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Hanford Site Groundwater Monitoring for Fiscal Year 2005

Editors
M. J. Hartman
L. F. Morasch
W. D. Webber

March 2006

Prepared for the U.S. Department of Energy
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CH2M HILL Hanford, Inc.; Fluor Hanford,
Inc.; and Washington Closure Hanford, LLC

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Abstract

This report presents the results of groundwater monitoring for fiscal year (FY) 2005 on the U.S. Department of Energy's (DOE's) Hanford Site in southeast Washington. Results of groundwater remediation, vadose zone monitoring, and characterization are summarized.

The most extensive contaminant plumes in groundwater are tritium, iodine-129, and nitrate, which all had multiple sources and are very mobile in groundwater. The largest portions of these plumes are migrating from the central Hanford Site to the southeast, toward the Columbia River.

Carbon tetrachloride and associated organic constituents form a relatively large plume beneath the west-central part of the Hanford Site. Hexavalent chromium is present in plumes beneath the reactor areas along the river and beneath the central part of the site. Strontium-90 exceeds standards beneath all but one of the reactor areas. Technetium-99 and uranium plumes exceeding standards are present in the 200 Areas. A uranium plume underlies the 300 Area. Minor contaminant plumes with concentrations greater than standards include carbon-14, cesium-137, cis-1,2-dichloroethene, cyanide, fluoride, plutonium, and trichloroethene.

Monitoring for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) is conducted in 11 groundwater operable units. The purpose of this monitoring is to define and track plumes and to monitor the effectiveness of interim remedial actions. Interim groundwater remediation in the 100 Areas continued with the goal of reducing the amount of chromium (100-K, 100-D, and 100-H) and strontium-90 (100-N) reaching the Columbia River. The objective of two interim remediation systems in the 200 West Area is to prevent the spread of carbon tetrachloride and technetium-99/uranium plumes.

Resource Conservation and Recovery Act (RCRA) groundwater monitoring continued at 25 waste management areas during FY 2005:

- 15 under interim or final status detection programs and data indicate that they are not adversely affecting groundwater
- 8 under interim status groundwater quality assessment programs to assess contamination
- 2 under final status corrective-action programs

During calendar year 2005, drillers completed 27 new monitoring wells: 17 for RCRA and CERCLA monitoring and 10 for barrier studies, treatability testing, and groundwater investigations. One hundred fifteen unneeded wells were decommissioned (filled with grout).

Vadose zone monitoring, characterization, and remediation continued in FY 2005. Remediation and associated monitoring continued at a soil-vapor extraction system in the 200 West Area, which removes gaseous carbon tetrachloride from the vadose zone. DOE uses geophysical methods to monitor potential movement of contamination beneath former waste sites.

This report is available on the Internet through the Hanford Groundwater Performance Assessment Project's web site: http://groundwater.pnl.gov/. Inquiries regarding this report may be directed to Ms. Mary J. Hartman, Pacific Northwest National Laboratory, P.O. Box 999, Richland, Washington 99352 or by electronic mail to mary.hartman@pnl.gov.

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John Fruchter and Stuart Luttrell manage the Groundwater Performance Assessment Project and the Groundwater Monitoring Task, respectively. Dot Stewart manages the monumental tasks of sampling and analysis, quality control, and data management.

Most of the graphics for this report were generated by Mickie Chamness and Chris Newbill, who put in many hours to meet our tight schedule. John McDonald, David Lanigan, and Shannon Neely also assisted with graphics. JoAnne Rieger retrieved and formatted data for maps and tables.

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Mary Hartman
Launa Morasch
Bill Webber

Report Contributors

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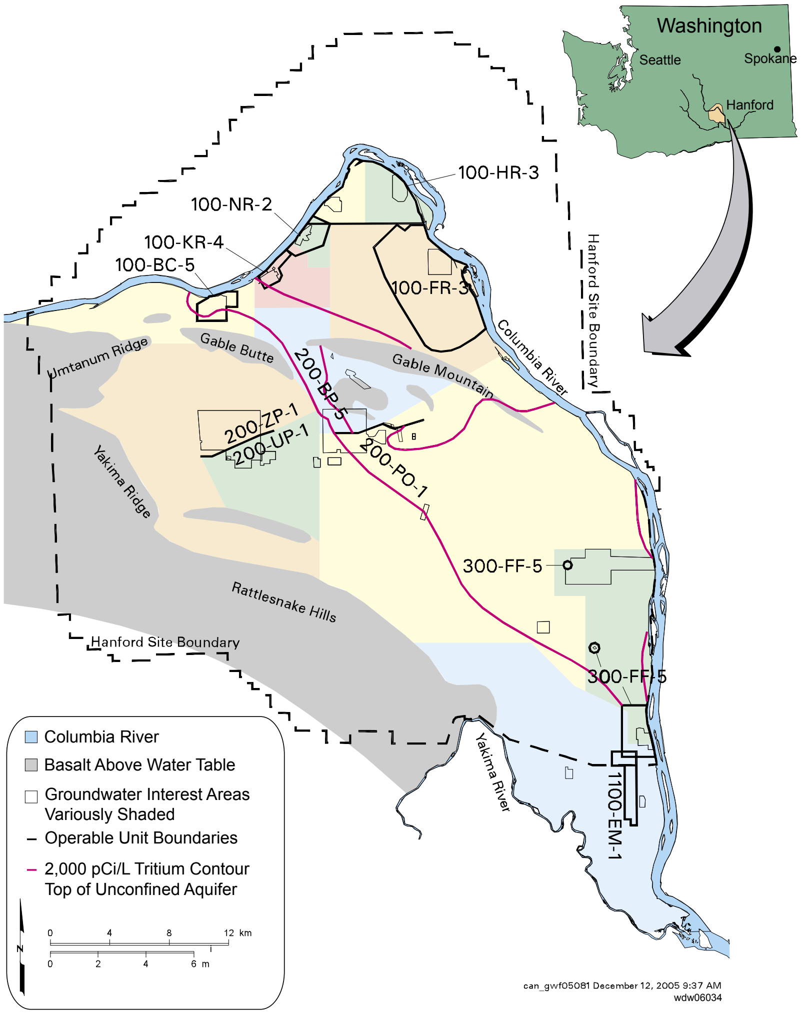
Summary

Introduction

The Hanford Site, a facility in the U.S. Department of Energy (DOE) nuclear weapons complex, encompasses ~1,517 square kilometers northwest of the city of Richland along the Columbia River in southeast Washington State. The federal government acquired the site in 1943, and until the 1980s, it was dedicated primarily to the production of plutonium for national defense. 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 on cleaning up the site.

DOE is committed to protecting the Columbia River from contaminated groundwater resulting from past, present, and future operations and remediating groundwater. The Hanford Site Groundwater Strategy, developed collaboratively by DOE, the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (EPA), presents a means for multiple regulatory authorities and government

The Hanford Site Groundwater Strategy focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater.

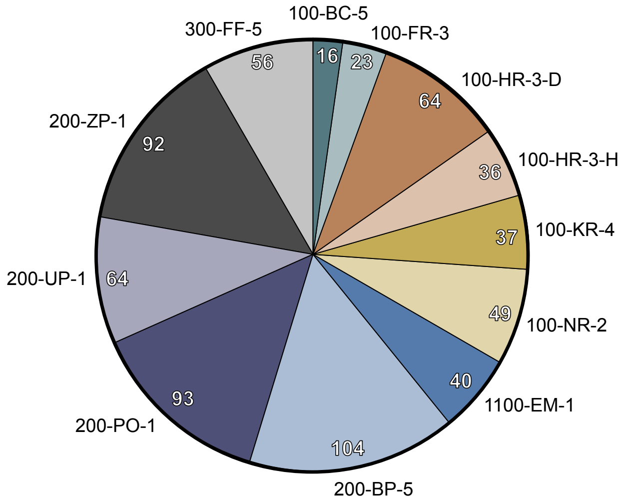


Hanford Site groundwater monitoring is organized by areas of interest, which are informally named after the groundwater operable units. The areas of interest are useful for planning and scheduling groundwater monitoring and interpreting data.

agencies to protect and restore groundwater at the Hanford Site. The strategy focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater.

DOE monitors groundwater at the Hanford Site to fulfill a variety of state and federal regulations, including the *Atomic Energy Act* (AEA), the *Resource Conservation and Recovery Act* (RCRA), the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), and Washington Administrative Code (WAC). DOE manages most of these activities through the Groundwater Performance Assessment Project (groundwater project).

DOE sampled 674 wells during FY 2005. Chromium, nitrate, and tritium are constituents most frequently analyzed.



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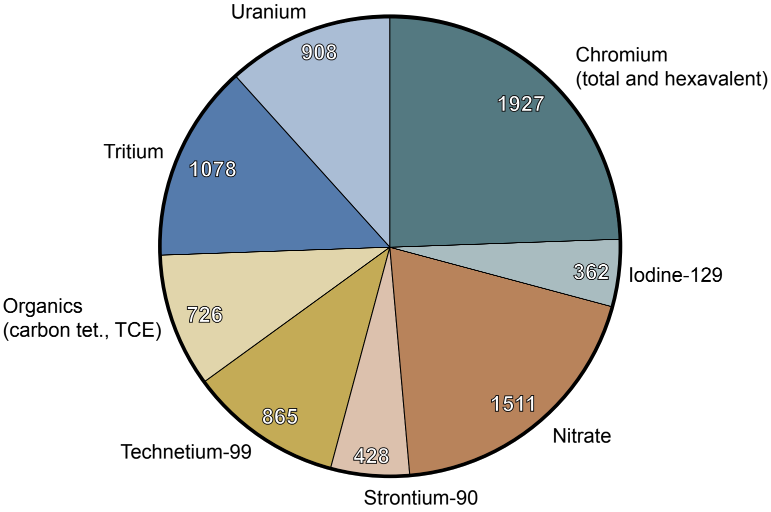
This chart shows the number of wells sampled in each groundwater interest area in FY 2005.



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The groundwater project requests specific laboratory analyses based on the well's location, historical contaminant trends, and regulatory requirements. This graph shows the number of analyses for the most common constituents during FY 2005.

Some contamination reached the Columbia River by moving downward from waste sites through the vadose zone, into the groundwater, and then into the river. The analysis of groundwater samples provides data that help determine the potential fate and transport of contaminants in the environment. DOE works with regulatory agencies such as the EPA and Ecology to make cleanup decisions based on sound technical information and the technical capabilities available.

In fiscal year (FY) 2005, workers sampled 674 monitoring wells and 175 shoreline aquifer tubes to determine the distribution and movement of contaminants. Many of the wells were sampled multiple times during the year for a total of 2,335 sampling trips. A total of 1,927 samples of Hanford groundwater were analyzed for chromium, 1,511 for nitrate, and 1,078 for tritium. Other constituents frequently analyzed include uranium (908), technetium-99 (865), and carbon tetrachloride (726).

DOE continued to study strontium-90 sequestration by apatite in FY 2005. A field test is planned for FY 2006.

Emerging Issues

This section briefly describes some of the high-priority groundwater topics for FY 2005. The groundwater chapter of the full report contains additional details.

100-N Pump-and-Treat Alternatives. DOE has operated a pump-and-treat system to contain and clean up groundwater contaminated with strontium-90 at the 100-N Area since 1994. Like most of the groundwater remedial actions undertaken at Hanford in the 1990s, the 100-N Area pump-and-treat system was intended as an interim measure, designed to show a bias for action as part of DOE's accelerated cleanup strategy. With additional research and characterization, it is likely that alternative methods of remediation will be employed for some of Hanford's groundwater contamination. To support 100-N Area remediation, laboratory studies of strontium-90 sequestration by apatite continued during FY 2005. Favorable results for one approach led to the decision to prepare a treatability test plan for a field test that includes a 91-meter barrier to be installed in FY 2006. The goal is to create a permeable, reactive barrier near the shoreline that will capture strontium-90 as groundwater flows through a treatment zone created by injection of apatite-forming chemicals.

In the 200 West Area, carbon tetrachloride, technetium-99, and nitrate have been observed at higher concentrations 10 to 45 meters below the water table in some locations.

300-FF-5 Operable Unit Phase III Feasibility Study. Because the uranium plume beneath the 300 Area has not decreased in concentration as rapidly as predicted by earlier remedial investigations, DOE continued a detailed investigation of the natural processes that cause the plume to persist and the residual sources that may supply uranium to the plume. DOE is evaluating potential treatment technologies that would result in lowering plume concentrations.

Rebound Study at 200-UP-1 Operable Unit. The 200-UP-1 pump-and-treat system was an interim action designed to contain the high concentration portions of the technetium-99 and uranium plumes in the 200 West Area. Following 18 months with contaminant concentrations below remedial action goals, and with approval by Ecology, DOE turned off the extraction well pumps and initiated a rebound study in January 2005. The goal of the rebound study is to assess the effectiveness of the pump-and-treat system and to evaluate whether concentrations of key constituents will remain below remedial action goals under natural groundwater flow conditions. Future actions at the pump-and-treat site will be based on the results of the rebound study.

KW Reactor Chromium Plume. In 1998, chromium concentrations in groundwater near the KW Reactor began to rise. The travel time for a plume to migrate from the vicinity of the reactor to the Columbia River is estimated at 10 to 12 years, and evidence is building that the plume has reached the shoreline. Planning is underway to add this plume to the interim remedial action that is currently addressing chromium in the vicinity of the 100-K trench.

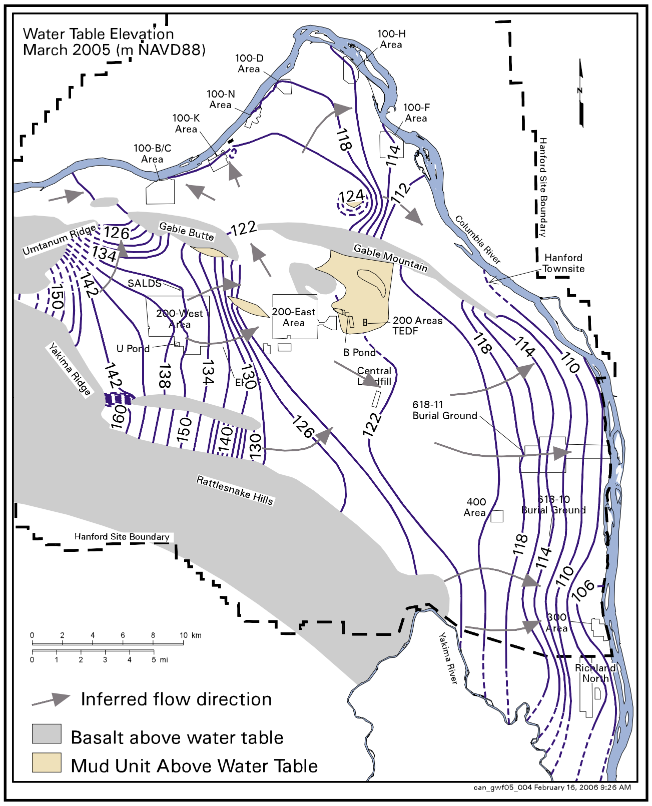
KE Basin. DOE has removed nuclear fuel from the KE fuel storage basin, is removing radioactive sludge, and is planning to demolish the basin and excavate contaminated sediments. As part of the demolition process, a large excavation will be made north of the reactor building to provide access for heavy equipment. The excavation will require removal of two or three groundwater monitoring wells. A strategy to provide groundwater monitoring capability during and after demolition will be developed during 2006.

Hanford groundwater flows into the Columbia River, which is used for recreation, drinking water, agriculture, and wildlife habitat. Therefore, DOE is focusing remediation efforts on activities that protect the Columbia River.

Vertical Distribution of Contaminants in 200 West Area. In recent years, depth-discrete sampling in existing wells, and sampling during drilling of new wells, have provided new information on how contaminant concentrations change with depth in the unconfined aquifer. At some locations in the carbon tetrachloride plume, the highest concentrations are up to 45 meters below the water table.

Technetium-99 at Waste Management Area T. Technetium-99 concentrations in wells east of Waste Management Area T, in the 200 West Area, continued to increase. A groundwater sample collected during drilling at 10 meters below the water table had the highest technetium-99 concentration (181,900 pCi/L) on the Hanford Site in FY 2005. The maximum nitrate concentration in the well was 590 mg/L, at about the same depth. Additional wells are being installed to delineate the deeper contamination and an investigation is being planned to evaluate sources, transport, and possible remedial alternatives for the contamination.

Technetium-99 at Waste Management Area A-AX. Technetium-99 concentrations continued to exceed the drinking water standard (900 pCi/L) in a well downgradient of these tank farms in the 200 East Area. The source or sources of this contamination is unknown. Data from two wells installed in FY 2005 will aid the interpretation. In addition, exceedance of the critical mean value[a] for specific conductance has resulted in the waste management area moving from detection to assessment monitoring under RCRA.



This map shows the water table and inferred flow directions in March 2005. Areas shaded in gray or tan show where the unconfined aquifer is absent.

Uranium Plume in Northwest 200 East Area. A uranium plume with concentrations up to 454 µg/L is found beneath and to the east of the BY Tank Farm. The contamination is present in a narrow northwest-southeast band. The leading interpretation is that the plume originated from a past tank release.

CERCLA Five-Year Review. The second 5-year review of records of decision for remedial actions under CERCLA started during FY 2005, with a completion target date of April 2006. DOE is conducting the review in coordination with the U.S. Environmental Protection Agency, which is responsible for certifying the review. More information on the 5-year review is available at: www.hanford.gov "CERCLA Five-Year Review." The purpose of the review is to evaluate the implementation and performance of the remedies in order to determine if they are protective of human health and the environment.

Groundwater Flow

Groundwater in the unconfined aquifer generally flows from west to east across the Hanford Site to discharge areas along the Columbia River. The direction of groundwater flow is inferred from water-table elevations, barriers to flow (e.g., basalt or mud units at the water table), and the distribution of contaminants.

(a) Critical means are statistical values used for upgradient/downgradient comparisons at interim status RCRA sites. Exceeding a critical mean value for an indicator parameter may signify that a release from the site has occurred.

General directions of groundwater flow are illustrated on the map for March 2005. Groundwater enters the Hanford Site from recharge areas to the west and eventually discharges to the Columbia River. Hydrologists estimate that the total discharge of groundwater from the Hanford Site aquifer to the Columbia River is in the range 1.1 to 2.8 cubic meters/second. This rate of discharge is very small compared to the average flow of the river, ~3,400 cubic meters/second. Consequently, Hanford Site groundwater becomes indistinguishable in the river within a short distance of its discharge location.

In the part of the site north of Gable Mountain and Gable Butte, groundwater flows generally northeast or east toward the river, except beneath the 100-B/C, 100-K, 100-N, and 100-D Areas where groundwater flows north and northwest toward the river. South of Gable Mountain and Gable Butte, groundwater flows toward the east and southeast. The water table beneath the 200 East Area is relatively flat because of the presence of highly permeable sediment of the Hanford formation at the water table. Groundwater enters the vicinity of the 200 East Area from the west and divides, with some migrating to the north through Gable Gap and some moving southeast toward the central part of the site. In the south part of the Hanford Site, groundwater converges on the 300 Area from the northwest, west, and southwest.

The natural pattern of groundwater flow was altered during the Hanford Site's operating years by water-table mounds. The mounds were created by the discharge of large volumes of wastewater to the ground and were present in each reactor area and beneath the 200 Areas. Since effluent disposal decreased significantly in the 1990s, these mounds have dissipated in the reactor areas and have declined considerably in the 200 Areas.

Groundwater flow is currently altered where extraction or injection wells are used for pump-and-treat systems or where wastewater is discharged to the land surface. Extraction wells in the 100-K, 100-N, 100-D, 100-H, and 200 West Areas capture contaminated water from the surrounding areas. Water flows away from injection wells, which are located upgradient of the contaminant plumes so the injection increases the hydraulic gradient toward the extraction wells. Wastewater is discharged to the ground at the State-Approved Land Disposal Site, north of the 200 West Area, affecting groundwater flow locally.

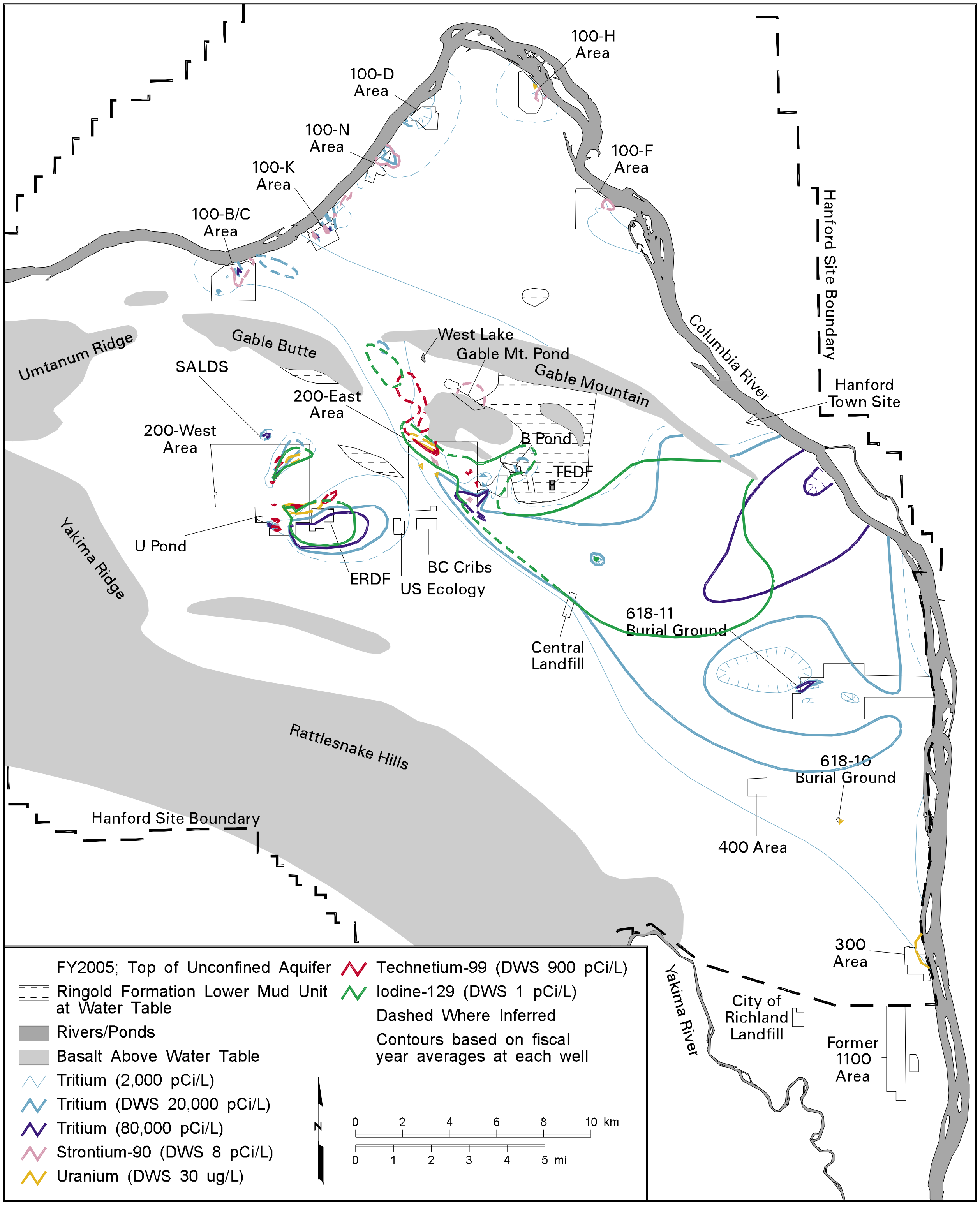
East of the 200 East Area, a fine-grained confining unit creates a barrier to groundwater movement in the surrounding unconfined aquifer. Beneath this confining unit, the uppermost aquifer is a permeable unit in the Ringold Formation. Groundwater flow in this locally confined aquifer still is influenced by a residual recharge mound.

DOE's cleanup plan includes the following elements: (a) remediate high-risk waste sites, (b) shrink the contaminated area, (c) reduce recharge, (d) remediate groundwater, and (e) monitor groundwater.

Groundwater Monitoring and Remediation

DOE has developed a plan to clean up Hanford's groundwater, which will return it to its beneficial use where practicable or will at least prevent further degradation. Under the accelerated plan DOE will (a) remediate high-risk waste sites, (b) shrink the contaminated area, (c) reduce natural and artificial recharge, (d) remediate groundwater, and (e) monitor groundwater. The maps on the following pages show the distribution of nine principal groundwater contaminant plumes.

Of the radionuclide plumes, tritium and iodine-129 have the largest areas with concentrations above drinking water standards. The dominant plumes had sources in the 200 East Area and extend toward the east and southeast. Extensive tritium and iodine-129 plumes are also present in 200 West Area. Technetium-99 exceeds standards in plumes within both the 200 East and 200 West Areas. One technetium-99 plume has moved northward from the 200 East Area. Uranium is less mobile than tritium, iodine-129, or technetium-99; plumes are found in the 200 East, 200 West, and 300 Areas. Strontium-90 is not very mobile in groundwater, but it exceeds standards in the 100 Areas (except 100-D), the 200 East Area, and beneath the former Gable Mountain Pond. Other radionuclides, including cesium-137, cobalt-60, and plutonium, are even less mobile in the subsurface and exceed drinking water standards in very few wells.



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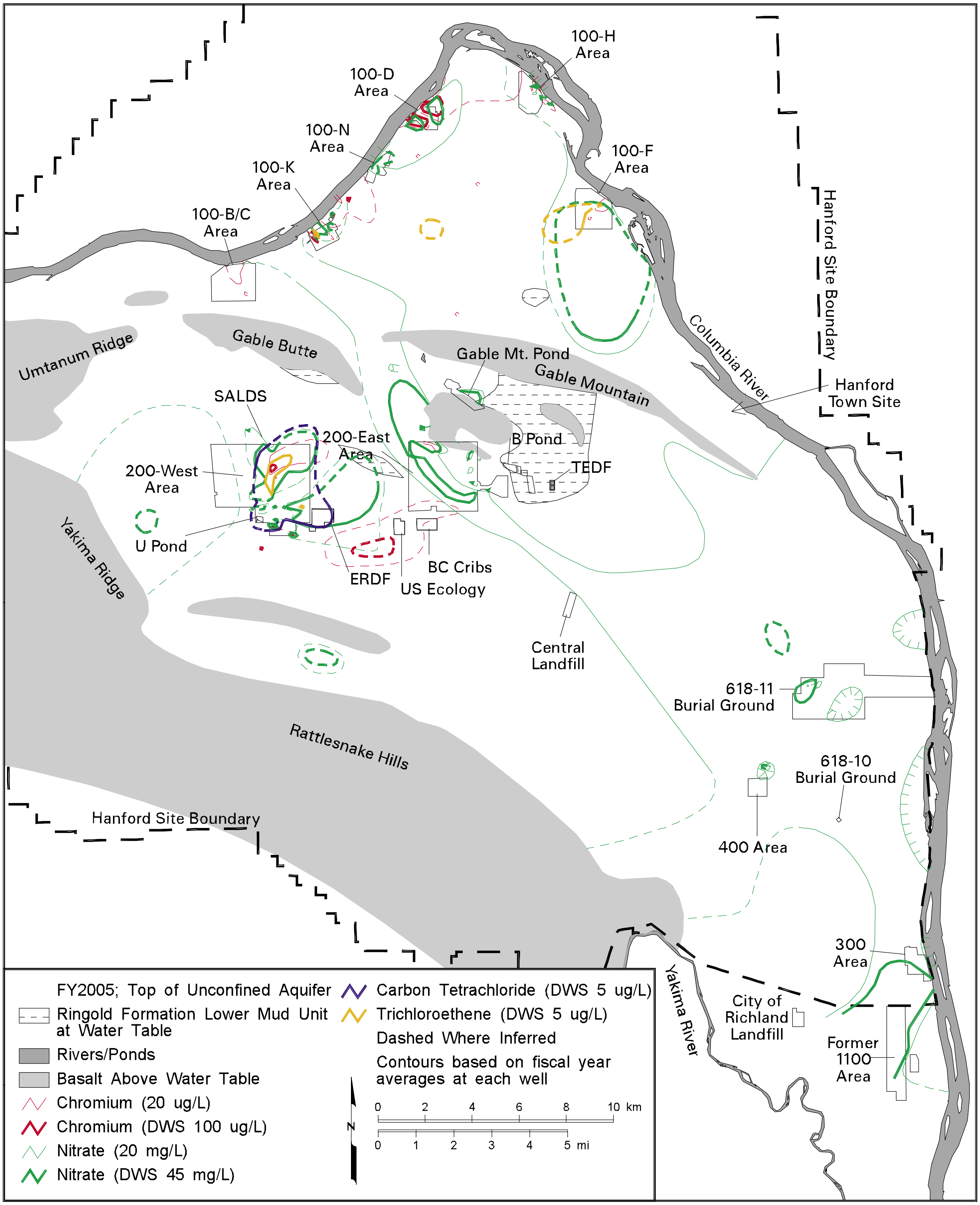
This map shows the distribution of radionuclides in groundwater at concentrations above drinking water standards during FY 2005 in the upper part of the unconfined aquifer.



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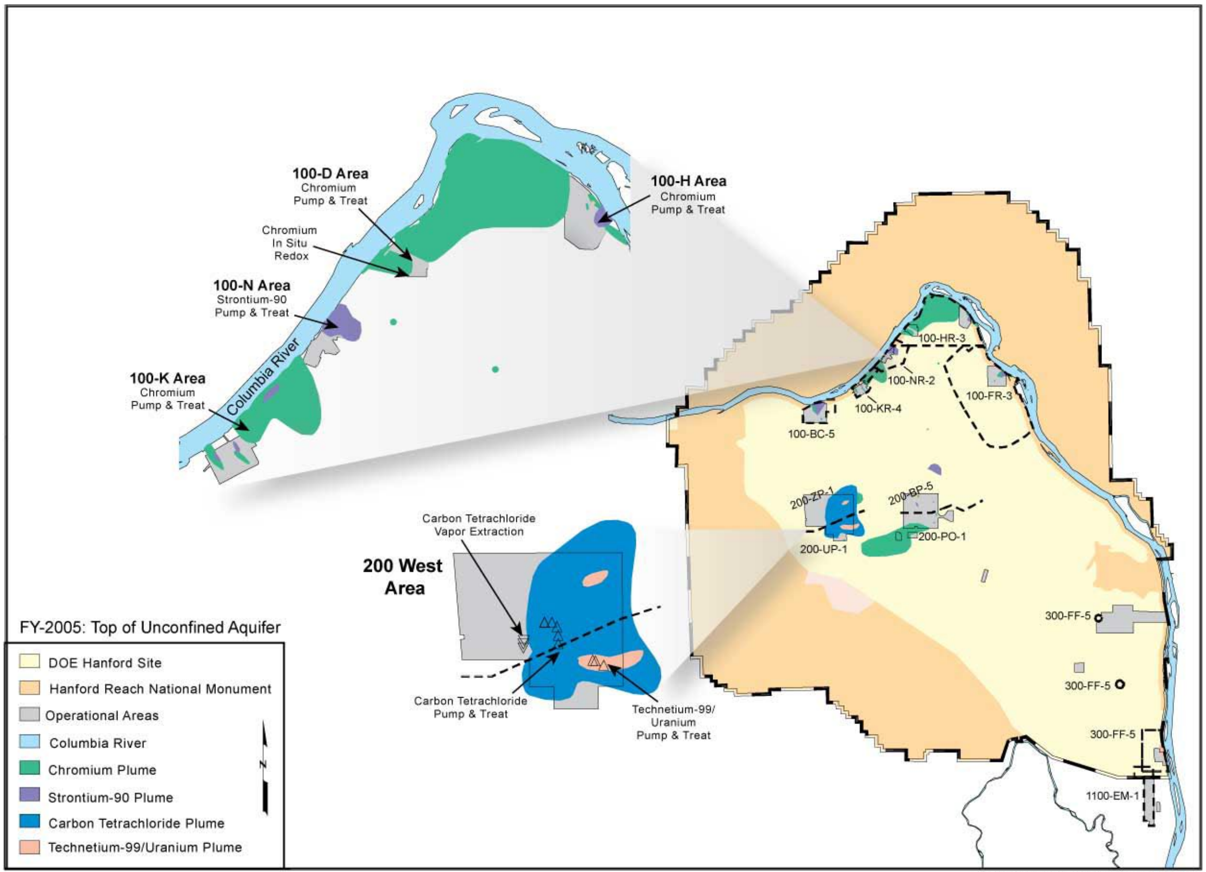
This map shows the distribution of hazardous chemicals in groundwater at concentrations above drinking water standards during FY 2005 in the upper part of the unconfined aquifer.

Groundwater Remediation

Remedial Action Site	Startup Date	Progress From Startup to September 2005
100-K Area – 100-KR-4 Pump-and-Treat	1997	Decreases chromium to river; 271 kilograms removed.
100-N Area – 100-NR-2 Pump-and-Treat	1995	Diverts strontium-90 from river; 1.7 curies removed.
100-D Area – 100-HR-3 Pump-and-Treat	1997	Decreases chromium to river; 263 kilograms removed.
100-D Area – 100-HR-3 In Situ Redox	1999	Decreases chromium concentrations downgradient of barrier.
100-H Area – 100-HR-3 Pump-and-Treat	1997	Decreases chromium to river; 42 kilograms removed.
200 West Area – 200-ZP-1 Pump-and-Treat	1994	Prevents high-concentration portion of carbon tetrachloride plume from spreading; 9,308 kilograms removed.
200 West Area – Soil-Vapor Extraction	1992	Reduces carbon tetrachloride movement to groundwater; 78,600 kilograms removed.
200 West Area – 200-UP-1 Pump-and-Treat	1994	Decreases lateral migration of contaminants; 119 grams technetium-99 (2.02 curies) and 212 kilograms uranium removed. Extraction ceased January 2005.
Waste Management Area S-SX – Well 299-W23-19 Pump-and-Treat	2003	0.20 grams (0.0034 curie) of technetium-99 removed.
300 Area – 300-FF-5 Natural Attenuation	Not applicable	Average trichloroethene concentrations below target level; uranium concentrations above target level.
1100-EM-1 – Natural Attenuation	Not applicable	Average trichloroethene concentrations below 5 μg/L since 2001.



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DOE operates six pump-and-treat systems, one in situ remediation system, and one soil-gas extraction system to remove contaminants and limit their movement in groundwater and the vadose zone.

Nitrate is a widespread chemical contaminant in Hanford Site groundwater; plumes originate from the 100 and 200 Areas and from offsite industry and agriculture. Carbon tetrachloride, the most widespread organic contaminant on the Hanford Site, forms a large plume beneath the 200 West Area. Other organic contaminants include chloroform, found in 200 West Area, and trichloroethene. Trichloroethene plumes are found in the 100-K, 100-F, and 200 West Areas. Chromium contamination underlies portions of the 100-K, 100-D, and 100-H Areas. Local plumes of chromium contamination also are present in the 200 Areas, particularly the north part of 200 West Area.

The following text discusses groundwater contamination, monitoring, and remediation for each of the 11 groundwater operable units and in the confined aquifers.

Area of Contaminant Plumes at Levels Above Drinking Water Standards (square kilometers)

Constituent (drinking water standard)	Fiscal Year 2000	Fiscal Year 2005
Carbon tetrachloride (5 µg/L)	9.8	10.8
Chromium (100 µg/L)	2.8	2.0
Iodine-129 (1 pCi/L)	89.7	75.4
Nitrate (45 mg/L)	36.3	43.3
Strontium-90 (8 pCi/L)	2.8	2.4
Technetium-99 (900 pCi/L)	2.3	2.5
Trichloroethene (5 µg/L)	4.2	3.8
Tritium (20,000 pCi/L)	176	135.5
Uranium (20/30 µg/L)[a]	2.0	1.4
Combined Plumes[b]	232	199

(a) Area of uranium plume based on 20 mg/L standard in 2000 and 30 mg/L standard in subsequent years.

(b) Area with one or more constituent above drinking water standards.

100-BC-5 Operable Unit

A complete discussion of the 100-BC-5 Operable Unit can be found in Section 2.2. This operable unit includes the groundwater beneath the 100-B/C Area, located in the northwest Hanford Site. Most of the groundwater contamination is found in the north portion of the area, beneath former waste trenches and retention basins. Tritium and strontium-90 exceeded drinking water standards in several wells. The tritium concentration in one well in the northeast 100-B/C Area increased sharply to 161,000 pCi/L in FY 2005, but the reason for the increase is not known. Nitrate and chromium were somewhat elevated, but have been below drinking water standards in recent years.

Tritium levels increased sharply in one well in the northeast 100-B/C Area in FY 2005.

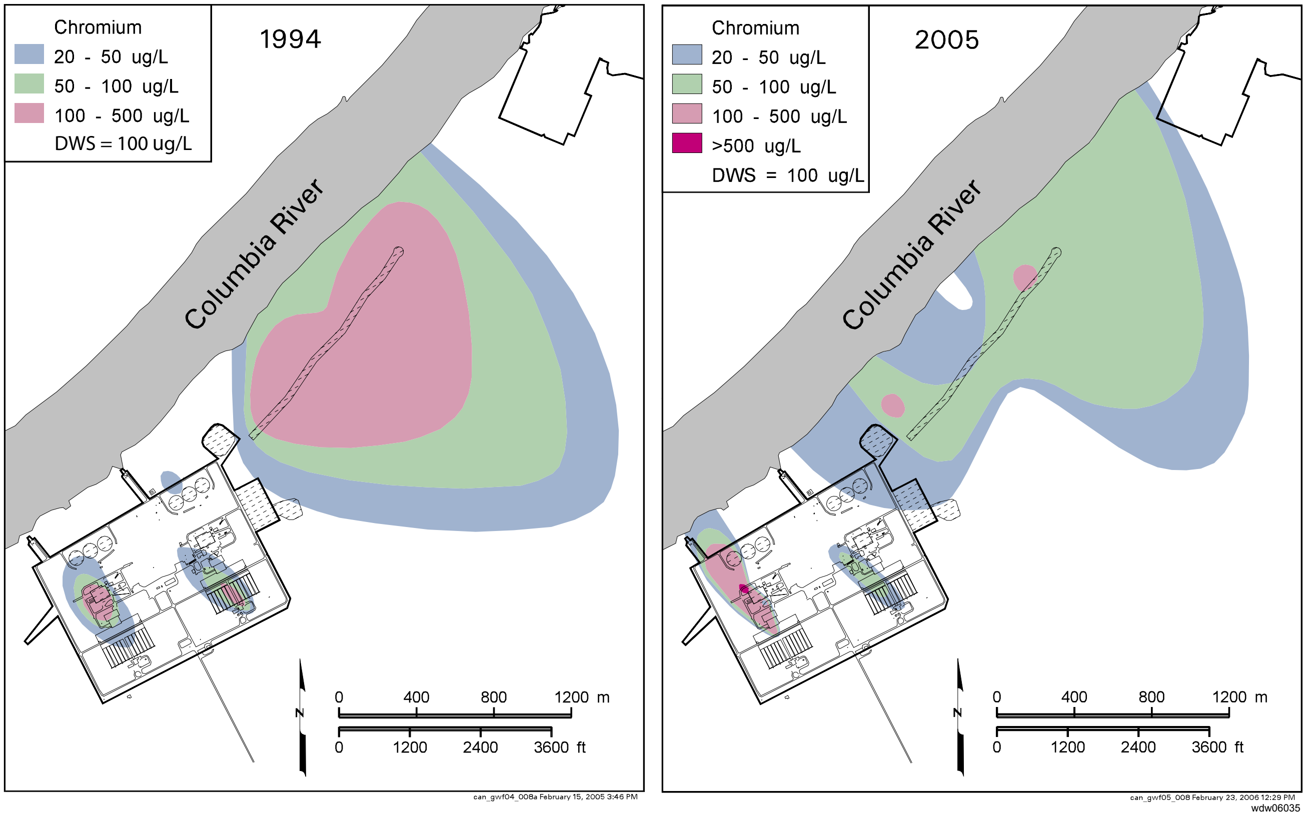
A record of decision has not yet been developed for the 100-BC-5 Operable Unit, and no active remediation of groundwater is underway. Monitoring contaminant conditions has continued since the initial remedial investigation and while waste site remedial actions are conducted. Results of a pilot project risk assessment were published in draft form in FY 2005, which will serve as a prototype for risk assessments in the other reactor areas. The pilot risk assessment characterized the potential risks to human health and the environment under the cleanup standards implemented in remedial actions performed to date.

100-KR-4 Operable Unit

A complete discussion of the 100-KR-4 Operable Unit can be found in Section 2.3. The principal groundwater issues in this operable unit include (a) remediation of groundwater beneath a large liquid-waste disposal trench; (b) tracking plumes from other past-practices sites; and (c) monitoring groundwater near the KE and KW Basins. Interim remedial action involves a pump-and-treat system that removes chromium from groundwater beneath the trench and injects the treated water farther from the river.

Interim Remedial Action. A pump-and-treat system is being used to remove hexavalent chromium from the aquifer beneath the large infiltration trench. Approximately 271 kilograms of chromium have been removed since startup in 1997. Although the mapped extent of contamination has remained fairly constant during the past 10 years, the area of highest concentrations (>100 µg/L) has decreased markedly. The concentration goal for the interim remedial action is 22 µg/L in groundwater near the Columbia River.

Four new wells were installed adjacent to one of the extraction wells, and a treatability test involving injection of calcium polysulfide was performed during the summer and fall of 2005. The calcium polysulfide acts to reduce hexavalent chromium in the aquifer by converting it to



These maps show chromium in the upper part of the unconfined aquifer in the 100-K Area. A pump-and-treat system reduces the amount of chromium entering the Columbia River. Concentrations decreased in most areas since 1994.

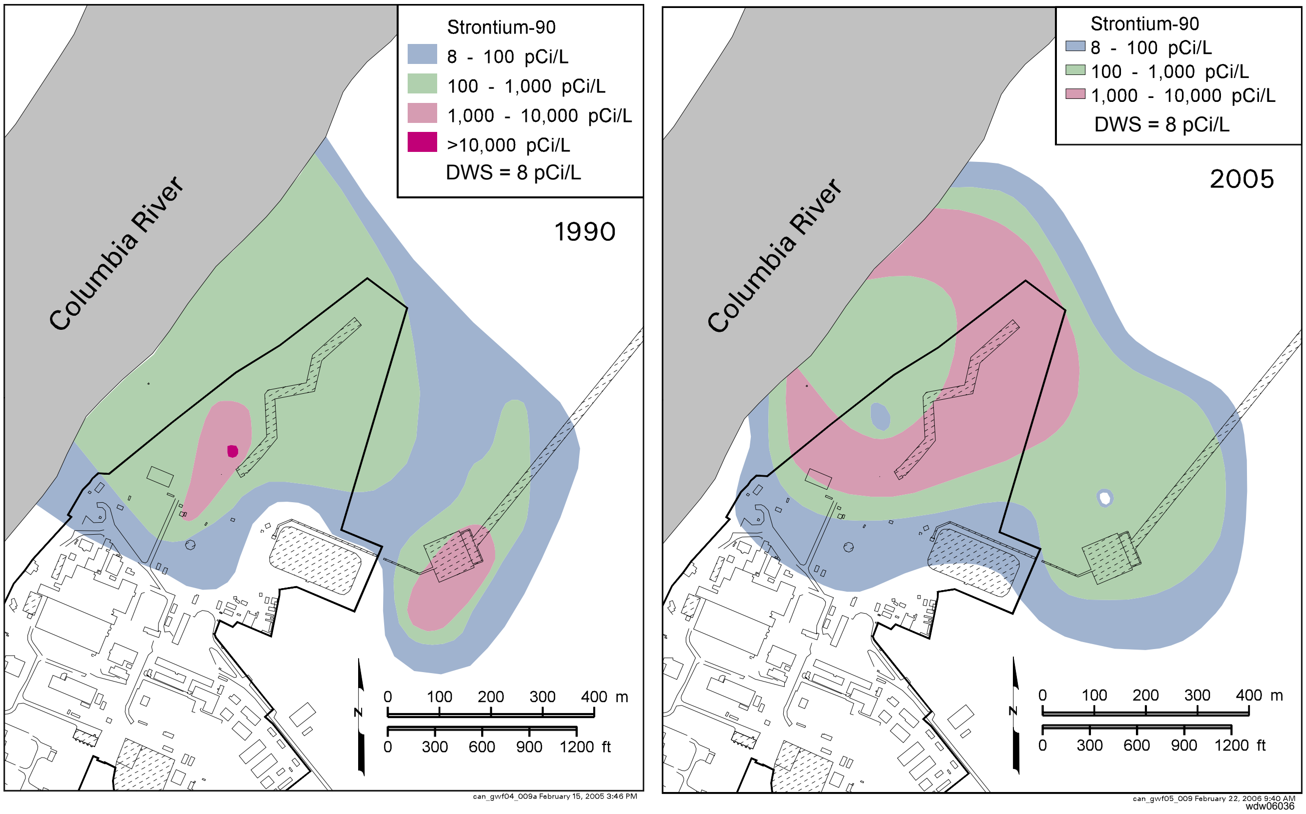
the less toxic and less mobile trivalent form. This method is a potential alternative to pump-and-treat systems for cleanup of groundwater contaminated by hexavalent chromium.

In 1998, chromium concentrations in groundwater near the KW Reactor began to rise. From their previous trend at ~160 µg/L, concentrations increased to ~500 µg/L in a relatively short period of time and remained high in FY 2005. Although an exact source for this chromium has not been identified, it is most likely related to past sodium dichromate handling. The travel time for a plume to migrate from the vicinity of the KW Reactor to the Columbia River is estimated at 10 to 12 years, based on migration of a plume from the KE Basin in 1993. Evidence is building that the KW chromium plume has reached the shoreline. That evidence includes chromium in groundwater at a newly installed well located between the reactor and the river, and at aquifer tubes. Planning is underway to add this plume to the interim remedial action that is currently addressing chromium in the vicinity of the 100-K trench.

In the 100-K Area, DOE performed a treatability test involving injection of calcium polysulfide to reduce hexavalent chromium in the aquifer.

Monitoring Past-Practices Waste Sites. Other contaminants of potential concern in the operable unit are carbon-14, nitrate, strontium-90, trichloroethene, and tritium. These contaminants are associated with waste disposal and facility operations that occurred during the reactor operating years (1955 to 1971). While levels remain above drinking water standards, risks to the river ecosystem are deemed low, so decisions regarding remedial actions have been deferred until source remedial actions are complete. Some recent variability in tritium concentrations near KW Reactor is believed to be caused by remobilization of contaminants held in the vadose zone.

K Basins. The KE and KW Basins are integral parts of each reactor building. Since the late 1970s, they have been used to store irradiated fuel from the last run of N Reactor, as well as miscellaneous fuel fragments recovered from cleanup at other reactor areas. DOE



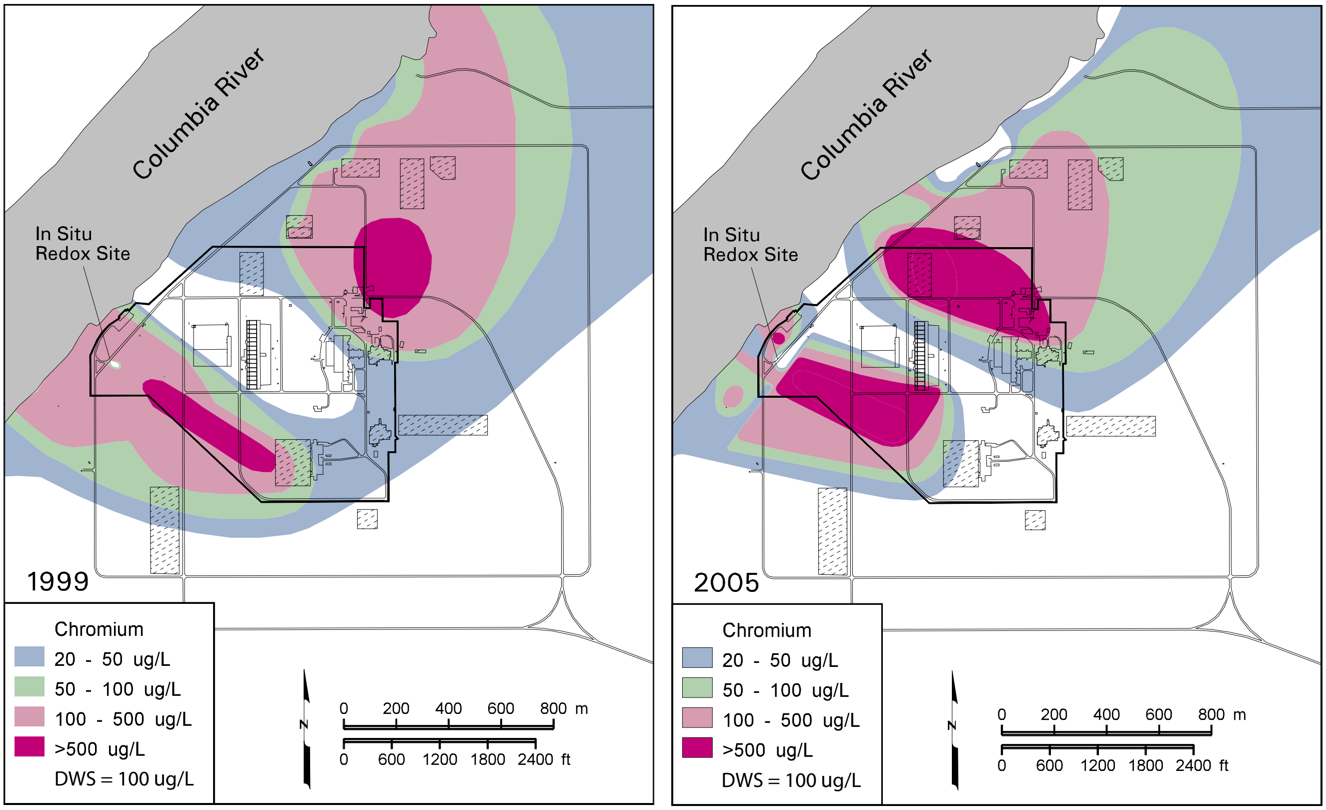
Concentrations of strontium-90 in some parts of the 100-N Area increased after 1990 because of changes in the water table, but the overall shape of the plume at the 8-pCi/L level remained about the same in 2005.

has removed the fuel and is currently removing radioactive sludge from KE Basin. Following sludge removal, KE Basin will be demolished. As part of the demolition process, a large excavation will be made on the north (river) side of the reactor building to provide access for the heavy equipment that will be used to divide the concrete basin into transportable sections. The excavation will require removal of two or three monitoring wells. A strategy to provide groundwater monitoring capability during and after the demolition activities will be developed during 2006. Demolition of KW Basin will follow work at KE Basin.

100-NR-2 Operable Unit

A complete discussion of the 100-NR-2 Operable Unit can be found in Section 2.4. The primary groundwater contaminant plume in the 100-N Area is strontium-90, which originated at two liquid waste disposal cribs. In FY 2005, data from new aquifer tubes enabled DOE to refine the interpretation of distribution of this contaminant near the river shore. A tritium plume also originated at the 100-N Area cribs. Tritium concentrations in groundwater are declining, and the plume is shrinking. Nitrate, sulfate, and petroleum hydrocarbons also are present in 100-N Area groundwater.

Interim Remedial Action. A pump-and-treat system in the 100-N Area operates as a CERCLA interim action to reduce the movement of strontium-90 toward the Columbia River. Although the pump-and-treat system may have reduced groundwater flux to the river, it is not an effective way to remove strontium-90, which binds to sediment grains in the aquifer. Therefore, DOE is evaluating alternative treatment methods. Laboratory studies of strontium-90 sequestration by apatite continued during FY 2005. Favorable results for one approach led to the decision to prepare a treatability test plan for a field test and install a 91-meter barrier in FY 2006. The goal is to create a permeable, reactive barrier near the



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These maps show chromium plumes in the upper part of the aquifer in the 100-D Area. To reduce the amount of chromium entering the Columbia River, DOE operates two pump-and-treat systems in the north and an in situ treatment system in the south.

shoreline that will capture strontium-90 as groundwater flows to the river through a treatment zone created by injection of apatite-forming chemicals.

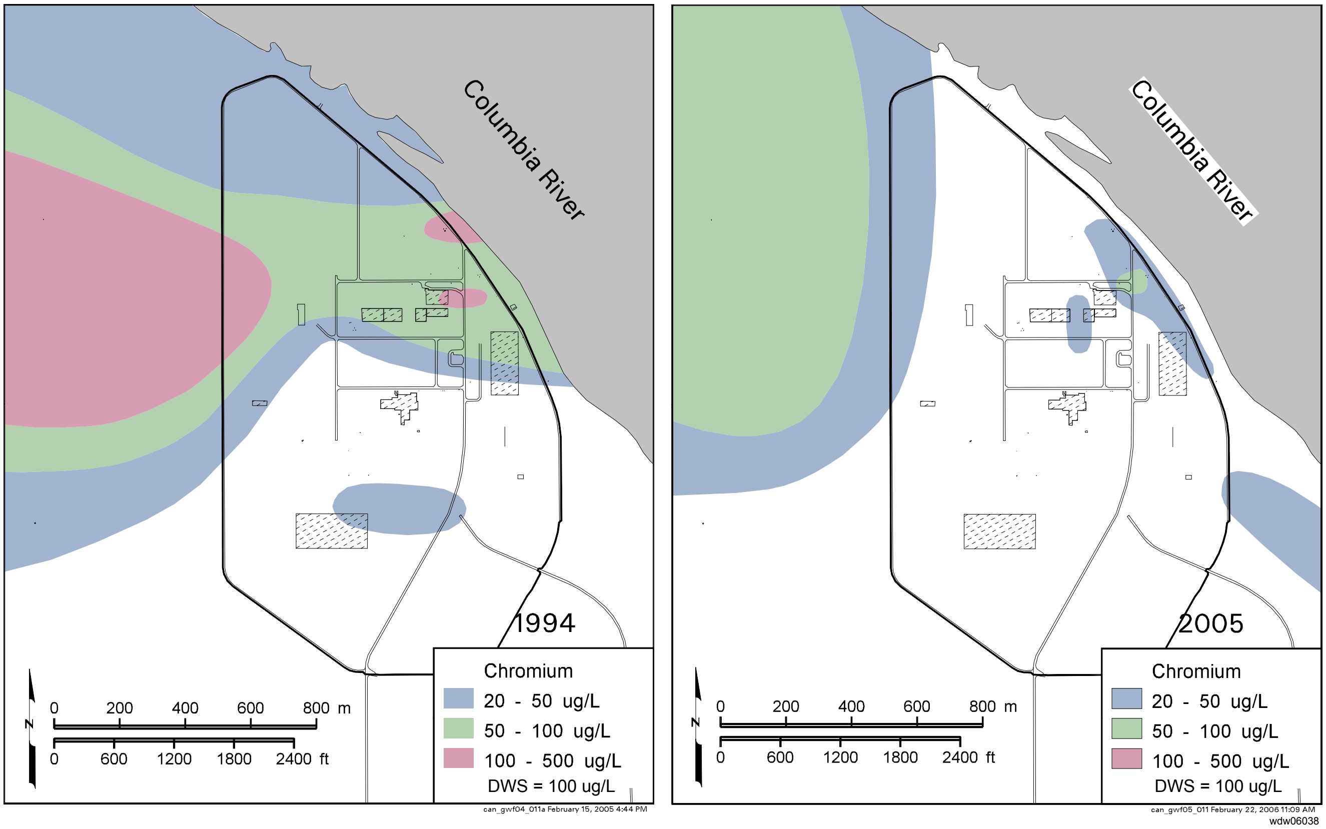
116-N-1, 116-N-3, 120-N-1, and 120-N-2 (1301-N, 1325-N, 1324-N/NA) Facilities. Four RCRA units are located in the 100-N Area. During FY 2005, the sites remained in detection monitoring programs. AEA and CERCLA monitoring continued to track strontium-90 and tritium plumes from the 116-N-1 and 116-N-3 facilities and sulfate from the 120-N-1 pond.

100-HR-3-D Operable Unit

The 100-HR-3 Operable Unit underlies the 100-D and 100-H Areas and the region between. Hexavalent chromium is the primary contaminant of concern in groundwater beneath the 100-D Area, which comprises the west part of the operable unit (100-HR-3-D; described in Section 2.5). A principal cause for this contamination was the routine discharge of reactor coolant, which contained sodium dichromate as a corrosion inhibitor, to ground disposal facilities, such as trenches. A second cause was periodic spillage and leakage of sodium dichromate stock solution to the ground. Chromium is distributed in two plumes. Other contaminant plumes include tritium, nitrate, and sulfate.

Interim Remedial Actions. The north chromium plume is the target of a pump-and-treat system, which is designed to reduce the amount of chromium entering the Columbia River. In FY 2005, chromium concentrations remained above the remediation goal (22 µg/L) in compliance wells. A second pump-and-treat system intercepts groundwater in the central 100-D Area near the shoreline. The southwest chromium plume is being remediated with

Chromium concentrations in 100-D Area groundwater are the highest on the Hanford Site. Three remediation systems operate to reduce the amount of chromium reaching the Columbia River.



A pump-and-treat system in the 100-H Area has reduced the amount of chromium entering the Columbia River. Between 1994 and 2005, concentrations decreased through most of the plume. The extraction and injection well network was modified in FY 2005.

a permeable barrier that immobilizes chromium in the aquifer. Chromium concentrations downgradient of the barrier have declined in some wells and aquifer tubes and were below the remediation goal (20 µg/L for this plume) in two of seven compliance wells in FY 2005. Four new wells were installed in FY 2005 as part of an investigation into the apparent breakthrough of a portion of the barrier.

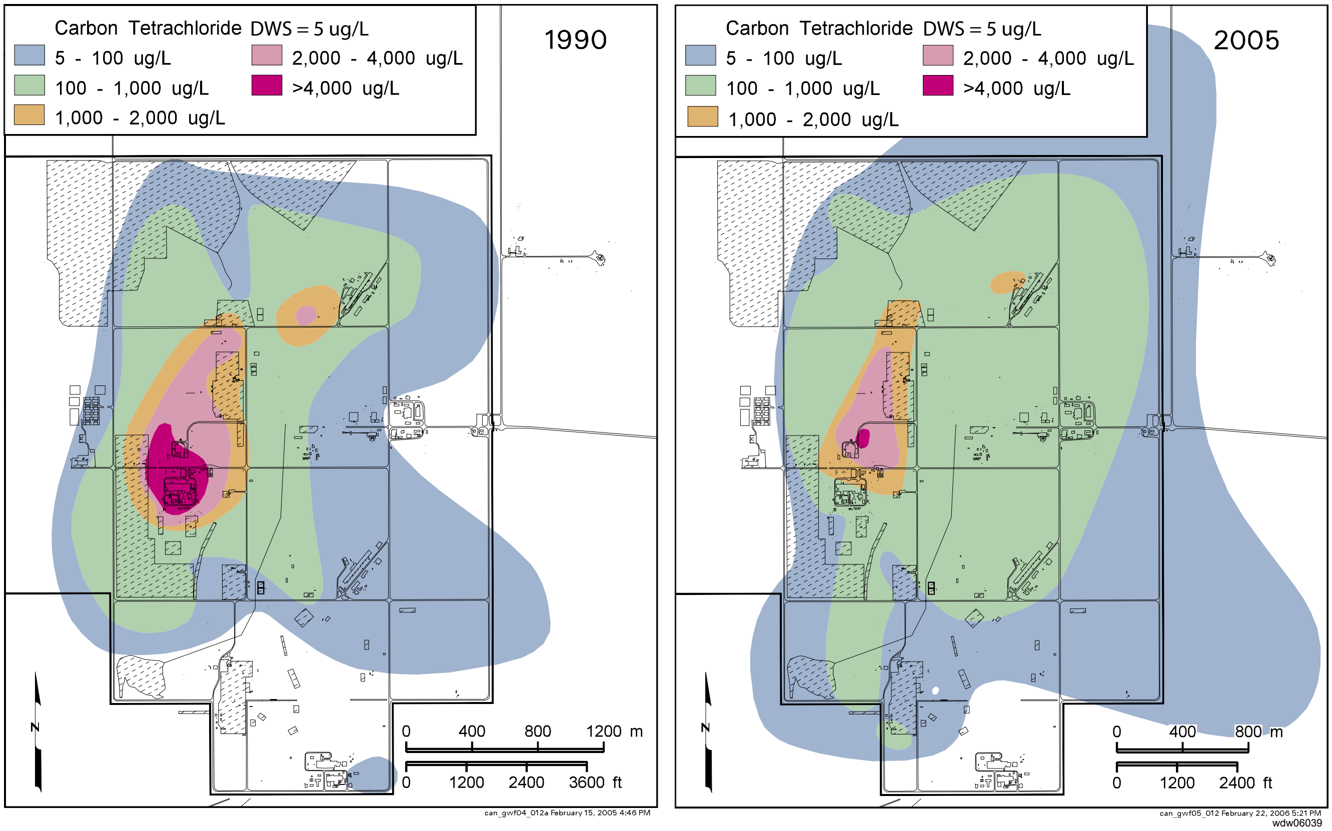
100-HR-3-H Operable Unit

The east part of the 100-HR-3 Operable Unit (100-HR-3-H) underlies the 100-H Area. A complete discussion of the 100-HR-3-H Operable Unit can be found in Section 2.6. Hexavalent chromium is the primary contaminant of concern, but the plume is smaller and concentrations are lower than in the 100-D Area. Nitrate also is elevated, but concentrations have declined from their peak levels. Strontium-90 exceeds the drinking water standard (8 pCi/L) beneath former retention basins, and technetium-99 and uranium are elevated in a small area.

Interim Remedial Action. The chromium plume is the target of a pump-and-treat system. The remediation in the 100-H Area has removed 42 kilograms of hexavalent chromium from the aquifer, which represents most of the amount estimated to be in the aquifer before remediation began. The extraction and injection networks were modified in FY 2005 to respond to the changing plume and to further reduce the remaining chromium mass.

Chromium concentrations in 100-H Area have declined due to remediation and natural processes.

116-H-6 (183-H) Evaporation Basins. These former basins comprise the only RCRA site in the 100-H Area. Leakage from the basins contaminated groundwater with chromium, nitrate, technetium-99, and uranium. The site is monitored during the post-closure period to



These maps show the carbon tetrachloride plume beneath the 200 West Area in the upper part of the unconfined aquifer. The edges of the plume spread between 1990 and 2005. Since 1996, a pump-and-treat system in the 200-ZP-1 Operable Unit is helping prevent further spreading of the core of the plume, shown here in pink and red.

track contaminant trends during the operation of the CERCLA interim action for chromium. Nitrate, technetium-99, and uranium concentrations increased sharply in a well northeast of the former basins in FY 2005.

DOE expanded the pump-and-treat system for carbon tetrachloride in the 200 West Area in FY 2005 to capture a portion of the plume beyond the reach of the former system.

100-FR-3 Operable Unit

A complete discussion of the 100-FR-3 Operable Unit can be found in Section 2.7. Nitrate concentrations in groundwater exceed the drinking water standard beneath much of the 100-F Area and the downgradient region. Other groundwater contaminants include strontium-90 and trichloroethene.

A record of decision has not yet been developed for the 100-FR-3 Operable Unit, and no active remediation of groundwater is underway. Monitoring contaminant conditions has continued since the initial remedial investigation and while waste site remedial actions are conducted.

200-ZP-1 Operable Unit

A complete discussion of the 200-ZP-1 Operable Unit can be found in Section 2.8. This operable unit encompasses the north portion of the 200 West Area. The primary contaminant of concern is carbon tetrachloride, which forms the largest plume of chlorinated hydrocarbons on the Hanford Site. The carbon tetrachloride contamination had sources associated with waste disposal from the Plutonium Finishing Plant, where organic chemicals were used to process plutonium. Trichloroethene and chloroform also are associated with this plume. Other contaminants in the 200-ZP-1 Operable Unit include tritium, nitrate, chromium, fluoride, iodine-129, technetium-99, and uranium.

The distribution of carbon tetrachloride is complex because of its potential to migrate as a dense, non-aqueous phase liquid, in the gaseous state, and dissolved in water. Data from depth-discrete sampling have shown the maximum concentrations of carbon tetrachloride at some locations is up to 45 meters below the water table. In other locations, the maximum is located closer to the water table.

The 200-ZP-1 Operable Unit contains one CERCLA interim action for groundwater, one remediation system for the vadose zone, four facilities monitored under RCRA (in conjunction with CERCLA and AEA), and one state-permitted unit.

Interim Remedial Action. Since 1994, DOE has operated an interim action pump-and-treat system to prevent carbon tetrachloride from spreading. The remediation system was extended to the north in late FY 2005 to capture carbon tetrachloride contamination at levels above 2,000 µg/L extending beyond the capture zone of the former system.

Soil-Vapor Extraction. Soil vapor is extracted from the vadose zone and treated to remove carbon tetrachloride. As of October 2005, ~78,600 kilograms of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

Low-Level Burial Grounds Waste Management Areas 3 and 4. RCRA groundwater monitoring continued under interim status requirements in FY 2005. Two wells went dry at Low-Level Waste Management Area 3 in FY 2005. In FY 2006, three downgradient wells will be installed in the south part of the area. The changing flow direction has left Low-Level Waste Management Area 3 without any upgradient wells. Until new upgradient wells are installed and background conditions are established, statistical evaluations of indicator parameters have been suspended. Three new wells were installed for Low-Level Waste Management Area 4 in FY 2005, and more are planned for FY 2006.

Waste Management Area T. RCRA assessment monitoring continued in FY 2005. The waste management area has introduced technetium-99 and other tank waste contaminants to the uppermost aquifer in the area. Additional contamination from other facilities is present in groundwater beneath the waste management area. Two new wells were installed in FY 2005 and another is planned for FY 2006. Unexpectedly high concentrations of contaminants were found in groundwater samples collected during drilling of one of the new wells. The maximum technetium-99 concentration was 181,900 pCi/L at 10 meters below the water table. The concentration decreased with depth, but concentrations at the bottom of the well remained in the 20,000 to 30,000 pCi/L range. Nitrate and chromium concentrations also were elevated in the new well. Another new well was installed farther downgradient, and technetium-99 concentrations were lower, but still far above the drinking water standard.

Unexpectedly high concentrations of contaminants were found in groundwater samples collected during drilling a new well downgradient of Waste Management Area T.

Dry Monitoring Wells

Some wells that were formerly sampled for the groundwater project have gone dry as the water table declined. Most of the wells are in the 200 Areas.

Fiscal Year	200 West	200 East	Other Areas	Total
1999	12	1	1	14
2000	8	2	1	11
2001	11	0	2	13
2002	9	2	1	12
2003	9	1	3	13
2004	6	1	2	9
2005	3	6	0	9
Total	**58**	**13**	**10**	**81**

Number of Wells for RCRA Statistical Comparisons, End of FY 2005

Some RCRA sites have insufficient monitoring networks because wells have gone dry. DOE is working with regulatory agencies to determine priorities for installing new wells for RCRA and CERCLA.

Site	Downgradient	Upgradient	Comments
Liquid Effluent Retention Facility	1	1	Unconfined aquifer too thin to monitor.
Low-Level Waste Management Area 3	4	0	
216-S-10 Pond and Ditch	2	0	

Concentrations of organic contaminants generally increase with depth in the east part of the 200-UP-1 Operable Unit.

Waste Management Area TX-TY. RCRA assessment monitoring continued in FY 2005. Sources in the waste management area have contaminated groundwater with chromium and other tank waste constituents. Other nearby sources of contamination make source determinations uncertain for some contaminants. Technetium-99, iodine-129, nitrate, and tritium exceed drinking water standards in groundwater beneath the area. One new well was installed in FY 2005 to sample at depth below the water table. Groundwater flow beneath Waste Management Area TX-TY is changing due to the operation of the 200-ZP-1 pump-and-treat remediation system. In particular, greater amounts of water are being pumped south of Waste Management Area TX-TY because replacement extraction wells have increased the pumping capacity and monitoring wells west of the waste management area were converted to extraction wells in late FY 2005.

State-Approved Land Disposal Site. This active disposal facility is regulated under a state waste discharge permit. Groundwater is monitored for tritium and 15 other constituents. Concentrations of all constituents considered in the permit did not exceed enforcement limits during FY 2005.

200-UP-1 Operable Unit

A complete discussion of the 200-UP-1 Operable Unit can be found in Section 2.9. This operable unit underlies the south portion of 200 West Area. The primary contaminants of concern are technetium-99 and uranium. Tritium, chromium, iodine-129, and nitrate plumes also have sources in this operable unit. Carbon tetrachloride in the 200-UP-1 Operable Unit originated from sources in the 200-ZP-1 Operable Unit.

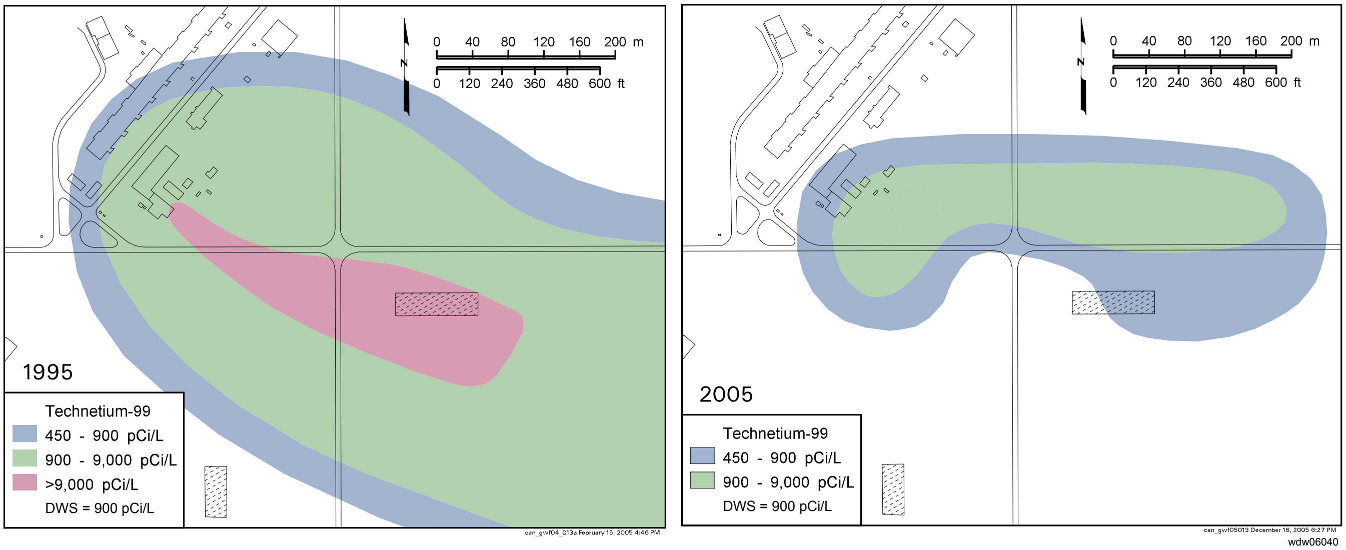
Depth-discrete sampling during well installation shows that carbon tetrachloride, chloroform, and trichloroethene concentrations generally increase with depth in the east part of the operable unit. Farther west, depth-discrete sampling showed peak carbon tetrachloride concentrations shallower in the aquifer.

There are four facilities monitored under RCRA (in conjunction with CERCLA and AEA), one CERCLA interim action, and a CERCLA disposal site in the 200-UP-1 Operable Unit. Monitoring activities are summarized in the following paragraphs.

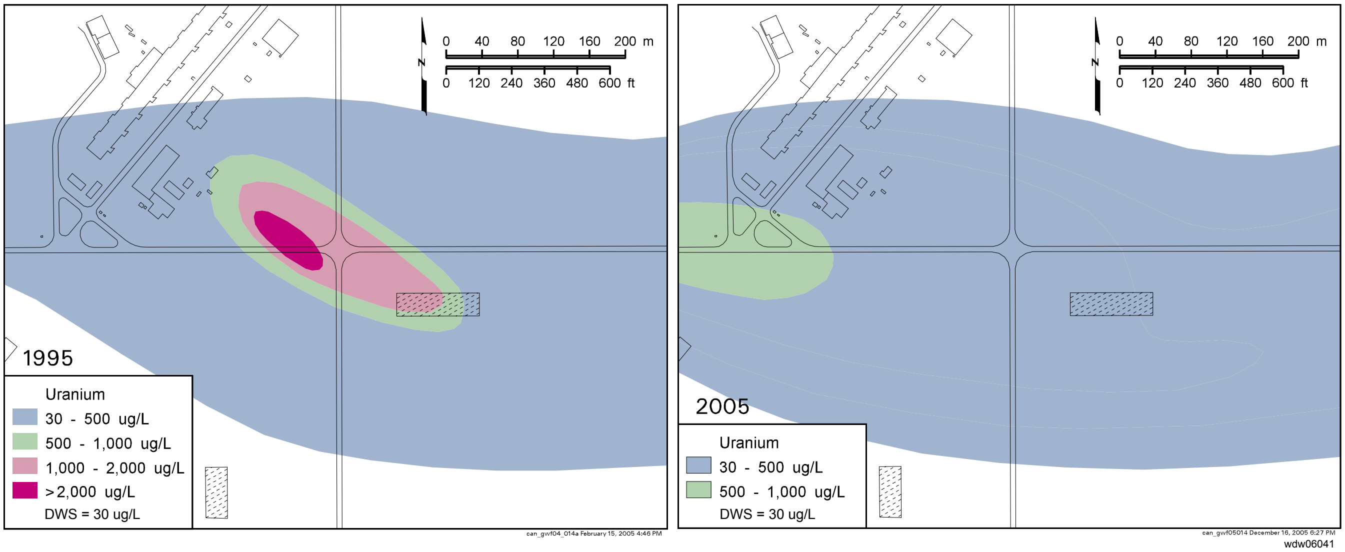
A groundwater pump-and-treat system operated near U Plant to contain the technetium-99 and uranium plumes there. The system was shut down in January 2005 and contaminant concentrations remained below remedial action goals.

Interim Remedial Action. A groundwater pump-and-treat system operated near U Plant to contain the technetium-99 and uranium plumes there. In January 2005, groundwater extraction ceased and a rebound study was initiated to determine if contaminant concentrations will remain below the remedial action goal under natural groundwater flow conditions. At the end of FY 2005, (8 months into the rebound study), technetium-99 and uranium concentrations remained below the remedial action objectives, but above drinking water standards.

Waste Management Area S-SX. RCRA assessment monitoring continued in FY 2005. Groundwater beneath this waste management area is contaminated with nitrate, hexavalent chromium, and technetium-99 attributed to two general source areas within the waste management area. Technetium-99, nitrate, and chromium concentrations in well 299-W23-19 increased in FY 2005, indicating that a pulse of contamination has entered the aquifer beneath the tank farm. This well continued to be purged at least 3,785 liters



A pump-and-treat system at the 200-UP-1 Operable Unit (200 West Area) has decreased the size of the technetium-99 plume in the upper part of the aquifer. The system began to operate in fall 1995 and was shut down in January 2005, when DOE began to conduct a rebound study.



Uranium contamination in the 200-UP-1 Operable Unit (200 West Area), although now below the remedial action goal, did not respond to the pump-and-treat system as quickly as the technetium-99. Unlike technetium-99, uranium interacts with sediment grains, slowing its movement and response to remediation.

after each quarterly sampling event, as Ecology requested in FY 2003. One well was installed in FY 2005, and sample results indicate the contaminant plume at the south end of the waste management area is wider than previously thought. Three wells will be installed in FY 2006.

Waste Management Area U. RCRA assessment monitoring continued in FY 2005. The waste management area has been identified as the source for a small contaminant plume that is limited to the downgradient (east) side of the site. Plume constituents of interest include nitrate and technetium-99. During FY 2005, technetium-99 concentrations exceeded the drinking water standard (900 pCi/L) for the first time since 1993.

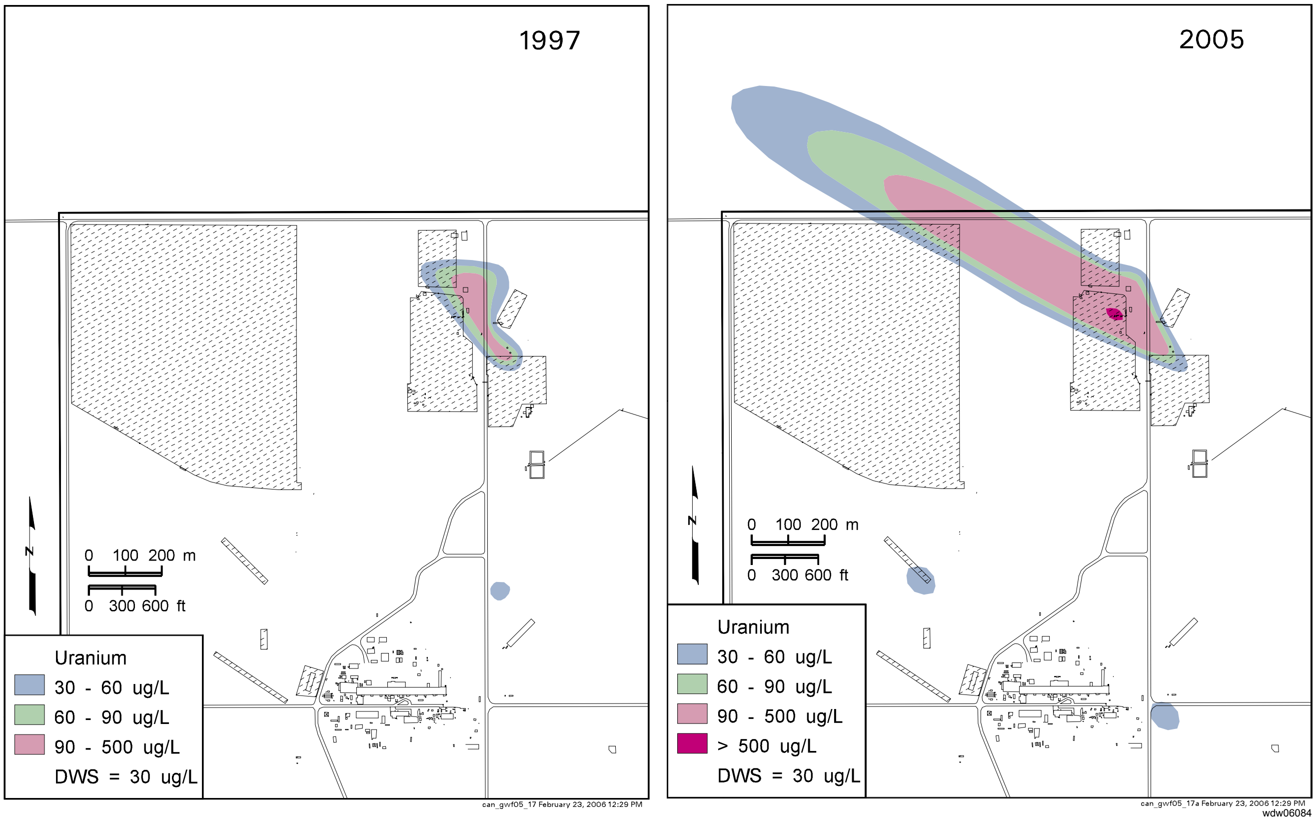
216-U-12 Crib. RCRA assessment monitoring continued in FY 2005. The crib is one of several sources that have contributed to nitrate and technetium-99 plumes in the area. Closure of the crib will be coordinated between RCRA and CERCLA. The monitoring network was revised in late FY 2005 to include one upgradient and three downgradient wells. An additional upgradient well is proposed for installation in 2006.

216-S-10 Pond and Ditch. The 216-S-10 facility continued to be monitored under a RCRA interim status detection program in FY 2005. The current RCRA monitoring network consists of only two shallow downgradient wells and one deeper downgradient well, because other wells have gone dry. Three new wells will be installed in conjunction with the 200-UP-1 Operable Unit in 2007.

Environmental Restoration Disposal Facility. This facility is a low-level, mixed waste facility where waste from surface remedial actions on the Hanford Site is disposed. The site is designed to meet RCRA standards, although it is not permitted as a RCRA unit. Results of groundwater monitoring continued to indicate that the facility has not adversely impacted groundwater quality.

200-BP-5 Operable Unit

A complete discussion of the 200-BP-5 Operable Unit can be found in Section 2.10. This operable unit includes groundwater beneath the north 200 East Area. Technetium-99 and tritium plumes extend northward between Gable Mountain and Gable Butte. Uranium forms a narrow plume that extends northwest of the 200 East Area. Nitrate forms a plume that extends to the north and probably originated from multiple sources within the 200 East Area. Other contaminants include cesium-137, cobalt-60, cyanide, iodine-129, nitrate, nitrite, plutonium, strontium-90, sulfate, and uranium.



A uranium plume has developed in the northwest corner of the 200 East Area. The plume appears to have sources in Waste Management Area B-BX-BY.

Groundwater monitoring under CERCLA continued in FY 2005. There is no active groundwater remediation in this operable unit, and final remediation decisions are yet to be made. One new well was installed near the gap between Gable Mountain and Gable Butte in FY 2005. This well is located above a topographic high on the basalt surface where the aquifer is very thin.

Five facilities in the 200-BP-5 Operable Unit are monitored under RCRA in conjunction with CERCLA and AEA. Monitoring activities are summarized in the following paragraphs.

Waste Management Area B-BX-BY. RCRA assessment monitoring continued at this site in FY 2005. Contaminants include uranium, technetium-99, and nitrate. Concentrations of these contaminants continued to increase in FY 2005.

A significant uranium plume continues to reside below the B-BX-BY tank farms and has spread to the northwest.

Waste Management Area C. This site continued to be monitored under an interim status RCRA detection program in FY 2005. RCRA indicator parameters did not exceed critical mean values. However, nitrate, technetium-99, and sulfate are elevated in the groundwater near the waste management area. Concentrations of sulfate in upgradient wells indicate an upgradient source. Although high levels of technetium-99 have been observed upgradient in the past, the plume is currently affecting only downgradient wells at levels above the drinking water standard (900 pCi/L).

216-B-63 Trench. This RCRA site continued to be monitored under an interim status detection monitoring program.

Low-Level Waste Management Areas 1 and 2. These sites continued to be monitored under RCRA interim status requirements. Specific conductance continued to exceed its critical mean value at Low-Level Waste Management Area 1, and total organic carbon continued to exceed its critical mean value in an upgradient well at Low-Level Waste Management Area 2. However, both exceedances were reported previously and neither appears to indicate contamination from these waste management areas. Most wells in the north part of Low-Level Waste Management Area 2 are dry, and the water table has dropped below the top of basalt.

Liquid Effluent Retention Facility. A 2001 letter from Ecology directed DOE to discontinue RCRA statistical evaluation of groundwater sample results because all but two wells have gone dry, and a 1999 variance to allow DOE to operate the remaining network expired. DOE has continued to sample the two remaining wells but is not conducting statistical analyses of the results. DOE and Ecology are pursuing an agreement for permit conditions for environmental monitoring.

200-PO-1 Operable Unit

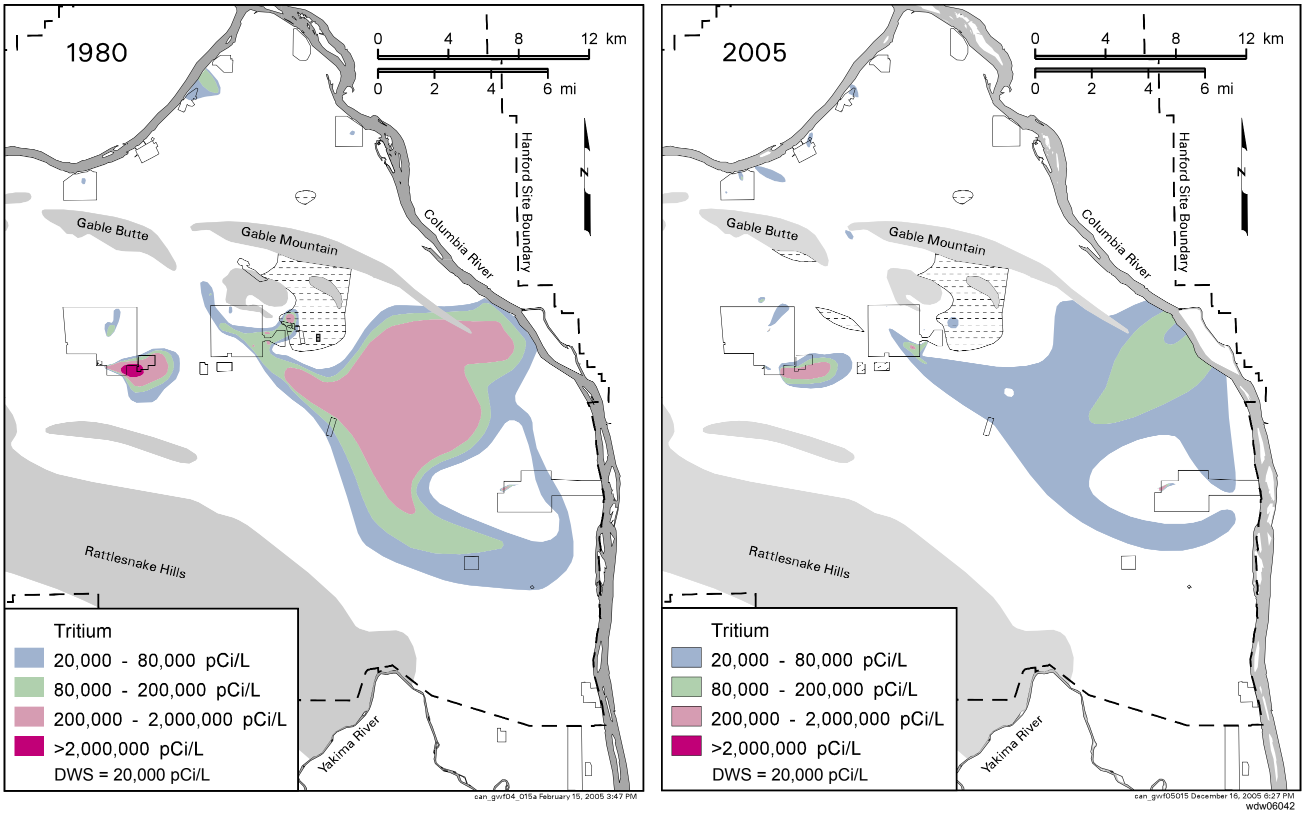
A complete discussion of the 200-PO-1 Operable Unit can be found in Section 2.11. This operable unit encompasses the south portion of the 200 East Area and a large portion of the Hanford Site extending to the east and southeast that is contaminated with plumes of tritium, nitrate, and iodine-129 that exceed drinking water standards. Concentrations of tritium continued to decline as the plume attenuates naturally due to radioactive decay and dispersion. Other contaminants include strontium-90 and technetium-99, but these are limited to very small areas near cribs or tank farms.

Tritium concentrations generally are decreasing southeast of the 200 East Area.

CERCLA groundwater monitoring continued in FY 2005, and the sampling and analysis plan was revised. Currently, no active groundwater remediation is occurring in this operable unit and final remediation decisions are yet to be made.

Groundwater is monitored at eight regulated units in the 200-PO-1 Operable Unit. Water supply wells in the 400 Area, which falls within the footprint of the 200-PO-1 Operable Unit, also are monitored.

Integrated Disposal Facility. This facility will be an expandable, lined, RCRA-compliant landfill. Construction began in September 2004. DOE submitted a Part B RCRA permit



These maps show site-wide tritium plumes in the upper part of the unconfined aquifer in 1980 and 2005. Concentrations in the core of the plume have decreased over the years; the south margin has ceased its southward migration.

application to the Washington State Department of Ecology, and it will be incorporated into the Hanford Facility RCRA Permit after approval. The facility is scheduled to receive its first waste in early 2007. Two wells were installed in FY 2005, bringing the total to three upgradient wells and four downgradient wells, and groundwater sampling began. One new well remains to be installed at a future date when required by facility expansion.

RCRA groundwater monitoring at Waste Management Area A-AX was elevated to an assessment program in FY 2005. Technetium-99 was also high in a downgradient well.

PUREX Cribs. Three cribs (216-A-10, 216-A-36B, and 216-A-37-1) are monitored jointly under a RCRA interim status assessment program, CERCLA, and AEA. The cribs have contributed to widespread contaminant plumes in the area, including nitrate, tritium, and iodine-129. The nitrate and tritium plumes are generally attenuating throughout most of their area. However, in recent years the concentration of nitrate in near-field wells at the PUREX cribs has either held steady or increased.

Waste Management Area A-AX. Based on results for FY 2005 sampling and analysis, this waste management area began RCRA assessment monitoring. Specific conductance in a downgradient well exceeded the critical mean value. Contributing constituents included calcium, nitrate, sodium, and sulfate. Technetium-99 concentrations continued to exceed the drinking water standard (900 pCi/L) in the same well. Data from two wells installed in FY 2005 will aid the interpretation.

216-A-29 Ditch. The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations. Except for specific conductance, RCRA indicator parameters in downgradient wells did not exceed critical mean values in FY 2005. Specific conductance continued to exceed its critical mean value in downgradient wells as groundwater quality returns to ambient conditions in response to the cessation of effluent disposal at B Pond. Groundwater quality beneath the ditch closely resembles regional patterns.

216-B-3 Pond. The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations.

200 Area Treated Effluent Disposal Facility. A state waste discharge permit governs groundwater sampling and analysis in the three monitoring wells at this facility. No permit criteria for constituents in groundwater were exceeded in FY 2005. The groundwater monitoring network continues to show that effluent from the facility is not taking a direct route to the uppermost aquifer, which is confined.

Nonradioactive Dangerous Waste Landfill. This RCRA site is located in the 600 Area, within the footprint of the 200-PO-1 regional plume. Interim status detection monitoring continued FY 2005.

Solid Waste Landfill. This facility is adjacent to the Nonradioactive Dangerous Waste Landfill and is regulated under state solid waste regulations. As in previous years, some downgradient wells showed higher chemical oxygen demand, chloride, coliform bacteria, specific conductance, and sulfate, and lower pH than upgradient wells. Some of these constituents may be related to past disposal of sewage materials to the Solid Waste Landfill.

400 Area Water Supply Wells. Three water supply wells provide drinking water and emergency supply water for the 400 Area. Because the 400 Area lies in the path of the site-wide tritium plume, the wells are routinely monitored for tritium. The main water supply well is completed deep in the unconfined aquifer and has low tritium values. Two backup wells are shallower and have higher tritium levels, but tritium concentrations in all samples were below the drinking water standard in FY 2005.

300-FF-5 Operable Unit

A complete discussion of the 300-FF-5 Operable Unit can be found in Section 2.12. This operable unit includes three geographic subdivisions: the 300 Area, the 618-11 burial ground region, and the 316-4 cribs/618-10 burial ground region. The operable unit is currently regulated under a record of decision that calls for continued monitoring of groundwater conditions and institutional controls on the use of groundwater as an interim action, until source remedial actions are complete. The operable unit includes groundwater associated with a former liquid waste disposal site regulated under a RCRA final status, corrective action monitoring program.

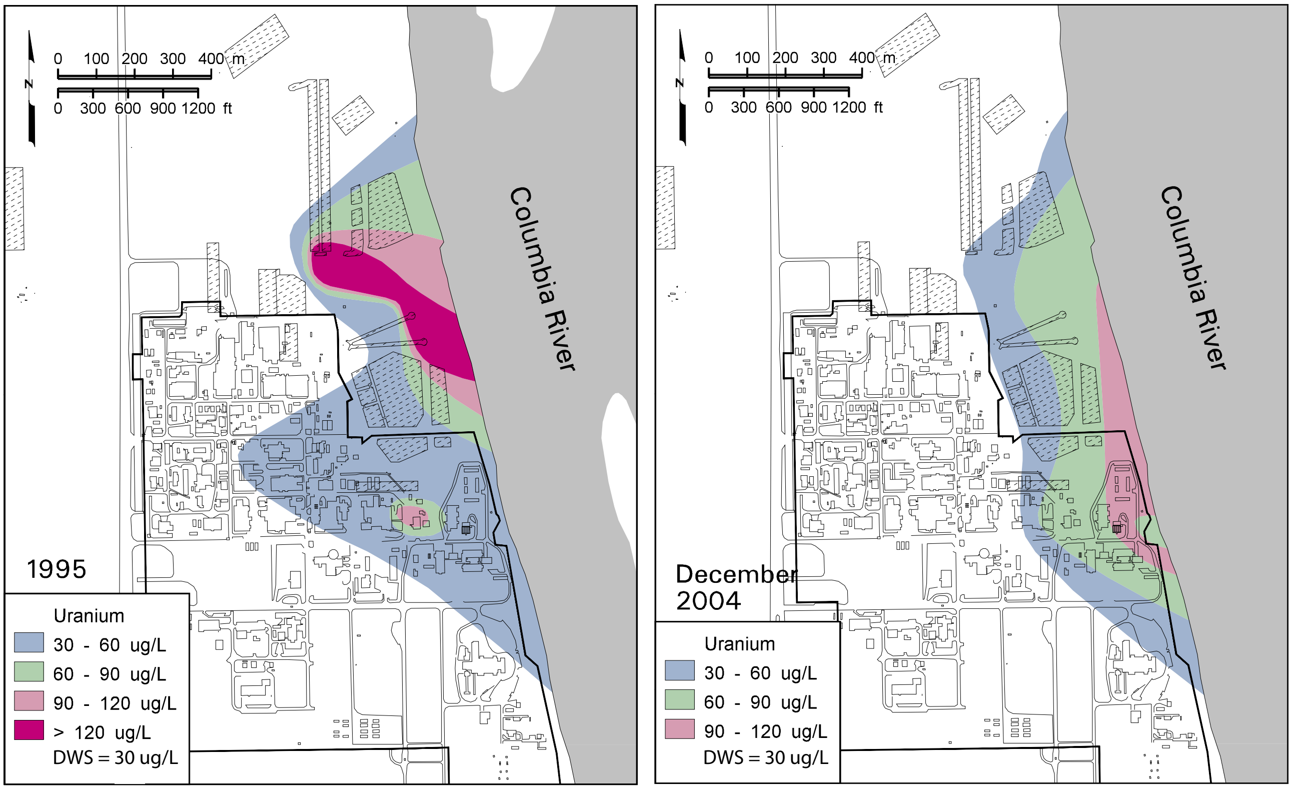
Status of Interim Remedial Actions. Contaminants of concern in 300 Area groundwater are uranium, trichloroethene, and cis-1,2-dichloroethene. Monitoring and plume characterization activities indicate relatively constant or gradually decreasing levels for these contaminants. Uranium is the primary contaminant of concern and remains above the drinking water standard (30 µg/L) beneath part of the 300 Area.

Groundwater downgradient of the 618-11 burial ground is contaminated by a high-concentration tritium plume, whose origin is believed to be irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from >8 million pCi/L in 2000 to 1.65 million pCi/L in FY 2005.

At the 316-4 cribs and 618-10 burial ground waste sites, uranium and tributyl phosphate are contaminants of potential concern. Both are associated with the 316-4 cribs, which were removed in 2004. Results of research involving uranium isotopes suggest that there also may be a uranium source from the 618-10 burial ground, where concentrations of uranium exceeded the drinking water standard in FY 2005 in one well. Tributyl phosphate concentrations were elevated for a brief period in early 2004, along with uranium, during the period when crib removal actions were underway. Since then, concentrations have remained very low.

The Tri-Parties proposed a new milestone for a feasibility study for the 300-FF-5 Operable Unit. The study involves remediation alternatives for reducing uranium concentrations in the 300 Area plume.

300-FF-5 Operable Unit Phase III Feasibility Study. A new Tri-Party Agreement milestone was proposed in early 2005 for the delivery of a Phase III Feasibility Study report for remediation technology alternatives and a draft proposed plan by May 2007. A work



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The uranium plume in the 300 Area, at the 30-µg/L level, is attenuating very slowly. DOE is investigating alternatives for more rapid remediation.

plan was prepared that describes these additional efforts, which include updated computer simulations of groundwater flow and uranium transport, an update to human health and ecological risk assessment in the 300 Area, a limited field investigation involving multiple characterization boreholes, and an assessment of potential remediation technologies for uranium.

316-5 Process Trenches. This liquid waste disposal site was the last in the 300 Area to receive uranium-bearing effluent, with discharges ending in the early 1990s, and is regulated under RCRA. These trenches have undergone two phases of remedial action (1991 and 1995), which included removal of contaminated soil and operational structures, and backfilling with clean soil. Uranium currently exceeds the drinking water standard in wells downgradient from the waste site, although concentrations appear to be decreasing with time. Cis-1,2,dichloroethene concentrations exceed the standard at only one downgradient well that is completed near the bottom of the aquifer.

In the 1100-EM-1 Operable Unit, trichloroethene concentrations continued to be below the cleanup level.

1100-EM-1 Operable Unit

A complete discussion of the 1100-EM-1 Operable Unit, located in the south part of the Hanford Site, can be found in Section 2.13. Trichloroethene was the primary contaminant of concern. Contaminants also flow into the area from offsite sources (e.g., nitrate from agriculture and industry).

Selected Remedial Action. The final remedy selected for 1100-EM-1 Operable Unit groundwater was monitored natural attenuation of volatile organic compounds. Concentrations of trichloroethene have remained below the drinking water standard since FY 2001.

Wells in the city of Richland well field are monitored frequently to detect any changes in Hanford contaminants near these wells. The tritium plume originating from sources in the 200 East Area has not been detected in these wells. Low levels of tritium, similar to Columbia River water, continued to be detected.

The city of Richland monitors groundwater quarterly for chemical constituents at their Horn Rapids Sanitary Landfill. The landfill is located in the central portion of the 1100-EM-1 groundwater interest area adjacent to the south boundary of the Hanford Site. Chlorinated hydrocarbons were detected in city landfill monitoring wells between ~1 and 1.5 kilometers south of the Hanford Site boundary at levels above their respective drinking water standards during FY 2005.

Confined Aquifers

A complete discussion of the confined aquifers can be found in Section 2.14. Although most of Hanford's groundwater contamination is in the unconfined aquifer, DOE monitors wells in deeper aquifers because of the potential for downward migration of contamination and the potential migration of contamination offsite through the basalt-confined aquifer.

The Ringold Formation confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of the Ringold Formation. It is confined below by basalt and above by the lower mud unit. Groundwater in this aquifer flows generally west to east in the vicinity of the 200 West Area. In the central portion of the aquifer, flow appears to converge into the 200 East Area from the west, south, and east. Groundwater likely discharges from the confined aquifer to the overlying unconfined aquifer where the confining mud unit has been removed by erosion.

While effluent disposal was occurring at the B Pond system, groundwater mounding forced groundwater a limited distance into the Ringold Formation confined aquifer. Groundwater analyses for FY 2005 at the 200 Area Treated Effluent Disposal Facility continued to demonstrate isolation of the confined aquifer from current disposal activities.

Within the upper basalt-confined aquifer system, groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds. Groundwater in the upper basalt-confined aquifer generally flows from west to east across the Hanford Site, up through fractures or other pathways in the confining layers, into the unconfined aquifer, and into the Columbia River. Vertical gradients between the basalt-confined aquifer and the unconfined aquifer are upward on most of the Hanford Site. Downward gradients are measured in the west portion of the Hanford Site, near B Pond, and north and east of the Columbia River.

Cyanide, nitrate, and technetium-99 were elevated in only one basalt-confined well. Contaminant migration during well construction is suspected.

Tritium continued to be detected at low levels in some basalt-confined wells. One elevated tritium concentration near the 200 East Area is associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer. Iodine-129, strontium-90, gamma-emitting isotopes, and uranium isotopes were not detected above the minimum detection limits in the upper basalt-confined aquifer. Cyanide, nitrate, and technetium-99 were elevated in an upper basalt-confined aquifer well in the northwest part of the 200 East Area. Migration of high-salt waste from the vadose zone or unconfined aquifer during well construction is responsible for this contamination.

Well Installation, Maintenance, and Decommissioning

A complete discussion of the well installation, maintenance, and decommissioning can be found in Chapter 4. DOE installs new wells when needed for monitoring or characterization, maintains wells to repair problems, and decommissions wells that are no longer needed. Ecology, EPA, and DOE worked together to develop a prioritized list of new wells needed to meet requirements of various groundwater monitoring regulations. Twenty-seven new monitoring wells were installed during calendar year 2005.

During FY 2005, 115 unneeded wells were decommissioned; 1,382 wells remain in use.

Approximately 3,975 permanent wells have been identified within the Hanford Site. Many of these have been decommissioned (sealed with grout) because they were no longer needed, were in poor condition, were in the path of intended remediation or construction activities, or posed an environmental, safety, or public health hazard. During FY 2005, 1,382 wells were in use and 115 wells were decommissioned.

Wells Installed in 2005

Site or Purpose	Number of New Wells Calendar Year 2005
100-BC-5	0
100-KR-4	4
100-NR-2	2
100-HR-3-D	4
100-HR-3-H	0
100-FR-3	0
200-BP-5	1
200-ZP-1	4
200-ZP-1 and Waste Management Areas T and TX/TY	3
200-UP-1	2
200-UP-1 and Waste Management Area S-SX	1
300-FF-5	1
Integrated Disposal Facility	2
Low-Level Waste Management Area 4	3
Total	**27**

Vadose Zone

Subsurface source characterization, vadose zone monitoring, soil-vapor monitoring, and sediment sampling were conducted in FY 2005. The complete discussion of these activities can be found in Chapter 3.

Geophysical techniques were employed to map subsurface features at the BC cribs and trenches, south of the 200 East Area. Similar methods may be employed at tank farms in the future.

Leachate Monitoring at Environmental Restoration Disposal Facility. Washington Closure Hanford (and formerly, Bechtel Hanford, Inc.) operates this facility to dispose of radioactive and mixed waste generated during waste management and remediation activities at the Hanford Site. Composite leachate samples contained detectable concentration of common metals, anions, and mobile radionuclides. Constituents that were generally increasing in concentration include chromium, potassium, specific conductance, bromide, and nitrate. Gross alpha and total uranium had been increasing until calendar year 2004. The facility is lined, and there is no evidence of impacts to groundwater.

Leachate and Soil Gas Monitoring at Solid Waste Landfill. Leachate is sampled and tested quarterly. Concentrations in the past year were similar to previous concentrations and did not identify any areas of concern. Soil gas is monitored quarterly to determine concentrations of oxygen, carbon dioxide, methane, and several key volatile organic compounds. Results were consistent with previous years. Contaminants of concern were near or below detection limits.

Soil-Vapor Extraction. This remedial action is being used to remove carbon tetrachloride from the vadose zone in the 200 West Area. As of October 2004, ~78,600 kilograms of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

Long-Term Hydrologic Performance of the 200-BP-1 Surface Barrier. A multilayered, vegetated capillary barrier was constructed over the 216-B-57 crib in Hanford's 200-BP-1 Operable Unit in 1994 in an effort to understand the long-term performance of field-scale surface barriers. Since 1998, monitoring has focused on barrier stability and the water balance. Performance data are currently being used to guide the design of final barriers for other waste management areas and in model validation.

Geophysical Characterization at the BC Cribs and Trenches and T Tank Farm. Characterization of the BC cribs and trenches, located south of the 200 East Area, continued in FY 2005. The purpose of the characterization is to find the concentration and extent of subsurface contamination in the area. Several surface geophysical methods were used to map subsurface features within the BC cribs and trenches area: magnetic gradiometry, electromagnetic induction, high resolution resistivity, and induced polarization. Geophysical exploration of the T Tank Farm and surrounding areas was carried out using similar methods to those applied at the BC cribs and trenches, to determine the extent to which surface resistivity techniques could be applied in the tank farm environment. Initial results confirmed the electrical complexity of the farm but pointed toward supplemental work that holds promise for more detailed interpretation.

Conceptual Model for Vadose Zone Transport of Technetium-99 at the BC Cribs. The BC cribs and trenches in the Hanford Site's 200 East Area are believed to have received ~113.5 million liters of scavenged tank waste containing large quantities of technetium-99, nitrate, and uranium. A detailed analysis of transport at the site required development of an accurate conceptual model. The purpose of this study was to develop a conceptual model for contaminant fate and transport at the 216-B-26 trench site. The conceptual model included (1) small-scale stratigraphy and changes in physical and chemical properties, (2) tilted layers to accommodate the natural slope to the formation, and (3) lateral spreading along multiple strata with contrasting physical properties. Predictions show that capping the waste site will reduce the threat to groundwater.

Vadose Zone Modeling and Related Studies. Several studies in FY 2005 relate to computer simulations of the vadose zone and to determining input parameters for such models. These studies included (1) changes in recommended methods for using chloride mass balance to estimate recharge, (2) correcting hydraulic properties for the effects of gravel, (3) estimating the hydraulic properties of the Hanford Site's grass site using the STOMP simulator, (4) sparse vegetation evapotranspiration model for the STOMP simulator, and (5) image analysis for detecting change in vegetation cover, which affects recharge rates.

Ground Penetrating Radar to Delineate Subsurface Heterogeneity in the 300-FF-5 Operable Unit. In FY 2005, a ground penetrating radar survey was done at the 300-FF-5 Operable Unit to develop an improved lithostratigraphic model and identify preferential paths that may control the migration of contaminants towards the Columbia River. The depth of the deepest reflector detected at the site was ~5 meters, much shallower than the desired 15 to 20 meters penetration depth. It is likely that elevated salt content in the sediments may be responsible for the reduced signal penetration. Ground penetrating radar was incapable of delineating aquifer lithologic heterogeneity at this site at the scale needed for model construction. Other geophysical methods may be able to overcome these limitations.

Ground penetrating radar was found to be incapable of characterizing the aquifer in the 300-FF-5 Operable Unit at the scale needed, so other geophysical methods will be investigated.

Laboratory Evaluation of Uranium Immobilization by Gaseous Reduction. In situ gaseous reduction of vadose zone sediments with diluted hydrogen sulfide is a potential way to immobilize contaminants that are less mobile in their reduced form (e.g., technetium-99, uranium, and chromium). In FY 2005, scientists conducted experiments to investigate whether the in situ gaseous reduction approach might be effective. Results showed that Hanford formation sediment treated by gaseous reduction was capable of immobilizing hexavalent uranium from simulated groundwater. The immobilization was further enhanced by sediment treatment with a moisturized hydrogen sulfide-nitrogen gas mixture. After pumping 20 pore volumes of simulated groundwater through the treated sediment, >80% of the mobile uranium was still immobilized.

Continued Monitoring

DOE will continue to monitor groundwater to meet the requirements of AEA, CERCLA, RCRA, and DOE Orders. During ongoing groundwater remediation, the groundwater project will monitor, assess, and report on activities at groundwater operable units. Both the unconfined and upper-confined aquifers are monitored and data are maintained and managed in a centralized database. Monitoring well locations, frequencies, and analytical constituents will continue to be documented each year. Water-level monitoring will continue to be performed to characterize groundwater flow and to determine the impact of Hanford Site operations on the flow system.

As such, groundwater monitoring remains a part of the Hanford Site baseline throughout the cleanup mission and will remain a component of long-term stewardship after remediation is completed.

Details about the Hanford Site Groundwater Remediation Project can be found online at http://www.hanford.gov/cp/gpp/.

Contents

Tables

Figures

1.0 Introduction

M. J. Hartman

The U.S. Department of Energy (DOE) has committed to protect the Columbia River from contaminated groundwater resulting from past, present, and future operations at its Hanford Site, and to protect and remediate groundwater. *Hanford Site Groundwater Strategy* (DOE/RL-2002-59) focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater.

One of the implementing documents for the groundwater strategy is *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection* (DOE/RL-2002-68). DOE established the Groundwater Remediation Project, managed by Fluor Hanford, Inc., to implement the accelerated plan. Protection of Hanford's groundwater requires an aggressive plan to limit and control the continued migration of contaminants already in the soil and the groundwater. To do this, the Groundwater Remediation Project performs the following tasks:

- Prevent degradation of groundwater by (a) remediating high-risk waste sites, (b) shrinking the contaminated area, and (c) reducing natural and artificial recharge.
- Remediate groundwater.
- Monitor groundwater.

DOE monitors groundwater at the Hanford Site to fulfill a variety of state and federal regulations, including the *Atomic Energy Act* (AEA), the *Resource Conservation and Recovery Act* (RCRA), the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), and Washington Administrative Code (WAC). DOE manages these activities through the Groundwater Performance Assessment Project (groundwater project), which is conducted by Pacific Northwest National Laboratory (PNNL). The groundwater project is under the umbrella of the Groundwater Remediation Project.

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

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 1.1-1). This report also summarizes groundwater remediation, vadose zone monitoring and characterization, and well installation activities. Monitoring results primarily rely on data from samples collected in fiscal year (FY) 2005, i.e., October 1, 2004 through September 30, 2005.

PNNL's groundwater project is responsible for most Hanford Site groundwater monitoring. Groundwater remediation and associated monitoring are the responsibility of Fluor

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 (for operable units where cleanup decisions have not yet been made), DOE Orders, 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, characterization, and studies associated with the vadose zone.***
- ***Summarize the installation, maintenance, and decommissioning of Hanford Site monitoring wells.***

Hanford, Inc. Vadose zone monitoring and characterization are conducted by Washington Closure Hanford (formerly Bechtel Hanford, Inc.); CH2M HILL Hanford Group, Inc.; Fluor Hanford, Inc.; and Pacific Northwest National Laboratory.

Background information, including descriptions of regulatory requirements, waste sites, analytical methods, regional geology, and statistics is included in a separately published companion volume, *Hanford Site Groundwater: Settings, Sources, and Methods* (PNNL-13080), and in the most recent update, which was provided in PNNL-13788, Appendix C. Those changes have been incorporated into the electronic version of PNNL-13080, provided with this groundwater monitoring report.

As in previous reports, this report includes a set of electronic files that contain groundwater data for the fiscal year and previous years.

DOE and contractors publish a variety of reports to describe progress on Hanford's groundwater program.

1.2 Related Reports

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

- *Calendar Year 2004 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operations* (DOE/RL-2005-18) — This report evaluates the performance of groundwater remediation systems in the 100-K, 100-N, 100-D, and 100-H Areas.
- *Fiscal Year 2004 Annual Summary Report for the In Situ Redox Manipulation Operations* (DOE/RL-2005-39) — This report describes activities related to the remediation system in the southwest 100-D Area.
- *Fiscal Year 2004 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE/RL-2004-72) — This report evaluates the performance of groundwater remediation systems in the 200 West Area.
- *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Carbon Tetrachloride Site, Fiscal Year 2004* (WMP-26178) — This report describes activities related to vadose zone remediation in the 200 West Area.
- Quarterly RCRA data transmittals — DOE transmits informal reports quarterly via e-mail to the Washington State Department of Ecology after groundwater data have been verified and evaluated. These reports describe changes or highlights of the quarter with reference to HEIS for the analytical results.
- Hanford Environmental Information System (HEIS) — This is the main environmental database for the Hanford Site that stores groundwater chemistry data, as well as other environmental data (e.g., soil chemistry, survey data).
- *Hanford Site Environmental Report for Calendar Year 2004* (PNNL-15222) — This annual report summarizes environmental data, including riverbank springs and river water. It also describes environmental management performance and reports the status of compliance with environmental regulations.
- *Hanford Site Climatological Data Summary 2004 with Historical Data* (PNNL-15160) — This annual report summarizes data on temperature, precipitation, and other weather conditions that may impact groundwater recharge.

