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Revision 1

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100-FR-3 Operable Unit Sampling and Analysis Plan

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Pacific Northwest National Laboratory for the
U.S. Department of Energy under Contract DE-AC06-76RL01830

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Summary

The 100-FR-3 Operable Unit comprises the groundwater beneath the 100-F Area of the Hanford Site. The 100-F Area housed one of the nine nuclear reactors on the Hanford Site involved in the production of plutonium.

This document describes groundwater sampling and analysis requirements for the 100-FR-3 Operable Unit. It specifies wells, aquifer sampling tubes, and shoreline springs to be monitored, constituents to be analyzed, and frequency of sampling. This monitoring plan differs from the previous plan slightly in the wells and constituents monitored. The changes were based on evaluation of data collected under previous monitoring plans.

The 100-FR-3 Operable Unit includes the groundwater beneath the 100-F Area and adjacent regions into which groundwater affected by operations in the 100-F Area may have migrated, including the Columbia River shoreline. The groundwater in the 100-FR-3 Operable Unit has been affected by past-practice discharge of liquid effluents to waste disposal facilities such as trenches, cribs, and retention basins. The groundwater operable unit does not include the waste disposal facilities and underlying vadose zone, which are associated with source operable units.

The Groundwater Performance Assessment Project (groundwater project) has defined a series of "groundwater interest areas" within the Hanford Site for purposes of (a) interpreting all groundwater data that may relate to an operable unit, and (b) scheduling and sampling wells efficiently. Consequently, this sampling and analysis plan addresses an area larger than the operable unit, termed the 100-FR-3 groundwater interest area. The interest area extends upgradient (west) of the 100-FR-3 Operable Unit, where it abuts the 100-NR-2, 100-KR-4, and 200-BP-5 groundwater interest areas. The 100-FR-3 groundwater interest area abuts the 200-PO-1 groundwater interest area to the southeast.

Thirty-four wells will be sampled annually or biennially. Nineteen aquifer sampling tube sites and three shoreline springs will be sampled annually in the fall. Contaminants of concern are hexavalent chromium, nitrate, strontium-90, trichloroethene, tritium, and uranium (gross alpha will be analyzed as an indicator of uranium). Selected samples also will be analyzed for additional constituents, including anions, metals, gross beta, and field parameters.

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1.0 Introduction

The 100-FR-3 Operable Unit comprises the groundwater beneath the 100-F Area of the Hanford Site. The 100-F Area housed one of the nine nuclear reactors on the Hanford Site involved in the production of plutonium. Unlike the other reactor areas, the 100-F Area also contained an experimental biological research station.

Groundwater monitoring at 100-F Area began during reactor operations and focused on relatively few chemical and radiological constituents. Groundwater monitoring continued in the early 1990s under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA; 40 CFR 300 Subpart E). More monitoring wells were installed as part of the Limited Field Investigations (DOE 1994 and 1996) to determine the nature and extent of contamination in groundwater.

The objective of this sampling and analysis plan is to bridge the gap between data obtained from earlier investigations and the information required to support remedial action decisions (e.g., groundwater data may be input to risk assessment models). This revision refines the monitoring network (wells and aquifer sampling tubes), constituents, and schedule based on results of data collected under previous plans. As in the previous plan, this document describes an integrated monitoring program that meet the objectives of CERCLA and the *Atomic Energy Act of 1954* (AEA). However, AEA information is provided for completeness and to fully integrate monitoring. Monitoring for contaminants under the AEA is implemented under DOE Order 450.1.

The 100-FR-3 Operable Unit includes the groundwater beneath the 100-F Area and adjacent regions into which groundwater affected by operations in the 100-F Area may have migrated, including the Columbia River shoreline. The groundwater in the 100-FR-3 Operable Unit has been affected by past-practice discharge of liquid effluents to waste disposal facilities such as trenches, cribs, and retention basins. The groundwater operable unit does not include the waste disposal facilities and underlying vadose zone, which are associated with source operable units.

The Groundwater Performance Assessment Project (groundwater project) has defined a series of "groundwater interest areas" (Figure 1) within the Hanford Site for purposes of (a) interpreting all groundwater data that may relate to an operable unit, and (b) scheduling and sampling wells efficiently. Consequently, this sampling and analysis plan addresses an area larger than the operable unit, termed the 100-FR-3 groundwater interest area. The interest area extends upgradient (west) of the 100-FR-3 Operable Unit, where it abuts the 100-NR-2, 100-KR-4, and 200-BP-5 groundwater interest areas. The 100-FR-3 groundwater interest area abuts the 200-PO-1 groundwater interest area to the southeast.

1.1 Background

Waste disposal and leakage from retention basins contaminated the vadose zone and groundwater in the 100-F Area during the operational lifespan of F Reactor (1945-1965). The operational history of the 100-F Reactor and its associated liquid and solid waste disposal sites, is presented in the *100-F Reactor*

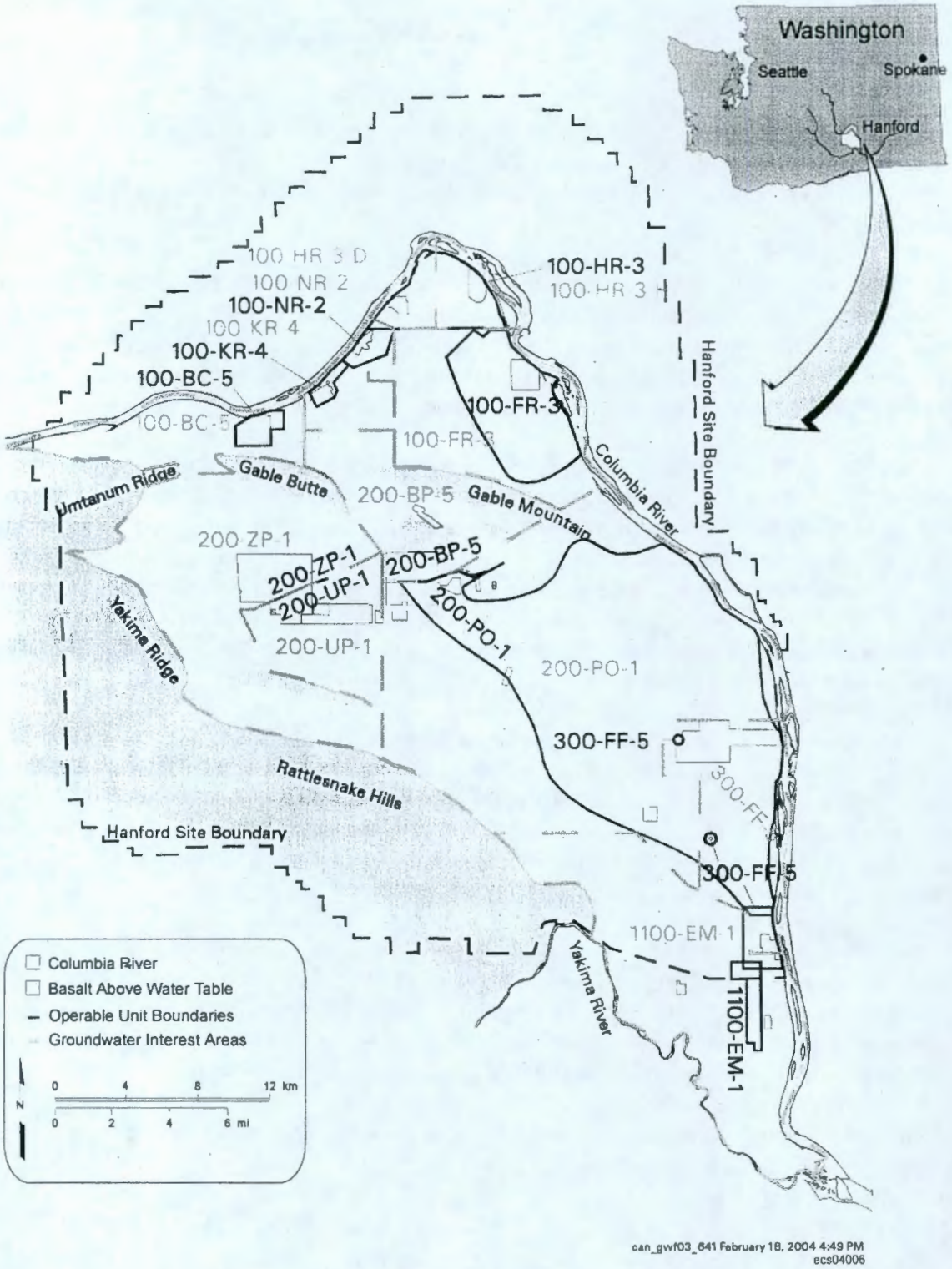

Figure 1. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site

Site Technical Baseline Report Including Operable Units 100-FR-1 and 100-FR-2 (Deford 1993). Waste stream categories identified in the *Remedial Investigation/Feasibility Work Plan for the 100-FR-3 Operable Unit, Hanford Site, Richland, Washington* (DOE 1992) include the following:

- Reactor process liquid waste and cooling water effluent
- Radioactive sludge/solid waste
- Reactor ventilation systems and inert gas system waste
- Animal research operations waste
- Sanitary liquid waste
- Non-radioactive liquid waste
- Non-radioactive solid waste

The single-pass design of the cooling system used in the F Reactor meant that treated Columbia River water passed through the reactor, into large retention basins for a short period, and was then discharged to the river via outfall pipes and spillways. Used coolant was held in the retention basins for several hours to allow the temperature to decrease and for short-lived radionuclides to decay, thus reducing negative impacts to the river's ecosystem. Occasional fuel element ruptures in the reactor would cause the coolant to become highly contaminated with long-lived radionuclides. When this occurred, the used coolant was diverted to a liquid waste disposal trench for infiltration into the soil column, rather than being discharged directly to the river. The timing of liquid discharges to ground was often based on the type of discharge. Condensate from process systems and septic systems, for example, were generally discharged on a continuous basis, whereas discharges from highly radioactive sources were sporadic and often followed an event such as the rupture of fuel cladding in the reactor.

