1.0 Introduction

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The Hanford Site, part of the U.S. Department of Energy's (DOE's) nuclear weapons complex, encompasses ~1,500 square kilometers in southeastern Washington State (Figure 1-1). The Hanford Site is located in the Lower Columbia Basin and is divided by the Columbia River. The federal government acquired the Hanford Site in 1943 and, until the 1980s, the site was used to produce plutonium for the national defense mission. Management of waste associated with plutonium production has been a major activity throughout Hanford's history and continues today at a much reduced scale. Beginning in the 1990s, DOE has focused primarily on characterization, removal, treatment, and disposal of contamination from past operations at the site.

The DOE is committed to protecting the Columbia River from the Hanford Site's contaminated groundwater. Groundwater is the primary exposure route for site contaminants to reach human and environmental receptors. The *Hanford Integrated Groundwater and Vadose Zone Management Plan* (DOE/RL-2007-20) outlines the steps for addressing groundwater and vadose zone contamination. The DOE developed the plan in consultation with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology).

The DOE's groundwater strategy focuses on protecting groundwater from contaminants, monitoring groundwater conditions, and cleaning up contaminated groundwater.

Key elements associated with managing the Hanford Site's groundwater and vadose zone are to (1) protect the Columbia River and groundwater, (2) develop a cleanup decision process, and (3) achieve final cleanup.

Protect the Columbia River and groundwater. Many actions have already been taken to address principal threats to the Columbia River and groundwater. These actions include the following:

- Cease discharge of all unpermitted liquids in the central Hanford Site
- Remediate the former liquid waste sites in the 100 and 300 Areas to reduce the potential for future groundwater contamination
- Contain groundwater plumes and reduce the mass of primary contaminants through remedial actions such as pump-and-treat.

Develop a process for cleanup decisions. Final decisions will be based on processes outlined in the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and/or the *Resource Conservation and Recovery Act of 1976* (RCRA). The following five key elements will support the final decisions:

This report is designed to meet the following objectives for the reporting period:

- ***Provide a comprehensive report of groundwater conditions on the Hanford Site***
- ***Fulfill the reporting requirements of RCRA, CERCLA, AEA, and Washington Administrative Code***
- ***Fulfill reporting requirements for monitoring of interim remedial actions conducted under CERCLA***
- ***Describe the results of monitoring the vadose zone***
- ***Summarize the installation, maintenance, and decommissioning of Hanford Site monitoring wells.***

- Gather sufficient characterization data, focusing on waste sites with deep contamination that pose a future risk to groundwater
- Evaluate the performance of early actions (waste site remediation along the River Corridor and groundwater interim actions) to help guide future cleanup
- Identify cleanup goals for waste sites that support long-term groundwater remediation
- Identify new technologies to reduce the mobility of deep contamination and limit its movement to groundwater
- Improve integration of cleanup decisions for waste sites and groundwater.

Attain final cleanup. The DOE, EPA, and Ecology are committed to complete cleanup of past-practice waste sites at the Hanford Site by September 2024. Substantial progress has been made toward cleanup of the 100 and 300 Areas. Strategies used for making final decisions in the 100 and 300 Areas will provide a basis for attaining similar final decisions for the 200 Areas.

Groundwater monitoring fulfills a variety of state and federal regulations, including the *Atomic Energy Act of 1954* (AEA), RCRA, CERCLA, and various sections of the *Washington Administrative Code* (WAC).

1.1 Purpose and Scope

This report presents the results of groundwater monitoring to meet the requirements of the AEA, RCRA, and CERCLA (Table 1-1), and it also summarizes vadose zone monitoring and well installation activities. The report covers the period from October 1, 2008, through December 31, 2009. The reason that this report covers a 15-month period is the result of moving from a fiscal year (FY) reporting period (October 1 to September 31) to a calendar year (CY) reporting period (January 1 to December 31). This change is being made so all groundwater information (i.e., pump-and-treat, RCRA, CERCLA, and AEA) can be presented in a single report. As a result of this change, the following date conventions are used throughout this report:

- FY 2009: Refers to the fiscal year named (i.e., October 1, 2008, to September 30, 2009).
- CY 2009: Refers to the calendar year named (i.e., January 1, 2009, to December 31, 2009).
- Reporting period: Refers to the entire 15-month reporting period covered for this report (i.e., October 1, 2008, to December 31 2009).

This report marks the first time that all groundwater monitoring information is presented in one report. The CERCLA remediation activities (e.g., pump-and-treat operations) previously presented in separate reports have been incorporated into this report. As a result of the increased amount of information provided, the report has been divided into two volumes. Volume 1 includes the groundwater activities and monitoring associated with the Central Plateau. For the purposes of this report, the Central Plateau includes the 200 East and 200 West Areas, off-river sites (400 Area), and the surrounding non-operational area (600 Area). Volume 2 discusses those portions of the Hanford Site adjacent to the Columbia River, referred to as the River Corridor. For the purposes of this report, the River Corridor includes the 100 Areas, 300 Area, and the 1100-EM-1 groundwater interest area (Figure 1-2). The portion

of the River Corridor north of the 300 Area and south of the 100-F Area is described in Volume 1 of this report as part of the 200-PO-1 Operable Unit (OU).

Appendix A includes supporting information for CERCLA monitoring, and Appendix B presents CERCLA cost information for the OUs with active groundwater remediation. Appendix C contains tables and figures that support RCRA and other facility monitoring. Appendix D provides the supporting information for the aquifer tube sampling. The quality assurance and quality control results and issues for the reporting period are included in Appendix E.

Background information, including descriptions of regulatory requirements, waste sites, analytical methods, regional geology, and statistics is provided separately in *Hanford Site Groundwater: Settings, Sources, and Methods* (PNNL-13080), with the most recent update provided in Appendix C of *Hanford Site Groundwater Monitoring for Fiscal Year 2001* (PNNL-13788). Some background information is summarized in this report for completeness.

1.2 Groundwater Monitoring

During the reporting period, staff sampled 922 wells and 326 aquifer tubes for radiological and chemical constituents.

To streamline cleanup, Hanford waste sites are grouped into source OUs (i.e., sites that received waste from the same or similar source[s]). Because groundwater at a given location may be impacted by multiple waste sites, it is divided into groundwater OUs that do not necessarily coincide with the waste site OUs. The concept of OUs is to group waste sites with similar characteristics/sources into manageable components for investigation and to allow for better prioritization of cleanup work. The defined groundwater OUs do not cover the entire Hanford Site (Figure 1-2). Groundwater staff has defined informal groundwater interest areas (which include the groundwater OUs and the intervening regions) to provide scheduling, data review, and data interpretation for the entire site. Figure 1-2 also illustrates the relationship between the interest areas and the OU boundaries.

Various documents (i.e., monitoring plans or sampling and analysis plans) define the wells to be sampled, sampling frequency, and constituents to be analyzed. These choices are based on the data needs for various monitoring purposes, such as complying with regulations, evaluating the performance of remediation activities, defining plumes and concentration trends, or identifying emerging problems.

During the reporting period, Hanford Site staff sampled 922 wells, approximately 10% more than in FY 2008. Staff sampled 326 aquifer tubes during the same period, approximately the same as sampled in FY 2008. Many of the sites were sampled multiple times, for a total of 5,307 sampling trips. These numbers include routine groundwater sampling associated with remediation activities.

Most of the monitoring wells on the Hanford Site are screened near the top of the unconfined aquifer. Data from the limited number of wells screened deeper in the unconfined aquifer suggest that, in most regions, the shallow portion of the aquifer is the most contaminated. Contaminant plume maps and plume area calculations in this report are based on data from the top of the aquifer. Some contaminants, most notably carbon tetrachloride, are more dense than water and can be more widespread deeper in the aquifer. Historical downward hydraulic gradients may also have increased the contamination at depth in some areas. Studies of contaminant distribution with depth have begun to be conducted for some plumes, particularly in the 200 West Area.

Chromium (total or hexavalent) was the most frequently analyzed constituent. Anions, tritium, iodine-129, metals, technetium-99, strontium-90, and volatile organic compounds were other commonly analyzed constituents (Table 1-2).

Tritium, nitrate, and iodine-129 are the most widespread contaminants on the Hanford Site.

Tritium, nitrate, and iodine-129 are the most widespread contaminants associated with past Hanford Site operations. Figures 1-3 through 1-5 depict the distributions of these contaminants in the upper unconfined aquifer. The most prominent portions of these plumes originated at waste sites in the 200 Areas and spread toward the southeast. Nitrate and tritium also had significant sources in the 100 Areas.

Table 1-3 lists the maximum concentrations of selected groundwater contaminants in each groundwater interest area. Electronic data files accompanying this report are included for the reporting period and historical data.

Groundwater monitoring objectives of RCRA, CERCLA, and AEA often differ slightly, and the contaminants monitored are not always the same. For RCRA-regulated units, monitoring focuses on non-radioactive dangerous waste constituents. While radionuclides (source, special nuclear, and byproduct materials) may be monitored in some RCRA unit wells to support objectives of monitoring under AEA and/or CERCLA, they are not subject to RCRA regulation. Pursuant to RCRA, the source, special nuclear, and byproduct material components of radioactive mixed waste are not regulated under RCRA but are instead regulated by DOE, acting pursuant to its AEA authority. Therefore, while this report is used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

1.3 Shoreline Monitoring

Monitoring groundwater quality along the Columbia River is accomplished by collecting samples from aquifer tubes and riverbank springs.

The DOE monitors groundwater quality along the Columbia River by collecting samples from aquifer tubes and riverbank seeps (springs). In 2009, DOE studied and collected porewater from within the gravel and sand of the Columbia River bed to define where groundwater is discharging to the river.

Hydrologists estimate that groundwater currently flows from the Hanford Site unconfined aquifer to the Columbia River at a rate between 1.1 and 2.5 cubic meters per second (PNNL-13447, *Transient Inverse Calibration of Hanford Site-Wide Groundwater Model to Hanford, Operational Impacts – 1943 to 1996*; PNNL-14753, *Groundwater Data Package for the 2004 Composite Analysis*). This rate is less than 0.074% of the average flow of the Columbia River, ~3,400 cubic meters per second.

The rise and fall of the Columbia River create a zone of interaction that influences contaminant concentrations and groundwater flow patterns. Water samples from aquifer tubes and riverbank seeps nearly always represent a mixture of river water and approaching groundwater. In general, the degree of dilution by river water decreases with depth in the aquifer near the river shoreline. The degree of dilution also varies by location and with seasonal river cycles (PNNL-13674, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River*).

Data from aquifer tubes and seeps are used for the following purposes:

- In mapping, data indicate minimum concentrations of contaminants in groundwater approaching the Columbia River (because the samples may be mixed with river water, actual concentrations in groundwater may be higher). However, if a group of aquifer tubes routinely shows no contamination, it is likely that the groundwater near the river is clean.
- Long-term declines in contamination in aquifer tubes or seeps may indicate a real trend in groundwater. The decline could represent movement of the plume, dispersion, or the influence of an upgradient remediation system.

Increasing concentrations may indicate plume movement, mobilization of contaminants, or breakthrough at an upgradient remediation system.

- Data from aquifer tubes have helped determine where additional monitoring and remediation are needed (e.g., aquifer tube data provided the first indication of the southern chromium plume in the 100-D Area).

Interpreters of these data must keep in mind the following limitations:

- Concentrations in aquifer tubes and seeps may vary seasonally (the same is true for near-river wells).
- Though dilution of contaminants by mixing with river can result in lower concentrations the amount (mass) of that contaminant is not decreased.
- Because aquifer tubes have much shorter screens than monitoring wells, the data may not be directly comparable to data from near-river wells.
- Aquifer tube and seep data currently are not used in remedial action decision making (i.e., are not compliance points for pump-and-treat systems).

Aquifer tubes are small-diameter, flexible tubes that have a screen on one end. The tubes are installed in the aquifer along the Columbia River shore by driving a temporary steel casing into the ground, clearing the casing of material, and inserting the screened end of a tube into the casing. The steel casing is then pulled out, leaving the tube in place. Water is withdrawn from the tube using a small suction pump. Most aquifer tube sites include a cluster of two or three individual tubes monitoring different depths, from ~1 to 8 meters.

Representatives from EPA and Ecology meet annually with DOE and its contractors to plan the annual aquifer tube sampling event, which usually occurs during the fall months (DOE/RL-2000-59, *Sampling and Analysis Plan for Aquifer Sampling Tubes*). The individual OU sections of this report summarize aquifer tube results and include location maps. Appendix D provides supporting information for the aquifer tube sampling.

Table 1-3 lists the maximum contaminant levels in aquifer tubes sampled during the reporting period. Section 5.2 in Volume 1 (200-PO-1 OU) and several sections in Volume 2 (River Corridor) present the results for aquifer tube monitoring.

1.4 Compliance Summary for CERCLA Operable Units

This section provides a brief status of compliance for each of the Hanford groundwater OUs. The OU discussions are presented in the order in which they appear in this report.

1.4.1 200-BP-5 Operable Unit

The CERCLA monitoring requirements for the 200-BP-5 OU are derived from the *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit* (DOE/RL-2001-49, Rev. 1). During the reporting period, all but 3 of the 105 wells scheduled were successfully sampled. In addition, several documents were released during the reporting period to document the remedial investigation activities completed during FY 2008. Details of the 200-BP-5 CERCLA groundwater monitoring activities for the reporting period are provided in Volume 1, Section 4.3. The data from the remedial investigation will be summarized into a draft remedial investigation report due in FY 2011. No milestone is associated with this report. *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) Milestone M-15-21A requires submittal of a combined 200-BP-5/200-PO-1 Draft A feasibility study and proposed plan by December 31, 2012.

1.4.2 200-PO-1 Operable Unit

Groundwater monitoring at the 200-PO-1 OU supports the remedial investigation/feasibility study process under the direction of *Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2007-31) and two sampling and analysis plans. One sampling and analysis plan covers routine groundwater sampling (DOE/RL-2003-04, *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit* [referred to as the "routine" sampling and analysis plan]) and the other covers short-term characterization to supplement routine groundwater monitoring (Appendix A of DOE/RL-2007-31 [referred to as the "characterization" sampling and analysis plan]). Details of the 200-PO-1 CERCLA groundwater monitoring activities for the reporting period are provided in Volume 1, Section 5.3.

Although 130 wells are listed in the routine sampling and analysis plan, only 83 wells were scheduled and sampled during the reporting period. The remaining wells are sampled only once every 3 years (triennially) and will be sampled again in 2010. Eighty-five wells were scheduled for sampling in the characterization sampling and analysis plan, including 43 active wells and 42 retired wells that were identified for decommissioning. Of the 43 active wells scheduled for sampling, 41 wells were sampled successfully. Twenty-five of the wells scheduled for decommissioning were sampled successfully. Failure to sample some of the characterization wells was due to a variety of reasons, including wellhead damage, access problems, and dry wells.