Units of Measure

μg/L	micrograms per liter
μS/cm	microsiemens per centimeter
M	molar
mg/L	milligrams per liter
mm/yr	millimeters per year
mrem/yr	millirem per year
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/mg	picocuries per milligram
ppb	parts per billion
ppm	parts per million
ppmv	parts per million volume

1.3 Conventions Used in This Report

Contaminant plume maps in this report, unless specified otherwise, are based on average results for samples collected in FY 2005 for each well, excluding data that appear erroneous. The values 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 2003 and 2004 if there were no new data for a well in FY 2005. These 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 generally show data from wells completed in the upper part of the unconfined aquifer.

Results less than detection limits (flagged "U" in HEIS) are treated in one of two ways when constructing maps:

- For **chemical constituents** (including 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.

Conversion Table

The primary units of measurement in this report are metric. To convert metric units to English units, use the information provided in this table.

Multiply	By	To Obtain
centimeters	0.394	inches
meters	3.28	feet
kilometers	0.621	miles
kilograms	2.205	pounds
liters	0.2642	gallons
square meters	10.76	square feet
hectares	2.47	acres
square kilometers	0.386	square miles
cubic meters	1.308	cubic yards
curie	3.7×10^{10}	becquerel
picocurie	0.03704	becquerel
rem	0.01	sievert
°C	(°C x 1.8) + 32	°F

Averaging data allows us to include wells that were sampled at different times and at differing frequencies. In some locations, it is advantageous to construct maps based on data from a single sampling event (e.g., uranium in the 300 Area in June 2005).

Our 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 that is contoured at 1 pCi/L (the drinking water standard), which in some cases is less than the laboratory's detection limit. This problem is exacerbated in samples that contain significant concentrations of technetium-99. Those samples are filtered to remove the technetium-99 prior to iodine-129 analyses (see Section C.6.1 of PNNL-15070). Despite this practice, some values >1 pCi/L were reported as undetected. The distribution of iodine-129 at levels near the drinking water standard is, therefore, less certain than other contaminants.

Trend plots generally include all analytical results, even those that appear to be erroneous if they do not distort or obscure the scale and data trends. If the outlying data distort the figure, they are not plotted. All of the data, with appropriate data quality flags, are included in the data files that accompany 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.

Common Abbreviations

AEA	*Atomic Energy Act*
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FY	fiscal year
groundwater project	Groundwater Performance Assessment Project
NAVD88	North American Vertical Datum of 1988
PNNL	Pacific Northwest National Laboratory
PUREX	Plutonium-Uranium Extraction (Plant)
RCRA	*Resource Conservation and Recovery Act*
REDOX	Reduction Oxidation (Plant)
WAC	Washington Administration Code

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.
- Figures 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), so filtered, total chromium represents hexavalent chromium.
- Contaminant concentrations are compared with state or federally enforceable drinking water standards (Table 1.1-2). 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 (Table 1.1-3).

Table 1.1-1. 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 RODs managed by FH (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 ROD managed by PNNL (300-FF-5)	This report	Unit manager's meeting presentations; this report
Operable unit with final ROD managed by PNNL (1100-EM-1)	This report	None
ERDF	Separate annual report covers groundwater and leachate (summarized in this report)	This report
	RCRA Units	
Indicator evaluation or detection sites (116-N-1 and -3, 120-N-1 and -2, 216-A-29, 216-B-63, 216-S-10, B Pond, IDF, LERF, LLBG, NRDWL, WMA C)	This report	Informal quarterly reports
Assessment sites (216-U-12; PUREX cribs; WMA A-AX, B-BX-BY, S-SX, T, TX-TY, and U)	This report; also occasional assessment reports	Informal quarterly reports
Corrective action sites (116-H-6, 316-5)	Semiannual letter reports to Ecology; this report	Informal quarterly reports
	Other Facilities	
AEA sites (K Basins, 400 Area water supply wells)	This report	Quarterly K Basins reports to facility operators and DOE
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

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AEA = *Atomic Energy Act*.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*.
DOE = U.S. Department of Energy.
Ecology = Washington State Department of Ecology.
ERDF = Environmental Restoration Disposal Facility.
FH = Fluor Hanford, Inc.
FY = Fiscal year.
IDF = Integrated Disposal Facility (planned).
LERF = Liquid Effluent Retention Facility.
LLBG = Low-level burial grounds.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PNNL = Pacific Northwest National Laboratory.
PUREX = Plutonium-Uranium Extraction (Plant).
RCRA = *Resource Conservation and Recovery Act*.
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 1.1-2. Drinking Water Standards

Constituent	DWS	Agency(a)
Aluminum(b)	50 to 200 µg/L	EPA, DOH
Antimony	6 µg/L	EPA, DOH
Arsenic	10 µg/L(c)	EPA, DOH
Barium	2,000 µg/L	EPA, DOH
Cadmium	5 µg/L	EPA
Carbon tetrachloride	5 µg/L	EPA, DOH
Chloride	250 mg/L(b)	EPA, DOH
Chloroform (THM)(d)	80 µg/L	EPA
Chromium	100 µg/L	EPA, DOH
cis-1,2-Dichloroethene	70 µg/L	EPA, DOH
Copper	1,000 µg/L(b)	EPA, DOH
Cyanide	200 µg/L	EPA, DOH
1,4-Dichlorobenzene	75 µg/L	EPA
Fluoride	4 mg/L	EPA, DOH
	2 mg/L(b)	EPA, DOH
Iron	300 µg/L(b)	EPA, DOH
Lead	15 µg/L(e)	EPA
Manganese	50 µg/L(b)	EPA, DOH
Mercury (inorganic)	2 µg/L	EPA, DOH
Methylene chloride	5 µg/L	EPA, DOH
Nitrate, as NO_3^-	45 mg/L	EPA, DOH
Nitrite, as NO_2^-	3.3 mg/L	EPA, DOH
Pentachlorophenol	1 µg/L	EPA, DOH
pH	6.5 to 8.5(b)	EPA
Selenium	50 µg/L	EPA, DOH
Silver	100 µg/L(b)	EPA, DOH
Sulfate	250 mg/L(b)	EPA, DOH
Tetrachloroethene	5 µg/L	EPA, DOH
Thallium	2 µg/L	EPA, DOH
Total dissolved solids	500 mg/L(b)	EPA
1,1,1-Trichloroethane	200 µg/L	EPA, DOH
Trichloroethene	5 µg/L	EPA, DOH
Zinc	5,000 µg/L(b)	EPA, DOH
Antimony-125	300 pCi/L(f)	EPA
Beta particle and photon activity	4 mrem/yr(g)	EPA, DOH
Carbon-14	2,000 pCi/L(f)	EPA
Cesium-137	200 pCi/L(f)	EPA
Cobalt-60	100 pCi/L(f)	EPA
Iodine-129	1 pCi/L(f)	EPA
Ruthenium-106	30 pCi/L(f)	EPA
Strontium-90	8 pCi/L(f)	EPA, DOH
Technetium-99	900 pCi/L(f)	EPA
Total alpha (excluding uranium)	15 pCi/L(f)	EPA, DOH
Tritium	20,000 pCi/L(f)	EPA, DOH
Uranium	30 µg/L	EPA, DOH

(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) Secondary standards are not associated with health effects, but with taste, odor, staining, or other aesthetic qualities.

(c) Effective January 23, 2006.

(d) Standard is for total trihalomethanes (THM).

(e) Action level.

(f) EPA drinking water standards for radionuclides were derived based on a 4-mrem/yr 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).

(g) 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 1.1-3. Derived Concentration Guides[(a,b,c)] and 4-mrem Effective Dose Equivalent Concentrations for Drinking Water[(d)]

Radionuclide	Derived Concentration Guide, pCi/L	4-mrem Effective Dose Equivalent, pCi/L
Tritium	2,000,000	80,000
Carbon-14	70,000	2,800
Cobalt-60	5,000	200
Strontium-90	1,000	40
Technetium-99	100,000	4,000
Ruthenium-103	50,000	2,000
Ruthenium-106	6,000	240
Antimony-125	60,000	2,400
Iodine-129	500	20
Iodine-131	3,000	120
Cesium-134	2,000	80
Cesium-137	3,000	120
Uranium-234	500	20
Uranium-235	600	24
Uranium-238	600	24
Plutonium-238	40	1.6
Plutonium-239	30	1.2
Plutonium-240	30	1.2
Americium-241	30	1.2

(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 table 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.

(d) Concentration of a specific radionuclide in water that would produce an effective dose equivalent of 4 mrem/yr if consumed at average annual rates. EPA drinking water standards for radionuclides listed in Table 1.1-2 were derived based on a 4-mrem/yr 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 Order 5400.5 in 1993).

DOE = U.S. Department of Energy.

EPA = U.S. Environmental Protection Agency.

For additional information on contaminants that are found at the Hanford Site, see "Summary Fact Sheets for Selected Environmental Contaminants to Support Health Risk Analysis" (Peterson et al. 2002), available on the web site of Environmental Assessment Division, Argonne National Laboratory (http://www.ead.anl.gov). Click on "publications" and search for the title.

2.0 Groundwater

This section discusses groundwater flow and chemistry on the Hanford Site. Section 2.1 gives a general overview of site-wide flow and plumes. Sections 2.2 through 2.13 describe groundwater for each of the groundwater interest areas/operable units. These regions are presented in geographic order (north to south, west to east). Monitoring of specific units under the *Comprehensive Environmental Response, Compensation, and Liability Act*; *Resource Conservation and Recovery Act*; *Atomic Energy Act*; or Washington Administrative Code are discussed within relevant sections. Section 2.14 describes groundwater flow and chemistry in the confined aquifers.

Waste sites, hydrogeology, and methods of sampling and analysis are described in *Hanford Site Groundwater: Settings, Sources, and Methods* (PNNL-13080).

2.1 Overview of Hanford Site Groundwater

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This section provides a broad picture of groundwater flow and contaminant distribution beneath the Hanford Site. Table 2.1-1 summarizes fiscal year (FY) 2005 highlights or activities for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) groundwater operable units, *Resource Conservation and Recovery Act* (RCRA) sites, and other regulated units and indicates where to find additional information in this report. Details for specific locations are included in Sections 2.2 through 2.14. Supporting tables and figures for sites monitored under CERCLA are compiled in Appendix A. Appendix B includes tables and figures for facilities monitored under RCRA or other regulations. Appendix C describes results of the quality control program.

Groundwater monitoring objectives of RCRA, CERCLA, and the *Atomic Energy Act* (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. 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 U.S. Department of Energy (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.

DOE monitors groundwater quality across the Hanford Site to know what contaminants are present and how they are moving.

The uppermost aquifer beneath most of the Hanford Site is unconfined and is composed of unconsolidated to semiconsolidated sediment of the Hanford and Ringold Formations, which was deposited on the basalt bedrock. In some areas, deeper parts of the aquifer are confined locally by layers of silt and clay. Confined aquifers occur within the underlying basalt and associated sedimentary interbeds.

For site characterization and cleanup, waste sites are grouped into source operable units, and the groundwater beneath the sites is divided into groundwater operable units. The formal, groundwater operable units do not include the entire Hanford Site. Therefore, to provide scheduling, data review, and interpretation for the entire Hanford Site, the Groundwater Performance Assessment Project (groundwater project) has informally defined "groundwater interest areas" that generally correspond to the groundwater operable units. Figure 2.1-1 illustrates these interest areas and the operable unit boundaries.

Well location maps for each geographic region are included in Sections 2.2 through 2.14. Wells in the 600 Area (i.e., portions of the Hanford Site other than the former operational areas) are shown in Figure 2.1-2.

Monitoring points near the river, called aquifer tubes, provide additional information on water quality near the Columbia River. The aquifer tubes are small diameter polyethylene

Groundwater is the water that fills the pores or cracks between grains in a layer of sediment or rock. Monitoring the groundwater helps determine what contamination exists beneath the Hanford Site. This information will help regulatory agencies and DOE make cleanup decisions based on scientific information and technical capabilities.

DOE monitors groundwater on the Hanford Site to help determine what chemical and radiological contaminants have made their way to groundwater and how they have migrated. Groundwater monitoring is a part of the cleanup mission and will remain a component of long-term stewardship after remediation is completed.

tubes installed in the unconfined aquifer and are located in the 100 Areas, Hanford town site, and 300-FF-5 Operable Unit. Their locations are shown on well location maps in applicable sections of this report.

Groundwater in the unconfined aquifer generally flows west to east beneath the Hanford Site and discharges to the Columbia River.

2.1.1 Groundwater Flow

During March 2005, 880 water-level measurements were collected from the unconfined aquifer system and the underlying confined aquifers beneath the Hanford Site. These data were used to (1) prepare contour maps that indicate the general direction of groundwater movement within an aquifer; (2) determine hydraulic gradients, which in conjunction with the hydraulic properties of the aquifer, are used to estimate groundwater flow velocities; (3) support conceptual and numerical groundwater model development, modification, and maintenance; and (4) interpret sampling results. This section describes the results of a regional-scale analysis of these data for the unconfined aquifer, which is the aquifer most affected by Hanford operations. Flow in the confined aquifer in the lower Ringold Formation and the upper basalt-confined aquifer system is discussed in Section 2.14.

Also during March 2005, 60 water-level measurements were collected from offsite wells north and east of the Columbia River. These measurements are collected every 5 years to assess the potential for contaminant migration off the Hanford Site. The data were used to prepare a current water-table map for the offsite areas. For more information regarding water-level monitoring activities, see PNNL-13021.

2.1.1.1 March 2005 Water Table

Figure 2.1-3 presents the March 2005 water-table map for the Hanford Site. Groundwater in the unconfined aquifer generally flows from upland areas in the west toward the regional discharge area east along the Columbia River. Steep gradients occur in the west, east, and north regions of the site. Shallow gradients occur southeast of the 100-F Area and in a broad arc extending from west of the 100-B/C Area southeast between Gable Butte and Gable Mountain (Gable Gap), and through the 200 East Area into the central portion of the site. The steep gradients in the west and east are due to the presence of the relatively low permeability sediment of the Ringold Formation at the water table, while the low gradient areas are associated with the highly permeable sand and gravel of the Hanford formation.

Over much of the Hanford Site, the water table continued to decline. The declining water table caused some monitoring wells to go dry; new wells are being installed.

North of Gable Butte and Gable Mountain, groundwater generally flows from west to east and discharges to the Columbia River. Groundwater enters this region from the Columbia River west (upstream) of the 100-B/C Area, through Gable Gap, and through the gap between Umtanum Ridge and Gable Butte. In the 100 Areas, the local groundwater flow is generally toward the Columbia River, although this pattern is perturbed to varying degrees by pump-and-treat remediation systems in the 100-K, 100-D, and 100-H Areas. An apparent groundwater mound exists ~2 kilometers north of Gable Mountain and is associated with low conductivity Ringold Formation muds at the water table. This mound is contoured as if it were part of the unconfined aquifer (Figure 2.1-3), but it could also represent a perched zone above the regional water table. There is insufficient information to distinguish between these alternatives.

Past effluent discharges at U Pond and other facilities caused a groundwater mound to form beneath the 200 West Area. These discharges had largely ceased by the mid-1990s, but a remnant mound remains, which is apparent from the shape of the water-table contours passing through the 200 West Area. Currently, the water-table elevation is ~12 meters above an estimated water-table elevation prior to the start of Hanford operations.[a] When equilibrium conditions are established in the aquifer after site closure, computer simulations

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[a] Based on the March 2005 water-level elevation in well 299-W18-15 (136.8 meters NAVD88) and the pre-Hanford water-table elevation at the location of this well estimated from BNWL-B-360 (~125.1 meters NAVD88). The peak historical water-level elevation within the 200 West Area occurred at well 299-W18-15 in 1984 (149.1 meters NAVD88).

show the water table may be ~5 to 7 meters higher than the pre-Hanford water table because of artificial recharge from offsite irrigation (PNNL-11801). The water table beneath the 200 West Area is locally perturbed by discharges associated with the State-Approved Land Disposal Site, as well as by operation of a groundwater pump-and-treat remediation system at the 200-ZP-1 Operable Unit. Formerly, the water table was affected locally by pumping at the 200-UP-1 Operable Unit pump-and-treat system, but groundwater extraction ceased in January 2005 to initiate a rebound study.

Groundwater flow in the central portion of the Hanford Site, encompassing the 200 East Area, is significantly affected by the presence of a buried flood channel, which lies in a northwest to southeast orientation (PNNL-12261). The water table in this area is very flat (i.e., the hydraulic gradient is estimated to be between 10^{-5} and 10^{-6}) due to the high permeability of the Hanford formation. Groundwater flow in this region is significantly affected by the presence of low permeability sediment of the Ringold Formation at the water table east and northeast of the 200 East Area, as well as basalt above the water table. These features constitute barriers to groundwater flow. The extent of the basalt units above the water table continues to increase slowly due to the declining water table, resulting in an even greater effect on groundwater flow in this area. The mapped extent of these units was revised for the March 2005 water-table map, to take into account further declines in the water level. The water table beneath the 200 East Area is 2.0 to 2.5 meters higher than the estimated pre-Hanford conditions.(b) Simulations of equilibrium conditions after site closure suggests that the water table in the 200 East Area will be near its pre-Hanford elevation (PNNL-11801).

Because of the very low hydraulic gradient in the 200 East Area and vicinity, uncertainty in the water-level elevation data is larger than the relief of the water table. Therefore, determining the hydraulic gradient (i.e., the groundwater flow direction) based on these data is problematic. Water enters the 200 East Area and vicinity from the west and southwest, as well as from beneath the mud units to the east and from the underlying aquifers where the confining units have been removed or thinned by erosion. The flow of water divides, with some migrating to the north through Gable Gap and some moving southeast toward the central part of the site. It is known that groundwater flows north through Gable Gap, because the hydraulic gradient can be determined using water-level elevation data (the gradient averages 1.5×10^{-4} with a flow direction of 354 degrees azimuth). Groundwater is known to flow southeast between the 200 East Area and the Central Landfill, because the average water-level elevation at the landfill (122.05 meters NAVD88) is ~0.10 meter less than the average elevation in the 200 East Area (122.15 meters NAVD88). The location of the groundwater flow divide is currently not known. Efforts are underway to develop alternative methods of determining groundwater flow directions in the 200 East Area and thereby establish a more precise conceptual model of groundwater flow in this region.

During FY 2005, staff sampled 674 wells and 175 aquifer tubes for radiological and chemical constituents.

Between the area southeast of the Central Landfill to the 300 Area, the highly permeable sediments of the Hanford formation occur above the water table. These sediments intercept the water table again at the 300 Area. For this reason, the hydraulic gradient in the 300 Area is also very low. Groundwater flow converges on the 300 Area from the northwest, west, and southwest, then generally moves along a southeast flowpath and discharges to the Columbia River (PNNL-15127).

In addition to the Hanford Site water table, Figure 2.1-3 depicts the water table north and east of the Columbia River (using a 50-meter-contour interval), based on water-level measurements collected during March 2005. The offsite water table is heavily influenced by irrigation practices, and its configuration is significantly controlled by topography. Many

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(b) Based on the average water-level elevation measured in 19 wells within the 200 East Area during March 2005, which have been corrected for deviations of the boreholes from vertical (122.2 meters NAVD88), and the pre-Hanford water-table elevation for the 200 East Area estimated from BNWL-B-360 (~120 meters NAVD88).

of the contour flexures and mounds coincide with topographic valleys and higher plateau areas. Hydraulic heads north and east of the Columbia River are significantly higher than on the Hanford Site, as evidenced by the proximity of the 150-meter contour to the Columbia River. Therefore, it is unlikely that groundwater contaminants from the Hanford Site would migrate underneath the Columbia River to these offsite areas. PNL-8122 contains a more complete discussion of the offsite water table.

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

2.1.1.2 Water-Table Change from FY 2004

In the 200 East Area, the elevation of the water table declined by an average of 0.13 meter from March 2004 to March 2005. This is greater than the previous annual decline (0.09 meter from March 2003 to March 2004, PNNL-15070), and is below the average rate of decline observed from June 1997 to March 2002 (0.17 meter per year). Beginning in the fall of 2002, the rate of decline slowed significantly with water levels actually increasing in some wells (Figure 2.1-4). The region affected by this smaller than normal decline extended from north of Gable Gap through the 200 East Area to the Central Landfill, i.e., in the highly conductive sediment of the Hanford formation. Apparently, the water table is recovering from this fluctuation and is resuming a more normal rate of decline.

The water-table elevation increased in the Dry Creek and Cold Creek Valleys, signifying increased recharge to the unconfined aquifer either from precipitation or offsite irrigation. Increases also occurred in the 100 Areas along the Columbia River north of Gable Butte and Gable Mountain, and in the southeast portion of the site between the Yakima and Columbia Rivers. These increases are attributed to changes in river stage in relation to the days water levels were measured. Elsewhere on site, the long-term decline in the water-table elevation continued in response to the curtailment of effluent discharges to ground during the 1980s and 1990s. The largest declines occurred in the 200 West Area, where the water table declined by an average of 0.36 meter (in those areas not influenced by pump-and-treat remediation systems) from March 2004 to March 2005.

2.1.2 Groundwater Contaminants

Although some contaminants exceed drinking water standards in groundwater samples, the concentrations measured in river water remained far below standards.

During FY 2005, Hanford Site staff sampled 674 wells and 175 aquifer tubes for radiological and chemical constituents. Many of the wells were sampled multiple times, for a total of 2335 sampling trips. An additional 58 sampling trips scheduled for FY 2005 were delayed into FY 2006.

Chromium (total or hexavalent) was the most frequently analyzed constituent, analyzed 1,927 times. Anions, tritium, iodine-129, metals, technetium-99, strontium-90, and volatile organic compounds were other commonly analyzed constituents (Table 2.1-2). The data from many wells on the Hanford Site are used to meet the objectives of multiple regulations, including AEA, CERCLA, and RCRA. Sampling and analysis are coordinated to avoid unnecessary costs.

Monitoring water quality along the river is accomplished by collecting samples from (a) aquifer tubes having sample ports at several depths beneath the shoreline, (b) riverbank springs, and (c) near-shore river water. Use of aquifer tubes at riverbank springs is included in CERCLA monitoring plans for groundwater operable units in the 100 and 300 Areas. Representatives from the U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) meet annually with DOE and its contractors to plan the annual sampling event, which usually occurs during the fall months (DOE/RL-2000-59).

Tritium, nitrate, and iodine-129 are the most widespread contaminants associated with past Hanford Site operations. Their distribution in the unconfined aquifer is shown in Figures 2.1-5, 2.1-6, and 2.1-7. 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. Other contaminant plumes on the Hanford Site are listed below:

- Carbon tetrachloride and associated trichloroethene in the 200 West Area.
- Chromium in the 100 Areas.
- Chromium in the 200 West Area and in the 600 Area south of the 200 Areas.
- Strontium-90 in the 100 Areas.
- Technetium-99 and uranium that extend eastward from the 200 West Area.
- Technetium-99 and uranium with minor amounts of cyanide and cobalt-60 in the northwest 200 East Area.
- Uranium in the 300 Area.
- Nitrate from offsite sources in the south Hanford Site.

The distribution of hexavalent chromium in aquifer tubes along the 100 Areas is illustrated in Figure 2.1-8. The highest concentrations are detected along the south 100-D Area shoreline.

Table 2.1-3 lists contaminants and refers to the sections in this report where they are discussed. The table highlights contaminants that exceed water quality standards. Analytical results including FY 2005 and historical data are included in the data files accompanying this report.

With the exception of carbon tetrachloride, the highest concentrations of most contaminants on the Hanford Site remain in the upper part of the unconfined aquifer. Relatively few wells are completed deeper in the aquifer, but in most cases, these detect lower levels of contamination than their shallow counterparts. In the upper basalt-confined aquifer ~25 meters below the water table, contamination has been detected in only two wells, both near the 200 East Area (see Section 2.14).

Carbon tetrachloride data have been collected from various depths within the unconfined aquifer in recent years. In some cases, concentrations are higher near the bottom of the aquifer than near the water table. Section 2.8 discusses the vertical distribution of carbon tetrachloride.

The discharge of the Columbia River along the Hanford Reach is controlled by releases from the Priest Rapids Dam, located upstream of the Hanford Site. Daily discharge cycles can cause river elevation changes of up to several meters along the reactor areas. These fluctuations create a bank storage zone containing highly variable water movement patterns. The influx of river water may dilute contamination carried toward the river by groundwater, prior to its discharge through the riverbed sediment and river bank springs. Seasonal discharge cycles also influence the release of groundwater into the river environment.

2.1.3 Groundwater Remediation

DOE is working to clean up groundwater contamination that may pose a risk to human health or the environment. Decision-making efforts are organized by groundwater operable unit. The following text summarizes the status of remediation in each operable unit and Table 2.1-4 lists the volume of water treated and amount of contaminant removed. Additional details are provided elsewhere in Chapter 2.

DOE, EPA, and Ecology have created records of decision for seven groundwater operable units:

- **100-HR-3 (100-D and 100-H Areas) and 100-KR-4 (100-K Area)** – In the 100-K, 100-D, and 100-H Areas, interim action pump-and-treat systems reduce the amount of

DOE is working to clean up groundwater contamination that may pose a risk to human health or the environment. Interim remedial actions reduce the movement of contaminants until final cleanup decisions are made.

chromium reaching the river. Also in the 100-D Area, an innovative treatment method immobilizes chromium in the aquifer. In FY 2005, chromium concentrations at all these interim action sites remained above remediation goals (ROD 1996a, 1999a).

- **100-NR-2 (100-N Area)** – DOE has operated a pump-and-treat system for strontium-90 as an interim action since 1995 and is investigating alternative remediation methods (apatite sequestration and phytoremediation; ROD 1999b). Strontium-90 concentrations remained much higher than the drinking water standard in wells at the river shore in FY 2005.
- **200-UP-1 (200 West Area)** – DOE operated an interim action pump-and-treat system for technetium-99 and uranium from 1995 through January 2005. Uranium and technetium concentrations declined below remedial action goals. DOE continues to monitor wells in this operable unit to track how contaminant concentrations respond to the cessation of pumping.
- **200-ZP-1 (200 West Area)** – DOE has operated an interim action pump-and-treat system to prevent carbon tetrachloride from spreading since 1994 (ROD 1995a). Carbon tetrachloride concentrations decreased in the original target area. In FY 2005, the pump-and-treat system was expanded by adding additional extraction wells.
- **300-FF-5 (300 Area and satellite areas to the north)** – The interim action involves natural attenuation of the cis-1,2-dichloroethene, trichloroethene, and uranium plumes in the 300 Area. In FY 2005, concentrations of the organic contaminants generally were low, but uranium remained elevated (ROD 1996b). DOE and EPA are investigating alternative forms of remediation via a remedial investigation/feasibility study process.
- **1100-EM-1 (Richland North Area)** – DOE and regulatory agencies have determined that the final cleanup action will be monitored natural attenuation of the trichloroethene plume (ROD 1993). Concentrations have remained below the remedial action goal since 2001.

DOE, EPA, and Ecology have created records of decision for seven groundwater operable units on the Hanford Site.

At the 100-BC-5, 100-FR-3, 200-BP-5, and 200-PO-1 Operable Units, monitoring indicates there is no imminent threat to human health or the environment, so no interim remedial actions are occurring. Remedial investigations and feasibility studies will be conducted to support final remediation decisions for these operable units. Meanwhile, waste sites and plumes will continue to be monitored.

2.1.4 Quality Control Highlights

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 data for FY 2005 are reliable and defensible. Details of the quality control program for FY 2005 are included in Appendix C. Highlights include the following:

- During FY 2005, 85% of the groundwater monitoring data was considered complete, i.e., not rejected, suspect, associated with a missed holding time, or out-of-limit quality control criteria. The groundwater project is attempting to improve completeness by working with the laboratories to reduce laboratory blank contamination.
- Analytical services are performed by four offsite contract laboratories. All four laboratories participated in two or more national performance evaluation studies. Overall, the percentage of acceptable results for FY 2005 was 95%; the percentages for the individual laboratories ranged from 86% to 98%.
- Field quality control samples include three types of field blanks (full trip, field transfer, and equipment blanks), field duplicates, and split samples. Greater than 97% of field

blank and field duplicate results for FY 2005 were acceptable, indicating little problem with contamination and good precision overall. A limited number of split samples were collected during the year for aluminum and total organic halides. A more sensitive method will be used in the future for any samples in which aluminum is a constituent of concern.

- Imprecise and elevated total organic halide results were observed at several wells across the site during the third quarter. Suspect data were flagged in the database. The cause of the problem is unknown, but quality control results for total organic halides were improved for the last quarter of the year.
- Recommended holding times were met for 97% of non-radiological sample analysis requests for both long-term and interim-action monitoring. In general, the missed holding times should not have a significant impact on the data.
- Laboratory performance on blind standards was good overall – 83% of the results were acceptable.
- Approximately 97% of the laboratory quality control results for FY 2005 were within the acceptance limits, suggesting that the analyses were in control and reliable data were generated. Specifically, 98% of method blanks, 98% of the laboratory control samples, 96% of the matrix spikes, 97% of the matrix duplicates, and 96% of the surrogates were within the acceptance limits.
- Eight audits of the commercial laboratories were conducted by DOE and its contractors. Several minor findings and observations were identified along with a number of proficiencies. Corrective actions have been accepted for all of the audits.

Evaluation of the groundwater project quality assurance program indicates that the majority of data for FY 2005 are reliable and defensible.

Table 2.1-1. Groundwater Operable Units and Regulated Units on the Hanford Site

Site or Operable Unit	Type of Monitoring Program	Text Section	FY 2005 Highlights or Activities
CERCLA Groundwater Operable Units (well/constituent tables in Appendix A)			
100-BC-5	Long-term monitoring	2.2	Continued monitoring
100-FR-3	Long-term monitoring	2.7	Continued monitoring
100-HR-3 (D pump and treat)	IRA; interim ROD	2.5	Chromium > remediation goal; central system modified
100-HR-3 (D redox site)	IRA; interim ROD	2.5	Chromium > remediation goal; four wells installed
100-HR-3 (H pump and treat)	IRA; interim ROD	2.6	Chromium declining; network modified
100-KR-4 (pump and treat)	IRA; interim ROD	2.3	Chromium > remediation goal; four wells installed for chromium treatability test
100-NR-2 (pump and treat)	IRA; interim ROD	2.4	No decrease in plume size; investigating alternatives; baseline monitoring; two wells installed
200-BP-5	Long-term monitoring	2.10	One well installed
200-PO-1	Long-term monitoring	2.11	Continued monitoring
200-UP-1 (pump and treat)	Interim action ROD	2.9	Technetium-99 and uranium < remediation goal; rebound study; three wells installed
	Long-term monitoring	2.9	Chromium and technetium-99 increasing and spreading from a source at WMA S-SX
200-ZP-1 (pump and treat)	Interim action ROD	2.8	System being expanded; seven wells installed
	Long-term monitoring	2.8	At WMA T, technetium-99 and nitrate at very high levels deep in aquifer
300-FF-5 (300 Area)	Natural attenuation; interim ROD	2.12	Average TCE < DWS; uranium remains elevated; DCE > DWS; RI/FS continued; one well installed
300-FF-5 (north)	Operations and Maintenance plan	2.12	Tritium levels decreasing
1100-EM-1	Natural attenuation; final ROD	2.13	Average TCE < DWS since FY 2001
Regulated Units (well location maps, well/constituent tables, statistics tables, and flow rates in Appendix B)			
100-K basins	AEA	2.3.3	No recent impacts to groundwater
116-N-1 (1301-N) facility	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.4.3.1	Continued detection[(a)]
116-N-3 (1325-N) facility	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.4.3.3	Continued detection[(a)]
120-N-1, 120-N-2 (1324-N/NA) facilities	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.4.3.2	Continued detection[(a)]
116-H-6 (183-H) evaporation basins	WAC 173-303-645(11)(g)	2.6.3	Monitoring during IRA; chromium, nitrate, technetium-99, uranium
200 Area TEDF	WAC 173-216	2.11.3.6	No influence in upper aquifer
216-A-29 ditch	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.11.3.4	Continued detection[(a)]
216-B-3 pond	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.11.3.5	Continued detection[(a)]
216-B-63 trench	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.2	Continued detection[(a)]
216-S-10 pond and ditch	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.9.3.3	Continued detection;[(a)] two shallow and one deep downgradient wells remain
216-U-12 crib	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.9.3.4	Continued assessment; new plan; network modified
316-5 process trenches	WAC 173-303-645(11)(g)	2.12.3	Monitoring during natural attenuation IRA; uranium and organics

Table 2.1-1. (contd)

Site or Operable Unit	Type of Monitoring Program	Text Section	FY 2005 Highlights or Activities
ERDF	CERCLA	2.9.3.5	No impact on groundwater
Integrated Disposal Facility	WAC 173-303-645(9)	2.11.3.1	Establishing background; two wells installed
LERF	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.5	Insufficient wells; no statistical comparisons
LLWMA 1	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.3	Continued detection[(a)]
LLWMA 2	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.4	Continued detection;[(a)] two more dry wells; no unconfined aquifer in north
LLWMA 3	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.8.3.1	No statistical comparisons until background re-established; two wells went dry
LLWMA 4	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.8.3.2	Continued detection;[(a)] three wells installed
NRDWL	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.11.3.7	Continued detection[(a)]
PUREX cribs	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.11.3.2	Continued assessment; iodine-129, nitrate, and tritium
SALDS	WAC 173-216	2.8.3.5	No permit limits exceeded
SST WMA A-AX	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.11.3.3	Began assessment monitoring based on specific conductance
SST WMA B-BX-BY	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.10.3.1	Continued assessment; nitrate, nitrite, technetium-99, uranium
SST WMA C	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.6	Continued detection[(a)]
SST WMA S-SX	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.9.3.2	Continued assessment; chromium, technetium-99; one well installed; one dry well
SST WMA T	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.8.3.3	Continued assessment; technetium-99, nitrate, and chromium; two wells installed
SST WMA TX-TY	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.8.3.4	Continued assessment; chromium, nitrate and technetium-99; one well installed
SST WMA U	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.9.3.1	Continued assessment; nitrate, technetium-99
SWL	WAC 173-304	2.11.3.8	Five constituents exceeded background or standards; low levels of organics

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(a) Analysis of RCRA CIP provided no evidence of groundwater contamination with hazardous constituents from the unit.

AEA = *Atomic Energy Act.*
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act.*
CFR = Code of Federal Regulations.
CIP = Contamination indicator parameters.
DCE = cis-1,2-Dichloroethene.
DWS = Drinking water standard.
ERDF = Environmental Restoration Disposal Facility.
FY = Fiscal year.
IRA = Interim remedial action.
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.*
RI/FS = Remedial investigation/feasibility study.
ROD = Record of decision.
SALDS = State-Approved Land Disposal Site.
SST = Single-shell tank.
SWL = Solid Waste Landfill.
TCE = Trichloroethene.
TEDF = Treated Effluent Disposal Facility.
WAC = Washington Administrative Code.
WMA = Waste management area.

Table 2.1-2. Number of Groundwater Analyses by Groundwater Interest Area,(a) FY 2005

Constituent	Site Total	100-BC-5	100-KR-4	100-NR-2	100-HR-3-D	100-HR-3-H	100-FR-3	200-ZP-1	200-UP-1	200-BP-5	200-PO-1	300-FF-5	1100-EM-1
Chromium (total and hexavalent)	1,927	42	184	143	464	174	57	211	174	240	184	48	6
Iodine-129	362	0	0	0	0	0	0	119	78	68	84	12	1
Nitrate	1,511	21	71	118	98	62	37	287	219	253	215	93	37
Organics (carbon tetrachloride, trichloroethene)	726	0	4	1	0	0	8	311	165	6	62	142	30
Plutonium-239/240	41	0	0	0	0	0	0	19	0	22	0	0	0
Strontium-90	428	25	56	106	21	22	13	47	22	36	75	5	0
Technetium-99	865	1	28	6	8	32	0	210	274	240	56	9	1
Tritium	1,078	26	113	112	52	40	25	217	73	210	101	75	34
Uranium	908	0	26	0	39	31	8	93	225	233	55	186	12

(a) Groundwater interest areas are shown on Figure 2.1-1.

FY = Fiscal year.

Table 2.1-3. Maximum Concentrations of Selected Groundwater Contaminants in FY 2005 in Groundwater Interest Areas (see Figure 2.1-1)

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
Antimony (filtered), µg/L[b]	6												
Arsenic (filtered), µg/L	10							4.8					
Carbon tetrachloride, µg/L	5												
Carbon-14, pCi/L	2,000 [70,000]			**14,200**	813								
Cesium-137, pCi/L	200 [3,000]					3.02							
Chloroform, µg/L	100			0.46								0.6	0.28
Chromium (dissolved), µg/L	100	52	33	**538**	85	**181**	45	**2,550**	**518**	**117**	44	61.1	14
cis-1,2-Dichloroethene, µg/L	70												
Cobalt-60, pCi/L	100 [5,000]					11.5							
Cyanide, µg/L	200												
Fluoride, mg/L	4	0.4	0.1	0.4	0.3	0.9	0.3	0.5	0.2	0.3	0.2	0.8	0.2
Gross alpha, pCi/L	15	3.2	3.6	**32**	2.9	4.8	3.7	7.3		**33.3**		13.1	
Gross beta, pCi/L	50	**52.7**	22.5	**3,450**	6.8	**17,900**	**8,320**	**181**		**192**		22	
Iodine-129, pCi/L	1 [500]												
Nitrate, mg/L	45	27.9	24.3	**340**	39.4	**238**	11.1	**70.8**	27.4	**514**	**46.5**	**102**	**46**
Nitrite, mg/L	3.3	0.9		0.8		1.1	0.5	**6.9**	0.1			0.1	
Plutonium-239/240, pCi/L[c]	NA [30]												
Strontium-90, pCi/L	8 [1,000]	**45.8**	**11.9**	**2,030**		**9,710**	**4,260**	**8.2**		**38.8**		**3.5**	2.3
Technetium-99, pCi/L	900 [100,000]	64.6		376						**1,510**			
Tetrachloroethene, µg/L	5												
Trichloroethene, µg/L	5			**5.5**								**6.8**	
Tritium, pCi/L	20,000 [2,000,000]	**161,000**	18,900	**2,240,000**	4,770	**28,100**	3,860	**26,100**	6,720	5,160		12,600	647
Uranium, µg/L	30			8.1				5.8		**93.5**	0.6	22.7	

Table 2.1-3. (contd)

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	Wells	Wells	Aquifer Tubes	Wells
Antimony (filtered), µg/L[b]	6	**41.1**		**21.4**[d]	**31.9**[d]			
Arsenic (filtered), µg/L	10	**14**	5.9	7.5	**11**			
Carbon tetrachloride, µg/L	5	**5,300**	**880**	0.64	0.97	1.4	0.18	0.81
Carbon-14, pCi/L	2,000 [70,000]		7.91					
Cesium-137, pCi/L	200 [3,000]			**663**				
Chloroform, µg/L	100	**1,100**	17		1.1	3.8	0.51	0.4
Chromium (dissolved), µg/L	100	**769**	**1,710**	40.4	43.7	10.9	3.3	
cis-1,2-Dichloroethene, µg/L	70		1.1			**230**	0.28	
Cobalt-60, pCi/L	100 [5,000]			**200**				
Cyanide, µg/L	200	29		**859**				
Fluoride, mg/L	4	**10.5**	0.8	1.0	**5.8**	0.4	0.7	0.9
Gross alpha, pCi/L	15	6.0	11.4	**223**	14.7	**43.3**		5.8
Gross beta, pCi/L	50	**14,500**	**71,800**	**7,770**	**2,920**	**67.5**		9.3
Iodine-129, pCi/L	1 [500]	**26.1**	**15.5**	**5.0**	**9.2**			
Nitrate, mg/L	45	**3,540**	**1,470**	**1,890**	**134**	**111**	**45.6**	**239**[e]
Nitrite, mg/L	3.3	2.6	2.2	1.8	0.8			0.4
Plutonium-239/240, pCi/L[c]	NA [30]	4.6		19.4				
Strontium-90, pCi/L	8 [1,000]	1.4	**32**	**3,900**	**20.5**	3.3		
Technetium-99, pCi/L	900 [100,000]	***181,900***[f]	***137,000***	**23,100**	**8,580**	40.3		23.4
Tetrachloroethene, µg/L	5	**26**	3.7		1.8	0.5	0.3	0.2
Trichloroethene, µg/L	5	**36**	**9.1**		1.1	**8.3**[d]	2.9	1.9
Tritium, pCi/L	20,000 [2,000,000]	**1,890,000**	**44,300**	**118,000**	**578,000**	**1,650,000**	10,500	361
Uranium, µg/L	30	**183**	**479**	**454**	25.8	**134**	**161**	21.6

Note: Table lists highest concentration for FY 2005 in each groundwater interest area. Concentrations in **bold** exceed drinking water standards. Concentrations in ***bold italic*** exceed DOE derived concentration guides. Blank space indicates the constituent was undetected or not analyzed.

(a) DWS = Drinking water standard; DCG = DOE derived concentration guide. See Tables 1.1-2 and 1.1-3 in Section 1.0 for more information on these standards.

(b) Detection limit is higher than DWS. Not a known contaminant of interest on the Hanford Site.

(c) There is no drinking water standard for plutonium-239/240.

(d) Suspected error.

(e) From offsite contaminant sources.

(f) Sampled during drilling of well 299-W11-25B at 10 meters below water table.

DOE = U.S. Department of Energy.
FY = Fiscal year.

Table 2.1-4. Hanford Site Groundwater and Vadose Zone Remediation

			Average Concentration in FY 2005		Volume of Water Treated (million liters)		Amount of Contaminant Removed	
Remediation Site	Year Initiated	Contaminant	Influent	Effluent	FY 2005	Since Startup	FY 2005	Since Startup
			Pump-and-Treat Systems					
100-KR-4	1997	Hexavalent chromium	54 µg/L	2 µg/L	524.9	3,110	26.8 kg	271.1 kg
100-NR-2	1995	Strontium-90	1,714 pCi/L	500 pCi/L	106	988	0.1 Ci	1.7 Ci
100-HR-3 North 100-D	1997	Hexavalent chromium	179 µg/L	5 µg/L	187.2	1,277	25.8 kg	217.9 kg
100-HR-3 Central 100-D	2004	Hexavalent chromium	868 µg/L	6 µg/L	36.7	7,937	36.6 kg	44.8 kg
100-HR-3, 100-H	1997	Hexavalent chromium	27 µg/L	5 µg/L	118.6	1,219	4.4 kg	41.6 kg
200-UP-1	1994	Uranium	No data for FY 2005		52.1	853	8.7 kg	212 kg
		Technetium-99					4.7 g (0.08 Ci)	118.8 g (2.02 Ci)
		Carbon tetrachloride					2.0 kg	33.2 kg
		Nitrate					1,255 kg	33,805 kg
WMA S-SX (299-W23-19)[(a)]	2003	Technetium-99	105,000 pCi/L	--			0.089 g (0.0015 Ci)	0.20 g (0.0034 Ci)
200-ZP-1	1994	Carbon tetrachloride	2,200 µg/L	<1 µg/L	340.0	2,762	799.8 kg	9,308 kg
			Other Remediation					
100-HR-3, South 100-D	1999	Hexavalent chromium	Permeable barrier, in situ redox manipulation. Concentrations in most compliance wells downgradient of barrier have decreased, but chromium rebounding in some barrier wells.					
200-ZP-1	1992	Carbon tetrachloride	Soil-vapor extraction (300 kg removed in FY 2005; 78,600 kg removed since startup).					
300-FF-5	1996	TCE cis-1,2-DCE Uranium	Natural attenuation selected as interim action. TCE and cis-1,2-DCE have declined below remedial action goals. Uranium is not attenuating at an acceptable rate and alternative forms of remediation are being investigated.					
1100-EM-1	1993	TCE	Natural attenuation selected as final remedy. Concentrations below remedial action goals since FY 2001.					

(a) Well is pumped to remove 3,785 liters after each sampling event.

DCE = Dichloroethene.
FY = Fiscal year.
TCE = Trichloroethene.
WMA = Waste management area.

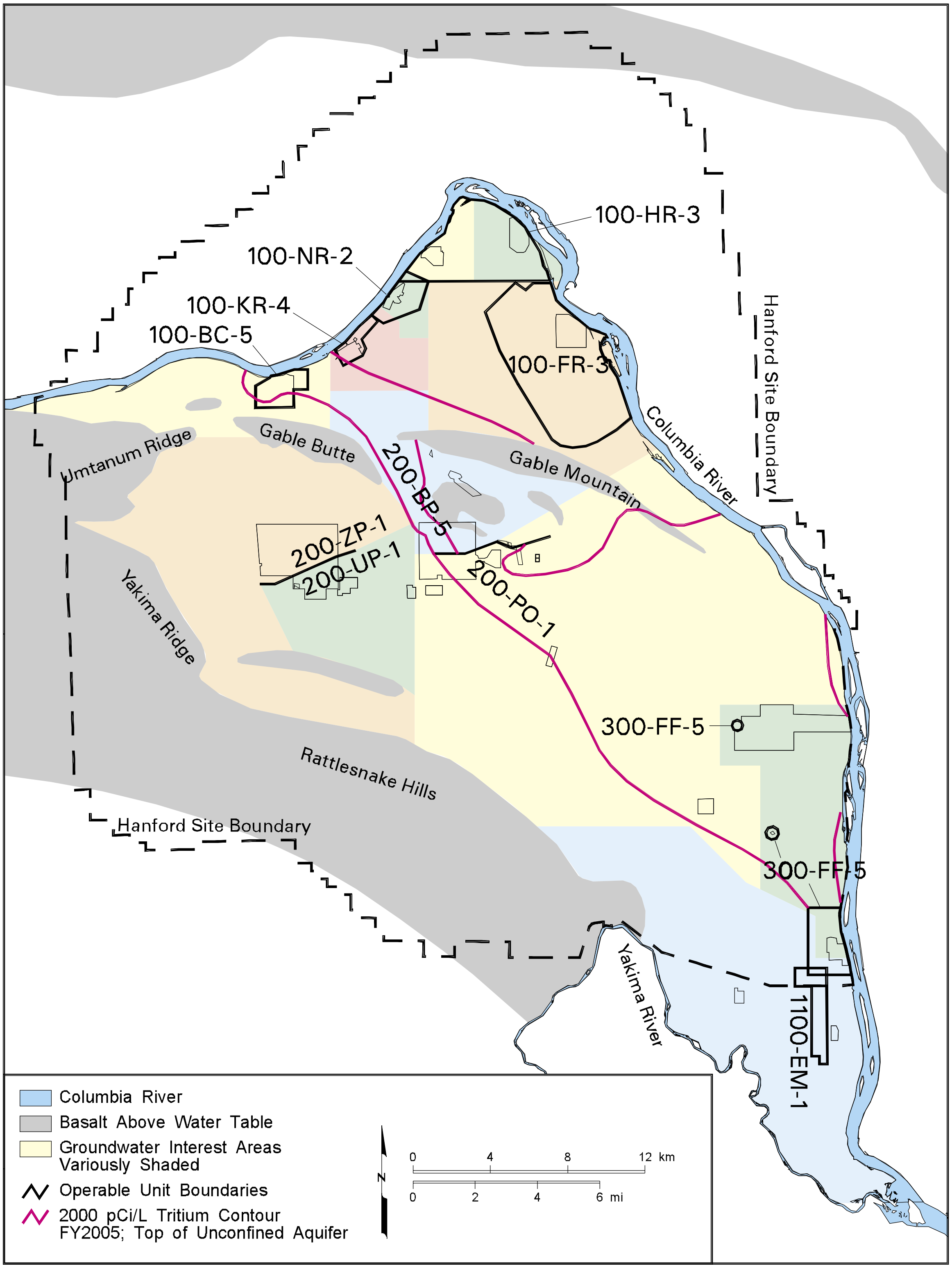

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Figure 2.1-1. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site

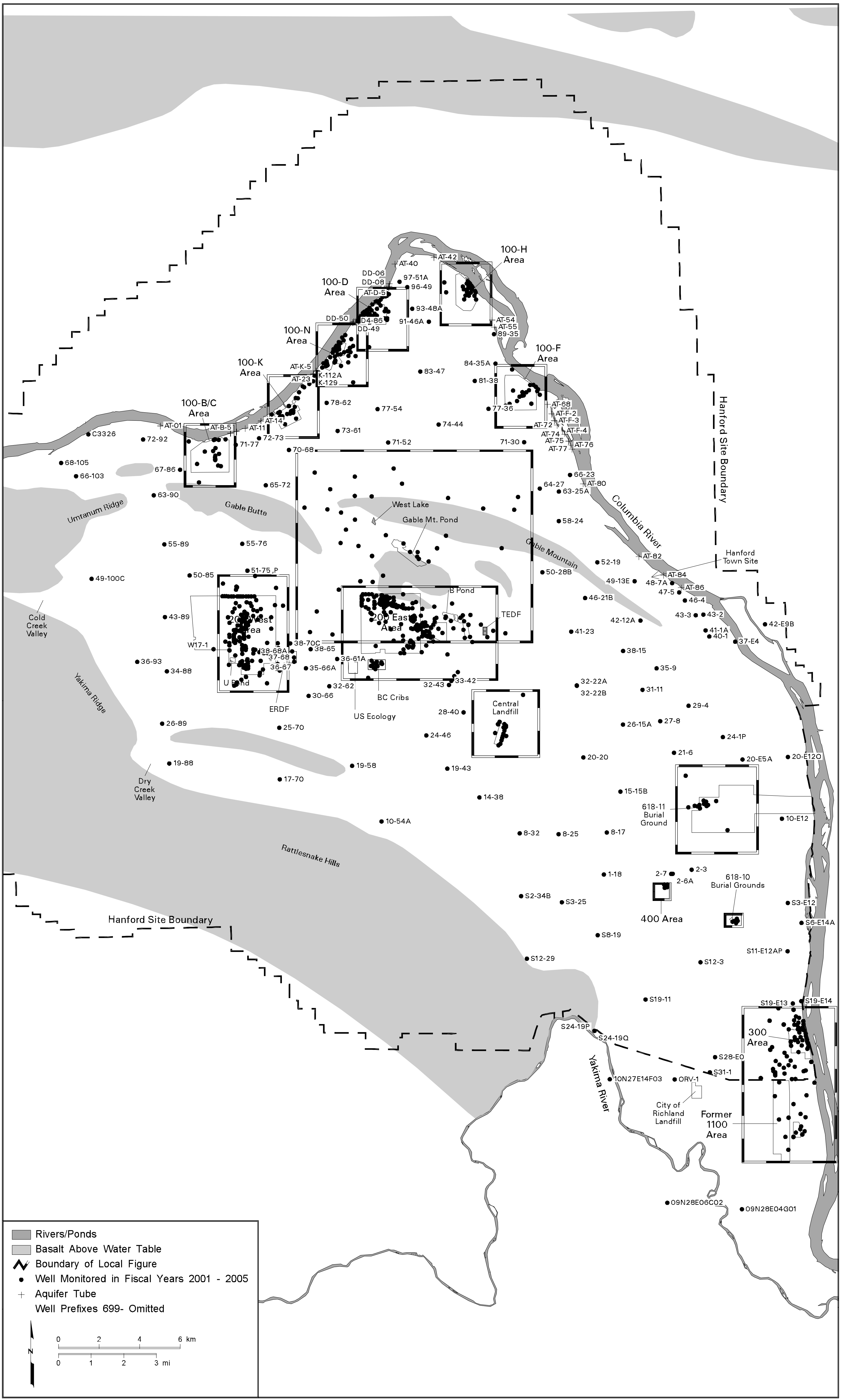

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Figure 2.1-2. Groundwater Monitoring Wells on the Hanford Site

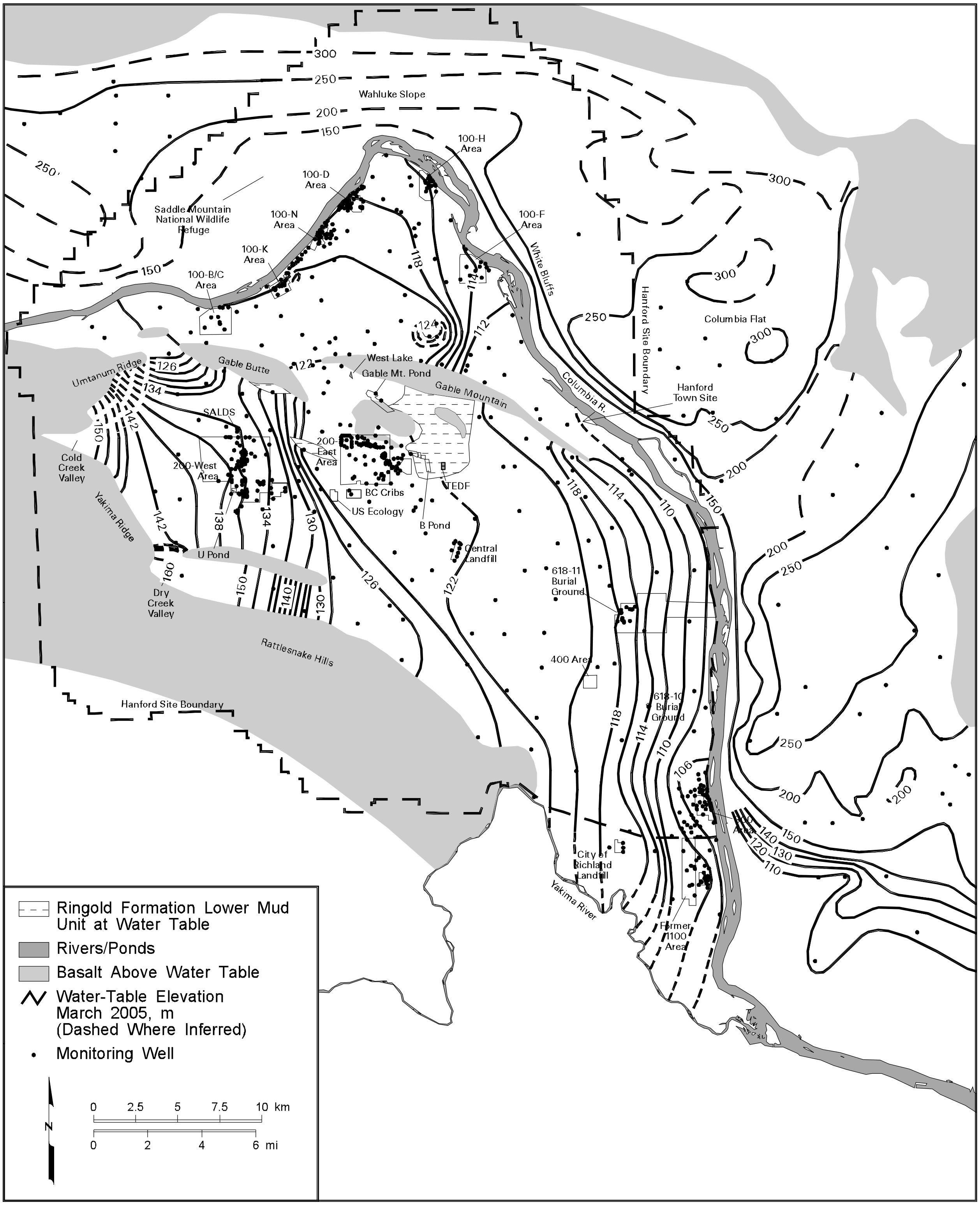

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Figure 2.1-3. Hanford Site and Outlying Areas Water-Table Map, March 2005

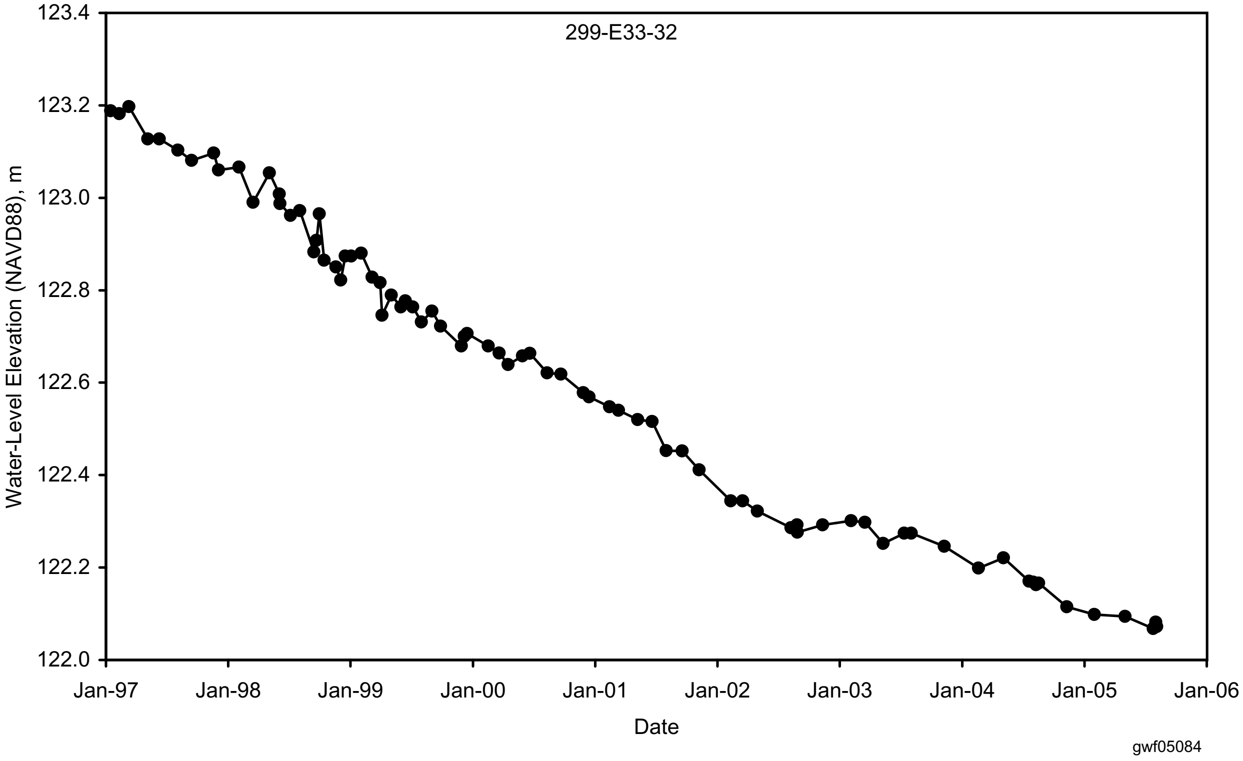

Figure 2.1-4. Water Level in Well 299-E33-32, Northwest 200 East Area

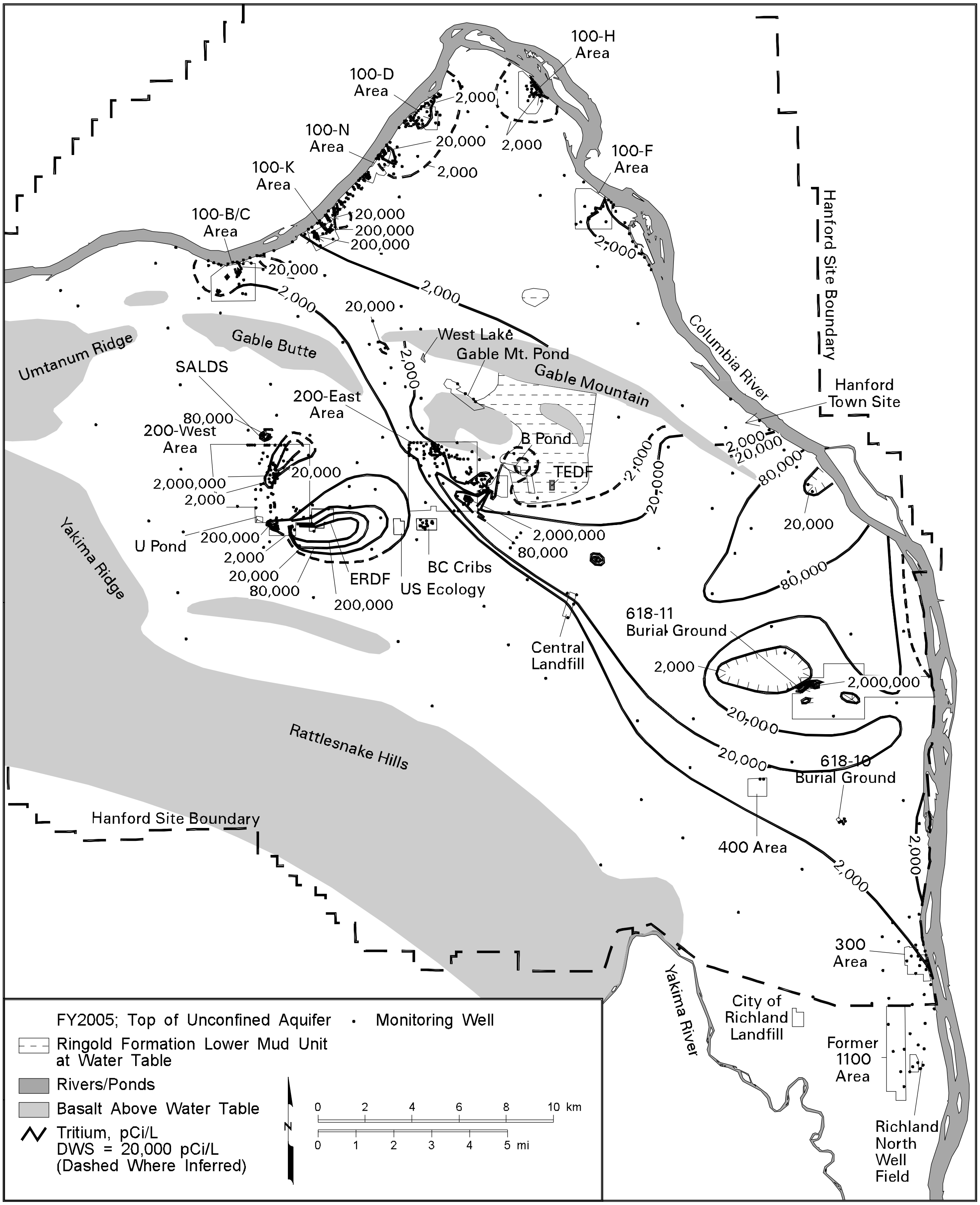

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Figure 2.1-5. Average FY 2005 Tritium Concentrations on the Hanford Site, Top of Unconfined Aquifer

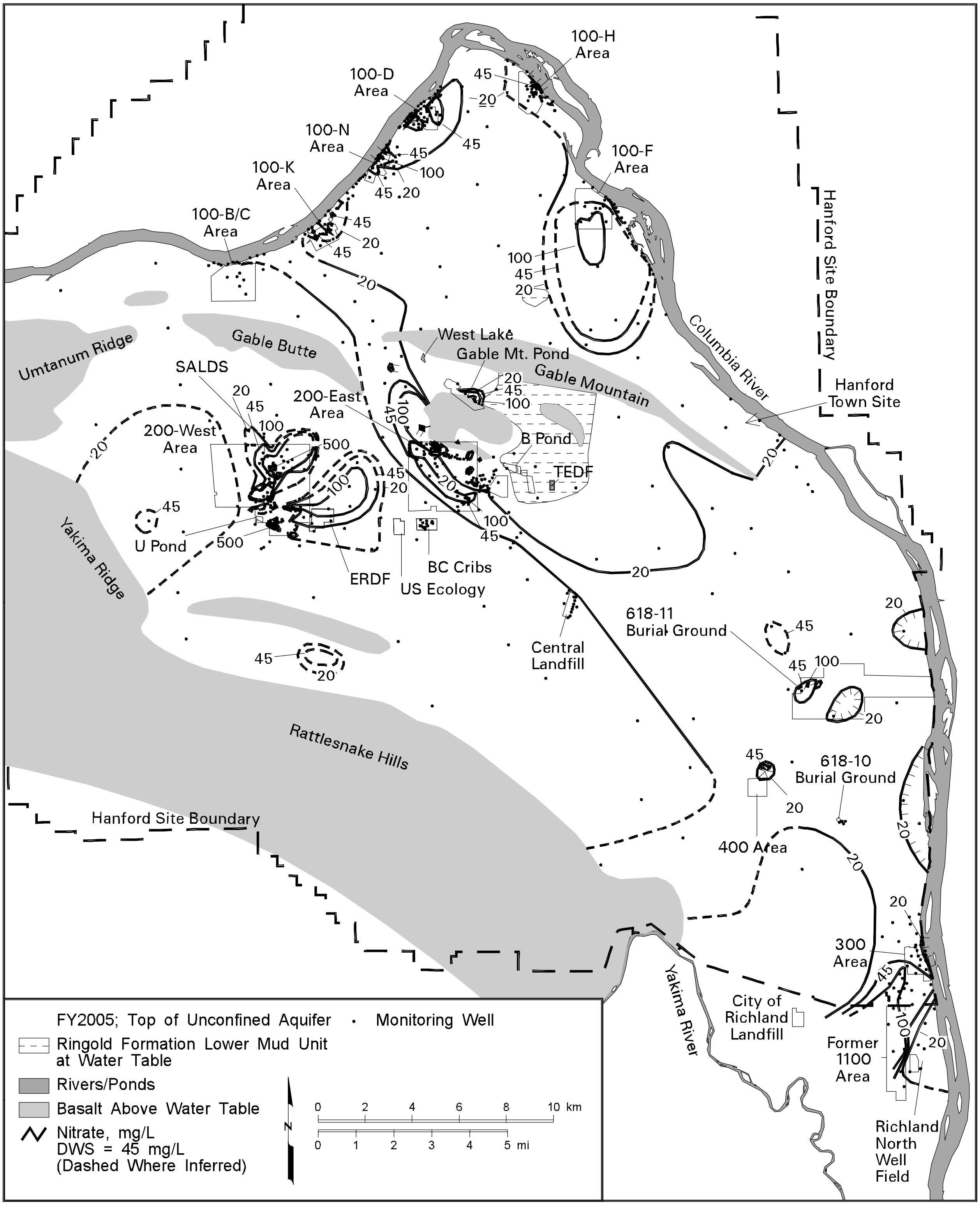

Figure 2.1-6. Average FY 2005 Nitrate Concentrations on the Hanford Site, Top of Unconfined Aquifer

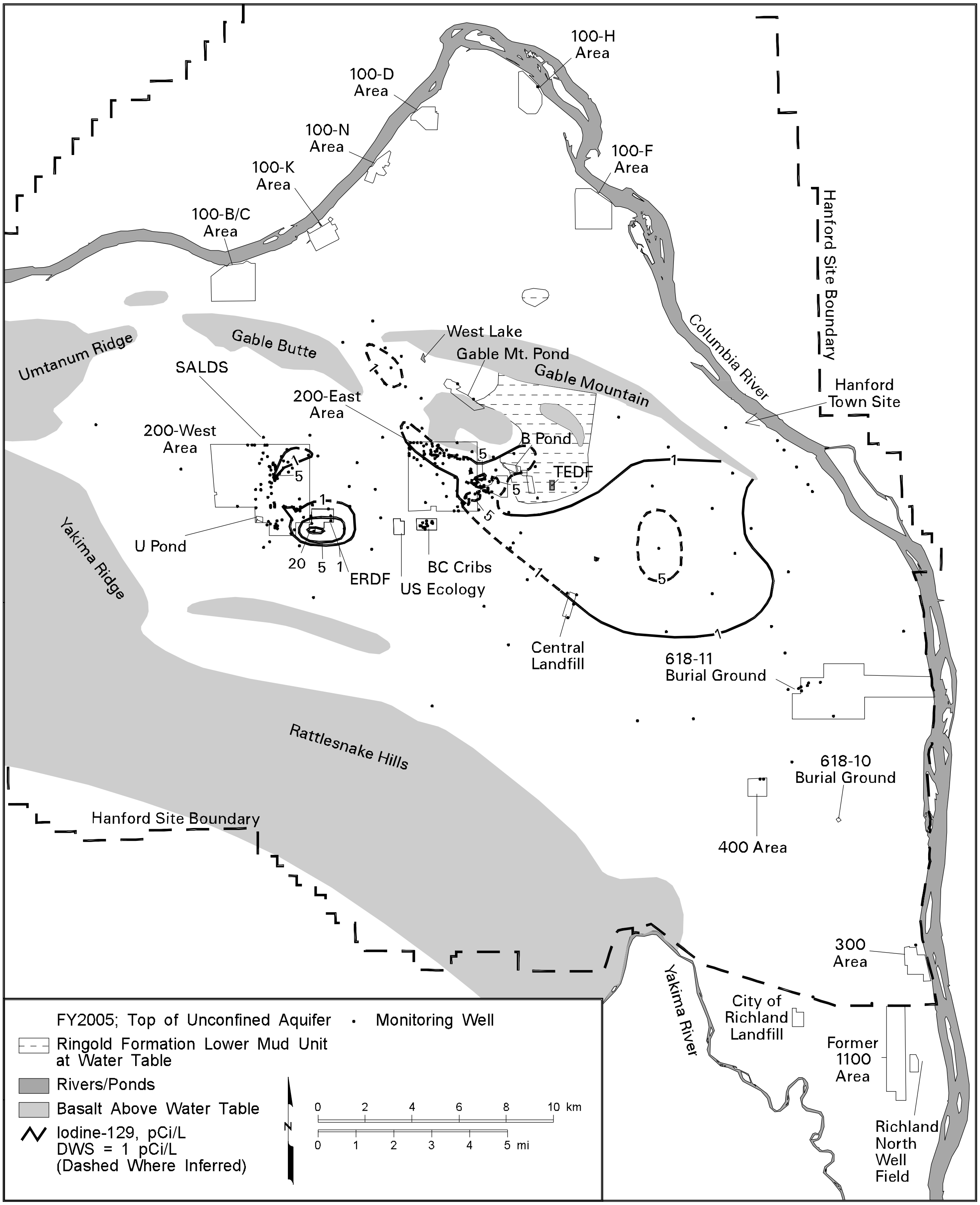

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Figure 2.1-7. Average FY 2005 Iodine-129 Concentrations on the Hanford Site, Top of Unconfined Aquifer

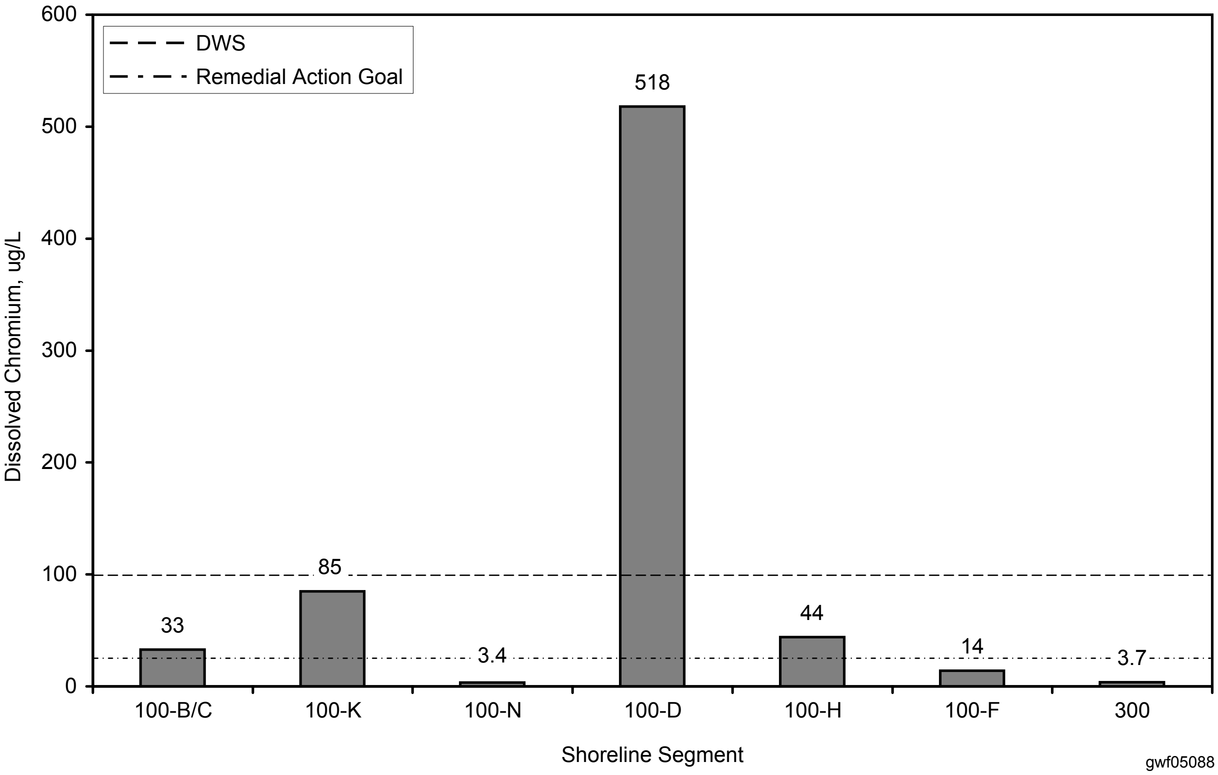

Figure 2.1-8. Maximum Dissolved Chromium in Aquifer Tubes in FY 2005

2.2 100-BC-5 Operable Unit

M. J. Hartman

The scope of this section is the 100-BC-5 groundwater interest area, which includes the 100-BC-5 Operable Unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined "groundwater interest areas" informally to facilitate scheduling, data review, and interpretation. Figure 2.2-1 shows facilities, wells, and shoreline monitoring sites in the 100-B/C Area.

Groundwater enters the 100-B/C Area from upstream areas along the Columbia River and the gaps between Umtanum Ridge, Gable Butte, and Gable Mountain (see Figure 2.1-3 in Section 2.1). Groundwater flows primarily to the north beneath the 100-B/C Area and discharges to the Columbia River (Figure 2.2-2). The hydraulic gradient is very flat in the south 100-B/C Area and in the west part of the interest area (see Figure 2.1-3 in Section 2.1).

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). Groundwater monitoring for the requirements of the *Atomic Energy Act* (AEA) are completely integrated with CERCLA monitoring. There are no active waste disposal facilities or *Resource Conservation and Recovery Act* (RCRA) sites in the 100-B/C Area.

Strontium-90 and tritium exceeded drinking water standards in groundwater at the 100-BC-5 Operable Unit during FY 2005. Both contaminants are limited to the upper aquifer and are not detected in deep wells.

2.2.1 Groundwater Contaminants

Wells in the 100-BC-5 Operable Unit are sampled annually to biennially for the contaminants of concern based on results of the data quality objectives process (PNNL-14287): strontium-90, tritium, and hexavalent chromium. This section describes distribution and trends of the groundwater contaminants of concern and nitrate beneath the 100-BC-5 groundwater interest area.

2.2.1.1 Strontium-90

The strontium-90 plume beneath the 100-B/C Area is wedge-shaped, with an apex in the central 100-B/C Area, extending and spreading north toward the Columbia River (Figure 2.2-3). The plume has not changed significantly in over 10 years. New data from aquifer tubes resulted in better definition of the plume boundary at the river's edge. Previous interpretations showed the 8-pCi/L contour extending farther east, based on elevated gross beta levels. Those gross beta values were found to be caused by technetium-99 contamination from the 200 Areas, not strontium-90 from the 100-B/C Area.

Strontium-90 concentrations are neither increasing nor decreasing overall. The highest and most variable concentrations are in well 199-B3-46, located downgradient of the 116-C-1 trench, near the Columbia River (Figure 2.2-4). Concentrations ranged from 39 to 170 pCi/L between fiscal years (FY) 1996 and 2005. Other wells have lower and steadier concentrations (20 to 40 pCi/L).

Groundwater monitoring in the 100-BC-5 groundwater interest area includes integrated CERCLA and AEA monitoring:

- ***Sixteen wells, fourteen aquifer tube sites, and two seeps were sampled as scheduled; three aquifer tubes were not sampled as scheduled and three wells were not sampled for all constituents (see Appendix A).***

Strontium-90 data from aquifer tubes are available for FY 2000 through 2005. This constituent is consistently detected in shallow and mid-depth aquifer tubes at sites AT-05 and AT-06, where concentrations declined to 11 pCi/L in November 2004 (Figure 2.2-5). Two shoreline seeps were sampled for strontium-90 in October 2004. Seep 037-1 had no detectable strontium-90 and seep 39-2 had a concentration of 3.05 pCi/L.

Strontium-90 is limited to the top of aquifer in the 100-B/C Area. None is detected in deeper well 199-B2-12, adjacent to well 199-B3-47, nor in deep aquifer tubes AT-05-D and AT-06-D.

Tritium concentrations increased sharply in one well in the northeast 100-B/C Area. The cause of this and previous spikes in tritium concentrations is unknown.

2.2.1.2 Tritium

The upper part of the unconfined aquifer beneath the 100-B/C Area is contaminated with tritium, which exceeds the drinking water standard (20,000 pCi/L) in several wells and aquifer tubes. Figure 2.2-6 shows tritium distribution in FY 2005. Groundwater beneath most of the 100-B/C Area has tritium concentrations above 2,000 pCi/L. An area with concentrations above the drinking water standard extends from south of the 116-C-5 retention basin to the Columbia River. The FY 2005 concentration also exceeded the standard in well 199-B8-6, near the 118-B-1 burial ground. Well 199-B5-1, in the west-central 100-B/C Area, has had very low values of tritium and specific conductance in recent years (see Figure 2.2-6). This may be caused by dilution of groundwater with fresh water. Water is pumped from the Columbia River to a reservoir and filter plant southwest of well 199-B5-1.

Several wells at various locations within the 100-B/C Area showed sharp spikes in tritium concentration in the late 1990s, with subsequently declining levels (Figure 2.2-7). In FY 2005, tritium increased to 161,000 pCi/L in well 199-B5-2, located between the reactor buildings and the 116-C-5 retention basins. This was the highest tritium concentration in the 100-B/C Area, but it was significantly lower than the tritium peak in the same well in the late 1990s (see Figure 2.2-7). The cause of either peak is unknown.

Plume areas (square kilometers) above the drinking water standard at the 100-BC-5 Operable Unit:

Strontium-90 — 0.63
**Tritium — 0.14*

**Excludes plume from 200-BP-5 Operable Unit.*

Tritium concentrations have declined in aquifer tubes at sites AT-06 and AT-07, located within the main tritium plume in the north 100-B/C Area (Figure 2.2-8). The most recent data from tube sites AT-B-5 and AT-B-7, located just east of the 100-B/C Area, were near or at the drinking water standard. Tritium east of the 100-B/C Area is believed to represent a plume from the 200 Areas that migrated northward.

Well 699-72-73, east of the 100-B/C Area (see Figure 2.1-2 in Section 2.1 for well location) has elevated tritium from a plume that migrated from the 200 East Area and moved through Gable Gap (see Figure 2.1-5 in Section 2.1). The tritium concentration in well 699-72-73 peaked at over 20,000 pCi/L in 2001 and was 13,500 pCi/L in FY 2005. Well 699-72-73 and the aquifer tubes also had elevated nitrate and technetium-99 from the 200 East Area plume.

2.2.1.3 Chromium

Chromium exceeded the 10-µg/L aquatic standard in several 100-B/C wells and aquifer tubes. Concentrations are steady or declining.

Hexavalent chromium is of potential concern to salmon or other aquatic life. Fall Chinook salmon and steelhead spawning areas have been recorded just downstream and toward the center of the river channel, but not in areas along the 100-B/C Area shoreline. Shoreline areas provide rearing habitat for young salmon and steelhead, as well as for many of the other species of fish in the Columbia River (DOE/RL-2005-40). The aquatic standard for hexavalent chromium is 10 µg/L.

Figure 2.2-9 shows the distribution of dissolved chromium at the top of the aquifer in FY 2005. Concentrations were below the drinking water standard (100 µg/L), but exceeded 20 µg/L in several wells and aquifer tubes in the north 100-B/C Area. The highest concentration was 52 µg/L in well 199-B3-47, downgradient of the 116-B-11 retention basin. Concentrations have ranged from 29 to 86 µg/L in this well since 2000, with no clear upward or downward trend.

Chromium concentrations are elevated and declining at aquifer tube sites AT-05 and AT-06. In November 2004, concentrations were between 22 and 33 µg/L, above the 10-µg/L aquatic standard. Dissolved chromium in seep samples ranged from 8 to ~20 µg/L in October 2004, which was consistent with levels in nearby wells and aquifer tubes.

2.2.1.4 Nitrate

The 100-B/C Pilot Project Risk Assessment Report (DOE/RL-2005-40) identified nitrate as a contaminant of concern based on its exceedance of the 45-mg/L drinking water standard in well 199-B3-47 in 1998 and 1999. Concentrations subsequently decreased, and the result in FY 2005 was 24.4 mg/L (Figure 2.2-10). Although nitrate is not listed as a contaminant of concern in the groundwater sampling and analysis plan (DOE/RL-2003-38, Rev. 1), it is monitored routinely in well 199-B3-47 and most of the other wells as a supporting parameter.

Well 699-72-73, located between 100-B/C and 100-K Areas, had a nitrate concentration of 27.9 mg/L in January 2005. Like tritium, the source of this nitrate is believed to be the 200 East Area. Aquifer tube AT-B-5-D, also located east of the main 100-B/C Area, had a nitrate concentration of 24.3 mg/L in FY 2005.

Tritium, nitrate, and technetium-99 are detected in wells and aquifer tubes east of the 100-B/C Area. This contamination most likely migrated from the 200 East Area.

2.2.2 Operable Unit Monitoring

The groundwater sampling and analysis plan (DOE/RL-2003-38, Rev. 1) specified annual sampling of 9 wells, 14 aquifer tube sites, and 2 seeps and biennial sampling of 14 wells (Appendix A). Of these, 16 wells and all of the aquifer tube sites and seeps were scheduled for sampling in FY 2005. The following sites were not sampled as scheduled:

- Samples from well 199-B8-6 were mistakenly not analyzed for alkalinity, metals, or anions. These constituents provide general chemistry information and are not contaminants of concern.
- Samples from wells 699-71-77 and 699-72-73 were not analyzed for technetium-99. This constituent was added to track influence of the 200 Area plume east of the 100-B/C Area and is not a contaminant of concern.
- Tube sites AT-07, AT-11, and AT-12 were not sampled. Tube AT-07 typically contains low levels of chromium, and was last sampled in February 2004. The other two tubes are located east of the 100-B/C Area and are intended to track the influence of the 200 Area plume.
- Samples from tube site AT-B-7 were not analyzed for alpha, beta, anions, or tritium.

Results of the 100-B/C Pilot Project Risk Assessment were published in draft form in FY 2005 (DOE/RL-2005-40). The purpose of the pilot risk assessment was to develop and apply a process to evaluate the protectiveness of remedial actions performed for the 100-BC-5 Operable Unit, with the intent that lessons learned would be applied to subsequent risk assessments performed for other locations within the Columbia River Corridor. The pilot project risk assessment characterized the potential risks to human health and the environment under the cleanup standards implemented in remedial actions performed to date. Conceptual exposure models were developed for the 100-B/C Area to describe the possible movement of contaminants to human and ecological receptors. Analytical data evaluated for the risk assessment included shallow-zone soil, deep-zone soil, surface sediment, riverbank seep water, surface water from the Columbia River, aquifer tube water, groundwater, and biota tissues.

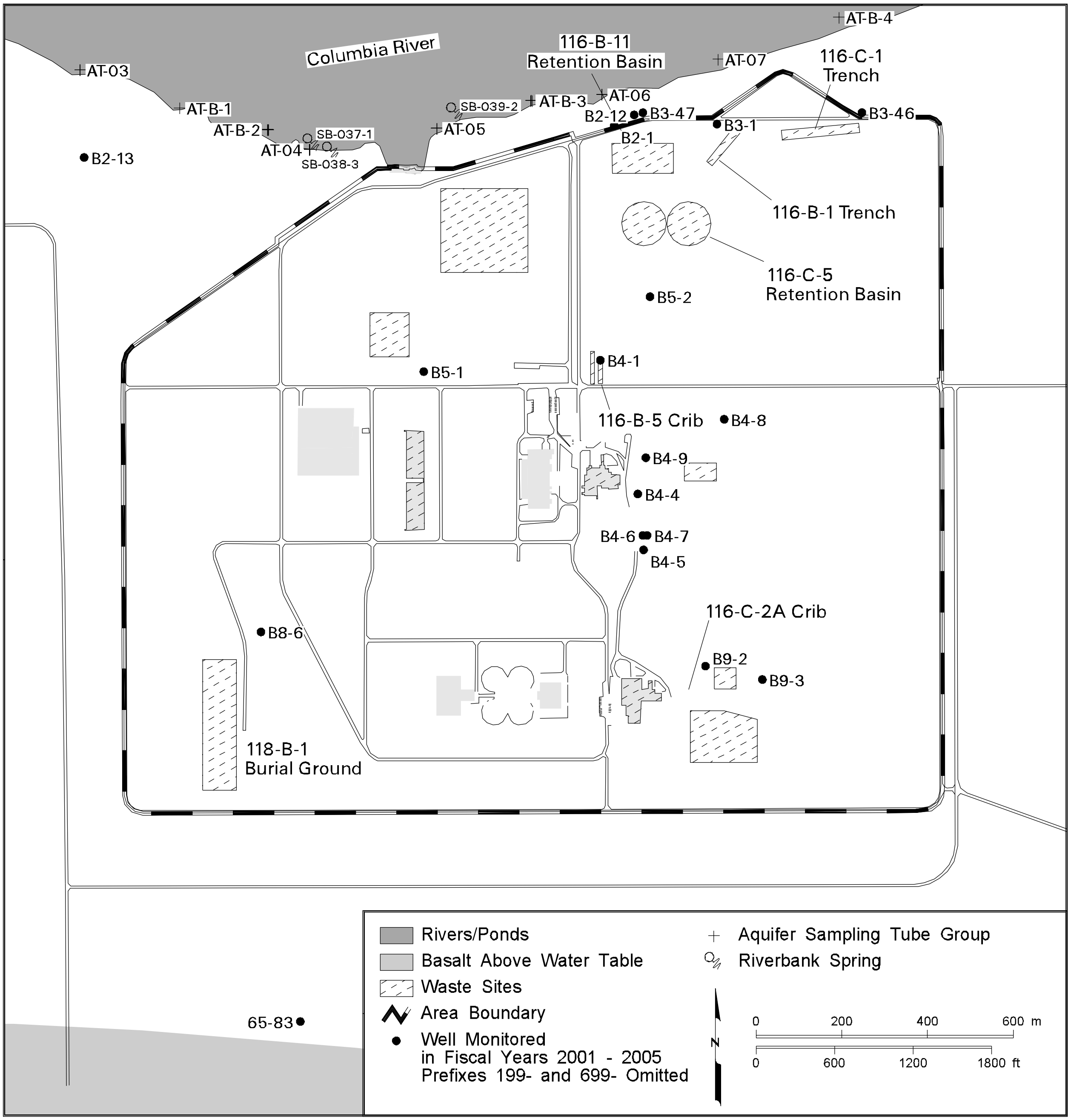

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Figure 2.2-1. Groundwater Monitoring Wells in 100-B/C Area

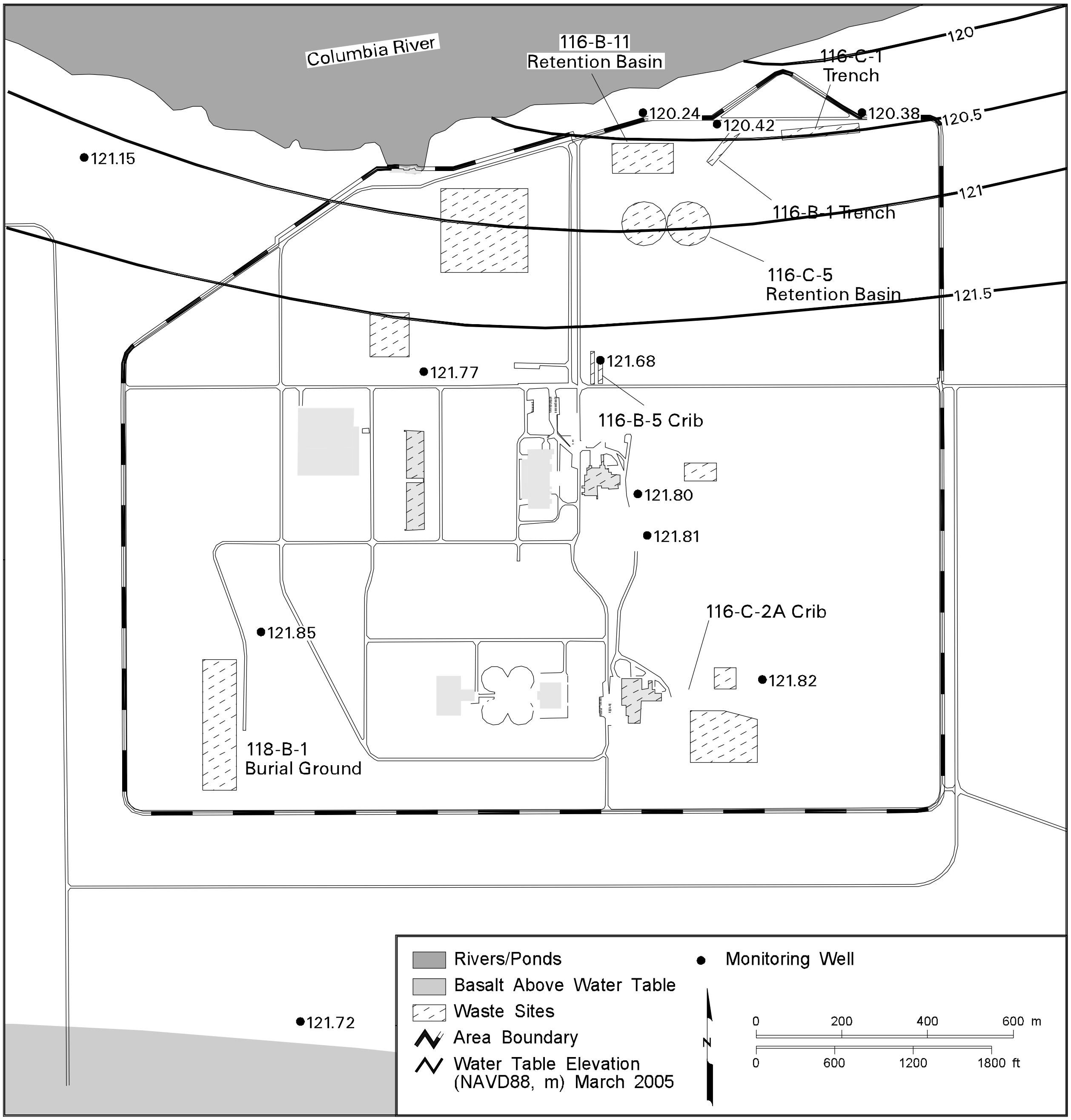

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Figure 2.2-2. 100-B/C Area Water-Table Map, March 2005

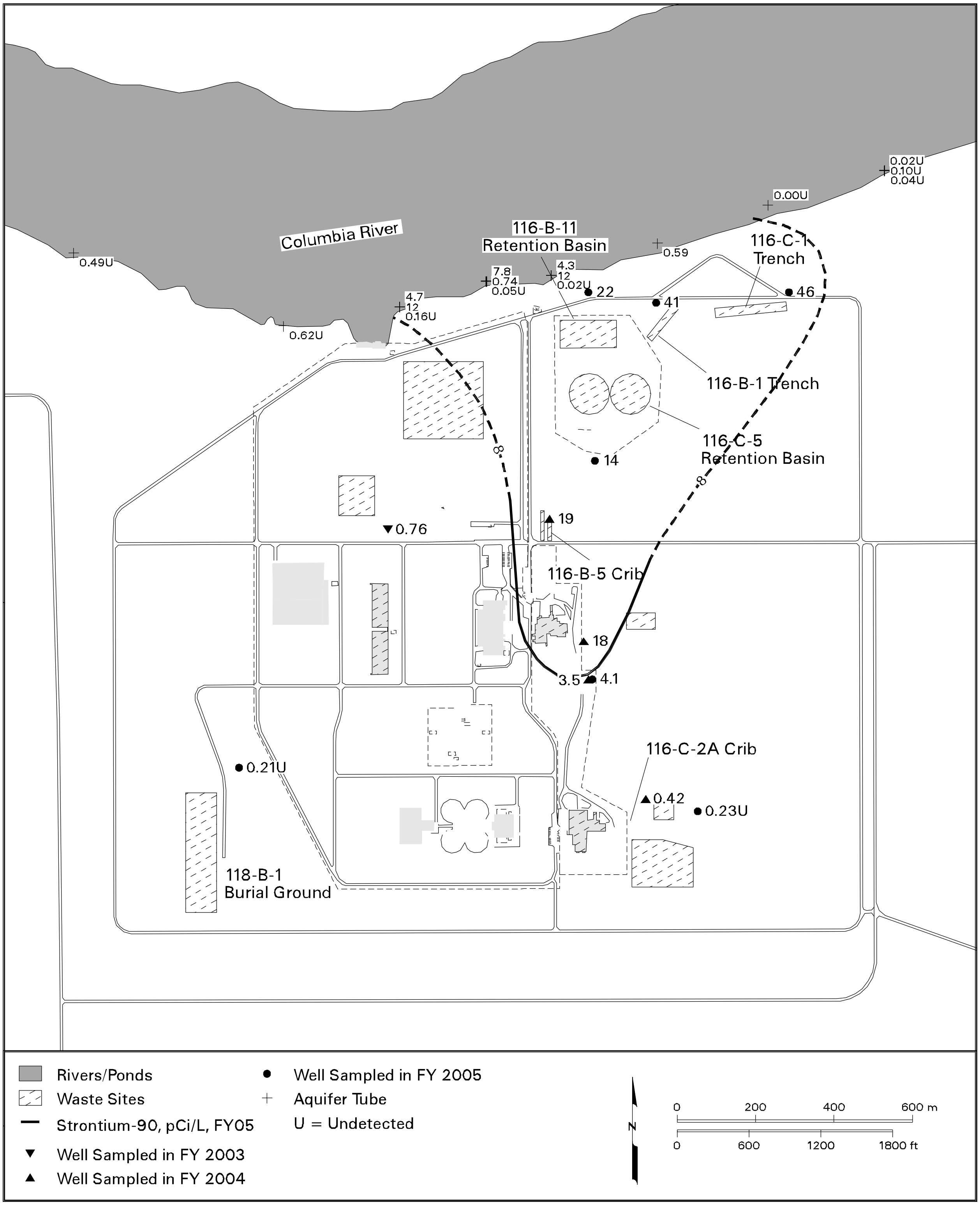

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Figure 2.2-3. Average Strontium-90 Concentrations in 100-B/C Area, Top of Unconfined Aquifer

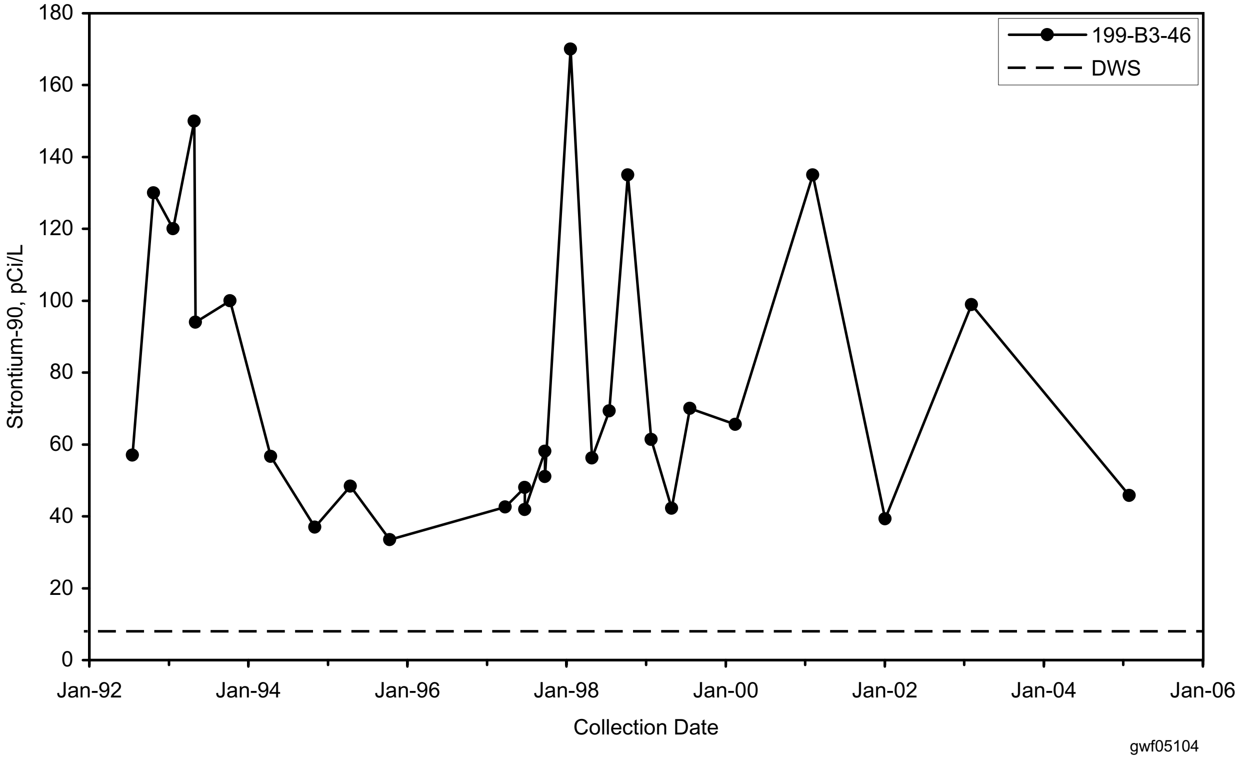

Figure 2.2-4. Strontium-90 Concentrations Near the 116-C-1 Trench

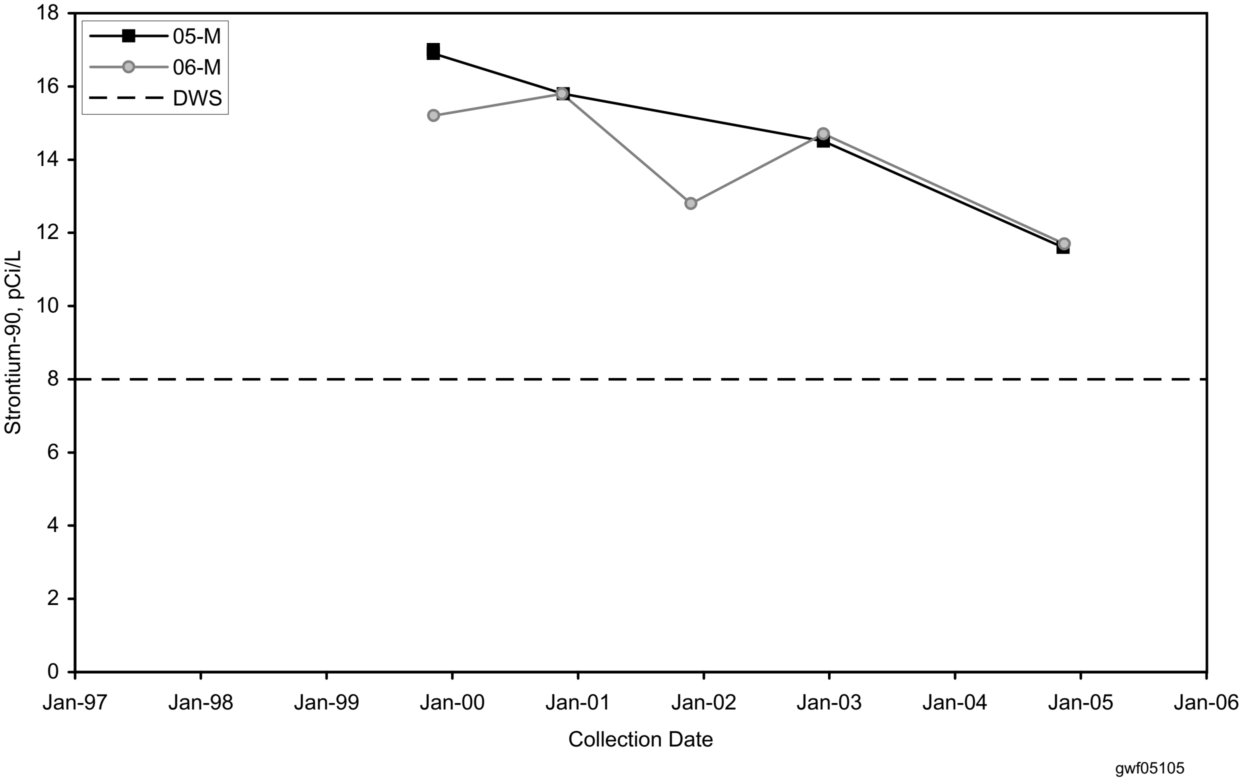

Figure 2.2-5. Strontium-90 Concentrations in Aquifer Tubes at 100-B/C Area

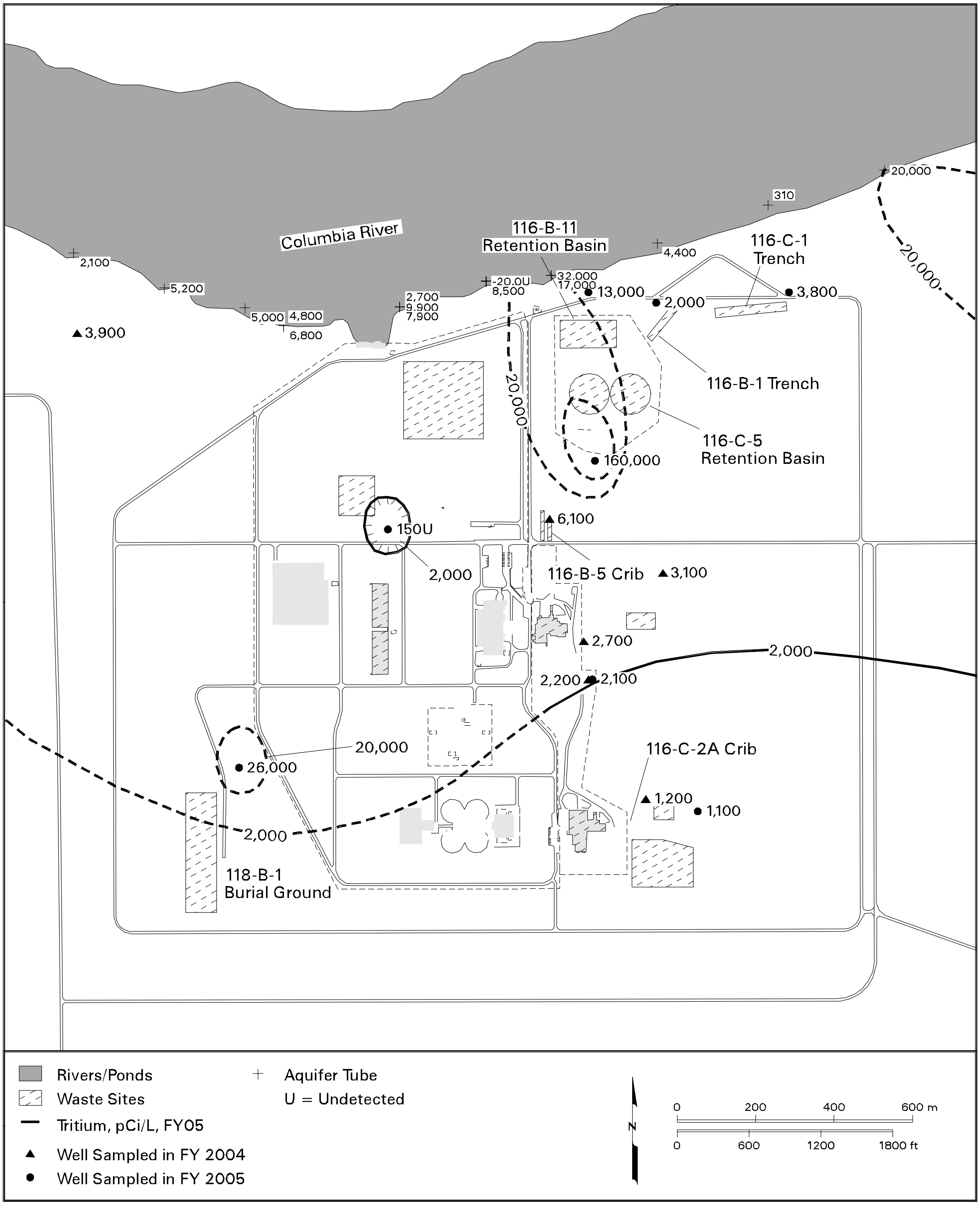

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Figure 2.2-6. Average Tritium Concentrations in 100-B/C Area, Top of Unconfined Aquifer

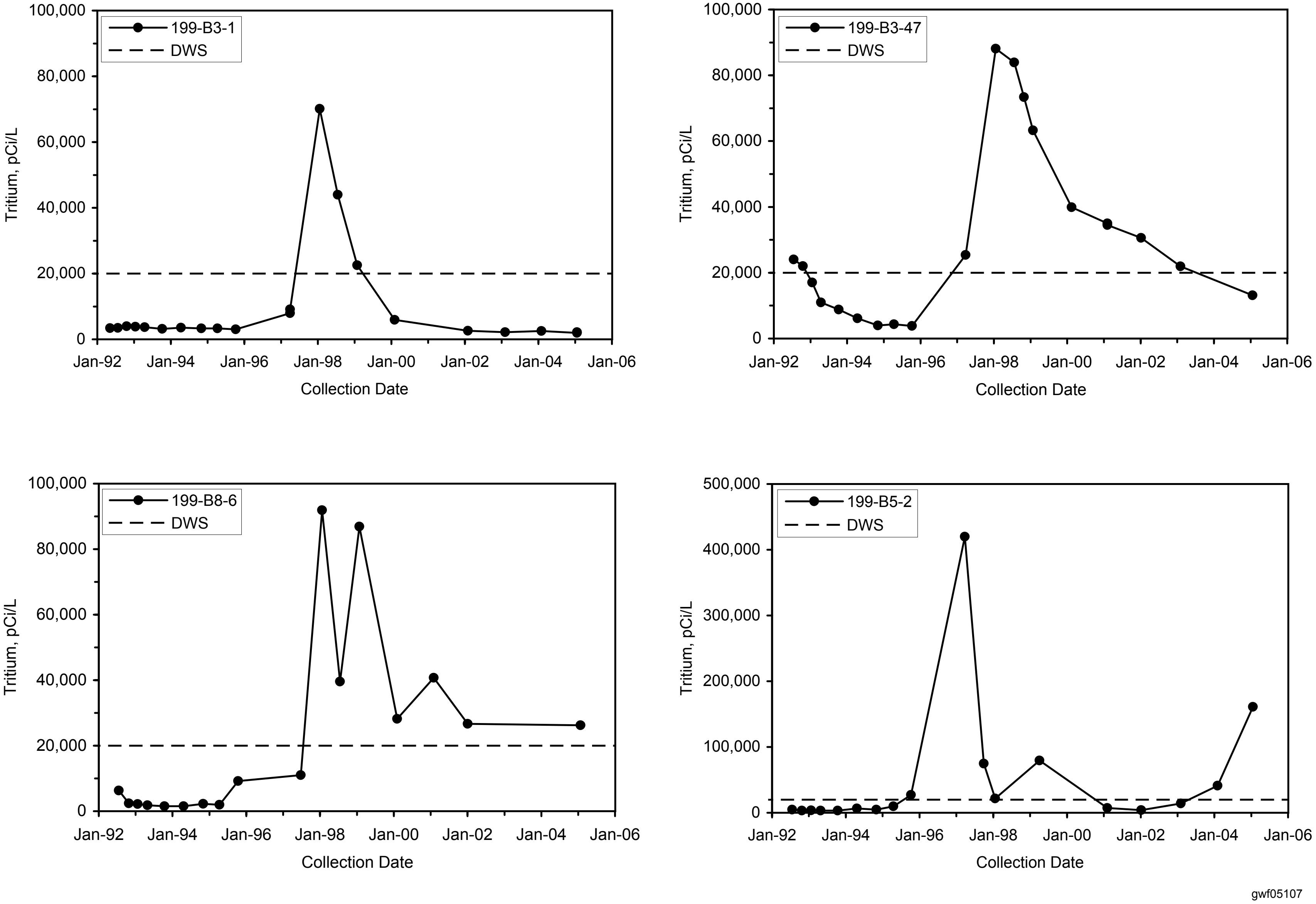

Figure 2.2-7. Tritium Concentrations in 100-B/C Area. Note different scale for well 199-B5-2.

