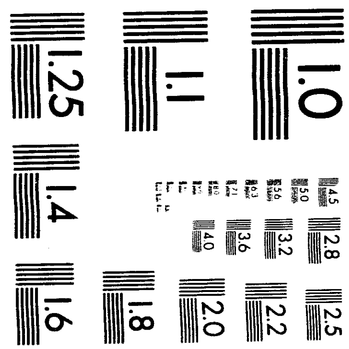

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

1 of 1

WHC-EP-0679

Groundwater Impact Assessment Report for the 284-WB Powerplant Ponds

D. J. Alexander
V. G. Johnson
K. A. Lindsey

Date Published
September 1993

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

Date Received: 9/22/93	INFORMATION RELEASE REQUEST	Reference: WHC-CM-3-4

Complete for all Types of Release

Purpose

[] Speech or Presentation
- [] Full Paper
- [] Summary
- [] Abstract
- [] Visual Aid

(Check only one suffix)

[] Speakers Bureau
[] Poster Session
[] Videotape

[] Reference
[X] Technical Report
[] Thesis or Dissertation
[] Manual
[] Brochure/Flier
[] Software/Database
[] Controlled Document
[] Other

ID Number (include revision, volume, etc.)
WHC-EP-0679, Rev. 0

List attachments.
N/A

Date Release Required
September 24, 1993

Title Groundwater Impact Assessment Report for the 284-WB Powerplant Ponds

Unclassified Category UC-630

Impact Level 3

New or novel (patentable) subject matter? [X] No [] Yes
If "Yes", has disclosure been submitted by WHC or other company?
[] No [] Yes Disclosure No(s).

Information received from others in confidence, such as proprietary data, trade secrets, and/or inventions?
[X] No [] Yes (Identify)

Copyrights? [X] No [] Yes
If "Yes", has written permission been granted?
[] No [] Yes (Attach Permission)

Trademarks?
[X] No [] Yes (Identify)

Complete for Speech or Presentation

Title of Conference or Meeting
N/A

Group or Society Sponsoring

Date(s) of Conference or Meeting

City/State

Will proceedings be published? [] Yes [] No
Will material be handed out? [] Yes [] No

Title of Journal

CHECKLIST FOR SIGNATORIES

Review Required per WHC-CM-3-4	Yes	No	Reviewer - Signature Indicates Approval: Name (printed)	Signature	Date
Classification/Unclassified Controlled Nuclear Information	[]	[X]			
Patent - General Counsel	[]	[X]	Approval per telecon		9/22/93
Legal - General Counsel	[]	[X]			
Applied Technology/Export Controlled Information or International Program	[]	[X]			
WHC Program/Project	[X]	[]	D. R. Speer	(signature)	9-22-93
Communications	[]	[X]			
RL Program/Project	[X]	[]	M. J. Furman	(signature)	9/21/93
Publication Services	[X]	[]	M. J. Van Vleet	(signature)	9/22/93
Other Program/Project	[]	[X]			

Information conforms to all applicable requirements. The above information is certified to be correct.

	Yes	No
References Available to Intended Audience	[X]	[]
Transmit to DOE-HQ/Office of Scientific and Technical Information	[X]	[]

Author/Requestor (Printed/Signature) Date
D. J. Alexander (signature) 9-21-93

Intended Audience
[] Internal [] Sponsor [X] External

Responsible Manager (Printed/Signature) Date
D. G. Horton (signature) 9/23/93

INFORMATION RELEASE ADMINISTRATION APPROVAL STAMP

Stamp is required before release. Release is contingent upon resolution of mandatory comments.

D.B. 9/23/93

Date Cancelled

Date Disapproved

Document Title: Groundwater Impact Assessment Report for the 284-WB Powerplant Ponds

Prepared by: D. J. Alexander — 9-21-93 Date
D. J. Alexander
Geosciences Function
Environmental Division

Technical Review by: D. K. Tyler — 9/23/93 Date
D. K. Tyler
Geosciences Function
Environmental Division

Approved by: K. R. Fecht — 9/23/93 Date
K. R. Fecht, Manager
Geosciences Function
Environmental Division

Dwayne R. Speer — 9-22-93 Date
D. R. Speer, Program Manager
Liquid Effluent Interim
Compliance

This page intentionally left blank.

EXECUTIVE SUMMARY

As required by the *Hanford Federal Facility Agreement and Consent Order*[1] (Tri-Party Agreement Milestone M-17-00A), this report assesses the impact of wastewater discharged to the 284-WB Powerplant Ponds on groundwater quality. The assessment reported herein expands upon the initial analysis conducted between 1989 and 1990 for the *Liquid Effluent Study Final Project Plan*.[2]

Facility Description

The 284-WB Powerplant Ponds, located in the west-central 200 West Area, have been in use since 1984 to dispose of liquid effluents from the 284-W Powerplant. The 284-W Powerplant produces steam for plant operations in conventional coal-fired boilers. Wastewater consists chiefly of once-through cooling water used in the powerplant. Other wastewater sources include boiler blowdowns, filter backwash, and water softener regenerant (approximately 9% sodium chloride). Powerplant operations include three operating modes: routine operations, water softener regeneration, and boiler blowdown. Wastewater discharge volumes fluctuate depending on operating mode. Overall long-term average discharge is approximately 150 gal/min. After June 1995, discharges to the ponds are scheduled to cease and powerplant effluent will be rerouted to the Treated Effluent Disposal Facility, which will be situated east of the 200 East Area.

---

[1]Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

[2]WHC, 1990, *Liquid Effluent Study Final Project Plan*, WHC-EP-0367, Westinghouse Hanford Company, Richland, Washington.

Impact Assessment

There are no local hydrogeologic or groundwater chemistry data available to directly support this assessment. Effluent data, vadose zone transport predictions, and circumstantial evidence suggest the 284-WB Powerplant Ponds contribute both directly and indirectly to groundwater contamination in the 200 West Area. The most likely groundwater contaminants are chloride, fluoride, and possibly barium from disposal of water softener regenerant. Process improvements are expected to reduce this source in the near future. Mobilization of radioactive constituents in the soil column beneath the ponds before their construction, and/or interaction of perched water from the ponds with adjacent sources is possible, but the magnitude and extent are unknown. Discharge of water to the ponds now represents a substantial portion of the artificial recharge to the 200 West Area, therefore some hydraulic influence on local groundwater flow paths is likely. The distribution pattern for chloride in groundwater provides an indication of the widespread influence of pond operations on water movement in the north-central 200 West Area.

Conclusion

Continued short-term operation of the 284-WB Powerplant Ponds will contribute to groundwater contamination in the 200 West Area. However, the existing groundwater contamination from past-practice sources has greater potential significance than the contribution from the ponds. The groundwater monitoring network for this facility is inadequate. Characterization and remediation activities conducted under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[3] program should consider

[3]*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.

the influence of the pond on distribution of contaminants in the 200 West Area. If discharges to the pond continue past the June 1995 cessation date, a vadose and groundwater monitoring network should be installed. Installation of any wells would have to be coordinated through existing 200 West Area operable unit work plans (T Plant, Z Plant, and/or U Plant), as the 284-WB Powerplant Ponds are located near the confluence of these operable units.

This page intentionally left blank.

CONTENTS

LIST OF FIGURES

FIGURES (cont)

LIST OF TABLES

LIST OF TERMS

CRBG	Columbia River Basalt Group
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ppb	parts per billion
ppm	parts per million
RL	Richland Operations Office
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
277-W Complex	277-W Fabrication and Machine Shops
284-W	284-W Powerplant
284-WB Ponds	284-WB Powerplant Ponds
WTF	Waste Treatment Facility
WWQS	Washington Water Quality Standards

GROUNDWATER IMPACT ASSESSMENT REPORT FOR THE 284-WB POWERPLANT PONDS

1.0 INTRODUCTION

Groundwater impact assessments are required for a number of liquid effluent receiving sites according to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) milestones M-17-00A and -00B, as agreed upon by the U.S. Department of Energy (DOE), the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (EPA) (Ecology et al. 1991). This report assesses the impacts to groundwater from the disposal of effluent to the 284-W Powerplant (or Powerhouse, the terms are used interchangeably) Ponds (284-WB Ponds) in the 200 West Area.

1.1 BACKGROUND

In response to public comments on the original Tri-Party Agreement, and at the request of the signatories on the Tri-Party Agreement, the DOE, Richland Field Office (RL) conducted a study to assess the impact of liquid effluents discharged to the ground at the Hanford Site (WHC 1990a, 1990b). The EPA and Ecology expressed concerns regarding uncertainties in the evaluations made by RL. Foremost among these concerns were the lack of site-specific data, the need to consider interactions with adjacent liquid discharge facilities, and the need for more rigorous models of contaminant transport. Because of these concerns, the RL, Ecology, and EPA (the three parties) created a series of Tri-Party Agreement milestones, including M-17-00A, M-17-00B, M-17-13, and M-17-13A, which pertain to groundwater impact assessments.

The Tri-Party Agreement milestones M-17-00A and M-17-00B require impact assessments for Phase I and II waste streams. Phase I and II waste streams are defined in Stordeur and Flyckt (1988). Effluents discharged to the 284-WB Ponds were defined as a Phase II waste stream. Tri-Party Agreement milestone M-17-13 required the development of a methodology for assessing the impact of liquid effluent discharge on groundwater, which resulted in the document *A Methodology for Assessing Impacts to Groundwater from Disposal of Liquid Effluent to the Soil at the Hanford Site* (Tyler 1991). Thirty days after regulatory approval of the methodology document, as required by Tri-Party Agreement milestone M-17-13A, a schedule for performing the assessments at 13 receiving sites was completed. The 284-WB Ponds are identified in the schedule as one of the receiving sites to undergo a groundwater impact assessment.

1.2 METHODOLOGY

The methodology presented in Tyler (1991) was followed in preparing the groundwater impact assessment for the 284-WB Ponds. Tyler (1991) included the categorization of each of the 13 receiving sites into one of three levels based on the amount of effort needed to perform the assessment. A level 1 receiving site groundwater impact assessment relies on available information. A groundwater impact assessment of a level 2 receiving site may require nonintrusive field work to verify the extent of existing contamination. A level 3 site may require intrusive field work. If it is discovered that existing information is inadequate through the course of performing a level 1 impact assessment, the assessment may be raised to a level 2 or 3 assessment.

The methodology document (Tyler 1991) outlines several tasks to be conducted as part of the groundwater impact assessment for level 1 receiving sites:

- Prepare and present plan describing how the groundwater assessment will be conducted
- Characterize the liquid effluent stream
- Evaluate the site-specific hydrogeology
- Develop a site conceptual model
- Assess the hydrologic impact of the liquid effluent stream
- Assess the contaminant impact of the liquid effluent stream
- Evaluate the adequacy of the existing monitoring well network
- Prepare a written report of the results.

The tasks required for level 2 and 3 receiving sites are similar to those outlined above, but also include field work-related activities. The 284-WB Ponds were categorized as a level 1 receiving site on the basis of the low hazard potential of the wastewater (Tyler 1991).

Several key assumptions inherent to all groundwater impact assessments are explained in the methodology document (Tyler 1991) and warrant summarizing here. For this impact assessment, the following assumptions are relevant.

- The expected level of impact from use of the receiving site determines how well the chemistry, geology, and hydrology need to be understood.
- Modeling sophistication is tailored to available information and the expected level of impact of the receiving site.
- Historical data are fully useable.

2.0 FACILITIES DESCRIPTION

2.1 LOCATION

The Hanford Site is a 1,450-km^2 (560-mi^2) tract of land located in Benton, Franklin, and Grant Counties in the south-central portion of Washington State. The 200 West Area is located in the west-central part of the Hanford Site, approximately 37 km (23 mi) northwest of the city of Richland (Figure 1). The 284-WB Ponds are located in the east-central part of the Hanford Site's 200 West Area, approximately 610 m (2,000 ft) west of the 284-WB Ponds (Figure 2). The ponds are elongated in a north-south direction, 183 m (600 ft) long, and 50 ft (15 m) wide at the top. The ponds are divided into a northern lobe approximately 91 m (325 ft) long; and a southern lobe approximately 73 m (240 ft) long (Figure 3). Pond depth, from berm top to pond floor, varies between 6 and 7.6 m (20 and 25 ft).

Generally the north pond contains between 0.3 and 0.9 m (1 to 3 ft) of standing water. Currently the south pond is dry. A layer of pebbles and cobbles covers the bottom, sides, and tops of the berms of the ponds. In addition, the bottom of the north pond is carpeted by a layer of coal ash, mud, and algae as deep as 46 cm (18 in.) in places, extending as much as 1 m (3 ft) up the sides of the pond. The north pond also contains a variety of aquatic vegetation and windblown vegetation (e.g., tumbleweeds). The surface of the southern end of the north pond often is covered with floating algae and fragments of unburned coal and coal ash.

A concrete weir box is located approximately 6.7 m (22 ft) north of the pond outfall and spillway. The weir box is 2.4 by 1.5 m (8 by 5 ft) and 3.7 m (12 ft) deep. The effluent line that runs out to the ponds is a 25-cm (10-in.) pipe that discharges from the easternmost end, where the old laundry (2723-W) and fabrication/machine shops (277-W Fabrication and Machine Shops [277-W Complex]) tie in to the powerplant filter plant (283-W). At this point it increases to a 91-cm (36-in.) line that runs from the filter plant (283-W) to where the reservoir (282-W) ties in. A 107-cm (42-in.) line (Figure 4) extends from the reservoir (282-W) to the weir box north of the ponds. There are six manholes along the length of the line. The effluent line route, the manholes along the line, and the weir box are all posted "Caution - Underground Radiation." The pond outfall and spillway, and the ponds themselves are not posted. The outfall consists of four 51-cm (20-in.) steel pipes; these pipes are set into the southern concrete wall of the weir box on the north end, span the 6.7 m (22 ft) of soil column to the pond, and are set in the concrete wall of the pond outfall on their southern end.

2.2 HISTORY AND FACILITIES

Before construction the site now occupied by the ponds formed the head end of the 216-U-14 Ditch. At this location the 216-U-14 Ditch received waste streams from the laundries (2723-W and 2724-W), mask cleaning station (2723-W), fabrication shops (277-W Complex), and the powerplant facilities (284-W, 283-W, and 282-W). The old laundry (2723-W) operated from 1944 to

Figure 1. Location of the 200 West Area on the Hanford Site.

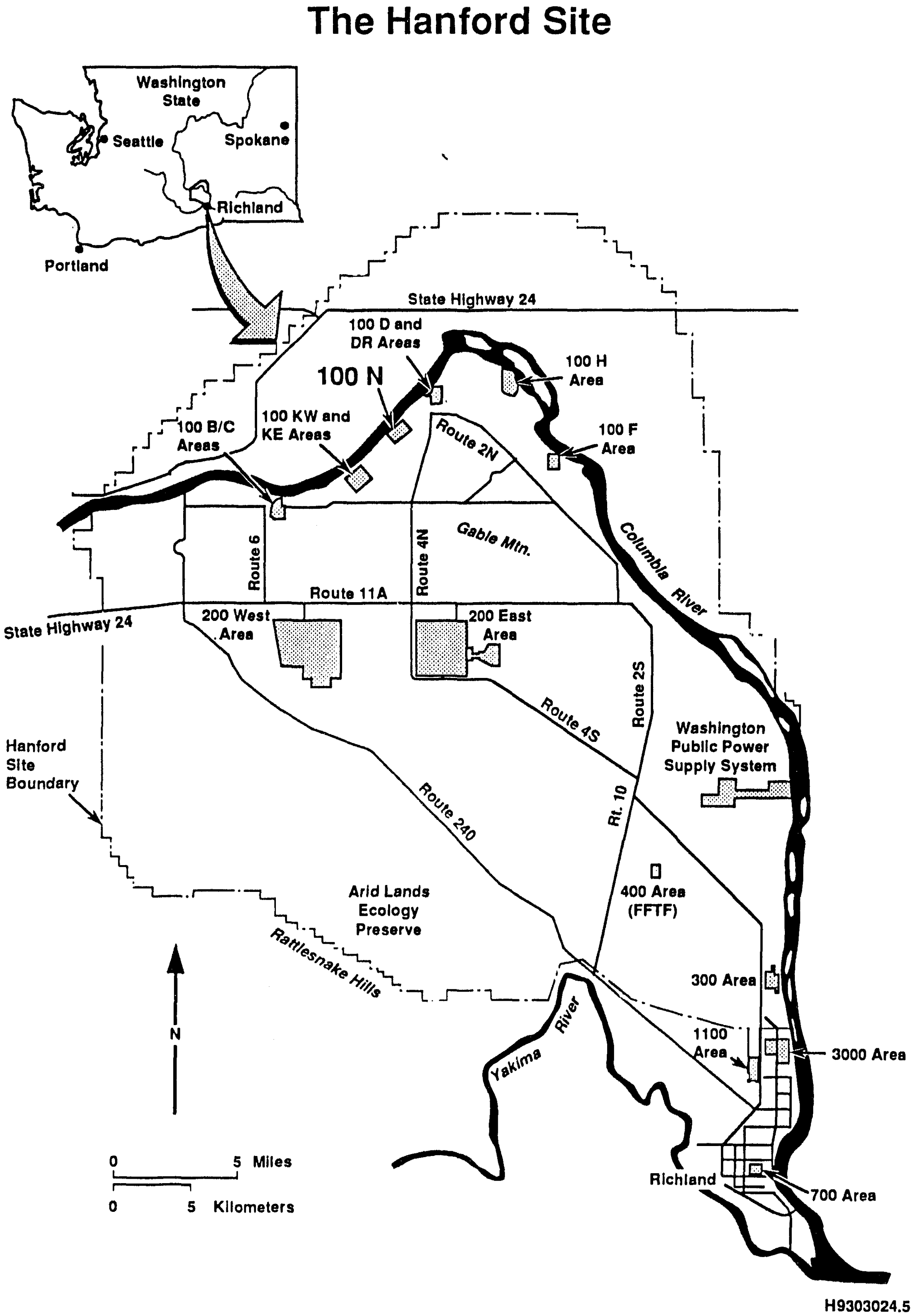


Figure 2. Location of the 284-WB Powerplant Ponds in the 200 West Area.

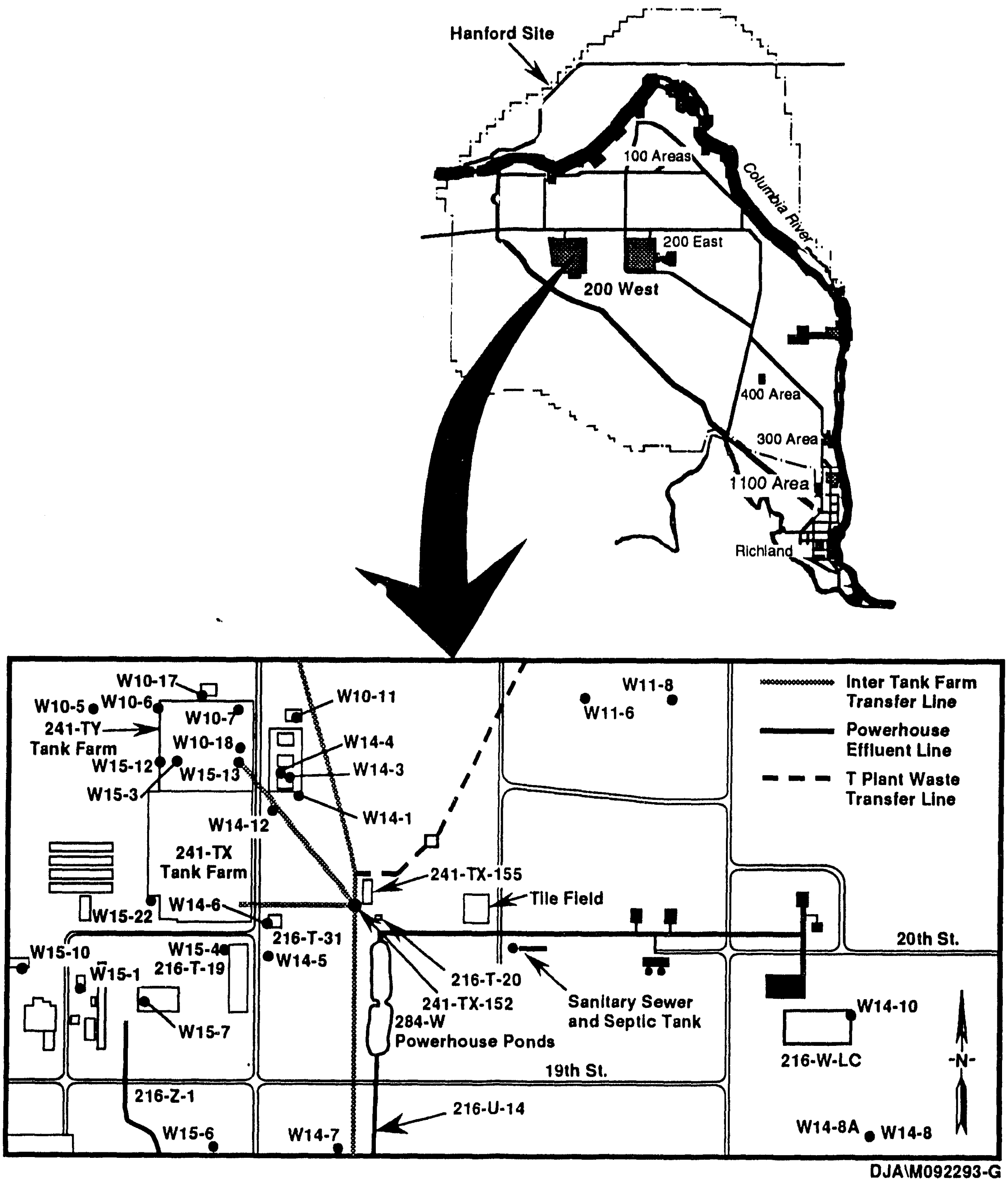
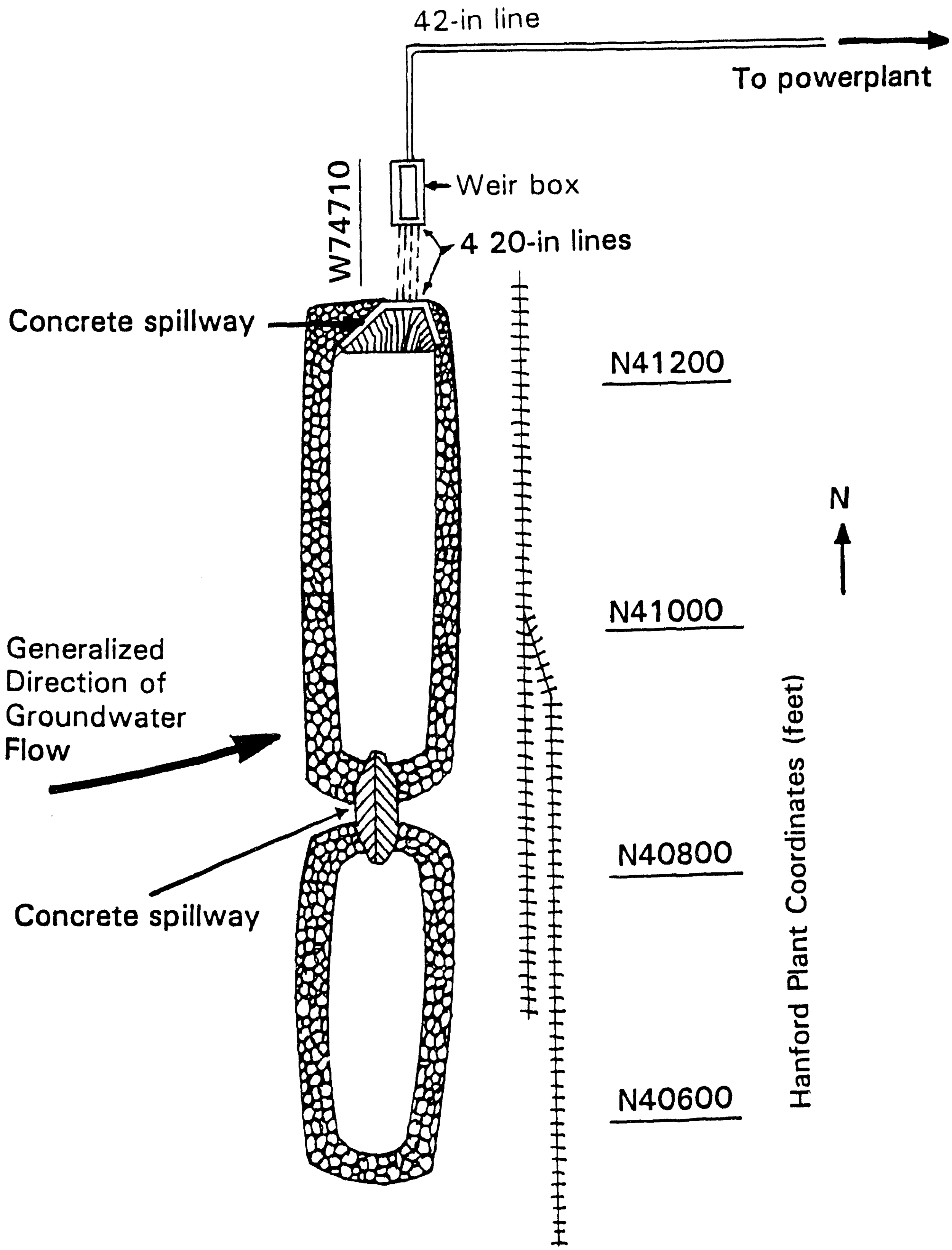


Figure 3. Plan View of the 284-WB Powerplant Ponds.