1.4.3 200-UP-1 Operable Unit

The CERCLA activities for the 200-UP-1 OU during the reporting period included preparing a remedial investigation/feasibility study, operating an interim remedial action pump-and-treat system, and long-term groundwater monitoring. The remedial investigation and long-term monitoring are governed by the *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76). The work plan contains the groundwater monitoring plan for the OU, which specifies the wells to be sampled, analytes, and sample frequency. Details of the 200-UP-1 CERCLA groundwater monitoring activities for this reporting period are provided in Section 6.3 of Volume 1.

During the reporting period, all wells were sampled as planned with the following exceptions: extraction wells 299-W19-36 and 299-W19-43 were missed once due to an outage of the pump-and-treat system, one sample from 299-W23-21 was delayed until early 2010, and well 299-W22-20 went dry. Data collection for the remedial investigation was deemed complete in February 2009, and preparation of the remedial investigation/feasibility study and a proposed plan is in progress. These reports have a Tri-Party Agreement milestone due date of September 30, 2010.

Operation of the pump-and-treat system is governed by the *Record of Decision for the 200-UP-1 Interim Remedial Measure* (EPA/ROD/R10-97/048). During the reporting period, an *Explanation of Significant Differences for the Interim Record of Decision for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Washington* (EPA et al. 2009) was issued, which modified the remedial action objectives, most notably by reducing the uranium remedial action objective, of ten times the drinking water standard (DWS), from 480 µg/L to 300 µg/L, to reflect the revised uranium DWS and removing the 189 liter per minute performance objective. The explanation of significant difference also formalized the requirement for extended purging during quarterly sampling of well 299-W23-19 at the SX Tank Farm. A draft,

revised *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE/RL-97-36, Rev. 3) was prepared to address these changes. This document also included a design for a pump-and-treat system targeting the technetium-99 plumes at the S and SX Tank Farms with treatment anticipated to occur at the 200 West Area treatment facility. The final work plan was published in January 2010.

1.4.4 200-ZP-1 Operable Unit

The CERCLA groundwater performance monitoring and interim remedial measures at the 200-ZP-1 OU are outlined in the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA/ROD/R10-95/114) and are implemented through the *200-ZP-1 Interim Remedial Measure Remedial Design Report* (DOE/RL-96-07) and the *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE/RL-2002-17). Details of the 200-ZP-1 CERCLA groundwater monitoring activities for the reporting period are provided in Volume 1, Section 7.3.

The primary contaminants of concern identified in the interim Record of Decision are carbon tetrachloride, chloroform, and trichloroethene. Remediation of elevated technetium-99 at wells east of Waste Management Area (WMA) T prompted interim remedial activity in accordance with EPA/ROD/R10-95/114 and the data quality objectives process (WMP-28389, *T-Area Technetium-99 Data Quality Objectives Summary Report*). Remediation activities require removing contaminants from the high concentration areas (greater than 2,000 µg /L) for carbon tetrachloride and reducing concentrations to the DWS of 900 pCi/L for technetium-99. The primary means to achieve remedial targets is through withdrawing groundwater and removing contaminant mass at pump-and-treat networks. During CY 2009, carbon tetrachloride was reduced in areas of highest concentration from 2,800 µg/L in FY 2008 to 2,200 µg /L during CY 2009. Technetium-99 concentrations that once exceeded 113,000 pCi/L have declined from 8,600 pCi/L to 4,600 pCi/L at extraction wells during CY 2009.

The design, installation, and operation of the remedial action monitoring network and treatment system is discussed in *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78), which was issued during the reporting period. Additional tasks performed during the reporting period to support the final Record of Decision (*Declaration of the Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* [EPA et al. 2008], issued in September 2008) included installing 9 of 21 extraction/injection wells to support the groundwater treatment facility and reaching 90% completion on the balance of design for the new groundwater treatment facility. Aquifer testing was performed at well 299-W15-225 to evaluate hydraulic properties and drawdown extent to support numerical modeling and extraction/injection well network design.

1.4.5 100-BC-5 Operable Unit

The CERCLA monitoring requirements for the 100-BC-5 OU are driven by the *100-BC-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-38) and Tri-Party Agreement change notices TPA-CN-240 and TPA-CN-293. All wells were sampled as scheduled during the reporting period. Details of the CERCLA groundwater monitoring activities for the 100-BC-5 OU are provided in Section 13.3 of Volume 2.

The DOE submitted Draft A of the CERCLA *Integrated 100 Area Remedial Investigation Study/Work Plan, Addendum 3: 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units* (DOE/RL-2008-46-ADD3) (Tri-Party Agreement Milestone M-15-67)

by the due date of September 30, 2009. The addendum and the associated sampling and analysis plan were finalized and approved by DOE and EPA on March 23, 2010.

1.4.6 100-KR-4 Operable Unit

The CERCLA activities for the 100-KR-4 OU are conducted in accordance with the requirements presented in the *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units* (EPA/ROD/R10-96/134). The interim Record of Decision focused on remediating hexavalent chromium in the groundwater associated with reactor operations using ion-exchange pump-and-treat systems, as discussed in the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action* (DOE/RL-96-84). Treatment has been expanded through the addition of two additional ion-exchange systems, KW and KX, described in *The KW Pump and Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action* (DOE/RL-2006-52, Rev. 2) and the *Supplement to the 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump and Treat System* (DOE/RL-2006-75, Rev. 1 Reissue), respectively. Details of the CERCLA groundwater monitoring activities for the 100-KR-4 OU are provided in Section 14.3 of Volume 2.

Hexavalent chromium is the contaminant of concern, with tritium and strontium-90 the contaminants of potential concern. Carbon-14, nitrate, technetium-99, and trichloroethene are considered to be target analytes (i.e., potential contaminants that may impact the final Record of Decision) and are tracked via routine sampling. Remediation activities are required to remove hexavalent chromium to concentrations of 20 µg/L or less near the Columbia River, which is a concentration that would meet the 10 µg/L ambient water quality standard set for aquatic life in the Columbia River. In addition, protection of human health will be achieved by reducing groundwater concentrations to the DWS for hexavalent chromium.

Pump-and-treat remediation activities have reduced the number of locations at which near-shore concentrations of hexavalent chromium exceeds 20 µg/L. Near-river concentrations ranged from non-detect (2 µg/L) to 64.1 µg/L. The plumes were reduced by 96.7 kilograms while treating 1.33 billion liters of groundwater. To date, 474.4 kilograms of chromium have been removed while treating 6.76 billion liters of water since 1997. Plume areas have expanded somewhat as decreases in known plume configurations are offset at recently drilled wells where hexavalent chromium has exceeded 20 µg/L.

1.4.7 100-NR-2 Operable Unit

The CERCLA monitoring requirements for the 100-NR-2 OU are driven by two documents: the *Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit* (DOE/RL-2001-27) (and associated Tri-Party Agreement change notices) for the interim action monitoring program, and *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater Operable Unit* (DOE/RL-2005-96) (and associated Tri-Party Agreement change notices) for the apatite permeable reactive barrier. An integrated monitoring plan combining all monitoring programs is being reviewed by the regulatory agencies at this time. Details of the 100-NR-2 CERCLA groundwater monitoring activities for the reporting period are provided in Section 15.3 of Volume 2.

The sampling schedules dictated by DOE/RL-2001-27 and DOE/RL-2005-96 were met, with two exceptions: (1) one well could not be sampled for interim action monitoring due to excavation activities, and (2) shallow (Hanford formation) apatite

permeable reactive barrier wells can only be sampled when the river level is high. Both of these wells were sampled once during the four quarters of the reporting period.

1.4.8 100-HR-3 Operable Unit

Three CERCLA interim action remedies are currently operating in the 100-HR-3 OU. These include the original 100-HR-3 pump-and-treat system in the 100-H Area (which treats groundwater from both the 100-D and 100-H Areas), the DR-5 pump-and-treat system in the 100-D Area, and the In Situ Redox Manipulation (ISRM) barrier also in the 100-D Area. Details of the 100-HR-3 CERCLA groundwater monitoring activities for the reporting period are provided in Volume 2, Section 16.3.

The monitoring requirements for the 100-HR-3 pump-and-treat system are specified in the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90). Long-term monitoring requirements in the 100-D Area have been modified (expanded) from *Sampling Changes to the 100-HR-3 and 100-KR-4 Operable Units* (Waneck 1998). There are currently no compliance wells for the DR-5 pump-and-treat system; however, the system is monitored on a regular basis. All data collection requirements for the pump-and-treat systems were met during the reporting period.

Hexavalent chromium concentrations in several compliance wells for the 100-HR-3 pump-and-treat system were above the 22 µg/L remedial action goal in both the 100-D and 100-H Area. Remedial process optimization is being conducted for the 100-HR-3 OU to provide additional treatment capacity and enhanced remediation. A new pump-and-treat facility (referred to as the DX facility) will expand the treatment capacity in the 100-D Area to 2,271 liters per minute, while a new pump-and-treat facility in the 100-H Area (referred to as the HX facility) will expand the treatment capacity there to 2,650 liters per minute and will optimize remedial efficiency.

Remedial action monitoring for the ISRM barrier is described in the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation* (DOE/RL-99-51). All wells were sampled as scheduled for the ISRM barrier. Overall, the ISRM barrier continues to help reduce hexavalent chromium in the aquifer; however, during periods of low river flow, hexavalent chromium values above the remedial action goal are observed in some wells. With the addition of the new DX pump-and-treat system (scheduled for startup in FY 2011), the intent is to reduce the contaminant load impinging on the barrier, as well as to capture and treat any remaining downgradient hexavalent chromium.

The DOE submitted Draft A of the CERCLA *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2008-46-ADD1) (Tri-Party Agreement Milestone M-15-69) by the due date of May 31, 2009. The addendum and its associated sampling and analysis plan were finalized and approved by DOE and Ecology on March 25, 2010. The remedial investigation/feasibility study report will address the data and information needed to support selection of a final remedy for the 100-D and 100-H Areas. The DOE will finalize the remedial investigation/feasibility study report and issue a proposed plan detailing the proposed final remedy by the Tri-Party Agreement milestone date of July 31, 2011.

1.4.9 100-FR-3 Operable Unit

The CERCLA monitoring requirements for the 100-FR-3 OU are driven by the *100-FR-3 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-49) and TPA-CN-241. All wells were sampled as scheduled during the reporting period.

Details of the 100-FR-3 CERCLA groundwater monitoring activities are provided in Section 17.3 of Volume 2.

The DOE submitted Draft A of the CERCLA *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 4: 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (DOE/RL-2008-46-ADD4) (Tri-Party Agreement Milestone M-15-67) by the due date of September 30, 2009. The addendum and its associated sampling and analysis plan were finalized and approved by DOE and EPA on April 12, 2010.

1.4.10 300-FF-5 Operable Unit

The 300-FF-5 OU is in the later stages of the remedial investigation/feasibility study process. Current activities are directed at assembling information to support decisions for final remedial actions involving groundwater (DOE/RL-2009-30, *300 Area Decision Unit Remedial Investigation/Feasibility Study Work Plan*). The principal contaminant of concern is uranium in the 300 Area, although additional waste indicators also exceed regulatory standards for groundwater in the 300 Area and in two outlying subregions containing the 618-10 and 618-11 Burial Grounds. Details of the 300-FF-5 CERCLA groundwater monitoring activities for the reporting period are provided in Section 18.3 of Volume 2.

While the remedial investigation/feasibility study process continues, groundwater is monitored under an operation and maintenance plan, which describes the strategy for monitoring and characterization activities during the period of interim remedial action (DOE/RL-95-73, Rev. 1). The *300-FF-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2002-11) implements the groundwater monitoring requirements. The period of interim action is governed by the *Declaration of the Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-96/143), which was prepared in 1996 and expanded geographically in 2000 to include the two outlying subregions (EPA/ESD/R10-00/524, *EPA Superfund Explanation of Significant Differences: Hanford 300-Area [USDOE]*). Remedial actions during the interim period involve continued monitoring of groundwater and institutional controls to restrict the use of groundwater. These activities are deemed appropriate while other actions are underway to remediate waste disposal sites, unplanned release sites, and former 300 Area facilities.

Significant activities contributing to the remedial investigation/feasibility study are underway in the 300 Area, including drilling at eleven locations, with the primary objective of characterizing the contamination remaining in the vadose zone and unconfined aquifer. Field testing is in progress using potential technologies to remediate uranium contamination in the subsurface. Groundwater monitoring via wells and river shoreline aquifer tubes is providing data used to evaluate the nature and extent of contamination, contaminant concentration trends, and associated risk. The DOE's Office of Science also supports detailed research on the mobility characteristics of uranium beneath the 300 Area, as well as on the groundwater pathway leading to discharge into the Columbia River. Completion of the remedial investigation/feasibility study process and submittal of a proposed plan for final remedial action have a Tri-Party Agreement milestone due date of December 31, 2012.

1.4.11 1100-EM-1 Operable Unit

The 1100-EM-1 OU, including the inactive Horn Rapids Landfill, was delisted from the National Priorities List in 1996 and is therefore no longer considered an active CERCLA site. The results of the CERCLA investigation for the

1100-EM-1 OU are presented in the *Draft Remedial Investigation/Feasibility Study for the 1100-EM-1 Operable Unit, Hanford* (DOE/RL-92-67) and the *Declaration of the Record of Decision for the 1100 Area* (EPA/ROD/R10-93/063). Details of the 1100-EM-1 OU groundwater monitoring activities for the reporting period are provided in Section 19.3 of Volume 2.

The selected remedy for groundwater, which consists of monitored natural attenuation of volatile organic compounds with institutional controls on drilling of new water supply wells, continues to be successful. Monitoring includes analysis of trichloroethene and its breakdown products (e.g., vinyl chloride and 1,1-dichloroethene), as well as nitrate in wells downgradient of the Horn Rapids Landfill, as recommended in the *Sampling and Analysis Plan Update for Groundwater Monitoring – 1100-EM-1 Operable Unit* (PNNL-12220). Concentrations of trichloroethene remained below the 5 µg/L DWS, and trichloroethene and its breakdown products were all near or below the detection limits.

1.5 Compliance Summary for Regulated Facilities

The groundwater monitoring requirements for the Hanford Site's RCRA units fall into one of two broad categories: interim status or final status. A permitted RCRA unit requires final status monitoring, as specified in WAC 173-303-645, "Dangerous Waste Regulations; Releases from Regulated Units." The RCRA units not currently incorporated into a permit require interim status monitoring, as specified in WAC 173-303-400, "Dangerous Waste Regulations; Interim Status Facility Standards" (based on 40 *Code of Federal Regulations* [CFR] 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities").