Surface and sub-surface disposal facilities that were associated with the operations at 100-F Area contributed to groundwater contamination. Many of these structures and their ancillary systems have been demolished, and many waste sites have been excavated to remove the contaminated sediment down to ~5 meters depth. The Tri-Party Agreement (Ecology et al. 1989) listed 30 individual sources aggregated into two source operable units (100-FR-1 and 100-FR-2). Other than the 105-F reactor building itself, several specific categories of waste sites are listed in the *100-F Reactor Site Technical Baseline Report Including Operable Units 100-FR-1 and 100-FR-2* (Deford 1993) and the *Remedial Investigation/ Feasibility Work Plan for the 100-FR-3 Operable Unit, Hanford Site, Richland, Washington* (DOE 1992).

- Retention basin area, including the 116-F-14 retention basin, the 116-F-2 overflow trench, and other areas associated with the control of cooling water from the retention basin.

- Cribs and trenches used to dispose of liquid waste associated with operation of the F Reactor. These include the 116-F-1 trench, 116-F-3 fuel storage basin trench, 116-F-4 pluto crib, 116-F-5 ball washer crib, and the 116-F-6 liquid waste trench.

- Trenches and burial areas used for disposal of liquid and solid waste associated with the animal research laboratories, which includes the 116-F-9 animal waste leach trench.

The cribs, trenches, and leaking retention basins allowed radioactive and chemical contaminants to flow through the vadose zone and reach groundwater. After the reactors were shut down, some of the waste sites continued to provide a source of groundwater contamination as less-mobile constituents migrated slowly through the vadose zone to reach groundwater. Recharge from natural precipitation and the effects of bank storage from the Columbia River alter the concentration of contaminants entering groundwater.

1.2 Contaminants of Concern

Contaminants of concern for the 100-FR-3 Operable Unit are hexavalent chromium, nitrate, strontium-90, trichloroethene, tritium, and uranium. These contaminants were identified using information from the *Limited Field Investigation for the 100-FR-3 Operable Unit* (DOE 1994) and groundwater sampling results, as described in the data quality objectives report (Sweeney and Chou 2003) and the previous version of this sampling and analysis plan (DOE 2003). Gross alpha activity, which is monitored as an indicator of uranium, has been below the 15 pCi/L drinking water standard in recent years but has increased in some wells and will continue to be monitored. Hexavalent chromium concentrations have remained below the 100 μg/L drinking water standards in recent years, but is highly variable in some wells so it is retained as a contaminant of concern. Additional constituents are monitored as supporting parameters. Section 2.3 presents details of constituent lists at each monitoring location.

1.3 Data Quality Objectives

In 2003, PNNL conducted a data quality objectives planning process for the 100-BC-5 and 100-FR-3 Operable Units, following *Guidance for the Data Quality Objectives Process* (EPA/600/R-96/055 (QA/G-4), EPA 2000, as revised). The results of that process were documented in *Data Quality Objectives Summary Report – Designing a Groundwater Monitoring and Assessment Network for the 100-BC-5 and 100-FR-3 Operable Units* (Sweeney and Chou 2003). As described in Sweeney and Chou (2003), the data quality objectives process for the 100-BC-5 and 100-FR-3 Operable Units established a framework to answer the following questions:

- Are representative samples of an aquifer with a fluctuating water-table elevation being obtained?
- Are the constituents monitored necessary and sufficient?
- Is the monitoring network adequate for purposes of tracking constituents that have potential human and other ecosystem impacts?
- Does the sampling frequency need to be revised for tracking plume movement?

The result of the data quality objectives process for the 100-FR-3 Operable Unit provided the basis for the monitoring network and design.

1.4 Changes from the Previous Plan

This document revises the previous sampling and analysis plan (DOE 2003) published in September 2003. While the overall approach to monitoring remains the same, sampling frequency and constituents have been modified in some wells to reflect data collected and evaluated after publication of the first plan. For example, if concentration trends of contaminants of concern were low and steady or declining, the sampling frequency was reduced from annual to biennial. Details and justification for the changes are given in Appendix A. Before September 2003, groundwater sampling in the 100-FR-3 Operable Unit was defined in Tri-Party Agreement Change Control Forms (Table 1).

Table 1. Monitoring Documents for the 100-FR-3 Operable Units

Monitoring Document (listed in order of most to least recent)	Comments
100-FR-3 Operable Unit Sampling and Analysis Plan (DOE 2003; this document)	Update to Rev. 0.
100-FR-3 Operable Unit Sampling and Analysis Plan (DOE 2003, 9/2003)	Superceded previous monitoring documents; implemented results of data quality objectives process.
Groundwater Sampling and Analysis Plan for the 100-FR-3 Operable Unit (Sweeney, 9/2000)	Same monitoring program specified in M-15-01-06 and -07.
Federal Facility Agreement and Consent Order Change Control Form M-15-01-07 (12/13/2001)	Duplicate of M-15-01-06 (filing error)
Federal Facility Agreement and Consent Order Change Control Form M-15-01-06 (12/13/01)	Eliminated requirement for quarterly sampling in one well and removed a dry well.
Federal Facility Agreement and Consent Order Change Control Form M-15-99-02 (7/14/1999)	Removed wells that had been decommissioned due to surface remediation work; other changes based on field conditions and previous results.
Federal Facility Agreement and Consent Order Change Control Form M-15-96-06 (7/31/1996)	Reduced frequency of sampling in many wells.
100 NPL Agreement/Change Control Form 39 (11/18/1992)	Initial 100-FR-3 monitoring network, using newly-installed wells.

The previous plan proposed the installation of aquifer sampling tubes (aquifer tubes) at four locations to supplement the existing aquifer tube network along the Columbia River shoreline. The new aquifer tubes were installed as planned. This revised plan includes monitoring aquifer tubes at a total of 19 locations along the shoreline of the 100-FR-3 groundwater interest area.

The previous plan called for vertical sampling of wells 199-F5-3 and 199-F5-6 with a special sampling assembly to assess the distribution of contaminants with depth. Well 199-F5-3 no longer produces enough water to sample reliably and was dropped from the monitoring network in fiscal year 2004. At the time of preparation of this plan, vertical sampling work in well 199-F5-6 had not been completed, but was still planned. If results show significant vertical variability that warrants special sampling techniques (e.g., sampling from a specific hydrogeologic horizon), this sampling and analysis plan will be revised.

Contaminant concentrations in aquifer tubes are generally highest in mid or deep-level tubes because the shallow tubes are more heavily diluted by river water. Strontium-90, however, generally is detected at lower concentrations in the deep tubes than in shallow or mid-level tubes in the 100-F Area because it is less mobile than other contaminants and stays near the top of the aquifer. For this reason, samples for strontium-90 analysis are collected from multiple depths at selected aquifer tube locations.

2.0 Field Sampling Plan

This section lists the wells, aquifer tubes, and shoreline springs to be monitored, and the sampling frequency and constituents. Protocol for sampling, analysis, and related activities are summarized.

2.1 Sampling Objectives

The primary objective of groundwater monitoring in the 100-FR-3 Operable Unit is to provide information on the concentration and flux of the contaminants of concern to the Columbia River through the aquifer. Secondary objectives are (a) to define the extent of contamination in the aquifer, (b) track concentration trends near former waste sites, and (c) provide information on groundwater quality and flow in the larger 100-FR-3 groundwater interest area.

2.2 Sampling Locations and Frequency

The 100-FR-3 monitoring network is designed to focus on the portion of the aquifer that discharges to the Columbia River, as monitored by the aquifer tubes. Monitoring wells farther inland provide data on contaminant concentrations closer to their sources. The groundwater wells, springs, and aquifer tubes to be sampled in support of the 100-FR-3 Operable Unit are listed in Table 2, and are shown in Figures 2 and 3. The table also includes constituents to be monitored and frequency of sampling, which ranges from annual to biennial. Samples are to be collected in accordance with the procedures described in Section 2.4.

