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Dear Messrs. Day and Jansen:

TRANSMITTAL OF THE COMPLETED MILESTONE M-17-06E "ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS FROM CONTINUED DISCHARGE TO THE 300 AREA PROCESS TRENCHES AT HANFORD"

Attached is the Assessment of Potential Environmental Impacts From Continued Discharge to the 300 Area Process Trenches at Hanford report. This document satisfies the Hanford Federal Facility Agreement and Consent Order Milestone M-17-06E which is due by July 1992.

If you or your staff have any questions regarding this milestone, please contact Mr. L. S. Mamiya, Department of Energy, Richland Field Office, on (509) 376-1471.

Sincerely,

Jon Yerxa for

Steven H. Wisness
Hanford Project Manager

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7. Abstract

To satisfy requirements of the Hanford Federal Facility Agreement and Consent Order (Milestone M-17-06E), this report assesses potential environmental impacts to the soil and groundwater underlying the 300 Area Process Trenches due to continued discharge of effluent. The assessment uses data collected from the following sources: published environmental studies and investigations; a recent Expedited Response Action which removed contaminated trench sediments; ongoing groundwater monitoring activities; and a recent characterization of effluent discharged to the trenches. The analysis is semi-quantitative and conclusions are based upon scientific principles and professional judgement. None of the process effluent constituents exceed drinking water standards. Uranium is the primary groundwater constituent of concern. That uranium left in the portion of the vadose zone affected by continued discharge is predicted to contribute only an additional 1-percent to the uranium already present in the unconfined aquifer. Potential impacts to the groundwater are expected to be small or indiscernible. Concentrations of uranium and nickel should eventually decrease as a result of the Expedited Response Action's removal of contaminated sediments in the bottom of the trenches. Continued monitoring of selected groundwater constituents is recommended.

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Part 2

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ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS FROM CONTINUED DISCHARGE TO THE 300 AREA PROCESS TRENCHES AT HANFORD

PREPARED BY

GOLDER ASSOCIATES, INC.

FOR

WESTINGHOUSE HANFORD COMPANY

EXECUTIVE SUMMARY

The 300 Area process trenches have received waste effluents since 1974. These trenches are regulated by the Washington State Department of Ecology under a Resource Conservation and Recovery Act Interim Status Permit, although the current effluent entering the trenches is not a dangerous waste. In 1985, administrative controls were instituted to reduce contaminant discharge to the trenches. Milestone M-17-09 of the Hanford Federal Facilities Agreement and Consent Order (the Tri-Party Agreement) specifies the construction and hot startup of a liquid effluent treatment facility by December 1994. This facility will discharge treated effluent to the Columbia River under an National Pollutant Discharge Elimination System (NPDES) permit, and discharge to the trenches will cease. An Expedited Response Action (ERA) to reduce the contaminant release and environment threat was performed in August and September 1991. This study was conducted to assess the groundwater impacts of continued discharge to the 300 Area process trenches, as required by Tri-Party Agreement Milestone M-17-06E.

The ERA was implemented to remove contaminated sediments that had accumulated in the bottom of the trenches from historic discharges. These sediments contained elevated concentrations of aluminum, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, vanadium, and uranium, and were perceived to be a continued source of contaminant loading to the underlying aquifer. The removal of these contaminated sediments was intended to reduce the ultimate quantity of contaminants released to the environment.

Following the ERA, the only constituents that appear to be elevated above background in groundwater near the process trenches are chloroform, nickel, and uranium. Chloroform concentrations are below drinking water standards and appear to be due to pre-treatment of the process water. Elevated nickel and uranium concentrations are not likely due to current discharge to the trenches but appear to reflect past discharges. Nickel is detected in wells near the process trenches at concentrations less than the proposed drinking water standard. Elevated uranium concentrations in groundwater appear to be associated with the process trenches at levels that exceed proposed drinking water standards. Other constituents that were present in trench sediments are not found at significantly elevated concentrations in groundwater.

Groundwater concentrations of uranium are expected to decrease as a result of the ERA. Further discharge to the process trenches will likely transport minor amounts of uranium remaining in the vadose zone to the saturated zone. However, the impact on groundwater concentrations is expected to be small, or indiscernible, because the uranium that remains in the vadose zone beneath the trenches is predicted to contribute only an additional 1-percent to the quantity already in the aquifer.

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1.0 INTRODUCTION

This report summarizes the results of an assessment of the potential groundwater impacts from continued use of the 300 Area process trenches following completion of an Expedited Response Action (ERA) in September 1991. This assessment was performed by a panel of technical specialists and is based upon a semi-quantitative review of information available as of June 1992.

1.1 BACKGROUND

The 300 Area process trenches have been used for soil column disposal of process water from facilities at the 300 Area since 1974. The 300 Area is located on the west bank of the Columbia River at the south end of the Hanford Site in southeastern Washington State. As shown in Figure 1-1, the trenches are located in the northern part of the 300 Area and are designated as the 316-5 process trenches. Before the ERA, this liquid effluent disposal facility consisted of two parallel trenches approximately 460 m (1500 ft) long and oriented in a north-south direction. The trenches were approximately 3.4 m (11 ft) deep, 3.0 m (10 ft) wide at the bottom, and 9 to 11 m (30 to 35 ft) wide at the top (DOE 1991b). The berm separating the trenches was approximately 4.6 to 6.1 m (15 to 20 ft) wide (Tyler 1991). The depth to groundwater from the bottom of the trenches was approximately 6.1 m (20 ft). The west trench had a southwest trending lobe at its northern end that was approximately 46 m (150 ft) long. The lobe was an active portion of the west trench until 1990 (DOE 1991b). Trench dimensions after the ERA are described in Section 2-4.

Effluent is discharged from outlet structures in the southern end of the trenches. Before the ERA, the trench floors sloped slightly to the north to allow water to drain their entire length. Due to removal of the fine-grained sediment in the bottom of the trenches during the ERA, the water now infiltrates into the subsurface near the outfall. The flow rate presently averages approximately 400 gallons per minute (gpm), as a result of flow reduction efforts. Historically, flows peaked at less than 3 million gallons per day (2,100 gpm) in the past (DOE 1991b).

The process trenches are currently regulated by the Washington State Department of Ecology under a Resource Conservation and Recovery Act (RCRA) Interim Status Permit. Administrative controls to reduce discharges of contaminants to the process sewer were instituted in 1985. Estimated quantities of hazardous and radioactive chemicals discharged to the trenches before 1985 are provided in Table 1-1. Chemical analyses of the current process sewer effluent were provided in a recent report (WHC 1992). It has been proposed that the current effluent should be designated a non-dangerous waste (WHC 1990). The effluent consists of: 1) purified or potable water, 2) equipment cooling water, 3) laboratory and research facility wastewater, and 4) direct precipitation. Fuel fabrication facilities were probably the most significant source of contaminants in the past, but have not been operated since 1987 (DOE 1991b).

The process trenches are included within the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup activities being conducted for operable units 300-FF-1 and 300-FF-5. Operable unit 300-FF-1 includes potential contaminant sources and soil contamination within the boundary shown in Figure 1-1. Operable unit 300-FF-5 includes all groundwater within and near the 300 Area.

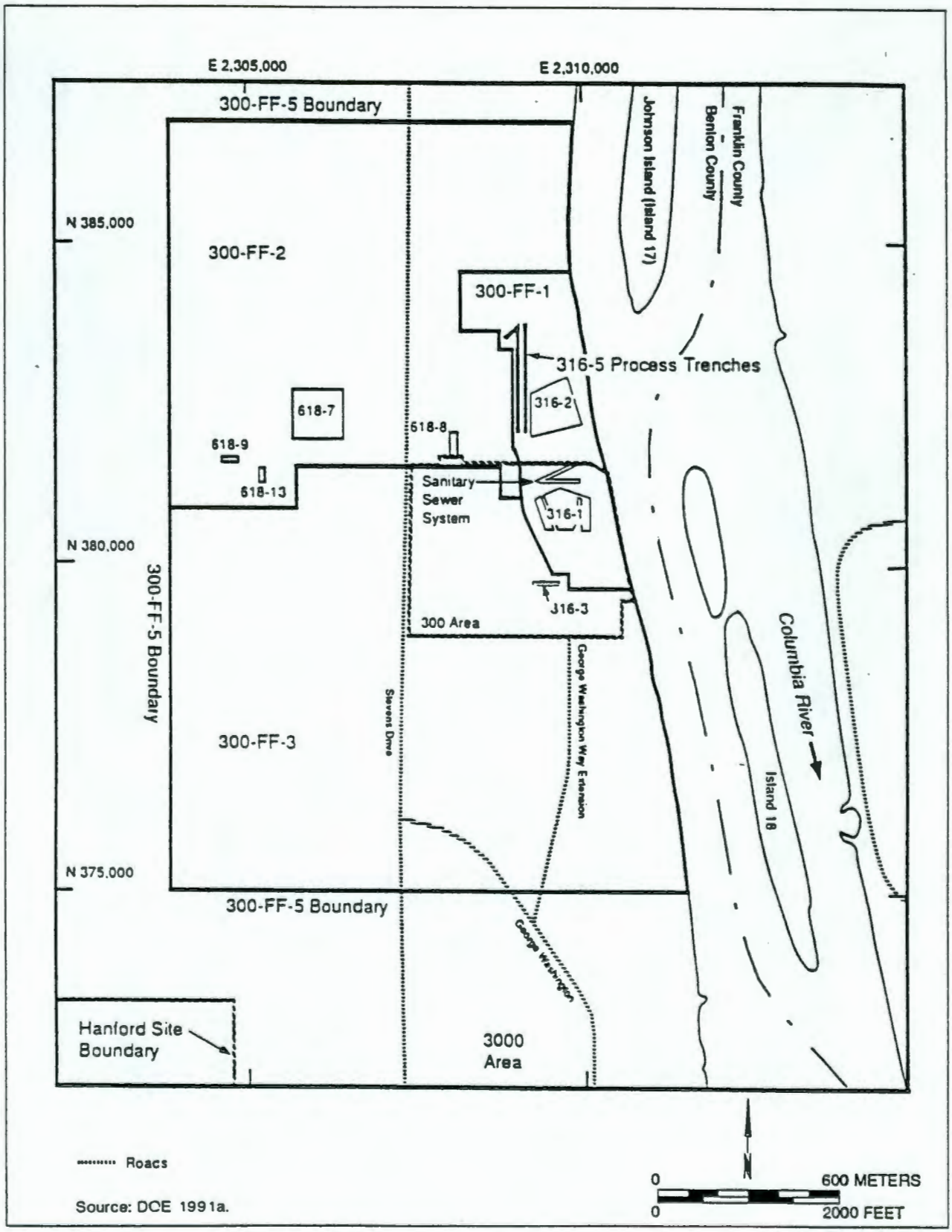

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Figure 1-1. Location of the 316-5 Process Trenches in the 300-FF-1 Operable Unit, Hanford Site, Richland, Washington.

Table 1-1. Estimated Nonradiological Chemical Waste Inventory for the Process Trenches (before implementation of administrative controls on February 1, 1985).

Intermittent discharges		Larger discharges[a]	
<gm	<kg		
Ammonium biofluoride	Benzene	Copper	~30 kg/month
Antimony	Carbon tetrachloride	Detergents	≤30 kg/month
Arsenic	Chromium	Ethylene glycol	≤200 L/month
Barium	Chlorinated benzenes	Heating oil	~300 L[b]
Cadmium	Degreasing solvents	Hydrofluoric acid	~100 kg/month
Dioxine	Formaldehyde	Nitrates	≤2,000 kg/month
Dioxin[c]	Formic acid	Nitric acid	≤300 L/month
Hydrocyanic acid	Hexachlorophene	Paint solvents	≤100 L/month
Pyridine	Kerosene	Tetrachloroethylene	~450 L[b]
Selenium and Selenium compounds	Lead	Photo chemicals	≤700 L/month
Thiourea	Methyl ethyl ketone	Sodium chloride	~75 ton/yr
Miscellaneous laboratory chemicals	Mercury	Sodium hydroxide	≤300 L/month
	Naphthalene	Uranium	~20 kg/month
	Nickel		
	Phenol		
	Silver		
	Sulfuric acid		
	Tetrachloroethylene		
	Toluene		
	Tributylphosphate (paraffin hydrocarbon solvents)		
	1,1,1-trichloroethane		
	Trichloroethylene		
	Xylenes		

Source: DOE (1985)

[a]These discharges, except for the spills, were relatively continuous.
[b]Known spills.
[c]Included only because of the potential for dioxin to exist as trace impurity in chlorinated benzenes.

