1.0 Introduction

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The Hanford Site, part of the U.S. Department of Energy's (DOE) nuclear weapons complex, encompasses ~1,500 km^2 in southeastern Washington State. The Columbia River flows through the Site. The federal government acquired the Hanford Site in 1943 and until the 1980s used it to produce plutonium for national defense. Management of waste associated with plutonium production has been a major activity throughout the Site's history and continues today at a much reduced scale. Beginning in the 1990s, the DOE has focused on cleaning up the Site.

The DOE is committed to protecting the Columbia River from the Site's contaminated groundwater. Groundwater is the primary exposure route for Site contaminants to reach human and environmental receptors. DOE/RL-2007-20, *Hanford Integrated Groundwater and Vadose Zone Management Plan*, lays out 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 primary elements associated with managing the Hanford Site's groundwater and vadose zone are (a) to protect the Columbia River and groundwater; (b) to develop a cleanup decision process, and (c) to attain final cleanup.

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

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 potential for future contamination to groundwater
- Contain groundwater plumes and reduce 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 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and/or *Resource Conservation and Recovery Act of 1976* (RCRA). The following five key elements will support final decisions:

- Gather sufficient characterization data, focusing on waste sites with deep contamination that post a future risk to groundwater

This report is designed to meet the following objectives.

- ***Provide a comprehensive report of groundwater conditions on the Hanford Site.***
- ***Fulfill the reporting requirements of RCRA, CERCLA, AEA, and Washington Administrative Code.***
- ***Summarize the results of groundwater monitoring conducted to assess the effects 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.***

- 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 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 completing cleanup of past-practice waste sites 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 Area.

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

1.1 Purpose and Scope

This document presents results of groundwater monitoring to meet the requirements of the AEA, RCRA, and those CERCLA groundwater operable units where cleanup decisions have not yet been made (Table 1.0-1). Other CERCLA groundwater operable units have independent reporting requirements and this document summarizes results reported elsewhere. This report also summarizes vadose zone monitoring and well installation activities. The report covers the period from October 1, 2007, through September 0, 2008 (i.e., fiscal year [FY] 2008). Appendix A lists supporting information for CERCLA monitoring. Appendix B contains tables and figures that support RCRA and other facility monitoring. Table 1.0-2 lists the status of RCRA monitoring for each monitored unit in FY 2008.

Background information, including descriptions of regulatory requirements, waste sites, analytical methods, regional geology, and statistics is published separately in a companion volume, PNNL-13080, *Hanford Site Groundwater: Settings, Sources, and Methods*, and in the most recent update, which was provided in PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, Appendix C.

1.2 Groundwater Monitoring

During FY 2008, staff sampled 865 wells and 297 aquifer tubes for radiological and chemical constituents.

Waste sites are grouped into source operable units, and the groundwater is divided into groundwater operable units. The concept of operable units is to group the waste sites into manageable components for investigation and to prioritize the cleanup work. The groundwater operable units do not cover the entire Hanford Site. To provide scheduling, data review, and interpretation for the entire Site, groundwater staff have defined informal groundwater interest areas that include the groundwater operable units and intervening regions. Figure 1.0-1 illustrates these interest areas and the operable unit boundaries.

Various documents (i.e., monitoring plans or sampling and analysis plans) define which wells to sample, how frequently, and which constituents to analyze.

These choices are based on the data needs for various monitoring purposes, such as complying with regulations, evaluating the performance of remediation, defining plumes and concentration trends, or identifying emerging problems.

During FY 2008, Hanford Site staff sampled 865 wells, approximately the same number as in FY 2007. Staff sampled 297 aquifer tubes in FY 2008, a 50% increase from FY 2007. Many of the sites were sampled multiple times, for a total of 2,601 sampling trips. These numbers do not include special groundwater sampling associated with remediation and research (e.g., treatability tests).

Most of the monitoring wells on the Hanford Site are screened near the top of the unconfined aquifer. In most regions, the shallow part 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 denser than water and can be more widespread deeper in the aquifer. Downward hydraulic gradients also may increase contamination at depth. Studies of contaminant distribution with depth are beginning to be conducted for some plumes, especially those in the 200 West Area.

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

Chromium (total or hexavalent) was the most frequently analyzed constituent. Anions, tritium, gross alpha, gross beta, iodine-129, metals, technetium-99, strontium-90, and volatile organic compounds were other commonly analyzed constituents (Table 1.0-3).

Tritium, nitrate, and iodine-129 are the most widespread contaminants associated with past Hanford Site operations. Figures 1.0-2 through 1.0-4 show their distribution in the upper unconfined aquifer. The most prominent portions of these plumes originated at waste sites in the 200 Area and spread toward the southeast. Nitrate and tritium also had significant sources in the 100 Area.

Table 1.0-4 lists maximum concentrations of selected groundwater contaminants in each groundwater interest area. Electronic data files accompany this report and include FY 2008 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 nonradioactive dangerous waste constituents. Radionuclides (source, special nuclear, and by-product materials) may be monitored in some RCRA unit wells to support objectives of monitoring under AEA and/or CERCLA. Please note that pursuant to RCRA, the source, special nuclear, and by-product material components of radioactive mixed waste are not regulated under RCRA and are regulated by the DOE acting pursuant to its AEA authority. Therefore, while this report may be 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

The DOE monitors groundwater quality along the river by collecting samples from aquifer tubes and riverbank seeps (springs). Hydrologists estimate that groundwater currently flows from the Hanford Site aquifer to the Columbia River at a rate between 1.1 and 2.5 m^3/sec (PNNL-13447; PNNL-14753). This rate is less than 0.075% of the average flow of the Columbia River, ~3,400 m^3/sec.

The rise and fall of the 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*).

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

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

- In mapping, data indicate minimum concentrations of contaminants in groundwater approaching the river (because the samples may be mixed with river water, actual concentrations in groundwater may be higher). However, if a group of 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 or mobilization of contaminants.
- 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 100-D Area chromium plume).

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

- Concentrations may vary seasonally.
- Because aquifer tubes have a much shorter screen interval 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).

1.3.1 Aquifer Tubes

Aquifer tubes are small-diameter flexible tubes that have a screen at the lower end. The tubes are implanted into the aquifer along the Columbia River shore by driving a temporary steel casing into the ground and inserting a tube with attached screen into the casing. The steel casing is then pulled out, leaving the tube in place. Water is withdrawn from the tube using a small pump. Most tube sites include two or three individual tubes monitoring different depths from ~1 to 8 m.

Representatives from the EPA and Ecology meet annually with the DOE and its contractors to plan the annual sampling event, which usually occurs during the fall months (DOE/RL-2000-59, *Sampling and Analysis Plan for Aquifer Sampling Tubes*). An upcoming report will present aquifer tube results for FY 2008. The individual operable unit sections of this report summarize aquifer tube results and include location maps.

In FY 2008, the DOE installed 139 new aquifer tubes at 61 locations along the shoreline.

In FY 2008, the DOE installed 139 new aquifer tubes at 61 locations from the 100-B/C Area to the 300 Area. Two hundred ninety-seven tubes at 150 locations were sampled in FY 2008.

Table 1.0-4 lists maximum contaminant levels in aquifer tubes sampled in FY 2008. Concentrations of strontium-90 exceed the 8 pCi/L drinking water standard in aquifer tubes in the 100-BC-5, 100-NR-2, and 100-H Areas. Levels exceed the 1,000 pCi/L DOE derived concentration guide in 100-N Area tubes. Concentrations are highest in shallow or mid-depth tubes. This reflects the distribution of strontium-90 near the top of the aquifer in the 100 Area.