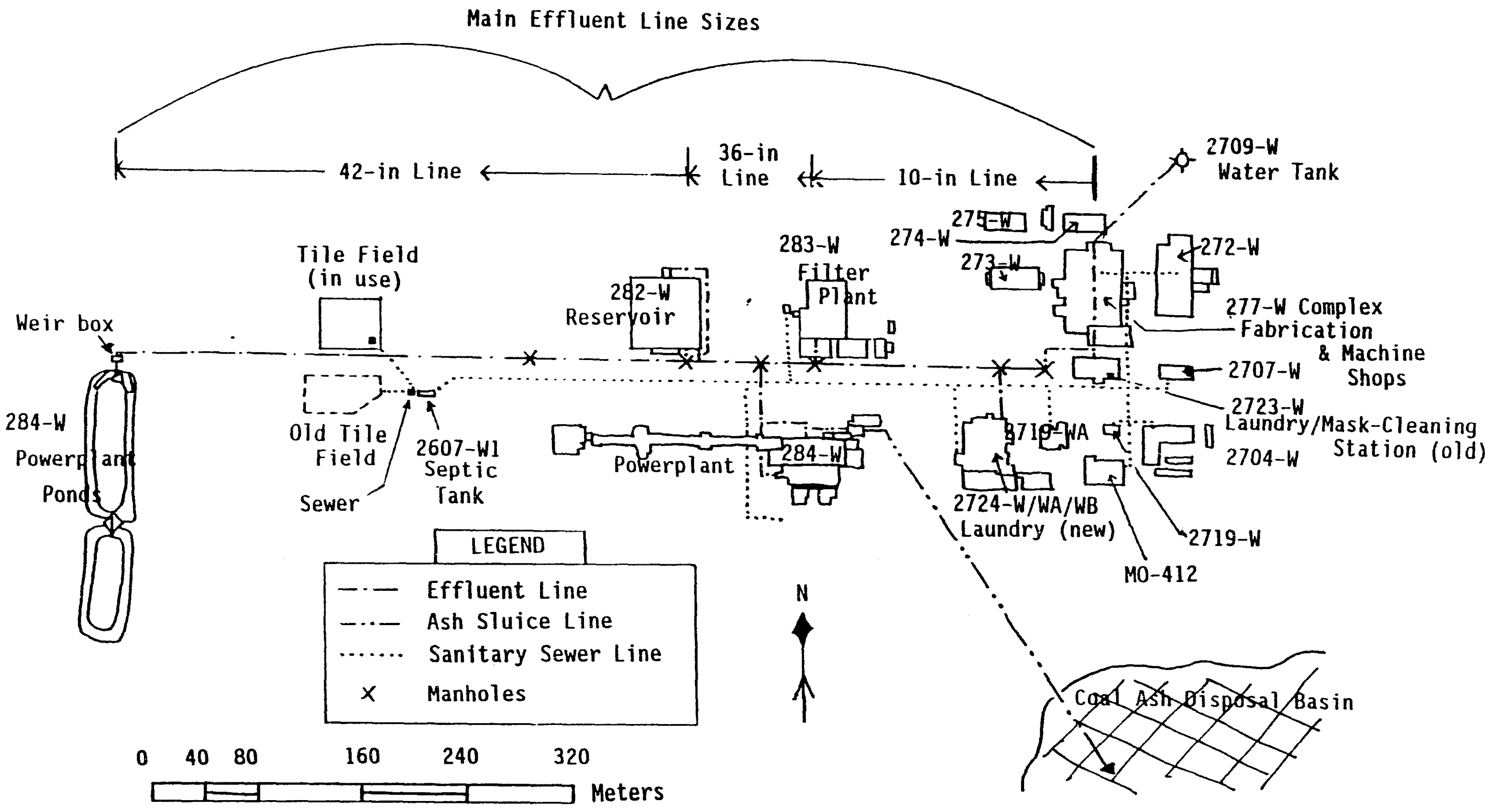


Figure 4. Schematic of 284-W Powerplant Effluent Line.

1952. In 1952, the old laundry became the mask cleaning station, when the new laundry (2724-W) began operations. Over the years, the laundry (2724-W) has expanded to include annexes 2724-WA and 2724-WB.

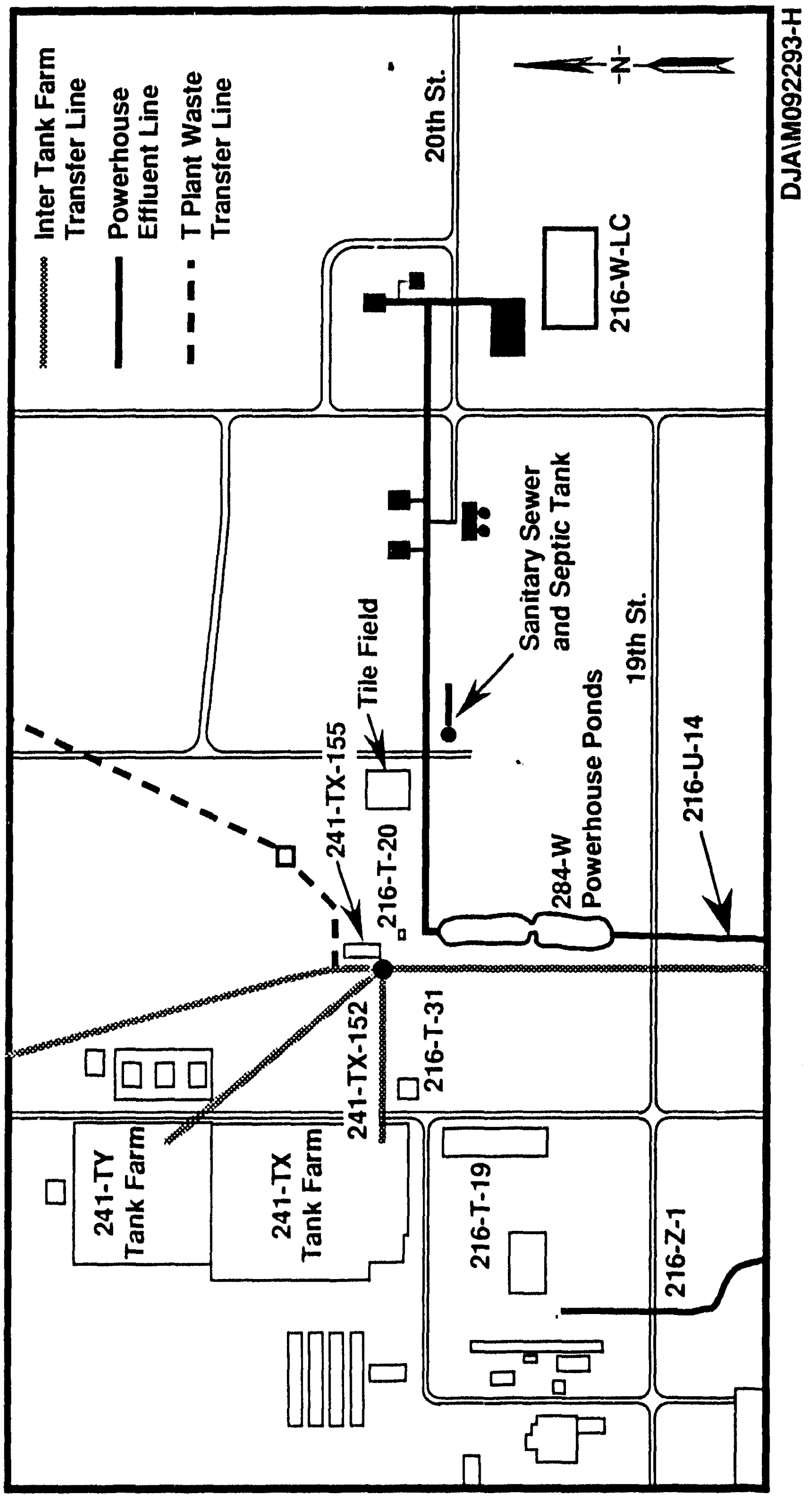
Based on construction specifications (KEH 1982, RHO 1983) the ponds were built directly upon the head end of 216-U-14 Ditch. According to pond construction specifications, a minimum of 0.3 m (1 ft) of potentially contaminated 216-U-14 Ditch soil was removed from the portion of the ditch that the ponds would eventually occupy. The contaminated soil was to be placed in the 216-U-14 Ditch (south of the pond location and north of 16th Street) as backfill material. Clean fill was placed over the backfill and the area revegetated to control contamination. The length of the 216-U-14 Ditch backfilled was posted as "Subsurface Contamination" per the radiological controls required at that time (KEH 1982). In addition, the 91- and 107-cm (36- and 42-in.) effluent pipes and manholes were scoured, cleaned, and decontaminated using a "hydroblast technique" (Power Master Company, Portland, Oregon). This technique used high-pressure (68,950,000 N/m^2 [10,000 psi] feed pressure) water jets to scour the surface of the concrete, brick, mortar, and pipes. The nozzle head was designed so the water jets are placed to push all the scour and fill debris backwards through the system to where it is eventually removed. The pipeline remains posted as "Underground Contamination" (because of fixed radiological contamination), but posting of the ponds was not necessary. While it appears that the residual near-surface contamination was removed as stated above, there are no records (that could be found at this time) to verify these statements. However, the radiological posting in this area is in concurrence with the statements above.

The ponds have been used continuously since their completion in 1984. Two main facilities have contributed effluent to the pond since its construction, the 284-W Powerplant and the 277-W Complex, which are located across Beloit Avenue to the northeast of the powerplant (Figures 4 and 5). The effluent line, which feeds the ponds today, is the same line that fed into the head end of the 216-U-14 Ditch before pond construction. When the ponds were constructed this line was modified to discharge to the ponds. Concrete wing walls were added to the existing concrete wall and effluent pipe outfall (KEH 1982; RHO 1983). Although the effluent stream is considered "clean" or nonradiological in nature, the effluent discharge line is still posted as "Underground Radiological Contamination" along its entire length because of the continued presence of "fixed" contamination.

Several other facilities are located within the immediate area (within a 152-m [500-ft] radius) of the 284-WB Ponds.

- A number of tank farm transfer lines converge at the location of two diversion boxes located 62 m (200 ft) north/northwest of the north end of the ponds (see Figure 5). Diversion Box 241-TX-155 is weatherproofed and isolated from the transfer piping system. The other diversion box, 241-TX-152, is still in service and all of its valves/lines can be traced and accounted for on the master board in Building 272-WA. Subsurface contamination warnings are posted along these tank farm transfer lines and at the diversion boxes. In the spring of 1954, a leak occurred from one of the jumpers in Diversion

Figure 5. Location of Effluent Lines and Other Structures in the Vicinity of the 284-WB Powerplant Ponds.



Box 241-TX-155, which caused an area 3 by 31 m (30 by 100 ft) west of the diversion box to become contaminated (Table 1). This area was covered with clean soil and temporarily posted as a radiation zone. Other unplanned releases are related to these diversion boxes (see Figure 5 and Table 1).

- The 216-T-20 Trench (also known as the 216-T-20 Crib) is located between these diversion boxes and the ponds (see Figure 5). This trench measures 3 by 3 by 1.2 m (10 by 10 by 4 ft). In November 1952, the trench was excavated to receive waste solution from the Diversion Box 241-TX-155 catch tank. The trench received 18,900 L (5,000 gal) of nitric acid contaminated with radionuclides (Table 2). The trench was deactivated the same month by backfilling the trench with about 0.9 m (3 ft) of clean soil and removing all aboveground piping. At that time the trench was also fenced off and posted with radiation zone signs. However, the fence and all aboveground markings of this trench are no longer present at the site.

- A 49 by 61 m (160 by 200 ft) sanitary tile field is located 152 m (500 ft) east of the ponds (see Figure 5). The sewer and septic tank (2706-W1) associated with this tile field are located 37 m (120 ft) southeast of the tile field, and 219 m (720 ft) east of the north pond. The sanitary sewer effluent line runs parallel (approximately 9 m [30 ft]) to the powerplant pond effluent line on the south side, along its entire length (from the east of the 2723-W Building to the septic tank). A former tile field is shown on maps that date from the 1950's, located just south of the current tile field (see Figure 5). This tile field is no longer marked above ground; the entire area is covered with gravel, and is sometimes used as an area to park equipment from nearby garage and maintenance buildings.

Table 1. Summary of Unplanned Releases Near the 284-WB Powerplant Ponds (adapted from DOE-RL 1992a).

Unplanned Release No.	Location (operable unit)	Date	Associated waste management unit	Report waste - related history
UN-200-W-113	213 m (700 ft) east of the 241-TX Tank Farm, just north of the 241-TX-155 Diversion Box (200-TP-2)	Mid-1950's	NA	• Discovered in 1977, when radioactive rabbit feces were found near diversion box • After soil removal, radioactivity increased and source believed to be a leak in a waste transfer line • Acid spill from diversion box catch tank is a possible influence • Stabilized with clean gravel • Area is stabilized with soil, sown with grass, and posted with underground radiation hazard signs
UN-200-W-135	46 m (150 ft) northwest of the 241-TX-155 Diversion Box (200-TP-2)	04/05/54	NA	• Failure of the jumper in the diversion box allowed liquid to flow along the encasement and exit on the hillside • Approximately 3,785 L (1,000 gal) of supernatant leaked; WIDS document estimates 1,699 m^3 (60,000 ft^3) • Dose rate of 5 r/h; 2.5 r/h at 0.6 m (2 ft) • Access roads barricaded until contamination was covered, area sealed, and covered with earth
UPR-200-W-5	Hillside to the west of the 216-T-20 Trench (200-TP-2)	1950	241-TX-155 Diversion Box	• Resulted from leaky jumpers or overflow and contaminated soil around the diversion box • Area around the diversion box was covered with clean soil • Presently the diversion box is coated with weather-proofing foam • Light chain barricade with surface contamination placards surrounds the diversion box
UPR-200-W-28	West of the 241-TX-155 Diversion Box (200-TP-2)	Spring 1954	241-TX-155 Diversion Box	• Resulted from leaky jumpers or overflow and contaminated soil around the diversion box • Area around the diversion box was covered with clean soil • Presently the diversion box is coated with weather-proofing foam • Light chain barricade with surface contamination placards surrounds the diversion box
UPR-200-W-131	1.5-m (5-ft) diameter around the 241-TX-155 Diversion Box risers (200-TP-2)	03/13/53	241-TX-155 Diversion Box	• Resulted from leaky jumpers or overflow and contaminated soil around the diversion box • Area around the diversion box was covered with clean soil • Light chain barricade with surface contamination placards surrounds the diversion box

NA = not applicable.
UN = release is treated as a distinct waste management unit for remediation purposes.
UPR = sites are not treated individually, but as part of closely related units already covered by the Hanford Federal Facility Agreement and Consent Order (Ecology et al. 1991).
WIDS = Waste Information Data System.

Table 2. Radionuclide Content of the 216-T-20 Trench (Maxfield 1979).

Radionuclide	At time of discharge	As of 06/30/77
Plutonium (g)	None	None
Beta activity (Ci)	50	<2.24
Strontium-90 (Ci)	0.99	0.54
Ruthenium-106 (Ci)	2.1	6.9 E-08
Cesium-137 (Ci)	1.1	0.60
Cobalt-60 (Ci)	None	None
Uranium (kg)	5.0	5.0

3.0 EFFLUENT CHARACTERISTICS

3.1 LAYOUT AND SYSTEM OPERATION

Water drawn from the Columbia River at the 100-B or 100-D Areas is pumped to a 94,635,000-L (25,000,000-gal) reservoir located in the 100 Areas (Figure 6). Water is then pumped from this reservoir to the 11,356,000-L (3,000,000-gal) 282-W Reservoir in the 200 West Area (Figures 6 and 7). Water from the 282-W Reservoir is pumped to the 283-Waste Treatment Facility (WTF) where alum is added to the water to neutralize electrically charged suspended particles and colloids. The alum-treated water is sent through one of five flocculation basins and then into a settling basin. Overflow from the settling basin is filtered through one of four gravity-feed multimedia filters, consisting of four layers of material (ceramic, gravel, sand, and anthracite, from bottom to top, respectively). The filters are backflushed four times a month to remove filtered materials and solids. The wastewater from these flushes flows into the combined wastewater stream that discharges to the 284-WB Ponds. The clean, filtered water from the 283-W WTF is then chlorinated and stored in two covered clearwells, with a total capacity of 1,514,160 L (400,000 gal). This treated water provides potable water to the 200 West Area (Herman 1992).

The 284-W Powerplant is a coal-fired steam plant that provides steam for 200 West Area operations. In total, four facilities contribute to the process wastewater stream: the 284-W Powerplant, the 283-WTF, the 282-W Reservoir, and the 277-W Complex. In the past only the 284-W Powerplant wastestream has been sampled. Under the new *Sampling and Analysis Plan for the 284-W Area Powerplant and 277-W Fabrication Shop Process Wastewater Streams* (284-W SAP) (Herman 1992), all the streams will be sampled and a new baseline established.

Effluent stream information is summarized in Table 3 (WHC 1990a). Key constituents are given in Table 4 and loading estimates are provided in Table 5 (WHC 1990a). Discharge from the four sources mentioned above converge near the 284-W Powerplant and then flow down the same pipeline to the ponds (see Figure 7). The sample point for effluent to the ponds (used for the *Liquid Effluent Study Final Project Report* [WHC 1990a]) is located downstream of this confluence. Consequently, contributions from the four facilities could not be differentiated for this assessment report.

3.2 DISCHARGE VOLUME AND FLOW RATE

Past-practice discharge volumes and flow rates from the head end of the 216-U-14 Ditch are difficult to determine. The facilities that contributed to the effluent stream, namely the 284-W Powerplant, the 277-W Complex, the 283-W WTF, the 282-W Reservoir, and the 2723-W and 2724-W Laundries, did not keep facility-specific records of discharges. Before 1968, records of discharge were documented in the 216-U-10 Pond (U Pond) inventory. The flow rates for the U Pond system before 1968 (which included several other discharge sources), are shown in Figure 8.

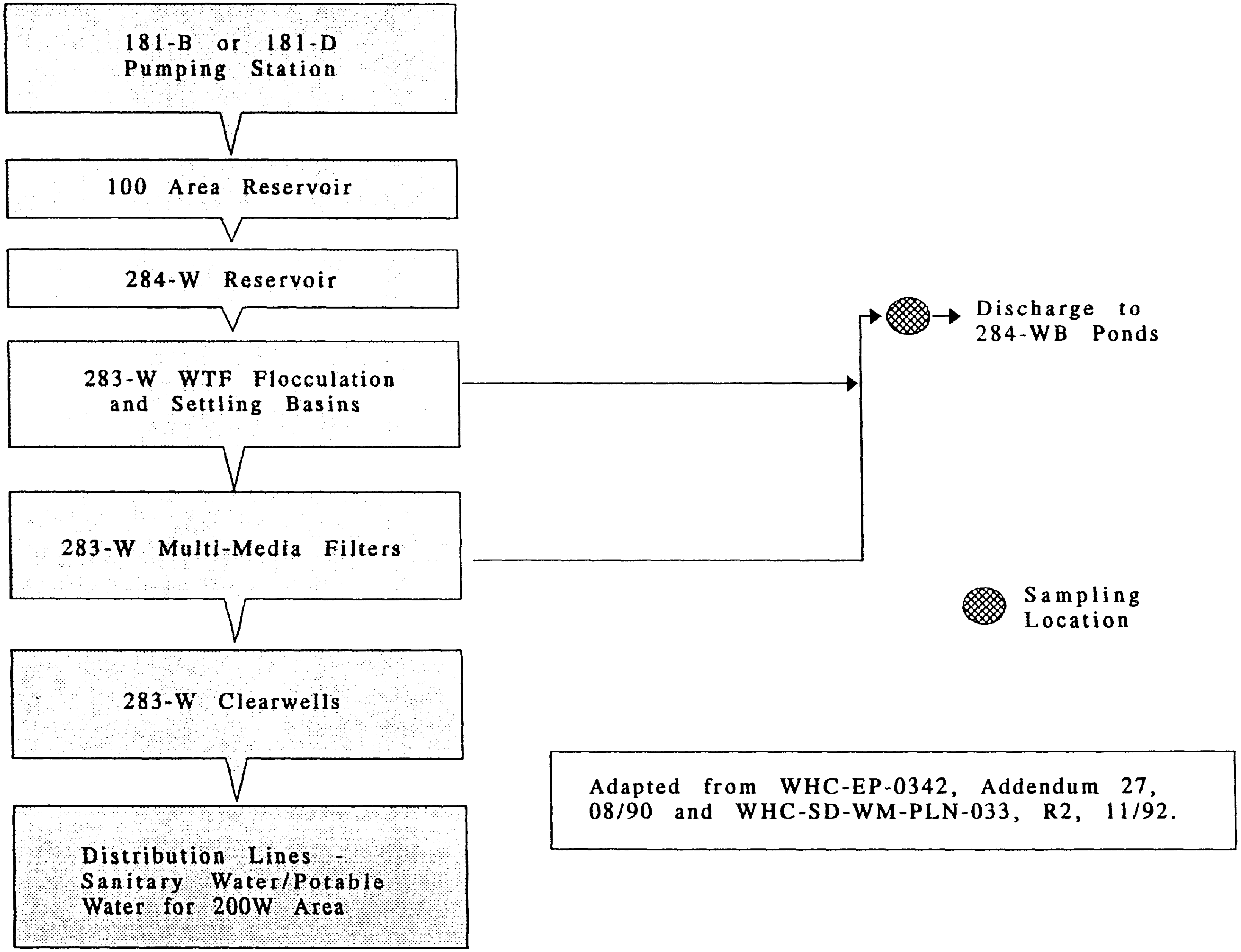


Figure 6. Flow Schematic of the 284-W Water Treatment Facility.

Figure 7. Map of Facilities and Monitoring Wells Near the 284-WB Powerplant Ponds.

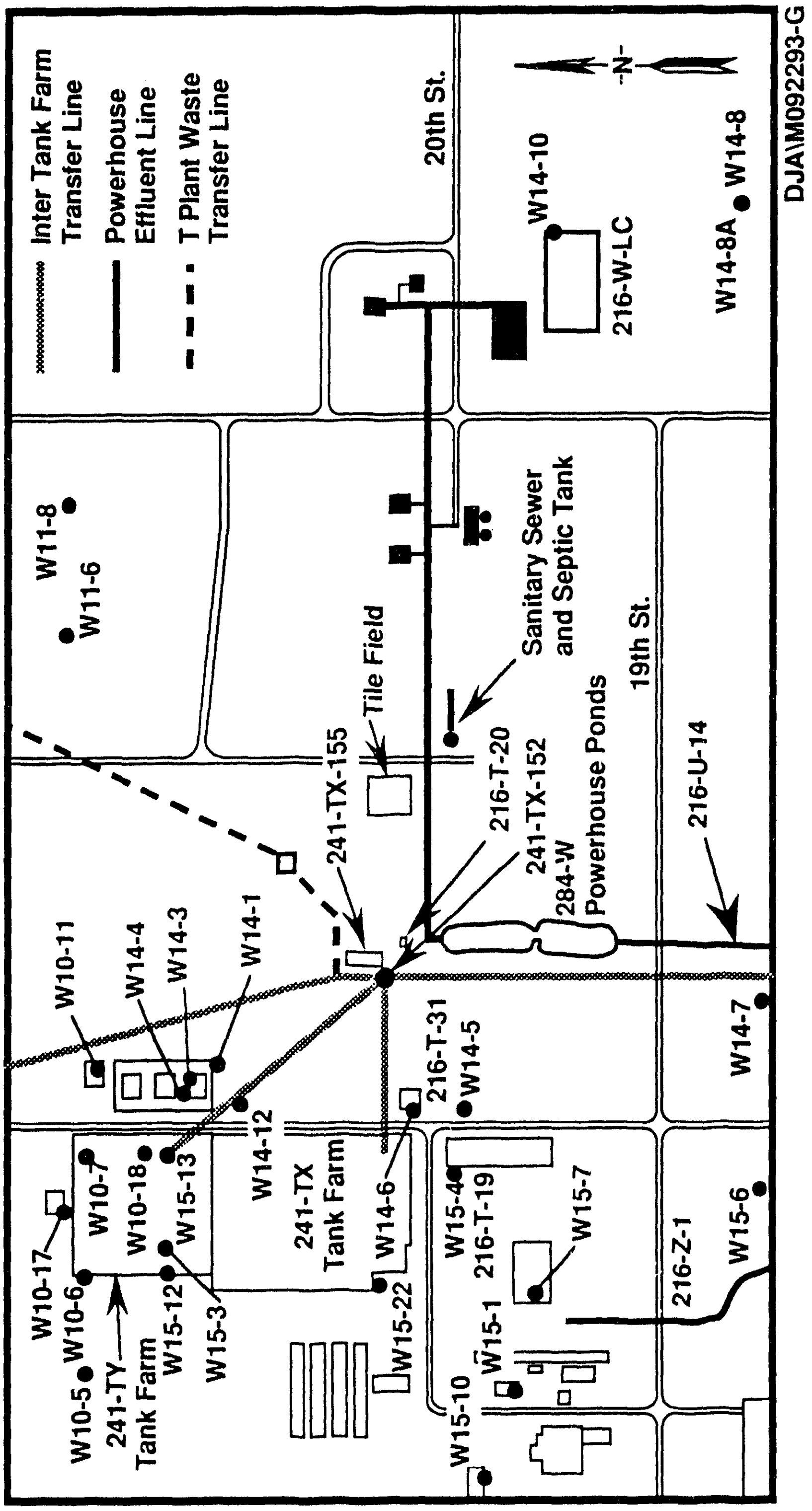


Figure 8. Flow Rates for the 216-U-Pond from 1944 to 1967.