As mentioned above, an ERA was conducted to reduce the contaminant release and environmental threat associated with the process trenches. The results of the ERA are summarized in Section 2.4. In addition, a waste minimization program is currently being implemented to decrease the flowrate and contaminant loading of the process sewer. The initial draft of this document, dated September 12, 1991, provided a preliminary assessment of the groundwater impacts of continued discharge to the trenches. This document was updated to include more recent data and address comments by Ecology on the initial draft.

1.2 SCOPE

The principal objective of this study is to assess the likely environmental impacts to underlying soil and groundwater due to continued discharge to the 300 Area process trenches, given:

(1) the effects of the ERA, and

(2) the effects of the ongoing waste minimization effort.

Secondary objectives of the task are: 1) evaluate the effectiveness of the existing groundwater monitoring system to detect changes in contaminant concentrations, and 2) provide recommendations for the collection of additional data and/or operational improvements. Additional field work and development of a numerical model are beyond the scope of this task. The analysis is intended to be semi-quantitative and conclusions are based upon scientific principles and professional judgement.

1.3 APPROACH

The approach for this study consisted of data review and assessment by a panel of technical specialists. The initial panel met in August 1991 and consisted of two hydrogeologists (Charlie Wilson and Scott Kindred) and one geochemist (Douglas Morell) from Golder Associates Inc., and a chemical engineer (Peter Keenan) from Engineering Science, Inc. Two representatives from Westinghouse Hanford Company (Anthony Knepp and Daniel Tyler) were present at the panel meeting to answer questions that arose during the discussion. In addition, the Westinghouse Hanford Company Project Manager for the ERA, George Henckel, was contacted by phone during the panel meeting to provide up-to-date information regarding implementation of the ERA. Following the panel discussion, the results were summarized in a report and circulated among the panel members for their review and approval. The results of the panel discussion and review were reflected in the September 12, 1991 draft of the study. This revised version of the groundwater impact study has been reviewed by the panel members from Golder Associates Inc.

The technical basis for determining the impacts of continued discharge to the trenches rested upon the following information:

1) observed concentrations of contaminants in soil and groundwater,

2) estimated quantities of chemicals discharged to the trenches,

3) observed groundwater flow patterns beneath and surrounding the trenches, and,

4) knowledge of the geochemical behavior of the contaminants associated with the trenches.

Given this information and the general knowledge of the panel members, it was possible to assess the environmental conditions that would result from continued discharge to the process trenches after implementation of the ERA. Since the groundwater is presently contaminated, and that contamination will remain even if effluent discharge were discontinued, the impact of continued discharge was assumed to be the difference between the anticipated levels of groundwater contamination with and without effluent discharge.

2.0 ENVIRONMENTAL CONDITIONS

2.1 HYDROGEOLOGY

The following discussion of the 300 Area hydrogeology is adapted from Delaney et al. (1991). The 300 Area is located one mile north of Richland on the west bank of the Columbia River. Unconfined and confined aquifers are present beneath the 300 Area. The uppermost aquifer is unconfined; the first underlying confined aquifer is contained in the flow top of the uppermost basalt and, locally in some areas of the 300 Area, the lowermost portion (less than 1.5 m [5 ft]) of the Ringold Formation.

The hydrostratigraphic units in the 300 Area are, in ascending order, as follows: (1) Levey interbed and Ice harbor Member of the Saddle Mountains Basalt, (2) the lower mud sequence and fluvial gravels of Ringold units FSE, FSC, and FSB, (3) coarse-grained deposits of the Hanford formation, and (4) eolian sand.

The Levey interbed is the uppermost confined aquifer in the 300 Area. This aquifer consists of the flow bottom of the Ice Harbor Basalt, the flow top of the Elephant Mountain Basalt, and the Levey interbed. Hydraulic conductivities for the Levey interbed range from 0.003 to 300.0 m/d (0.01 to 1,000 ft/d). The overlying Ice Harbor Member acts as a confining unit to the Levey interbed aquifer, separating it from the overlying upper or suprabasalt aquifer.

The uppermost aquifer system in the 300 Area, as throughout most of the site, is located in the Ringold Formation and Hanford formation. The lower mud sequence of the Ringold Formation forms the base of the upper aquifer and acts as a local confining unit to discontinuous sand lenses located on top of the Ice Harbor Member. The lower mud sequence is up to 18 m (60 ft) thick in the 300 Area, except in the north where it pinches out.

The main body of the upper aquifer occurs in the fluvial gravels of Ringold units FSE and possibly FSC and FSB. These gravelly deposits reach a maximum thickness of approximately 21 m (70 ft) in the 300 Area and are inferred to be laterally continuous in the area. The lower part of the unconfined aquifer in the fluvial gravel facies may be hydraulically isolated by discontinuous thin interbeds of silt and clay. The hydraulic properties of the unconfined aquifer vary considerably with location (due to changes in local stratigraphy). Hydraulic conductivities measured in the 300 Area for the Ringold Formation vary from 0.6 to 3,000 m/d (1.9 to 10,000 ft/d).

In the 300 Area, the water table is located near the contact between the Hanford formation and Ringold Formation. The water table is at a depth of approximately 9 to 21 m (30 to 70 ft) below the land surface, and the top of the Ringold Formation is at a depth of 11 to 20 m (35 to 65 ft) below land surface. Therefore, depending on location, the water table is present in both formations.

The Hanford formation in the 300 Area typically consists of sandy gravel with cobbles and boulders increasing with depth. The Hanford formation varies from 9 to 20 m (30 to 65 ft) in thickness, but only a small part (up to 4.6 m [15 ft]) of the lower half of the unit is usually saturated with water. Hydraulic conductivities measured in the 300 Area for the Hanford formation vary from 3,000 to 15,000 m/d (11,000 to 50,000 ft/d).

As shown in Figures 2-1 through 2-3, groundwater generally flows to the southeast beneath the process trenches. Groundwater flow in the 300 Area is influenced by water level in the Columbia River. Lindberg and Bond (1979) show that when the river stage rises bank storage increases and the water table gradient is temporally reversed. During these periods, groundwater tends to flow in a more southerly direction, roughly subparallel to the river. When the river level drops, the general gradient is restored and groundwater flows more easterly in a direction nearly perpendicular to the river. The effects of river-level fluctuation have been measured at locations up to 2.5 mi (4.0 km) from the river. Lindberg and Bond (1979) suggest that a paleoriver channel exposed in a 1958 excavation is responsible for the rapid response of groundwater levels to changes in river stage. As shown in Figure 2-4, this paleochannel lies beneath the 300 Area process trenches.

2.2 VADOSE ZONE CONTAMINATION BEFORE THE EXPEDITED RESPONSE ACTION

An investigation of contaminant concentrations in sediments and soils within and beneath the process trenches was conducted by Zimmerman and Kossik (1987). The investigation included two phases: 1) shallow sampling of sediments and underlying soils at 16 locations within each trench to a maximum depth of 0.5 m (1.5 feet), and 2) borehole drilling and soil sampling of vadose zone soils beneath the berm separating the two trenches. In the first phase, shallow samples were collected from up to three depths at 30 m (100 ft) intervals along the bottom of each trench. In the second phase, boreholes were drilled to a final depth of 12 m (40 ft) at six locations in the berm separating the two trenches. Samples were collected at 1.5 m (5 ft) intervals in each of these boreholes.

The constituents in the trench samples that had concentrations appearing to be elevated above background levels include aluminum, antimony, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, vanadium, gross alpha, and gross beta. Background was based upon five samples located outside the south process pond. It is presumed that uranium accounts for most of the gross alpha and beta readings. The concentrations of these constituents are summarized in Table 2-1. In general, these metals appeared to be concentrated in the surficial, fine-grained sediments in the trenches (Zimmerman and Kossik 1987). An estimate of the mass of some of these constituents contained within the bottom of the trench (which were removed during the ERA) is provided in Table 2-2. From this table, it is evident that chromium, copper, nickel, silver and uranium appear to be most elevated above background concentrations. Extractive Procedure (EP) toxic leach tests on one sediment sample from the trench did not exceed dangerous waste criteria for this test according to Washington State regulations (Zimmerman and Kossik 1987).

The deep soil samples obtained from the berm between the trenches contained constituent concentrations near background levels. A summary of the sampling results is provided in Table 2-1. The absence of significantly elevated contaminant concentrations in the vadose zone beneath the trenches, even for those constituents with elevated concentrations within trench sediments, suggests that mobile contaminants have already migrated through the system, and strongly sorbed or insoluble contaminants were primarily retained near the trench bottom.

In addition, pre-ERA soil samples from the trenches were collected and analyzed as part of the ERA. The results of this sampling effort are discussed in Section 2.3.

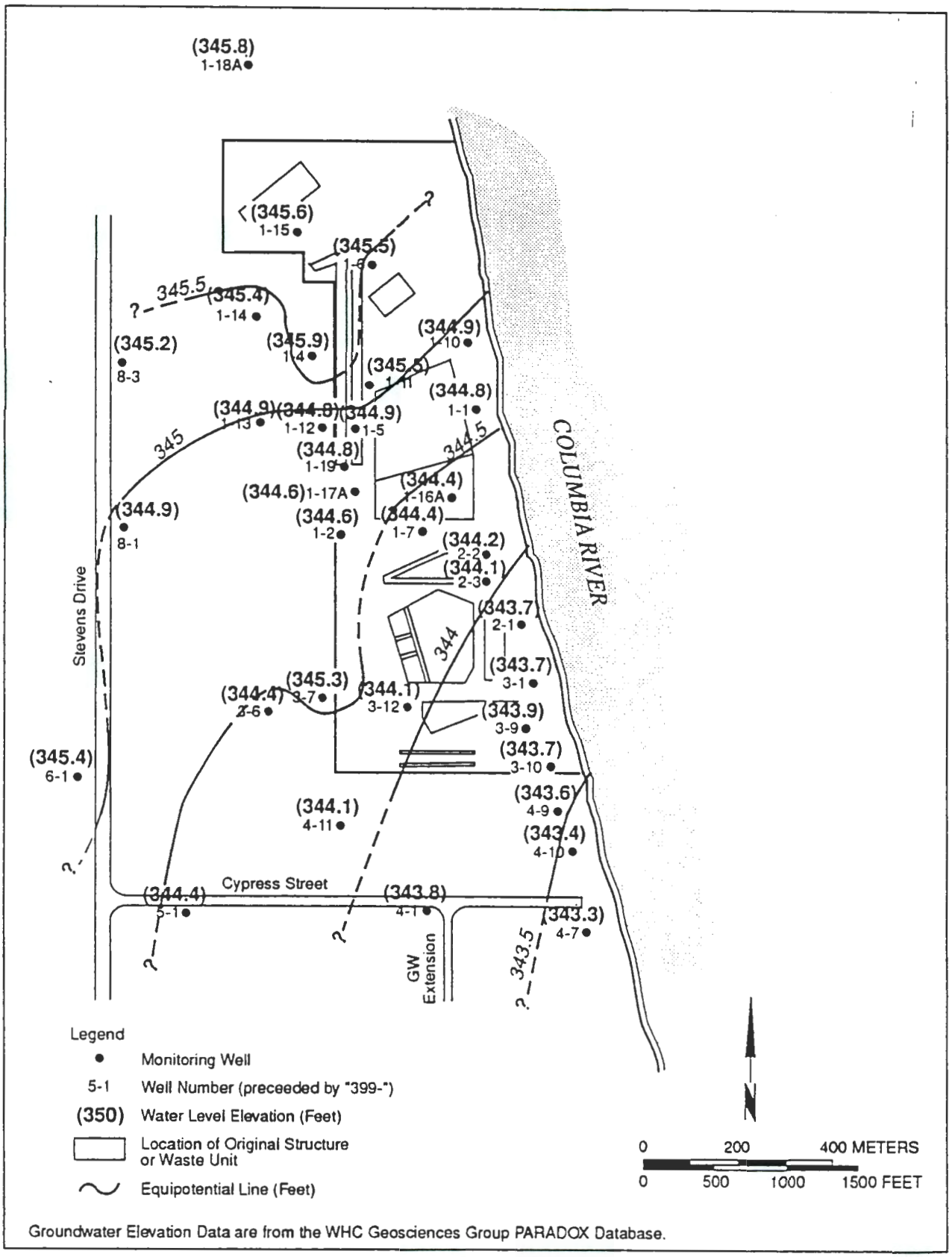

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Figure 2-1. Potentiometric Surface (feet)-March 1991.

