BHI-01624
Rev. 0

Aquifer Sampling Tubes Data Summary, Fall 2001

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Environmental Restoration

Submitted by: Bechtel Hanford, Inc.

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Printed in the United States of America

DISCLM-5.CHP (11/99)

BHI-01624
Rev. 0
OU: 100 Area Common/
GW/VZ 100
TSD: N/A
ERA: N/A

APPROVAL PAGE

Title: Aquifer Sampling Tubes Data Summary, Fall 2001

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BHI-01624
Rev. 0

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Date Published

June 2002

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ACRONYMS

COC	contaminant of concern
EPA	U.S. Environmental Protection Agency
FY	fiscal year
ISRM	In Situ Redox Manipulation
MCL	maximum contaminant level
OU	operable unit
RAO	remedial action objective

METRIC CONVERSION CHART

Into Metric Units		
If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	millibecquerel
Electricity		
Specific conductance mho	10^{-7}	microsiemens/cm

Out of Metric Units		
If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries
Electricity		
Specific conductance microsiemens/cm	10^{7}	mho

1.0 INTRODUCTION

Groundwater contamination is known to occur along the Hanford Site shoreline of the Columbia River adjacent to the retired reactor areas. Previous characterization of contamination near the river has relied on data from a limited number of near-river wells, contaminant plume migration predictions, and riverbank seepage sampling to evaluate shoreline conditions.

Aquifer sampling tubes were installed along the 100 Area and Hanford townsite shorelines in an effort to monitor the extent and concentration of contaminated groundwater discharging into the river. Aquifer sampling tubes are driven into the aquifer at the shoreline to obtain groundwater samples from near or within the groundwater/river water interface. The tubes provide coverage of the Hanford Site shoreline between groundwater monitoring wells. Additional tubes were installed offshore along the 100-D Area shoreline to sample porewater in the river-bottom gravels. Data from these sites support the In Situ Redox Manipulation (ISRM) Project. In addition, hexavalent chromium contained in the groundwater is a contaminant of concern (COC) and can be toxic to aquatic ecological receptors, including chinook salmon that spawn within the Hanford Reach (Hope and Peterson 1996b).

This report summarizes the aquifer sampling tube results for samples collected along the Columbia River shoreline in the fall of 2001. The focus of this effort was to identify the tubes that best represented groundwater quality as compared to those affected by the groundwater/river water mixing zone. Figure 1-1 shows the locations of tubes that were sampled during the fall of 2001 and the locations of other existing aquifer sampling tubes which were not sampled. This data report describes the sampling methods, the results of sampling activities, a comparison of the results to fall 2001 groundwater plume maps, and recommendations for data evaluation and future use of the aquifer sampling tubes.

1.1 PROJECT OVERVIEW

1.1.1 Purpose

Aquifer tubes were installed along the Columbia River shoreline to provide additional sampling locations for obtaining water quality data on contaminated groundwater discharging into the river. The tubes augment existing near-river monitoring wells and riverbank seepage sites. Initial sampling locations, analytes, and screening criteria were finalized in July 1997 meetings between Environmental Restoration Contractor staff and the regulatory agencies.

Meeting minutes are included in *Description of Work for Installing Aquifer Tubes Along the 100 Area and Hanford Townsite Shoreline* (Peterson et al. 1997). The data obtained from the tubes will be used to enhance existing descriptions of groundwater contamination in support of remediation decisions. Example applications (Peterson et al. 1997) of the data include the following:

- Describing the nature, concentration, and extent of chemical and radiological indicator contaminants in groundwater and in the groundwater/river water mixing zone at locations adjacent to the Columbia River
- Verifying the presence or absence of contamination at other locations along the shoreline
- Augmenting existing sampling provided by near-river monitoring wells and riverbank seepage sites
- Monitoring the performance of remedial measures
- Monitoring contaminant concentrations in porewater in the riverbed and providing a baseline for assessing the potential for impacts to salmon fry and shoreline biota.

1.1.2 History

Columbia River substrate porewater samples collected offshore in the 100-H Area in March and April 1995 indicated three sites with hexavalent chromium concentrations at a level of concern (greater than 22 μg/L). Porewater (river substrate) sampling offshore in the 100-D/DR Area in October and November 1995 detected hexavalent chromium concentrations up to 632 μg/L.

Aquifer sampling tubes were installed at 14 sites in the fall of 1995 and at 70 sites in the spring of 1997. The tube sites extend along the Columbia River from the B/C Reactor to the Hanford townsite (about 40.2 km). The locations are spaced approximately 610 m apart along the shoreline away from the reactor areas and 305 m apart along the reactor areas.

Aquifer sampling tubes are small-diameter polyethylene tubes that have a screen at the lower end. The tubes are implanted in the aquifer by driving a temporary steel casing and then inserting a tube into the casing. The end of each tube is fitted with a screened section that acts as the sampling port. The temporary steel casing is driven by either a hydraulic ram mounted on a vehicle or by a hand-carried pneumatic air hammer. The steel casing is then backpulled, leaving the tube in place. Water is withdrawn from the tube using a peristaltic pump. The tubing exposed at the ground surface is of minimal length (several feet) and is protected from wildlife and weather elements by polyvinyl chloride conduit. The main components of aquifer sampling tube installations are shown in Figure 1-2.

Installation and sampling of the first 14 aquifer sampling tubes occurred in October and November 1995 along the 100-D/DR Area shoreline. Aquifer sampling tube DD-39, located

adjacent to the high hexavalent chromium (632 μg/L) porewater (river substrate) sampling site, was characterized by up to 839 μg/L hexavalent chromium. The result of this effort is discussed in the *Chromium in River Substrate Pore Water and Adjacent Groundwater: 100-D/DR Area, Hanford Site, Washington* (Hope and Peterson 1996a) and led to the discovery of the "hot spot" plume located west of the D and DR Reactors. The unexpected high survivability of the tubes installed in the fall of 1995 over the course of six winter seasons provides a strong basis for continued sampling and installation of additional tubes. However, as described below, individual tubes installed in 1995 and 1997 have started to deteriorate considerably.

Tubes were installed and sampled at 70 additional locations in September through November 1997. Each location included a cluster of one, two, or three tubes at different depths (for a total of 178 new aquifer sampling tubes). The results of this effort are presented in *Aquifer Sampling Tube Completion Report: 100 Area and Hanford Townsite Shorelines* (Peterson et al. 1998). Approximately 45 tubes were sampled again in October and November 1998. Highlights of the results from this sampling include elevated hexavalent chromium in the 100-K, 100-D/DR, and 100-H Areas; elevated gross beta in the 100-B/C and 100-H Areas; and elevated tritium in the 100-B/C Area. The tube clusters selected for sampling in the fall of 1999, 2000, and 2001 were selected based on historical results, proximity to active remediation sites, and proximity to identified contaminant plumes. The individual tubes sampled in each cluster during the fall 2001 sampling were those that best represent groundwater quality (i.e., not affected by mixing with river water).

1.2 TASK DESCRIPTIONS

The scope of work for the fall 2001 field effort was described in the *Sampling and Analysis Plan for the Aquifer Sampling Tubes* (DOE-RL 2000b). Specific requirements for the fall 2001 sampling round are described in the *Sampling and Analysis Instruction for the Aquifer Sampling Tubes, Fall 2001* (Appendix B).

The fiscal year (FY) 2002 sampling effort was conducted in the fall to take advantage of the "controlled" low stage of the river. The term "stage" refers to the depth of the river at a gauging station. The higher the stage, the deeper (and therefore wider) the river. October and November are the months of historic low stage for the Columbia River (Figure 1-3). The river stage is held at a low stage during daylight hours of approximately 2×10^6 L/sec or less during daylight hours.

Salmon select and develop their spawning sites, called redds, mostly during daylight hours, and one of their selection criteria is shallow water depth. If the river was allowed to be at high stage during daylight, the salmon would develop their nests along the shallow edges of the wide river. When the river goes to low stage, such as at night, the redds could be exposed and the eggs would die. By controlling the river at a relatively constant low stage during daylight hours, the salmon are forced to spawn in water that will almost always cover the redds. Access to the majority of the tubes, the river substrate, and the aquifer is only practical at low river stage, because they were installed at low stage.

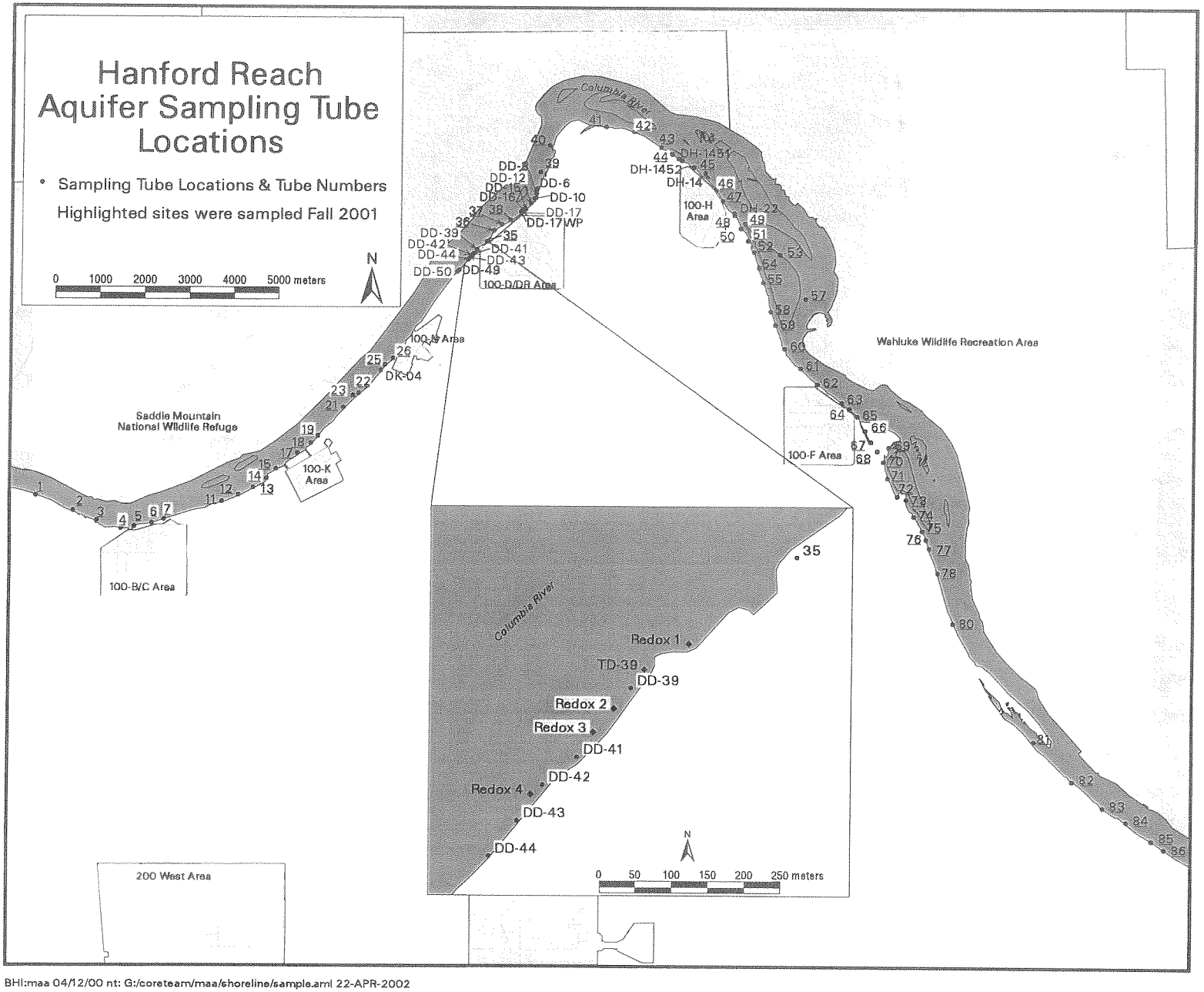
All ecological and cultural resource mitigation requirements prescribed for the project were followed during the sampling effort. An ecological review resulted in access restrictions to some sampling aquifer tubes near eagle nesting or roosting sites.

Radiological Control Engineering reviewed the analytical results of the 1997, 1998, and 1999 sampling rounds and indicated that support would be required only if the samplers were entering sites posted as radiological. Radiological Control support was not required for the fall 2001 sampling effort because no tube sites sampled were in areas posted as radiological.

Purgewater was removed from the tubes during the sampling process and managed in accordance with the following operable unit (OU)-specific waste management plan or waste control plan:

- *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE-RL 2000a)
- *100-BC-5 Operable Unit Waste Control Plan* (Woolard 2000a)
- *100-FR-3 Operable Unit Waste Control Plan* (Woolard 2000b).

Figure 1-1. Northern Portion of the Hanford Site and Aquifer Sampling Tube Locations.



BHI:maa 04/12/00 nt: G:/coreteam/maa/shoreline/sample.aml 22-APR-2002

Figure 1-2. Main Components of Aquifer Sampling Tube Installation.