Appendix A notes where the current wells or sampling frequency have changed from the previous sampling and analysis plan, and provides rationale for those changes. Groundwater project staff developed the sampling matrix in conjunction with the U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA).

A typical aquifer tube site includes three tubes monitoring different depths: one just beneath the low river stage water table; a second near the bottom of the uppermost hydrologic unit; and the third at mid-depth between the other two ports. Field conditions may result in more or fewer tubes at a particular location. Specific conductance will be measured at each aquifer tube listed in Table 2. At each site, additional samples will be collected from the tube that is most representative of groundwater (generally

Table 2. Groundwater Sampling Matrix for the 100-FR-3 Operable Unit

Well ID	Well, Aquifer Tube, or Spring Name	Status	WAC Compliant	Contaminants of Concern								Supporting Constituents						
				Chromium (hexavalent filtered)	Chromium (total, filtered)	Gross Alpha (indicates uranium)	Nitrate	Strontium-90	Trichloroethene	Tritium	Uranium (total)	Specific Conductance[a]	Temperature (a)	Turbidity[a]	Water Level[a]	Alkalinity	Anions[b]	Metals (filtered)[c]
Wells																		
A4586	199-F1-2	Active	C		BO		BO					BO	BO	BO	BO	BO	BO	BO
A4587	199-F5-1	Active	N		A	BE	A	BE		BE		A	A	A	A	A	A	A
A4590	199-F5-4	Active	N		A	BO	A		BO	BO		A	A	A	A	A	A	A
A4600	199-F5-6	Active	N		A	BE	A	BE		BE		A	A	A	A	A	A	A
A4591	199-F5-42	Active	C		BO	BO	BO	BO		BO		BO	BO	BO	BO	BO	BO	BO
A4592	199-F5-43A	Active	C		BE	BE	BE	BE		BE		BE	BE	BE	BE	BE	BE	BE
A4593	199-F5-43B	Active	C		BE	BE	BE	BE				BE	BE	BE	BE	BE	BE	BE
A4594	199-F5-44	Active	C		BE	BE	BE	BE		BE		BE	BE	BE	BE	BE	BE	BE
A4595	199-F5-45	Active	C		BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO	BO
A4596	199-F5-46	Active	C		BE	A	BE	BE	BE	A	A	A	A	A	A	BE	BE	BE
A4597	199-F5-47	Active	C		A	BE	A			A	A	A	A	A	A	A	A	A
A4598	199-F5-48	Active	C		BO	BO	BO			BO	BO	BO	BO	BO	BO	BO	BO	BO
A4602	199-F6-1	Active	C		BO	BO	BO	BO		BO		BO	BO	BO	BO	BO	BO	BO
A4603	199-F7-1	Active	N		BE		BE		BE			BE	BE	BE	BE	BE	BE	BE
A4604	199-F7-2	Active	C		BE	BE	BE		BE	BE		BE	BE	BE	BE	BE	BE	BE
A4605	199-F7-3	Active	C		BE	BE	BE		BE	BE		BE	BE	BE	BE	BE	BE	BE
A4607	199-F8-2	Active	N		BO	BO	BO			BO	BO	BO	BO	BO	BO	BO	BO	BO
A4608	199-F8-3	Active	C		BO	A	BO		BO	A	A	A	A	A	A	BO	BO	BO
A4609	199-F8-4	Active	C		BE	A	BE			BE	A	A	A	A	A	BE	BE	BE
A5275	699-58-24	Active	N		BE		BE					BE	BE	BE	BE	BE	BE	BE

Table 2. (contd)

Well ID	Well, Aquifer Tube, or Spring Name	Status	WAC Compliant	Contaminants of Concern								Supporting Constituents						
				Chromium (hexavalent filtered)	Chromium (total, filtered)	Gross Alpha (indicates uranium)	Nitrate	Strontium-90	Trichloroethene	Tritium	Uranium (total)	Specific Conductance[a]	Temperature (a)	Turbidity[a]	Water Level[a]	Alkalinity	Anions[b]	Metals (filtered)[c]
A5279	699-60-32	Active	N		BO		BO					BO	BO	BO	BO	BO	BO	BO
A5287	699-62-31	Active	N		BO		BO					BO	BO	BO	BO	BO	BO	BO
A8944	699-62-43F	Active	N		A		A			A		A	A	A	A	A	A	A
A5289	699-63-25A	Active	N		BO		BO			BO		BO	BO	BO	BO	BO	BO	BO
A5291	699-63-55	Active	N		BO		BO			A		A	A	A	A	BO	BO	BO
A5295	699-64-27	Active	N		BE		BE					BE	BE	BE	BE	BE	BE	BE
A5306	699-66-23	Active	N		BE		BE			BE		BE	BE	BE	BE	BE	BE	BE
A5312	699-67-51	Active	N		BO		BO			BO		BO	BO	BO	BO	BO	BO	BO
A5320	699-71-30	Active	N		BO	BO	BO			BO		BO	BO	BO	BO	BO	BO	BO
A5328	699-74-44	Active	N		BO		BO		BO			BO	BO	BO	BO	BO	BO	BO
A5330	699-77-36	Active	N		BE		BE		BE			BE	BE	BE	BE	BE	BE	BE
A5331	699-77-54	Active	N		BO		BO					BO	BO	BO	BO	BO	BO	BO
A5337	699-81-38	Active	N		BE		BE					BE	BE	BE	BE	BE	BE	BE
A5341	699-83-47	Active	N		BE		BE		BE			BE	BE	BE	BE	BE	BE	BE
Aquifer Tubes[d]																		
B8336, 35	AT-62 (S,M)	Active	NA	A	A		A					A	A	A		A	A	A
B8339	AT-63 (S)	Active	NA	A	A		A					A	A	A		A	A	A
B8341, 40	AT-64 (M,D)	Active	NA	A	A		A	A				A	A	A		A	A	A
B8345, 44	AT-65 (S,M)	Active	NA	A	A		A	A				A	A	A		A	A	A
C4391, 90, 89	AT-F-1 (S,M,D)	Active	NA	A	A		A	A				A	A	A		A	A	A
B8348, 47, 46	AT-66 (S,M,D)	Active	NA	A	A		A	A	A			A	A	A		A	A	A

Table 2. (contd)

Well ID	Well, Aquifer Tube, or Spring Name	Status	WAC Compliant	Contaminants of Concern								Supporting Constituents						
				Chromium (hexavalent filtered)	Chromium (total, filtered)	Gross Alpha (indicates uranium)	Nitrate	Strontium-90	Trichloroethene	Tritium	Uranium (total)	Specific Conductance[a]	Temperature (a)	Turbidity[a]	Water Level[a]	Alkalinity	Anions[b]	Metals (filtered)[c]
B8351, 50	AT-67 (S,M)	Active	NA	A	A		A					A	A	A		A	A	A
B8354, 53, 52	AT-68 (S,M,D)	Active	NA	A	A		A			A		A	A	A		A	A	A
C4394, 93,92	AT-F-2 (S,M,D)	Active	NA	A	A		A		A	A		A	A	A		A	A	A
C4385, 84, 83	AT-F-3 (S,M,D)	Active	NA	A	A		A		A	A		A	A	A		A	A	A
B8366, 65, 64	AT-72 (S,M,D)	Active	NA	A	A		A			A		A	A	A		A	A	A
B8369, 68, 67	AT-73 (S,M,D)	Active	NA	A	A		A			A		A	A	A		A	A	A
C4388, 87, 86	AT-F-4 (S,M,D)	Active	NA	A	A		A			A		A	A	A		A	A	A
B8371, 70	AT-74 (M,D)	Active	NA	A	A		A			A		A	A	A		A	A	A
B8375, 74, 73	AT-75 (S,M,D)	Active	NA	A	A		A			A		A	A	A		A	A	A
B8378, 77, 76	AT-76 (S,M,D)	Active	NA	A	A		A			A		A	A	A		A	A	A
B8381, 80, 79	AT-77 (S,M,D)	Active	NA	A	A		A					A	A	A		A	A	A
B9384, 83, 82	AT-78 (S,M,D)	Active	NA	A	A		A					A	A	A		A	A	A
B8389, 88	AT-80 (M,D)	Active	NA	A	A		A			A		A	A	A		A	A	A
Springs[e]																		
NA	SF-187-1	Active	NA	A	A		A			A		A	A	A		A	A	A
NA	SF-190-4	Active	NA	A	A		A			A		A	A	A		A	A	A
NA	SF-207-1	Active	NA	A	A		A			A		A	A	A		A	A	A

Table 2. (contd)

Well ID	Well, Aquifer Tube, or Spring Name	Status	WAC Compliant	Contaminants of Concern								Supporting Constituents						
				Chromium (hexavalent filtered)	Chromium (total, filtered)	Gross Alpha (indicates uranium)	Nitrate	Strontium-90	Trichloroethene	Tritium	Uranium (total)	Specific Conductance[a]	Temperature (a)	Turbidity[a]	Water Level[a]	Alkalinity	Anions[b]	Metals (filtered)[c]
NA	Other springs[f]	Possible	NA	A	A		A			A		A	A	A		A	A	A

(a) Field measurement.
(b) Anions - Analytes include but not limited to chloride, nitrate, and sulfate.
(c) Metals - Analytes include but not limited to calcium, potassium, magnesium, and sodium.
(d) Aquifer tube sites may include multiple depths: deep (D), medium, (M), and shallow (S). Each aquifer tube will be sampled for field parameters if conditions permit. If specific conductance in at least one tube is >160 µS/cm, samplers will select the tube with the highest specific conductance for laboratory analyses. However, if strontium-90 is scheduled at a tube site, all tube depths will be analyzed for strontium-90.
(e) Springs sampled if specific conductance is greater than river water.
(f) Springs are not always constant from year to year. Samplers elect to collect samples from other springs at their discretion.