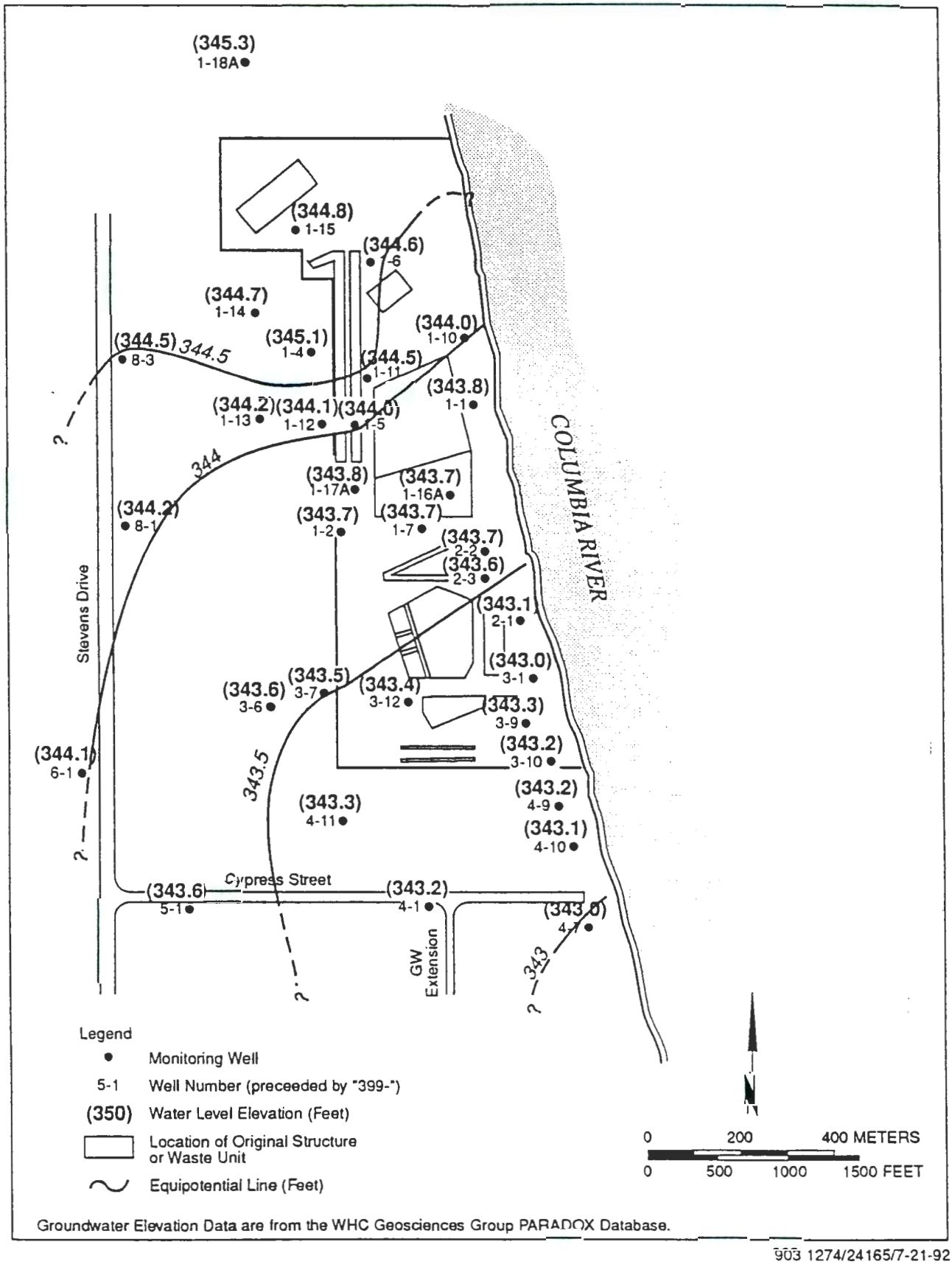

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Figure 2-2. Potentiometric Surface (feet)-July 1991.

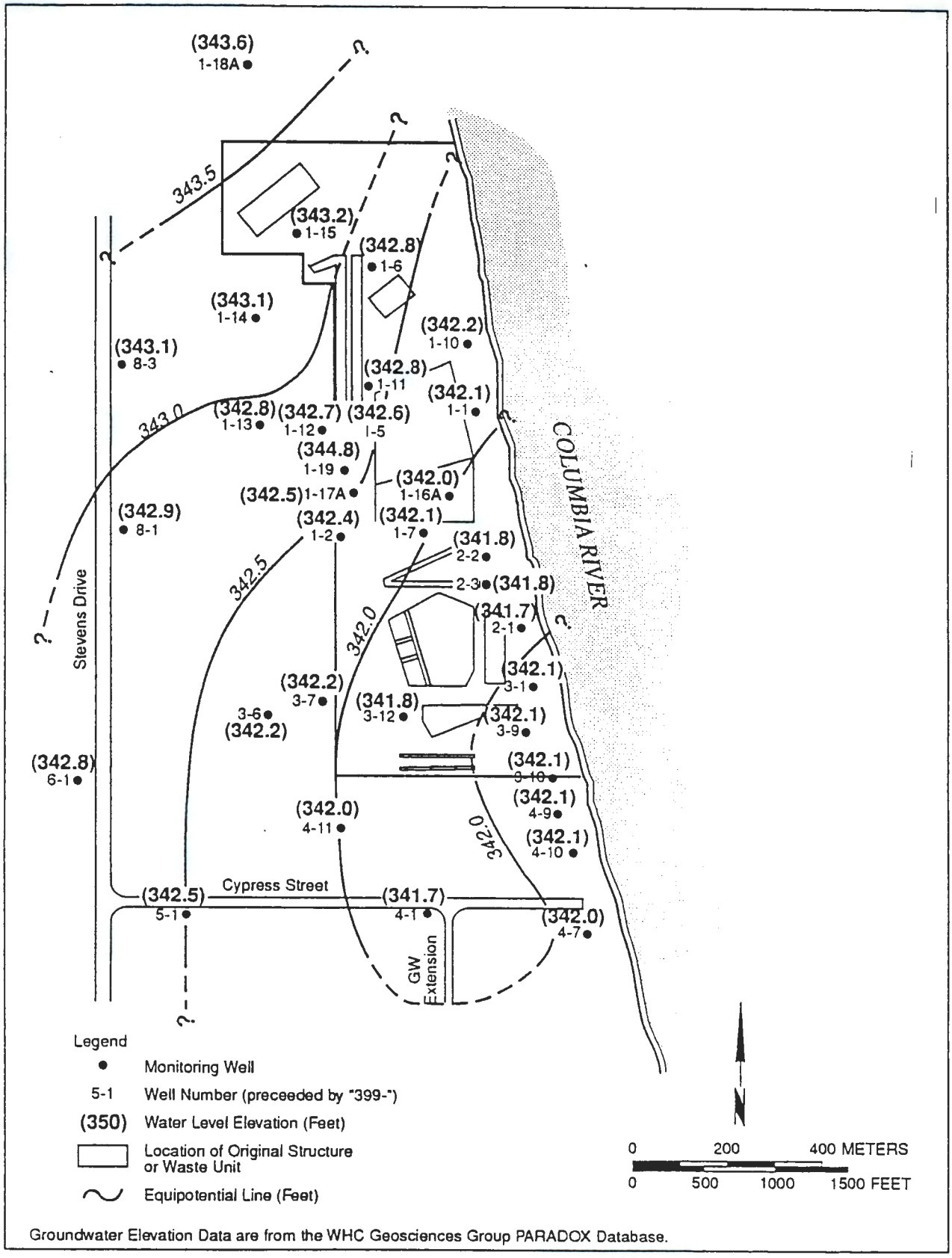

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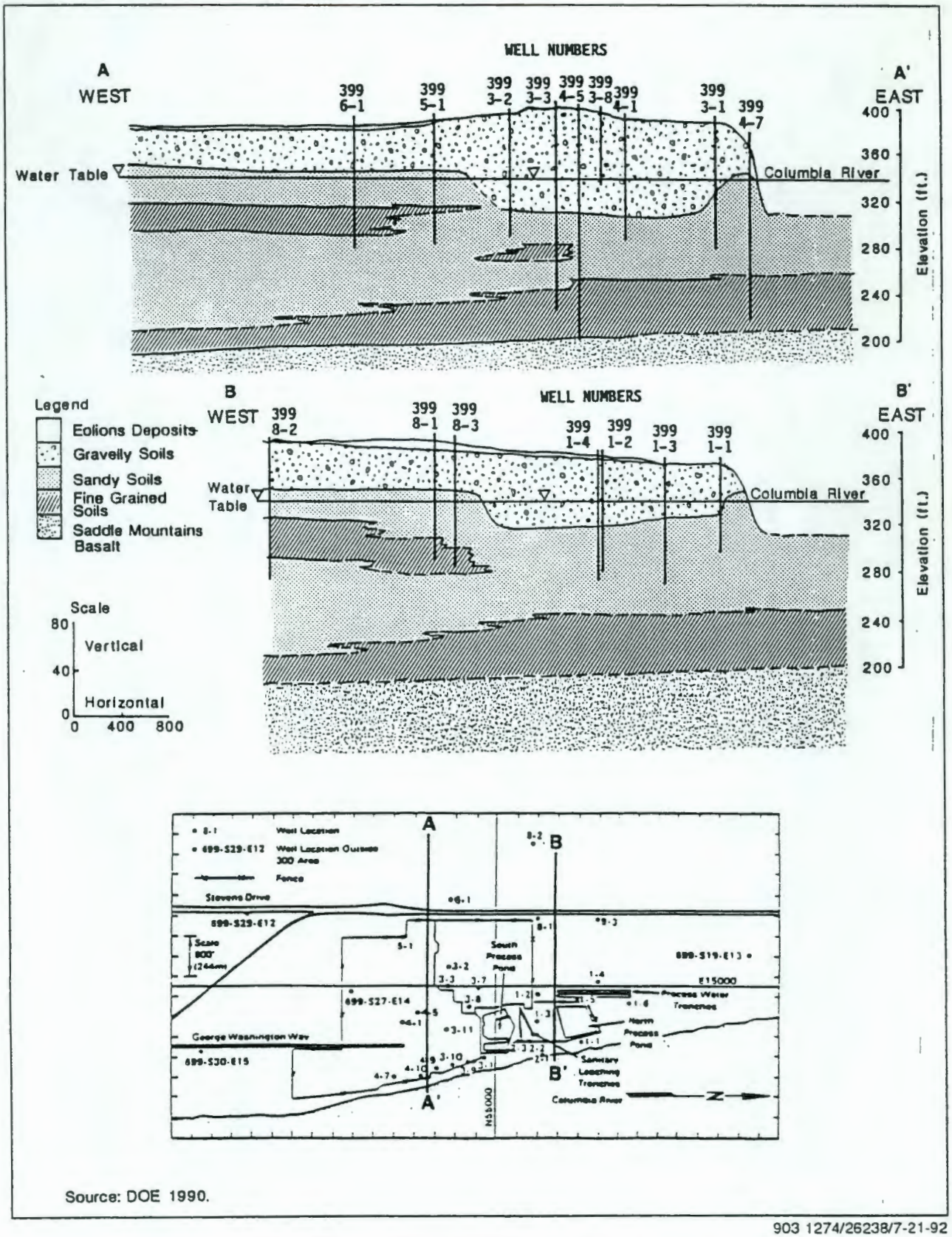
Figure 2-3. Potentiometric Surface-November 1991.



Source: DOE 1990.

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Figure 2-4. Geologic Cross-Sections of the 300 Area.

Table 2-1. Summary of Analyses for Sediment Samples from the 300 Area Process Trenches and Soil Samples from the Berm Separating the Trenches.