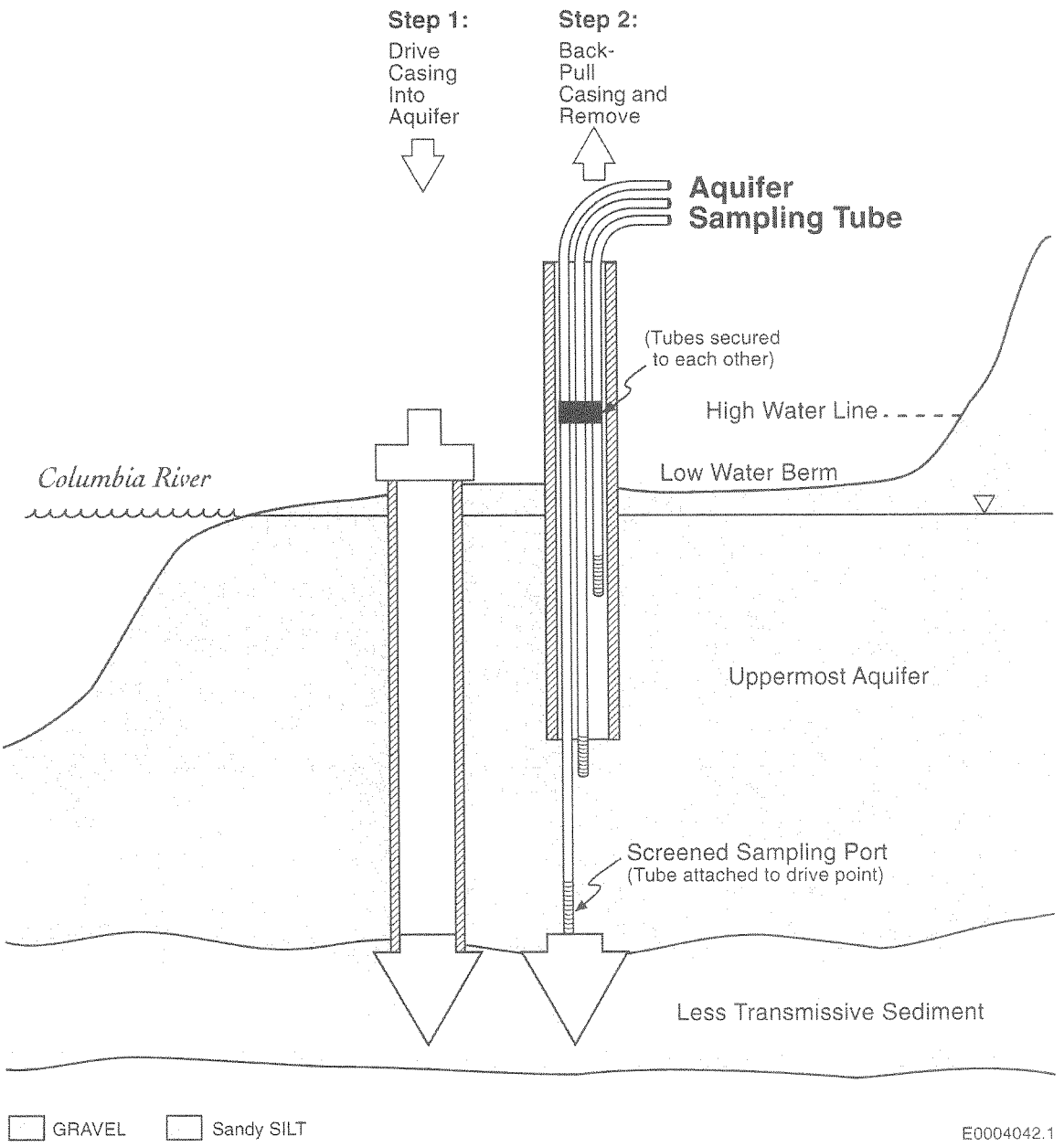
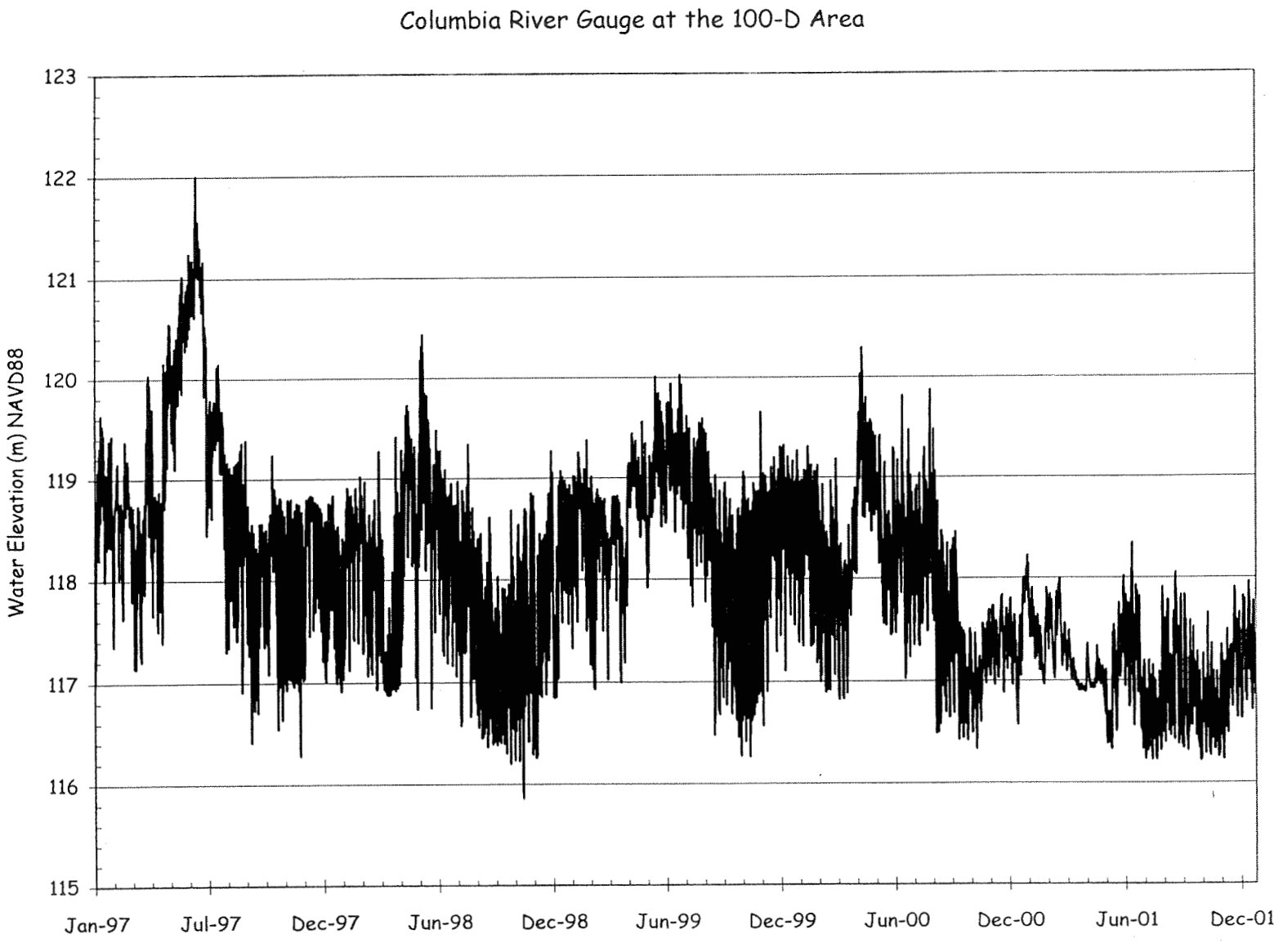


Figure 1-3. Hydrograph of the 100-H Area River Gauge from 1997 Through 2001.



2.0 SAMPLING METHODS

This section describes the methods used to obtain samples from the aquifer tubes. Technical procedural requirements, quality assurance, and training are identified in the sampling and analysis plan (DOE-RL 2000b). Standard Environmental Restoration Contractor sampling and recordkeeping procedures in BHI-EE-01, *Environmental Investigations Procedures*, were implemented for the sampling activities. The aquifer sampling tubes selected for the fall 2001 sampling round, the analyte list for the individual aquifer sampling tubes, and the sampling rationale developed during meetings with the regulators are discussed in detail in the sampling and analysis instruction (Appendix B).

The specific conductance of all samples withdrawn from the tubes was used as an indicator of the degree to which river water had influenced water quality. Water from each tube in a tube cluster was collected and the specific conductance was measured. If the specific conductance of the sample was less than 200 μS/cm (indicating primarily river water held in bank storage), no sample was retained for field or offsite analysis. The sample with the highest specific conductance in each tube cluster was retained for analysis if the minimum 200-μS/cm screen was satisfied. In addition, the specific conductance of the river water was measured at each site as an indicator when comparing groundwater and river water.

Table 2-1 identifies the 37 sites that were identified for fall 2001 sampling and the proposed analyses. These sites were selected jointly by Bechtel Hanford, Inc., the U.S. Department of Energy, Richland Operations Office, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology. Samples from only 28 sites were analyzed because some of the tubes did not yield a sufficient volume of water for a sample, the specific conductance of the collected sample was less than the 200-μS/cm screen, or the tube could not be located. The tube sites and analyses selected were based on historical results or proximity to existing plumes.

Water samples were collected and then measured at the sampling location for pH, temperature, turbidity, specific conductance, and dissolved oxygen. Hexavalent chromium, nitrate, and sulfate analyses were conducted using field screening methods. Selected samples from locations near radiological sources were sent to offsite laboratories for radionuclide analysis (including gross beta, strontium-90, carbon-14, tritium analyses, and gamma scanning).

Samples from aquifer sampling tubes within the 100-D Area near the ISRM treatment test site were analyzed for sulfate to assess the potential impact of injected sodium dithionite on the groundwater located downgradient of the treatment zone. Analyses for sulfate were performed using Hach spectrophotometer methods. The detection limit for sulfate is 5 mg/L.

Analyses for hexavalent chromium and nitrate were performed using Hach spectrophotometer methods and Reflectoquant® methods, respectively. The detection limits for hexavalent chromium and nitrate are approximately 0.005 mg/L and 3 mg/L, respectively.

Analyses for gross beta activity, tritium, strontium-90, and gamma emitters were performed by Eberline Services, Richmond, California (formerly TMA/Richmond). Gross beta analysis was determined by gas proportional counting (using EPA Method 900.0), and tritium was determined by liquid scintillation counting (EPA Method 906.0). Strontium-90 was determined by total radioactive strontium in water using gas proportional counting. Carbon-14 was determined by a laboratory-specific method of liquid scintillation counting. Gamma emitters were identified using EPA Method 901.1.

Contractual required detection limits vary for each analyte, but are approximately 4.0 pCi/L for gross beta, 400 pCi/L for tritium, 2 pCi/L for radioactive strontium, and 200 pCi/L for carbon-14. Contractual required limits for the gamma emitters are isotope specific and not included in this data summary report.

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Table 2-1. Summary of Fall 2001 Aquifer Tubes Proposed Sampling Sites and Analyses. (2 Pages)

Map Location and Relative Depth of Screen[a]	Area	Proposed Laboratory Analyses								Field Measurements					
		Onsite			Offsite										
		Hexavalent Chromium (µg/L)	Nitrate (mg/L)	Sulfate (mg/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Strontium-90 (pCi/L)	Carbon-14 (pCi/L)	Gamma Scan[b]	River-Specific Conductance (µS/cm)	Sample-Specific Conductance (µS/cm)	pH	Temperature (°C)	Turbidity (NTU)	Dissolved Oxygen (mg/L)
1S/M/D	100-BC-5	X				X				X	X	X	X	X	X
2S[c]	100-BC-5	X				X				X	X	X	X	X	X
4S/M/D[d]	100-BC-5	X			X	X	X			X	X	X	X	X	X
5S/M/D	100-BC-5	X			X	X	X			X	X	X	X	X	X
6S/M/D	100-BC-5	X			X	X	X			X	X	X	X	X	X
7M/D	100-BC-5	X				X				X	X	X	X	X	X
14S/M/D	100-KR-4	X				X			X	X	X	X	X	X	X
17M/D	100-KR-4	X				X				X	X	X	X	X	X
19M/D	100-KR-4	X				X	X	X		X	X	X	X	X	X
21S/M	100-KR-4	X								X	X	X	X	X	X
22M/D	100-KR-4	X								X	X	X	X	X	X
23M/D	100-KR-4	X								X	X	X	X	X	X
25D	100-KR-4	X								X	X	X	X	X	X
26S/M/D	100-KR-4	X	X							X	X	X	X	X	X
DD-50-3	100-D/DR	X		X		X				X	X	X	X	X	X
DD-44	100-D/DR	X		X		X				X	X	X	X	X	X
DD-39	100-D/DR	X								X	X	X	X	X	X
DD-12	100-D/DR	X				X				X	X	X	X	X	X
DD-17	100-D/DR	X				X				X	X	X	X	X	X
DD-41-3	100-D/DR	X		X						X	X	X	X	X	X
DD-42	100-D/DR	X		X						X	X	X	X	X	X
DD-43	100-D/DR	X		X						X	X	X	X	X	X
Redox-1[e]	ISRM	X		X						X	X	X	X	X	X
Redox-2[e]	ISRM	X		X						X	X	X	X	X	X
Redox-3[e]	ISRM	X		X						X	X	X	X	X	X
Redox-4[e]	ISRM	X		X						X	X	X	X	X	X
42	100-H	X								X	X	X	X	X	X
43M/D	100-H	X								X	X	X	X	X	X
44M/D	100-H	X								X	X	X	X	X	X

Table 2-1. Summary of Fall 2001 Aquifer Tubes Proposed Sampling Sites and Analyses. (2 Pages)

Map Location and Relative Depth of Screen[a]	Area	Proposed Laboratory Analyses								Field Measurements					
		Onsite			Offsite										
		Hexavalent Chromium (µg/L)	Nitrate (mg/L)	Sulfate (mg/L)	Gross Beta (pCi/L)	Tritium (pCi/L)	Strontium-90 (pCi/L)	Carbon-14 (pCi/L)	Gamma Scan[b]	River-Specific Conductance (µS/cm)	Sample-Specific Conductance (µS/cm)	pH	Temperature (°C)	Turbidity (NTU)	Dissolved Oxygen (mg/L)
46D	100-H	X								X	X	X	X	X	X
48S/M	100-H	X								X	X	X	X	X	X
49S/M/D	100-H	X								X	X	X	X	X	X
50S/M	100-H	X								X	X	X	X	X	X
51S/M/D	100-H	X								X	X	X	X	X	X
64D	100-F	X								X	X	X	X	X	X
65S/M	100-F	X								X	X	X	X	X	X
66S/M/D	100-F	X								X	X	X	X	X	X

[a]There are up to three tubes at a map location: S (shallow), M (medium), and D (deep); samples were attempted from each tube and the sample with highest specific conductance was retained for analysis. Aquifer tubes with a "DD" prefix also have a numerical suffix indicating relative depth of screened interval. For these tubes "1" = shallowest and "4" = deepest. Redox porewater (river substrate) sampling tubes include screens at 0.9 and 1.8 m (3 and 6 ft) in the substrate.
[b]Gamma scan includes the following isotopes: americium-241, cesium-137, cobalt-60, europium-152, europium-154, europium-155, potassium-40, radium-226, radium-228, thorium-232, uranium-235, and uranium-238.
[c]Alternate site for #1.
[d]Alternate site for #5.
[e]Indicates a porewater (river substrate) sampling tube.

3.0 AQUIFER SAMPLING TUBE RESULTS

This section summarizes the analytical results of the tube sampling. A general discussion of each analyte is included. All analytical results obtained are listed in Table 3-1. The data are also available in the Hanford Environmental Information System database.

The following criteria have been used to assign "undetected" qualifiers to analytical results. The detection limit for hexavalent chromium results determined by Hach methods is 0.005 mg/L. The detection limit for nitrate results determined by Reflectoquant methods is 3 mg/L. The detection limit for Hach sulfate analysis is 5 mg/L. If the reported result is equal to or less than these detection limits, a "U" qualifier was assigned to the result shown in Table 3-1.

For radiological analyses, a "U" qualifier was assigned if the reported activity is a negative number or if the reported activity is less than the minimum detectable activity/instrument detection limit as reported by the laboratory.

The following generalizations are based on initial review of all data obtained from the fall 2001 results (see Table 3-1). Additional discussion of the results based on previously published descriptions of groundwater contamination in each reactor area is presented in Section 4.0.

3.1 SPECIFIC CONDUCTANCE

The specific conductance of all samples withdrawn from the tubes was used as an indicator of the degree to which river water had influenced water quality. The specific conductance of the river water ranged from 130 to 339 µS/cm, with an average of 156 µS/cm (see Table 3-1). Typically, the specific conductance of groundwater samples from the near-river wells is 400 to 500 µS/cm.

As a general rule, water samples with specific conductance less than 200 µS/cm, which indicates river water held in bank storage, were not retained for analysis. Specific conductance of samples from the tubes ranged from 96 to 923 µS/cm and averaged 340 µS/cm (see Table 3-1). Two river substrate porewater sites could not be sampled because of low production during pumping, and four sites were rejected because sample conductivity was less than the 200 µS/cm screening criterion. Eleven of the 28 samples retained for analyses were characterized by specific conductance over 400 µS/cm.

3.2 HEXAVALENT CHROMIUM

Hexavalent chromium concentrations were determined for all 28 samples collected from the tubes (see Table 3-1). Concentrations ranged from 6 to 430 µg/L and averaged 85 µg/L. Samples from 20 of 28 sites contained hexavalent chromium above 20 µg/L, the remedial action

objective (RAO) for groundwater samples from compliance wells associated with the interim action pump-and-treat systems (DOE-RL 2001). The ambient water quality criterion for protection of aquatic organisms, 10 µg/L, was exceeded in the two porewater (river substrate) samples collected from aquifer tubes installed offshore of the ISRM Project in the 100-D/DR Reactor area.

Hexavalent chromium concentrations are summarized as follows by reactor area and plume.