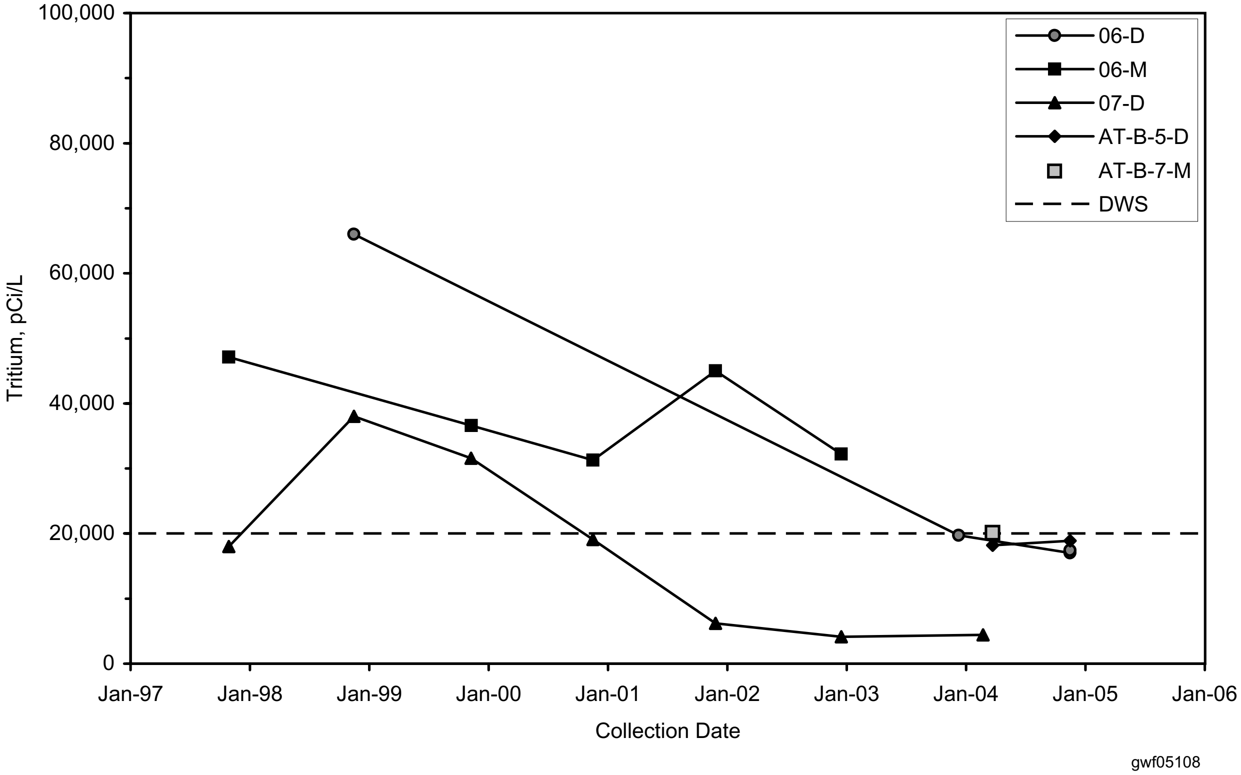

Figure 2.2-8. Tritium Concentrations in Aquifer Tubes at 100-B/C Area

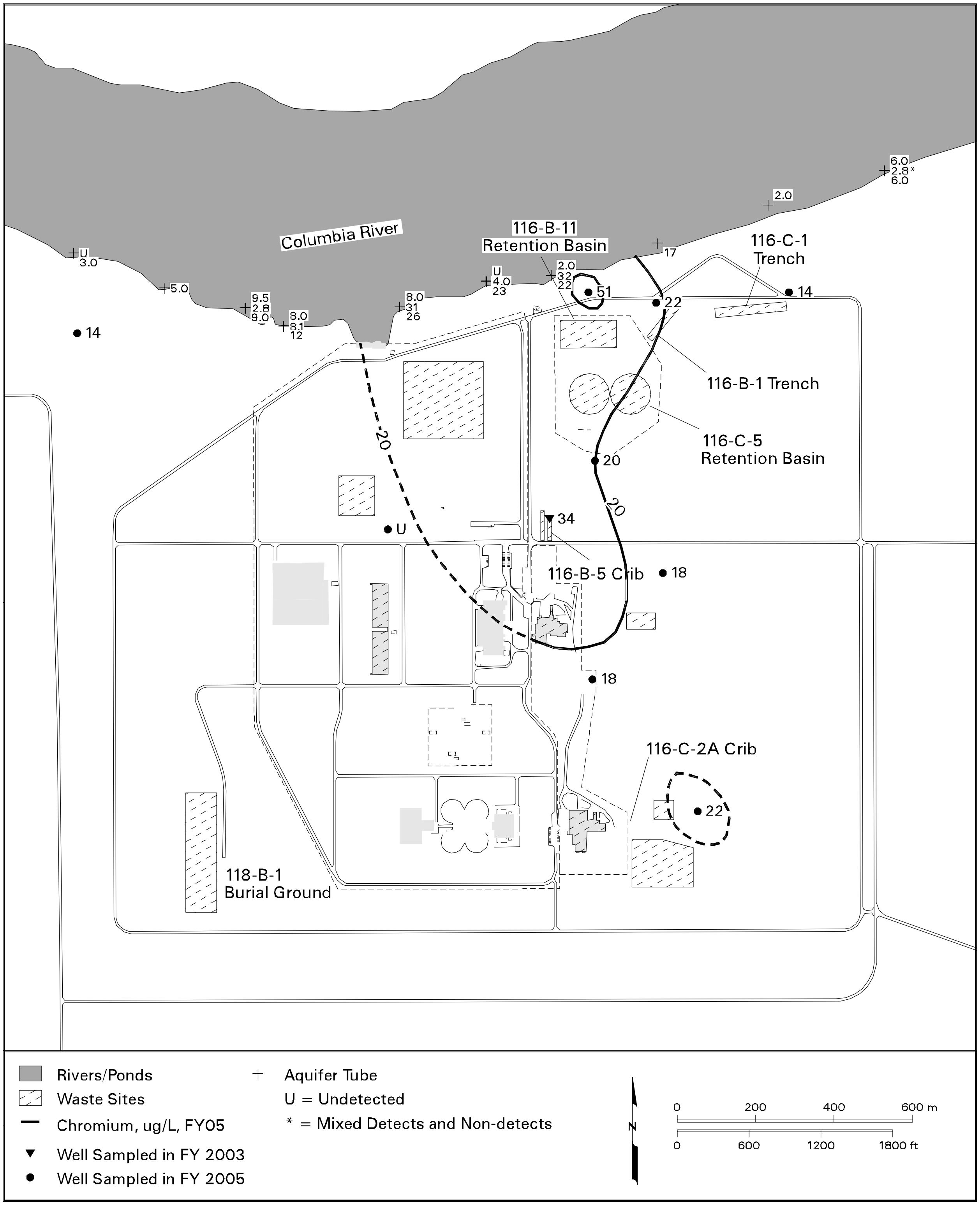

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Figure 2.2-9. Average Dissolved Chromium Concentrations in 100-B/C Area, Top of Unconfined Aquifer

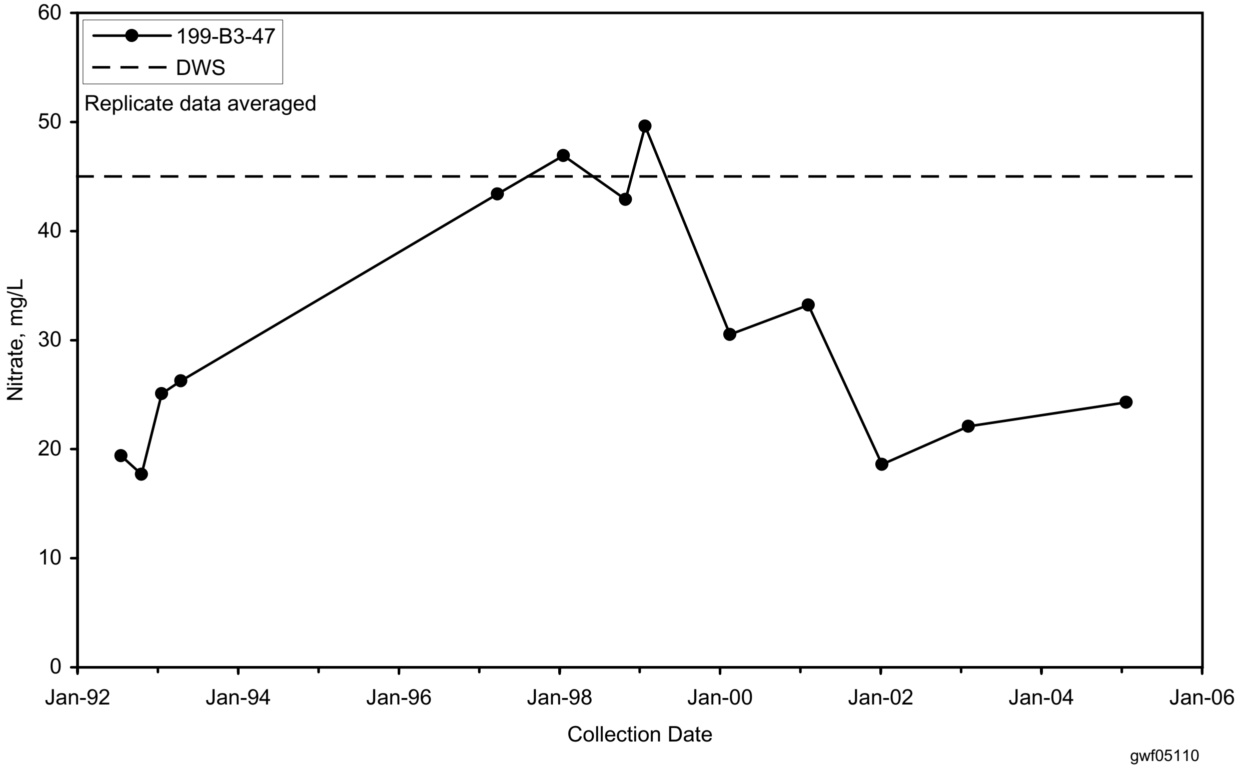

Figure 2.2-10. Nitrate Concentrations Near 116-B-11 Retention Basin

2.3 100-KR-4 Operable Unit

R. E. Peterson, R. F. Raidl, and S. W. Petersen

The 100-KR-4 Operable Unit includes groundwater potentially impacted by contaminant releases from facilities and waste sites within the 100-KR-1 and 100-KR-2 source operable units (Tri-Party Agreement Action Plan [Ecology et al. 1989]; Appendix C). Most of the facilities and waste sites within these source operable units are associated with former production reactor operations contained within the 100-K Area, which consists of the KE and KW Reactors and their support facilities. A description of 100-K Area facilities, reactor operations, and designated waste sites is presented in a technical baseline report (WHC-SD-EN-TI-239), which is the primary source for historical information presented in the following sections. The operable unit lies within a larger groundwater interest area, as defined by the Groundwater Performance Assessment Project (groundwater project) (see Figure 2.1-1 in Section 2.1). These interest areas are defined to facilitate scheduling, data review, and interpretation. Figure 2.3-1 is a location map showing 100-K Area facilities, waste sites, monitoring wells, and shoreline monitoring sites.

Chromium is the contaminant of concern in groundwater currently being targeted by interim remedial action.

Principal groundwater issues for the 100-KR-4 Operable Unit involve (a) a chromium plume created by past disposal to a large infiltration trench located near the Columbia River, (b) contamination associated with past discharges to the ground near the KE and KW Reactor buildings, and (c) groundwater conditions near the fuel storage basins associated with each reactor building. Remedial actions continued during fiscal year (FY) 2005 and included (a) removing contaminated facilities and soil associated with past operations, (b) removing contaminated sludge from the KE fuel storage basin, (c) planning for demolition and removal

Groundwater monitoring in the 100-KR-4 groundwater interest area includes the following activities:

CERCLA Long-Term Monitoring

- ***Twenty-five wells are sampled annually or biennially for contaminants of concern and constituents of interest.***
- ***Riverbank springs (three locations) and aquifer tubes (sixteen locations) are sampled annually along the 100-K Area river shore.***
- ***During FY 2005, all wells were sampled as scheduled; several aquifer tube sites and riverbank springs that were scheduled did not produce water for samples.***

CERCLA Interim Remedial Action Performance Evaluation

- ***Four compliance wells and ten extraction wells are sampled monthly for hexavalent chromium.***
- ***Seven performance wells are sampled monthly or semiannually to track changes in chromium and co-contaminant concentrations.***
- ***Treatment system influent and effluent chromium concentrations are sampled weekly.***
- ***During FY 2005, all wells were sampled as scheduled.***

Facility Monitoring

- ***Five wells are sampled quarterly to detect potential shielding water loss to the ground from the KW and KE Basins, with three wells also sampled monthly.***
- ***Four wells are sampled quarterly to monitor plumes created by past leakage from the KE Basin.***
- ***Riverbank springs (two locations) and aquifer tubes (six locations) are sampled annually to monitor conditions at the rivershore.***
- ***In FY 2005, all wells were sampled as scheduled.***

of the highly contaminated KE and KW fuel storage basins themselves, (d) operating a pump-and-treat system that removes hexavalent chromium from groundwater near the 116-K-2 trench, and (e) conducting a treatability test on chromium using calcium polysulfide.

Groundwater flow is generally to the northwest, toward the Columbia River.

Groundwater flow beneath the 100-K Area is generally to the northwest. Average rates of flow toward the Columbia River are in the range 0.1 to 0.3 meter/day, as estimated from hydraulic gradients, and from migration rates of plumes. Figure 2.3-1 shows water-table elevation contours; flow direction is generally perpendicular to contours. The best-supported estimate for groundwater flow rate between the KE Reactor and the river is 0.12 meter/day and is based on the migration of a plume created by a leak from the KE Basin in 1993. This suggests a 10- to 12-year travel time for tritium and other dissolved waste constituents to travel from the vicinity of the KE Reactor to the river (PNNL-14031). Waste constituents that interact with sediment, such as strontium-90 and carbon-14, travel more slowly. Groundwater discharge to the Columbia River occurs through the riverbed sediment, and to a limited degree, as riverbank springs during periods of low river stage.

The current movement of contaminant plumes beneath most of the 100-K Area is controlled by the flow of groundwater under natural conditions. However, in the region to the northeast of the KE Reactor, treated effluent from the interim remedial action pump-and-treatment system is injected back into the aquifer. A mound has formed on the water table, and a radial flow pattern has developed around the injection sites (DOE/RL-2005-18). Localized disruptions in the natural flow system also occur around the groundwater extraction wells.

Near the Columbia River, the groundwater system is influenced by fluctuations in river stage (i.e., elevation), which is controlled by releases from Priest Rapids Dam. The pattern of movement and the rate at which groundwater discharges to the river are affected by these fluctuations. Because river water infiltrates the banks during periods of high river stage, contaminants carried by groundwater may become diluted prior to their eventual release to the river through riverbed sediment and via riverbank springs.

Groundwater monitoring in the 100-K Area is conducted under two regulatory drivers: the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) governs the 100-KR-4 Operable Unit, while the *Atomic Energy Act* provides the basis for monitoring the fuel storage basins at each reactor building (i.e., K Basins). CERCLA requirements are further subdivided into monitoring conducted to (a) characterize and track all contaminants of potential concern in the operable unit, and (b) evaluate the performance of the pump-and-treat system that removes hexavalent chromium from groundwater contaminated by past disposal to the 116-K-2 trench.

Plume areas (square kilometers) above the drinking water standard at the 100-KR-4 Operable Unit:

Chromium — 0.09
Nitrate — 0.31
Strontium-90 — 0.14
Tritium — 0.28
Trichloroethene — 0.03

During FY 2005, essentially all sampling and analysis activities, as described in monitoring plans approved by regulatory agencies, were implemented. Changes to schedules presented in the plans were caused by minor shifting of wells in the pump-and-treat system network, and by minor changes to scheduling dates and analysis suites in response to new information that became available during the year (see Appendices A and B).

2.3.1 Groundwater Contaminants

Chromium has been identified as a contaminant of concern in the 100-KR-4 Operable Unit that warrants interim remedial action (ROD 1996a). Where groundwater containing chromium discharges into the river environment, there exists a potential risk of harm to aquatic life that uses the zone where groundwater meets river water as habitat. Other contaminants of potential concern in the operable unit include carbon-14, nitrate, strontium-90, technetium-99, trichloroethene, and tritium. These constituents are being monitored while source removal actions continue.

The following descriptions of contaminants refer to conditions at wells that monitor the uppermost hydrologic unit. Only one well exists in the 100-K Area that is completed to monitor conditions below the uppermost aquifer (well 199-K-32B), and groundwater at that deep well is essentially contaminant free.

2.3.1.1 Chromium

Sodium dichromate was used in large quantities as a corrosion inhibitor at the KE and KW Reactors during their years of operation (1955 through 1971). The chemical was added to reactor coolant in amounts that resulted in a concentration of ~700 μg/L of hexavalent chromium. The hexavalent form of chromium is fully soluble in water and is toxic to aquatic organisms and humans. The relevant Washington State standards are 10 μg/L for chronic exposure by aquatic organisms (measured as hexavalent chromium) and 100 μg/L (measured as total chromium) for drinking water supplies.

The extent of chromium contamination in groundwater beneath the 100-K Area during 2005 is shown in Figure 2.3-2. The contour shapes reflect the various source locations and the direction of plume migration inferred from water-table elevation contours. Where information is lacking or uncertain, contours are dashed lines.

The largest area of chromium contamination is associated with past disposal to the 116-K-2 trench. A second area of concern is between KW Reactor and the Columbia River.

Chromium Beneath 116-K-2 Trench. The largest area of chromium contamination is associated with the 116-K-2 trench, which received large volumes of reactor coolant. The interpretation shown in Figure 2.3-2 assumes that chromium detected at well 699-78-62, which is east of the 100-K Area (Figure 2.3-1), was pushed inland by radial flow around a mound beneath the 116-K-2 trench during the operating years. The trench plume is the target of interim remedial action intended to protect aquatic receptors in the Columbia River from exposure to chromium in groundwater that discharges through the riverbed. The interim action involves extracting groundwater and removing the chromium using a treatment system (ROD 1996a), thus reducing the flux of chromium to the river ecosystem and the total amount of chromium in the environment. The system began operating in October 1997 (see Section 2.3.2).

Concentrations at wells that monitor the trench plume are typically <100 μg/L (the drinking water standard) and appear to be decreasing with time or remaining nearly constant, with exceptions at several locations. The overall decrease in the level of contamination is a combined consequence of the pump-and-treat operation and natural attenuation by dispersion. Figures 2.3-3, 2.3-4, and 2.3-5 illustrate concentration trends for southwest, central, and northeast groups of monitoring wells, respectively, within this plume area.

An exception to the generally decreasing trends occurs at well 199-K-18, located near the southwest edge of the plume, where concentrations have been increasing during recent years, although a leveling of the rate of increase appears to have started (Figure 2.3-3). The start of the increasing trend at this location correlates with the start of the pump-and-treat system in October 1997, and the trend may be related to the altered flow pattern in the area as a result of the extraction and injection of groundwater. Chromium concentrations are also relatively higher at nearby aquifer tube site AT-K-3, compared to conditions immediately upstream and downstream along this segment of shoreline. Based on groundwater flow directions, an area of elevated chromium may be present in the region immediately south of well 199-K-18, although the absence of wells in this area precludes confirmation.

At the northeast end of the trench, chromium concentrations are gradually decreasing, though conditions at wells 199-K-37 and 199-K-130 suggest recent, gradually rising trends (Figure 2.3-5). Also, concentrations at recently installed well 199-K-131 (~80 μg/L), which is located ~300 meters northeast of well 199-K-130, provide evidence to extend the plume boundaries farther to the northeast than previously mapped. Water samples were also collected in May 2005 from several old boreholes associated with the Hanford Generating Plant and analyzed for hexavalent chromium, with results ranging from non-detect to 9 μg/L. These boreholes were not constructed as monitoring wells, so the representativeness of these results is questionable. Results from aquifer tubes for this part of shoreline indicated a gradually decreasing trend in concentrations (PNNL-14444 and preliminary FY 2005 results).

Chromium Near KE and KW Reactors. Two additional areas contain elevated concentrations of chromium, although the extent of each is poorly defined. Near KE Reactor, a plume is apparently present that extends from the southeast side of the water treatment plant basins downgradient to the southwest corner of the reactor building. The source is likely to be contaminated soil in the vicinity of a former sodium dichromate storage tank and railcar transfer station (WHC-SD-EN-TI-239). Periodic events appear to remobilize chromium and create concentration changes in groundwater, as seen at well 199-K-36 (Figure 2.3-6), although concentrations have remained below the drinking water standard the past 2 years. In the past, leakage of clean water from the water treatment plant basins may have provided the remobilization mechanism. Migration downgradient beyond the KE Reactor appears to be very limited, as shown by the low concentrations at wells 199-K-23, 199-K-109A, and 199-K-11.

Near KW Reactor, chromium concentrations are elevated above the drinking water standard at several wells, with the suspected source being sodium dichromate in the vadose zone at as yet unidentified locations. Candidate locations include the storage tank and transfer station at the southeast side of the KW Water Treatment Plant (same as at KE), and also the underground piping associated with the system used to add sodium dichromate to coolant water. Figure 2.3-7 shows concentration trends for wells located within this plume. The abrupt drop in concentrations at well 199-K-108A in 1999 was caused by groundwater being diluted by clean water from an unknown source. During FY 2005, this dilution apparently stopped, and groundwater constituents may be returning to their pre-1999 concentrations. This chromium plume has migrated downgradient of the KW Reactor, and its presence at newly installed well 199-K-132 (replacement for 199-K-33) is revealed by concentrations in the range 80 to 140 μg/L during the first three quarters of sampling at that well (Figure 2.3-8). Monitoring results from sites at the Columbia River also showed evidence for the arrival of this plume at the river during FY 2005, with a concentration of 45 μg/L observed at aquifer tube site AT-K-1. The plume impinges on a relatively short segment of shoreline, as shown by low concentrations at well 199-K-31 (10 to 15 μg/L and constant) and aquifer tube site 17 (<10 μg/L).

The highest tritium concentrations beneath 100-K Area are downgradient of the former KE and KW condensate cribs.

2.3.1.2 Tritium

Tritium was common in liquid effluent discharged to the ground during 100-K Reactor operations. However, some of the tritium currently observed in groundwater was introduced after the shutdown of the reactors in 1971. Current sources and potential sources for providing tritium to groundwater include shielding water in the KE and KW Basins, the soil columns beneath the former reactor atmosphere gas condensate cribs located to the east of each reactor building, and possibly irradiated materials contained in the 118-K-1 burial ground. Tritium has a radioactive decay half-life of 12.3 years. The drinking water standard for this radionuclide is 20,000 pCi/L.

The distribution of tritium in groundwater beneath the 100-K Area during FY 2005 is shown in Figure 2.3-9. The areas of contamination outlined by contours reflect several past and present known source locations, the direction of plume migration inferred from water-table elevations, and concentrations observed at wells. The highest tritium concentrations are associated with locations immediately downgradient of the former 116-KE-1 and 116-KW-1 condensate cribs at each reactor, which were excavated and backfilled with clean material during the period December 2003 to March 2004. Some contaminated soil remained at the bottom of the excavations. Because high concentrations of tritium are present in the shielding water of each fuel storage basin, tritium in groundwater is closely monitored for evidence of shielding water loss to the ground (PNNL-14033). There is also evidence to suggest that tritium releases from materials in the 118-K-1 burial ground are affecting groundwater, causing the area of groundwater contamination north of the burial ground. The treated effluent from the interim action pump-and-treat system also contained tritium at a concentration of ~8,000 pCi/L during FY 2005. This causes a localized area around the injection wells of concentrations that are greater than background levels (Figure 2.3-9).

Recent variability in tritium concentrations observed near each reactor building do not have a clear explanation.

Tritium Near KE Reactor. The plume shown in Figure 2.3-9 near KE Reactor has been formed by tritium from past disposal to the former 116-KE-1 condensate crib; leaks to the ground from KE Basin (1976 to 1979, and again in 1993); and possible remobilization of contamination from the vadose zone beneath the 116-KE-3 drain field and associated catch tank (100-K-68 "D-sump"). The tritium distribution pattern reflects a coalescing of plumes from these sources and the timing of release from each source. The highest concentrations are immediately downgradient of the former 116-KE-1 crib. The concentration trend for tritium, along with that for co-contaminant carbon-14, at well 199-K-30 near this source is shown in Figure 2.3-10.

Tritium concentration trends at wells immediately downgradient of the KE Reactor are shown in Figure 2.3-11. Wells 199-K-27 and 199-K-109A are the wells most likely to detect loss of basin water to the ground. The increases at those wells that started in early 2003 remain unexplained, although there is no evidence from facility operations suggesting a significant loss of shielding water. Technetium-99, a second indicator of shielding water, has not been detected at these wells. Since mid-2004, tritium concentrations have declined and by the end of FY 2005 are approaching pre-2003 levels.

The tritium trend at well 199-K-29 also showed an increase that started in January 2001 (Figure 2.3-11). This well is located off to the side of the flow path directly beneath the KE Basin. The trend most likely reflects downgradient migration and lateral spread of the plume associated with the former 116-KE-1 crib, rather than water loss from the KE Basin.

Tritium Near KW Reactor. The tritium plume mapped near the KW Reactor is associated with effluent disposed during the operating years to the former 116-KW-1 condensate crib. An unexplained increase in tritium concentrations at well 199-K-106A, located downgradient of the crib, began in 2001, peaked sharply in 2003 and early 2005, and remains elevated compared to pre-2001 levels (Figure 2.3-12). Other constituents showing a similar trend include chloride, nitrate, and possibly technetium-99. Carbon-14, which was disposed to the crib but is less mobile than tritium, does not follow the tritium trend. The cause for the trends at well 199-K-106A is presumed to be remobilization of contaminants associated with the crib and underlying soil column, although a driving mechanism has not been positively identified. The presence of technetium-99 at this well, at concentrations well below the drinking water standard, is also unexplained. Soil samples collected during the excavation of the crib in early 2004 did not reveal the presence of technetium-99. Technetium-99 migrates into the region between 100-B and 100-K Areas from sources in 200 East Area, but there is inconclusive evidence to relate that plume to the technetium-99 observed at well 199-K-106A.

Tritium in groundwater at a well near the 100-K burial ground suggest the possible release of tritium from buried materials.

There is no evidence in groundwater data to suggest water loss to the ground from the KW Basin in recent years. Tritium concentrations in wells most likely to detect shielding water are shown in Figure 2.3-13. The groundwater concentrations are significantly lower than concentrations in KW Basin shielding water. The change in concentrations at well 199-K-34 that began in late 2003 has no obvious explanation, but trend changes of this magnitude have occurred in the past.

Tritium Near the 118-K-1 Burial Ground. Tritium concentrations at well 199-K-111A, located at the northwest corner of the burial ground, began rising abruptly in mid-2000 to a peak value of 98,200 pCi/L in April 2002 (Figure 2.3-14). Since that time, concentrations steadily declined to a level of ~14,000 pCi/L in mid-2004 and have remained nearly constant throughout FY 2005. No monitoring wells exist along the direct downgradient flow path to the river. However, the nearest well just to the side of that flow path is well 199-K-18, located ~450 meters to the north of well 199-K-111A. Tritium concentrations are gradually rising at that well.

Tritium contamination at the southwest end of the 116-K-2 trench may be from past disposal to the 116-K-1 crib or 116-K-2 trench, or possibly from a source farther inland, such as the 100-K burial ground.

The source for the tritium near the burial ground was the subject of a multifaceted investigation during 2002 (PNNL-14031) and a subsequent soil-gas survey along the north perimeter of the burial ground in 2003 (PNNL-14548) during which soil gas was analyzed for helium isotopes (helium-3 is a decay product of tritium). An excess of helium-3, as compared to ambient air amounts, was measured at all sites and indicated the nearby presence of tritium. The pattern of isotope ratios suggests the likelihood of a tritium source in the burial ground, along with an underlying groundwater plume. Therefore, the current best explanation for the elevated tritium trend observed at well 199-K-111A is that a tritium plume lies to the east of the well, i.e., beneath the burial ground. The peaked character of the trend at the well suggests periodic displacement of that plume to the west, perhaps because of the groundwater mound that has formed beneath the pump-and-treat injection site (see water-table contours in Figure 2.3-1), and/or episodic generation of a plume beneath the burial ground. These ideas are supported by (a) the pattern of groundwater movement inferred from water-table gradients, (b) the soil gas evidence for a tritium source at the burial ground, (c) historical evidence regarding the contents of the burial ground and a possible analogy to the situation at the 618-11 burial ground (see Section 2.12), and (d) gradually increasing chromium concentrations as the pump-and-treat plume shifts somewhat to the west.

Tritium Near 116-K-2 Trench. Groundwater downgradient of the trench typically contains low concentrations of tritium, i.e., <2,000 pCi/L. The exception occurs at the southwest end of the trench, where recent concentrations are ~35,000 and ~41,000 pCi/L at wells 199-K-18 and 199-K-120A (a pump-and-treat system extraction well), respectively, during the past year (see Figure 2.3-9). The trend at well 199-K-19 rose gradually between 1993 and 2000, when the trend reversed and dropped to very low concentrations. The source for tritium at this location is uncertain; it may represent past disposal to the 116-K-1 crib or 116-K-2 trench, or possibly tritium from a source farther inland, such as the 100-K burial ground.

Tritium is being re-introduced to the aquifer via injection of the effluent from the pump-and-treat system (see Figure 2.3-1 for location of injection wells). The average tritium concentration in effluent was ~8,000 pCi/L during FY 2005, and most of that tritium comes from extraction well 199-K-120A, where concentrations were ~41,000 pCi/L in 2005. Injected effluent appears to have arrived at downgradient well 199-K-125A as early as 1999, as shown by increasing tritium concentrations at that and nearby wells (Figure 2.3-15). Increasing trends are also present at nearby wells 199-K-20, 199-K-116A, and 199-K-127.

2.3.1.3 Carbon-14

Carbon-14 levels exceeded the drinking water standard in several wells that monitor infiltration cribs near KE and KW Reactors.

Condensate from gas circulated through the KE and KW Reactors contained carbon-14 (along with tritium) and was discharged to infiltration cribs at the east side of each reactor building. Release of carbon-14 from the cribs, which were excavated and backfilled during 2004, is the source for the two carbon-14 plumes near each reactor. The drinking water standard is 2,000 pCi/L, which is exceeded at several wells that monitor these plumes. The half-life for carbon-14 is 5,730 years. This radionuclide exchanges with carbon in carbonate minerals, and so its movement is more restricted and variable than a non-exchanging constituent like tritium.

The two plumes are positioned between the crib source locations and the Columbia River (Figure 2.3-16). Current concentrations of carbon-14 in groundwater at wells immediately downgradient of each crib are shown in Figures 2.3-10 and 2.3-12. Near the 116-KE-1 crib, recent results at well 199-K-30 indicate concentrations of ~5,000 pCi/L. Concentrations observed along the rivershore downgradient of the 116-KE-1 crib are very low and likely to be representative of background levels. Near the 116-KW-1 crib, recent results at well 199-K-106A are ~15,000 pCi/L. There is evidence that the plume front in this region has reached the river. A 2005 sample from aquifer tube 17-D revealed a concentration of 813 pCi/L, which is above background levels.

Carbon-14 has also been detected at well 199-K-108A in an area upgradient of the 116-KW-1 condensate crib. Concentrations exceeded the drinking water standard (2,000 pCi/L) during the mid-1990s, with monitoring results relatively constant at ~4,000 pCi/L. During the period 2000 to 2004, groundwater at this location was diluted by clean water from an unknown source, and contamination indicators were dramatically reduced in concentration. During FY 2005, dilution by clean water has stopped, and monitoring data for numerous constituents indicate the start of a return to pre-diluted conditions, with carbon-14 concentrations rising to ~1,500 pCi/L during the fiscal year.

2.3.1.4 Strontium-90

Strontium-90 was released to the environment at 100-K Area primarily via used reactor coolant. It may also have been present in fuel storage basin shielding water, which was discharged to nearby drain fields and injection wells during the reactor operating period. Strontium-90 continues to be present at relatively high concentrations in the shielding water at KE and KW Basins, although all fuel has now been removed from these basins. The radionuclide is moderately mobile in the environment and has a half-life of ~29 years. The drinking water standard is 8 pCi/L, which is based on a radiological dose rate. If strontium-90 is the only beta-emitting radionuclide present in a groundwater sample, the associated gross beta concentration will be approximately twice that for the strontium-90 concentration.

At 100-K Area, the highest concentration of strontium-90 in groundwater samples has been detected near the northwest corner of the KE Reactor.

Strontium-90 Near the KE and KW Reactors. The highest concentrations in 100-K Area groundwater have been observed near the northwest corner of the KE Reactor, at well 199-K-109A, and reached a peak of ~18,000 pCi/L in 1997. Concentrations declined following that peak value, and since 2002, have remained variable within the range of several hundred up to ~3,100 pCi/L (Figure 2.3-17). The elevated gross beta concentrations also observed in groundwater at this location appear to be caused primary by strontium-90. The elevated concentrations during the period 1996 through 2000 correlate with a period of sustained high water-table conditions (see hydrograph on Figure 2.3-17). This suggests that a raised water table remobilizes strontium-90 that remains in the lower vadose zone beneath the 116-KE-3 drain field. Periodic infiltration of water, perhaps as the result of precipitation events and loss from fire hydrant utility lines, may also contribute to moving contamination from the vadose zone beneath the former drain field to groundwater (PNNL-12023).

Strontium-90 concentrations are lower at equivalent locations near KW Reactor, and during 2005 continued to range from 24 to 34 pCi/L, with essentially constant trends. Leakage from hydrant utility lines has not been observed near the northwest corner of the KW Basin and adjacent drain field. There are indications at well 199-K-107A of temporarily elevated levels during the high water-table conditions in 1996 and 1997, based on gross beta measurements. The strontium-90 observed at well 199-K-107A has not migrated any significant distance downgradient, and is not detected at well 199-K-132, which is midway between the KW Reactor and the Columbia River.

Strontium-90 Near the 116-K-2 Trench. The effluent disposed to the 116-K-2 trench contained strontium-90, which is still present in groundwater affected by trench operations. The highest concentrations are generally <40 pCi/L and limited in areal extent. Within this limited area, concentrations did increase during the high water-table period of 1996-1997, suggesting remobilization of strontium held in the lower vadose zone. Throughout most of the area covered by the interim action chromium plume, concentrations are near or below the drinking water standard (8 pCi/L). Also, most concentration trends indicate a gradual decline.

Nitrate and trichloroethene concentrations exceed drinking water standards in some 100-K Area monitoring wells.

2.3.1.5 Other Constituents

Nitrate is widely distributed beneath the 100-K Area; potential sources include currently active septic systems and past-practices waste sites. The distribution patterns do not clearly delineate specific source sites. Nitrate exceeds the drinking water standard (45 mg/L) in some areas. Concentration trends vary depending on monitoring location, and the cause for the variability is likely to be shifts in plume position because of groundwater flow.

Trichloroethene is detected at wells 199-K-106A and 199-K-132 and also was present at decommissioned well 199-K-33. All of these wells are located within the downgradient flow path from the 116-KW-1 crib. During FY 2005, concentrations ranged between 1.7 and 5.5 µg/L at these wells (the drinking water standard is 5 µg/L).

In the past, several metals have been measured in filtered samples at concentrations above the secondary drinking water standards (e.g., aluminum, iron, and manganese). These occurrences have not been positively connected to waste sites or waste streams. They are not considered contaminants of concern because of (a) limited areal extent, (b) sporadic occurrence, and (c) possibility that their occurrence may be related to well construction and, therefore, not representative of groundwater conditions. However, their concentrations continue to be monitored as part of basic water quality analyses (e.g., collective analyses for major cations and anions).

The interim remedial action consists of a pump-and-treat system involving ten extraction wells, five injection wells, and an ion-exchange resin treatment system that removes hexavalent chromium from the extracted groundwater.

2.3.2 Interim Action Groundwater Remediation for Chromium

Interim remedial action under CERCLA at the 100-KR-4 Operable Unit involves a pump-and-treat system designed to remove hexavalent chromium from groundwater. The target plume for this interim action is located in the vicinity of the 116-K-2 trench and the Columbia River (DOE/RL-96-84). Hexavalent chromium poses a threat to aquatic organisms that use the riverbed substrate for habitat. Fall Chinook salmon, which spawn in riverbed gravels, are of particular concern in the Hanford Reach. As described in the record of decision (ROD 1996a), the protection standard for aquatic life is 11 µg/L as measured in riverbed substrate pore water. Because some dilution of contaminants by river water occurs along the pathway between the aquifer and riverbed substrate, the record of decision considers a value of 22 µg/L in near-river compliance wells as being protective of aquatic life.

The interim remedial action consists of a pump-and-treat system involving ten extraction wells, five injection wells, and an ion-exchange resin treatment system that removes hexavalent chromium from the extracted groundwater (DOE/RL-2005-18). The system began operating in October 1997. Performance monitoring of the pump-and-treat system is described in an interim remedial action monitoring plan (DOE/RL-96-90). Four wells, located between the extraction wells and the Columbia River, were originally identified as compliance monitoring locations; during FY 2005, one of those wells was converted to an extraction well. Seven additional wells are monitored to help evaluate the performance of the system regarding aquifer conditions, along with aquifer tubes at eleven sites and several riverbank spring sites located along the rivershore. Lists of sampling frequencies and analyses performed are included in Appendix A.

The results of the interim remedial action for chromium are described in an annual summary report for each calendar year, which is prepared by the remedial action contractor. Highlights from the summary report for calendar year 2004 (DOE/RL-2005-18, the most recent report available) are presented in the following sections, and include updates for groundwater volumes treated and mass of chromium removed through September 2005.

The remedial action objectives for the 100-KR-4 Operable Unit (ROD 1996a) are:

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminant in the groundwater.***
- ***Provide information that will lead to the final remedy.***

The contaminant of concern is hexavalent chromium. The record of decision identifies the cleanup goal at compliance wells as 22 µg/L.

2.3.2.1 Progress During FY 2005

During the period October 1, 2004, through September 30, 2005, ~525 million liters of groundwater were extracted and treated, and ~27 kilograms of hexavalent chromium were removed. Since the startup of operations in October 1997, the total volume of groundwater extracted is ~3.11 billion liters, and total mass of hexavalent chromium removed is ~271 kilograms. The 2005 average flow rate for each extraction well ranged between 54 and 168 liters/minute, with a combined average flow rate of 1,179 liters/minute (DOE/RL-2005-18).

Changes in the pump-and-treat system during FY 2005 included converting compliance well 199-K-114A to an extraction well in fall 2004 and modifying the treatment plant to now include a sacrificial ion exchange column. This was done to address the buildup of natural uranium on the resins, which precludes the regeneration of the resin. Four new wells were installed adjacent to well 199-K-126, where a treatability test involving injection of calcium polysulfide was performed during the summer and fall of 2005 (see Section 2.3.2.3). The calcium polysulfide acts to reduce hexavalent chromium in the aquifer by converting it to the less toxic and less mobile trivalent form. This method is a potential alternative to pump-and-treat systems for cleanup of groundwater contaminated by hexavalent chromium. Calcium polysulfide injection has been used at other sites in the United States to remediate chromium plumes, but it has not been applied previously at the Hanford Site.

2.3.2.2 Influence on Aquifer Conditions

Chromium concentrations within the target plume area show generally decreasing trends (Figures 2.3-3, 2.3-4, and 2.3-5; see Section 2.3.1.1). Strongly decreasing trends are present at wells 199-K-20, 199-K-117A, and 199-K-125A. More gradual decreasing trends are noted at wells 199-K-19, 199-K-120A, 199-K-114A, 199-K-112A, and 199-K-126. Several wells are strongly influenced by infiltration of river water, where contaminant concentrations are reduced by dilution, i.e., by mixing of groundwater and river water (wells 199-K-117A and 199-K-114A). Exceptions to the generally decreasing trends occur at the southwest and northeast boundaries of the plume, at wells 199-K-18 (southwest) and 199-K-37 and 199-K-130 (northeast). The cause for these increases is discussed in Section 2.3.1.1.

Chromium concentrations appear to be generally decreasing in the area of the pump-and-treat system.

Concentrations consistently at or below the remedial action goal (22 µg/L) for near-river wells are observed only at well 199-K-117A. Chromium levels in compliance well 199-K-114A (converted to extraction in fall 2004) have fluctuated above and below the target level for several years, depending on river stage (Figure 2.3-4). Conditions at both of these wells are strongly influenced by the infiltration of river water, which reduces contaminant concentrations by dilution, prior to discharge into the river system.

Chromium concentrations in aquifer tubes along the shore segment affected by the plume appear to have decreased with time, although the results are limited in number (PNNL-14444). When results are available for tube samples from several depths at a particular site, the deeper site typically shows the higher concentration, thus revealing the diluting effect of river water in the hyporheic zone associated with the river channel.

The injection of treated effluent at five wells has created a mound of uncertain magnitude on the water table. The injected treated effluent has migrated downgradient and arrived at wells 199-K-20, 199-K-116A, 199-K-119A, and 199-K-125A, as shown by increasing tritium concentrations at those wells (Figure 2.3-15). Tritium is a good tracer for the effects of injection, as effluent concentrations are higher than in groundwater near most of the extraction wells. During FY 2005, tritium concentrations in effluent were ~8,000 pCi/L (the first effluent in late 1997 had a level of ~16,000 pCi/L). The timing of the arrival of this plume front at the four wells does not correlate precisely with distance from the injection site, probably because of variability in flow paths and rates created by the pumping activities, and by heterogeneity in the aquifer. The mounding may also cause the southwestern boundary of the chromium plume to shift to the west, where the edge of the plume may now be detected at well 199-K-111A (Figure 2.3-2).

Uncertainties regarding the pump-and-treat system's influence on aquifer conditions involve the (1) extent of plume inland of the trench, and whether or not chromium observed at well 699-78-62 is part of the plume; (2) source for chromium and tritium at wells 199-K-18 and 199-K-120A, where some concentration trends are increasing; (3) height and extent of the mound created at the injection site, and its influence on flow patterns; and (4) mass of potentially mobile chromium remaining in the lower vadose zone and in the aquifer upgradient of the trench.

2.3.2.3 Calcium Polysulfide Treatability Test

During the summer of 2005, a treatability test involving removal of hexavalent chromium from the aquifer was performed near the northeast end of the 100-K trench (see Figure 2.3-1). This test used the chemical calcium polysulfide, which is a strong reductant that remediates chromium in the groundwater and reduces the aquifer materials to form a permeable reactive barrier that will continue to remove hexavalent chromium from groundwater. The primary purpose of this test was to evaluate the practicality and cost of using calcium polysulfide to remediate chromium in the aquifer (DOE/RL-2005-05). The test also determined important hydrologic information for the 100-K Area aquifer, provided experience in designing systems to implement this type of technology, and revealed several lessons learned that will be valuable if this technology is implemented.

A treatability test of a new method to reduce chromium contamination in groundwater was successfully completed in summer 2005.

The test included the following objectives:

- Verify the ability to achieve in situ chromium reduction using an active remediation system involving calcium polysulfide and a carbon source, which together reduce the groundwater and aquifer by both inorganic and microbiological processes.
- Determine if aquifer constituents such as manganese or arsenic are mobilized as a result of this reduction and how other parameters such as nitrate or dissolved oxygen are affected as a result of the groundwater treatment.
- Obtain operational experience in the treatment of chromium-contaminated groundwater by the use of calcium polysulfide as the reducing medium.

Five wells were used for the treatability test – an extraction well surrounded by four injection wells drilled specifically for this test. Groundwater was withdrawn from well 199-K-126 and the treated effluent returned to the aquifer via surrounding wells 199-K-133 through 199-K-136 (see Figure 2.3-1). During the test, groundwater was withdrawn and mixed with calcium polysulfide in an above-ground tank. This solution reacted for a minimum of 2 hours and was then pumped through the injection wells in approximately equal amounts to permeate the aquifer. This is referred to as a “five-spot” configuration and is ideal for a test of this type because it provides operational field experience and kinetics information in a manageable area and also cleans up a section of the aquifer.

The treatability test began operation on June 28, 2005, in compliance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement, Ecology et al. 1989) Milestone M-016-28B, *Initiate In-Field Treatability Test at 100-KR-4*, which had a due date of July 1, 2005. Prior to startup, systems were tested for leaks and proper operation, and a tracer study was initiated. Water was circulated without calcium polysulfide on June 27, when a lithium bromide tracer was pumped into one of the injection wells. This tracer test, along with slug tests carried out in the extraction and injection wells before and after the treatability test was performed, was conducted to quantify the hydraulic conductivity in the aquifer beneath the treatability test area. The slug tests were rerun after completion of the treatability test to determine if the aquifer permeability was degraded as a result of the test.

During the treatability test, a total of 25 samples were collected on a regular basis and analyzed for basic chemical properties (e.g., pH, oxidation-reduction potential) and major and trace constituents. The amount of water extracted and injected was recorded, along with the volume of calcium polysulfide mixed with the water. Over 1.3 million liters were treated during the course of the test, which was completed on August 11.

All of the performance goals were met by the end of the test. Chromium was effectively reduced in the aquifer, which should remain a persistent permeable reactive barrier to treat additional amounts of chromium under natural groundwater flow conditions. Analysis of groundwater chemistry before, during, and after the test show that manganese and iron were mobilized under the strongly reducing conditions in the aquifer, but that arsenic was at near background conditions after test completion. The pre- and post-treatment aquifer tests showed that chemical injection did not degrade the permeability of the aquifer.

This test is considered successful, and the data collected are sufficient to scale up the treatment technology. Water in the treatment area will continue to be monitored for a number of months, along with water from a well ~200 meters downgradient of the test area, to evaluate the persistence of the reduced zone and any potentially adverse effects the test may have had on aquifer chemistry. A comprehensive test report will become available in March 2006.

2.3.3 Facility Monitoring — K Basins

The fuel storage basins located within the KE and KW Reactor buildings were used from the late 1970s to 2004 to store irradiated fuel from the 100-N Reactor, along with other miscellaneous fuel recovered during remedial actions at other reactor areas. Each basin holds ~4.9 million liters of shielding water that is highly contaminated with long-lived radionuclides, some of which are mobile in the environment (e.g., tritium and strontium-90). KE Basin has leaked in the past, and the leakage has affected groundwater. The vadose zone beneath the basin is also known to contain radionuclides that are absorbed onto soil. Information on the removal of spent fuel and contaminated sludge, and the demolition of these basins, can be found at DOE's Richland Operations Office web site (www.hanford.gov/rl; communications tab, programs, Spent Nuclear Fuel). Tri-Party Agreement (Ecology et al. 1989) Milestone M-34-00 covers the fuel removal and basin cleanup project.

All spent fuel has been removed from the K Basins. Work to remove radioactive sludge is underway.

Groundwater Monitoring. Groundwater monitoring near the K Basins is conducted under a subtask within the groundwater project. The K Basins sampling and analysis schedule complements schedules associated with the 100-KR-4 Operable Unit. The monitoring plan (PNNL-14033) describes the objectives for the subtask:

- Characterize groundwater conditions between the K Basins and the Columbia River to provide a periodic status of current conditions and the attenuation of plumes.
- Distinguish between groundwater contamination associated with K Basins and contamination from other past-practices sources to help guide operational and remedial action decisions.
- Maintain a strategy for the potential expansion of monitoring capabilities to respond to future basin-related issues.

The primary indicator for detecting shielding water in groundwater is tritium, which is present at concentrations in the millions-of-picocuries per liter range in KE and KW Basin water. Other less mobile radionuclides (e.g., strontium-90, cesium-137) are also present at relatively high concentrations in shielding water. However, if small volumes or low rates of leakage were to occur, these contaminants might not show up in groundwater because they would be retained in the vadose zone. One additional tracer for shielding water is technetium-99, which is mobile, like tritium, but is at relatively low concentrations in shielding water. Therefore, it might not be apparent in groundwater if only small volumes of basin water loss are involved.

Recent Groundwater Monitoring Trends. During FY 2005, tritium concentrations at wells 199-K-27 and 199-K-109A, which are located adjacent to the KE Basin on its northwest side, returned to levels more consistent with earlier long-term trends (see Figure 2.3-1 for locations, Figure 2.3-11 for concentration trends, and Section 2.3.1.2 for discussion of tritium contamination). There is still no clear explanation as to the cause for the abrupt increase in concentrations that started in January 2003 at these wells. There has been no unexplained loss of water from the basin to account for the trend changes in groundwater. However, it is possible that very low rates of loss from the basin to the ground might not be detected by monitoring the basin volume and that a relatively small volume of shielding water could account for the trend changes seen in groundwater. Other past-practices disposal sites are located in the area but are not in the direct groundwater flow paths monitored by these wells.

Near the KW Reactor, tritium concentrations at a well downgradient of the former 116-KW-1 condensate crib have been rising gradually since 2001, with a sharp peaking in mid-2003 (see Figure 2.13-12). The source for the tritium is likely to be the vadose zone beneath the former crib and not related to potential water loss from the KW Basin.

Remedial Actions at KE Basin. Planning is underway to demolish the KE Basin, now that fuel removal is complete and sludge removal is progressing. Demolition will involve creating a large excavation on the river (north) side of the basin and will include removal of three wells used for monitoring: 199-K-27, 199-K-29, and 199-K-109A. The excavation will also encounter grouted casing associated with previously decommissioned well 199-K-28 and the injection well associated with the 116-KE-3 drain field, which has not been decommissioned. Discussion of groundwater monitoring requirements for the period during excavation and demolition activities, and for post-remedial action long-term monitoring, started during FY 2005. Excavation and demolition activities are expected to begin in late 2006.

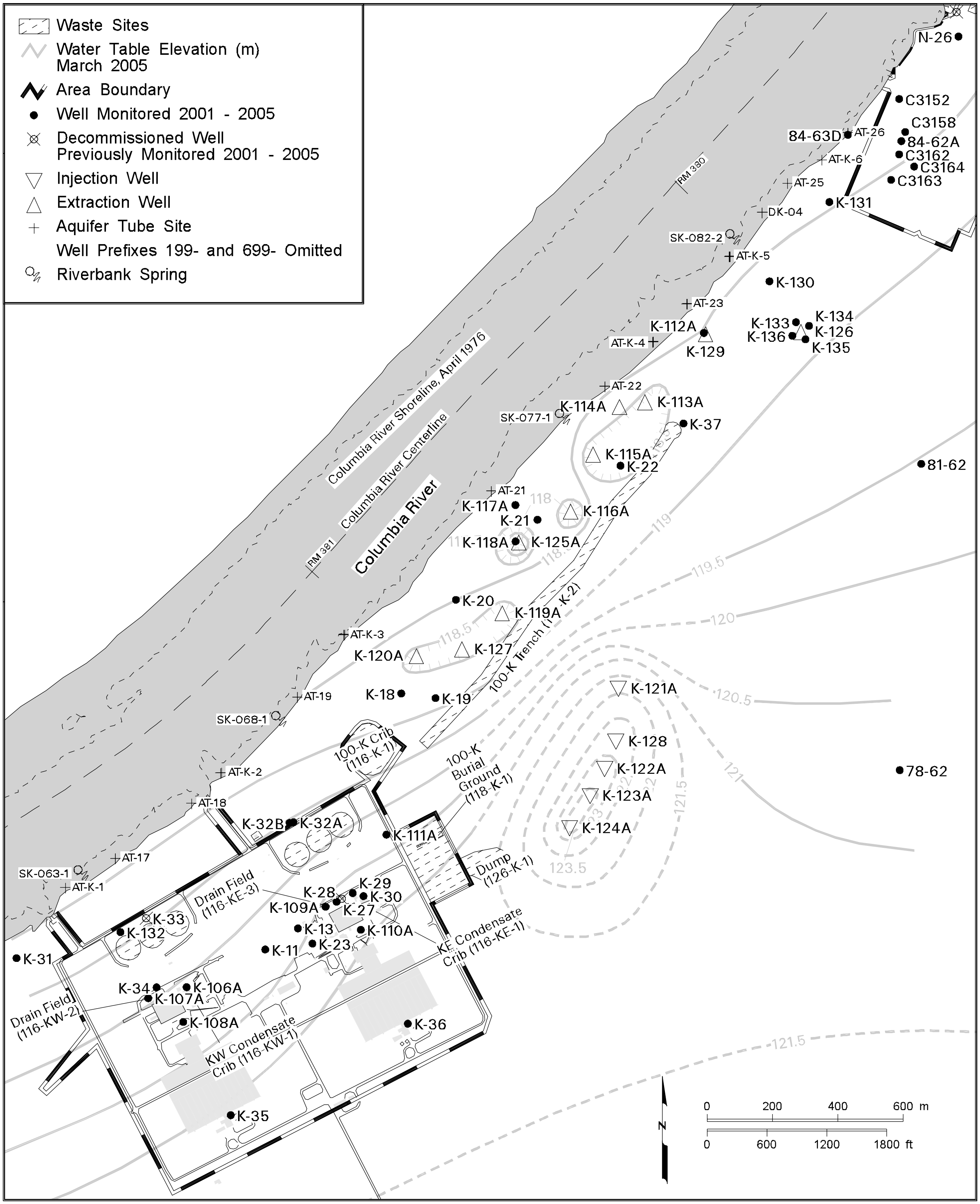

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Figure 2.3-1. Location Map for 100-K Area Facilities, Waste Sites, Monitoring Wells, and Shoreline Monitoring Sites

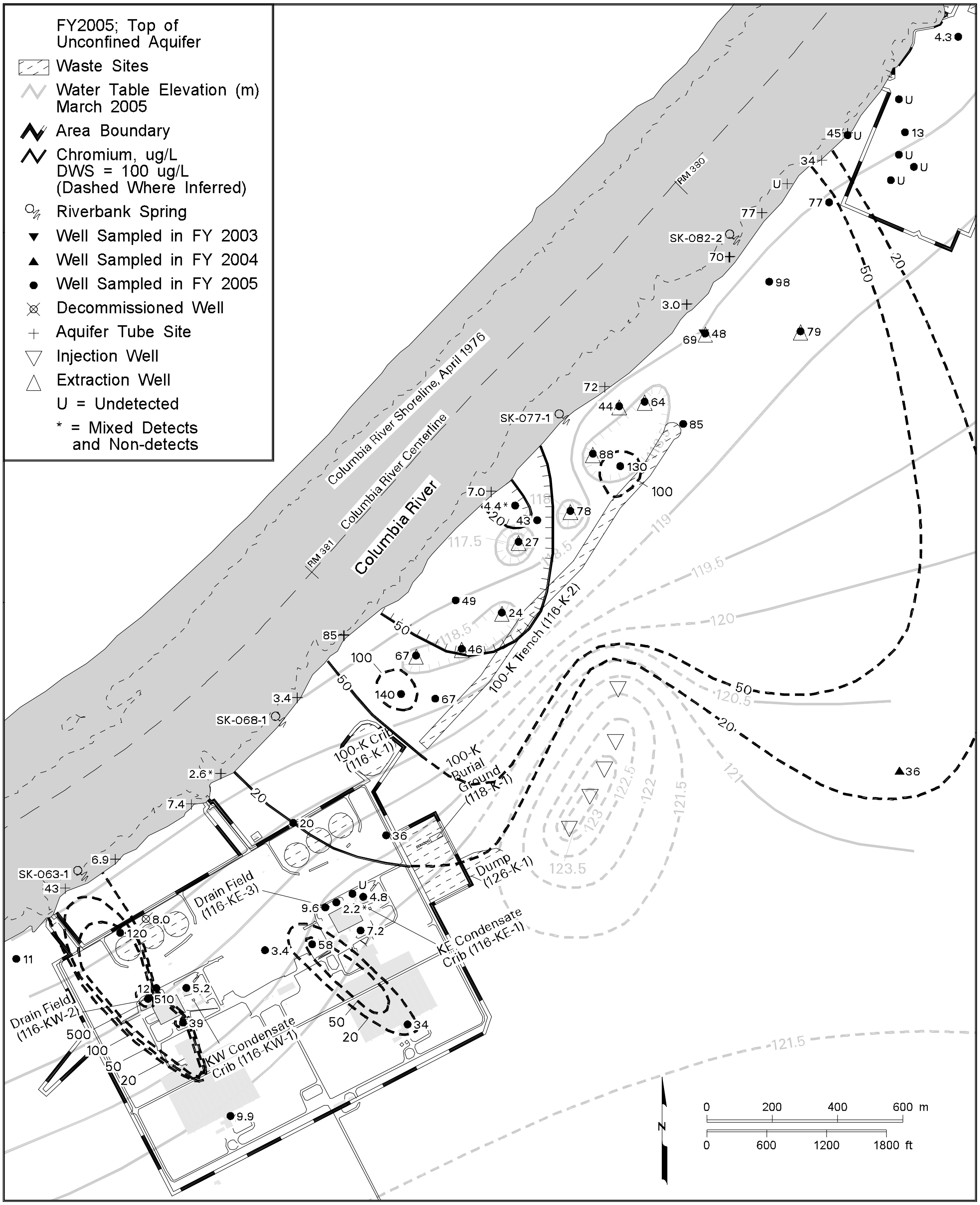

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Figure 2.3-2. Average Chromium Concentrations in 100-K Area Groundwater, Top of Unconfined Aquifer, FY 2005

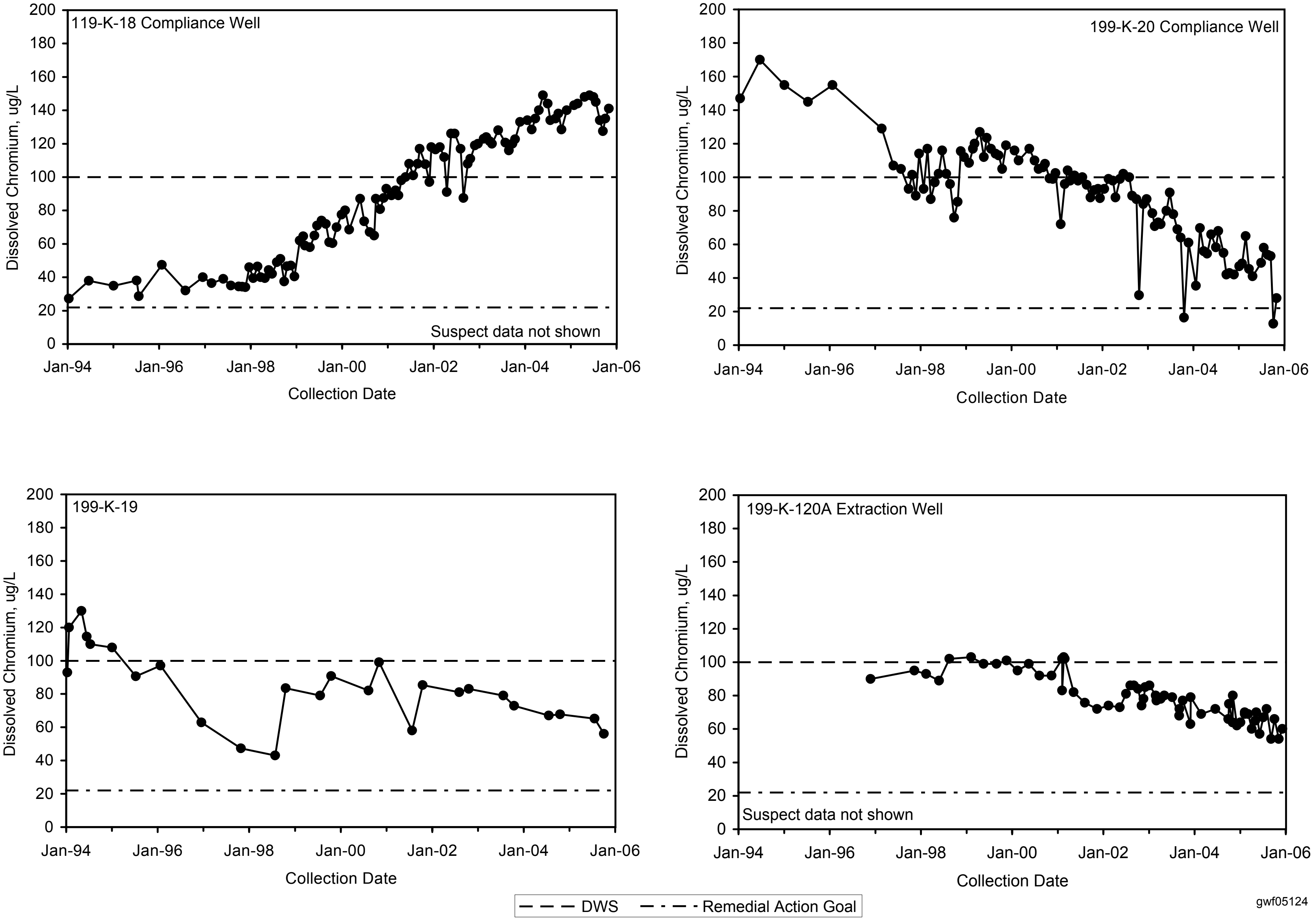

Figure 2.3-3. Chromium Concentrations in Wells Located at the Southwest Edge of the Interim Remedial Action Plume

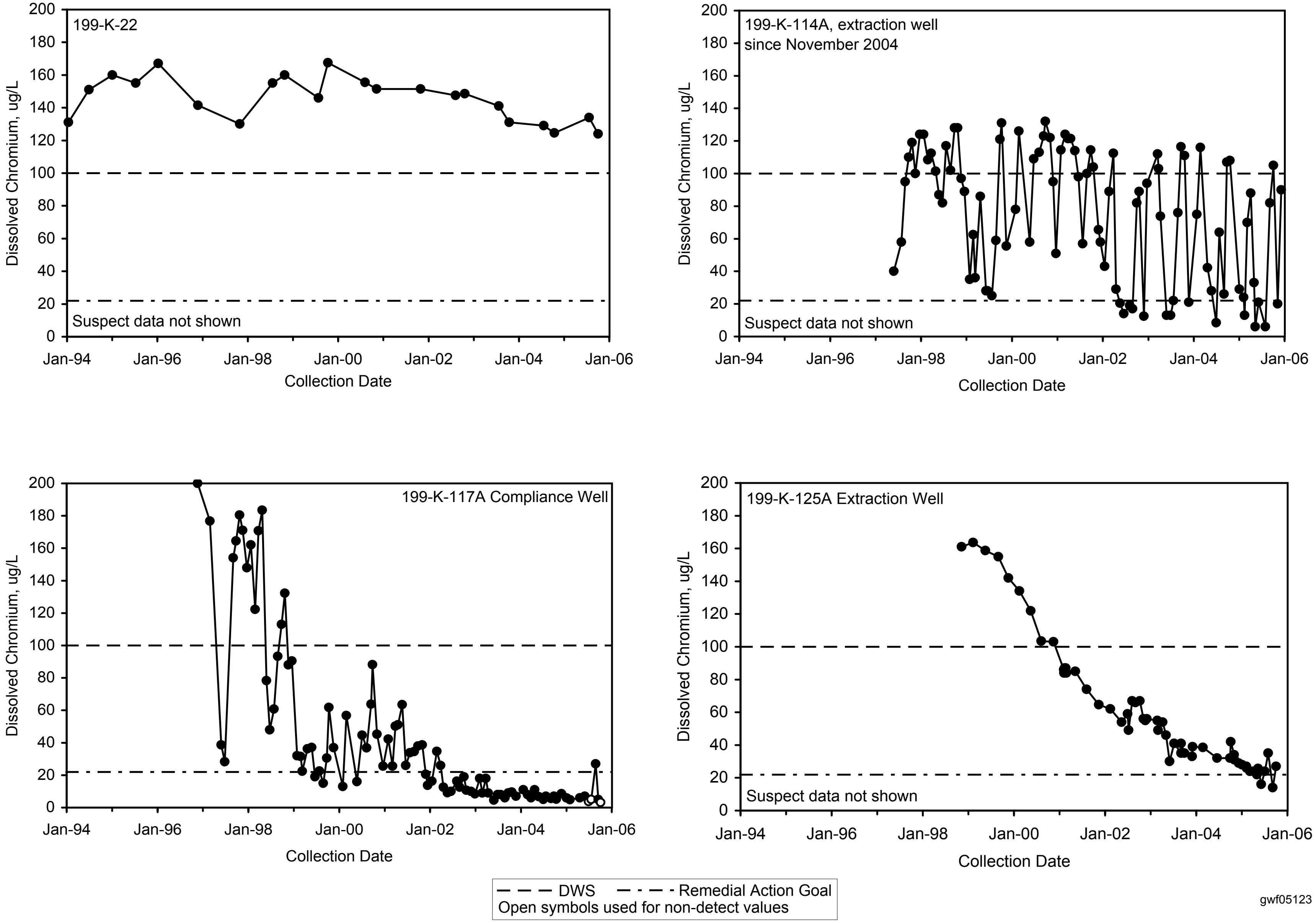

Figure 2.3-4. Chromium Concentrations in Wells Located in the Central Portion of the Interim Remedial Action Plume

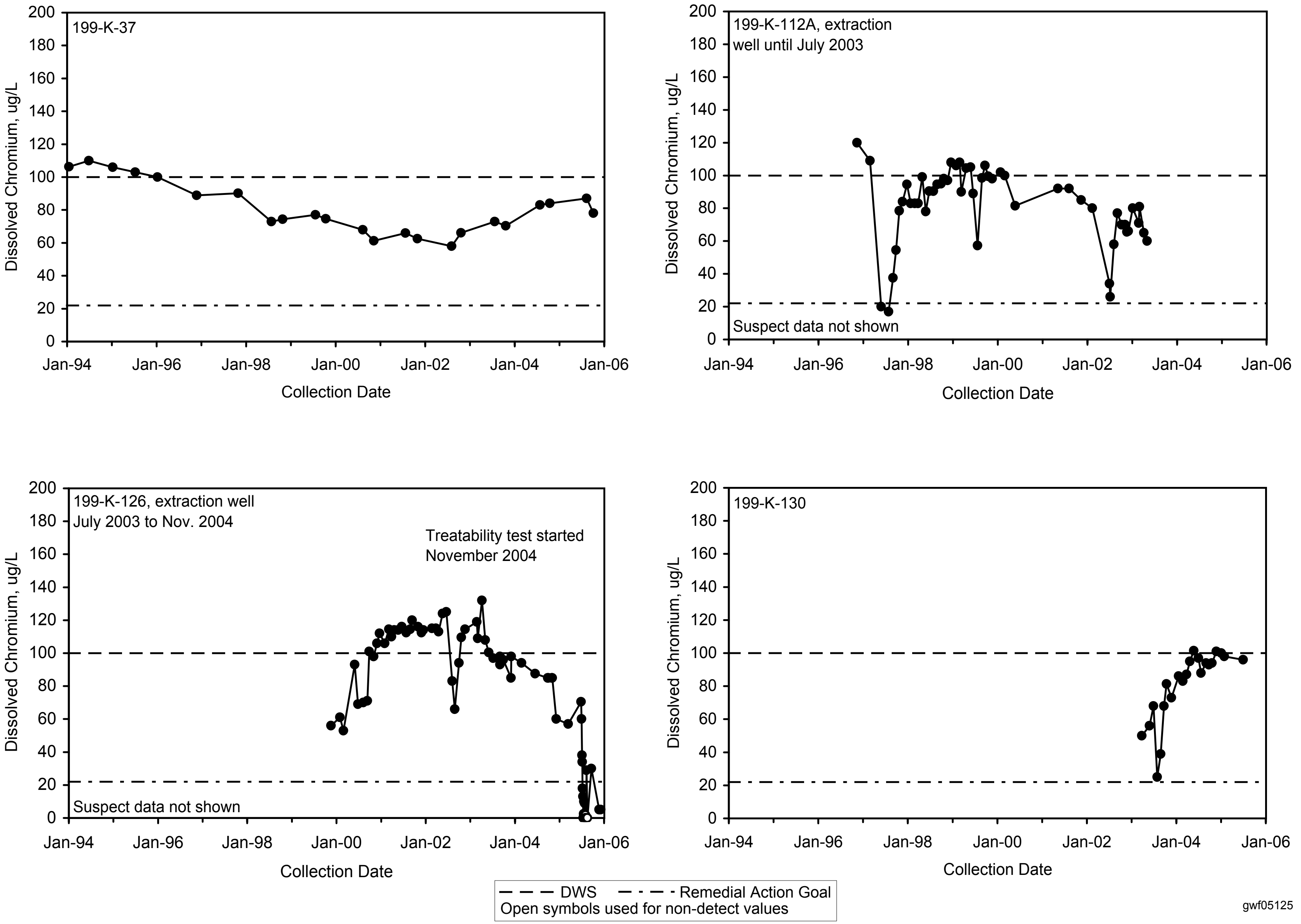

Figure 2.3-5. Chromium Concentrations in Wells Located at the Northeast Edge of the Interim Remedial Action Plume

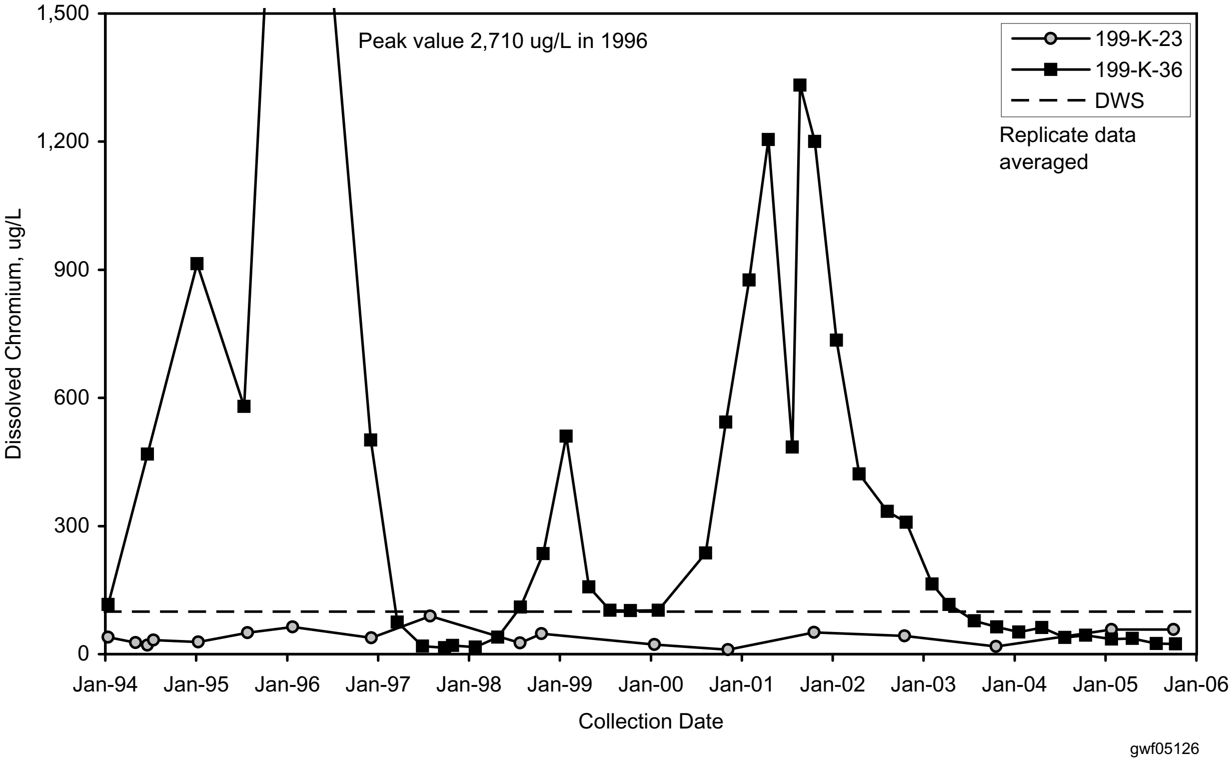

Figure 2.3-6. Chromium Concentrations Near KE Water Treatment Plant Basins

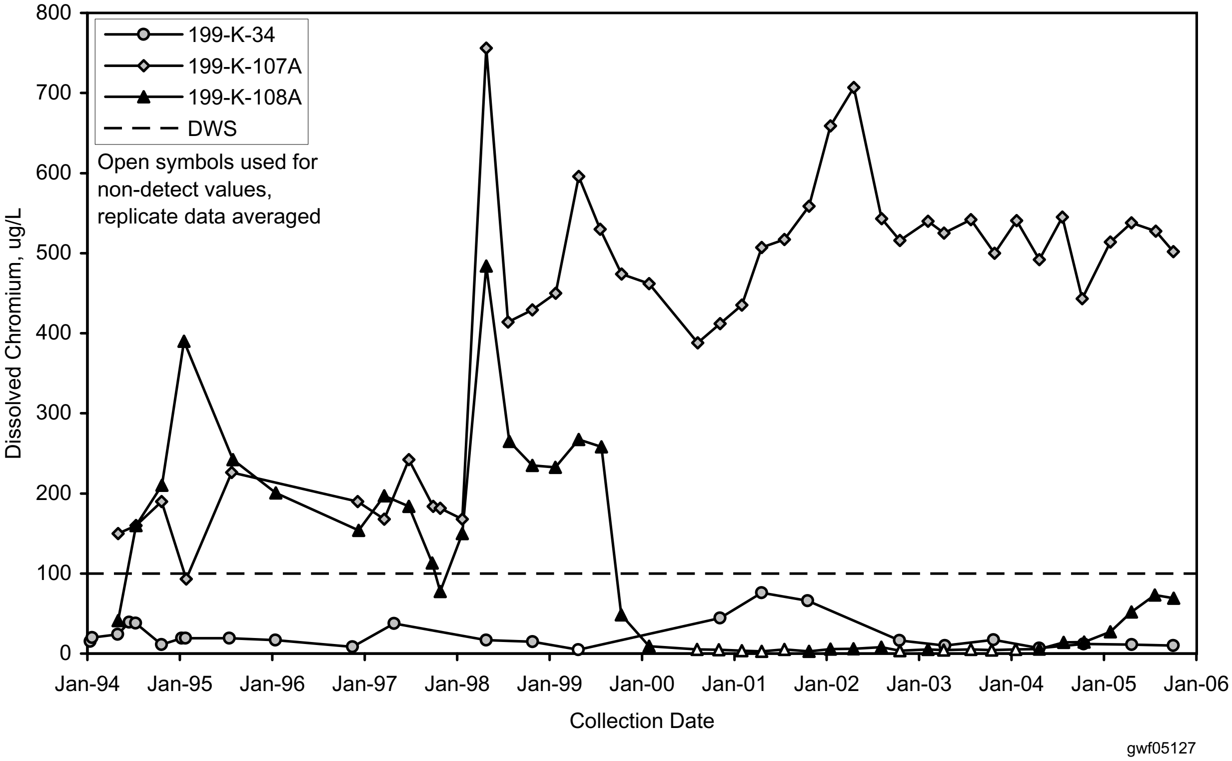

Figure 2.3-7. Chromium Concentrations Near KW Reactor

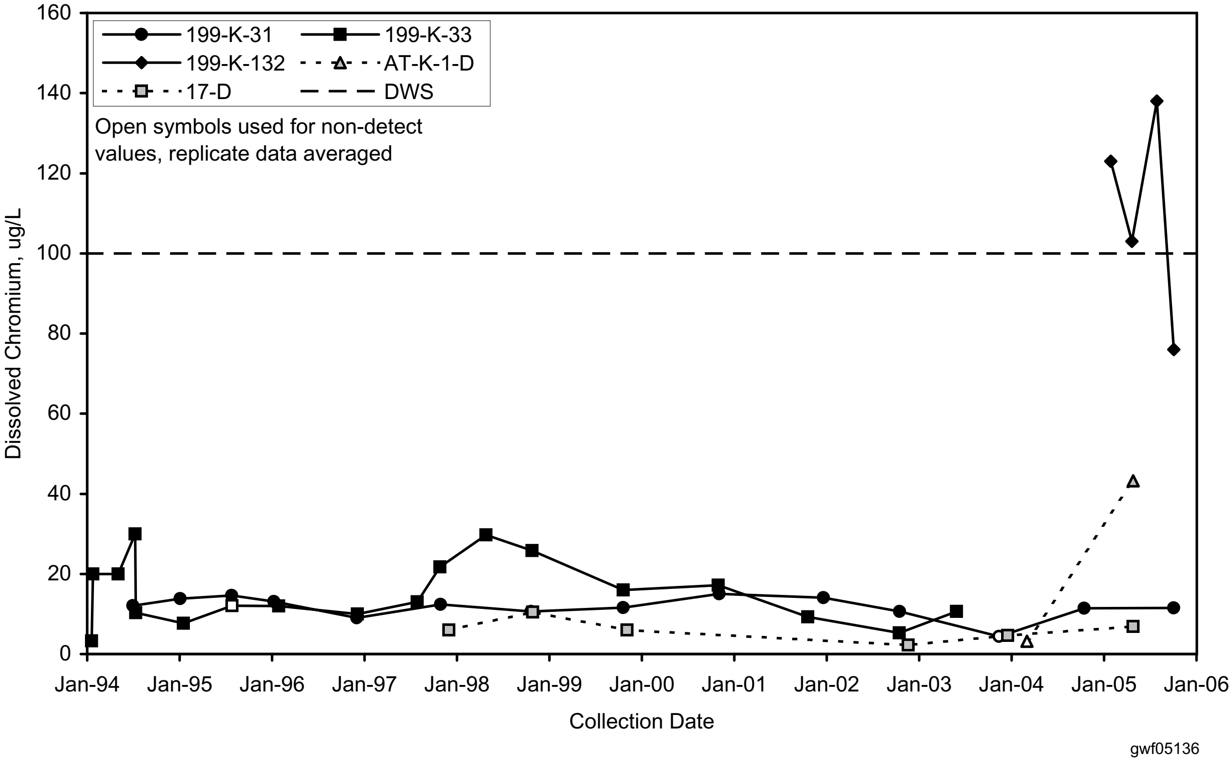

Figure 2.3-8. Chromium Concentrations Downgradient of the KW Reactor

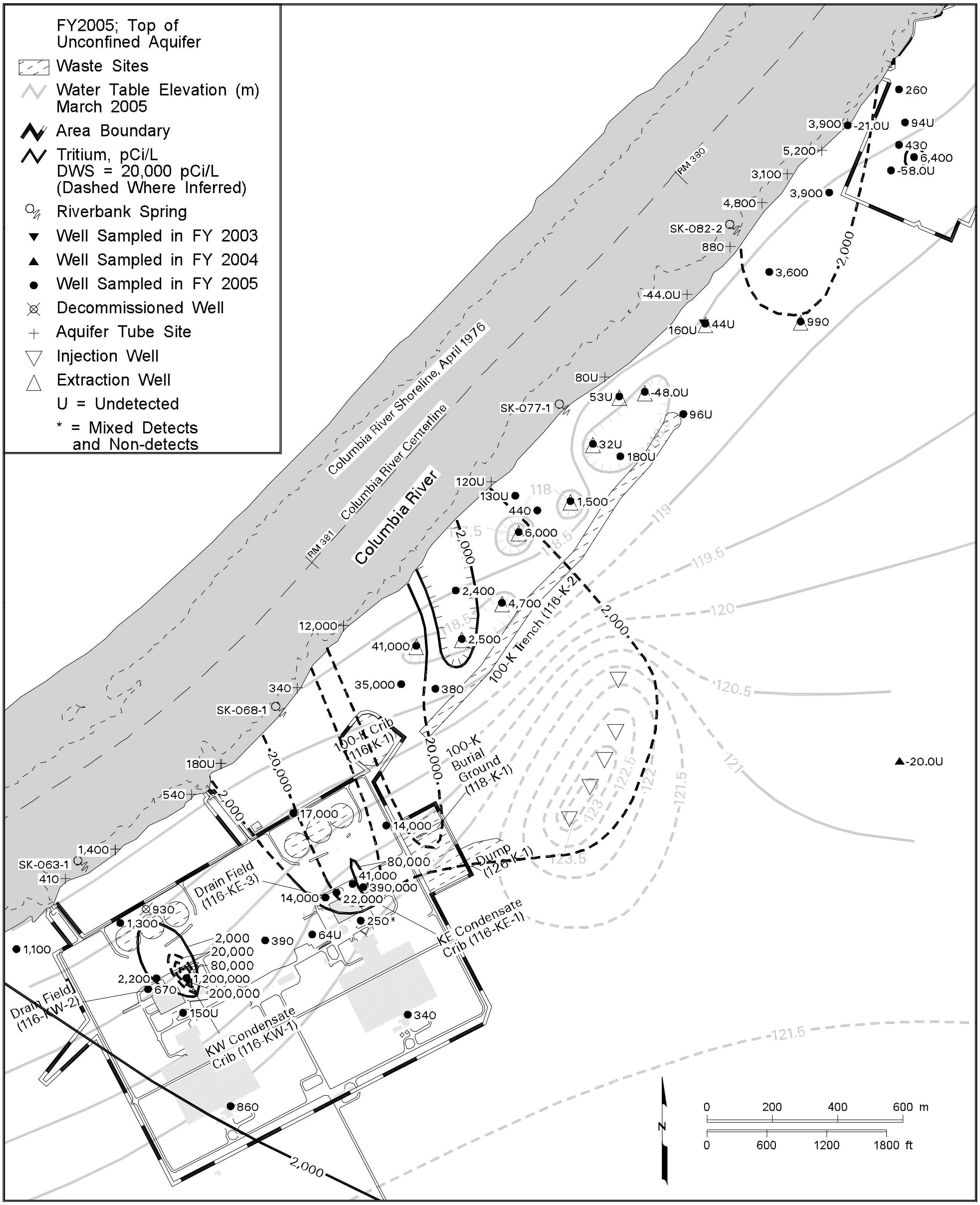

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Figure 2.3-9. Average Tritium Concentrations in 100-K Area Groundwater, Top of Unconfined Aquifer, FY 2005

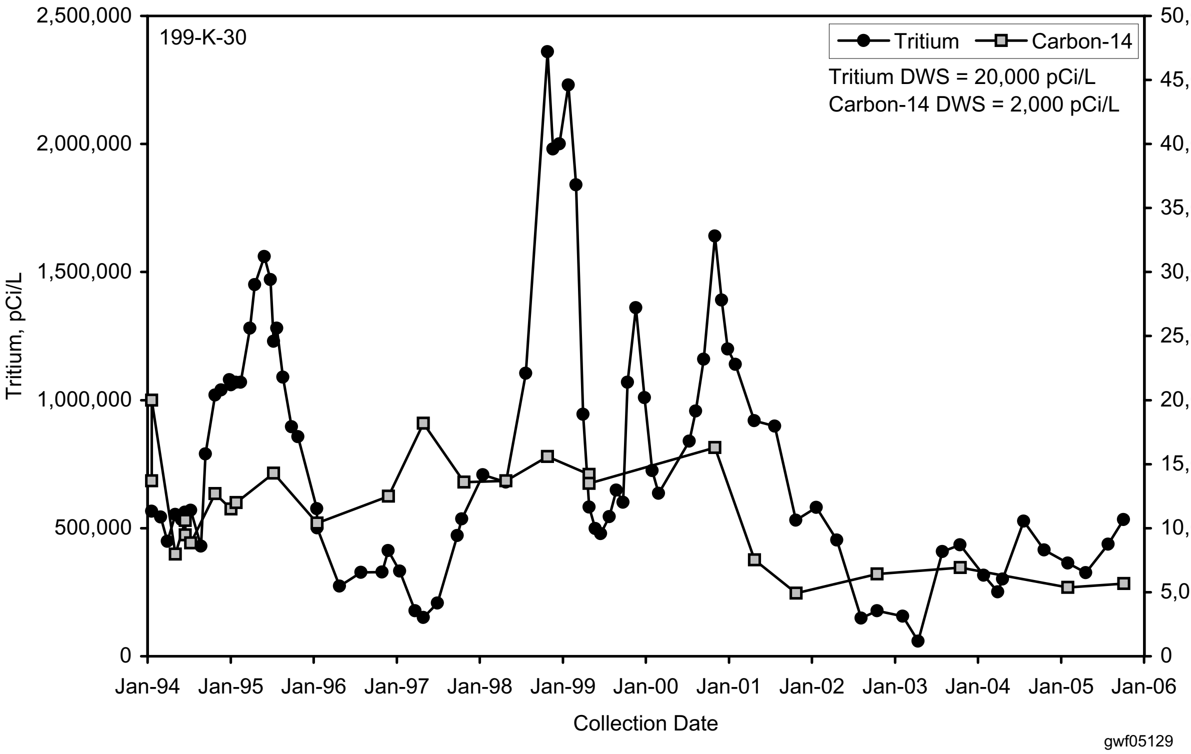

Figure 2.3-10. Tritium and Carbon-14 Concentrations Near the 116-KE-1 Crib

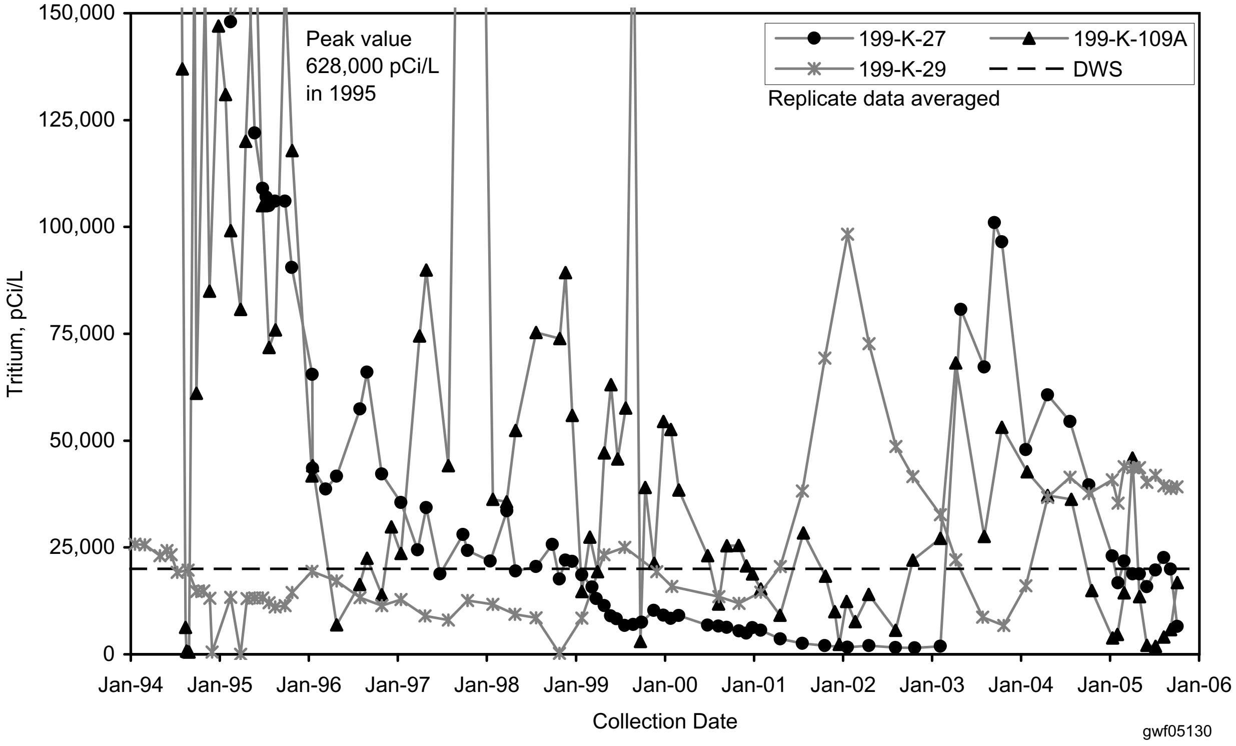

Figure 2.3-11. Tritium Concentrations Near KE Basin

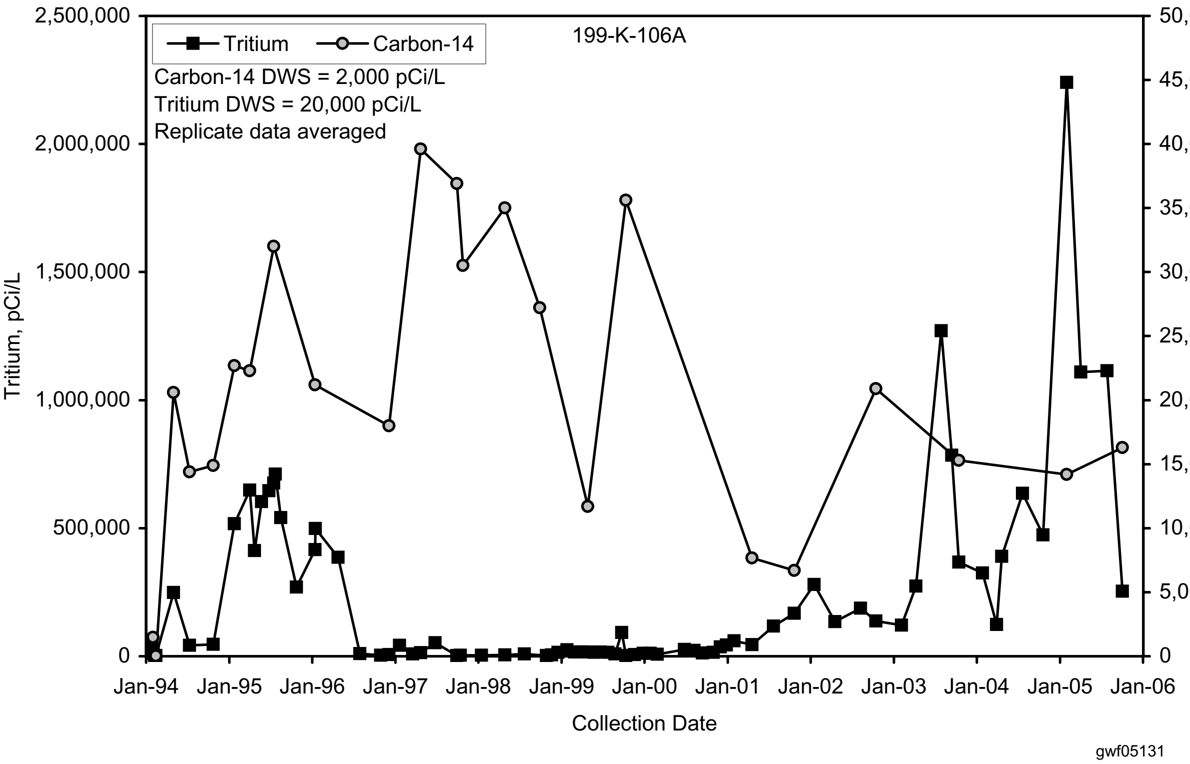

Figure 2.3-12. Tritium and Carbon-14 Concentrations Near the 116-KW-1 Crib

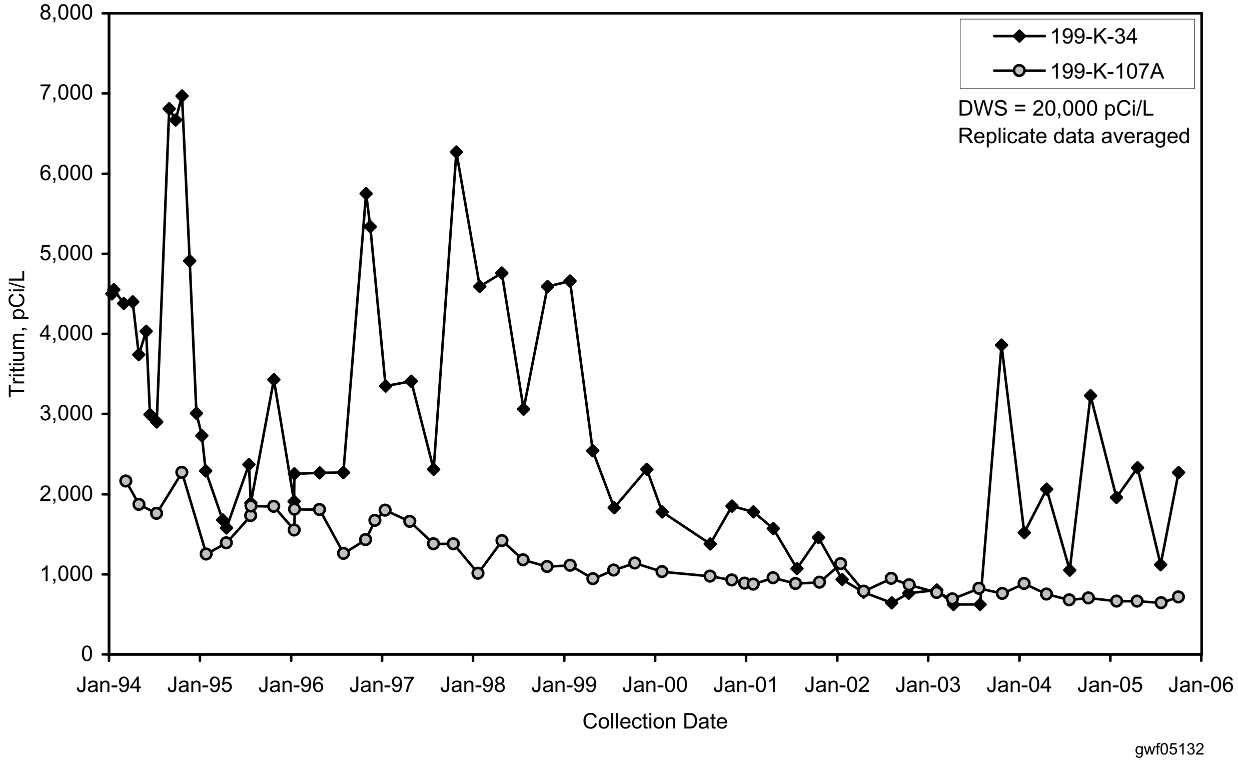

Figure 2.3-13. Tritium Concentrations Near KW Basin

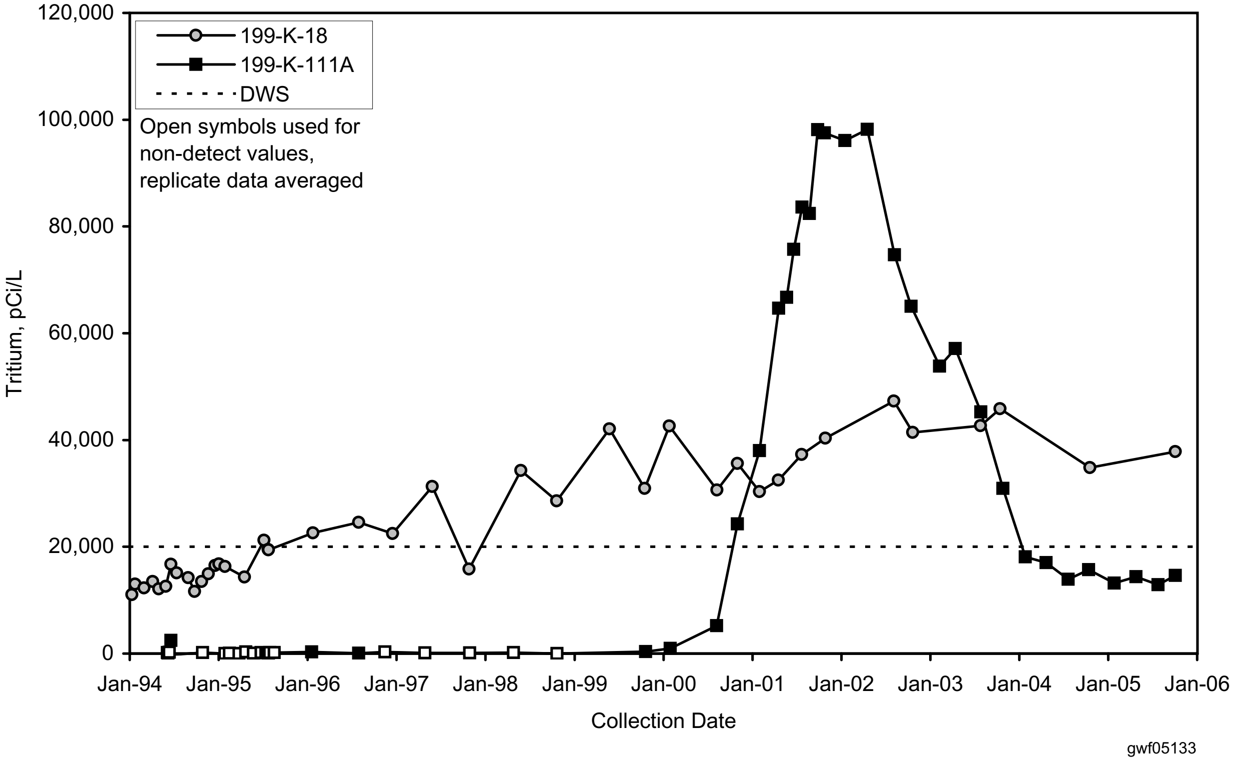

Figure 2.3-14. Tritium Concentrations Near 118-K-1 Burial Ground

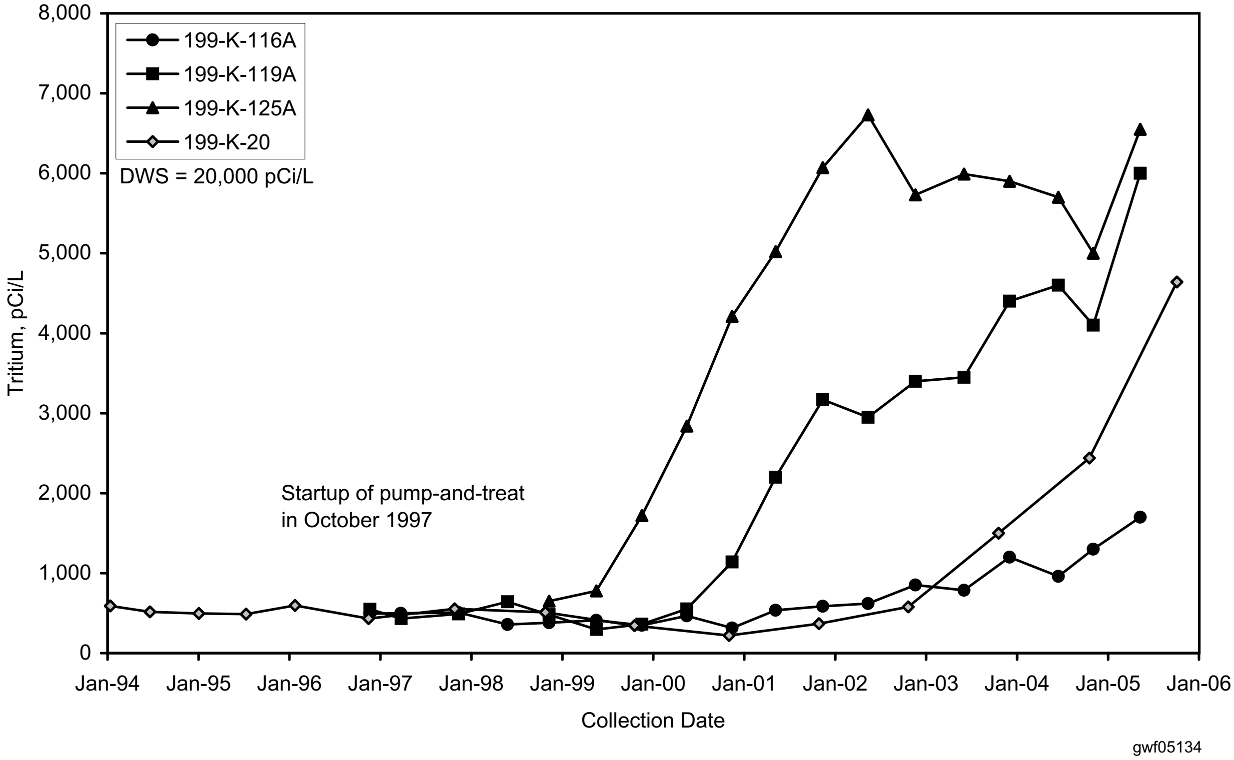

Figure 2.3-15. Tritium Concentrations in Wells Downgradient of the Pump-and-Treat Injection Site

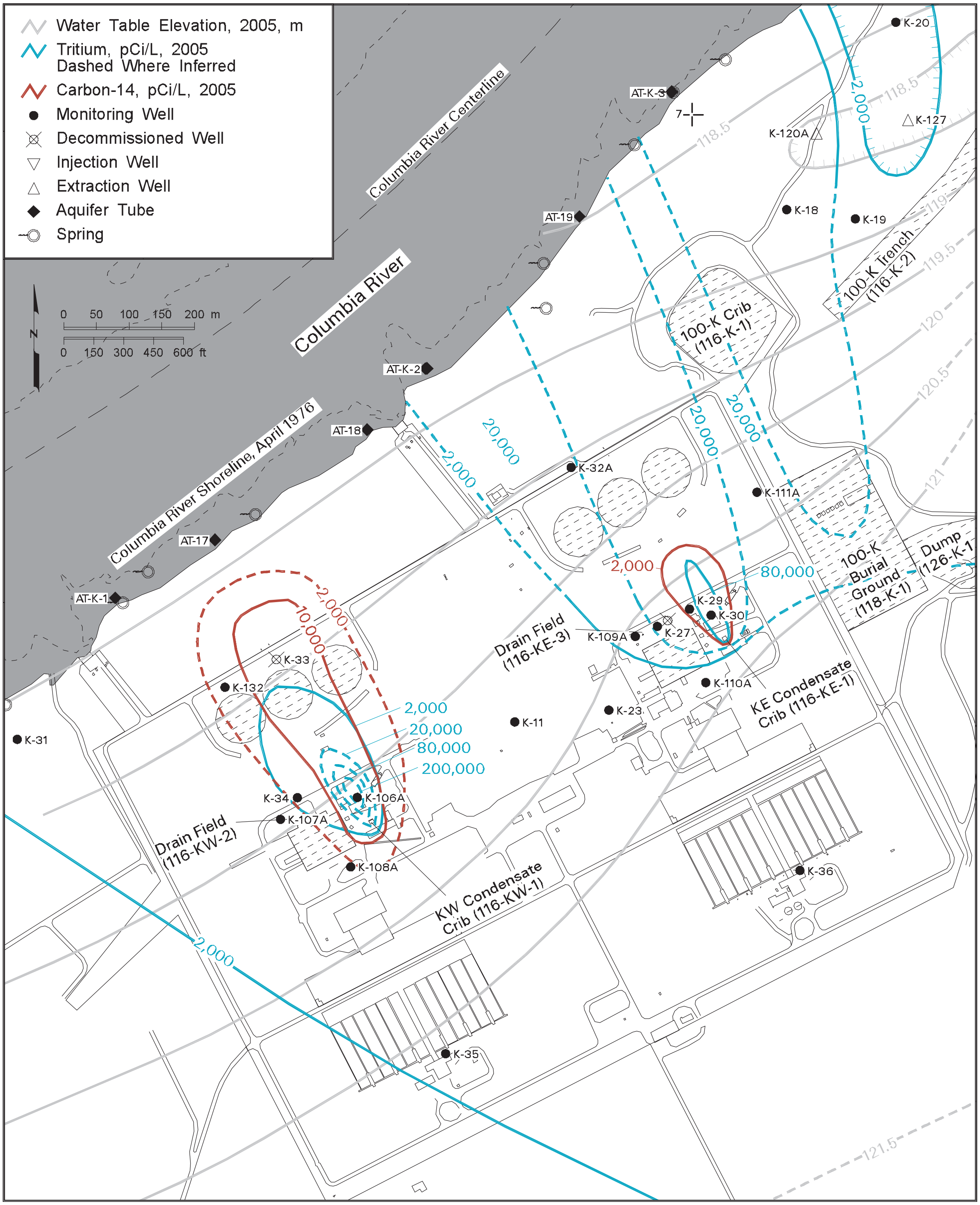

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Figure 2.3-16. Carbon-14 and Tritium Plumes Between KW and KE Cribs and the Columbia River

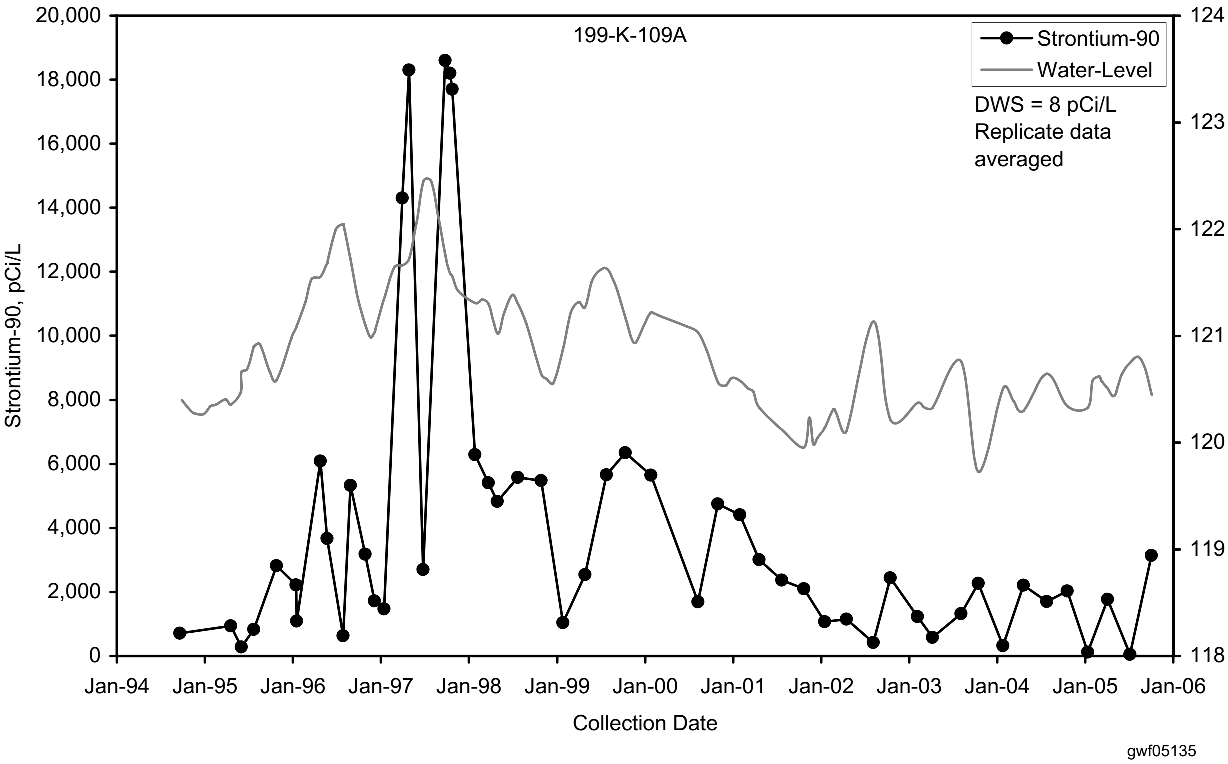


Figure 2.3-17. Strontium-90 Concentrations and Water-Table Elevation Near KE Basin

2.4 100-NR-2 Operable Unit

M. J. Hartman

The scope of this section is the 100-NR-2 groundwater interest area, which includes the 100-NR-2 Operable Unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined the "interest areas" informally to facilitate scheduling, data review, and interpretation. Figure 2.4-1 shows facilities and wells in this region and Figure 2.4-2 shows shoreline monitoring sites and wells in an area of particular interest for monitoring. Strontium-90 is the contaminant of greatest significance in groundwater at this operable unit. Groundwater is monitored to assess the performance of a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) interim action pump-and-treat system for strontium-90, to monitor three *Resource Conservation and Recovery Act* (RCRA) sites, and to track other contaminant plumes for the *Atomic Energy Act* (AEA).

Strontium-90 is the most significant groundwater contaminant beneath the 100-NR-2 Operable Unit. The general shape of the plume has not changed in many years.

Waste site remediation continued at the 116-N-1 crib and trench in FY 2005. The site was excavated to remove contaminated sediment to a depth of ~4.6 meters between September 2002 and October 2005. The 116-N-3 crib and trench were excavated to a depth of ~4.6 meters between June 2000 and August 2003, backfilled with clean soil in FY 2004 and 2005, and planted with native vegetation in December 2005. While excavations were underway, clean water was occasionally sprayed on the sites to control dust that could be an inhalation hazard for workers. The volume of dust-control water was minimized to reduce the likelihood that increased recharge would move contaminants from the vadose zone to groundwater.

Groundwater flows primarily to the north and northwest, toward the Columbia River (Figure 2.4-3). Water levels fluctuate with river stage and are also affected by groundwater extraction near the 116-N-1 liquid waste disposal facility (116-N-1 facility) and injection near the 116-N-3 liquid waste disposal facility (116-N-3 facility).

Groundwater monitoring in the 100-NR-2 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring

- ***Wells are sampled semiannually to annually for strontium-90 and co-contaminants.***
- ***In FY 2005, three wells were not sampled as scheduled (see Appendix A).***
- ***Shoreline monitoring was expanded in FY 2005.***

Facility Monitoring

- ***Five wells are sampled semiannually for the 116-N-1 liquid waste disposal facility for requirements of RCRA and AEA.***
- ***Five wells are sampled semiannually for the 120-N-1 percolation pond and 120-N-2 surface impoundment for requirements of RCRA and AEA.***
- ***Five wells were sampled semiannually for the 116-N-3 liquid waste disposal facility for requirements of RCRA.***
- ***In FY 2005, two RCRA wells were not sampled as scheduled (see text and Appendix B).***
- ***Monitoring is coordinated with other programs to avoid duplication.***

AEA Monitoring

- ***Wells sampled annually or triennially to track plumes, trends, and general chemistry.***
- ***Monitoring is coordinated with other programs to avoid duplication.***

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under AEA, CERCLA, or RCRA monitoring.

2.4.1 Groundwater Contaminants

This section describes distributions and trends for the contaminants of concern for the 100-NR-2 Operable Unit (ROD 1999b). In addition to the strontium-90 plume, contaminants of concern include tritium, nitrate, sulfate, petroleum hydrocarbons, manganese, and chromium.

2.4.1.1 Strontium-90

Data from aquifer tubes along the shoreline helped define details of the strontium-90 plume. A narrow finger of the plume at levels >1,000 pCi/L reaches the river.

The size and shape of the strontium-90 plume change very little from year to year, extending from beneath the 116-N-1 and 116-N-3 facilities to the Columbia River at levels above the drinking water standard (8 pCi/L) (Figure 2.4-4).

The U.S. Department of Energy (DOE) is studying the 100-N Area shoreline to evaluate alternative forms of remediation. An upcoming report on the results of a science and technology project will present additional details. This section summarizes some of the main points of the science and technology project.

New monitoring points (aquifer tubes) on the 100-N Area shoreline have allowed a detailed depiction of the strontium-90 plume in the area of greatest interest (Figure 2.4-5). The tubes range from 0.5 to 2.4 meters deep and are shallower than most aquifer tubes elsewhere on the Hanford Site. A narrow part of the strontium-90 plume at concentrations >1,000 pCi/L extends to the Columbia River. This part of the plume does not appear to extend very far beneath the river, but additional data are needed to confirm this conclusion.

Strontium-90 concentrations are highest in wells that monitor the upper part of the aquifer in the 100-N Area. Well pairs 199-N-67 and 199-N-69; 199-N-81 and 199-N-70 illustrate this distribution at locations near waste sources (see Figure 2.4-1 for well locations). Data from well cluster 199-N-119, 199-N-120, and 199-N-121 indicate the same distribution is present at the shoreline. Figure 2.4-6 shows strontium-90 in this cluster in June 2005, which is representative of the distribution seen throughout the year. Well 199-N-119, screened near the water table, had a strontium-90 concentration of 281 pCi/L, the mid-depth well 199-N-120 had 15.7 pCi/L, and well 199-N-121, completed at the bottom of the unconfined aquifer, had <1 pCi/L.

Figure 2.4-7 shows the vertical distribution of gross beta at the 100-N Area shoreline aquifer tube cluster NVP-1 in June and August 2005. The maximum concentrations were measured at an elevation of 115.7 meters. The samples collected in June and August had very similar gross beta concentrations despite the difference in river stage and higher specific conductance in August. Gross beta is analyzed in monthly samples at the 100-N Area shoreline as an indicator of strontium-90 because beta analyses cost less and require less sample volume. Strontium-90 decays to the beta emitter yttrium-90. Since yttrium-90 has a short half-life, it rapidly grows to the same activity as the strontium-90. Thus, the gross beta analysis measures twice the beta emissions as strontium-90. To estimate strontium-90 concentrations, gross beta results should be divided by two.