C Well is constructed as a WAC 173-160, Part Two resource protection well.
N Well construction is not compliant with WAC 173-160, Part Two resource protection requirements.
A To be sampled annually.
BE To be sampled biennially in even-numbered fiscal years (e.g., fiscal year 2006).
BO To be sampled biennially in odd-numbered fiscal years (e.g., fiscal year 2005).
NA Not applicable.

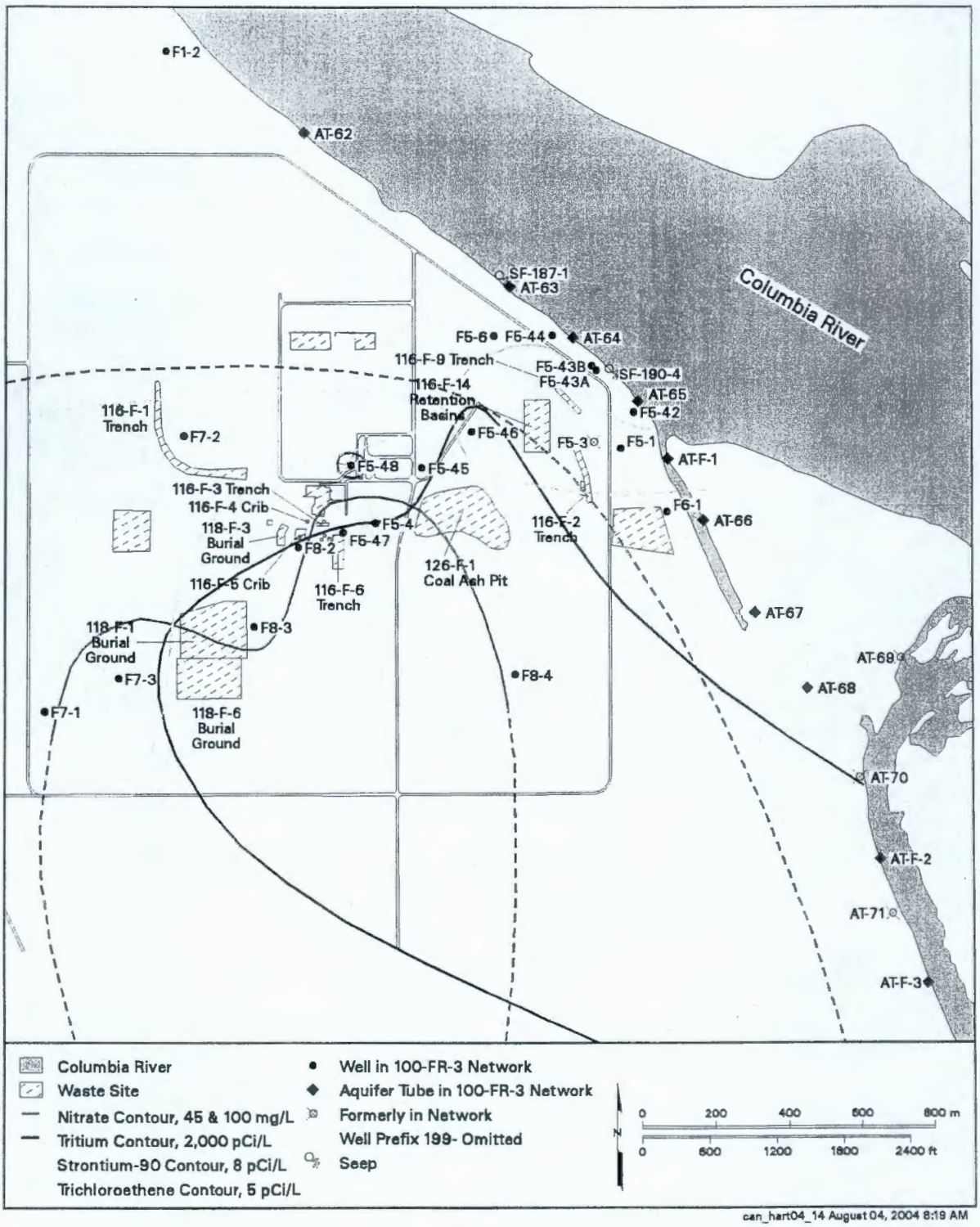

Figure 2. Wells, Aquifer Tubes, and Springs in the 100-F Area with Fiscal Year 2003 Contaminant Plumes

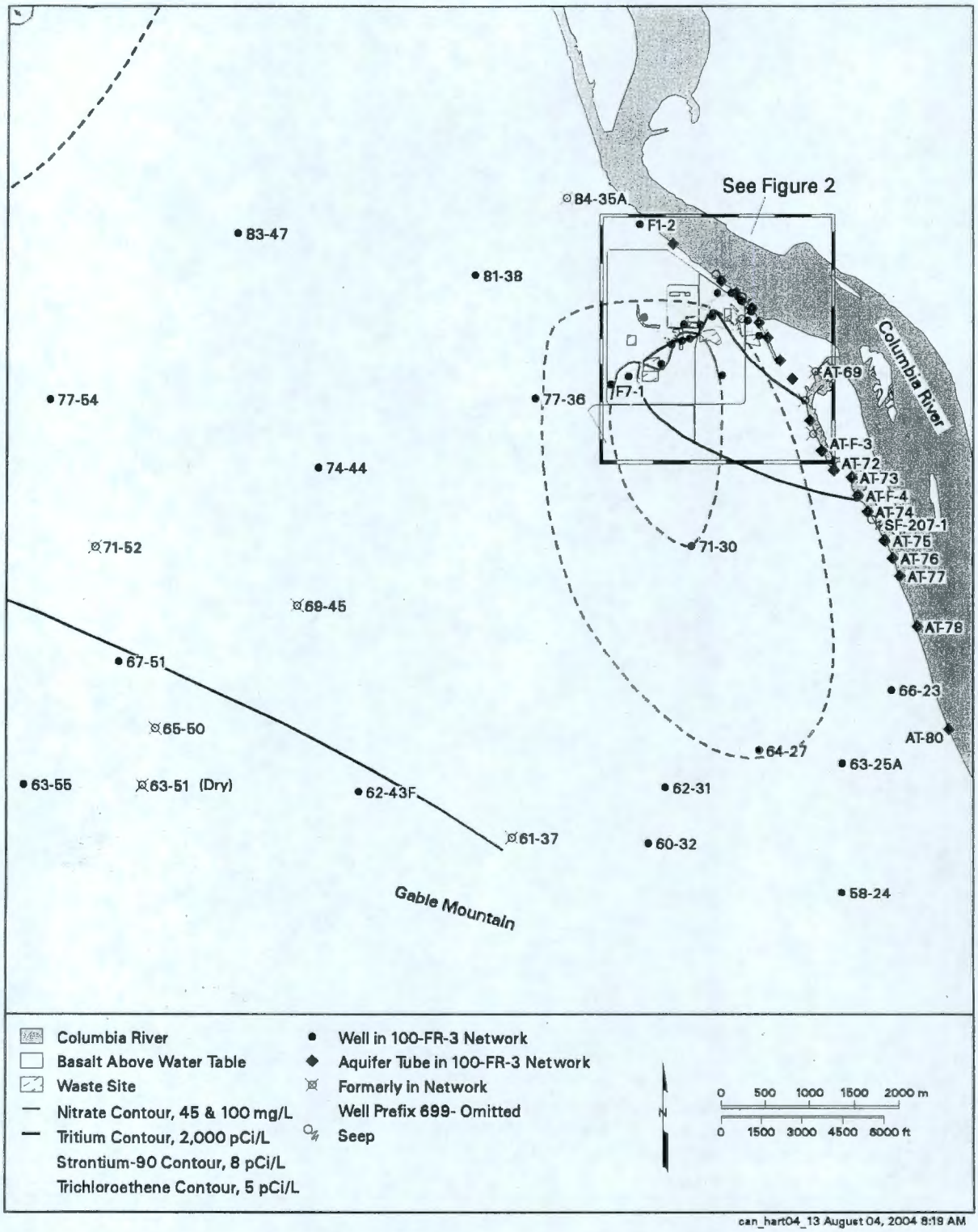

Figure 3. Wells, Aquifer Tubes, and Springs in the 600 Area Near the 100-F Area with Fiscal Year 2003 Contamiant Plumes

the tube with highest specific conductance). If specific conductance is less than 160 µS/cm in all tubes, the site is considered not representative of groundwater and no samples are collected for additional analyses.