- 100-D/DR Southwest Chromium Plume. Samples from sites DD-41, DD-42, and DD-43 were characterized by the three highest hexavalent chromium concentrations of the 28 samples analyzed during the FY 2002 sampling round. These concentrations were 335 µg/L, 430 µg/L, and 324 µg/L, respectively. The sample/specific conductances were 435 µS/cm, 437 µS/cm, and 520 µS/cm, respectively, suggesting minor, if any, mixing of groundwater and bank storage. Porewater (river substrate) samples from ISRM-2 and ISRM-3 were characterized by 82 µg/L and 119 µg/L hexavalent chromium, respectively. All eight samples collected from this plume area had chromium concentrations above 20 µg/L.

- 100-D/DR Northeast Chromium Plume. Tube sites DD-17 and DD-12 are located in the contaminant plume currently being remediated by the interim action pump-and-treat system (DOE-RL 1996). Hexavalent chromium concentrations in samples collected from these tubes in November 2001 were 75 µg/L and 40 µg/L, respectively. The specific conductance measurements were 250 µS/cm and 255 µS/cm, respectively, suggesting some mixing of groundwater and bank storage.

- 100-H Area. Seven tube sites were sampled along the shoreline adjacent to the H Reactor. Hexavalent chromium ranged between 20 µg/L and 46 µg/L for the seven samples, and conductivities ranged from 270 µS/cm to 548 µS/cm. Six samples contained chromium concentrations above 20 µg/L.

- 100-K Area. Six tube sites were sampled along the shoreline adjacent to the 100-K Area reactors. Hexavalent chromium concentrations ranged from 6 µg/L at site 14 to 59 µg/L at site 23. Conductivities ranged from 264 µS/cm to 371 µS/cm. Three samples contained chromium concentrations above 20 µg/L.

- 100-B/C Area. Three tube sites were sampled along the shoreline adjacent to the 100-B/C Reactor area. Hexavalent chromium ranged from 6 µg/L at site 7 to 39 µg/L at site 6. Conductivity readings for these samples were 253 µS/cm and 410 µS/cm, respectively. One sample contained chromium above 20 µg/L.

3.3 DISSOLVED OXYGEN

Dissolved oxygen was measured in all retained samples collected during the fall 2001 sampling round (see Table 3-1). Dissolved oxygen concentrations in the 100-D/DR Area were of particular interest because ISRM dithionite the treatment creates a reducing environment. Dissolved oxygen concentrations in the 100-D/DR Area ranged from 5.07 mg/L at site DD-39 to 9.64 mg/L at DD-43. Porewater from river substrate samples at sites Redox-2 and Redox-3 had dissolved oxygen concentrations of 8.63 mg/L and 8.24 mg/L, respectively. It appears that any reducing effect caused by the injection of sodium dithionite did not extend to the aquifer sampling tubes or river substrate tubes.

3.4 SULFATE

Sulfate concentrations were determined for seven samples collected from the tubes near the ISRM barrier (see Table 3-1). Concentrations ranged from 38 mg/L to 215 mg/L. None of the samples analyzed exceeded the secondary maximum contaminant level (MCL) for sulfate of 250 mg/L. The highest observed sulfate concentration was 215 mg/L at Redox-3, which is a porewater (river substrate) site located offshore from the ISRM treatment zone. The fall 2000 sulfate concentration at the Redox-3 site was 110 mg/L. It appears that the sulfate plume caused by the sodium dithionite injection has extended farther from the barrier than the reducing low dissolved oxygen conditions.

3.5 GROSS BETA

Gross beta activities were determined for two samples collected from 100-B/C tube sites 4S and 6M (see Table 3-1). Activities were 7.54 (4S) and 41.3 (6M) pCi/L. Fall 2000 readings at these sites were 7.48 pCi/L and 48.8 pCi/L, respectively. Therefore, there has been no real change in gross beta.

3.6 GAMMA SCAN

The sample from aquifer tube site 14 was analyzed for gamma emitters to confirm that previously high concentrations of gross beta (82.4 pCi/L) in FY 2000 had been correctly identified as potassium-40, a naturally occurring isotope. The fall 2001 sample was nondetect for all the suite isotopes, including potassium-40.

3.7 TRITIUM

Tritium activities were determined for nine samples collected from the aquifer sampling tubes (see Table 3-1). Activities ranged from 1,680 to 45,000 pCi/L. Three samples were collected from the 100-B/C Area, and tritium in these samples averaged 19,317 pCi/L. One sample from

site 6 was characterized by an activity of 45,000 pCi/L (±4,600 pCi/L), which exceeded the MCL for tritium of 20,000 pCi/L. This tritium activity is consistent with activities in upgradient well 199-B3-47 (PNNL 2001).

The highest observed tritium activity outside the 100-B/C Area was 29,400 pCi/L (±3,000 pCi/L) from site DD-44 upriver from the ISRM barrier. The tritium activity measured at nearby site DD-50 was 17,000 pCi/L (±1,700 pCi/L). Samples collected from the 100-D Area near the 100-HR-3 pump-and-treat system were 1,700 pCi/L (DD-17) and 1,680 pCi/L (DD-12). The tritium detected in these wells is probably from sources in the 100-N Area.

3.8 STRONTIUM-90

Strontium-90 analyses were conducted on samples collected from three sites at the 100-B/C and 100-K Areas because strontium-90 has been detected above the MCLs in upgradient wells (see Table 3-1). Activities ranged from undetected to 12.8 pCi/L at site 6M, consistent with the fall 2000 activity of 15.8 pCi/L. The MCL for strontium-90 is 8 pCi/L.

3.9 CARBON-14

Carbon-14 was undetect in a sample from site 19 in the 100-K Area. Carbon-14 activity has been increasing in upgradient well 199-K-32A, where the fall 2001 activity was 267 pCi/L (±37 pCi/L). Carbon-14 has a proposed MCL of 3,200 pCi/L. High carbon-14 activities have not been detected in the aquifer sampling tubes along the 100-K Area shoreline since sampling started in 1997.

Table 3-1. Fall 2001 Aquifer Sampling Tube Analytical Results. (3 Pages)

ID Number	Map Location and Relative Depth of Screen[a]	Area	Sample Collected?	Analyses[h]							Field Measurements					
				Onsite			Offsite									
				Hexavalent Chromium (mg/L)[c]	Nitrate (mg/L)[d]	Sulfate (mg/L)[e]	Gross Beta (pCi/L)[d]	Tritium (pCi/L)[d]	Strontium-90 (pCi/L)[d]	Carbon-14 (pCi/L)c	River Specific Conductance (µS/cm)	Sample Specific Conductance (µS/cm)	pH	Temperature (°C)	Turbidity (NTU)	Dissolved Oxygen (mg/L)
B8113	1D	100-BC-5	N[b]									183				
B8118	2S	100-BC-5	N[b]									131				
B8123	4M	100-BC-5	Y	0.008			7.54	6760	0.027		137	366	7.62	14.6	22.9	8.06
B8126	5M	100-BC-5	N[f]													
B8129	6M	100-BC-5	Y	0.039			41.3	45000	12.8		134	410	8.03	18.5	1.65	7.97
B8131	7M/D	100-BC-5	Y[g]	0.006				6190			135	253	8	16.6	6.28	7.9
B8153	14M	100-KR-4	Y	0.006				7290			136	341	7.95	15.2	11.3	6.82
B8205	19D	100-KR-4	Y	0.015				2020	-0.104	5.33	134	325	8.12	15.5	29.1	7.27
	21S/M	100-KR-4	N[b]									167				
B8215	22M	100-KR-4	Y	0.056							136	264	7.43	14.8	70.7	8.86
B8217	23D	100-KR-4	Y[g]	0.059							339	276	8.25	14.8	14.2	8.25
B8223	25D	100-KR-4	Y	0.018							138	289	7.2	14.9	17.7	10.72
B8227	26M	100-KR-4	Y	0.036							241	371	8.22	16	14.6	8.61
B8517	DD-50-3	100-D/DR	Y	0.049		38		17000			153	298	7.93	14	5.26	9.02
	DD-44	100-D/DR	Y[g]	0.229		102		29400			146	534	8.01	15.4	4.36	9.59
	DD-39	100-D/DR	Y[g]	0.191							311	922	7.66	15.3	5.03	5.07

Table 3-1. Fall 2001 Aquifer Sampling Tube Analytical Results. (3 Pages)

ID Number	Map Location and Relative Depth of Screen[a]	Area	Sample Collected?	Analyses[h]							Field Measurements					
				Onsite			Offsite									
				Hexavalent Chromium (mg/L)[c]	Nitrate (mg/L)[d]	Sulfate (mg/L)[e]	Gross Beta (pCi/L)[d]	Tritium (pCi/L)[d]	Strontium-90 (pCi/L)[d]	Carbon-14 (pCi/L)c	River Specific Conductance (µS/cm)	Sample Specific Conductance (µS/cm)	pH	Temperature (°C)	Turbidity (NTU)	Dissolved Oxygen (mg/L)
	DD-12	100-D/DR	Y[g]	0.04				1680			130	255	7.83	11.6	29.6	7.7
	DD-17	100-D/DR	Y[g]	0.075				1700			138	250	7.56	13	250	7.24
	DD-41-3	100-D/DR	Y	0.335		82					138	435	7.8	15.5	4.35	7.58
	DD-42	100-D/DR	Y[g]	0.43		72					144	437	7.92	13.8	250	9.32
	DD-43	100-D/DR	Y[g]	0.324		82					138	520	8.06	13.6	1.03	9.64
	Redox-1	ISRM	N[f]													
	Redox-2	ISRM	Y	0.082		88					198	434	7.6	7.5	3.4	8.63
	Redox-3	ISRM	Y	0.119		215					153	708	7.98	13.6	5.44	8.24
	Redox-4	ISRM	N[f]													
B8274	42S/M	100-H	Y[g]	0.021							138	270	7.49	14.2	4.38	9.5
B8277	43M/D	100-H	N[b]								144	182				
B8280	44M	100-H	Y	0.04							140	308	7.13	13.6	14.3	9.12
B8286	46D	100-H	Y	0.02							140	316	7.68	14.9	5.69	7.11
B8293	48M	100-H	Y	0.025							136	499	N/A	16.2	5.14	7.64
B8297	49M	100-H	Y	0.037							135	525	N/A	15.5	4.14	7.74
B8299	50M	100-H	Y	0.046							135	542	7.43	15.3	7.52	7.92
B8302	51M	100-H	Y	0.046							134	548	7.51	13.2	3.55	7.77
B8340	64D	100-F		0.01							136	299	7.86	11.6	25.9	5.89

Table 3-1. Fall 2001 Aquifer Sampling Tube Analytical Results. (3 Pages)

ID Number	Map Location and Relative Depth of Screen[a]	Area	Sample Collected?	Analyses[h]							Field Measurements					
				Onsite			Offsite									
				Hexavalent Chromium (mg/L)[c]	Nitrate (mg/L)[d]	Sulfate (mg/L)[e]	Gross Beta (pCi/L)[d]	Tritium (pCi/L)[d]	Strontium-90 (pCi/L)[d]	Carbon-14 (pCi/L)c	River Specific Conductance (µS/cm)	Sample Specific Conductance (µS/cm)	pH	Temperature (°C)	Turbidity (NTU)	Dissolved Oxygen (mg/L)
B8344	65S/M[b]	100-F	N[b]								134	179				
B8347	66M	100-F	Y	0.006							128	218	8.04	15.7	6.4	3.1

[a]There are up to three individual tubes installed at a map location: deep (D), medium (M), and shallow (S).
[b]Sample not analyzed because specific conductance was less than 200 µS/cm.
[c]Washington State ambient water quality criterion (freshwater-chronic) for hexavalent chromium in 10 µg/L.
[d]EPA MCLs for drinking water are as follows: nitrate = 45 mg/L, tritium = 20,000 pCi/L, strontium-90 = 8 pCi/L, and carbon-14 = 3,200 pCi/L (proposed).
[e]The secondary MCL for sulfate is 250 mg/L.
[f]Sample not collected because no flow or very slow flow.
[g]Individual tube labeling too deteriorated by weathering to identify depths of tubes, or only one surviving tube in cluster.

4.0 COMPARISON OF AQUIFER SAMPLING TUBE RESULTS WITH NEAR-RIVER GROUNDWATER CHEMISTRY

This section summarizes the fall 2001 aquifer sampling tube results, compares the results to previous results, and relates the information to published descriptions of groundwater plumes. The *Hanford Site Groundwater Monitoring for Fiscal Year 2000* report (PNNL 2001) presents configurations and information on the Hanford Site plumes. The fall 2001 groundwater plume configurations for the 100-K, 100-D/DR, and 100-H Areas are presented in the *Annual Summary Report Calendar Year 2001 for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations and Operable Units* (DOE-RL 2002). Groundwater plume maps from the calendar year 2001 pump-and-treat annual summary report were used for comparison of tube results because the tube samples were collected in approximately the same time frame (fall) when the river stage was low. These (fall 2001) plume data are available in the Hanford Environmental Information System, but have not yet been published.

4.1 100-B/C AREA

- Contaminants of concern: hexavalent chromium, strontium-90, and tritium.
- Other contamination indicators: gross beta and nitrate.
- Tube sites proposed for fall 2001 sampling round: 1D, 2S, 4 S/M/D, 5M, 6S/M/D, and 7M/D.
- Samples analyzed from tubes: 4M, 6M and 7 (surviving tube not distinguishable).
- Tube sites not sampled: 1D and 2S (specific conductance <200 µS/cm); 5M (did not produce water).
- Fall 2001 analytical results (see Table 4-1 and Appendix A)
  - Hexavalent chromium range: 6 µg/L (tube 7) to 39 µg/L (tube 6M)
  - Tritium range: 6,190 pCi/L (tube 7) to 45,000 pCi/L (tube 6M)
  - Strontium-90 range: 0.027 pCi/L (U) (tube 4M) to 12.8 pCi/L (tube 6M)
- Fall 2000 analytical results (see BHI 2001 and Table 4-1)
  - Hexavalent chromium range: 5 µg/L (tube 1D) to 47 µg/L (tube 6M)
  - Tritium range: 6,000 pCi/L (tube 3D) to 36,600 pCi/L (tube 6M)
  - Strontium-90 range: 0.24 pCi/L (tubes 4M and 7D) to 15.8 pCi/L (tubes 5M and 6M)

- Fall 2001 upgradient well summary (199-B3-47)

  - Total chromium: 66.9 μg/L
  - Strontium-90: 135 pCi/L
  - Tritium: 35 pCi/L

- Analysis: Hexavalent chromium, tritium, and strontium-90 values remained consistent between the fall 2000 and fall 2001 sampling rounds. Strontium-90 and chromium may increase in aquifer tube 6M if the contaminant plume moves downgradient from well 199-B3-47.

The 100-B/C Area has not been selected for an interim remedial measure (pump and treat) because good salmon spawning habitat is lacking in this stretch of the river compared to other areas of the Hanford Reach.

4.2 100-K AREA

- Contaminants of concern: Hexavalent chromium, nitrate, strontium-90, tritium, and carbon-14.

- Tube sites proposed for fall 2001 sampling round: 14S/M/D, 17M/D, 19M/D, 21S/M, 22M/D, 23M/D, 25D, and 26S/M/D.

- Samples analyzed from tubes: 14M, 19D, 22M, 23D, 25D, and 26M.

- Tube sites not sampled: 21S/M (specific conductance <200 μS/cm), 17M/D radiological posting.

