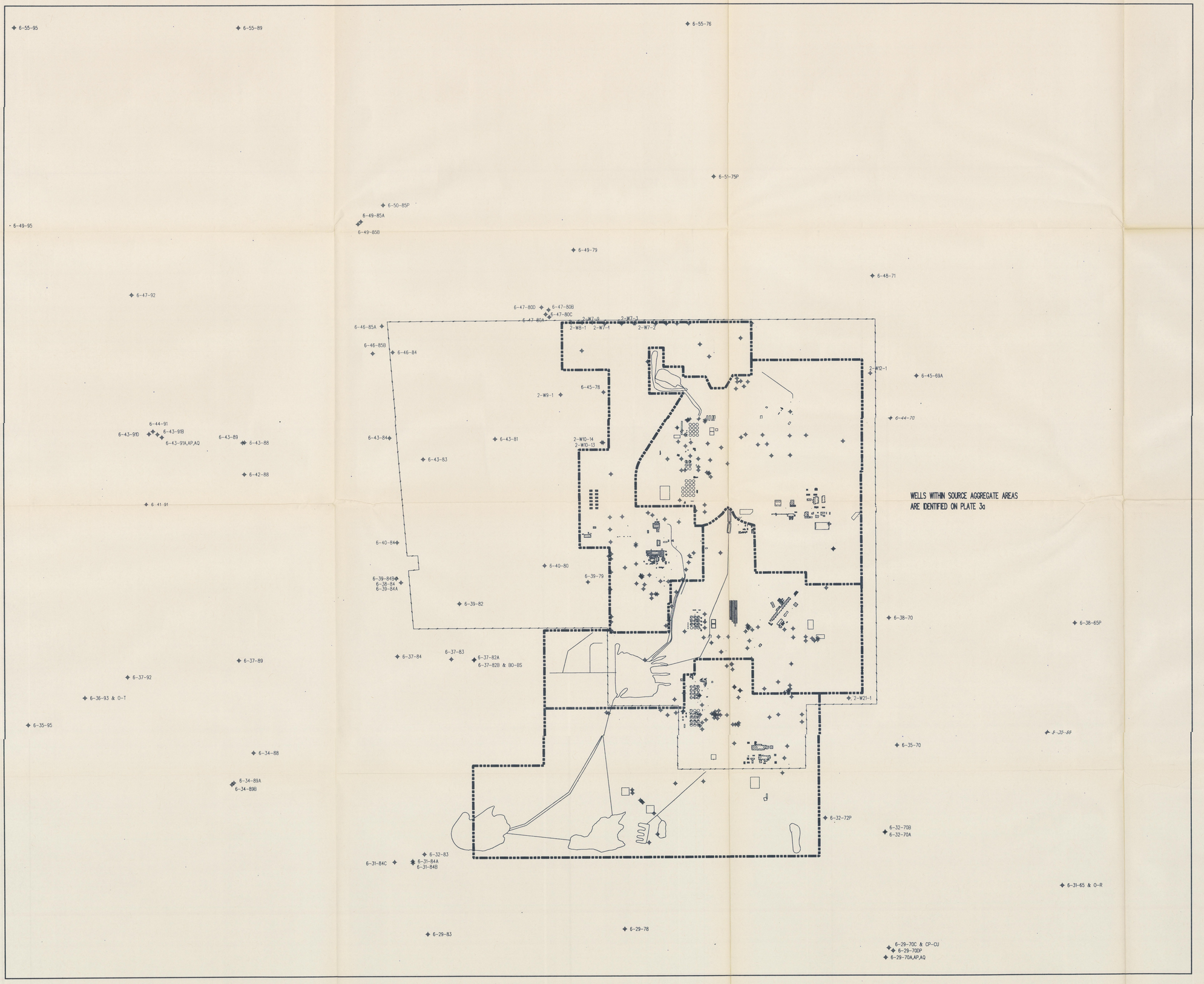
LEGEND

- Aggregate Area Boundary
- Security Systems/Fences
- Perimeter Boundary
- Buildings
- Monitoring Wells (Note: Well numbers have been abbreviated by eliminating the "299" of the first 3-digit numbering code. For example, well "2-W26-2" has the complete number "299-W26-2".)

Scale in Feet
0 1000 2000

Scale in Meters
0 100 500

23057



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Westinghouse Hanford Company
Aggregate Area Management Studies

200 WEST GROUNDWATER
PLATE 3b - Monitor Wells

LEGEND

- Aggregate Area Boundary
- Hazardous Waste Units
- Perimeter Boundary
- Buildings
- Monitoring Wells (Note: Well numbers have been abbreviated by eliminating the "299" of the first 3-digit numbering code. For example, well "2-W26-2" has the complete number "299-W26-2".)