Hexavalent chromium exceeded the 100 µg/L drinking water standard in 100-D Area aquifer tubes, and exceeded the 10 µg/L aquatic standard (WAC 173-201A) in tubes in each of the 100 Areas (Figure 1.0-5), except 100-N Area. Concentrations are generally highest in deeper tubes because samples are less diluted with river water.

Nitrate concentrations exceeded the 45 mg/L drinking water standard in aquifer tubes at the 100-K, 100-N, and 100-H Areas in FY 2008. An aquifer tube in the southern 300 Area also exceeded the standard. The source of the nitrate is a plume from location off the Hanford Site.

Trichloroethene is detected in several aquifer tubes in the 300 Area and continued to exceed the 5 µg/L drinking water standard in some tubes that monitor a fine-grained unit.

Tritium exceeded the 20,000 pCi/L drinking water standard in a tube in the southern 100-D Area, part of a small plume that originated in the 100-N Area, especially the shallow and mid-depth tubes. New aquifer tubers near the Hanford townsite also exceeded the standard.

Uranium concentrations continued to exceed the 30 µg/L drinking water standard in most of the aquifer tubes in the 300 Area, especially the shallow and mid-depth tubes.

1.3.2 Shoreline Seeps

Columbia River seeps (springs) are sampled each autumn by the DOE's Surface Environmental Surveillance Project. Some seeps are sampled to support CERCLA operable unit requirements. Analytical results for seep samples, along with results for adjacent river water, are published in the annual Hanford Site Environmental Report (e.g., PNNL-17603, *Hanford Site Environmental Report for Calendar Year 2007*). Contaminant concentrations typically are much lower in seep water than in groundwater samples from wells and aquifer tubes. In fall 2007, seeps were sampled between September and December.

Chromium concentrations in samples from seeps were below the 100 µg/L drinking water standard for total chromium. Total chromium in filtered samples (equivalent to hexavalent chromium) exceeded the 10 µg/L aquatic standard for hexavalent chromium (WAC 173-201A) in the 100-D, 100-K, and 100-H Areas. The maximum concentration in a filtered sample was 71.9 µg/L in a 100-K Area spring.

The highest strontium-90 concentration in a shoreline seep was 6.2 pCi/L in a 100-H Area seep near a former retention basin. The only flowing 100-N Area seep is located downgradient of the strontium-90 plume there.

Tritium concentrations exceeded the 20,000 pCi/L drinking water standard in one seep from the former Hanford townsite. Results of three samples from the seep ranged from 29,300 to 52,600 pCi/L.

Uranium exceeded the 30 µg/L drinking water standard in 300 Area seeps. The highest concentration was 120 µg/L (total uranium, converted from isotopic data).

1.4 Quality Control Highlights

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Evaluation of the groundwater project quality assurance program indicates that the data for FY 2008 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 these components indicates that the majority of the FY 2008 data are reliable and defensible. Specific data values associated with out-of-limits quality control results are flagged in the Hanford Environmental Information System (HEIS) database so that users can be circumspect when using them for interpretation. Appendix C includes details about the quality control program for FY 2008. Highlights for FY 2008 include the following.

- Of the groundwater monitoring data, 94% were considered complete (i.e., not rejected, suspect, associated with a missed holding time, or out-of-limit quality control criteria).
- Transfer of groundwater monitoring analytical services from four offsite contract laboratories to the Waste Sampling and Characterization Facility was completed. The Waste Sampling and Characterization Facility performed 80% of the analytical services for the groundwater project.
- The four laboratories supporting groundwater monitoring participated in several national performance evaluation studies. Overall, the percentage of acceptable results was 98%.
- Field quality control samples include three types of field blanks (full trip, field transfer, and equipment blanks), field duplicates, and split samples. Approximately 96% of field blank, 97% of field duplicate, and 89% of split sample results were acceptable, indicating good precision.
- Recommended holding times were met for 99% of nonradiological sample analysis requests. In general, the missed holding times should not have a significant impact on the data.
- Overall, laboratory performance on blind standards was good; 90% of the results were acceptable.
- Approximately 97% of the laboratory quality control results were within the acceptance limits, indicating that the analyses were in control and reliable data were generated. Specifically, 98% of method blanks, 99% of the laboratory control samples, 96% of the matrix spikes and matrix duplicates, and 99% of the surrogates were within the acceptance limits.
- The DOE and its contractors conducted audits and assessments of the laboratories. Several findings and observations were identified, along with a number of proficiencies. Corrective actions have been accepted for all of the audits.

1.5 Related Reports

Other reports and databases relating to Hanford Site groundwater include the following.

- Hanford Environmental Information System database — The main environmental database for the Hanford Site that stores groundwater chemistry data and other environmental data (e.g., soil chemistry, survey data).
- Annual summary reports for interim actions — The annual reports evaluate the performance of pump-and-treat and other remediation systems in the 100 and 200 Areas. Results are summarized in the applicable sections of this report.
- Quarterly RCRA data transmittals — The DOE transmits informal reports quarterly to Ecology after groundwater data have been verified and evaluated (e.g., SGW-37533; SGW-38473; SGW-39325). These reports describe changes or highlights of the quarter with reference to the HEIS database for the analytical results.
- Annual aquifer tube sampling results report (planned publication in FY 2009) — The report discusses chemical and radiological monitoring of aquifer tubes in greater detail than presented in the groundwater annual report.
- PNNL-17603, *Hanford Site Environmental Report for Calendar Year 2007* — The annual report summarizes environmental data, including groundwater, riverbank springs, and river water. It also describes environmental management performance and reports the status of compliance with environmental regulations.
- DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* (planned publication in FY 2009) — The work plan will contain the planning elements common to all decision units within the 100 Area, and a summary of the remedial investigation/feasibility study tasks. A series of addenda will provide information and planning specific to each of the decision units.
- River Corridor Baseline Risk Assessment — A critical step in developing final remedial action decisions is 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 townsites.
  - 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* — The report describes the 2006 to

Websites

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/default.cfm

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

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.

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 five years. The DOE released DOE/RL-2006-20, *The Second CERCLA Five-Year Review Report for the Hanford Site* in November 2006. The purpose of the review was to determine whether the selected remedies are protective of human health and the environment, and recommend appropriate corrective actions if the remedy is not achieving the established goals. The report made the following conclusions regarding groundwater operable units.

- 100-KR-4 and 100-HR-3 Operable Units — Because the groundwater interim actions in the 100 Area are not designed to be remedial actions, the protectiveness of the selected remedies could not be assessed. Contaminants other than the selected principle threat contaminants may be addressed in the interim actions that need to be addressed in the final records of decision.
- 100-NR-2 and 300-FF-5 Operable Units — The interim remedies have not achieved their objectives. Institutional controls are effective in protecting human health. However, determinations of protectiveness are being deferred until a final remedy is selected through the CERCLA remedial investigation/feasibility study process.
- 100-BC-5 and 100-FR-3 Operable Units — Records of decision for groundwater remediation have not been established for these areas. Previous assessments have not identified groundwater conditions that warrant interim remedial measures, assuming that the source control measures will meet established remedial action objectives designed to reduce contaminant recharge to the aquifer.
- 200-BP-5 and 200-PO-1 Operable Units — Records of decision for groundwater remediation have not been established for these areas.
- 200-ZP-1 Groundwater Operable Unit — Protectiveness determinations for the pump-and-treat and vapor-extraction systems were deferred until a final remedy is selected through the CERCLA remedial investigation/feasibility study process. The final record of decision for this operable unit was approved in September 2008.
- 200-UP-1 Operable Unit — This system has met the remedial action objectives identified in the record of decision for interim action. The need for additional work will be assessed through the CERCLA remedial investigation/feasibility study process.
- 1100-EM-1 Operable Unit — The selected remedial actions have been completed and the remedy remains protective. The operable unit was removed from the National Priorities List (40 CFR 300, Appendix B), and is no longer considered a CERCLA site.