- Fall 2001 analytical results (see Table 4-2 and Appendix A)

  - Hexavalent chromium range: 6 μg/L (tube 14M) to 59 μg/L (tube 23D)
  - Tritium range: 2,020 pCi/L (tube 14M) to 7,290 pCi/L (tube 19D)
  - Strontium-90: -0.104 (U) pCi/L (tube 19D)
  - Carbon-14: 5.33 pCi/L (tube 19D)

- Fall 2000 analytical results (see BHI 2001 and Table 4-2)

  - Hexavalent chromium range: 5 μg/L (tubes 25D and 26M) to 110 μg/L (tube 23D)
  - Tritium range: 1334 pCi/L (tube 19D)
  - Strontium-90: 0.3 (U) pCi/L (tubes 19D and 14M)
  - Carbon-14: 2.14 (U) pCi/L (tube 19D)

- Fall 2001 upgradient well summary
  - Hexavalent chromium: 199-K-114A (65 μg/L), 199-K-117A (21 μg/L)
  - Tritium: 199-K-32A (79,400 pCi/L)
  - Strontium-90: 199-K-20 (9.01 pCi/L)

- Analysis: The pump-and-treat system has removed hexavalent chromium from groundwater upgradient of the 100-K Area aquifer tubes located near the 116-K-2 Trench. Compliance well chromium concentrations decreased from 2000 to 2001, and these decreases should be reflected in lower chromium concentrations reaching the shoreline and aquifer tubes.

  High tritium concentrations in well 199-K-32A may be seen in downgradient aquifer tubes as the tritium plume migrates toward the Columbia River.

4.3 100-N AREA

No aquifer tubes were installed along the 100-N Area shoreline during the fall 2001 sampling project. The riprap that covers the shoreline makes access impossible for truck-mounted drilling and penetration impossible for an air hammer.

4.4 100-D/DR AREA

The COCs in the 100-D/DR Area include hexavalent chromium, nitrate, strontium-90, and tritium. Ten tube sites were sampled during the fall 2001 sampling round, including two porewater (river substrate) sites located in the Columbia River adjacent to the ISRM treatment zone. All samples collected were analyzed for hexavalent chromium. Those in the vicinity of the ISRM treatment zone were also analyzed for sulfate, a chemical byproduct produced during treatment zone emplacement. Appendix A summarizes the results from the fall 2001 and previous 4 years of tube sampling results.

- Contaminants of concern: Hexavalent chromium, nitrate, strontium-90, and tritium.

- Tube sites proposed for fall 2001 sampling round: DD-50, DD-44, DD-39, DD-12, DD-17, DD-41, DD-42, DD-43, Redox-1, Redox-2, Redox-3, and Redox-4.

- Samples analyzed from tubes: DD-12, DD-17, DD-41-3, DD-42, DD-43, DD-44, DD-50-3, Redox-2, Redox-3, and DD-39.

- Tubes sites not sampled: Redox-1 and Redox 4 because the flow was too slow to collect enough sample.

- Tube clusters where individual tubes too deteriorated to distinguish depths of individual tubes: DD-12, DD-17, DD-42, DD-43, DD-44, and DD-39.

- Fall 2001 analytical results

  - Hexavalent chromium range: 40 µg/L (DD-12) to 430 µg/L (DD-42)
  - Tritium range: 17,000 pCi/L (DD-50-3) to 29,400 pCi/L (DD-44) (see Table 4-4)
  - Sulfate range: 38 mg/L (DD-50-3) to 215 mg/L (Redox-3)

- Fall 2000 analytical results (see BHI 2001 and Tables 4-3 and 4-4):

  - Hexavalent chromium range: 42 µg/L (DD-50-3) to 521 µg/L (Redox-3)
  - Tritium range: 22,100 pCi/L (DD-50-3)
  - Sulfate range: 35 mg/L (DD-50-3) to 110 mg/L (Redox-3)

- Fall 2001 upgradient well summary:

  - Hexavalent chromium: 135 µg/L (199-D4-23), 745 µg/L in September 2000; 650 µg/L (199-D4-39), 5 µg/L (U) in September 2000

  - Sulfate: 144 mg/L (199-D4-39), 230 mg/L in September 2000; 250 mg/L (199-D4-23), 120 mg/L in September 2000.

Analysis:

- The range of concentrations for hexavalent chromium, tritium, and sulfate has not changed significantly from 2000 to 2001.

- Chromium concentrations in aquifer substrate tube Redox-3 declined from 521 µg/L in 2000 to 119 µg/L in 2001. Sulfate concentrations increased from 110 mg/L to 215 mg/L in 2001.

- There were swings in concentration in upgradient wells 199-D4-23 and 199-D4-39 with chromium decreasing in well 199-D4-23 and increasing in well 199-D4-39. These changes in chromium and sulfate concentrations may be reflected in the next round of aquifer tube sampling.

- Tritium remains slightly elevated along the upstream limit of the 100-D/DR Area shoreline. Samples from tubes DD-50-3 and DD-44 (see Table 4-4) exhibited tritium activities near 20,000 pCi/L. The source of this tritium may be liquid waste disposal at the 100-N Area (PNNL 2001).

4.5 100-H AREA

- Contaminants of concern: Hexavalent chromium, nitrate, fluoride, strontium-90, technetium-99, tritium, and uranium.
- Tubes sites selected for fall 2001 sampling round: 42S/M, 43M/D, 44M/D, 46D, 48S/M, 49S/M/D, 50S/M, and 51S/M/D.
- Samples analyzed from tubes: 42, 44M, 46D, 48M, 49M, 50M, and 51M.
- Tube site not sampled: 43M/D (conductivity less than 200 μS/cm).
- Tube sites with only one surviving tube in cluster: 42 and 43.
- Fall 2001 hexavalent chromium range: 20 μg/L (46D) to 46 μg/L (51 M) (Table 4-5 and Appendix A).
- Fall 2001 hexavalent chromium range: 21 μg/L (49S) to 53 μg/L (44D).
- Fall 2001 upgradient well summary: 82 μg/L (199-H4-64) and 74 μg/L (199-H4-63).
- Analysis: Data in Table 4-5 suggest that the interim action pump-and-treat system has been effective in removing chromium from the groundwater. Chromium concentrations are uniformly less than 50 μg/L in the aquifer tubes and less than 100 μg/L in the compliance monitoring wells. Increases in monitoring well concentrations may be due to lowered river stage, plume heterogeneities, or a combination of both. The lowered river stage may have resulted in less mixing of groundwater and river water near the shoreline where the aquifer tubes are located.

4.6 100-F AREA

Chromium, nitrate, trichloroethene, gross alpha, gross beta, strontium-90, and tritium are tracked as COCs in the 100-F Area. Samples were collected from sites 64 and 66 during the fall 2000 sampling round and analyzed for chromium. One of the sampling objectives was to assess the effect of the source area remediation on groundwater samples. Appendix A summarizes the results from the fall 2001 and previous 4 years of tube sampling results. The fall 2001 results are included in Table 3-1.

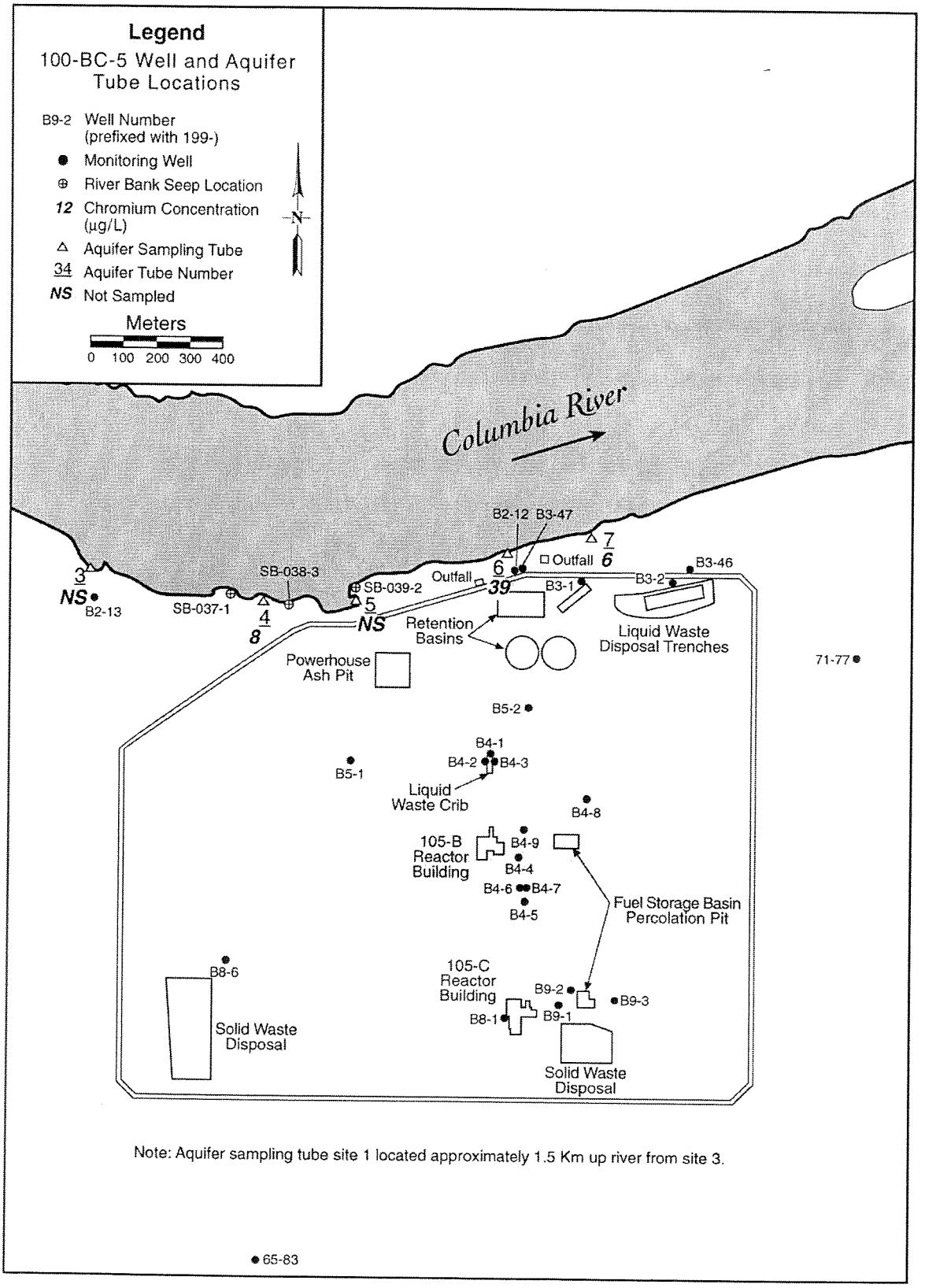
- Contaminants of concern: hexavalent chromium, nitrate, trichloroethene, gross alpha, gross beta, strontium-90, and tritium.
- Tube sites proposed for sampling: 64D, 65S/M, and 66S/M/D.

- Samples analyzed from tube sites: 64D and 66M.
- Tube sites not sampled: 65S/M (specific conductances less than 200 µS/cm).
- Fall 2001 hexavalent chromium range: 6 µg/L (66M) to 10 µg/L (64D).
- Fall 2000 hexavalent chromium range: 5 µg/L (66M) to 9 µg/L (64D).
- Analysis: Ongoing surface remediation of source area OUs has not affected chromium concentrations in aquifer sampling tubes.

4.7 HANFORD TOWNSITE

No aquifer sampling tubes were sampled along the Hanford townsite shoreline during the fall 2001 sampling project.

Figure 4-1. Well Locations, Aquifer Sampling Tubes, and Principal Facilities in the 100-B/C Area.



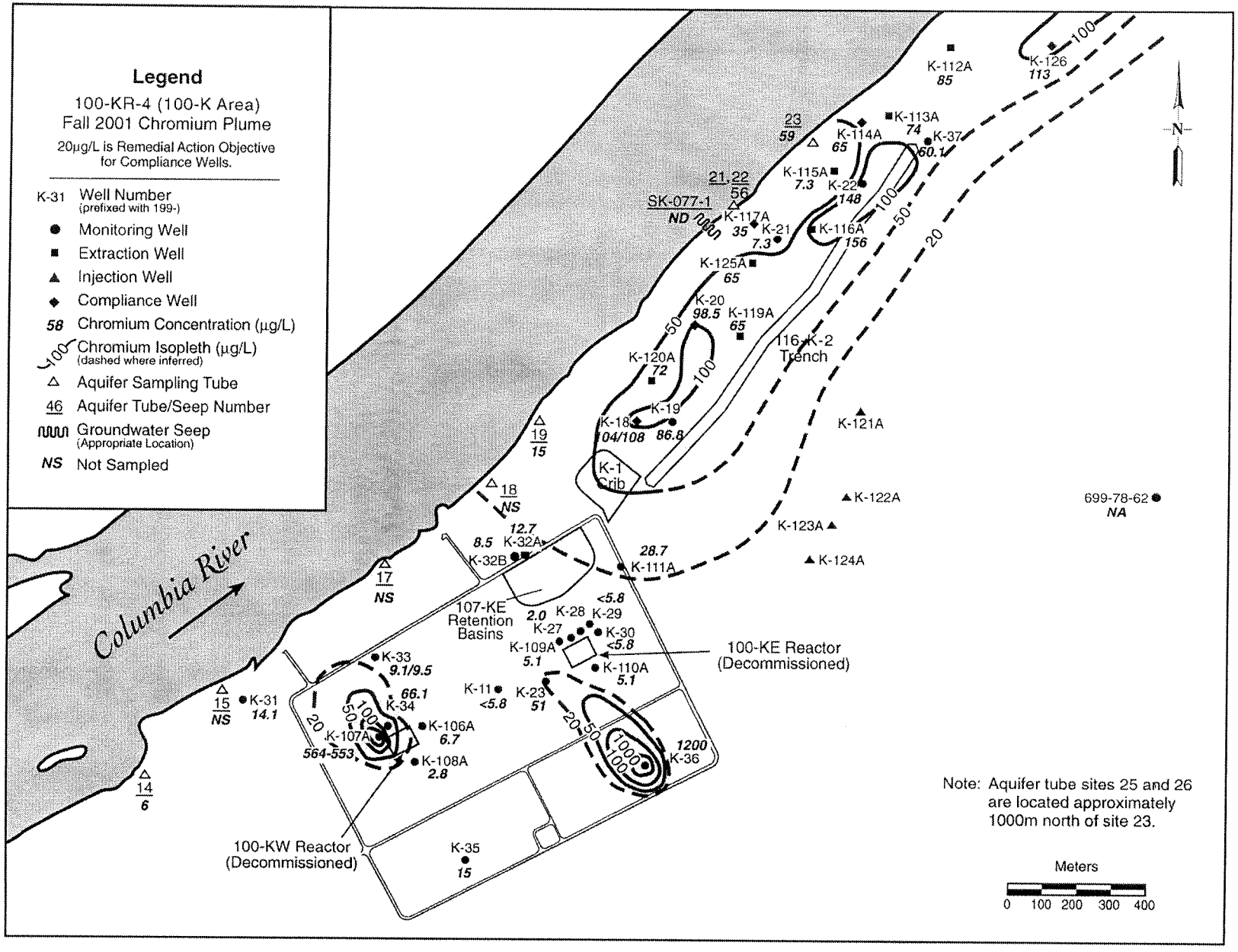


Figure 4-2. Fall 2001 Chromium Plume for the 100-K Area.

Figure 4-3. Fall 2001 Chromium Plume for the 100-D/DR Area.