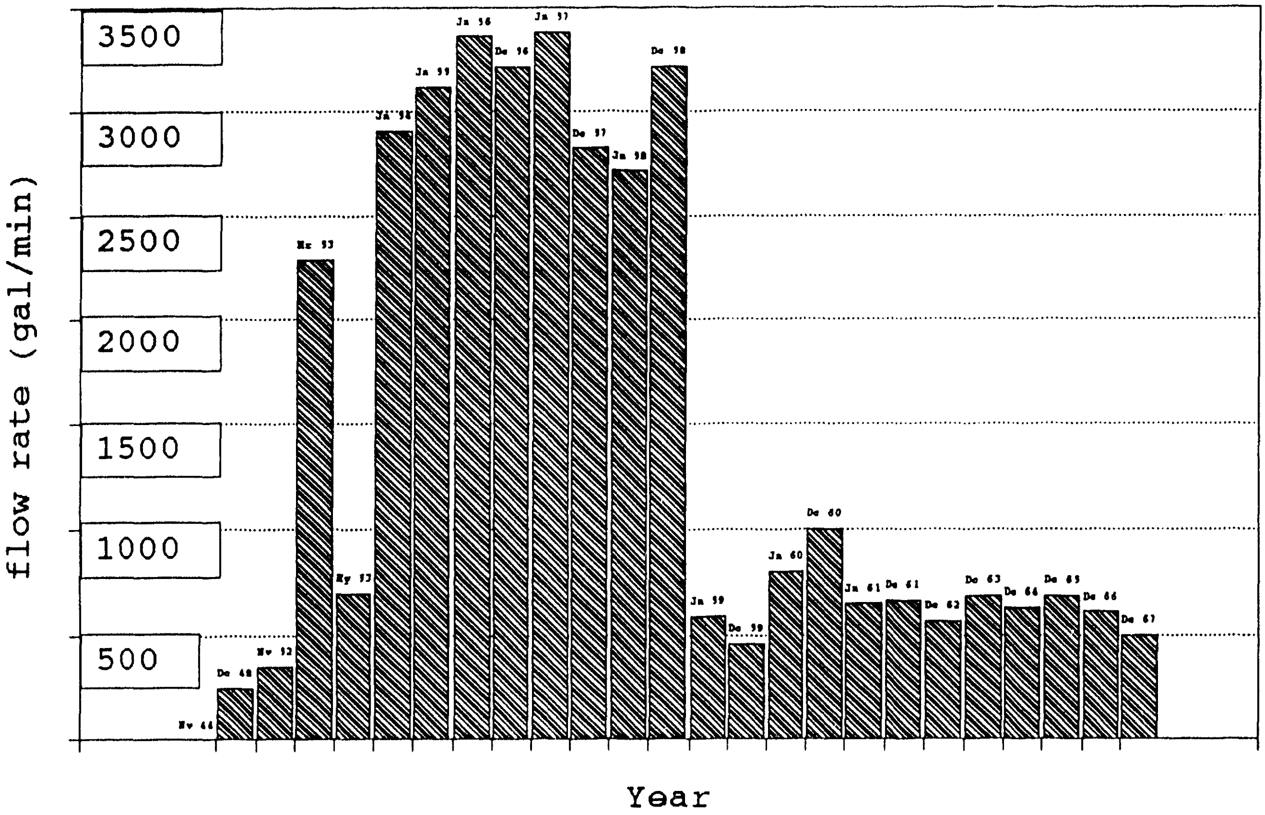


Table 3. Effluent Stream Description, 284-W Powerplant Wastewater (adapted and modified from WHC 1990a).

Total volume of effluent discharged to subject receiving site:	No data available
Average effluent discharge rate, by operating mode (WHC 1990b, Addendum 27)	Routine: 1.23 E+07 L/month Softener regenerate: 5.68 E+05 L/month Blowdown: additional 1.89 E+05 L/month
Current average effluent discharge rate (WHC 1990b, Addendum 27)	1.31 E+07 L/month total average monthly flow rate
Effluent designation (WHC 1990b, Addendum 27)	Nondangerous, nonradioactive
Effluent status	Active discharge to 284-WB Powerplant Ponds

Table 4. Effluent Stream Sampling Data, 284-W Powerplant Wastewater (WHC 1990a) (2 sheets).

Key constituents	Detection limit[a]	Detection/ analyses	Sample concentration (90% confidence interval)
September 1985 to January 1987, during blowdown			
Aluminum	NA	4/5	550
Iron	30	5/5	980
November 1987 to April 1988, during water softener regeneration			
Aluminum	NA	1/4	830
Barium	6	4/4	75,000
Chloride	500	4/4	61,000,000
Fluoride	50	3/4	150,000
Lead	5	2/4	170
Manganese	5	3/4	380
July 1988 to March 1989, during routine operation			
Aluminum	NA	1/5	160
Chloride	500	5/5	3,600

Table 4. Effluent Stream Sampling Data, 284-W Powerplant Wastewater (WHC 1990a) (2 sheets).

Key constituents	Detection limit[a]	Detection/ analyses	Sample concentration (90% confidence interval)
October 1989 to March 1990, during blowdown			
Aluminum	No data		
Iron	No data		
October 1989 to March 1990, during water softener regeneration			
Aluminum	No data		
Barium	No data		
Chloride	No data		
Fluoride	No data		
Lead	No data		
Manganese	No data		
October 1989 to March 1990, during routine operation			
Aluminum	NA	3/4	292
Chloride	500	4/4	1,920,000

[a]Units: chemical--parts per billion, radionuclides--pCi/L.
NA = not available.

Table 5. Radionuclide and Chemical Loading, 284-W Powerplant Wastewater (WHC 1990a) (2 sheets).

Flow rate: 1.31 E+07 L/month

Constituent	kg/L[a]	kg/mo[a]	Constituent	kg/L[a]	kg/mo[a]
Aluminum	2.08E-07	2.72E+00	Potassium	8.74E-06	1.14E+02
Barium	2.43E-07	3.17E+00	Silicon	2.87E-06	3.75E+01
Boron	6.02E-08	7.86E-01	Sodium	2.92E-04	3.81E+03
Cadmium	4.25E-09	5.55E-02	Strontium	1.01E-06	1.32E+01
Calcium	1.98E-04	2.59E+03	Sulfate	2.68E-05	3.50E+02
Chloride	7.31E-04	9.55E+03	Uranium	5.18E-10	6.76E-03
Cobalt	2.65E-08	3.46E-01	Vanadium	5.00E-09	6.53E-02
Copper	1.12E-08	1.46E-01	Zinc	2.20E-08	2.87E-01

Table 5. Radionuclide and Chemical Loading, 284-W Powerplant Wastewater (WHC 1990a) (2 sheets).

Flow rate: 1.31 E+07 L/month

Constituent	kg/L[a]	kg/mo[a]	Constituent	kg/L[a]	kg/mo[a]
Fluoride	1.64E-07	2.14E+00	Trichloromethane	6.25E-09	8.16E-02
Iron	1.04E-07	1.36E+00	Beta activity[a]	3.15E-12	4.11E-05
Lithium	1.72E-08	2.25E-01	Suspended solids	7.25E-06	9.47E+01
Magnesium	7.23E-05	9.44E+02	Total dissolved solids	9.69E-04	1.27E+04
Manganese	9.50E-09	1.24E-01	Total organic carbon	1.30E-06	1.70E+01
Mercury	4.10E-10	5.35E-03	Total carbon	1.55E-05	2.02E+02
Nitrate	5.75E-07	7.51E+00	Total organic halogens (as chloride)	5.15E-08	6.72E-01

[a]Concentration units of these constituents are reported as curies per liter. Loading units of these constituents are reported as curies per month.

Notes:

1. Data collected from October 1989 through March 1990.
2. Flow rate is average of rates from the *Hanford Site Stream-Specific Reports* (WHC 1990b, Addendum 27).
3. Constituent concentrations are average values from the statistics in the *Hanford Site Stream-Specific Reports* (WHC 1990b, Addendum 27).

Recent flow rates into the ponds were measured with a flow meter installed near the ponds and averaged 443 L/min (117 gal/min) (Herman 1992). These flow rates do not agree with the flow rates reported by the 284-W Powerplant operations; the flow rates from the separate facilities will be measured as a part of the effluent sampling efforts (Herman 1992). Flow rates vary with the season; higher rates occur during the colder months, as more steam is needed for heat throughout the 200 West Area.

The largest contributors to the discharge at the ponds are the 284-W Powerplant, the 283-W WTF, and the 282-W Reservoir. Table 6 gives a breakdown of wastewater contributors, sources, estimated amounts of wastewater contributed by each source, and the approximate frequency of discharge by each source (Herman 1992).

Table 6. Facilities that Contribute to Discharge into the 284-WB Ponds[a] (adapted from Herman 1992).

Facility	Source	Discharge[b]	Estimated Amount Contributed (flow rate during discharge)[c]
282-W Reservoir	Cooling water Pump strainer back flush water Heater condensate	C B C	1,325 L/min (350 gal/min -- --
	Reservoir overflow	B	26,498 L/min (7,000 gal/min)
283-W WTF	Filter backwash[d] Floor drains Heater condensate Cooling water Basin wash down water Clearwell overflow Basin overflow Water testing and sampling station Continuous turbidity meter	B B C C B B B B C	8,831 L/min (2,333 gal/min)/filter x 4 filters x 30 min/filter = 1,059,720 L (279,960 gal) x 4 backwashes/month = 4,238,880 L/month (1,119,840 gal/month) -- -- -- -- -- -- -- --
284-W Powerplant	Cooling water	C	189 L/min (50 gal/min) with 2 boilers online; 8,327,880 L/month (2,200,000 gal/month) with 2 boilers online
	Continuous blowdown[d]	C	34 to 80 L/min (9 to 21 gal/min); varies from 11,340 kg/h (25,000 lb/h) steam load using 2,044 L/h (540 gal/h) to 27,216 kg/h (60,000 lb/h) steam load using 4,717 L/h (1,246 gal/h)
	Mud drum blowdown[e]	C	4.32 L/min (1.14 gal/min)/blowdown; 189,270 L/month (50,000 gal/month)
	Water softener regeneration[d]	B	212 to 254 L/min (56 to 67 gal/min) for 3 hours, 8 times/month = 305,280 to 365,760 L/month (80,640 to 96,480 gal/month)
	Steam heater condensate	C	--
277-W Complex	Floor drains	B	Volume unknown, but drains washed down three to four times per year
	Cooling water	C	1.7 L/min (0.44 gal/min); 7,912 L/week (2,090 gal/week) + 9,085 L/week (2,400 gal/week) = 16,656 L/week (4,400 gal/week) total
	Steam jet condensate	B	--
	Fire water blowdown	B	189 L/year (50 gal/year)
	Hydrotesting	B	37,854 L/test (10,000 gal/test)

283-W WTF = Waste Treatment Facility.
[a]All flow estimates taken from WHC 1990c.
[b]Identification of discharge type: B = batch, C = continuous.
[c]Flow quantities not shown are nominal.
[d]Based on information supplied by plant operations. There are four filters in the 283-W WTF.
[e]Based on 189,270 L/month (50,000 gal/month; information provided by plant operations.

3.3 EFFLUENT CONSTITUENTS

The effluent analytical data indicate that all modes produce metallic ions and anions exceeding *Washington Administrative Code* 173-200, "Groundwater Quality Standards of the State of Washington" or Washington Water Quality Standards (WWQS), by large margins, the predominant species being chloride. The sampling results for water softener operations are typical for such systems.

Recent discharges to the ponds generally have a high total salt concentration and a neutral to moderately basic pH. Aluminum, calcium, chloride, fluoride, iron, magnesium, nitrate, sodium, strontium (nonradiological), sulfate, potassium, barium, and total dissolved solids have been detected in effluent entering the ponds. Of these, chloride, fluoride, barium, and total dissolved solids exceed the WWQS limits. 284-W SAP data for the ponds indicate aluminum sulfate, sodium chloride, and <4% potassium hydroxide may also be present.

3.4 CONSTITUENTS OF INTEREST AND KEY INDICATORS

Data presented in WHC (1990a) indicate constituents found in the effluent stream at that time were derived from water softener regeneration (Table 7). During regeneration activities aluminum, barium, chloride, fluoride, lead, and manganese are detected in the effluent. Additional data indicate that most of the calcium, sodium, strontium (nonradiological), sulfate, potassium, and cerium found in the waste stream also are generated during water softener regeneration. These data (see Table 4) indicate that only aluminum and iron are found in effluents generated during boiler blowdown activities. During normal operations only aluminum and chloride are detected.

The amount of salt used by the 284-W Powerplant for a 5-year period was tabulated to determine an average amount of salt used in a year (Table 8). This average was then used to calculate a revised estimate of chloride concentration for the 284-WB Ponds. The revised estimate is 250,000 parts per billion (ppb) chloride based on the salt usage data. This is significantly lower than the value of 1,500,000 ppb given in Table 7, and is believed to be a more accurate estimate than those previously used for the ponds.

Table 7. Major Chemical Constituents in Contributor Streams and Weighted Average Concentrations for the Combined 284-W Powerplant Effluent Stream (WHC 1990a).

Constituent	Blowdown flush (1.5%)[a]	Softener regeneration (4.5%)[a]	Normal operations (94%)[a]	Weighted average (ppb)
Aluminum	340	830	160	193
Calcium	18,000	23,000,000	17,000	1,100,000
Chloride	3,800	33,000,000	3,100	1,500,000
Fluoride	100[b]	85,000	130	4,000
Iron	630	210	120	132
Magnesium	4,200	1,000,000	3,800	49,000
Nitrate (NO_3)	900	100[b]	900	860
Sodium	38,000	90,000,000	20,000	4,100,000
Strontium	100[b]	29,000	89	1,400
Sulfate (SO_4)	30,000	65,000	24,000	26,010
Potassium	1,600	170,000	1,000	8,600
Barium	34	32,000	25	1,500
Cerium	240	270	15	30

[a]Based on percent of total effluent discharge rate contributed by each mode (see Table 3).

[b]Assigned value for purpose of calculating weighted average.

ppb = parts per billion.

Table 8. Amount of Salt Used to Make Brine for 284-W Powerplant Water Softeners.

1988		1989		1990		1991		1992	
Week	Amount[a]	Week	Amount[a]	Week	Amount[a]	Week	Amount[a]	Week	Amount[a]
12/21/87 to 1/25/88	20,962	12/19/88 to 1/22/89	Data missing	12/19/89 to 1/23/90	7,274	12/20/90 to 1/22/91	Data missing	12/19/91 to 1/22/92	25,694
1/25 to 2/27	13,706	1/22 to 2/22	0	1/23 to 2/15	10,502	1/22 to 2/19	11,518	1/22 to 2/18	Data missing
2/27 to 3/22	10,672	2/22 to 3/20	17,204	2/15 to 3/15	Data missing	2/19 to 3/20	6,114	2/18 to 3/23	12,404
3/22 to 4/19	10,632	3/20 to 4/24	11,538	3/15 to 4/23	14,176	3/20 to 4/23	4,430	3/23 to 4/21	Data missing
4/19 to 5/17	22,150	4/24 to 5/23	10,632	4/23 to 5/22	6,202	4/23 to 5/20	Data missing	4/21 to 5/27	7,974
5/17 to 6/20	Data missing	5/23 to 6/19	7,088	5/22 to 6/19	12,404	5/20 to 6/25	12,404	5/27 to 6/23	8,860
6/20 to 7/26	7,088	6/19 to 7/26	13,290	6/19 to 7/24	4,430	6/25 to 7/24	31,896	6/23 to 7/21	630
7/26 to 8/22	2,658	7/26 to 8/16	6,202	7/24 to 8/21	4,352	7/24 to 8/15	3,544	7/21 to 8/19	Data missing
8/22 to 9/26	7,974	8/16 to 9/27	18,606	8/12 to 9/26	1,772	8/15 to 9/25	886	8/19 to 9/23	79,449
9/26 to 10/24	7,974	9/27 to 10/23	11,518	9/26 to 10/24	13,290	9/25 to 10/23	18,880	9/23 to 10/21	6,202
10/24 to 11/21	8,860	10/23 to 11/21	20,378	10/24 to 11/20	9,746	10/23 to 11/19	17,720	10/21 to 11/24	7,088
11/21 to 12/19	14,176	11/21 to 12/19	1,142	11/20 to 12/20	12,404	11/19 to 12/19	11,518	11/24 to 12/17	886
11,532 lb/month[b] (5,231 kg/month)		11,759 lb/month[b] (5,334 kg/month)		8,777 lb/month[b] (3,981 kg/month)		11,882 lb/month[b] (5,390 kg/month)		16,576 lb/month[b] (7,519 kg/month)	
12,105 lb/month[c] (5,502 kg/month)									

[a]Pounds (lb) of rock salt (sodium chloride).
[b]Average for the calendar year.
[c]Average for the 5-year period, 1988 to 1992.

This page intentionally left blank.

4.0 CONCEPTUAL MODEL OF HYDROLOGIC RESPONSE AND CONTAMINANT MIGRATION

4.1 HYDROGEOLOGIC FRAMEWORK

4.1.1 Regional and Hanford Site Geology

The Pasco Basin and the Hanford Site are underlain by pre-Miocene sedimentary and crystalline rocks (Campbell 1989), Miocene-aged (17.5 to 6 Ma) basalts of the Columbia River Basalt Group (CRBG) (Myers et al. 1979; Reidel and Fecht 1981; DOE 1988; Tolan et al. 1989; Reidel et al. 1989, 1992) and interbedded sediments of the Ellensburg Formation (Reidel and Fecht 1981; DOE 1988; Smith 1988), and a late Miocene to Holocene-aged (<8.5 Ma to present) suprabasalt sediment sequence (Myers et al. 1979; Tallman et al. 1981; DOE 1988; Smith et al. 1989; Lindsey 1991a, 1991b; Reidel et al. 1992).

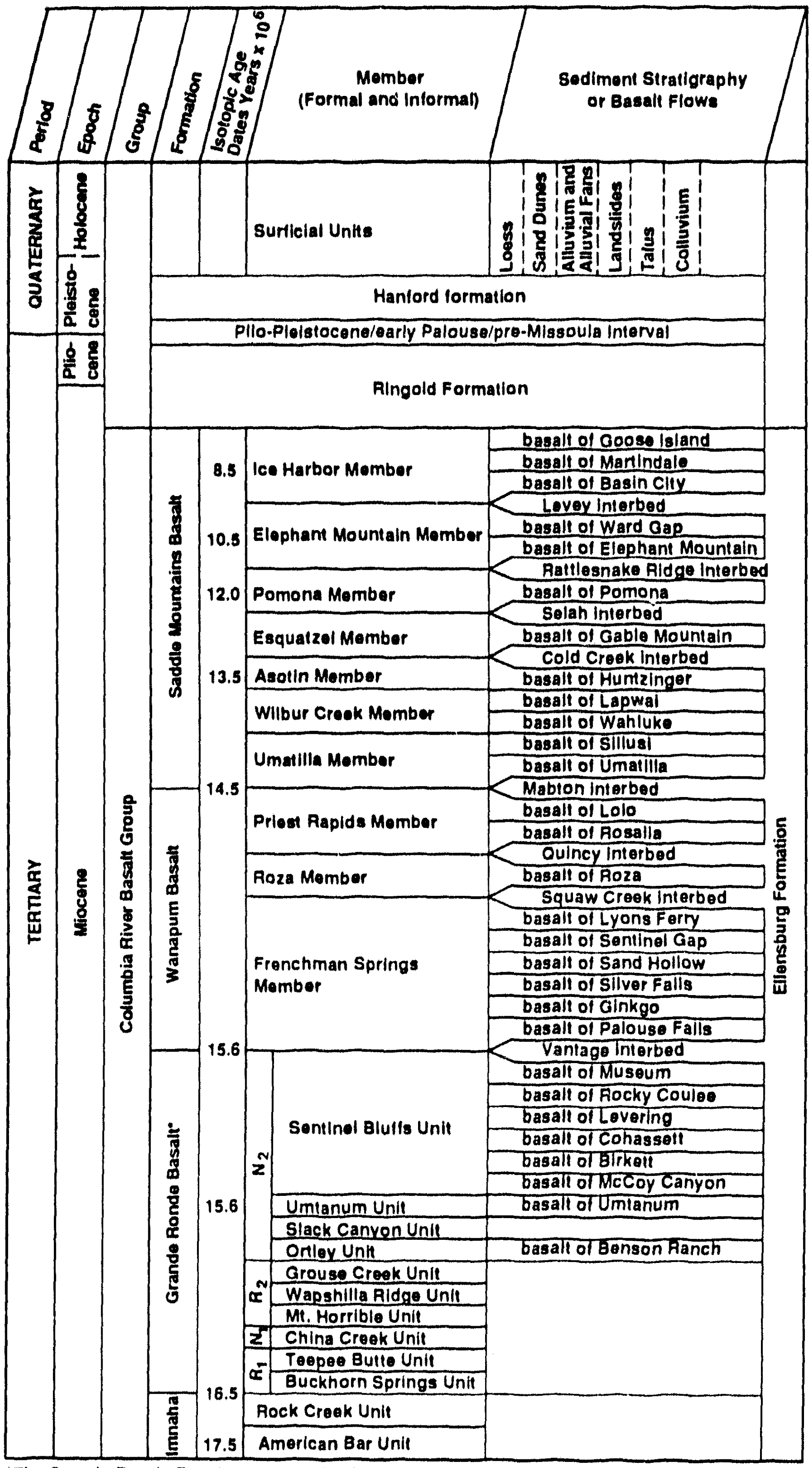
4.1.1.1 Columbia River Basalt Group. The CRBG is an assemblage of tholeiitic, continental flood basalts that cover an area of more than 163,157 km^2 (63,000 mi^2) in Washington, Oregon, and Idaho and have an estimated volume of about 174,356 km^3 (40,800 mi^3) (DOE 1988; Reidel and Hooper 1989; Tolan et al. 1989). The CRBG is divided, from oldest to youngest, into five formations: Imnaha Basalt, Picture Gorge Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt (DOE 1988; Tolan et al. 1989) (Figure 9). The Saddle Mountains Basalt (the uppermost basalt at the Hanford Site) is divided into (from oldest to youngest) the Umatilla, Wilbur Creek, Asotin, Esquatzel, Pomona Mountain, Elephant Mountain, and Ice Harbor Members (Reidel and Fecht 1981).

4.1.1.2 Ellensburg Formation. The Ellensburg Formation consists of volcaniclastic and siliciclastic deposits that occur between CRBG basalt flows (DOE 1988; Smith 1988). At the Hanford Site the three uppermost units of the Ellensburg Formation are, from oldest to youngest, the Selah, the Rattlesnake Ridge, and the Levy interbeds. A detailed discussion of the Ellensburg Formation at the Hanford Site is given in Reidel and Fecht (1981). Smith (1988) and Smith et al. (1989) discuss the Ellensburg Formation and correlative units throughout the region.

4.1.1.3 Suprabasalt Sediments. Discussions of various aspects of suprabasalt sediment geology are found in Myers et al. (1979); Tallman et al. (1979, 1981); PSPL (1982); Bjornstad (1984); Fecht et al. (1987); DOE (1988); Baker et al. (1991); Smith et al. (1989); Delaney et al. (1991); Lindsey (1991a, 1992); Lindsey et al. (1991, 1992); and Reidel et al. (1992). Delaney et al. (1991), Lindsey (1991a), and Reidel et al. (1992) provide the most recent synopsis of suprabasalt sediment geology for the Hanford Site. The following discussion is summarized from these recent reports.

The suprabasalt sedimentary sequence (Figure 10) is up to 229 m (750 ft) thick at the Hanford Site. It is dominated by the laterally extensive late Miocene to Pliocene Ringold Formation and the Pleistocene Hanford formation. Laterally discontinuous units, referred to as the Plio-Pleistocene unit, early

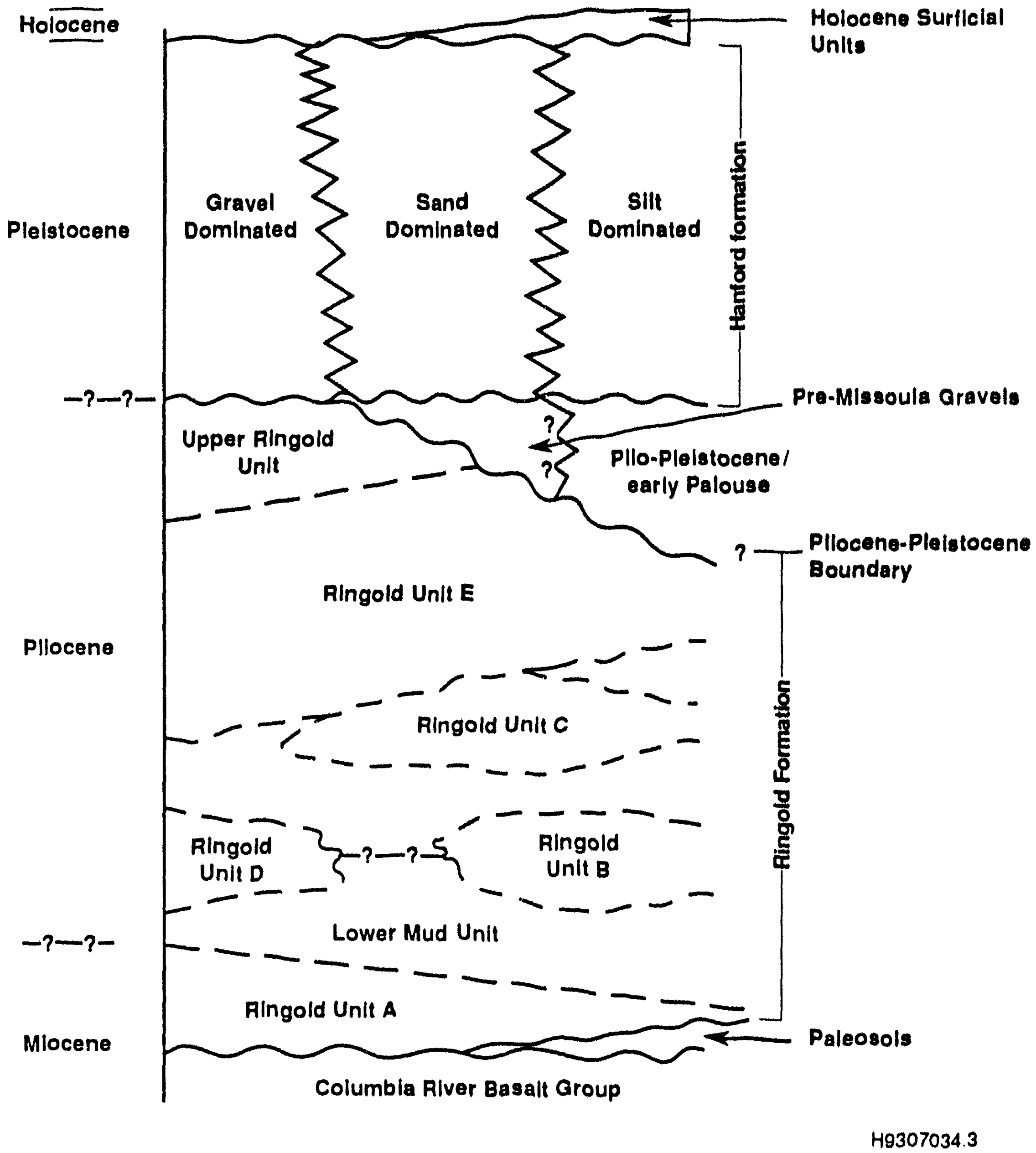
Figure 9. Generalized Stratigraphy of the Pasco Basin and Surrounding Area.