One exception to this general aquifer tube sampling procedure is for strontium-90. Where strontium-90 is scheduled at an aquifer tube site, samples will be collected from all tubes, regardless of the specific conductance results. Previous data from the 100-B/C Area indicate that strontium-90 concentrations are higher in shallow and mid-level tubes and are lower or undetectable in deep tubes (there are no multiple-depth data from 100-F Area). Therefore, it is desirable to obtain several years of data from multiple depths to confirm these trends.

2.3 Constituents to be Monitored

As stated in Section 1.2, the contaminants of concern for the 100-FR-3 Operable Unit are hexavalent chromium, nitrate, strontium-90, tritium, trichloroethene, and uranium. Gross alpha activity will continue to be analyzed as an indicator for uranium. This revision of the sampling and analysis plan does not change any constituents of concern, although the choice of analyses has been modified in some cases (see Appendix A).

Gross alpha concentrations from samples collected in fiscal year 2004 were <10 pCi/L in most wells. The highest values were ~14 pCi/L in wells 199-F5-46 and 199-F8-4, and concentrations in those wells have increased overall in the past 10 years. In addition to gross alpha, samples from those wells and selected others will be analyzed for total uranium under this revised plan.

Concentrations of hexavalent chromium have remained below the 100-µg/L drinking water at all monitoring wells and aquifer tubes in recent years. However, concentrations exceed the 10-µg/L Water Quality Standard for Surface Waters of the State of Washington at some sampling locations. Also, dissolved chromium increased to very near the drinking water standard in the fiscal year 2004 sample from well 199-F5-6, so chromium will also be retained as a contaminant of concern.

All the wells, aquifer tubes, and springs are analyzed for a full suite of anions and metals to provide information on general water chemistry. These analytical groups include the constituents of concern nitrate (anions) and chromium (metals). Total chromium in filtered samples represents the soluble species of chromium (hexavalent); thus, the wells are not sampled specifically for hexavalent chromium.

The previous sampling and analysis plan called for sampling all aquifer tubes for trichloroethene. This revision eliminates the constituent at aquifer tubes that are not near the trichloroethene groundwater plumes (see Appendix A for details). Trichloroethene was undetected in all of the aquifer tubes sampled in fiscal year 2004.

2.4 Water-Level Monitoring

Groundwater levels are monitored on the Hanford Site primarily to help determine the direction and rate of groundwater flow. This information is used to interpret contaminant plume movement and to predict future movement.

Static water levels are measured in the monitoring well prior to sampling, and a minimum of two consistent measurements are taken to confirm precision of the measurement. In addition, the groundwater project measures water levels across the Hanford Site annually to construct a site-wide water-table map. A list of wells used for water-level measurements, criteria for their selection, hydrogeologic units monitored, and descriptions of the techniques used to collect the data are provided in *Water-Level Monitoring Plan for the Hanford Groundwater Monitoring Project* (McDonald et al. 1999). The wells identified in McDonald et al. (1999) will be used for annual measurements for the 100-FR-3 Operable Unit. Samplers measure depth to groundwater according to a subcontractor's procedure. The depth to groundwater is subtracted from the elevation of a reference point (usually top of casing) to obtain the water-level elevation.

2.5 Sampling and Analysis Protocol

Groundwater monitoring for the 100-FR-3 Operable Unit is part of the groundwater project and follows the project's quality assurance plan, which is compliant with *EPA Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003, EPA QA/R-5, March 2001, as revised). Groundwater monitoring will follow the requirements of the most recent revision of the quality assurance project plan; this monitoring plan need not be revised to cite future revisions of the quality assurance plan.

Project staff schedule sampling and initiate paperwork. The project uses subcontractors for sample collection, shipping, and analysis. Quality requirements for the subcontracted work are specified in statements of work or contracts.

The statement of work for sampling activities specifies that activities shall be in accordance with a quality assurance project plan that meets the requirements defined in *Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003, EPA QA/R-5, 2001, as revised). Additional requirements are specified in the statement of work.

Groundwater project staff conduct laboratory audits and field surveillances to assess the quality of subcontracted work and initiate corrective action if needed.

The current controlling document for the aquifer tube task is the *Sampling and Analysis Plan for Aquifer Sampling Tubes* (DOE 2000). To foster consistency in aquifer tube sampling, procedures and methods for the 100-FR-3 Operable Unit will be as described in DOE (2000).

Riverbanks springs are sampled annually during the fall months, and in conjunction with spring sampling conducted under the Surface Environmental Surveillance Project at PNNL.

2.5.1 Scheduling Groundwater Sampling

The groundwater project has the responsibility for scheduling well sampling. Many Hanford Site wells are sampled for multiple objectives and requirements. Scheduling activities help manage the overlap, eliminating redundant sampling and meeting the needs of each sampling objective.

2.5.2 Chain of Custody

PNNL and the well sampling subcontractor use chain-of-custody procedures and documentation that are consistent with *Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003, EPA QA/R-5, March 2001, as revised). Use of these protocols documents the integrity of groundwater samples from the time of collection through data reporting. The forms are generated during scheduling (see Section 2.5.1) and managed by the samplers.

2.5.3 Sample Collection

Groundwater samples are collected as described in a subcontractor procedure. Samples generally are collected after three casing volumes of water have been purged from the well or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized (i.e., after two consecutive measurements are within 0.2 units pH, 0.2°C for temperature, 10% for specific conductance, and turbidity <5 Nephelometric Turbidity Units [NTU]). For routine groundwater samples, preservatives are added to the collection bottles before their use in the field. Samples to be analyzed for metals are usually filtered in the field so that results represent dissolved metals.

2.5.4 Analytical Protocols

Procedures for field measurements are specified in subcontractor's procedures. Each instrument is assigned a unique number that is tracked on field documentation and is calibrated and controlled according to procedure. Additional calibration and use instructions are specified in the instrument user's manuals.

Laboratory analytical methods are specified in contracts with the laboratories, and are standard methods from *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA SW-86, as amended) or *Methods for Chemical Analysis of Water and Wastes* (EPA 600/4-79-020, 1979, as revised).

3.0 Quality Assurance

The groundwater project's quality assurance plan is compliant with *EPA Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003, EPA QA/R-5, March 2001, as revised). A quality control plan is included in the groundwater project quality assurance plan, and quality control sampling requirements for subcontracted work are discussed in a statement of work.

The groundwater project's quality control program is designed to assess and enhance the reliability and validity of groundwater data. This is accomplished through evaluating the results of quality control samples, conducting audits, and validating groundwater data. This section describes the quality control program for the entire groundwater project, which includes the 100-FR-3 Operable Unit. The quality control practices of the groundwater project are compliant with the *Tri-Party Agreement* (Ecology et al.

1989, as amended), Section 7.8. Accuracy, precision, and detection are the primary parameters used to assess data. Data for these parameters are obtained from two categories of quality control samples: those that provide checks on field and laboratory activities (field quality control) and those that monitor laboratory performance (laboratory quality control). Table 3 summarizes the types of samples in each category and the sample frequencies and characteristics evaluated.

Table 3. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field Quality Control		
Full Trip Blank	Contamination from containers or transportation	1 per 20 well trips
Field Transfer Blank	Airborne contamination from the sampling site	1 each day volatile organic compound samples are collected
Equipment Blank	Contamination from non-dedicated sampling equipment	1 per 10 well trips or as needed[a]
Duplicate Samples	Reproducibility	1 per 20 well trips
Laboratory Quality Control		
Method Blank	Laboratory contamination	1 per batch
Lab Duplicates	Laboratory reproducibility	Method/contract specific[b]
Matrix Spike	Matrix effects and laboratory accuracy	Method/contract specific[b]
Matrix Spike Duplicate	Laboratory reproducibility and accuracy	Method/contract specific[b]
Surrogates	Recovery/yield	Method/contract specific[b]
Laboratory Control Sample	Accuracy	1 per batch
Double Blind Standards	Accuracy and precision	Varies by constituent[c]

(a) When a new type of non-dedicated sampling equipment is used, an equipment blank should be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the equipment's decontamination procedure.
(b) If called for by the analytical method, duplicates, matrix spikes, and matrix spike duplicates are typically analyzed at a frequency of 1 per 20 samples. Surrogates are routinely included in every sample for most gas chromatographic methods.
(c) Double blind standards containing known concentrations of selected analytes are typically submitted in triplicate or quadruplicate on a quarterly, semi-annual, or annual basis.

3.1 Quality Control Criteria

Quality control data are evaluated based on established acceptance criteria for each quality control sample type. For field and method blanks, the acceptance limit is generally two times the instrument detection limit (metals), method detection limit (other chemical parameters), or minimum detectable activity (radiochemistry parameters). However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and phthalate esters, the limit is five times the method detection limit.

Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks are flagged with a Q in the database to indicate a potential contamination problem.

Field duplicates must agree within 20%, as measured by the relative percent difference (RPD), to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results are also flagged with a "Q" in the database.