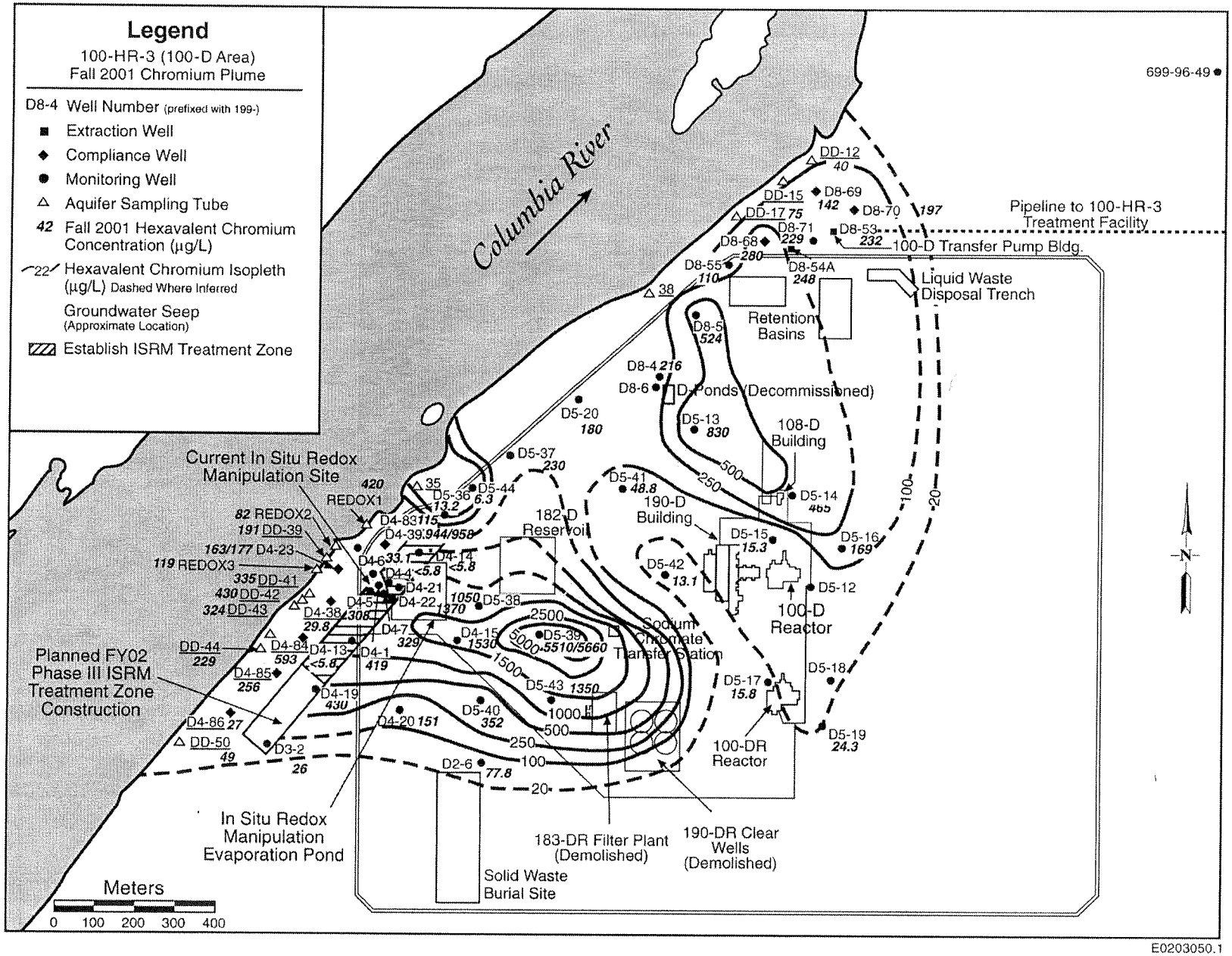


Figure 4-4. Fall 2001 Chromium Plume for the 100-H Area.

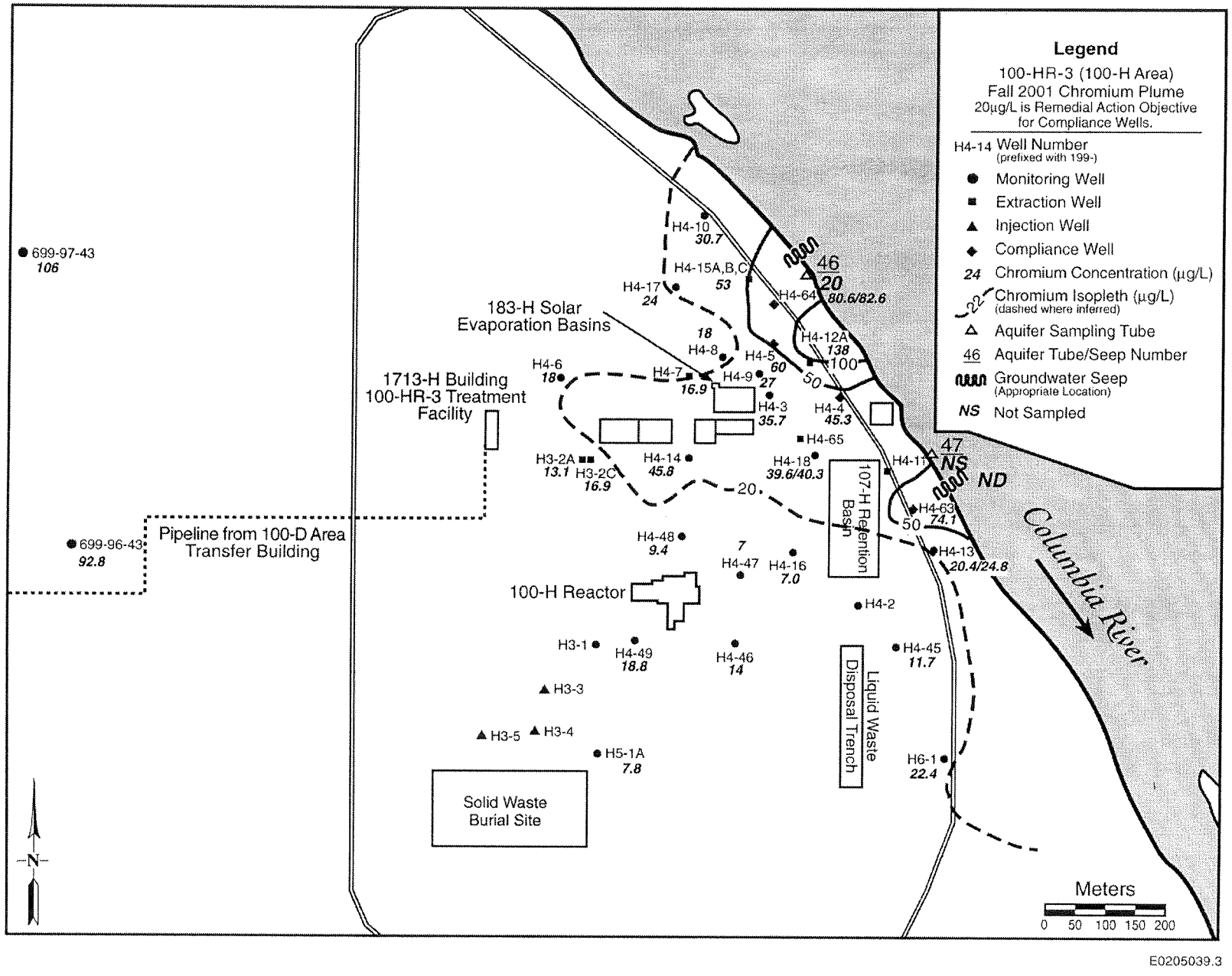


Table 4-1. Summary of 100-B/C Fall 2001 Contaminant Concentrations from Aquifer Tubes and Nearby Wells.

Aquifer Tube or Well Name	Date Sampled	Hexavalent or Total Dissolved Chromium[b] (μg/L)	Gross Beta (pCi/L)	Strontium-90 (pCi/L)	Tritium (pCi/L)	Specific Conductance (μS/cm)
4M[a]	11/28/01	8	7.54	0.027(U)	6,760	366
6M[a]	11/26/01	39	41.3	12.8	45,000	410
7[a]	11/26/01	6	N/A	N/A	6,190	253
199-B3-46[c]	2/5/01	7.6	270	135	5,140	415
199-B3-47[c]	2/5/01	66.9	46	20.8	35,000	428

NOTES:
Washington State ambient water quality criterion for hexavalent chromium = 100 μg/L.
Hexavalent chromium RAO for the 100 Area pump-and-treat system is 20 μg/L.
Strontium-90 MCL = 8 pCi/L.
Tritium MCL = 20,000 pCi/L.
[a] Aquifer sampling tube; see notes in Table 2-1 for explanation of tube depth designation; site 7 characterized by one surviving tube in cluster.
[b] Total dissolved chromium includes hexavalent chromium measured by Color_TDK_FLD method for aquifer tube sample or 6010_Metals_ICP method for monitoring well sample.
[c] Monitoring well.
N/A = analyte not requested

Table 4-2. Summary of 100-KR-4 Fall 2001 Contaminant Concentrations in Aquifer Tubes and Nearby Wells.

Aquifer Tube or Well Name	Date Sampled	Hexavalent or Total Chromium[b] (μg/L)	Tritium (pCi/L)	Strontium-90 (pCi/L)	Carbon-14 (pCi/L)	Specific Conductance (μS/cm)
14M[a]	11/8/01	6	7,290	NA	NA	341
19D[a]	11/12/01	15	2,020	-0.104 (U)	5.33	325
22M[a]	11/12/01	56	NA	NA	NA	264
23D[a]	11/13/01	59	NA	NA	NA	276
25D[a]	11/13/01	18	NA	NA	NA	289
26M[a]	11/13/01	36	NA	NA	NA	371
199-K-32A[c]	10/19/01	12.7	79,400	NA	267	336
199-K-20[c]	10/29/01	98.5	368(J)	9.01	NA	316
199-K-117A[c]	11/28/01	21	-137(U)	1.27(J)	NA	200
199-K-114A[c]	11/28/01	65	93.4(U)	18.6	NA	288

NOTES:
Washington State ambient water quality criterion for hexavalent chromium = 10 μg/L.
Interim action monitoring RAO = 20 μg/L.
Strontium-90 = 8 pCi/L.
Carbon-14 = 3,200 pCi/L (proposed).
[a] Aquifer sampling tube; see notes in Table 2-1 for explanation of tube depth designation.
[b] Total dissolved chromium includes hexavalent chromium measured by COLOR_TDK_FLD method for aquifer tube sample or 6010_Metals_ICP method for monitoring well sample.
[c] Monitoring well.
NA = analyte not requested

Table 4-3. Summary of 100-D/DR Fall 2001 Contaminant Concentrations in Aquifer Tubes, Porewater Tubes, and Upgradient Monitoring Wells.

Aquifer Tube or Well Name	Date Sample Collected	Hexavalent or Total Dissolved Chromium[c] (µg/L)	Sulfate (mg/L)	Specific Conductance (µS/cm)
DD-12[a,b]	11/19/01	40	NA	255
DD-17[a,b]	11/19/01	75	NA	250
199-D8-68[d]	11/01/00	382	NA	655
199-D8-69[d]	11/19/01	112	NA	536
REDOX-2[e]	11/19/01	82	88	434
REDOX-3[b]	11/19/01	119	215	708
DD-41-3[a]	11/14/01	335	82	435
DD-42[a,b]	11/15/01	430	72	437
DD-43[a,b]	11/15/01	324	82	520
DD-44[a,b]	11/14/01	229	102	534
DD-50-3[a]	11/15/01	49	38	298
199-D4-23[d]	11/27/01	175	250	820
199-D4-38[d]	8/20/01	66	300	1,005
199-D4-39[d]	11/15/01	944	144	688

NOTES:
Hexavalent chromium Washington State ambient water quality criteria = 10 µg/L.
ISRM Project RAO = 20 µg/L.
Sulfate, secondary MCL = 250 mg/L.
[a] Aquifer sampling tube; see notes in Table 2-1 for explanation of tube depth designation.
[b] Aquifer tube sites have deteriorated so that depths of individual tubes in cluster can no longer be identified.
[c] Chromium includes hexavalent chromium measured by COLOR_TDK_FLD method for aquifer tube samples and compliance well samples or 6010_Metals_ICP method for August and November 2001 ISRM monitoring well samples.
[d] Monitoring well.
[e] Porewater (river substrate) sampling tube.
NA = analyte not requested

Table 4-4. Summary of Tritium Activity and Specific Conductance in Aquifer Tubes DD-50-3 and DD-44.

Aquifer Tube Name[a]	Date Sampled	Value Reported (pCi/L)	Total Error (pCi/L)	Specific Conductance (µS/cm)
DD-50-3	11/12/98	24,000	2,500	NA
DD-50-3	11/05/99	20,200	2,300	278
DD-50-3	11/07/00	22,100	2,300	291
DD-50-3	11/15/01	17,000		298
DD-44[b]	11/14/01	29,400	3,000	534

[a]Aquifer sampling tube; see notes in Table 2-1 for explanation of depth designation.
[b]Aquifer tube cluster deteriorated so that depths of individual tubes can no longer be identified.
NA = not available

Table 4-5. Chromium Concentrations and Specific Conductance in 100-HR-3(H) Aquifer Sampling Tubes and Compliance Wells, 1998 Through 2001.

Aquifer Tube Name	Date Sampled	Chromium Concentration (µg/L)	Specific Conductance (µS/cm)	Well Name	Date Sampled	Chromium Concentration (µg/L)	Specific Conductance (µS/cm)
46D	10/14/98	32.1	298	199-H4-64	10/14/98	87	472
47M	10/15/98	71.9	308	199-H4-63	10/14/98	111	416
4S8	10/19/98	43.4	436				
46D	10/25/99	24	236	199-H4-64	10/05/99	58	432
47M	10/25/99	20	250	199-H4-63	10/02/99	82	541
48M	10/26/99	45	473				
46D	11/02/00	27	300	199-H4-64	11/07/00	44	454
47M	NS		165	199-H4-63	11/14/00	59	456
48M	11/02/00	40	524				
46D	11/5/01	20	316	199-H4-64	11/2/01	82	419
47	NS			199-H4-63	11/6/01	74	
48S	11/6/01	25	499				

See notes in Table 2-1 for explanation of tube depth designations.
NS = not sampled

5.0 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the trends from the fall 2001 aquifer tube sample results and provides conclusions and recommendations for future activities.

5.1 CONCLUSIONS

The following conclusions are presented for the fall 2001 aquifer sample tube results.

Chromium

- Hexavalent chromium concentrations exceeded the 20 µg/L RAO in 19 of 28 tube sample analyses. The maximum concentration was 430 µg/L from aquifer tube DD-42, which is located within the 100-D/DR Area southwest chromium plume.

- Sample analyses within interim remedial measure sites are consistent with the fall 2001 chromium plume maps presented in the 100-HR-3 and 100-KR-4 calendar year 2001 annual report (to be issued).

Radionuclides

- Strontium-90, carbon-14, and tritium activities of samples collected during the fall of 2001 are consistent with existing plume maps of the interim remedial measure sites.

Anions

- Sulfate was measured at 215 mg/L in Redox-3, a porewater (river substrate) sampling tube in the river substrate. Sulfate concentrations downgradient of the ISRM are increasing both in aquifer tube and compliance monitoring wells.

Historical Hexavalent Chromium Trends (1997 Through 2001)

- 100-D/DR Southwest Chromium Plume (Hot Spot): This area is monitored by the tubes installed in 1996 with the "DD" prefix and the porewater (river substrate) tubes, Redox-1 through Redox-4. The southwest chromium plume extends from site Redox-1 upriver to site DD-50. The year-to-year concentrations have fluctuated with river stage but remain the highest of any aquifer sample tube chromium concentrations along the Columbia River. The 2001 hexavalent chromium concentrations ranged from 430 µg/L in DD-42 to 49 µg/L in DD-50. Specific conductance readings ranged from 298 µS/cm in DD-50 to 708 µS/cm in Redox-3.

There was a dramatic change in chromium concentrations between the fall of 2000 and the fall of 2001 in the Redox-3 aquifer sampling tube downgradient of the ISRM treatment zone. Chromium concentrations dropped from 521 µg/L to 119 µg/L.