*The Grande Ronde Basalt consists of at least 120 major basalt flows. Only a few flows have been named. N_2, R_2, N_1 and R_1 are magnetostratigraphic units.

H9102029.6b

Figure 10. Generalized Stratigraphy of the Suprabasalt Sediments in the Pasco Basin.



"Palouse" soil, and pre-Missoula gravels, separate the Hanford formation and Ringold Formation locally. Holocene-aged alluvial and eolian deposits cap the suprabasalt sequence.

The Ringold Formation is up to 183 m (600 ft) thick within the Pasco Basin; it pinches out against basalt ridges around the edge of and within the basin; and it consists of semi-indurated clay, silt, fine- to coarse-grained sand, and pebble to cobble gravel. Ringold Formation deposits are grouped into five sediment facies associations (fluvial gravel, fluvial sand, overbank-paleosol, lacustrine, and basaltic alluvium) that are defined on the basis of lithology, petrology, stratification, and pedogenic alteration. The associations are summarized as follows:

(1) Fluvial gravel--consists of clast and matrix-supported pebble to cobble gravel with a fine- to medium-grained sand matrix. Grain size distributions tend to be bimodal with granules and coarse-grained sand being rare. Crude to well-defined stratification and low-angle lenticular bedding geometries generally dominate.

(2) Fluvial sand--fine- to coarse-grained quartzo-feldspathic sands displaying well-defined stratification dominate. Fining upwards packages less than one to several meters thick are common.

(3) Overbank-paleosol--laminated to massive silty sand, silt, and clay, displaying evidence of pedogenic alteration.

(4) Lacustrine--characterized by well stratified clay with interbedded silt and silty sand.

(5) Basaltic alluvium--massive to crudely stratified, weathered to unweathered, basaltic, pebble to cobble gravel, commonly with a mud-rich matrix.

The distribution of facies associations within the Ringold Formation forms the basis for stratigraphic subdivision (Lindsey 1991a, 1991b). The lower half of the Ringold Formation is characterized by fluvial gravel and sand-dominated intervals designated units A, B, C, D, and E (see Figure 10) that interfinger with fine-grained deposits typical of the overbank-paleosol and lacustrine facies associations. The lowest of these fine-grained intervals is designated the lower mud unit (see Figure 10). Interstratified deposits of the fluvial sand and overbank-paleosol facies associations and strata dominated by the lacustrine facies association form the upper half of the Ringold Formation (commonly referred to as the upper Ringold).

Several localized, informal units separate the Ringold Formation from the Hanford formation. These units are the: (1) Plio-Pleistocene unit, (2) pre-Missoula gravels, and (3) early "Palouse" soil (see Figure 10) (Myers et al. 1979; Tallman et al. 1979, 1981; DOE 1988; Reidel et al. 1992). The Plio-Pleistocene unit and early "Palouse" soil consist of loess, pedogenic calcium carbonate, and basaltic sands and gravels. Uncemented mixed lithology gravels with a quartzo-feldspathic matrix dominate the pre-Missoula gravels.

The Hanford formation consists of uncemented gravel, sand, and silt deposited by Pleistocene cataclysmic flood waters (Fecht et al. 1987; DOE 1988; Baker et al. 1991). The Hanford formation is thickest in the vicinity of the 200 West and 200 East Areas where it can be up to 107 m (350 ft) thick. The Hanford formation is divided into three facies (gravel, sand, and silt dominated) that are gradational with each other. The facies are summarized as follows:

(1) Gravel-dominated facies--generally consists of cross-stratified, coarse-grained sand and granule to boulder gravel that contain minor intercalated silt-rich horizons. These gravels generally are uncemented and matrix poor, displaying an open-framework texture.

(2) Sand-dominated facies--well-stratified, fine- to coarse-grained sand, and granule gravel dominate. Silt content is variable, but where it is low an open-framework texture is common. Small pebbles and rip-up clasts in addition to lenticular, pebble-gravel interbeds and silty interbeds may be present.

(3) Silt-dominated facies--interbedded silt and fine- to coarse-grained sand forming well-stratified normally graded rhythmites are characteristic.

In addition to the three facies, clastic dikes also are commonly found in the Hanford formation as well as locally in other sedimentary units at the Hanford Site (Black 1979). These clastic dikes are structures that generally cross cut bedding, although they do locally parallel bedding. The dikes usually consist of thin, alternating vertical to subvertical layers of silt, sand, and granules. Where the dikes intersect the ground surface a feature known as patterned ground can be observed.

Holocene surficial deposits consist of silt, sand, and gravel that form a thin (4.9 m [<16 ft]) veneer across much of the Hanford Site. These sediments were deposited by a mix of eolian and alluvial processes.

4.1.1.4 Structural Geology. The Columbia Plateau is divided into three informal structural subprovinces: Blue Mountains, Palouse, and Yakima Fold Belt (Reidel et al. 1989; Tolan and Reidel 1989). These structural subprovinces are delineated on the basis of their structural fabric. The Hanford Site is located in the eastern Yakima Fold Belt near its junction with the Palouse subprovince.

The Yakima Fold Belt consists of a series of segmented, narrow, asymmetric, and generally east-west trending anticlines that separate broad, low-amplitude structural basins (Reidel 1984; Reidel et al. 1989). The Pasco Basin (where the Hanford Site is situated) is one of the largest structural basins within the Yakima Fold Belt. The Pasco Basin is bounded on the north by the Saddle Mountains anticline, on the west by the Hog Ranch-Naneum Ridge anticline, and on the south by the Rattlesnake Mountain anticline. The Palouse slope, a west-dipping monocline, bounds the Pasco Basin on the east. The Pasco Basin is divided into the Wahluke and Cold Creek synclines by the Gable Mountain anticline, the easternmost extension of the Umtanum Ridge anticline.

4.1.2 284-WB Ponds Geology

The boreholes nearest the ponds (299-W14-5 and 299-W14-6) are located 198 to 229 m (650 to 750 ft) to the west. Consequently, site-specific geologic data for the immediate area of the ponds are lacking. The following discussion of the geology in the vicinity of the 284-WB Powerplant Ponds is derived from these two wells, geologic information from other boreholes (299-W14-7, 299-W11-6, and 299-W14-10), and from studies of outcrops analogous to strata thought to occur in the pond area. However, because of the lack of site-specific data this discussion is necessarily generalized. A generalized stratigraphic column for the central 200 West Area is illustrated in Figure 11.

Geologic trends in the 284-WB Ponds area are similar to those typically seen in the 200 West Area (Figures 12 and 13). The Hanford formation, the Plio-Pleistocene/early "Palouse" interval, and the Ringold Formation comprise the unsaturated zone in the ponds area. Holocene-aged eolian sands are found west of the site, but examination of the area immediately surrounding the ponds location suggests that these deposits have been removed by human activity.

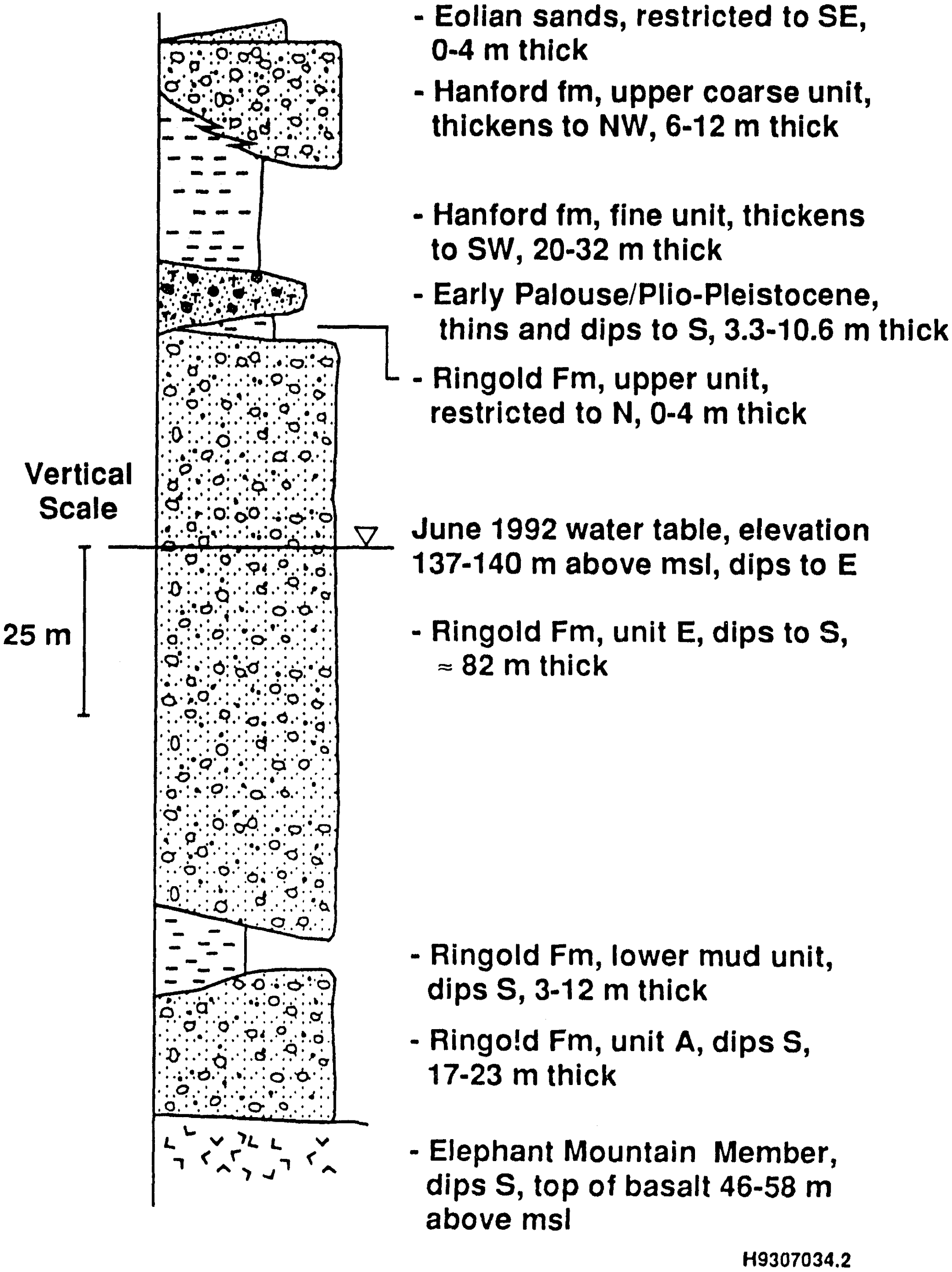
Gravel, sand, and silt of the Hanford formation form the majority of the vadose zone in the central 200 West Area and are divided into two main intervals, an upper coarse unit and a lower fine unit. Strata typical of the gravel-dominated facies form most of the upper coarse unit (Lindsey et al. 1992). Borehole data and outcrop studies elsewhere in Hanford gravels suggest minor occurrences of the sand- and silt-dominated facies may occur as lenticular interbeds within the upper coarse unit. In the area of the ponds the unit is somewhere between 6 and 12 m (20 and 40 ft) thick and generally appears to thicken to the north.

The lower fine unit of the Hanford formation consists of interbedded strata typical of both the sand- and silt-dominated facies. Based on drilling logs elsewhere in the 200 West Area, gravelly interbeds may be present. The lower unit is between 20 and 32 m (66 to 105 ft) thick in the central 200 West Area around the ponds and borehole trends indicate it thickens to the southwest. The nature of the contact between the upper and lower units is not known, and could be sharp or gradational.

The Hanford formation is underlain in the central 200 West Area by the early "Palouse" and Plio-Pleistocene interval. This interval is dominated by basaltic sands and gravels containing variable amounts of pedogenic calcium carbonate, in the form of concretions, nodules, and discontinuous layers less than 0.3 m (1 ft) thick. Loess-like silts, such as are thought to typify the early "Palouse" soil (DOE 1988; Last et al. 1989), probably are not present beneath the ponds. Recent data indicate that the loess-like silts may be less common throughout the 200 West Area than originally thought. The combined early "Palouse" and Plio-Pleistocene interval is between 3.3 and 10.6 m (10 and 35 ft) thick in the area and thins and dips to the south.

The thickest unit in the central 200 West Area around the ponds is the Ringold Formation. At this location it consists of the upper unit, unit E, the lower mud unit, and unit A. Each of these units generally dips to the

Figure 11. Generalized Stratigraphic Column for the Central 200 West Area.



This page intentionally left blank.

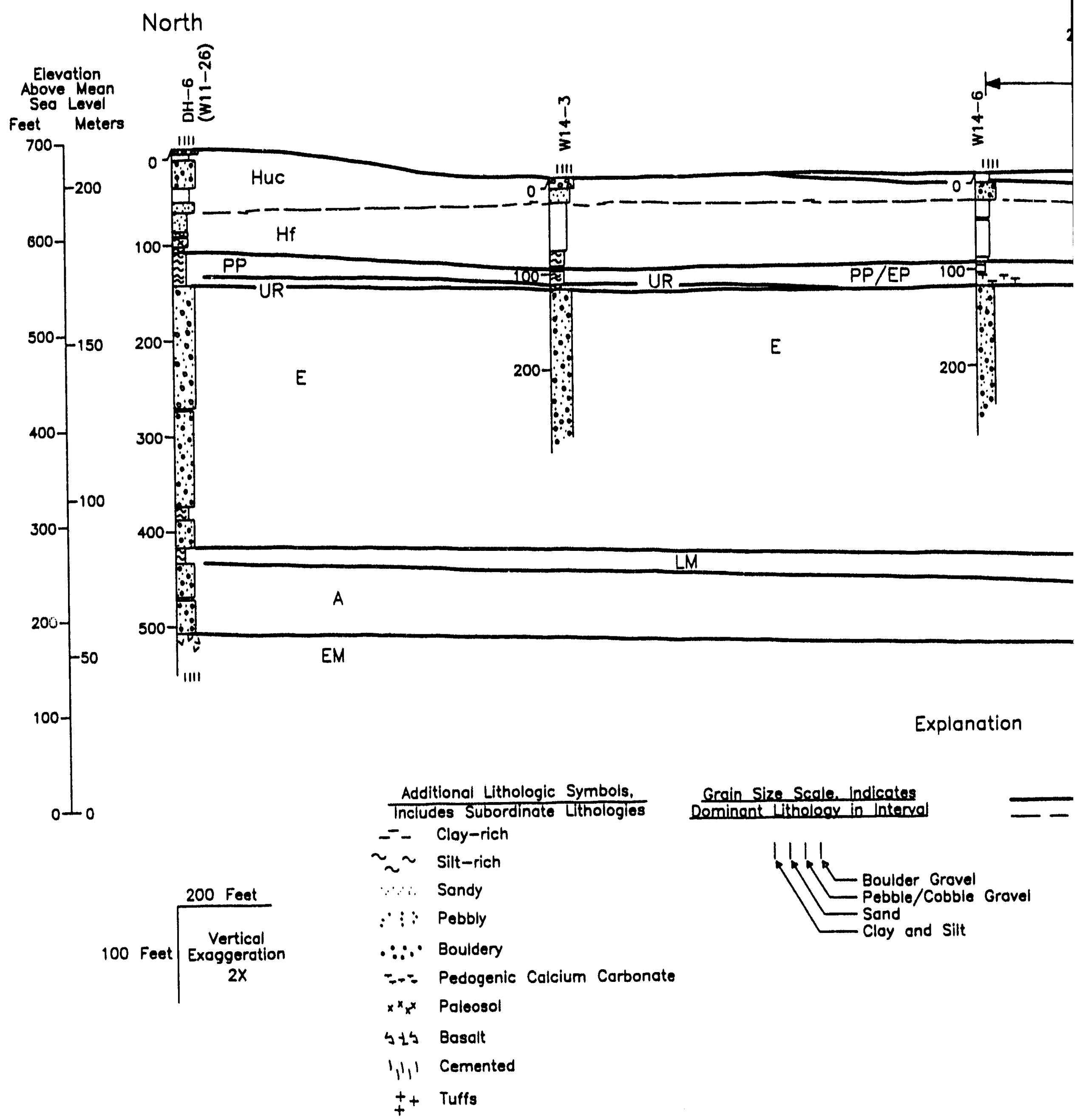
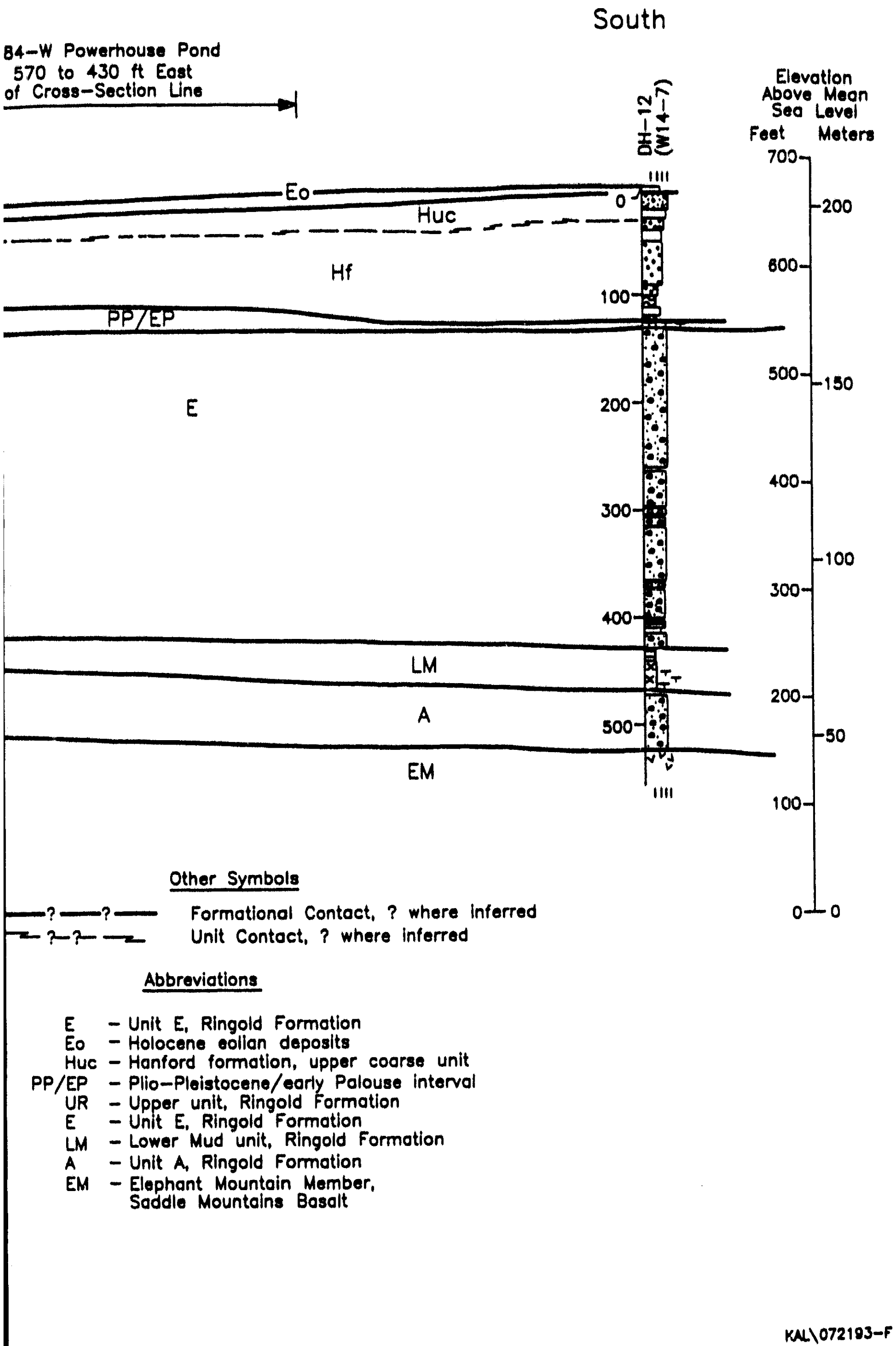
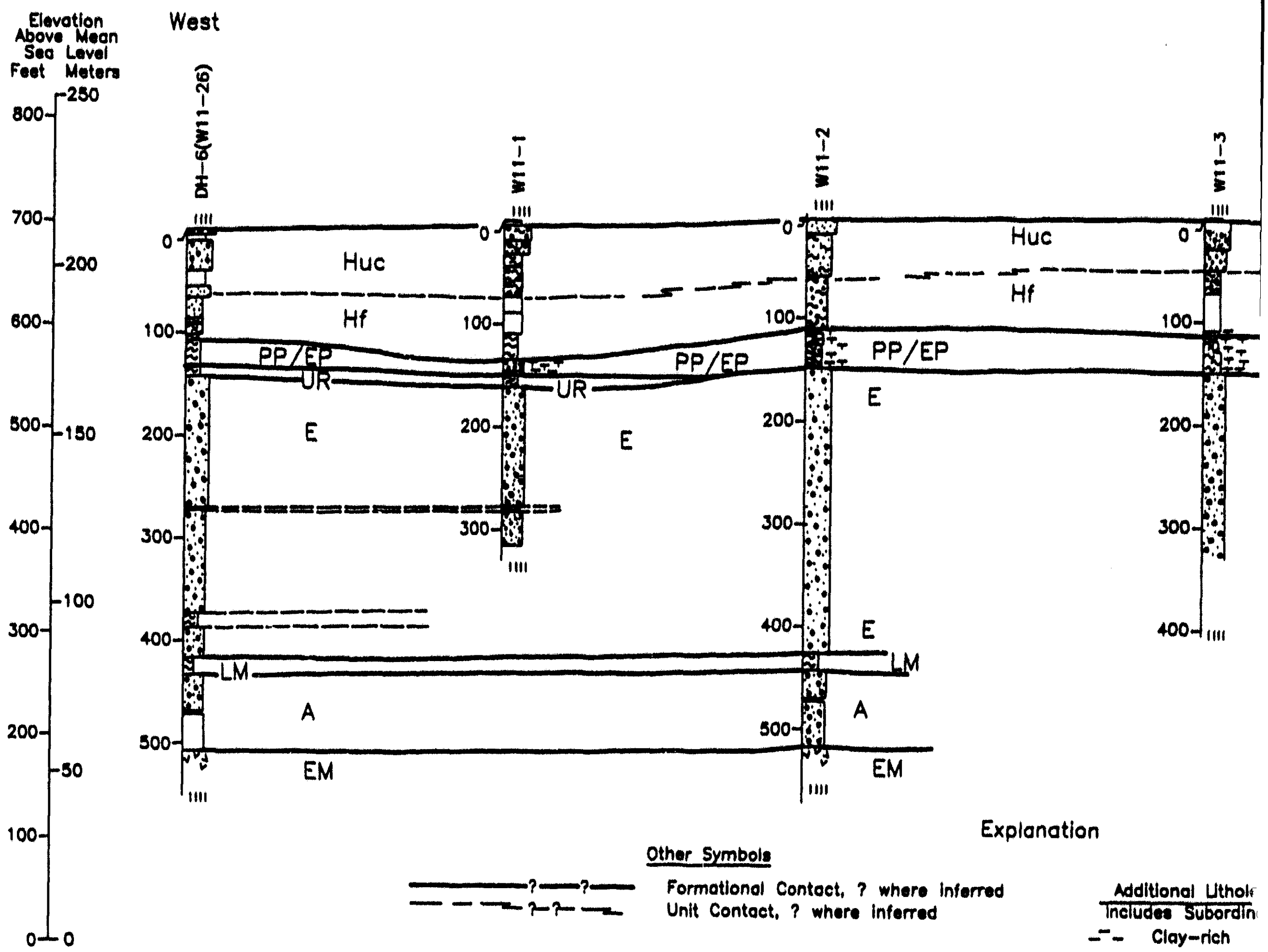

North
Elevation Above Mean Sea Level
Feet
Meters
700
600
500
400
300
200
100
0
200
150
100
50
0
DH-6 (W11-26)
W14-3
W14-6
0
100
200
300
400
500
Huc
Hf
PP
UR
E
LM
A
EM
PP/EP
Explanation
Additional Lithologic Symbols, Includes Subordinate Lithologies
Clay-rich
Silt-rich
Sandy
Pebbly
Bouldery
Pedogenic Calcium Carbonate
Paleosol
Basalt
Cemented
Tuffs
Grain Size Scale, Indicates Dominant Lithology in Interval
Boulder Gravel
Pebble/Cobble Gravel
Sand
Clay and Silt
200 Feet
100 Feet
Vertical Exaggeration 2X

Figure 12. North to South Geologic Cross Section of the Central 200 West Area.