Under the two broad categories noted above, RCRA groundwater monitoring is conducted under one of three possible phases:

- ***Contaminant indicator evaluation (or final status detection).*** Any interim status facility subject to RCRA regulations initially implements a contamination indicator evaluation monitoring program. This program uses groundwater data from specified indicator parameters to determine and monitor the impact of the facility, if any, on groundwater. A contamination indicator evaluation monitoring program started under interim status continues until a permit is issued or until monitoring results indicate a statistically significant change in one of the specified indicator parameters. A facility operating permit will include requirements for the final status detection monitoring program. Determination of a statistically significant change is made by comparing the concentrations of the specified indicator parameters in downgradient wells to a critical mean that is statistically derived from the upgradient wells. If a statistically significant change in the specified indicator parameters is confirmed, then the facility is required to move to the second phase of monitoring.
- ***Groundwater quality assessment (or final status compliance).*** When contamination indicator evaluation (or final status detection) monitoring data confirm a statistically significant change in specified indicator parameters, then a groundwater quality assessment or compliance phase monitoring program is implemented. Unlike the contamination indicator evaluation programs, where any potential impact from the facility is being monitored, a groundwater quality assessment/compliance program has confirmed that an impact to groundwater has occurred. Therefore, the objectives under the groundwater quality assessment/

compliance program change from looking for a problem to assessing the nature and extent of the problem.

- ***Corrective action (via administrative order for interim and final status sites.*** This phase of RCRA groundwater monitoring occurs if the source of the contamination is determined to be the RCRA unit and contaminant concentrations exceed applicable limits. If this occurs, Ecology may then require corrective action. A corrective action is implemented if groundwater contamination is determined to be an imminent threat to human health or the environment. A corrective action may also be implemented if it is clear that the cause of the contamination can be easily and rapidly contained. Groundwater is monitored to determine if the corrective action is effective.

Table 1-4 lists the status of RCRA facility monitoring for each unit during the reporting period. The following discussion presents a compliance summary for these regulated facilities.

1.5.1 Low-Level Waste Management Area 1

Low-Level Waste Management Area 1 (LLWMA-1) continued in interim status contaminant indicator evaluation monitoring in accordance with 40 CFR 265.93(b) ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; Preparation, Evaluation, and Response"), as referenced by WAC 173-303-400 ("Dangerous Waste Regulations; Interim Status Facility Standards)" throughout the reporting period. During the reporting period, specific conductance remained above the critical mean in wells 299-E32-10 and 299-E33-34. The high specific conductance is not related to a release from LLWMA-1. All of the wells were successfully sampled during the reporting period, with the exception of the December 2008 sampling of well 299-E28-27. The monitoring well network is considered adequate for determining groundwater quality downgradient of the site and for performing the required statistical comparisons. A summary of the LLWMA-1 groundwater monitoring activities for the reporting period is provided in Section 4.4.1 of Volume 1.

1.5.2 Low-Level Waste Management Area 2

The LLWMA-2 continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. During the reporting period, three of the indicator parameters (i.e., pH, total organic halides, and specific conductance) were consistent with previous results and did not exceed critical means. Total organic carbon was reported in well 299-E34-2 in October 2009 at an average concentration of 3,848 µg/L, which was above the critical mean value of 3,036 µg/L. This was the first time that total organic carbon had ever been reported above the critical mean in this well. The value reported is also inconsistent with previous results. Verification samples were collected in January 2010 to determine if there was a possible reporting error or laboratory contamination issue. The eight total organic carbon validation results were all non-detect, which is consistent with previous results. All wells were successfully sampled during this reporting period. The monitoring well network is considered adequate for performing the required statistical comparisons. A low-gradient study is currently being conducted with the goal of better defining groundwater flow direction in the area. A summary of the LLWMA-2 groundwater monitoring activities for the reporting period is provided in Volume 1, Section 4.4.2.

1.5.3 Waste Management Area B-BX-BY

Waste Management Area (WMA) B-BX-BY continued under an interim status groundwater assessment program during the reporting period. The primary dangerous waste constituent found beneath WMA B-BX-BY is cyanide. It is important to note that the cyanide found beneath WMA B-BX-BY did not originate from the WMA, but rather from an adjacent non-RCRA waste site. Nitrate is monitored as a major supporting constituent. Certain non-RCRA-regulated constituents (i.e., sulfate and radionuclides) are also found within the boundaries of the WMA (DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*). These constituents are attributed to multiple facilities, including WMA B-BX-BY and the surrounding cribs. Contaminant levels in network monitoring wells continued general increasing trends during the reporting period, with nitrate, sulfate, and uranium above their respective DWSs in wells monitoring the tank farms. The current network, including the five new wells, will remain adequate for monitoring extent and concentration of contaminants throughout 2010. A summary of the WMA B-BX-BY groundwater monitoring activities for the reporting period is provided in Section 4.4.3 of Volume 1.

1.5.4 Waste Management Area C

The WMA C began the reporting period under interim status contamination indicator monitoring requirements in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. In July 2009, the indicator parameter specific conductance was verified to have exceeded the critical mean. As a result, a groundwater quality assessment plan was prepared and reviewed by Ecology, and assessment monitoring requirements were initiated in December 2009. The current assessment plan for WMA C (DOE/RL-2009-77, *Interim Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Area C*) calls for installation of two new wells to assess groundwater both northwest and south of well 299-E27-14, where specific conductance exceeding the critical mean occurred. A summary of the WMA C groundwater monitoring activities for the reporting period is provided in Volume 1, Section 4.4.4.

1.5.5 Liquid Effluent Retention Facility

The Liquid Effluent Retention Facility (LERF) operates under final status permit conditions agreed to by DOE and Ecology. Analysis of samples collected during the reporting period indicate that all constituents in the permit were either undetected or were below DWSs. All four of the wells at the LERF were sampled as required and remain adequate for continued monitoring in CY 2010. A summary of the LERF groundwater monitoring activities for the reporting period is provided in Section 4.4.5 of Volume 1.

1.5.6 216-B-63 Trench

The 216-B-63 Trench continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. The monitoring well network is sufficient for determining groundwater quality downgradient of the site and for performing required statistical comparisons. To date, the required statistical evaluations of the RCRA contamination indicator parameters have not exceeded critical mean values, and do not indicate that the 216-B-63 Trench has affected groundwater quality in the uppermost aquifer beneath the unit. A summary of the 216-B-63 Trench groundwater monitoring activities for the reporting period is provided in Volume 1, Section 4.4.6.

1.5.7 Integrated Disposal Facility

The Integrated Disposal Facility is an expandable, lined, RCRA-compliant landfill. The objective of RCRA and operational monitoring is to determine whether the facility has impacted groundwater quality. The facility is not yet operational, and the current monitoring is directed at obtaining baseline values for monitored constituents. A summary of the Integrated Disposal Facility groundwater monitoring activities for the reporting period is provided in Section 5.4.1 of Volume 1.

1.5.8 RCRA PUREX Cribs

The RCRA Plutonium-Uranium Extraction (PUREX) Cribs remained in interim status groundwater quality assessment monitoring, in accordance with 40 CFR 265.93(d), as referenced by WAC 173-303-400. The non-RCRA constituent nitrate remained above the DWS during the reporting period. During the reporting period, groundwater flow direction was re-evaluated. It was concluded that the flow direction has changed from southwest to south or southeast near the 216-A-37-1 Crib since the B Pond ceased operations. A revised groundwater monitoring plan will identify a new upgradient well based on flow direction changes. A summary of the groundwater monitoring activities for the reporting period at the PUREX Cribs is provided in Volume 1, Section 5.4.2.

1.5.9 Waste Management Area A-AX

The WMA A-AX also remained in interim status groundwater assessment monitoring in accordance with 40 CFR 265.93(d), as referenced by WAC 173-303-400. During the reporting period, the supporting constituent nitrate continued to exhibit higher concentrations at one or more downgradient wells than in upgradient wells. With the installation of well 299-E25-236 in 2008, the groundwater monitoring well network is considered sufficient for determining groundwater quality downgradient of the site and for performing the required statistical comparisons. The locations of the current wells are appropriately oriented with respect to the southeast groundwater flow direction. A summary of the WMA A-AX groundwater monitoring activities for the reporting period is provided in Section 5.4.3 of Volume 1.

1.5.10 216-A-29 Ditch

The 216-A-29 Ditch continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. Required statistical evaluations of the specified indicator parameters continue to show specific conductance above the critical mean in three wells. The elevated specific conductance is from a source other than the 216-A-29 Ditch, as documented in *Results of Groundwater Quality Assessment Program at the 216-A-29 Ditch RCRA Facility* (WHC-SD-EN-EV-032). To date, no dangerous waste/dangerous waste constituent subject to WAC 173-303 regulations has affected groundwater quality in the uppermost aquifer beneath the 216-A-29 Ditch. The monitoring well network is sufficient for determining groundwater quality downgradient of the site and for performing the required statistical comparisons. A summary of the groundwater monitoring activities for the reporting period at the 216-A-29 Ditch is provided in Section 5.4.4 of Volume 1.

1.5.11 216-B-3 Pond

The 216-B-3 Pond continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. To date, the required statistical evaluations of the specified indicator parameters have not exceeded critical mean values and do not

indicate that the 216-B-3 Pond has affected the groundwater quality in the uppermost aquifer beneath the unit. The monitoring well network continues to be sufficient for determining groundwater quality downgradient of the site and for performing required statistical comparisons. A summary of the 216-B-3 Pond groundwater monitoring activities for the reporting period is provided in Section 5.4.5 of Volume 1.

1.5.12 Nonradioactive Dangerous Waste Landfill

During the reporting period, the first determination assessment plan was being implemented at the Nonradioactive Dangerous Waste Landfill (NRDWL) due to the critical mean exceedance for total organic carbon in 2008 (PNNL-12227, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill*). The first determination assessment monitoring program showed that elevated total organic carbon was not due to dangerous waste constituents associated with the NRDWL. Therefore, the NRDWL will revert to in an interim status indicator parameter evaluation program. A summary of the NRDWL groundwater monitoring activities for the reporting period is provided in Volume 1, Section 5.4.6.

1.5.13 Solid Waste Landfill

The Solid Waste Landfill (SWL), located south of the NRDWL, is regulated by Ecology under WAC 173-350, "Solid Waste Handling Standards." The WAC 173-350 constituents and site-specific constituents (including volatile organic compounds and filtered arsenic) are analyzed quarterly in groundwater samples collected in accordance with the *Groundwater Monitoring Plan for the Solid Waste Landfill* (PNNL-13014). Compliance is determined by comparing sampling results from downgradient wells with statistically derived background threshold values from upgradient wells. Most constituents were below their respective compliance limits. However, some downgradient wells continue to show chemical oxygen demand, coliform bacteria, specific conductance, and sulfate above compliance limits, and pH below the compliance limit. Soil vapor analysis shows elevated levels of carbon dioxide. A summary of the groundwater monitoring activities for the reporting period at the SWL is provided in Section 5.4.7 of Volume 1.

1.5.14 200 Areas Treated Effluent Disposal Facility

The 200 Areas Treated Effluent Disposal Facility is monitored under *State Waste Discharge Permit ST 4502* (Ecology 2000b), WAC 173-216 ("State Waste Discharge Permit Program"), and *Groundwater Monitoring Plan for the Hanford Site 200 Area Treated Effluent Disposal Facility* (PNNL-13032). The wells are monitored for three constituents with enforcement limits (i.e., lead at 5 µg/L, cadmium at 10 µg/L, and pH of 6.5 to 8.5) as required by the state waste discharge permit, and the indicator parameters (i.e., specific conductance, gross alpha and beta, anions, metals, total dissolved solids, trace metals, and tritium). During the reporting period, all groundwater samples were collected as scheduled, and none of the enforcement limits were exceeded. A summary of the groundwater monitoring activities for the reporting period at the 200 Areas Treated Effluent Disposal Facility is provided in Volume 1, Section 5.4.8.

1.5.15 Waste Management Area S-SX

The WMA S-SX remained in interim status groundwater quality assessment monitoring in accordance with 40 CFR 265.93(d), as referenced by WAC 173-303-400. The RCRA constituent chromium and supporting constituent nitrate remained above their respective DWSs during the reporting period. The well network is adequate for monitoring the distribution of contamination, with the exception of the southern extent of the plume from the SX Tank Farm. A new monitoring well is planned

for installation in 2010, ~50 meters south of well 299-W22-47, with the goal of determining the southern extent of the plume. A summary of the WMA S-SX groundwater monitoring activities for the reporting period is provided in Section 6.4.1 of Volume 1.

1.5.16 Waste Management Area U

The WMA U remains in interim status groundwater quality assessment monitoring in accordance with 40 CFR 265.93(d), as referenced by WAC 173-303-400. Nitrate remained above the DWS during the reporting period, while the RCRA constituent chromium remained below the analytical detection limit. The well network is adequate for monitoring the distribution of contamination from the WMA. A summary of the WMA U groundwater monitoring activities for the reporting period is provided in Volume 1, Section 6.4.2.

1.5.17 216-S-10 Pond and Ditch

The 216-S-10 Pond and Ditch remain in interim status contaminant indicator evaluation monitoring in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. Required statistical evaluations of specified indicator parameters have been conducted using the most recent collected background values from well 299-W26-7 before the well went dry in 2003. The period of CY 2009 marked completion for the collection of four quarters of RCRA-compliant data from the new upgradient well; thus, new background values are calculated for CY 2010 for the required upgradient/downgradient comparisons. To date, RCRA contamination indicator parameters have not exceeded critical mean values and do not indicate that the 216-S-10 Pond and Ditch have affected the groundwater quality in the uppermost aquifer beneath the unit. The monitoring well network is sufficient for determining groundwater quality downgradient of the site and for performing the required statistical comparisons. A summary of the groundwater monitoring activities for the reporting period at the 216-S-10 Pond and Ditch is provided in Section 6.4.3 of Volume 1.

1.5.18 Low-Level Waste Management Area 3

The LLWMA-3 continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. Statistical evaluations at LLWMA-3 are suspended until the effects of the enhanced 200-ZP-1 OU pump-and-treat system are known and a new upgradient well is installed. During the reporting period, carbon tetrachloride was the only constituent to exceed a DWS. All wells were successfully sampled during the reporting period. Interim status indicator evaluation groundwater monitoring at LLWMA-3 will continue in FY 2010. A summary of the LLWMA-3 groundwater monitoring activities for the reporting period is provided in Volume 1, Section 7.6.1.