The review identified 20 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 operable units are

discussed in the applicable sections of this report. The three actions pertaining to the River Corridor cut across operable unit boundaries and have all been completed (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, Table 1.0-4).

1.7 EM-22 Technology Proposals

In FY 2006, the U.S. Congress authorized 10 million dollars for "...analyzing contaminant migration to the Columbia River, and for the introduction of 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 in FY 2008:

- Inject micron-size iron into the deteriorating portions of the redox barrier (100-HR-3-D)
- Field test electrocoagulation for accelerated cleanup (100-HR-3-D)
- In situ biostimulation of groundwater (100-HR-3-D)
- Chromium vadose zone characterization and geochemistry (100-HR-3-D)
- Location refinement of the chromium source and a geochemical/mineralogical study of chromium in the vadose zone (100-HR-3-D)
- Strontium-90 treatability demonstration of phytoremediation (100-NR-2)
- Sequestration of strontium-90 subsurface contamination by surface infiltration of an apatite solution (100-NR-2)
- Uranium stabilization through polyphosphate injection (300-FF-5)
- Carbon tetrachloride and chloroform attenuation parameter studies (200-ZP-1).

Website
More information on the EM-22 projects is available at http://www.hanford.gov/cp/gpp/science/em21.cfm.

Progress on these projects is summarized in the applicable sections of this report.

1.8 Conventions Used in This Report

Well location maps in this report show any well used for sampling or water-level measurements in the past five years. Dry or decommissioned wells are shown with different symbols. On most of the maps well name prefixes (e.g., 199- in the 100 Area, 299- in the 200 Area) are omitted. Aquifer tubes, which are often installed in multi-depth clusters, are usually shown as a single point and depth suffixes (e.g., –S, –M, and –D) are omitted.

Unless specified otherwise, contaminant plume maps in this report are based on average results for samples collected in FY 2008 for each well, excluding data that appear unrepresentative.[1] Averaging data allows the maps to include wells sampled at different times and at different frequencies. In some locations, it is advantageous

1 A table of data excluded from the plume maps, and the rationale for exclusion, is included in the electronic files accompanying this report. The excluded data have been deemed unrepresentative of upper aquifer conditions for reasons such as laboratory error or unusual sampling conditions (e.g., samples collected during drilling or using a method not comparable to routine monitoring).

to construct maps based on data from a single sampling event (e.g., uranium in the 300 Area in June 2008).

Contour levels are chosen to meet of the following objectives:

- Drinking water standards and multiples of 10 (e.g., 8, 80, and 800 pCi/L for strontium-90)
- Cleanup levels, where applicable (e.g., 20 µg/L for chromium)
- Levels lower than drinking water standards to show areas affected by contamination (e.g., 2,000 pCi/L for tritium)
- Intermediate levels to help define plumes (e.g., 60 and 90 µg/L for uranium).

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

Mapped data are rounded to two significant digits. The maps are interpretations by project staff using current and historical data, source knowledge, and groundwater flow directions. Staff use data from FY 2006 and FY 2007 for wells that did not have new data in FY 2008. Older data and data from aquifer tubes along the Columbia River are given less weight than the current well data when the maps are contoured. The maps show data from wells completed in the upper part of the unconfined aquifer (generally the top ~10 m).

Results less than detection limits (flagged "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 analytical detection limits. These values are treated as zeroes and included in the data to be averaged. If all results (or the only result) for the fiscal year were undetected, a U is plotted on the map. If the data represent a mixture of detected and undetected results, the average is plotted on the map, followed by an asterisk.
- For radiological parameters, if the counting error is greater than the result, the result is flagged U. Other factors also may result in values being flagged U. For plotting on maps, all of the results for the fiscal 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 fiscal year were undetected) or an asterisk (if the data represent a mixture of detected and undetected values). Note that the laboratories correct results for background radiation. In some cases, background corrected values 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 drinking water standard), which can be less than the laboratory's detection limit. Historically, samples containing significant concentrations of technetium-99 required pretreatment to remove technetium-99 prior to iodine-129 analysis (PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, Section C.6.1). Despite this practice, some values greater than 1 pCi/L were reported as undetected. Currently, the laboratory can process technetium-99 containing samples without the pretreatment, while maintaining the minimum detectable activity at 1 pCi/L. However, the laboratory still requires that both primary and secondary energy peaks are present before considering iodine-129 detected. Requiring the secondary (less sensitive) energy peak adds conservatism to the laboratory's report (i.e., the laboratory only reports a detection when certain of the detection). Many

of the U-flagged values are believed to be real detections, and they are contoured as such. The contour lines are dashed to show that the distribution of iodine-129 at levels near the drinking water standard 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 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. Trend plots in this report use open symbols to show values so low the laboratory could not detect them. 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 generally are based on qualitative observation, not statistical evaluation.

When groundwater samples are collected for metals analysis, two samples are routinely collected: one filtered in the field and the other unfiltered. Collection of unfiltered samples for metals analysis began in FY 2008 in response to a letter from EPA and Ecology (Hedges and Ceto, 2007, "Field-Filtering of Ground Water Samples Prior to Laboratory Analysis"). Previously, only filtered metals samples were collected from most wells. Unfiltered samples, especially from turbid samples, may contain particulate material from the well screen or aquifer that affects concentrations of some metals. EPA and Ecology were concerned that the use of field-filtered samples might cause an underestimation of the amount of contamination that is naturally mobile in groundwater. Collecting both filtered and unfiltered samples will provide data with which to compare dissolved trace metals concentrations (filtered samples) to total trace metals concentrations (unfiltered samples). In this report, both filtered and unfiltered results are provided in discussions of metals. Other samples, including non-metals, hexavalent chromium, and uranium, generally are not filtered in the field unless the sample turbidity is excessive.

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. DOE/RL-2008-01, Appendix C compares chromium data from filtered, unfiltered, total, and hexavalent analyses.
- Contaminant concentrations are compared with state or federally enforceable drinking water standards (Table 1.0-5). Although Hanford Site groundwater is not generally used for drinking, 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 1.0-6).

Dissolved chromium in Hanford Site groundwater is virtually all hexavalent.

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

Table 1.0-1. Reporting Requirements for Groundwater Monitoring.