- 100-D/DR Northeast Plume (Pump-and-Treat). This area is being monitored by aquifer sampling tubes DD-17 and DD-12. In addition, upgradient compliance monitoring wells 199-D8-68, 199-D8-69, and 199-D8-70 are monitoring the performance of the interim remedial measure pump-and-treat system. The chromium concentrations in both the compliance wells and aquifer sampling tubes have varied year to year with the level of the Columbia River. Chromium concentrations decreased in 2001 in the compliance monitoring wells compared to 2000.

  Chromium concentrations in samples from the DD-12 and DD17 tubes were considerably lower than concentrations in the compliance monitoring wells. Specific conductance readings were also much lower in the tube samples, suggesting mixing of river water and groundwater.

- 100-H Area OU: The chromium concentrations in samples from tubes 46, 47, and 48 have generally decreased or remained stable from 1998 through 2001. The aquifer tube chromium concentrations have stabilized at less than 50 µg/L for all the 100-H Area shoreline. Chromium concentrations in the compliance wells have ranged from 44 µg/L to 82 µg/L since the fall of 1999.

- 100-BC-5 OU: Hexavalent chromium concentrations for all three 100-BC-5 aquifer tubes sites declined from 2000 to 2001. The decrease is consistent with stable to slightly decreasing hexavalent chromium concentrations in upgradient wells 199-B3-47 and 199-B3-46.

- 100-KR-4 OU: Hexavalent chromium concentrations in samples from sites 22 and 23 are consistent with the plume map of the 100-KR-4 pump-and-treat area. These sites are downgradient of the highest concentration parts of the plume. Chromium has ranged from 56 µg/L at site 22 and to 59 µg/L at site 23.

Historical Radiological Trends (1997 Through 2000)

- Spectral Gamma

  - 100-KR-4 OU: A spectral gamma analysis was performed on a sample from site 4. All isotopes in the analytical suite were nondetects. A sample from this site had tested positive for potassium-40, a naturally occurring isotope during the fall 2000 sampling round.

- 100-BC-5 OU: Gross beta activities at sites 4 and 6 were 7.54 pCi/L and 41.3 pCi/L, respectively. These activities were very similar to the fall 2000 results. Strontium-90 was detected at 12.8 pCi/L, about one-third of the gross beta activity in the fall 2001 sample.

- Tritium

  - 100-BC-5: Aquifer tube activities are consistent with upgradient monitoring wells. Tritium has decreased from 66,000 pCi/L in 1998 to 45,000 pCi/L in 2001.

  - 100-HR-3 (100-D/DR Area): Tritium has decreased from 24,000 pCi/L in 1998 to 17,000 pCi/L in 2001.

5.2 RECOMMENDATIONS

During the planning stage of the project, numerous parties were presented with the Environmental Restoration Program's objectives for aquifer sampling tubes and were given the opportunity to suggest additional objectives. The following recommendations have evolved not only from the evaluation of data from the tubes, but also from the discussions during the planning stages of the project (Peterson et al. 1997, Appendix C).

1. Conduct an in-house planning session to focus on future uses of aquifer tube data. The original use of the data was to fill in coverage gaps along the river. Future uses may be to support performance evaluation at pump-and-treat facilities, OU monitoring, and ecological impacts. Topics to be considered at the planning session include the following:

   - Extend the tube network upriver from DD-50. This is desirable to aid in potentially delineating the upriver extent of the 100-D/DR hot spot plume (22 pCi/L isopleth) and providing control points for the tritium plume between the 100-N and 100-D/DR Areas.

   - Install tubes along the 300-FF-5 OU shoreline to monitor tritium and other radionuclides.

   - Increase the frequency of aquifer tube and porewater (river substrate) tubes sampling to quarterly, if the tubes are accessible, which would allow correlation of the results with compliance well monitoring.

   - Obtain an up-to-date salmon redd map to use with plume maps to help focus the next sampling round.

   - Collect and analyze samples from all tubes in a cluster near redds if one tube in the cluster has historic concentrations of chromium above RAOs and specific conductance greater than 200 µs/cm. These analyses will aid in evaluating vertical mixing.

2. Replace lost or destroyed tubes in critical locations, particularly those adjacent to the ISRM treatment zone.

3. Complete documentation for decommissioned tubes.

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APPENDIX A

SUMMARY OF AQUIFER SAMPLING TUBE RESULTS, 1997 THROUGH 2001

Table A-1. Summary of Aquifer Sampling Tube Results, 1997 Through 2001. (6 Pages)

Area	Site Number	Hexavalent Chromium (μg/L)					Nitrate (mg/L)					Gross Beta (pCi/L)					Tritium (pCi/L)				
		Fall					Fall					Fall					Fall				
		1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
100-B/C	01-D				5										3.78J					1120	
100-B/C	01-M	5 U					3 U					4.24					610				
100-B/C	01-S																				
100-B/C	02-S	5 U					6					2.92									
100-B/C	03-D	5 U			12		5					5.32			5.25		8,460			6,000	
100-B/C	03-M	5 U					3 U												1,960		
100-B/C	04-D	15					11														
100-B/C	04-M	11			14		11								7.48				6,510	8,930	
100-B/C	04-S	8	16.1	12		8	16	12	16			7.52		9.04		7.54	15,400	16,000	11,100		6760
100-B/C	05-D	5 U	29.3[a]				8	12					-0.091					5,300			
100-B/C	05-M	12		33[a]	39		9		18					58.3[c]	49.5				6,110	9,030	
100-B/C	05-S	5 U					4					29.7					2,150				
100-B/C	06-D	6	49.5[a]				16	43					19					66,000[d]			
100-B/C	06-M	41[a]		115[a]	47	39	32		39			41.8			48.8	41.3	47,100[d]		36,600[d]	31,300	45,000
100-B/C	06-S	5 U					25														
100-B/C	07-D	6	20.1	20	19		22	23	24			20.6	-0.046	25.9	27.4		18,000	38,000[d]	31,600[d]	19,100	
100-B/C	07-M	5 U					15														
100-B/C	07					6															6190
100-B/C	11-D	5 U		12			7					23.4					1,970				
100-B/C	12-D	5 U					32					36.2					4,320				
100-B/C	13-S	5 U					5					13.2					1,040				
100-K	14-D	5 U	4.8U			6	14	24				27					2,010	4,500			7290
100-K	14-M	5 U		6	8		14		27					67.1[c]	82.4						
100-K	14-S	5 U					7														
100-K	15-M	5 U					3 U										576				
100-K	17-D	6	8.9	6			25	23.1	15			4.86					1930	1,600			
100-K	17-M	5 U					20														
100-K	18-S	5 U	6.8	2 U			3 U	11				2.01U					38.3 U	880	68.5		
100-K	19-D	5 U			6		3 U					2.8					10.7 U			-133U	
100-K	19-M																				
100-K	21-M	42[a]	23.9[a]				3 U	0.25 U				5.73	1.6				244 U	150 U			
100-K	21-S																				
100-K	22-M	59[a]	112[a]	50[a]	95	56	4	9.84				41.8	26	4.42			95.1U	220 U	178		
100-K	23-D	81[a]	111[a]		110		3 U	5.35				3.54	-0.037				284 U	340			
100-K	23-M	5 U		76[a]			3 U														

Table A-1. Summary of Aquifer Sampling Tube Results, 1997 Through 2001. (6 Pages)

Area	Site Number	Hexavalent Chromium (µg/L)					Nitrate (mg/L)					Gross Beta (pCi/L)					Tritium (pCi/L)				
		Fall					Fall					Fall					Fall				
		1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
100-K	23					59															
100-K	DK-04-3	18					3 U														
100-K	DK-04-2	25[a]	42.8[a]				3 U	9				2.76	-0.039				5,620	11,000			
100-K	25-D	5 U	33.3[a]		5	18	3 U	8.7				3.12	-0.048				2,020	9,200			
100-K	26-D	5 U				36	3 U														
100-K	26-M	5 U			5		36					2.74					855				
100-K	26-S	5 U	4.8U				3 U	60[b]					-0.051					890			
100-D/DR	DD-50-3	22[a]	40.7[a]	34[a]	42	49	5	11.2										24,000[d]		22,100	17,000
100-D/DR	DD-50-4	29[a]					5														
100-D/DR	DD-50-2											2.24U					20,000[d]		20,200[d]		
100-D/DR	DD-50-1	23[a]					5														
100-D/DR	DD-44-4	359[a]	310[a]	330[a]	253		34	32		25.3		3.08					17,000	16,000	15,700		
100-D/DR	DD-44-3	262[a]					25														
100-D/DR	DD-44					229															29,400
100-D/DR	DD-43-3				304																
100-D/DR	DD-43					324															
100-D/DR	DD-42-4				276																
100-D/DR	DD-42					430															
100-D/DR	DD-41-3				211	335															
100-D/DR	DD-39-3	603[a]	783[a]				38	40.9				3.3					292 U	490			
100-D/DR	DD-39-2	593[a]		641[a]			38														
100-D/DR	DD-39-1																				
100-D/DR	DD-39					191															
100-D/DR	TD-39-3[e]	239[a]					17														
100-D/DR	TD-39-1[e]	184[a]					12														
100-D/DR	TD-39-2[e]				437																
ISRM	Redox 1-06[e]				420																
ISRM	Redox 2-06[e]				78	82															
ISRM	Redox 3-03[e]				521																
ISRM	Redox 3-06					119															
100-D/DR	35-M						3 U														
100-D/DR	35-S						3U														
100-D/DR	36-D	5 U					13														
100-D/DR	36-M	5 U					8														
100-D/DR	36-S	5 U	11.8	3 U			3 U	0.49				3.32	0.12				243 U	80 U			

Table A-1. Summary of Aquifer Sampling Tube Results, 1997 Through 2001. (6 Pages)

Area	Site Number	Hexavalent Chromium (μg/L)					Nitrate (mg/L)					Gross Beta (pCi/L)					Tritium (pCi/L)				
		Fall					Fall					Fall					Fall				
		1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
100-D/DR	37-S																				
100-D/DR	38-D	5 U	10.4				3 U	1.93				4.4					127 U	93 U			
100-D/DR	38-M	5 U					3 U														
100-D/DR	DD-06-3		11.6	6				6.1	3 U									1,200			
100-D/DR	DD-06-2		10.9																		
100-D/DR	DD-10-4		4.8U					1,000[b]										33			
100-D/DR	DD-12-2		89.9[b]	6				2.8										510			
100-D/DR	DD-12					40															1680
100-D/DR	DD-15-4	60[a]	87.4[a]				6 U	1,100[b]				5.95					1920	2,600			
100-D/DR	DD-15-3	34[a]					3 U														
100-D/DR	DD-15-2																				
100-D/DR	DD-17-3		216[a]	160[a]	103			24						10.5				3,200			
100-D/DR	DD-17					75															1700
100-D/DR	DD-41-4		230[a]					11.2										230			
100-D/DR	DD-42																				
100-D/DR	DD-43																				
100-D/DR	DD-49-3		31.1[a]					11.2										12,000			
100-D/DR	TD-15-2																				
100-D/DR	39-D																				
100-D/DR	39-M	5 U					3 U					5.66					170 U				
100-D/DR	39-S	5 U					3 U														
100-D/DR	40-S	5 U			5		3 U					2.76					133 U				
100-H	41-D																				
100-H	41-M																				
100-H	42-D				24																
100-H	42-M	11					10					4.36					1,610				
100-H	42-S	7					9														
100-H	42					21															
100-H	43-D	11		20	26		9		12												
100-H	43-M	12	47.5[a]				22	22.5				3.55	0.025				2,010	2,200			
100-H	44-D	25[a]		49[a]	53		44					3.59					1370				
100-H	44-M	5 U				40	41														
100-H	45-D	5 U										6.33					122 U				
100-H	45-M	5 U		3 U																	
100-H	45-S	5 U																			

Table A-1. Summary of Aquifer Sampling Tube Results, 1997 Through 2001. (6 Pages)

Area	Site Number	Hexavalent Chromium (µg/L)					Nitrate (mg/L)					Gross Beta (pCi/L)					Tritium (pCi/L)				
		Fall					Fall					Fall					Fall				
		1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
100-H	46-D	10	32.1[a]	24[a]	27	20	8	16	14			4.8	-0.13	2.23				1,000			
100-H	47-D	5 U		20			25		6			54.4[c]		21.4			391				
100-H	47-M	7	71.9[a]					23					31					1,200			
100-H	DH-22-1																				
100-H	48-M	6		45[a]	40	25	7		60[b]			6.58		7.54	6.52		1,240				
100-H	48-S	5 U	43.4[a]				7	50[b]					-0.073					3,200			
100-H	49-D	16					9					4.59					2,830				
100-H	49-M	11				37	6														
100-H	49-S		20.2	30[a]	21			14	29				-0.12	4.92				2,500			
100-H	50-M	13	27.2[a]	43[a]	46	46	9	23	55[b]	17		4.71	0.019				2,480	3,500			
100-H	50-S	11					10														
100-H	51-D	29[a]	49[a]				19	28				3.53	-0.056				3,060	3,800			
100-H	51-M	21			49	46	20														
100-H	51-S	15					3 U														
100-H	52-D	5 U					3 U					4.7					398				
100-H	52-M	5 U					3 U														
100-H	52-S	5 U					3 U														
100-H	53-M																				
100-H	53-S																				
100-H	54-D	5 U					3 U					4.56					563				
100-H	54-M	5 U					7														
100-H	54-S	5 U					7														
100-H	55-M				11																
100-H	55-S	9	11	21			9	13	21			3.4	-0.001				1,790	2,100			
100-H	57-M																				
100-H	57-S																				
100-H	58-D	5 U	6				11	12					-0.14				121 U	150 U			
100-H	58-M	5 U					11					8.13									
100-H	58-S	5 U					11														
100-H	59-D	5 U					12.7														
100-H	59-M	5 U					12.11														
100-H	59-S						14.7					7.6					-13.8 U				
100-H	60-M	5 U					3 U														
100-H	60-S	5 U					3 U					12.3					87.5 U				
100-H	DH-1451-1		8.6					25										4,300			

Table A-1. Summary of Aquifer Sampling Tube Results, 1997 Through 2001. (6 Pages)

Area	Site Number	Hexavalent Chromium (µg/L)					Nitrate (mg/L)					Gross Beta (pCi/L)					Tritium (pCi/L)				
		Fall					Fall					Fall					Fall				
		1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
100-F	61-D	5 U					3 U					3.96					125 U				
100-F	61-M																				
100-F	61-S																				
100-F	62-M	5 U	4.8U				16	13				3.96					143 U	170 U			
100-F	62-S																				
100-F	63-M	5 U					3 U														
100-F	63-S	5 U					3 U														
100-F	64-D	5 U	4.8U	8	9	10	11	16				7.7					208 U	160 U		152U	
100-F	64-M	5 U					7														
100-F	64-S	5 U					3 U														
100-F	65-M																				
100-F	65-S																				
100-F	66-D	5 U					3 U														
100-F	66-M	5 U	4.8U		5	6	3 U	7.9				4.08					96.8 U	300		81.8U	
100-F	66-S	5 U					3 U														
100-F	67-M																				
100-F	67-S	6					3 U					5.31					30.2 U				
100-F	68-D																				
100-F	68-M																				
100-F	68-S	6					3 U					2.39U					-48.6 U				
100-F	69-M	5 U					4					2.98					-23 U				
100-F	70-D																				
100-F	70-M	9					13					2.25U					140 U				
100-F	70-S	12					14														
100-F	71-D	14					19					5.81					961				
100-F	72-D	6					9					4.07					406				
100-F	72-M	5 U					12														
100-F	72-S	5 U					13														
100-F	73-D	5 U					3 U					2.51U					51.8 U				
100-F	73-M	5 U					3 U														
100-F	73-S	5 U					3 U														
100-F	74-D	9					6					4.18					434				
100-F	74-M	13					9														
100-F	74-S	8	4.8U	11			8	17	21									730			
100-F	75-D	15		16			30		54[b]			4.65					1040				

Table A-1. Summary of Aquifer Sampling Tube Results, 1997 Through 2001. (6 Pages)

Area	Site Number	Hexavalent Chromium (μg/L)					Nitrate (mg/L)					Gross Beta (pCi/L)					Tritium (pCi/L)				
		Fall					Fall					Fall					Fall				
		1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
100-F	75-M	15	11.2				30	49.3[b]										930			
100-F	75-S	10					26														
100-F	76-D	5 U					10														
100-F	76-M	5 U	29.4				12	25										1,100			
100-F	76-S	5 U					22					2.85					801				
100-F	77-D	5 U					20														
100-F	77-M	5 U					24					3.07					720				
100-F	77-S	5 U					24														
100-F	78-M	5 U					24					1.68U					-81.4 U				
100-F	78-S	5U					5														
100-F	80-D	5 U					4					3.59					140 U				
100-F	80-M																				
HANF	81-M	5 U					4														
HANF	81-S	5 U					4					4.61					43.7 U				
HANF	82-S	5 U					6					2.35U					-34.4 U				
HANF	84-D		4.8U					5.5										2,800			
HANF	84-S																				
HANF	85-D																				
HANF	85-M																				
HANF	85-S																				
HANF	86-D	5 U					8					7.05					1,260				
HANF	86-M	5 U					7														
HANF	86-S	5 U					7														

1. Values exceeding action level for hexavalent chromium or MCLs for nitrate, gross beta, and tritium are indicated as follows:
   [a] ≥ 22 μg/L hexavalent chromium
   [b] ≥ 45 mg/L nitrate
   [c] ≥ 50 pCi/L gross beta
   [d] ≥ 20,000 pCi/L tritium.