1.5.19 Low-Level Waste Management Area 4

The LLWMA-4 continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with 40 CFR 265.93(b),

For additional information on contaminants that are found at the Hanford Site, see the Radiological and Chemical Fact Sheets to Support Health Risk Analyses for Contaminated Areas (Peterson et al. 2007), available on the Environmental Assessment Division, Argonne National Laboratory website (http://www.ead.anl.gov/pub).

as referenced by WAC 173-303-400. Total organic carbon exceeded the statistical critical mean in well 299-W15-224 in August 2008. A resampling event took place in December 2008. The results, received in January 2009, indicated that no organic compounds were identified that would account for the elevated total organic carbon.

Following receipt of the January results, Groundwater Project staff prepared a groundwater quality assessment plan to evaluate the elevated total organic carbon (SGW-40211, *First Determination RCRA Groundwater Quality Assessment Plan for the Low-Level Burial Grounds Low-Level Waste Management Area 4)*. Under this plan samples were analyzed for 40 CFR 264, Appendix IX ("Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; Ground-Water Monitoring List") volatile organic, semivolatile organic compounds, total organic halides, chemical oxygen demand, oil and grease, phenols, pesticides, herbicides, polychlorinated biphenyls, dioxans, dissolved oxygen, total petroleum hydrocarbons (diesel, gasoline, and kerosene), and coliform bacteria. Results of the first determination assessment did not find dangerous waste/dangerous waste constituents in the groundwater at LLWMA-4, and monitoring returned to indicator evaluation monitoring. All wells were successfully sampled during the reporting period. Interim status indicator evaluation groundwater monitoring at LLWMA-4 will continue in FY 2010. A summary of the LLWMA-4 groundwater monitoring activities for the reporting period is provided in Volume 1, Section 7.6.2.

1.5.20 Waste Management Area T

The WMA T remains in interim status groundwater quality assessment monitoring in accordance with 40 CFR 265.93(d), as referenced by WAC 173-303-400. The primary dangerous waste constituents found beneath WMA T are chromium, carbon tetrachloride, and trichloroethene. The source for the carbon tetrachloride and trichloroethene contamination was liquid disposal associated with processes at the Plutonium Finishing Plant and not WMA T. Chromium and the supporting constituents fluoride and nitrate each had at least one well that exceeded the DWS for that contaminant during the reporting period. The well network is adequate for monitoring the distribution of contamination from the WMA and all wells were sampled as scheduled during the reporting period. A summary of the groundwater monitoring activities for the reporting period at WMA T is provided in Section 7.6.3 of Volume 1.

1.5.21 Waste Management Area TX-TY

The WMA TX-TY remains in interim status groundwater quality assessment monitoring in accordance with 40 CFR 265.93(d), as referenced by WAC 173-303-400. The primary dangerous waste constituents found beneath WMA TX-TY are chromium, carbon tetrachloride, and trichloroethene. The source for the carbon tetrachloride and trichloroethene contamination was liquid disposal associated with processes at the Plutonium Finishing Plant and not WMA TX-TY. Chromium and the co-contaminant nitrate each continued to exceed their respective DWS in wells monitoring the WMA during the reporting period. Other co-contaminants, technetium-99 and iodine-129, also exceeded their DWSs in wells at the WMA. The well network remains adequate for monitoring the distribution of contamination from the WMA, and all wells were sampled as scheduled during the reporting period. A summary of the WMA TX-TY groundwater monitoring activities for the reporting period is provided in Section 7.6.4 of Volume 1.

1.5.22 State-Approved Land Disposal Site

The State-Approved Land Disposal Site is monitored under *State Waste Discharge Permit ST 4500* (Ecology 2000a), WAC 173-216, and *Groundwater Monitoring and Tritium Tracking Plan for the 200 Area State-Approved Land Disposal Site* (PNNL-13121). Twelve wells are monitored for tritium, and additional constituents including pH, specific conductance, metals, anions, total dissolved solids, and volatile organic analytes. Concentrations of all chemical constituents with permit limits were within the permit limits or below detection limits during the entire reporting period. During the reporting period, all groundwater samples were collected as scheduled. A summary of the groundwater monitoring activities for the reporting period at the State-Approved Land Disposal Site is provided in Section 7.6.5 of Volume 1.

1.5.23 116-N-1 Liquid Waste Disposal Facility

This facility is included in the Hanford Facility RCRA Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*). The Permit states that RCRA monitoring during closure activities will follow the requirements of the *100-N Pilot Project: Proposed Consolidated Groundwater Monitoring Program* (BHI-00725). That plan and a supplemental plan (PNNL-13914, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*) are similar to an interim status indicator evaluation program. Average specific conductance in downgradient well 199-N-3 continued to exceed the critical mean value in March 2009. This was a continuation of previous exceedances, and prior assessment results indicated that the elevated specific conductance is related to constituents from the 120-N-1 percolation pond; recent data indicate that this conclusion remains valid. The average specific conductance dropped below the critical mean value in September 2009, and other indicator parameters remained below the critical mean value in 2009. Upgradient/downgradient comparison values for indicator parameters have been revised based on recent data for use in 2010 comparisons. A summary of the groundwater monitoring activities for the reporting period at the 116-N-1 liquid waste disposal facility (LWDF) is provided in Section 15.4.1 of Volume 2.

1.5.24 116-N-3 Liquid Waste Disposal Facility

The 116-N-3 LWDF is also included in the Hanford Facility RCRA Permit. The Permit states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. The average specific conductance values in downgradient well 199-N-41 continued to exceed the critical mean value in 2009, which was a continuation of previous exceedances noted in from 1999 through 2008. The DOE notified Ecology of the original exceedance and submitted an assessment report that concluded the exceedance was caused by past discharges to the 120-N-1 percolation pond. Recent data indicate that this conclusion remains valid. No other critical mean exceedances occurred in 2009. Detection monitoring will continue in 2010. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2010. A summary of the groundwater monitoring activities for the reporting period at the 116-N-1 LWDF is provided in Section 15.4.3 of Volume 2.

1.5.25 120-N-1 Percolation Pond and 120-N-2 Surface Impoundment

The 120-N-1 percolation pond and the 120-N-2 surface impoundment are both included in the Hanford Facility RCRA Permit. The Permit states that RCRA

monitoring during closure activities will follow the requirements of BHI-00725. The two units are monitored as a single site (WMA) because of their proximity and similar waste types. Average specific conductance values in downgradient wells 199-N-72 and 199-N-165 continued to exceed the critical mean value in March 2009. Well 199-N-165 also exceeded the critical mean value in September 2009. A previous groundwater quality assessment indicated that the high specific conductance is caused by sulfate and sodium (WHC-SD-EN-EV-003, *Results of Groundwater Quality Assessment Monitoring at the 1301-N and 1324-N/NA Facilities*), which are not listed dangerous waste constituents. Recent data indicate that this conclusion remains valid. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2010 comparisons.

The average total organic carbon concentration from downgradient well 199-N-165 exceeded the critical mean value in March 2009. The well was resampled in July 2009, and the results from two laboratories confirmed the exceedance. The DOE notified Ecology of the exceedance, stating that no organic waste constituents were disposed at these treatment, storage, and disposal units; therefore, elevated total organic carbon cannot indicate dangerous constituents derived from the units. The 2009 critical mean value of 1,003 µg/L was much lower than the 2008 value of 1,787 µg/L due to the reduced variability in the updated data set from the upgradient well. Average total organic carbon in well 199-N-165 decreased below the critical mean value in September 2009. No other critical mean exceedances occurred in during the reporting period. A summary of the 120-N-1 percolation pond and 120-N-2 surface impoundment groundwater monitoring activities for the reporting period is provided in Section 15.4.2 of Volume 2.

1.5.26 183-H Solar Evaporation Basins

The 183-H solar evaporation basins are the only RCRA site in the 100-H Area. The 116-H-6 solar evaporation basins are incorporated into the Hanford Facility RCRA Permit (WA7890008967) as the "183-H solar evaporation basins." The site is being monitored during the post-closure period under the corrective action monitoring requirements of WAC 173-303-645(11)(g). The RCRA Permit requires annual monitoring of the facility, which includes sampling four wells (199-H4-3, 199-H4-8, 199-H4-12, and 199-H4-12C) for chromium, fluoride, nitrate, technetium-99, and uranium. The four wells in the RCRA network were sampled as scheduled for the constituents of interest listed in the groundwater monitoring plan. It should be noted that wells 199-H4-3 and 199-H4-4 also serve as extraction wells for the 100-H Area pump-and-treat system. Overall, the contaminant concentrations at the 183-H solar evaporation basins remained below applicable permit limits during the reporting period. A summary of the 183-H solar evaporation basins groundwater monitoring activities for the reporting period is provided in Section 16.4 of Volume 2.

Chromium concentrations have been below the 122 µg/L permit limit in all four wells since 2004, although the November 2009 concentrations in well 199-H4-12C were near this level (117 and 120 µg/L in filtered and unfiltered samples, respectively). In FY 2009, the total chromium concentration ranged from 10 to 120 µg/L. The highest chromium concentrations continued to be found in deep well 199-H4-12C. Nitrate concentrations ranged from 4.55 to 39.8 mg/L during the reporting period. Levels have been below the permit limit of 45 mg/L since 2006. Fluoride concentrations also remained low in groundwater downgradient of the 183-H solar evaporation basins. The highest concentration for the reporting period was 250 µg/L in well 199-H4-12C, which is well below the permit limit of 4,000 µg/L.

Technetium-99 was positively detected in at least one sample from each well during the reporting period. Uranium was positively detected in all samples collected during the reporting period; however, technetium-99 and uranium did not exceed the permit limits of 900 pCi/L and 20 µg/L, respectively, in any of the samples. The highest technetium-99 concentration was 55 pCi/L and the highest uranium concentration was 14.4 µg/L, both in well 199-H4-3.

1.5.27 Former 300 Area Process Trenches (316-5 Waste Site)

Groundwater is monitored in accordance with the requirements of the RCRA for dangerous waste constituents and the requirements of AEA for uranium. The modified closure plan (DOE/RL-93-73, *300 Area Process Trenches Modified Closure/ Postclosure Plan*), which is incorporated into the Hanford Facility RCRA Permit, states that groundwater remediation is deferred to the 300-FF-5 OU under CERCLA. In 2009, sampling was performed as planned, and reports on the effectiveness of the corrective action monitoring program were prepared semiannually in accordance with WAC 173-303-645(11)(g). The network of one upgradient well (north of the former facility) and three downgradient wells (east, southeast, and south of the facility) remains adequate for the required monitoring.

Uranium concentrations in groundwater remained above the 30 µg/L DWS at each of the three downgradient wells screened in the upper portion of the unconfined aquifer. Uranium concentrations were lower at the deeper wells (undetected at well 399-1-10B and 399-1-17B, and less than 15 µg/L at well 399-1-16B). At well 399-1-16B, which monitors conditions in the lower portion of the unconfined aquifer, cis-1,2-dichloroethene remains at concentrations approximately twice the 70 µg/L DWS. Concentrations in the other RCRA network monitoring wells ranged from undetected to 5.6 µg/L. Analytical results for trichloroethene were all below the detection limit of 1 µg/L during 2009, with the exception of two detections in samples from well 399-1-16B (1.0 and 1.2 µg/L). Analytical results for tetrachloroethene were all below the 1 µg/L detection limit during 2009.

1.6 CERCLA Five-Year Review

Whenever contaminants remain in the environment following a remedial action decision, CERCLA regulations require that the regulatory agency conduct a review of the decision at least every 5 years. The DOE released *The Second* CERCLA *Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20) in November 2006. The purpose of the review was to determine whether the selected remedies remain protective of human health and the environment, and to recommend appropriate corrective actions if the remedy is not achieving the established goals.

The review identified twenty issues and associated corrective actions that are recommended to ensure selected remedies remain protective of human health and the environment. Actions that pertain to individual groundwater OUs are discussed in the applicable sections of this report. The three actions pertaining to the River Corridor cross OU boundaries and have all been completed (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*).

1.7 Remediation Decision Support Function

The Remediation Decision Support provides a Hanford Sitewide support function that applies an integrated systems approach to develop and maintain consistent geological, hydrogeological, and geophysical data, parameters, and conceptual

models to support the CERCLA assessment process. The development and application of conceptual models, mathematical models, numerical models, and risk assessment models is highly dependent upon hydrogeological data and subsurface interpretations, including boundary conditions and derived parameter values. In addition to maintaining these data as Hanford Site accessible databases via the Environmental Database Management group, they also contain information necessary to fulfill configuration control and quality assurance requirements. Therefore, these databases can be used for various modeling efforts across the range of CERCLA processes.

The Remediation Decision Support function includes the following:

- Serves as a focal point for consolidating, maintaining, and communicating technical baseline information and data to serve as the foundation for all subsurface conceptual models and parameter assumptions
- Facilitates the development of consistent and defensible conceptual models to serve as basis for organizing and addressing cross-cutting and/or overlapping technical issues
- Provides conceptual model and parameter data package support to specific assessments (e.g., numerical contaminant and risk assessment modeling).

During FY 2009, Remedial Decision Support activities for the Central Plateau included the following:

- Operate and maintain the Hanford Borehole Geologic Information System
- Develop and maintain a subsurface graphics database
- Develop and populate the petrologic, mineralogic, and bulk rock geochemical database
- Update and maintain aquifer test database
- Update and maintain contaminant distribution coefficient database
- Develop, verify, and maintain the physical and hydrologic properties database
- Establish and maintain interpreted parameters databases including maintenance of a geologic contacts database, gravel correction for hydraulic properties, unsaturated hydraulic conductivity models, document the selection and traceability of flow and transport parameters
- Update and revise hydrogeologic interpretations including hydrogeologic solid model development for the gap area, update and revise the hydrogeologic interpretation for the Central Plateau.

1.8 EM-22 Technology Proposals

In FY 2006, the U.S. Congress authorized $10 million for analyzing contaminant migration to the Columbia River and for introducing new technology approaches to solving contamination migration issues. The DOE's Office of Environmental Management (EM-22) administers these funds. The following studies were underway during the reporting period of October 2008 through December 2009:

- Inject micron-size iron into the deteriorating portions of the reduction-oxidation barrier (100-D Area)
- Conduct field test of electrocoagulation for accelerated cleanup (100-D Area)

More information on the EM-22 projects is available at http://www.em.doe.gov/PDFs/SRNL-STI-2008-00424%20final.pdf.

- Conduct in situ biostimulation test of groundwater (100-D Area)
- Conduct location refinement of the chromium source and a geochemical/ mineralogical study of chromium in the vadose zone (100-D Area)
- Perform a strontium-90 treatability demonstration of phytoremediation (100-N Area)
- Sequester strontium-90 subsurface contamination by surface infiltration of an apatite solution (100-N Area)
- Perform uranium stabilization through polyphosphate injection (300 Area)
- Conduct carbon tetrachloride and chloroform attenuation parameter studies (200-ZP-1 OU).

The progress of these projects is summarized in applicable sections of this report.