Operable Unit or Facility	Formal Report	Supplemental Reports or Summaries
CERCLA		
Operable units without RODs (100-BC-5, 100-FR-3, 200-BP-5, 200-PO-1)	This report	Unit manager's meeting presentations
Operable units with interim action RODs (100-KR-4, 100-NR-2, 100-HR-3, 200-UP-1, 200-ZP-1)	Interim action annual reports (summarized in this report)	Unit manager's meeting presentations; this report
Operable unit with interim action ROD (300-FF-5)	This report	Unit manager's meeting presentations; this report
Operable unit with final ROD (1100-EM-1)	This report	None
ERDF	Separate annual report covers groundwater and leachate (summarized in this report)	This report
RCRA Units		
Operating RCRA units (IDF, LERF, LLBG)	This report	Informal quarterly reports
Closure RCRA units (116-N-1 and -3; 120-N-1 and -2)	This report	Informal quarterly reports
Post-closure RCRA units (116-H-6 and 316-5)	Semiannual reports to Ecology; this report	Informal quarterly reports
Interim-status assessment RCRA sites (PUREX Cribs, WMA A-AX, B-BX-BY, S-SX, T, TX-TY, and U)	This report; also occasional assessment reports	Informal quarterly reports
Interim-status detection (216-A-29, 216-B-63, 216-S-10 Pond, NRDWL, and WMA C)	This report	Informal quarterly reports
Other Facilities		
AEA sites (K Basins, 400 Area water supply wells)	This report	Unit manager's meeting presentation
SALDS (WAC 173-216)	Separate annual report	This report
TEDF (WAC 173-216)	This report	None
SWL (WAC 173-304)	This report for groundwater; separate report for leachate and soil gas	None

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 1.0-2. Fiscal Year 2008 RCRA Monitoring Status.

RCRA Unit	Report Section	FY 2008 Status
116-N-1 (1301-N) Facility	2.4.3.1	Continued detection*
120-N-1, (1324-NA) 120-N-2 (1324-N) Facilities	2.4.3.2	Continued detection;* one new well completed early FY 2009 to replace seasonally dry well.
116-N-3 (1325-N) facility	2.4.3.3	Continued detection*
116-H-6 (183-H) Evaporation Basins	2.6.3	Corrective action alternative program during interim remedial action. Chromium, nitrate.
216-A-29 Ditch	2.11.3.4	Continued detection*
216-B-3 Pond	2.11.3.5	Continued detection*
216-B-63 Trench	2.10.3.2	Continued detection*
216-S-10 Pond and Ditch	2.9.3.3	Continued detection;* three new wells.
316-5 (300 Area) Process Trenches	2.12.3	Compliance/corrective action; organics.
Integrated Disposal Facility	2.11.3.1	Not yet in use; monitoring results added to background data set.
LERF	2.10.3.5	Two new wells monitor fractured basalt flow-top. DOE and Ecology pursuing agreement for monitoring.
LLWMA 1	2.10.3.3	Continued detection*
LLWMA 2	2.10.3.4	Continued detection*
LLWMA 3	2.8.3.1	Statistical evaluations suspended until upgradient wells installed and background values established.
LLWMA 4	2.8.3.2	TOC exceeded critical mean value in August 2008; beginning assessment FY 2009; remaining upgradient wells went dry.
NRDWL	2.11.3.6	TOC exceeded critical mean value in August 2008; beginning assessment FY 2009.
PUREX Cribs	2.11.3.2	Continued assessment: nitrate.
SST WMA A-AX	2.11.3.3	Continued assessment (first determination); new well.
SST WMA B-BX-BY	2.10.3.1	Continued assessment: nitrate.
SST WMA C	2.10.3.6	Continued detection*
SST WMA S-SX	2.9.3.2	Continued assessment: chromium, nitrate.
SST WMA T	2.8.3.3	Continued assessment: chromium, nitrate.
SST WMA TX-TY	2.8.3.4	Continued assessment: chromium, nitrate.
SST WMA U	2.9.3.1	Continued assessment: nitrate.

* Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with hazardous constituents from the unit.

FY = fiscal year.
LERF = Liquid Effluent Retention Facility.
LLWMA = Low Level Waste Management Area.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PUREX = Plutonium-Uranium Extraction Plant.
RCRA = *Resource Conservation and Recovery Act of 1976*.
SST = single-shell tanks.
TOC = total organic carbon.
WMA = Waste Management Area.

Table 1.0-3. Number of Groundwater Analyses, Fiscal Year 2008.

Constituent	Site Total
Chromium (total and hexavalent)	3,968
Gross alpha	933
Gross beta	1,139
Iodine-129	485
Nitrate	2,146
Organics (carbon tetrachloride, trichloroethene)	835
Plutonium-239/240	49
Strontium-90	557
Technetium-99	1,068
Tritium	1,409
Uranium	994

Table 1.0-4. Maximum Concentrations of Selected Groundwater Contaminants in Groundwater Interest Areas, Fiscal Year 2008.

Contaminant, units (alphabetical order)	DWS (DCG)[a]	100-BC-5		100-KR-4		100-NR-2		100-HR-3-D		100-HR-3-H		100-FR-3	
		Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes
Arsenic[b] (filtered) (µg/L)	10				2.59			4.87	0.761				
Arsenic[b] (µg/L)	10			8.04	2.85			5	0.678				
Carbon tetrachloride (µg/L)	5												
Carbon-14 (pCi/L)	2,000 (70,000)			**6,740**	349	10.7							
Cesium-137 (Ci/L)	200 (3,000)												
Chloroform (µg/L)	100			0.4		0.91							
Chromium,[b] total (filtered) (µg/L)	100	50.5		**3,350**	79.7	**172**	13.2	**10,500**	**364**	**100**		42.5	11.7
Chromium,[b] total (µg/L)	100	52.5		**3,550**	72.4	**493**	15.7	**9,970**	**362**	93.8		51.8	17.3
Chromium,[b] hexavalent (filtered) (µg/L)	100							**296**					
Chromium,[b] hexavalent (µg/L)	100	54.8	46.3	**3,540**	80.9	87	64.9[c]	**39,900**	**422**	**157**	73.7	10.9	11.9
cis-1,2-Dichloroethylene (µg/L)	70												
Cobalt-60 (pCi/L)	100 (5,000)												
Cyanide (µg/L)	200												
Fluoride (mg/L)	4	0.23	0.181	0.44	0.303	0.686	0.434	0.508	0.191	0.5	0.182	0.681	0.21
Gross alpha (pCi/L)	15	1.57	2.4	**24.1**	2.58	5.7	4.6	3.34		4.3	3.67	12	2.9
Gross beta (pCi/L)	50	**87**	40	**3,000**	6.96	**51,000**[d]	**150,000**[d]	**152**	15	**57.2**	24.3	**51.2**	6.2
Iodine-129 (pCi/L)	1 (500)												
Nitrate (mg/L)	45	39.5	22.3	**139**	**52.7**	**259**	**54**	**116**	35.4	44.3	**45.6**	**114**	40.9
Nitrite (mg/L)	3.3	0.414		0.371	0.053	0.805	0.079	**5.42**		0.453	0.049		0.039
Plutonium-239/240 (pCi/L)	1.2[e] (30)												
Strontium-90 (pCi/L)	8 (1,000)	**44.7**	**16**	***1,610***	3.3	***17,000***	***75,000***[d]	7.7	2.56	**24.8**	**11.6**	**25.8**	4.4
Technetium-99 (pCi/L)	900 (100,000)	11.4	45.4	63				87		31			
Tetrachloroethene (µg/L)	5												
Trichloroethene (µg/L)	5			**7.7**								**9.7**	
Tritium (pCi/L)	20,000 (2,000,000)	**57,000**	20,000	**621,000**	8,300	**22,000**	12,000	**27,000**	**23,000**	5,500		15,000	920
Uranium (µg/L)	30			6.93				3.89		8.38	2.32	17.6	

Table 1.0-4. (cont.)