Explanation

Other Symbols

Formational Contact, ? where inferred
Unit Contact, ? where inferred

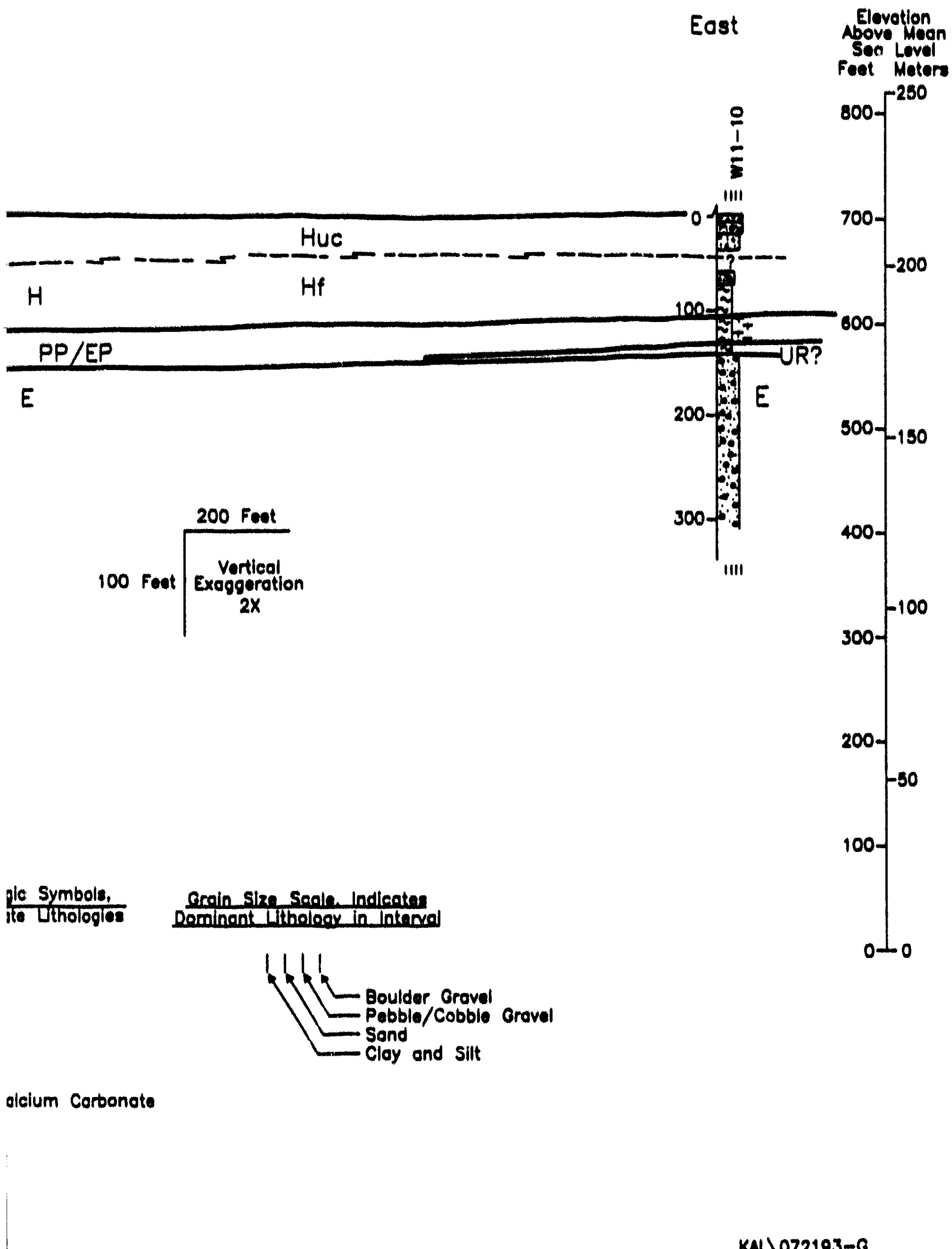
Abbreviations

- E – Unit E, Ringold Formation
- Eo – Holocene eolian deposits
- Huc – Hanford formation, upper coarse unit
- PP/EP – Plio-Pleistocene/early Palouse interval
- UR – Upper unit, Ringold Formation
- E – Unit E, Ringold Formation
- LM – Lower Mud unit, Ringold Formation
- A – Unit A, Ringold Formation
- EM – Elephant Mountain Member, Saddle Mountains Basalt

Additional Lithol… Includes Subordin…

- Clay-rich
- Silt-rich
- Sandy
- Pebbly
- Bouldery
- Pedogenic (
- Paleosol
- Basalt
- Cemented
- Tuffs

Figure 13. West to East Geologic Cross Section of the Central 200 West Area.



south. The upper unit probably is less than 4 m (13 ft) thick and consists of strata typical of the fluvial sand and overbank-paleosol facies. Ringold unit E is approximately 82 m (269 ft) thick and consists largely of the fluvial gravel facies although minor interbedded occurrences of the fluvial sand and overbank-paleosol facies also may be present. The lower mud unit typically consists of the overbank-paleosol and lacustrine facies and is between 3 and 12 m (10 and 40 ft) thick in the area. Unit A displays lithologies like those found in unit E and is between 17 and 23 m (56 and 75 ft) thick.

The uppermost basalt beneath in the area is the Elephant Mountain Member of the Saddle Mountains Basalt (Reidel and Fecht 1981). The top of the basalt lies between approximately 155 and 162 m (510 and 530 ft) below the surface and generally dips to the south.

4.1.3 Regional and Hanford Site Hydrology

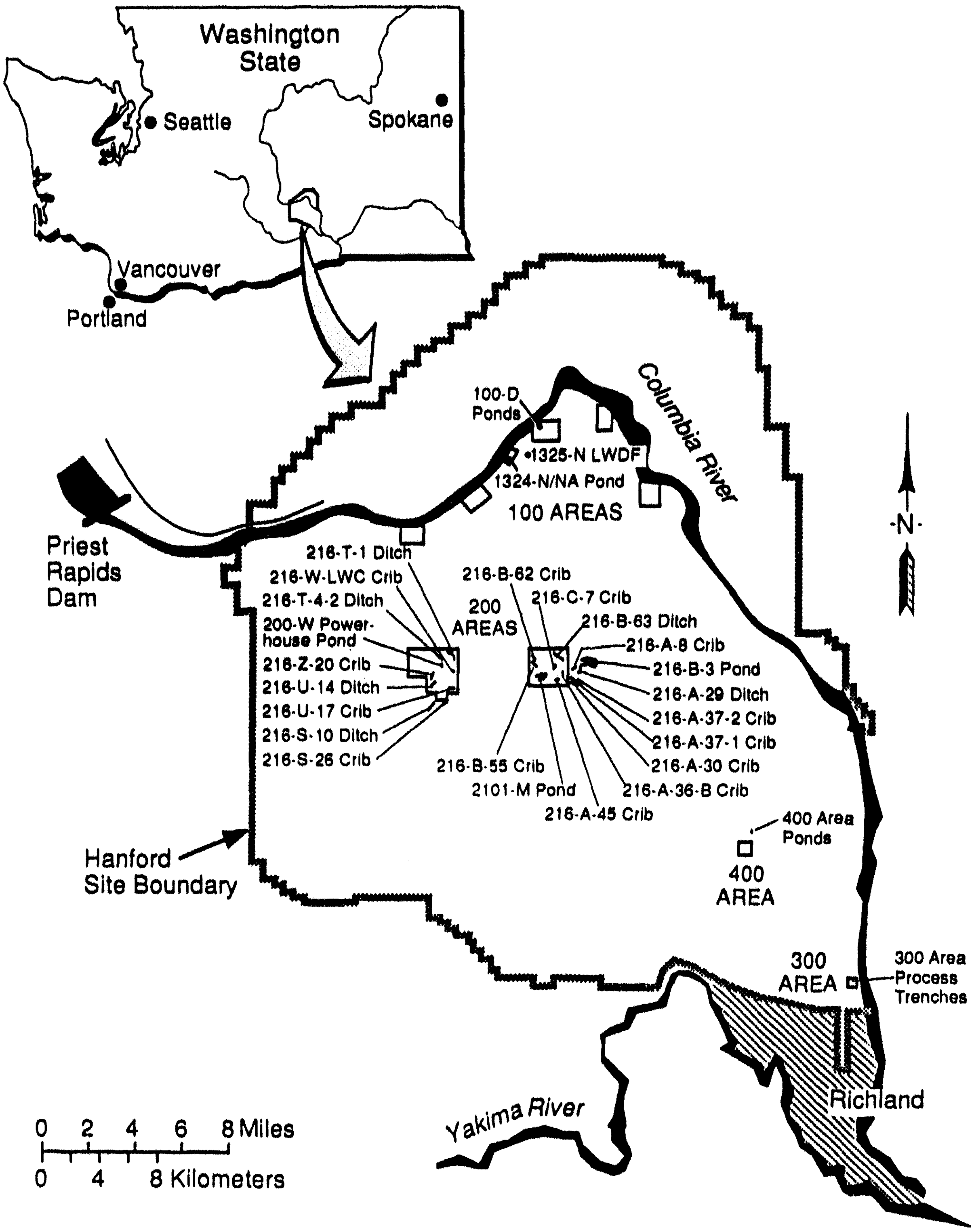
Delaney et al. (1991) presents a synopsis of regional and Hanford Site hydrology. Connelly et al. (1992) summarizes the hydrology of the 200 West Area. This section is summarized from Delaney et al. (1991).

4.1.3.1 Surface Water. Primary surface-water features near the Hanford Site are the Columbia and Yakima Rivers, and the two tributaries of the Columbia, the Snake, and the Walla Walla Rivers. The free-flowing stretch of the Columbia River adjacent to the Hanford Site is known as the Hanford Reach. It extends from Priest Rapids Dam to the headwaters of Lake Wallula (the reservoir behind McNary Dam). Flow along the Hanford Reach is controlled by Priest Rapids Dam. Approximately one-third of the Hanford Site is drained by the Yakima River system. Cold Creek and its tributary, Dry Creek, are ephemeral streams 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. West Lake, about 40,470 m^2 (10 acres) in size and less than 1 m (3 ft) deep, is the only natural lake within the Hanford Site (DOE 1988). Wastewater ponds, cribs and ditches associated with nuclear fuel reprocessing and waste disposal activities are also present on the Hanford Site (Figure 14).

4.1.3.2 Groundwater. The Pasco Basin is characterized by a multiaquifer system that consists of four hydrogeologic units that correspond with the upper three formations of the CRBG and the suprabasalt sediments.

The basalt aquifers generally are confined and found within sedimentary interbeds of the Ellensburg Formation and interflow zones that occur between basalt flows. Recharge to the shallow basalt aquifers results from infiltration of precipitation and runoff along the margins of the Pasco Basin. Recharge of the deep basalt aquifers is inferred to result from interbasin groundwater movement originating northeast and northwest of the Pasco Basin in areas where the Wanapum and Grande Ronde Basalts crop out extensively (DOE 1988). Groundwater discharge from shallow basalt aquifers is probably to the overlying aquifers and to the Columbia River. Discharge areas for the deeper groundwater systems are uncertain, but flow is inferred to be generally

Figure 14. Location of Water Disposal Sites on the Hanford Site.



southeastward with discharge speculated to be south of the Hanford Site (DOE 1988). Erosional "windows" through dense basalt flow interiors allow direct interconnection between the unconfined and uppermost confined aquifers (Graham et al. 1984).

The suprabasalt sediment aquifer is contained within glaciofluvial deposits of the Hanford formation and alluvial/lacustrine sediments of the Ringold Formation. This aquifer lies at depths ranging from less than 0.3 m (1 ft) near West Lake and the Columbia and Yakima Rivers, to greater than 107 m (350 ft) near the center of the Hanford Site. The position of the water table beneath the western portion of the Hanford Site generally is within Ringold unit E. In the northern and eastern portions of the Hanford Site the water table generally is within the Hanford formation. Hydraulic conductivities for the Hanford formation (610 to 3,050 m/day [2,000 to 10,000 ft/day]) are much greater than those of the gravel facies of the Ringold Formation [186 to 930 m/day (610 to 3,050 ft/day]). The main body of the unconfined aquifer occurs within the Ringold Formation.

The base of the uppermost aquifer system is defined as the surface of the uppermost basalt flow. However, overbank and lacustrine deposits in the Ringold Formation locally form confining layers for the underlying Ringold Formation fluvial gravel and sand. The uppermost aquifer system is bounded laterally by anticlinal basalt ridges and is approximately 152 m (500 ft) thick near the center of the basin.

Natural recharge to the uppermost aquifer consists of rainfall and run-off from the higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Yakima and Columbia Rivers. The movement of moisture from precipitation through the unsaturated (vadose) zone varies with vegetative cover, soil type, and depth to water table. Gee (1987) and Routson and Johnson (1990) indicate that water movement is nonexistent across much of the Hanford Site while Rockhold et al. (1990) suggest that downward water movement below the root zone is common in the 300 Area. Artificial recharge occurs from the disposal of wastewater on the Hanford Site (principally in the 200 Areas), and from large irrigation projects surrounding the Hanford Site.

4.1.4 200 West Area Hydrology

The hydrostratigraphic units of most concern in the 200 West Area are the: (1) Rattlesnake Ridge interbed, (2) Elephant Mountain Basalt, (3) Ringold Formation, (4) Plio-Pleistocene/early "Palouse" interval, and (5) Hanford formation. The Rattlesnake Ridge interbed forms the uppermost confined aquifer in the area; ranges from 15 to 25 m (50 to 82 ft) in thickness; and consists of the flow bottom of the Elephant Mountain Basalt, the flow top of the Pomona Basalt, and the Rattlesnake Ridge interbed. Groundwater flow generally is toward the northeast beneath the 200 West Area. Graham et al. (1981, 1984) report transmissivity values of 0.7 to 108 m^2/day (8 to 1,165 ft^2/day) for the Rattlesnake Ridge interbed.

The Rattlesnake Ridge aquifer is separated from the overlying uppermost unconfined aquifer system by the Elephant Mountain Member of the Saddle Mountains Basalt. The basalt has low hydraulic conductivities (0.009 m/day

[0.03 ft/day]). The surface of the Elephant Mountain Member dips south-southeast toward the axis of the Cold Creek syncline from a high just north of the 200 East Area.

The suprabasalt aquifer beneath the 200 West Area is contained within Ringold Formation units A and E and the lower mud unit. These strata exhibit locally confined to unconfined conditions. The saturated thickness of the unconfined aquifer ranges from approximately 67 to 112 m (220 to 368 ft) beneath the entire 200 West Area. Hydraulic conductivities for the gravels and sands of units A and E range from 0.02 to 61 m/day (0.06 to 200 ft/day). A mean hydraulic conductivity of 1.58 x 10^{-5} m/day (5.19 x 10^{-5} ft/day) is reported for the lower mud unit by Last et al. (1989).

The thickness of the unsaturated zone beneath the 200 West Area ranges from approximately 55 to 100 m (180 to 328 ft) (Connelly et al. 1992). Less than 12 to greater than 43 m (<40 to >140 ft) of Ringold unit E extends above the water table. This variation in thickness is the result of erosional and depositional variations within these sediments, structural relief within the Ringold Formation, and the sustained groundwater mounds derived from wastewater disposal. The upper unit is discontinuous throughout the 200 West Area, reaching a maximum thickness of 11 m (35 ft).

The Plio-Pleistocene/early "Palouse" interval reaches a thickness of 11 m (35 ft) in the central 200 West Area. The top of the unit dips approximately 1.5 degrees to the southwest beneath the northern portion of the 200 West Area and flattens to the south. Pedogenic, calcium carbonate-cemented horizons within the interval may create locally perched conditions. However, lateral discontinuities within this interval suggest these perched zones, if they exist, will be of relatively local extent. No perched water was reported by Last et al. (1989) above this unit.

Hanford formation strata (upper coarse and lower fine units) form the uppermost, continuous unit in the unsaturated zone. Recent investigations at the 216-U-14 Ditch indicate significant perching of water occurs locally within the interbedded sands and silts of the lower unit. Experience gained at the 216-U-14 Ditch indicates these interbedded strata probably have a greater influence on the migration of water through the vadose zone than the underlying Plio-Pleistocene/early "Palouse" interval. The only barriers to fluid migration within the upper coarse unit may be silty interbeds that have been shown to occur in the gravels that characterize the unit elsewhere. Hydrologic properties for the Hanford formation are summarized in Connelly et al. (1992).

4.2 HYDROLOGIC RESPONSES TO EFFLUENT DISPOSAL

Because of the absence of groundwater monitoring wells in or near the 284-WB Ponds, it is not possible to directly determine if water discharged to the ponds has influenced groundwater. Consequently, it is only possible to speculate on the nature of groundwater conditions beneath the ponds. Based on experience elsewhere at the Hanford Site a very general conceptualization of water movement through the ground beneath the ponds is presented here.

Water from the 284-WB Ponds probably percolates generally downward, experiencing little spreading through the uppermost 12 m (40 ft) of the Hanford formation strata, which is characterized by the open-framework gravels of the gravel-dominated facies. When water reaches the interbedded sand- and silt-dominated facies of the lower unit, lateral spreading may occur. Because lateral discontinuities such as pinchouts and clastic dikes are common in the silt-rich horizons, lateral spreading is inferred to be of a relatively local extent on individual beds. However, because of the presence of multiple silt-rich horizons and the cumulative thickness of this interbedded interval, lateral spreading may be quite pronounced through the entire interval.

Lateral spreading of moisture may also occur on the underlying Plio-Pleistocene/early "Palouse" interval.

Carbonate-cemented horizons within the Plio-Pleistocene/early "Palouse" interval, as well as interbedded silts within the underlying upper Ringold unit, and the presence of laterally variable cemented zones in Ringold unit E may contribute to continued lateral movement of waters. If lateral movement occurs across these horizons, a preferential migration of vadose waters to the south (opposite general groundwater flow directions in this area) may exist because of the marked southward structural dip into the Cold Creek syncline.

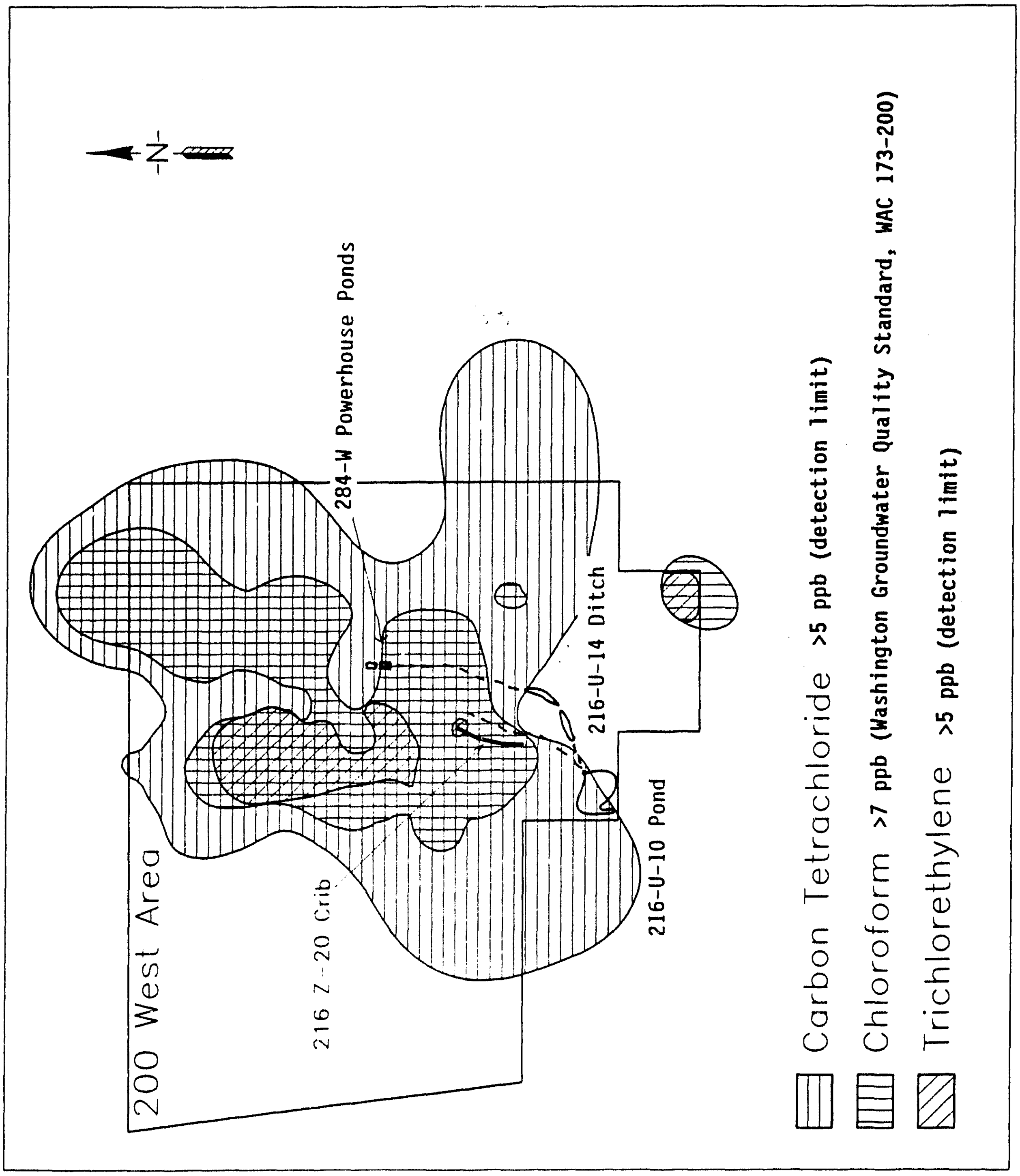
4.3 GROUNDWATER QUALITY

Contaminant plume maps have been compiled for the entire 200 West Area for the 200 West Aggregate Area Management Study programs (Connelly et al. 1992). This information indicates that any plumes present beneath the ponds area probably are derived from contaminant sources within the 200 West Area.

4.3.1 Hanford Site and the 200 West Area

The purpose of this section is to list potential contaminant plumes in the vicinity of the 284-WB Ponds, as derived from Connelly et al. (1992). Because of the absence of groundwater monitoring wells near the ponds, it is not possible to determine the true extent of plumes beneath the site. The nearest wells to the site are over 183 m (600 ft) away. However, examination of Figures 15, 16, and 17, and comparison to the regulatory limits indicate eight major contaminant plumes may be present beneath the ponds area including: carbon tetrachloride, chloroform, trichloroethylene, fluoride, nitrate, tritium, gross alpha, and gross beta (arsenic and chromium are minor plumes, considerably south of the ponds). The apparent groundwater flow direction beneath the site is from the southwest to the east-northeast. Only two wells (299-W15-5 and 299-W18-7) for which data are available are situated upgradient of the ponds. These wells are over 274 m (900 ft) away. The closest wells to the ponds (299-W14-5, 299-W14-6, and 299-W15-4, a cluster of three) are situated 183 to 274 m (600 to 900 ft) to the west, and as such are not truly upgradient. Only one downgradient well (299-W14-10) exists. However, that well is over 828 m (2,700 ft) away and may not be screened in a representative interval of the aquifer. The concentrations of the eight constituents upgradient and downgradient of the pond site are given in the following paragraphs.

Figure 15. Contaminant Plume Map for Carbon Tetrachloride, Chloroform, and Trichloroethylene--200 West Area.