Figure 2.4-8 illustrates gross beta concentrations in aquifer tubes completed at multiple depths (measured monthly) from April 2004 through September 2005. The highest concentrations of contamination are in the mid-depth tubes. Concentrations in the B series tubes (farther from shore) are much lower than in the A series tubes. Concentrations of gross beta in the aquifer tubes varied by only a factor of ~2 throughout the year despite changes in river stage. Tube NS-3A-87cm showed the clearest trend, with the highest gross beta concentrations during periods of high river stage (June 2004 and June 2005). Specific conductance showed a similar trend.

Plume areas (square kilometers) above the drinking water standard at the 100-NR-2 Operable Unit:

Nitrate — 0.34
Strontium-90 — 0.58
Tritium — 0.27

This observation was not consistent with aquifer tubes elsewhere on the Hanford Site, where contaminant concentrations are diluted during periods of high river stage. Shoreline wells in the 100-N Area also show evidence of dilution during periods of high river stage.

Closer to the former waste sites, changes in strontium-90 concentrations vary directly with water level because strontium-90 from the vadose zone is mobilized by a high water table. Concentrations are highest in well 199-N-67 (Figure 2.4-9), where the maximum value in fiscal year (FY) 2005 was 9,710 pCi/L, exceeding the DOE derived concentration guide of 1,000 pCi/L (see Table 1.1-3).

The portion of the plume downgradient of the 116-N-1 facility is the focus of a pump-and-treat system that has been operating since 1995 (Section 2.4.2). Strontium-90 trends in extraction wells are shown in Figure 2.4-10. Extraction well 199-N-106A, located farthest north beyond the tail end of the trench, continued to have the highest concentrations in any of the extraction wells. Concentrations increased sharply in extraction well 199-N-105A, ending FY 2005 at 1,360 pCi/L compared to 277 pCi/L a year earlier. Because the increase occurred in September when the weather was dry and river stage was low, it does not appear to represent mobilization by a high water table or precipitation.

Nitrate concentrations continued to exceed the drinking water standard in FY 2005.

2.4.1.2 Tritium

The tritium plume has diminished in the years since effluent discharge to the 116-N-1 and 116-N-3 facilities ceased in 1991. The remaining plume extends from the south part of the 116-N-3 facility to the river to the northwest at levels above the drinking water standard (20,000 pCi/L) (see Figure 2.4-5 in PNNL-14548 for FY 2003 plume map). Tritium contamination is observed throughout the upper aquifer and also in well 199-N-80, which monitors a confined aquifer in the Ringold Formation. The maximum concentration in FY 2005 was 28,100 pCi/L in well 199-N-67, an increase from the previous year. Tritium was not detected in shoreline aquifer tubes in FY 2005.

2.4.1.3 Nitrate

Nitrate concentrations exceed the drinking water standard (45 mg/L) beneath a portion of the 100-N Area. The extent of the plume in FY 2005 did not change significantly from the previous year (see Figure 2.4-8 in PNNL-15070 for the FY 2004 map). The highest nitrate concentrations in FY 2005 were again in well 199-N-67 near the 116-N-1 facility, with a maximum concentration of 238 mg/L.

Figure 2.4-11 shows nitrate trend plots for wells near the 116-N-1 and 116-N-3 facilities for their entire period of record. The 116-N-1 facility was in use through 1985 and the 116-N-3 facility was in use from 1983 to 1991. Nitrate concentrations were high in the mid-1980s in both wells and declined sharply by 1990. Recent concentrations have returned to levels observed in the mid-1980s.

Near the 120-N-1 percolation pond in south 100-N Area, nitrate concentrations also increased in the 1990s (Figure 2.4-12). During the pond's period of use (1977 to 1990), only low levels of nitrate (~1 mg/L) were detected in effluent to the facility (see Appendix B of DOE/RL-96-39). Monitoring began in 1987 and nitrate concentrations in groundwater were also low (1 to 4 mg/L). Nitrate levels exceeded the drinking water standard in well 199-N-59 from 1998 to 2002, which was the last time the well could be sampled. Nearby well 199-N-72 showed a sharp increase in nitrate in FY 2004 and 2005, exceeding the drinking water standard in March 2005.

Anomalously low nitrate concentrations continued to be observed in well 199-N-18 (undetected). The low concentrations are believed to be caused by chemical reduction of the nitrate caused by biodegradation of hydrocarbons (Section 2.4.1.5). Other chemical constituents and parameters also support the interpretation of chemical reduction around well 199-N-18: low dissolved oxygen, low pH, detectable nitrite, and high concentrations of metals (especially iron and manganese).

2.4.1.4 Sulfate

The former 120-N-1 percolation pond introduced sulfate and sodium to 100-N Area groundwater. Sulfate concentrations remained elevated in groundwater north and northwest of the 120-N-1 site (Figure 2.4-13). A second area of elevated sulfate concentrations underlies the 116-N-3 trench. This contamination is residual from previous flow conditions that carried sulfate from the 120-N-1 percolation pond inland and then toward the north.

The highest sulfate concentration in FY 2005 was 200 mg/L in well 199-N-3, at the north edge of the main plume. Levels have been steady in well 199-N-3 since 2002. The secondary drinking water standard for sulfate is 250 mg/L.

2.4.1.5 Petroleum Hydrocarbons

Petroleum hydrocarbons continued to be detected in 100-N Area groundwater, but concentrations declined.

Petroleum hydrocarbons from a 1960s diesel fuel leak (DOE/RL-95-111) continued to be detected in 100-N Area groundwater. Of the affected wells, 199-N-18 is closest to the former leak site and had the highest levels of groundwater contamination. The maximum FY 2005 result for total petroleum hydrocarbons in the diesel range was 69 mg/L, a decrease from 340 mg/L in FY 2004.

Evidence of low levels of hydrocarbon contamination has been observed in wells 199-N-3, 199-N-19, and 199-N-96A in the past (PNNL-14187, Section 2.4). These wells are located near well 199-N-18 and may be influenced by contamination from the same source. In FY 2005, total petroleum hydrocarbons were undetected. Total organic carbon declined in wells 199-N-3 (1,850 µg/L) and 199-N-96A (2,300 µg/L).

Near the N Reactor building, well 199-N-16 also has evidence of petroleum contamination, believed to be from a separate past source. Total petroleum hydrocarbons (diesel) was measured at up to 11 mg/L in September 2005, an increase from the previous year.

2.4.1.6 Manganese and Iron

Manganese continued to exceed its secondary drinking water standard (50 µg/L) in two wells affected by petroleum contamination: 199-N-16 (927 µg/L) and 199-N-18 (3,630 µg/L). Iron also exceeded its secondary drinking water standard (300 µg/L) in well 199-N-18 (19,900 µg/L). Biodegradation of the hydrocarbons creates reducing conditions, which increases the solubility of metals such as manganese and iron from the well casing or aquifer sediment.

Manganese and iron are elevated in some samples from the three clusters of aquifer tubes that are made of galvanized steel (NS-2A, NS-3A, and NS-4A). The metals are believed to reflect tube construction materials and are not representative of groundwater.

2.4.1.7 Chromium

Only one well in the 100-N Area has chromium concentrations above the drinking water standard (100 µg/L). Well 199-N-80, which is completed in a thin, confined aquifer in the Ringold Formation, had a maximum chromium concentration in FY 2005 of ~181 µg/L in a field-filtered sample. The source for chromium in this deep horizon is unknown.

2.4.2 Interim Groundwater Remediation for Strontium-90

A pump-and-treat system has been operating in the 100-N Area since 1995 as part of a CERCLA interim action for the 100-NR-2 Operable Unit (ROD 1999b). The monitoring requirements for the pump-and-treat system at this operable unit are specified by Tri-Party

Agreement Change Control Form M-15-96-08 as modified by Fluor Hanford, Inc.[(a)] Wells, constituents, and sampling frequencies for interim action monitoring are shown in Appendix A. During FY 2005, one well was not sampled as scheduled and sampling was delayed in two wells.

DOE continued supplemental monitoring of the shoreline area affected by the pump-and-treat system in FY 2005 to establish a baseline of monthly sampling results prior to initiating a treatability test to evaluate an alternative remedial action (see Section 2.4.2.2). The supplemental monitoring program, which is not described in a formal monitoring plan, is summarized in Appendix A. Results are integrated with the discussion of strontium-90 in Section 2.4.1.1.

In FY 2006, DOE will conduct a treatability test of a passive remediation barrier designed to sequester strontium-90 in the aquifer.

2.4.2.1 Progress During FY 2005

The pump-and-treat system has not affected the distribution or concentration of strontium-90 in the aquifer to any observable extent. The extraction wells create a hydraulic sink between the 116-N-1 facility and the Columbia River and, thus, reduce or reverse the hydraulic gradient in the groundwater toward the Columbia River. The reduction or reversal of the hydraulic gradient results in less groundwater and strontium-90 discharging to the Columbia River through the N Springs area. However, the pump-and-treat system is not capable of completely controlling the water discharged because of the cyclical river stage and bank storage effects of the Columbia River.

During FY 2005, the system extracted ~106 million liters of contaminated water and removed ~0.1 curie of strontium-90. The total amount removed since the system began to operate in 1994 is ~1.7 curies.

Additional details on the pump-and-treat system and operational data for calendar year 2004 are available in DOE/RL-2005-18. An upcoming report will present results for calendar year 2005.

2.4.2.2 Influence on Aquifer Conditions

The extraction wells have created an area of lower strontium-90 concentrations between the 116-N-1 trench and the Columbia River (see Figure 2.4-4). However, this area does not represent significant clean up of the aquifer. The low concentrations are believed to be caused by (a) drawdown of the water table (strontium-90 concentrations are highest at the top of the aquifer and in the vadose zone); and (b) dilution with river water drawn in by pumping.

Figure 2.4-10 shows strontium-90 concentrations with time in 100-N Area extraction wells. Concentrations vary in response to a fluctuating water table and other changes in groundwater flow, but there are no clear upward or downward trends overall.

Because the pump-and-treat system has been ineffective in reducing strontium-90 concentrations in groundwater that reaches the river, alternative treatment methods are being evaluated. Laboratory studies of strontium-90 sequestration by apatite continued during FY 2005. Favorable results for one approach led to the decision to prepare a treatability

The remedial action objectives in the 100-NR-2 Operable Unit (ROD 1999b) are:

- *Protect the Columbia River from the adverse impact of groundwater contamination by limiting exposure pathways, reducing or removing sources, controlling groundwater movement, or reducing the concentration of contaminants.*
- *Protect the unconfined aquifer by implementing remedial actions that reduce the concentration of contaminants.*
- *Obtain information to evaluate technologies to remove strontium-90 and evaluate the impact to ecological receptors.*
- *Prevent destruction of sensitive wildlife habitat and minimize the disruption of cultural resources.*

During their 5-year review (EPA 2001), EPA added a requirement for DOE to investigate alternative remedial action technologies for strontium-90.

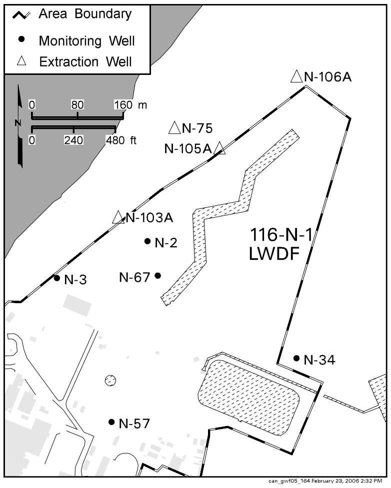
(a) Letter FH-0402972 from H Hermanas and BH Ford (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.

test plan for a field test and installation of a 91-meter barrier in FY 2006. The barrier will be placed where the highest concentrations of strontium-90 in aquifer tubes and in clam tissue have been observed. The goal is to create a permeable, reactive barrier near the shoreline that will capture strontium-90 as groundwater flows to the river through a treatment zone created by injection of apatite-forming chemicals.

2.4.3 Facility Monitoring

This section describes results of monitoring individual facilities: the 116-N-1 and 116-N-2 liquid waste disposal facilities, 120-N-1 percolation pond, and 120-N-2 surface impoundment. Groundwater is monitored at these facilities to meet the requirements of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations for each facility. As discussed in Section 2.1, pursuant to RCRA units, DOE has sole and exclusive responsibility and authority to regulate source, special nuclear, and by-product materials. Groundwater data for these facilities are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

2.4.3.1 116-N-1 (1301-N) Liquid Waste Disposal Facility



This facility contaminated groundwater with radionuclides during its period of use in the 1960s through 1985. Strontium-90 and tritium concentrations in groundwater exceed drinking water standards. Results of monitoring were discussed in Section 2.4.1. The facility has been excavated to remove shallow vadose zone sediment, where most of the radionuclide contamination resides, and will be backfilled. Wells downgradient of the 116-N-1 facility are sampled quarterly to semiannually for strontium-90 and semiannually for gamma activity. The only gamma-emitters detected in FY 2005 were cesium-137 (3.02 ± 3.0 pCi/L) and cobalt-60 (11.5 ± 3.6 pCi/L) in well 199-N-67 in June 2005. No cesium-137 or cobalt-60 were detected in well 199-N-67 in samples collected in March or September. Strontium-90 concentrations increased in well 199-N-105A in September 2005 and were within historical ranges (see Figure 2.4-10).

This facility is included in the Hanford Facility RCRA Permit (Ecology 1994a). The closure plan (see Appendix A of DOE/RL-96-39) states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan and a supplemental plan (PNNL-13914) are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

Groundwater flows to the northwest beneath the 116-N-1 facility, discharging to the Columbia River. The hydraulic gradient in March 2005 was 0.0033, and flow rate was estimated to be between 0.07 to 1.2 meter/day (Appendix B).

Upgradient and downgradient wells were sampled twice in FY 2005 for contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and once for groundwater quality and site-specific parameters, as planned (see Appendix B).

Average specific conductance in downgradient well 199-N-3 continued to exceed the critical mean value in March and September 2005. Prior assessment results (WHC-SD-EN-EV-003) indicated the elevated specific conductance is related to constituents from the 120-N-1 percolation pond. Total organic halides in upgradient well 199-N-34 were anomalously high in September 2005 were flagged as suspect. Other indicators remained below critical mean values in FY 2005. The site will remain in detection monitoring and there are no plans to modify the network in FY 2006. Upgradient/downgradient comparison values for indicator parameters have been revised based on recent data for use in FY 2006 comparisons (see Appendix B).

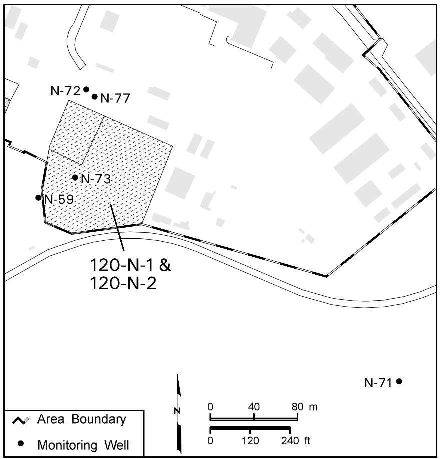
2.4.3.2 120-N-1 (1324-NA) Percolation Pond and 120-N-2 (1324-N) Surface Impoundment

These facilities were used to treat and dispose of corrosive, non-radioactive waste from 1977 to 1990. They have been remediated and backfilled.

These facilities are included in the Hanford Facility RCRA Permit (Ecology 1994a). The closure plan (see Appendix B of DOE/RL-96-39) states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan, and a supplemental plan (PNNL-13914), are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

Groundwater flows to the northwest beneath the 120-N-1 and 120-N-2 facilities, discharging to the Columbia River. The hydraulic gradient in March 2005 was 0.0037, and flow rate was estimated to be between 0.07 to 1.4 meter/day (Appendix B).

During FY 2005, four of the five monitoring wells for this site were sampled twice for contamination indicator parameters and groundwater quality and site-specific parameters, as planned (see Appendix B). Downgradient well 199-N-59 contained too little water to sample in 2005.



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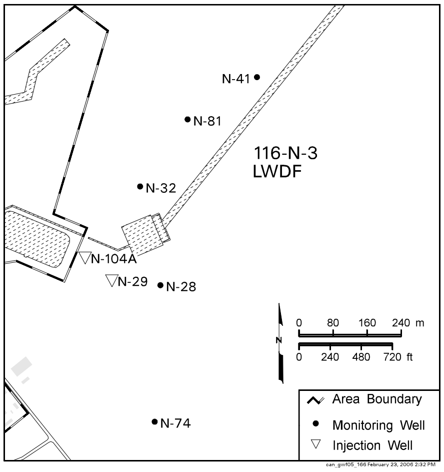
Average specific conductance values in wells downgradient of the facilities continued to exceed the critical mean values in FY 2005. A previous groundwater quality assessment indicated that the high specific conductance is caused by sulfate and sodium (WHC-SD-EN-EV-003), which are not listed hazardous waste constituents. Because an assessment has already been completed and non-listed constituents caused the high conductance, detection monitoring has continued.

The average of quadruplicate results for total organic halides in downgradient well 199-N-72 (23.95 µg/L) exceeded the critical mean value (21.8 µg/L) in June 2005. However, the data showed a large variability among replicates: 16.8, 17.9, 27.7, and 33.4 µg/L. The two high values were out of trend. Project-wide data indicate laboratory problems with total organic halides analyses (see Appendix C), so the two high values were flagged as suspect and no confirmation sampling was scheduled. The site remained in detection monitoring. Other indicators remained below critical mean values in FY 2005, and there are no plans to modify the network in FY 2006. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in FY 2006 comparisons (see Appendix B).

2.4.3.3 116-N-3 (1325-N) Liquid Waste Disposal Facility

This facility contaminated groundwater with radionuclides during its period of use from 1983 to 1991. Strontium-90 and tritium concentrations in groundwater exceed drinking water standards. Results of monitoring were discussed in Section 2.4.1. The facility was excavated to remove the shallow vadose zone material, which contains the highest concentrations of radionuclides. The site was backfilled with clean soil in FY 2005. Well 199-N-81 was monitored for strontium-90 and gamma semiannually to look for potential impacts of source remediation and dust control on groundwater. Gamma emitters continued to be undetected in FY 2005, and strontium-90 concentrations continued in established ranges.

This facility is included in the Hanford Facility RCRA Permit (Ecology 1994a). The closure plan (Appendix A of DOE/RL-96-39) states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan,



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and a supplemental plan (PNNL-13914), are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

Groundwater flows to the north beneath the 116-N-3 facility, then turns to the northwest and discharges to the Columbia River. The hydraulic gradient in March 2005 was 0.0021, and flow rate was estimated to be between 0.04 to 0.77 meter/day (Appendix B).

During FY 2005, four of the five wells were sampled twice for contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and once for groundwater quality and site-specific parameters, as planned (see Appendix B). The remaining well, 199-N-32, could only be sampled once because of access restrictions.

Average specific conductance values in downgradient wells 199-N-32, 199-N-41, and 199-N-81 continued to exceed the critical mean value, although levels are declining. This was a continuation of previous exceedances noted in 1999 through 2004. DOE notified Washington State Department of Ecology of that original exceedance and submitted an assessment report that concluded the exceedance was caused by past discharges to the 120-N-1 percolation pond. Detection monitoring will continue in FY 2006. Other indicators remained below critical mean values in FY 2005 and there are no plans to modify the network during FY 2006. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in FY 2006 (see Appendix B).

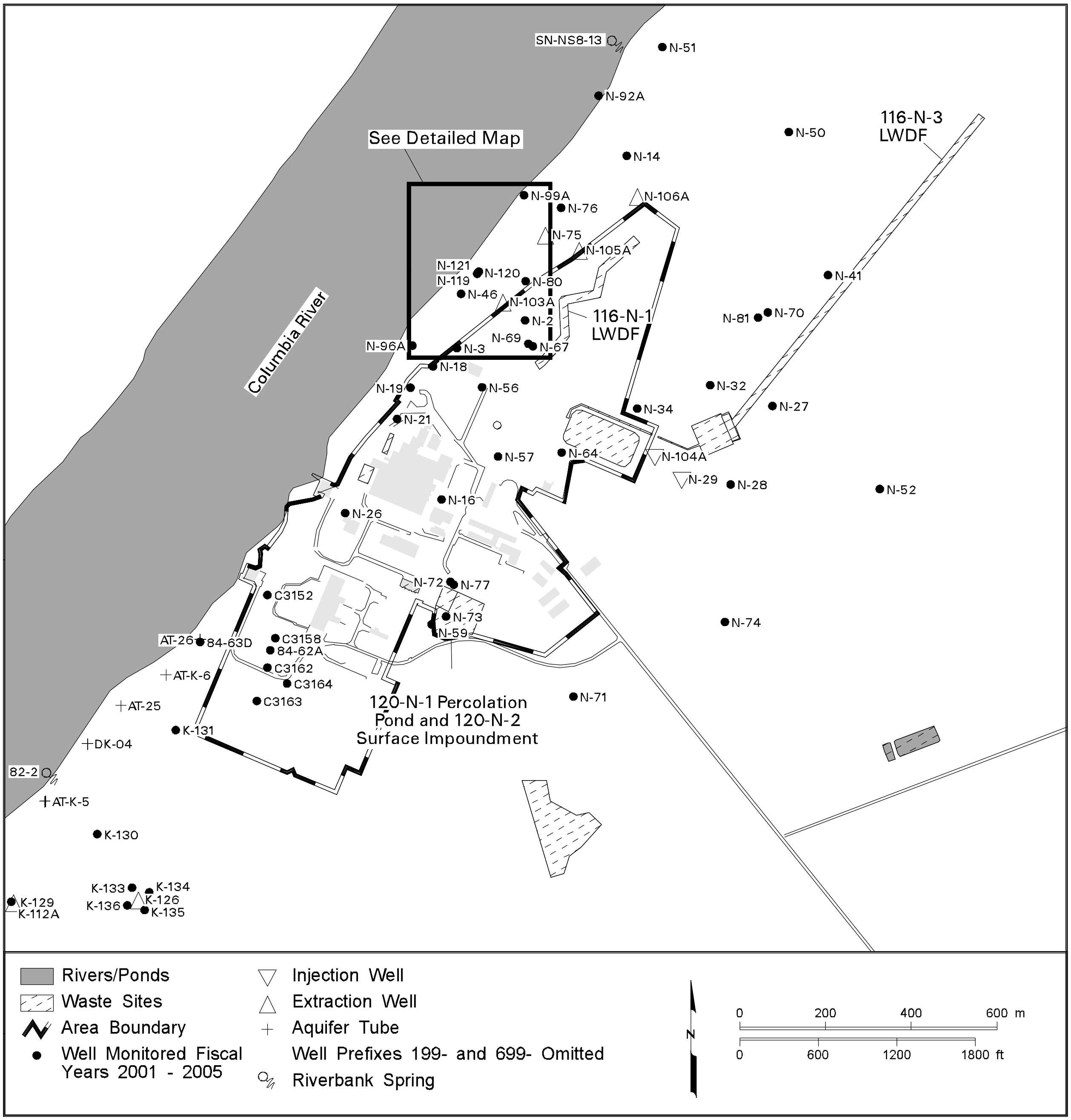

Figure 2.4-1. Groundwater Monitoring Wells in 100-N Area

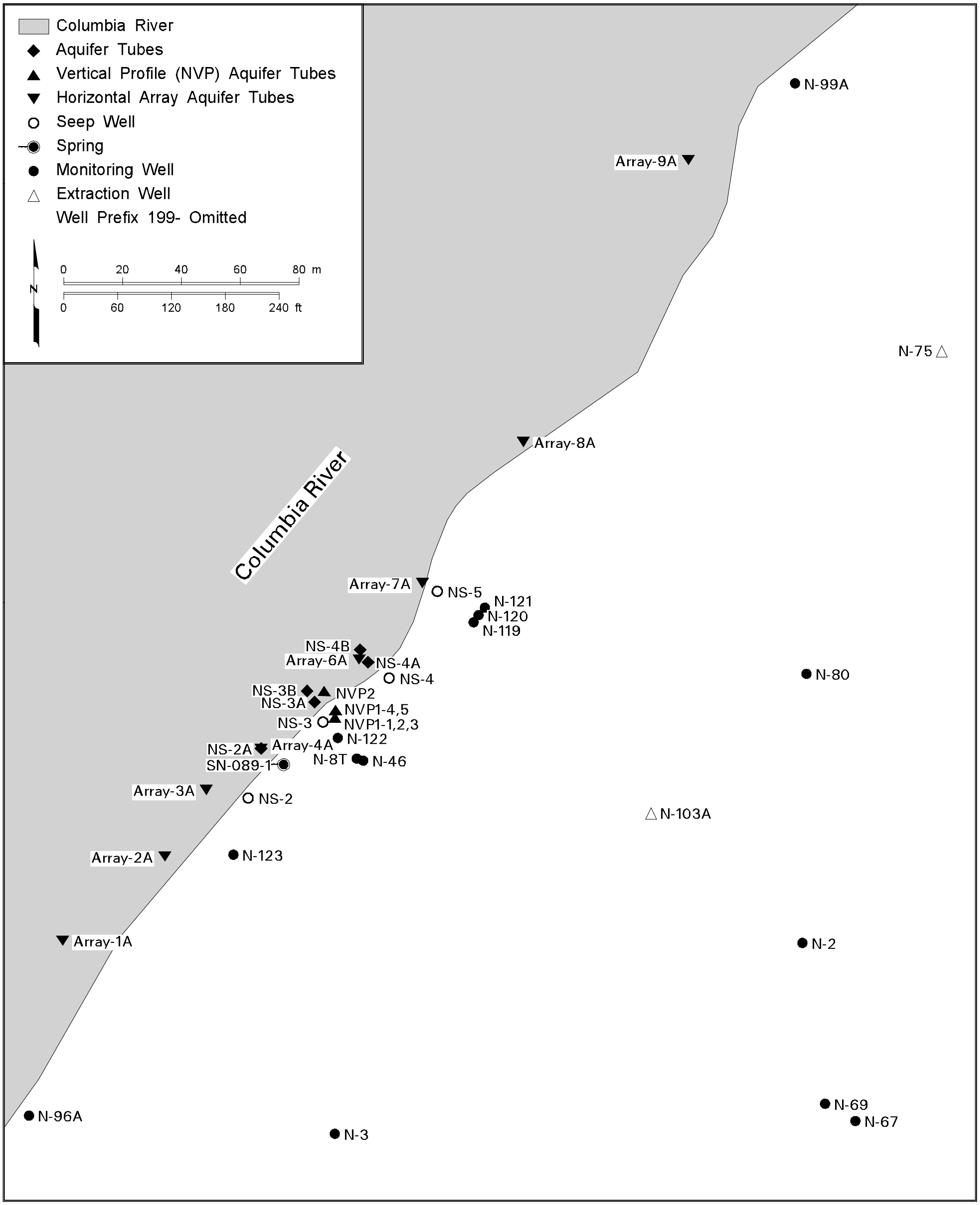

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Figure 2.4-2. Aquifer Tubes, Seep Wells, and Monitoring Wells on 100-N Shoreline

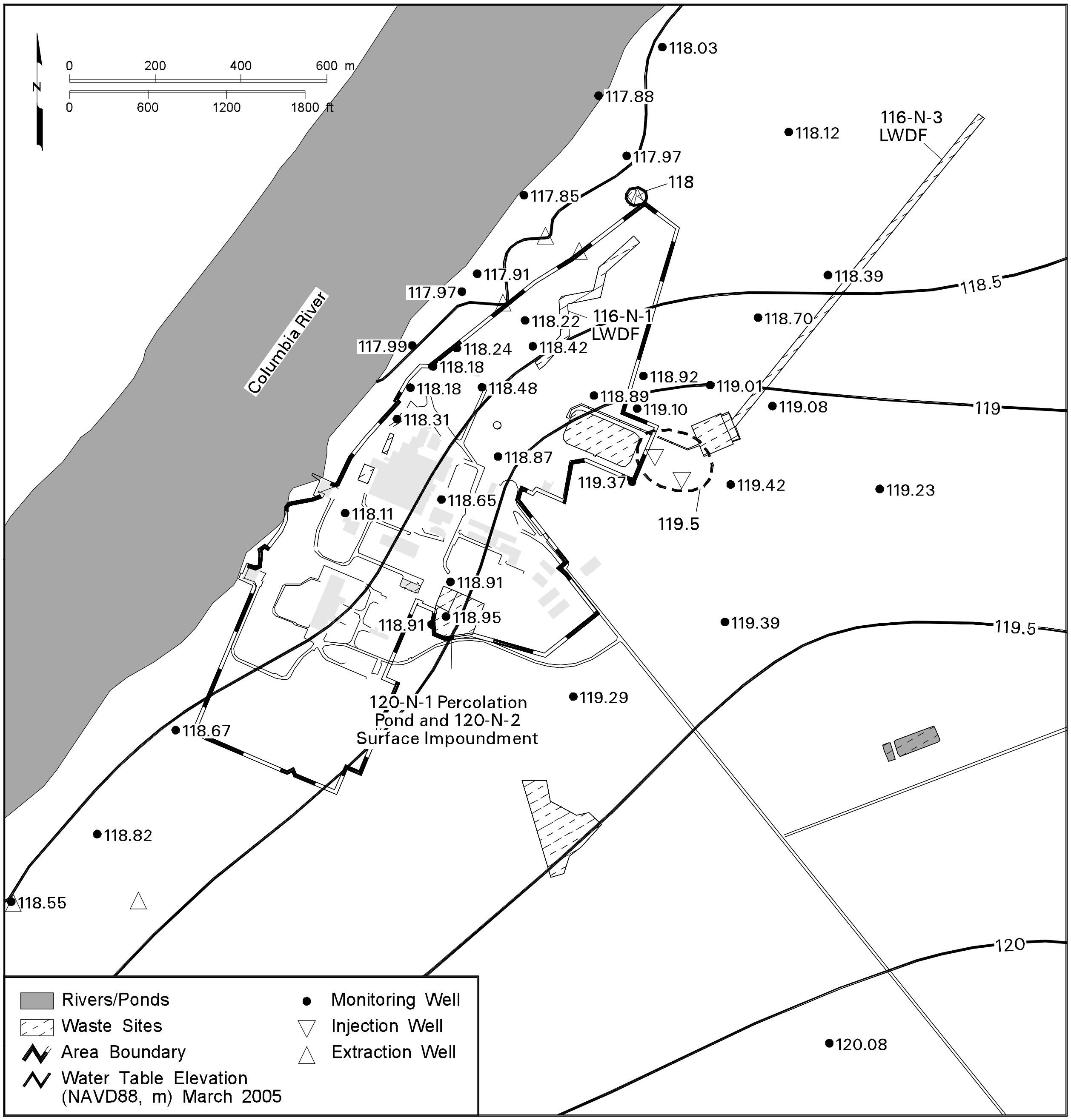

Figure 2.4-3. 100-N Area Water-Table Map, March 2005

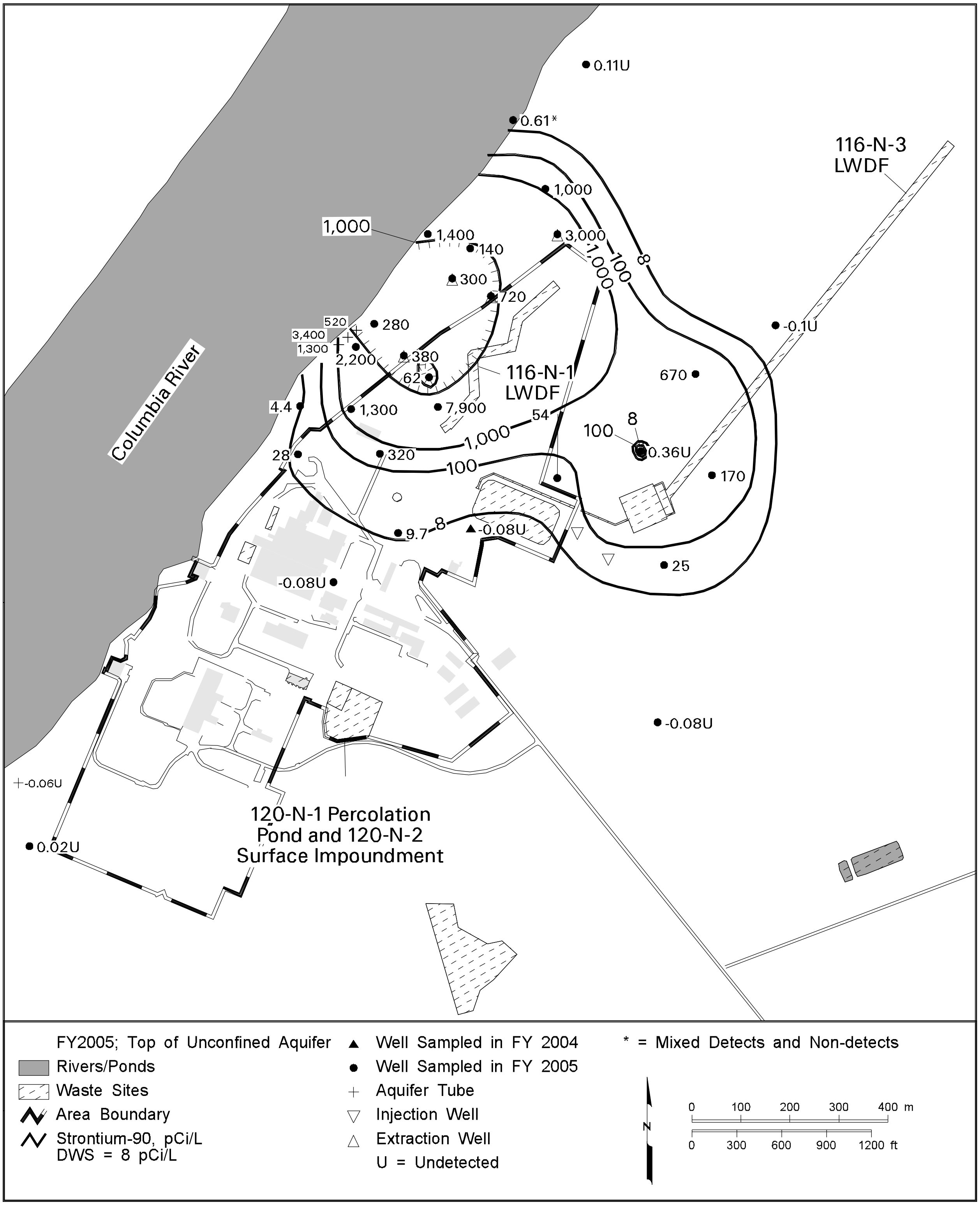

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Figure 2.4-4. Average Strontium-90 Concentrations in 100-N Area, Top of Unconfined Aquifer

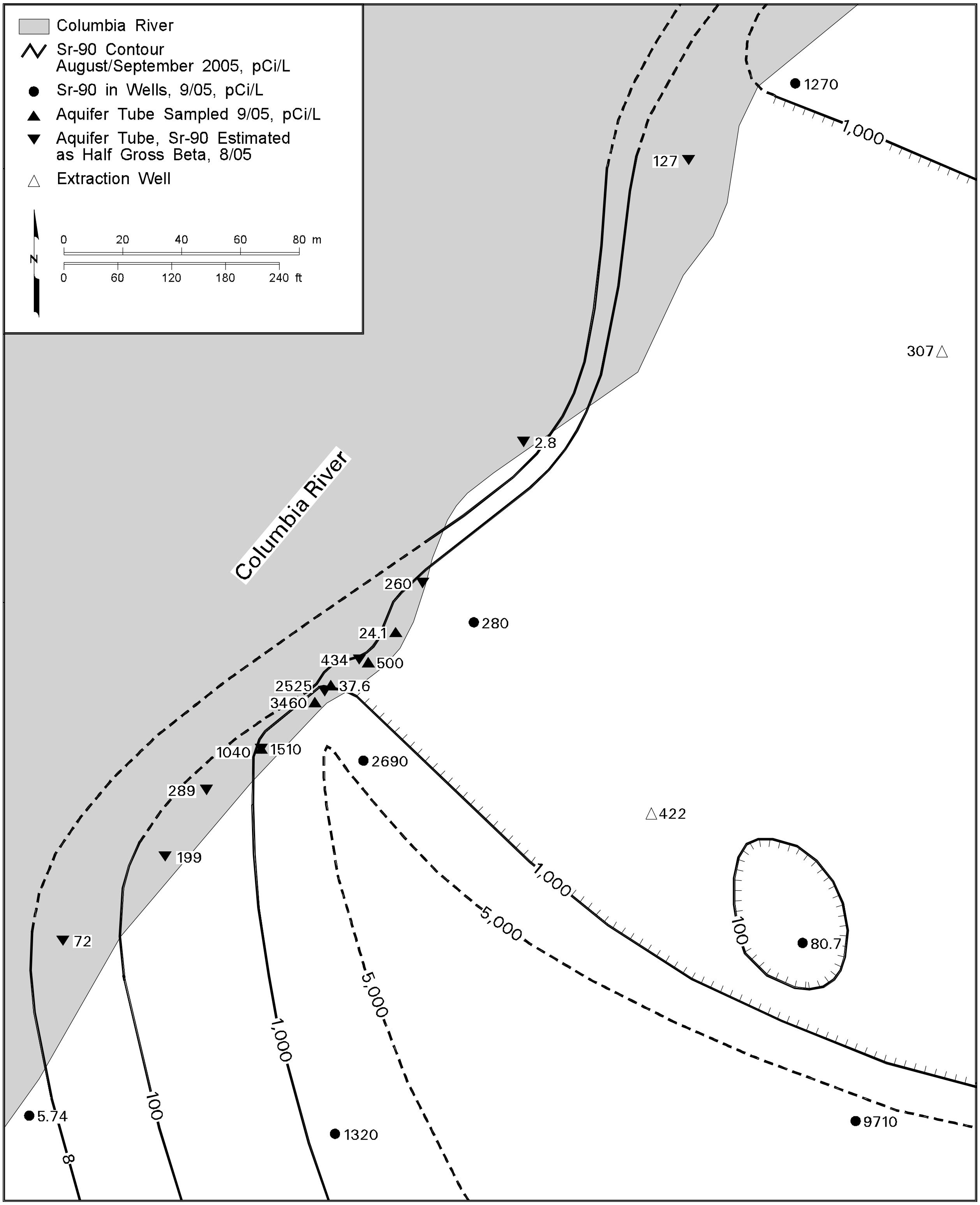

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Figure 2.4-5. Strontium-90 Distribution in Shoreline Study Area, August/September 2005

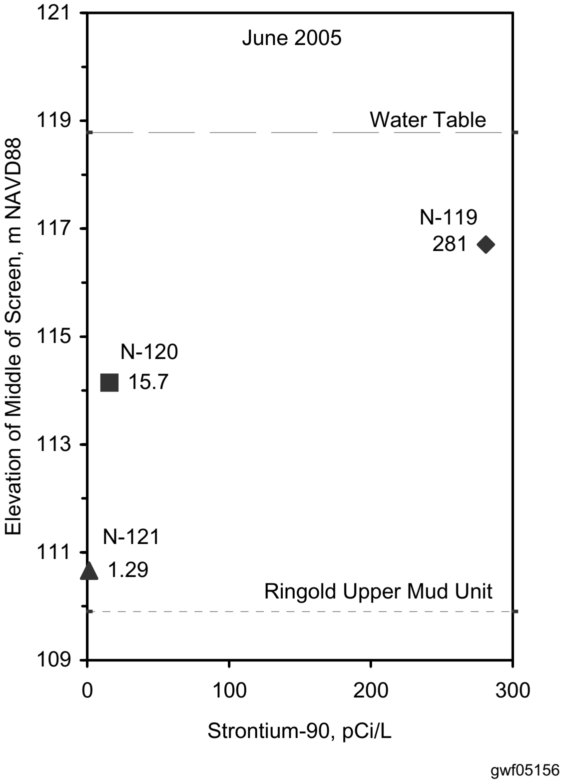

Figure 2.4-6. Strontium-90 Concentrations in 100-N Shoreline Well Cluster, June 2005

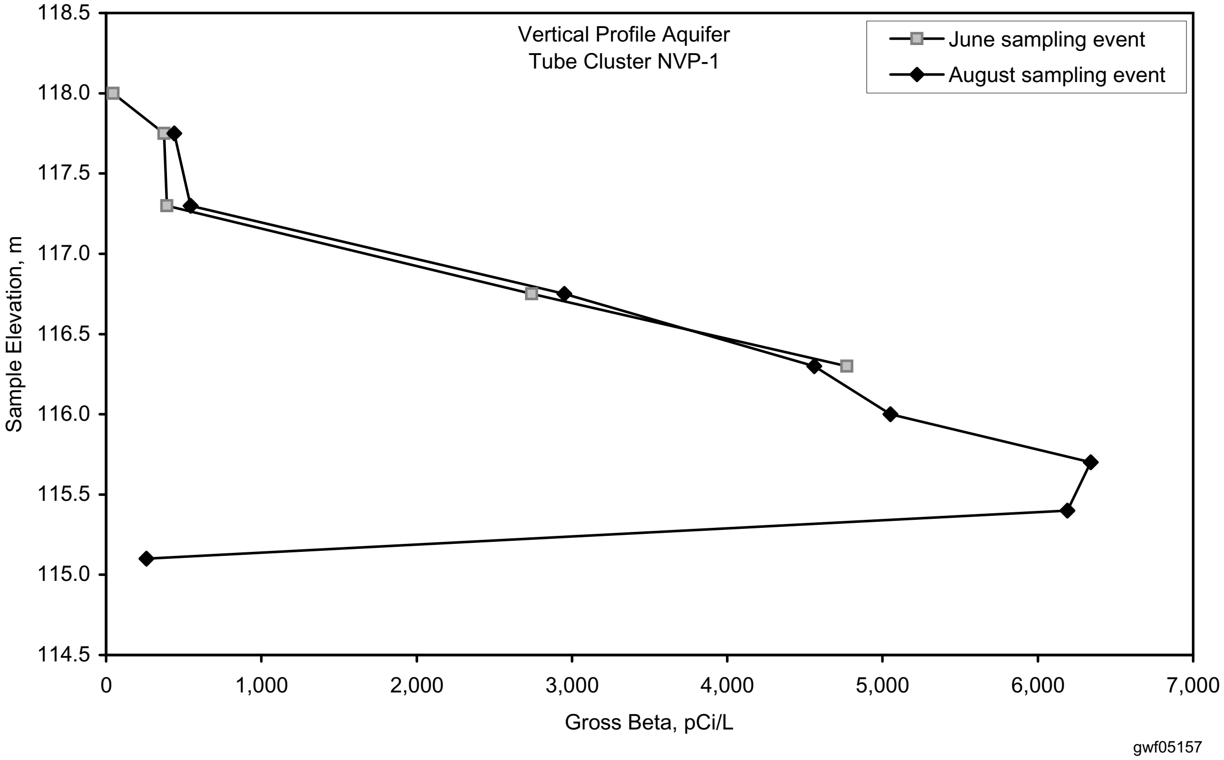

Figure 2.4-7. Vertical Distribution of Gross Beta in 100-N Area Aquifer Tube Cluster NVP-1

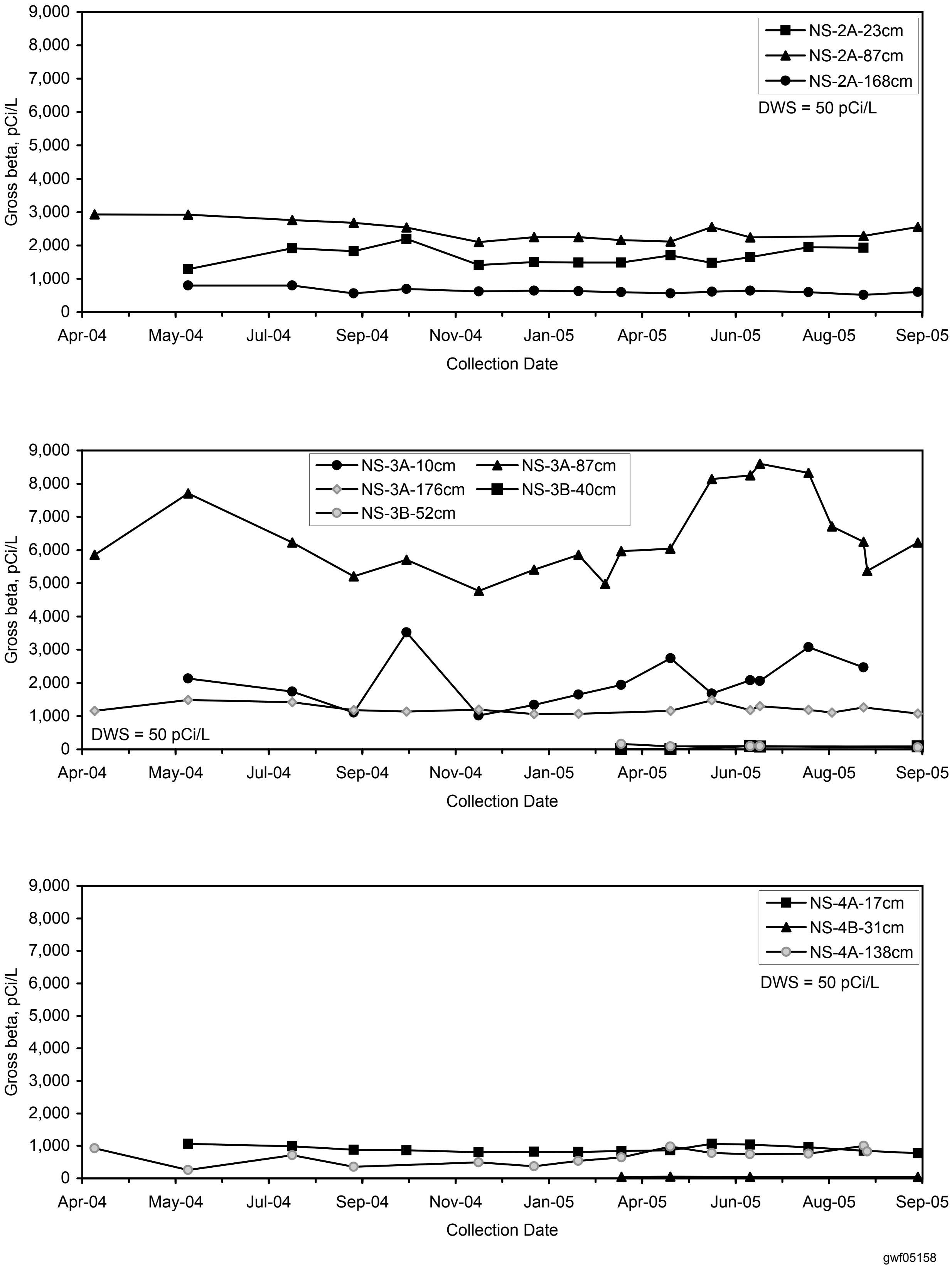

Figure 2.4-8. Gross Beta Concentrations in 100-N Area Aquifer Tubes

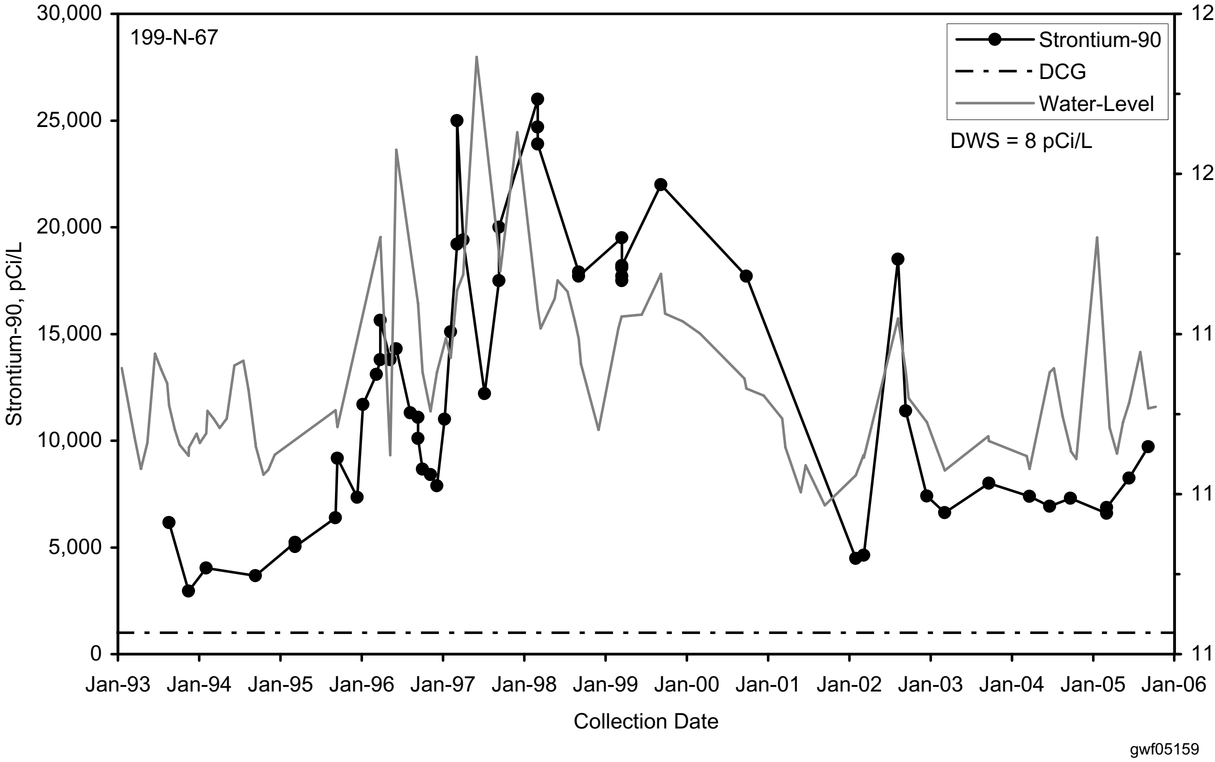

Figure 2.4-9. Strontium-90 Concentrations and Water Level Near the 116-N-1 Facility

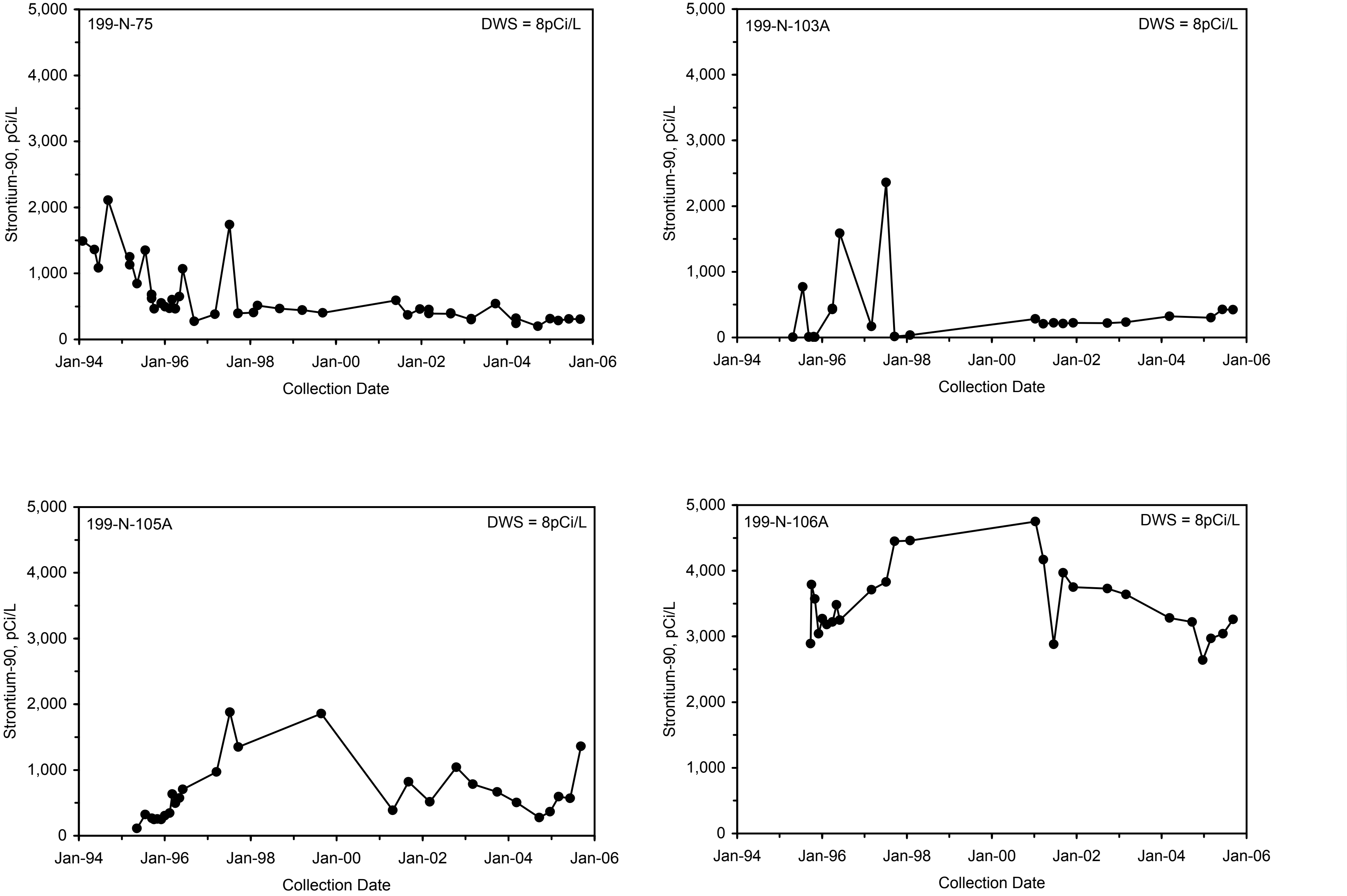

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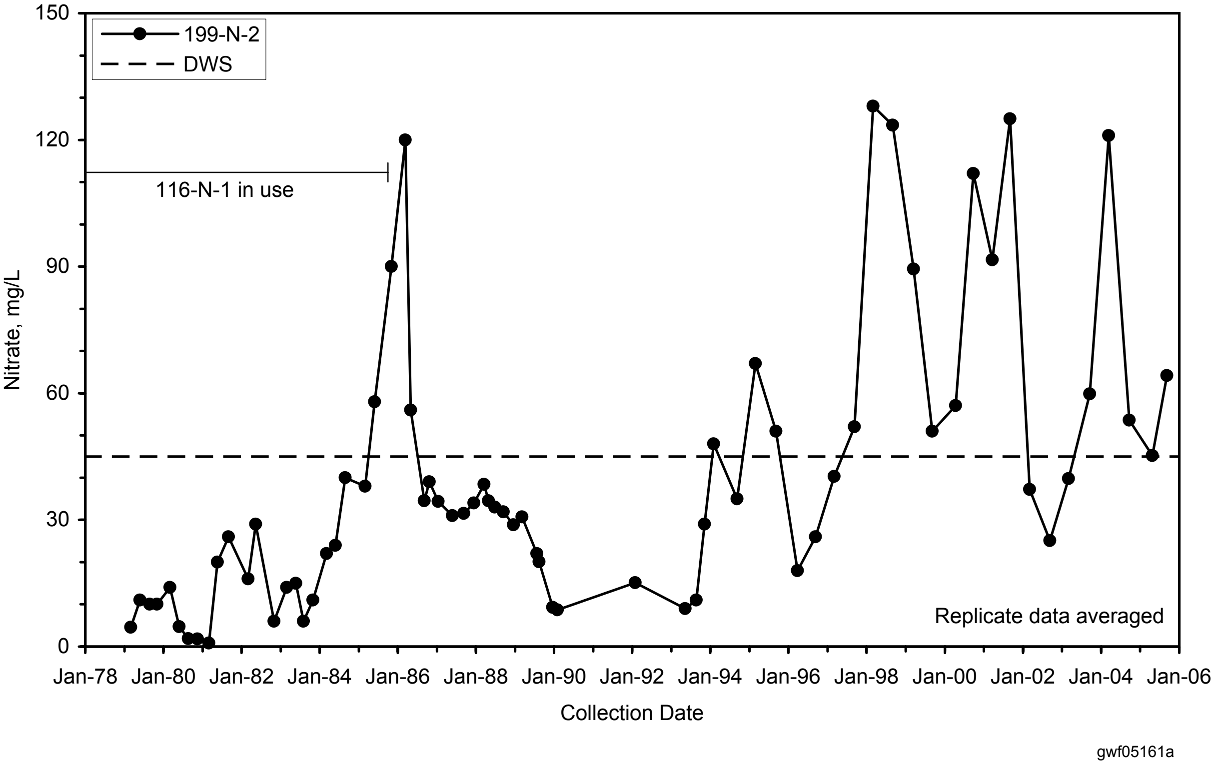
Figure 2.4-10. Strontium-90 Concentrations in 100-N Area Extraction Wells



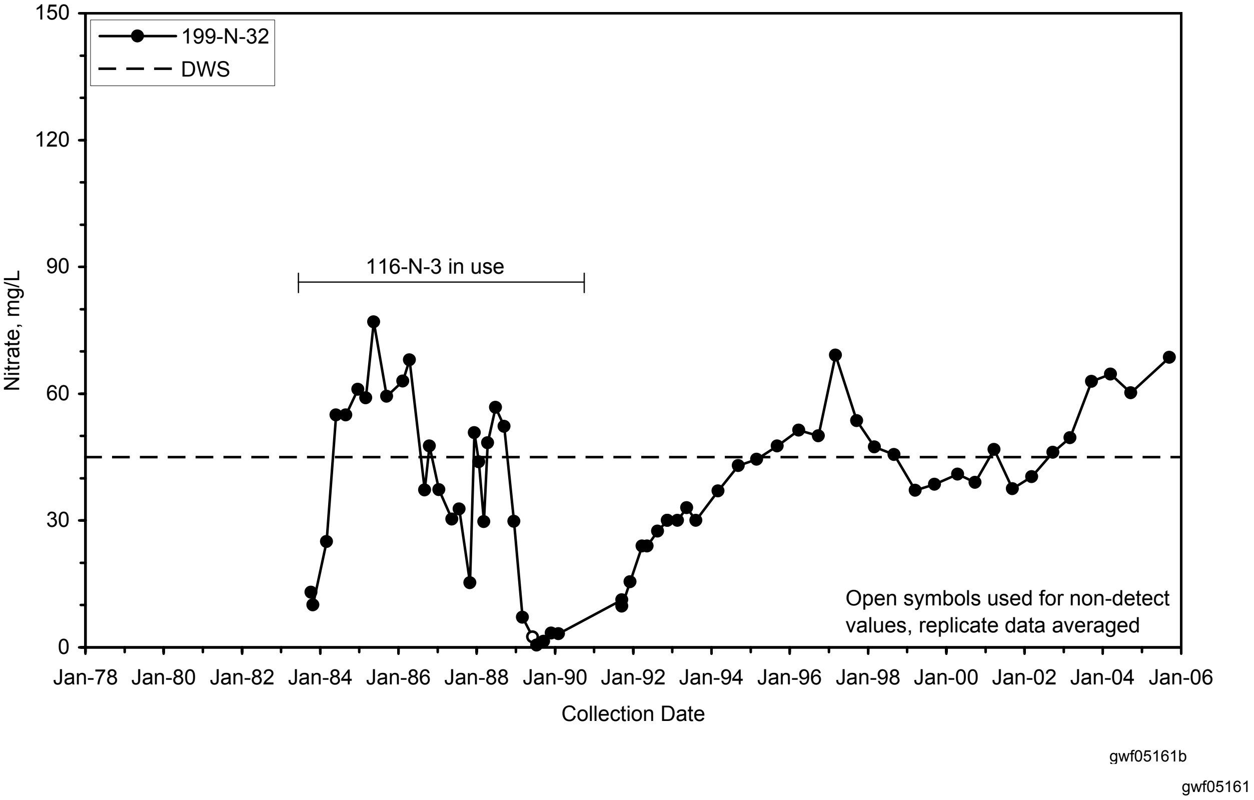


Figure 2.4-11. Nitrate Concentrations Near the 116-N-1 Facility (top) and 116-N-3 Facility (bottom)

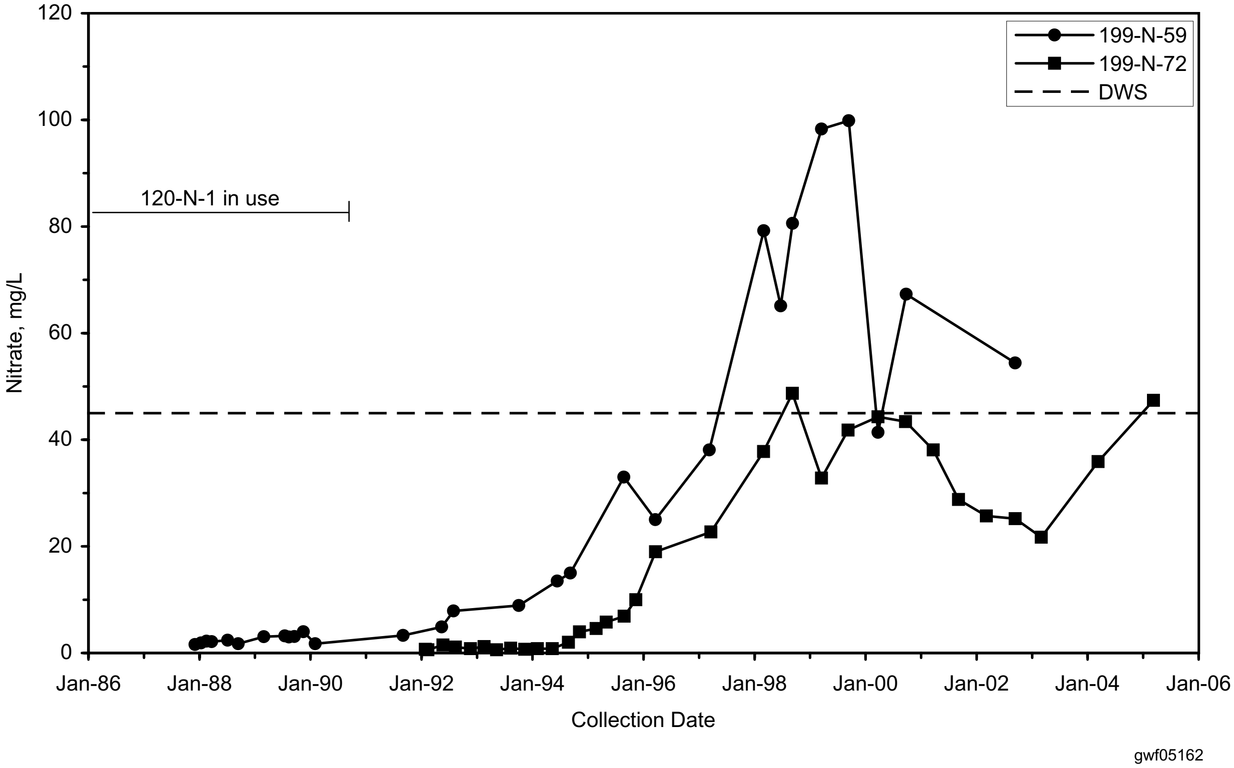


Figure 2.4-12. Nitrate Concentrations Near 120-N-1 Percolation Pond in South 100-N Area

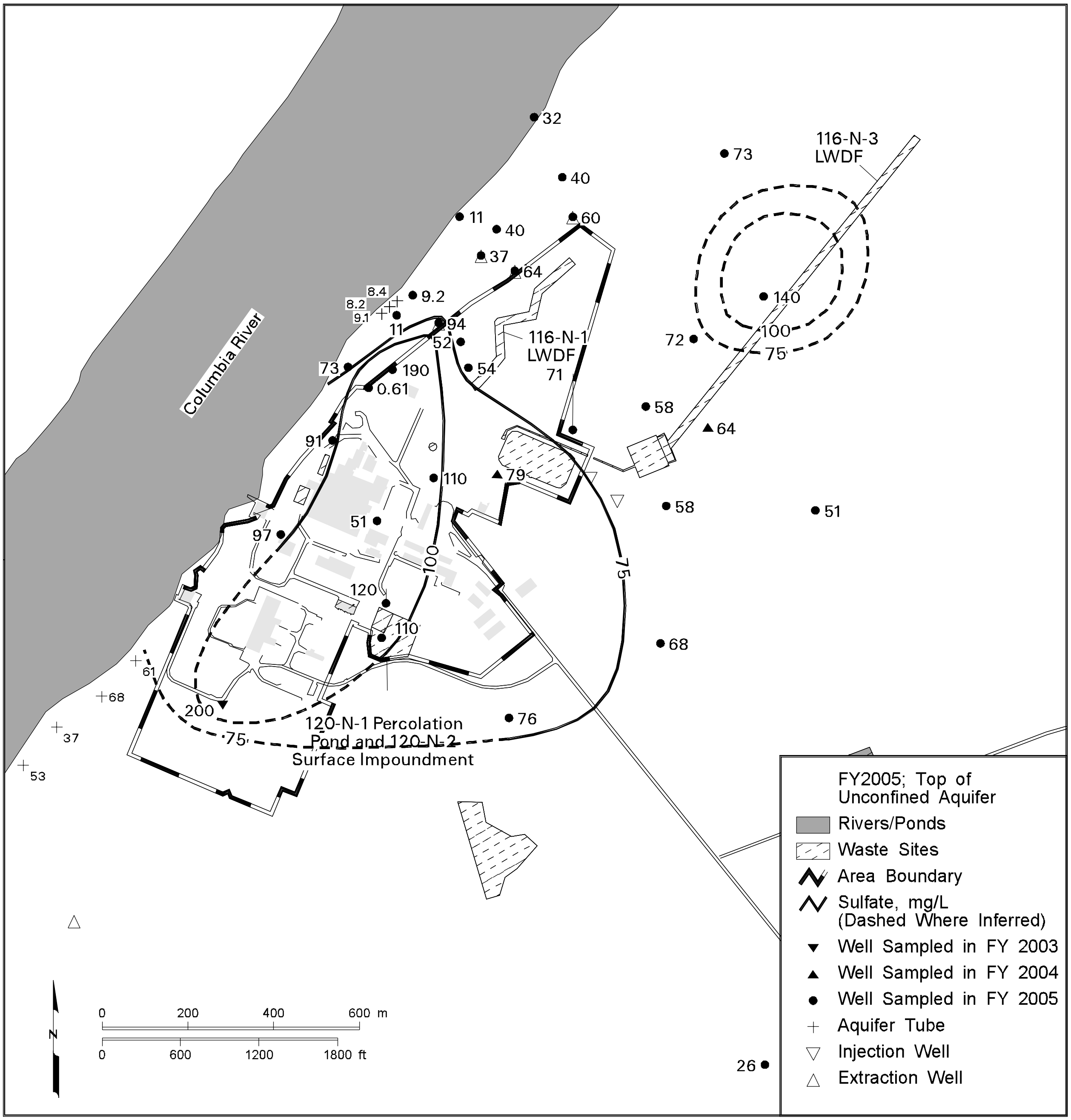


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Figure 2.4-13. Average Sulfate Concentrations in 100-N Area, Top of Unconfined Aquifer

2.5 100-HR-3-D Operable Unit

M. J. Hartman, R. O. Mahood, and R. F. Raidl

The scope of this section is the 100-HR-3-D groundwater interest area that occupies the west half of the 100-HR-3 Operable Unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined the "interest areas" informally to facilitate scheduling, data review, and interpretation. Figures 2.5-1 and 2.5-2 show facilities, wells, and shoreline monitoring sites in this region. Hexavalent chromium is the contaminant of greatest significance in groundwater. Groundwater is monitored to assess the performance of three *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) interim actions for chromium: two pump-and-treat systems and an in situ reduction-oxidation (redox) manipulation system. Groundwater also is monitored to track other contaminant plumes including strontium-90, tritium, nitrate, and sulfate.

Groundwater flows primarily to the north and northwest, toward the Columbia River (Figure 2.5-3). Near the Columbia River, including the redox site, the average flow direction is toward the northwest. Farther inland, average flow is northward. Leakage from the 182-D reservoir (see Section 2.5.2.2) and injection of treated groundwater into well 199-D5-42 form a broad groundwater mound in the central region of the 100-D Area.

The remainder of this section describes contaminant plumes and concentration trends for the constituents of interest under CERCLA and *Atomic Energy Act* (AEA) monitoring.

Hexavalent chromium is the contaminant of greatest concern in the 100-D Area.

2.5.1 Groundwater Contaminants

This section describes the distribution and trends of chromium, strontium-90, tritium, nitrate, and sulfate in groundwater in the 100-D Area.

2.5.1.1 Chromium

Chromium contamination underlies most of the 100-D Area in two plumes (Figures 2.5-4 and 2.5-5). The north plume had sources in the central 100-D Area and the south plume had unknown sources near the former 183-DR filter plant. The area devoid of chromium contamination between the two plumes is likely related to leakage of clean water from the 182-D reservoir (see Section 2.5.2.2).

Groundwater monitoring in the 100-HR-3-D groundwater interest area includes the following monitoring activities:

CERCLA Interim Remedial Action Performance Evaluation

- *A pump-and-treat system in north 100-D Area has operated since 1997, and a second system was added in FY 2004. Wells are monitored monthly to annually for chromium and co-contaminants.*
- *An in situ redox system operates in the southwest 100-D Area. Compliance wells, barrier wells, additional wells, and aquifer tubes are monitored monthly to annually. Three wells were not sampled as scheduled in FY 2005 (see Appendix A).*

CERCLA and AEA Long-Term Monitoring

- *Wells throughout the 100-D Area and surrounding 600 Area are sampled monthly to biennially, and aquifer tubes are sampled annually. Two wells were not sampled as scheduled in FY 2005 (see Appendix A).*

Aquifer tubes provide additional monitoring points along the 100-D Area shoreline (Figure 2.5-6). Historically, the highest concentrations were downgradient of the south chromium plume. The highest concentration in fiscal year (FY) 2005 was in the central 100-D Area shoreline.

North Plume. The axis of the north chromium plume extends from the former reactor building toward the northwest, perpendicular to the Columbia River. Near the former sources, chromium continued a gradual decline in most wells (e.g., well 199-D5-16 in Figure 2.5-7). Well 199-D5-15 is an exception to this declining trend; the average concentration in August 2005 was 1,066 µg/L, the highest value in this well since 1994. Chromium concentrations in well 199-D5-15 have been variable since FY 1997. Until 2003, specific conductance and other constituents varied with the chromium, suggesting dilution of groundwater with fresh water. Specific conductance stabilized in 2003 at ~600 µS/cm. Chromium continues to fluctuate, but not as widely as it did from 1999 to 2002.

At 100-D Area, three remediation systems help reduce the amount of chromium reaching the Columbia River: two pump-and-treat systems in the north and in situ remediation in the southwest.

In the north 100-D Area near the pump-and-treat system, compliance wells continued to show variable chromium concentrations, with the lowest concentrations in the early summer when river stage was high (Figure 2.5-8). The concentrations remained above the remedial action goal in the compliance wells except for a few samples collected in early summer. The seasonal concentration peaks (fall and winter of each year) have declined since 2000. Section 2.5.2.1 contains more information about the pump-and-treat systems.

On the southwest side of the north plume, chromium concentrations in wells 199-D5-20 and 199-D5-41 decreased from their peak values observed in 2004 (Figure 2.5-9). Well 199-D5-20 was converted to an extraction well in July 2004. Chromium concentrations dropped from 1,400 µg/L in May 2004 to 622 µg/L in May 2005. In well 199-D5-41, concentrations dropped from 2,500 µg/L in November 2004 to 1,550 µg/L in May 2005. The cause of the variable concentrations in this part of the plume is unknown.

Chromium concentrations in aquifer tubes in the north 100-D Area are consistent with concentrations in the aquifer. The highest concentration was 518 µg/L at tube site AT-36.

South Plume. This chromium plume lies south and southwest of the 182-D reservoir and west of the 183-DR filter plant, extending to the Columbia River (see Figures 2.5-4 and 2.5-5). The core of the plume, with concentrations >500 µg/L, is oriented southeast-northwest, perpendicular to the Columbia River. The redox barrier intersects the south chromium plume and terminates the highest-concentration portion of the plume.

Chromium concentrations in the south plume have varied by an order of magnitude in some wells since 2001, and the reason for the variability is not understood. The source of this plume has not been located despite previous investigations (e.g., PNNL-13486). DOE is continuing to characterize the site in an attempt to identify the source or sources of chromium contamination.

Compliance monitoring wells downgradient of the redox barrier show inconsistent trends (Figure 2.5-10). The northernmost well, 199-D4-83, shows variable chromium concentrations with decreasing peaks. Well 199-D4-39, near the north end of the barrier, shows high variability since 2000, with concentrations over 850 µg/L during FY 2005. South of well 199-D4-39, chromium trends in wells 199-D4-23, 199-D4-84, 199-D4-85, and 199-D4-86 continued to decline overall, with some variability. Concentrations in well 199-D4-38 have shown an increasing trend in FY 2004 and 2005. Concentrations in the southernmost wells, 199-D4-85 and 199-D4-86, were below the remedial action goal (20 µg/L) for much of the fiscal year.

The highest concentration in an aquifer tube in the south chromium plume was 233 µg/L at tube site Redox-3. Chromium concentrations in several of the tubes in this region have declined since they were first sampled in 1997. The decline may be caused, in part, by remediation effects.

Plume areas (square kilometers) above the drinking water standard at the 100-HR-3-D Operable Unit:

Chromium — 0.76
Nitrate — 0.80
Tritium — 0.04

Chromium concentrations have increased in recent years in some of the redox barrier wells, as reported previously. Section 2.5.2.2 contains more information about the redox system.

2.5.1.2 Strontium-90

Two locations in the 100-D Area have a history of strontium-90 detections in groundwater: near the former retention basins in the north and near the D Reactor building in central 100-D Area.

Near the former retention basins, the strontium-90 concentration in well 199-D8-68 was at the drinking water standard (8 pCi/L) in November 2004 and declined to 3.7 pCi/L in May 2005. Strontium-90 was also detected in four other wells in this region, but at levels below the drinking water standard.

Near the former D Reactor, strontium-90 continued to be detected in well 199-D5-15 at levels below 4 pCi/L. Nearby well 199-D5-16 continued to have no detectable strontium-90.

2.5.1.3 Tritium

Tritium contamination in the south 100-D Area may have originated in the 100-N Area.

Tritium concentrations remained below the 20,000-pCi/L drinking water standard in most wells in the 100-D Area, but continued to exceed the standard in well 199-D4-19 near the south end of the redox barrier (Figure 2.5-11). The FY 2005 value of 26,100 pCi/L was part of a gradually increasing trend. Nearby aquifer tube DD-44 has had tritium concentrations exceeding the standard in the past, but was not sampled for tritium in FY 2005. The tritium contamination is believed to have originated as part of the 100-N Area tritium plume to the south. A peak of contamination moved past well 199-D3-2 in the late 1990s (see Figure 2.5-11). Concentrations gradually increased in well 199-D4-19 and aquifer tube DD-44 as the plume moved north toward the river.

Tritium was slightly above the drinking water standard in FY 2005 in well 199-D5-17, located near the former DR reactor, for the first time since 1996 (20,400 pCi/L; Figure 2.5-12). Concentrations in nearby wells remained below the standard.

2.5.1.4 Nitrate and Nitrite

Nitrate distribution is generally similar to chromium in the 100-D Area; both constituents form two plumes. Although concentrations are decreasing overall, the nitrate plume has changed little in the past year (see Figure 2.5-16 in PNNL-15070). Nitrate concentrations continued to exceed the drinking water standard (45 mg/L) in both plumes, with a FY 2005 maximum concentration of 71 mg/L in well 199-D5-16 near the former D Reactor. The south plume is truncated by the redox system, which converts the nitrate to nitrite.

Nitrite concentrations continued to exceed the drinking water standard (3.3 mg/L) in some wells in the redox barrier in FY 2005. Nitrite was below detection limits in downgradient wells.

2.5.1.5 Sulfate

Sulfate concentrations remained >100 mg/L beneath much of the 100-D Area. Excluding wells influenced by the redox system, concentrations all were below the secondary drinking water standard (250 mg/L) in FY 2005.

Injections of sodium dithionite solution at the redox site increased sulfate concentrations in the barrier and in some downgradient wells and aquifer tubes. Within the barrier, the maximum concentration in FY 2005 was 1,500 mg/L in well 199-D4-19, but the concentration fell to 340 mg/L by the end of the year. Downgradient wells 199-D4-23 and 199-D4-84 also exceeded the standard for sulfate, with FY 2005 maxima of 502 and 510 mg/L, respectively. Sulfate concentrations exceeded the secondary drinking water standard for the first time in aquifer tubes DD-39-2 and DD-41-2 (267 and 268 mg/L, respectively, in November 2004).

2.5.2 Interim Groundwater Remediation for Chromium

Chromium concentrations continued decreasing in most redox compliance wells.

Hexavalent chromium is the contaminant of greatest concern in the 100-D Area. Three CERCLA remediation systems operate as interim actions to reduce the amount of chromium reaching the Columbia River: a pump-and-treat remediation system in the north, a pump-and-treat system (known as DR-5) in the central 100-D Area, and an in situ redox manipulation barrier in the southwest. The DR-5 pump-and-treat system fills a gap between the north system and the redox barrier and also extracts contamination from high-concentration portions of the plume upgradient of the redox barrier.

2.5.2.1 Pump-and-Treat Systems

A pump-and-treat system in the north 100-D Area includes four extraction wells located near the former 116-D-7 and 116-DR-9 retention basins. The system began operating in July 1997 and has undergone several changes over the years.

July 1997	May 2002 to Present
Extraction Wells	
199-D8-53	199-D8-53
199-D8-54A	199-D8-54A
	199-D8-68
	199-D8-72

Extracted groundwater is transferred via pipeline to the 100-H Area where it is treated and injected into the aquifer. Monitoring requirements for this system are included in DOE/RL-96-90, as modified by DOE/RL-96-84. Long-term monitoring requirements in the 100-D Area were derived from Change Control Form 107 as modified by Fluor Hanford, Inc.[a] Wells, constituents, and sampling frequencies for interim action monitoring are shown in Appendix A. Details regarding 100-HR-3 pump-and-treat operations may be found in the annual reports that are issued by the U.S. Department of Energy (DOE).

During FY 2005, two pump-and-treat systems extracted ~224 million liters of groundwater from the 100-D Area, removing ~63 kilograms of hexavalent chromium.

A second pump-and-treat system (DR-5 system) began operating at the end of July 2004 to treat increasing hexavalent chromium concentrations in the wells southwest of the original pump-and-treat system. The system was modified in FY 2005 to increase the rate of remediation and widen the capture zone.

July 2004	August 2005 to Present
Extraction Wells	
199-D5-20	199-D5-20
199-D5-32	199-D5-32
199-D5-37	199-D5-39
	199-D5-92
Injection Well	
199-D5-42	199-D5-42

The extracted water is treated in the 100-D Area using a metal chelating medium designated MR3, and injected into well 199-D5-42. An upcoming report on the 100 Areas pump-and-treat systems will provide a more detailed discussion of this new technology and its application to the 100-D Area.

(a) Letter FH-0402972 from H Hermanas and BH Ford (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.

Progress During FY 2005. The 100-D Area pump-and-treat systems are reducing overall contamination in the operable unit by removing contaminant mass. During FY 2005, the original 100-D Area pump-and-treat system extracted ~187.2 million liters of groundwater, removing 25.8 kilograms of hexavalent chromium. An additional ~36.7 million liters of groundwater were processed and 36.6 kilograms of chromium removed by the DR-5 system.

A total of ~217.9 kilograms of chromium has been removed from the 100-D chromium plume since the start up of the original system in July 1997. The DR-5 system has removed ~44.8 kilograms of chromium since July 2004, and an additional 30 kilograms were removed during a pilot-scale test conducted in the 100-D reactor area between August 1992 and August 1994 (DOE/RL-95-83). The total hexavalent chromium in the plume has been estimated at 590 kilograms (DOE/RL-94-95). That estimate did not include the chromium plume in the southwest 100-D Area nor in the vadose zone.

Influence on Aquifer Conditions. In FY 2005, chromium concentrations remained elevated in the 100-D Area, although the trend over the last three years is clearly down in compliance wells 199-D8-69 and 199-D8-70 (see Figure 2.5-8). Chromium concentrations vary inversely with river stage, and have remained above the 22 µg/L remedial action goal except for occasional readings during summer months when river stage is high and dilution occurs.

DOE/RL-2005-18 presents results of operational monitoring and additional details about the pump-and-treat systems for calendar year 2004. Results for calendar year 2005 will be included in an upcoming report on the 100 Areas pump-and-treat systems.

2.5.2.2 In Situ Redox Manipulation System

This treatment system uses a change in redox potential to reduce dissolved hexavalent chromium in groundwater to trivalent chromium, a much less soluble and less toxic species. Objectives of the redox interim action are the same as for the 100-D Area pump-and-treat system except that the remedial action goal for chromium at the redox site is 20 µg/L. Remedial action monitoring is described in DOE/RL-99-51.

Progress During Fiscal Year 2005. The in situ redox manipulation treatment zone is ~680 meters in length, aligned parallel to the Columbia River shoreline and ~100 to 200 meters inland. The treatment zone is designed to reduce the concentration of hexavalent chromium in groundwater to ≤20 µg/L at seven compliance wells situated between the treatment zone and Columbia River. The 20-µg/L goal was met at two of the seven compliance wells: 199-D4-23 and 199-D4-86.[b] Chromium trends in the other compliance wells were generally decreasing except for a two-fold increase in concentration at well 199-D4-38[c] (see Figure 2.5-10). The increase at well 199-D4-38 is attributed to the continuing loss of treatment zone reductive capacity between wells 199-D4-26 and 199-D4-31.

The remedial action objectives of the 100-HR-3 Operable Unit (ROD 1996a, 1999a) are:

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminant in the groundwater.***
- ***Provide information that will lead to the final remedy.***

The contaminant of concern is hexavalent chromium. The records of decision set the cleanup goal at compliance wells as 22 µg/L for the pump-and-treat system and 20 µg/L for the redox system. EPA specified enhancements needed to the pump-and-treat system in their 5-year review (EPA 2001).

An automated water-level monitoring system was installed in fifteen wells, the 182-D reservoir, and at the Columbia River. Hydrographs of data from the automated water-level monitoring systems detected the loss of ~15 million liters of water from the 182-D reservoir

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(b) FY 2005 average of filtered, total chromium and filtered, hexavalent chromium.

(c) Comparing FY 2004 and FY 2005 averages for filtered samples.

to the ground in December 2004 through February 2005. The water table beneath the reservoir temporarily rose in response to the leakage. The causes of the changes in leakage rates are unknown.

Influence on Aquifer Conditions. During FY 2005, as well as in recent years, chromium concentrations increased in redox barrier wells beyond what was expected based on the design. At the end of FY 2005, chromium concentrations in ~61% of the barrier wells were below the remedial action goal of 20 µg/L. Concentrations ranged from below detection limits to 1,020 µg/L. Most of the elevated concentrations are in the northeast half of the barrier.

In 2004, a team of experts was convened with key Hanford Site technical personnel to review site conditions and processes in establishing the barrier. The panel concluded that the primary cause of the premature breakdown in reductive capacity was physical and chemical aquifer heterogeneity (DOE 2004a, 2004b). In 2005, Pacific Northwest National Laboratory conducted studies to assess the following:

- Effect of geochemical and physical heterogeneity on redox barrier longevity.
- Influence of nitrate on redox barrier longevity.
- Emplacement of micron-sized, zero-valent iron using polymer-enhanced fluids, a possible treatment method to restore reductive capacity of the barrier.

Results of these studies will be evaluated further in FY 2006.

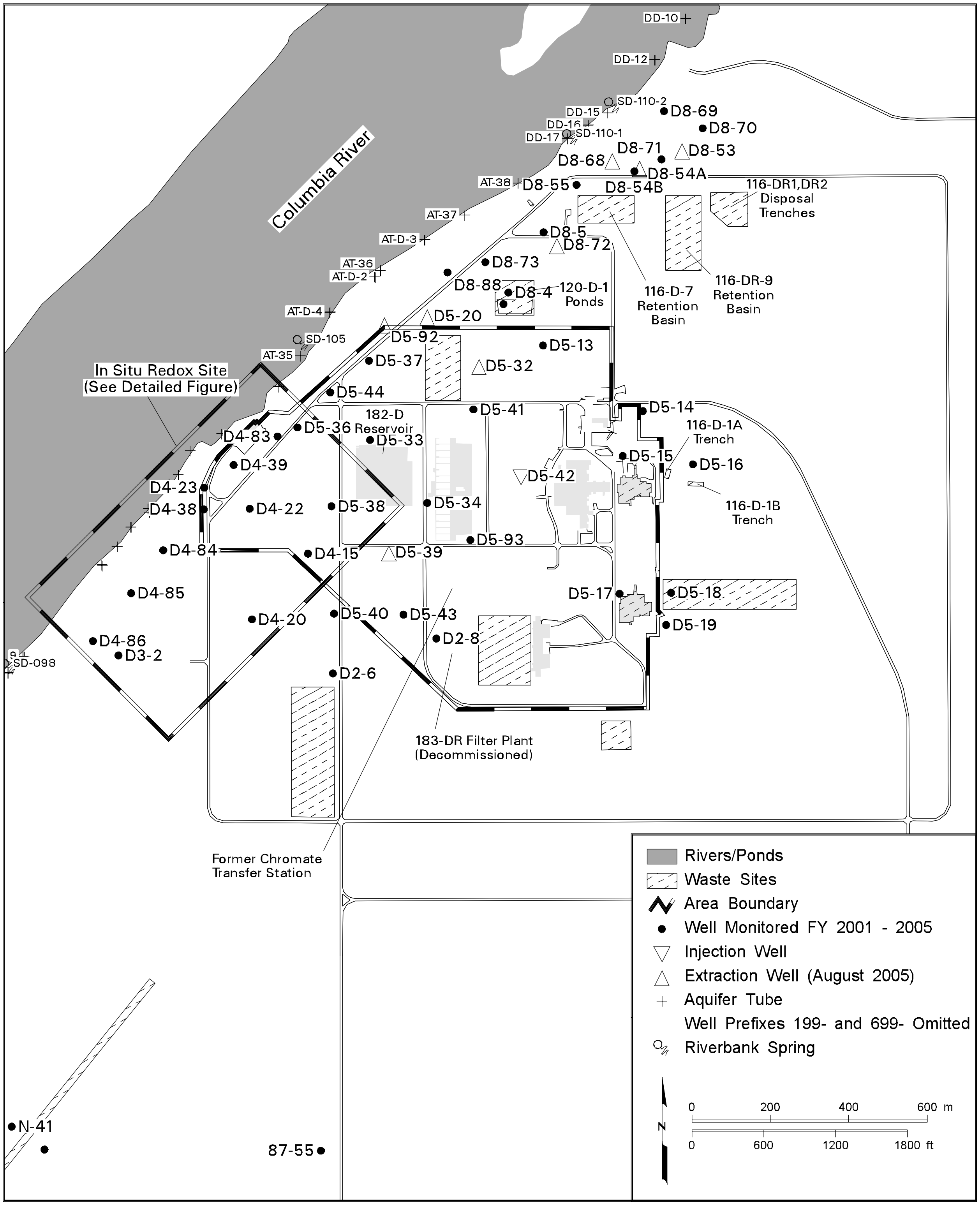

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Figure 2.5-1. Groundwater Monitoring Wells in 100-D Area

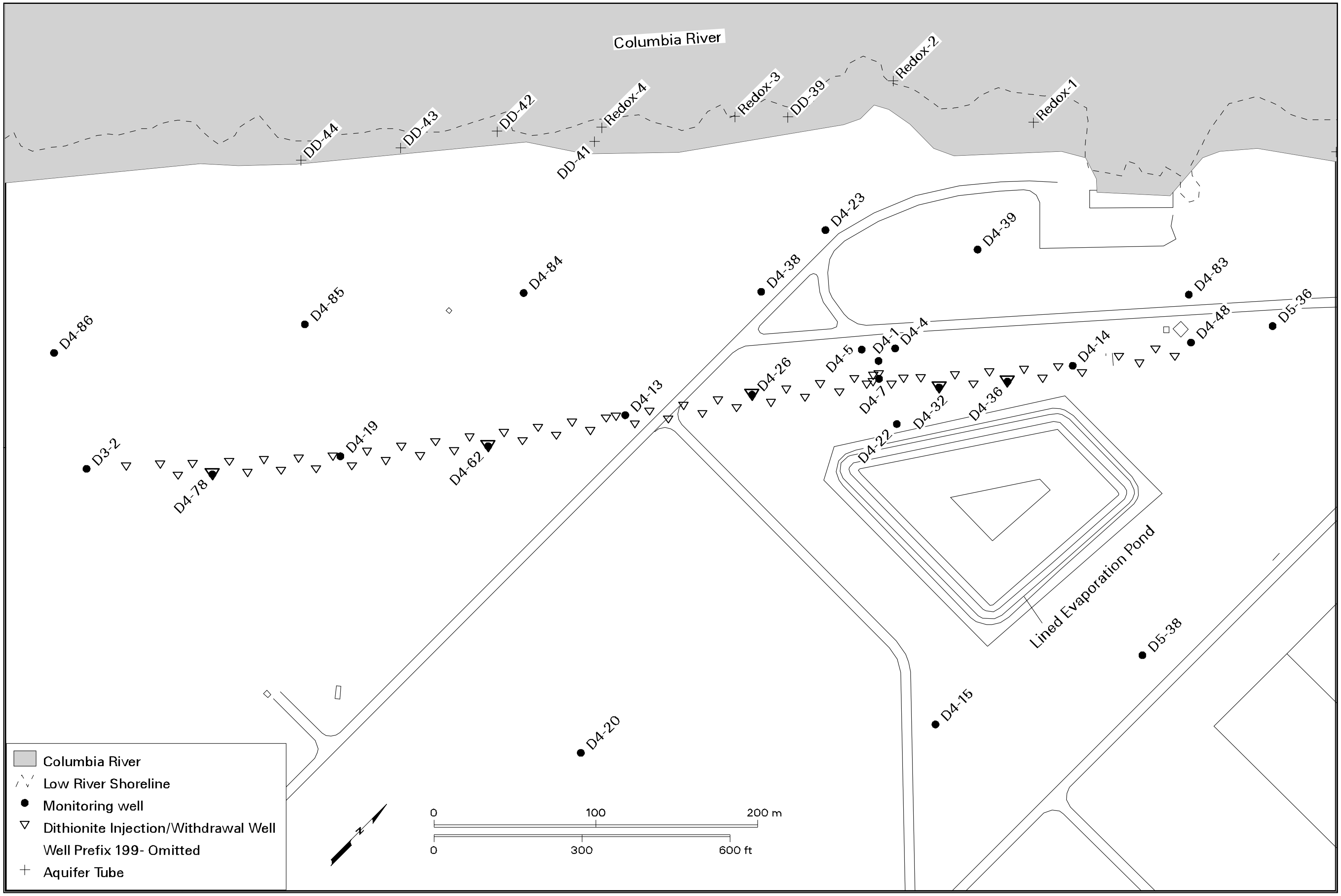

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Figure 2.5-2. Groundwater Monitoring Wells Near the Redox Site in 100-D Area

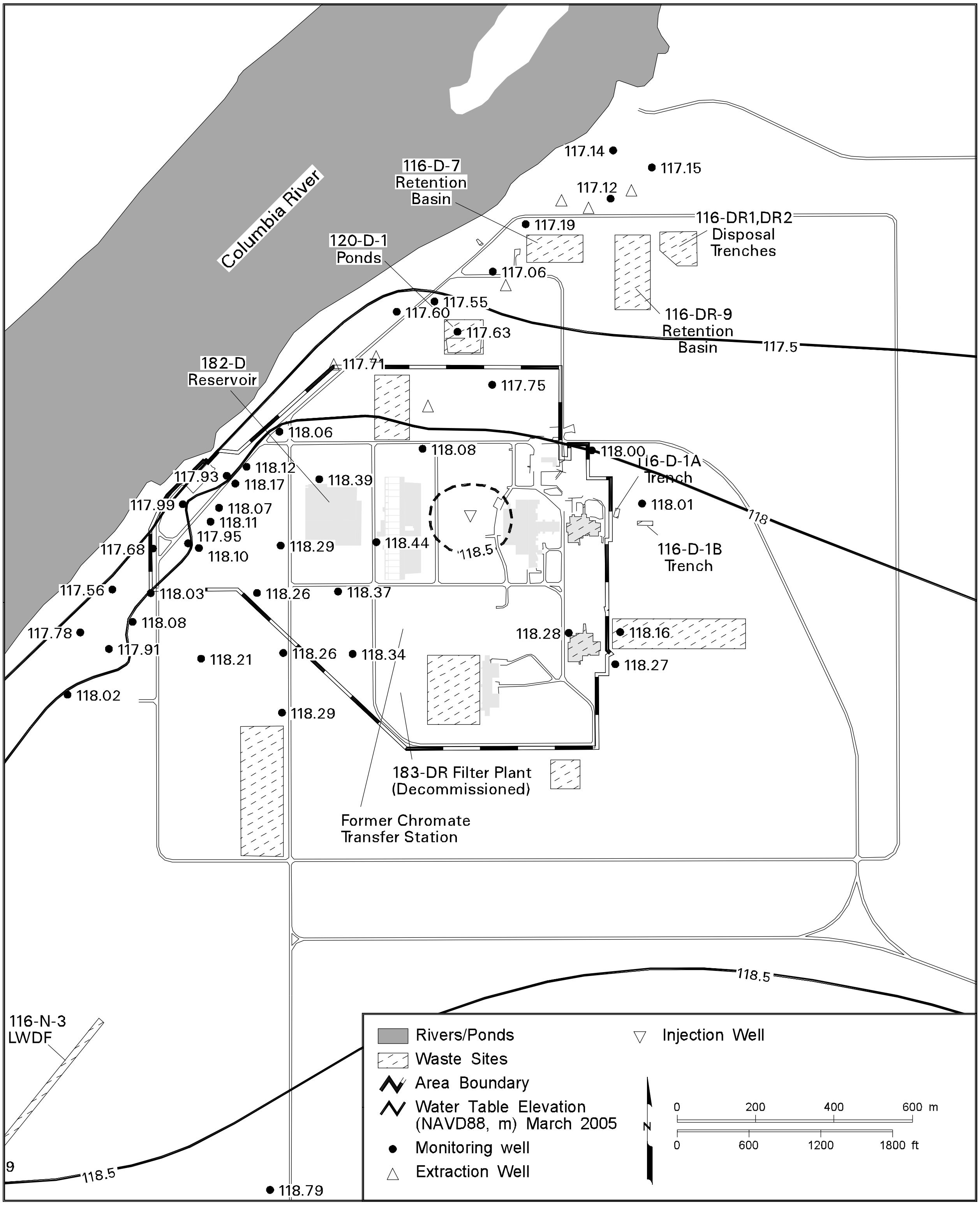

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Figure 2.5-3. 100-D Area Water-Table Map, March 2005

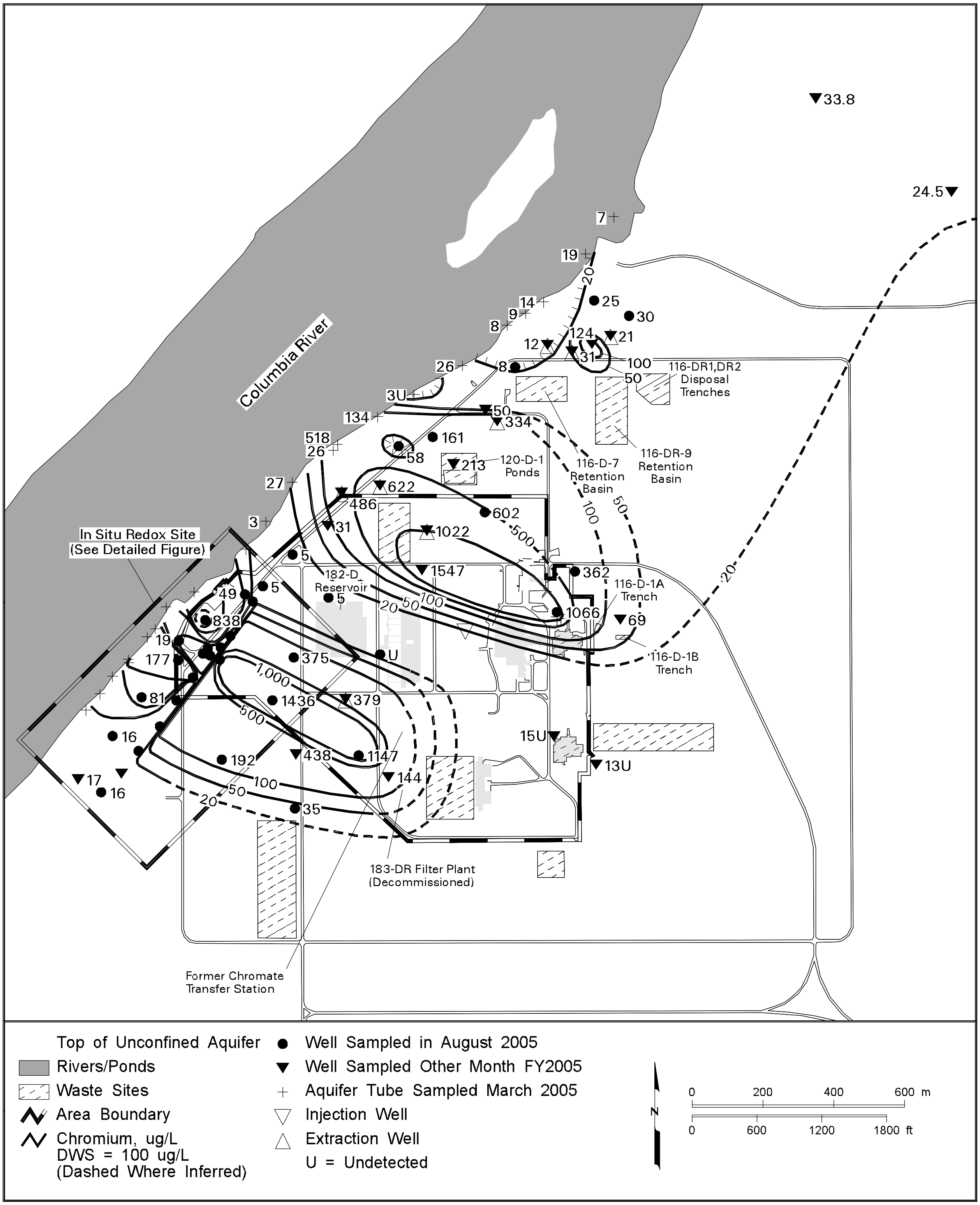

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Figure 2.5-4. Dissolved Chromium Concentrations in the 100-D Area, Top of Unconfined Aquifer, August-September 2005

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Figure 2.5-5. Dissolved Chromium Concentrations Near the Redox Site, 100-D Area, August 2005

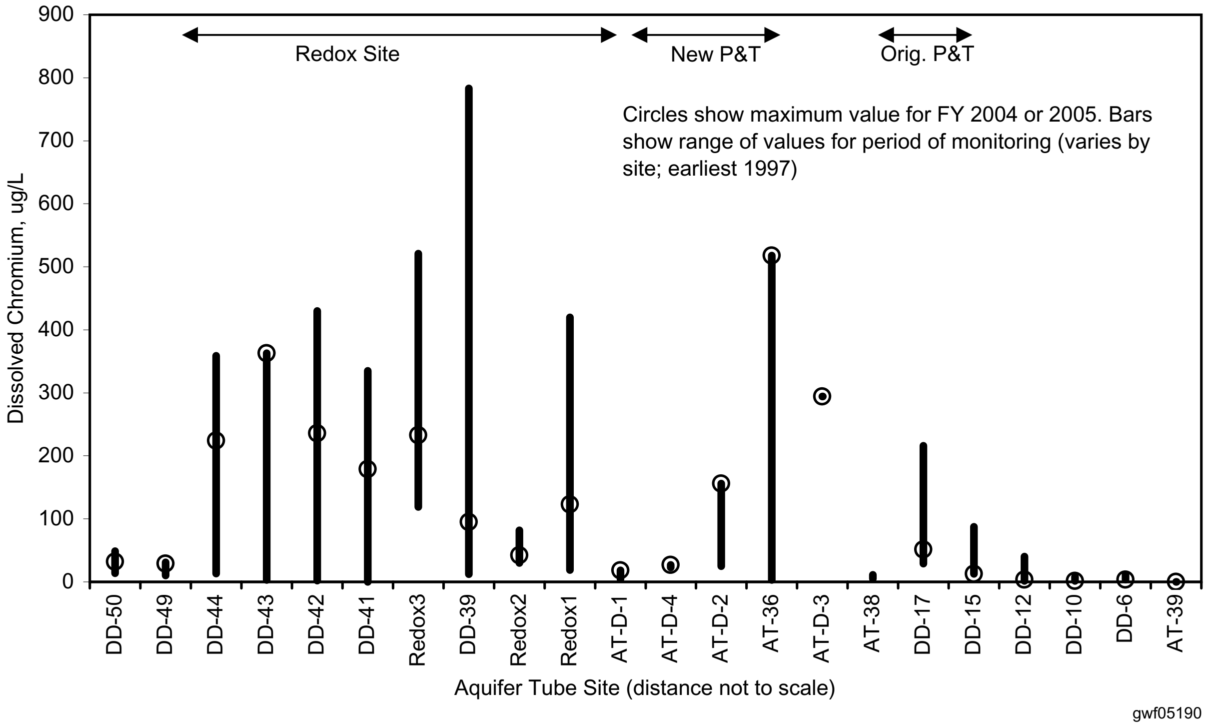


Figure 2.5-6. Dissolved Chromium Concentrations at Selected Aquifer Tube Sites at 100-D Area

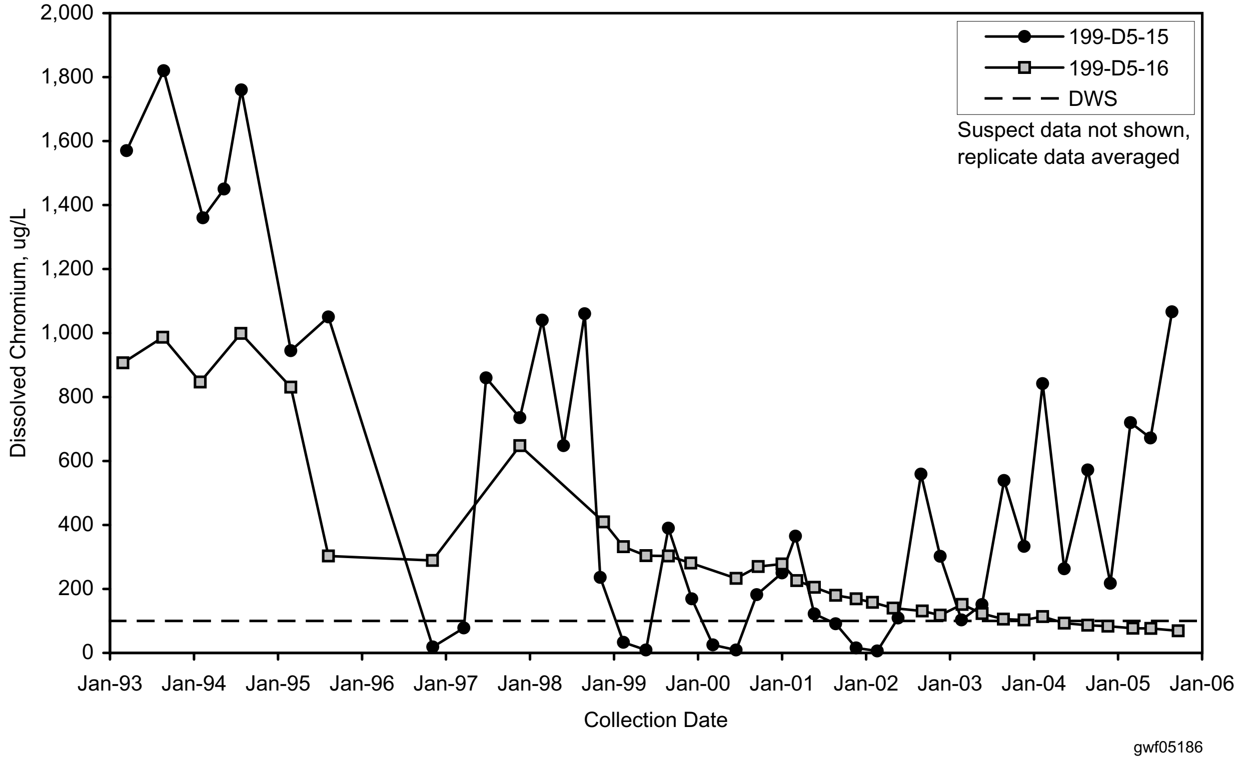
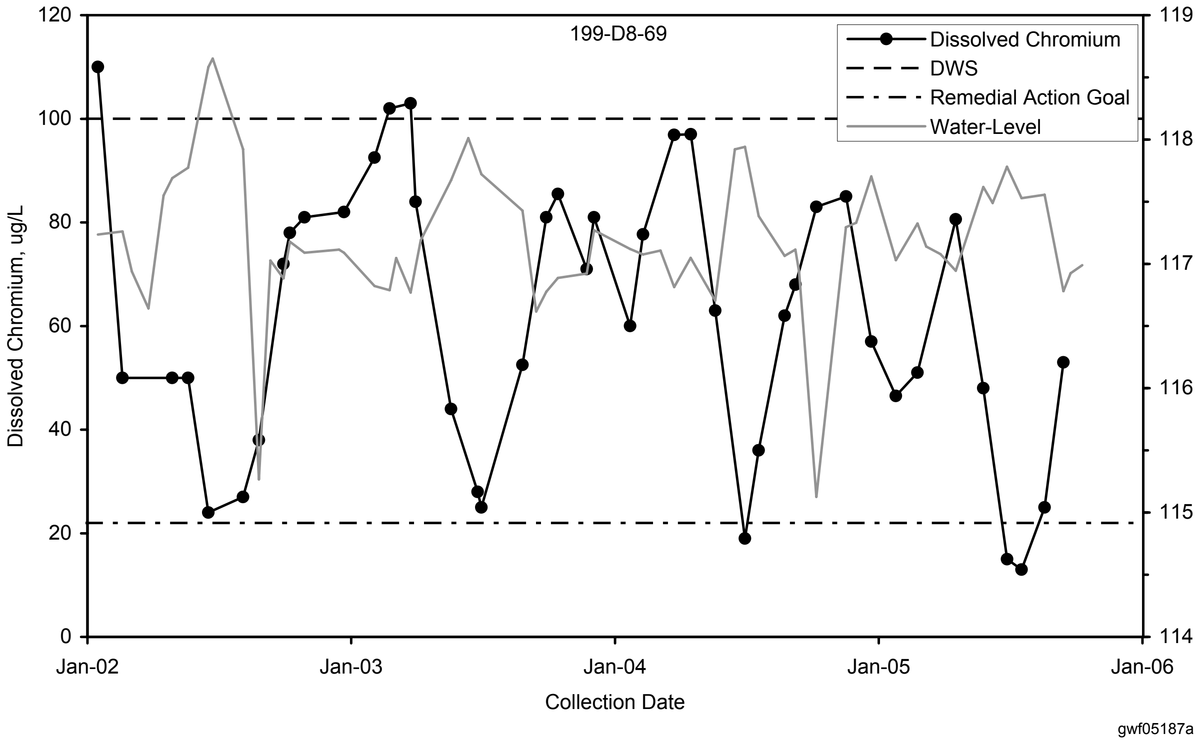


Figure 2.5-7. Chromium Concentrations in Wells Near Former D Reactor



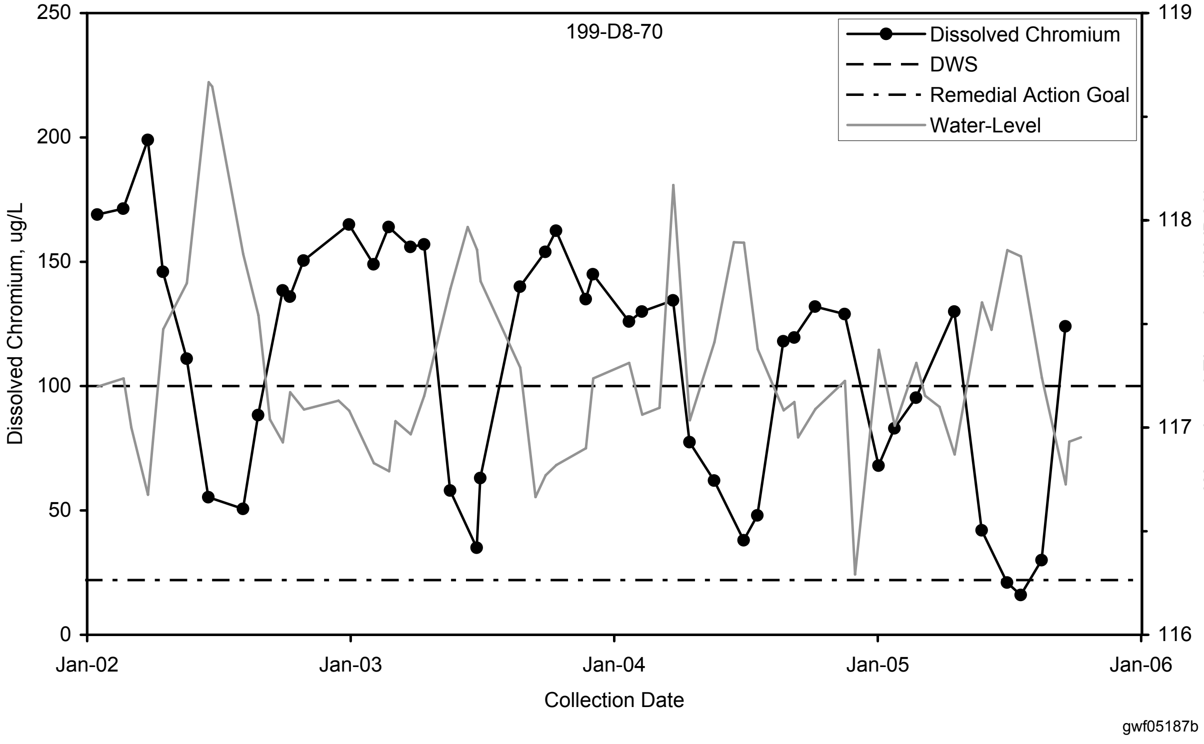


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Figure 2.5-8. Dissolved Chromium Concentrations and Water Levels in Compliance Wells for the 100-HR-3 Pump-and-Treat System at 100-D Area

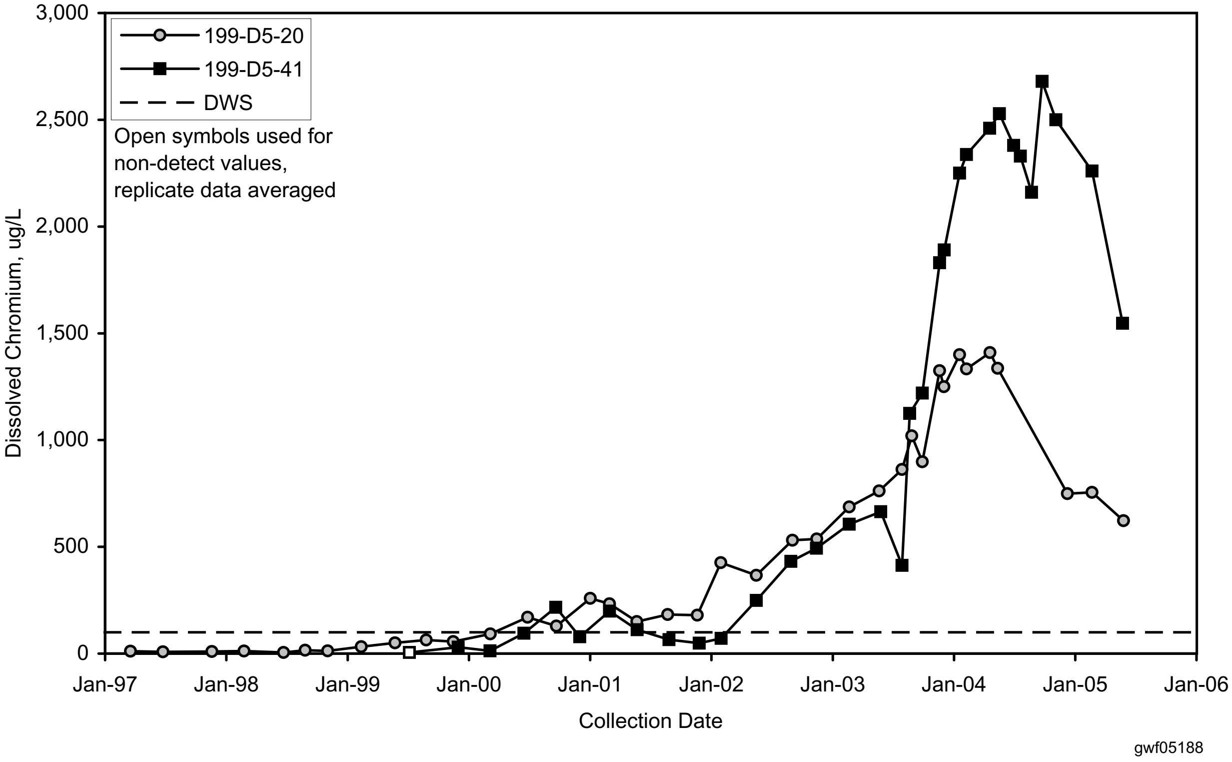


Figure 2.5-9. Dissolved Chromium Concentrations in Central 100-D Area

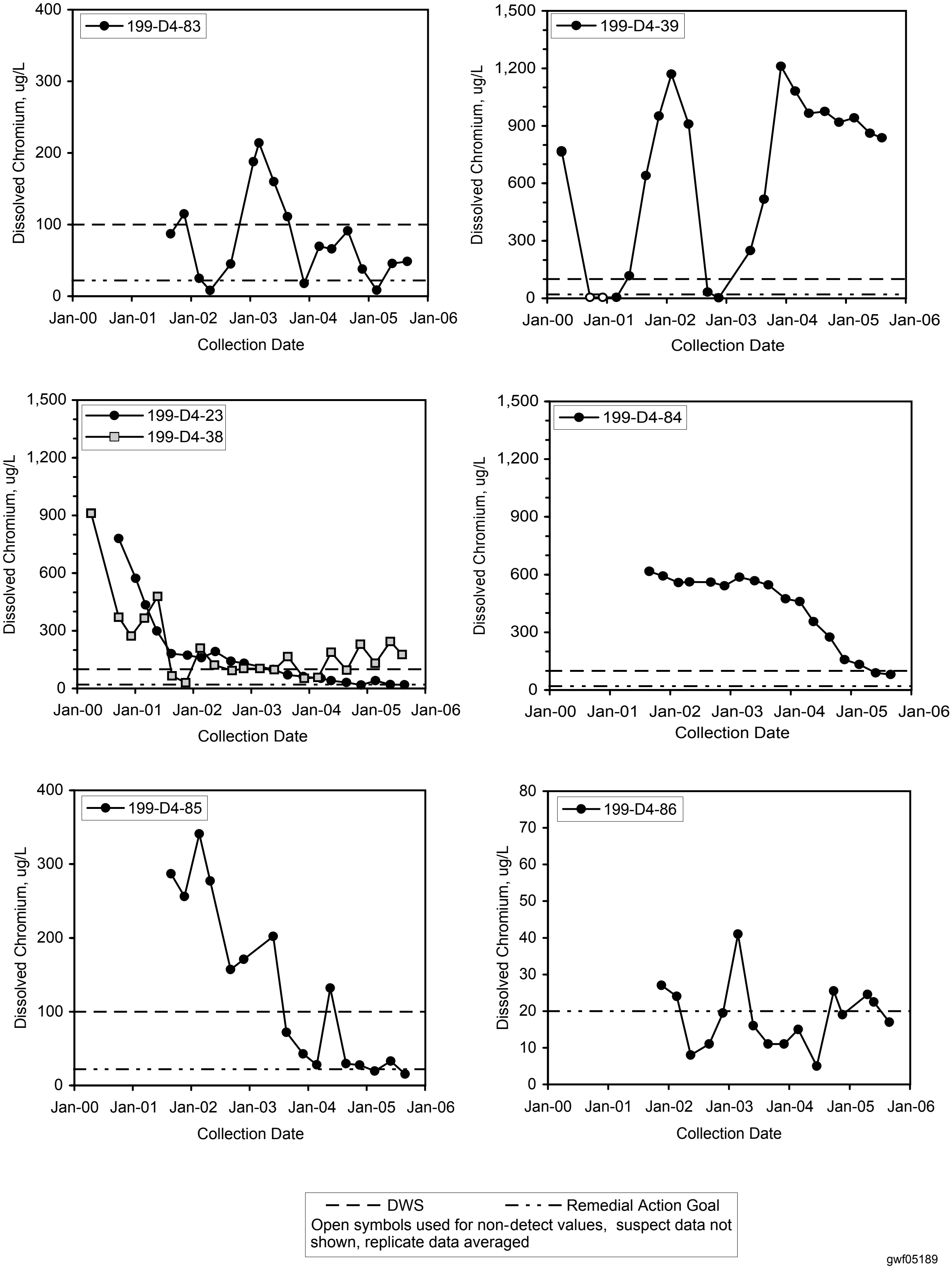


Figure 2.5-10. Dissolved Chromium Concentrations in Compliance Wells Downgradient of the Redox Barrier

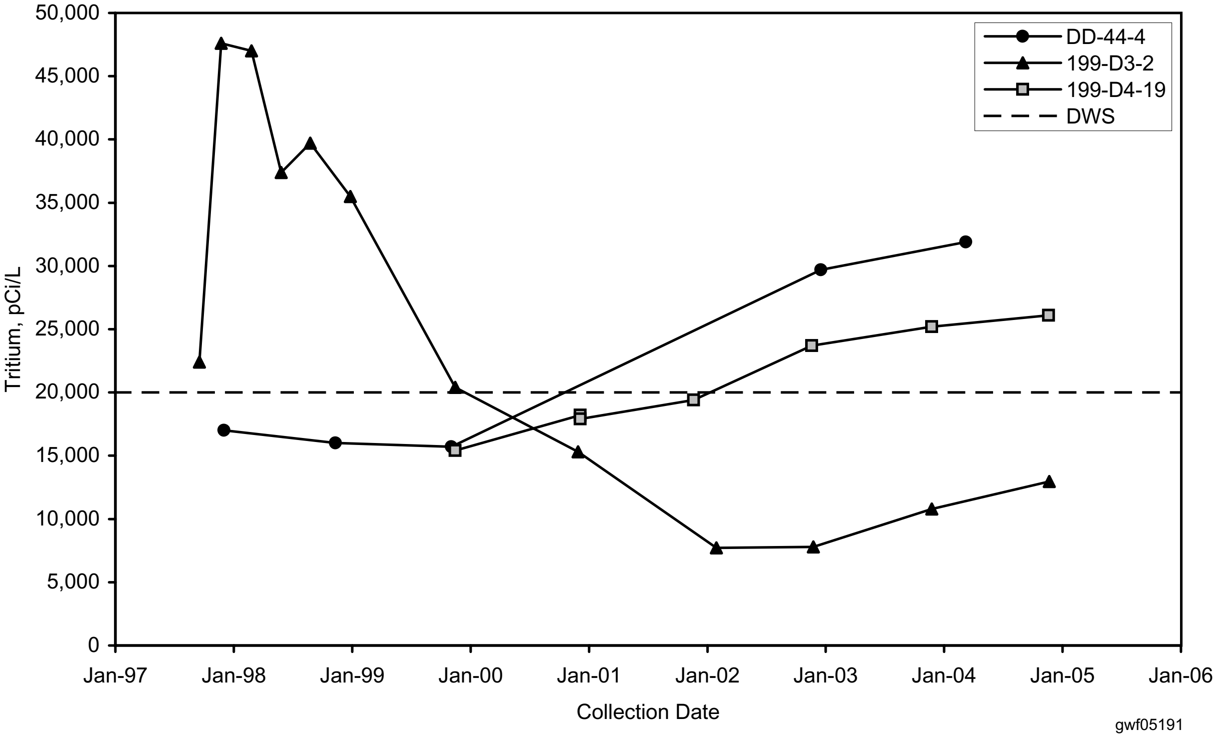


Figure 2.5-11. Tritium Concentrations in South 100-D Area

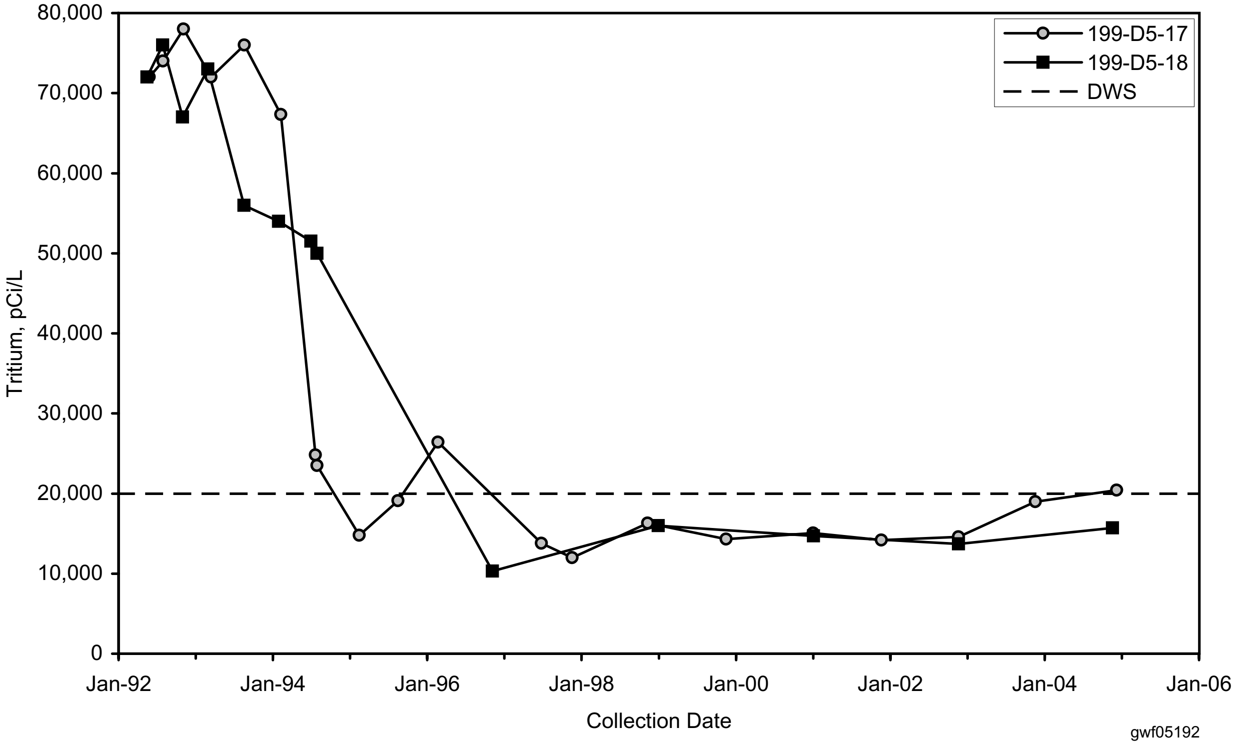


Figure 2.5-12. Tritium Concentrations in Wells Near Former DR Reactor

2.6 100-HR-3-H Operable Unit

M. J. Hartman and R. F. Raidl

The scope of this section is the 100-HR-3-H groundwater interest area, which is the east portion of the 100-HR-3 Operable Unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined the "interest areas" informally to facilitate scheduling, data review, and interpretation. Figure 2.6-1 shows facilities, wells, and shoreline monitoring sites in this region. Chromium is the contaminant of greatest significance in groundwater. Groundwater is monitored to assess the performance of a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) interim action pump-and-treat system for chromium, to track other contaminant plumes, and for the 116-H-6 evaporation basins, a *Resource Conservation and Recovery Act* (RCRA) unit.