1.9 New Tri-Party Agreement Milestones for Groundwater

In August 2009 the Tri-Parties added eighteen new milestones.

In August 2009, the DOE, EPA, and Ecology defined interim milestones and cleanup target goals toward meeting groundwater and soil requirements for Tri-Party Agreement Milestone M-16-00, "Complete remedial actions for all non-tank farm operable units by September 30, 2024." Change Control Form M-16-08-07 ("New and Accelerated Groundwater and Columbia River Protection Hanford Federal Facility Agreement and Consent Order Milestone") lists the new milestones and goals. Table 1-5 summarizes the new milestones and goals.

Documents relating to Hanford Site groundwater are available on the following websites:

Tri-Party Agreement Administrative Record and Public Information Repository – http://www2.hanford.gov/arpir/

DOE Public Reading Room – http://reading-room.pnl.gov/

DOE Information Bridge – http://www.osti.gov/bridge/

Hanford Technical Library – http://libraryweb.pnl.gov/

Hanford Site Groundwater Remediation Project –http://www.hanford.gov/cp/gpp/

River Corridor Baseline Risk Assessment – http://www.washingtonclosure.com/Projects/EndState/baseline risk assessment.html

1.10 Quality Control Summary

H. L. Anastos

Evaluation of the groundwater project quality assurance program indicates that the data for the reporting period are reliable and defensible.

Groundwater data quality is assessed and enhanced by a multifaceted quality assurance/quality control program. Major components of the program include performance evaluation studies, field quality control samples, blind standards, laboratory quality control samples, and laboratory audits. Overall, evaluation of

The HEIS database can be accessed through the Environmental Dashboard Application at http://environet.rl.gov/EDA/.

these components indicates that the majority of the data from the reporting period are reliable and defensible. Specific data values that are associated with out-of-limit quality control results are flagged in the Hanford Environmental Information System (HEIS) database so users can be circumspect when using them for interpretation. Details of the quality control program for the reporting period are included in Appendix E. Highlights include the following:

- Of the groundwater monitoring data, 97% were considered complete (i.e., not rejected, suspect, associated with a missed holding time, or out-of-limit quality control criteria).
- The four laboratories supporting groundwater monitoring participated in several national performance evaluation studies. Overall, the performance was acceptable.
- Field quality control samples include three types of field blanks (full trip, field transfer, and equipment blanks), field duplicates, and split samples. Approximately 97% of the field blank, 99% of the field duplicate, and 91% of the split sample results were acceptable, indicating good precision.
- Recommended holding times were met for 99% of non-radiological sample analysis requests for both long-term and interim action monitoring.
- Overall, laboratory performance on blind standards was good; 87% of the results were acceptable.
- Approximately 98% of the laboratory quality control results were within the acceptance limits, indicating that the analyses were in control and reliable data were generated. Specifically, 99.8% of method blanks, 99.4% of the laboratory control samples, and 99% of the matrix spikes and matrix duplicates were within the acceptance limits.
- Audits and assessments of the laboratories were conducted by DOE and its contractors. Several findings and observations were identified, along with a number of proficiencies. Corrective actions have been accepted for all of the audits.

1.11 Related Reports

Other reports and databases relating to Hanford Site groundwater are discussed below.

Hanford Environmental Information System (HEIS) database. The HEIS database is the main environmental database for the Hanford Site. The database is used to store groundwater chemistry data and other environmental data (e.g., soil chemistry and survey data).

PNNL-19455, Hanford Site Environmental Report for Calendar Year 2009. The annual report summarizes environmental data, including groundwater, riverbank seeps, and river water. It also describes environmental management performance and reports the status of compliance with environmental regulations.

Quarterly RCRA summary. The DOE transmits informal reports quarterly to Ecology after groundwater data have been verified and evaluated. These reports describe the changes or highlights from the quarter, with reference to the HEIS database for the analytical results. These written reports will be replaced with quarterly presentations, beginning with data from the July through September 2009 quarter (i.e., the third quarter of CY 2009).

Remedial investigation/feasibility study work plans. The DOE recently released work plans for the 100 Area (DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*) and the 300 Area (DOE/RL-2009-30, *300 Area Decision Unit Remedial Investigation/Feasibility Study Work Plan*). These documents present a strategy to make final decisions that are necessary to complete cleanup in the River Corridor. See Volume 2, Chapter 12 for more information.

River Corridor baseline risk assessment. A critical step in developing final remedial action decisions is the completion of a quantitative baseline risk assessment. Some of the recent documents associated with this effort include the following:

- DOE/RL-2007-21, *Risk Assessment for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment*: The risk assessment addresses post-remediation residual contaminant concentrations in the 100 and 300 Areas, as well as the Hanford and White Bluffs town sites.
- DOE/RL-2005-42, *100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan*: The plan presents the rationale and approach for sampling and analysis to support risk characterization.
- WCH-274, *Inter-Areas Component of the River Corridor Baseline Risk Assessment Sampling Summary*: This document describes the 2006 to 2007 supplemental data collection effort, including sampling locations, samples collected, and any modifications and additions made to the sampling and analysis plan for the 100 and 300 Areas Component of the baseline risk assessment.

Beginning with this annual report, the CERCLA annual summary reports for interim actions, which evaluate the performance of pump-and-treat and other remediation systems, will be incorporated in the applicable sections of the annual report.

1.12 Conventions Used in This Report

The well location maps presented in this report include any well used for sampling or water-level measurements in the past 5 years. Wells that have gone dry or that have been decommissioned during this time period are shown with symbols that are different from regularly sampled wells. For clarity, the well name prefixes (e.g., “199-” in the 100 Areas and “299-” in the 200 Areas) are omitted from most of the maps. Aquifer tubes, which are often installed in multi-depth clusters, are usually shown as a single point with the depth suffixes (e.g., “–S,” “–M,” and “–D”) omitted.

Unless specified otherwise, contaminant plume maps in this report are based on average results for samples collected during CY 2009 for each well shown, excluding data that appear not to be representative. Data representativeness is determined by the Project Scientist in charge of the OU or monitored unit using various methods and best professional judgment (Appendix E). Data are averaged to allow the maps to include wells sampled at different times and at different frequencies. In some locations or for certain operations (i.e., pump-and-treat operations), it is advantageous to construct maps based on data from a single sampling event (e.g., chromium in the 100-D Area in the spring of 2009). Such maps are captioned with the specific timeframe illustrated.

Contour levels are chosen to meet of the following objectives:

- DWSs and multiples of 10 (e.g., 8, 80, and 800 pCi/L for strontium-90)
- Common divisions such as 50, 100, 500, etc.

- Cleanup levels, where applicable (e.g., 20 µg/L for hexavalent chromium)
- Levels lower than DWSs to show applicable OU boundaries (e.g., 2,000 pCi/L tritium contour for the 200-PO-1 OU)
- Intermediate levels to help define plume shape (e.g., 30, 90, 300, 600, 900, and greater than 2,000 µg/L for uranium).

Most plume maps in this report show average concentrations in the upper portion of the aquifer.

Mapped data are rounded to two significant digits. The plume maps are drawn manually and represent the best professional interpretations by project staff using current and historical data, source knowledge, and groundwater flow directions. Staff used data from CY 2007 and CY 2008 if new data were not available for a well in CY 2009. Wells that did not have samples collected during the reporting period and use older data for averaging are given a different symbol than used for wells with current-year data. Older data and data from aquifer tubes along the Columbia River are given less weight than the current well data when maps are contoured. The maps show data from wells completed in the upper portion of the unconfined aquifer (i.e., generally the top ~10 meters).

Results that were less than detection limits (i.e., flagged as "U" in the HEIS database) are treated in one of two ways when constructing maps:

- For chemical constituents (including total uranium), "U"-flagged values represent the analytical detection limits. These values are treated as zeroes in the data to be averaged. If all of the results (or the only result) for the year were undetected, a "U" qualifier is plotted on the map. If the data represent a mixture of detected and undetected results, the average value is plotted on the map followed by an asterisk. If the data represent only detected results, the average value is plotted on the map.
- For radiological parameters, if the counting error is greater than the result, the result is flagged with "U." Other factors may also result in values being "U"-flagged. For plotting on maps, all of the results for the year are averaged, whether "U"-flagged or not, because the reported values are statistically significant. The average values are plotted on the map, followed by "U" (if all results for the year were undetected) or an asterisk (if the data represent a mixture of detected and undetected values). It should be noted that the laboratories correct results for background radiation, which in some cases, can result in values that are negative.

Conventions for handling undetected values do not adversely affect data interpretation for most constituents because the contour intervals are far above detection limits. A notable exception is iodine-129. Iodine-129 is contoured at 1 pCi/L (the DWS), which can be less than the laboratory's detection limit. Historically, the laboratory required that both primary and secondary energy peaks be present before considering iodine-129 as detected. Requiring the secondary (less sensitive) energy peak added conservatism to the laboratory's report (i.e., the laboratory reports a detection only when certain of the detection); however, review of data indicated that many "U"-flagged values were actual detections and were included in the contours. In FY 2009, groundwater analytical support staff worked with the laboratories to improve the iodine-129 method and resolve the issues identified in FY 2008. The goal was to ensure that the detection levels reported were at or below the 1 pCi/L DWS. This effort was successful, enabling future data to be at or below the DWS. However, 3 years of data are used to support the plume contours. Until sufficient data using the improved technique are obtained, the contour lines will be

dashed to show that the distribution of iodine-129 at levels near the DWS is less certain than other contaminants.

Trend plots may omit results that appear to be erroneous if they distort or obscure the scale and data trends; the figures presented in this report note the omission. All of the data, with appropriate data quality flags, are included in the data files accompanying this report and are available in the HEIS database. The trend plots presented in this report use open symbols to show values below the laboratory detection limit. These results are typically reported and plotted as values that represent the detection limit for chemical parameters and reported values for radiological parameters. Discussion of increasing or decreasing trends is generally based on qualitative observation and not on statistical evaluation.

This report uses the following conventions for chemical results:

- Text, figures, and tables express nitrate and nitrite as the NO_3^- and NO_2^- ions, respectively.
- Maps showing chromium include total chromium in filtered samples and hexavalent chromium in filtered or unfiltered samples. Dissolved chromium in Hanford Site groundwater is virtually all hexavalent (WHC-SD-EN-TI-302, *Speciation and Transport Characteristics of Chromium in the 100D/H Areas of the Hanford Site*), so filtered total chromium data effectively represent hexavalent chromium. Appendix C in DOE/RL-2008-01 compares chromium data from filtered, unfiltered, total, and hexavalent analyses.

Dissolved chromium in Hanford Site groundwater is virtually all hexavalent.

- Contaminant concentrations are compared with state or federally enforceable DWSs (Table 1-6). Although Hanford Site groundwater is not generally used for drinking water purposes, these levels provide perspective on contaminant concentrations. Radionuclide concentrations also are compared with DOE-derived concentration guides and risk-based concentrations based on cancer risk coefficients (Table 1-7).

1.13 Sources of Additional Information

All of the data presented in this report are provided on a CD-ROM at the back of this report. Data may also be reviewed on the internet through the DOE's Environmental Dashboard Application at http://environet.rl.gov/EDA/.

The documents referenced in this report are generally available at the public reading rooms around the state. Documents are also available online as part of the Administrative Record at http://www5.hanford.gov/arpir/. Requests for documents can also be made through inter-library loan directly to the DOE or Pacific Northwest National Laboratory libraries.

Table 1-1. Reporting Requirements for Groundwater Monitoring.

Operable Unit or Facility	Formal Report	Supplemental Report or Summaries
CERCLA		
Operable units without RODs (100-BC-5, 100-FR-3, 200-BP-5, and 200-PO-1)	This report	Unit managers' meeting presentations
Operable units with interim action RODs (100KR4, 100-NR-2, 10-0HR-3, 200-UP-1, 200-ZP-1, and 300-FF-5)	This report	Unit managers' meeting presentations; this report
Operable unit with final action ROD (1100-EM-1)	This report	None
ERDF	This report	This report
RCRA		
Operating RCRA units (IDF, LERF, and LLBG)	This report	Informal quarterly presentations
Closure RCRA units (116-N-1 and 3;120-N-1 and 2)	This report	Informal quarterly presentations
Post-closure RCRA units (116-H-6 and 316-5)	Semiannual reports to Ecology; this report	Informal quarterly presentations
Interim status groundwater quality assessment RCRA sites (PUREX Cribs; WMAs A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U)	This report; also occasional assessment reports	Informal quarterly presentations
Interim status indicator evaluation RCRA sites (216-A-29, 216-B-63, 216-S-10 Pond, and NRDWL)	This report	Informal quarterly presentations
Other Facilities		
AEA sites (K Basins; Richland North, 400 Area water supply wells, Confined aquifers)	This report	Unit managers' meeting presentations
SALDS (WAC 173216)	This report	None
TEDF (WAC 173216)	This report	None
SWL (WAC 173350)	This report	None

Notes:
WAC 173-216, "State Waste Discharge Permit Program."
WAC 173-350, "Solid Waste Handling Standards.".

AEA = Atomic Energy Act of 1954
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
Ecology = Washington State Department of Ecology
ERDF = Environmental Restoration Disposal Facility
IDF = Integrated Disposal Facility (planned)
LERF = Liquid Effluent Retention Facility
LLBG = Low-Level Burial Grounds
NRDWL = Nonradioactive Dangerous Waste Landfill
PUREX = Plutonium-Uranium Extraction (Plant)
RCRA = Resource Conservation and Recovery Act of 1976
ROD = Record of Decision
SALDS = State-Approved Land Disposal Site
SWL = Solid Waste Landfill
TEDF = Treated Effluent Disposal Facility
WAC = Washington Administrative Code
WMA = Waste Management Area

Table 1-2. Number of Groundwater Analyses for Selected Constituents During Calendar Year 2009.

Constituent	Site Total
Carbon tetrachloride	1,273
Chromium (total)	4,333
Chromium (hexavalent)	4,637
Iodine129	859
Nitrate	2,883
Plutonium239/240	55
Strontium90	861
Technetium99	1,395
Trichloroethene	1,273
Tritium	1,930
Uranium	1,279

Table 1-3. Maximum Concentrations of Selected Groundwater Contaminants in Groundwater Interest Areas, October 2008 Through December 2009.