HANF = Hanford townsite
U = undetected

2. Site numbers refer to aquifer sampling tubes or porewater (river substrate) tubes at a map site. Sites with a "D, M. S" suffix refer to deep, medium, or shallow installation as part of a cluster of three tubes. Tube sites with a DD or DK prefix refer to aquifer sampling tubes in the 100-D Area or 100-K Area, respectively. The relative depth of these tubes in the cluster is designated by 1-4 with "1" the shallowest and "4" the deepest.
3. Porewater (river substrate) sampling tubes designated with an "e."
4. Tubes without a suffix sampled in 2001 denote sites where tube labels deteriorated so that individual tubes not identifiable. These sites include the following: 7, 23, 25, DD-44, DD-39, DD-12, DD-17, DD-42, DD-43, and 42.

APPENDIX B

SAMPLING AND ANALYSIS INSTRUCTION FOR THE AQUIFER SAMPLING TUBES, FALL 2001

B1.0 INTRODUCTION

Results of aquifer tube sampling are used for the following:

- Verifying the presence or absence of contaminants of concern (COCs) at locations along the Columbia River shoreline.
- Increasing knowledge of the nature, concentration, and extent of chemical and radiological indicators and the COCs in the groundwater at locations adjacent to the river.
- Increasing understanding of the vertical distribution of contamination in the aquifer adjacent to the Columbia River.
- Supporting final action decisions for interim remedial actions that are underway at the 100-H, 100-K, and 100-D Areas.
- Supporting monitoring efforts for other Hanford Site projects.

The following section provides background information about the project, a summary of the results from any previous investigations, and a list of the contaminants of concern (COCs).

B1.1 BACKGROUND

The Hanford Site became a Federal facility in 1943 when the U. S. Government took possession of the land to produce nuclear materials for defense purposes. The Hanford Site's production mission continued until the late 1980s, when the mission changed from producing nuclear materials to cleaning up the radioactive and hazardous wastes that had been generated over the previous 45 years.

Aquifer sampling tubes are small-diameter polyethylene tubes that have a screen at the lower end. The tubes are implanted into the aquifer by driving a temporary steel casing into the ground and inserting a tube into the casing. The end of each tube is fitted with a screened section that acts as the sampling port. The process is repeated at each sampling horizon. The temporary steel casing is driven by either a hydraulic ram attached to a vehicle or by a hand-carried pneumatic air hammer. The steel casing is then backpulled, leaving the tube (and the stainless-steel drive point) in place. Water is withdrawn from the tube using a peristaltic pump. The tubing exposed at the ground surface is of minimal length (several feet) and is protected from wildlife and the elements by polyvinyl chloride conduit.

B1.2 PREVIOUS INVESTIGATIONS

After completion of initial porewater studies, installation and sampling of the first 14 aquifer sampling tubes occurred in October and November 1995 along the 100-D/DR Area shoreline.

Aquifer sampling tube DD-39, located adjacent to the high hexavalent chromium (632 pCi/L) porewater sampling site, reported up to 839 pCi/L of hexavalent chromium. The result of this effort was documented by *Chromium in River Substrate Pore Water and Adjacent Groundwater: 100-D/DR Area, Hanford Site, Washington* (Hope and Peterson 1996) and led to the discovery of the chromium hot spot plume located west of the D and D/R Reactors.

Aquifer tube locations and sampling methodology were developed in a series of workshops held by Environmental Restoration Contractor (ERC) personnel with DOE/RL, the U. S. Environmental Protection Agency, the Washington Department of Health, and the Washington State Department of Ecology during July 1997 (Borghese et al. 1997). Tubes were installed and sampled at 70 of the planned 89 additional locations in September through November 1997. Each location was equipped with one to three tubes, for a total of 178 new aquifer sampling tubes. Water was withdrawn from each installed tube, and the sample with the highest specific conductivity greater than 200 µS/cm (judged to be most representative of groundwater) was selected for additional onsite and offsite analysis.

The results of this effort are presented in *Aquifer Sampling Tube Completion Report: 100 Area and Hanford Townsite Shorelines* (Peterson et al. 1998). The tubes were sampled in October through November 1998 (Lee and Raidl 2000). Highlights of the results from this sampling include elevated hexavalent chromium in the 100-K, 100-D/DR, and 100-H Areas; elevated gross beta in the 100-B/C and 100-H Areas; and elevated tritium in the 100-B/C Area.

An additional 29 tubes from the 32 planned sites were sampled in the 100-B/C, 100-K, 100-D/DR, 100-H, and 100-F Areas in the fall of 1999 (Lee and Raidl 2000) using the same screening techniques used in the 1998 sampling effort. Table B-1 lists the tube numbers, operable units, and coordinates for the existing tubes. During the fall 2000 (FY 2001) sampling event, 34 samples were collected out of the 41 sites selected (Raidl 2001).

B1.3 CONTAMINANTS OF CONCERN

Contaminants of concern for Aquifer Sampling Tubes are documented in DOE-RL (2000), *Sampling and Anaylsis Plan for Aquifer Sampling Tubes.*

B2.0 PROJECT MANAGEMENT

This section identifies the individuals or organizations participating in the project and discusses the specific roles and responsibilities of the individuals/organizations. This section also discusses the quality objectives for measurement data and discusses the special training requirements for staff performing the work.

B2.1 PROJECT/TASK ORGANIZATION

The aquifer sampling tube project will be managed through the Groundwater Project, managed by Bechtel Hanford, Inc. (BHI). The task lead is Jane Borghese, CH2M Hill Hanford, Inc. (CHI) and the CHI client services manager is Tim Lee. BHI field support services will provide field management, and the field superintendent will be Scott Strope, BHI. Samplers will be from the CHI analytical field services group managed by David St. John (Steve Marske). A plan of the day meeting will be conducted on a daily basis to discuss safety and sampling objectives, and to provide personnel accountability. Bob Raidl, CHI, will be the daily facilitator for the plan of the day meetings.

B2.2 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The required detection limits and precision and accuracy requirements for each of the analyses to be performed are summarized in Table B-1.

Table B-1. Contaminants of Concern Analytical Parameters for Aquifer Tube Samples. (2 Pages)

COCs	CAS#	MCL[c]	Name/ Analytical Technical	Target Required Quanitation Limits	Precision Water	Accuracy Water
		GW[a]		Water[b] Low Level		
Radionuclides		**pCi/L**		**pCi/L**		
Gross alpha	12587-46-1	15	GPC	3	+-20%	70-130%
Gross beta	12587-46-2	50	GPC	4	+-20%	70-130%
Carbon-14	14762-75-5	2,000	Chemical sep. - liquid scintillation	200	+-20%	70-130%
Hydrogen-3 (tritium)	10028-17-8	20,000	Tritium - liquid scintillation	400	+-20%	70-130%
Total radioactive strontium	Sr-rad	8[c]	Total radioactive strontium - GPC	2	+-20%	70-130%
Chemicals						
Anions		**mg/L**		**mg/L**		
Chloride	16887-48-8	250	Anions - 9056 - IC	0.2	d	d
Fluoride	16984-48-8	4	Anions - 9056 - IC	0.5	d	d
Nitrate (as NO_3)	14797-55-8	45	Reflectometer-MS100 and MS310	5 mg/L		
Nitrite (as NO_2)	14797-65-0	3.3	Anions - 9056 - IC	0.25	d	d
Phosphate	14265-44-2	None	Anions - 9056 - IC	0.5	d	d

Table B-1. Contaminants of Concern Analytical Parameters for Aquifer Tube Samples. (2 Pages)

COCs	CAS#	MCL[c]	Name/ Analytical Technical	Target Required Quanitation Limits	Precision Water	Accuracy Water
		GW[a]		Water[b] Low Level		
Sulfate	14808-79-8	250	Anions - 9056 - IC	0.5	d	d
Sulfide	18496-25-8	2	Sulfide - 9030	0.5	d	d
Metals (Inorganics)		**mg/L**		**mg/L**		
Chromium VI	18540-29-9	0.1	Chromium (hexavalent) - 7196 - colorimetric	0.01	d	d

[a] Unless otherwise noted, radionuclide values were calculated from National Bureau of Standard maximum permissible concentrations (in accordance with Handbook 69 [NBS 1963]); chemical values based on maximum contaminant level (40 CFR 141).
[b] Water values for sampling QC (e.g., equipment blanks or rinses) or drainable liquids (if recovered).
[c] Maximum contaminant level (40 CFR 141).
[d] Precision and accuracy requirements as defined for the referenced U.S. Environmental Protection Agency procedures.
AEA = alpha energy analysis
CAS# = Chemical Abstracts Service registry number
CFR = *Code of Federal Regulations*
GPC = gas proportional counting
GW = groundwater
IC = ion chromatography
ICPMS = inductively coupled plasma/mass spectrometry
TBD = to be determined

Selected aquifer tubes (Table B-3) will be sampled for gamma spectrometry using the RCRA groundwater list using laboratory specific methods. These analytes are included in Table B-2.

Table B-2 - Gamma Spectrometry Sampling.

Radionuclide	CAS No.	MDL (pCi/L)
Cesium-137	10045-97-3	15
Colbalt-60	10198-40-0	25
Beryllium-7	13966-02-4	50
Antimony-125	14234-35-6	50
Europium-155	14391-16-3	50
Europium-152	14683-23-9	50
Europium-154	15585-10-1	50

B2.3 SPECIAL TRAINING REQUIREMENTS

Training or certification requirements for personnel are described in BHI-HR-02, *ERC Training Procedures*, and BHI-QA-03, *ERC Quality Assurance Program Plans*, Procedure Nos. 5.1, 5.2, and 5.3. Field personnel shall have completed the following mandatory training before starting work:

- Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker Training
- Radiation Worker Training
- Hanford General Employee Training.

Training will be required for field screening instruments and onsite analytical equipment including BHI-EE-05 procedures as follows:

- Procedure 1.9, "Field Immunoassay Test Kits"
- Procedure 1.12, "Determination of Nitrate in Water by a Reflectometry-Based Instrument"
- Procedure 1.17, "Determination of Hexavalent Chromium in Water, Wastewater, and Soils Utilizing the HachDR/2000 and DR/2010 Spectrophotometers."

B3.0 MEASUREMENT/DATA ACQUISITION

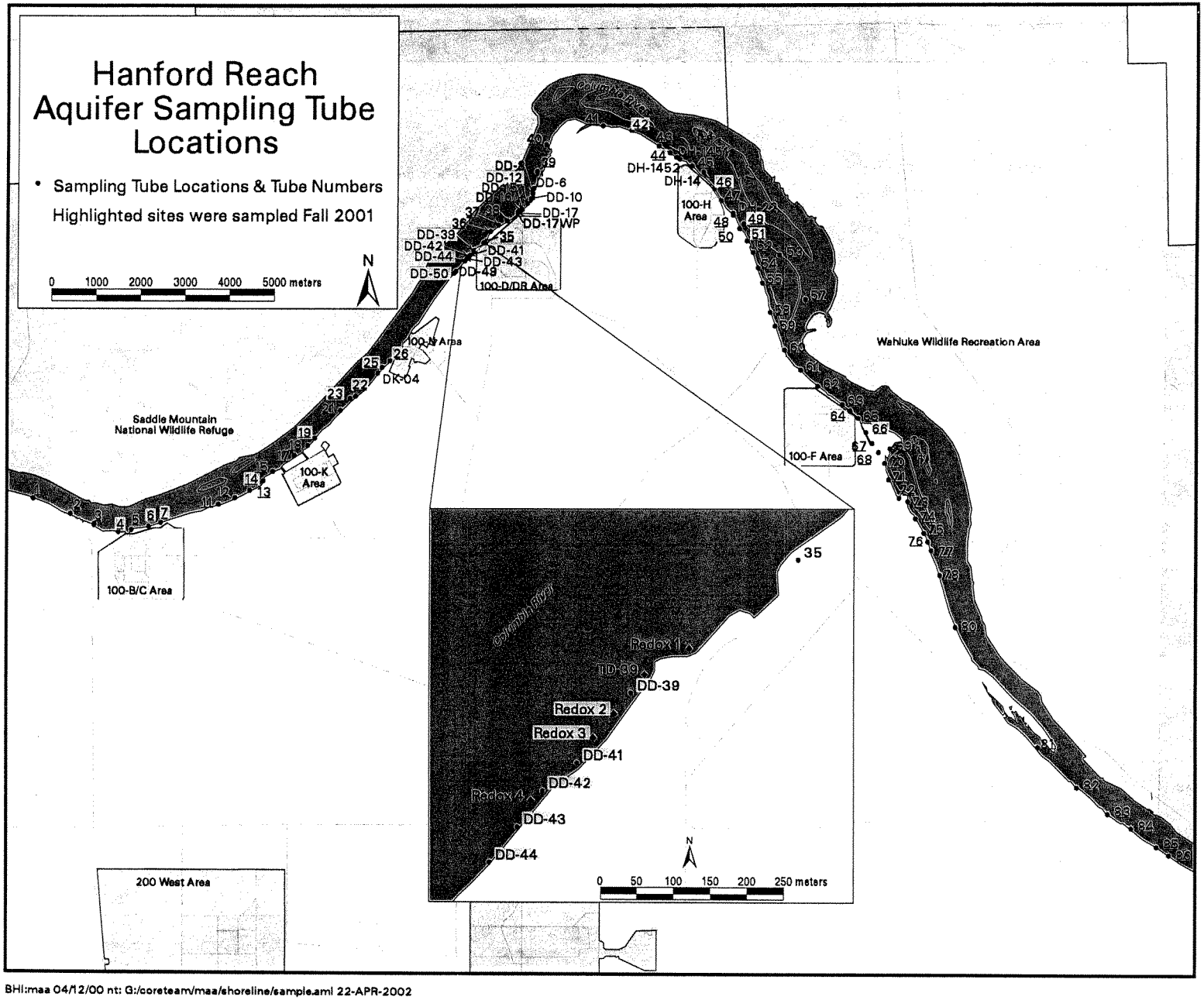
This section presents the sampling process design and the requirements for sampling methods, sample handling, custody, preservation, containers, and holding times. This section also addresses the requirements for field and laboratory quality control (QC), instrument calibration and maintenance, and field documentation.