Contaminant, units (alphabetical order)	DWS (DCG)[a]	200-ZP-1	200-UP-1	200-BP-5		200-PO-1		300-FF-5		1100-EM-1
		Wells	Wells	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells
Arsenic[b] (filtered) (µg/L)	10	**10.8**	6.19	**17.4**		**10.2**			3.07	
Arsenic[b] (µg/L)	10	**14.2**	5.8	**23.4**		**10.5**			2.56	
Carbon tetrachloride (µg/L)	5	**4,900**	**1,400**	3.4		1		3.5	1.4	2.9
Carbon-14 (pCi/L)	2,000 (70,000)		32.9	141						
Cesium-137 (Ci/L)	200 (3,000)			**1,650**						
Chloroform (µg/L)	100	32	17	0.52		0.3		2.1	2.8	
Chromium,[b] total (filtered) (µg/L)	**100**	**640**	**823**	**233**		47.1	3.2	90.7	7	6.6
Chromium,[b] total (µg/L)	**100**	**670**	**846**	**140**	8.1	71.2	3.3	86.3	12.9	16.5
Chromium,[b] hexavalent (filtered) (µg/L)	100									
Chromium,[b] hexavalent (µg/L)	100	50	61	43.2	16		3.7			
cis-1,2-Dichloroethylene (µg/L)	70							**190**	4.8	
Cobalt-60 (pCi/L)	100 (5,000)			**1,040** [f]						
Cyanide (µg/L)	200		4.1	**7,180** [f]						
Fluoride (mg/L)	4	**4.56**	0.55	**107**	0.316	**9.09**	0.16	**16.7**	0.717	1.24
Gross alpha (pCi/L)	15	8.3	8.27	**1,800**	1.93	**30**	5.03	**110**	**54**	7.6
Gross beta (pCi/L)	50	**5,200**	**10,400**	**34,000**	40.6	**4,400**	6.32	**160**	**53**	9.4
Iodine-129 (pCi/L)	1 (500)	**37.6**	**37.1**	**5.63**		**10.4**				
Nitrate (mg/L)	45	**2,820**	**868**	**17,800**[f]	28.4	**127**	33	**293**	**52.2**[g]	**307**[g]
Nitrite (mg/L)	3.3	0.907	0.545	**18.6**		0.552		0.69	0.161	
Plutonium-239/240 (pCi/L)	1.2 [e] (30)	0.021		**27**						
Strontium-90 (pCi/L)	8 (1,000)	3.8	2.8	***3,740***		**20.2**	1.9			
Technetium-99 (pCi/L)	900 (100,000)	**18,000**	**67,000**	**100,000** [f]	114	**8,000**		225		
Tetrachloroethene (µg/L)	5	2.1				2.6			4.7	
Trichloroethene (µg/L)	5	**11**	**9.6**			1.7		4.2	**530**	
Tritium (pCi/L)	20,000 (2,000,000)	**1,200,000**	**290,000**	**170,000** [f]	13,000	**650,000**	**35,000**	**940,000**	9,100	1,500
Uranium (µg/L)	30	**48.8**	**391**	**3,910**		30		**225**	**180**	26.5

Note: Table lists highest value for fiscal year 2008 in each groundwater interest area, excluding those flagged "R" or "Y" or special (non-routine) samples (except as noted).
Concentrations in bold exceed DWS. Those in bold italics exceed DCG.
Blank cells indicate a constituent was not detected or not analyzed.
[a] DWS = drinking water standard; DCG = derived concentration guide. See Table 1.0-5 and 1.0-6 for more information.
[b] 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.
[c] Value from aquifer tube on boundary of 100-KR-4 groundwater interest area. 100-N Area aquifer tubes have lower chromium.
[d] Results from special sampling for apatite treatability test. Strontium-90 value was calculated as one-half the maximum gross beta value.
[e] There is no DWS for plutonium-239/240. The 4 mrem/yr effective dose equivalent is 1.2 pCi/L.
[f] Sample from well 299-E33-4, which is nearly dry.
[g] Nitrate from offsite sources.

Table 1.0-5. Selected Drinking Water Standards and Groundwater Cleanup Levels.

Constituent	DWS	Agency [a]	MTCA [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
Barium (µg/L)	2,000	EPA, DOH	3,200
Cadmium (µg/L)	5	EPA, DOH	8.0
Carbon tetrachloride (µg/L)	5	EPA, DOH	0.337
Chloride (mg/L)	250 [c]	EPA, DOH	
Chloroform (THM) [d] (µg/L)	70	EPA, DOH	7.17
Chromium (µg/L)	100 [e]	EPA, DOH	48 [f]
cis-1,2-Dichloroethene (µg/L)	70	EPA, DOH	80
Copper (µg/L)	1,300 [g]	EPA, DOH	640
	1,000 [c]	EPA	
Cyanide (µg/L)	200	EPA, DOH	0.104
Fluoride (mg/L)	4	EPA, DOH	0.960
	2 [c]	EPA, DOH	
Iron (µg/L)	300 [c]	EPA, DOH	11,200
Lead (µg/L)	15 [g]	EPA, DOH	
Manganese (µg/L)	50 [c]	EPA, DOH	752
Mercury (inorganic) (µg/L)	2	EPA, DOH	4.8
Methylene chloride (Dichloromethane) (µg/L)	5	EPA	5.83
Nitrate, as NO_3^- (mg/L)	45 [h]	EPA, DOH	115
Nitrite, as NO_2^- (mg/L)	3.3 [i]	EPA, DOH	5.3
pH	6.5 to 8.5 [c]	EPA	
Selenium (µg/L)	50	EPA, DOH	80
Silver (µg/L)	100 [c]	EPA, DOH	80
Sulfate (mg/L)	250 [c]	EPA, DOH	
Tetrachloroethene (µg/L)	5	EPA, DOH	80
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
Trichloroethene (µg/L)	5	EPA, DOH	0.49
Zinc (µg/L)	5,000 [c]	EPA, DOH	4,800
Antimony-125 (pCi/L)	300 [j]	EPA	
Beta particle and photon activity (mrem/yr)	4 [k]	EPA, DOH	
Carbon-14 (pCi/L)	2,000 [j]	EPA	
Cesium-137 (pCi/L)	200 [j]	EPA	
Cobalt-60 (pCi/L)	100 pCi/L [j]	EPA	
Iodine-129 (pCi/L)	1 pCi/L [j]	EPA	
Ruthenium-106 (pCi/L)	30 pCi/L [j]	EPA	
Strontium-90 (pCi/L)	8 pCi/L [j]	EPA, DOH	
Technetium-99 (pCi/L)	900 pCi/L [j]	EPA	

Table 1.0-5. (cont.)