Contaminant, Units (alphabetical order)	DWS (DCG)[a]	200-BP-5 OU		200-PO-1 OU		200-UP-1 OU	200-ZP-1 OU	Confined Aquifers
		Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Wells	Wells
Antimony[a] (µg/L)	6			**42.3**		**39.9**	**45.1**	
Antimony[a] (filtered) (µg/L)	6					**41.1**	**38.1**	
Arsenic[a] (µg/L)	10	9.11		**12.9**		6.6	**12**	4.22
Arsenic[a] (filtered) (µg/L)	10	**16.3**		**12.3**		6.67	**10.3**	4.43
Benzene (µg/L)	5	2.5		**35**			2.8	
Cadmium[a] (µg/L)	5			4.9			**7.9**	
Cadmium[a] (filtered) (µg/L)	5			6.8		4.5		
Carbon tetrachloride (µg/L)	5	**5.9**		2		**1,300**	**3,900**	
Carbon14 (pCi/L)	2,000 (70,000)	565	285			23.5		
Cesium137 (pCi/L)	200 (3,000)	**2,430**						
Chloroform (µg/L)	100	1.5		0.71		18	20	
Chromium[a] total (µg/L)	100	97.9		**118**		**1,100**	**744**	
Chromium[a] total (filtered) (µg/L)	100	89.9		**124**		**1,090**	**736**	
Chromium[a] hexavalent (µg/L)	100	75.4	11		2.3	**236**	**158**	
Chromium[a] hexavalent (filtered) (µg/L)	100	76.4	5.8	2.6		51.2	**158**	
cis1,2Dichloroethylene (µg/L)	70			5.9				
Cobalt60 (pCi/L)	100 (5,000)	**104**					**150**	
Cyanide (µg/L)	200	**1,730**						6.4
Fluoride (mg/L)	4	0.72	0.207	**9.14**	0.18	0.527	**4.86**	**9.14**
Gross alpha (pCi/L)	15	**2,000**		**33**	1.6	4.2	**18**	4
Gross beta (pCi/L)	50	**22,000**	**60**	**2,700**	**54**	**1,200**	**5,590**	**52**
Iodine129 (pCi/L)	1 (500)	**6.74**	0.274	**9.7**		**10.8**	**34.5**	0.345
Nitrate (mg/L)	45	**1, 700**	28.9	**158**	32.8	**1,080**	**3,410**	6.24
Nitrite (mg/L)	3.3	**5.72**		0.163		0.466	0.68	0.634
Plutonium239/240 (pCi/L)	1.2[b] (30)	**42**					0.091	0.17
Strontium90 (pCi/L)	8 (1,000)	***4,900***		**11**				
Technetium99 (pCi/L)	900 (100,000)	**39,000**	81	**5,700**	85	**75,000**	**40,000**	43
Tetrachloroethene (µg/L)	5			2.52		3.8	4.4	
Thallium[a] (µg/L)	2	0.63		**61.9**				
Thallium[a] (filtered) (µg/L)	2	0.79		**69.6**			**43.9**	
Trichloroethene (µg/L)	5	3.1		3.1		**9.4**	14	
Tritium (pCi/L)	20,000 (2,000,000)	**91,000**	12,000	**510,000**	**36,000**	**270,000**	**1,600,000**	3.900
Uranium (µg/L)	30	**5,550**		**106**		**416**	**36.6**	3.27

Notes: Table lists highest value for the 15-month reporting period (October 1, 2008, to December 31, 2009) in each groundwater interest area, excluding those flagged "R" or "Y" or special (non-routine) samples.
Concentrations in **bold** exceed DWS; those in ***bold italics*** exceed DCG.
Blank cells indicate a constituent was not detected or not analyzed.

a. Most metals analyses are run both unfiltered and field-filtered samples. Higher concentrations in unfiltered samples indicate particulate matter in the sample. Note that analyses specifically for hexavalent chromium usually are not filtered in the field.
b. There is no DWS for plutonium-239/240. The 4 mrem/year effective dose equivalent is 1.2 pCi/L.
DCG = derived concentration guide
DWS = drinking water standard
OU = operable unit

Table 1-3. (cont.)

Contaminant, Units (alphabetical order)	100-BC-5 OU		100-KR-4 OU		100-NR-2 OU		100-HR-3-D	
	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes
Antimony[a] (µg/L)							**42.6**	**38.3**
Antimony[a] (filtered) (µg/L)					**40.5**		**46.8**	**48.4**
Arsenic[a] (µg/L)			7.34	3.25	5.38		6.8	1.1
Arsenic[a] (filtered) (µg/L)			7.91	3.13	5.38		6.4	1.12
Benzene (µg/L)					2.8			
Cadmium[a] (µg/L)			4.7		**18.9**		4	
Cadmium[a] (filtered) (µg/L)			**15.2**		**12.7**	4.7	**7.1**	
Carbon tetrachloride (µg/L)					1.8		2.7	
Carbon14 (pCi/L)			**9,120**	398	45.1	15.3		
Cesium137 (pCi/L)								
Chloroform (µg/L)	54.1		2.3		6.5	1.7	8.3	
Chromium[a] total (µg/L)	48.3	44.8	**1,260**	58.4	**1,200**	14.5	**5,750**	**152**
Chromium[a] total (filtered) (µg/L)	56.1	52.5	**1,230**	66.4	**169**	17.2	**5,750**	**160**
Chromium[a] hexavalent (µg/L)	48.7	78.1	**2,530**	62.8	84	13	**58,900**	**384**
Chromium[a] hexavalent (filtered) (µg/L)		44.5	**808**	64.1	70.7	12.8	**59,600**	**380**
cis1,2Dichloroethylene (µg/L)								
Cobalt60 (pCi/L)								
Cyanide (µg/L)								
Fluoride (mg/L)	0.329	0.204	0.456	0.19	0.711	0.897	1.15	0.187
Gross alpha (pCi/L)	3.4	5.1	10	4.4	4.2	1.8	5	
Gross beta (pCi/L)	49	**50**	**760**	14	**18,000**	**3,900**	**140**	
Iodine129 (pCi/L)								
Nitrate (mg/L)	34.1	**45.2**	**174**	**66.4**	**383**	**64.6**	**95.2**	30.5
Nitrite (mg/L)			1.66		0.18	0.746	3.88	0.46
Plutonium239/240 (pCi/L)								
Strontium90 (pCi/L)	**29**	**25**	41	5.2	***9,000***	***1,800***	6.4	3.5
Technetium99 (pCi/L)		30	95	10			15	
Tetrachloroethene (µg/L)								
Thallium[a] (µg/L)								
Thallium[a] (filtered) (µg/L)								
Trichloroethene (µg/L)			**9.2**		0.21			
Tritium (pCi/L)	**47,000**	**29,000**	**430,000**	11,000	**20,000**	14,000	**25,000**	19,000
Uranium (µg/L)			10.5		3.67		4.29	

Notes:
Table lists highest value for the 15-month reporting period (October 1, 2008, to December 31, 2009) in each groundwater interest area, excluding those flagged “R” or “Y” or special (non-routine) samples.
Concentrations in **bold** exceed DWS; those in ***bold italics*** exceed DCG.
Blank cells indicate a constituent was not detected or not analyzed.

a. Most metals analyses are run both unfiltered and field-filtered samples. Higher concentrations in unfiltered samples indicate particulate matter in the sample. Note that analyses specifically for hexavalent chromium usually are not filtered in the field.
b. There is no DWS for plutonium-239/240. The 4 mrem/year effective dose equivalent is 1.2 pCi/L.
DCG = derived concentration guide
DWS = drinking water standard
OU = operable unit

Table 1-3. (cont.)

Contaminant, Units (alphabetical order)	100-HR-3-H		100-FR-3 OU		300-FF-5 OU		1100-EM-1
	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells
Antimony[a] (µg/L)	1.02		**38.4**				
Antimony[a] (filtered) (µg/L)	0.716						
Arsenic[a] (µg/L)	5.54				**19**	3.2	
Arsenic[a] (filtered) (µg/L)	5.94				**19.3**	2.6	
Benzene (µg/L)					2.8		
Cadmium[a] (µg/L)	4.1				4.5		
Cadmium[a] (filtered) (µg/L)	1.8			4.1	4.2		4.8
Carbon tetrachloride (µg/L)	2				1.3		2.9
Carbon14 (pCi/L)							
Cesium137 (pCi/L)							
Chloroform (µg/L)	2				2.7	2.7	1.4
Chromium[a] total (µg/L)	**215**	22.2	56		**105**	18.7	6.2
Chromium[a] total (filtered) (µg/L)	**117**	25	53.7		88.7	19	
Chromium[a] hexavalent (µg/L)	**121**	54	14.3	14.7		2.2	
Chromium[a] hexavalent (filtered) (µg/L)	**120**	31	14.9	14.7		2.6	
cis1,2Dichloroethylene (µg/L)					**190**	7.2	
Cobalt60 (pCi/L)							
Cyanide (µg/L)							
Fluoride (mg/L)	0.486	0.16	0.571	0.175	3.78	0.570	1.21
Gross alpha (pCi/L)	4.7		12		**101**	**76**	6.2
Gross beta (pCi/L)	**74**	24	42		**140**	**68**	24
Iodine129 (pCi/L)						0.274	
Nitrate (mg/L)	**1,500**	**46.0**	**126**	43.1	**98.7**	**84.1**	**331**
Nitrite (mg/L)	1.14		0.47			0.143	
Plutonium239/240 (pCi/L)							
Strontium90 (pCi/L)	***110***	**10**	**12**	5.8	1.1		
Technetium99 (pCi/L)	55				210	34	75
Tetrachloroethene (µg/L)			3.59		4	4	
Thallium[a] (µg/L)	0.276				0.64	1.3	
Thallium[a] (filtered) (µg/L)						1.5	
Trichloroethene (µg/L)			**13**		3	**470**	
Tritium (pCi/L)	**11,000**		9,000	19,000	**910,000**	12,000	371
Uranium (µg/L)	14.4	1.73	17.9		**211**	**160**	24.1

Notes:
Table lists highest value for the 15-month reporting period (October 1, 2008, to December 31, 2009) in each groundwater interest area, excluding those flagged “R” or “Y” or special (non-routine) samples.
Concentrations in **bold** exceed DWS; those in ***bold italics*** exceed DCG.
Blank cells indicate a constituent was not detected or not analyzed.

a. Most metals analyses are run both unfiltered and field-filtered samples. Higher concentrations in unfiltered samples indicate particulate matter in the sample. Note that analyses specifically for hexavalent chromium usually are not filtered in the field.
b. There is no DWS for plutonium-239/240. The 4 mrem/year effective dose equivalent is 1.2 pCi/L.
DCG = derived concentration guide
DWS = drinking water standard
OU = operable unit

Table 1-4. RCRA Monitoring Status for the Reporting Period.

RCRA Unit	Report Section	Status for Reporting Period
1301-N (116-N-1) Liquid Waste Disposal Facility	Vol. 2, Chapter 15.0, Section 15.4.1	Continued indicator evaluation.*
1325-N (116-N-3) Liquid Waste Disposal Facility	Vol. 2, Chapter 15.0, Section 15.4.3	Continued indicator evaluation.*
11324NA (120-N-) and 1324N (120N2) ponds	Vol. 2, Chapter 15.0, Section 15.4.2	Continued indicator evaluation.*
116-H-6 (183-H) evaporation basins	Vol. 2, Chapter 16.0, Section 16.4	Corrective action alternative program during interim remedial action; chromium and nitrate.
216-A-29 Ditch	Vol. 1, Chapter 5.0, Section 5.4.4	Continued indicator evaluation.*
216-B-3 Pond	Vol. 1, Chapter 5.0, Section 5.4.5	Continued indicator evaluation.*
216-B-63 Trench	Vol. 1, Chapter 4.0, Section 4.4.6	Continued indicator evaluation.*
216-S-10 Pond and Ditch	Vol. 1, Chapter 6.0, Section 6.4.3	Continued indicator evaluation;* completion of first year of RCRA analyses for three new wells; establishment of new background critical mean values.
316-5 (300 Area) Process Trenches	Vol. 2, Chapter 18.0, Section 18.4	Compliance/corrective action; organics.
Integrated Disposal Facility	Vol. 1, Chapter 5.0, Section 5.4.1	Not yet in use; monitoring results added to background data set.
Liquid Effluent Retention Facility	Vol. 1, Chapter 4.0, Section 4.4.5	Two new wells monitor fractured basalt flow-top; DOE and Ecology pursuing agreement for monitoring.
LLWMA-1	Vol. 1, Chapter 4.0, Section 4.4.1	Continued indicator evaluation.*
LLWMA-2	Vol. 1, Chapter 4.0, Section 4.4.2	Continued indicator evaluation.*
LLWMA-3	Vol. 1, Chapter 7.0, Section 7.6.1	Statistical evaluations suspended until upgradient wells installed and background values established.
LLWMA-4	Vol. 1, Chapter 7.0, Section 7.6.2	Total organic carbon exceeded critical mean value in August 2008; returned to indicator evaluation status CY 2009; remaining upgradient wells went dry.
Nonradioactive Dangerous Waste Landfill	Vol. 1, Chapter 5.0, Section 5.4.6	Total organic carbon exceeded critical mean value in August 2008; beginning assessment FY 2009.
PUREX Cribs	Vol. 1, Chapter 5.0, Section 5.4.2	Continued assessment; nitrate.
SST WMA A-AX	Vol. 1, Chapter 5.0, Section 5.4.3	Continued assessment (first determination); new well.
SST WMA B-BX-BY	Vol. 1, Chapter 4.0, Section 4.4.3	Continued assessment; nitrate.
SST WMA C	Vol. 1, Chapter 4.0, Section 4.4.4	Specific conductance exceeded critical mean value in July 2009; initiated groundwater quality assessment monitoring in December 2009.
SST WMA S-SX	Vol. 1, Chapter 6.0, Section 6.4.1	Continued assessment; chromium and nitrate.
SST WMA T	Vol. 1, Chapter 7.0, Section 7.6.3	Continued assessment; chromium and nitrate.
SST WMA TX-TY	Vol. 1, Chapter 7.0, Section 7.6.4	Continued assessment; chromium and nitrate.
SST WMA U	Vol. 1, Chapter 6.0, Section 6.4.2	Continued assessment; nitrate.

Notes:
* Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with dangerous waste/dangerous waste constituents from the unit.
CY = calendar year
DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
FY = fiscal year
LLWMA = Low Level Waste Management Area
PUREX = Plutonium-Uranium Extraction Plant
RCRA = *Resource Conservation and Recovery Act of 1976*
SST = single-shell tank
WMA = waste management area

Table 1-5. Summary of Changes to Tri-Party Agreement (as approved in Milestone M-16-08-07).