Constituent[a]	Background[b]	Trench Sediments			Berm Soils		
		Range	Mean	s[c]	Range	Mean	s[c]
Ag	<1.0	2-405	66.7	86.0	nd[d]	--	--
Ba	96.6 ± 26.0	53-491	138.1	98.2	57-110	85.7	13.3
Cd	0.5 ± 0.3	4-28	9.5[f]	3.6	0.5-9	5.5[f]	1.1
Cr	9.8 ± 1.2	5-551	92.8	129.7	4-10	6.5	1.5
Cu	18.4 ± 4.9	104-8470	1390	1804	8-42	18.1	6.8
Hg	<0.1	0.2-69	6.6	13.3	0.11	0.11	--
Mn	396.2 ± 63.5	121-6740	457.7	874.6	167-346	277.6	35.3
Ni	7.6 ± 1.0	15-4700	280.3	667.2	2-11	5.1	1.7
Pb	5.1 ± 0.88	2-486	63.2	102.7	2-6	3.3	1.0
Sb	<10.0	13-128	55.2	40.3	n.d.	--	--
V	60 ± 7.0	1-207	52.1	34.5	46-83	60.5	8.1
Zn	50.2 ± 8.2	49-1160	203.8	205.7	29-50	39.9	5.0
gross alpha[e]	6.4 ± 2.1	16-18700	1740	3440	<1-11	5.0	2.7
gross beta[e]	21.4 ± 2.4	75-20800	3280	5690	11-25	15.4	2.7

Source: Schalla et al. (1988)

(a) Units are mg/kg except for gross alpha and gross beta, which are in pCi/g.
(b) Average, plus or minus one standard deviation, of concentrations in five samples from alocation outside the south process pond.
(c) s is one standard deviation.
(d) Not detected.
(e) Alpha and beta are likely due to uranium.
(f) Zimmerman and Kossik (1987) report mean cadmium concentrations of approximately 1.8 mg/kg for the trenches and 0.5 mg/kg for the berm.

Table 2-2. Estimated Total Amount of Constituents in the Trench Sediment (kg).

Constituent	Shallow Trench Sediments	Estimated Amount from Background
As[a]	2	8
Cd	3	3
Cr	341	19
Cu	2261	30
Pb[b]	108	33
Hg[b]	12.8	3
Ni	578	17
Ag	74	3
U	720	9

Source: Zimmerman and Kossik (1987)

(a) The arsenic is always within background range.
(b) The lead and mercury are within the range of background values except in some of the loose and shallow sediments.

2.3 RESULTS OF THE EXPEDITED RESPONSE ACTION

The ERA was conducted in August and September of 1991 and the results are reported in DOE (1992). The ERA involved excavation of approximately 1.2 m (4 ft) from the bottom of each trench. Approximately 9,200 m^3 (7,000 cy) of soils were excavated. The excavated material was placed in the north end of the trenches or the fenced area northwest of the trenches. The ERA resulted in shortening the trenches to approximately 335 to 366 m (1,100 to 1,200 ft), deepening them to 4.6 m (15 ft, and widening them by several feet.

The goal of the ERA was to reduce the radiation levels in the trenches to less than three times the upper tolerance limit of background levels. Background levels were based upon radiological surveys in uncontaminated areas of the Hanford Site (DOE 1992). Radiological surveys using a Geiger Mueller detector, a sodium iodide detector, and a micro-R meter, were conducted both before and after the ERA. All three surveys indicated that the remediation goals were achieved.

In addition, soil sampling in the process trenches was conducted for the ERA. Results of both pre-ERA sampling and post-ERA sampling are provided in DOE (1992). Maximum concentrations before and after the ERA for metals and radionuclides are shown in Table 2-3. Background levels were not determined. For the significantly elevated constituents identified in Section 2.2, including chromium, copper, nickel, silver and uranium, these results indicate that the ERA reduced maximum concentrations by factors ranging from 10 (silver) to 200 (uranium).

Concentrations of total uranium in soil samples from the trenches are summarized in Table 2-4. The highest concentration in pre-ERA samples was 21,000 pCi/g. Uranium concentrations in post-ERA soil samples ranged from 6.0 to 110 pCi/g. The post-ERA samples for the west trench were obtained from a test pit located inside the trench at a distance of 20 m (66 ft) from the outfall. Soil samples were obtained from the test pit at

Table 2-3. Maximum Constituent Concentration in Soil Samples Collected Before and After the Expedited Response Action (ERA).

Constituent	Units	Pre-ERA Maximum	Post-ERA Maximum	Ratio Post/Pre
Strontium-90	pCi/g	18	0.9	0.05
Technicium-99	pCi/g	3,600	1.7	0.0005
Uranium-234	pCi/g	11,900	64	0.005
Uranium-235	pCi/g	1,600	7.7	0.005
Uranium-238	pCi/g	9,130	44	0.005
Plutonium-238	pCi/g	1.2	<0.1	<0.08
Plutonium-239/240	pCi/g	4.7	<0.1	<0.02
Potassium-40	pCi/g	24	19	0.8
Cobalt-60	pCi/g	0.96	0.3	0.3
Cesium-137	pCi/g	2.4	1.5	0.6
Radium-226	pCi/g	1.2	1.5	1.3
Thorium-228	pCi/g	17	0.8	0.05
Thorium-232	pCi/g	1.8	0.7	0.4
Aluminum	mg/kg	10,000	9,120	0.9
Antimony	mg/kg	20.3	23	1.1
Beryllium	mg/kg	1.9	0.5	0.3
Cadmium	mg/kg	2.9	0.7	0.2
Chromium	mg/kg	177	8.6	0.05
Copper	mg/kg	3,560	102	0.03
Iron	mg/kg	31,000	27,400	0.9
Lead	mg/kg	167	6.1	0.04
Manganese	mg/kg	2,500	640	0.3
Mercury	mg/kg	3.6	0.2	0.06
Nickel	mg/kg	960	32	0.03
Silver	mg/kg	144	14	0.1
Zinc	mg/kg	590	96	0.2
From DOE (1992).				

Table 2-4. Uranium Concentrations in Soil Samples Collected Before and After the Expedited Response Action (ERA).

Sample #	Trench	Pre or Post ERA	Distance[1] (m)	Depth (ft)	Uranium[2] Conc. (pCi/g)
B01034	East	Pre-ERA	0	0	7,100
B01033	East	Pre-ERA	0	3	950
B01032	East	Pre-ERA	0	5	24
B01038	East	Pre-ERA	20	0	16,000
B01040	East	Pre-ERA	20	0	21,000
B01036	East	Pre-ERA	20	3	2,700
B01035	East	Pre-ERA	20	5	130
B01043	East	Pre-ERA	100	0	200
B01042	East	Pre-ERA	100	3	86
B01041	East	Pre-ERA	100	5	24
B01046	East	Pre-ERA	400	0	160
B01045	East	Pre-ERA	400	3	10
B01044	East	Pre-ERA	400	5	75
B01031	East	Post-ERA	0	0	6.0
B01029	East	Post-ERA	20	0	16
B01025	East	Post-ERA	100	0	13
B01027	East	Post-ERA	370	0	12
B01020	West	Pre-ERA	0	0	4,600
B01022	West	Pre-ERA	0	0	2,700
B01019	West	Pre-ERA	0	3	220
B01018	West	Pre-ERA	0	5	40
B01016	West	Post-ERA	20	0	110
B014Q2	West	Post-ERA	20	0	110
B014Q3	West	Post-ERA	20	1.5	84
B014Q4	West	Post-ERA	20	6	16
B014Q5	West	Post-ERA	20	11	30
B014Q7	West	Post-ERA	20	11	26
B014Q8	West	Post-ERA	20	16	49

[1]Measured from south end of trench.
[2]Sum of U-234, U-235, and U-238.

From DOE (1992).

depths ranging from 0 to 5 m (0 to 16 ft) below the surface. Although the highest concentration was obtained at the surface (110 pCi/g), the sample from 5 m (16 ft) had a relatively high concentration of 49 pCi/g. Since the water table was encountered in the test pit at a depth of approximately 3.5 m (11.5 ft) below the trench bottom, these results indicate that concentrations of uranium in saturated zone soils beneath the trenches are similar to concentrations in vadose zone soils beneath the trenches.

Total uranium concentrations in other soil samples from below the water table are shown in Figure 2-5. Concentrations just east of the process trenches (beneath the north process pond) range from 2.9 to 7.4 pCi/g. Samples from the south end of the 300 Area (near the south process pond and the 307 retention basins) range from 1.0 pCi/g to 3.3 pCi/g. Although not shown on the figure, concentrations in samples from background locations (such as 699-527-E9B) are approximately 0.1 pCi/g.

Removal of the trench sediments has increased the permeability of the trench bottom. As a result, the effluent now percolates into the subsurface at a much higher rate per unit area. Whereas the recharge zone extended along the entire length of the trenches before the ERA, no ponding is currently observed in the trenches, indicating that the zone of recharge is isolated to an area near the south end of the trenches. The significant consequences of this change are: 1) the portion of the vadose zone impacted by effluent discharge is much smaller, and 2) wells 399-1-11 and 399-1-12 are no longer downgradient of the recharge zone.

2.4 GROUNDWATER CONSTITUENTS

Groundwater sampling has been conducted several times per year in the vicinity of the 300 Area. In addition, well 399-1-17A has been sampled approximately four times per month to more closely track groundwater concentrations directly downgradient of the process trenches. The analytical chemistry results for groundwater samples were reviewed to identify elevated constituents associated with the process trenches.

Table 2-5 lists constituents that have been detected in wells downgradient of the process trenches at concentrations that exceed background concentrations by a factor of two or more. Background concentrations were assumed to equal the maximum concentration detected (or the detection level if not detected) in either well 399-1-18A or well 399-8-1. These wells were believed to represent upgradient or background quality specific to the process trenches. For a variety of reasons, a number of these constituents can be dropped from further consideration as elevated constituents. Cesium-137, cobalt-60, filtered iron, lead, methylene chloride, and technetium-99 are only slightly elevated in occasional samples that do not suggest a groundwater plume. The gross alpha and gross beta are likely associated with elevated uranium concentrations and will not be considered as separate constituents. Likewise, total organic halogen is likely due to chloroform and will not be considered a separate constituent. As shown in Figure 2-6, the pattern of chloride concentrations does not indicate a significant plume associated with the process trenches. Elevated fluoride concentrations tend to be associated with the deeper portions of the aquifer, and probably reflect the influence of groundwater from the basalt aquifer that is naturally elevated in fluoride (Schalla et al. 1988). Although chromium has been detected in unfiltered groundwater samples at concentrations as high as 73 ppb, it has not been detected in filtered samples and is not considered an elevated constituent. The

Table 2-5. Constituent Concentrations in the 300 Area Groundwater.

CONSTITUENT NAME	UNITS	MAX[a]					PRIMARY MCL	SECONDARY MCL
		300 Area Wells	Q	Background Wells	Q	Ratio 300/Bkgd		
Alpha, High Detection Level	pCi/L	159		3.94		40.4	NA	NA
Cesium-137	pCi/L	3.73		1.21	U	3.0	120	NA
Chloride	ppb	140000		16300		8.6	NA	250,000
Chloroform	ppb	29		5	U	5.8	100[d]	NA
Chromium	ppb	73		31.5		2.3	50/100[c]	NA
Cobalt-60	pCi/L	8.71		-3.21	U	-2.7	220	NA
Fluoride	ppb	25000		500	U	50.0	4,000	2,000
Gross alpha	pCi/L	200		2.99		66.9	15[b]	NA
Gross beta	pCi/L	102		10		10.2	NA	NA
Iron, filtered	ppb	78		30	U	2.6	NA	300
Lead, filtered	ppb	13		5	U	2.6	50/5.0[a]	NA
Methylene Chloride	ppb	18		5	U	3.6	NA	NA
Nickel	ppb	85		30.5		2.8	NA/100[a]	NA
Nickel, filtered	ppb	70		30	U	2.3	NA/100[a]	NA
Technetium-99	pCi/L	54.4		8.63		6.3	3,800	NA
Total Organic Halogen, Low Det	ppb	76		10	U	7.6	NA	NA

9513388.1034

Table 2-5. Constituent Concentrations of the 300 Area Groundwater. (sheet 2 of 2)

CONSTITUENT NAME	UNITS	MAX[e]					PRIMARY MCL	SECONDARY MCL
		300 Area Wells	Q	Background Wells	Q	Ratio 300/Bkgd		
Uranium	pCi/L	524		6.5		80.6	30	NA

U - Undetected value

[a]Proposed.
[b]Excludes radon and uranium.
[c]Effective July 30, 1992.
[d]MCL for tri-halogenated - methanes
[e]Based upon maximum concentration since 1990 in WHC Geosciences Group PARADOX Database.
NA - Not applicable.