For chemical analyses, the acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are generally derived from historical data at the laboratories in accordance with *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA SW-86, as amended). Typical acceptance limits are within 25% of the expected values, although the limits may vary considerably with the method and analyte. For radiological analyses, the acceptance limits for laboratory quality control samples are specified in the laboratory contract. Current values for laboratory duplicates, matrix spikes, and laboratory control samples are 20% RPD, 60%-140%, and 70%-130%, respectively. These values are subject to change if the contract is modified or replaced.

Table 4 lists the acceptable recovery limits for the double blind standards. These samples are prepared by spiking background well water (currently wells 699-19-88 and 699-49-100C) with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper limit of concentration determined in groundwater on the Hanford Site. Double blind standard results that are outside the acceptance limits are investigated and appropriate actions are taken if necessary.

Holding time is the elapsed time period between sample collection and analysis. Exceeding recommended holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA SW-86, as amended) or *Methods for Chemical Analysis of Water and Wastes* (EPA 600/4-79-020, 1979, as revised). Holding times are specified in laboratory contracts. Data associated with exceeded holding times are flagged with an "H" in the Hanford Environmental Information System (HEIS) database.

Additional quality control measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned water pollution and water supply performance evaluation studies. The groundwater project periodically audits the analytical laboratories to identify and solve quality problems, or to prevent such problems. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report.

Table 4. Recovery Limits for Double Blind Standards

Constituent	Frequency	Recovery Limits	Precision Limits (RSD)
Specific conductance	Quarterly	75–125%	25%
Fluoride	Quarterly	75–125%	25%
Nitrate	Quarterly	75–125%	25%
Chromium	Annually	80–120%	20%
Carbon tetrachloride	Quarterly	75–125%	25%
Chloroform	Quarterly	75–125%	25%
Trichloroethene	Quarterly	75–125%	25%
Gross alpha[(a)]	Quarterly	70–130%	20%
Gross beta[(b)]	Quarterly	70–130%	20%
Tritium	Annually	70–130%	20%
Strontium-90	Semiannually	70–130%	20%

Gross alpha standards will be spiked with plutonium-239.
Gross beta standards will be spiked with strontium-90.
RSD = Relative Standard Deviation

3.2 Groundwater Data Validation Process

The groundwater project's data validation process provides requirements and guidance for validation of groundwater data that are routinely collected as part of the groundwater project. Validation is a systematic process of reviewing data against a set of criteria to determine whether the data are acceptable for their intended use. This process applies to groundwater data that have been verified (see Section 4.1) and loaded into HEIS. The outcome of the activities described below is an electronic data set with suspect or erroneous data corrected or flagged. Groundwater monitoring project staff document the validation process quarterly by signing a checklist, which is stored in the project file.

Responsibilities for data validation are divided among project staff. Each groundwater interest area is assigned to a project scientist, who is familiar with the hydrogeologic conditions of that site. The data validation process includes the following elements.

- **Generation of data reports**. Twice each month, data management staff provide tables of newly loaded data to project scientists for evaluation (biweekly reports). Also, after laboratory results from a reporting quarter have been loaded into HEIS, staff produce tables of water-level data and analytical data for wells sampled within that quarter (quarterly reports). The quarterly data reports include any data flags added during the quality control evaluation or as a result of prior data review.

- **Project scientist evaluation**. As soon as practical after receiving biweekly reports, project scientists review the data to identify changes in groundwater quality or potential data errors. Evaluation techniques include comparing key constituents to historical trends or spatial patterns. Other data

checks may include comparison of general parameters to their specific counterparts (e.g., conductivity to ions) and calculation of charge balances. Project scientists request data reviews if appropriate (see Section 4.2). If necessary, the laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. After receiving quarterly reports, project scientists review sampling summary tables to determine whether network wells were sampled and analyzed as scheduled. If not, they work with other project staff to resolve the problem. Project scientists also review quarterly reports of analytical and water-level data using the same techniques as for biweekly reports. Unlike the biweekly reports, the quarterly reports usually include a full data set (i.e., all the data from the wells sampled during the previous quarter have been received and loaded into HEIS).

- Staff report results of quality control evaluations informally to project staff, DOE, and Washington State Department of Ecology each quarter; DOE will provide them to EPA on request. Results for each fiscal year are described in the annual groundwater monitoring report.

4.0 Data Management, Evaluation, and Reporting

This section describes how groundwater data are stored, retrieved, and interpreted.

4.1 Loading and Verifying Data

The contract laboratories report analytical results electronically and in hard copy. The electronic results are loaded into HEIS. Hard copy data reports and field records are maintained as part of the Tri-Party Agreement administrative record. Project staff perform an array of computer checks on the electronic file for formatting, allowed values, data flagging (qualifiers), and completeness. Verification of the hard copy results includes checks for (1) completeness, (2) notes on condition of samples upon receipt by the laboratory, (3) notes on problems that arose during the analysis of the samples, and (4) correct reporting of results. If data are incomplete or deficient, staff work with the laboratory to get the problems corrected. Notes on condition of samples or problems during analysis may be used to support data reviews (see Section 4.2).

Field data such as specific conductance, pH, temperature, turbidity, and depth-to-water are recorded on field records. Data management staff enter these into HEIS manually through data-entry screens, verify each value against the hard copy, and initial each value on the hard copy.

4.2 Data Review

The groundwater project conducts special reviews of groundwater analytical data or field measurements when results are in question. Groundwater project staff document the process on review forms, and results are used to flag the data appropriately in HEIS. Various staff may initiate a review form: e.g., project scientists, data management staff, and quality control staff. A project scientist assigned to

examine a review form determines and records the appropriate response and action on the review form, including changes to be made to the data flags in HEIS. Actions may include updating HEIS with corrected data or result of re-analysis, flagging existing data (e.g., "R" for reject, "Y" for suspect, "G" for good), and/or adding comments. Data management staff updates the temporary "F" flag to the final flag in HEIS.

4.3 Interpretation

After data are validated and verified, the acceptable data are used to interpret groundwater conditions at the site. Interpretive techniques include:

- Hydrographs – graph water levels vsersus time to determine decreases, increases, seasonal, or man-made fluctuations in groundwater levels.
- Water-table maps – use water-table elevations from multiple wells to construct contour maps to estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential.
- Trend plots – graph concentrations of constituents vs. time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water-table maps to determine if concentrations relate to changes in water level or in groundwater flow directions.
- Plume maps – map distributions of chemical or radiological constituents are in the aquifer to determine extent of contamination. Changes in plume distribution over time aid in determining movement of plumes and direction of flow.
- Contaminant ratios – can sometimes be used to distinguish between different sources of contamination.

4.4 Reporting

Chemistry and water-level data are reviewed after each sampling event and are available in HEIS.

Any unusual results for the 100-FR-3 Operable Unit will be summarized in letter reports or informal reports to EPA (e.g., reports via e-mail or presented at unit manager's meetings). Formal, interpretive reports for the entire Hanford Site are issued annually in March (e.g., *Hanford Site Groundwater Monitoring for Fiscal Year 2003,* Hartman et al. 2004).

4.5 Change Control

The approach to making changes in 100-FR-3 Operable Unit monitoring activities, associated documents, and approval requirements are listed in Table 5.

Table 5. Change Control for Groundwater Monitoring in the 100-FR-3 Operable Unit

Type of Change	Action	Documentation
Temporarily (≤1 year) adding constituents, wells, or increasing sampling frequency	Project management approval; notify regulator if appropriate	Project's schedule tracking system.
Permanently (>1 year) adding constituents, wells, or increasing sampling frequency	Revise sampling and analysis plan	Revised plan.
Deleting constituents or wells; decreasing frequency	Obtain regulator approval prior to change.	Initial approval may be verbal or e-mail. Formal approval via letter or signed meeting minutes.
Unavoidable changes (e.g., dry wells; delayed samples, one-time missed samples due to broken pump, lost bottle, etc.)	Notify regulator.	Project's schedule tracking system; notification via letter, report, e-mail or meeting minutes.
Revision to sampling and analysis plan	Revise plan; obtain regulator approval; distribute plan.	Revised plan.

5.0 Health and Safety

All field operations will be performed consistent with PNNL health and safety requirements as described in PNNL's online Systems Based Management System. For work performed by other contractors, these standards are implemented via subcontracts and work orders.

Where necessary, work planning packages will include, as appropriate, a job hazard analysis, and/or a site-specific health and safety plan, and applicable radiological permits.

The sampling procedures and associated activities will implement as low as reasonably achievable practices to minimize radiation exposure to the sampling team, consistent with requirements outlined in accepted PNNL procedures.

6.0 References

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Appendix A

Comparison of Revised and Previous Monitoring Networks for 100-FR-3 Operable Unit

Appendix A

Comparison of Revised and Previous Monitoring Networks for 100-FR-3 Operable Unit

Table A.1 lists wells, aquifer tubes, and springs in the revised and previous monitoring networks, summarizes changes to the monitoring program, and provides justification for those changes.