Groundwater flows primarily from the southwest to northeast, toward the Columbia River (Figure 2.6-2). Local flow directions are influenced by groundwater extraction and injection. Groundwater flows generally toward the northeast across the entire horn of the Columbia River north of Gable Mountain, so groundwater approaching the 100-H Area may contain contaminants that originated in the 100-D and 100-N Areas.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of interest (Section 2.6.1), summarizes groundwater remediation (Section 2.6.2), and discusses groundwater monitoring of the 116-H-6 evaporation basins (Section 2.6.3).

Hexavalent chromium is the groundwater contaminant of greatest concern in the 100-H Area. A pump-and-treat system helps reduce the amount reaching the Columbia River.

2.6.1 Groundwater Contaminants

This section describes monitoring results for chromium, strontium-90, technetium-99, uranium, nitrate, and tritium.

2.6.1.1 Chromium

Hexavalent chromium is the contaminant of concern for the 100-HR-3 groundwater interim action, which includes the 100-H Area. The pump-and-treat system is discussed in Section 2.6.2. This section describes the distribution and trends of hexavalent chromium. Results for filtered samples analyzed for total chromium represent hexavalent chromium, which is more soluble than trivalent chromium. Many groundwater samples also are analyzed specifically for hexavalent chromium.

Groundwater monitoring in the 100-HR-3-H groundwater interest area includes the following monitoring activities:

CERCLA Interim Remedial Action Performance Evaluation

- ***A pump-and-treat system in 100-H Area has operated since 1997. Wells are monitored monthly to annually for chromium and co-contaminants.***

CERCLA and AEA Long-Term Monitoring

- ***Wells throughout the 100-H Area and surrounding 600 Area are sampled annually to biennially, and aquifer tubes are sampled annually. One well was not sampled as scheduled in FY 2005 (see Appendix A).***

Facility Monitoring – 116-H-6 Evaporation Basins

- ***Four downgradient wells are sampled annually for chromium, nitrate, technetium-99, and uranium for requirements of RCRA and AEA.***
- ***Sampling is coordinated with CERCLA to avoid duplication.***
- ***In FY 2005, all wells were sampled as scheduled.***

Dissolved chromium continued to exceed the remedial action goal of 22 µg/L beneath a portion of the 100-H Area (Figure 2.6-3), but concentrations have decreased in most wells since the late 1990s. The plume had various sources, but the highest concentrations in fiscal year (FY) 2005 continued to be near the former 116-H-6 evaporation basins, where the annual average concentrations ranged from 10 to 73 µg/L. The drinking standard for chromium is 100 µg/L. Chromium concentrations in this area decreased more than an order of magnitude since the 1980s and continued to decrease in FY 2005 (Figure 2.6-4).

Plume areas (square kilometers) above the drinking water standard at the 100-HR-3-H Operable Unit:

Nitrate — 0.11
Strontium-90 — 0.16
Technetium-99 — <0.01
Uranium — 0.01

Four wells were monitored monthly as compliance wells for the 100-HR-3 pump-and-treat system (Figure 2.6-5), though well use changed later in the year (see Section 2.6.2). Wells 199-H4-5 and 199-H4-64 are located northeast of the former 116-H-6 evaporation basins. Well 199-H4-4 is located within the plume east of the former basins. Well 199-H4-63 is located farther south between the former 116-H-7 retention basin and the Columbia River. Concentrations in these wells varied inversely with river stage but declined overall.

Chromium concentrations at 100-H Area vary with river stage but are declining overall.

Chromium concentrations at five of the ten 100-HR-3 aquifer tube sites sampled in FY 2005 exceeded the 10-µg/L aquatic standard, and one tube site exceeded the 22-µg/L remediation goal. The highest concentrations were south of the main 100-H Area at tube sites 50 and 51 (Figure 2.6-6). Concentrations in the shallow tubes (50-S and 51-S) have increased gradually since the tubes were first sampled in 1997. Concentrations in mid-depth tube 50-M declined in FY 2003, 2004, and 2005 (21 µg/L in November 2004). Concentrations are neither increasing nor decreasing in tubes 51-M and 51-D, where the maximum FY 2005 concentration was 44 µg/L. This contamination south of the main 100-H Area could have moved south along the shoreline from 100-H Area sources. Chromium was lower in tubes monitoring the shoreline downgradient of the 100-H Area pump-and-treat system (2 to 14 µg/L).

Chromium concentrations in wells 199-H4-12C and 199-H4-15CS, which monitor deeper in the Ringold Formation, continued to be elevated (maximum 110 µg/L in well 199-H4-12C), but are declining. Concentrations of other contaminants that would indicate the influence of the 116-H-6 basins (nitrate, technetium-99, and uranium) are low in the deeper wells. The source of this deeper chromium is unknown.

Wells upgradient of the 100-H Area continued to have chromium concentrations near the drinking water standard (97.4 µg/L in well 699-97-43), but concentrations show an overall decline since the early 1990s (Figure 2.6-7). The source of this contamination is probably old contamination that originated in the 100-D Area when a water-table mound was present there (WHC-SD-EN-TI-023).

Technetium-99, uranium, and nitrate increased sharply in a well northeast of the former 116-H-6 evaporation basins and are now the highest in the 100-H Area. The cause of the increase is unknown.

2.6.1.2 Strontium-90

Strontium-90 concentrations continued to exceed the drinking water standard (8 pCi/L) beneath a portion of the southeast 100-H Area near the former retention basin and disposal trenches (Figure 2.6-8). The plume distribution has not changed appreciably in over 10 years. The highest concentration in FY 2005 was 38.8 pCi/L in well 199-H4-63. Concentrations are variable but are neither increasing nor decreasing overall. Strontium-90 was not analyzed in aquifer tubes near the 100-H Area in FY 2005, but exceeded the drinking water standard at tube site 47 in FY 1999 and 2000. A nearby shoreline seep (SH-153-1) had a strontium-90 concentration of 6.81 pCi/L in October 2004.

2.6.1.3 Technetium-99 and Uranium

Technetium-99 is elevated in groundwater downgradient of the former 116-H-6 evaporation basins, and levels exceeded the drinking water standard (900 pCi/L) in one well, 199-H4-9, in FY 2005. The well is located at the northeast corner of the former basins, and had 1,510 pCi/L technetium-99 in May 2005. The trend in the well is highly variable but increasing overall (Figure 2.6-9). Uranium shows a similar trend, with a concentration of 90 µg/L in April 2005. The cause of the increases in technetium-99 and uranium in well 199-H4-9 is unknown.

Well 199-H4-3, immediately downgradient of the basins, historically has shown the highest technetium-99 and uranium concentrations. The technetium-99 concentration in FY 2005 was 694 pCi/L (Figure 2.6-10). Concentrations have declined two orders of magnitude since the mid-1990s, but increased gradually during the past 3 years. The uranium concentration in this well was 93.5 µg/L in FY 2005.

2.6.1.4 Tritium

Tritium concentrations continued to decline in most wells. The highest concentration in the 100-H Area was 3,420 pCi/L in well 199-H4-46. Well 699-97-43, located west (upgradient) of the 100-H Area, continued to have a higher tritium concentration (5,160 pCi/L).

2.6.1.5 Nitrate

Nitrate concentrations continued to exceed the drinking water standard (45 mg/L) in numerous wells near the former 116-H-6 evaporation basins and in several wells in the southeast 100-H Area. Concentrations in many wells decreased between FY 2004 and 2005 and the area with concentrations above the drinking water standard was smaller in 2005.

The nitrate concentrations in well 199-H4-9, northeast of the basins, increased sharply during FY 2005 to 514 mg/L in April 2005. The sudden increase was similar to those seen in technetium-99 and uranium. Well 199-H4-3, located due east of the former basins, has historically shown the highest nitrate concentrations. The FY 2005 concentration in that well was 244 mg/L. Concentrations have increased slightly since 2001, but have decreased overall since the 1990s.

In previous years, a second nitrate plume has been mapped at levels above the drinking water standard (45 mg/L) in southeast 100-H Area, but concentrations in FY 2005 were below the standard except in aquifer tube 50-M, which had a value of 47 mg/L. The nitrate concentration in well 199-H6-1, in the southeast 100-H Area, declined to 42.5 mg/L during FY 2005, the first time it has been below the standard since 1996. Nitrate concentrations continued to be unusually low for the 100-H Area (<20 mg/L) in two wells east of the reactor building, 199-H4-47 (5.8 mg/L) and 199-H4-16 (17 mg/L).

Nitrate concentrations exceed drinking water standards near the former 116-H-6 evaporation basins.

2.6.2 Interim Groundwater Remediation for Chromium

A pump-and-treat system operates in the 100-H Area as part of a CERCLA interim action for the 100-HR-3-H Operable Unit (ROD 1996a). Interim remedial action monitoring is described in DOE/RL-96-90. Long-term monitoring requirements in the 100-H Area were derived from Change Control Form 107 as modified by Fluor Hanford, Inc.[(a)] Figure 2.6-1 displays locations of extraction and injection wells and Appendix A lists sampling frequencies and constituents.

The remedial action objectives for the 100-HR-3 Operable Unit (ROD 1996a) are:

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminant in the groundwater.***
- ***Provide information that will lead to the final remedy.***

The contaminant of concern is hexavalent chromium. The record of decision specifies the cleanup goal at compliance wells as 22 µg/L. EPA specified enhancements needed to the system in their 5-year review (EPA 2001).

(a) Letter FH-0402972 from H Hermanas and BH Ford (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.

2.6.2.1 Progress During FY 2005

During FY 2005, the pump-and-treat system at 100-H Area extracted ~118.6 million liters of groundwater, removing ~4.4 kilograms of hexavalent chromium.

The 100-H pump-and-treat system is reducing overall contamination in the operable unit by removing contaminant mass. During FY 2005, the pump-and-treat system extracted ~118.6 million liters of groundwater from the 100-H Area, removing ~4.4 kilograms of hexavalent chromium.

The pump-and-treat system has removed ~41.6 kilograms of hexavalent chromium from the 100-H Area groundwater since startup in July 1997. This represents most of the ~42 kilograms estimated in the plume in 1992 (WHC-SA-1674-VA). That estimate did not include chromium from upgradient sources (100-D) nor in the vadose zone.

2.6.2.2 Influence on Aquifer Conditions

Chromium concentrations in 100-H Area groundwater have declined, and the size of the plume in the uppermost aquifer has shrunk since the pump-and-treat system began to operate in 1997. Those changes are likely due to a combination of the effects of the pump-and-treat system and dispersion (e.g., natural processes). In FY 2005, with Washington State Department of Ecology (Ecology) approval, U.S. Department of Energy (DOE) modified the system twice to respond to the changing plume and to most effectively reduce the remaining mass and achieve the 22-µg/L remedial action goal in near-river wells. The network changes are summarized below:

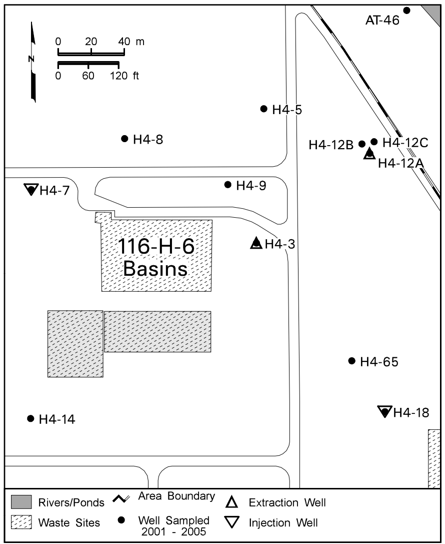
1997-2004	January 2005	August 2005
	Extraction Wells	
199-H3-2A	199-H4-4	199-H4-3
199-H4-7	199-H4-11	199-H4-4
199-H4-11	199-H4-12A	199-H4-12A
199-H4-12A	199-H4-15A	199-H4-15A
199-H4-15A	199-H4-64	199-H4-63
199-H4-65	199-H4-65	199-H4-64
	Injection Wells	
199-H3-3	199-H3-2A	199-H3-2A
199-H3-4	199-H4-18	199-H4-7
199-H3-5	199-H3-5	199-H4-17
		199-H4-18

Hexavalent chromium concentrations in compliance wells continued to decline in FY 2005 (see Figure 2.6-5). Concentrations in former compliance well 199-H4-4 declined below the 22-µg/L remedial action goal after the well was converted to an extraction well. Chromium concentrations in former compliance wells 199-H4-63 and 199-H4-64 ended FY 2005 at ~30 µg/L, with an overall downward trend since FY 2003. Similarly, concentrations continued a downward trend in compliance well 199-H4-5.

Results of performance monitoring are incorporated with the discussion of general contamination in Section 2.6.1. Results of operational monitoring and additional details about the pump-and-treat system for calendar year 2004 can be found in DOE/RL-2005-18. Results for 2005 will be published in an upcoming annual report on the 100-HR-3, 100-KR-4, and 100-NR-2 pump-and-treat systems.

2.6.3 Facility Monitoring — 116-H-6 (183-H) Evaporation Basins

The 116-H-6 (183-H) evaporation basins are the only RCRA site in the 100-H Area. The site is monitored during the post-closure period under corrective action monitoring requirements of WAC 173-303-645(11)(g). Lists of wells and constituents monitored and a well location map are included in Appendix B.



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The unit was incorporated into the Hanford Facility RCRA Permit (Ecology 1994a). While the pump-and-treat system is operating, RCRA monitoring consists of annual sampling of four wells for chromium, fluoride, nitrate, technetium-99, and uranium. The latter two constituents are not regulated under RCRA but were included in the monitoring plan for completeness and were incorporated by reference in the Hanford Facility RCRA Permit (Ecology 1994a). The objective of monitoring during the operation of the pump-and-treat system is to determine whether concentrations of the contaminants of concern are decreasing. DOE proposed a change to the monitoring requirements with a permit modification in FY 2004. The proposed change would bring the site under a post-closure monitoring program that is integrated with the CERCLA monitoring program, as allowed under Section II.K.7 of the Hanford Facility RCRA Permit (Ecology 1994a).

The four wells in the RCRA network were sampled as scheduled in FY 2005 for the constituents of interest listed in the groundwater monitoring plan. Trends in the constituents of interest (except fluoride) were discussed in Section 2.6.1. Fluoride concentrations remained low (<300 µg/L) in groundwater downgradient of the 116-H-6 evaporation basins.

One of the wells (199-H4-7) in the RCRA network was converted to an injection well in August 2005. Thus, the well can no longer meet its objective to track chromium trends in groundwater. DOE and Ecology have agreed that well 199-H4-8 will be substituted for well 199-H4-7.(b)

(b) Hanford Facility RCRA Permit Modification Notification Form, signed by GP Davis (Washington State Department of Ecology), January 10, 2006. 183-H Solar Evaporation Basins, Part VI, Chapter 2 and Attachment 37.

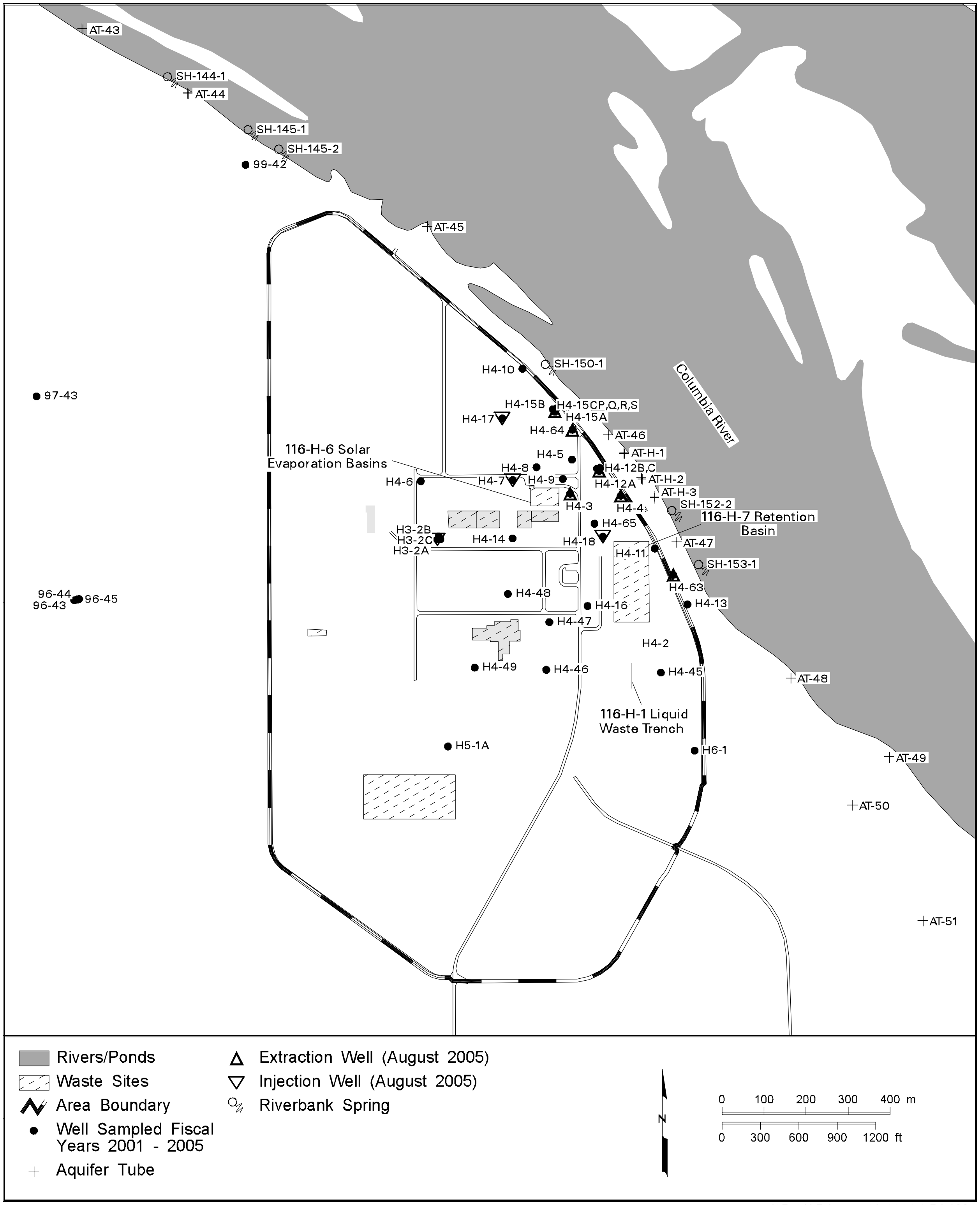

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Figure 2.6-1. Groundwater Monitoring Wells in 100-H Area

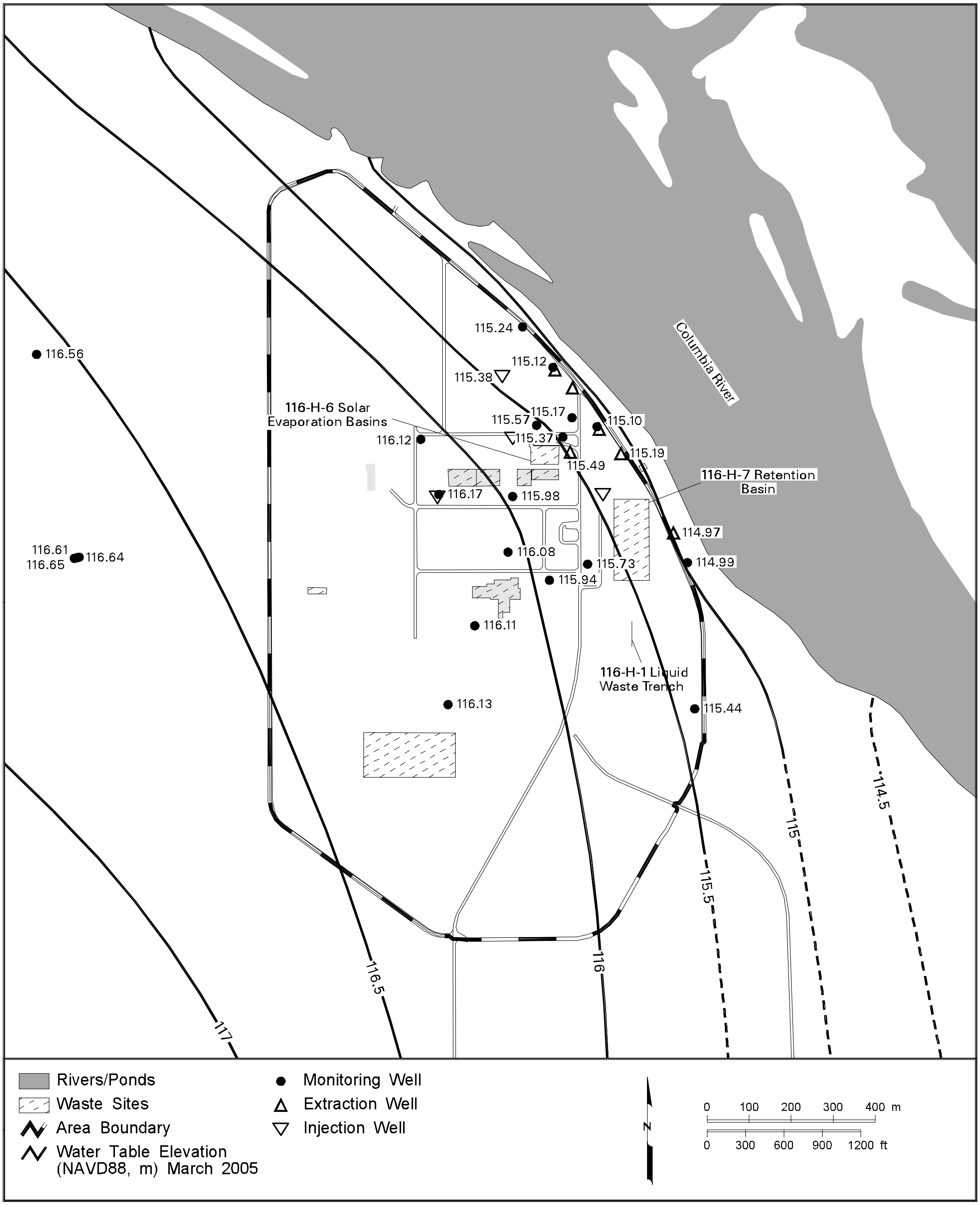

Figure 2.6-2. 100-H Area Water-Table Map, March 2005

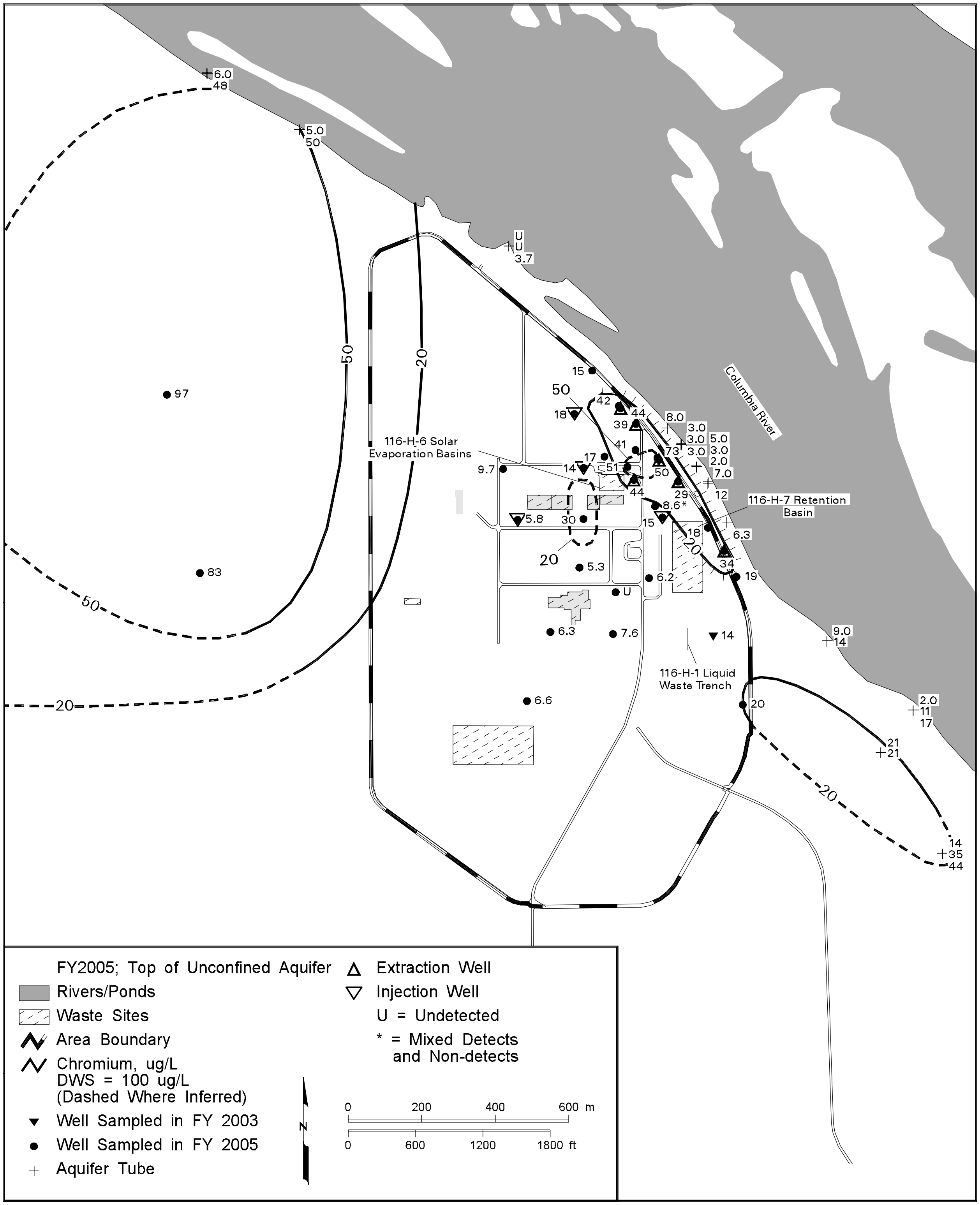

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Figure 2.6-3. Average Chromium Concentrations in 100-H Area, Top of Unconfined Aquifer

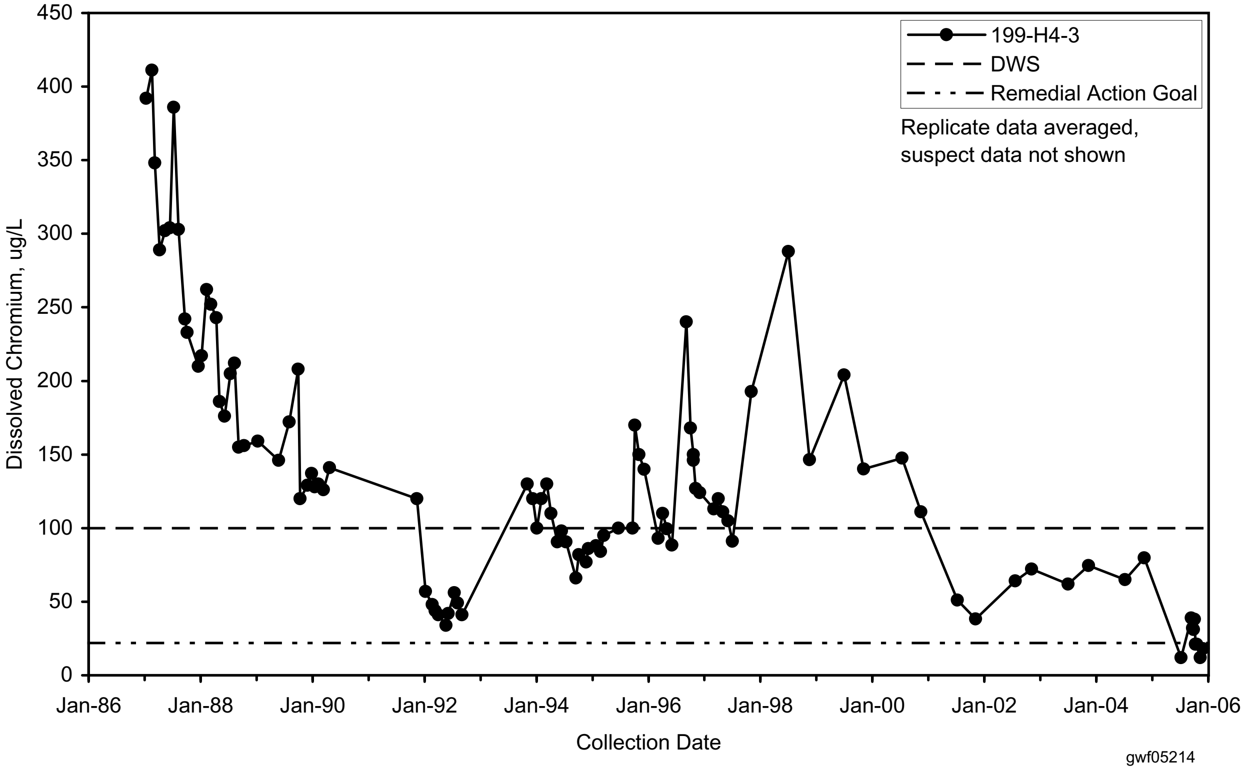
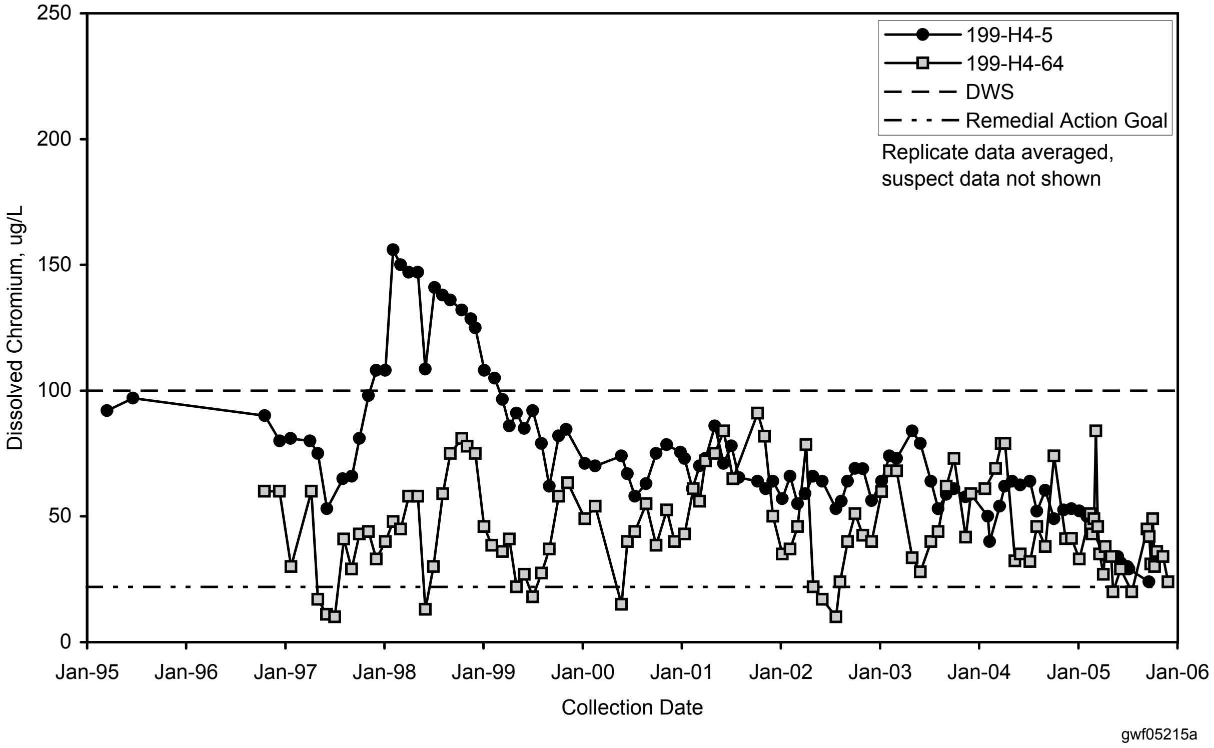


Figure 2.6-4. Chromium Concentrations East of 116-H-6 Evaporation Basins



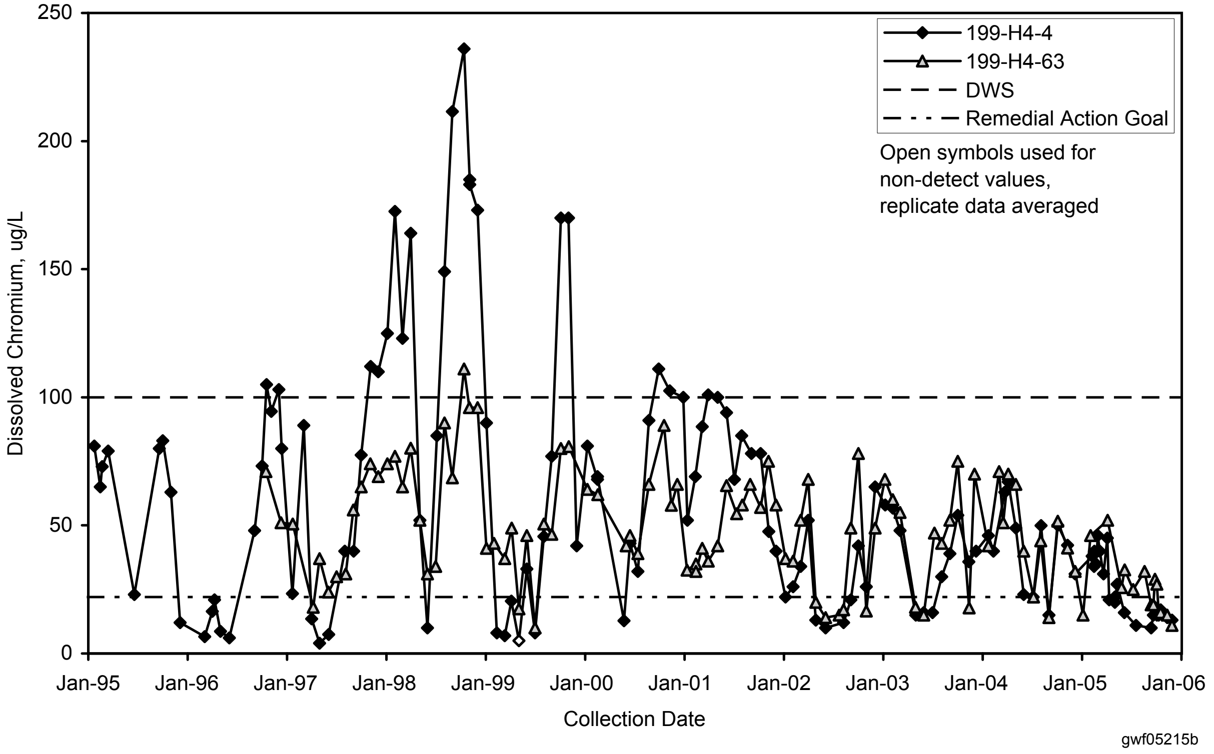


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Figure 2.6-5. Chromium Concentrations in Compliance Wells for the 100-HR-3 Pump-and-Treat System at 100-H Area

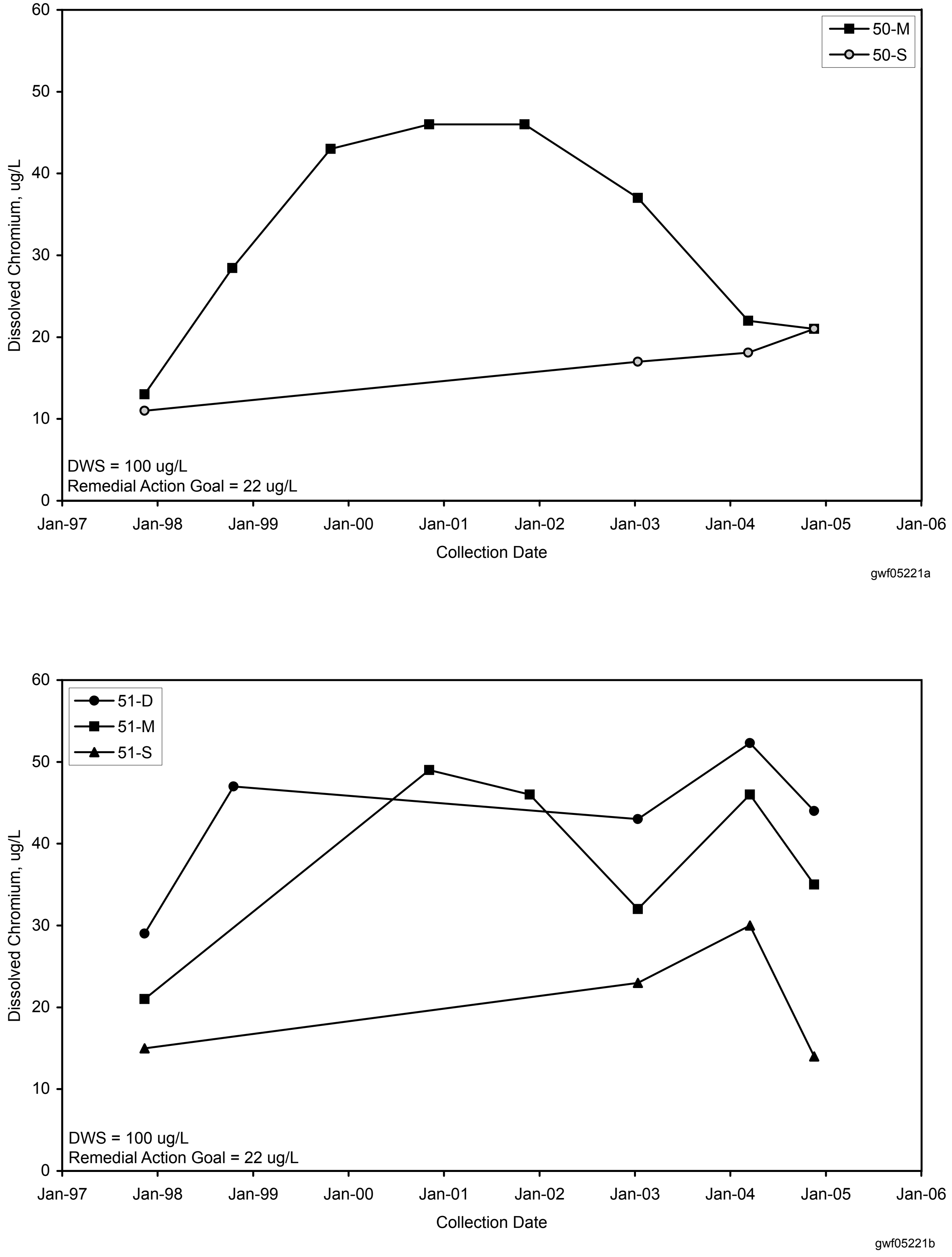

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Figure 2.6-6. Chromium Concentrations in Aquifer Tube Samples at 100-H Area

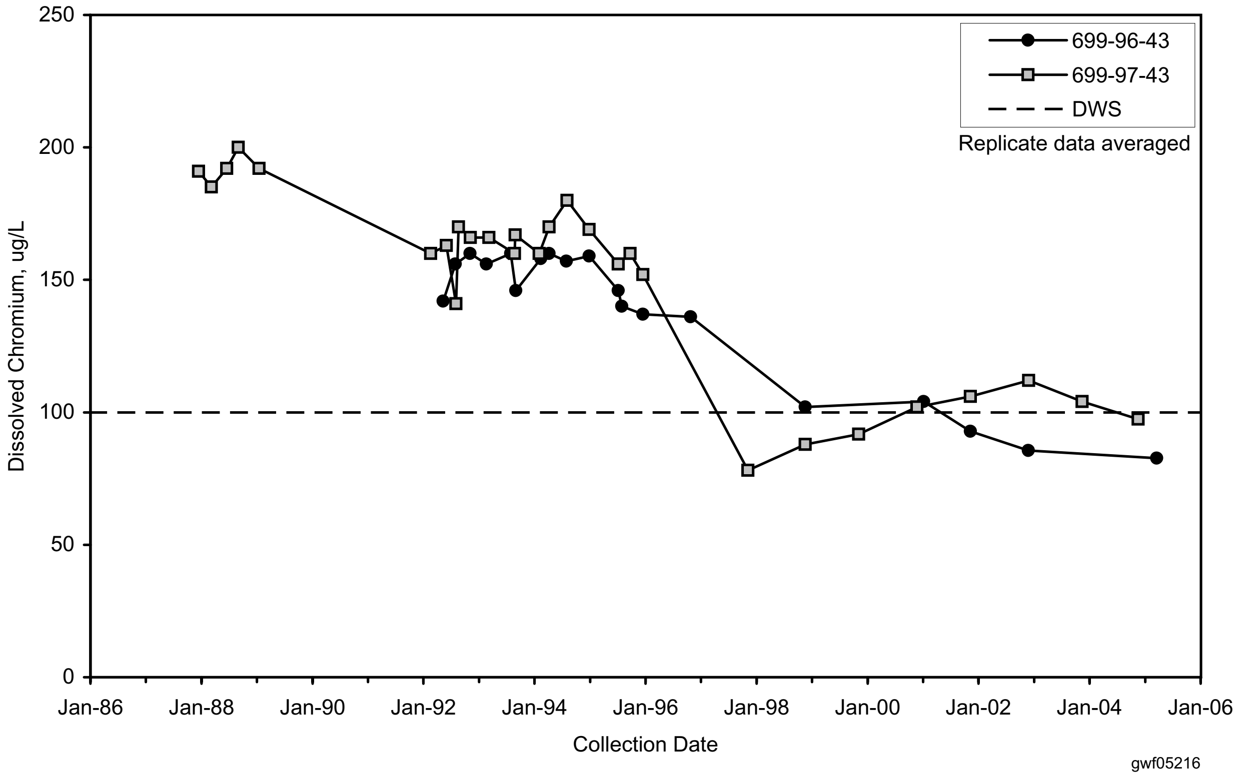

Figure 2.6-7. Chromium Concentrations Upgradient of 100-H Area

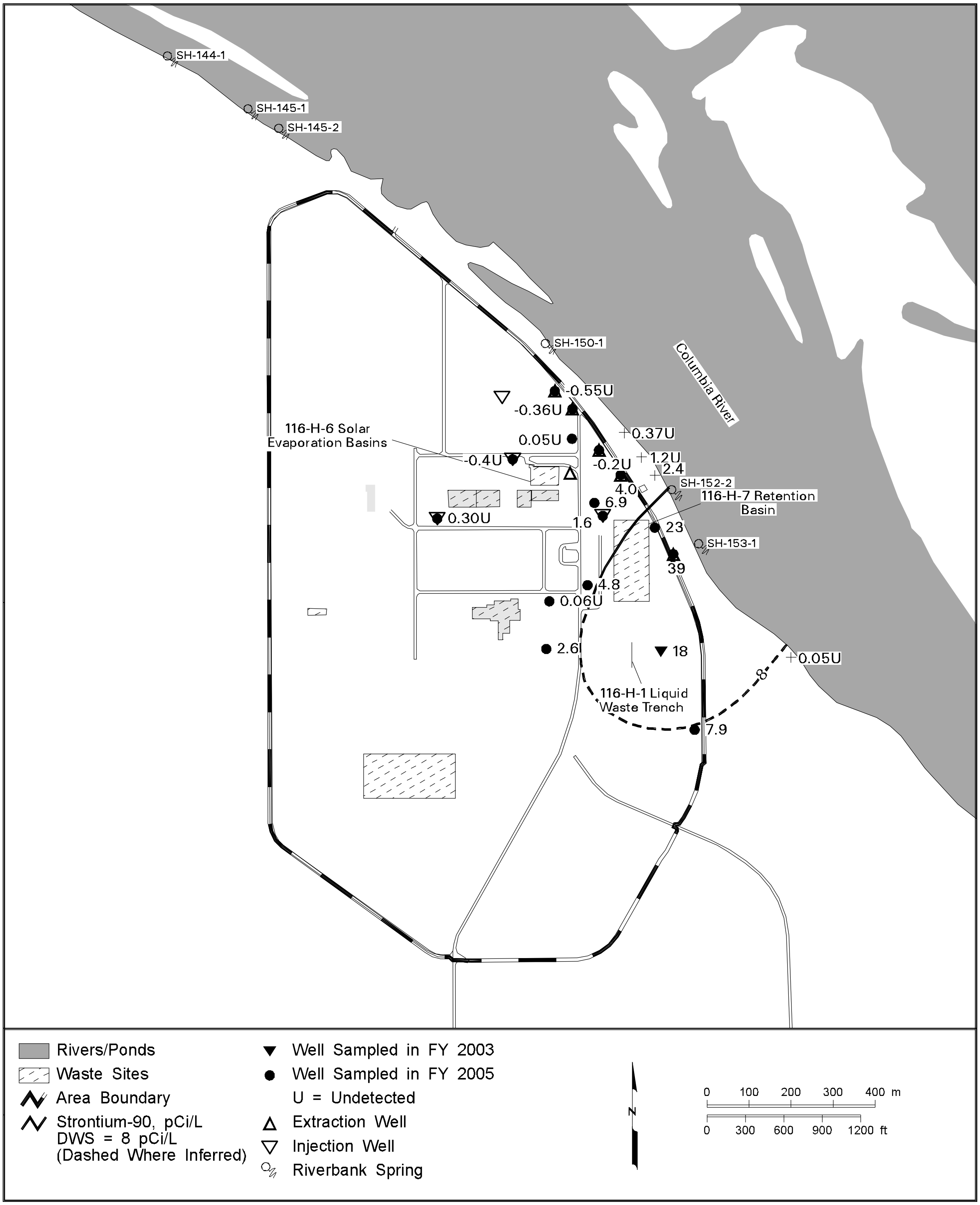

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Figure 2.6-8. Strontium-90 Concentrations in 100-H Area, Top of Unconfined Aquifer

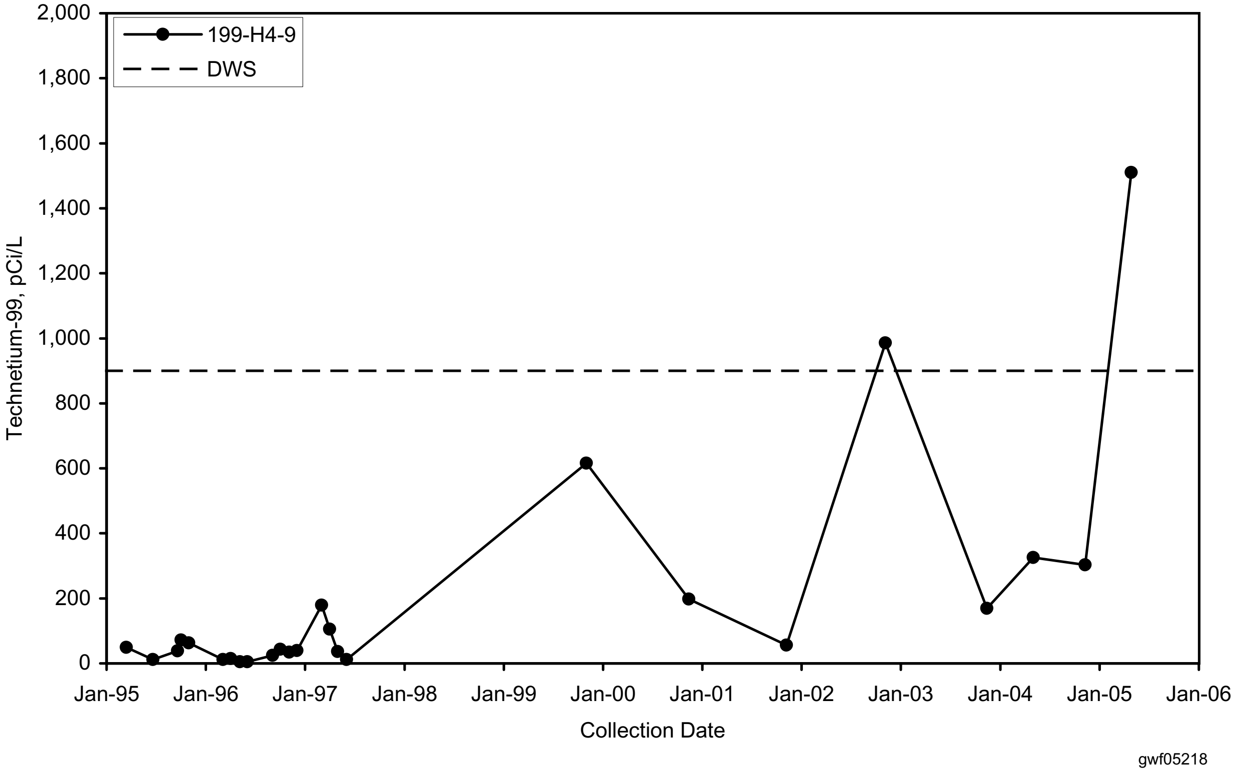

Figure 2.6-9. Technetium-99 Concentrations Northeast of 116-H-6 Evaporation Basins

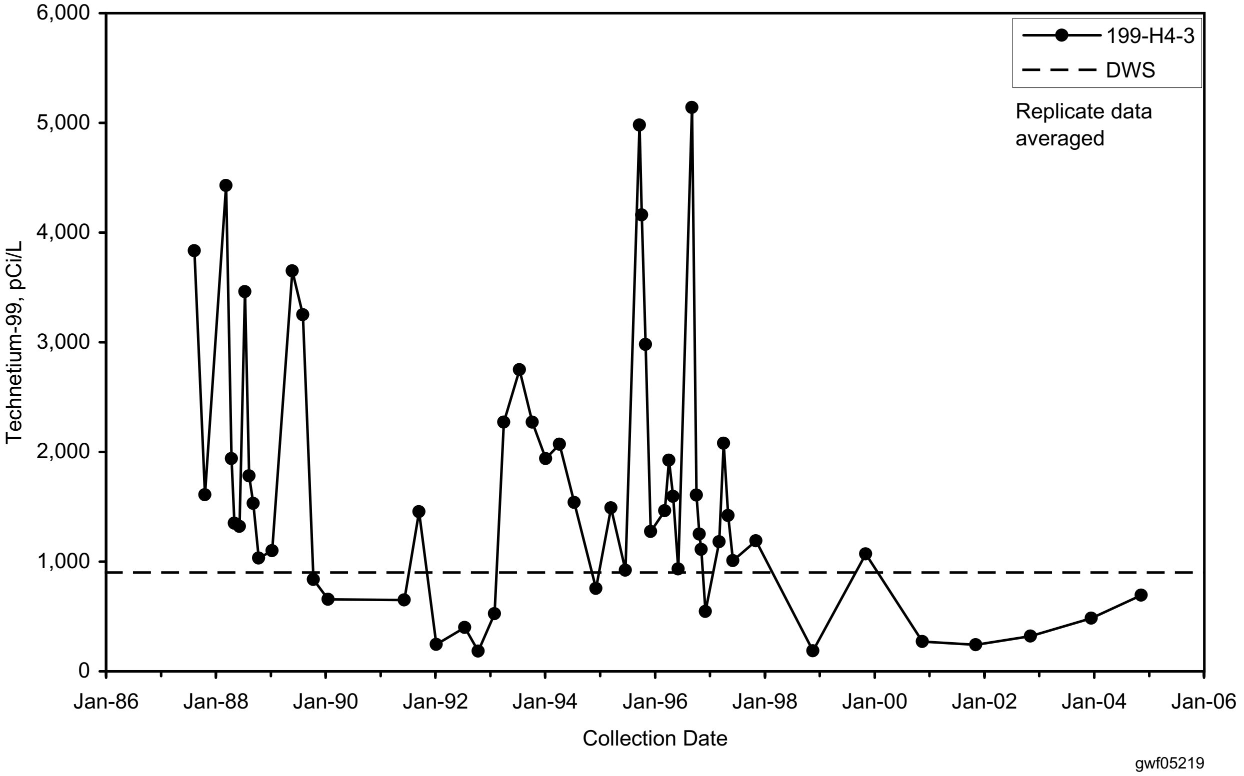

Figure 2.6-10. Technetium-99 Concentrations East of 116-H-6 Evaporation Basins

2.7 100-FR-3 Operable Unit

M. J. Hartman

The scope of this section is the 100-FR-3 groundwater interest area, which encompasses the 100-FR-3 Operable Unit and a large section of the 600 Area north of Gable Mountain (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined "groundwater interest areas" informally to facilitate scheduling, data review, and interpretation. Figure 2.7-1 shows facilities, wells, and shoreline monitoring sites in the 100-F Area.

Groundwater flows primarily to the east and southeast beneath the 100-F Area (Figure 2.7-2). Movement of the nitrate plume indicates flow to the south-southeast.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). Groundwater monitoring for the *Atomic Energy Act* (AEA) is integrated fully with CERCLA monitoring. Most of the former liquid waste sites in the 100-F Area have been excavated and backfilled. There are no active waste disposal facilities or *Resource Conservation and Recovery Act* (RCRA) sites in the 100-F Area.

A nitrate plume extends from the central 100-F Area south into the 600 Area.

2.7.1 Groundwater Contaminants

This section describes the distribution and trends of the contaminants of concern for the 100-FR-3 Operable Unit: nitrate, strontium-90, tritium, trichloroethene, uranium, and hexavalent chromium.

2.7.1.1 Nitrate

A large nitrate plume extends from the 100-F Area southward (Figure 2.7-3). The portion of the plume with concentrations above the drinking water standard (45 mg/L) is interpreted to extend south from the 100-F Area nearly 5 kilometers, although data are sparse in the 600 Area.

Wells in the main 100-F Area continued to show levels of nitrate that exceeded the drinking water standard in fiscal year (FY) 2005 (Figure 2.7-4). The highest, recent nitrate concentration was 166 mg/L in well 199-F7-3 in February 2004 (well is sampled biennially). Concentrations had been increasing in this well from the late 1990s until 2002. Concentrations are lower and declining in well 199-F8-4.

South of the 100-F Area, nitrate concentrations are near 100 mg/L in wells 699-62-31 and 699-71-30. Concentrations increased in these wells since the early 1990s, but decreased in the most recent samples (October 2004 and January 2005, respectively).

Aquifer tubes south of the main 100-F Area also have elevated nitrate concentrations. Tubes at site AT-75 typically exceed the drinking water standard (45 mg/L). There is no aquatic standard for nitrate.

Groundwater monitoring in the 100-FR-3 groundwater interest area includes integrated CERCLA and AEA monitoring:

- ***Nine wells, nineteen aquifer tubes, and three seeps are sampled annually.***
- ***Twenty-five wells are sampled biennially; thirteen of these were scheduled in FY 2005.***
- ***All wells were sampled as scheduled.***
- ***Four aquifer tube sites and two seeps were not sampled (see Appendix A).***

2.7.1.2 Strontium-90

Strontium-90 concentrations exceed the drinking water standard (8 pCi/L) beneath a portion of the 100-F Area around the 116-F-14 retention basin and nearby disposal trenches. The extent of the plume has not changed significantly in over 10 years (Figure 2.7-5).

Plume areas (square kilometers) above the drinking water standard at the 100-FR-3 Operable Unit:

Nitrate — 17.55
Strontium-90 — 0.16
Trichloroethene — 2.98

Well 199-F5-1 currently has the highest strontium-90 concentrations (22.6 pCi/L in FY 2004; the well is sampled biennially). Strontium-90 also exceeds the drinking water standard in wells 199-F5-44 and 199-F5-46. The trends are neither increasing nor decreasing overall.

Strontium-90 is limited to the shallow portion of the aquifer. No strontium-90 is detected in deep well 199-F5-43B, while adjacent well 199-F5-43A typically detects 2 to 4 pCi/L of strontium-90.

Strontium-90 concentrations in aquifer tubes are below the drinking water standard. The maximum concentration detected to date was 2.25 pCi/L in tube 65-M. There is no aquatic standard for strontium-90.

2.7.1.3 Tritium

Tritium concentrations are somewhat elevated beneath the south 100-F Area, but do not currently exceed the drinking water standard (20,000 pCi/L). The plume extends to the southeast into the 600 Area at concentrations above 2,000 pCi/L (see Figure 2.1-5 in Section 2.1).

The only well where tritium historically exceeded the drinking water standard is well 199-F8-3, near the 118-F-1 burial ground, where concentrations were nearly 180,000 pCi/L in the mid-1990s. Concentrations declined in the late 1990s and the most recent result was 12,600 pCi/L in October 2004.

2.7.1.4 Trichloroethene

Trichloroethene concentrations in the southwest 100-F Area (Figure 2.7-6) exceed the drinking water standard (5 µg/L). The plume appears to be centered west of the 100-F Area but is not well defined because of a lack of wells. A soil-gas investigation (DOE/RL-95-99) helped define the area of contamination but did not identify the source of contamination. Concentrations in groundwater are declining.

Trichloroethene exceeds the drinking water standard in southwest 100-F Area.

Trichloroethene concentrations near the drinking water standard also are detected in wells in the central 100-F Area. The plume appears to have moved slightly eastward over the past 10 years. Well 199-F7-1 has the highest concentration of trichloroethene (19 µg/L in FY 2004; sampled biennially).

Trichloroethene has been detected in several wells 5 to 6 kilometers west of the 100-F Area. The concentration in well 699-77-54 in July 2005 was 6.8 µg/L, exceeding the drinking water standard. Other wells in the 600 Area (699-71-52 and 699-83-47) far west of the 100-F Area have had detectable trichloroethene. The source of this contamination is not known, but it appears to be separate from the plume closer to the 100-F Area.

2.7.1.5 Uranium and Gross Alpha

For most of the period of operable unit groundwater monitoring, gross alpha has been monitored to screen for uranium. There are uranium data from FY 1996-2000 and FY 2005.

Uranium concentrations have remained below the drinking water standard (30 µg/L) in all of the available data (Figure 2.7-7). The maximum concentration in FY 2005 was 22.7 µg/L in well 199-F8-2 in the central 100-F Area, where uranium concentrations increased slightly since 1996. Gross alpha concentrations in this well show no overall trend; levels were above the drinking water standard (15 pCi/L) occasionally in the early 1990s but are now below the standard (13 pCi/L in FY 2005). Gross alpha concentrations increased slightly in well 199-F5-46 in the past 10 years (see Figure 2.7-7). In other wells, concentrations show no clear trend.

2.7.1.6 Hexavalent Chromium

Figure 2.7-8 shows the distribution of dissolved chromium in the upper part of the aquifer. Concentrations are all below the drinking water standard (100 µg/L). The overall extent of the plume at levels above 20 µg/L has changed little in the past 10 years. In addition to the main plume near the Columbia River, one well (199-F8-3) near the 118-F-6 burial ground showed a concentration >20 µg/L (36 µg/L) in FY 2005. This well has shown variable chromium concentrations throughout its history of monitoring.

Figure 2.7-9 shows trend plots for chromium in four 100-F Area wells that typically have the highest concentrations of chromium. Three of the four wells show variable trends that are increasing overall. In FY 2005, the maximum concentration was 61 µg/L in well 199-F5-45. A value of 98 µg/L, just below the drinking water standard (100 µg/L), was measured in well 199-F5-6 in FY 2004, but the level declined to 54 µg/L in FY 2005. Meanwhile, well 199-F5-46 shows an overall decreasing trend, although it is located between wells with increasing trends.

Chromium concentrations in aquifer tubes at 100-F Area are generally low, but exceeded the aquatic standard (10 µg/L) at tube sites 72 through 75, located south of the main 100-F Area. The highest concentration in FY 2005 was 14 µg/L.

Chromium concentrations in 100-F Area groundwater remained below the drinking water standard in FY 2005.

2.7.2 Operable Unit Monitoring

A record of decision has not yet been developed for the 100-FR-3 Operable Unit, and no active remediation of groundwater is underway. U.S. Department of Energy (DOE) continues monitoring contaminant conditions while waste site remedial actions are conducted.

The groundwater sampling and analysis plan (DOE/RL-2003-49, Rev. 1) calls for annual sampling of 9 wells, 19 aquifer tube sites, and 3 shoreline seeps, and biennial sampling of 25 wells (see Appendix A). All of the 22 wells scheduled for sampling in FY 2005 were sampled successfully. Four of the aquifer tube sites were not sampled: AT-73, AT-78, and AT-F-4 were under water when sampling was attempted, and AT-80 is considered a low-priority site. Only one of the three seeps was sampled in FY 2005. The scope of aquifer tube sampling increased across the Hanford Site in recent years, and seep sampling was given a lower priority.

Until groundwater remediation decisions are made for the 100-FR-3 Operable Unit, the groundwater project will continue to monitor contaminant plumes and trends.

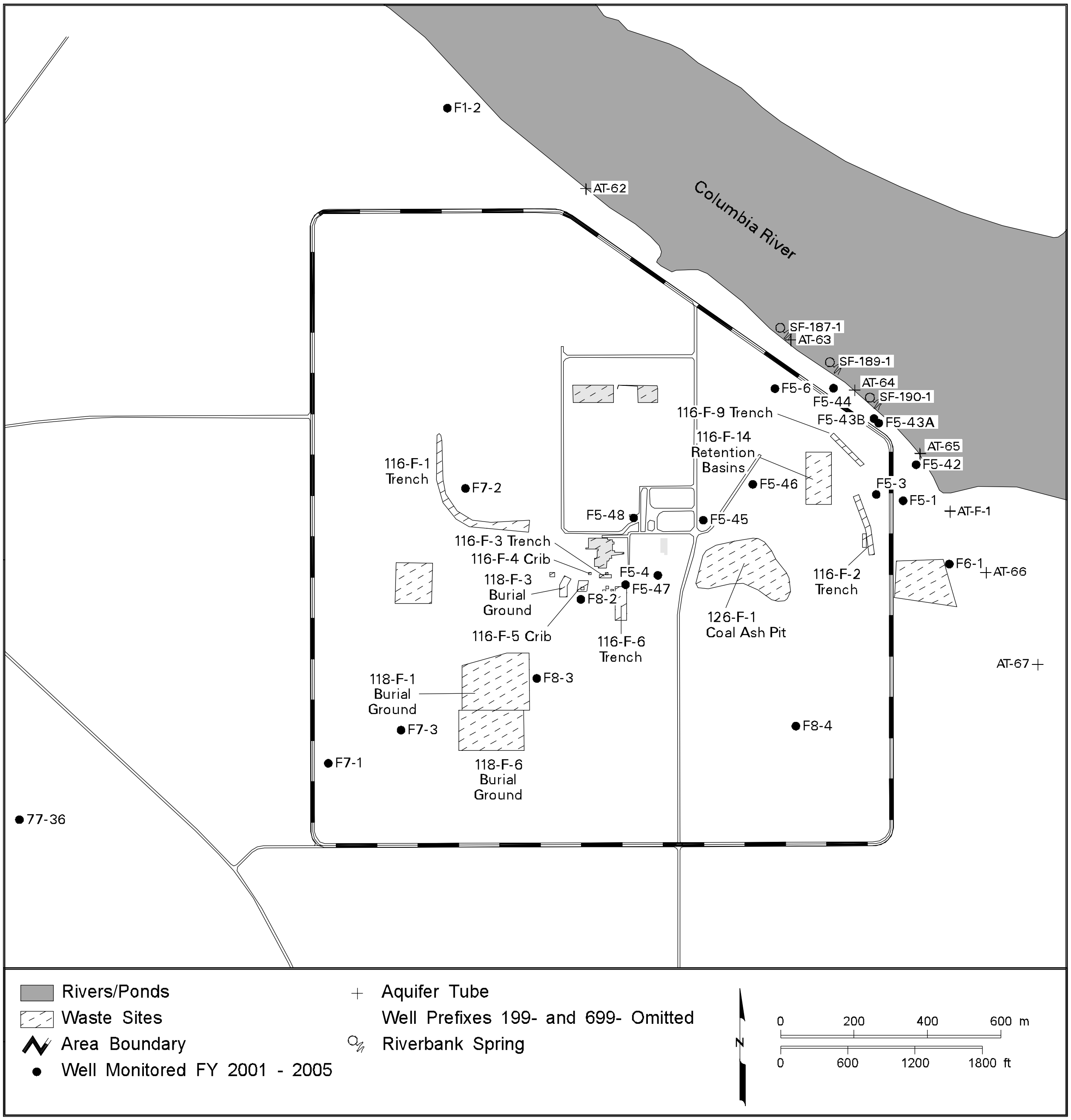

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Figure 2.7-1. Groundwater Monitoring Wells in 100-F Area

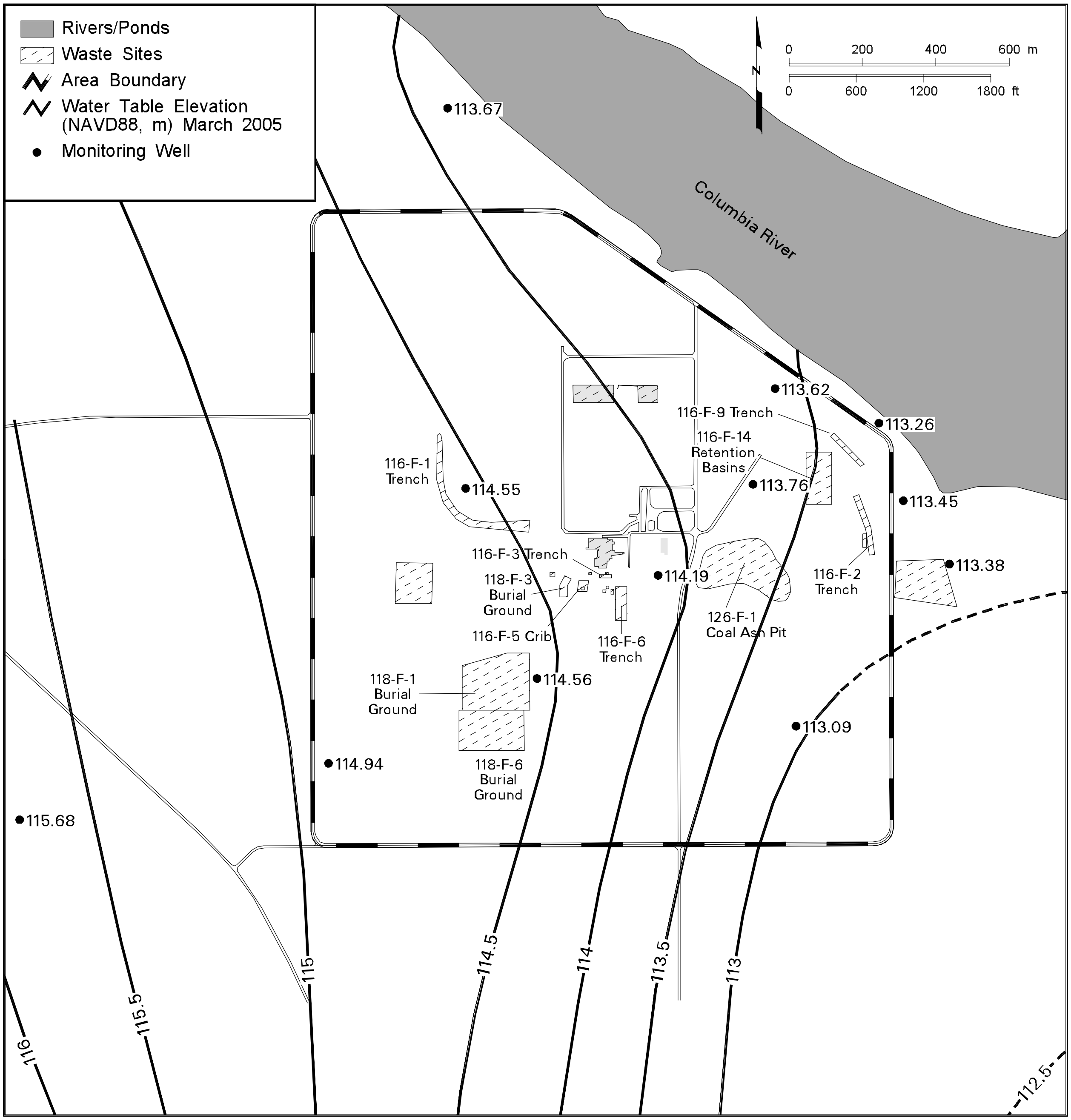

Figure 2.7-2. 100-F Area Water-Table Map, March 2005

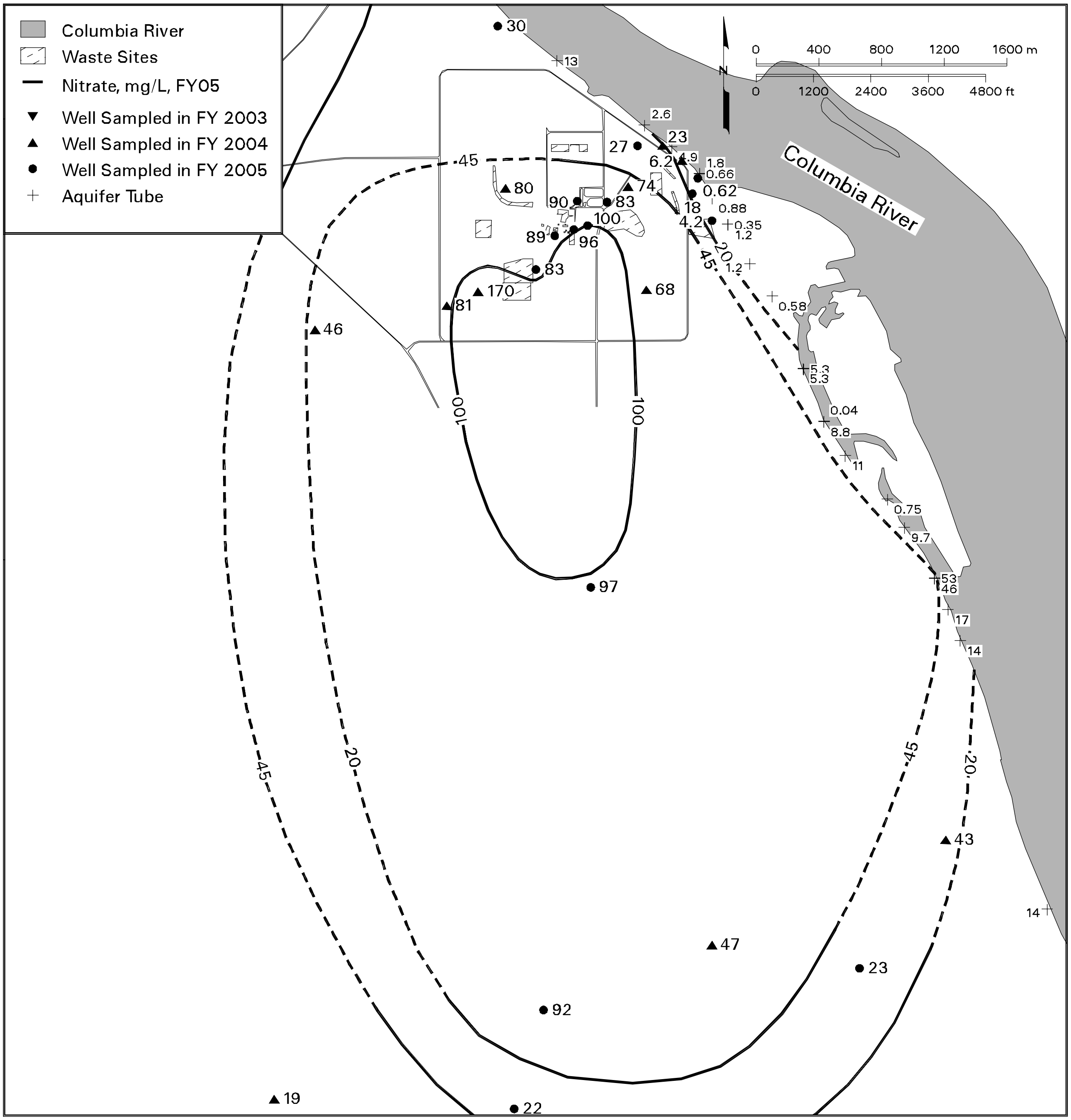

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Figure 2.7-3. Average Nitrate Concentrations in 100-F Area, Top of Unconfined Aquifer

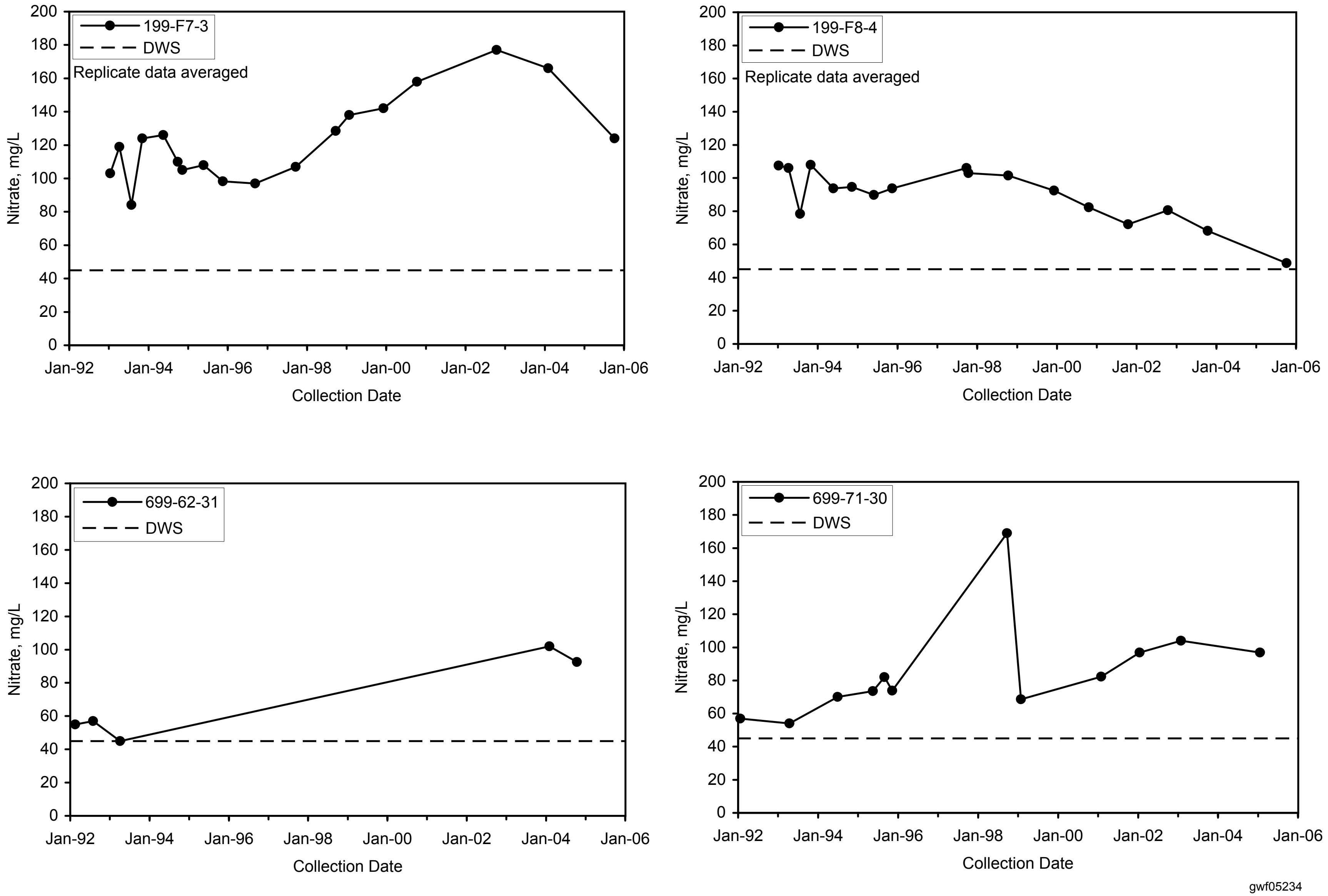

Figure 2.7-4. Nitrate Concentrations in Monitoring Wells in and South of 100-F Area

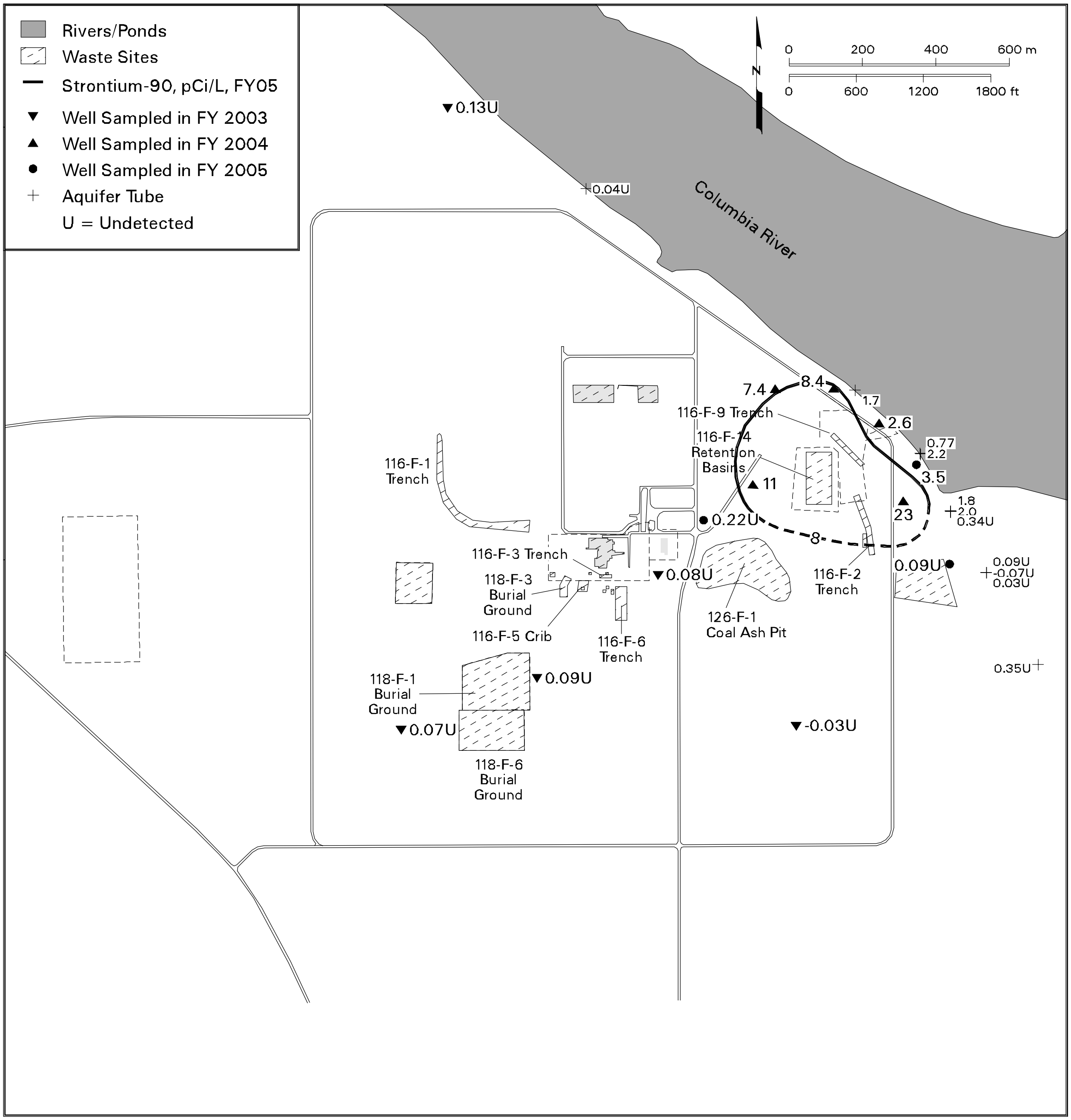

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Figure 2.7-5. Average Strontium-90 Concentrations in 100-F Area, Top of Unconfined Aquifer

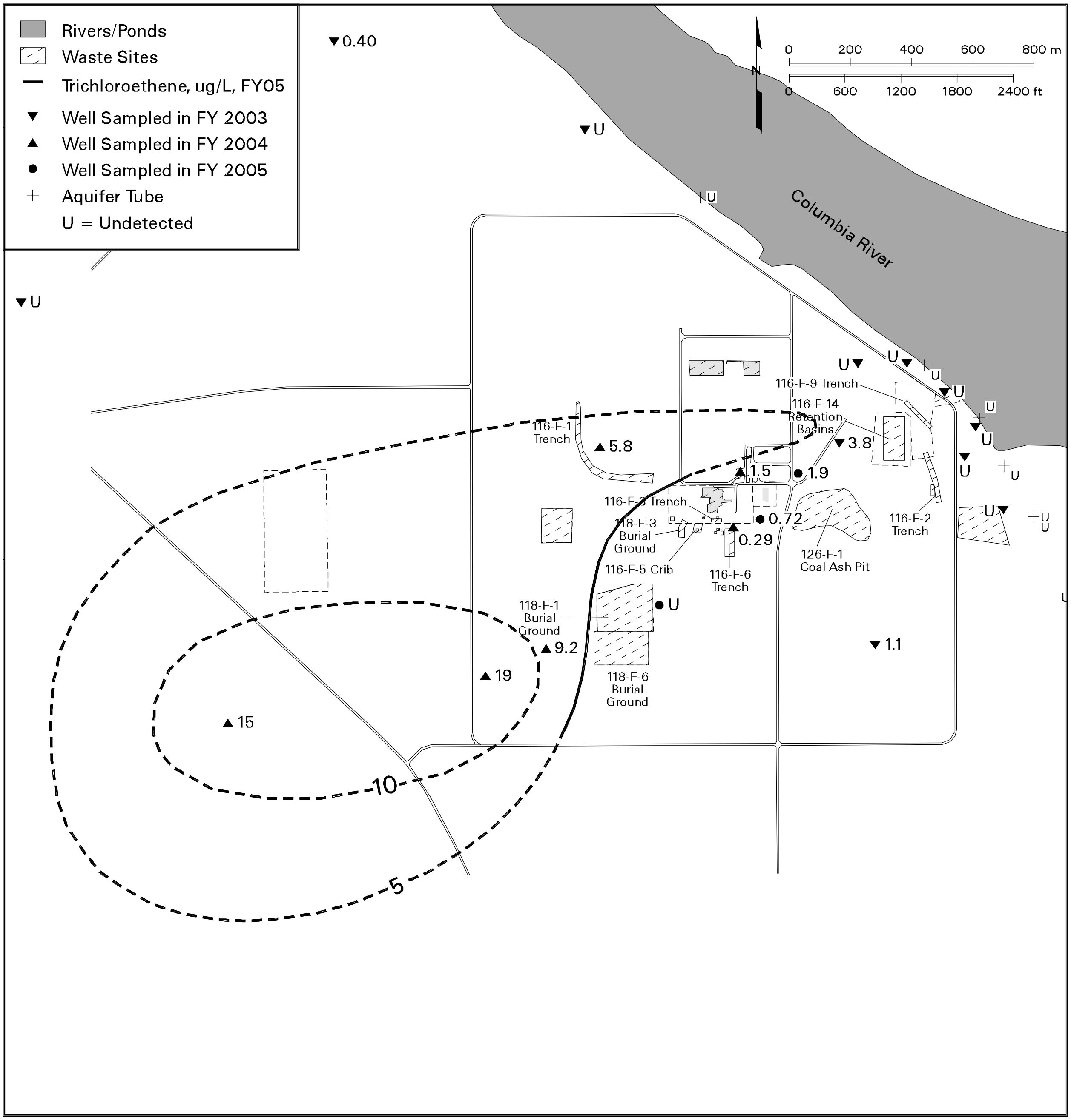

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Figure 2.7-6. Average Trichloroethene Concentrations in 100-F Area, Top of Unconfined Aquifer

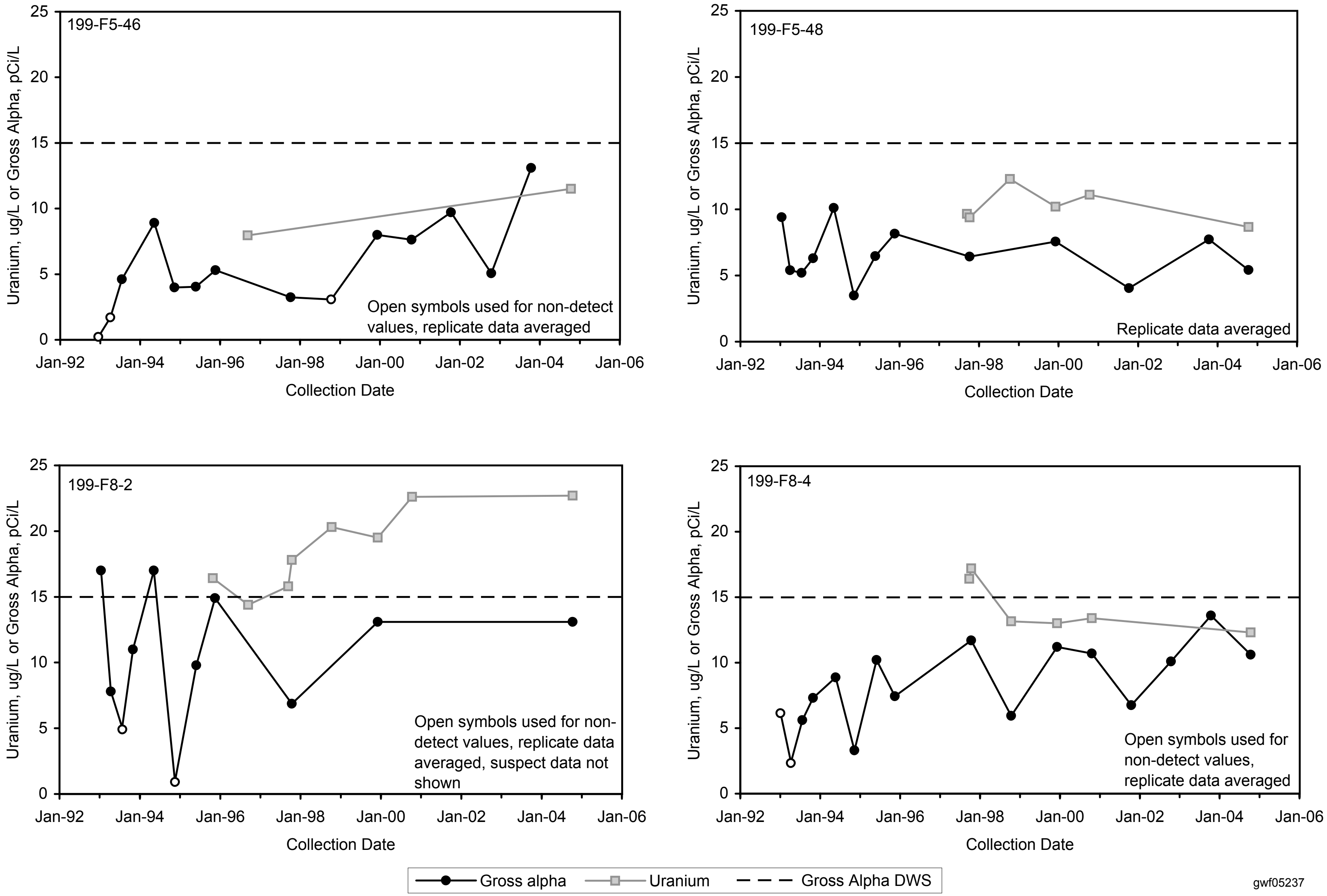

Figure 2.7-7. Uranium and Gross Alpha Concentrations in Monitoring Wells in 100-F Area

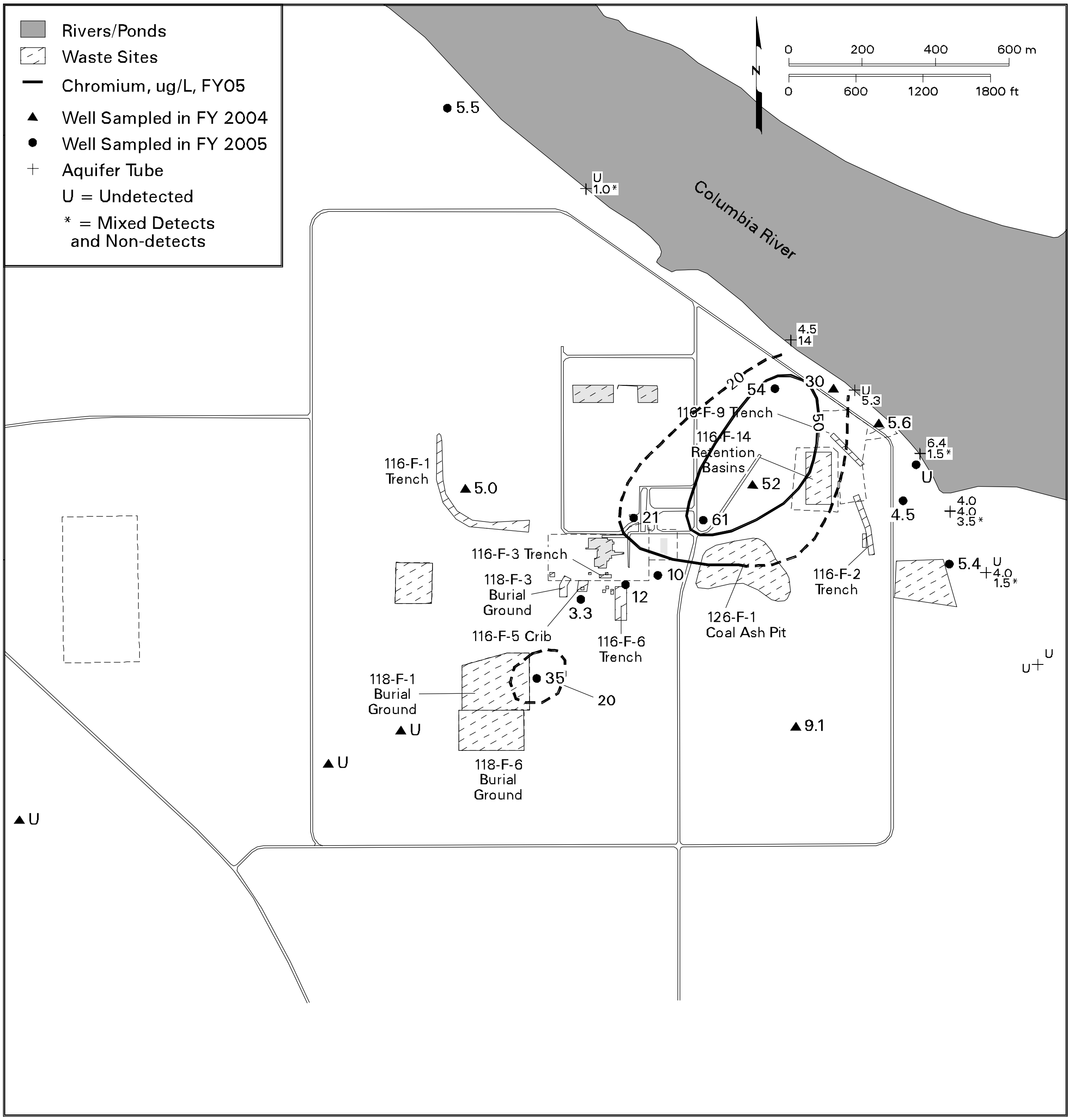

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Figure 2.7-8. Average Dissolved Chromium Concentrations in 100-F Area, Top of Unconfined Aquifer

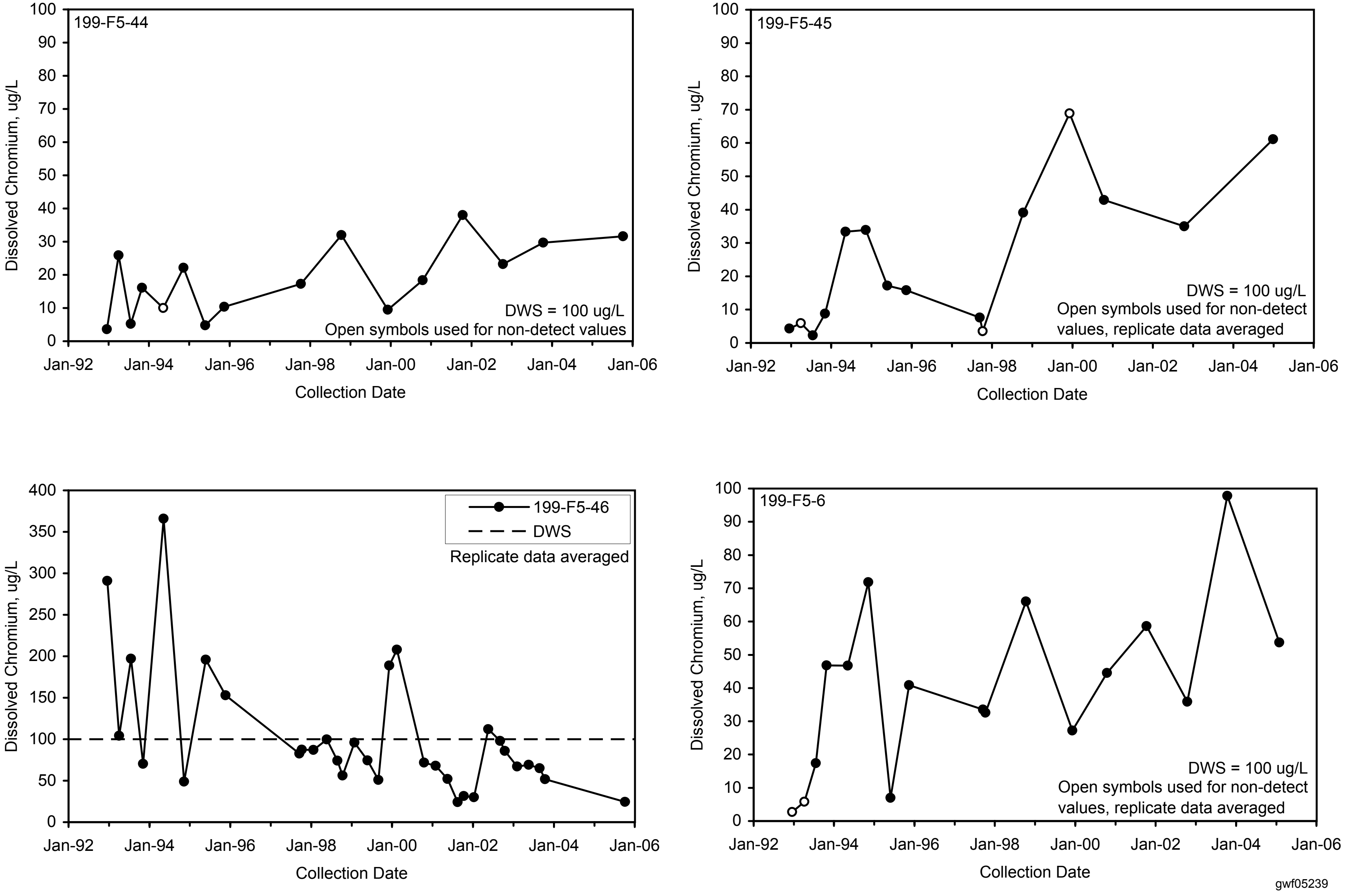


Figure 2.7-9. Chromium Concentrations in Monitoring Wells in 100-F Area

2.8 200-ZP-1 Operable Unit

P. E. Dresel, D. G. Horton, L. C. Swanson, D. B. Erb, and R. F. Raidl

The scope of this section encompasses the 200-ZP-1 Operable Unit and surroundings and includes the northern and central parts of the 200 West Area. This region is informally termed the 200-ZP-1 groundwater interest area (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined groundwater interest areas informally to facilitate scheduling, data review, and interpretation. Figure 2.8-1 shows facilities and wells in this region. Groundwater is monitored to assess the performance of an interim action pump-and-treat system for carbon tetrachloride contamination, to track other contaminant plumes, and for four *Resource Conservation and Recovery Act* (RCRA) units and the State-Approved Land Disposal Site. Data from facility-specific monitoring are also integrated into the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) groundwater investigations. The major contamination plumes in this area include carbon tetrachloride, chloroform, trichloroethene, nitrate, chromium, fluoride, tritium, iodine-129, technetium-99, and uranium.

Carbon tetrachloride is the primary contaminant of concern in this operable unit.

Within the 200-ZP-1 Operable Unit, interim actions have been implemented for remediation of carbon tetrachloride, chloroform, and trichloroethene in the vicinity of the 216-Z liquid waste disposal units (216-Z cribs and trenches). Remediation of other groundwater contaminants will be determined through the remedial investigation/feasibility study process per Section 5.5 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). A *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit* was prepared in fiscal year (FY) 2004 (DOE/RL-2003-55) and implemented in FY 2005.

Groundwater in the north portion of the 200 West Area predominantly flows toward the east-northeast but is locally influenced by the 200-ZP-1 Operable Unit pump-and-treat system and effluent discharges to the State-Approved Land Disposal Site (Figure 2.8-2). The water table in the 200 West Area was raised by past discharge of wastewater and the aquifer is still re-equilibrating after the termination of discharges. Thus, the flow direction is changing with time. The flow direction in the north part of the operable unit has changed ~35 degrees over the past decade from a north-northeast direction to a more eastward direction.