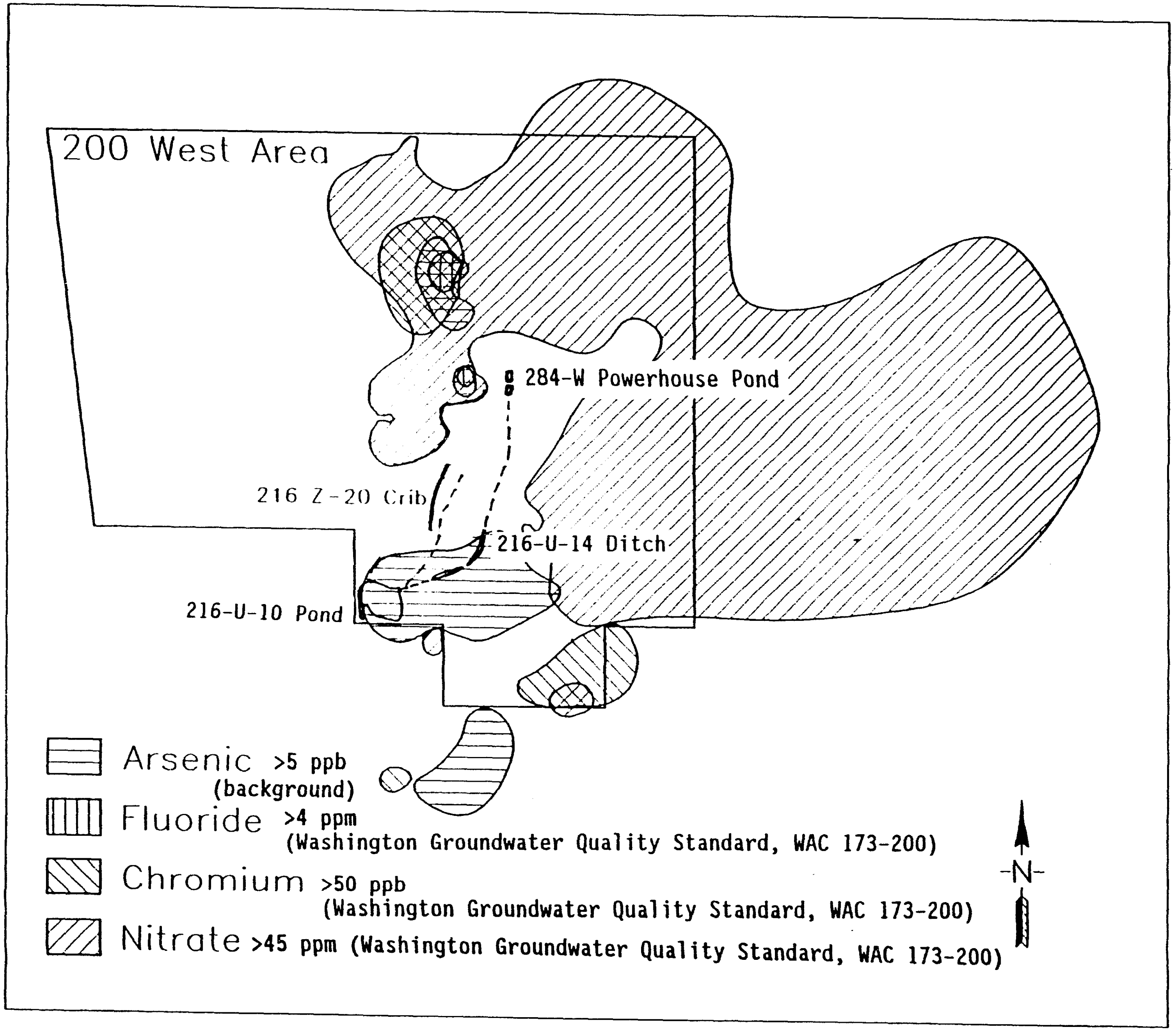
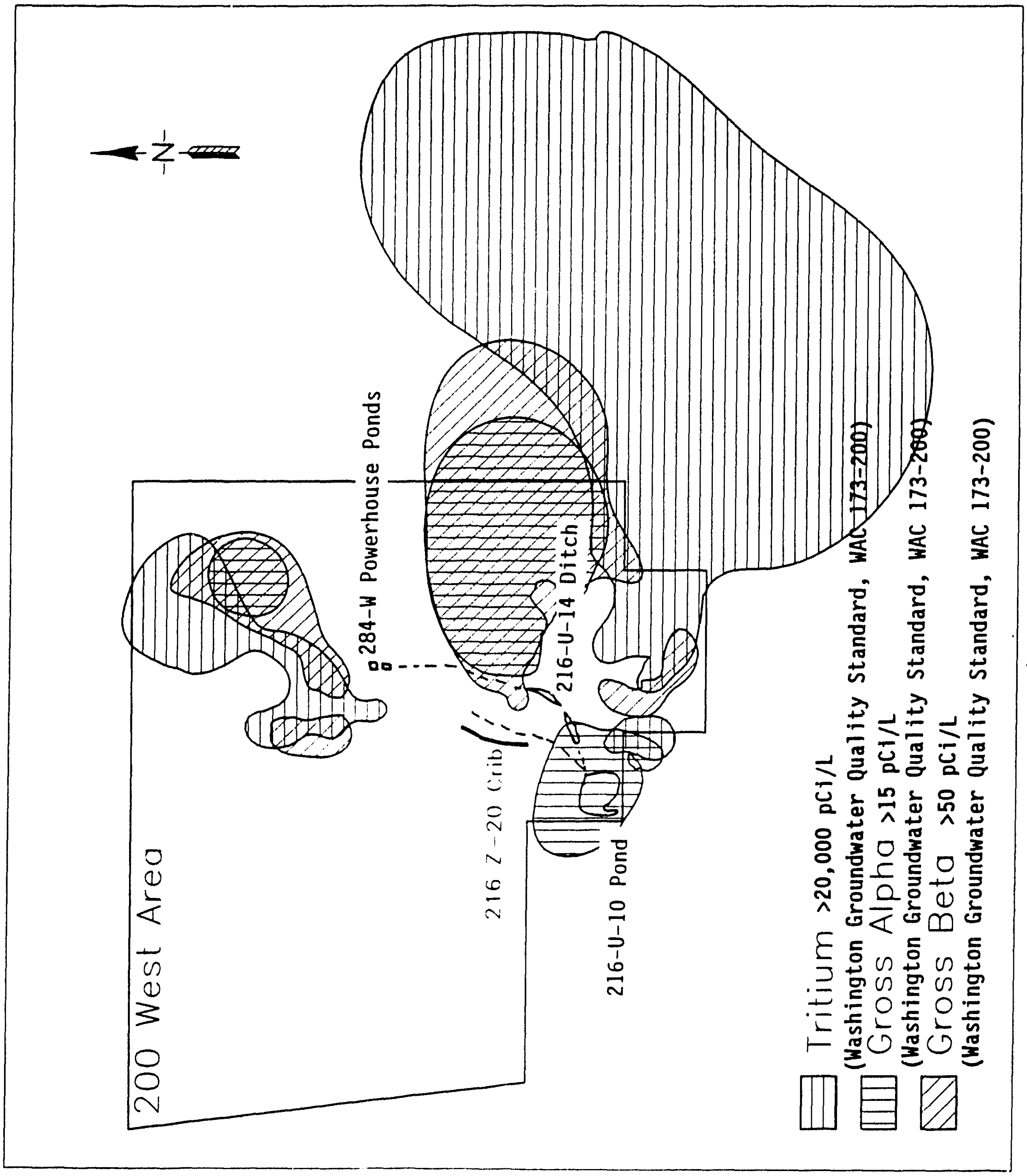


Figure 16. Contaminant Plume Map for Arsenic, Fluoride, Chromium, and Nitrate--200 West Area.

Figure 17. Contaminant Plume Map for Tritium, Gross Alpha, and and Gross Beta--200 West Area.



- Carbon tetrachloride is found in highly variable concentrations west and southwest of the ponds. Concentrations in the first three wells to the west range from 301 to 1,960 ppb while a concentration of 4,744 ppb is found in the closest well (299-W14-7) to the southwest. Plume reconstructions east of the ponds suggest values as low as 10 ppb are possible. The one monitoring well in this region has a concentration of less than 5 ppb.

- The chloroform plume map indicates concentrations southwest of the ponds are highest at 1,595 ppb. Concentrations due west of the ponds range from 4 to 18 ppb while the one well east (299-W14-10) of the ponds yields values of 4 ppb.

- Trichloroethylene concentrations east and west of the ponds show little variation. Concentrations due west of the ponds range from 5 to 12 ppb, those to the southwest range from 3 to 8 ppb, while the single value east of the ponds is 5 ppb.

- Fluoride is not detected southwest or east of the ponds. However, due west of the ponds fluoride concentrations ranging from 2 to 12 parts per million (ppm) are measured.

- Nitrate concentrations east and west of the ponds are variable. The wells just to the west have values ranging from 25 to 520 ppm. Concentrations to the southwest display similar variability, with two values at 105 ppm and 563 ppm. The only downgradient value is 39 ppm.

- Tritium concentrations around the ponds are relatively low compared to much of the rest of the 200 West Area. Concentrations immediately to the west range from 4 to 178 pCi/L while none is reported to the southwest. A concentration of 1 pCi/L is given for the single downgradient well (east).

- Gross alpha values are lowest in wells to the west and highest in wells to the east, although the range of values is small. All of the wells immediately upgradient of the ponds (west and southwest) have readings of 0 or 1 pCi/L. The downgradient well has a value of 6 pCi/L.

- A range of values characterizes the gross beta plume in the ponds area. Values immediately to the west range from 9 to 33 pCi/L. Those to the south are 4 and 79 pCi/L, while the single downgradient value (east) is 12 pCi/L.

4.3.2 Potential Local Influences on Groundwater Quality

With few exceptions effluent entering the ponds contains few chemicals or waste products of concern (Table 9). Consequently, the water in the ponds was not thought to have a significant influence on groundwater quality in the area. However, because of the lack of any site-specific data, it is not possible to verify this conclusion for groundwater near the ponds.

Table 9. Statistics on Effluent Chemistry Data--284-WB Powerplant Ponds Wastewater (WHC 1990c). (3 sheets)

Constituent	N	MDA	Meth	Mean	StdErr	90%CILim	Maximum
Aluminum	4	1	DL	2.08E+02	5.11E+01	2.92E+02	3.61E+02
Arsenic (EP toxic)	4	4	NA	<5.00E+02	0.00E+00	<5.00E+02	<5.00E+02
Barium	4	0	NA	2.43E+02	1.97E+02	5.65E+02	8.33E+02
Barium (EP toxic)	4	3	DL	1.01E+03	1.00E+01	1.03E+03	1.04E+03
Boron	4	0	NA	6.02E+01	3.07E+01	1.10E+02	1.50E+02
Cadmium	4	3	DL	4.25E+00	2.25E+00	7.94E+00	1.10E+01
Cadmium (EP toxic)	4	4	NA	<1.00E+02	0.00E+00	<1.00E+02	<1.00E+02
Calcium	4	0	NA	1.98E+05	1.80E+05	4.93E+05	7.39E+05
Chloride	4	0	NA	7.31E+05	7.26E+05	1.92E+06	2.91E+06
Chromium (EP toxic)	4	4	NA	<5.00E+02	0.00E+00	<5.00E+02	<5.00E+02
Cobalt	4	3	DL	2.65E+01	6.50E+00	3.71E+01	4.60E+01
Copper	4	2	DL	1.12E+01	1.25E+00	1.33E+01	1.50E+01
Fluoride	4	0	NA	1.64E+02	4.13E++00	1.71E+02	1.74E+02
Iron	4	0	NA	1.04E+02	3.28E+01	1.58E+02	1.71E+02
Lead (EP toxic)	4	4	NA	<5.00E+02	0.00E+00	<5.00E+02	<5.00E+02
Lithium	4	3	DL	1.72E+01	7.25E+00	2.91E+01	3.90E+01
Magnesium	4	0	NA	7.23E+04	6.86E+04	1.85E+05	2.78E+05
Manganese	4	3	DL	9.50E+00	4.50E+00	1.69E+01	2.30E+01
Mercury	4	3	DL	4.10E+01	3.10E-01	9.18E-01	1.34E+00
Mercury (EP toxic)	4	4	NA	<2.00E+01	0.00E+00	<2.00E+01	<2.00E+01
Nitrate	4	3	DL	5.75E+02	7.50E+01	6.98E+02	8.00E+02
Potassium	4	0	NA	8.74E+03	7.82E+03	2.16E+04	3.22E+04
Selenium (EP toxic)	4	4	NA	<5.00E+02	0.00E+00	<5.00E+02	<5.00E+02
Silicon	4	0	NA	2.87E+03	2.08E+02	3.21E+03	3.22E+03
Silver (EP toxic)	4	4	NA	<5.00E+02	0.00E+00	<5.00E+02	<5.00E+02
Sodium	4	0	NA	2.92E+05	2.73E+05	7.39E+05	1.11E+06

Table 9. Statistics on Effluent Chemistry Data--284-WB Powerplant Ponds Wastewater (WHC 1990c). (3 sheets)

Constituent	N	MDA	Meth	Mean	StdErr	90%CILim	Maximum
Strontium	4	0	NA	1.01E+03	7.22E+02	2.20E+03	3.16E+03
Sulfate	4	0	NA	2.68E+04	5.12E+03	3.52E+04	4.17E+04
Uranium	3	0	NA	5.18E-01	7.40E-02	6.58E-01	6.15E-01
Vanadium	4	3	DL	5.00E+00	0.00E+00	5.00E+00	5.00E+00
Zinc	4	2	DL	2.20E+01	1.48E+01	4.62E+01	6.60E+01
Trichloro-methane	4	2	DL	6.25E+00	1.25E+00	8.30E+00	1.00E+01
Alkalinity (Method B)	4	0	NA	7.12E+04	3.20E+03	7.65E+04	7.80E+04
Beta activity (pCi/L)	3	1	DL	3.15E+00	1.16E+00	5.33E+00	5.37E+00
Conductivity (μmhos/cm)	4	0	NA	4.14E+02	2.00E+02	7.42E+02	1.01E+03
Ignitability (°F)	4	0	NA	2.05E+02	3.30E+00	2.00E+02	1.98E+02
pH (dimen-sionless)	4	0	NA	9.04E+00	1.49E-01	9.29E+00	9.35E+00
Reactivity cyanide (mg/kg)	4	4	NA	<1.00E+02	0.00E+00	<1.00E+02	<1.00E+02
Reactivity sulfide (mg/kg)	4	4	NA	<1.00E+02	0.00E+00	<1.00E+02	<1.00E+02
Suspended solids	4	3	DL	7.25E+03	2.25E+03	1.09E+04	1.40E+04
Total dissolved solids	4	0	NA	9.69E+05	8.57E+05	2.37E+06	3.54E+06
Temperature (°C)	4	0	NA	1.39E+01	3.53E+00	1.97E+01	2.42E+01
Total organic carbon	2	0	NA	1.30E+03	0.00E+00	1.30E+03	1.30E+03

Table 9. Statistics on Effluent Chemistry Data--284-WB Powerplant Ponds Wastewater (WHC 1990c). (3 sheets)

Constituent	N	MDA	Meth	Mean	StdErr	90%CILim	Maximum
Total carbon	4	0	NA	1.55E+04	5.31E+02	1.64E+04	1.68E+04
Total organic halides (as chloride)	4	0	NA	5.15E+01	1.38E+01	7.40E+01	7.70E+01

EP = Extraction procedure.

MDA = minimum detectable amount. This number reflects the results in each data set below the detection limit.

Meth = The MDA replacement method used: replacement by the detection limit (DL), replacement by single-valued MDAs by the log-normal plotting position method (LM), or replacement of multiple-valued MDAs by the normal plotting position method.

90%CILim = 90% confidence interval limit. This is the lower limit of the one-tailed 90% confidence interval for all ignitability data sets the upper limit of one-tailed 90% confidence interval.

NA = not available.

Notes:

Mean values, standard errors, confidence interval limits, and maxima are in ppb unless otherwise indicated.

The column headed "Maximum" is the minimum value in the data set for ignitability, the value furthest from 7.25 for pH, and the maximum value for all other analytes.

Chloride concentrations are elevated in the pond effluent (Table 10), and wells to the west and northeast (up and downgradient) show evidence of elevated chloride concentrations. An extensive search of the various sources in the 200 West Area was performed using the T Plant, U Plant, Z Plant, and S Plant Aggregate Area Management Study reports (DOE-RL 1992a, 1992b, 1992c, and 1992d, respectively), to determine if there are other sources of chloride. The ponds appear to be the only known source of chloride in excess of normal groundwater concentrations and, therefore, the cause of the chloride "plume."

Another source of potential groundwater contamination is related directly to the ponds, but was not examined in the original effluents report (WHC 1990a). This potential source of contamination is the radioactive material in the pre-existing 216-U-14 Ditch. The 284-WB Ponds were constructed on top of the head end of the 216-U-14 Ditch. The construction plans specified that a minimum of 0.3 m (1 ft) of contaminated soil was removed from the sides and bottom of the ditch (KEH 1982; RHO 1983). Although the top layer of contaminated soil is assumed to have been removed, the soil column beneath the pond may contain contamination from pre-1984 discharges to the 216-U-14 Ditch.

4.4 SOIL COLUMN CHEMICAL FACTORS

Spills and liquid wastes discharged to the head end of the 216-U-14 Ditch before construction of the ponds may have contributed unknown amounts of chemical and radioactive wastes to the soil column. These liquid wastes included effluent from the "radioactive" laundry as well as from the 284-W Powerplant, which were both slightly basic (pH of ~8 to 9). A soil of basic pH usually is conducive to retention of many metals and radionuclides. However, early studies (Knoll 1957) showed a marked reduction in radionuclide sorption by Hanford Site soils in the presence of laundry detergents and related decontamination chemicals. For example, 0.1 weight percent solutions of various detergents reduced distribution coefficients (K_d values) significantly for long-lived radionuclides such as strontium-90, cesium-137, and plutonium (Table 11). Apparently detergents either form a complex with the radionuclides or block the sorption sites on the soil.

The potential significance of the above statement is that contaminant retention properties of the soil column beneath the ponds may have been altered. Consequently, the potential radionuclide inventory in the soil column may be distributed to a much greater depth than expected. The altered K_d values (see Table 11) are used to assess the magnitude of this effect (Section 5.2.3).

4.5 CONCEPTUAL MODEL

Based on the limited data available, a conceptual model of potential impacts of effluent discharges to the 284-WB Ponds is summarized below.

- Unknown amounts of long-lived radionuclides from the 200 West Area laundry (2723-W and 2724-W) released to the 216-U-14 Ditch are assumed to have been present in the soil column beneath the head end of the ditch now occupied by the ponds.

Table 10. Field Chemistry Data for the 284-WB Powerplant Ponds Effluent and Pond Water.

Location:	284-WB Powerplant Ponds
Test type:	NA
Test interval:	North pond
Depth interval:	Surface

Test equipment and calibration numbers:

HACH One portable pH meter - P/N 43800-00; S/N 930200019612
HACH Conductivity/TDS meter - S/N 910706830
HACH Drel/2000 Spectrophotometer - P/N 44800-00; S/N 910815701

Sample number	Date	Time (PST)	Flowmeter/ weir reading	pH	Temp (°C)	Cond. (µmhos/ cm)	Cr^{+6} (mg/L)	NO_3^{2-} (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)	Sample cell number	Sample type
284W-93-1	8-2-93	1340	NA	9.17	24.1	168	--	--	--	--	--	Pond
284W-93-2	8-6-93	1649	NA	9.51	25.1	170	--	--	--	--	--	Pond
284W-93-3	8-6-93	1653	NA	9.43	26.4	355	0.01	0.8	70.0	3.5	278	Effluent
284W-93-4	8-6-93	1751	NA	9.41	27.4	172	0.00	0.6	17.0	134	278	Pond
284W-93-5	8-6-93	1826	NA	9.48	26.3	363	0.00	0.8	18.0	36.5	278	Effluent
284W-93-6	8-6-93	1903	NA	7.61	25.4	979	0.08	0.1	21.0	48.5	278	Effluent[a]
284W-93-7	8-6-93	1915	NA	7.50	26.2	1,065	0.01	0.7	18.0	37	864	Effluent[b]
284W-93-8	8-6-93	1957	NA	8.64	25.5	5,720	0.01	0.7	18.0	860	278, 864	Pond[c]
284W-93-9	8-6-93	2027	NA	8.54	25.8	1,455	0.00	1.0	18.0	121	864	Pond[d]
284W-93-10	8-6-93	2027	NA	8.69	25.3	9,490	0.01	35.8	14.0 18.0	>5,000	278	Pond[d]

Comments: (1) Temperature = 98 °F, sunny, windy (from the W); (2) all samples are unfiltered.
HACH = HACH Company, Loveland, Colorado.
NA = not applicable.
P/N = part number.
PST = Pacific Standard Time.
S/N = serial number.

[a]Discharge event began at ~1845 PST, water very yellow and slightly cloudy, flow is two to three times as much as usual discharge rate.

[b]Water is flowing slower than at beginning of discharge, still higher than usual flow, 10 minutes after discharge began water was clear again.

[c]After discharge event was over (~1942 PST) and flow returned to normal; pond level raised ~1 ft by discharge event.

[d]Duplicate samples, taken side by side, ~0.5 ft apart, ~15 ft south of spillway into pond.

Table 11. K_d Values for Strontium-90, Cesium-137, and Plutonium-239 in Soils Treated with Various Detergents (adapted from Knoll 1957).

Detergent	Strontium-90					Cesium-137					Plutonium-239				
	pH of Deter. Soln.	pH at Equil. with Soil	K_d of Deter. Soln.	K_d of Water at Equil. pH	DK_d/WK_d	pH of Deter. Soln.	pH at Equil. with Soil	K_d of Deter. Soln.	K_d of Water at Equil. pH	DK_d/WK_d	pH of Deter. Soln.	pH at Equil. with Soil	K_d of Deter. Soln.	K_d of Water at Equil. pH	DK_d/WK_d
Duponal[a]	6.5	8.8	19.8	110	0.18	6.5	8.8	24	356	0.07	6.5	8.8	6	30	0.5
Lanokleen[b]	9.7	8.2	26.0	72	0.36	9.7	8.4	59	420	0.14	9.7	8.4	7	42	0.16
Calgon[c]	8.6	8.4	3.8	86	0.04	8.6	8.4	60	420	0.14	8.6	8.4	9	42	0.21
Trisodium phosphate	9.8	11.7	8.9	348	0.02	11.7	9.6	34	250	0.13	11.7	9.6	10	45	0.22
Sulfamic acid	2.3	8.4	7.6	86	0.09	2.3	8.4	31	420	0.07	2.3	8.4	>160	42	>3.8
Tide[d]	10.0	9.0	9.8	122	0.08	10.6	8.7	40	375	0.1	10.0	8.7	36	30	1.2
Kerful[e]	12.0	10.7	16.6	270	0.05	2.1	8.4	<40	420	<0.09	12.0	10.7	10	86	0.11
Oakite #32[f]	2.1	8.4	14.1	8.6	1.65	11.7	9.9	60	200	0.3	2.1	8.4	>160	42	>3.8
Triangle 100[g]	11.7	10.0	35.0	210	0.16	2.1	8.3	>180	430	>0.4	11.7	9.9	8	62	0.13
Bowlene[h]	2.1	8.3	9.4	78	0.12	12.0	10.9	25	65	0.38	2.1	8.3	>160	45	>3.5
Blast[i]	12.0	10.7	24.8	270	0.09	12.0	10.7	23	60	0.38	12.0	10.9	16	94	0.17
Turco 4306-B[j]	2.5	7.0	4.8	34	0.14	2.5	8.0	427	480	0.9	2.5	8.0	>2,500	55	>40

[a]Duponal is a trademark of E. I. duPont de Nemours & Company.
[b]Lanokleen is a trademark of West Disinfecting Company.
[c]Calgon is a trademark of Calgon, Inc.
[d]Tide is a trademark of Proctor & Gamble.
[e]Kerful is a trademark of Clayton Manufacturing Company.
[f]Oakite #32 is a trademark of Oakite Products Company.
[g]Triangle 100 is a trademark of L. H. Butcher Company.
[h]Bowlene is a trademark of Climaline Company.
[i]Blast is a trademark of DuBois Company.
[j]Turco 4306-B is a trademark of Turco Products, Incorporated.

- Historical discharges of laundry effluent containing low-level radioactive wastes contributed to the soil column inventory. Based on laboratory sorption studies, it is also assumed the detergents present in the laundry wastewater enhanced radionuclide mobility.

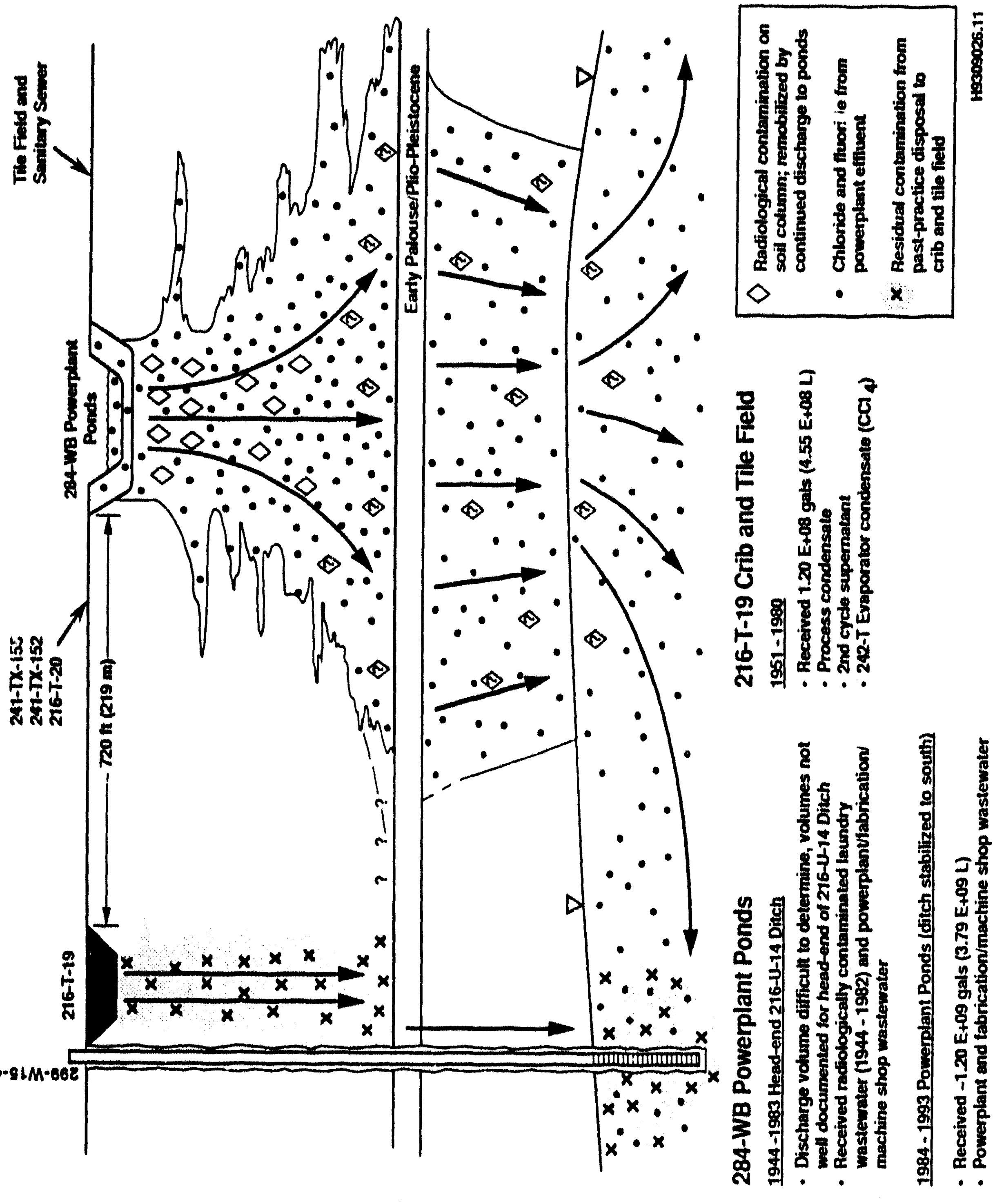
- Discharge of powerplant-related wastewater to the ponds accelerated downward transport of contaminants located directly beneath the ponds (i.e., from the former 216-U-14 Ditch sections).