9513388.1035

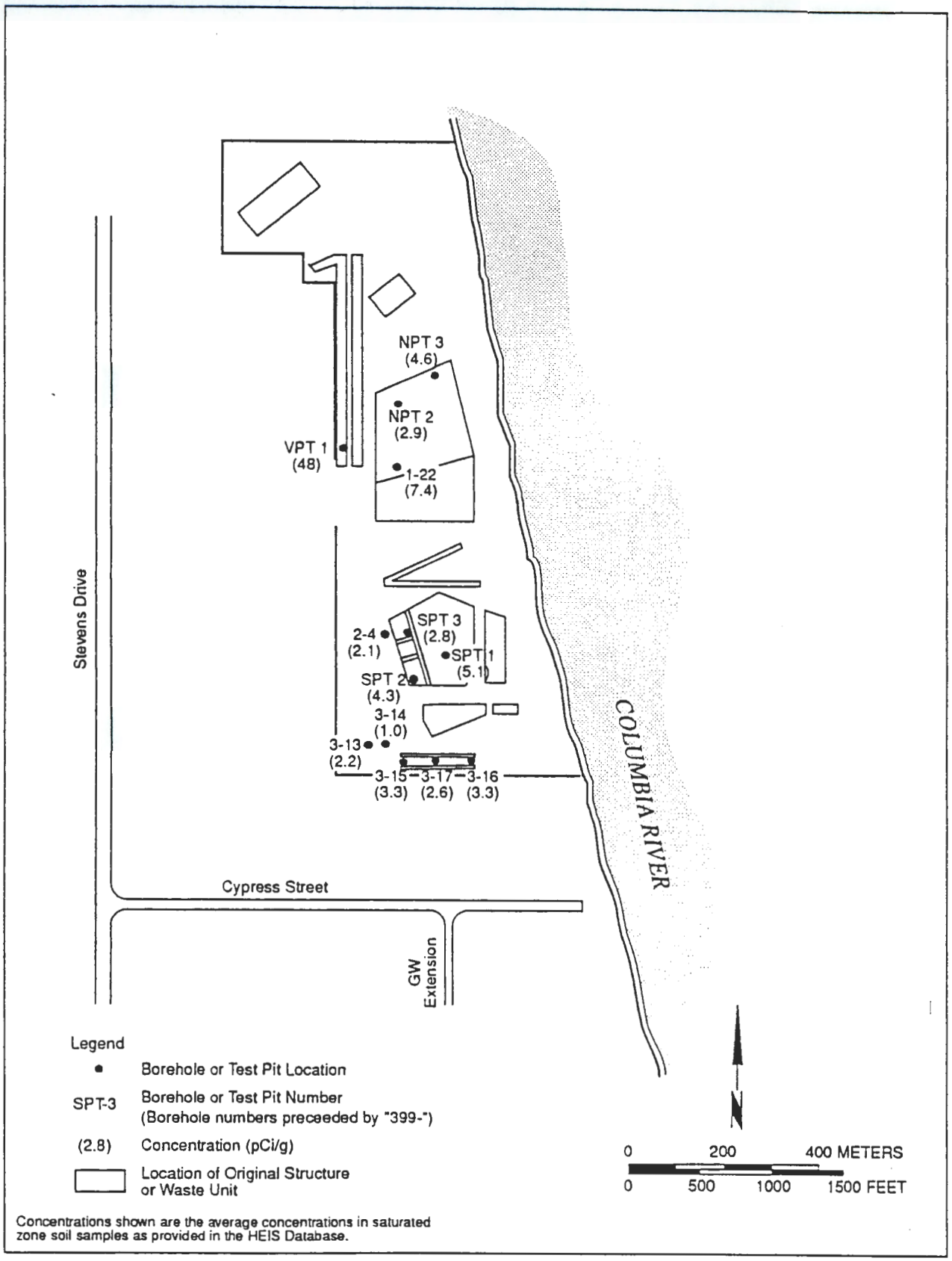

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Figure 2-5. Uranium Concentration in Saturated Zone Soil Samples.

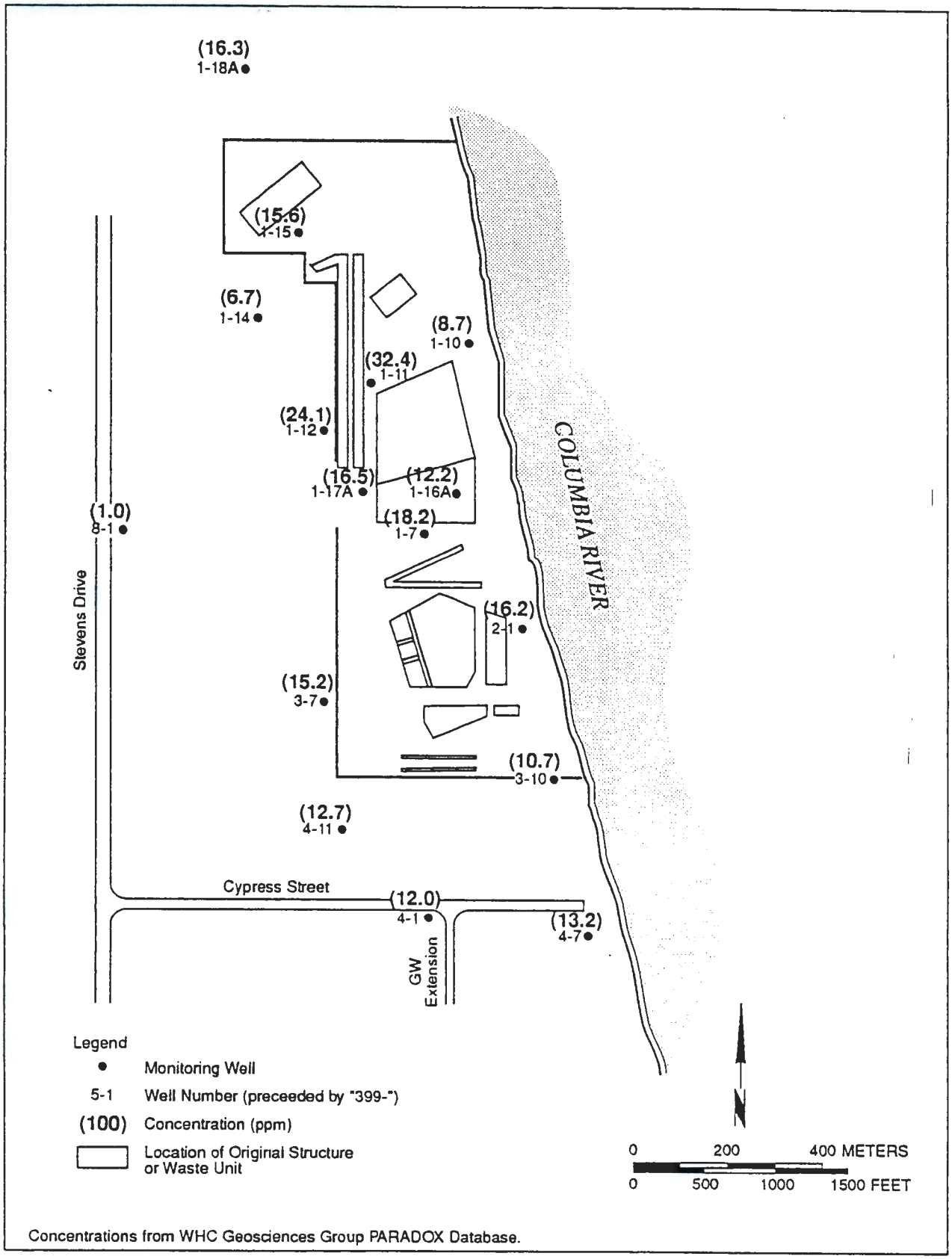

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Figure 2-6. Chloride Concentrations in Groundwater-December 1991.

chromium in the unfiltered samples may be trivalent chromium associated with particulates (Belden 1992). At present, the only constituents that appear to be elevated in groundwater due to discharges to the process trenches are chloroform, nickel, and uranium.

Chloroform

The map of chloroform concentrations, provided in Figure 2-7, indicates that the elevated chloroform concentrations are associated with the process trenches. The elevated chloroform concentrations are likely due to disposal of chlorinated water used in 300 Area facilities. The maximum concentration in December 1991 was 14 ppb in well 399-1-7. The maximum concentration in any well since 1990 was 29 ppb in well 399-1-12). As shown in Figure 2-8, chloroform concentrations in well 399-1-17A have declined from approximately 20 ppb in the summer of 1991 to approximately 8 ppb in recent months. Since these concentrations are considerably less than the drinking water standard of 100 ppb (total trihalogenated methanes), chloroform is not considered a significant elevated constituent.

Nickel

The map of unfiltered nickel concentrations, provided in Figure 2-9, indicates that the elevated nickel concentrations are associated with the process trenches. The maximum unfiltered concentration in any well since 1990 was 85 ppb in well 399-1-16A. The filtered concentration in the same well was 70 ppb. Since these concentrations are less than the proposed drinking water standard of 100 ppb, nickel is not considered a significant elevated constituent.

Uranium

As suggested in Figure 2-10, the elevated uranium concentrations in groundwater appear to be associated with the process trenches. However, the north process pond, located immediately east of the process trenches, is also a likely source of uranium. Stenner et al. (1988) estimates that 30,000 kg of uranium were released to the north process pond. The highest uranium concentration in December 1991 was 150 pCi/L in well 399-1-10. As shown in Figure 2-11, uranium concentrations in well 399-1-17A (located just downgradient of the trenches) have ranged from 2 to 524 pCi/L since October 1987. Uranium concentrations in well 399-1-17A have followed an annual cycle of low concentrations in the fall and high concentrations in the spring, suggesting a correlation with river stage.

Because of its near proximity to the process trenches, the other well of particular interest is well 399-1-11. Uranium concentrations in this well since 1987 have varied from 11 pCi/L (August 1989) to 280 pCi/L (January 1988). As shown in Figure 2-10, the December 1991 uranium concentration in 399-1-11 was 102 pCi/L. This concentration was higher than in all the 1989 samples, even though well 399-1-11 is no longer downgradient of the effluent discharge zone (see discussion in Section 2.3). No samples were collected in this well during 1990.
It appears that the ERA has not yet significantly lowered uranium concentrations in groundwater. Since the ERA, uranium concentrations appear to have dropped in 399-1-17A and may have risen in 399-1-11. Moreover, uranium concentrations have increased since the ERA in the other nearby downgradient wells, including 399-1-10 (97 to 150 pCi/L), 399-1-12 (20 to 82 pCi/L), 399-1-16A (50 to 65 pCi/L), and 300-1-7 (28 to 87 pCi/L). In fact, uranium concentrations for