Groundwater monitoring in the 200-ZP-1 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring

- ***Wells are sampled quarterly to biennially.***
- ***In FY 2005, three wells were not sampled as scheduled and sampling was delayed at seven wells (see Appendix A).***

Facility Monitoring

- ***Wells are sampled semiannually for Low-Level Waste Management Area 3.***
- ***Wells are sampled semiannually for Low-Level Waste Management Area 4.***
- ***Wells are sampled quarterly to semiannually for Waste Management Area T.***
- ***Wells are sampled quarterly to semiannually for Waste Management Area TX-TY.***
- ***Wells are sampled quarterly to semiannually for the State-Approved Land Disposal Site.***
- ***In FY 2005, three RCRA wells were not sampled as scheduled (see text and Appendix B).***

Flow in the central part of the 200 West Area (the south part of the 200-ZP-1 Operable Unit) is heavily influenced by the operation of the 200-ZP-1 groundwater pump-and-treat remediation system. This system extracts water from the vicinity of the 216-Z cribs and trenches shown on Figure 2.8-1, treats it to remove carbon tetrachloride and other volatile organic compounds, then re-injects the water into the aquifer to the west of the area. A small groundwater mound is associated with the injection wells, and a region of drawdown is associated with the extraction wells, causing flow to converge on the extraction zone from all directions. The extension of the pump-and-treat extraction to the north of the baseline plume area in FY 2005 is beginning to alter flow in this part of the 200 West Area. In particular, flow is expected to reverse beneath the Waste Management Area TX-TY tank farms, affecting the assessment monitoring network and potentially drawing tank-farm associated contaminants into the new extraction wells of the pump-and-treat system. These flow conditions are expected to continue until the end of the pump-and-treat program, at which time the flow direction will resume a general west to east pattern.

Groundwater flows generally west to east and northeast except where affected by pumping, injection, or waste discharge.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern, summarizes the status of groundwater remediation efforts, and discusses the results of monitoring of specific facilities under CERCLA, RCRA, state permits, and the *Atomic Energy Act* (AEA).

2.8.1 Groundwater Contaminants

The groundwater contaminants of concern discussed below are defined in the 200-ZP-1 remedial investigation/feasibility study work plan (DOE/RL-2003-55). The contaminants of concern and their preliminary target action levels, defined in the work plan, are listed in Table 2.8-1. In addition, the table summarizes the sampling results for each contaminant of concern in the 200-ZP-1 sampling and analysis plan (DOE/RL-2003-55; Appendix A) at all wells within the general area. The contaminants of concern that exceeded the preliminary target action levels are discussed below. During FY 2005, a number of wells were sampled for selected volatile organic compounds as part of a CERCLA study by using a bailer to collect water very near the water table. These samples are not included in the discussion below because they are not considered representative of general aquifer conditions and the study is not yet complete.

2.8.1.1 Carbon Tetrachloride

Carbon tetrachloride contamination is found at levels greater than the drinking water standard (5 µg/L) in the groundwater under most of the 200 West Area (Figure 2.8-3). The main sources are believed to be the 216-Z cribs and trenches that received waste from the Plutonium Finishing Plant. Other possible carbon tetrachloride sources exist in the north part of the operable unit. Investigation of carbon tetrachloride in the vadose zone at Low-Level Waste Management Area 4 to evaluate its potential impact on groundwater is ongoing. The maximum carbon tetrachloride levels in groundwater are found near the Plutonium Finishing Plant and range up to 5,300 µg/L in individual samples. During FY 2005, monitoring well 299-W15-1 had the highest average concentrations (4,200 µg/L). Thus the area with a yearly average concentration >4,000 µg/L is smaller than in previous years. Some of the changes in reported concentrations and averages may be due to fewer field analyses being available in FY 2005. The field gas chromatograph was not operational from March 2005 until it was replaced with a new instrument in September. In previous years, field measurements have been systematically higher than laboratory measurements, although the cause has not been established. More data are needed to compare the field results from the new instrument to the laboratory results.

Plume areas (square kilometers) above the drinking water standard at the 200-ZP-1 Operable Unit:

***Carbon tetrachloride**	***10.78***
Chromium	***0.05***
Iodine-129	***0.78***
Nitrate	***6.06***
Technetium-99	***0.12***
Trichloroethene	***0.73***
Tritium	***0.80***
Uranium	***0.16***

****Also includes portion of plume beneath 200-UP-1 Operable Unit.***

Carbon tetrachloride remediation is the subject of the 200-ZP-1 interim record of decision (ROD 1995a). The target for remediation is the area with concentrations >2,000 to 3,000 µg/L in the vicinity of the 216-Z cribs and trenches. The remediation activities and more details on the contaminant distribution are summarized in Section 2.8.2.

Significant features of the carbon tetrachloride plume at the top of the aquifer include:

- The area of carbon tetrachloride >4,000 µg/L in the vicinity of the 216-Z cribs and trenches is decreasing due to the remediation however the area >2,000 µg/L has only changed slightly between FY 2004 and FY 2005 (see Section 2.8.2.1).
- An area of carbon tetrachloride at levels >2,000 µg/L extends north to the vicinity of Waste Management Area TX-TY. The west side of this lobe is defined by monitoring well 299-W15-43, where the average concentration was 1,300 µg/L, a decrease from FY 2004. This well was drilled early in FY 2003. The carbon tetrachloride contamination reaches the north part of Waste Management Area TX-TY where concentrations in well 299-W15-765 averaged 2,400 µg/L. In FY 2005, the pump-and-treat extraction system was expanded to capture this northern extension on the plume. Monitoring wells 299-W15-40, 299-W15-42, 299-W15-43, and 299-W15-765, were turned into extraction wells (see Section 2.8.2.2).
- Levels of carbon tetrachloride >1,000 µg/L are seen in the northeast part of the operable unit. The single routine sample in FY 2005 from well 299-W11-10 near the east boundary of the 200 West Area contained 1,100 µg/L of carbon tetrachloride. The extent beyond the area boundary for this high concentration has not been determined since there are no wells for ~2 kilometers downgradient.
- In the past several years, increasing concentrations of carbon tetrachloride have been seen in the vicinity of the tank farms in Waste Management Area S-SX (in the 200-UP-1 Operable Unit). Concentrations appear to have leveled off or declined in several wells in this area, but more time is needed to confirm the trends.
- Carbon tetrachloride levels continue to increase in well 699-48-71 indicating contamination is moving northeast from the 200 West Area. The FY 2005 average carbon tetrachloride in this well was 21 µg/L.
- The extent of carbon tetrachloride at the drinking water standard (5 µg/L) shown in Figure 2.8-3 did not change significantly from the previous year.

Carbon tetrachloride contamination is found at levels greater than the drinking water standard (5 µg/L) in groundwater beneath most of the 200 West Area.

Characterization samples collected at different depths during drilling of boreholes during the past several years have increased our understanding of the three-dimensional distribution of carbon tetrachloride. Carbon tetrachloride concentrations in several locations are higher at depth than at the top of the unconfined aquifer. Carbon tetrachloride may have moved deeper in the aquifer as a dense, non-aqueous liquid or under hydrodynamic gradients when dissolved. The depth distribution of carbon tetrachloride is part of an ongoing investigation under the 200-ZP-1 remedial investigation/feasibility study. Carbon tetrachloride concentration versus depth data for selected borings is shown in Figure 2.8-4. Laboratory analyses are shown with the exception of well 299-W13-1, where only field analyses were performed with depth. Pertinent results include:

- On the north and east sides of the carbon tetrachloride plume, the maximum concentrations are seen at depths between ~15 and 45 meters below the water table. The highest concentration seen at depth was 1,500 µg/L at 24 meters below the water table in well 299-W11-25B.
- On the west side of the carbon tetrachloride plume very different behavior is seen in wells 299-W15-49 and 299-W11-152. In well 299-W15-49, the highest concentration was 640 µg/L seen in the uppermost sample at 10.8 meters below the water table. However, in well 299-W15-152, the concentration increased continuously with depth, reaching a maximum of 390 µg/L at 36.9 meters below the water table. Well 299-W15-152 did not reach the bottom of the unconfined aquifer as defined by the top of the Ringold Formation lower mud unit.

- On the south end of the carbon tetrachloride plume, south of the Waste Management Area S-SX tank farms in the 200-UP-1 Operable Unit, the highest carbon tetrachloride concentration appears to be near the top of the aquifer, based on the data from well 299-W22-47. Lower levels of carbon tetrachloride are seen in nearby well 299-W22-50, but the highest concentrations are also seen at the top of the aquifer.
- Carbon tetrachloride concentrations continue their overall upward trend in well 299-W15-17, located west of the 216-Z cribs and trenches and completed above the Ringold Formation lower mud unit. The maximum concentration detected in FY 2005 was 26 µg/L, far below the concentration in nearby wells completed at the top of the unconfined aquifer.
- Monitoring wells completed at depth in the unconfined aquifer near the 200-UP-1 pump-and-treat system showed carbon tetrachloride levels of 112 µg/L in well 299-W19-34A at ~25 meters below the water table. Carbon tetrachloride levels in nearby water-table wells averaged from 80 to 220 µg/L.

2.8.1.2 Trichloroethene

Trichloroethene is also detected at levels above the drinking water standard (5 µg/L) in the 200-ZP-1 Operable Unit (Figure 2.8-5). Trichloroethene contamination extends into the 200-UP-1 Operable Unit but, in wells completed across the water table, appears to form two additional plumes at the 1 µg/L level (see Section 2.9.1.6). The main trichloroethene plume extends north and northeast from the vicinity of the 216-Z cribs and trenches, the 216-Z-9 trench in particular. Levels are lower and the extent is generally less than for carbon tetrachloride. The maximum trichloroethene detected in FY 2005 routine monitoring was 36 µg/L in the August sample from new well 299-W15-50, north of the 216-Z-9 trench. Well 299-W15-50 is screened ~7.6 to 18.3 meters below the water table and, thus, is not shown in Figure 2.8-5. The size of the plume is similar to FY 2004.

Trichloroethene is detected at levels above the drinking water standard in the 200-ZP-1 Operable Unit.

2.8.1.3 Chloroform

Chloroform concentrations in the 200-ZP-1 wells remained below the 80-µg/L drinking water standard (the standard is defined for total trihalomethane) for routine samples collected during FY 2005. Numerous characterization samples collected from various depths during well drilling contained chloroform at levels above the drinking water standard. Those values ranged up to 1,100 µg/L in well 299-W15-46, located near the 216-Z-9 trench. The 200-ZP-1 remedial investigation/feasibility study work plan (DOE/RL-2003-55) designates a preliminary target action level of 7.17 µg/L based on the cleanup levels and risk calculations under the *Model Toxics Control Act* (WAC 173-340) cleanup regulation methods. Possible chloroform sources include biodegradation of carbon tetrachloride and sanitary sewer discharges to the 2607-Z tile field.

2.8.1.4 Nitrate

Nitrate continued to be present in groundwater at concentrations in excess of the drinking water standard (45 mg/L) beneath much of the 200-ZP-1 Operable Unit (Figure 2.8-6). The maximum concentration in this vicinity during FY 2005 was 3,540 mg/L in well 299-W10-4 near the 216-T-36 crib, south of Waste Management Area T (excluding an off-trend value of 7,610 mg/L, which is considered suspect). The average nitrate concentration in well 299-W10-4 was 3,000 mg/L for FY 2005. Nitrate concentrations increased rapidly in this well through FY 2004 but the concentration remained relatively stable in FY 2005. The nitrate contamination is more widespread than the tritium, iodine-129, or technetium-99 contamination discussed in Sections 2.8.1.7, 2.8.1.8, and 2.8.1.9, respectively. Multiple sources of nitrate probably exist in this area, including the cribs near Waste Management Area T and the 216-Z crib and trench disposal facilities.

A well near the 216-T-36 crib has the highest nitrate concentration (3,430 mg/L) on the Hanford Site.

Elevated nitrate concentrations in well 299-W14-13 on the east side of Waste Management Area TX-TY correlate with elevated chromium, tritium, iodine-129, and technetium-99. Because of the lower levels of contaminants in surrounding wells, this contamination is interpreted as being from a nearby source and is discussed further in Section 2.8.3.4.

A new well (299-W18-16) was drilled east of the 216-Z-1A crib in the first quarter of FY 2005. The nitrate concentration collected after completion of this well was 766 mg/L, which is higher than in surrounding wells.

Nitrate continued to increase sharply in well 699-48-71, indicating that contamination is moving northeast from the 200 West Area. The average nitrate concentration for FY 2005 was 210 mg/L, more than four times the drinking water standard. Carbon tetrachloride is also increasing in this well as discussed in Section 2.8.1.1.

Elevated nitrate levels are found in the west part of the Hanford Site (see Figure 2.1-6 in Section 2.1). This contamination is believed to be due to offsite agriculture because it is persistent, far upgradient of the site waste disposal areas, and is not associated with other Hanford contaminants. Constituents indicative of Hanford contamination, such as tritium, are low in this area. One well (699-36-93, see Figure 2.1-2 in Section 2.1 for location) in the west part of the Hanford Site had nitrate levels (49 mg/L) above the drinking water standard (45 mg/L) in FY 2003. Most wells in the west part of the site, upgradient of the production areas, were not scheduled for sampling in FY 2005.

2.8.1.5 Chromium

Chromium contamination is found at levels above the drinking water standard (100 µg/L) in filtered samples in the immediate vicinity of Waste Management Areas T and TX-TY (Figure 2.8-7). Hexavalent chromium is included in this discussion because it is the most soluble and mobile form under Hanford aquifer conditions. Thus, all chromium in filtered samples is assumed to be soluble hexavalent chromium. Chromium at lower levels extends downgradient toward or past the 200 West Area boundary.

The chromium plume in the vicinity of Waste Management Area T has changed little in size over the past decade, although the extent of lower concentrations beyond the 200 West Area fence line is uncertain due to the lower density of monitoring wells. The highest levels are found west (upgradient) and south of Waste Management Area T. The highest chromium concentration was 722 µg/L and the average concentration was 670 µg/L in well 299-W10-4 during FY 2005. Chromium concentrations peaked in this well in October 2004 and have declined since that time. Chromium near Waste Management Area T is discussed in more detail in Section 2.8.3.3.

The highest concentrations of chromium are found west and south of Waste Management Area T. However, concentrations peaked in October 2004 and have declined since.

Chromium is also elevated east of Waste Management Area TX-TY in well 299-W14-13. The concentrations detected in filtered samples from this well in FY 2005 remained fairly constant with an average value of 690 µg/L. The chromium contamination is associated with elevated nitrate, tritium, technetium-99, and iodine-129. The contamination is discussed further in Section 2.8.3.4.

2.8.1.6 Fluoride

Fluoride contamination at levels greater than the primary drinking water standard (4 mg/L) is seen in a local area around Waste Management Area T. In FY 2005, one well north of Waste Management Area T had an average fluoride concentration greater than the drinking water standard (Figure 2.8-8); however, all wells had average concentrations below the drinking water standard in FY 2004. Lanthanum fluorine used in the bismuth phosphate process is a possible cause of this contamination.

2.8.1.7 Tritium

Tritium contamination at levels greater than the drinking water standard (20,000 pCi/L) in the 200-ZP-1 Operable Unit is mainly restricted to a plume extending northeast from waste disposal facilities in the vicinity of Waste Management Areas T and TX-TY. Multiple potential sources of tritium exist in this vicinity. In addition, tritium from permitted discharge at the State-Approved Land Disposal Site is found in the groundwater (Figure 2.8-9). Tritium at the State-Approved Land Disposal Site is discussed in Section 2.8.3.5.

The highest tritium concentrations were in a well east of Waste Management Area TX-TY where the average concentration was 1.54 million pCi/L.

The highest tritium concentrations in water-table wells remained at well 299-W14-13, located east of Waste Management Area TX-TY, where the concentration in FY 2005 ranged from 1.17 million pCi/L to 1.98 million pCi/L, with an average of 1.5 million pCi/L. This represents a slight decline from FY 2004. The maximum tritium concentration detected in this well was 2.94 million pCi/L in FY 2000. Well 299-W14-13 replaced well 299-W14-12, and the trend plot for these two wells indicates that the high contamination levels arrived at this location in approximately 1999 (Figure 2.8-10). High levels of chromium, nitrate, technetium-99, and iodine-129 are associated with the tritium contamination. Data on the depth distribution of tritium near well 299-W14-13 are available from well 299-W14-11, which was drilled in FY 2005. The concentration declined with depth from the water table. This contamination is discussed further in Section 2.8.3.4. Overall, tritium levels in the 200-ZP-1 Operable Unit are fairly low with a few wells having average concentrations >20,000-pCi/L drinking water standard in FY 2005.

2.8.1.8 Iodine-129

An iodine-129 plume is found in the 200-ZP-1 Operable Unit emanating from the vicinity of Waste Management Area TX-TY and extending to the northeast (Figure 2.8-11). The highest concentration detected in FY 2005 was in well 299-W14-13, where concentration ranged from 11.2 to 26.1 pCi/L with an average of 18 pCi/L, similar to FY 2004 levels. Iodine-129 near Waste Management Area TX-TY is discussed further in Section 2.8.3.4. Iodine-129 contamination at levels above the drinking water standard (1 pCi/L) now appears to extend just beyond the 200 West Area boundary in contrast to previous years where the contamination at levels above the drinking water standard was contoured as remaining within the 200 West Area. Determining the extent of iodine-129 contamination is difficult because the detection limit is at or sometimes above the drinking water standard.

Iodine-129 concentrations (18 µg/L) in a well east of Waste Management Area TX-TY is among the highest on the Hanford Site.

2.8.1.9 Technetium-99

Technetium-99 within the 200-ZP-1 Operable Unit is found at levels above the drinking water standard (900 pCi/L) only on the east (downgradient) side of Waste Management Area T and the east and south sides of Waste Management Area TX-TY (both downgradient of parts of the Waste Management Area) (Figure 2.8-12). Evidence points to multiple sources of technetium-99 within those areas.

Near Waste Management Area T, technetium-99 concentrations decreased slightly during the first part of the fiscal year before returning to an increasing trend during the latter part of the fiscal year. Well 299-W11-39, near the northeast corner of the waste management area, had the highest concentration in samples collected near the water table in the area with values in FY 2005 ranging from 12,000 to 27,400 pCi/L. However, well 299-W11-25B was drilled to 51 meters below the water table in FY 2005, and samples collected during drilling showed technetium-99 concentrations up to 182,000 pCi/L at depths greater than the screened interval in the other monitoring wells at the waste management area. Technetium-99 contamination around Waste Management Area T is discussed in greater detail in Section 2.8.3.3.

Technetium-99 concentrations east of Waste Management Area TX-TY in well 299-W14-13 decreased slightly throughout most of FY 2005 but increased again during the last quarter of the year. The fiscal year average concentration in this well was 7,100 pCi/L, down somewhat from the previous year's average of 8,500 pCi/L. This contamination is associated with elevated levels of chromium, nitrate, tritium, and iodine-129. Contamination exhibited in this area is discussed further in Section 2.8.3.4.

2.8.1.10 Uranium

Few analyses for uranium were performed on groundwater samples from the 200-ZP-1 Operable Unit during FY 2005 because most wells showed insignificant levels in previous monitoring. Some wells monitored near the single-shell tank farms and low-level burial grounds are sampled for gross alpha measurements, which would show an increase if uranium contamination appeared.

Uranium was detected above the drinking water standard (30 μg/L) in well 299-W11-37 in northeast 200 West Area. The uranium concentration detected in well 299-W11-37 was 180 μg/L. Well 299-W11-14, ~200 meters southwest of well 299-W11-37, also contained elevated uranium until it went dry after the FY 2004 sampling.

Uranium declined below the drinking water standard near the southwest corner (upgradient) of Low-Level Waste Management Area 4 in well 299-W18-21, which had levels just above the drinking water standard in several FY 2004 samples. The uranium concentration in well 299-W18-21 ranged from 25.7 to 27.3 μg/L in FY 2005.

Technetium-99 within the 200-ZP-1 Operable Unit is found above the drinking water standard downgradient of Waste Management Areas T and TX-TY.

2.8.1.11 Other Contaminants of Concern

Most of the other contaminants of concern in the 200-ZP-1 remedial investigation/feasibility study work plan (DOE/RL-2003-55) were not detected in FY 2005 sampling (see Table 2.8-1). Other contaminants of concern that were detected at concentrations above the preliminary target action level are discussed in this section.

Antimony was reported as detected in two wells at levels above the 10-μg/L preliminary target action level in FY 2005. In well 699-48-77C, the filtered sample for September 2005 was reported as containing 41.1 μg/L of antimony, but no antimony was detected in the unfiltered sample. In well 699-48-77D, the unfiltered sample for January was reported as containing 36.6 μg/L of antimony, but it was not detected in the filtered sample. All other samples from these wells for the fiscal year were non-detect. The detections were very close to the reported detection limit and, like sporadic detections in previous years, are believed to be false positives.

Few analyses for uranium were performed on groundwater samples from the 200-ZP-1 Operable Unit during FY 2005 because most wells showed insignificant levels in previous monitoring.

Arsenic was only detected at levels above the 10-μg/L drinking water standard/preliminary target action level in well 299-W10-4. The maximum concentration detected was 14 μg/L. More data are needed to determine trends in this well.

Iron was present at levels above the 300-μg/L preliminary target action level/secondary drinking water standard in one unfiltered sample from well 299-W11-46, near Waste Management Area T and one unfiltered sample from well 699-48-77D, near the State-Approved Land Disposal Site. Iron is a naturally occurring component of the aquifer sediment and is found in well materials so seeing elevated iron levels in unfiltered samples is not a surprising observation.

Lead was detected at levels above the drinking water standard (15 μg/L) in two samples collected during drilling of well 299-W15-46. The concentration in an unfiltered sample from 161 meters below ground surface (bgs) was 23.7 μg/L, but lead was not detected in the corresponding filtered sample. Lead was reported in a filtered sample from 113 meters bgs at 25.8 μg/L, but a filtered sample sent to a different laboratory had no detectable lead.

Manganese was detected at levels above the 50-μg/L preliminary target action level/secondary drinking water standard in 5 200-ZP-1 wells in FY 2005. All of the values were from samples collected during or shortly after drilling. Manganese levels reported in well 299-W10-27 ranged from 94 to 235 μg/L in FY 2005. Manganese concentrations have declined overall since this well was installed and first sampled in 2001. It is not uncommon for new wells on the Hanford Site to have elevated manganese values in the first few years of sampling, probably due to reaction of groundwater with freshly crushed rock surfaces.

Methylene chloride was detected at levels above the drinking water standard (5 μg/L) in several wells during FY 2005. All of the values above the standard were from characterization

The pump-and-treat system is successfully containing and capturing the highest concentration portion of the carbon tetrachloride plume near the upper part of the aquifer.

samples collected during well drilling. The maximum concentration reported was 77 µg/L in a sample from drilling well 299-W15-46. Methylene chloride (dichloromethane) could be a degradation product or impurity in carbon tetrachloride (tetrachloromethane) but is also a common laboratory contaminant.

One filtered and one unfiltered sample collected during drilling of well 299-W18-16 contained selenium at levels above the 50-µg/L maximum contaminant level. The filtered sample contained 51 µg/L and the unfiltered 64.4 µg/L of selenium. The samples were from different depth intervals. The lack of detections in the majority of samples during the drilling suggests that these results may be artifacts of sampling or analysis.

Tetrachloroethene is often detected at levels below the drinking water standard (5 ppb) in the 200-ZP-1 Operable Unit. In FY 2005, three wells had results with tetrachloroethene above the drinking water standard. All of these results appear off trend from previous samples so further sampling is needed to confirm the results or determine if they are analytical errors. The maximum reported was 26 µg/L in well 299-W15-1.

2.8.2 Interim Groundwater Remediation for Carbon Tetrachloride

A pump-and-treat system is in operation for the 200-ZP-1 Operable Unit to contain and capture the high concentration portion of the carbon tetrachloride plume located in the vicinity of the 216-Z cribs and trenches, and the Plutonium Finishing Plant. The pump-and-treat system for the 200-ZP-1 Operable Unit was implemented in three phases as an interim remedial action, starting in 1996.

The remedial action objectives for the interim action pump-and-treat system are to capture the high concentration area of the carbon tetrachloride plume near the water table and to reduce contaminant mass (ROD 1995a). Extraction wells have screen lengths between 10.7 and 18.2 meters and thus do not penetrate the full aquifer. The high concentration area is defined as that area inside the 2,000- to 3,000-µg/L plume contour that has been centered generally beneath the Plutonium Finishing Plant, associated buildings, and surrounding waste sites. More recently, carbon tetrachloride concentrations have been identified at levels above remedial action objective levels north of the Plutonium Finishing Plant, just west of the TX-TY Tank Farm. The pump-and-treat system was expanded in July 2005 to contain this part of the plume by converting four monitoring wells to extraction wells and connecting them to the 200-ZP-1 Treatment System.

The remedial action objectives for the 200-ZP-1 Operable Unit (ROD 1995a) are:

- *Reduce contamination in the area of highest concentration of carbon tetrachloride.*
- *Prevent further movement of these contaminants from the highest concentration area.*
- *Provide information that will lead to development of a final remedy that will protect human health and the environment.*

EPA specified enhancements needed to the system in their 5-year review (EPA 2001). The record of decision for the interim remedial measure states the high concentration portion of the plume corresponds to the area within the 2,000- to 3,000-µg/L contour of carbon tetrachloride.

Concentrations above remedial action objectives for carbon tetrachloride have been found at well 299-W13-1, east of the old Laundry site. This and other well data indicates contamination is present deeper in the unconfined aquifer than is being addressed by the current remediation system. A summary of the remediation activities and progress is given in the following sections, with more details presented in DOE/RL-2005-91.

2.8.2.1 Progress During FY 2005

Carbon tetrachloride contamination was reduced in the area of highest concentrations as measured near the top of the aquifer through mass removal. Approximately

340 million liters of contaminated groundwater were treated in FY 2005 at an average daily flow rate of 695 liters/minute (including all down time). The two extraction wells (299-W15-45 and 299-W15-47) brought online in late FY 2004 significantly increased production in FY 2005, to an average of 713 liters/minute, up from 484 liters/minute in the first 10 months of FY 2004. With the July 2005 addition of the four new extraction wells, the average daily rate increased to 808 liters/minute for the remainder of the year. By the end of the year, the system was processing ~1,200 liters/minute. The remedial action objective for pumping is 568 liters/minute.

During FY 2005, the pump-and-treat system extracted ~340 million liters of groundwater, removing ~800 kilograms of carbon tetrachloride.

Extraction well carbon tetrachloride concentrations ranged from 560 to over 4,700 µg/L, while concentrations measured at the influent tank ranged from 1,600 to 2,700 µg/L. Treatment of the 340 million liters of groundwater resulted in the removal of ~800 kilograms of carbon tetrachloride during FY 2005. Since startup of the pump-and-treat system in August 1994, treatment of over 2.76 billion liters of groundwater has led to the removal of ~9,308 kilograms of carbon tetrachloride.

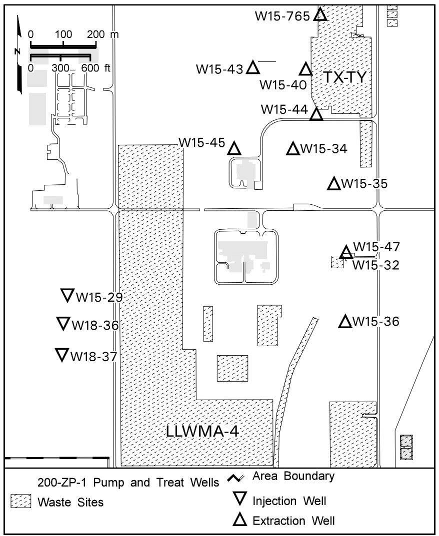
Wells are sampled for technetium-99 to ascertain if the pump-and-treat system is being affected by radiological contamination in a way that could require changes to operations. No technetium-99 concentrations were above the drinking water standard of 900 pCi/L. The highest measured concentrations in the area of the pump-and-treat system were 248 and 340 pCi/L at extraction wells 299-W15-47 and 299-W15-35, respectively. Technetium-99 acts as a tracer and has been detected in wells downgradient from the injection wells. At well 299-W15-15, the measured technetium-99 concentration has increased from 18.5 pCi/L in 1994 to 161 pCi/L in FY 2005, while carbon tetrachloride concentrations have simultaneously decreased from 1,400 to 6.9 µg/L. As discussed in Section 2.8.1.10, technetium-99 in monitoring wells on the west side of Low-Level Waste Management Area 4, near the injection wells, appears to be due to the injection of treated water.

2.8.2.2 Influence on Aquifer Conditions

During FY 2005, the >2,000-µg/L center of the carbon tetrachloride plume at the top of the aquifer continued to shrink in the original target area of the plume (beneath the Plutonium Finishing Plant) (Figure 2.8-3). However, following only 2 months of extraction pumping, the northern extension of the plume, not unexpectedly, remained unchanged.

The 4,000-µg/L carbon tetrachloride plume contour has nearly disappeared in FY 2005. Concentrations from laboratory-based data at extraction well 299-W15-34 ranged between 3,200 and 4,500 µg/L in FY 2005. Extraction well 299-W15-40 reached the highest concentration (3,900 µg/L) observed in the north part of the plume. Well 299-W15-1, upgradient of well 299-W15-34, is the only other well that averaged over 3,000 µg/L for FY 2005. A carbon tetrachloride concentration of 5,300 µg/L was reported in August 2005.

Concentrations of carbon tetrachloride continued to decline to the west of the Plutonium Finishing Plant in response to the cumulative injection of treated groundwater. In this area, well 299-W15-30 attained a concentration of 7,100 µg/L in 1997 but had decreased to 720 µg/L by September 2005.



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Carbon tetrachloride levels in the former extraction well (299-W15-37), south of well 299-W15-36, have declined to 60 to 115 µg/L, indicating that there is no loss of control of the plume at the south edge. At extraction well 299-W15-36, north of well 299-W15-37, concentrations have declined as low as 480 µg/L in August 2005 and averaged 660 µg/L for the year. This value is well below the 2,000-µg/L interim remedial action objective. Although consideration was given to taking well 299-W15-36 off-line, it has remained in use in case increased injection rates began pushing the high concentration plume segment farther east. All of these changes show that the pump-and-treat system is having the desired remediation effect on the plume.

The remediation system was extended to the north in late FY 2005 to capture carbon tetrachloride contamination at levels above 2,000 µg/L extending beyond the capture zone of the former system.

Recently installed monitoring wells have revealed that carbon tetrachloride concentrations are above the remedial action objectives north of the pump-and-treat system and west of the TX-TY Tank Farm. This area is being brought within the capture zone of the pump-and-treat system with the conversion of wells 299-W15-765, 299-W15-40, 299-W15-43, and 299-W15-44 to extraction wells. The conversion was completed and pumping started in July 2005.

The extraction wells have significantly increased the volume of groundwater sent to the pump-and-treat system. Extraction rates have averaged ~37.8 liters/minute for wells 299-W15-40 and 299-W15-44. Well 299-W15-43 averaged ~189 liters/minute and well 299-W15-765 ~113.5 liters/minute. In addition, upgrades to the processing plant have also improved the volume treated, such that the system was able to process almost 1,200 liters/minute by the last week in September 2005.

Vertical profile sampling at monitoring well 299-W13-1, installed east of the Laundry facility site in December 2003, demonstrated the presence of carbon tetrachloride at concentrations above the drinking water standard to near remedial action objective concentrations throughout the aquifer, although the current system only addresses contamination near the top of the aquifer (see Figure 2.8-4). Following well construction and screen installation just above the Ringold Formation lower mud unit, carbon tetrachloride concentrations have ranged between 1,300 and 1,900 µg/L. In September 2005, carbon tetrachloride concentrations exceeded the remedial action objectives, reaching 2,200 µg/L. Additional wells are scheduled to be installed in FY 2006 that will monitor the aquifer between the 216-Z-9 crib and well 299-W13-1, along an east-northeast trend predicted by particle tracking models. Vertical profile characterization of the aquifer will be conducted at all new wells.

Regional groundwater flow in the vicinity of the pump-and-treat system is still to the east-northeast (Figure 2.8-2). Water levels continued to decline, but at an annual rate of ~0.24 meter/year (DOE/RL-2005-91). This rate of decline is markedly less than last year's rate of 0.37 meter/year, but on par with the decline observed at the 200-UP-1 wells. The declining water table will continue to be an issue as additional monitoring wells go dry.

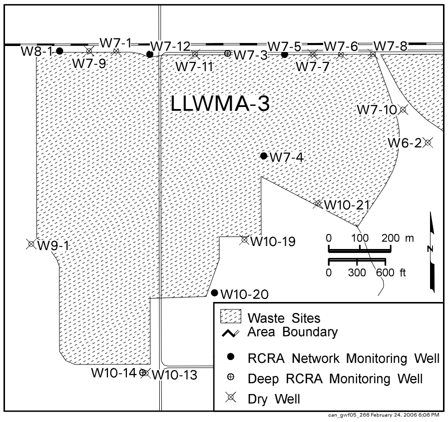
In conclusion, the pump-and-treat system appears to be hydraulically containing at least the baseline carbon tetrachloride plume and reducing contaminant mass in the baseline area. For the north portion of the plume, the recent startup of additional extraction wells has not yet had an impact on plume extent. Contaminant concentrations have decreased most notably in the monitoring wells, but also in the extraction wells. Additional characterization is required, and planned, to evaluate the distribution of carbon tetrachloride deeper in the aquifer.

2.8.3 Facility Monitoring

This section describes results of monitoring individual facilities such as treatment, storage, and disposal units or tank farms. Some of these facilities are monitored under the requirements of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Facility monitoring also supports CERCLA investigations of hazardous substances and radionuclides. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 2.1 for RCRA sites, the U.S. Department of Energy (DOE) has sole and exclusive responsibility and authority to regulate source, special nuclear, and by-product materials. Groundwater data for these facilities are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

2.8.3.1 Low-Level Waste Management Area 3

Groundwater at Low-Level Waste Management Area 3 continued to be monitored under RCRA and AEA. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (WHC-SD-EN-AP-015; see Appendix B). Six of eight wells attempted for sampling in FY 2005 were successfully sampled. Wells 299-W7-5 and 299-W10-21 went dry in the second half of this year and have been removed from the sampling schedule. When wells go dry and no potential future use (e.g., well deepening) is identified, they are added to a list of wells to be decommissioned as described in Section 4.3. New downgradient well locations have been identified and prioritized under the Tri-Party Agreement (Ecology et al. 1989) M-24 milestone. Well installation at Low-Level Waste Management Area 3 is scheduled to begin in early FY 2006 with installation of three downgradient wells (299-W10-25, 299-W10-29, and 299-W10-30) in the south part of the area.



One of the remaining wastewater discharges on site, the State-Approved Land Disposal Site, is located north of Low-Level Waste Management 3. Discharge to the facility began in December 1995. Although a local groundwater mound is seen near the discharge, it does not appear to have a major impact on flow in Low-Level Waste Management Area 3, as shown by the water-table map in Figure 2.8-2. The water table continues to decline in Low-Level Waste Management Area 3 monitoring wells in response to the greatly reduced discharge of wastewater around the 200 West Area. Monitoring at the State-Approved Land Disposal Site is discussed further in Section 2.8.3.5.

The groundwater flow in this portion of the 200 West Area is to the east-northeast (75 degrees), based on trend surface fit to March 2005 water-level measurements, with a calculated gradient of 0.0012. The estimated flow rate at Low-Level Waste Management Area 3, using this gradient, is 0.00008 to 0.12 meter/day (see Appendix B).

Under current flow directions, previously designated upgradient wells 299-W10-19, 299-W10-20, and 299-W10-21 remain upgradient of the east portion of the waste management area but are now downgradient of the southwest part of the waste management area. Nitrate and carbon tetrachloride routinely exceed drinking water standards in these wells. Flow and monitoring data since RCRA monitoring was instituted in the 1980s indicate that these constituents are from plumes originating from sources to the south. Changing flow directions mean that currently there are no monitoring wells on the upgradient (west) side of Low-Level Waste Management Area 3. For this reason, statistical upgradient/downgradient comparisons have been suspended until background statistics can be re-established. The new upgradient wells have been proposed and are included in the Tri-Party Agreement priority list. No suitable upgradient wells have been identified to use in the interim.

Upgradient/ downgradient statistical analysis has been suspended until new upgradient wells are installed.

The September 2005 samples from several Low-Level Waste Management Area 3 wells contained anomalously high total organic carbon compared to previous trends. The values were all still below the limit of quantitation (2,240 µg/L) and are considered suspect. Laboratory issues with total organic carbon are discussed in Appendix C.

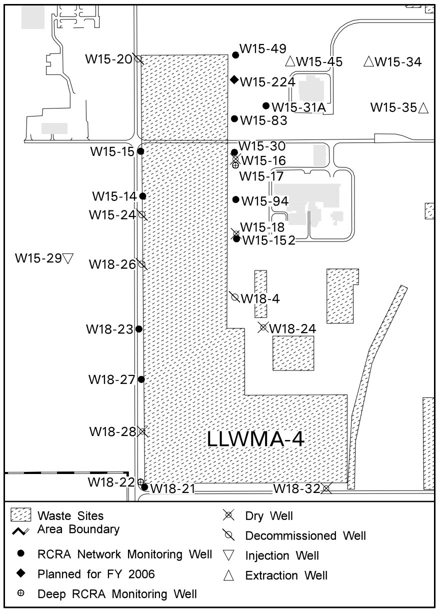
Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 3 is designed to complement RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level Waste Management Area 3 is to gather data to assess changes in concentrations at downgradient wells using statistical tests and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, and uranium are monitored specifically for performance assessment.

Contaminant characteristics in groundwater at Low-Level Waste Management Area 3 include the following:

- Technetium-99 concentrations are all <100 pCi/L and generally show steady or declining trends. The highest concentration in FY 2005 was 44 pCi/L in well 299-W10-21, located on the south edge of Low-Level Waste Management Area 3. Although this well is currently downgradient of part of the burial ground, it was initially designated an upgradient well when flow was toward the north and has likely been affected by contaminant sources to the south. Well 299-W10-21 went dry prior to the second sampling event in FY 2005. Technetium-99 was also detected in wells 299-W7-4 and 299-W10-20 in FY 2005. The technetium-99 distribution in the 200-ZP-1 Operable Unit is discussed in Section 2.8.1.9.
- Uranium concentrations at Low-Level Waste Management Area 3 were <2 μg/L.
- Iodine-129 was not detected in any wells at Low-Level Waste Management Area 3. The minimum detectable activity is ~0.3 pCi/L.
- Tritium concentrations were all less than the drinking water standard, and tritium was undetected in most wells. The maximum concentration detected in FY 2005 was 522 pCi/L in well 299-W10-21. This well has likely been affected by contaminant sources to the south as discussed for technetium-99.
- As discussed in Sections 2.8.1.1, 2.8.1.2, and 2.8.1.3, carbon tetrachloride and associated trichloroethene and chloroform concentrations in Low-Level Waste Management Area 3 wells are consistent with those seen in regional plumes. Only carbon tetrachloride was detected at levels above the drinking water standard. The highest concentration in a regular groundwater sample was 140 μg/L in well 299-W7-4.
- The nitrate distribution at Low-Level Waste Management Area 3 is consistent with regional plumes, as discussed in Section 2.8.1.4. The maximum concentration (116 mg/L) was found in well 299-W10-21.

2.8.3.2 Low-Level Waste Management Area 4

Groundwater at Low-Level Waste Management Area 4 continued to be monitored under RCRA and AEA. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (WHC-SD-EN-AP-015; see Appendix B). Of the six wells where sampling was attempted during FY 2005, sampling was successful in all of the wells. Sampling of well 299-W15-30 was delayed due to security changes in the area. New downgradient well locations have been identified and prioritized under the Tri-Party Agreement M-24 milestone. Well installation at Low-Level Waste Management Area 4 began in calendar year 2005, and the new downgradient wells (299-W15-83, 299-W15-94, and 299-W15-152) will be sampled in FY 2006. A fourth well (299-W15-224) is also planned for FY 2006 and will be added to the sampling schedule when it is completed.



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The groundwater flow in this portion of the 200 West Area is generally to the east (90 degrees), based on water-table contours. The flow direction is affected to a large degree by the 200-ZP-1 pump-and-treat system, which has extraction wells to the east and injection wells to the west of this RCRA site. The gradient is steeper and has a component to the northeast in the north part of the area and is somewhat less steep with a component to the southeast in the south part of the area. The gradient calculated from the contours ranges from 0.004 in the north part of the area to 0.0025 in the south part of the area. The estimated flow rate at Low-Level Waste Management Area 4 using this gradient is ~0.2 to 1.0 meter/day (see Appendix B).

Downgradient well 299-W15-30 exceeded the statistical comparison value for total organic halides in the February 2005 sample. The second semiannual sample from this well was late, so the analytical results were not available for inclusion in this report. Well 299-W15-30 is a replacement for well 299-W15-16, which has gone dry. DOE reported the exceedance of the statistical comparison value in well 299-W15-16 to the U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) in August 1999. The elevated total organic halide concentrations are consistent with observed levels of carbon tetrachloride from Plutonium Finishing Plant operations (see Section 2.8.1.1 and 2.8.2). As discussed in Section 2.8.2, carbon tetrachloride concentrations in well 299-W11-30 have declined from 7,100 µg/L in 1997 to 720 µg/L by September 2005. Carbon tetrachloride and other volatile organic compounds were detected in vapor samples collected from the trenches and vadose zone within Low-Level Waste Management Area 4 during FY 2002. Investigation of the vadose zone is ongoing in FY 2005 as part of the 200-PW-1 Operable Unit. Statistical comparison values for use in FY 2006 are listed in Appendix B.

Three new monitoring wells were installed during FY 2005 to replace wells that have gone dry in Low-Level Waste Management Area 4.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 4 is designed to complement the RCRA detection monitoring. The current goal of performance assessment monitoring at Low-Level Waste Management Area 4 is to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, and uranium are monitored specifically for performance assessment.

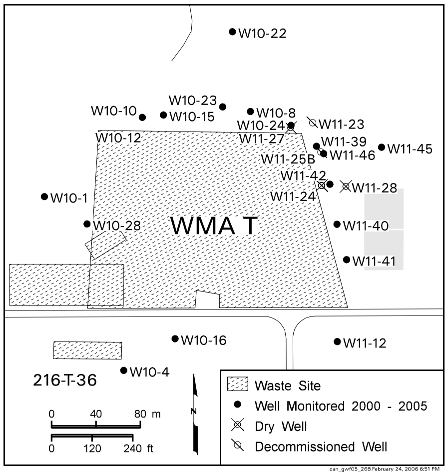
Contaminant characteristics at Low-Level Waste Management Area 4 include the following:

- Technetium-99 concentrations remained slightly elevated in wells on the west (upgradient) of Low-Level Waste Management Area 4 (wells 299-W15-15, 299-W18-21, and 299-W18-23). Technetium-99 concentrations were all <200 pCi/L. As discussed in Section 2.8.1.9, this occurrence may result at least in part from technetium-99 in water injected by the 200-ZP-1 pump-and-treat system. However, the concentrations are over one-third the highest technetium-99 concentration in any extraction well. This, and the distance of the wells in question from the injection wells, suggests that part of the technetium-99 may be from upgradient. Technetium-99 may have moved to the west under past flow conditions and be re-entering the area under present flow conditions.
- Uranium concentrations are elevated in upgradient well 299-W18-21 in the southwest corner of the waste management area. Concentrations were just under the drinking water standard (30 µg/L) in FY 2005.
- Iodine-129 was not detected in Low-Level Waste Management Area 4 wells. The minimum detectable activity is ~0.3 pCi/L.
- Tritium levels were all <2,000 pCi/L and, thus, less than one tenth of the drinking water standard.
- Nitrate continued to exceed the drinking water standard at many monitoring wells in Low-Level Waste Management Area 4. This contamination is not believed to be related to waste disposal at the burial grounds. Some of the nitrate contamination is related to injection of 200-ZP-1 treated water upgradient of the burial ground. The treatment system does not remove nitrate from the water.
- In the southwest corner of Low-Level Waste Management Area 4, upgradient monitoring well 299-W18-21 has slowly increasing nitrate concentrations that have not been associated with the large contaminant plumes of the 200 West Area. The FY 2005 average nitrate concentration in this well was 120 mg/L.
- Carbon tetrachloride and associated trichloroethene and chloroform in the groundwater beneath Low-Level Waste Management Area 4 are consistent with regional

plumes as shown in Sections 2.8.1.1, 2.8.1.2, and 2.8.1.3. Investigation of carbon tetrachloride in the vadose zone at Low-Level Waste Management Area 4 is continuing.

2.8.3.3 Waste Management Area T

Waste Management Area T is located in the north-central part of the 200 West Area and consists of the T Tank Farm and ancillary equipment (e.g., diversion boxes and pipelines). The tank farm contains twelve 2-million-liter tanks and four 208,000-liter tanks constructed between 1943 and 1944. Seven of the tanks in the waste management area are known or suspected to have leaked. This section describes groundwater monitoring at Waste Management Area T. A well location map and a table of wells and analytes for this waste management area are included in Appendix B.



The objective of RCRA groundwater monitoring at Waste Management Area T is to assess the extent and rate of movement of dangerous waste in groundwater that have a source from the waste management area (40 CFR 265.93(d) as referenced by WAC 173-303-400). The current groundwater assessment plan is PNNL-12057, as modified by PNNL-12057-ICN-1. An update to this plan will be issued in FY 2006 that incorporates the wells drilled and the data collected since the previous plan. In addition to monitoring dangerous waste constituents for RCRA assessment, the site is monitored for CERCLA and AEA purposes. Waste Management Area T was originally placed in RCRA assessment monitoring because of elevated specific conductance in downgradient well 299-W10-15 (WHC-SD-EN-AP-132). However, it remained in assessment because of contaminants observed in downgradient well 299-W11-27 (PNNL-11809).

A data quality objectives process document and a work plan are being prepared to address the increasing technetium-99 contamination on the east side of Waste Management Area T. This investigation will also address the unexpected high technetium-99 levels found deeper in the aquifer at well 299-W11-25B, as discussed in this section.

Dangerous waste constituents found beneath Waste Management Area T in FY 2005 are chromium and nitrate. These constituents probably have more than one source including the waste management area. Other constituents found beneath the waste management area in FY 2005 include carbon tetrachloride, trichloroethene, tritium, and technetium-99. The carbon tetrachloride and trichloroethene are attributed to Plutonium Finishing Plant operations and are discussed in Sections 2.8.1.1 and 2.8.1.2. The tritium is believed to be part of a regional plume and is not attributed to the T Tank Farm. The technetium-99 plume, located east (downgradient) of the T Tank Farm, is attributed, at least in part, to the tank farm.

One boring at Waste Management Area T was drilled in FY 2005 but was not completed as a well due to technical problems. Several new monitoring wells are planned for FY 2006.

Calculated average linear groundwater flow velocities at Waste Management Area T range from 0.017 to 0.28 meter/day with most values <0.1 meter/day. Groundwater flow direction beneath the waste management area is between 85 and 98 degrees from north as determined by trend surface analyses (PNNL-13378; PNNL-14113) and the most current water-table map (Figure 2.8-2).

The monitoring network for Waste Management Area T includes thirteen wells that are sampled quarterly and two wells sampled semiannually. Two new RCRA assessment monitoring wells were installed in calendar year 2005. The first new well (299-W11-25B) was installed in February and March 2005 adjacent to well 299-W11-39 (Appendix B, Figure B.20). The purpose of the well was to assess the vertical extent of contamination near the northeast corner of the waste management area. The well was drilled to the top of the Ringold Formation lower mud unit at ~125 meters below the ground surface (~51 meters below the water table). Unexpected high concentrations of technetium-99 and chromium were found in groundwater samples collected during drilling of the well. This contamination is discussed in detail below. Well 299-W11-25B was damaged during construction and well 299-W11-46 was drilled and constructed as a replacement.

The second new well (299-W11-45) was started in September 2005 but was not completed before the end of the fiscal year. Preliminary data from sampling during drilling of well 299-W11-45 are discussed in the following paragraphs. Well 299-W11-45 is located ~80 meters downgradient of wells 299-W11-25B and 299-W11-46. The purpose of the well is to help ascertain the horizontal limit and, if present, the vertical distribution of the technetium-99 plume discovered in well 299-W11-25B.

A third new well at Waste Management Area T is scheduled to be drilled in FY 2006. This well will be located adjacent to existing well 299-W11-41 along the downgradient side of the waste management area for the purpose of learning the vertical extent of the technetium-99 and other contaminants in that area.

A plume map depicting the FY 2005 average chromium concentration in wells in the uppermost part of the aquifer near the Waste Management Area T is shown in Figure 2.8-7. The map shows that the chromium plume extends from the west and southwest part of the waste management area to east of the waste management area. The highest average concentrations in FY 2005 were in upgradient well 299-W10-28 (average 280 μg/L) and well 299-W10-4 (average 670 μg/L) located south of the waste management area. The chromium concentration in the upper part of the aquifer also exceeded the drinking water standard in two downgradient wells, 299-W11-41 (average 160 μg/L) and 299-W11-42 (average 180 μg/L) during FY 2005. The average chromium concentrations in top of the aquifer wells that exceed the drinking water standard (100 μg/L) increased during FY 2005. The largest increase was in well 299-W10-4, where the average chromium concentration increased from 460 μg/L in FY 2004 to 670 μg/L in FY 2005.

Sampling and analysis during drilling of new wells 299-W11-25B, 299-W11-45, and 299-W11-46, in FY 2005, revealed higher concentrations of chromium than depicted by the top of the aquifer map (Figure 2.8-7). The results from this sampling and analysis activity are discussed below.

Technetium-99 concentrations increased in four wells downgradient of Waste Management Area T in FY 2004.

A fluoride plume, exceeding the secondary drinking water standard of 2,000 μg/L, extends from the southwest to the north and east of Waste Management Area T (Figure 2.8-8). The extent of the plume remained almost unchanged from the previous year. However, the average FY 2005 fluoride concentration exceeded the primary drinking water standard (4,000 μg/L) in one well north of the waste management area, whereas no well exceeded the primary drinking water standard in FY 2004.

A local nitrate plume sits within the regional nitrate plume and beneath Waste Management Area T (Figure 2.8-6). The extent of the plume and the concentration of nitrate in most wells did not change significantly from the previous year. The highest average concentration and the largest change from the previous year were in well 299-W10-4. Here, the average nitrate concentration was 3,000 mg/L in FY 2005, up from 2,600 mg/L the previous year. More than one source, including the Waste Management Area T, probably contributed to the nitrate plume beneath the waste management area. A discussion of nitrate contamination in the north central part of 200 West Area is given in Section 2.8.1.4.

Tritium exceeded the interim drinking water standard (20,000 pCi/L) in one well (299-W11-12) at Waste Management Area T. The well is located at the southeast corner of the waste management area, and the source of the tritium encountered at that location is thought to be farther south near the TX and TY Tank Farms (Figure 2.8-9). The average tritium concentration in the well during FY 2005 was 44,000 pCi/L, which is down slightly from the previous year's average concentration of 48,600 pCi/L. The tritium concentration in this well has been decreasing for the past several years. A more complete discussion of tritium in the groundwater beneath the north part of 200 West Area is in Section 2.8.1.7.

A technetium-99 plume is located along the east (downgradient) side of Waste Management Area T (Figure 2.8-12). The lateral extent of the plume at the top of the aquifer has not changed appreciably from what was observed in FY 2004. The highest technetium-99 concentrations near the top of the aquifer are in well 299-W11-39 at the northeast corner of the waste management area, where the average technetium-99 concentration was 17,000 pCi/L in FY 2005. This was up somewhat from an average concentration of 16,000 pCi/L during the previous year. Prior to FY 2005, the technetium-99 concentration had been increasing regularly in the south three downgradient wells. During FY 2005, the concentration began to drop in those three wells before increasing again during the last part of the year (Figure 2.8-13). One new well is planned to be drilled adjacent to existing well 299-W11-41 during FY 2006 to determine the vertical distribution of technetium-99 throughout the unconfined aquifer at that location.

Groundwater from well 299-W11-25B was sampled and analyzed during drilling in February and March 2005. Two types of samples were collected: air lifted and pumped. All samples were analyzed for technetium-99, chromium, and nitrate. The air-lifted slurry samples were collected every 1.5 meters throughout the drilled portion of the aquifer. These samples were collected in one gallon jars and sat overnight to allow the particulates to settle. The following day, the samples were pumped through a filter into sample bottles and delivered to the laboratory.

Pumped samples were collected every 6.1 meters throughout the drilled part of the aquifer. A pump was lowered into the borehole, and the borehole was purged for at least 1 hour prior to sampling.

The maximum technetium-99 concentration found during drilling at well 299-11-25B, northeast of Waste Management Area T, was 181,900 pCi/L at 10 meters below the water table.

Figure 2.8-14 shows the depth distribution of technetium-99 in well 299-W11-25B. The maximum technetium-99 concentration was 181,900 pCi/L at 10 meters below the water table. The technetium-99 concentration decreases abruptly between 12 and 14 meters below the water table and then gradually decreases to the bottom of the well. However, concentrations at the bottom of the well remain quite high, in the 20,000 to 30,000 pCi/L range.

The open symbols on Figure 2.8-14 represent pumped samples and the solid symbols represent air-lifted samples. Differences between the pumped and air-lifted values suggest that some of the technetium-99 was being reduced in the air-lifted samples while the groundwater sat overnight in contact with freshly crushed rock.

Figure 2.8-15 shows the depth distribution of nitrate and technetium-99 in well 299-W11-25B. The maximum nitrate concentration (663,540 µg/L) coincided with the depth of the technetium-99 maximum concentration at 10 meters below the water table. The concentrations of both technetium-99 and nitrate tracked each other throughout the upper part of the aquifer.

Figure 2.8-16 shows the depth distribution chromium and manganese in well 299-W11-25B. There is a substantial difference between the air-lifted and pumped sample results for both chromium and manganese. The groundwater associated with the air-lifted samples was in contact with the drill cuttings for at least 24 hours before analysis. It is probable that the soluble hexavalent chromium was reduced to insoluble trivalent chromium by being in contact with the drill cuttings. Extensive purging of the well before collection of the pumped samples removed most or all of the groundwater affected by drilling so that the resulting chromium concentrations were unaffected by reducing conditions created during drilling. The highest chromium concentration in the pumped samples was 1,033 µg/L at 5.5 meters below the water table.

The distribution of manganese (Figure 2.8-16) supports the idea of reduction of chromium in the air-lifted samples. Soluble divalent manganese is expected to be released from the basaltic sediments during drilling, and it was this manganese that was measured during analysis of the air-lifted samples. Purging the well before collecting the pumped samples removed the artificially introduced manganese, resulting in manganese concentrations closer to background.

Well 299-W11-25B was to be constructed with a 6-meter screen centered at the depth of maximum technetium-99 concentration. However, the well was damaged during construction and well 299-W11-46 was drilled 2.5 meters from well 299-W11-25B as a replacement. Well 299-W11-46 has a 6-meter screen centered at 9.1 meters below the water table. The first routine, quarterly sampling of the well was November 2005.

Drilling began on well 299-W11-45 in September 2005. Preliminary results from sampling during drilling became available during early FY 2006. These results are discussed briefly here and will be discussed more fully in FY 2006 after the well is completed.

Well 299-W11-45 is located ~80 meters downgradient of well 299-W11-46 (and 299-W11-25B). Groundwater from well 299-W11-45 was sampled every 1.5 meters throughout the upper 56 meters of the aquifer. The technetium-99 and nitrate concentrations found during drilling are shown on Figure 2.8-17.

The maximum technetium-99 concentration found during drilling of well 299-W11-45 was 15,646 pCi/L at 9.1 meters below the water table. The depths of the maximum concentrations are similar in wells 299-W11-25B and 299-W11-45. Although the technetium-99 concentration was very high in well 299-W11-45, it was much less than the 181,900 pCi/L maximum found in well 299-W11-25B. This suggests that, if the technetium-99 found in the two wells is from the same plume, the front edge of the plume is probably a short distance east of well 299-W11-45.

The nitrate and technetium-99 concentrations tracked each other in well 299-W11-25B. This did not seem to be the case in well 299-W11-45 (Figure 2.8-17). The maximum nitrate concentration (590 mg/L) roughly coincided with the maximum technetium-99 concentration, but the nitrate had a much broader high concentration interval before gradually decreasing. Both wells are located in the regional nitrate plume (Figure 2.8-6) and, perhaps, the regional nitrate masks the nitrate associated with the technetium-99 at lower technetium-99 concentrations (and presumably lower associated nitrate concentrations).

One or more of the cribs and trenches west and southwest of Waste Management Area T are likely sources for much of the chromium contamination although some chromium appears to come from the tank farm.

In 2004, the technetium-99/chromium concentration ratios in groundwater were compared to the estimated concentration ratios of single-shell tank leaks from tanks T-101 and T-106 and to the concentration ratios of some cribs and trenches in the area of Waste Management Area T (PNNL-15070; PNNL-14849). The conclusion was made that crib waste had impacted the groundwater in the southwest, north, and east of the waste management area and tank waste had impacted the recent groundwater in the east and northeast of the waste management area. Those conclusions were based on 2001 estimates for the tank leaks and discharges to past-practice disposal facilities (BHI-01496; RPP-7218). Leak and discharge inventory estimates were updated in FY 2005 (RPP-26744) and the new data necessitate a reinterpretation of the groundwater data.

Figure 2.8-18 shows the technetium-99/chromium concentration ratios in samples of groundwater from selected wells at Waste Management Area T compared to updated estimated ratios for two tank leaks and several past-practice disposal facilities in the vicinity of Waste Management Area T. As was previously concluded (PNNL-15070; PNNL-14849), the figure shows that groundwater in the northeast part of the waste management area, and probably the more recent samples from the east part of the waste management area, have technetium-99/chromium concentration ratios similar to those in the fluids leaked from tank T-101 and T-106. However, the groundwater in the southwest, west, and north parts of the waste management area now do not appear to have been influenced to any great extent by waste disposed to the nearby cribs and trenches located upgradient of the waste management area as was previously concluded.

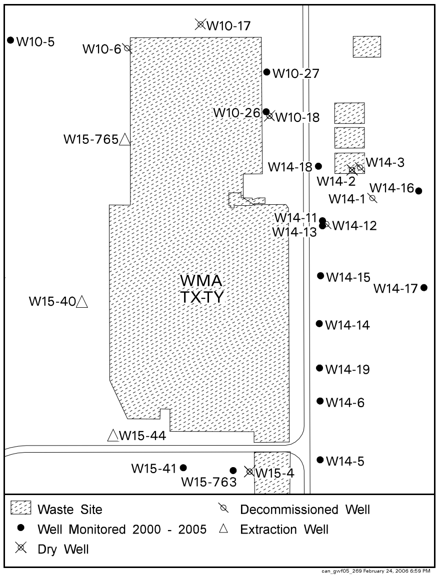
Figure 2.8-19 shows the technetium-99/chromium concentration ratios for 1:1 water: sediment extracts (vadose zone pore water) collected from two boreholes drilled through the tank T-106 leak (PNNL-14849) and for groundwater collected during drilling of boreholes 299-W11-25B and 299-W11-45. Supposedly, the pore water collected from the two T-106 characterization boreholes represents the fluid leaked from the tank. The technetium-99/chromium composition ratios from the samples of groundwater collected during drilling are similar to the pore waters collected from the characterization boreholes. This suggests that the groundwater sampled from the two new wells has been impacted by tank wastes.

Figure 2.8-20 compares the technetium-99/nitrate ratios in samples of groundwater from selected wells at Waste Management Area T with estimated compositions for two tank leaks and several past-practice disposal facilities in the vicinity of Waste Management Area T. The technetium-99/nitrate concentration ratios suggest the same conclusions reached with the technetium-99/chromium ratios. That is, groundwater from wells at the northeast corner of Waste Management Area T (Figure 2.8-20, Panel C) has a technetium-99/nitrate composition similar to estimated tank leak fluids. Groundwater from wells elsewhere at the waste management area does not have an obvious tank waste influence.

Figure 2.8-21(A) shows the technetium-99/nitrate composition ratios estimated for the two tank leaks with ratios measured from vadose zone pore water associated with the tank T-106 leak. Figure 2.8-21(B) compares the technetium-99/nitrate ratios estimated for two tank leaks with the compositions in samples of groundwater from wells 299-W11-25B and 299-W11-45. The technetium-99/nitrate concentrations ratios suggest the same conclusion reached with the technetium-99/chromium ratios. That is, the groundwater from wells 299-W11-25B and 299-W11-45 and the pore water representing the T-106 leak are similar in composition and similar to the estimated tank leak compositions. The conclusion is that groundwater beneath the northeast part of Waste Management Area T has been contaminated with tank waste from the T Tank Farm.

2.8.3.4 Waste Management Area TX-TY

Waste Management Area TX-TY is located in the north-central part of the 200 West Area and consists of the TX and TY Tank Farms and ancillary equipment (e.g., diversion boxes and pipelines). The tank farms contain twenty-four 2.9-million-liter tanks constructed between 1944 and 1952. Twelve of the tanks in the waste management area are known or suspected to have leaked. A well location map and a table of wells and analytes for this waste management area are shown in Appendix B.



Waste Management Area TX-TY was originally placed in RCRA assessment monitoring (40 CFR 265.93(d) as referenced by WAC 173-303-400) because of elevated specific conductance in downgradient wells 299-W10-27 and 299-W14-12 (WHC-SD-EN-AP-132). The current groundwater assessment plan is PNNL-12072 as modified by PNNL-12072-ICN-1. The groundwater assessment plan is scheduled to be updated in FY 2006 to reflect new information from wells drilled since the existing plan. The objective of RCRA groundwater monitoring at Waste Management Area TX-TY is to assess the extent and rate of movement of dangerous waste in groundwater that have a source from the waste management area. In addition to monitoring dangerous waste constituents for RCRA assessments, the site is monitored for AEA and CERCLA.

The monitoring network for Waste Management Area TX-TY includes 16 wells that are sampled quarterly. One well (299-W14-15) was not sampled as scheduled during the second quarter of FY 2005 because of problems with the pump. One new RCRA assessment monitoring well (299-W14-11) (Figure 2.8-1) was installed during FY 2005. The new well is located adjacent to well 299-W14-13 and was installed to assess the vertical extent of contamination downgradient of the waste management area. The well was drilled to 38 meters below the water table and groundwater was sampled and analyzed every 1.5 meters throughout the drilled part of the aquifer. The results of that sampling effort are discussed in the following paragraphs.

Calculated average linear flow velocities in wells at Waste Management Area TX-TY range from ~0.0007 to ~2.5 meters/day with most values <0.1 meter/day. Groundwater flow velocities as determined from aquifer tracer tests range between 0.2 and 1.1 meters/day (PNNL-13378; PNNL-14113; PNNL-14186). Groundwater flow direction varies beneath the site. Trend surface analysis for the northeast part of the waste management area, at the

TY Tank Farm, shows a groundwater flow direction of 108 degrees, or to the east-southeast (PNNL-13378). Farther south, along the downgradient (east) side of the TX Tank Farm, groundwater flow direction changes from 108 degrees at well 299-W14-13 to 133 degrees (southeast) at well 299-W14-14 (PNNL-13378; PNNL-14311; PNNL-14186). South of Waste Management Area TX-TY, groundwater flow direction, as determined by water-level measurements, is toward the south or southwest. The change in flow direction at Waste Management Area TX-TY is due to the 200-ZP-1 pump-and-treat system extraction wells located south and west of the waste management area.

Waste Management Area TX-TY may have contributed to chromium and radionuclide contamination in groundwater.

Four existing wells near Waste Management Area TX-TY were converted to extraction wells for the 200-ZP-1 pump-and-treat system in FY 2005. The four new extraction wells include the upgradient monitoring wells for the waste management area monitoring network (299-W15-765, 299-W15-40) and one downgradient well in the network (299-W15-44). The inclusion of these wells in the pump-and-treat system is expected to reverse the flow direction from toward the east to toward the west in the north part of the waste management area and to reinforce flow toward the south and southwest beneath the south part of the waste management area.

Dangerous waste constituents found beneath Waste Management Area TX-TY in FY 2005 are chromium and nitrate. Other constituents found beneath the waste management area in 2005 include carbon tetrachloride, trichloroethene, tritium, technetium-99, and iodine-129. The carbon tetrachloride and trichloroethene are attributed to Plutonium Finishing Plant operations and are discussed in Sections 2.8.1.1 and 2.8.1.2.

Nitrate concentrations exceeded the drinking water standard (45 mg/L) in all wells in the Waste Management Area TX-TY monitoring network in FY 2005. Figure 2.8-6 shows a plume map for nitrate in the area. The nitrate in groundwater beneath Waste Management Area TX-TY is part of the regional nitrate plume that underlies much of the north 200 West Area.

The highest average nitrate concentration at the waste management area was 430 mg/L during FY 2005 in well 299-W14-13. This was a decrease from 480 mg/L during the previous fiscal year. Much of the nitrate contamination at Waste Management Area TX-TY is attributed to Plutonium Finishing Plant operations as well as past-practice disposal to cribs and trenches in the area. Some nitrate contamination may be from Waste Management Area TX-TY, although distinguishing the different sources is extremely difficult. More discussion of nitrate in north-central 200 West Area is given in Section 2.8.1.4.

Nitrate concentrations exceeded the drinking water standard (45 mg/L) in all wells in the Waste Management Area TX-TY monitoring network in FY 2005.

Chromium was detected above the drinking water standard (100 µg/L) in two wells at Waste Management Area TX-TY during FY 2005 (see Figure 2.8-7). The average chromium concentration in well 299-W14-13 was 690 µg/L during the year and was 100 µg/L in the first regularly scheduled, quarterly sample from new well 299-W14-11. Chromium concentrations in wells adjacent to the well pair 299-W14-11/299-W14-13 were all less than the drinking water standard during the fiscal year indicating that the chromium contamination is limited to the immediate area of the two wells. The most likely source for the chromium is assumed to be Waste Management Area TX-TY because no alternative sources have been identified.

A small tritium plume exists along the east-central part of Waste Management Area TX-TY. The tritium concentration exceeded the interim drinking water standard (20,000 pCi/L) in three wells in the area (Figure 2.8-9). The highest average tritium concentration was 1.57 million pCi/L in well 299-W14-13 during the fiscal year, which was down from 1.7 million pCi/L during the previous year. The tritium concentration in the first routine, quarterly sample from the adjacent new well 299-W14-11 was 217,000 pCi/L. Well 299-W14-11 is screened from 11.6 to 17.3 meters below the water table. The tritium concentration increased in well 299-W14-15, located south of well 299-W14-13, from an average of 33,000 pCi/L in FY 2004 to 53,000 pCi/L in FY 2005. This increase may indicate that the tritium plume in well 299-W14-13 is moving south to well 299-W14-15 perhaps under the influence of the 200-ZP-1 pump-and-treat operation. The source for the high tritium in well 299-W14-13 could be Waste Management Area TX-TY, the 242-T evaporator, the 216-T-19 crib and tile field (which received evaporator condensate from the 242-T evaporator), the 216-T-26 through 216-T-28 cribs, or a combination of these potential sources.

During drilling of well 299-W14-11, east of Waste Management Area TX-TY, the highest iodine-129 and nitrate concentrations were found near the water table. The highest technetium-99 concentration was ~4.5 meters below the water table.

Technetium-99 exceeded the interim drinking water standard (900 pCi/L) in both wells in the well pair 299-W14-11/299-W14-13 at Waste Management Area TX-TY in FY 2005 (see Figure 2.8-12). The average technetium-99 concentration decreased from 8,500 pCi/L in FY 2004 to 7,100 pCi/L in FY 2005 in well 299-W14-13. Previously, the technetium-99 concentration had been increasing in the well since early 2001. The technetium-99 concentration in the first routinely collected groundwater sample from new well 299-W14-11 was 2,650 pCi/L. The source for the technetium-99 in both wells could be Waste Management Area TX-TY or one of the past-practice disposal facilities in the area or both. Technetium-99 is also found at levels above the drinking water standard south of the waste management area.

Iodine-129 was detected in two wells at Waste Management Area TX-TY during FY 2005 (see Figure 2.8-11). The highest iodine-129 concentration measured at the waste management area during the reporting period was 26.1 pCi/L in the February 2005 sample from well 299-W14-13; the average iodine-129 concentration in the well was 18 pCi/L during the year. Iodine-129 also was detected in a single sample from well 299-W14-15 with a concentration of 2.04 pCi/L in May 2005. Iodine-129 was not detected in the first, routinely collected sample from new well 299-W14-11, located next to well 299-W14-13. The new well is screened deeper in the aquifer than well 299-W14-13, and the lack of detectable iodine-129 in the new well suggests that iodine-129 resides near the water table.

Well 299-W14-11 was drilled to 36 meters below the water table in April 2005 to delineate the vertical extent of contamination along the downgradient side of Waste Management Area TX-TY. The new well is located ~4 meters from existing well 299-W14-13. Groundwater samples were air lifted every 1.5 meters during drilling and pumped samples were collected every 6 meters. The samples were analyzed for technetium-99, hexavalent chromium, anions, tritium, and iodine-129. The results of the sampling and analysis effort are discussed in the following paragraphs. Well 299-W14-11 was screened from 11.6 to 14.3 meters below the water table.

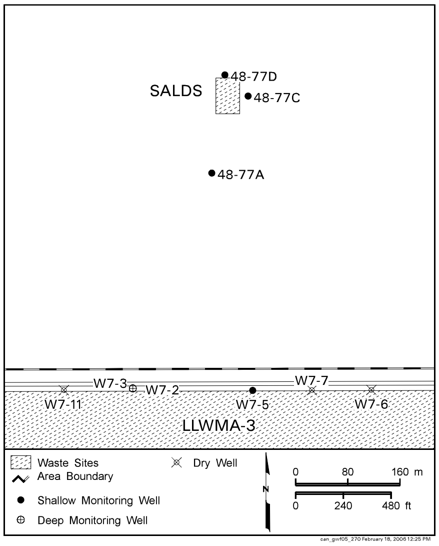
Average tritium concentrations decreased in two of three proximal wells at the State-Approved Land Disposal Site during FY 2005. Fluctuations in tritium concentrations in well 699-48-77A probably reflect changes in the amount of tritium in the discharge.

Figure 2.8-22 shows the distribution of technetium-99 in the upper part of the aquifer at well 299-W14-11. Technetium-99 had a maximum concentration of 7,532 pCi/L at ~4.5 meters below the water table and generally decreased with increasing depth. The adjacent well (299-W14-13) is screened from the water table to 8.2 meters below the water table and the latest (August 2005) technetium-99 concentration from that well was 7,270 pCi/L, comparable to the maximum result from the new well. Finally, Figure 2.8-22 shows the technetium-99 concentration in the August 2005 pumped sample from well 299-W14-11 and that concentration corresponds well with the technetium-99 versus depth curve established from the drilling samples.

Figure 2.8-23 shows the distribution of nitrate in the upper part of the aquifer at well 299-W14-11. The maximum nitrate concentration was 603 mg/L at ~0.7 meter below the water table and decreased with increasing depth until ~18 meters depth at which depth the nitrate concentration began to increase slightly. The nitrate concentrations measured in the August quarterly samples from both wells 299-W14-11 and 299-W14-13 corresponded with the nitrate concentration versus depth curve. A similar relationship exists for tritium (not shown).

Figure 2.8-24 shows the iodine-129 concentration versus depth below the water table in samples from 299-W14-11. All analyses from deeper than 25 meters below the water table yielded undetectable concentrations; non-detectable values have been omitted from the figure. Clearly, the concentration of iodine-129 decreases with increasing depth in the aquifer. The highest iodine-129 concentration was 72 pCi/L at 0.7 meter below the water table. This was the highest iodine-129 concentration measured on the Hanford Site in FY 2005. The August quarterly sample from well 299-W14-11 yielded undetectable iodine-129. The August quarterly sample from well 299-W14-13 yielded 22.1 pCi/L iodine-129 (Figure 2.8-24), consistent with a mix of concentrations over the upper 8 meters of the aquifer (the screened interval) as determined by the drilling samples.

2.8.3.5 Groundwater Monitoring for the State-Approved Land Disposal Site



The Hanford Site 200 Area Effluent Treatment Facility processes contaminated aqueous waste from Hanford Site facilities. The treated wastewater occasionally contains tritium, which is not removed by the Effluent Treatment Facility, and is discharged to the 200 Area State-Approved Land Disposal Site. During FY 2005 (through July 31), 36.7 million liters of water were discharged to the State-Approved Land Disposal Site as documented in the annual report for the site (WMP-26782).

A state waste discharge permit (WAC 173-216) requires groundwater monitoring at this site. The permit was granted in June 1995, and the site began to operate in December 1995. Groundwater monitoring requirements are described in the site monitoring plan (PNNL-13121). Groundwater monitoring for tritium only was conducted in 11 wells near the facility (Appendix B). The permit stipulates requirements for groundwater monitoring and establishes enforcement limits for concentrations of 15 constituents in three additional wells immediately surrounding the facility (Appendix B).

Wells immediately surrounding the facility were sampled in October 2004, and January, May, and September 2005. Tritium-tracking wells were sampled in January, March, April, July and September 2005. Water-level measurements in three wells nearest the State-Approved Land Disposal Site indicated the continuation of a small hydraulic mound beneath the site as a result of discharges. This mound results in radial flow outward a short distance before the regional northeastward flow predominates. This condition also places several wells south of the State-Approved Land Disposal Site hydraulically downgradient of the facility.

Many of the wells south of the State-Approved Land Disposal Site in the tritium-tracking network have gone dry. Specifically, wells 299-W6-7, 299-W6-8, 299-W7-1, 299-W7-6, 299-W7-7, 299-W7-8, 299-W7-9, and 299-W7-11 have gone dry in the past few years.

Average tritium concentrations decreased in two of three State-Approved Land Disposal Site proximal wells during FY 2005 compared with FY 2004 (Figure 2.8-25; see also Figure 2.8-9 for tritium distribution contours). During FY 2005, maximum tritium concentrations for State-Approved Land Disposal Site proximal wells were 280,000 pCi/L in well 699-48-77A (January 2005), 150,000 pCi/L in well 699-48-77C (January 2005), and 65,000 pCi/L in well 699-48-77D (October 2004). Fluctuations in tritium concentrations in well 699-48-77A probably reflect changes in the amount of tritium in the discharge.

Concentrations of all chemical constituents with permit limits were within those limits during all of FY 2005. Acetone, benzene, chloroform, cadmium, and mercury were below method detection limits in all samples. Lead and copper produced detectable concentrations of 0.23 µg/L lead and 0.52 µg/L copper in samples from well 699-48-77D. Concentrations of major cations and anions continued below background concentrations observed prior to operation of the facility. This condition is due to dilution by the clean water discharged to the State-Approved Land Disposal Site.

Concentrations of chemical constituents remained within permit limits at the State-Approved Land Disposal Site.

Hydraulic head in March 2005 (Figure 2.8-2) declined ~0.32 meter from March 2004 to March 2005 in the vicinity of the State-Approved Land Disposal Site. Head in well 699-48-77A for March 2005 was ~0.02 meter higher than for the same period in 2004; however, this well responds rapidly to changes in discharge from the facility, and the overall trend for head remains downward.

Numerical flow-and-transport modeling of the State-Approved Land Disposal Site was conducted in August 2004, as required by the permit (PNNL-14898).

Table 2.8-1. Contaminants of Concern in all Wells in the 200-ZP-1 Groundwater Interest Area, FY 2005 (DOE/RL-2003-55)

Constituent	Filtered	Number of Wells, FY 20005	Number of Results	Detects	Rejects	Preliminary Target Action Level	Action Level Source	Results Above Standard	Wells Above Standard
1,1,1-Trichloroethane, µg/L	N	65	183	4		200	MCL		
1,1,1-Trichloroethane, µg/L	Y	8	26			200	MCL		
1,2-Dichloroethane, µg/L	N	65	183			5	CRDL		
1,2-Dichloroethane, µg/L	Y	8	26			5	CRDL		
2-Butanone, µg/L	N	65	192	9		4,800	CLARC		
2-Butanone, µg/L	Y	8	26	8		4,800	CLARC		
4-Methyl-2-Pentanone, µg/L	N	65	183			640	CLARC		
4-Methyl-2-Pentanone, µg/L	Y	8	26			640	CLARC		
Acetone, µg/L	N	65	192	44		800	CLARC		
Acetone, µg/L	Y	8	26	3		800	CLARC		
Ammonium ion, µg/L	N	5	18	18			TBD		
Ammonium ion, µg/L	Y	4	9	9			TBD		
Antimony, µg/L	N	10	34	2		10	CRDL	1	1
Antimony, µg/L	Y	59	178	1		10	CRDL	1	1
Arsenic, µg/L	N	8	31	18		10	CRDL		
Arsenic, µg/L	Y	13	32	21		10	CRDL	2	1
Benzene, µg/L	N	65	192	4		5	CRDL		
Benzene, µg/L	Y	8	26			5	CRDL		
Cadmium, µg/L	N	10	34	1		5	MCL		
Cadmium, µg/L	Y	59	178	1		5	MCL		
Carbon disulfide, µg/L	N	65	183	27		800	CLARC		
Carbon disulfide, µg/L	Y	8	26	4		800	CLARC		
Carbon tetrachloride, µg/L	N	65	280	174		3	CRDL	158	52
Carbon tetrachloride, µg/L	Y	8	30	29		3	CRDL	28	8
Carbon-14, pCi/L	N	5	18			2,000	MCL		
Carbon-14, pCi/L	Y	4	12			2,000	MCL		
Cesium-137, pCi/L	N	24	45	1	1	60	MCL		
Cesium-137, pCi/L	Y	4	9			60	MCL		
Chlorobenzene, µg/L	N	33	93	1		100	MCL		
Chlorobenzene, µg/L	Y	8	26			100	MCL		
Chloroform, µg/L	N	65	277	172		7	CLARC	125	35
Chloroform, µg/L	Y	8	30	29		7	CLARC	25	5
Chromium, µg/L	N	10	34	18		100	MCL	1	1
Chromium, µg/L	Y	59	178	149		100	MCL	23	6
cis-1,2-Dichloroethylene, µg/L	N	61	152			70	MCL		
cis-1,2-Dichloroethylene, µg/L	Y	6	22			70	MCL		
Cresol (total):						80	CLARC		
2-Methylphenol (cresol, o-), µg/L	N	17	37						
2-Methylphenol (cresol, o-), µg/L	Y	4	20						
3+4 Methylphenol (cresol, m+p), µg/L	N	17	35						
3+4 Methylphenol (cresol, m+p), µg/L	Y	4	18						
4-Methylphenol (cresol, p-), µg/L	N	1	1						
4-Methylphenol (cresol, p-), µg/L	Y	1	2						
Cyanide, µg/L	N	7	21			200	MCL		
Cyanide, µg/L	Y	4	11	2		200	MCL		

Table 2.8-1. (contd)

Constituent	Filtered	Number of Wells, FY 20005	Number of Results	Detects	Rejects	Preliminary Target Action Level	Action Level Source	Results Above Standard	Wells Above Standard
Ethylbenzene, µg/L	N	64	170	2		700	MCL		
Ethylbenzene, µg/L	Y	8	26			700	MCL		
Fluoride, µg/L	N	75	230	223	2	4,000	MCL	7	3
Fluoride, µg/L	Y	5	12	9		4,000	MCL		
Hexavalent chromium, µg/L	N	5	18	3		48	CLARC		
Hexavalent chromium, µg/L	Y	11	15	9		48	CLARC	6	6
Iodine-129, pCi/L	N	48	107	9		1	MCL	9	5
Iodine-129, pCi/L	Y	5	13			1	MCL		
Iron, µg/L	N	10	34	22		300	2nd MCL	2	2
Iron, µg/L	Y	59	178	132		300	2nd MCL		
Lead, µg/L	N	8	32	2		15	MCL	1	1
Lead, µg/L	Y	19	45	5		15	MCL	1	1
Lithium, µg/L	N	5	18	17			TBD		
Lithium, µg/L	Y	5	12	11			TBD		
Magnesium, µg/L	N	10	34	32			TBD		
Magnesium, µg/L	Y	59	178	178			TBD		
Manganese, µg/L	N	10	33	21		50	2nd MCL	11	5
Manganese, µg/L	Y	59	178	122	2	50	2nd MCL	15	5
Mercury, µg/L	N	8	32	2		2	MCL		
Mercury, µg/L	Y	19	44	1		2	MCL		
Methylene chloride, µg/L	N	65	192	17		5	MCL	8	3
Methylene chloride, µg/L	Y	8	26	13		5	MCL	12	1
n-Butylbenzene, µg/L	N	27	51			320	CLARC		
n-Butylbenzene, µg/L	Y	6	22			320	CLARC		
Neptunium-237, pCi/L	N	6	19	2		15	MCL		
Neptunium-237, pCi/L	Y	4	11			15	MCL		
Nickel, µg/L	N	10	45	33		320	CLARC		
Nickel, µg/L	Y	59	183	65	1	320	CLARC		
Nitrate, µg/L	N	75	257	245	1	12,400	Background	219	69
Nitrate, µg/L	Y	5	30	30		12,400	Background	30	5
Nitrite, µg/L	N	75	230	27	5	3,268	MCL		
Nitrite, µg/L	Y	5	12	8		3,268	MCL		
Pentachlorophenol, µg/L	N	17	37				TBD		
Pentachlorophenol, µg/L	Y	4	20				TBD		
Phenol (total):							TBD		
2,3,4,6-Tetrachlorophenol, µg/L	N	12	13						
2,4,5-Trichlorophenol, µg/L	N	17	36						
2,4,5-Trichlorophenol, µg/L	Y	4	20						
2,4,6-Trichlorophenol, µg/L	N	17	36						
2,4,6-Trichlorophenol, µg/L	Y	4	20						
2,4-Dichlorophenol, µg/L	N	17	37						
2,4-Dichlorophenol, µg/L	Y	4	20						
2,4-Dimethylphenol, µg/L	N	17	36						
2,4-Dimethylphenol, µg/L	Y	4	20						
2,4-Dinitrophenol, µg/L	N	17	35						
2,4-Dinitrophenol, µg/L	Y	4	20						

Table 2.8-1. (contd)

Constituent	Filtered	Number of Wells, FY 20005	Number of Results	Detects	Rejects	Preliminary Target Action Level	Action Level Source	Results Above Standard	Wells Above Standard
2,6-Dichlorophenol, µg/L	N	12	13						
2-Chlorophenol, µg/L	N	17	36						
2-Chlorophenol, µg/L	Y	4	20						
2-Nitrophenol, µg/L	N	17	37						
2-Nitrophenol, µg/L	Y	4	20						
2-Secbutyl-4,6-dinitrophenol (Dinoseb), µg/L	N	12	13						
4,6-Dinitro-2-methylphenol, µg/L	N	17	36						
4,6-Dinitro-2-methylphenol, µg/L	Y	4	20						
4-Chloro-3-methylphenol, µg/L	N	17	36	1					
4-Chloro-3-methylphenol, µg/L	Y	4	20						
4-Nitrophenol, µg/L	N	17	36	1					
4-Nitrophenol, µg/L	Y	4	20						
Phenol, µg/L	N	17	38	5					
Phenol, µg/L	Y	4	20						
Phosphate, µg/L	N	8	32				TBD		
Phosphate, µg/L	Y	4	11	1			TBD		
Protactinium-231, pCi/L	N	5	17	1		15	MCL		
Protactinium-231, pCi/L	Y	4	10			15	MCL		
Selenium, µg/L	N	8	43	23		50	MCL	1	1
Selenium, µg/L	Y	7	29	15		50	MCL	1	1
Selenium-79, pCi/L	N	5	18				MCL		
Selenium-79, pCi/L	Y	4	12				MCL		
Silver, µg/L	N	10	46	13		80	CLARC		
Silver, µg/L	Y	59	183	2		80	CLARC		
Strontium-90, pCi/L	N	10	35	3		8	MCL		
Strontium-90, pCi/L	Y	4	12	2		8	MCL		
Technetium-99, pCi/L	N	59	193	158		900	MCL	33	11
Technetium-99, pCi/L	Y	5	21	17		900	MCL		
Tetrachloroethene, µg/L	N	65	228	58		5	CRDL	3	3
Tetrachloroethene, µg/L	Y	8	30	1		5	CRDL		
Toluene, µg/L	N	65	192	7		1,000	MCL		
Toluene, µg/L	Y	8	26	5		1,000	MCL		
trans-1,2-Dichloroethylene, µg/L	N	61	152			100	MCL		
trans-1,2-Dichloroethylene, µg/L	Y	6	22			100	MCL		
Trichloroethene, µg/L	N	65	277	135		5	CRDL	64	17
Trichloroethene, µg/L	Y	8	30	15		5	CRDL	4	3
Tritium, pCi/L	N	69	210	164		20,000	MCL	34	9
Tritium, pCi/L	Y	5	9	8		20,000	MCL	3	2
Uranium, µg/L	N	30	71	65		30	MCL	2	1
Uranium, µg/L	Y	8	23	21		30	MCL		
Vanadium, µg/L	N	10	33	28		112	CLARC		
Vanadium, µg/L	Y	59	178	176		112	CLARC		
Xylenes (total), µg/L	N	65	183	2		10,000	MCL		
Xylenes (total), µg/L	Y	8	26			10,000	MCL		

CLARC = Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation (Ecology 2001).
CRDL = Contact-required detection limit.
MCL = Maximum contaminant level.
TBD = To be determined.

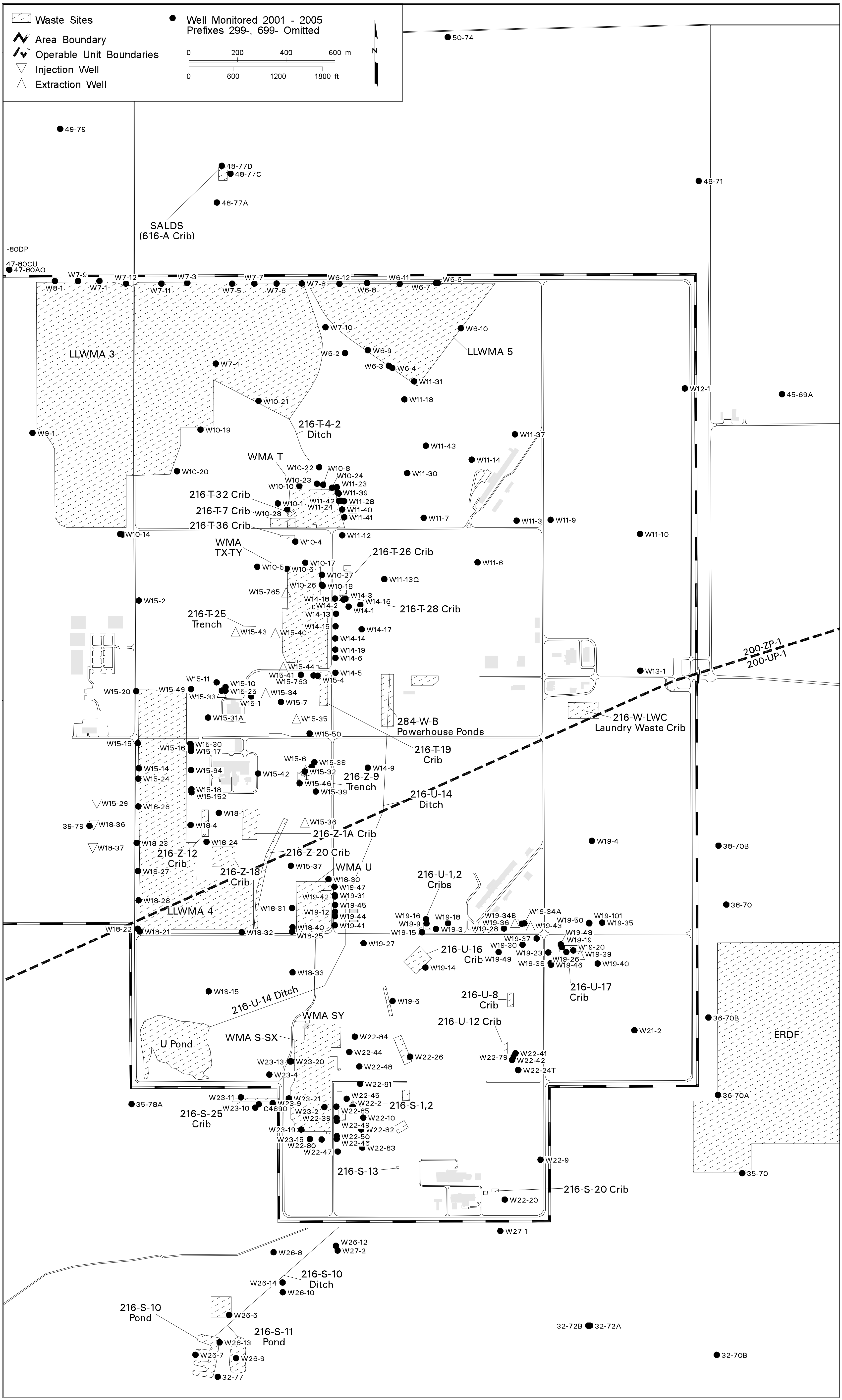


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Figure 2.8-1. Groundwater Monitoring Wells in the 200 West Area

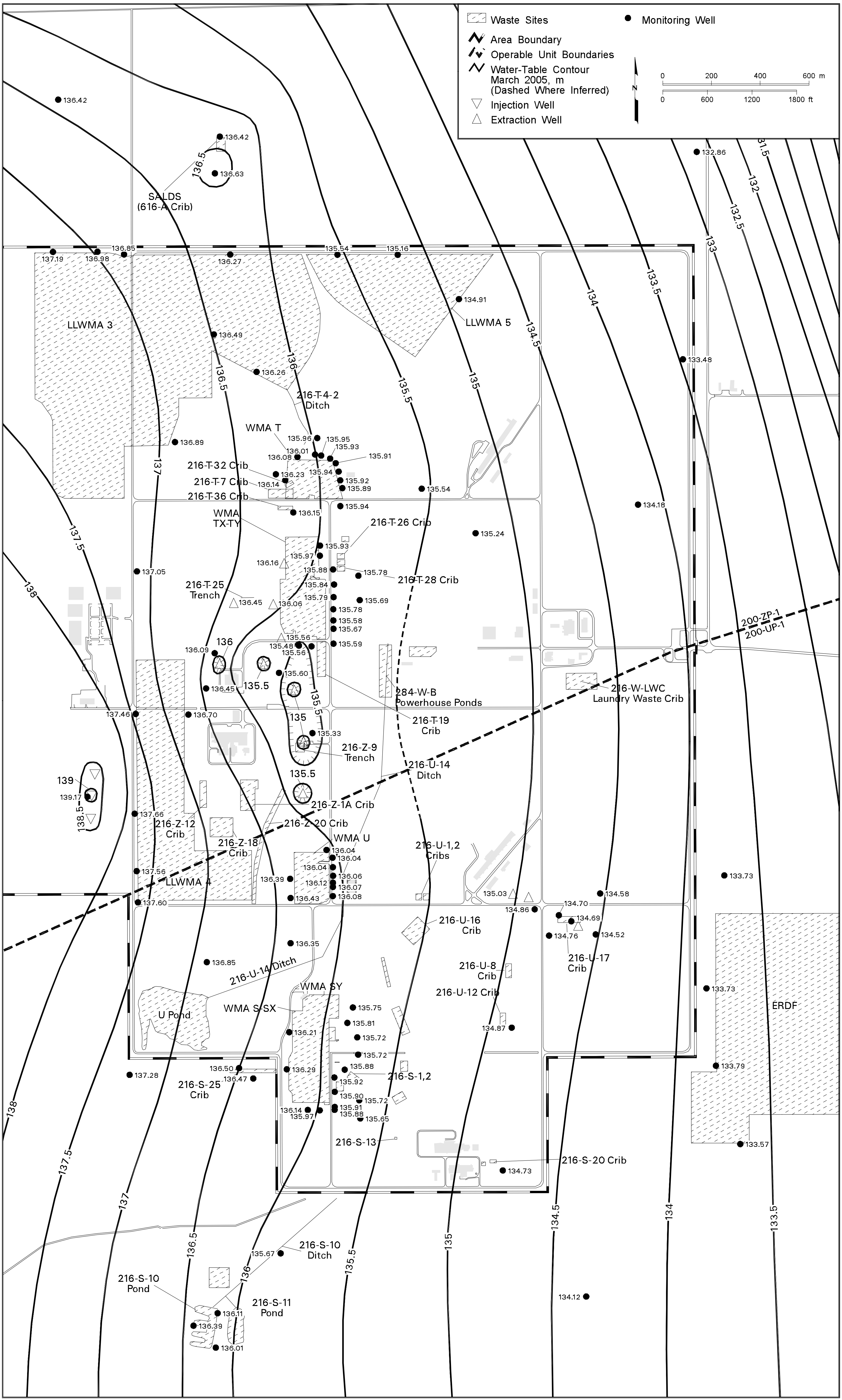

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Figure 2.8-2. Water-Table Contours in the 200 West Area

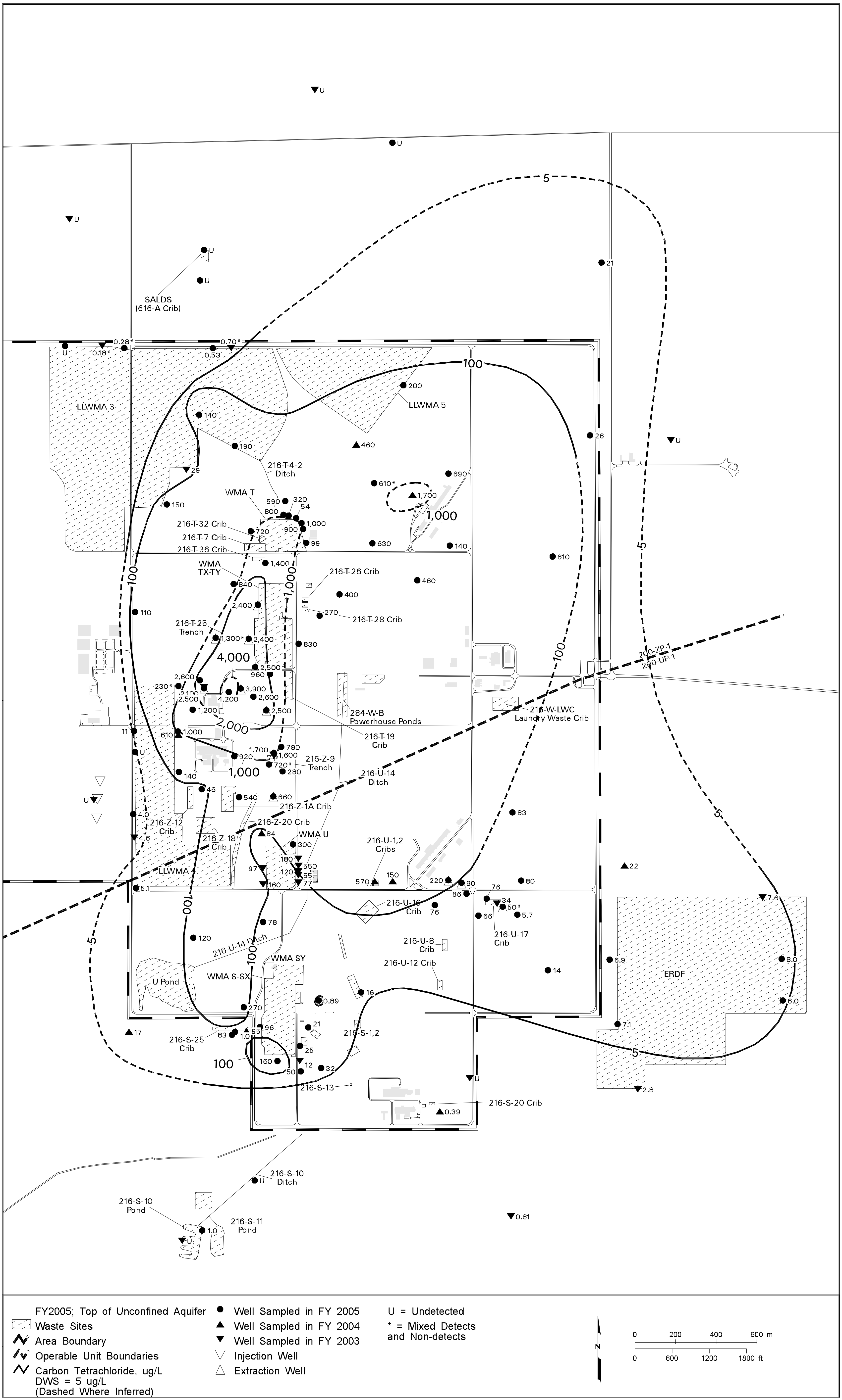

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Figure 2.8-3. Average Carbon Tetrachloride Concentrations in 200 West Area, Top of Unconfined Aquifer

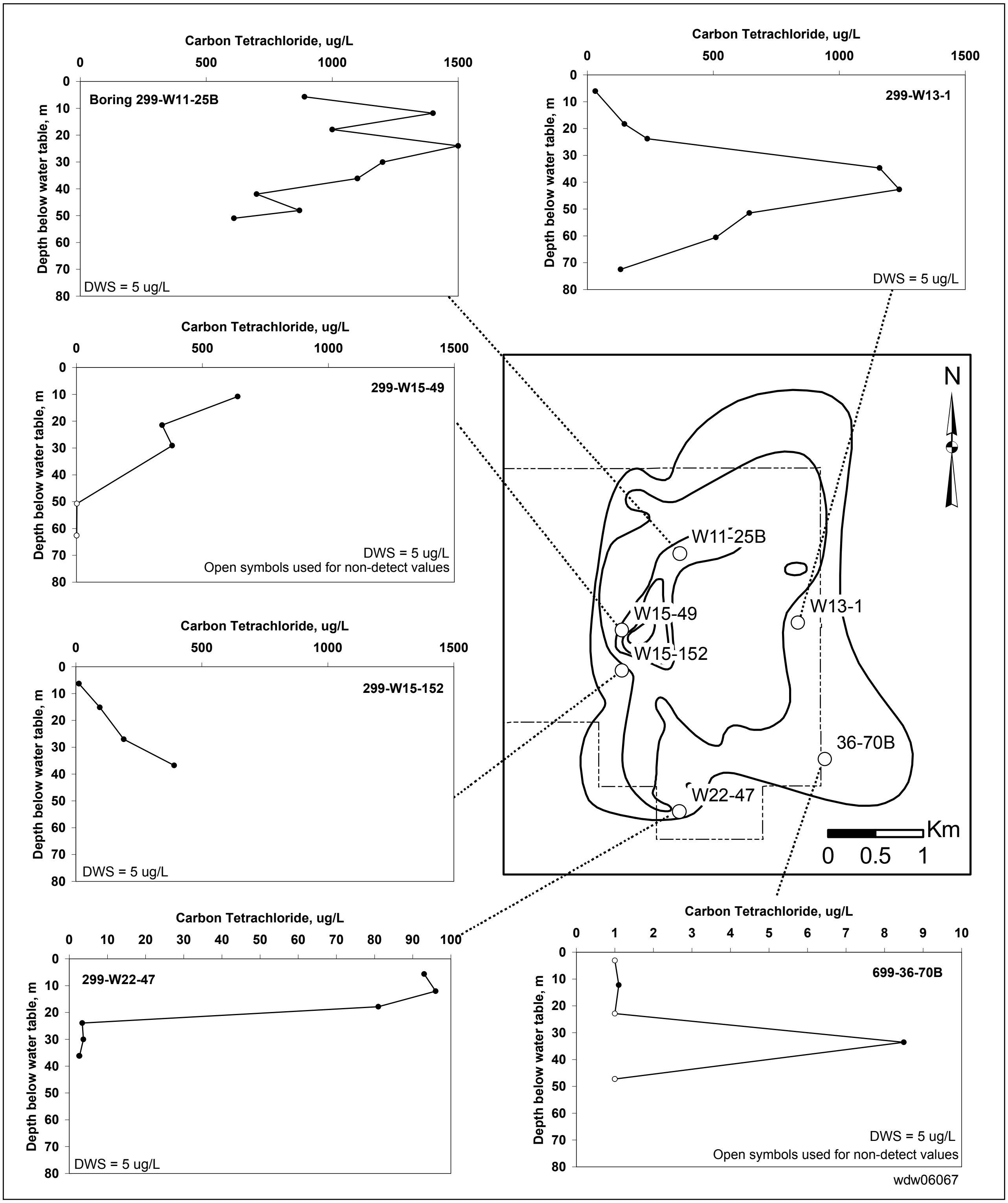

Figure 2.8-4. Carbon Tetrachloride Concentration versus Depth for Selected Wells and Boring 299-W11-25B in the 200 West Area

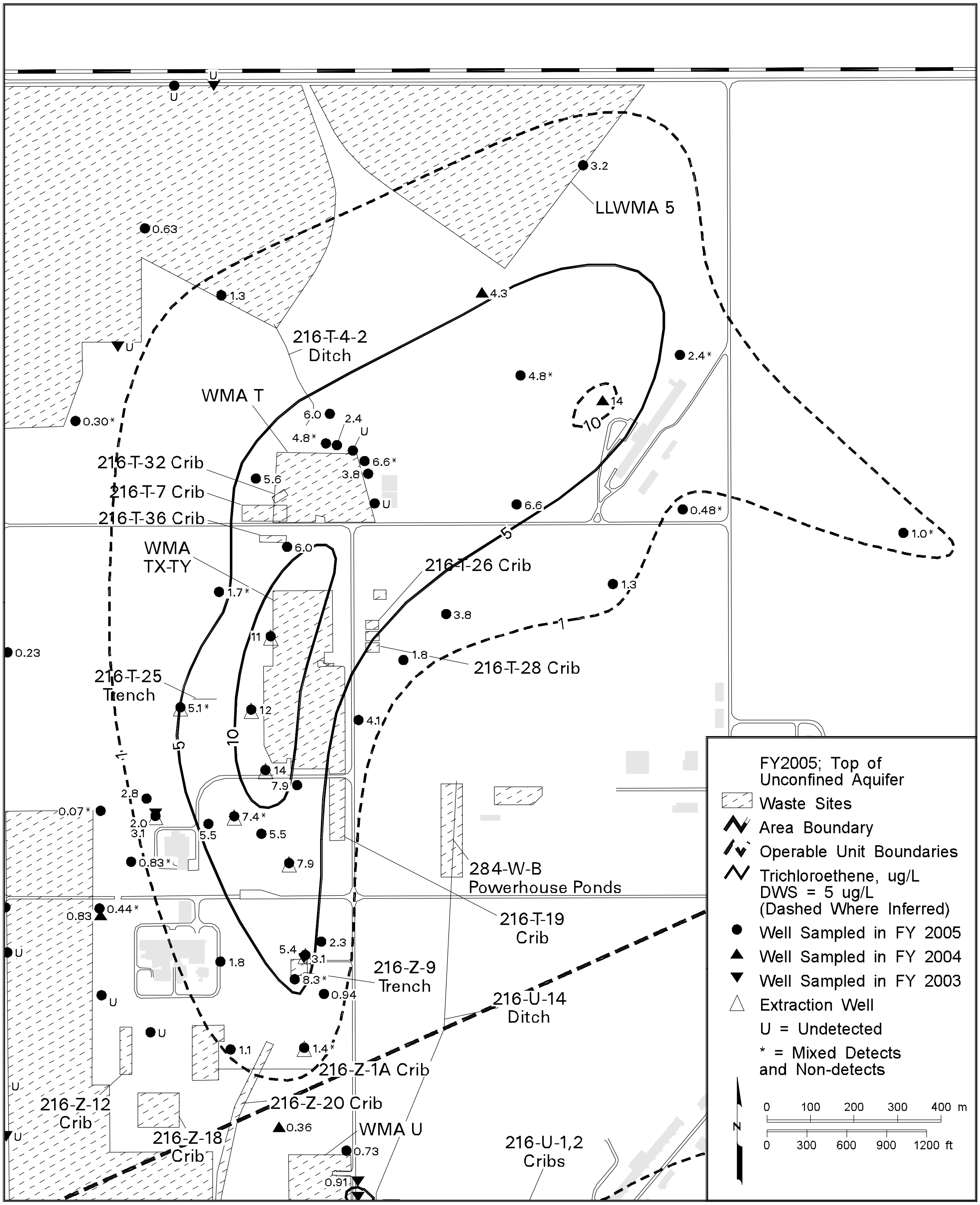

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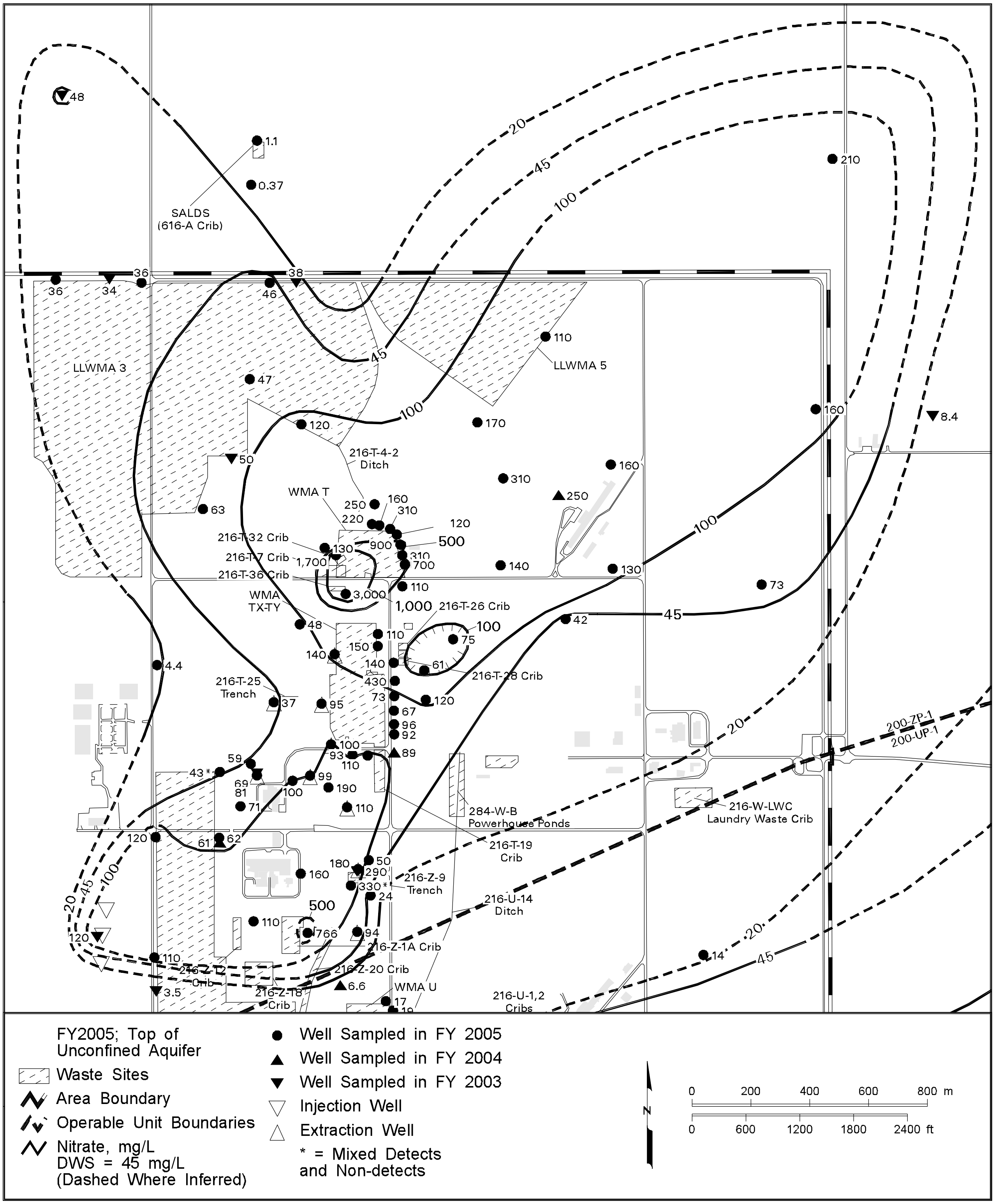
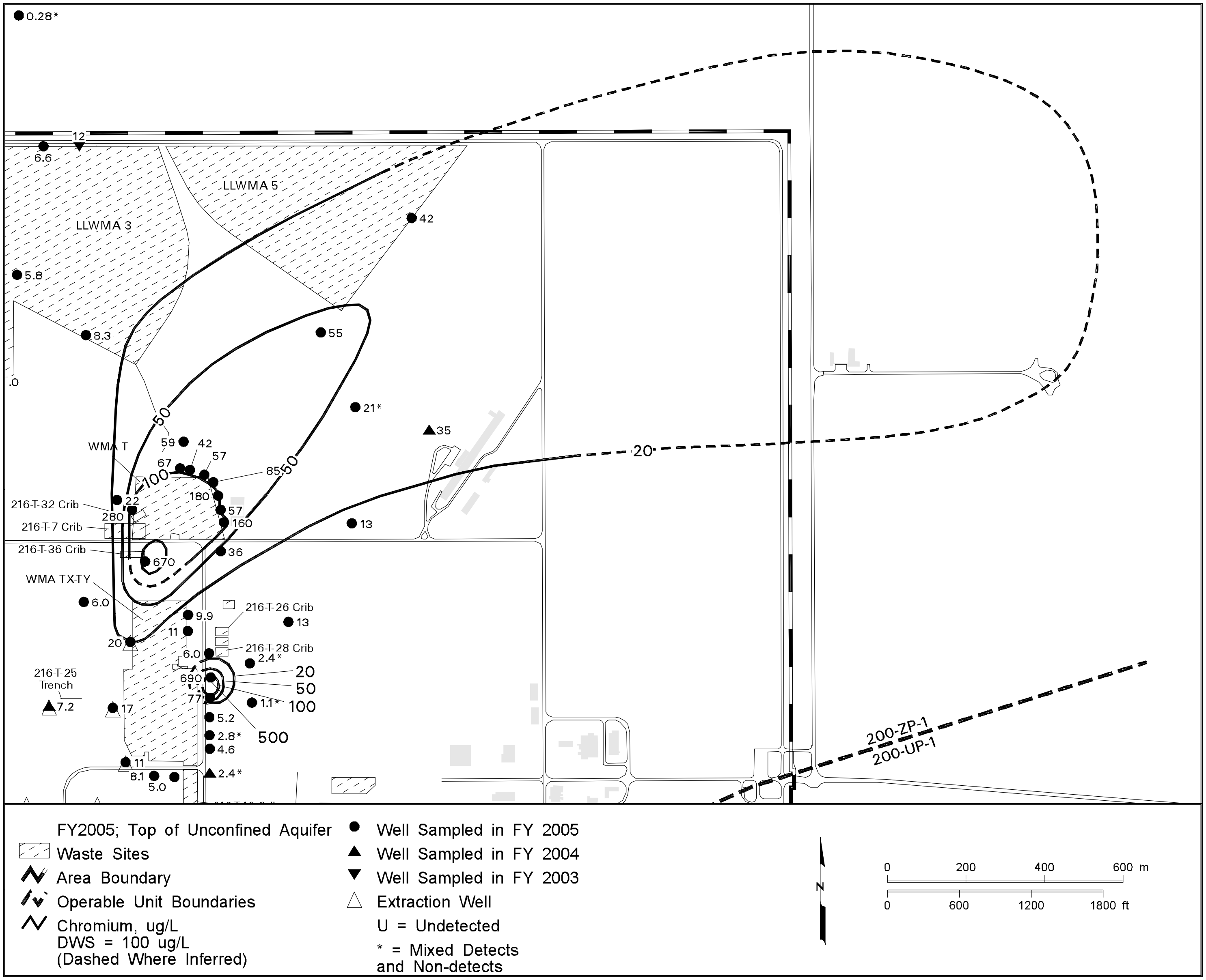
Figure 2.8-5. Average Trichloroethene Concentrations in Central and North 200 West Area, Top of Unconfined Aquifer



can_gwf05_275 February 28, 2006 11:17 AM

Figure 2.8-6. Average Nitrate Concentrations in Central and North 200 West Area, Top of Unconfined Aquifer



can_gwf05_276 February 24, 2006 8:44 PM

Figure 2.8-7. Average Dissolved Chromium Concentrations Near Waste Management Areas T and TX-TY, Top of Unconfined Aquifer