Milestone	Description	Due Date
M-016-110-T01	Take actions to contain or remediate hexavalent chromium groundwater plumes so the AWQS (10 µg/L) concentration is achieved in the hyporheic zone and river water column.	12/31/2012
M-016-110-T02	Take actions to remediate hexavalent chromium groundwater plumes so plumes will meet DWS in each of the 100 Areas.	12/31/2020
M-016-110-T03	Take actions to contain the strontium-90 groundwater plume at the 100-N Area so the DWS (8 pCi/L) is achieved in the hyporheic zone and river water column.	12/31/2016
M-016-110-T04	Implement remediation actions selected in all 100 Area RODs for groundwater OUs so no contamination above DWS or AWQS enters the Columbia River unless otherwise specified in a CERCLA decision.	12/31/2016
M-016-110-T05	Have a remedy in place designed to meet the DWS (30 µg/L) concentration in the 300 Area uranium plume unless otherwise specified in a CERCLA decision.	12/31/2015
M-016-111A	Expand 100-KR-4 pump-and-treat system to be at a total 900-gpm capacity (see Section 14.3.5.1).	5/31/2009
M-016-111B	Expand 100-HR-3 pump-and-treat system to a total 500-gpm capacity, or as specified in the work plan (see Section 16.3.2).	12/31/2010
M-016-111C	Expand 100-HR-3 pump-and-treat system to a total of 800-gpm capacity, or as specified in the work plan.	12/31/2011
M-016-112A	Complete demonstrating for biostimulation and electrocoagulation (see Section 16.3.8).	12/31/2009
M-016-119-T01	Have a remedy in place to contain groundwater plumes (except iodine, nitrate, and tritium) in the 200 Areas.	12/31/2020
M-016-120	Have a groundwater treatment system for the technetium-99 plume at the S-SX Tank Farm.	12/31/2011
M-016-122	Begin Phase 1 operation of new 200 West Area pump-and-treat system in accordance with the ROD.	12/31/2011
M-016-123	Submit CERCLA RD/RA work plan for the 200-ZP-1 OU. Completed DOE/RL200878, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*.	3/31/2009
M-015-00D	Complete the remedial investigation/feasibility study process through submittal of a proposed plan for all 100 and 300 Area OUs.	12/31/2012
M-015-60	If an amendment to the 100-NR-1/2 ROD for interim action is issued, submit RD/RA work plan.	6 months after ROD amended
M-015-61 to 72	Submit RI/FS work plans, reports, and proposed plans for River Corridor decision units (see Volume 2 for specific milestone dates and status).	See Volume 2
M-015-73	Submit feasibility study report and proposed plan for the 200PO1 OU.	12/31/2011
M-015-82	Submit a treatability test plan for the 200-BP-5 OU to determine feasibility of pump-and-treat for uranium and technetium-99 near WMA B-BX-BY. (On schedule.)	12/31/2010

Notes:
Milestone descriptions are paraphrased from Tri-Party Agreement Milestone M-16-08-07.

AWQS = ambient water quality standard
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DWS = drinking water standard
gpm = gallons per minute (to convert to liters per minute, multiply by 3.8)
OU = operable unit
RD/RA = remedial design/remedial action
ROD = Record of Decision
Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)
WMA = waste management area

Table 1-6. Selected Drinking Water Standards and Groundwater Cleanup Levels.

Constituent (Unit)	DWS	DWS Responsible Agency	MTCA[a]	Groundwater Quality Criteria[b]
Aluminum (µg/L)	50 to 200[c]	EPA	16,000	
Antimony (µg/L)	6	EPA, DOH	6.4	
Arsenic (µg/L)	10	EPA, DOH	0.058	50
Barium (µg/L)	2,000	EPA, DOH	3,200	1,000
Cadmium (µg/L)	5	EPA, DOH	8.0	10
Carbon tetrachloride (µg/L)	5	EPA, DOH	0.337	300
Chloride (mg/L)	250[c]	EPA, DOH		250
Chloroform (TTHM)[d] (µg/L)	80	EPA, DOH	7.17	7.0
Chromium (µg/L)	100[e]	EPA, DOH	48[f]	50
cis-1,2-Dichloroethene (µg/L)	70	EPA, DOH	80	
Copper (µg/L)	1,300[g]	EPA, DOH	640	
	1,000[c]	EPA		
Cyanide (mg/L)	200	EPA, DOH	0.104	
Fluoride (mg/L)	4	EPA, DOH	0.960	4
	2[c]	EPA, DOH		
Iron (µg/L)	300[c]	EPA, DOH	11,200	
Lead (µg/L)	15[g]	EPA, DOH		50
Manganese (µg/L)	50[c]	EPA, DOH	752	
Mercury(inorganic) (µg/L)	2	EPA, DOH	4.8	2
Methylene chloride (dichloromethane) (µg/L)	5	EPA	5.83	
Nitrate, as NO^{3-} (mg/L)	45[h]	EPA, DOH	115	45[h]
Nitrite, as NO^{2-} (mg/L)	3.31[i]	EPA, DOH	5.3	
pH	6.5 to 8.5[c]	EPA, DOH		
Selenium (µg/L)	50	EPA, DOH	80	10
Silver (µg/L)	100[c]	EPA, DOH	80	50
Sulfate (mg/L)	250[c]	EPA, DOH		250
Tetrachloroethene (µg/L)	5	EPA, DOH	80	0.8
Thallium (µg/L)	2	EPA, DOH	1.12	
Total dissolved solids (mg/L)	500[c]	EPA, DOH		
1,1,1-Trichloroethane (µg/L)	200	EPA, DOH	16,000	200
Trichloroethene (µg/L)	5	EPA, DOH	0.49	3
Uranium (total) (µg/L)	30	EPA, DOH	48	
Zinc (µg/L)	5,000[c]	EPA, DOH	4,800	

Notes:
a. Model Toxics Control Act (MTCA), Method B cleanup levels for groundwater (WAC 173-340, "Model Toxics Control Act – Cleanup").
b. Groundwater Quality Criteria are regulated by Ecology under WAC 173-200 "Water Quality Standards for Ground Waters of the State of Washington."
c. Secondary standards are not associated with health effects, but associated with taste, odor, staining, or other aesthetic qualities.
d. Standard is for total trihalomethanes.
e. Total chromium.
f. Total chromium/hexavalent chromium.
g. Action level.
h. 45 mg/L as NO3- is equivalent to 10 mg/L of nitrate as nitrogen.
i. 3.3 mg/L as NO2- is equivalent to 1 mg/L of nitrite as nitrogen.

CFR = *Code of Federal Regulations*
DWS = drinking water standard (maximum contaminant level for drinking water supplies)
DOH = Washington State Department of Health (WAC 246-290, "Group A Public Water Supplies")
EPA = U.S. Environmental Protection Agency (40 CFR 141, "National Primary Drinking Water Regulations"; 40 CFR 143, "National Secondary Drinking Water Regulations"; and EPA 822/R-96/001, *Drinking Water Regulations and Health Advisories*)
WAC = Washington Administrative Code

Table 1-7. Derived Concentration Guides, 4-mrem Effective Dose Equivalent Concentrations, Drinking Water Standards, and Risk Based Concentrations for Hanford Site Radionuclides in Groundwater.

Radionuclide	Derived Concentration Guide[a,b,c] (pCi/L)	4-mrem Effective Dose Equivalent[d] (pCi/L)	Drinking Water Standard[e] (pCi/L)	Risk-Based Concentration[f] (pCi/L)	
				Industrial	Residential
Antimony-125	60,000	300	300[g]	---[h]	---[h]
Beta particle and photon activity (mrem/yr)	Not applicable	50	4[i], 50[j]	---[k]	---[k]
Carbon-14	70,000	2,800	2,000[g]	1,030	34
Cesium-137	3,000	120	200[g]	60	1.7
Cobalt-60	5,000	200	100[g]	102	3.4
Iodine-129	500	20	1	11	0.36
Plutonium-239/240	30	1.2	None	12	0.39
Ruthenium-106	6,000	30	30[i]	---[h]	---[h]
Strontium-90	1,000	40	8	29	0.95
Technetium-99	100,000	4,000	900[g]	580	19
Tritium	2,000,000	80,000	20,000	2,600	160
Uranium-234[l]	500	20	None	23	0.75
Uranium-235[l]	600	24	None	23	0.76
Uranium-238[l]	600	24	None	25	0.83

Notes:

a. Concentration of a specific radionuclide in water that could be continuously consumed at average annual rates and not exceed an effective dose equivalent of 100 mrem/year.

b. Values in this column represent the lowest, most conservative derived concentration guides considered potentially applicable to Hanford Site operations, and may be adjusted upward (larger) if accurate solubility information is available.

c. From DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.

d. Concentration of a specific radionuclide in water that would produce an effective dose equivalent of 4 mrem/year if consumed at average annual rates. The EPA drinking water standards for radionuclides listed in Table 15 were derived based on a 4-mrem/year dose standard using maximum permissible concentrations in water specified in the *National Bureau of Standards Handbook 69* (NBS 1959). The 4-mrem/year dose standard listed in this table was calculated using a more recent dosimetry system adopted by DOE and other regulatory agencies (as implemented in DOE Order 5400.5 in 1993).

e. Concentrations listed in 40 CFR 141, "National Primary Drinking Water Regulations."

f. Based on slope factors from EPA's risk website: "Radionuclide Carcinogenicity Slope Factors" (http://epa.gov/radiation/heastindex.html). In turn, this was based on *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (EPA/402/R-99/001). These slope factors represent the risk of getting cancer if a person ingested water contaminated with each radionuclide over a lifetime (residential) or over a working lifetime (industrial). The tritium calculation also considers inhalation of tritium in air; for the other radionuclides, this path is insignificant.

g. The EPA drinking water standards for radionuclides were derived based on a 4-mrem/year dose standard using maximum permissible concentrations in water specified in *National Bureau of Standards Handbook 69* (NBS 1959).

h. Due to short life (less than 3 years), no risk-based concentration is calculated.

i. Beta and gamma radioactivity from anthropogenic radionuclides. Annual average concentration shall not produce an annual dose from anthropogenic radionuclides equivalent to the total body or any internal organ dose >4 mrem/year. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/year. Compliance may be assumed if annual average concentrations of total beta, tritium, and strontium-90 are <50, 20,000, and 8 pCi/L, respectively.

j. Groundwater quality criteria from Table 1C of WAC 173-200-040, "Water Quality Standards for Ground Waters of the State of Washington; Criteria."

k. See specific radionuclides for risk-based concentrations.

l. See Table 1-5 for total uranium.

CFR = *Code of Federal Regulations*

DOE = U.S. Department of Energy

EPA = U.S. Environmental Protection Agency

WAC = *Washington Administrative Code*

Figure 1-1. Location of the Hanford Site.

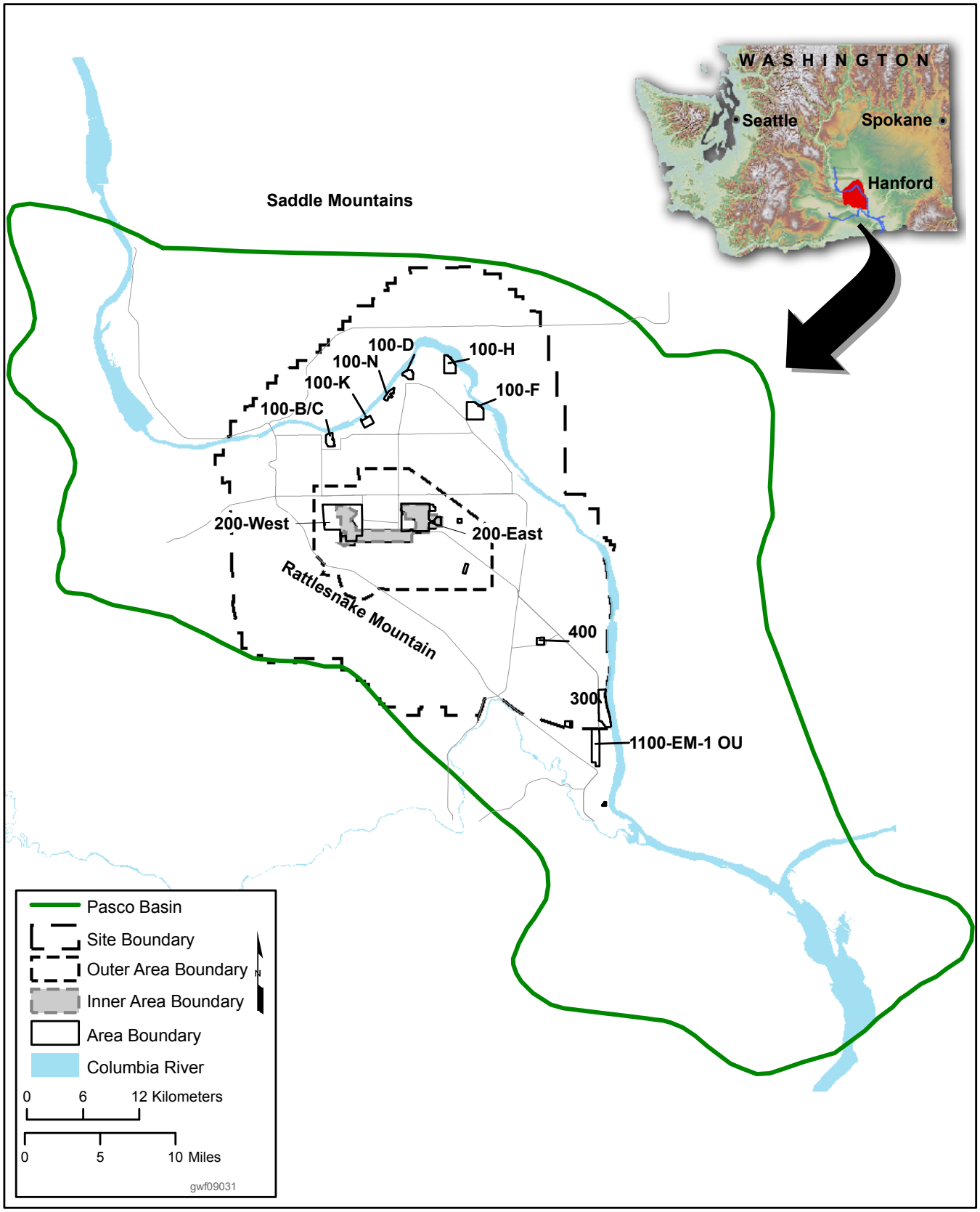


Figure 1-2. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site.