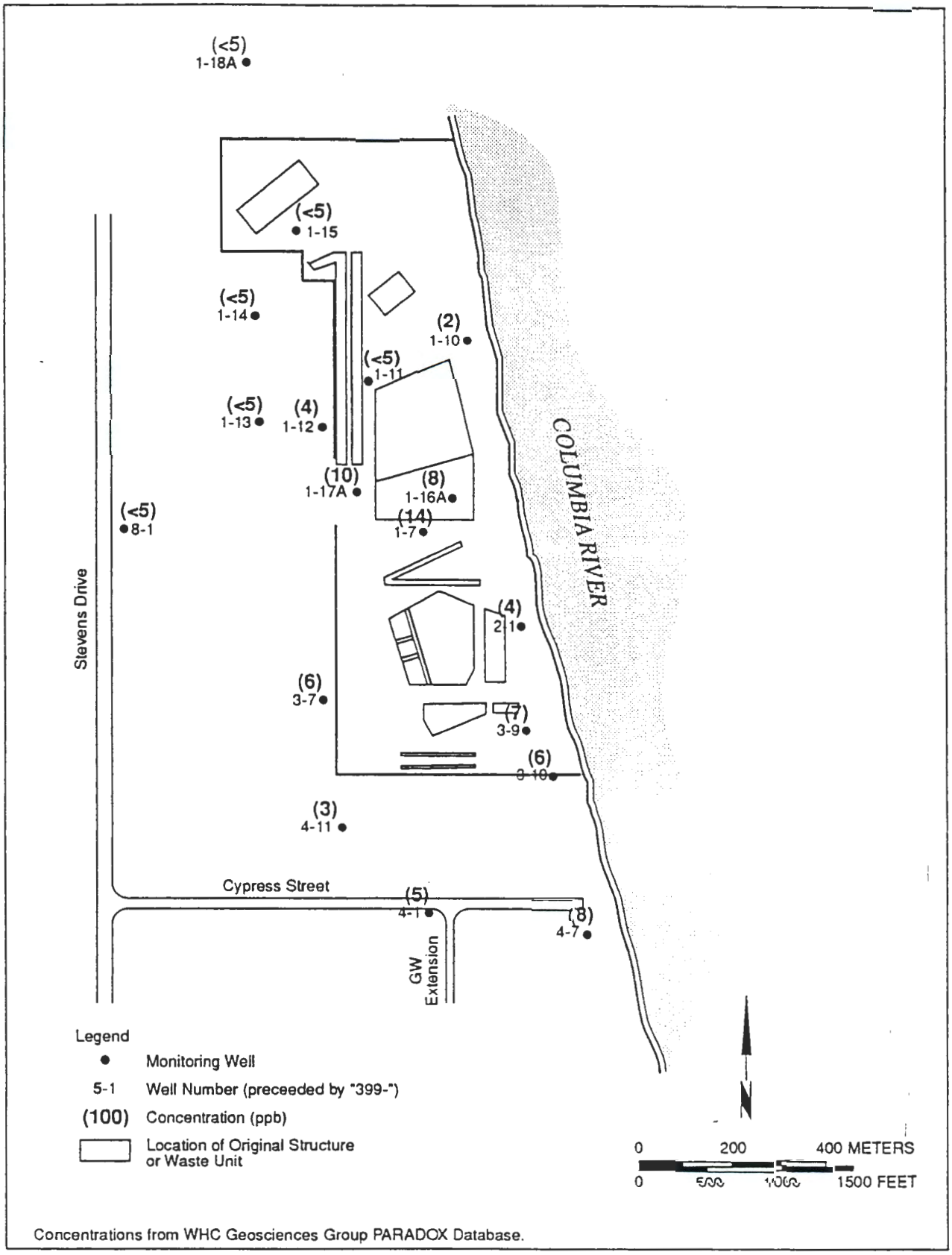

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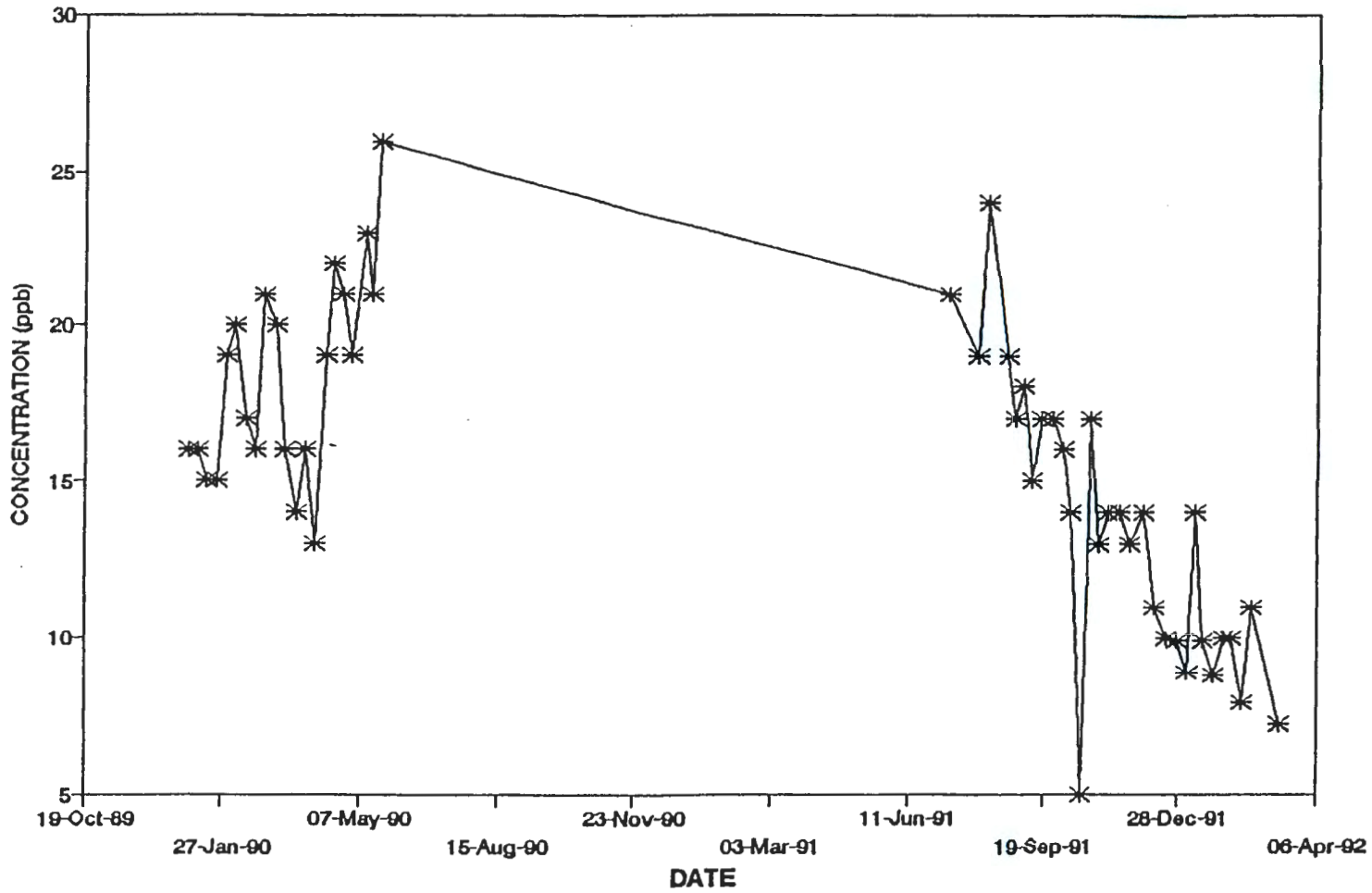
Figure 2-7. Chloroform Concentrations in Groundwater -December 1991.



Concentrations from WHC Geosciences Group PARADOX Database.

903 1274/28759/7-21-92

Figure 2-8. Chloroform Concentration in Groundwater at Well 399-1-17A.

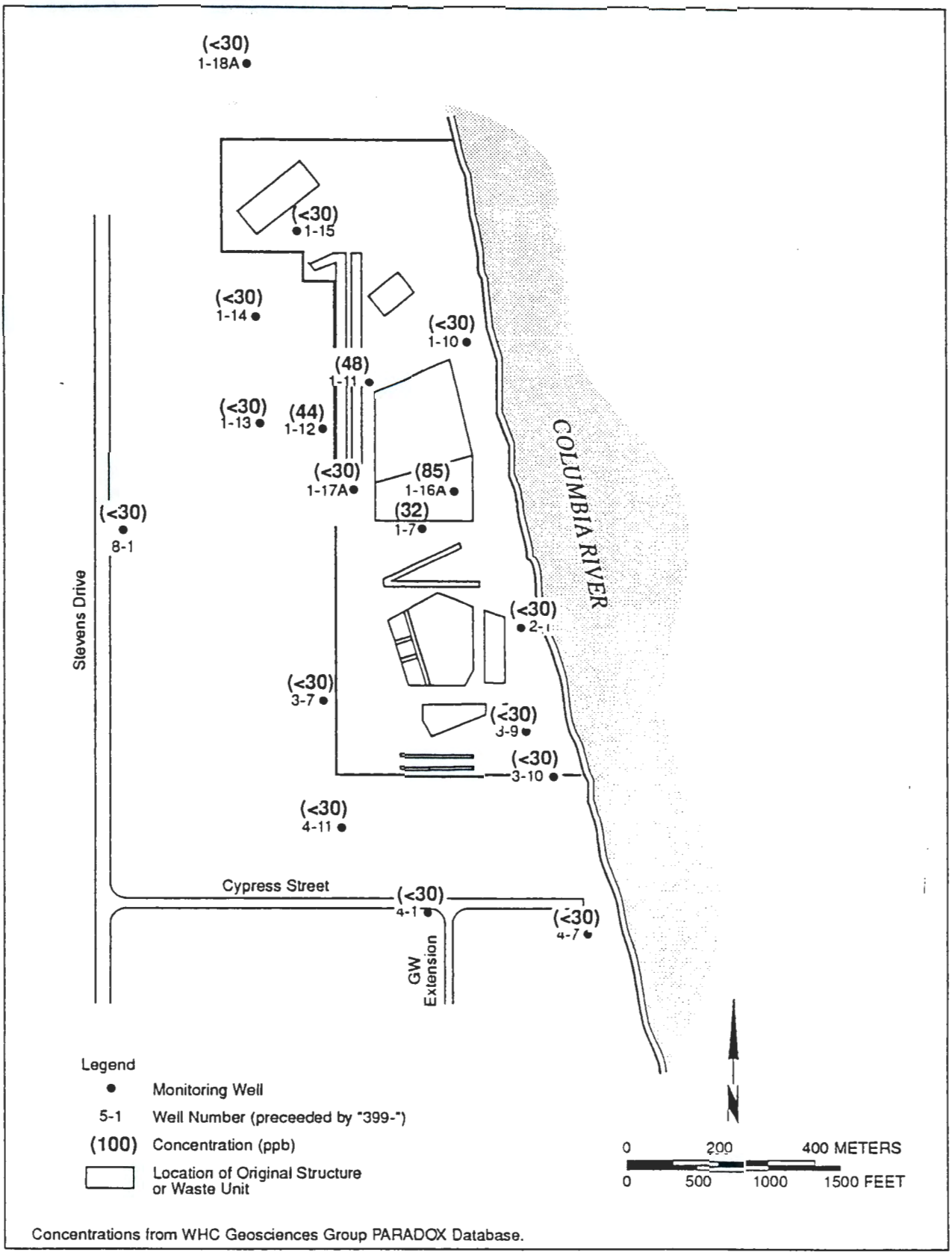


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Figure 2-9. Nickel Concentrations (Unfiltered) in Groundwater-December 1991.