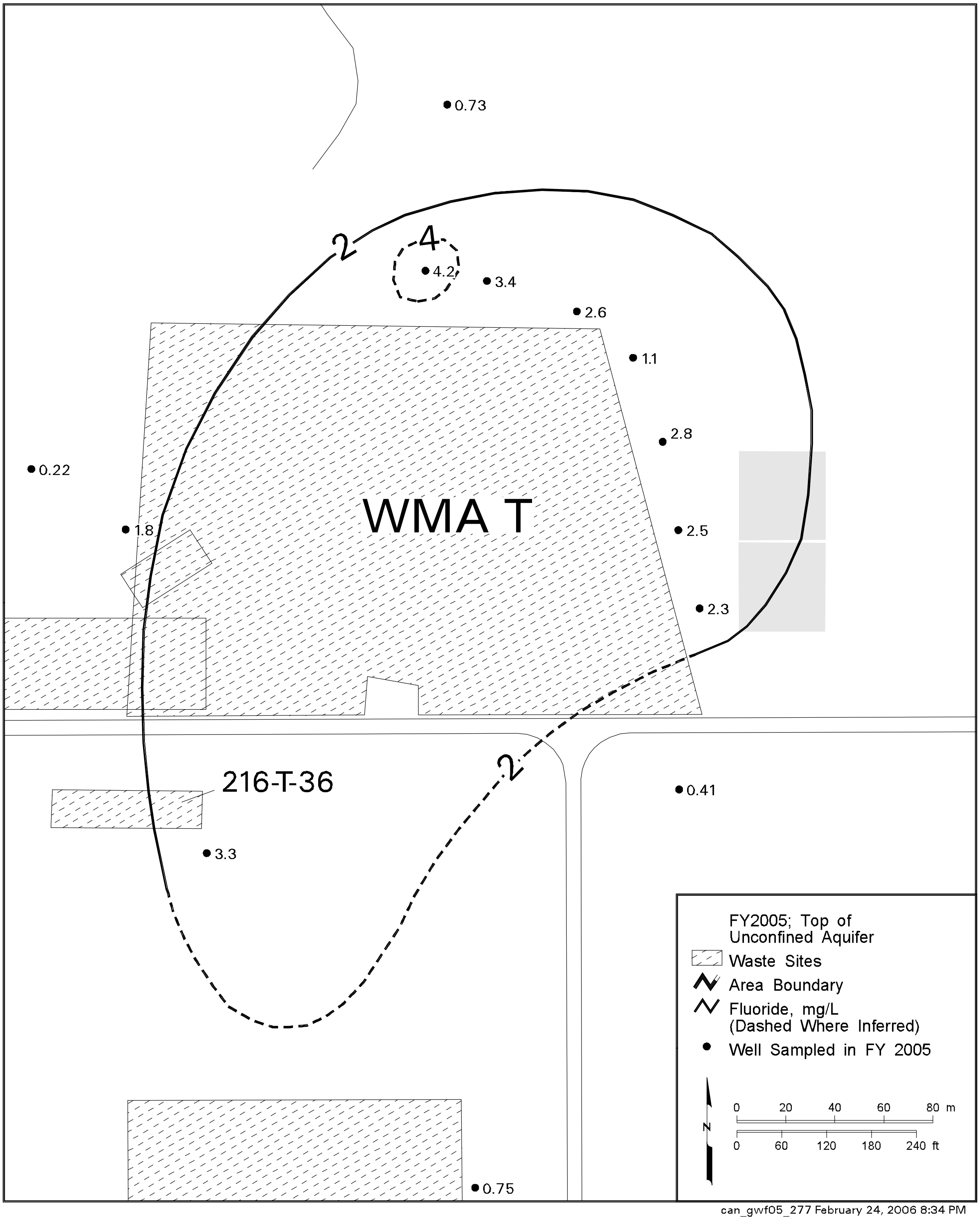


Figure 2.8-8. Average Fluoride Concentrations Near Waste Management Area T in North 200 West Area, Top of the Unconfined Aquifer

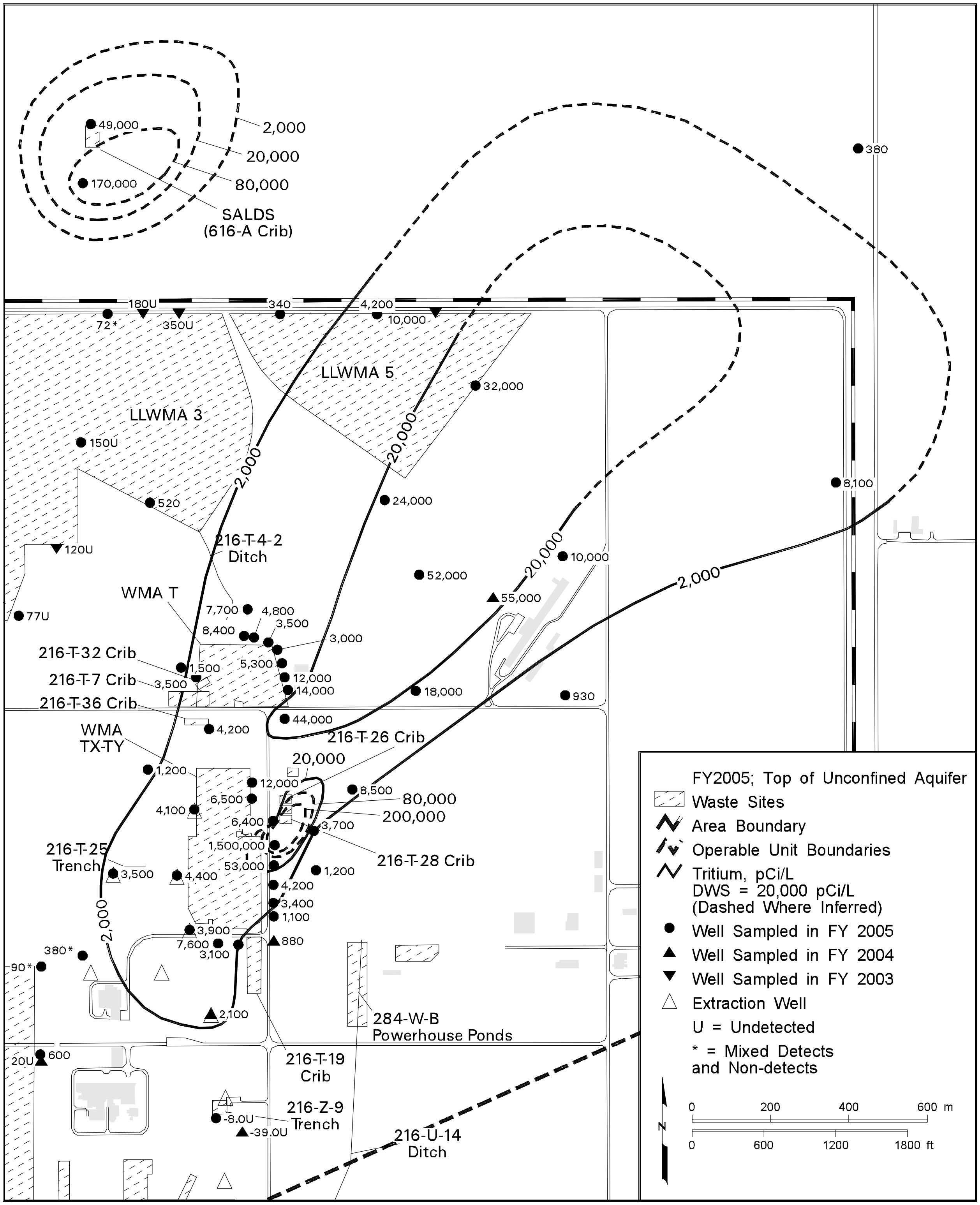


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Figure 2.8-9. Average Tritium Concentrations in North 200 West Area, Top of Unconfined Aquifer

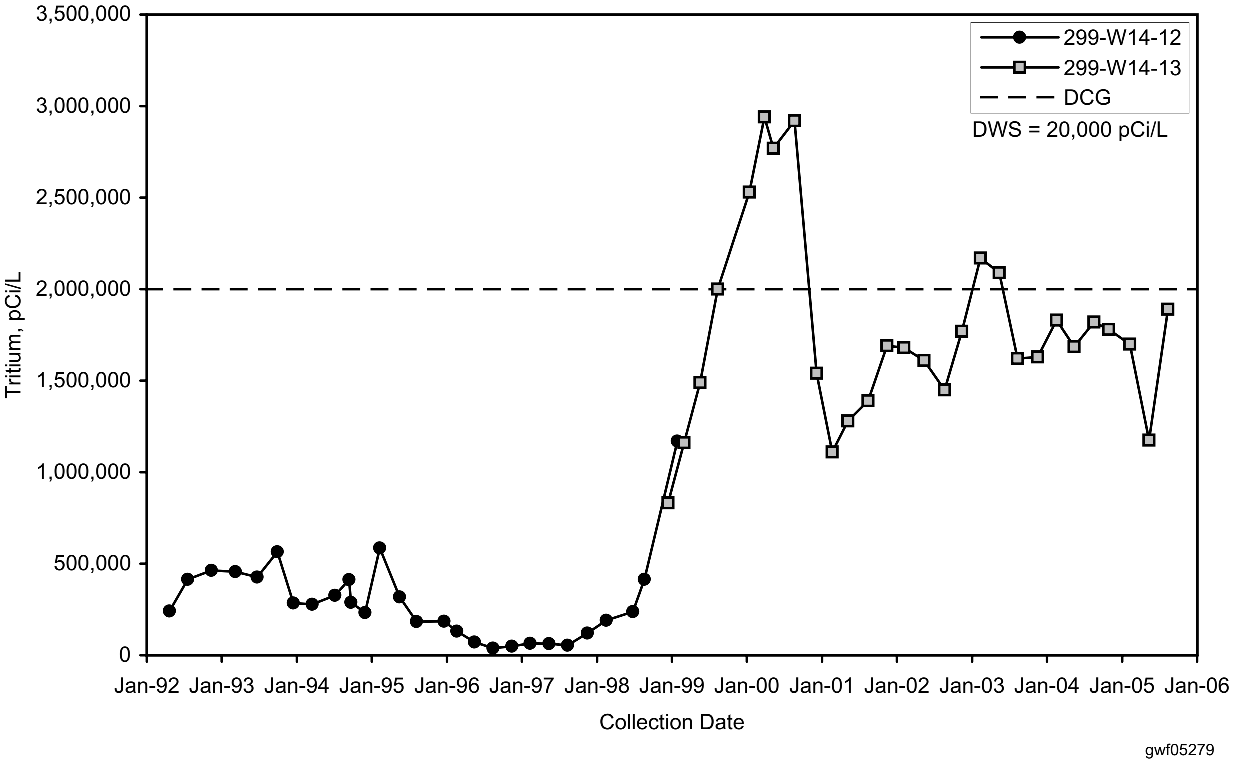
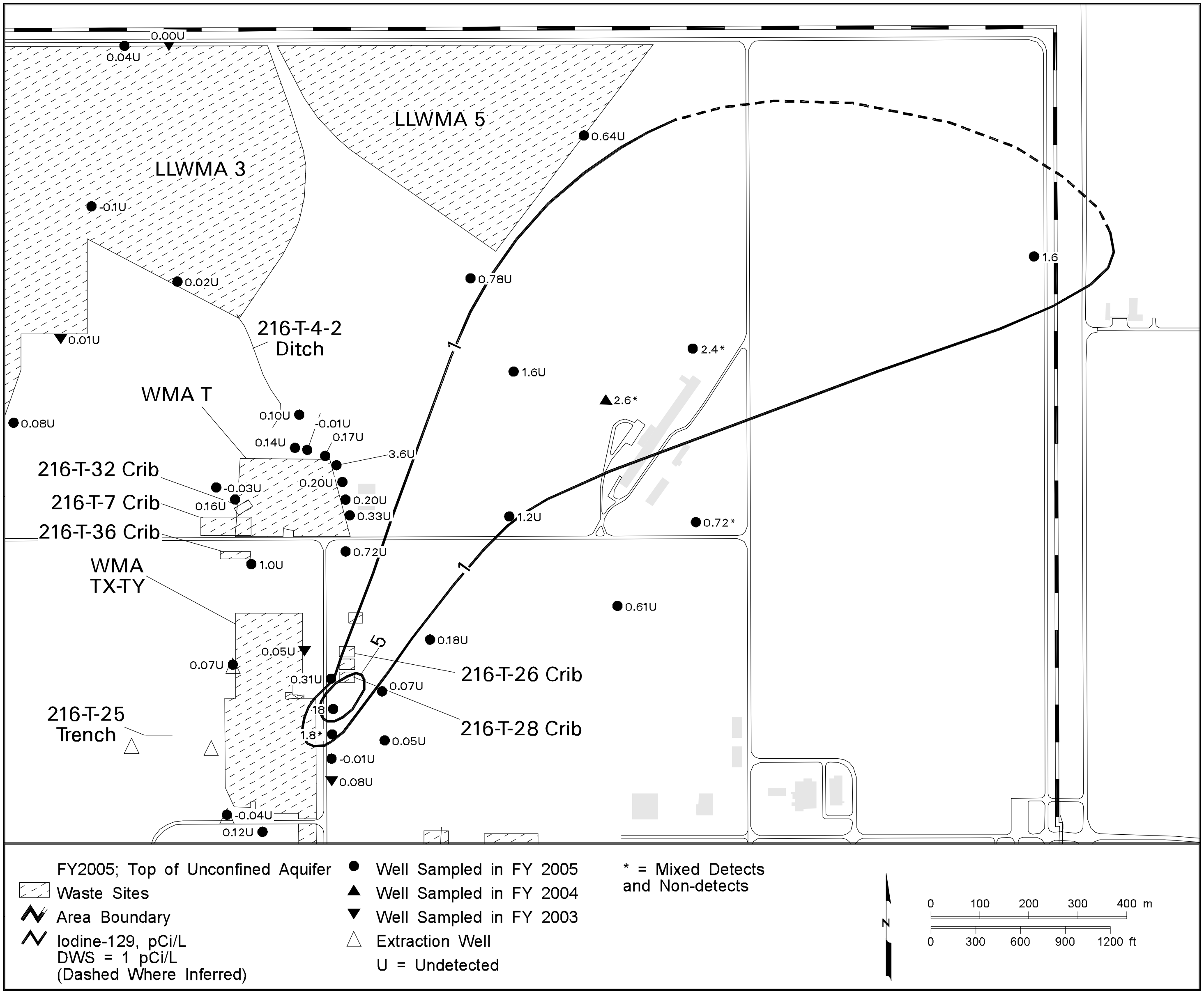
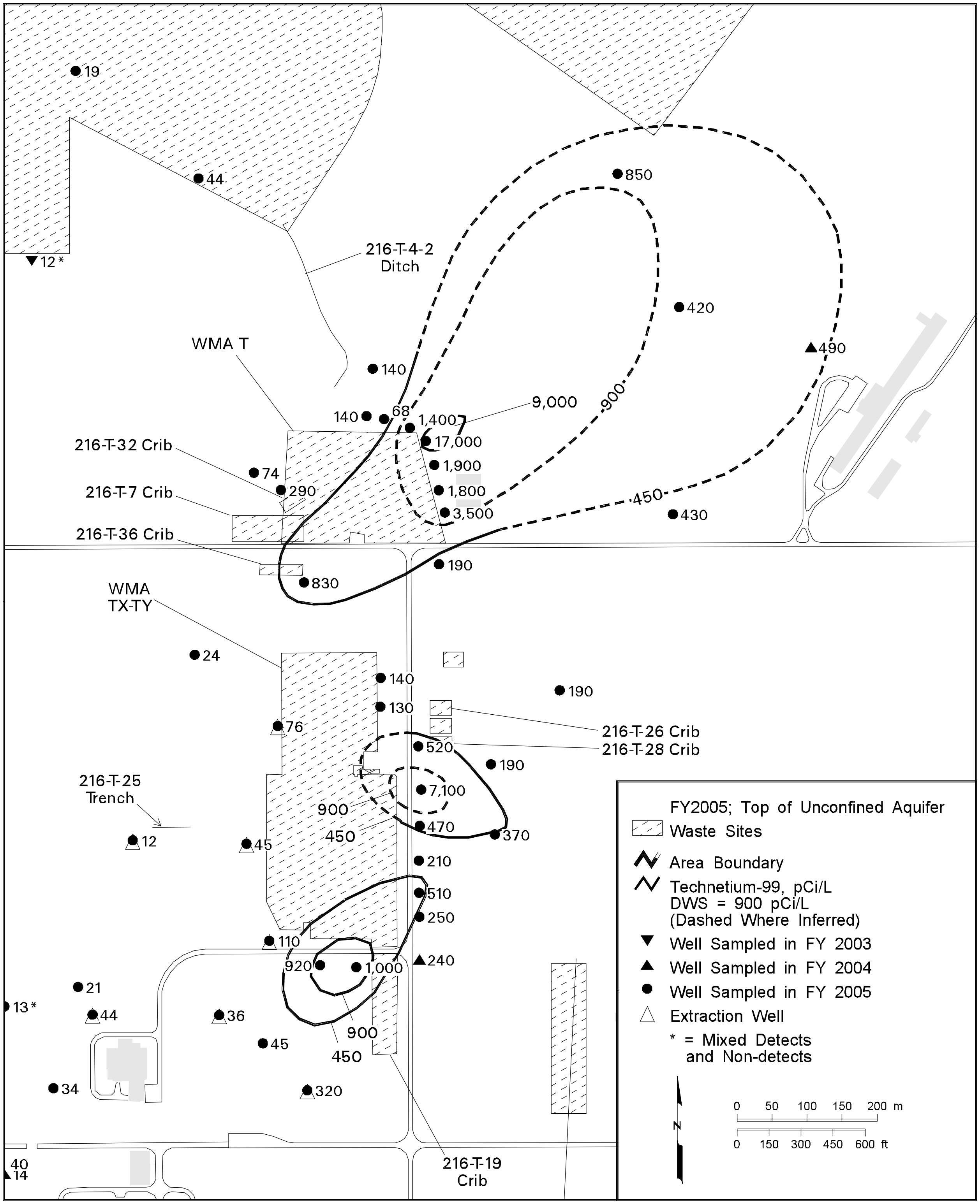


Figure 2.8-10. Tritium Concentrations versus Time in Wells 299-W14-12 and 299-W14-13, Waste Management Area TX-TY



can_gwf05_280 February 24, 2006 8:34 PM

Figure 2.8-11. Average Iodine-129 Concentrations in North 200 West Area, Top of Unconfined Aquifer



can_gwf05_281 February 24, 2006 8:02 PM

Figure 2.8-12. Average Technetium-99 Concentrations in North 200 West Area, Top of Unconfined Aquifer

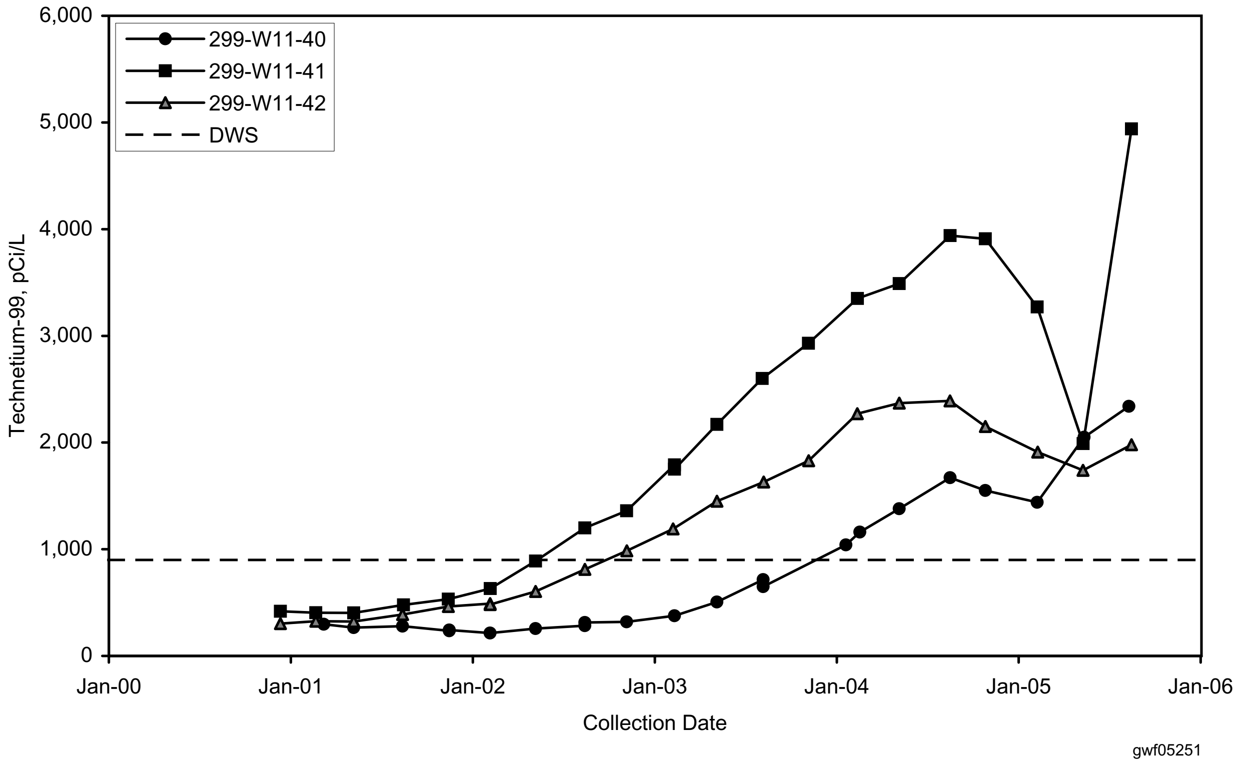


Figure 2.8-13. Technetium-99 Concentrations in Selected Wells Downgradient at Waste Management Area T

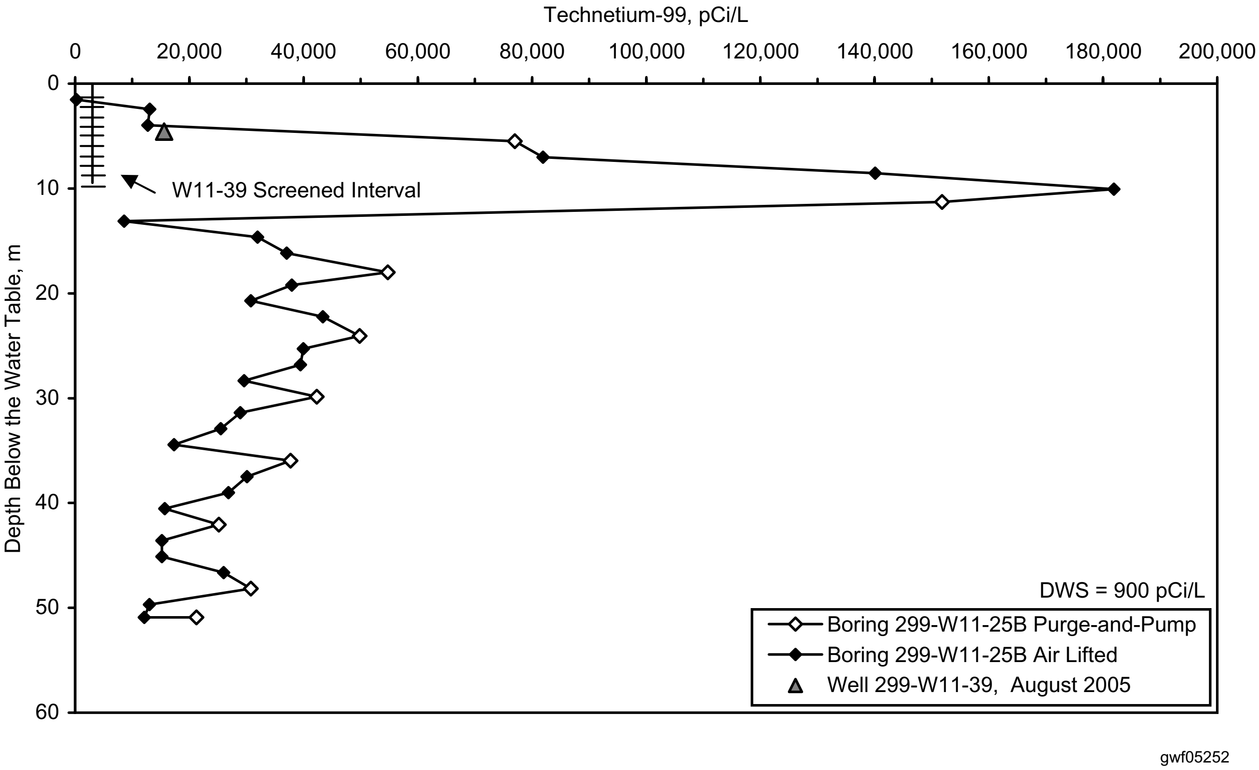


Figure 2.8-14. Technetium-99 Concentrations in Boring 299-W11-25B and Well 299-W11-39

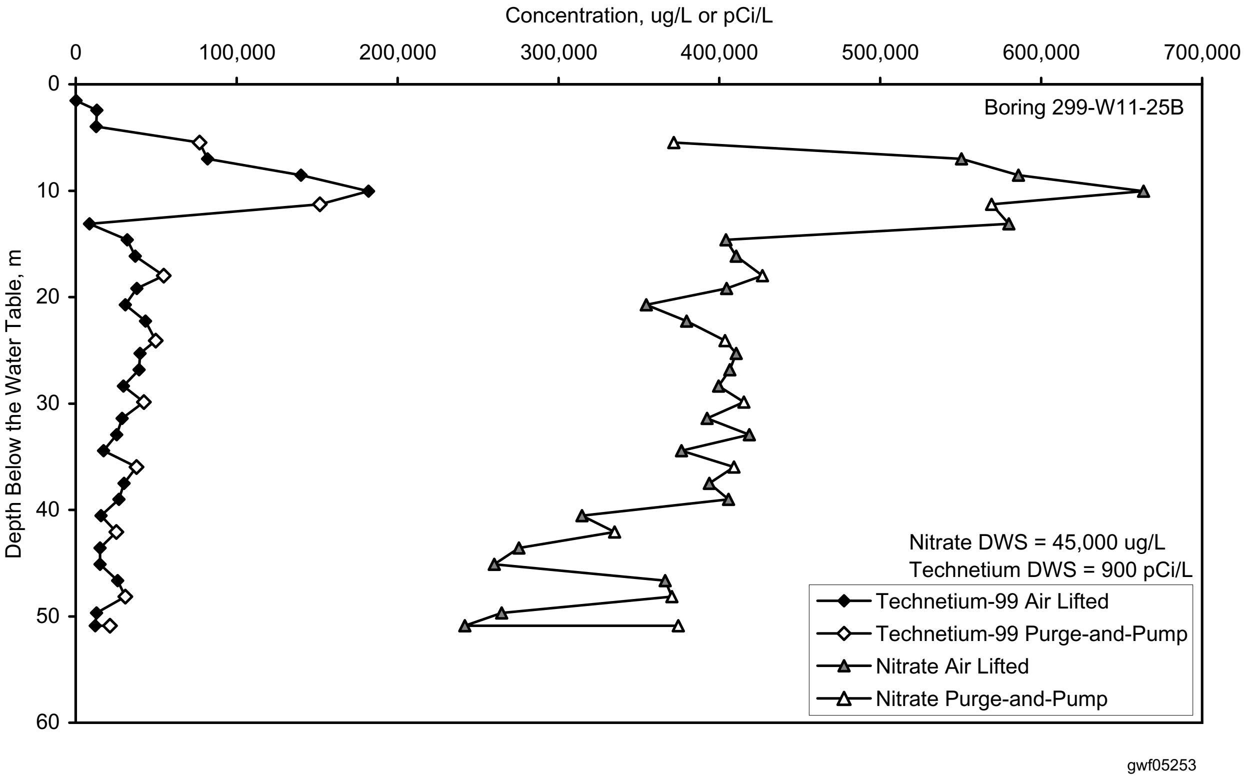


Figure 2.8-15. Depth Distribution of Technetium-99 and Nitrate at Boring 299-W11-25B

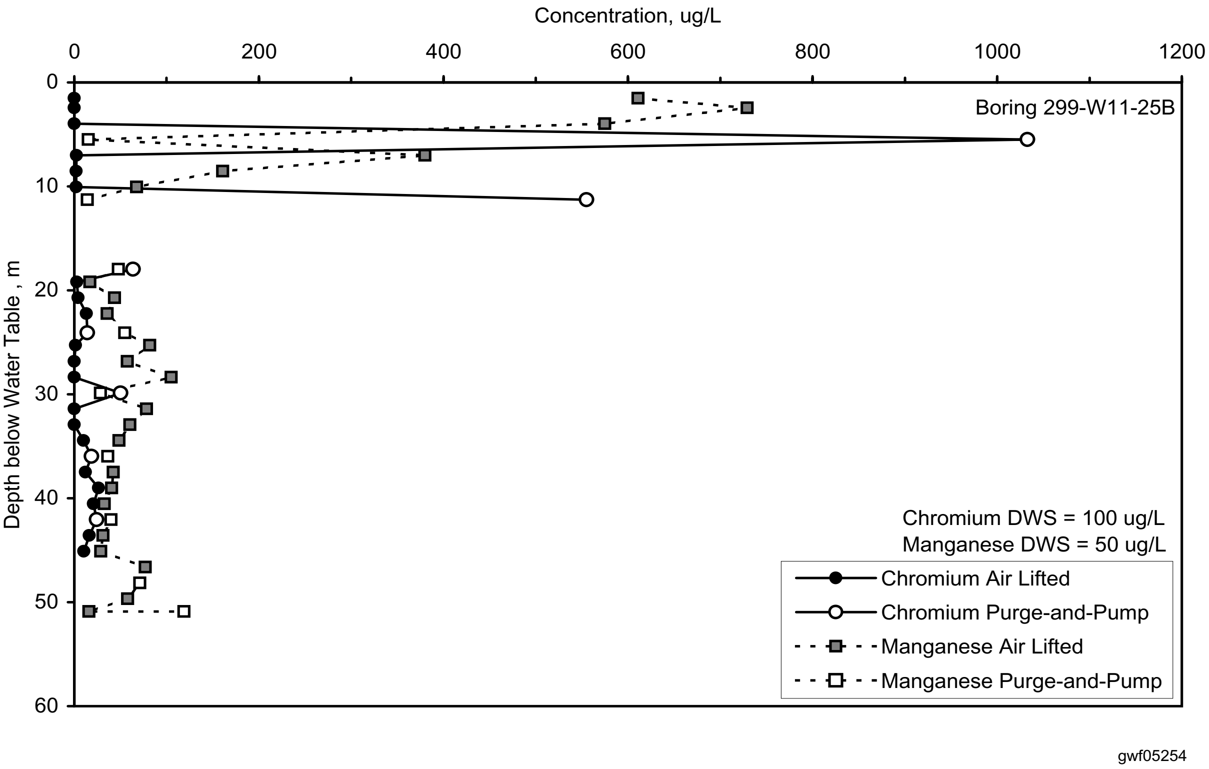


Figure 2.8-16. Depth Distribution of Chromium and Manganese in Boring 299-W11-25B, Waste Management Area T

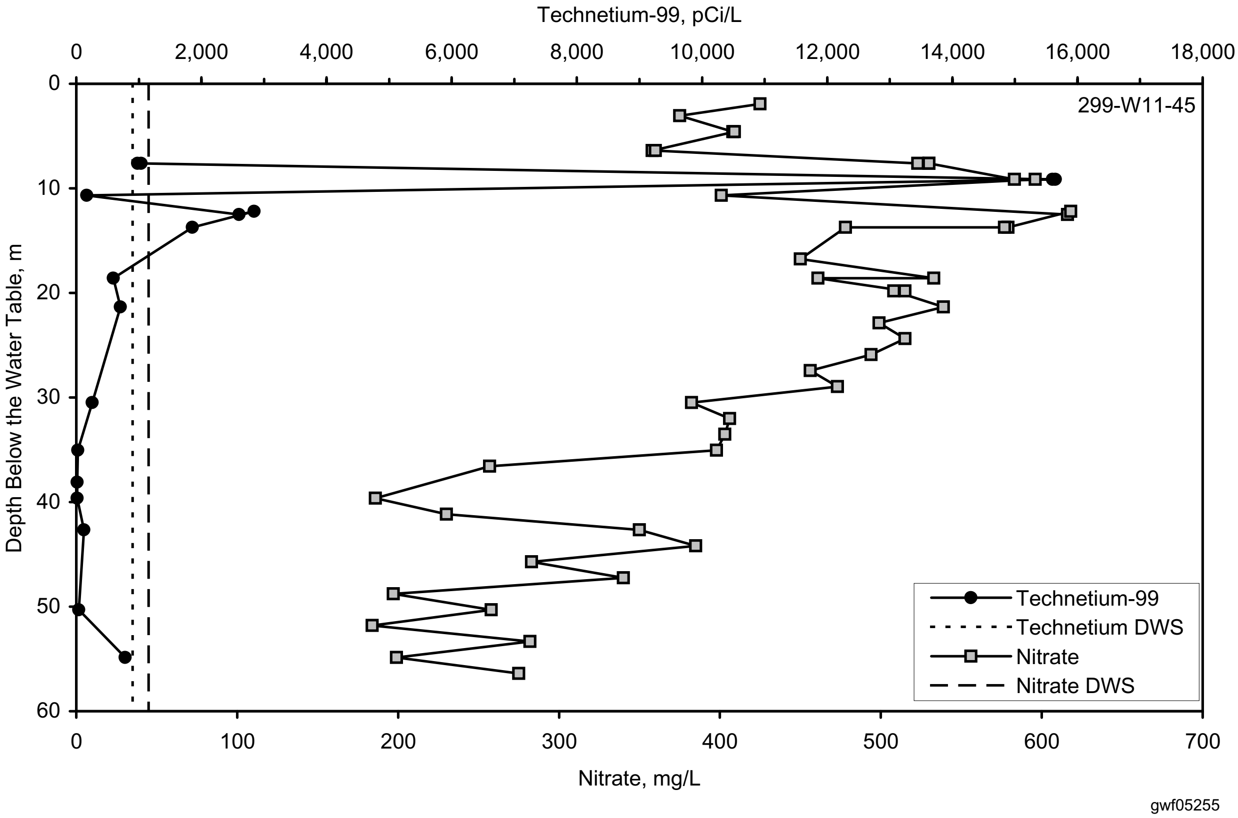


Figure 2.8-17. Technetium-99 and Nitrate Concentrations Encountered During Drilling of Well 299-W11-45

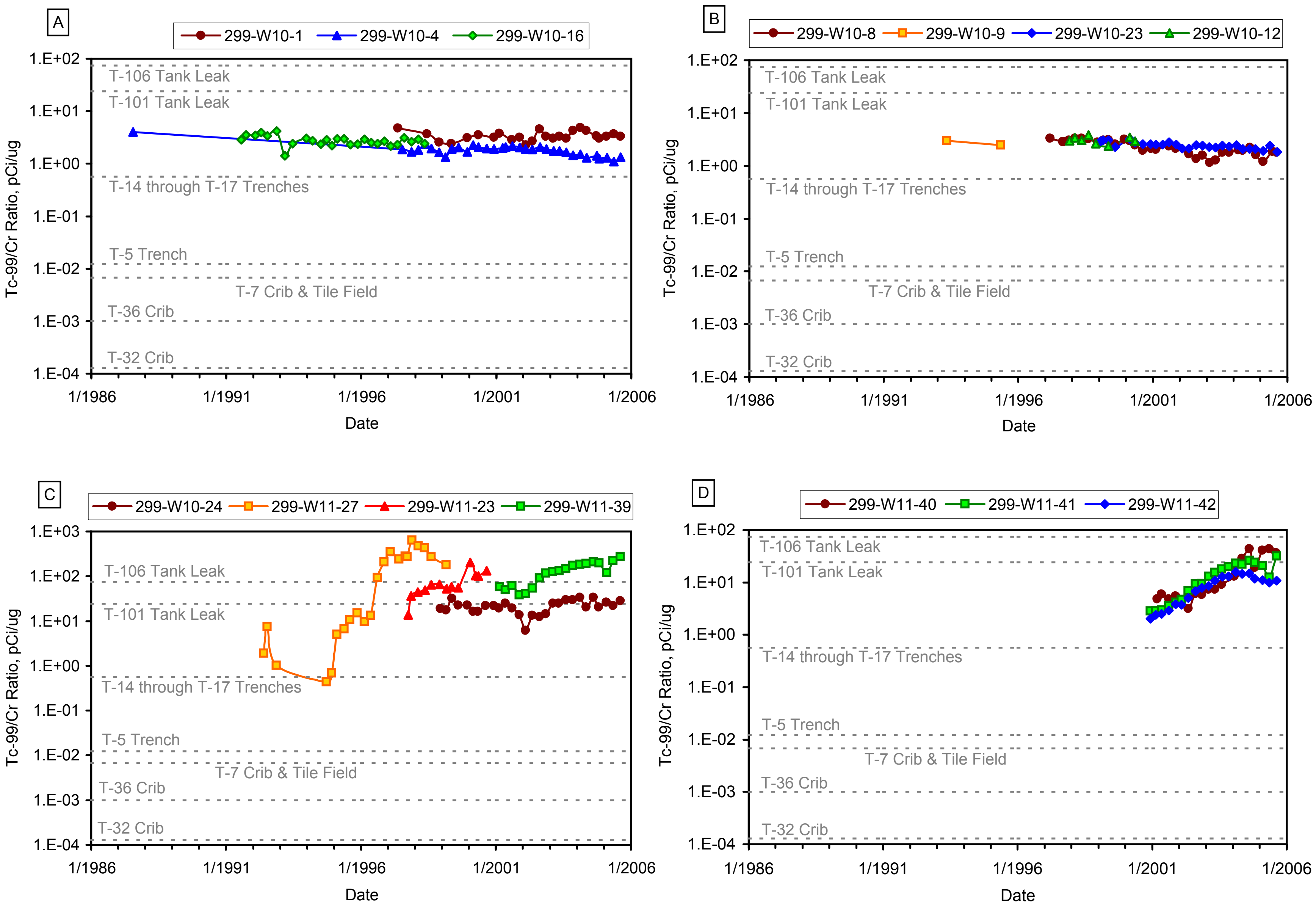


Figure 2.8-18. Technetium-99/Chromium Concentration Ratios in Groundwater from Selected Wells (a) West, (b) North, (c) Northeast, and (d) East of Waste Management Area T

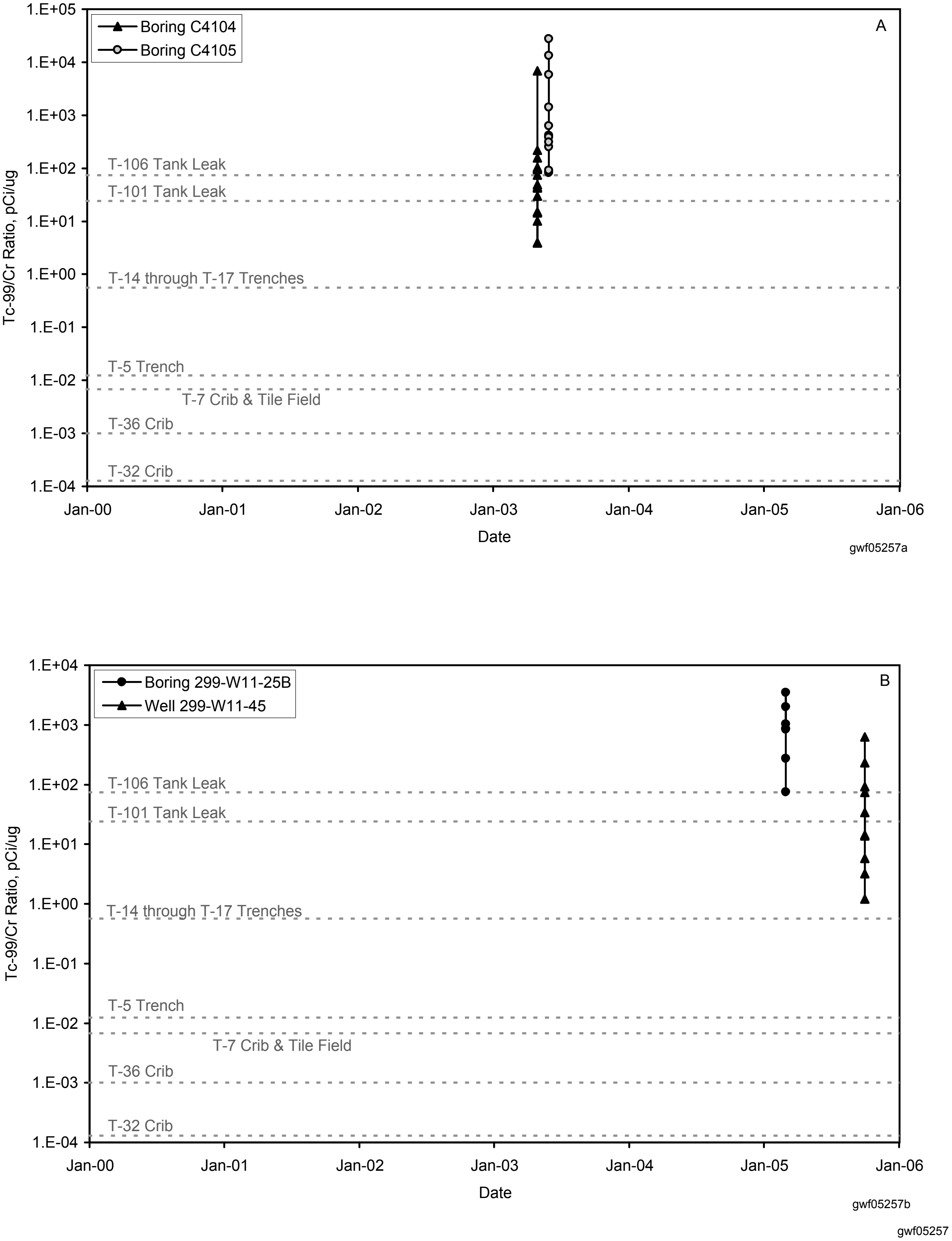


Figure 2.8-19. Technetium-99/Chromium Concentration Ratios in (a) Vadose Zone Pore Water and (b) Groundwater at Waste Management Area T

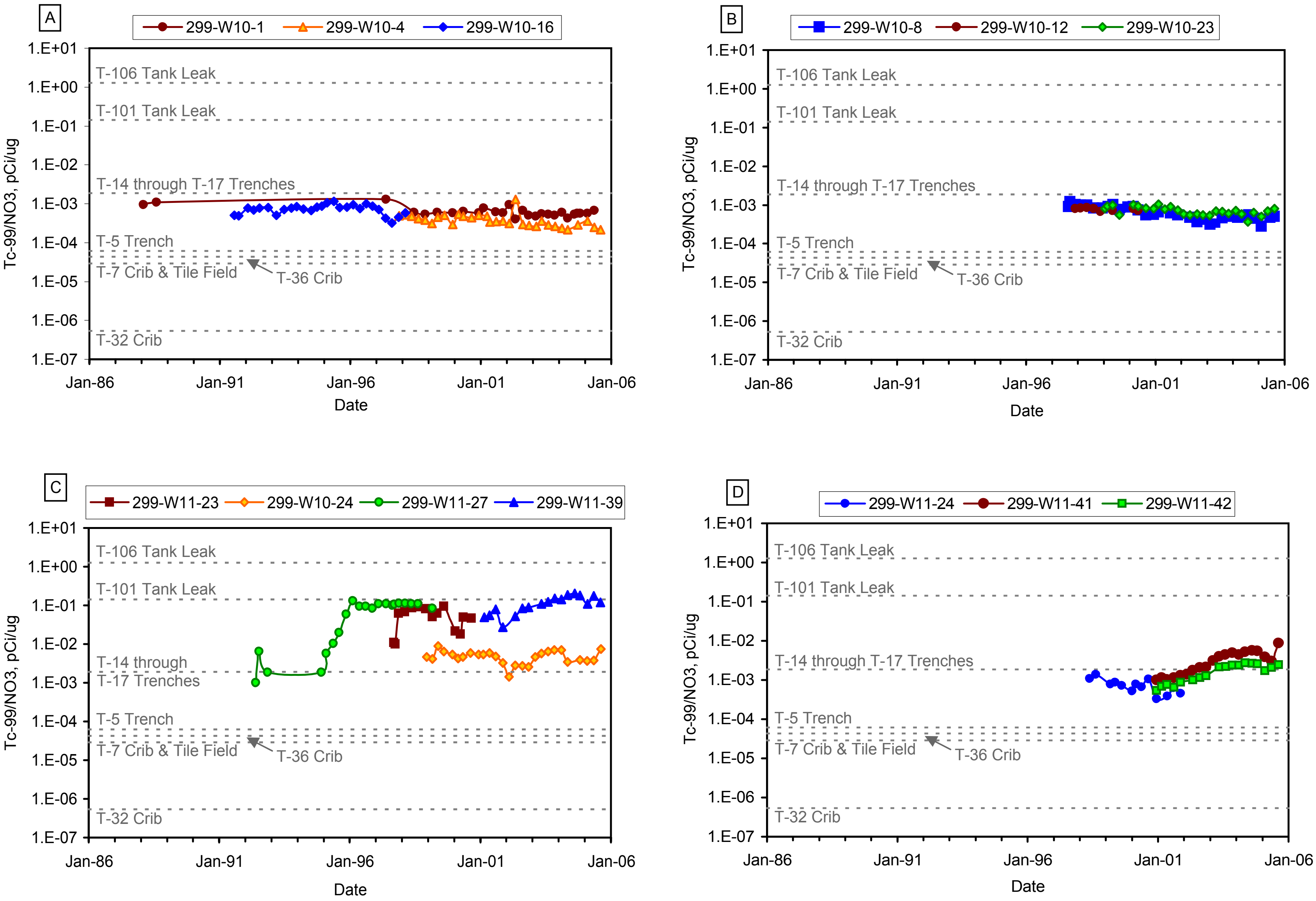


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Figure 2.8-20. Technetium-99/Nitrate Ratios in Groundwater from Selected Wells (a) West, (b) North, (c) Northwest, and (d) East of Waste Management Area T

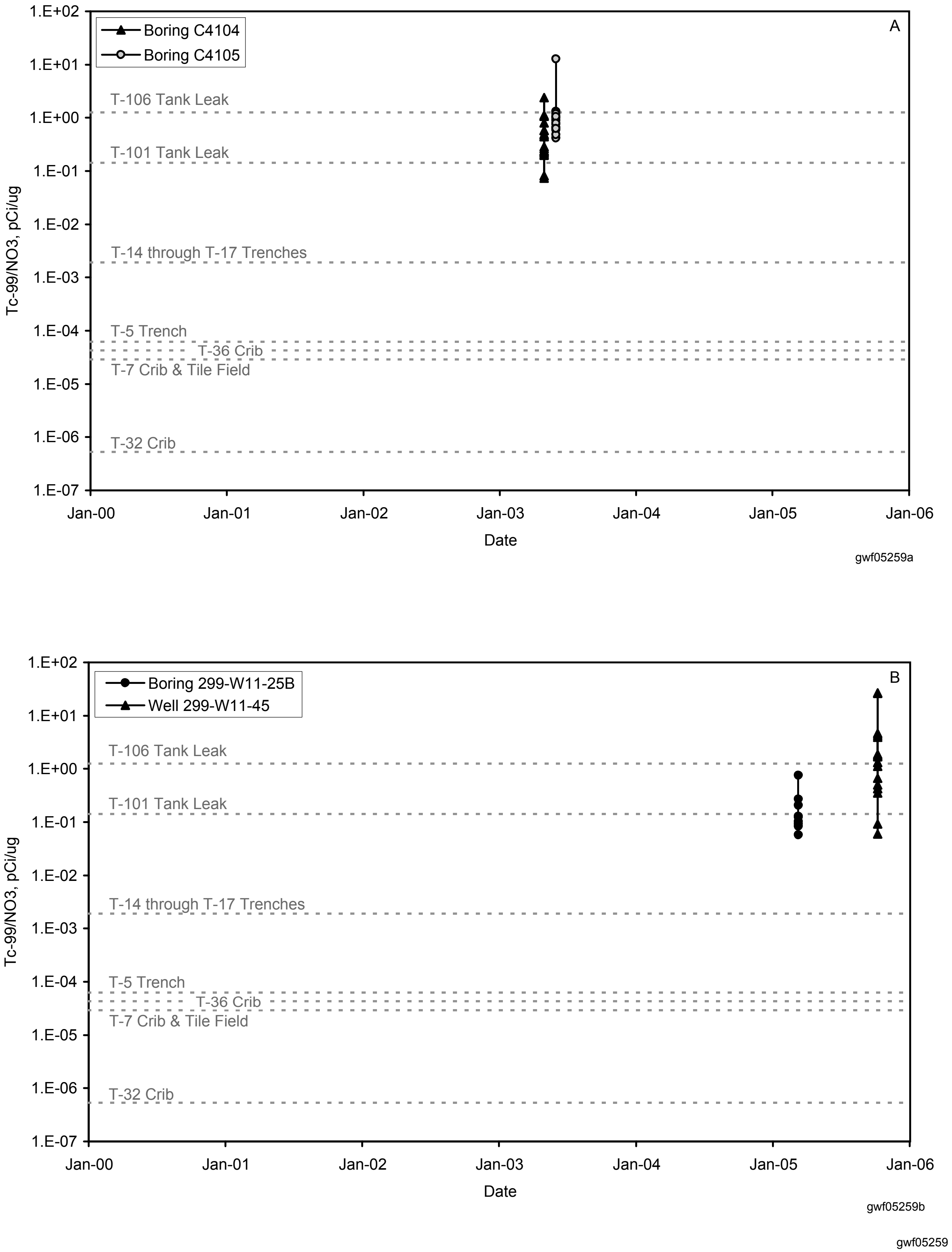


Figure 2.8-21. Technetium-99/Nitrate Concentration Ratios in (a) Vadose Zone Pore Water and (b) Groundwater at Waste Management Area T

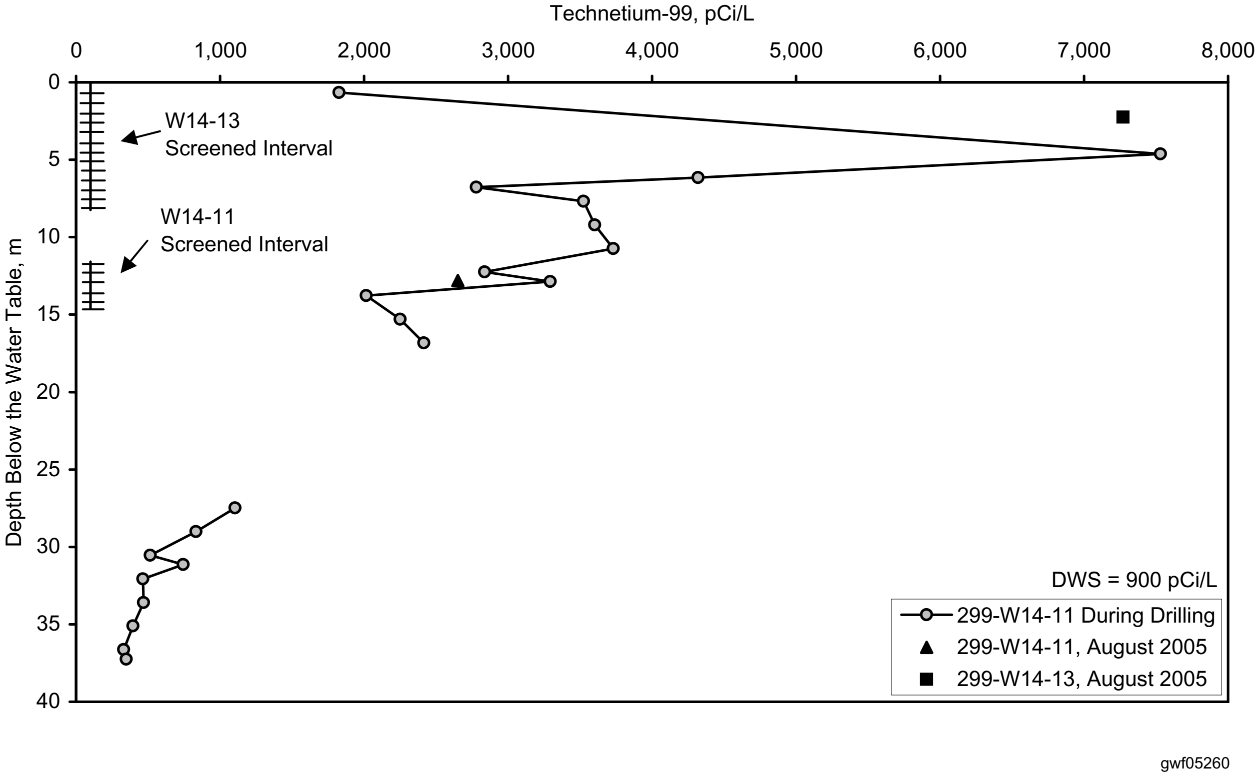


Figure 2.8-22. Distribution of Technetium-99 in the Upper Aquifer in Well 299-W14-11, Waste Management Area TX-TY

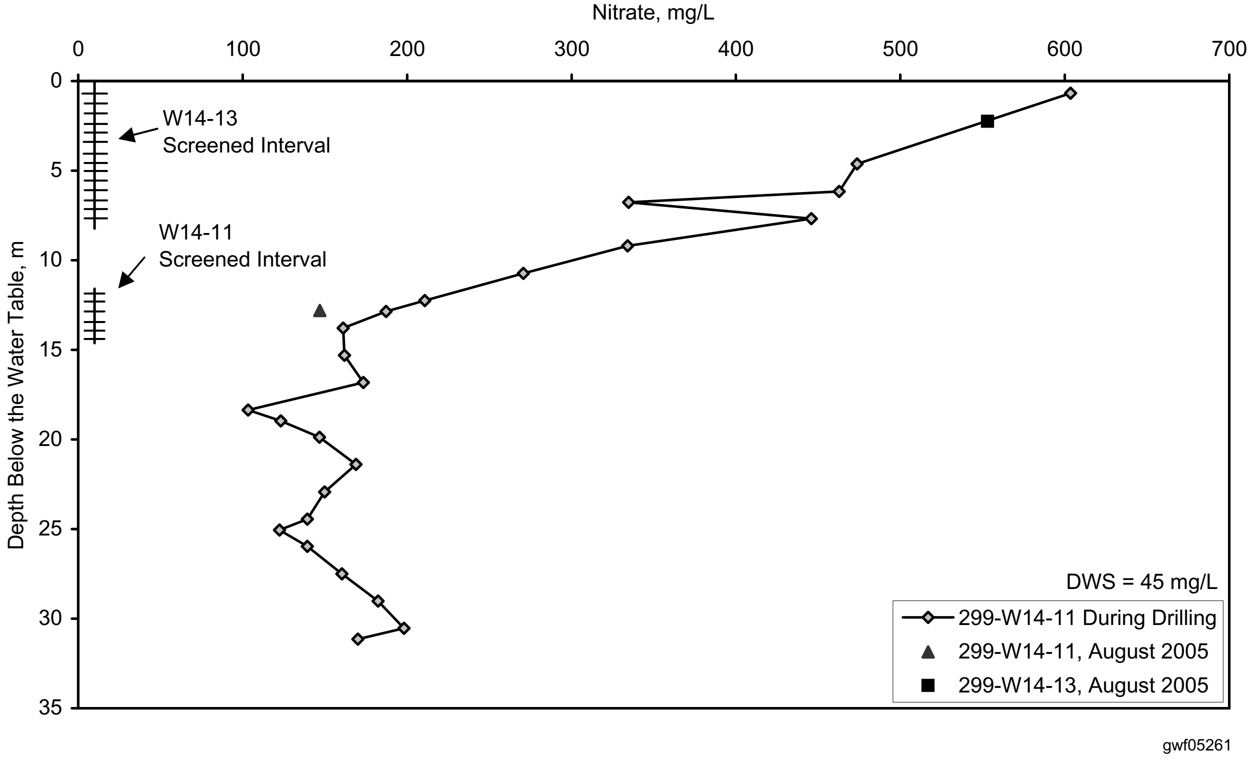


Figure 2.8-23. Distribution of Nitrate in the Upper Aquifer in Well 299-W14-11, Waste Management Area TX-TY

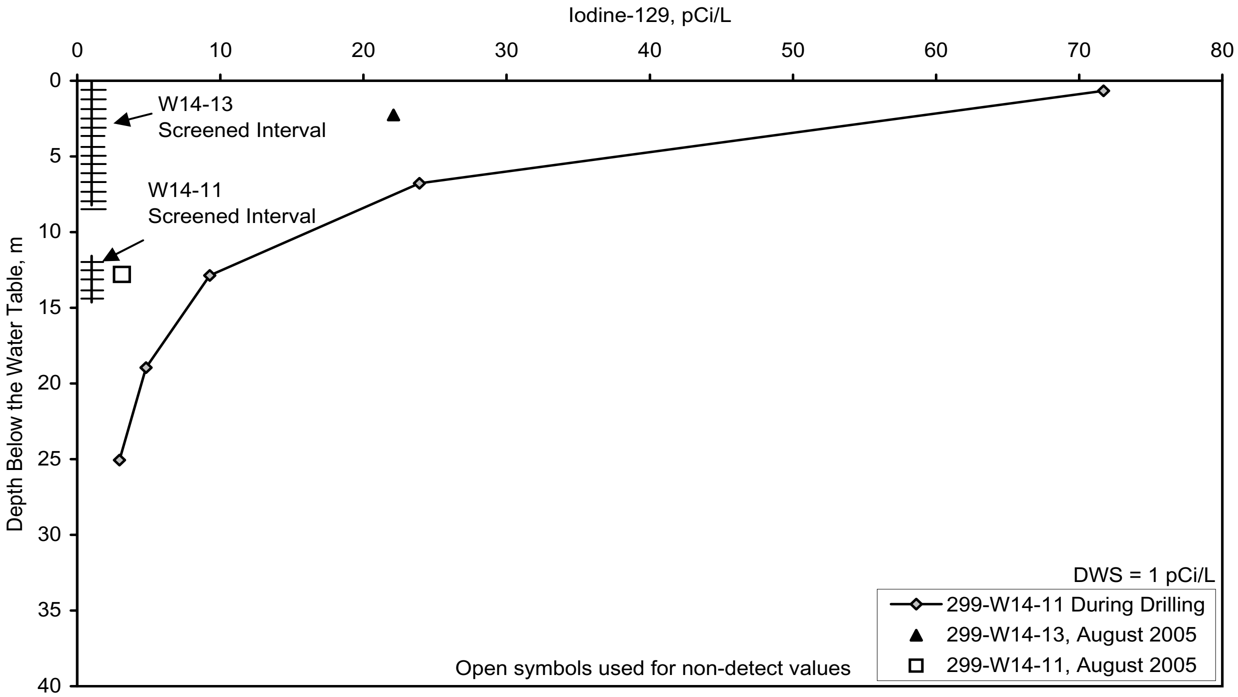


Figure 2.8-24. Iodine-129 Concentration versus Depth Below the Water Table in Samples from Well 299-W14-11, Waste Management Area TX-TY

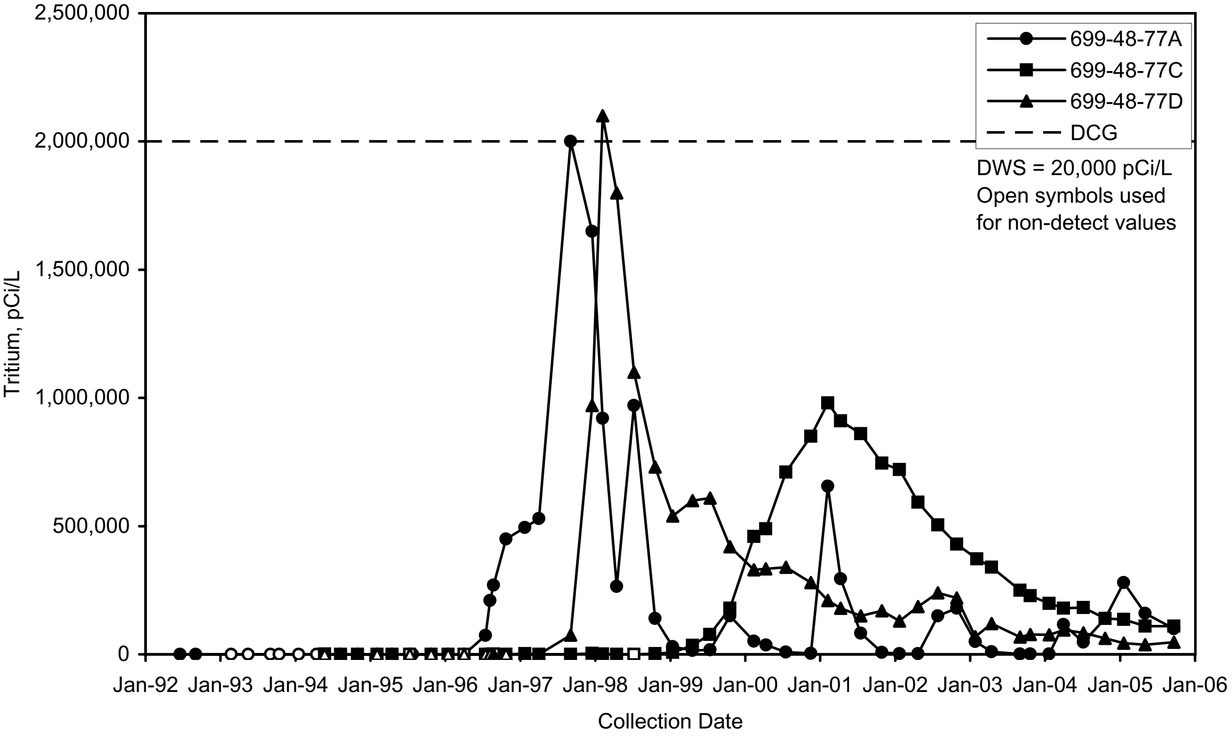


Figure 2.8-25. Tritium Concentrations in Wells Monitoring the State-Approved Land Disposal Site

2.9 200-UP-1 Operable Unit

J. P. McDonald, R. M. Smith, B. A. Williams, D. B. Erb, and R. L. Weiss

The scope of this section is the 200-UP-1 groundwater interest area, which includes the 200-UP-1 groundwater operable unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined the groundwater interest areas informally to facilitate scheduling, data review, and interpretation. Figure 2.9-1 shows facilities and groundwater monitoring wells in the 200-UP-1 groundwater interest area. Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater and form extensive plumes within the region. Groundwater is monitored to

- evaluate the extent and migration of existing contaminant plumes within the operable unit
- assess the technetium-99 and uranium concentration response to the termination of groundwater extraction at an interim action pump-and-treat remediation system (i.e., a rebound study)
- assess the rate and extent of contaminant migration from Waste Management Areas U and S-SX, as well as the 216-U-12 crib, under the *Resource Conservation and Recovery Act* (RCRA)
- detect impacts to groundwater quality from the 216-S-10 pond and ditch under RCRA
- detect impacts to groundwater quality from operation of the Environmental Restoration Disposal Facility under a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) record of decision (ROD 1995b)
- identify emerging groundwater contamination issues within the interest area

In addition to the above mentioned constituents, high-priority contaminants of concern include strontium-90, trichloroethene, chloroform, chromium, cadmium, and arsenic (DOE/RL-92-76, Rev. 1).

Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater and form extensive plumes within the region.

Groundwater monitoring in the 200-UP-1 groundwater interest area includes the following monitoring activities:

CERCLA Interim Remedial Action Performance Evaluation

- ***Twelve wells are sampled monthly and one well is sampled biennially at the pump-and-treat area.***

CERCLA and AEA Long-Term Monitoring

- ***Thirty-nine wells are sampled annually, semiannually, or biennially for constituents of concern throughout the 200-UP-1 Operable Unit (outside of the pump-and-treat area).***
- ***Four wells are sampled semiannually at the Environmental Restoration Disposal Facility.***
- ***Most wells were sampled as scheduled, but some were delayed until FY 2006.***

RCRA Monitoring

- ***Nine wells are sampled quarterly at Waste Management Area U.***
- ***Sixteen wells are sampled quarterly at Waste Management Area S-SX.***
- ***Three wells are sampled semiannually for the 216-S-10 pond and ditch.***
- ***Four wells are sampled quarterly at the 216-U-12 crib.***
- ***All but one RCRA monitoring well in the operable unit were sampled as scheduled.***
- ***Sampling is coordinated with other programs to avoid duplication.***

The sampling and analysis plan for fiscal year (FY) 2005 sampling of the 200-UP-1 Operable Unit is incorporated into the draft *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76, Rev. 1, Draft B). This document was finalized during the year (DOE/RL-92-76, Rev. 1) and contains the sampling and analysis plan for FY 2006. This plan integrates CERCLA and *Atomic Energy Act* (AEA) monitoring, and is a revision of the original integrated plan issued during June 2002 (DOE/RL-2002-10). Appendix A presents the monitoring well network for the 200-UP-1 Operable Unit, including a well list, sampling frequencies, and analyte lists.

Groundwater flows primarily to the east within the 200-UP-1 groundwater interest area (see Figure 2.8-2 in Section 2.8). Water levels have been falling in this area since the 1980s, and flow directions have generally changed from southeast to east during this time. When U Pond and the 216-U-14 ditch were active, a groundwater mound resulted in westward flow in the northwest portion of the interest area. Discharges to ground ceased in the mid-1990s, and the groundwater flow resumed its pre-Hanford flow direction toward the east. Based on water-level measurements in March 2004 and March 2005, the water-table elevation fell by an average of 0.28 meter in the south 200 West Area over a 1-year period.

Plume areas (square kilometers) above the drinking water standard at the 200-UP-1 Operable Unit:

Chromium — 1.10
Iodine-129 — 4.49
Nitrate — 6.85
Technetium-99 — 0.25
Trichloroethene — 0.03
Tritium — 6.60
Uranium — 0.56

****Carbon tetrachloride included in Section 2.8.***

Three new groundwater monitoring wells were installed in the operable unit during calendar year 2005. Two wells (299-W19-49 and 299-W19-101) were installed at the 200-UP-1 pump-and-treat area, and one well (299-W22-47) was installed at Waste Management Area S-SX. Sampling results for these wells are included in the following sections, as appropriate. Twelve new wells have been proposed for the operable unit to support a remedial investigation/feasibility study (DOE/RL-92-76, Rev. 1).

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under CERCLA, RCRA, and AEA monitoring.

2.9.1 Groundwater Contaminants

Large-scale waste disposal at the 200-UP-1 groundwater interest area began during the early 1950s when plutonium separation operations began at the Reduction-Oxidation (REDOX) Plant and uranium recovery operations began at U Plant. Low-activity radioactive liquid waste streams were sent to ponds and cribs, while high-level radioactive waste was stored in underground storage tanks. Groundwater plumes of nitrate, tritium, and iodine-129 formed from the pond and crib waste. These plumes continued to grow in size while effluent disposal operations continued. Effluent disposal to the ponds and cribs ceased during the 1990s. At present, the groundwater plumes from these sources are dispersing naturally. However, constituents of lower mobility in the vadose zone beneath the ponds and cribs may potentially reach the water table in the future and affect groundwater quality.

Within the tank farms (Waste Management Areas U and S-SX), some of the underground storage tanks have leaked, resulting in contamination of the vadose zone beneath the tanks. Some of this contamination has migrated downward and reached the water table (e.g., PNNL-11810). Currently, plumes of nitrate, technetium-99, and chromium from the tank farms are found in groundwater and are generally growing in areal extent and exhibit increasing constituent concentrations. In addition, carbon tetrachloride is migrating into the 200-UP-1 groundwater interest area from the 200-ZP-1 interest area and represents a growing contamination issue.

The following sections give an overview of the contaminant plumes and contaminants of concern for the 200-UP-1 groundwater interest area. These sections are a summary of the combined results of CERCLA, RCRA, and AEA monitoring performed in this area with the focus being the upper part of the unconfined aquifer. Information on the vertical distribution of contaminants in the aquifer is given where available.

2.9.1.1 Technetium-99

Technetium-99 concentrations occur above the drinking water standard (900 pCi/L) in three regions of the 200-UP-1 groundwater interest area: downgradient from the 216-U-1,2 cribs, at Waste Management Area S-SX, and at Waste Management Area U (Figure 2.9-2). A large technetium-99 plume emanates from the 216-U-1,2 cribs, which were active in the 1950s and 1960s. The plume extends ~1.5 to 2 kilometers east into the 600 Area. When effluent was disposed at the nearby 216-U-16 crib in the mid-1980s, it migrated north along a caliche layer and mobilized the technetium-99 and uranium in the soil column beneath the 216-U-1,2 cribs, adding contaminant to the groundwater plume (DOE/RL-92-76, Rev. 1).

A pump-and-treat system successfully reduced technetium-99 concentrations downgradient of the 216-U-1,2 cribs to below the remedial action goal (9,000 pCi/L). In January 2005, groundwater extraction ceased and a rebound study was initiated.

Historically, the highest measured technetium-99 concentration in the 216-U-1,2 cribs plume was 41,000 pCi/L in well 299-W19-24 during October 1989. An interim remedial action pump-and-treat system operated in the central part of this plume from 1994 until early 2005. The remediation effort was successful in reducing concentrations below the remedial action objective of 9,000 pCi/L. During January 2005, groundwater extraction was terminated and a rebound study was initiated. Monthly sampling was performed to assess plume response to the termination of pumping. Technetium-99 concentrations increased to a high of 14,500 pCi/L in former extraction well 299-W19-36 during late February, but declined to below the remedial action objective in late April (Figure 2.9-3). In September 2005, the concentration had declined to 2,200 pCi/L. By the end of FY 2005, the maximum technetium-99 concentration measured in this plume was 2,700 pCi/L in former extraction well 299-W19-43, which exhibits a slow increasing concentration trend (Figure 2.9-3). Section 2.9.2 gives a more thorough discussion of the rebound study.

Depth-discrete groundwater sampling during new well construction has provided three-dimensional information about the plume structure. Between December 2002 and September 2005, seven new wells were installed in the vicinity of the 216-U-1,2 cribs plume. Groundwater sampling during drilling was typically performed near the water table and at discrete depths down to 37 meters below the water table. The technetium-99 plume was found to occur mostly in the upper part of the aquifer, although concentrations above the drinking water standard occurred down to the Ringold Formation lower mud unit (lower confining unit) in one well: 699-38-70C. Thirteen wells within this plume are routinely sampled, and technetium-99 concentrations are stable or declining in twelve of these wells.

At Waste Management Area S-SX, a technetium-99 plume originates from the southwest corner of the waste management area and another plume originates from the north part of the waste management area. During FY 2005, the technetium-99 concentration in well 299-W23-19 (located in the SX Tank Farm near the source of the south plume) increased to above the U.S. Department of Energy (DOE) derived concentration guide of 100,000 pCi/L (Figure 2.9-4). Quarterly sampling in June yielded a value of 128,000 pCi/L (average of duplicate samples), and sampling in September yielded a result of 137,000 pCi/L. This is the second time that technetium-99 concentrations have exceeded the derived concentration guide at this well. In January 2003, the concentration peaked at 188,000 pCi/L, then fell to ~74,300 pCi/L by the end of FY 2003. Nine wells monitor this plume, and concentrations exceed the drinking water standard in six of them. In these six wells, trends are stable in two wells and increasing in the other four, and the plume areal extent is growing. The plume is migrating to the east-southeast, and the plume front has entered a region of sparse well coverage and cannot be tracked further. Three new wells are scheduled for installation downgradient from this plume during calendar year 2006 and will likely be useful for monitoring this plume in the future.

Concentrations of technetium-99 in well 299-W23-19, at Waste Management Area S-SX, increased during FY 2005 to 137,000 pCi/L.

The north plume at Waste Management Area S-SX originates from the S Tank Farm. Historically, the highest measured technetium-99 concentration in this plume was 4,600 pCi/L in well 299-W22-48 during September 2002. The maximum concentration measured during FY 2005 was 2,000 pCi/L in this same well. Five wells monitor this plume, and concentrations are decreasing at all of them. This indicates that the plume is currently not a growing contamination issue. Refer to Section 2.9.3.2 for more information about technetium-99 at this waste management area.

Technetium-99 concentrations in the downgradient wells at Waste Management Area U are elevated compared to concentrations in the upgradient wells. Thus, the U Tank Farm is a source of technetium-99 contamination. Concentrations are increasing in five wells and declining in one. During FY 2005, technetium-99 concentrations at this site exceeded the drinking water standard for the first time since 1993. The maximum concentration measured during the fiscal year was 1,200 pCi/L in well 299-W19-45. The downgradient extent of the plume is not known, because there are no wells beyond the downgradient edge of the tank farm. Refer to Section 2.9.3.1 for more information about technetium-99 at this waste management area.

2.9.1.2 Uranium

Within the 200-UP-1 groundwater interest area, uranium primarily occurs in an extensive plume downgradient from the 216-U-1,2 cribs (Figure 2.9-5) and is associated with the technetium-99 plume here. The plume extends a total of ~1.5 kilometers to the east and northeast. The uranium originated from the 216-U-1,2 cribs, which were active in the 1950s and 1960s. Additional mass was added to the plume when effluent disposed of at the nearby 216-U-16 crib in the mid-1980s migrated north along a caliche layer in the vadose zone and mobilized the technetium-99 and uranium in the soil column beneath the 216-U-1,2 cribs (DOE/RL-92-76, Rev. 1).

Uranium responded more slowly than technetium-99 to the pump-and-treat system. All concentrations were below the remedial action goal (480 µg/L) but above the drinking water standard (30 µg/L) within the pump-and-treat area.

An interim remedial action pump-and-treat system operated on a high concentration portion of this plume from 1994 to January 2005. The system was successful in reducing uranium concentrations to below the remedial action objective (480 µg/L). However, concentrations remained above the drinking water standard (30 µg/L). In late January 2005, groundwater extraction was terminated and a rebound study was initiated. In former extraction well 299-W19-36, concentrations increased to 479 µg/L during March 2005, but then quickly declined to an average of 370 µg/L for the remainder of the fiscal year (Figure 2.9-6). At all other wells within the area targeted for remediation, uranium concentrations remained below the remedial action objective. Ten wells within this plume exhibit stable concentrations at levels above the drinking water standard, and two wells exhibit slightly declining concentrations. The overall picture is of a plume that is mostly at steady state where concentrations are not declining naturally.

Recent laboratory work investigating the adsorption/desorption of uranium on aquifer sediment samples from the 200-UP-1 Operable Unit observed hysteresis in the adsorption/desorption equilibrium coefficients (K_d) fitted to flow-through column test results with desorption coefficients being higher (i.e., 5.0 mL/g compared to 4.0 mL/g for a sediment sample from well 699-36-70B) (PNNL-15502). This means that the rate of desorption from sediment grains into the pore water was found to be slower than the rate of adsorption. Further, the desorption of aged contamination in an aquifer (i.e., contamination that has been present for several years or more) is thought to occur at an even slower rate than observed in laboratory tests (PNNL-15502). Thus, uranium desorption in the aquifer may be a slower process than adsorption. This may explain why the pump-and-treat system has not been very effective in removing uranium from the aquifer – uranium may be slowly desorbing from sediment grains into the aquifer pore water.

During FY 2004 , uranium was found at 600 µg/L in well 299-W19-18 located 70 meters downgradient of the 216-U-1,2 cribs and upgradient of the area targeted for remediation (Figure 2.9-7). The uranium concentration has changed little in this well over the past 10 years. Perhaps when uranium from beneath the cribs reached the groundwater, a good portion of it precipitated or sorbed onto sediment grains. This region may be acting as a source in the aquifer with uranium slowly desorbing into groundwater. Another possibility is that residual uranium continues to leach from the vadose zone beneath the cribs and enter the groundwater.

During FY 2005, uranium was measured above the drinking water standard in well 299-W23-4, downgradient from the 216-S-21 crib (north of the 216-S-25 crib). During February, uranium was found at 31 µg/L, but fell to 27 µg/L in September. Uranium has been very slowly trending upward here since the mid-1990s. This crib received S-SX Tank Farm condensate containing high tritium, and it was reported that 4 kilograms of uranium was also disposed to this crib (ARH-CD-745). The crib was active in the 1950s and 1960s. Uranium was found in this well above the drinking water standard from 1970 through to the late 1980s.

2.9.1.3 Tritium

Disposal facilities associated with REDOX Plant are the primary sources of tritium in the 200-UP-1 groundwater interest area. The REDOX Plant operated from 1952 until 1967, although effluent releases continued to occur after this time. A large tritium plume emanates from the south part of the 200 West Area from REDOX Plant cribs to the east and northeast (extending ~5 kilometers). Two high concentration areas occur within this plume – a large one extending to the east and northeast from the 200 West Area and a smaller one extending ~550 meters to the east-southeast from the vicinity of the 216-S-25 crib (Figure 2.9-8). Most wells within the tritium plume east of the 200 West Area were scheduled for sampling in August 2005, but sampling was delayed until FY 2006.

The tritium plume emanating from the southeast 200 West Area is attenuating from dispersion and radiological decay.

Measured concentrations in the central part of the plume typically range from ~200,000 to 600,000 pCi/L. Concentrations are declining at 11 wells and increasing at 4, suggesting that the plume is heterogeneous with localized areas of high concentrations probably due to the merging of plumes from several different sources. When these areas migrate past wells, increasing concentrations can occur. However, the plume overall exhibits declining concentrations and the areal extent is stable, indicating natural attenuation by dispersion and radiological decay.

Tritium occurs above the drinking water standard in nine wells downgradient of the 216-S-25 crib. Concentrations fluctuate in a single well (299-W23-9) on the downgradient side of the crib. Farther downgradient, trends are stable in three wells and increasing in four wells. Radioactive liquid effluent was disposed to this crib from 1973 through 1980; in 1985, effluent from a pump-and-treat system at the 216-U-1,2 cribs was disposed to this crib. In the vadose zone beneath this crib, tritium in the residual soil moisture may be slowly migrating to the water table, which would account for the fluctuating tritium concentration trend in well 299-W23-9. The plume passes under Waste Management Area S-SX, but the tank farms are not a direct source of tritium to the groundwater. Tritiated water in the tanks was removed by the 242-S evaporator and disposed of at the 216-S-25 crib. The areal extent of the plume is growing as evidenced by increasing trends in wells 299-W22-82 and 299-W22-83, the farthest downgradient wells for Waste Management Area S-SX.

Information on the vertical distribution of tritium in the aquifer is sparse. Three of the eight wells (299-W19-48, 699-30-66, and 699-36-70B) installed within the operable unit during calendar year 2004 were sampled for tritium at different depths during drilling. The results indicate that tritium mainly occurs in the upper part of the aquifer near the water table. However, none of these wells were completed in a high concentration portion of the plume.

A high concentration portion of the iodine-129 plume is migrating to the east out of the 200 West Area.

2.9.1.4 Iodine-129

Iodine-129 plumes in the 200-UP-1 groundwater interest area originate from both U Plant and REDOX Plant disposal facilities (Figure 2.9-9). One plume emanates from the vicinity of the 216-U-1,2 cribs, while another originates from the south part of the 200 West Area. At the current level of monitoring detail, these plumes merge downgradient and become indistinguishable. This combined plume (as denoted by the 1-pCi/L contour level) extends to the east and northeast a total distance of ~3.5 kilometers. Measured concentrations near the REDOX Plant cribs are below the drinking water standard. Most wells within the iodine-129 plume east of the 200 West Area were scheduled for sampling in August 2005, but sampling was delayed until FY 2006.

Groundwater sampling results near the 216-U-1,2 and 216-U-12 cribs are flagged as non-detects (Figure 2.9-9) but are believed to represent valid approximations of the iodine-129 concentration in the aquifer. In the late 1980s, shortly after the large uranium release to the aquifer beneath the 216-U-1,2 cribs, iodine-129 was detected at ~30 pCi/L. Iodine-129 was detected at ~9 pCi/L in 2000 in a single well just before it went dry (well 299-W19-3). Similarly at the 216-U-12 crib, iodine-129 was detected at ~12 pCi/L during the 1990s. Thus, these cribs were a source of iodine-129, and it is reasonable to conclude that the vadose zone beneath these cribs contains residual iodine-129 currently leaching into the aquifer.

A high concentration part of the iodine-129 plume is migrating to the east out of the 200 West Area into the surrounding 600 Area. Measured concentrations in the central part of this plume typically range from 5 to 35 pCi/L. Concentrations are generally declining or stable throughout the plume, and dispersion is slowly reducing the plume size (i.e., the region of the plume above the drinking water standard). Radiological decay is not a factor in the declining areal extent, because iodine-129 has a long half-life.

2.9.1.5 Strontium-90

During FY 2005, 22 analyses for strontium-90 were performed on samples collected from 13 wells within the groundwater interest area. Strontium-90 was found above the drinking water standard (8 pCi/L) in only one well: 299-W22-10, located downgradient of the 216-S-1,2 cribs. The result was 32 pCi/L during December 2004. Concentrations have been falling here after increasing to 76 pCi/L in December 2001. The 216-S-1,2 cribs received highly acidic waste from the REDOX Plant between 1952 and 1956. In 1955, the waste is believed to have corroded the casing of a nearby well (299-W22-3), which allowed the effluent to bypass the soil column and flow down the well directly into groundwater (Waste Information Data System [WIDS]). This is the pathway by which strontium-90 is believed to have reached groundwater. Strontium-90 was reported above detection limits for two other wells (299-W19-46 and 299-W23-21), but levels were <1 pCi/L.

Carbon tetrachloride is widespread in the 200-UP-1 groundwater interest area. The plume originated from disposal facilities in the 200-ZP-1 groundwater interest area.

2.9.1.6 Chlorinated Hydrocarbons

Carbon tetrachloride occurs above the drinking water standard (5 µg/L) in numerous wells within the 200-UP-1 groundwater interest area. At the water table, the plume is widespread in the south 200 West Area, and extends ~1 kilometer east into the 600 Area (Figure 2.8-3 in Section 2.8). The plume originated from waste disposal sites associated with the Plutonium Finishing Plant in the 200-ZP-1 groundwater interest area. Concentration trends are increasing in ten wells, decreasing in twelve wells, and stable in seven wells. No clear spatial pattern exists among wells having increasing or decreasing trends. Depth-discrete sampling in the eastern part of the plume shows that concentrations generally increase with depth to the Ringold Formation lower mud unit. This data suggests that the areal extent of the plume may be greater in this area than shown in Figure 2.8-3, which depicts the plume at the water table. The highest measured concentration during FY 2005 was 880 µg/L in well 699-38-70B, completed from 35 to 40 meters below the water table in the east part of the plume beyond the 200 West Area boundary. The pattern of increasing concentrations with depth is not consistent with what has been observed in the west part of the plume. Depth-discrete sampling during installation of well 299-W22-47 at Waste Management Area S-SX showed that concentrations peaked (at 96 µg/L) 12 meters below the water table and then quickly declined to about the drinking water standard 37 meters below the water table.

Chloroform is a degradation product of carbon tetrachloride, and tends to occur in the same wells with carbon tetrachloride. A total of 164 chloroform analyses were performed on samples from 43 wells within the 200-UP-1 groundwater interest area, and no exceedances of the drinking water standard (100 µg/L) were observed in FY 2005. The maximum concentration measured during the fiscal year was 17 µg/L in well 699-38-70B, the same well having the highest carbon tetrachloride concentration. Depth-discrete sampling during new well installation showed that concentrations tend to increase with depth, similar to carbon tetrachloride. The presence of chloroform in association with carbon tetrachloride suggests that some degradation of carbon tetrachloride is occurring.

Trichloroethene is found within the 200-UP-1 groundwater interest area above the drinking water standard (5 µg/L) in two regions – one in the vicinity of the pump-and-treat system and another near the 216-S-20 crib. A total of 164 trichloroethene analyses were performed on samples from 43 wells within the interest area, and the drinking water standard was exceeded in five wells in FY 2005, all in the vicinity of the pump-and-treat system. The maximum concentration measured was 9 µg/L in well 699-38-70B. Depth-discrete sampling during new well installation showed that concentrations tend to increase with depth. The distribution of trichloroethene is different from carbon tetrachloride and is thought to have a local source near U Plant.

Depth-discrete sampling during well installation shows that carbon tetrachloride, chloroform, and trichloroethene concentrations generally increase with depth in the eastern part of the operable unit.

2.9.1.7 Chromium

Chromium is found in four regions of the 200-UP-1 groundwater interest area: at Waste Management Area S-SX, at the 216-S-10 pond and ditch, in the vicinity of the 216-S-20 crib, and in the 600 Area east and southeast of the 200 West Area. During FY 2005, samples from five wells exceeded the drinking water standard (100 µg/L), all within a chromium plume emanating from the south part of Waste Management Area S-SX. The highest concentration occurred at well 299-W23-19, where filtered total chromium increased significantly during the fiscal year from 320 to 1,710 µg/L (Figure 2.9-4). This observation indicates that a significant pulse of chromium has entered the aquifer from the vadose zone beneath the tank farm. This plume is associated with a technetium-99 plume. Chromium concentrations are increasing, and the areal extent of the plume is growing. Chromium at Waste Management Area S-SX is further discussed in Section 2.9.3.2.

Filtered total chromium has been found above the drinking water standard in well 299-W26-7 at the 216-S-10 pond and ditch. The June 2003 sample result was 209 µg/L. The well has since gone dry, so no further sampling is possible. The source is unconfirmed, but it could be the 216-S-10 pond and ditch, even though well 299-W26-7 is an upgradient well. The areal extent of the plume appears to be small and stable, because chromium concentrations in downgradient and side-gradient wells are minimal to non-detectable.

Filtered total chromium is frequently detected in wells east and southeast of the 200 West Area. Several wells in this area were scheduled for sampling during late FY 2005, but were not sampled until FY 2006 because of delays. The concentration in well 699-32-62 was 151 µg/L in October 2005. Chromium concentrations have declined slowly since this constituent was first analyzed at this well in 1992. The sources and extent of this contamination are uncertain. The location of this plume is consistent with disposal to the REDOX Plant ponds/ditches south and southwest of the 200 West Area. Chromium is detected in several other wells in this area, but its extent to the south of well 699-32-62 is poorly defined.

In well 299-W23-19 at Waste Management Area S-SX, chromium concentrations increased significantly during the fiscal year from 320 to 1,710 µg/L.

Filtered total chromium has also been found above the drinking water standard in well 299-W22-20, adjacent to the 216-S-20 crib. A concentration of 560 µg/L was measured in September 2004, and concentrations had been increasing since 2000. The sample scheduled for FY 2005 was collected during the first quarter of FY 2006, and the result was 210 µg/L. Thus, the increasing trend may have reversed. This well has a perforated, carbon steel casing and is filling in with fine sand. The sand quickly destroys sample pump seals, so the well must be sampled with a bailer and cannot be purged. Chromium is not a component of carbon steel, so well corrosion apparently does not explain the high concentrations. The source of the chromium may be the 216-S-20 crib. The areal extent of plume is not known since no other wells exist downgradient.

2.9.1.8 Nitrate

Nitrate plumes in the 200-UP-1 groundwater interest area are thought to have originated from both the U Plant and REDOX Plant disposal facilities and are widespread throughout the area. Sources of nitrate from U Plant include the 216-U-1,2; 216-U-8; and 216-U-12 cribs. The nitrate plumes from these and other sources merge downgradient into a single large plume, which extends to the east and northeast a total distance of ~4 kilometers (Figure 2.9-10). Nitrate sources from REDOX Plant disposal facilities may also have contributed to this plume. Only a few wells within this plume (outside of the 200 West Area) were sampled during the fiscal year – most were due to be sampled during late FY 2005, but sampling was delayed until FY 2006. With a few exceptions, concentrations throughout this plume are stable or declining. On the eastern margin of the plume, concentrations are stable in wells 699-36-61A and 699-44-64, and rising in well 699-40-62.

At the pump-and-treat area, nitrate concentrations increased during FY 2005 in well 299-W19-43, presumably in response to the termination of pumping for the rebound study. During the fiscal year, nitrate reached 1,400 mg/L in this well after declining to a low value of 450 mg/L in September 2004.

Multiple sources of nitrate created a large plume, which is moving to the east.

The occurrence of nitrate above the drinking water standard deep in the unconfined aquifer does not appear to be widespread. The nitrate distribution depicted in Figure 2.9-10 represents nitrate concentrations in the upper portion of the unconfined aquifer, since most of the wells are screened across the water table. Of the wells actively being sampled within the interest area, six are screened deeper in the aquifer (wells 299-W19-34A, 299-W19-34B, 299-W27-2, 699-30-66, 699-38-70B, and 699-38-70C), and five of these are within the mapped nitrate plume (well 299-W27-2 is outside the plume area). In only one of these deeper wells is nitrate found at levels above the 45-mg/L drinking water standard: well 699-38-70C, which had an average concentration of 175 mg/L during the fiscal year.

In Figure 2.9-10, a nitrate plume is depicted extending from west and southwest of Low-Level Waste Management Area 4 to Waste Management Area U. In well 299-W18-21, an upgradient well for Low-Level Waste Management Area 4, nitrate concentrations have been rising since 1993 and reached 132 mg/L during FY 2005. In the two upgradient wells (299-W18-31 and 299-W18-40) for the U Tank Farm, nitrate concentrations have been rising significantly since approximately 2001 and reached 34 and 24 mg/L, respectively, during FY 2005. Nitrate in all three of these wells is interpreted to be a single plume, which implies an advective travel time of ~8 years from well 299-W18-21 to the U Tank Farm. This travel time is within the range expected based on the reported groundwater flow velocities for Low-Level Waste Management Area 4 and the U Tank Farm. The source of this plume is not known, but since well 299-W18-21 is an upgradient well at Low-Level Waste Management Area 4, the plume is interpreted to emanate from somewhere west and southwest of Low-Level Waste Management Area 4. The only known waste site in this area is the 216-U-11 trench, which received overflow water from the 216-U-10 pond during the 1940s and 1950s. However, it has not been confirmed that this trench is the source of the nitrate. The nitrate may also be coming from the 200-ZP-1 pump-and-treat injection wells located to the northwest.

Waste Management Area U is also a source of nitrate to groundwater (see Section 2.9.3.1). Nitrate concentrations in several of the downgradient wells remained above the drinking water standard during the fiscal year. The maximum measured nitrate concentration at the U Tank Farm during FY 2005 was 71 mg/L in well 299-W19-44.

Nitrate occurs in two small plumes associated with REDOX Plant disposal facilities: one near the 216-S-20 crib and another near the 216-S-25 crib. Well 299-W22-20 downgradient of the 216-S-20 crib was sampled during the first quarter of FY 2006 and had nitrate at 140 mg/L. From 1952 through 1972, this crib received waste from laboratory hoods and decontamination sinks in the 222-S Building, along with laboratory waste from the 300 Area. In well 299-W23-9, at the downgradient end of the 216-S-25 crib, concentrations have been elevated in recent years, suggesting that a pulse of nitrate has entered the aquifer from the soil column beneath the crib. The well was sampled during the first quarter of FY 2006, and the concentration was 470 mg/L, which was up from 240 mg/L in FY 2004.

The nitrate plume from the 216-S-25 crib merges with a nitrate plume emanating from Waste Management Area S-SX (see Section 2.9.3.2). Nitrate from the tank farm is co-variate with technetium-99. In well 299-W23-19 at the southwest corner of Waste Management Area S-SX, both constituents increased significantly in concentration during the fiscal year. This well had the highest nitrate concentration in this area, reaching 1,560 mg/L during June 2005.

2.9.1.9 Other Constituents

In seven wells supporting the remedial investigation/ feasibility study, there were no detections above the drinking water standard for 35 additional constituents of concern.

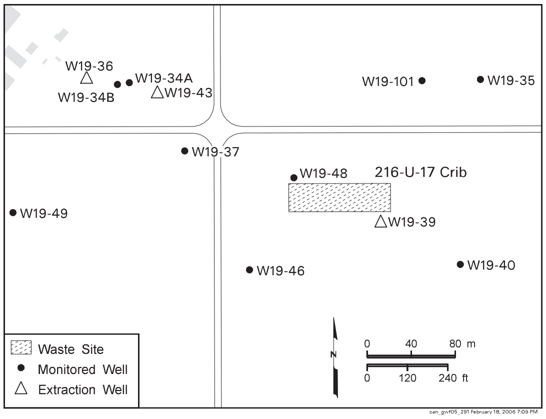
Arsenic and cadmium are listed as contaminants of concern for the 200-UP-1 Operable Unit (DOE/RL-92-76, Rev. 1). During FY 2005, 24 analyses were performed for arsenic in 14 wells and 166 analyses were done for cadmium in 50 wells. No detections above a drinking water standard (10 µg/L for arsenic and 5 µg/L for cadmium) were observed.

The contaminants of concern for the 200-UP-1 Operable Unit have been classified into an initial list of high priority constituents (i.e., strontium-90, iodine-129, technetium-99, uranium, tritium, carbon tetrachloride, chloroform, trichloroethene, chromium, arsenic, cadmium, and nitrate) to support integrated CERCLA and AEA long-term monitoring, as well as additional contaminants of concern specifically identified to support the remedial investigation/feasibility study (DOE/RL-92-76, Rev. 1). These additional constituents of concern are documented in the remedial investigation/feasibility study work plan (DOE/RL-92-76, Rev. 1) and include an extended list of volatile organic compounds, metals, anions, ammonium ion, ammonia, cyanide, sulfide, cresols, phenols, total petroleum hydrocarbons (kerosene range), beta emitters (carbon-14 and selenium-79), alpha emitters (neptunium-237 and protactinium-231), and gamma emitters (cesium-137 and cobalt-60).

Most of the groundwater sampling conducted within the operable unit has been for the high priority constituents. Sampling for the additional constituents of concern began during FY 2004. Seven wells were chosen for this initial round of sampling: 299-W19-43 and 299-W19-46 within the pump-and-treat area; 699-38-70 downgradient from the pump-and-treat area; and 299-W22-83, 299-W23-4, 299-W23-10, and 299-W23-21 in the vicinity of the 216-S-25 crib and Waste Management Area S-SX. Other than those constituents that are naturally present in groundwater (i.e., magnesium, manganese, and vanadium), no confirmed detections of an additional contaminant of concern have occurred. Only two of the additional contaminants of concern (other than those naturally present) were found at levels above twice their detection limit: selenium-79 in well 299-W22-83 and tetrachloroethene in well 299-W23-21, but these results were considered tentative and may have been false positives.

To confirm the findings of FY 2004, all seven wells were re-sampled for the additional constituents of concern during FY 2005 and early FY 2006. As was the case in FY 2004, other than those constituents that are naturally present in groundwater (i.e., magnesium, manganese, and vanadium), no confirmed detections of an additional contaminant of concern were observed. Selenium-79 and tetrachloroethene were not detected in wells 299-W22-83 and 299-W23-21, respectively, as they were in FY 2004. Selenium-79 was detected in samples from well 299-W23-19 at Waste Management Area S-SX, but its presence in groundwater has not been confirmed (see Section 2.9.3.2 for a discussion of selenium-79 in well 299-W23-19). Sulfide was detected in well 299-W19-43 at 1,600 µg/L. However, this constituent was not detected in this well during FY 2004. During FY 2004, sulfide was found in one sample from well 699-38-70, but not in a duplicate, and sulfide was not detected in early FY 2006. Sulfide was detected in wells 299-W22-83 and 299-W23-10 in FY 2004, but not found in these wells in FY 2005. Given these inconsistencies, it cannot be concluded that sulfide is present in the groundwater. Other constituents were found very near their detection limits and were qualified by the analytical laboratory as being estimates and are believed to be false positives.

2.9.2 Interim Groundwater Remediation for Technetium-99 and Uranium



The 200-UP-1 pump-and-treat system was active around the baseline plume area for the first 4 months of FY 2005. During this time, three extraction wells pumped groundwater to the Effluent Treatment Facility in the 200 East Area via an 11-kilometer pipeline. Upon completion of 18 months of groundwater extraction with technetium-99 and uranium concentrations in groundwater below their remedial action objectives, pumping was terminated in January 2005 to initiate a rebound study. The rebound study continued for the remainder of FY 2005 and is scheduled to end in January 2006.

The pump-and-treat system was an interim remedial action to contain high concentrations of uranium and technetium-99 emanating from the 216-U-1,2 cribs. Interim remedial action objectives required that technetium-99 and uranium concentrations be reduced to below 9,000 pCi/L and 480 µg/L, respectively. The complete remedial action objectives are listed in a separate textbox on this page. The baseline plume area is defined by the location of the 9,000-pCi/L technetium-99 and 480-µg/L uranium contours in the aquifer. The concentration objectives were achieved in July 2003 when uranium concentrations met the 480-µg/L mark at extraction well 299-W19-43, and which subsequently declined to 285 µg/L in February 2004. The other objectives have also been met, as described in the 200-UP-1 pump-and-treat annual report (DOE/RL-2005-91).

The pump-and-treat system at the 200-UP-1 Operable Unit was active for the first 4 months of FY 2005, and then groundwater pumping was terminated to initiate a rebound study.

The goal of the rebound study is to assess the level of remediation achieved in the aquifer by tracking contaminant trends over time under natural hydraulic conditions. The rebound study was started on January 26, 2005, and will run for 1 year. Routine monthly sampling of uranium and technetium-99 results are trended to determine if contaminant concentrations are likely to exceed the original remedial action objective concentrations. Future actions at the pump-and-treat system will be based on the results of the rebound study.

The sampling and analysis plan for FY 2005 was incorporated into the draft *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76, Rev. 1, Draft B). Appendix A presents the monitoring well network including a well list, sampling frequencies, and analyte lists. All wells were sampled as scheduled.

The remedial action objectives for the 200-UP-1 Operable Unit (ROD 1997) are:

- *Reduce contamination in the areas with the highest concentration to below 480 µg/L for uranium and 9,000 pCi/L for technetium-99.*
- *Reduce potential adverse human health risks through reduction of contaminant mass.*
- *Prevent further movement of these contaminants from the highest contamination area.*
- *Provide information that will lead to the development and implementation of a final remedy that will protect human health and the environment.*

EPA specified enhancements needed to the system in their 5-year review (EPA 2001).

2.9.2.1 Progress During FY 2005

During the fiscal year, ~52.1 million liters of contaminated groundwater from the pump-and-treat system were treated at the Effluent Treatment Facility. Over 853 million liters have been treated since startup of remediation. During FY 2005, 8.7 kilograms of uranium and 4.7 grams (0.08 curie) of technetium-99 were removed from the aquifer. In addition, 3.4 kilograms of carbon tetrachloride and 2,166 kilograms of nitrate (secondary contaminants of concern) were removed. These values, along with the amount of mass removed since startup of operations, are given in Table 2.9-1.

The regional decline of the water-table elevation has affected the ability to monitor and track plume changes at the pump-and-treat system, because several wells have gone dry over the years. At present, water levels in well 299-W19-40 have declined such that a depth of 0.45 meter of groundwater remain in the well. The sampling pump was removed in July 2004, and samples from this well are now obtained by bailing.

The regional water-level decline is also responsible for the steady decline in pumping rates at the three extraction wells. The average extraction system pumping rate for the 4 months of operation during FY 2005 was 181.8 liters/minute, below the remedial design objective of 189.3 liters/minute. For the year prior to shutdown, the system averaged 188.4 liters/minute.

To improve plume tracking, three new wells were installed in FY 2005. Well 299-W19-48 was installed in the first quarter of FY 2005 as a replacement for well 299-W19-20, upgradient of extraction well 299-W19-39. In August and September 2005, wells 299-W19-101 and 299-W19-49 were drilled to help bound the north and southwest extent of the plumes. Preliminary data from well 299-W19-49 indicates it is located south of the current 900-pCi/L technetium-99 contour and very near the 30-µg/L uranium contour. Sampling at well 299-W19-101 indicated concentrations are above the drinking water standards for technetium-99 and uranium. Depth-discrete sampling results indicate that the uranium and technetium-99 plumes are generally located in the upper unconfined aquifer. One sample from well 299-W19-49 at 27 meters below the water table had a technetium-99 concentration (1,300 pCi/L) above the drinking water standard (900 pCi/L).

The purpose of the rebound study is to determine if contaminant concentrations will remain below the remedial action objectives under natural groundwater flow conditions.

With the concentration objectives met at all wells within the baseline plume area, a 1-year rebound study was initiated on January 26, 2005. Weekly sampling of 10 wells in the pump-and-treat area was performed for the first 2 weeks after shutdown and was followed by monthly sampling. The purpose of the rebound study is to determine whether enough technetium-99 and uranium have been removed from the aquifer to maintain groundwater concentrations below the remedial action objectives under unstressed regional groundwater flow. Contaminant trends at the individual wells should indicate if the objective levels will be exceeded in the foreseeable future. The rebound study is expected to end on January 25, 2006, and will lead to a decision on whether the pump-and-treat system can remain shut down. For more detailed information about operations during FY 2005, the reader is referred to the pump-and-treat annual report (DOE/RL-2005-91.)

2.9.2.2 Influence on Aquifer Conditions

At the end of FY 2005 (8 months into the rebound study), technetium-99 and uranium concentrations were below the remedial action objectives.

Throughout FY 2005, measured technetium-99 and uranium concentrations were consistently below their respective remedial action objectives at nine of ten wells in and around the baseline plume area. The exception was the extraction well 299-W19-36, which experienced a temporary increase in technetium-99 concentrations after the rebound study was initiated. Technetium-99 concentration peaked in this well at 14,500 pCi/L in a February sample, declined to below the remedial action objective by April, and continued declining to ~2,400 pCi/L in September (Figure 2.9-3). At the end of the fiscal year, technetium-99 concentrations were below the drinking water standard (900 pCi/L) for seven of ten wells and below 3,000 pCi/L in the other three.

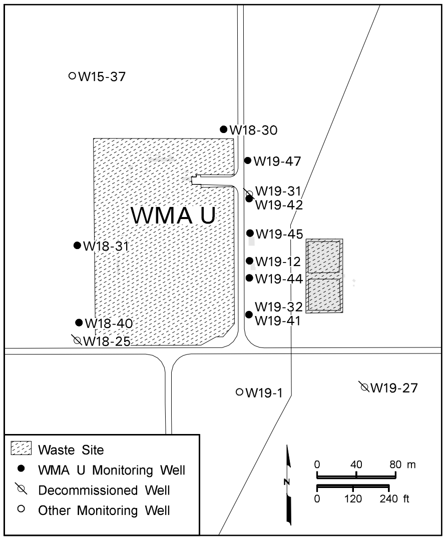
The pump-and-treat system was successful in reducing uranium concentrations to below the remedial action objective (480 µg/L) in all wells. The uranium concentration in well 299-W19-36 reach 479 µg/L in early March but has stabilized at an average concentration of 394 µg/L over the last 5 months of FY 2005. Uranium concentrations at all other wells were further below the remedial action objective but are still spread out across a broad range of concentrations (Figure 2.9-6). For wells within or adjacent to the baseline plume area and monitoring the upper unconfined aquifer, average concentrations in FY 2005 have ranged from 42 µg/L at well 299-W19-35 to 400 µg/L at well 299-W19-36. Concentrations at all wells within the baseline plume area are above the uranium drinking water standard (30 µg/L).

The technetium-99 and uranium plumes are shown in Figures 2.9-11 and 2.9-12 and are based on average concentrations for the fiscal year. Maps depicting the baseline technetium-99 and uranium plumes in 1995 and the current plumes in August 2005 are presented in the summary of this report.

For FY 2005, water-table measurements indicate that the water-table elevation increased marginally, by ~0.05 meter, due primarily to a 5-week period following start of the rebound study during which water levels recovered from the drawdown imposed by extraction well pumping. A steady 0.28-meter/year rate of decline in water levels was observed during extraction pumping and following the 5-week water-level recovery period. This rate of decline was somewhat less than the 0.36-meter/year rate of decline observed in FY 2004.

Theoretically, the cessation of pumping could result in the migration of high concentration portions of the plumes (i.e., concentrations above the remedial action objectives) to regions beyond the capture zone of the extraction wells. This could result in loss of the ability to re-establish hydraulic control over these plumes by the resumption of extraction well pumping. However, sampling results for wells near the extraction wells (well 299-W19-37 near extraction wells 299-W19-36 and 299-W19-43, and well 299-W19-40 near extraction well 299-W19-39) do not indicate that a loss of control has occurred, because elevated concentrations of both uranium and technetium-99 have not been observed in these wells. In addition, groundwater flow velocities in the baseline plume area under natural gradient conditions are lower than during extraction well pumping. This reduction in flow velocities slows down the movement of contaminants within the baseline plume area making it less likely that a high concentration portion of the plumes would reach the capture zone boundary during the rebound study.

2.9.3 Facility Monitoring



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This section describes results of monitoring individual facilities such as treatment, storage, and disposal units or tank farms. Some of these facilities are monitored under the requirements of RCRA for hazardous waste constituents and the AEA for source, special nuclear and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 2.1 pursuant to RCRA, the source, special nuclear, and by-product material component of radioactive mixed waste are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority.

Detailed groundwater monitoring is conducted at five facilities within the 200-UP-1 Operable Unit. Four of these sites are monitored in accordance with RCRA regulations. Assessment monitoring is conducted at Waste Management Areas U and S-SX and the 216-U-12 crib, and detection monitoring is conducted at the 216-S-10 pond and ditch. Groundwater monitoring at the Environmental Restoration Disposal Facility is conducted in accordance with a CERCLA record of decision (ROD 1995b). Groundwater data for these facilities are available on the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report.

2.9.3.1 Single-Shell Tank Waste Management Area U

The objective of RCRA monitoring at this waste management area is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer (40 CFR 265.93(d) as referenced by WAC 173-303-400). Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for Waste Management Area U.

Waste Management Area U was placed into assessment status in 2000 when specific conductance in groundwater monitoring wells downgradient of the waste management area

The contaminant plume from Waste Management Area U primarily consists of nitrate and technetium-99.

exceeded upgradient levels (PNNL-13185). An assessment of that finding determined that the waste management area had affected groundwater quality with elevated concentrations of nitrate and possibly chromium in wells downgradient of the waste management area (PNNL-13282). The contaminant concentrations did not exceed their respective drinking water standards, and the area affected appeared to be limited to the southeast corner of the waste management area. A groundwater quality assessment plan (PNNL-13612) was prepared in 2001. The plan was modified in 2003 (PNNL-13612-ICN-1) to include monitoring of new wells 299-W18-40, 299-W19-44, and 299-W19-45 and to modify the analyte list. The plan was again changed during 2005 (PNNL-13612-ICN-2) to include new well 299-W19-47 in the monitoring network. The plan as modified serves as the current plan by which groundwater quality is assessed at Waste Management Area U.

The monitoring network includes nine wells sampled quarterly – two upgradient and seven downgradient of the waste management area. All nine wells were sampled each quarter during FY 2005 as planned. All monitoring locations identified for the waste management area have groundwater monitoring wells installed and are being sampled. The monitoring network is adequate to assess the impact of the waste management area on groundwater quality beneath the site.

During FY 2005, technetium-99 concentrations at Waste Management Area U exceeded the drinking water standard (900 pCi/L) for the first time since 1993 indicating that tank waste has recently reached the water table and migrated to the downgradient wells.

Groundwater flow conditions at Waste Management Area U have varied greatly over the past several decades because of changing wastewater disposal in areas surrounding the waste management area, but groundwater flow has been generally to the east since 1996. During FY 2005, the direction and velocity of groundwater flow have remained the same as in the previous year. The rate at which the water table is dropping has also remained constant at ~0.3 meter/year in all of the monitoring wells during FY 2005. Therefore, the hydraulic gradient has not changed. The average linear velocity calculated based on a hydraulic conductivity of 6.12 meters/day, a specific yield of 0.17 determined in well 299-W19-42 (PNNL-13378), and a gradient of 0.0021 is ~0.08 meter/day (see Appendix B).

Groundwater chemistry beneath Waste Management Area U in FY 2005 remained similar to that presented in FY 2004 for wells downgradient of the waste management area. The waste management area has been identified as the source for a small contaminant plume that is limited to the downgradient (east) side of the site (PNNL-13282). Plume constituents of interest originally included chromium, nitrate, and technetium-99, but chromium concentrations decreased last year to near the analytical detection limit. In FY 2005, chromium concentrations increased in well 299-W19-44 to ~12 μg/L, the highest level in the waste management area, but still about eight times lower than the drinking water standard (100 μg/L).

Currently, the Waste Management Area U contaminant plume includes two major constituents: nitrate and technetium-99. During FY 2005, measured technetium-99 concentrations exceeded the drinking water standard (900 pCi/L) for the first time at the waste management area since 1993 (1,230 pCi/L in well 299-W19-45 and 980 pCi/L in well 299-W19-47). Nitrate and technetium-99 appear to have different sources because they have different distributions within the plume. These constituents are both mobile in groundwater and would be expected to travel together if they were from the same source. Nitrate concentrations are highest in the south half of the plume and technetium-99 concentrations are highest in the north half of the plume (Figure 2.9-13).

Another way to evaluate this situation is to examine the nitrate to technetium-99 ratios. Figure 2.9-14 shows how the ratios for wells in the waste management area varied over the past 8 years. The wells fall into three distinct groups: upgradient wells with fairly constant ratios above 1,000; downgradient wells on the south half of the waste management area with increasing ratios to between ~300 and 1,000; and downgradient wells on the north half of the waste management area with decreasing ratios to between ~30 and 80. These trends indicate that different sources of contamination are affecting groundwater quality beneath the tank farm. Also shown in Figure 2.9-14 are the nitrate to technetium-99 ratios for the four tanks suspected of leaking, which represent possible sources for the groundwater contamination (RPP-26744). Because nitrate and technetium-99 have similar mobility characteristics, they should not separate during migration through the groundwater system and their concentration ratio should remain the same as in the source, even if the waste solutions are diluted. Upgradient wells show the influence of a nitrate plume that has migrated beneath the tank farm from some upgradient source to the west. This plume can be seen in Figure 2.9-10 where the regional nitrate plume is presented. Ratios on the downgradient side seem to suggest mixing of tank farm waste with the upgradient plume, because the downgradient well ratios are between the ratios for the upgradient plume and the tank waste. The two downgradient plumes appear to have different sources in the waste management area, because ratios in the south wells are rising and approaching the levels in the upgradient wells, and ratios in the north wells are falling and approaching the ratios in the tank waste. It appears that the relative contribution to groundwater contamination from the tank farm is declining in the south wells, but increasing in the north wells. This suggests there are at least two separate locations where tank waste has entered the groundwater.