Constituent	DWS	Agency [a]	MTCA [b]
Total alpha (excluding uranium) (pCi/L)	15[j]	EPA, DOH	
Tritium (pCi/L)	20,000[j]	EPA, DOH	
Uranium (µg/L)	30	EPA, DOH	48

[a] DOH = Washington State Department of Health at WAC 246-290; EPA = U.S. Environmental Protection Agency at 40 CFR 141, 40 CFR 143, and EPA/822/R-96/001.
[b] Model Toxics Control Act, Method B cleanup levels for groundwater (WAC 173-340).
[c] Secondary standards are not associated with health effects, but with taste, odor, staining, or other aesthetic qualities.
[d] Standard is for total trihalomethanes.
[e] Total chromium.
[f] Hexavalent chromium.
[g] Action level.
[h] 45 mg/L as NO_3- is equivalent to 10 mg/L as N.
[i] 3.3 mg/L as NO_2- is equivalent to 1 mg/L as N.
[j] EPA drinking water standards for radionuclides were derived based on a 4-mrem/yr dose standard using maximum permissible concentrations in water specified in NBS Handbook 69 (U.S. Department of Commerce, as amended August 1963).
[k] 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/yr. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr. Compliance may be assumed if annual average concentrations of total beta, tritium, and strontium-90 are <50, 20,000, and 8 pCi/L, respectively.

DWS = drinking water standard (maximum contaminant level for drinking water supplies).

Table 1.0-6. Derived Concentration Guides, 4 mrem Effective Dose Equivalent Concentrations, for 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 (pCi/L)	Risk-Based Concentration [e] (pCi/L) Industrial	Risk-Based Concentration (pCi/L) Residential
Carbon-14	70,000	2,800	2,000	1,030	34
Cesium-137	3,000	120	200	60	1.7
Cobalt-60	5,000	200	100	102	3.4
Iodine-129	500	20	1	11	0.36
Plutonium-239/240	30	1.2	None	12	0.39
Strontium-90	1,000	40	8	29	0.95
Technetium-99	100,000	4,000	900	580	19
Tritium	2,000,000	80,000	20,000	2,600	160
Uranium-234 [f]	500	20	None	23	0.75
Uranium-235 [f]	600	24	None	23	0.76
Uranium-238 [f]	600	24	None	25	0.83

[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/yr.
[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 O 5400.5.
[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. EPA drinking water standards for radionuclides listed in Table 1.1-5 were derived based on a 4-mrem/year dose standard using maximum permissible concentrations in water specified in National Bureau of Standards Handbook 69 (U.S. Department of Commerce, as amended August 1963). The 4-mrem/yr 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 O 5400.5 in 1993).
[e] Based on slope factors from EPA's risk website: "Radionuclide Carcinogenicity Slope Factors," http://epa.gov/radiation/heast/index.html, in turn based on FGR-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.
[f] See Table 1.1-5 for total uranium.

DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.

Figure 1.0-1. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site.

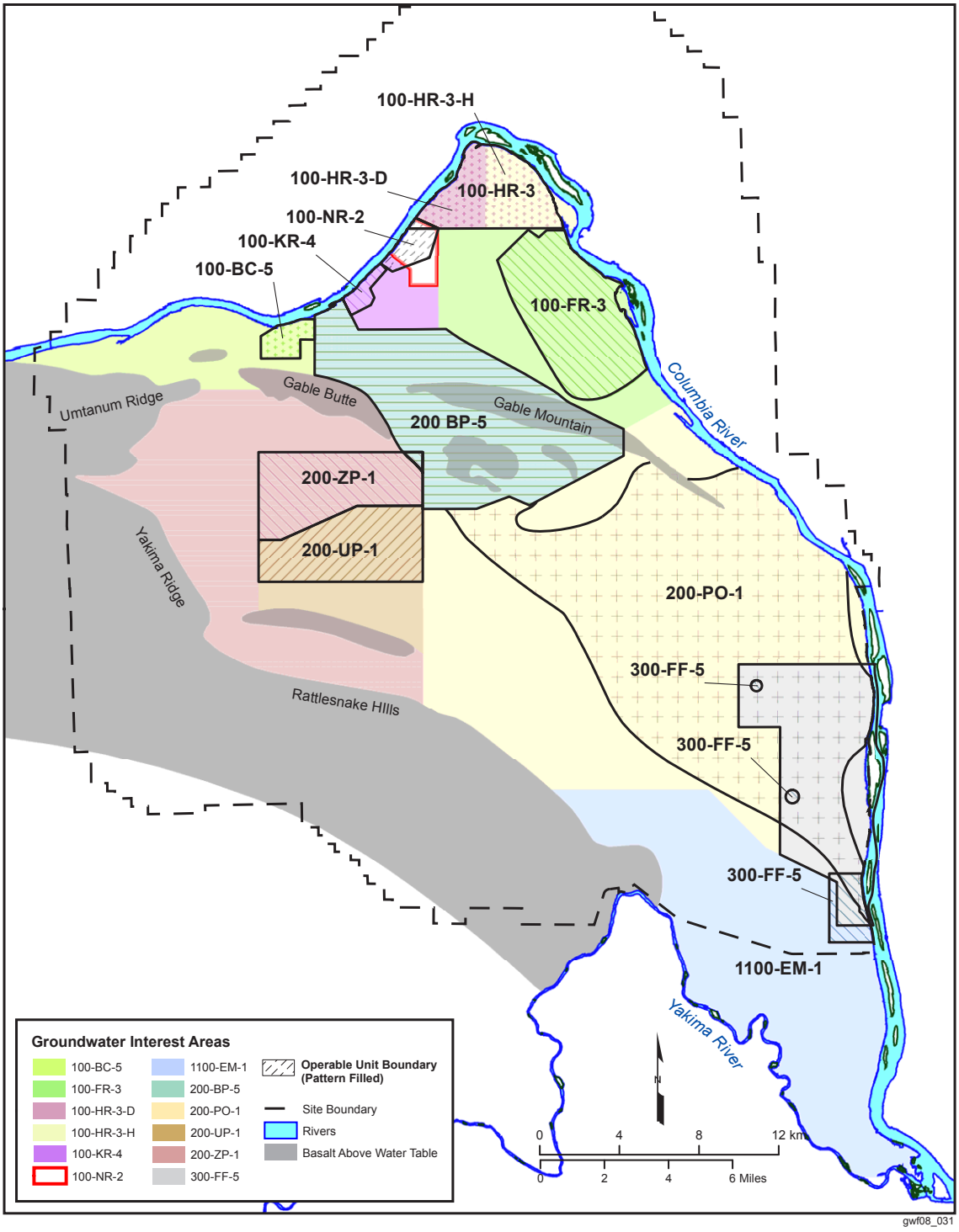

Figure 1.0-2. Average FY 2008 Tritium Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer.