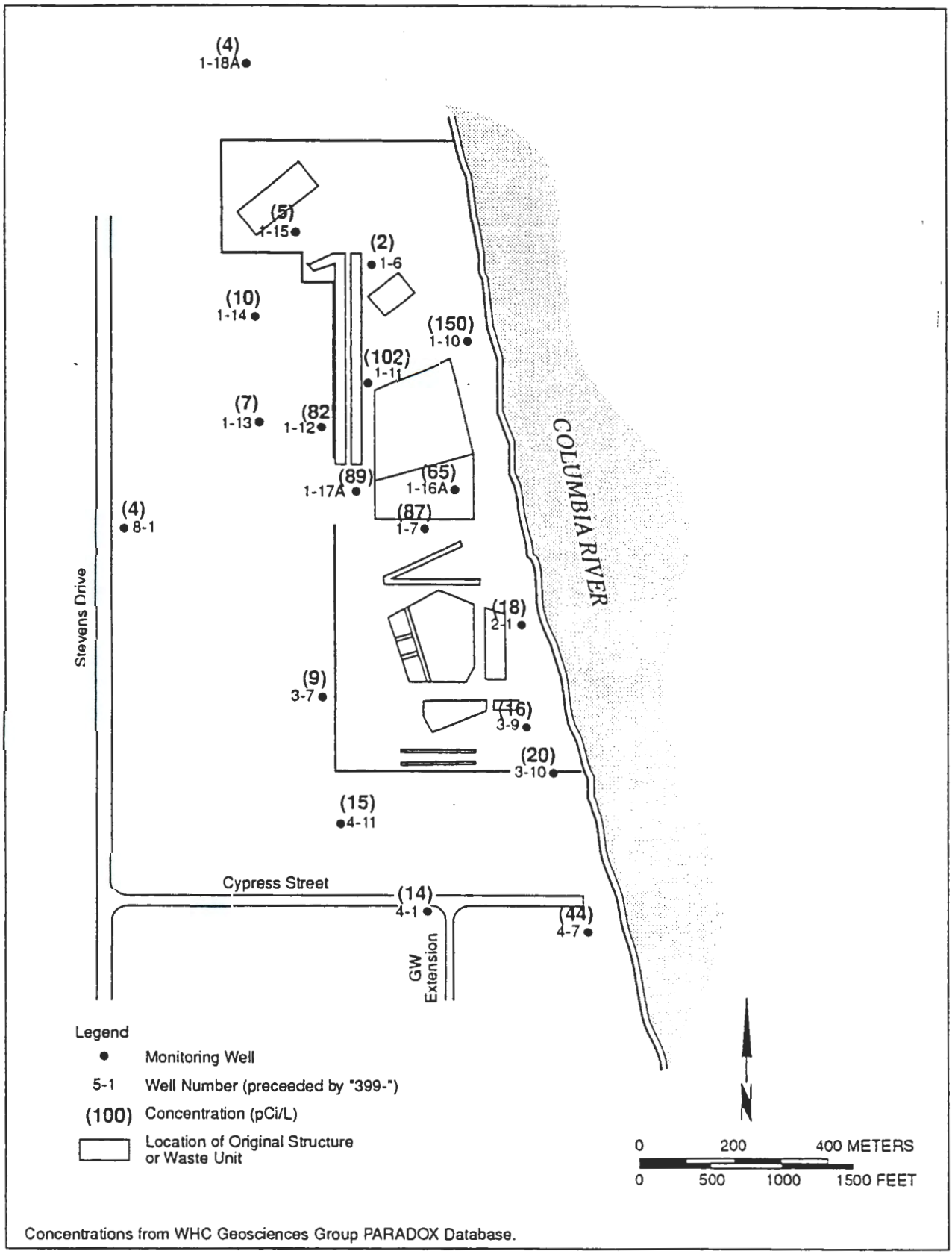

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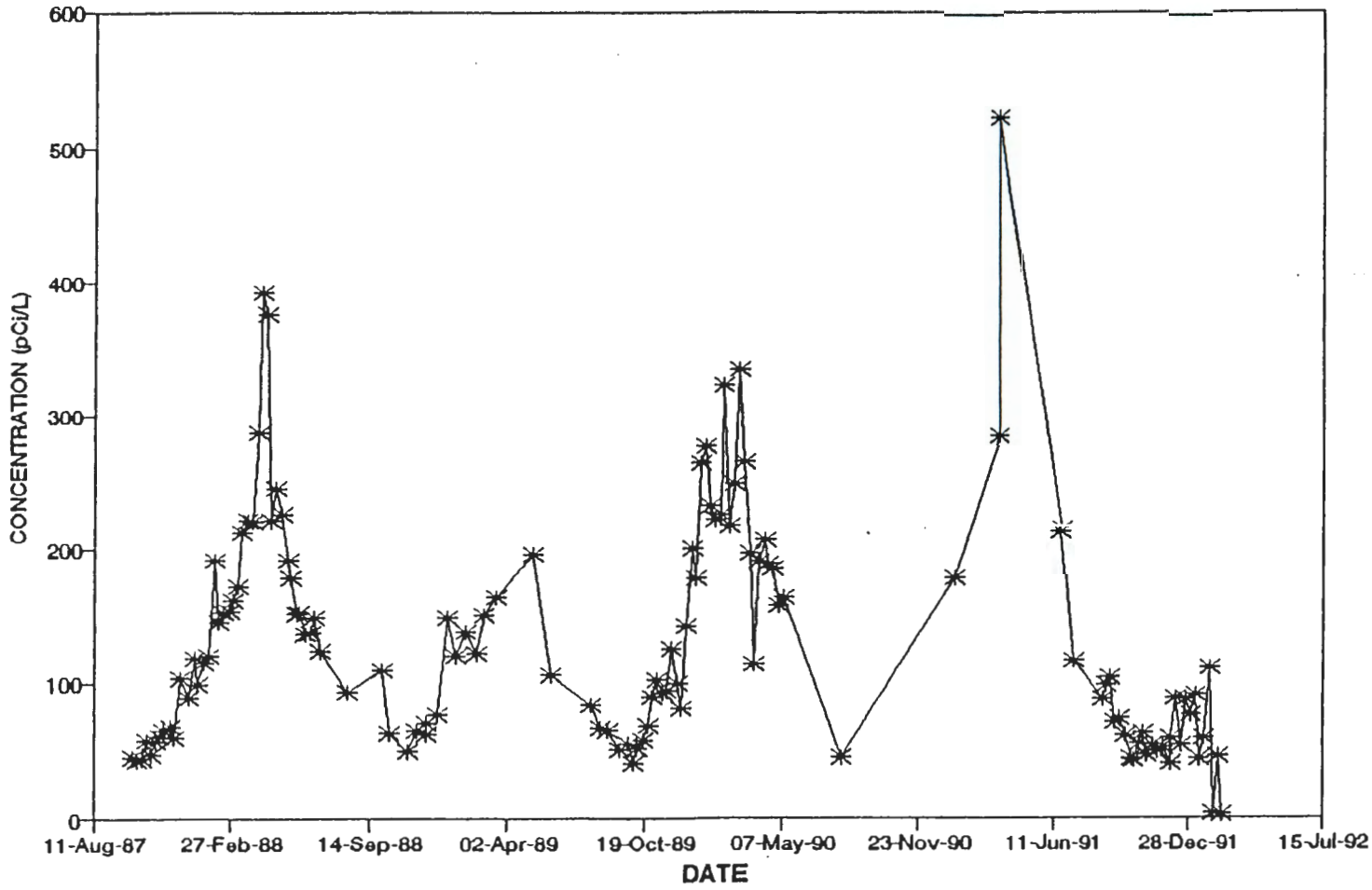
Figure 2-10. Uranium Concentrations in Groundwater- December 1991.



Concentrations from WHC Geosciences Group PARADOX Database.

903 1274/28783/7-21-92

Figure 2-11. Uranium Concentration in Groundwater at Well 399-1-17A.

December 1991 were the highest concentrations measured in these wells since they were installed in the mid 1980's. Although it may be that the effects of the ERA were not yet apparent in these wells, the general rise in groundwater concentrations suggests that the uranium-enriched sediments in the bottom of the trenches were not the only factor controlling groundwater concentrations. Conceptual models explaining these groundwater concentration patterns are discussed in Section 3-2.

Nitrate

Although not shown on Table 2-5, nitrate has been measured in 300 Area groundwater wells at concentrations greater than the drinking water standard. However, nitrate concentrations downgradient of the process trenches are actually lower than in upgradient wells, suggesting that elevated nitrate concentrations are due to upgradient sources. Effluent discharge appears to reduce nitrate concentrations in wells downgradient of the process trenches.

Copper

Although it is also not shown on Table 2-5 (because it is not elevated more than twice background concentrations) copper was identified in the previous version of this report as an elevated groundwater constituent. Because copper concentrations have dropped off to background levels since July 1991, copper is no longer considered an elevated constituent.

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3.0 ASSESSMENT OF IMPACTS

3.1 CURRENT EFFLUENT CHARACTERISTICS

A study of the 300 Area process wastewater sewer was conducted in the fall of 1991 (WHC 1992). Samples were collected of both the influent water supply stream and the effluent process sewer stream on two occasions and analyzed for a broad range of constituents. The results were reviewed for this study to identify constituents present in the effluent due to activities in the 300 Area. Table 3-1 lists all constituents for which the maximum or mean effluent concentration was greater than twice the maximum or mean influent concentration. This comparison was complicated by the fact that many of the constituents were not present at concentrations greater than the detection limits. The only elevated constituents that were detected at concentrations greater than both the instrument detection limit (IDL) and the contract required detection limit (CRDL) were titanium, nitrate, total carbon, total organic carbon, and uranium. None of these constituents exceeded drinking water standards.

3.2 CONCEPTUAL MODEL OF CONTAMINANT TRANSPORT

The information presented in Section 2 forms the basis for the conceptual model of contaminant transport beneath the process trenches. One of the most important observations (illustrated in Figure 2-10) is that uranium groundwater concentrations have not abated since administrative controls were instituted in 1985. Because significantly elevated concentrations of uranium were not present during the past six years in the process sewer effluent before entering the trench, it is assumed that the continuing source of dissolved uranium in groundwater is uranium remaining in trench sediments, the vadose zone, and the saturated zone. This remnant uranium could be present as particulates, precipitate, and/or sorbed on the soil matrix.

The ERA removed trench sediments that contained significantly elevated concentrations of uranium. Effluent discharged to the trenches no longer percolates through these sediments. As discussed in Section 2-3, with the exception of well 399-1-17A, uranium concentrations in groundwater have not decreased downgradient of the process trenches in the relatively short time since the ERA was conducted. Possible explanations for this continued presence of uranium in groundwater near the trenches include the following:

1) A significant source of particulate uranium is still present in the vadose zone beneath the trenches that is mobilized by continued effluent discharge.

2) Uranium in the vadose zone beneath the north process pond is mobilized during periods of high river stage when water levels are elevated.

3) The uranium is strongly partitioned onto the soil matrix and moves much slower than groundwater flow rates.

The first mechanism appears relatively unimportant given the observation (discussed in Section 2-3) that uranium concentrations in the bottom of the process trenches and the vadose zone are similar in magnitude to the concentrations in the saturated zone beneath

Table 3-1. Constituent Concentrations of the 300 Area Process Sewer Effluent and Water Supply Influent. (sheet 2 of 2)

CONSTITUENT NAME	UNITS	MAX					MEAN			Primary MCL	Secondary MCL
		Effluent	Q	Influent	Q	Ratio Eff/Inf	Effluent	Influent	Ratio Eff/Inf		
BROMOMETHANE, EPA624(MOD)	ppb	30.00	J	12.00	J	2.50	10.21	8.40	1.22	NA	NA
2,4-DINITROPHENOL, EPA604(MOD)	ppb	51.00	U	10.00	U	5.10	12.93	10.00	1.29	NA	NA
AMERICIUM-241	pCi/L	0.72	UQ	0.26		2.77	0.22	0.15	1.47	NA	NA
STRONTIUM, TOTAL[d]	pCi/L	2.48	U	0.63	U	3.94	0.87	0.54	1.61	8/42[a]	NA
URANIUM, TOTAL	pCi/L	4.57		1.10		4.15	1.96	0.63	3.11	30	NA
FIELD SPECIFIC CONDUCTANCE	umhos/cm	545.00		122.60		4.45	145.24	122.60	1.18	NA	NA

NOTE: Effluent and influent data incorporate both Round 1 and 2 values as provided in WHC (1992).

[a]Proposed.
[b]Excludes radon and uranium.
[c]Effective July 30, 1992.
[d]Assumes MCL of strontium-90.

NA - Not applicable.

Definition of qualifiers:
FOR METALS:
U - the value was less than the IDL or was not detected
B - value less than the CRDL but greater than or equal to the IDL
N - spiked sample recovery not within the control limits

FOR ORGANICS:
U - not detected
J - estimated value, mass spectral data indicate the presence of a compound below the stated practical quantitation limit

FOR RADIONUCLIDES:
U - value less than laboratory reported minimum detectable activity
Q - error is greater than one-half the reported value, use with caution

the trenches. The amount of uranium added to the saturated zone due to this mechanism is estimated in Section 3.3

The second mechanism is partially supported by the seasonal fluctuations of uranium concentrations in well 399-1-17A (shown in Figure 2-11). A statistical study is currently underway to assess the correlation between river stage and groundwater concentrations of uranium. Even if a correlation does exist, this does not necessarily demonstrate that uranium in the vadose zone beneath the north process pond is the source. In fact, soil samples from test pits (NPT-1, NPT-2, and NPT-3) and boreholes (399-1-22) beneath the north process pond do not indicate a significant difference in uranium concentrations between the saturated zone and the vadose zone. Additional data is necessary to assess the potential impact of this mechanism. In any case, the influence of river stage does not appreciably affect the assessment of groundwater impacts from continued discharge to the process trenches.

The third mechanism is supported by comparison of chloroform and uranium concentrations in the three wells (399-1-11, 399-1-12, and 399-1-17A) nearest the process trenches. Note that the rationale discussed below is based upon the presumption that chloroform is more mobile in groundwater than uranium. Before the ERA, when effluent infiltrated along the entire length of the process trenches, chloroform concentrations in the three wells were similar (22 ppb in 399-1-11, 29 ppb in 399-1-12, and 21 ppb in 399-1-17A). Following the ERA, which resulted in all the effluent infiltrating downgradient of wells 399-1-11 and 399-1-12, chloroform concentrations in these wells dropped to <5 ppb and 4 ppb, respectively. The chloroform concentration in 399-1-17A only dropped to 10 ppb. These results support the premise that wells 399-1-11 and 399-1-12 are no longer impacted by the effluent discharge to the process trenches and they should be representative of groundwater beneath the trenches without the influence of continued discharge. Because the concentrations of uranium in these wells has actually increased since the ERA, it appears that the migration of uranium is much slower than the migration rate of relatively conservative constituents (such as chloroform).