B3.1 SAMPLING PROCESS DESIGN

Aquifer sampling tube sites, as shown in Figure B-1, were selected for the Fall 2000 sampling round based on meeting one or more of the following criteria:

- A contaminant identified previously in a sample collected from the tube was present in concentrations above MCLs or the pump and treat action level for hexavalent chromium (20 μg/L)
- The aquifer tube site is adjacent to an active surface source remediation that could impact downgradient water quality
- The aquifer tube site would provide coverage to fill in gaps between groundwater monitoring wells
- The aquifer tube site would provide a background sample.

Figure B-1. Northern Portion of the Hanford Site and Aquifer Sampling Tube Sites.



BHI:maa 04/12/00 nt: G:/coreteam/maa/shoreline/sample.aml 22-APR-2002

Samples will be collected from aquifer tube sites as close as possible to the date that nearby CERCLA groundwater monitoring wells are sampled.

Site selection was discussed with the Department of Ecology and with EPA on October 22 and 25, 2001. Sites and analyses were selected based on historical results and proximity to existing plumes.

Table B-3. Sampling Locations and Required Analytes.[a] (2 Pages)

Tube No.[b]	Hexavalent Chromium	Dissolved Oxygen	Sulfate	Gross Beta	Spectral Gamma	Strontium 90	Tritium	Carbon-14
100-BC-5								
1M/S	X						X	
2S[c]	X						X	
04/S/M/D[c]	X						X	
05-S/M/D	X			X		X	X	
06-S/M/D	X			X		X	X	
07-M/D	X						X	
100-KR-4								
14-S/M/D	X				X		X	
15M[c]	X				X		X	
17-M/D	X						X	
18S	X						X	
19-M/D	X					X	X	X
21-S/M	X					X	X	X
22-M/D	X							
23-M/D	X							
25D	X							
26-S/M/D	X							
100 D/DR								
DD-50-2	X		X				X	
DD-44-4	X		X				X	
DD-39-3	X							
39-S/M								
40S								
41-M/D								
DD-12-2	X						X	

Table B-3. Sampling Locations and Required Analytes.[a] (2 Pages)

Tube No.[b]	Hexavalent Chromium	Dissolved Oxygen	Sulfate	Gross Beta	Spectral Gamma	Strontium 90	Tritium	Carbon-14
DD-17-3	X						X	
DD-41	X		X					
DD-42	X		X					
DD-43	X		X					
ISRM Porewater Tubes[d]								
Redox-1	X	X	X					
Redox-2	X	X	X					
Redox-3	X	X	X					
Redox-4	X	X	X					
100-H								
42-S/M	X							
43-M/D	X							
44-M/D	X							
46-D	X							
47-M/D[c]	X							
48-S/M	X							
49-S/M/D	X							
50-S/M	X							
51-S/M/D[c]	X							
52-S/M/D								
100-FR-3								
64-D	X							
65-S/M	X							
66-S/M/D	X							

[a] Analyte priority as follows: hexavalent chromium, strontium-90, gross beta, spectral gamma, carbon-14, tritium, sulfate, nitrate.
[b] All tubes in cluster will be sampled, highest conductivity will be saved for analysis.
[c] Sampling conditional based on success in adjacent tube sites or tube survival.
[d] A riverwater sample will be collected near a REDOX porewater tube, filtered and analyzed for ICP metals and anions.
D = deep
M = mid depth
S = shallow

B3.2 SAMPLING METHODS REQUIREMENTS

Samples will be collected using a peristaltic pump. Analyte suite, QC samples, and analytical method requirements (specified in Table B-3) will dictate sample volumes. Final sample volumes and containers are specified in the SAF.

The aquifer tube sampling procedure is described below:

1. Confirm that selected tubes remain.
2. Re-label, if necessary.
3. Collect a water sample from each tube, measuring specific conductance.
4. If highest specific conductance is >200 µS/cm, continue with sampling.
5. Measure field parameters (i.e., temperature, pH, specific conductance, turbidity, and dissolved oxygen).
6. Collect samples in accordance with the analyte list for the tube site as specified in Table B-3.
7. If the tube with highest specific conductance does not produce an adequate amount of water for sampling, proceed to tube with next highest specific conductance and attempt to collect samples.
8. If none of the tubes at a site produces an adequate amount of water for sampling, proceed to an alternate site and collect samples in accordance with the priorities specified in Table B-3 for the primary site.
9. Measure conductivity (field parameter) of river water.
10. After sampling is completed, measure field parameters as specified in #5.
11. Document all measurements and field sampling observations in a field logbook in accordance with BHI-EE-01, Procedure 1.5, "Field Logbooks."
12. Place tubes back into the PVC, if winterized, recap, re-flag, and prepare a site map that will assist future sampling efforts to locate aquifer tubes.
13. Move to the next site.

The ERC will perform field screening analysis in accordance with BHI-EE-01 and BHI-EE-05. Selected field methods include the following:

- Procedure 1.12, "Determination of Nitrate in Water by a Reflectometry Based Instrument"

- Procedure 1.17, "Determination of Hexavalent Chromium in Water, Wastewater, and Soils Utilizing the HachDR/2000 and DR/2010 Spectrophotometers"

In addition to field screening procedures outlined in DOE-RL (2000), selected samples (Table B-3) will be field screened for sulfate using the manufacturer's procedures for determination for sulfate in water and wastewater utilizing the HachDR/2000 and DR/2010 spectrophotmeters.

Field pH, conductivity, turbidity, dissolved oxygen, and temperature measurements will be performed in accordance with the manufacturer's instructions for the instrument.

B3.3 SAMPLE HANDLING, SHIPPING, AND CUSTODY REQUIREMENTS

All sample handling, shipping and custody should be performed in accordance with BHI-EE-01, Procedure 3.1, "Sample Packaging and Shipping"; Procedure 3.0, "Chain of Custody"; and Procedure 4.2, "Sample Storage and Shipping Facility."

B3.4 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIMES

The sample preservation, container, and holding-time requirements for the offsite analyses to be performed are summarized in Table B-4.

Table B-4. Holding Times, Volume Requirements, and Containers for Potential Groundwater Analyses. (2 Pages)

Lab Code	Class	Method Name	Holding Time	Bottle Type	No. Bottles	Volume	Units
Radionuclides							
STLRL	RAD	906.0_H3_LSC	6 months	P	1	1,000	mL
TMA	RAD	906.0_H3_LSC	6 months	P	1	1,000	mL
STLRL	RAD	ALPHA_GPC	6 months	G/P	1	600	mL
STLRL	RAD	ALPHA_GPC	6 months	G/P	1	1,000	mL
TMA	RAD	ALPHA_GPC	6 months	G/P	2	1,000	mL
WSCF	RAD	ALPHA_GPC	6 months	G/P	1	1,000	mL
STLRL	RAD	BETA_GPC	6 months	G/P	1	600	mL
STLRL	RAD	BETA_GPC	6 months	G/P	1	1,000	mL
TMA	RAD	BETA_GPC	6 months	G/P	2	1,000	mL
WSCF	RAD	BETA_GPC	6 months	G/P	1	1,000	mL
STLRL	RAD	C14_LSC	6 months	G/P	1	1,500	mL
TMA	RAD	C14_LSC	6 months	G/P	1	1,000	mL
222-S	RAD	GAMMA_GS	6 months	G/P	1	1,000	mL
STLRL	RAD	GAMMA_GS	6 months	G/P	1	2,250	mL
TMA	RAD	GAMMA_GS	6 months	G/P	1	1,000	mL
WSCF	RAD	GAMMA_GS	6 months	G/P	1	1,000	mL
222-S	RAD	SRTOT_SEP_PRECIP_GPC	6 months	G/P	1	1,000	mL
STLRL	RAD	SRTOT_SEP_PRECIP_GPC	6 months	G/P	3	1,000	mL
TMA	RAD	SRTOT_SEP_PRECIP_GPC	6 months	G/P	2	1,000	mL
WSCF	RAD	SRTOT_SEP_PRECIP_GPC	6 months	G/P	1	1,000	mL
222-S	RAD	GAMMA_GS WATER		G/P	1	100	g
222-S	RAD	GAMMA_GS WATER	6 months	G/P	1	1,000	mL

Table B-4. Holding Times, Volume Requirements, and Containers for Potential Groundwater Analyses. (2 Pages)

Lab Code	Class	Method Name	Holding Time	Bottle Type	No. Bottles	Volume	Units
STLRL	RAD	GAMMA_GS WATER	6 months	G/P	1	1,500	G
STLRL	RAD	GAMMA_GS WATER	6 months	G/P	1	2,250	mL
TMA	RAD	GAMMA_GS WATER	6 months	G/P	1	1,000	mL
TMA	RAD	GAMMA_GS WATER	6 months	G/P	1	1,500	g
WSCF	RAD	GAMMA_GS WATER	6 months	G/P	1	100	g
WSCF	RAD	GAMMA_GS WATER	6 months	G/P	1	1,000	mL

Specific field analyses requirements include the following:

- Chrome 6-Hach: If water samples cannot be analyzed within 4 hours, samples should be stored at 4°C (±2°C) for up to 24 hours. All water samples shall be analyzed within 24 hours of sample collection.

- Nitrate: The nitrate test should be performed as soon as possible (no later than 24 hours) after samples are collected.

- Sulfate: According to the manufacturer's procedures for determination for sulfate in water and wastewater utilizing the HachDR/2000 and DR/2010 spectrophotometers.

B3.5 QUALITY CONTROL REQUIREMENTS

The minimum number of QC samples required for the analytical laboratory are to be conducted in accordance with established laboratory contracts and are summarized below:

- One laboratory method blank for every 20 samples (5% of all samples), analytical batch, or sample delivery group (whichever is most frequent) will be carried through the complete sample preparation and analytical procedure. The method blank will be used to document contamination resulting from the analytical process.

- A matrix spike sample will be prepared and analyzed for every 20 samples (as applicable to the method used) of the same matrix or sample preparation batch, whichever is most frequent. The matrix spike results are used to document the bias of an analytical process in a given matrix.

- Laboratory duplicates or matrix spike duplicates will be used to assess precision and will be analyzed at the same frequency as the matrix spikes.

The field QC sample requirements are as follows:

- Field duplicate samples will be collected at a minimum frequency of 1 per 20 samples. Field duplicates are analyzed independently and provide information concerning the homogeneity of the matrix, as well as an evaluation of the precision of the sampling and analysis process.

- Split samples will be collected at a minimum frequency of 1 per 20 samples. Field split samples are two uniquely numbered samples produced through homogenizing a field sample and separating laboratories for independent analysis, generally for the purpose of auditing the performance of the primary laboratory relative to a particular sample matrix and analytical method. Split samples may also be collected by regulatory agencies at any time deemed appropriate by the agencies.

B3.6 INSTRUMENT CALIBRATION AND MAINTENANCE

All field screening and analytical instruments shall be calibrated and maintained in accordance with BHI-QA-03, Plan No. 5.2, "Onsite Measurements Quality Assurance Program." The results from all instrument calibration and maintenance activities shall be recorded in a bound logbook in accordance with procedures outlined in BHI-EE-01, Procedure 1.5, "Field Logbooks." Tags will be attached to all field screening and onsite analytical instruments noting the date when the instrument was last calibrated and the calibration expiration date.

B3.7 FIELD DOCUMENTATION

Field documentation shall be kept in accordance with BHI-EE-01, *Environmental Investigation Procedures*, including the following procedures:

- Procedure 1.5, "Field Logbooks"
- Procedure 1.13, "Environmental Site Identification and Information Reporting"
- Procedure 3.0, "Chain of Custody"

B4.0 ASSESSMENTS AND RESPONSE ACTION

The Compliance and Quality Programs group may conduct random surveillance and assessments in accordance with BHI-MA-02, *ERC Project Procedures*, Procedure 5.3, "Self-Assessments," to verify compliance with the requirements outlined in this SAI, project work packages, the BHI quality management plan, BHI procedures, and regulatory requirements.

Deficiencies identified by one of these assessments shall be reported in accordance with BHI-MA-02, Procedure 5.3, "Self-Assessments." When appropriate, corrective actions will be taken by the Project Engineer in accordance with the *Hanford Analytical Services Quality*

Assurance Requirements Document (HASQARD), Vol. 1, Section 4.0 (DOE-RL 1996a), to minimize recurrence.

B5.0 DATA VERIFICATION AND VALIDATION

Data verification and validation are not required by this project. Other programs for aquifer tube samples (e.g., In Situ Redox Manipulation compliance sampling) may require project-specific data validation and verification. In those cases, verification and validation will be carried out using program-specific data validation procedures.

B6.0 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Waste, including purgewater, generated by sampling activities will be managed in accordance with existing regulator-approved waste management plans or waste control plans. For the aquifer sampling tubes, the approved plans are as follows:

- *Interim Action Waste Management Plan for the 100 HR-3 and 100-KR-4 Operable Units* (DOE-RL 1997)
- *100-BC-5 Operable Unit Waste Control Plan* (Woolard 2000a)
- *100-FR-3 Operable Unit Waste Control Plan* (Woolard 2000b)

B7.0 HEALTH AND SAFETY

All field operations will be performed in accordance with BHI health and safety requirements, which are outlined in BHI-SH-01, *ERC Safety and Health Program*, and the requirements of the *Hanford Site Radiological Control Manual* (HSRCM) (DOE-RL 1996b). In addition, a work control package will be prepared in accordance with BHI-MA-02, which will further control site operations. The work control package will include an activity hazard analysis, site-specific health and safety plan, and applicable radiological work permits.

The sampling procedures and associated activities will consider exposure reduction and contamination control techniques that will minimize the radiation exposure to the sampling team as required by BHI-SH-01, *Hanford ERC Safety and Health Program*, and BHI-QA-01, *ERC Quality Program.*

B8.0 REFERENCES

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

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

BHI-EE-05, *Field Screening Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-HR-02, *ERC Training Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-MA-02, *ERC Project Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-01, *ERC Quality Program*, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-03, *ERC Quality Assurance Program Plans*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-01, *ERC Safety and Health Program*, Bechtel Hanford, Inc., Richland, Washington.

Borghese, J. V., R. E. Peterson, and K. M. Singleton, 1997, *Description of Work for Installing Aquifer Sampling Tubes Along the 100 Area and Hanford Townsite Shorelines*, BHI-01090, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1996a, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), DOE/RL-96-68, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996b, *Hanford Site Radiological Control Manual* (HSRCM), DOE/RL-96-109, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units,* DOE-RL-97-01, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Hope, S. J., and R. E. Peterson, 1996, *Chromium in River Substrate Pore Water and Adjacent Groundwater: 100-D/DR Area, Hanford Site, Washington*, BHI-00778, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

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NBS, 1963, *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure*, NBS Handbook 69, as amended, U.S. Department of Commerce, Washington, D.C.

Peterson, R. E., J. V. Borghese, and D. B. Erb, 1998, *Aquifer Sampling Tube Completion Report: 100 Area and Hanford Townsite Shoreline*, BHI-01153, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Raidl, R. F., 2000, *Aquifer Sampling Tubes Data Summary*, BHI-01494, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Woolard, J. G., 2000a, *100-BC-5 Operable Unit Waste Control Plan*, CCN 0518024, Bechtel Hanford, Inc., Richland, Washington.

Woolard, J. G., 2000b, *100-FR-3 Operable Unit Waste Control Plan*, CCN 0518025, Bechtel Hanford, Inc., Richland, Washington.

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