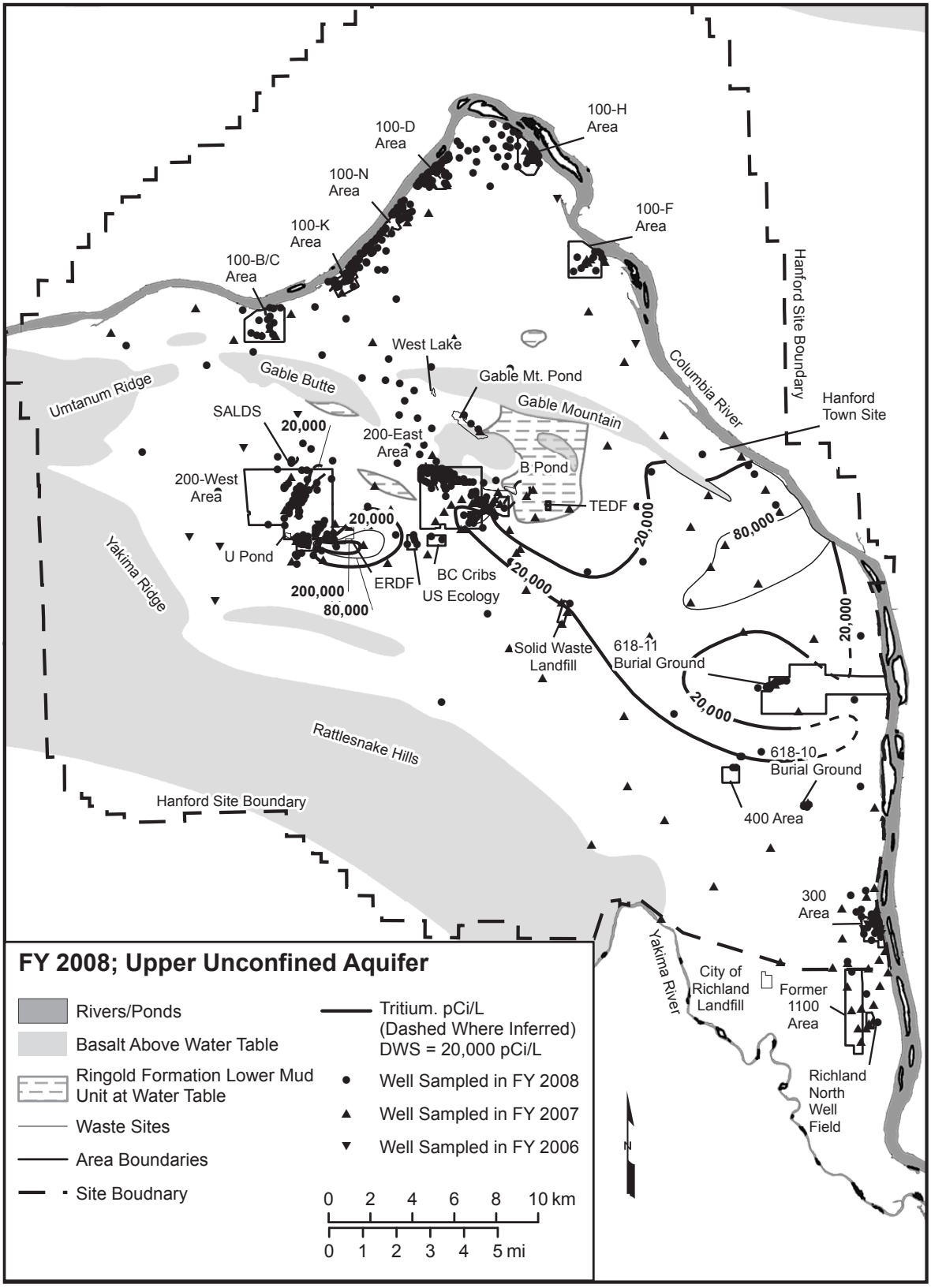

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Figure 1.0-3. Average FY 2008 Nitrate Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer.

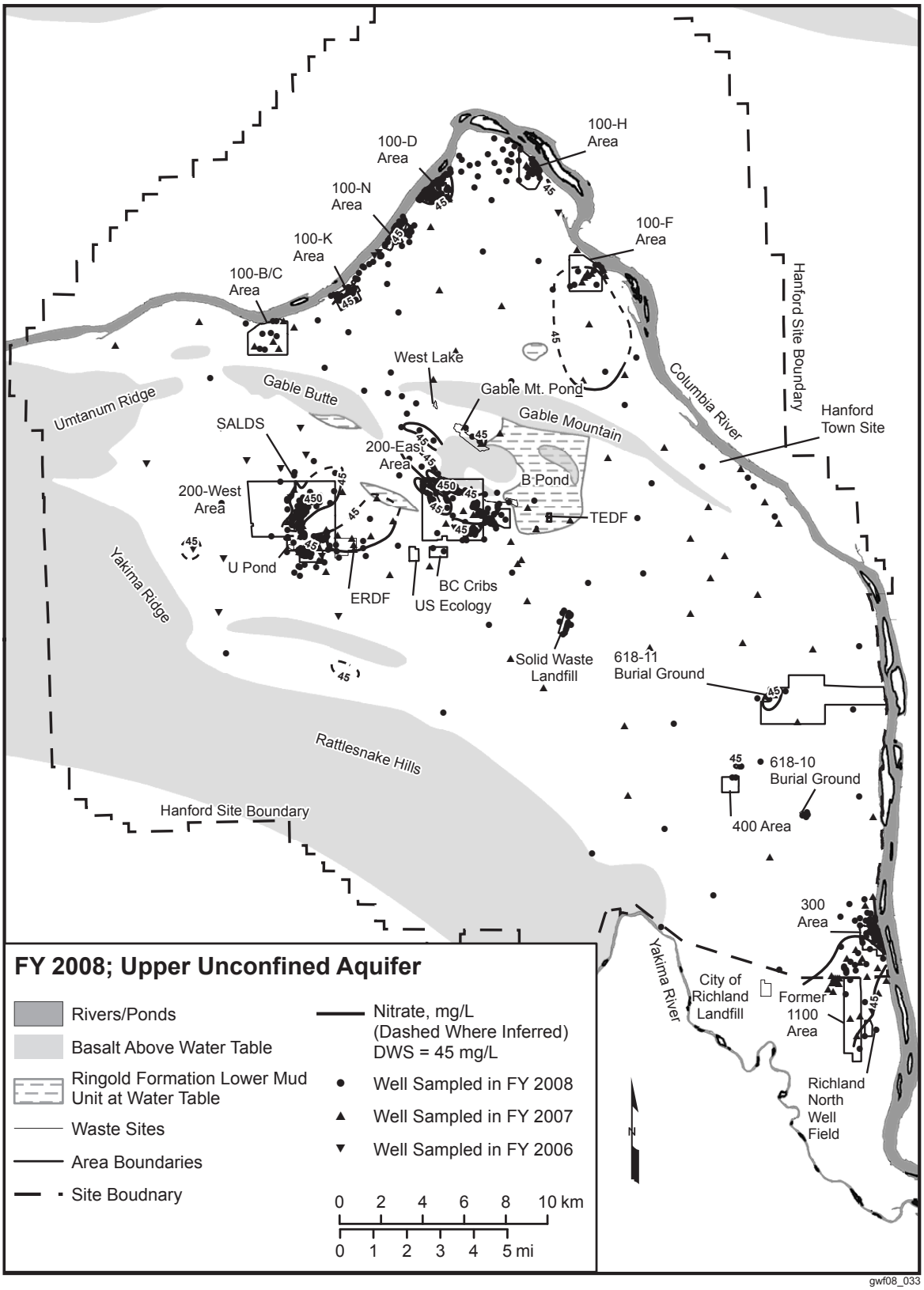

Figure 1.0-4. Average FY 2008 Iodine-129 Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer.