The retarded migration of uranium is likely due to sorption rather than precipitation reactions. If uranium concentrations in groundwater were predominately solubility controlled, much higher soil concentrations would be expected directly beneath the trenches than in the downgradient plume. As described in Section 2-3, uranium concentrations in soils directly beneath the trench were similar in magnitude to concentrations in the downgradient plume. Furthermore, comparison of uranium concentrations in groundwater (Figure 2-10) and saturated soils (Figure 2-5) suggests a relatively consistent partitioning coefficient (K_d) between groundwater and the soil matrix. Comparisons of soil and water concentrations from nearby locations are shown in Table 3-2. Using December 1991 groundwater data, three of the five comparisons provide estimates of K_d between 28 and 33 ml/g. The other two comparisons provide considerably higher estimates (83 and 165 ml/g). The higher estimate for K_d in well 399-1-17A could be explained by kinetic desorption factors, whereby the soil concentration reflects higher groundwater concentrations in the past. Using the maximum groundwater concentrations since 1987, the estimates of K_d range from 10 to 43 ml/g. For the purposes of this analysis, it will be assumed that concentrations in soil and groundwater are related by a K_d of 25 ml/g. Assuming this K_d, a soil density of 1.6 g/ml, and a porosity of 0.3, the retardation factor would be approximately 133.

Table 3-2. Comparison of Uranium Concentrations From Soil Samples and Groundwater Samples.

Soil Sample Location[a,b]	Well Number[a]	Soil Concentration[f] (pCi/g)	Groundwater Concentration in Dec. 1991 (pCi/mL)	Maximum[e] Groundwater Concentration (pCi/mL)	Partitioning Coefficient A[c] (mL/g)	Partitioning Coefficient B[d] (mL/g)
Background	Background	0.1	0.003	0.003	33	33
NPT3	399-1-10	4.6	0.15	0.15	31	31
399-1-22	399-1-17A	7.4	0.089	0.52	83	14
NPT2	399-1-11	2.9	0.102	0.28	28	10
399-3-16	399-3-10	3.3	0.020	0.077	165	43

[a]Soil samples locations shown on Figure 2-5 and well locations shown on Figure 2-10.
[b]Soil samples were collected in November or December 1991.
[c]Calculated using December 1991 groundwater data obtained from the WHC Geosciences Group PARADOX Database.
[d]Calculated using maximum groundwater concentration obtained from the WHC Geosciences Group PARADOX database.
[e]Maximum groundwater concentration since 1987.
[f]Soil concentrations shown here are average concentrations in saturated samples at the indicated location, and were obtained from the HEIS Database.

In a status report by Serne and Wood (1990), uranium is described as poorly sorbed. For neutral to basic solutions with low organic and salt concentrations, they estimated a K_d range for uranium between 0 and 10 ml/g. The reasons for the discrepancy between the observations described in this report and the Serne and Wood report are uncertain, although it may be due to irreversible sorption and/or precipitation reactions not accounted for in this study. The site-specific observations of K_d presented in this report will be considered empirical evidence suitable for the uranium mass comparisons presented in Section 3.3.

3.3 COMPARISON OF URANIUM MASSES IN THE VADOSE AND SATURATED ZONES

Even if discharges to the trenches were discontinued, the environment would continue to be affected by the elevated concentrations of uranium that remain in the saturated zone. An estimate of the mass of dissolved uranium remaining in the groundwater can be obtained using the concentrations shown in Figure 2-10. It will be assumed that the plume associated with the process trenches is represented by the following wells:

- 399-1-7 (87 pCi/L)
- 399-1-10 (150 pCi/L)
- 399-1-11 (102 pCi/L)
- 399-1-12 (82 pCi/L)
- 399-1-16A (65 pCi/L)
- 399-1-17A (89 pCi/L)

The average concentration of these wells is 96 pCi/L for the December 1991 sampling event. Assuming a K_d of 25, this water concentration corresponds to a soil concentration of 2.4 pCi/g (3.0 ug/g). This estimated soil concentration is consistent with the measured concentrations shown in Figure 2-5. Assuming the plume has an area of 460 by 610 m (1,500 by 2,000 ft), a thickness of 6 m (20 ft), and a soil density of 1.6, the total mass of uranium is estimated to equal 8,000 kg. The inventory provided in Table 1-1 indicates an approximate uranium discharge rate of 20 kg/month for the process trenches. Assuming 12 years of discharge, the total amount of uranium discharged to the process trenches is approximately 2,900 kg. Assuming 30,000 kg of uranium were discharged to the north process pond (Stenner et al. 1988), the total uranium inventory discharged in the north end of the 300 Area would be approximately 33,000 kg. Assuming that significant uranium has entered the Columbia River over the years, and that approximately 720 kg of uranium were contained within the sediments excavated during the ERA (see Table 2-2), the inventory estimate of 8,000 kg for the present day uranium plume appears reasonable.

The mass of uranium within the vadose zone impacted by effluent discharge to the process trenches can be estimated from the volume of vadose zone impacted by effluent discharge and average concentration in the vadose zone soils. As discussed in Section 2-4, effluent discharge to the process trenches infiltrates into the bottom of the trenches within a short distance from the outfall. The area of vadose zone soils impacted by effluent discharge is likely less than 18 m (60 ft) by 12 m (40 ft) and the thickness of the vadose zone is less than 4.6 m (15 ft). Uranium concentration in vadose zone soils after the ERA are provided in Table 2-4. The average concentration in soils within 20 m (65 ft) of the outfall is 43 pCi/g (54 ug/g). Given these dimensions and average concentration, the total mass of uranium in the vadose zone impacted by effluent discharge is estimated to equal 87 kg. This is approximately 1 percent of the mass of uranium in the saturated zone. Note

that this calculation assumes that the region of vadose zone impacted by effluent discharge does not increase. It the effluent discharge rate increases, or the trench bottom becomes clogged with sediment, the region of vadose zone impacted by effluent discharge will increase and additional uranium will migrate out of the vadose zone.

4.0 GROUNDWATER MONITORING SYSTEM EVALUATION

A brief overview of the 300 Area monitoring well network was conducted to assess the effectiveness of groundwater monitoring for the process trenches. An effective monitoring well network should allow comparison of constituent concentration downgradient of the process trenches with upgradient concentrations. In addition, to allow collection of representative samples, the wells should be constructed with less that 6 m (20 ft) of stainless-steel screen placed across the water table.

Upgradient concentrations can be monitored with wells 399-1-18A and 399-1-14. Concentrations near and downgradient of the trenches can be monitored by wells 399-1-12, 399-1-11, 399-1-10, 399-1-16A, and 399-1-17A. Wells 399-2-3 and 399-3-10 can monitor concentrations further downgradient from the trenches. The recommended well monitoring network includes 9 wells and is shown in Figure 4-1.

As discussed in Section 2.4, constituents elevated in groundwater near the process trenches include chloroform, nickel, and uranium. Other constituents elevated in trench soils include aluminum, antimony, barium, cadmium, chromium, copper, lead, manganese, mercury, silver, and vanadium. It is recommended that these constituents continue to be analyzed in the future. Particular emphasis should be given to uranium.

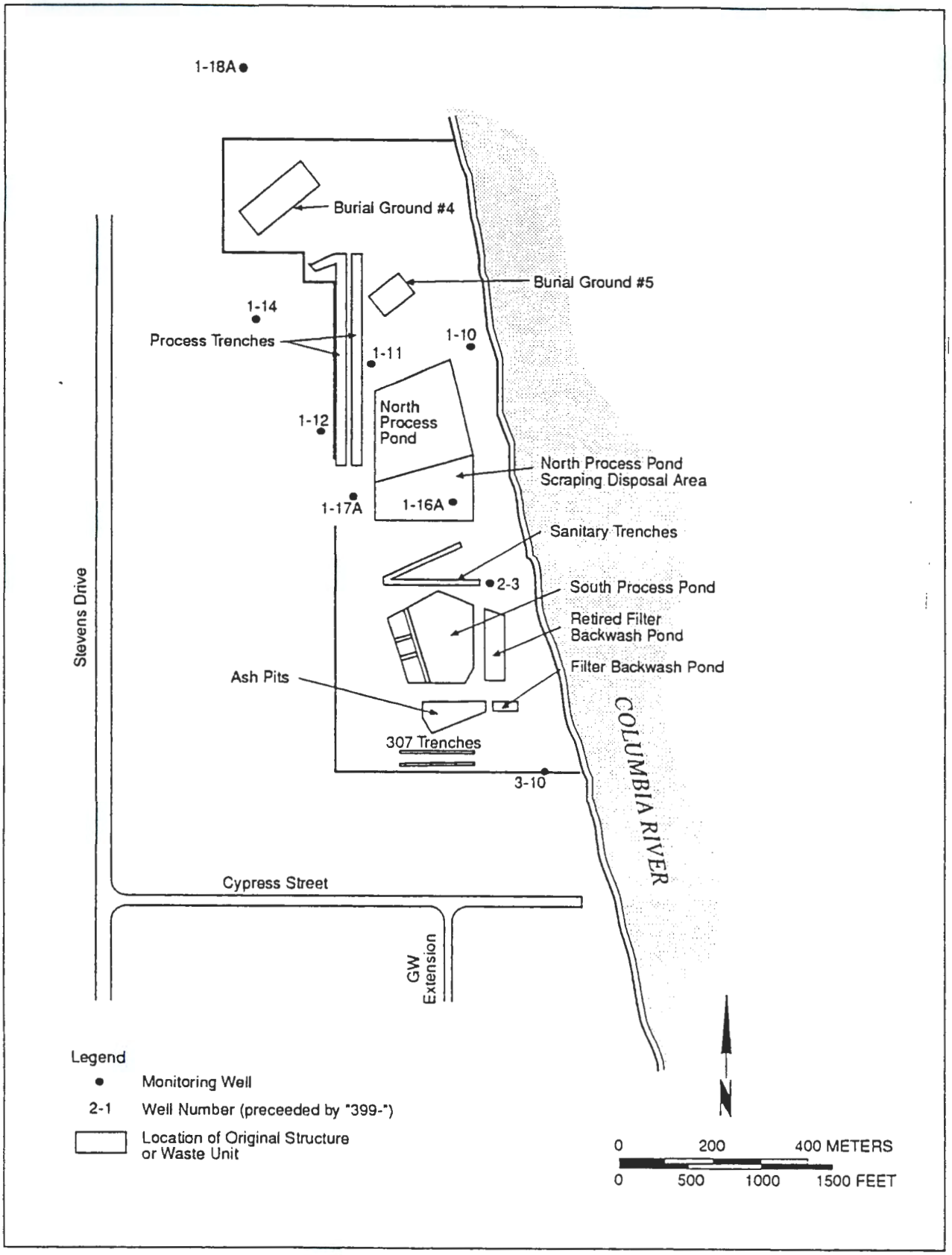

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Figure 4-1. Suitable Groundwater Monitoring Wells for the Process Trenches.

5.0 CONCLUSIONS

Elevated concentrations of aluminum, antimony, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, vanadium, and uranium have been detected in sediments and near-surface soils in the 300 Area process trenches. At the present time, it appears that the only elevated groundwater contaminants associated with the trenches are chloroform, nickel, and uranium. Chloroform concentrations are below drinking water standards and appear to be due to pre-treatment of the process water. Elevated nickel and uranium groundwater concentrations are evidently due to leaching of these constituents from sediments and soils near the bottom of the trenches. Groundwater concentrations of nickel are below proposed drinking water standards, while uranium concentrations exceed proposed drinking water standards (see Table 2-5). Other constituents that were present in trench sediments are not present at elevated concentrations in groundwater. Concentrations of nickel and uranium should eventually decrease due to removal of the contaminated sediments and soils in the bottom of the trenches.

Following the ERA, it is likely that remnant uranium in the vadose zone is migrating to the saturated zone as a result of effluent discharge. However, the impact on groundwater concentrations is expected to be small, or indiscernible, because the uranium that was left in the vadose zone affected by effluent discharge was predicted to contribute only an additional 1-percent to the quantity that are already in the unconfined aquifer.

This assessment of groundwater impacts assumed that the zone of recharge within the process trenches would not increase. If the zone of recharge increases, the extent of vadose zone impacted by effluent discharge will increase and additional uranium may be transported to the saturated zone.

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