- Because of the relatively high discharge rates to the ponds, a perched water zone may have formed. Interaction of perched water with residual contamination beneath adjacent disposal facilities and downward migration to the water table via unsealed monitoring wells is a potential secondary groundwater contamination pathway.

- The moderately large discharge volumes create a localized groundwater mound. The mound, in combination with a zone of high transmissivity, results in movement of high-chloride pond water in a southwest-northeast direction along the surface of the unconfined aquifer. Exceedance of the secondary water quality standard is possible for chloride (250 ppm) within the core of the resulting groundwater plume. A schematic illustration of the conceptual model and potential impacts are shown in Figure 18.

The impact assessment presented in the following section addresses these issues using a combination of contaminant migration modeling, groundwater sampling and analysis results, and existing groundwater hydraulic data from other ongoing programs.

Figure 18. Illustrated Conceptual Model for the 284-WB Powerplant Ponds.



This page intentionally left blank.

5.0 IMPACT ASSESSMENT

As indicated in the assessment methodology document (Tyler 1991) and Section 1.0, the impact of continued wastewater discharge to the ground involves consideration of mass movement of water as well as contaminant transport factors. Hydrologic impacts are discussed first, followed by evaluation of the contaminant transport and behavior issues summarized in Section 4.5.

5.1 HYDROLOGIC IMPACTS

5.1.1 Water Table Elevation

The hypothesized occurrence of a localized groundwater mound (Section 4.5) is difficult to discern from water table maps of the area (Figure 19). The multiple sources of water in this area and changing hydraulic conditions obscure the extent and magnitude of the potential effect. However, an indication of the magnitude of the possible increase in water table elevation can be estimated by comparison of historical discharge records with changes in water table elevation. For example, as illustrated in Figure 20 (a,b), an increase in elevation of approximately 3 m (10 ft) is equivalent to wastewater discharge rates of about 5,678 L/min (1,500 gal/min). Assuming a similar hydrologic response in the vicinity of the 284-WB Ponds, an incremental increase in water table elevation of a few feet (a meter) should result from a maximum discharge of approximately 757 L/min (200 gal/min) (maximum infiltration capacity of the north pond).

5.1.2 Mounding Effects

Regardless of the actual contribution to the local water table elevations, the important question is whether or not the ponds influence groundwater movement and contaminant dispersal. The high chloride concentration of the pond water should provide evidence of water originating from this source. For example, the average chloride content of groundwater for the Hanford Site is less than 10 ppm. Thus, the dispersal of a plume containing an average chloride concentration greatly in excess of 10 ppm should be apparent.

Chloride data with which to test the above inference are available from the various monitoring programs. Accordingly, chloride concentration contours for the 200 West Area were prepared using a computerized contouring program (Figure 21). As shown, elevated chloride concentrations occur both to the west and to the north-northeast of the ponds. While well locations are very limited in the near-field portion of 200 West Area (east of the ponds), wells that lie in the hypothetical downgradient direction near the T Plant and vicinity (north and northeast of the ponds) have concentrations of chloride that are clearly elevated. Assuming that the ponds are the source of elevated chloride concentrations, then these data support the hypothesis that the ponds influence groundwater movement to the west (normally an upgradient direction), as well as in the known downgradient easterly direction.

Figure 19. Water Table Map for 200 West Area and Surrounding Areas, December 1991.

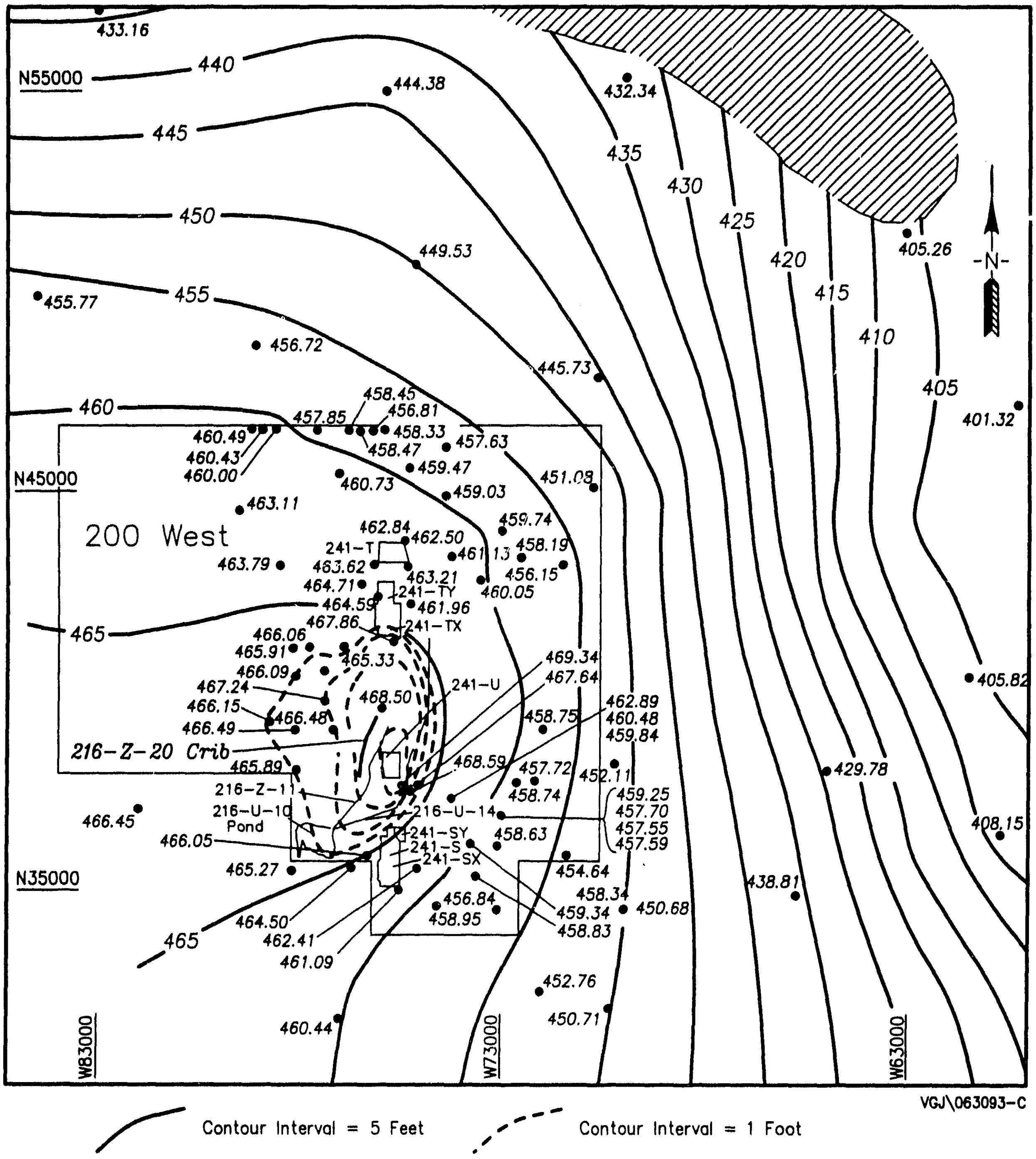


Figure 20. (a) Fluctuations in Water Table Elevations and (b) Correlation of Discharge History (In Wells South/Southwest of the 284-WB Powerplant Ponds).

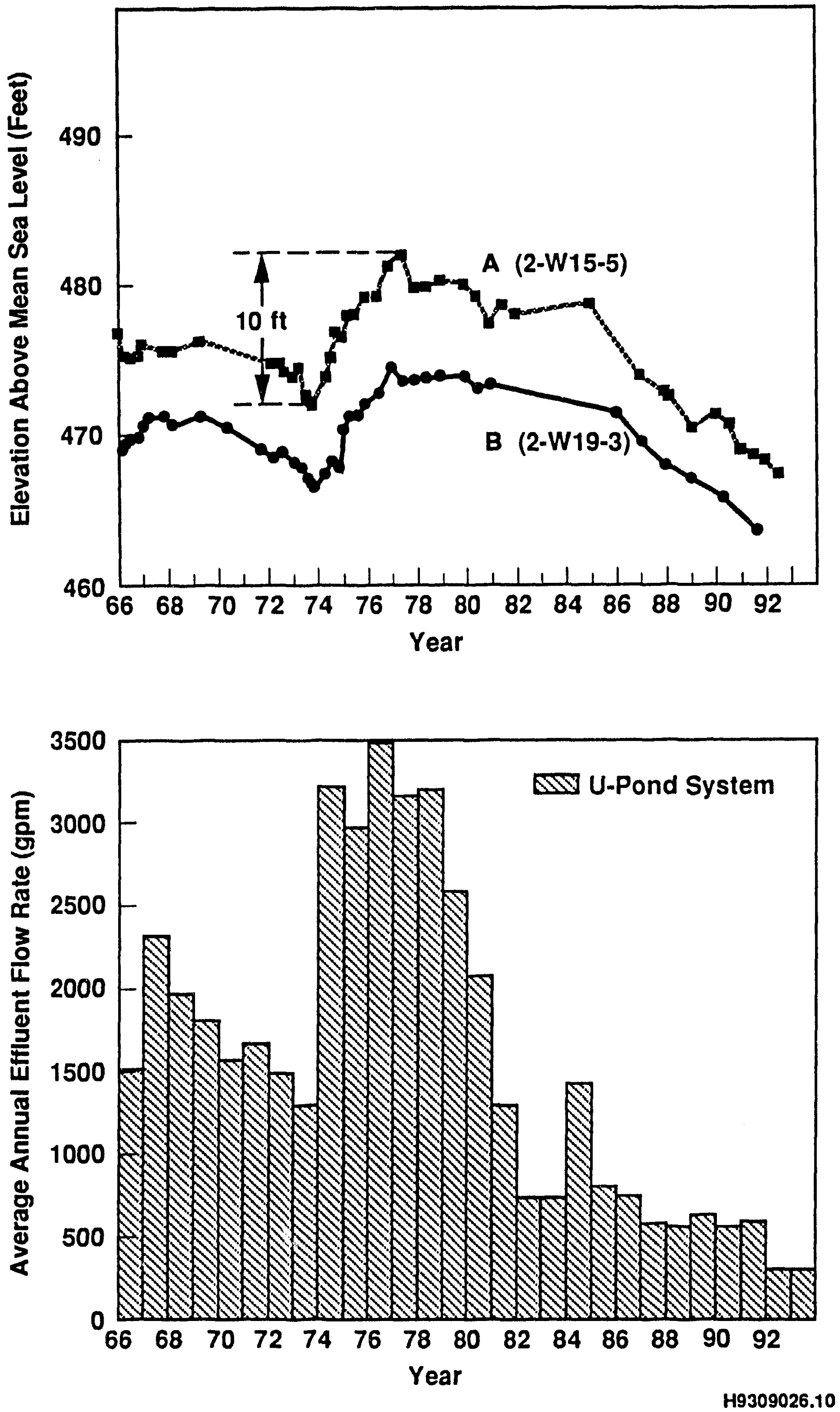
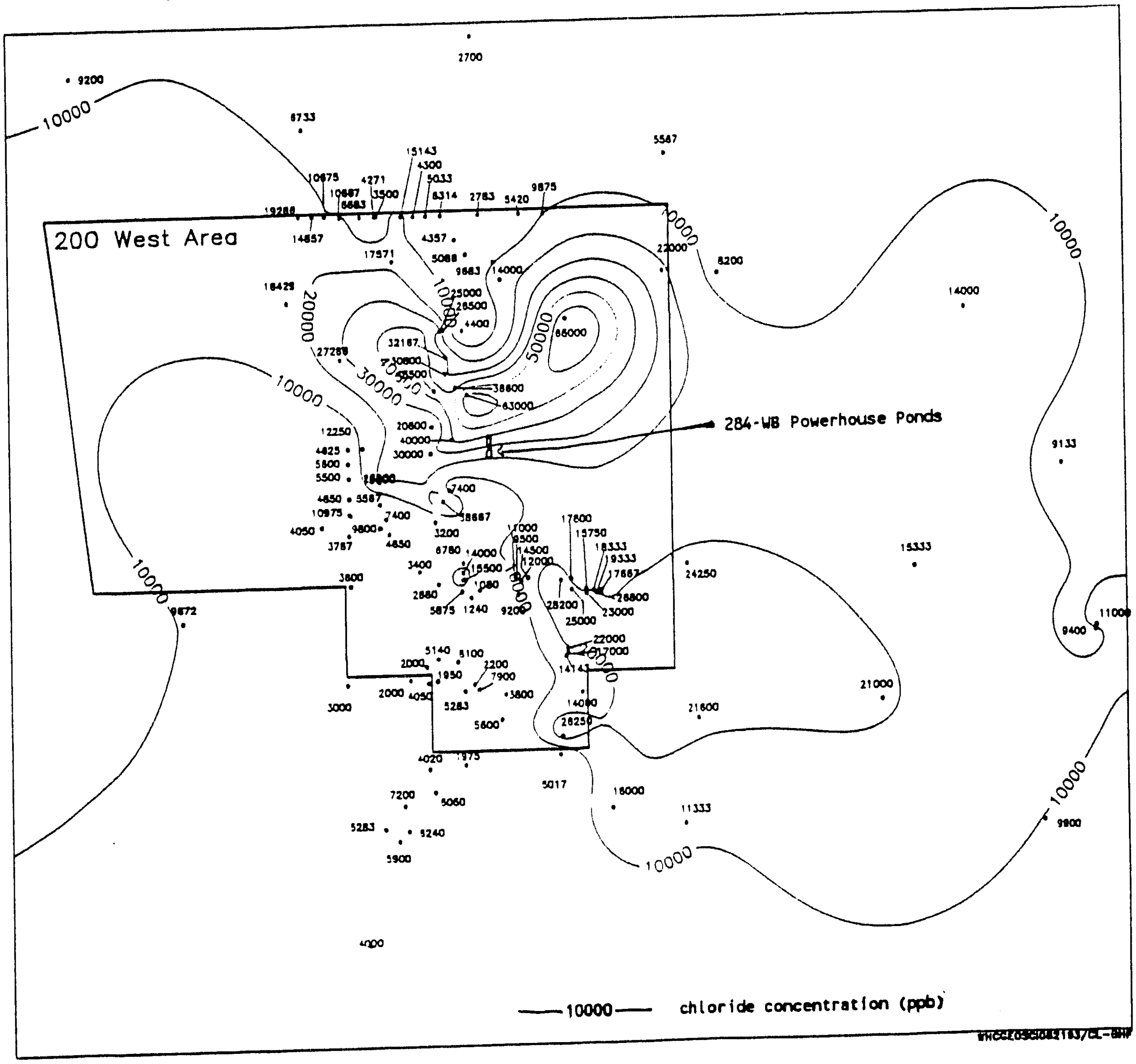


Figure 21. Chloride Concentration Map for the 200 West Area.



5.2 CONTAMINANT IMPACTS

The absence of monitoring wells at the 284-WB Ponds limits the contaminant impact evaluation to model predictions based on flow and transport analysis, as described in this section.

5.2.1 One-Dimensional Flow and Transport Analysis (Analytical Methods)

The same one-dimensional analytical method described in the *Liquid Effluent Study Final Project Report* (WHC 1990a) was employed to estimate the rate of moisture and contaminant movement through the soil column beneath the ponds. The method considers only flow in the vertical direction and does not allow for lateral spreading. Thus it is expected to provide migration rates that are faster than those that occur under actual conditions.

The method is based on steady-state flow conditions in the unsaturated zone and assumes a unit hydraulic gradient. The basic equation for any layer of sediments is

$$t = L \times \Theta/q \qquad (1)$$

where:

t = time of travel through layer, seconds
L = thickness of layer, centimeters
Θ = moisture content of sediment, related to hydraulic conductivity
q = Darcy velocity or moisture flux in layer, centimeter/second.

The total travel time, T, is determined as the summation of the travel times for each of the "i" layers:

$$T = \sum_{i=1}^{n} L_i \times \Theta_i/q_i \qquad (2)$$

where n is the number of sediment layers. For transport calculation purposes, the soil column beneath the settling pond was treated as a five-layer system (Figure 22).

The relationship between hydraulic conductivity, K, and moisture content, Θ, is described graphically in Figure 23. These curves were derived empirically from laboratory tests on over 20 different Hanford Site sediment types and were used to establish 5 major sediment types, as noted in the figure.

The one-dimensional flow analysis embodied in equation 2 was carried out on a Symphony[1] spreadsheet. The total travel time, T, obtained with

---

[1]Symphony is a registered trademark of Lotus Development Corporation.

Figure 22. Lithology of Well 299-W14-9 South of the 284-WB Powerplant Ponds (WHC 1990a).

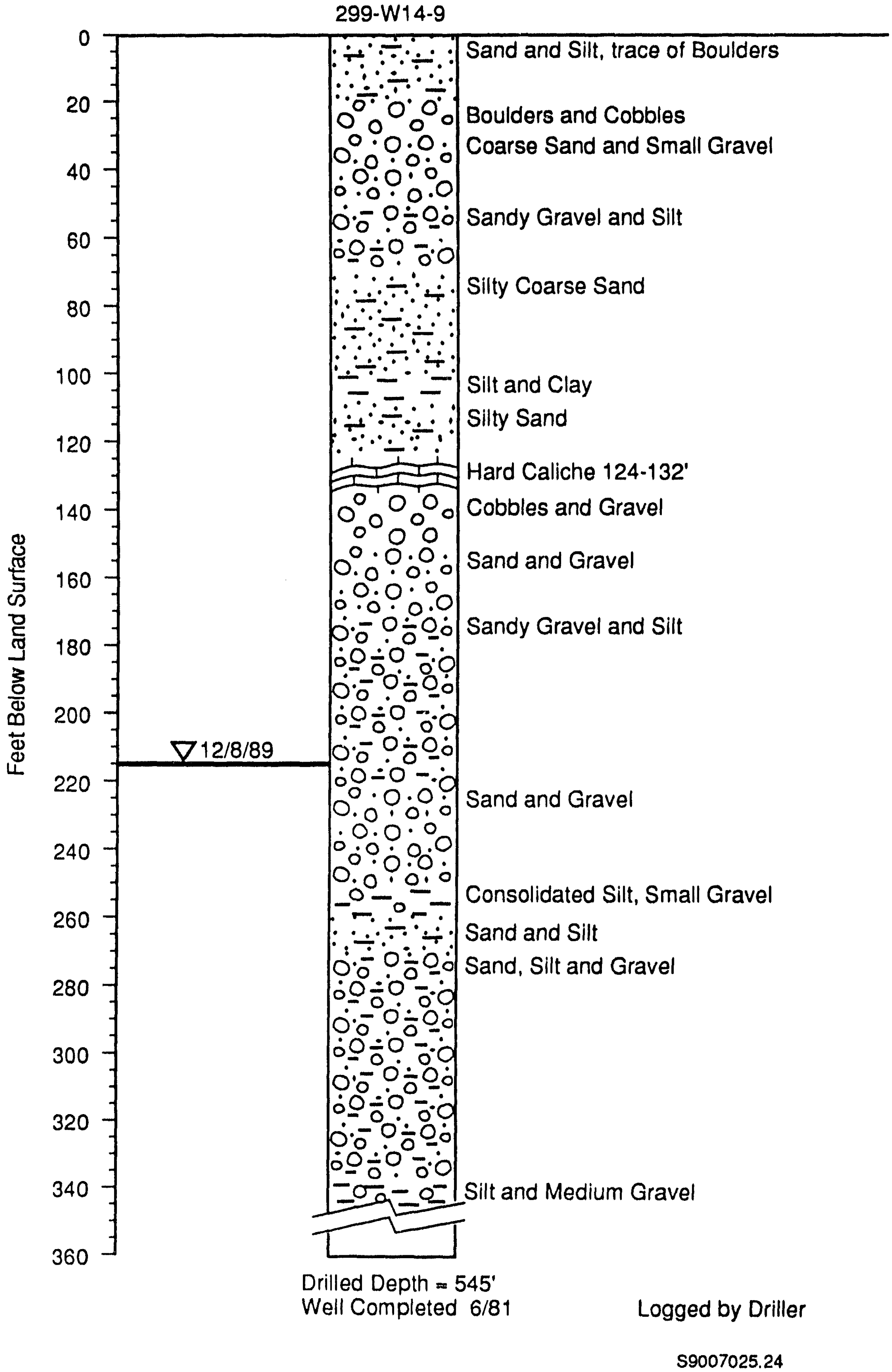
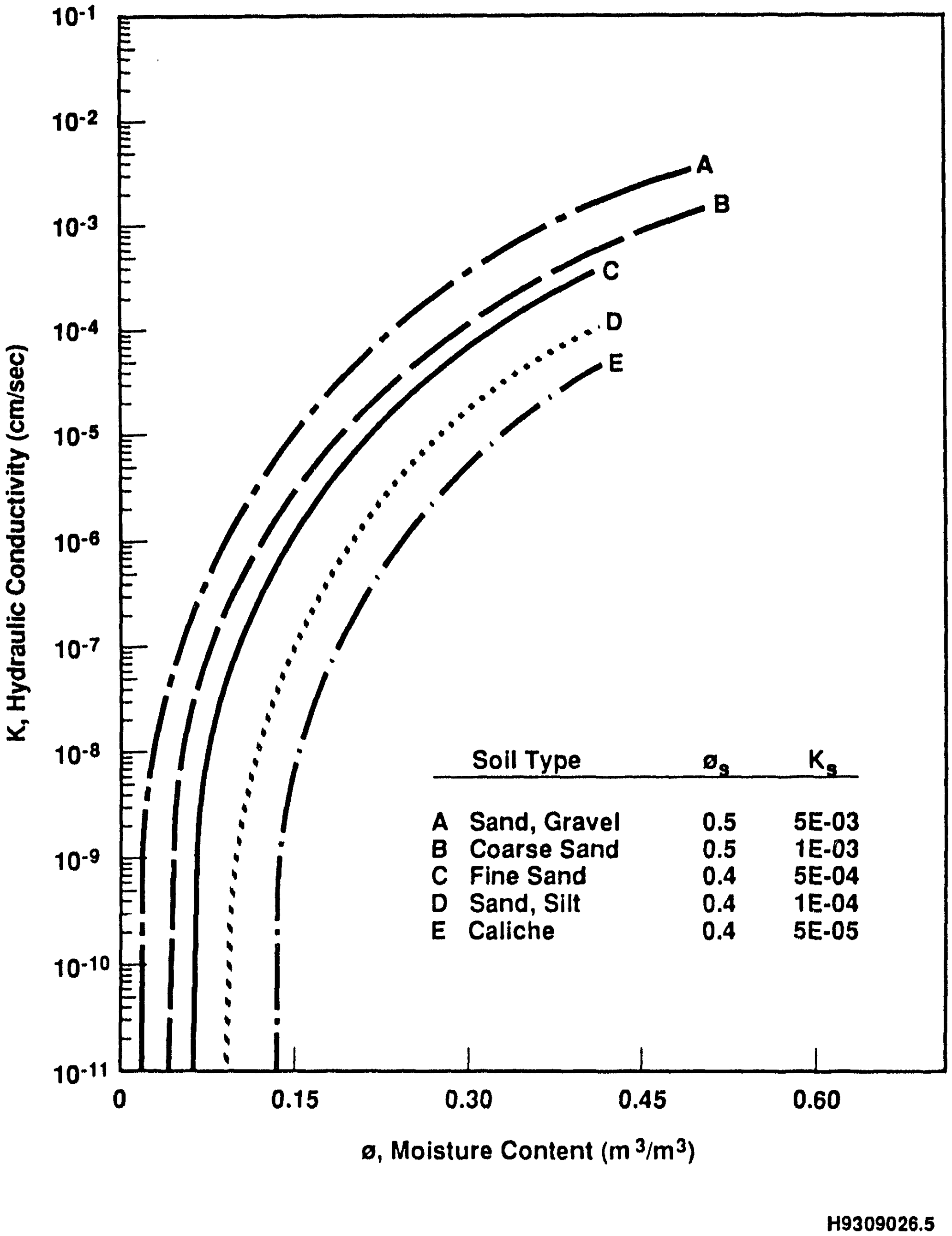


Figure 23. Hydraulic Conductivity Versus Moisture Content (WHC 1990a).



equation 2 is divided into the vadose zone thickness to provide an estimate of the rate of moisture migration from the disposal facility to the groundwater.

To obtain an estimate of the rate of contaminant migration, the retardation factor, R_f, for each of the contaminants identified was estimated from the following approximation for Hanford Site soils:

$$R_f = 1 + 5K_d \tag{3}$$

The K_d values were selected from Ames and Serne (1991). When the rate of moisture migration is divided by the R_f for the contaminant of interest, the result is an estimate of the contaminant migration rate. These computations were also carried out using the Symphony spreadsheet method.

The effluent discharge rate, as described previously, is entered as liters per month in the spreadsheet computational method. Effluent volumes through 1987 listed in WHC-EP-0287, Vol. 3, were updated to include 1988 and 1989 (WHC 1989) for the *Liquid Effluent Study Final Project Plan* (WHC 1990a; the same average infiltration rate was also assumed for the time period subsequent to 1989). The total volume (liters) was divided by the corresponding operating period (months) to establish an average rate of inflow (L/month). This effluent discharge rate was divided by the effective pond area to obtain an estimate of the average infiltration rate. Because the ponds are only partially wetted, an estimate of this area was used.

More details and an illustrative example for application of the overall computational approach are provided in WHC (1990a).

5.2.2 Results of Initial Analytical Solution

The following discussion summarizes the results from the *Liquid Effluent Study Final Project Report* (WHC 1990a).