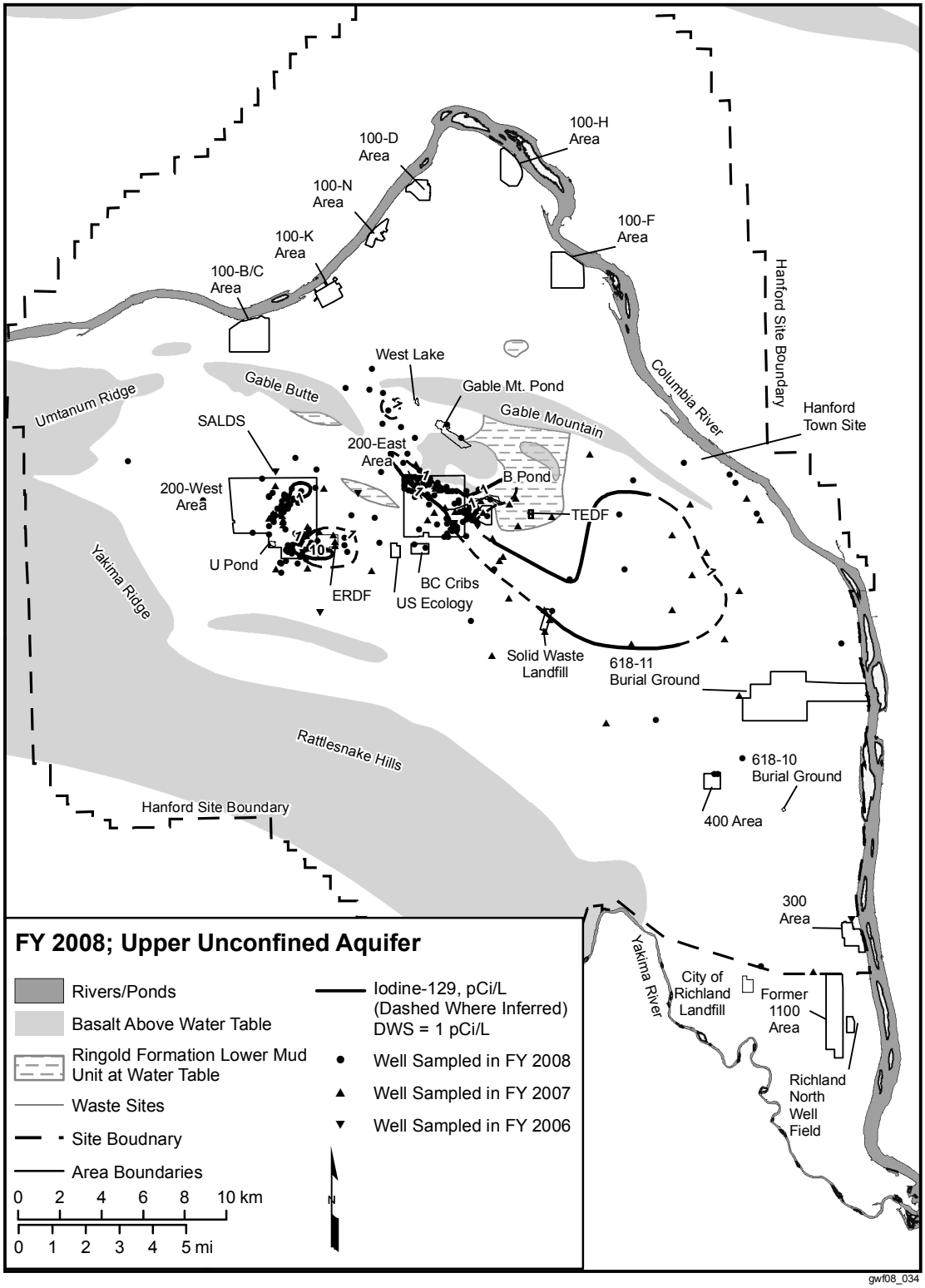
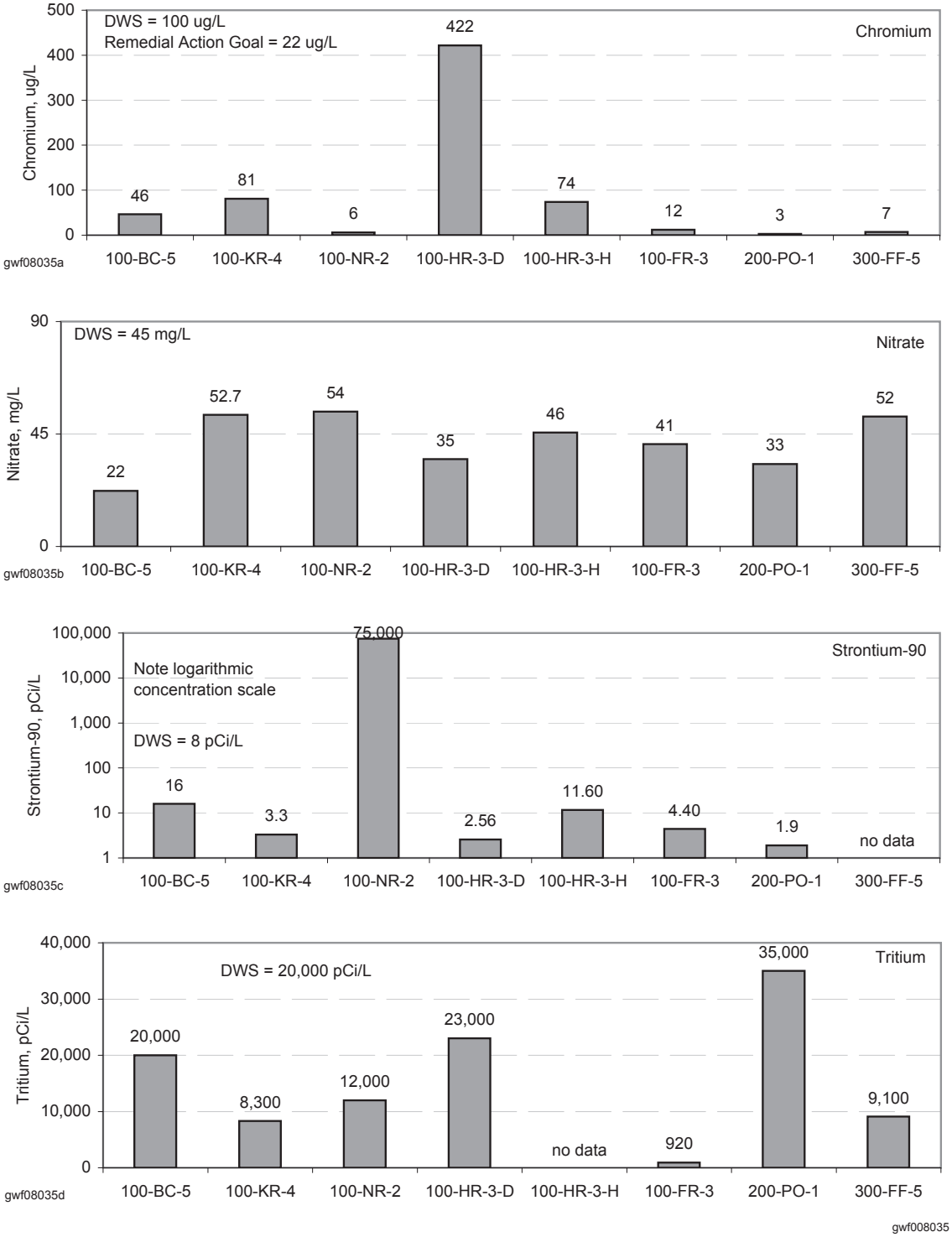
Figure 1.0-5. Maximum Concentrations of Four Contaminants in Aquifer Tubes in Each Groundwater Interest Area, FY 2008.