Table A.1. Comparison of Revised and Previous Monitoring Networks for 100-FR-3 Operable Unit

Well, Aquifer Tube, or Spring	Alkalinity	Anions (NO3)	Alpha (Uranium)	Metals (Chromium)	TCE	Sr-90	Tritium	Uranium	Changes from Rev. 0 Sampling and Analysis Plan	Justification for Change
199-F1-2	BO	BO	xx	BO	xx	xx	xx	xx	No change	
199-F5-1	A	A	BE	A	xx	BE	BE	xx	Decrease frequency of tritium analyses from annual to biennial	Tritium typically undetected to 500 pCi/L
199-F5-3	xx	xx	xx	xx	xx	xx	xx	xx	Drop well	Does not produce water; dropped April 2004
199-F5-4	A	A	BO	A	BO	xx	BO	xx	Decrease frequency of tritium analyses from annual to biennial	Tritium steadily declining; <2000 pCi/L
199-F5-6	A	A	BE	A	xx	BE	BE	xx	Increase frequency of anions and metals from biennial to annual	Chromium and nitrate variable; both increased to near DWS in FY 2004
199-F5-42	BO	BO	BO	BO	xx	BO	BO	xx	No change	
199-F5-43A	BE	BE	BE	BE	xx	BE	BE	xx	No change	
199-F5-43B	BE	BE	BE	BE	xx	BE	xx	xx	Switch biennial sampling from odd to even FY	Match schedule of sister well -43A
199-F5-44	BE	BE	BE	BE	xx	BE	BE	xx	No change	
199-F5-45	BO	BO	BO	BO	BO	BO	BO	BO	Add TCE and uranium biennially	TCE has been near or at DWS in past; alpha increases nearby
199-F5-46	BE	BE	A	BE	BE	BE	A	A	Increase frequency of alpha from biennial to annual; eliminate hexavalent chromium (keep total chromium) add TCE and uranium	Alpha near DWS and rising; hexavalent chromium redundant with filtered, total chromium; TCE has been near or at DWS in past; alpha increase in FY 2004
199-F5-47	A	A	BE	A	xx	xx	A	A	Drop TCE; add uranium	TCE undetected or very low; nearby well F5-4 analyzed for TCE; alpha increases nearby
199-F5-48	BO	BO	BO	BO	xx	xx	BO	BO	No change	
199-F6-1	BO	BO	BO	BO	xx	BO	BO	xx	No change	
199-F7-1	BE	BE	xx	BE	BE	xx	xx	xx	Drop tritium	Tritium undetected since 1999; nearby well F7-3 analyzed for tritium
199-F7-2	BE	BE	BE	BE	BE	xx	BE	xx	Add alpha and TCE biennially	Alpha increased 1993-2001; TCE recently >DWS; this is only well near head of Lewis Canal
199-F7-3	BE	BE	BE	BE	BE	xx	BE	xx	No change	
199-F8-2	BO	BO	BO	BO	xx	xx	BO	BO	Add uranium	Increasing uranium in past (no recent data)

Table A.1. (contd)

Well, Aquifer Tube, or Spring	Alkalinity	Anions (NO3)	Alpha (Uranium)	Metals (Chromium)	TCE	Sr-90	Tritium	Uranium	Changes from Rev. 0 Sampling and Analysis Plan	Justification for Change
199-F8-3	BO	BO	A	BO	BO	xx	A	A	Add uranium	Increasing uranium in past while alpha decrease (no recent uranium data)
199-F8-4	BE	BE	A	BE	xx	xx	BE	A	Add uranium	Alpha fluctuating; near DWS in FY04
699-58-24	BE	BE	xx	BE	xx	xx	xx	xx	No change	
699-60-32	BO	BO	xx	BO	xx	xx		xx	No change	
699-61-37	xx	xx	xx	xx	xx	xx	xx	xx	Drop well	Not needed to define plumes
699-62-31	BO	BO	xx	BO	xx	xx	xx	xx	Switch biennial sampling from even to odd FY	Nitrate increased in FY 2004; want to confirm in FY 2005
699-62-43F	A	A	xx	A	xx	xx	A	xx	Add metals	Add metals for general chemistry
699-63-25A	BO	BO	xx	BO	xx	xx	BO	xx	Add tritium biennially	In path of tritium plume
699-63-55	BO	BO	xx	BO	xx	xx	A	xx	No change	
699-64-27	BE	BE	xx	BE	xx	xx	xx	xx	No change	
699-65-50	xx	xx	xx	xx	xx	xx	xx	xx	Drop well	Not needed to define plumes
699-66-23	BE	BE	xx	BE	xx	xx	BE	xx	Add tritium biennially	Helps define tritium plume
699-67-51	BO	BO	xx	BO	xx	xx	BO	xx	No change	
699-69-45	xx	xx	xx	xx	xx	xx	xx	xx	Drop well	Deep well with piezometers; uncertain construction details
699-71-30	BO	BO	BO	BO	xx	xx	BO	xx	Add alpha and tritium biennially	Alpha ~10 pCi/L recently; in flow path from 100-F; helps define tritium plume
699-71-52	xx	xx	xx	xx	xx	xx	xx	xx	Drop well	Not needed to define plumes
699-74-44	BO	BO	xx	BO	BO	xx	xx	xx	No change	
699-77-36	BE	BE	xx	BE	BE	xx	xx	xx	Decrease frequency from annual to biennial	Nitrate steady; TCE declining gradually
699-77-54	BO	BO	xx	BO	xx	xx	xx	xx	No change	
699-81-38	BE	BE	xx	BE	xx	xx	xx	xx	Add well; substitute for 699-84-35A	Shallow well to monitor top of aquifer
699-83-47	BE	BE	xx	BE	BE	xx	xx	xx	No change	

Table A.1. (contd)

Well, Aquifer Tube, or Spring	Alkalinity	Anions (NO3)	Alpha (Uranium)	Metals (Chromium)	TCE	Sr-90	Tritium	Uranium	Changes from Rev. 0 Sampling and Analysis Plan	Justification for Change
699-84-35A	xx	xx	xx	xx	xx	xx	xx	xx	Drop well	Deep well with piezometers; uncertain construction details
62-S,M	A	A	xx	A*	xx	xx	xx	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
63-S	A	A	xx	A*	xx	xx	xx	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
64-M,D	A	A	xx	A*	xx	A	xx	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
65-S,M	A	A	xx	A*	xx	A	xx	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
AT-F-1-S,M,D	A	A	xx	A*	xx	A	xx	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
66-S,M,D	A	A	xx	A*	A	A	xx	xx	No change	Keep TCE to confirm ND
67-S,M	A	A	xx	A*	xx	xx	xx	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
68-S,M,D	A	A	xx	A*	xx	xx	A	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
69-M,D	xx	xx	xx	xx	xx	xx	xx	xx	Delete site	Not found FY04
70-S,M,D	xx	xx	xx	xx	xx	xx	xx	xx	Delete site	Destroyed
AT-F-2-S,M,D	A	A	xx	A*	A	xx	A	xx	No change	Keep TCE to confirm ND
71-D	xx	xx	xx	xx	xx	xx	xx	xx	Delete site	Destroyed
AT-F-3-S,M,D	A	A	xx	A*	A	xx	A	xx	No change	Keep TCE to confirm ND
72-S,M,D	A	A	xx	A*	xx	xx	A	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
73-S,M,D	A	A	xx	A*	xx	xx	A	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
AT-F-4-S,M,D	A	A	xx	A*	xx	xx	A	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
74-M,D	A	A	xx	A*	xx	xx	A	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
75-S,M,D	A	A	xx	A*	xx	xx	A	xx	Drop TCE; add tritium	Not near TCE groundwater plume; TCE ND 2004; detectable tritium
76-S,M,D	A	A	xx	A*	xx	xx	A	xx	Drop TCE; add tritium	Not near TCE groundwater plume; TCE ND 2004; detectable tritium
77-S,M,D	A	A	xx	A*	xx	xx	xx	xx	Drop TCE	Not near TCE groundwater plume; ND 2004
78-S,M,D	A	A	xx	A*	xx	xx	xx	xx	Drop TCE	Not near TCE groundwater plume; ND 2004

Table A.1. (contd)

Well, Aquifer Tube, or Spring	Alkalinity	Anions (NO3)	Alpha (Uranium)	Metals (Chromium)	TCE	Sr-90	Tritium	Uranium	Changes from Rev. 0 Sampling and Analysis Plan	Justification for Change
80-M,D	A	A	xx	A*	xx	xx	A	xx	Drop TCE; add tritium	Not near TCE groundwater plume; TCE ND 2004; bounds tritium
Spring 187-1	A	A	xx	A*	xx	xx	A	xx	Drop TCE	TCE ND in near-river wells and aquifer tubes
Spring 190-4	A	A	xx	A*	xx	xx	A	xx	Drop TCE	TCE ND in near-river wells and aquifer tubes
Spring 207-1	A	A	xx	A*	xx	xx	A	xx	Drop TCE	TCE ND in near-river wells and aquifer tubes
Other springs	A	A	xx	A*	xx	xx	A	xx	Add other springs if present, at discretion of samplers	Supporting data on general chemistry and tritium

* Analyze for hexavalent and total chromium.