Based on general effluent characteristics and corresponding sorption parameters (Section 5.2.1) for the key constituents identified in Table 3, the calculated migration rates (Table 12) are 31 cm/day (12 in./day) for mobile constituents (fluoride and chloride), 0.6 cm/day (0.2 in./day) for less mobile constituents (barium, manganese, and iron), and 0.3 and 0.2 cm/day (0.1 and 0.08 in./day), respectively, for the least mobile constituents (aluminum and lead). These migration rates suggest that after a 10-year discharge period (1984 to present), and assuming a continuous average discharge rate of 2.38×10^7 L/month (6.29×10^6 gal/month) (see Table 12), the maximum depth of penetration of the least mobile constituents is about 3 m (10 ft). Breakthrough of the mobile constituents occurs after less than 1 year and after 27 years for the less mobile constituents (see Table 12). Breakthrough of the least mobile constituents would occur after 55 and 82 years, respectively.

Migration rate estimates for most of the key constituents in the effluent stream (see Table 12) suggest that they are retained on the soil column. Aluminum and chloride are significantly above the WWQS (i.e., approximately three and six times higher than the WWQS, respectively).

Table 12. Initial Analytical Solution Results for the 284-WB Powerplant Ponds (WHC 1990a).

Disposal facility	Rate (L/month)	Area (m^2)	f (infiltration rate, cm/s)	Number of layers	Thickness (m)	Soil type
284-WB Powerplant Ponds	2.38 E+07	3,642	2.49 E-04	1 2 3 4 5	18 9 8 3 24 62	A B D E A

θ_s	K_s	θ	Moisture state	q (cm/s)	t (s)	T (d)	Estimated moisture migration (cm/day)
0.5 0.5 0.4 0.4 0.5	5.0 E-03 1.0 E-03 1.0 E-04 5.0 E-05 5.0 E-03	0.26 0.33 0.4 0.4 0.18	Unsaturated Unsaturated Saturated Saturated Unsaturated	2.49 E-04 2.49 E-04 1.00 E-04 5.00 E-05 5.00 E-05	1.88 E+06 1.19 E+06 3.20 E+06 2.40 E+06 8.64 E+06 1.73 E+07	200	31

Constituent	R_f (retardation factor)	Estimated contaminant migration (cm/day)	Contaminant transport to water table (year)
Barium	50	0.6	27
Chloride	1	31	0.55
Fluoride	1	31	0.55
Lead	150	0.2	82
Manganese	50	0.6	27
Aluminum	100	0.3	55
Iron	50	0.6	27

Based on the above considerations, the estimated travel time and the volume of water discharged to this site, it was concluded that chloride in groundwater within the vicinity of this disposal site may have exceeded its secondary water quality standard. Mitigating conditions include dilution and dispersion.

5.2.3 Results of Revised Analytical Solution

This section summarizes contaminant transport estimates using revised infiltration rates, soil chemical factors (see Section 4.4), and inclusion of key radioactive contaminant constituents of interest.

5.2.3.1 Infiltration Rate Assumptions. Uncertainties in historical discharge rates to the ditch and pond system are resolved by assuming the water is applied at the infiltration capacity of typical soils in the 200 West Area. For example, the 216-U-17 Crib was designed based on an assumed capacity factor of (4.72×10^{-6} m/s) (10 gal/day/ft^2) (Reidel et al. 1993).

The above infiltration capacity factor implies a steady-state discharge of 3.27×10^7 L/month (8.64×10^7 gal/month) or 757 L/month (200 gal/month) (north pond only with a wetted area of 1,057 m^2 (11,375 ft^2). This rate seems consistent with the discharge history for 200 West Area and operator recollection. During peak periods the overflow pond would have received any flow in excess of the above.

5.2.3.2 Radioactive Contaminants and K_d Assumptions. Although effluent records for historical use of the 216-U-14 Ditch are somewhat obscure, it is known that the principal radioactive constituents of concern in laundry wastewater included plutonium, strontium-90 and cesium-137 (Knoll 1957). Because the laundry wastewater entered the former 216-U-14 Ditch where the ponds are now located, it is assumed the soil column beneath the ponds was loaded with these radioactive constituents as well as with the other chemical contaminants included in the original analysis (Table 13). It is further assumed that detergents either modified the soil or formed complexes with the radioactive contaminants and this resulted in an assumed 20-fold reduction in the K_d for strontium-90 and a 5-fold reduction for cesium-137 and plutonium (based on the lower DK_d/WK_d factors in Table 11 and assuming Tide[1] and Calgon[2] were the most representative detergents used). These factors are applied to the best judgment (conservative) K_d values from Ames and Serne (1991) for waste streams with a basic pH, low organic, and high salt content.

The influence of detergent on the K_d values for the other chemical constituents of concern considered in the original analysis (see Table 12) is unknown. However, certain constituents are chemical analogs of the radionuclides considered. For example, barium is chemically similar to strontium (i.e., both are alkaline earth metals). Thus the same detergent factor used for strontium above is assumed to apply to barium. The effect of

[1]Tide is a trademark of Proctor & Gamble.
[2]Calgon is a trademark of Calgon, Inc.

Table 13. Revised Analytical Solution Results for the 284-WB Powerplant Ponds--Worst-Case Scenario/Laundry Detergent Modified Sorption.

Disposal facility	Rate (L/month)	Area (m^2)	f (infiltration rate, cm/s)	Number of layers	Thickness (m)	Soil type
284-WB Powerplant Ponds	3.27 E+07	1,057	1.2 E-03	1	62	N/A

θ_s	K_s	θ	Moisture state	q (cm/s)	t (s)	T (d)	Estimated moisture migration rate (cm/day)
N/A	N/A	N/A	Saturated	1.2 E-03	5.18 E+06	60	104

Constituent	R_f (retardation factor)	Estimated contaminant migration (cm/day) (rounded to nearest whole number)	Contaminant transport to water table (year) (rounded to 1 signf. digit)
Barium	6	20	0.8
Chloride	1	100	0.2
Fluoride	1	100	0.2
Lead	30	4	4
Manganese	10	10	2
Aluminum	20	5	3
Iron	10	10	2
Plutonium	50	2	8
Strontium	6	20	0.8
Cesium	10	10	2

N/A = not applicable.

detergents on the other metals (aluminum, manganese, iron, and lead) is more difficult to assess. A five-fold detergent reduction factor is arbitrarily assumed to apply to these metals.

5.2.3.3 Contaminant Migration Rates and Travel Time Estimates. Based on the assumptions described in Sections 5.2.3.1 and 5.2.3.2, revised migration rates and travel times are as shown in Table 13. The estimates for migration rates and travel times contain uncertainties because the hydrogeologic and chemical parameters controlling these rates are not known exactly. Therefore, the estimates are the expected values based on the best information available. These estimates suggest that most of the constituents of concern were distributed over the entire soil column by the time the pond system was constructed. This result stands in contrast to the initial model predictions (Section 5.1) primarily because of incorporation of the modified K_d values caused by the detergent effect and a greater infiltration rate. After laundry discharge to the 216-U-14 Ditch was stopped in 1982, effluent did not include detergent. The primary impact after 1982 should have been (1) washout of the contaminant inventory remaining on the "detergent-conditioned" soil column, and (2) continued addition of chloride and fluoride from the powerplant chemical inputs.

The migration rate estimates summarized in Table 13, and discussed above, support the pond/soil column portion of the conceptual model described in Figure 18. However, as previously indicated, there are no monitoring wells in the vicinity of the ponds to further test the contaminant transport predictions. If breakthrough of heavy metals and radionuclides has already occurred, as suggested by Table 13, the more slowly migrating contaminants should be limited to the portion of the unconfined aquifer in the immediate vicinity of the ponds. On the other hand, the more mobile contaminants (fluoride and chloride) should be more widely dispersed. As indicated in Section 5.1.2 and Figure 21, there is evidence supporting the chloride/pond water dispersal hypothesis. However, the highest chloride concentration in groundwater downgradient from the 284-WB Ponds is only 63,000 ppb as compared to a weighted average effluent concentration of 1,500,000 ppb (see Table 7). Even if the revised estimate of chloride concentration of 250,000 ppb (given in Section 3.4) is used, there is still a significant difference in values. Either significant dilution of the pond water occurs as the plume spreads, dilution occurs within the borehole during sampling, or the source term is in error. Current chemical data for all of the contributor waste streams were not available to check the latter possibility at the time of this writing.

5.2.4 Evidence for Interaction with Adjacent Facilities

As suggested in Figure 18, lateral movement of pond water along the top of the early "Palouse"/Plio-Pleistocene units may remobilize residual contaminants beneath adjacent sources (e.g., leakage from tank farm transfer lines, the 241-TX-155 Diversion Box, and the T-19 Crib and Tile Field [T-19 Crib]). Downward migration of "perched water" along the outside of unsealed well casings, such as well 299-W15-4, could result in direct injection of contaminants at the water table. Whether or not perched water actually extends horizontally for 213 m (700 ft) from the 284-WB Ponds to sources such as the T-19 Crib is unknown. However, Figures 15, 16, and 17 suggest both radiological and chemical contaminants continue to emanate from a point source immediately west of the T-19 Crib. Additional discussion and alternatives to perched water from the ponds are in the following sections.

5.2.4.1 Natural Processes. The large volume of process condensate and second-cycle supernatant discharged to the T-19 Crib was sufficient to completely wet the entire soil column. The mobile constituents associated with this waste source include tritium, technetium-99, carbon tetrachloride, chloroform, and trichloroethylene. Following termination of input to the T-19 Crib approximately 13 years ago, the remaining liquid would have drained. Mobile contaminants associated with liquid waste would be held in pore spaces of the soil column by surface tension. Continued downward migration of the residual contamination may occur by diffusion and enhanced natural infiltration because of disturbance of the soil and removal of vegetation from the crib area.

5.2.4.2 Surface Water and Preferential Pathways. Snow melt and seasonal "ponding" of surface water during melts and heavy rains may migrate downward between the borehole and casing. This process could carry residual contaminants to groundwater on a continuing basis.

Additional vadose zone test borings would be needed to determine if perched water from the 284-WB Ponds is involved in what appears to be a continuing (minor) source of groundwater contamination near the T-19 Crib. However, regardless of the driving force, the wells adjacent to the crib (299-W14-5 and 299-W15-4) should be sealed as a groundwater protection measure.

5.3 EVALUATION OF MONITORING NETWORK ADEQUACY

The complete absence of groundwater monitoring wells in the immediate vicinity of the 284-WB Ponds should be remedied if continuous use of the ponds (beyond the June 1995 cutoff date) becomes necessary. Ongoing *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) characterization and remediation activities should address the potential influence of the 284-WB Ponds, and the lack of monitoring wells and groundwater chemistry data for the central portion of the 200 West Area.

This pag? intentionally left blank.

6.0 SUMMARY AND CONCLUSIONS

Effluent data, vadose zone transport predictions, and circumstantial evidence suggest the 284-WB Ponds contribute both directly and indirectly to groundwater contamination in the 200 West Area. The most likely groundwater contaminants are chloride, fluoride, and possibly barium from disposal of water softener regenerant. Process improvements are expected to reduce this source in the near future. Mobilization of radioactive constituents in the soil column beneath the ponds before their construction, and/or interaction of perched water from the ponds with adjacent sources is possible, but the magnitude and extent are unknown.

6.1 GROUNDWATER QUALITY IMPACTS

Laboratory sorption data combined with flow and transport estimates suggest laundry detergents may have enhanced the mobility of strontium-90, cesium-137, and isotopes of plutonium in the soil column from disposal operations before construction of the ponds. Calculated transport times to the water table, based on worst-case assumptions, were all less than 10 years. It is thus theoretically possible that breakthrough to groundwater has occurred or will occur soon. However, it is not possible to confirm this prediction without groundwater sampling and analysis data from near the ponds. Such data are necessary to evaluate impacts from continued operation in the unexpected event that the termination date (June 1995) for discharge to the 284-WB Ponds cannot be met.

6.2 HYDROLOGIC IMPACTS

Discharge of water to the ponds now represents a substantial portion of the artificial recharge to the 200 West Area, and so some hydraulic influence on local groundwater flow paths is likely. The distribution pattern for chloride in groundwater provides an indication of the widespread influence of pond operations on water movement in the north-central 200 West Area.

6.3 CONCLUSION

Continued short-term operation of the 284-WB Ponds will contribute to groundwater contamination in the 200 West Area. In addition, a slow migration drainage will continue to occur after discharges cease. However, the existing groundwater contamination from past-practice sources has greater potential significance than the contribution from the ponds. Ongoing CERCLA characterization and remediation activities should consider the potential influence of the 284-WB Ponds on contaminant distribution, and the lack of hydrogeologic and groundwater chemistry data (caused by the lack of monitoring wells) for the central portion of the 200 West Area. If discharges to the 284-WB Ponds continue beyond the scheduled cessation date of June 1995, a groundwater monitoring network should be installed for this site.

This page intentionally left blank.

7.0 REFERENCES

Ames, L. L. and R. J. Serne, 1991, *Compilation of Data to Estimate Groundwater Migration Potential for Constituents in Active Liquid Discharges at the Hanford Site*, PNL-7660, Pacific Northwest Laboratory, Richland, Washington.

Baker, V. R., B. N. Bjornstad, A. J. Busacca, K. R. Fecht, E. P. Kiver, U. L. Moody, J. G. Rigby, D. F. Stradling, and A. M. Tallman, 1991, *Quaternary Geology of the Columbia Plateau*, in Quaternary Nonglacial Geology; Conterminous United States, R.B. Morrison (editor), Geological Society of america, The Geology of North America, v. K-2, p. 215-250, Boulder, Colorado.

Bjornstad, B. N., 1984, *Suprabasalt Stratigraphy Within and Adjacent to the Reference Repository Location*, SD-BWI-DP-039, Rockwell Hanford Operations, Richland, Washington.

Campbell, N. P., 1989, *Structural and Stratigraphic Interpretation of Rocks Under the Yakima Fold Belt, Columbia Basin, Based on Recent Surface mapping and Well Data*, in Volcanism and Tectonism in the Columbia Flood-Basalt Province, Special Paper 239, edited by S. P. Reidel and P. R. Hooper, Geological Society of America, Boulder, Colorado, p. 209-222.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

Connelly, M. P., B. H. Ford, and J. V. Borghese, 1992, *Hydrogeologic Model for the 200 West Groundwater Aggregate Area*, WHC-SD-EN-TI-014, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Delaney, C. D., K. A. Lindsey, and S. P. Reidel, 1991, *Geology and Hydrology of the Hanford Site: A Standardized Text for use in Westinghouse Hanford Company Documents and Reports*, WHC-SD-ER-TI-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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

DOE-RL, 1992a, *T Plant Aggregate Area Management Study Report*, DOE/RL-91-61, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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

DOE-RL, 1992c, *Z Plant Source Aggregate Area Management Study Report*, DOE/RL-91-58, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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

Ecology, EPA, DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ecology, EPA, DOE, 1991, *Hanford Federal Facility Agreement and Consent Order*, second amendment, 2 volumes, Rev. 2, Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Fecht, K. R., S. P. Reidel, and A. M. Tallman, 1987, *Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State -- A Summary*, in Selected Papers on the Geology of Washington, Division of Geology and Earth Resources, Bulletin 77, p. 219-248, edited by J. E. Schuster.

Gee, G. W., 1987, *Recharge of the Hanford Site: Status Report*, PNL-6403, Pacific Northwest Laboratory, Richland, Washington.

Graham, M. J., M. D. Hall, S. R. Strait, and W. R. Brown, 1981, *Hydrology of the Separations Area*, RHO-ST-42, Rockwell Hanford Operations, Richland, Washington.

Graham, M. J., G. V. Last, and K. R. Fecht, 1984, *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*, RHO-RE-ST-12, Rockwell Hanford Operations, Richland, Washington.

Herman, D. R., 1992, *Sampling and Analysis Plan for the 284-W Area Powerplant and 277-W Fabrication Shop Process Wastewater Streams*, WHC-SD-WM-PLN-033, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

KEH, 1982, *Conceptual Design Report Powerhouse Effluents Pond - 200 West Area Project B-405*, SD-405-CDR-001, Kaiser Engineers Hanford Company, Richland, Washington.

Knoll, K. C., 1957, *Effects of Detergents Upon Absorption of Radioisotopes by Soils*, HW-52055, General Electric Company, Hanford Atomic Products Operation, Richland, Washington.

Last, G. V., B. N. Bjornstad, M. P. Bergeron, R. W. Wallace, D. R. Newcomer, J. A. Schramke, M. A. Chamness, C. S. Cline, S. P. Airhart, and J. S. Wilbur, 1989, *Hydrogeology of the 200 Areas Low-Level Burial Grounds -- An Interim Report*, PNL-6820, Pacific Northwest Laboratory, Richland, Washington.

Lindsey, K. A., 1991a, *Revised Stratigraphy for the Ringold Formation, Hanford Site, South-Central Washington*, WHC-SD-EN-EE-004, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Lindsey, K. A., 1991b, *Sedimentation and Basin Evolution of the Late Neogene Ringold Formation, Central Columbia Plateau, South-Central Washington*, Geological Society of America Abstracts with Programs, v. 23, no. 5, p. A285, Boulder, Colorado.

Lindsey, K. A., 1992, *Geology of the Northern Part of the Hanford Site: An Outline of Data Sources and the Geologic Setting of the 100 Areas*, WHC-SD-EN-TI-011, Westinghouse Hanford Company, Richland, Washington.

Lindsey, K. A., M. P. Connelly, and B. N. Bjornstad, 1991, *Geologic Setting of the 200 West Area: An Update*, WHC-SD-EN-TI-008, Westinghouse Hanford Company, Richland, Washington.

Lindsey, K. A., B. N. Bjornstad, J. W. Lindberg, and K. M. Hoffman, 1992, *Geologic Setting of the 200 East: An Update*, WHC-SD-EN-TI-012, Westinghouse Hanford Company, Richland, Washington.

Maxfield, H. L., 1979, *200 Areas Waste Sites*, RHO-CD-673, Volumes 1-3, Rockwell Hanford Operations, Richland, Washington.

Myers, C. W., S. M. Price, J. A. Caggiano, M. P. Cochran, W. J. Czimer, N. J. Davidson, R. C. Edwards, K. R. Fecht, G. E. Holmes, M. G. Jones, J. R. Kunk, R. D. Landon, R. K. Ledgerwood, J. T. Lillie, P. E. Long, T. H. Mitchell, E. H. Price, S. P. Reidel, and A. M. Tallman, 1979, *Geologic Studies of the Columbia Plateau: A Status Report*, RHO-BWI-ST-4, Rockwell Hanford Operations, Richland, Washington.

PSPL, 1982, *Skagit/Hanford Nuclear Project, Preliminary Safety Analysis Report*, Vol. 4, App. 20, Amendment 23, Puget Sound Power and Light Company, Bellevue, Washington.

Reidel, S. P., 1984, *The Saddle Mountains: The Evolution of an Anticline in the Yakima Belt*, American Journal of Science, v. 284, p. 942-978.

Reidel, S. P. and K. R. Fecht, 1981, *Wanapum and Saddle Mountains Basalt in the Cold Creek Syncline Area*, in Subsurface Geology of the Cold Creek Syncline, RHO-BWI-ST-14, Rockwell Hanford Operations, Richland, Washington.

Reidel, S. P. and P. R. Hooper, 1989, editors, "Volcanism and Tectonism in the Columbia River Flood Basalt Province," Special Paper 239, *Geological Society of America*, Boulder, Colorado, 386 p.

Reidel, S. P., K. R. Fecht, M. C. Hagood, and T. L. Tolan, 1989, *The Geologic Evolution of the Central Columbia Plateau*, in Volcanism and Tectonism in the Columbia River Flood-Basalt Province, Special Paper 239, edited by S. P. Reidel and P. R. Hooper, Geological Society of America, Boulder, Colorado, p. 247-264.

Reidel, S. P., K. A. Lindsey, and K. R. Fecht, 1992, *Field Trip Guide to the Hanford Site*, WHC-MR-0391, Westinghouse Hanford Company, Richland, Washington.

Reidel, S. P., V. G. Johnson, and N. W. Kline, 1993, *Groundwater Impact Assessment for the 216-U-17 Crib, 200 West Area*, WHC-EP-0664, Westinghouse Hanford Company, Richland, Washington.

RHO, 1983, *Specifications Powerhouse Effluents Pond - 200 West Area Project B-405*, Prepared for Rockwell Hanford Operations, Richland, Washington, by Systems Architects Engineers Inc., Seattle, Washington.

Rockhold, M. L., M. J. Fayer, G. W. Gee, and M. J. Kanyid, 1990, *Natural Groundwater Recharge and Water Balance at the Hanford Site*, PNL-7215, Pacific Northwest Laboratory, Richland, Washington.

Routson, R. C. and V. G. Johnson, 1990, *Recharge Estimates for the Hanford Site 200 Areas Plateau*, Northwest Science, v. 64, no. 3.

Smith, G. A., 1988, *Neogene Synvolcanic and Syntectonic Sedimentation in Central Washington*, v. 100, p. 1479-1492, Geological Society of America Bulletin, Boulder, Colorado.

Smith, G. A., B. N. Bjornstad, and K. R. Fecht, 1989, *Neogene Terrestrial Sedimentation on and Adjacent to the Columbia Plateau; Washington, Oregon, and Idaho*, in Volcanism and Tectonism in the Columbia River Flood-Basalt Province, Special Paper 239, edited by S. P. Reidel and P. R. Hooper, Geological Society of America, Boulder, Colorado, p. 187-198.

Stordeur, R. T. and D. L. Flyckt, 1988, *Annual Status Report of the Plan and Schedule to Discontinue Disposal of Contaminated Liquids into the Soil Column at the Hanford Site*, WHC-EP-0196-1, Westinghouse Hanford Company, Richland, Washington.

Tallman, A. M., K. R. Fecht, M. C. Marratt, and G. V. Last, 1979, *Geology of the Separations Areas, Hanford Site, South-Central Washington*, RHO-ST-23, Rockwell Hanford Operations, Richland, Washington.

Tallman, A. M., J. T. Lillie, and K. R. Fecht, 1981, *Suprabasalt Sediments of the Cold Creek Syncline Area*, in Subsurface Geology of the Cold Creek Syncline, RHO-BWI-ST-14, C. W. Myers, and S. M. Price, Rockwell Hanford Operations, Richland, Washington.

Tolan, T. L. and S. P. Reidel, 1989, *Structure Map of a Portion of the Columbia River Flood-Basalt Province*, in Volcanism and Tectonism in the Columbia River Flood-Basalt Province, Special Paper 239, edited by S. P. Reidel and P. R. Hooper, Geological Society of America, Boulder, Colorado, plate 1.

Tolan, T. L., S. P. Reidel, M. H. Beeson, J. L. Anderson, K. R. Fecht, and D. A. Swanson, 1989, *Revisions to the Extent and Volume of the Columbia River Basalt Group*, in Volcanism and Tectonism in the Columbia River Flood-Basalt Province, Special Paper 239, edited by S. P. Reidel and P. R. Hooper, Geological Society of America, Boulder, Colorado, p. 1-20.

Tyler, D. K., 1991, *A Methodology for Assessing Impacts to Groundwater from Disposal of Liquid Effluent to the Soil at the Hanford Site*, WHC-SD-EN-EV-008, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WAC 173-200, 1990, "Water Quality Standards of the State of Washington," *Washington Administrative Code*, as amended.

WHC, 1989, *Waste Stream Characterization Report*, WHC-EP-0287, Vol. 3, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990a, *Liquid Effluent Study Final Project Report*, WHC-EP-0367, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990b, *Liquid Effluent Study: Ground Water Characterization Data*, WHC-EP-0366, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990c, *284-W Powerplant Wastewater Stream-Specific Report*, WHC-EP-0342, Addendum 27, Westinghouse Hanford Company, Richland, Washington.

This page intentionally left blank.

DISTRIBUTION

Number of copies

OFFSITE

Number of copies	Addressee	
4	Confederated Tribes of the Umatilla Reservation P.O. Box 638 Pendleton, Oregon 97801	
	J. R. Wilkinson	
	Nez Perce Tribal Office P.O. Box 305 LaPwai, Idaho 83540	
	D. Powaukee	
	Southwest Research Institute 6220 Culebra Road San Antonio, Texas 78284	
	B. Sagar	
	Yakima Indian Nation 2552 Haines Richland, Washington 99352	
	R. F. Cook	

ONSITE

Number of copies	Addressee	MSIN
9	U.S. Department of Energy, Richland Operations Office	
	K. V. Clarke	A5-15
	B. A. Davis	R3-82
	M. J. Furman	R3-81
	J. M. Hennig	R3-80
	M. P. Johansen	A5-19
	J. E. Rasmussen	A5-15
	R. K. Stewart	A5-19
	S. H. Wisness	A5-15
	RL Public Reading Room	A1-65
1	Pacific Northwest Laboratory	
	PNL Technical Files	K1-11

DISTRIBUTION (cont.)

Number of copies

ONSITE

42	Westinghouse Hanford Company	
	D. J. Alexander (5)	H6-06
	L. E. Borneman	B2-35
	K. R. Fecht	H6-06
	B. H. Ford	H6-06
	D. R. Herman	S2-66
	D. G. Horton	H6-06
	B. E. Innis	H6-03
	V. G. Johnson (5)	H6-06
	D. E. Kelley	R3-46
	G. G. Kelty	H6-06
	A. J. Knepp	H6-06
	K. A. Lindsey (5)	H6-06
	D. L. Parker	H6-03
	S. P. Reidel	H6-06
	K. R. Simpson	H6-06
	K. M. Singleton	H6-06
	D. R. Speer	R1-48
	D. K. Tyler (3)	H6-06
	C. D. Wittreich	H6-03
	Central Files	L8-04
	Document Processing and Distribution (2)	L8-15
	Environmental Restoration Program Information Center (5)	H6-08
	Information Release Administration	L8-07

DATE

FILMED

11/22/93

END