N

Scale in Feet
0 1250 5000

Scale in Meters
0 500 1500

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Aggregate Area Management Studies

200 WEST GROUNDWATER
PLATE 4 - Total Relative Risk Index (RRI) for Carcinogenic Detections

RRI Contours at 1,10,100,1000,10000

Contaminant Data Based on Groundwater Sampling January 1988 - April 1992

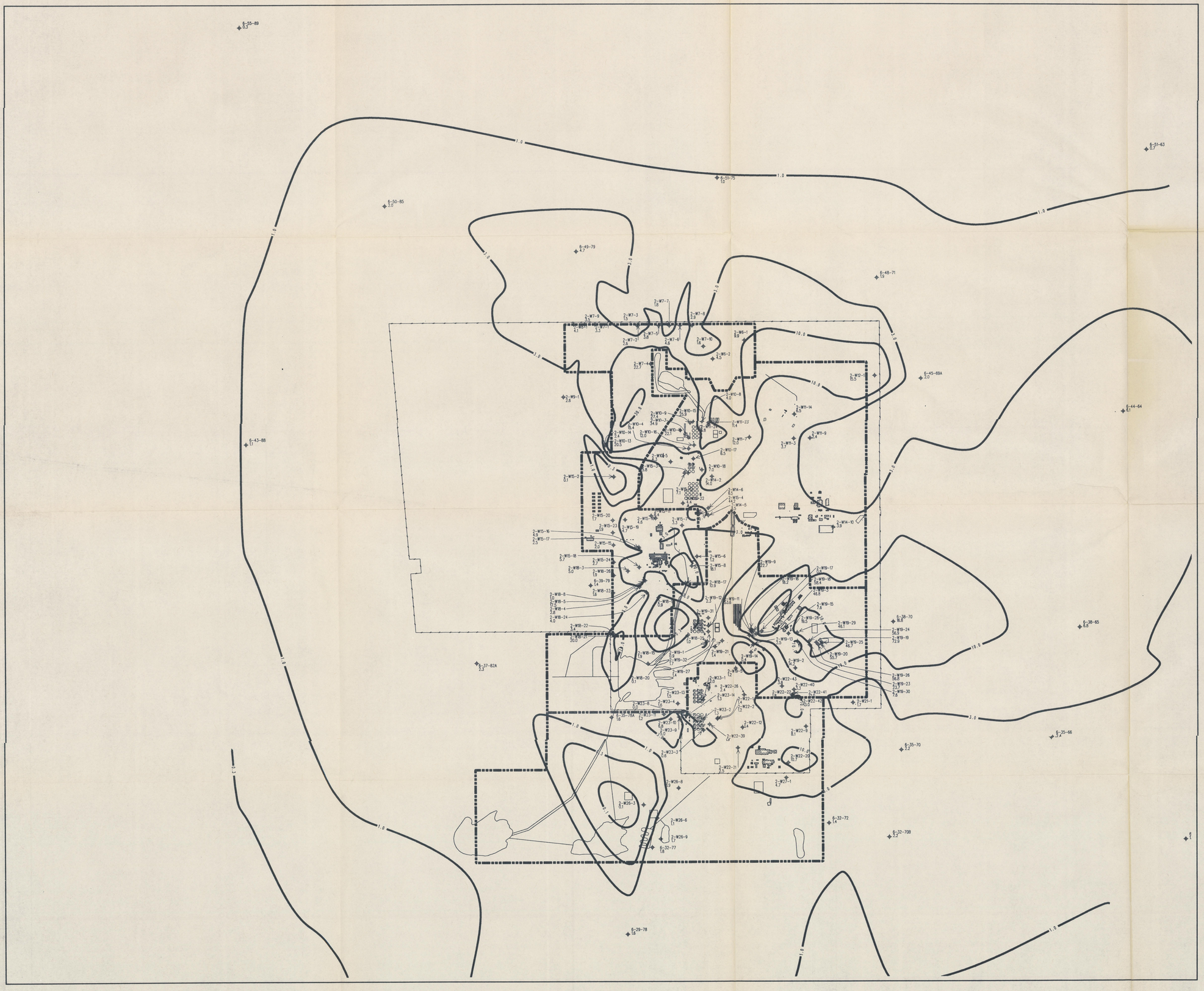
LEGEND

- Aggregate Area Boundary
- Hazardous Waste Units
- Perimeter Boundary
- Buildings
- Monitoring Wells (Note: Well numbers have been abbreviated by eliminating the "299" of the first 3-digit numbering code. For example, well "5-WI16-7" has the complete number "299-W16-7".)

N

Scale in Feet
0 1250 5000

Scale in Meters
0 500 1500



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200 WEST GROUNDWATER
PLATE 5 - Total Relative Risk Index (RRI) for Non-Carcinogenic Detections

RRI Contours at 0.1,0.3,1,3,10,30

Contaminant Data Based on Groundwater Sampling January 1988 - April 1992

LEGEND

- Aggregate Area Boundary
- Hazardous Waste Units
- Perimeter Boundary
- Buildings
- Monitoring Wells (Note: Well numbers have been abbreviated by eliminating the "299" of the first 3-digit numbering code. For example, well "2-W26-2" has the complete number "299-W26-2".)

Scale in Feet
0 1250 5000

Scale in Meters
0 500 1500