A = annually
BE = biennially in even fiscal years (e.g., fiscal year 2006).
BO = biennially in odd fiscal years (e.g., fiscal year 2005).
xx = not analyzed.
ND = not detected.
TCE = trichloroethene.

Appendix B

Well Construction Summary

Appendix B

Well Construction Summary

Table B.1 summarizes well construction information, including casing material, type of open interval (screened or perforated), elevation of open interval, and water column thickness. Table B.2 lists aquifer tube depths and years installed. All aquifer tubes are constructed of polyethylene tubing with a screened port in the aquifer.

Table B.1. Construction Information for Wells in the 100-FR-3 Monitoring Network

Well ID	Well Name	Year Drilled	Casing[a]	Screen[b]	Unit[c]	Open Interval Elevation, m		Water-Level Elevation, m	Water-Level Date	Water Column, m[d]
						Top	Bottom			
A4586	199-F1-2	1992	SS	S	TU	114.37	109.80	113.43	3/8/2004	3.63
A4587	199-F5-1	1948	CS	P	TU	112.91	104.37	113.19	3/8/2004	8.82
A4590	199-F5-4	1953	CS	P	TU	114.97	93.64	113.67	3/8/2004	20.03
A4591	199-F5-42	1992	SS	S	TU	115.62	109.53	112.97	10/13/2003	3.44
A4592	199-F5-43A	1992	SS	S	TU	115.38	109.28	113.08	3/8/2004	3.80
A4593	199-F5-43B	1992	SS	S	RC	76.28	73.24	113.30	10/13/2003	40.06
A4594	199-F5-44	1992	SS	S	TU	115.28	109.19	112.75	10/13/2003	3.56
A4595	199-F5-45	1992	SS	S	TU	116.16	111.49	113.50	10/14/2003	2.01
A4596	199-F5-46	1992	SS	S	TU	114.69	110.12	113.22	3/8/2004	3.10
A4597	199-F5-47	1992	SS	S	TU	116.65	110.55	114.10	10/14/2003	3.54
A4598	199-F5-48	1992	SS	S	TU	116.63	111.97	113.80	10/14/2003	1.83
A4600	199-F5-6	1956	CS	P	TU	115.37	67.51	113.34	3/8/2004	45.83
A4602	199-F6-1	1992	SS	S	TU	113.63	107.53	113.10	3/8/2004	5.57
A4603	199-F7-1	1956	CS	P	TU	116.25	76.63	114.82	3/8/2004	38.19
A4604	199-F7-2	1988	SS	S	TU	116.06	111.19	114.40	3/8/2004	3.21
A4605	199-F7-3	1992	SS	S	TU	116.14	111.56	114.92	2/3/2004	3.36
A4607	199-F8-2	1960	CS	P	TU	123.15	110.04	114.24	10/13/2003	4.20
A4608	199-F8-3	1992	SS	S	TU	115.55	112.50	114.28	3/8/2004	1.78
A4609	199-F8-4	1992	SS	S	TU	114.40	111.35	113.03	3/8/2004	1.68
A5275	699-58-24	1971	CS	S	TU	112.42	109.07	110.89	3/11/2004	1.82
A5279	699-60-32	1971	CS	S	UU	106.79	103.74	110.93	3/10/2004	7.19
A5287	699-62-31	1971	CS	S	UU	109.78	106.73	110.93	3/10/2004	4.20
A8944	699-62-43F	1959	CS	P	UU	122.41	107.78	119.19	12/30/2003	11.41
A5289	699-63-25A	1949	CS	P	U	112.91	92.18	110.89	3/11/2004	18.71
A5291	699-63-55	1972	CS	P	UU	123.00	110.20	121.91	3/10/2004	11.71
A5295	699-64-27	1974	CS	P	TU	111.81	104.50	110.93	3/11/2004	6.43
A5306	699-66-23	1961	CS	P	U	113.47	90.31	110.59	3/11/2004	20.28
A5312	699-67-51	1961	CS	P	U	129.40	83.68	121.76	3/9/2004	38.08

Table B.1. (contd)

Well ID	Well Name	Year Drilled	Casing[a]	Screen[b]	Unit[c]	Open Interval Elevation, m		Water-Level Elevation, m	Water-Level Date	Water Column, m[d]
						Top	Bottom			
A5320	699-71-30	1957	CS	P	U	115.51	96.91	114.02	3/12/2004	17.11
A5328	699-74-44	1957	CS	P	TU	130.52	115.28	121.60	3/11/2004	6.32
A5330	699-77-36	1957	CS	P	UU	115.92	100.68	115.75	3/11/2004	15.07
A5331	699-77-54	1957	CS	P	UU	125.01	109.77	120.99	3/9/2004	11.22
A5337	699-81-38	Unknown	CS	P	U	118.68	97.68	116.48	3/11/2004	18.80
A5341	699-83-47	1957	CS	P	U	122.04	86.98	119.07	3/12/2004	32.09

(a) Casing material. CS = carbon steel; SS = stainless steel.
(b) Open interval type. S = screen; P = perforated casing.
(c) Hydrogeologic unit monitored (based on data presented above and associated well logs).
(d) Thickness of water column in well (water-level minus bottom of open interval).
TU = Top of unconfined aquifer (screened across water table with open interval ≤10 meters below water table.
U = Undifferentiated unconfined. Open to more than 15 meters of the unconfined aquifer system, or poorly documented.
UU = Upper unconfined. Screened across water table with open interval 10-15 m below water table, or screened below water table and <15 m below water table.
RC = Ringold confined aquifer.

Table B.2. Construction Information for Aquifer Tubes in the 100-FR-3 Monitoring Network

Well ID	Aquifer Tube Name	Hanford River Mile	Year Installed	Port Depth (ft bgs)	Port Depth (m bgs)
B8335	62-M	18.40	1997	18	5.49
B8336	62-S	18.40	1997	8	2.44
B8339	63-S	18.80	1997	10	3.05
B8340	64-D	18.94	1997	27	8.23
B8341	64-M	18.94	1997	17	5.18
B8344	65-M	19.10	1997	16	4.88
B8345	65-S	19.10	1997	8.5	2.59
C4389	AT-F-1-D	19.22	2004	26.1	7.96
C4390	AT-F-1-M	20.11	2004	18.1	5.52
C4391	AT-F-1-S	20.42	2004	10.3	3.14
B8346	66-D	19.37	1997	28.1	8.56
B8347	66-M	19.37	1997	19.2	5.85
B8348	66-S	19.37	1997	10	3.05
B8350	67-M	19.58	1997	20	6.10
B8351	67-S	19.58	1997	10	3.05
B8352	68-D	19.76	1997	25	7.62
B8353	68-M	19.76	1997	18.3	5.58
B8354	68-S	19.76	1997	10.5	3.20
C4392	AT-F-2-D	20.11	2004	19.3	5.88
C4393	AT-F-2-M	20.11	2004	13.6	4.15
C4394	AT-F-2-S	20.11	2004	7.5	2.29
C4383	AT-F-3-D	20.42	2004	14.1	4.30
C4384	AT-F-3-M	20.42	2004	10.8	3.29
C4385	AT-F-3-S	20.42	2004	6	1.83
B8364	72-D	20.67	1997	28	8.53
B8365	72-M	20.67	1997	18	5.49
B8366	72-S	20.67	1997	9.5	2.90
B8367	73-D	20.81	1997	27	8.23
B8368	73-M	20.81	1997	19	5.79
B8369	73-S	20.81	1997	10.5	3.20
C4386	AT-F-4-D	21.00	2004	32.3	9.85
C4387	AT-F-4-M	21.00	2004	18	5.49
C4389	AT-F-4-S	21.00	2004	7.2	2.19
B8370	74-D	21.16	1997	29	8.84
B8371	74-M	21.16	1997	17	5.18
B8373	75-D	21.49	1997	27	8.23
B8374	75-M	21.49	1997	19	5.79
B8375	75-S	21.49	1997	11	3.35

Table B.2. (contd)

Well ID	Aquifer Tube Name	Hanford River Mile	Year Installed	Port Depth (ft bgs)	Port Depth (m bgs)
B8376	76-D	21.68	1997	25	7.62
B8377	76-M	21.68	1997	19	5.79
B8378	76-S	21.68	1997	11	3.35
B8379	77-D	21.86	1997	24.5	7.47
B8380	77-M	21.86	1997	16.5	5.03
B8381	77-S	21.86	1997	8.5	2.59
B9382	78-D	22.30	1997	24	7.32
B9383	78-M	22.30	1997	16	4.88
B9384	78-S	22.30	1997	8	2.44
B838	80-D	23.10	1997	25.5	7.77
B8389	80-M	23.10	1997	15.5	4.72

Aquifer tubes are completed at 3 relative depths in the unconfined aquifer: near the water table (S), mid-depth (M), and above the first less-permeable unit (D).

bgs = below ground surface.