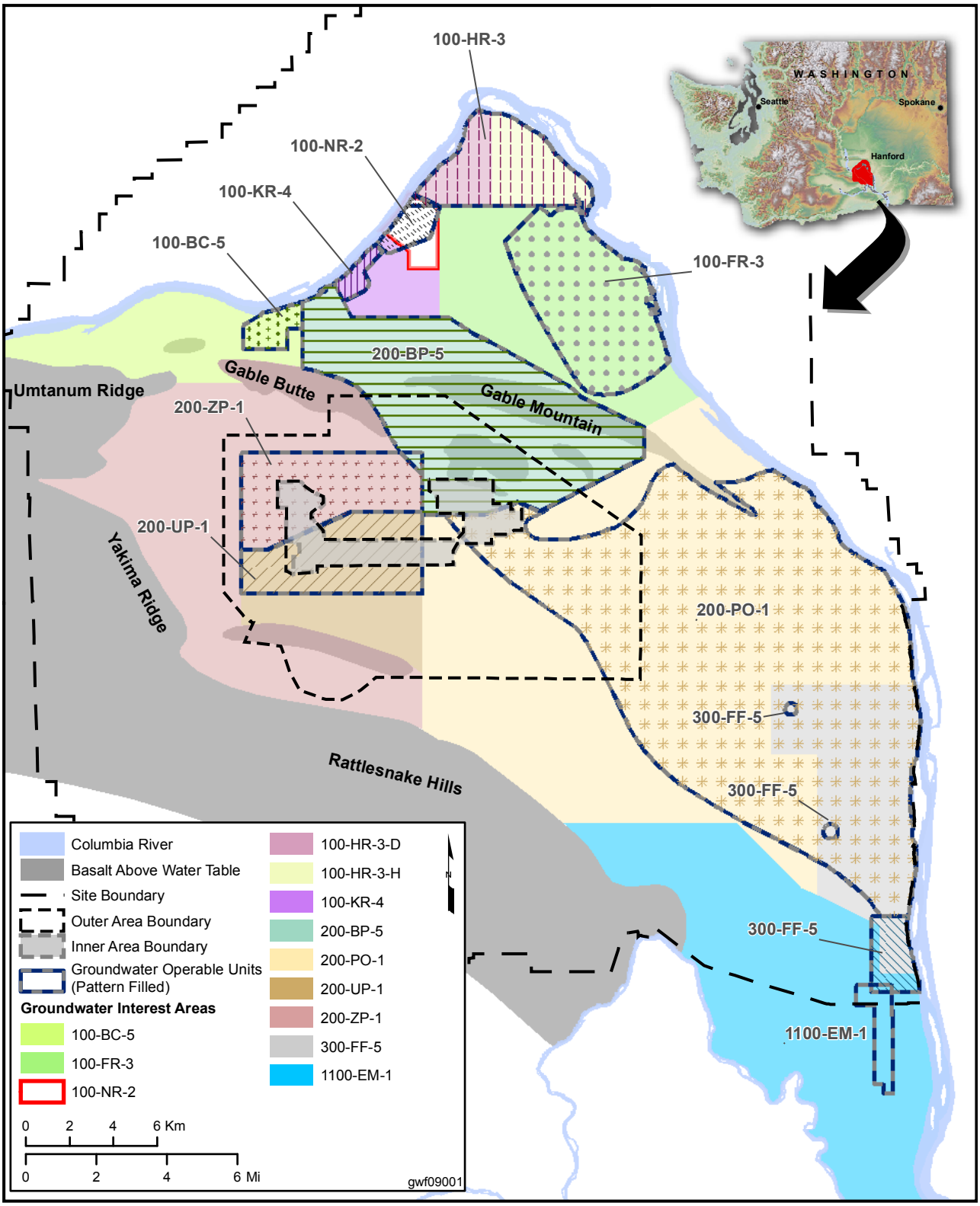


Figure 1-3. Average Calendar Year 2009 Tritium Concentrations on the Hanford Site, Upper Portion of Unconfined Aquifer.

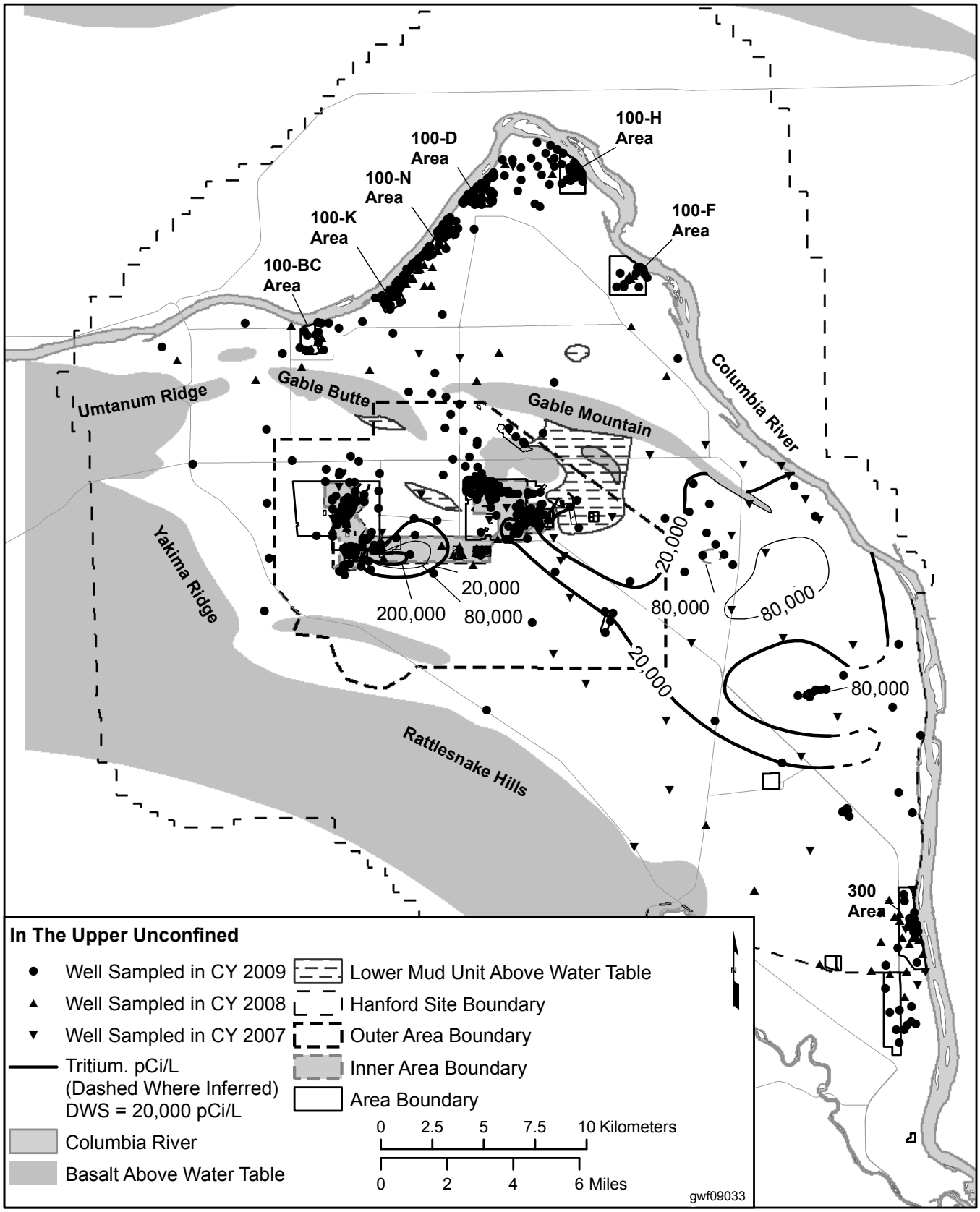


Figure 1-4. Average Calendar Year 2009 Nitrate Concentrations on the Hanford Site, Upper Portion of Unconfined Aquifer.

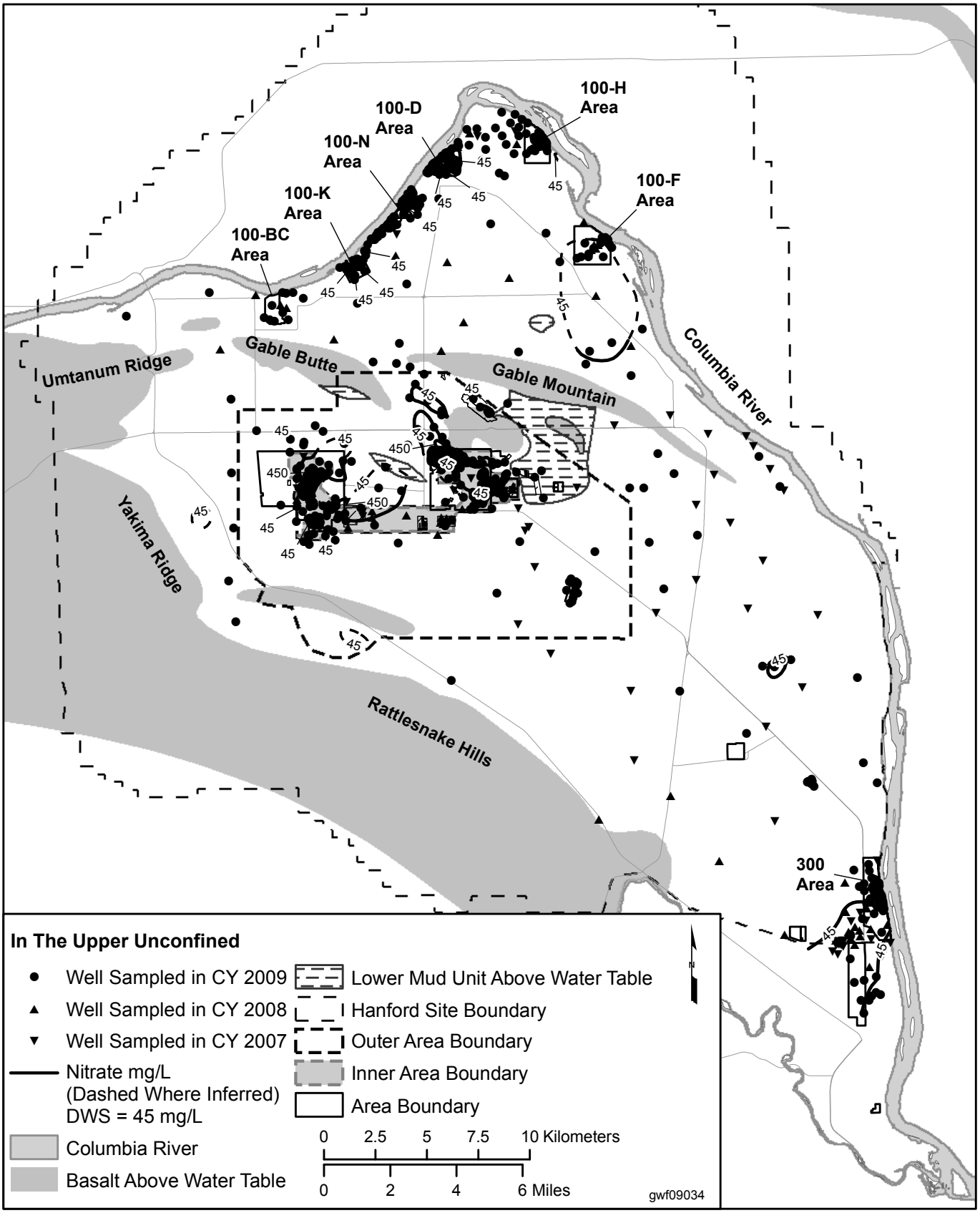
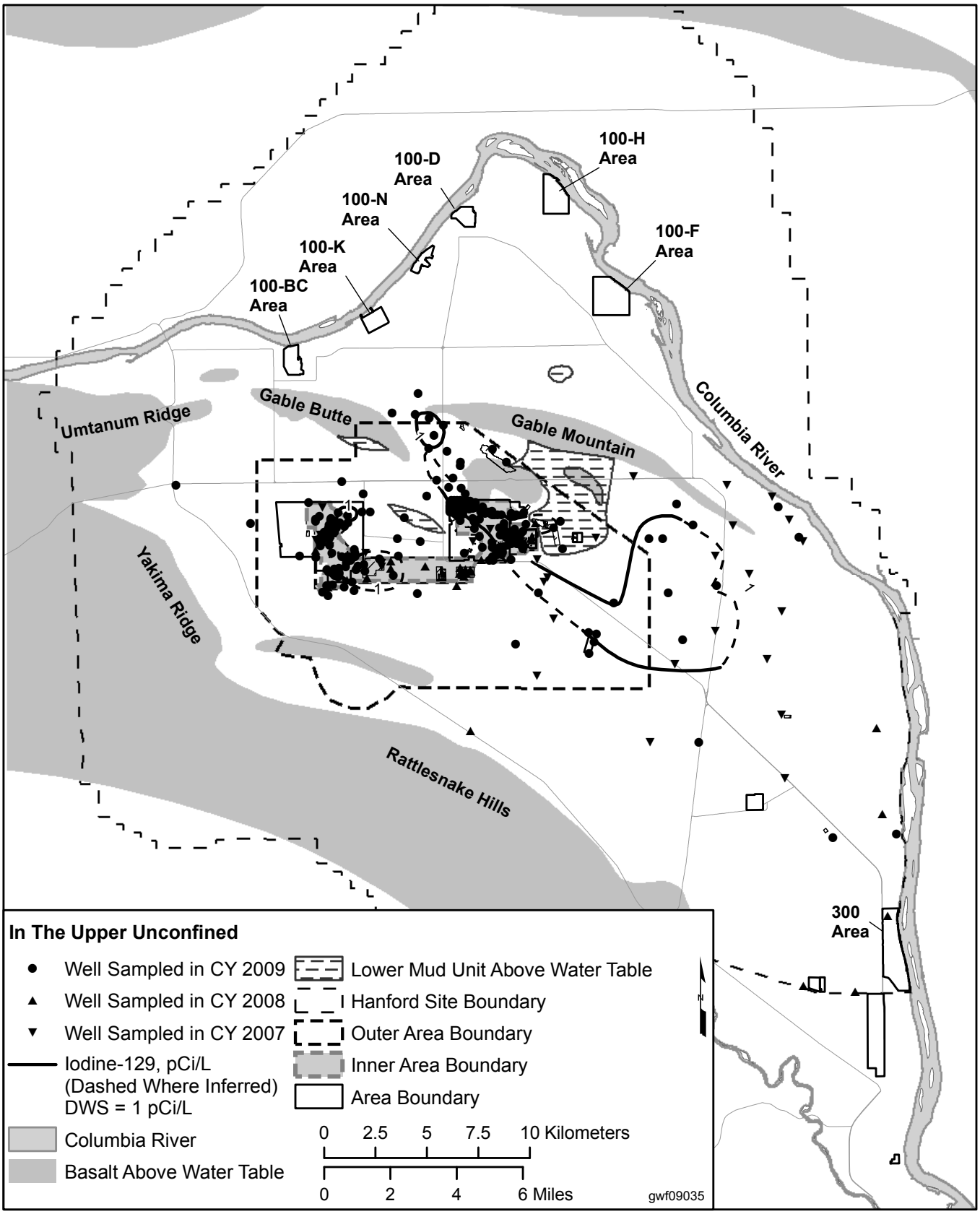


Figure 1-5. Average Calendar Year 2009 Iodine129 Concentrations on the Hanford Site, Upper Portion of Unconfined Aquifer.



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