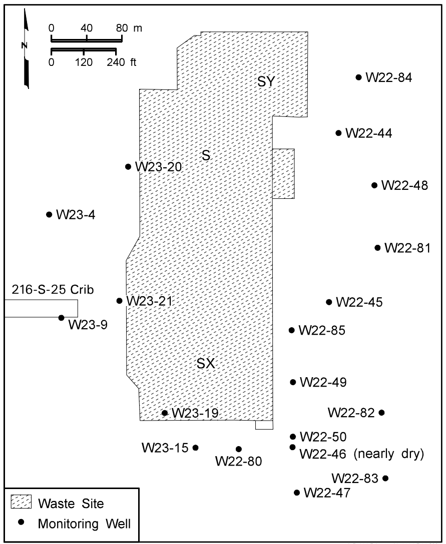
Sources within Waste Management Area S-SX have contaminated groundwater with nitrate, chromium, and technetium-99.

Nitrate, carbon tetrachloride, and technetium-99 exceeded their respective drinking water standards in groundwater beneath the tank farm. Nitrate concentrations continued to increase in all but one monitoring well at Waste Management Area U, including the two upgradient wells. Nitrate concentrations were above the drinking water standard (45 mg/L) in two downgradient wells, 299-W19-41 and 299-W19-44, at maximum concentrations of ~70 mg/L. These are the only wells with nitrate concentrations above the drinking water standard at the waste management area.

Carbon tetrachloride is found in groundwater beneath Waste Management Area U at concentrations above its drinking water standard of 5 μg/L. Well 299-W18-30 is the only well analyzed for carbon tetrachloride, and it contained levels of 300 μg/L in August 2005, a factor of two increase from FY 2004. The regional carbon tetrachloride distribution (see Figure 2.8-3 in Section 2.8) indicates that the source of carbon tetrachloride found in the Waste Management Area U vicinity is from liquid waste disposal sites at the Plutonium Finishing Plant located northwest of the waste management area. Because well 299-W18-30 is near the 100-μg/L contour, a slight lateral shift in the plume in the vicinity of the well can explain the large observed increases in carbon tetrachloride without a major change in the overall plume distribution.

2.9.3.2 Single-Shell Tank Waste Management Area S-SX

The objective of RCRA monitoring at this waste management area is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer. Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for Waste Management Area S-SX.



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Waste Management Area S-SX was placed into assessment status (40 CFR 265.93(d) as referenced by WAC 173-303-400) in 1996 at the direction of Ecology because of elevated specific conductance and technetium-99 (not regulated by RCRA) in downgradient monitoring wells. A groundwater quality assessment plan (WHC-SD-EN-AP-191) was prepared in 1996 and the planned assessment work conducted in 1996 and 1997. An assessment of the waste management area determined (first determination) that multiple sources within the waste management area had affected groundwater quality with elevated concentrations of nitrate, technetium-99, and chromium in wells downgradient of the waste management area (PNNL-11810). A second groundwater quality assessment plan (PNNL-12114) was prepared in 1999 to further evaluate the contamination found. Since that time, two groundwater quality assessment reports have been published (PNNL-13441; PNNL-13801) covering the time period from November 1997 through December 2001, and the assessment plan was revised twice (PNNL-12114-ICN-1; PNNL-12114-ICN-2) to account for new wells added to the monitoring network and revisions to the sampling and analysis schedule. The plan was revised a third time (PNNL-12114-ICN-3) in FY 2005 to add one new well and remove one dry well from the monitoring network. The plan as modified serves as the current plan by which groundwater quality is assessed at Waste Management Area S-SX.

At the end of the fiscal year, the monitoring network consisted of 16 wells: 2 upgradient and 13 downgradient of the waste management area, and 1 well located within the area. During FY 2005, one downgradient well was drilled (299-W22-47) and added to the network and another well (299-W22-46) went dry and was removed from the network. The wells are sampled quarterly, and all were sampled during FY 2005 as scheduled, except for well 299-W22-49. This well was not sampled in March 2005 because of pump problems that were not corrected until the following quarter. Well 299-W22-46 was sampled in December 2004 and March 2005 before the water table dropped too far for it to be sampled in June. New well 299-W22-47 was not available to be sampled in December 2004, but was sampled for the first time in April 2005. Over the past several years, the leading fronts (as indicated by concentrations above background levels) of contaminant plumes emanating from the waste management area have migrated beyond the farthest downgradient monitoring wells in the network. Additional, further downgradient wells have been identified (DOE/RL-92-76, Rev. 1) as part of the 200-UP-1 Operable Unit well drilling plans.

Groundwater Flow. During FY 2005, the direction and rate of groundwater flow remained the same as in the previous year, despite the falling water-table elevation. The rate at which the water table is declining remained the same as last year, at ~0.3 meter/year based on water-level measurements for the monitoring wells. This decline was the same in all wells across the waste management area; therefore, the hydraulic gradient has remained stable. Estimates of groundwater flow velocity, using travel times for tritium and technetium-99 between monitoring wells in the vicinity of Waste Management Area S-SX, suggest groundwater flow rates of 25 to 50 meters/year, or 0.07 to 0.14 meter/day. Calculated average linear velocities (using Darcy's method) based on hydraulic conductivity and tracer test data, also suggest similar flow rates (0.009 to 0.36 meter/day; see Appendix B). The groundwater flow direction inferred from water-table elevation contours suggests an east-southeast flow direction over the larger area around the waste management area (see Figure 2.8-2 in Section 2.8). This direction of flow is consistent with the shape of the contaminant plume on the south side of the waste management area and the direction in which it is expanding.

Increases of chromium and technetium-99 concentrations in well 299-W23-19 at Waste Management Area S-SX indicate that a pulse of contamination has entered the aquifer beneath the tank farm.

Groundwater Contamination. Groundwater beneath this waste management area is contaminated with nitrate, hexavalent chromium, and technetium-99 attributed to two general source areas within the waste management area. One source area is in the S Tank Farm and the other is located to the south in the SX Tank Farm. The nitrate, chromium, and technetium-99 plumes are depicted in Figures 2.9-15, 2.9-16, and 2.9-17, which show average concentrations for the fiscal year. Carbon tetrachloride (see Figure 2.8-3 in Section 2.8) is also present in groundwater beneath the waste management area, but its source is upgradient of the waste management area (PNNL-13441). Tritium is also present beneath the waste management area as seen in Figure 2.9-8, but its source is the 216-S-25 crib located just west (upgradient) of the SX Tank Farm (PNNL-13441).

The northern plume has migrated eastward from the S Tank Farm. During FY 2005, constituent concentrations in this plume (chromium, nitrate, and technetium-99) generally decreased, with the exception of nitrate in well 299-W22-44 located on the north side of the plume. In general, the maximum chromium concentration in the plume was ~20 µg/L, slightly reduced from FY 2004. Maximum nitrate concentrations are at or just above the drinking water standard (45 mg/L), which was similar to that observed in FY 2004. Technetium 99 concentrations also decreased during FY 2005, but the highest concentrations were still about twice the 900-pCi/L drinking water standard.

The contaminant plume located in the south portion of the waste management area, having a source in the SX Tank Farm includes nitrate, chromium, and technetium-99 just as in the S Tank Farm plume to the north. During FY 2005, major changes were observed

Flow meter results confirmed previous work that indicated an upward flow of water within well 299-W22-80, resulting in dilution of the groundwater plume in the vicinity of this well.

in the SX Tank Farm plume near the source area as represented by well 299-W23-19. In this well, chromium concentrations increased by a factor of ~5 from 320 to 1,710 µg/L, more than ten times the drinking water standard of 100 µg/L (Figure 2.9-4). During FY 2004, concentrations also increased by a factor of ~5 from 58 to 320 µg/L. In addition, technetium-99 concentrations increased by a factor of ~3 during the year from 46,100 pCi/L to a high of 137,000 pCi/L (exceeding the derived concentration guide of 100,000 pCi/L) in September after having remained fairly stable in FY 2004 (Figure 2.9-4). These data suggest that a significant pulse of contamination has recently entered the aquifer from the vadose zone beneath the tank farm.

Constituent concentrations in the middle of the south plume, represented by well 299-W22-50, and the distal end of the plume represented by well 299-W22-83, continued on the same trends as reported in FY 2004. In the middle of the plume, constituent concentrations reached a peak in FY 2003 and have continued to decrease or remain stable throughout 2005 (Figure 2.9-18). The downgradient migrating nitrate front, as indicated by the 45-mg/L isopleth, has migrated beyond the farthest downgradient monitoring well 299-W22-83 (Figure 2.9-15). Nitrate concentrations in this well increased from 70 mg/L at the end of FY 2004 to a maximum of 87 mg/L in September 2005. A similar pattern was observed for the chromium and technetium-99 distributions at this distal end of the plume (Figure 2.9-19), but a leveling off of the rate of increase for these two constituents is apparent.

During FY 2005, selenium-79 was reported as detected in two samples from well 299-W23-19, although the presence of this constituent in groundwater has not been confirmed. This constituent was added to the analyte list in wells 299-W22-50, 299-W22-83, 299-W23-19, and 299-W23-21 in the Waste Management Area S-SX monitoring network as part of CERCLA and AEA monitoring. Analyses were performed on the March samples for all four wells, and selenium-79 was not detected. Selenium-79 was further analyzed in two additional samples from well 299-W23-19. Duplicate samples in June had a reported mean value of 2,035 pCi/L, but with a minimum detectable activity of 1,920 pCi/L. Given this high minimum detectable activity (due to a low sample aliquot volume), these results are considered suspect. A value of 495 pCi/L with a minimum detectable activity of 27 pCi/L was reported for the September sample, suggesting that selenium-79 may be present in groundwater. Because of the variable results and the elevated detection limit in some samples, and the possibility that high levels of technetium-99 may be interfering with the selenium-79 laboratory analysis, it is premature to conclude that selenium-79 is actually present in the groundwater.

The contaminant plume from Waste Management Area S-SX occurs in the upper 23 meters of the aquifer at well 299-W22-47.

As described last year, a low concentration island has been drawn in the plume maps at wells 299-W22-80 and 299-W23-15 to reflect information that indicates that constituent concentrations in samples collected from these wells are low relative to concentrations in other nearby wells (Figures 2.9-15, 2.9-16, and 2.9-17). The evidence reported last year (PNNL-15070) included (1) aquifer tests that indicate a natural upward flow exists in the screened section of well 299-W22-80 and (2) preliminary time series sampling during extensive pumping that indicates water near well 299-W22-80 is much less contaminated than water farther from the well. In FY 2005, a borehole flow meter test in well 299-W22-80 indicated that a measurable upward flow of ~0.3 liter/minute exists during static (i.e., non-pumping) conditions. These data suggest that relatively uncontaminated water near the bottom of well 299-W22-80 may be flowing up through the well and diluting the plume in the upper part of the aquifer at a rate of 430 liters/day, or ~40,000 liters between each quarterly sampling period. A similar situation is assumed to be occurring at well 299-W23-15 due to its proximity to well 299-W22-80 and similarly low concentrations. In FY 2004, the contaminant plumes were re-interpreted as occurring farther south than previously depicted (PNNL-15070). Elevated technetium-99 and chromium concentrations at new well 299-W22-47 installed ~50 meters south of well 299-W22-46, has helped to confirm this interpretation.

During drilling of new well 299-W22-47, water samples were collected every 1.5 meters using air-lift techniques and every 6.1 meters by pumping. The results indicate that the plume originating in the SX Tank Farm is present at this location with concentrations of chromium, nitrate, carbon tetrachloride, and technetium-99 greater than their respective drinking water standards (Figure 2.9-20). Only the pumped water samples are included for chromium in Figure 2.9-20. Air-lifted samples were deemed non-representative because the water samples were in contact with sediment in a collection bottle for up to several days before a filtered sample was collected. During this time, the chromium in solution is believed to have been reduced by freshly exposed sediment surfaces (ground up basalt particles) and precipitated from solution, resulting in artificially low chromium concentrations. Chromium concentrations in all of the air-lifted samples were much lower than adjacent pumped samples. Based on these preliminary characterization data, the plume is present in the upper 23 meters of the aquifer at this location, and it appears that the longitudinal axis of the SX Tank Farm plume is farther south than previously thought. The three routine quarterly samples collected from the well in FY 2005 yielded constituent concentrations (see Figure 2.9-19) at the same levels as reported in Figure 2.9-20.

In 2003, DOE and Ecology agreed to the practice of extended purging during sampling at well 299-W23-19 to remove technetium-99 from the groundwater. This practice continued during FY 2005.

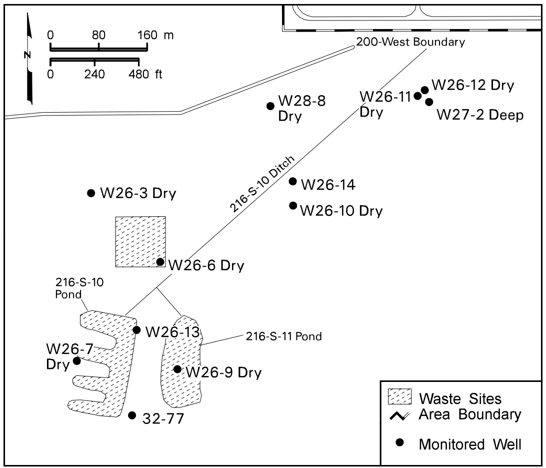
Specific Conductance Measurements in Well 299-W23-19. Well 299-W23-19 was re-configured in February and March 2003 with a permanent sampling pump and four specific conductance probes located at regularly spaced vertical positions along the well screen. Details of the installation are presented in the annual report for FY 2003 (PNNL-14548). This work was done to test the possibility that fluctuations in sample groundwater chemistry reflected actual variations in the plume. Specific conductance is a measure of the quantity of the major dissolved constituents such as calcium, magnesium, chloride, and nitrate in the water. Because these constituents are major components of the contaminant plume, specific conductance is an easily measured indicator of plume location and temporal variations. Specific conductance measurements collected in FY 2005 are presented in Figure 2.9-21. The four instances where the trends are perturbed reflect changes in wellbore specific conductance caused by quarterly sampling. Figure 2.9-21 shows that specific conductance in the well began to increase in February and reached a maximum in July. These data are consistent with the quarterly sampling results when significant increases in nitrate, chromium, and technetium-99 were observed. Because the probes are spaced at vertical positions in the well, the results indicate how the aquifer chemistry is stratified. In the last quarter of the fiscal year, Probe 3 had the highest specific conductance, a change from the past where Probe 2 had the highest level. This change is likely due to the fact that the water table has dropped, changing the absolute positions of the probes in the aquifer. The location of Probe 3 is now approaching the position in the aquifer that was previously occupied by Probe 2. Probe 4 results are considered suspect because the specific conductance portion of the probe does not respond immediately when the pump is turned off, as do the other three probes and the temperature portion of Probe 4.

Groundwater Treatment. To remove technetium-99 from the groundwater, the practice of extended purging during sampling at well 299-W23-19 was continued during FY 2005. This practice was agreed to by DOE and Ecology and was begun in 2003. After samples are collected from this well each quarter, purging of the well is continued at a higher flow rate until a minimum of 3,785 liters of water is removed from the aquifer. This water is transferred to the Effluent Treatment Facility for treatment and disposal. Table 2.9-2 presents the date, amount of water collected, and a calculation of the mass and activity of technetium-99 removed from the aquifer. A total of ~0.0015 curie (~0.089 gram) of technetium-99 was recovered during FY 2005. Since the start of this treatment in 2003, a total of ~0.0034 curie (~0.20 gram) of technetium-99 has been recovered.

2.9.3.3 216-S-10 Pond and Ditch

The 216-S-10 pond and ditch was active from 1951 through 1991, and received effluent primarily from the REDOX Plant chemical sewer. The site is monitored semiannually under

RCRA interim status indicator parameter monitoring (40 CFR 265.93(b) and by reference WAC 173-303-400) to detect any effect on groundwater that may occur from past facility operations. Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for the 216-S-10 pond and ditch.



RCRA groundwater monitoring has been conducted under interim status requirements since 1991. The 216-S-10 pond and ditch unit has not received liquid waste since October 1991. The treatment, storage, and disposal unit will be closed under a RCRA closure plan integrated with a future CERCLA record of decision. The RCRA closure plan for the 216-S-10 pond and ditch is being coordinated with the CERCLA 200-CS-1 source operable unit in accordance with Tri-Party Agreement Milestone M-15-39C. The proposed 216-S-10 pond and ditch groundwater closure approach will be post-closure monitoring under a final status detection monitoring program. The closure approach is based on the data gathered to date from the monitoring network (PNNL-14070), groundwater data contained in the Hanford Environmental Information System, and groundwater monitoring reports (e.g., PNNL-15070). Groundwater monitoring, as described in the following paragraphs, has shown an elevated level of chromium in an upgradient well. The source of this contamination has not been conclusively determined, and as chromium is a dangerous waste constituent for the treatment, storage, and disposal unit, the 216-S-10 pond and ditch cannot currently be ruled out as the source of the contamination.

All but three of the monitoring wells for the 216-S-10 pond and ditch have gone dry.

The decline in the water table beneath the 216-S-10 pond and ditch during FY 2005 ranged from ~0.3 meter at the north end of the ditch to ~0.5 meter near the pond in the south (based on the regional water-table map). The current RCRA monitoring network consists of two downgradient wells (the others having gone dry): well 299-W26-13 located near the pond and well 299-W26-14 located just east of the central portion of the ditch. Upgradient well 299-W26-7 went dry in 2003. The network also includes one deep downgradient well, 299-W27-2, which is screened at the bottom of the uppermost unconfined aquifer. RCRA requirements for interim status monitoring specify that a minimum of one upgradient and three downgradient monitoring wells are needed to monitor the site. The groundwater monitoring plan, updated in 2002 (PNNL-14070), proposed to deepen or replace two existing dry wells to meet these requirements. All new RCRA wells installed at Hanford are negotiated annually by Ecology, DOE, and the U.S. Environmental Protection Agency (EPA) and approved under the Tri-Party Agreement (Ecology et al. 1989) Milestone M-24-00. During FY 2005, all wells were sampled as scheduled, although the June 2005 sampling of well 299-W26-14 was delayed until August.

There were no exceedances of an indicator parameter during FY 2005, so the 216-S-10 pond and ditch remains in detection monitoring.

Nickel is elevated in well 299-W27-2, but its source is unknown. The long, gradual increase in nickel concentrations followed by a stable elevated trend in FY 2005 (most recent value is 124 µg/L in December, 2004), suggests this occurrence is not an analytical or sampling artifact but may be due to corrosion of stainless steel well materials. Carbon tetrachloride values from this well have averaged above the drinking water standard (5 µg/L) for several years, but dropped slightly below 5 µg/L during FY 2005. The source is believed to be from upgradient (north). Total organic halides have shown a wide variation in concentration in quadruplicate samples collected from the two shallow wells 299-W26-13 and 299-W26-14. These data are currently suspect, and more details concerning the validity of the data are presented in Appendix C.

Elevated chromium concentrations at well 299-W26-7 (now dry) had exceeded the drinking water standard (100 µg/L) during the past 10-year life of the well. This may have been caused by short-term releases migrating through the vadose zone from past effluent releases to the pond or from upgradient sources. Historical records document a 1983 release to the 216-S-10 ditch of a high-salt waste (simulated tank waste) containing hexavalent chromium. Although well 299-W26-7 was designated as an upgradient well, it is located very close to one lobe of the pond system and may have been affected by drainage spreading laterally in the vadose zone (see Appendix B). A REDOX Plant disposal pond, which is located immediately upgradient of the 216-S-10 pond and ditch, has not been ruled out as a potential source of chromium contamination.

Nitrate concentrations were co-variate with chromium concentrations in wells 299-W26-7, 299-W26-9, 299-W26-10, and 299-W26-12, which are now dry. The upgradient well 299-W26-7 had the highest nitrate concentrations. These and other data presented in PNNL-14070 suggest that the 216-S-10 pond could be the source of this nitrate and chromium increase. Although chromium and nitrate were elevated in the dry upgradient well 299-W26-7, significant concentrations of these constituents have not been detected in the downgradient wells. Chromium concentrations in new well 299-W26-13 (located nearby and just downgradient of well 299-W26-7) are only slightly elevated above the chromium concentrations in the other two downgradient wells, which are near background.

Because the only upgradient well, 299-W26-7, went dry in year 2003, the comparison of RCRA indicator parameters (specific conductance, pH, total organic carbon, and total organic halides) between upgradient and downgradient wells was conducted using the most recent collected background values of contaminant indicator parameters from well 299-W26-7 before it went dry (see Appendix B). One new upgradient and two downgradient wells have been approved for installation surrounding the 216-S-10 pond and ditch per Tri-Party Agreement Milestone M-24-57. When data from the new upgradient well becomes available, new background values will be calculated and used for the required upgradient/downgradient comparisons. Based on statistical evaluations of contamination indicator parameters conducted during FY 2005, there were no statistically significant differences (i.e., constituents in the downgradient wells were not elevated compared to the upgradient well). Therefore, this site remains in detection monitoring.

Based on regional groundwater elevations, the groundwater flow direction continues toward the east-southeast. The average linear velocity has increased since last year, due to a slight increase in the groundwater gradient, and ranges from 0.075 to 2.25 meter/day (see Appendix B).

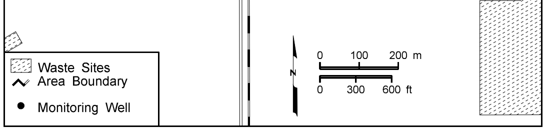
The 216-U-12 crib contributed to nitrate and technetium-99 contamination.

2.9.3.4 216-U-12 Crib

The 216-U-12 crib is located ~600 meters south of U Plant in the southeast portion of the 200 West Area. The crib is an unlined, gravel-bottom, percolation crib 3 meters by 30 meters, and 4.6 meters deep. The crib received process effluent from U Plant, including corrosive liquid condensate from the 224-U Building, and operated from 1960 through 1972 and from 1981 until it was permanently retired in February 1988. A yearly average of over 1.02 x 10^7 liters/year of effluent was disposed to the crib from 1960 through 1972 (RHO-CD-673). Total volume disposed to the 216-U-12 crib exceeded 1.33 x 10^8 liters from 1960 through 1972.

The current objective of RCRA monitoring at the 216-U-12 crib is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer. The site is in assessment for elevated specific conductance, and nitrate and is sampled quarterly. Groundwater monitoring under the AEA tracks radionuclides at this crib and surrounding vicinity. Appendix B includes a well location map and lists the wells and constituents monitored for the 216-U-12 crib.

During FY 2005, the 216-U-12 crib was regulated under a RCRA interim-status assessment program (40 CFR 265.93(d) and by reference WAC 173-303-400). For the first half of FY 2005, monitoring was conducted under a groundwater assessment sampling and analysis plan



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issued in 2003 (PNNL-14301). Between FY 2003 and September, 2005, only two network monitoring wells were available. Declining water levels in the 200 West Area had reduced the 216-U-12 crib monitoring network from the original four wells to just two downgradient wells (299-W22-79 and 699-36-70A), fewer than the minimum number of wells required by RCRA. In September 2005, a revised groundwater monitoring plan for this crib was released (PNNL-14301, Rev. 2). This revised interim status plan updated the network from the two former wells to four wells, which include one upgradient well (299-W22-26), and three downgradient wells (299-W22-79, 699-36-70A, and 299-W21-2). The upgradient well, 299-W22-26, is a pre-existing well that will be used until a new upgradient replacement well is installed. The new upgradient well will be available for sampling during the spring of calendar year 2006. This upgradient well is located near the now dry original upgradient well 299-W22-43. Well 299-W21-2 is a new downgradient well that was installed in support of the CERCLA 200-UP-1 Operable Unit. This well is located downgradient between the near field well 299-W22-79 and the far-field monitoring well 699-36-70A. The revised 216-U-12 crib monitoring network is sampled quarterly for the constituents of interest (see Appendix B). During FY 2005, all wells were sampled as scheduled.

The objective of interim status assessment monitoring is to assess the migration of dangerous waste constituents out of the vadose zone into groundwater and to support the delineation of the existing known plumes that, through RCRA/CERCLA integration, is being managed under the CERCLA and AEA 200-UP-1 Operable Unit monitoring program. The existing 216-U-12 crib plumes co-mingle with plumes from other U Plant and REDOX Plant source areas, making it difficult to distinguish the aerial extent of specific plumes emanating from the crib.

The 216-U-12 crib was placed into assessment status due to elevated specific conductance downgradient of the treatment, storage, and disposal unit. Elevated calcium and nitrate are the major contributors to specific conductance. Technetium-99 is also defined as a co-contaminant that is migrating with nitrate in the groundwater. These constituents are being evaluated through quarterly groundwater monitoring. The regional nitrate and technetium-99 plumes are actually a co-mingled series of smaller plumes with sources from several cribs (216-U-1,2; 216-U-8; and 216-U-12) in the U Plant area.

The 216-U-12 crib monitoring well network formerly consisted of only two wells, the others have gone dry. The network was revised during FY 2005 to include one upgradient and three downgradient wells.

The key indicator parameter, specific conductance, continued to decline in the near field downgradient well 299-W22-79 and the far downgradient well 699-36-70A during FY 2005. The new intermediate downgradient well 299-W21-2, has only been active since February 2005, but the trends of the results are as expected.

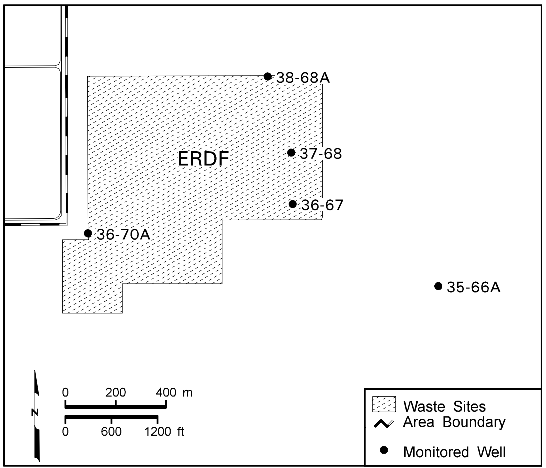
Specific conductance is now declining below the former critical mean (457.8 µSm/cm) in well 299-W22-79, but remains above the former critical mean in the two farthest downgradient wells, 299-W21-2 and 699-36-70A. Specific conductance in the upgradient well 299-W22-26 is on the rise (since 2001), but below the former critical mean value (current value is 276 µSm/cm). The data from these wells, including past results from the dry network wells, suggest that the bulk of the mobile residual vadose contamination (i.e., nitrate and technetium-99) beneath the 216-U-12 crib has moved into the groundwater and has migrated beyond the near field point-of-compliance well (e.g., 299-W22-79).

During FY 2005, nitrate continued to decline below the drinking water standard (45 mg/L) in well 299-W22-79. It also declined in far-field wells 699-36-70A and 299-W21-2, although concentrations remain above the drinking water standard. However, nitrate in the upgradient well (299-W22-26) increased (to ~29 mg/L), indicating a potential upgradient source may be encroaching toward the site. The co-contaminant, technetium-99 (which is not regulated under RCRA), continued to be detected in all downgradient network wells (highest value reported for FY 2005 was 164 pCi/L in well 299-W21-2), but at levels well below the drinking water standard (900 pCi/L). Technetium-99 is undetected in upgradient well 299-W22-26. All other constituents remained on trend or near background throughout the year.

Based on the surrounding RCRA and CERCLA well groundwater elevations, the direction of groundwater flow beneath the 216-U-12 crib continued relatively unchanged toward the east-southeast to east (see Figure 2.8-2 in Section 2.8). The pre-Hanford flow direction in the vicinity of the 216-U-12 crib is believed to have been from west to east, and it is expected that groundwater flow will eventually return to a more eastward direction. The water-table elevation continued to decline around the 216-U-12 crib and vicinity, but at a slower rate than last year. Annual declines ranged between ~0.18 meter near the crib to 0.29 meter farther downgradient. Average linear groundwater flow velocities increased slightly over last year's calculations, ranging from ~0.03 to ~0.07 meter/day (see Appendix B). This change was mainly due to a change (improvement) in the methods to calculate the gradient by including water-level data from more wells.

2.9.3.5 Environmental Restoration Disposal Facility

The Environmental Restoration Disposal Facility is a low-level, mixed waste facility where waste from surface remedial actions on the Hanford Site is disposed. The site is designed to meet RCRA standards, although it is not permitted as a RCRA facility. Groundwater monitoring is conducted in accordance with a CERCLA record of decision (ROD 1995b). One upgradient well (699-36-70A) and three downgradient wells (699-37-68, 699-36-67, and 699-35-66A) are sampled semiannually, typically in the second and fourth quarters of the fiscal year (March and September). All four wells were sampled as planned during FY 2005, although the fourth quarter sampling of well 699-35-66A was delayed until October 2005 due to a maintenance issue. Appendix B contains additional information regarding the Environmental Restoration Disposal Facility. For a discussion of leachate monitoring at this facility, see Section 3.1 and see BHI-01777 for calendar year 2004 groundwater and leachate monitoring results. Calendar year 2005 results will be described in an upcoming report. See BHI-00873 for the groundwater sampling and analysis plan.



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Results of groundwater monitoring at the Environmental Restoration Disposal Facility continued to indicate that the facility has not adversely impacted groundwater quality. Several constituents (tritium, iodine-129, nitrate, and carbon tetrachloride) are present in the groundwater at or above drinking water standards, but these constituents are elevated in both the upgradient and downgradient wells. Figures 2.9-8, 2.9-9, and 2.9-10, and Figure 2.8-3 in Section 2.8 indicate that these plumes originated in the 200 West Area and have migrated into the vicinity of the Environmental Restoration Disposal Facility.

Results of groundwater monitoring at the Environmental Restoration Disposal Facility continued to indicate that the facility has not adversely impacted groundwater quality.

Both filtered and unfiltered samples are collected for metals (except for uranium samples, which are unfiltered). No sampling results were noted significantly out of trend during the fiscal year. Overall, uranium appears to be trending downward. Both technetium-99 and gross beta appear to be trending upward in two downgradient wells (699-37-68 and 699-35-66A) and downward in the upgradient well (699-36-70A). The gross beta and technetium-99 increases are not large relative to the previous years, but the wells show a nominal tripling of the technetium-99 concentrations over the last 6 years. These trends should continue to be monitored. Overall, the FY 2005 results appear stable. High turbidity (suspended solids), a common source for variability in the analytical results, was not seen in the FY 2005 sampling.

Table 2.9-1. Summary of Contaminant Mass Removed from the Aquifer during Pump-and-Treat Operations at the 200-UP-1 Operable Unit, FY 2005 and Totals Since Startup of Operations

Contaminant	Fiscal Year 2005	Since Startup (March 1994)
Uranium	8.7 kg	212 kg
Technetium-99	4.7 g (0.08 Ci)	118.8 g (2.02 Ci)
Carbon tetrachloride	3.4 kg	34.6 kg
Nitrate	2,166 kg	34,716 kg

Table 2.9-2. Quantity of Treated Groundwater and Technetium-99 Mass Removed from the Aquifer during Extended Purging at Well 299-W23-19, FY 2005

Sample Date	Volume of Water Treated Liters (gal)	Technetium-99 Concentration (pCi/L)	Activity of Technetium-99 Removed (Ci)	Mass of Technetium-99 Removed (g)
December 20, 2004	3,849 (1,017)	62,300	0.00024	0.014
March 9, 2005	3,789 (1,001)	69,400	0.00026	0.015
June 14, 2005	3,785 (1,000)	128,000	0.00048	0.029
September 27, 2005	3,785 (1,000)	137,000	0.00052	0.031
Totals	15,208 (4,018)	NA	0.0015	0.089

NA = Not applicable.

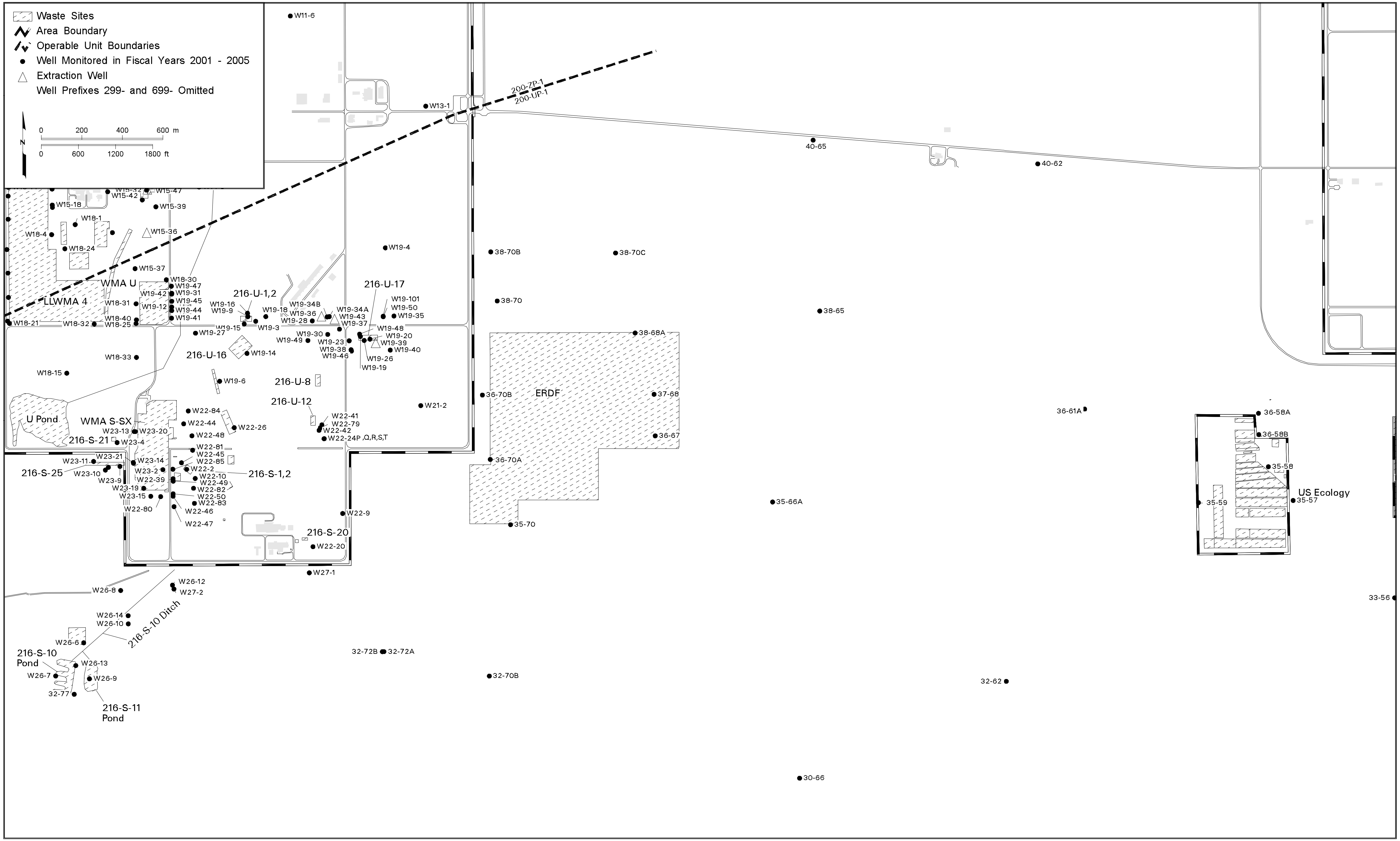

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Figure 2.9-1. Facilities and Groundwater Monitoring Wells in the 200-UP-1 Groundwater Interest Area

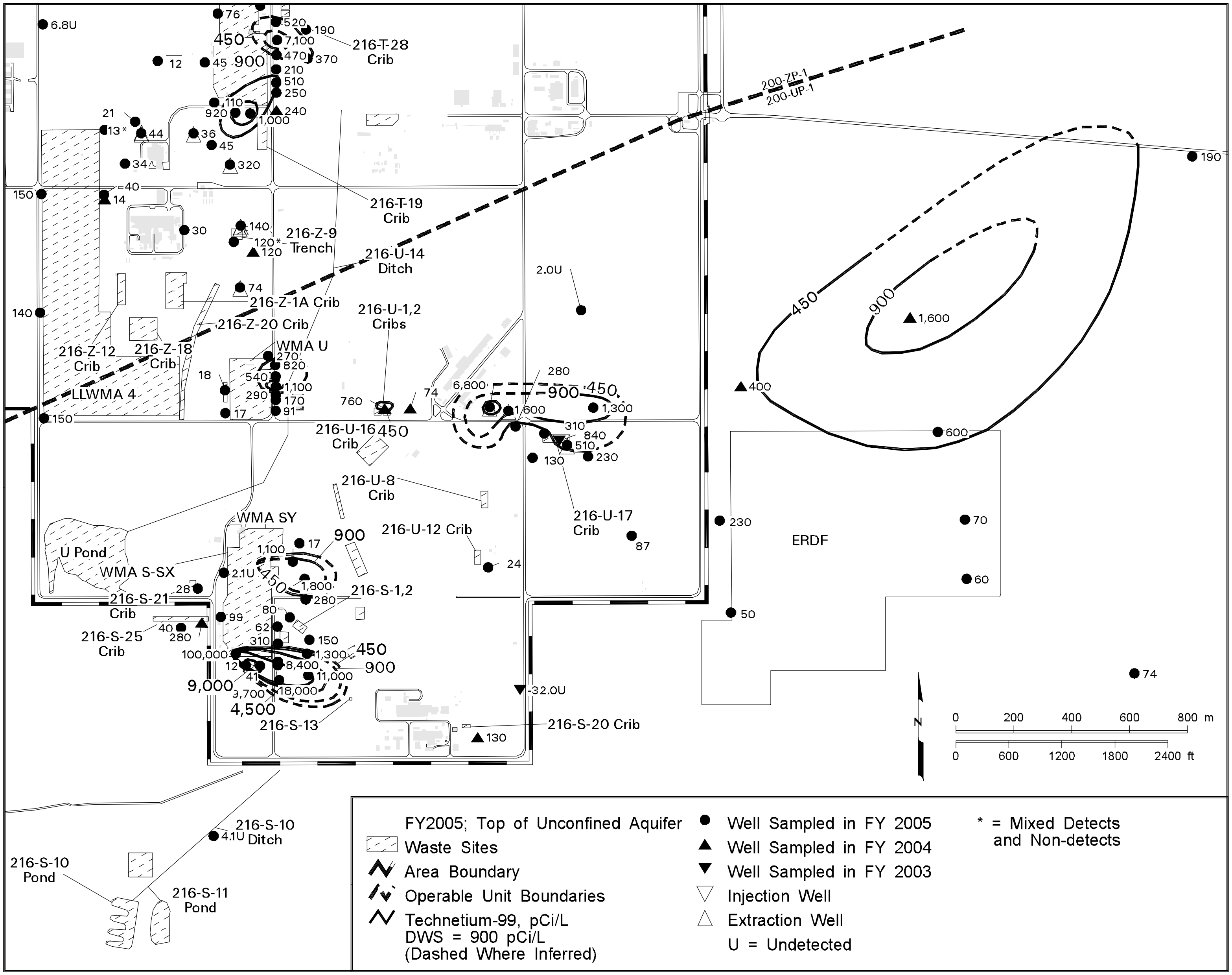

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Figure 2.9-2. Average Technetium-99 Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

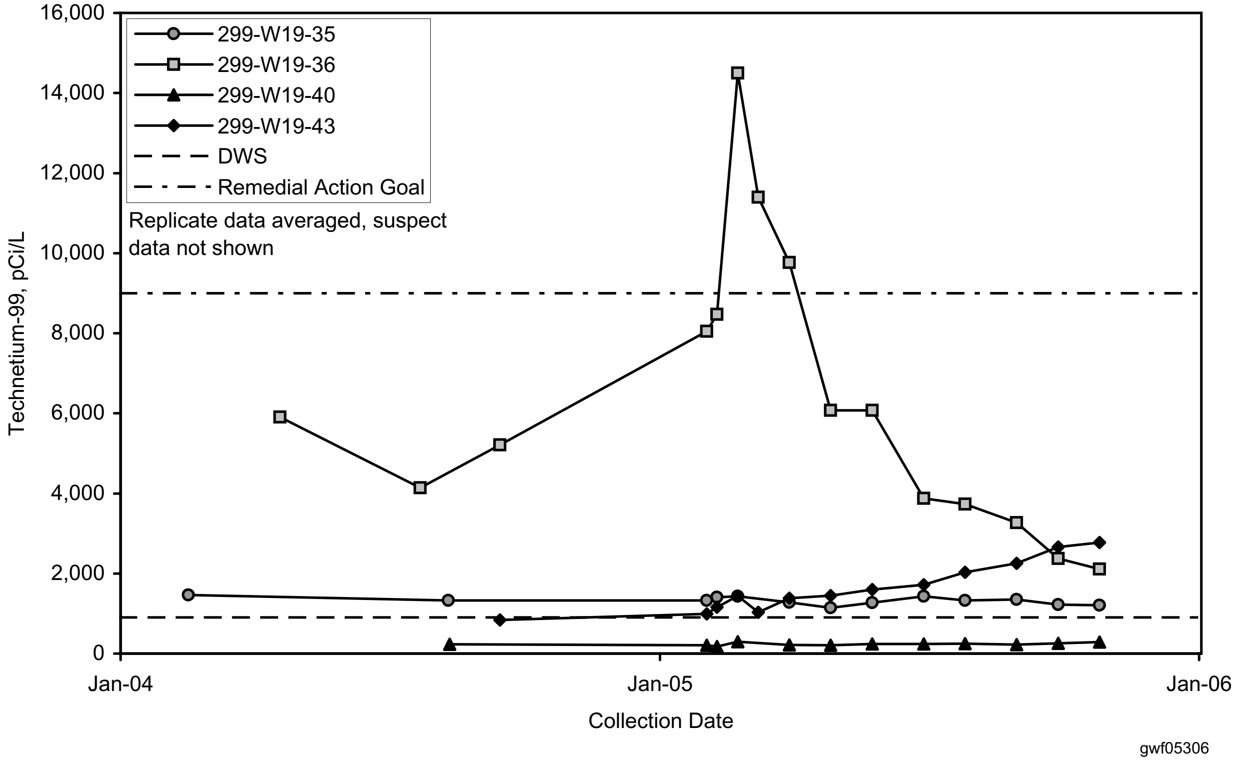

Figure 2.9-3. Technetium-99 Concentrations in Selected Wells at the 200-UP-1 Pump-and-Treat Area

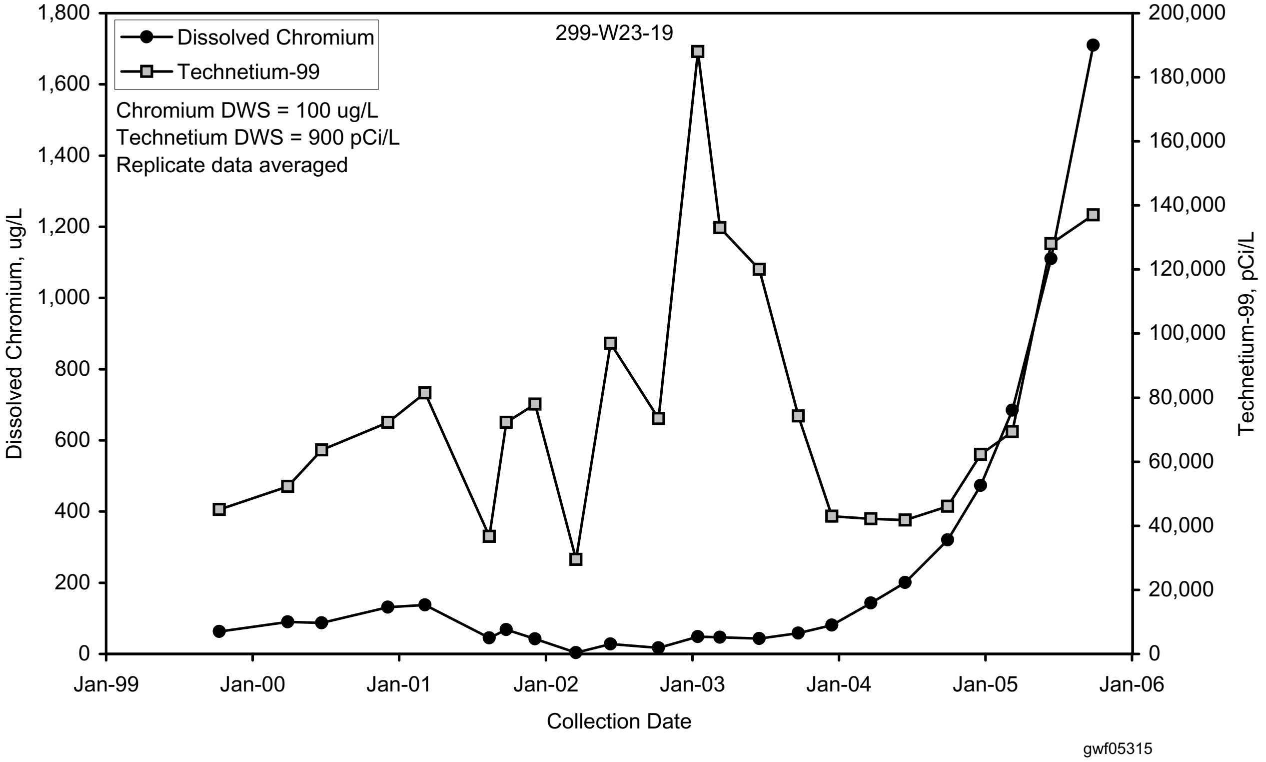

Figure 2.9-4. Chromium and Technetium-99 Concentrations in Well 299-W23-19 Near a Source Area Within the South Portion of Waste Management Area S-SX

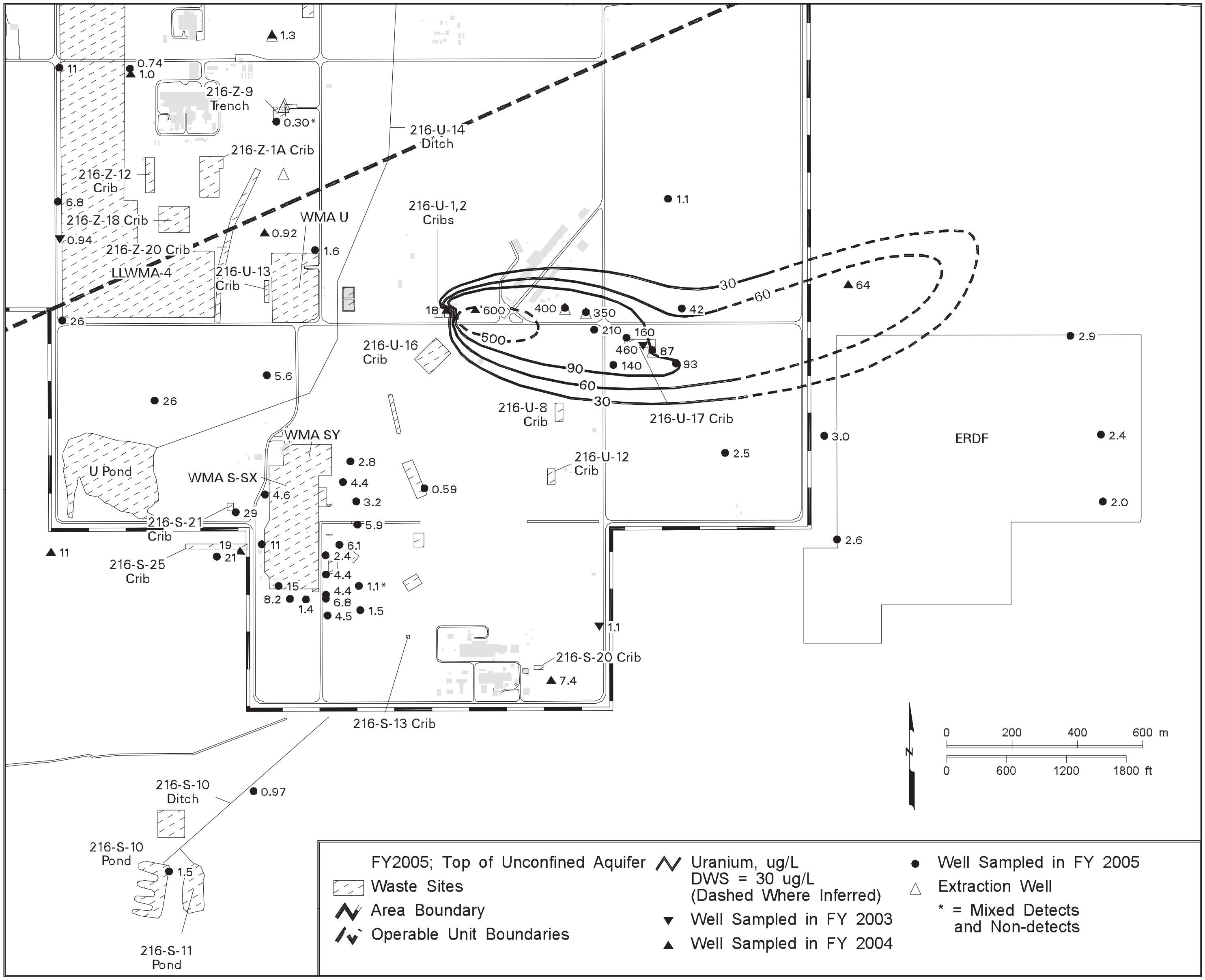

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Figure 2.9-5. Average Uranium Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

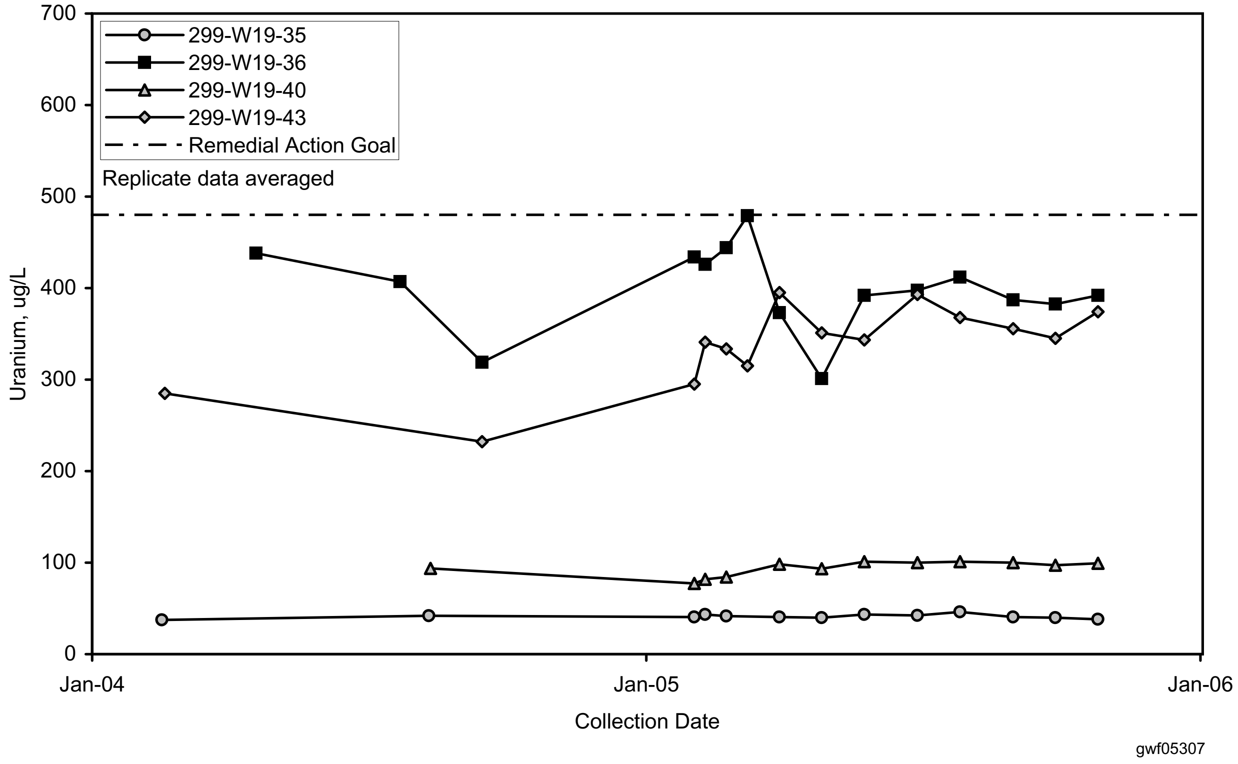

Figure 2.9-6. Uranium Concentrations in Selected Wells at the 200-UP-1 Pump-and-Treat Area

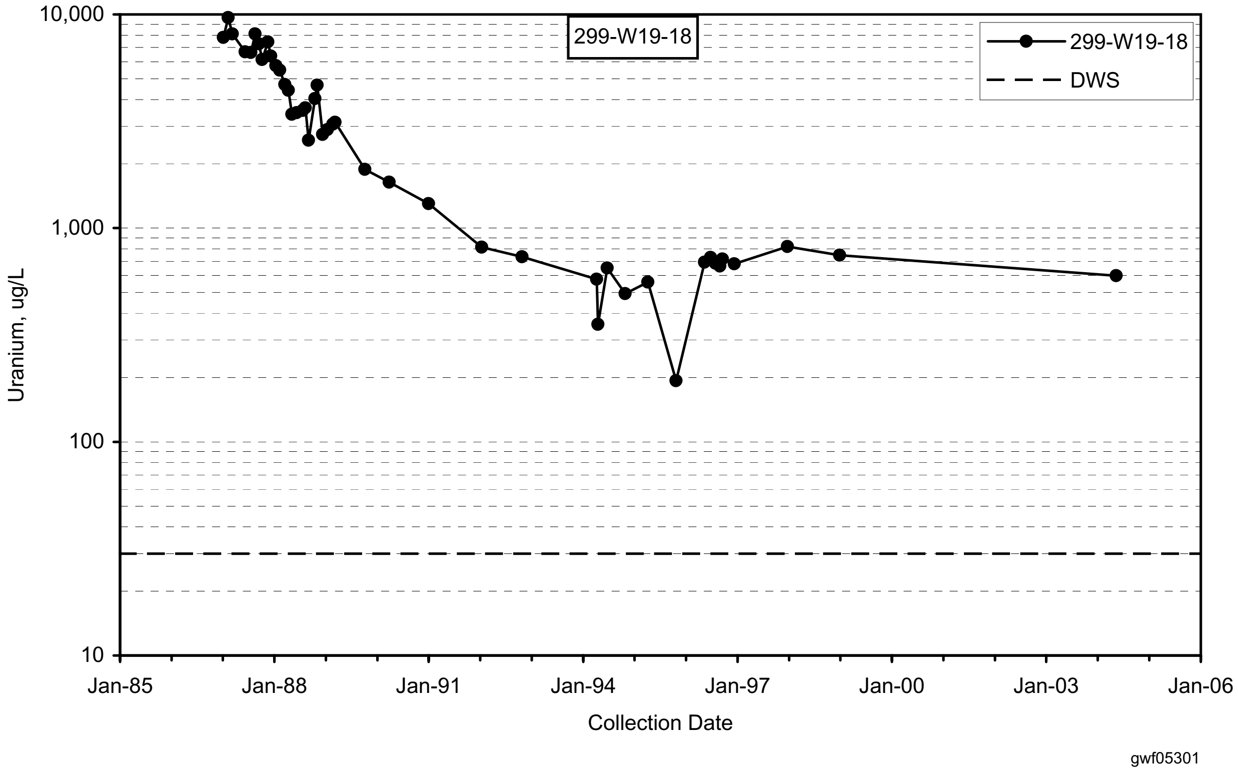

Figure 2.9-7. Uranium Concentrations in Well 299-W19-18 Near the 216-U-1,2 Cribs

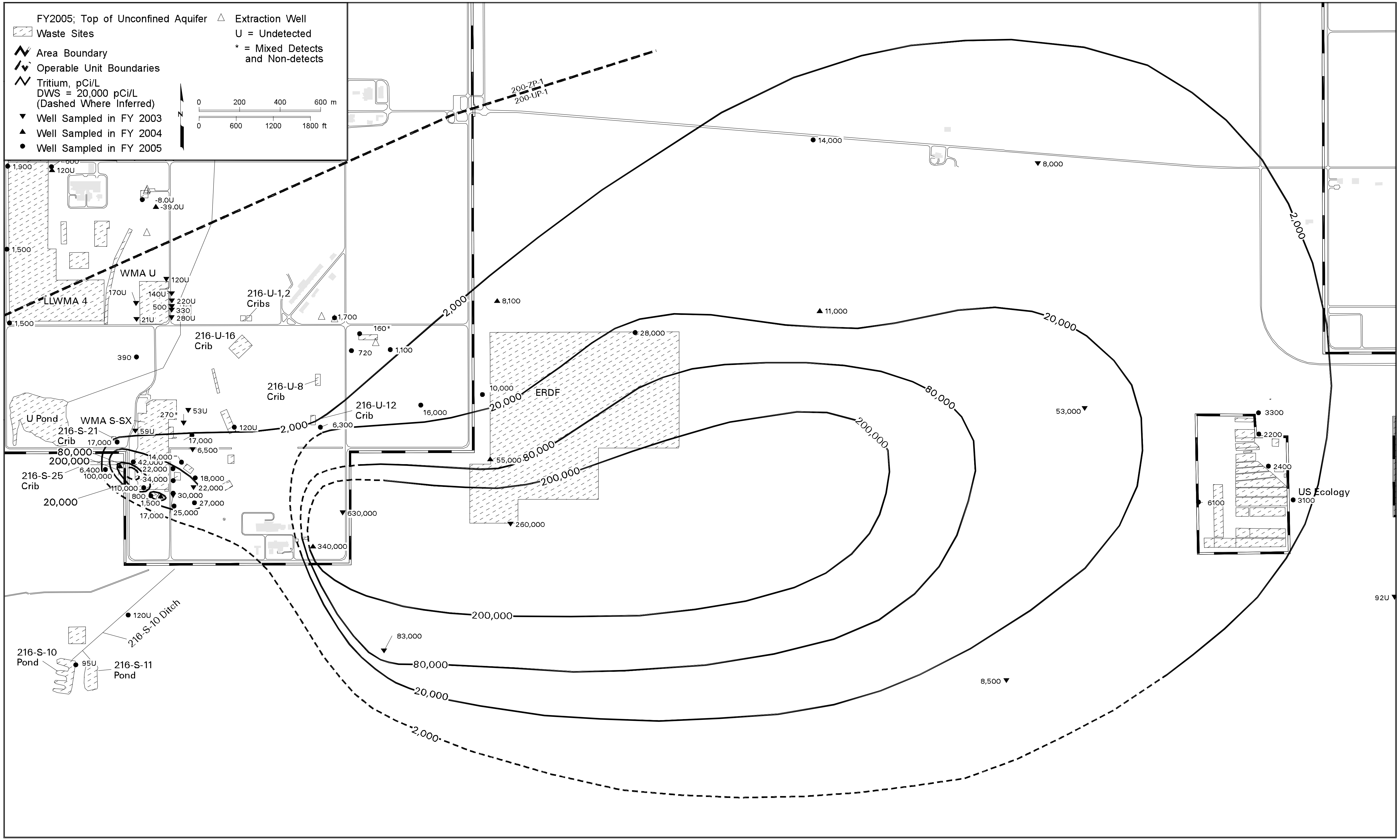

Figure 2.9-8. Average Tritium Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

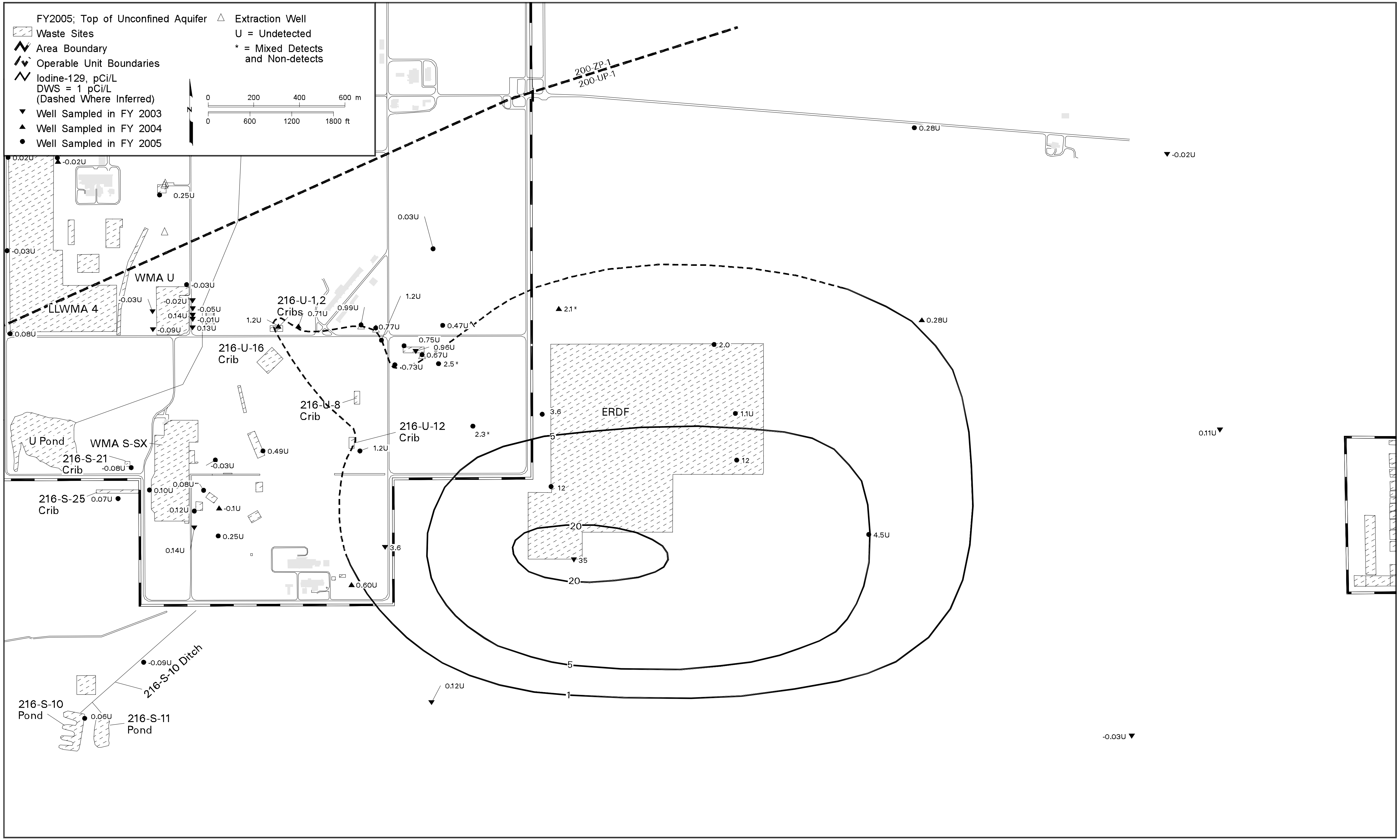

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Figure 2.9-9. Average Iodine-129 Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

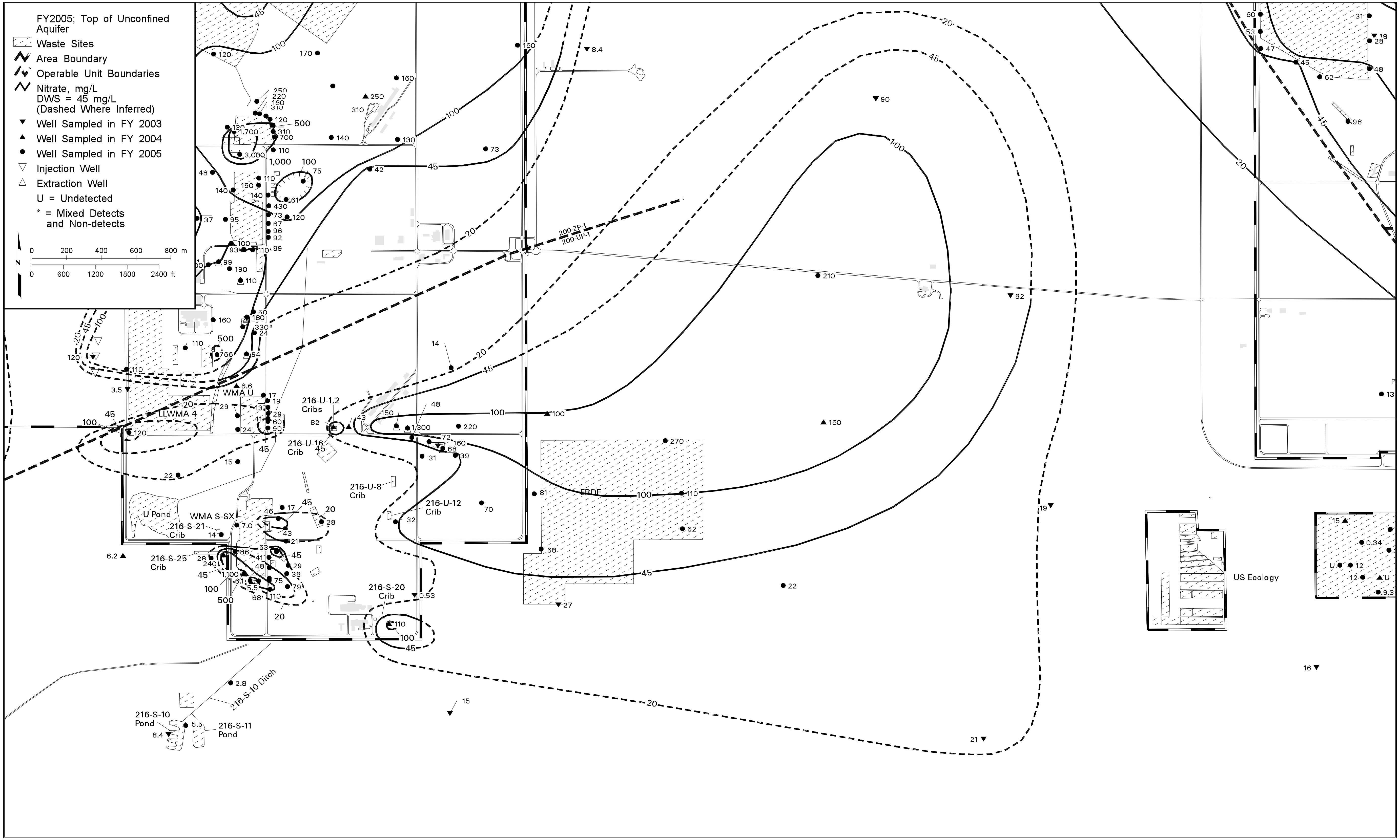

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Figure 2.9-10. Average Nitrate Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

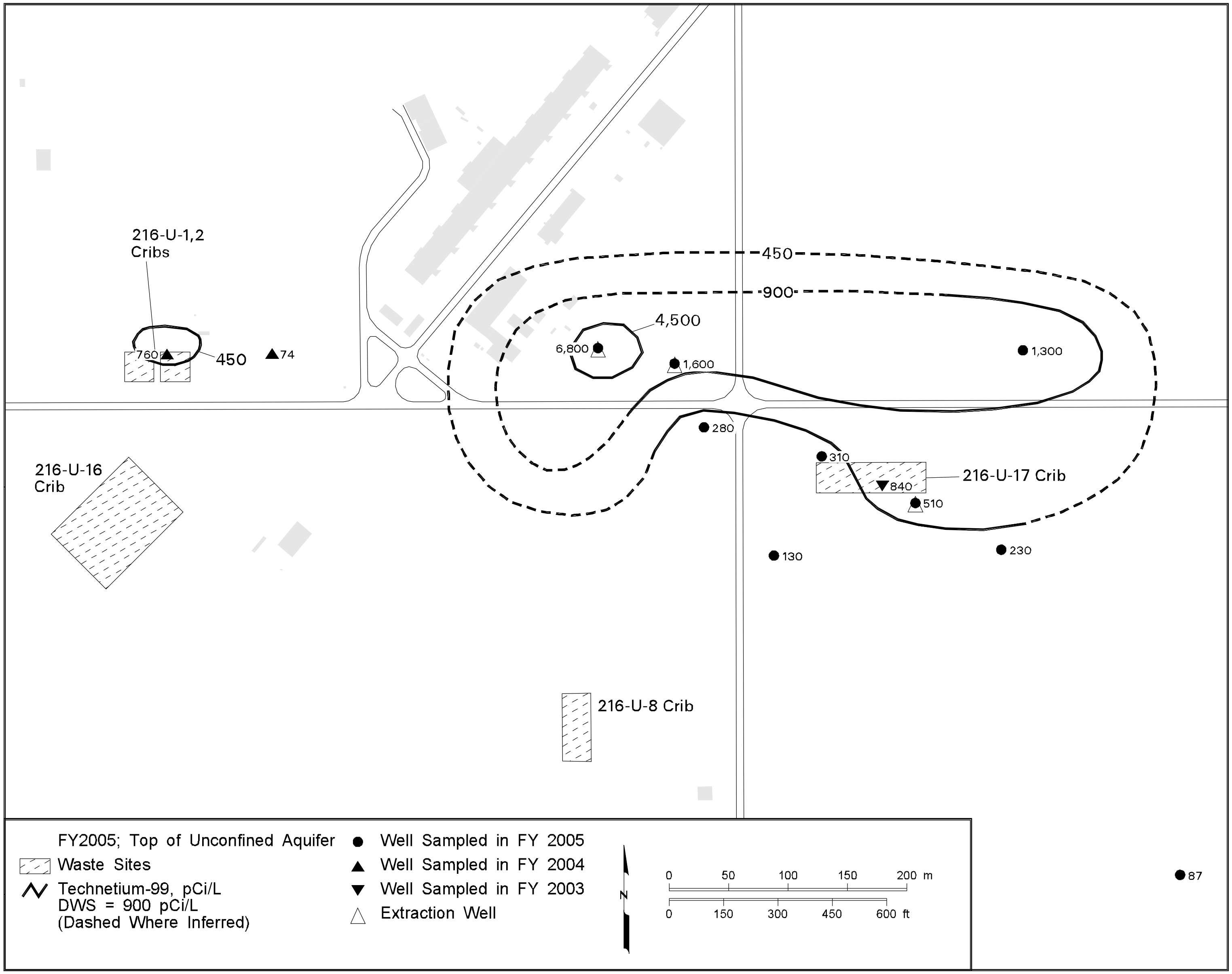

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Figure 2.9-11. Average Technetium-99 Concentrations in the 200-UP-1 Pump-and-Treat Area, Top of Unconfined Aquifer

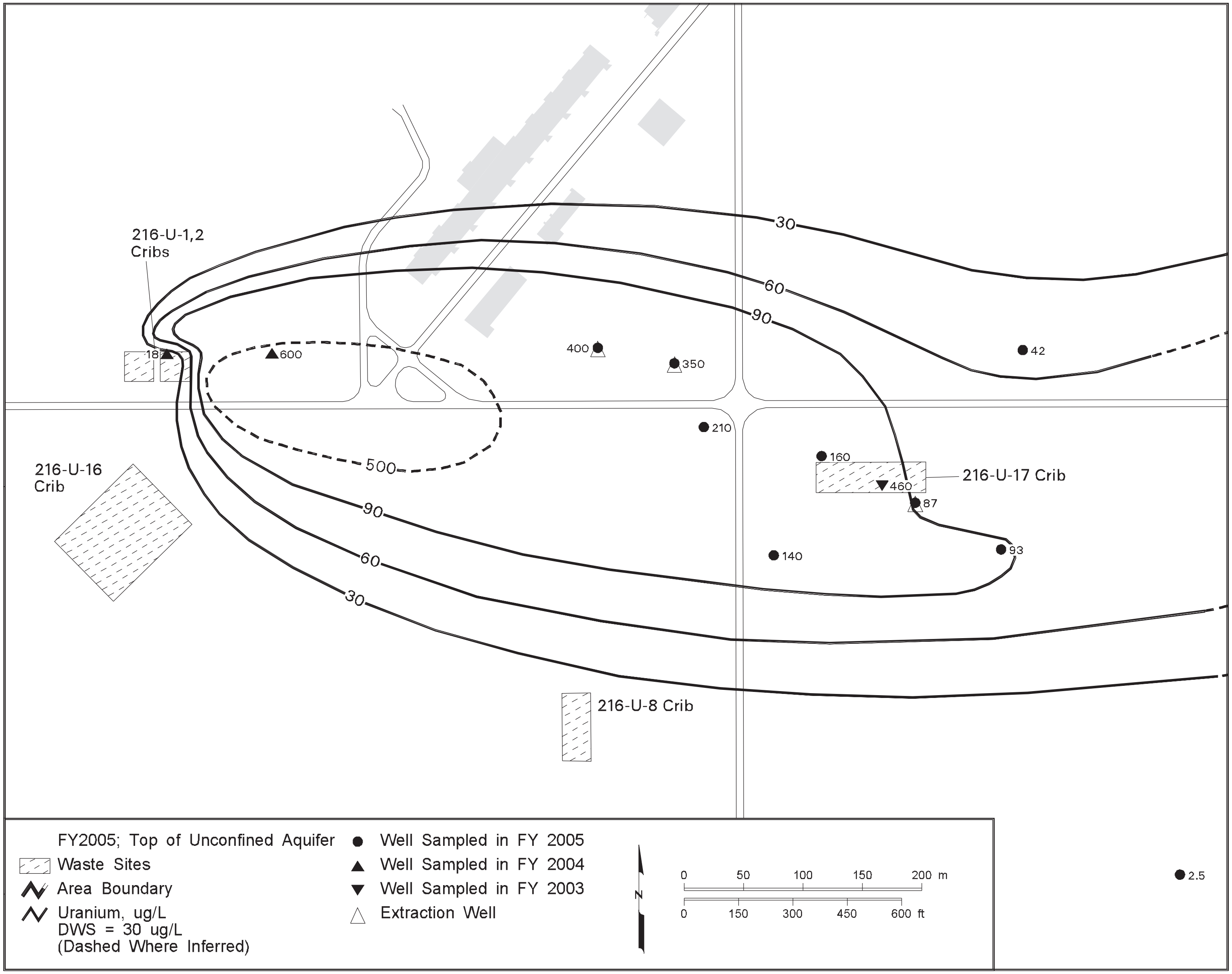

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Figure 2.9-12. Average Uranium Concentrations in the 200-UP-1 Pump-and-Treat Area, Top of Unconfined Aquifer

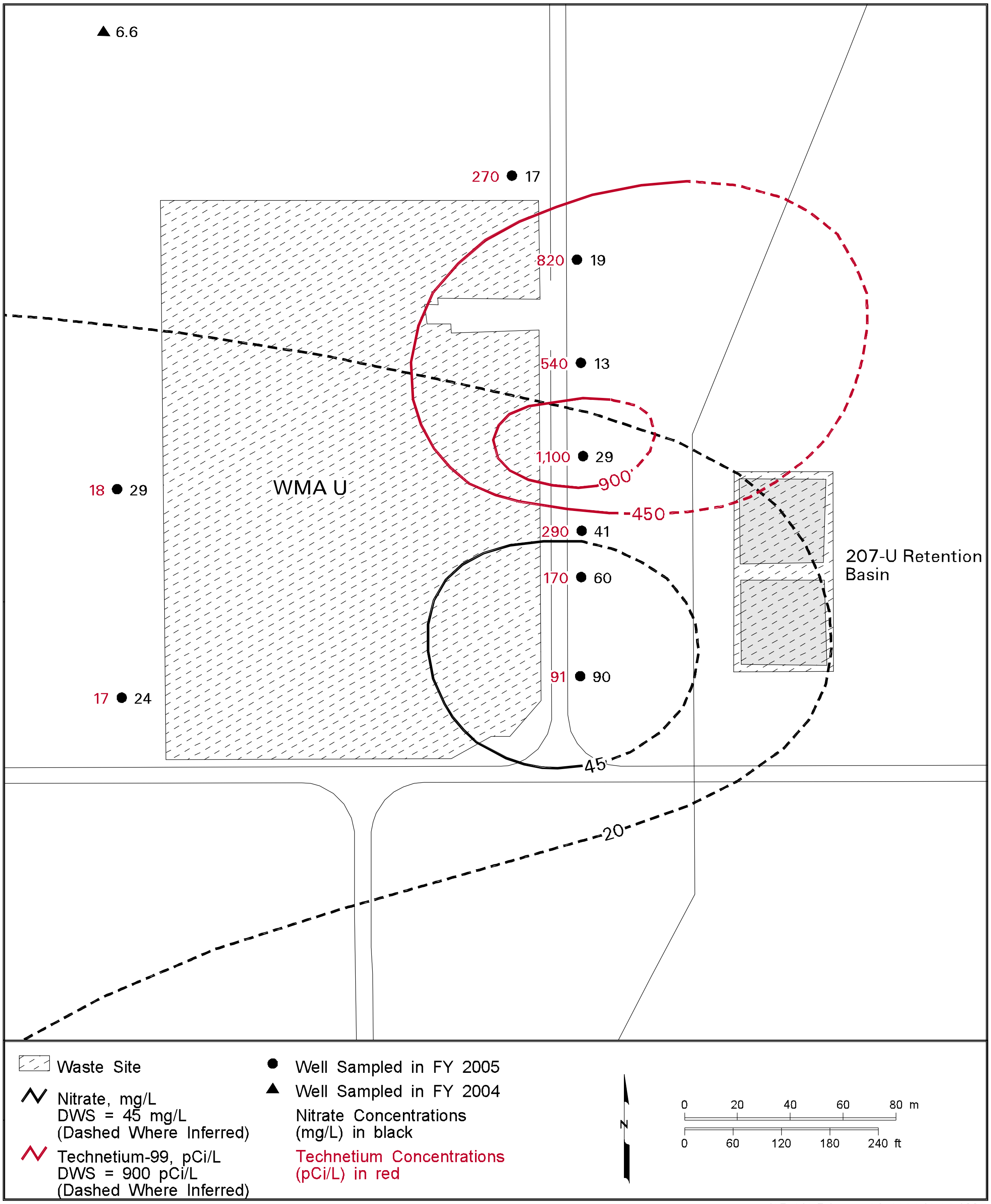

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Figure 2.9-13. Average Nitrate and Technetium-99 Concentrations at Waste Management Area U, Top of Unconfined Aquifer

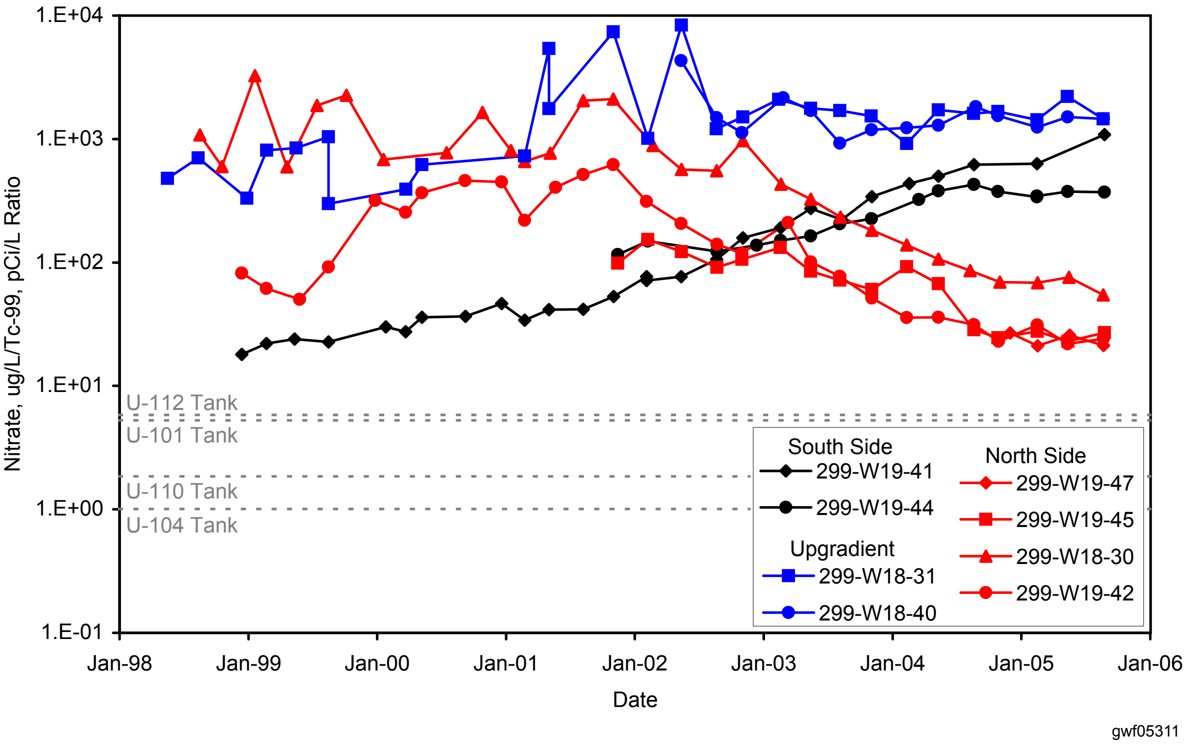

Figure 2.9-14. Nitrate:Technetium-99 Concentration Ratios in Selected Wells at Waste Management Area U

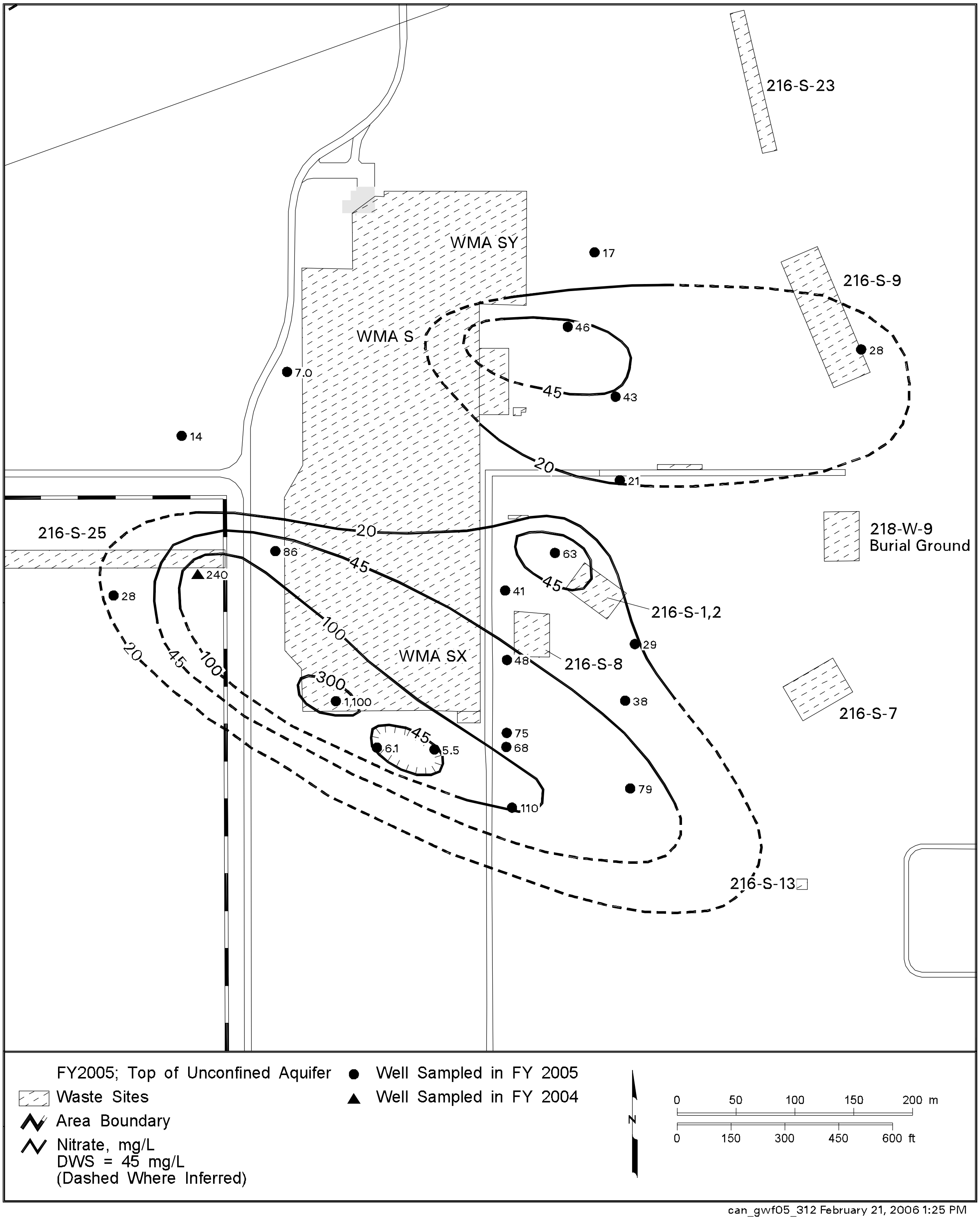

Figure 2.9-15. Average Nitrate Concentrations at Waste Management Area S-SX, Top of Unconfined Aquifer

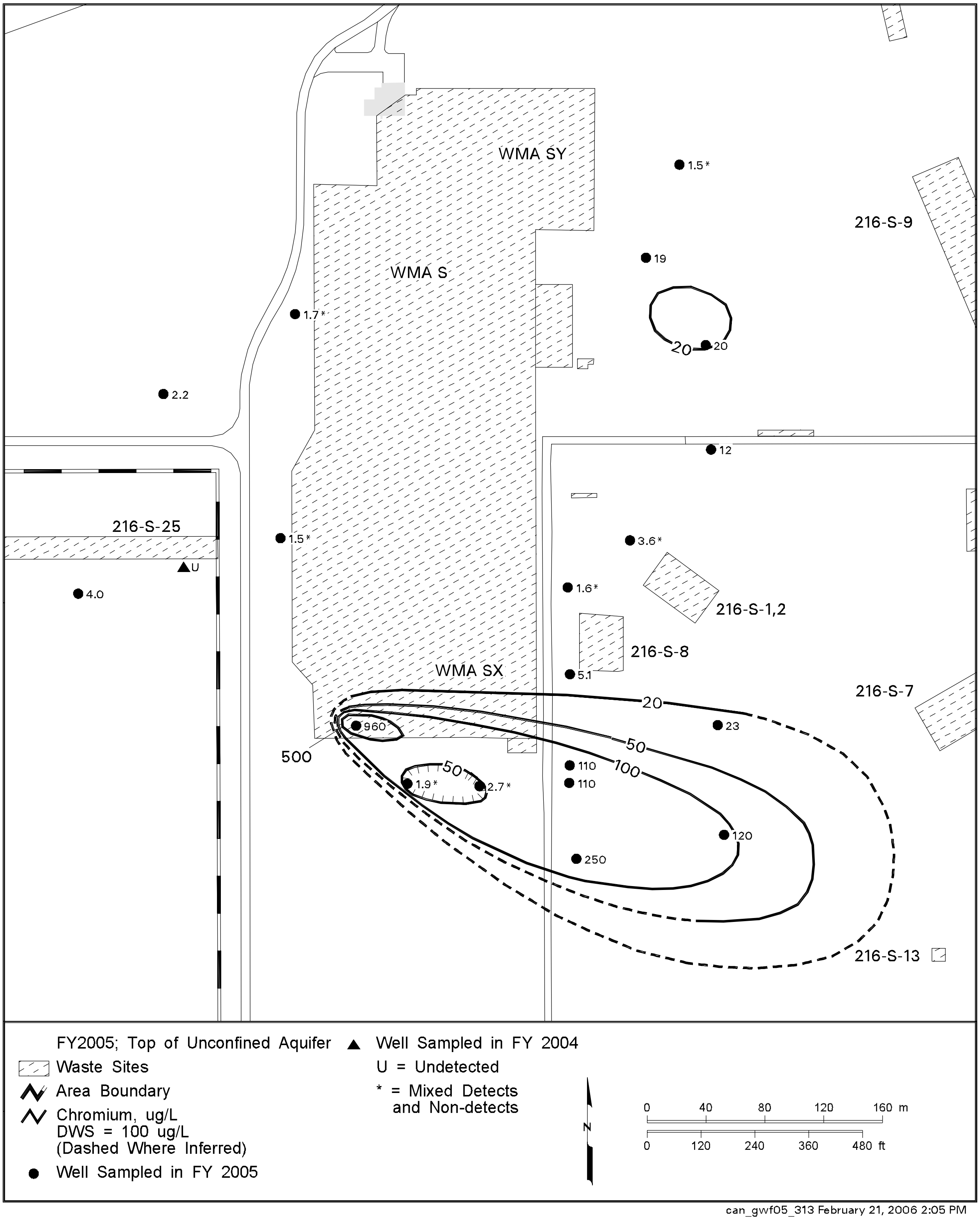

Figure 2.9-16. Average Chromium Concentrations at Waste Management Area S-SX, Top of Unconfined Aquifer

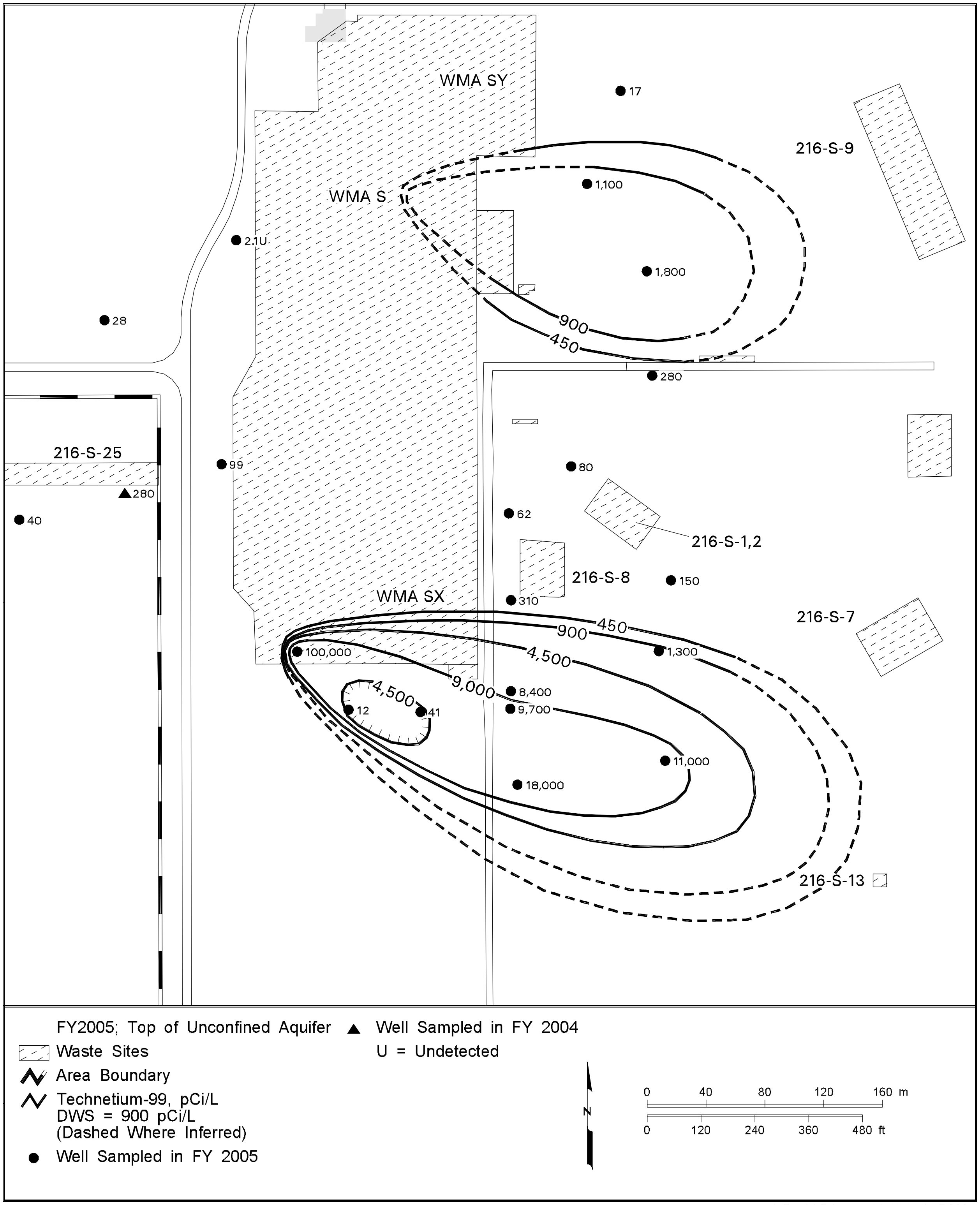

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Figure 2.9-17. Average Technetium-99 Concentrations at Waste Management Area S-SX, Top of Unconfined Aquifer

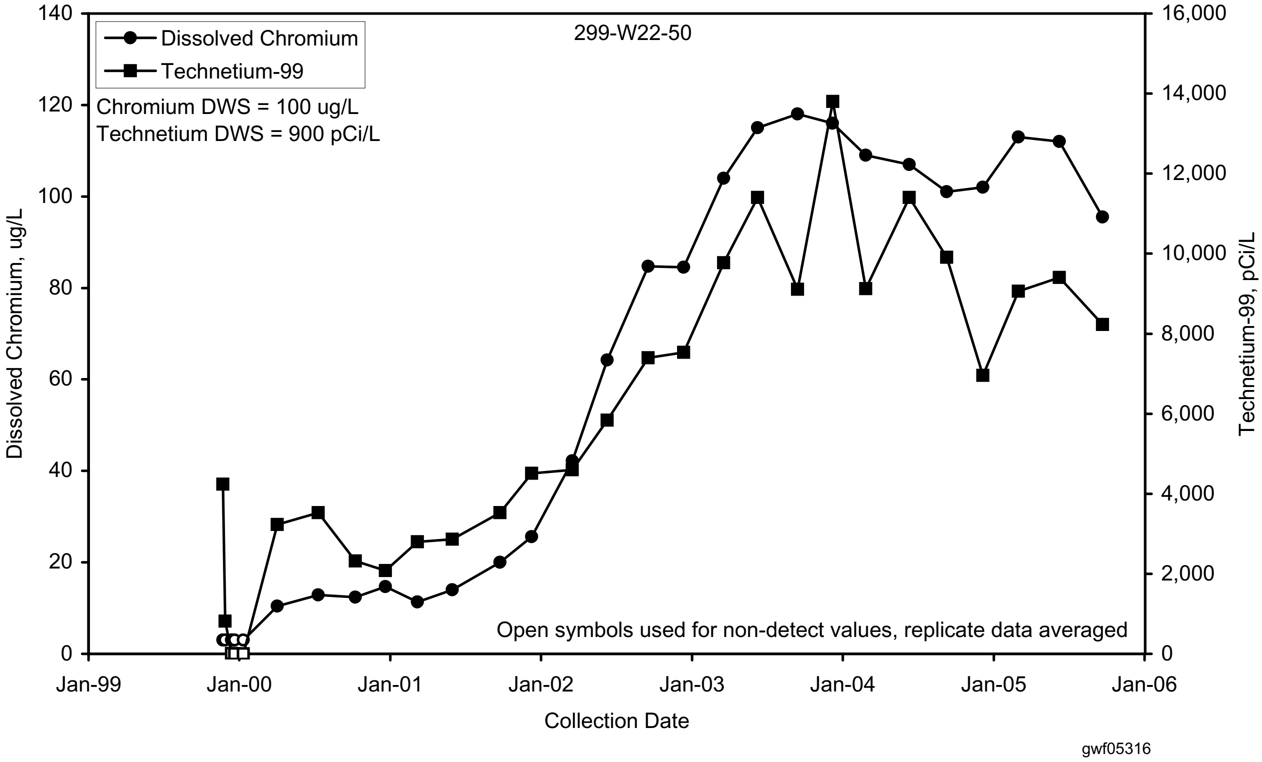


Figure 2.9-18. Chromium and Technetium-99 Concentrations in Well 299-W22-50 Near the Middle of a Plume Emanating from the South Portion of Waste Management Area S-SX

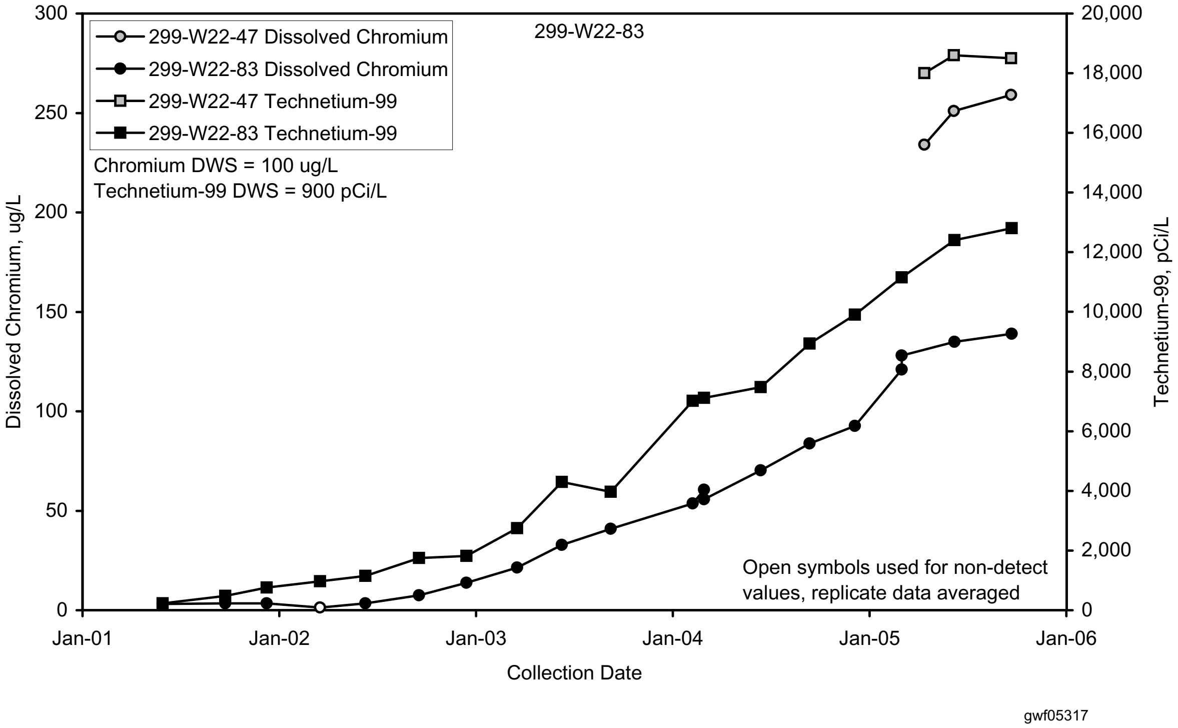


Figure 2.9-19. Chromium and Technetium-99 Concentrations in Well 299-W22-83 Near the Distal End of a Plume Emanating from the South Portion of Waste Management Area S-SX

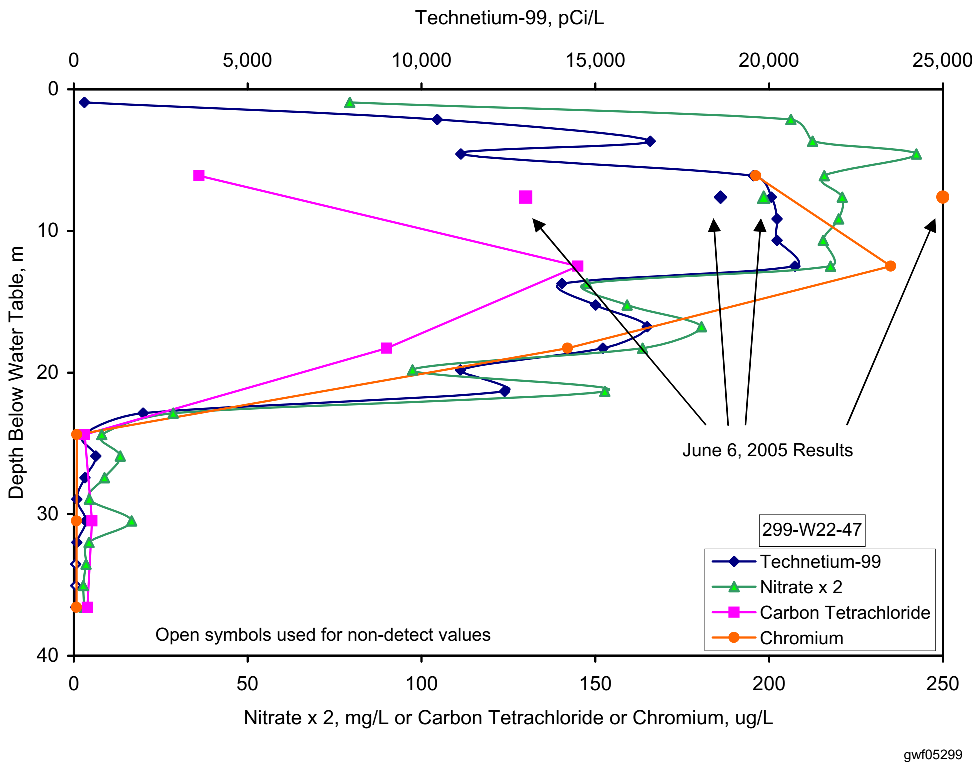


Figure 2.9-20. Carbon Tetrachloride, Nitrate, Technetium-99, and Chromium Concentrations in Well 299-W22-47 at Waste Management Area S-SX. Depth-discrete samples were collected during drilling between January 5, 2005, and January 21, 2005.

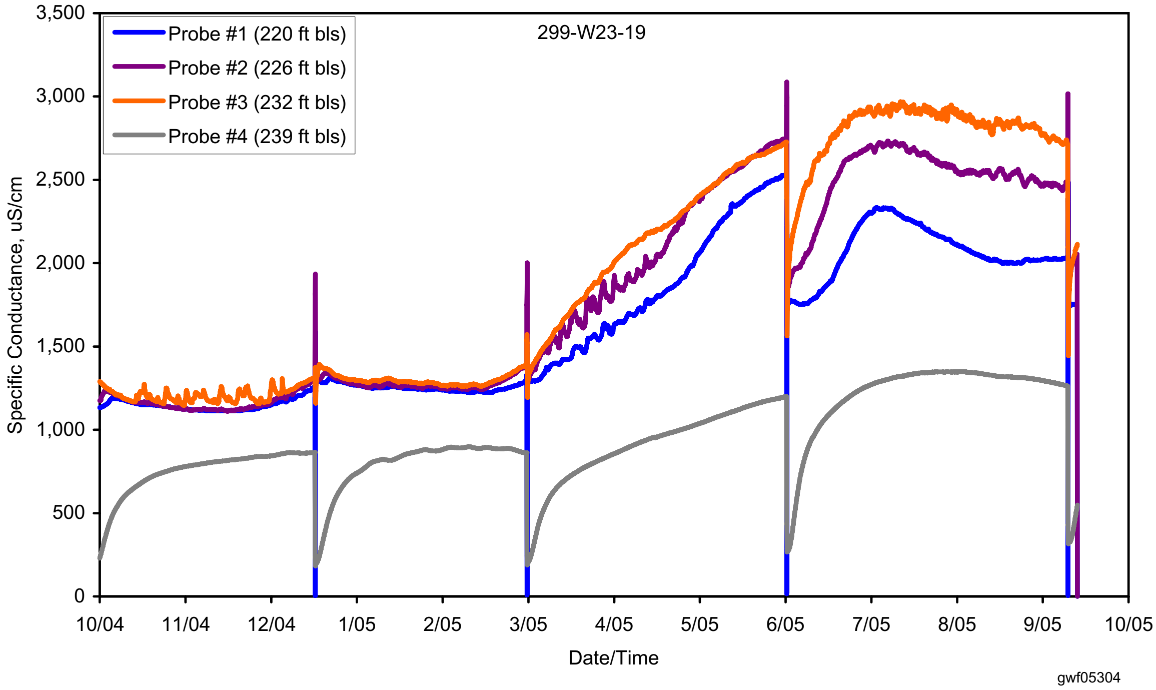


Figure 2.9-21. FY 2005 Wellbore-Fluid Specific Conductance Measurements Collected in Well 299-W23-19 at Waste Management Area S-SX (Data from probe #4 are shown for information purposes but are considered unreliable.)

2.10 200-BP-5 Operable Unit

E. C. Thornton, P. E. Dresel, S. M. Narbutovskih, and M. D. Sweeney

The scope of this section is the 200-BP-5 groundwater interest area, which includes the 200-BP-5 Operable Unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined groundwater interest areas to aid in planning, scheduling, and interpreting groundwater data. This operable unit includes several *Resource Conservation and Recovery Act* (RCRA) units and *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) past-practice sites in the north part of the 200 East Area and extends north to Gable Gap. Figures 2.10-1 and 2.10-2 show facilities and wells in this operable unit. The south part of the 200 East Area lies within the 200-PO-1 Operable Unit and is discussed in Section 2.11. The boundary between the two operable units is shown in Figure 2.10-1.

Technetium-99 is the contaminant of greatest concern in the 200-BP-5 Operable Unit.

Technetium-99 is the contaminant of greatest concern in the 200-BP-5 Operable Unit owing to its mobility and broad areal extent of contamination (DOE/RL-2001-49; PNNL-14049). Uranium, though more limited in terms of areal distribution, has also recently been recognized as an important contaminant of concern. Groundwater is monitored in this operable unit to define the regional extent of technetium-99, uranium, and other significant contaminants across the operable unit as well as the local extent of contamination associated with specific RCRA treatment, storage, and disposal units in the area.

The small differences in water-table elevation across the operable unit make it difficult to determine the direction of groundwater flow from water-table maps (see Figure 2.1-3 in Section 2.1). Groundwater currently entering the 200 East Area from the west divides and flows to the Columbia River along two separate paths: one to the southeast and one to the northwest through Gable Gap. The water table has been generally declining following the decrease in liquid effluent discharges to the soil in the 200 East Area. This appears to have resulted in changes in groundwater flow directions in the northwest part of the 200 East Area. The ability to describe current flow characteristics, however, is limited owing to the

Groundwater monitoring in the 200-BP-5 Operable Unit includes the following monitoring activities:

CERCLA and AEA Monitoring

- ***Wells are sampled annually to triennially for contaminants of concern and supporting parameters in the uppermost aquifer.***
- ***Six guard wells are sampled annually at Gable Gap.***
- ***Additional wells are sampled triennially in the upper basalt-confined aquifer (see Section 2.14).***
- ***Sampling of one well was delayed until October 2005 because of scheduling constraints; all other wells were sampled as scheduled (see Appendix A).***

Facility Monitoring

- ***Twenty-five wells are sampled quarterly to semiannually at Waste Management Area B-BX-BY.***
- ***Twelve wells are sampled quarterly to semiannually at the 216-B-63 trench.***
- ***Seventeen wells are sampled semiannually at Low-Level Waste Management Area 1.***
- ***Eleven wells are sampled semiannually at Low-Level Waste Management Area 2.***
- ***Two wells are sampled semiannually at the Liquid Effluent Retention Facility.***
- ***Nine wells are sampled quarterly at Waste Management Area C.***
- ***All RCRA wells were sampled as scheduled with the exception of two wells at Waste Management Area B-BX-BY (see Appendix B).***

low hydraulic gradients present. The extent of the basalt units above the water table also continues to increase due to the declining water table, resulting in an effect on groundwater flow in this area.

Techniques used to evaluate the direction of groundwater flow in the 200-BP-5 Operable Unit consist of detailed examination and interpretation of water-table maps, plume and contaminant trend plots, water-level trend surface analysis, water-level hydrographs for multiple wells, and in situ flow measurements at groundwater wells. These techniques have been applied extensively in an effort to understand the direction of groundwater flow around the RCRA units in the 200-BP-5 Operable Unit and are discussed in more detail later in Section 2.10.3. General inferences regarding groundwater flow direction based on plume configurations (especially tritium, nitrate, iodine-129, and technetium-99) are also discussed in Section 2.10.1.

Water-level measurements are generally made in March and are used to construct Hanford Site water-table maps. Small differences in water elevations make it difficult to define the water-table surface in 200-BP-5 Operable Unit; the change in water-level elevation is only ~4 centimeters across the 200 East Area. Significant sources of error in water-elevation measurements include changes in barometric pressure, borehole deviations from vertical, elevation survey errors, and instrument or operator errors. Rigorous quantitation of these errors has not been accomplished to date. In general, however, an ~10-centimeter range in water-level elevations is seen for wells not corrected for borehole deviation and ~5-centimeter range for those that have been corrected.

A set of water-elevation measurements were collected in July 2005, when the variation in barometric pressure was minimal. The results of this effort are presented in the water-table map shown in Figure 2.10-3. The map elevation contours suggest that there is a general low in water elevation trending in a northwest-southeast direction across the 200 East Area, which is consistent with the geometry of contaminant plumes in the region and also with the trend of high-permeability aquifer sediment. Significant uncertainty owing to possible errors besides barometric pressure effects, in particular borehole deviations from vertical, still make interpretation of water-level measurement results somewhat tenuous, however. Another collection of water-elevation measurements may be undertaken in July 2006. An ongoing effort to provide corrections to borehole deviation error will also continue. These activities may allow a more detailed interpretation of water-level information to be presented.

The upper basalt-confined aquifer is also monitored in the 200-BP-5 Operable Unit because of the potential for migration of contaminants from the overlying unconfined aquifer (Section 2.14). The basalt north of the 200 East Area was significantly eroded by late Pleistocene flooding, which may facilitate aquifer intercommunication. Discharge to overlying or underlying aquifers in the vicinity of the Gable Butte/Gable Mountain structural area, for example, may occur through erosional windows in the basalt where removal of the Elephant Mountain basalt has left a region of intercommunication between the Rattlesnake Ridge interbed aquifer and the unconfined aquifer. While the magnitude and extent of the window through Elephant Mountain member is not known, wells 699-55-60A and 699-53-55A (Figure 2.10-2) appear to have gone directly from the Hanford formation into the Rattlesnake Ridge during drilling (DOE/RL-2005-76).

Section 2.10.1 provides general information regarding geometry of contaminant plumes and concentration trends for contaminants of concern. Section 2.10.2 discusses aspects of groundwater monitoring specific to the 200-BP-5 Operable Unit. Specific information regarding contaminant distribution for RCRA units within the 200-BP-5 Operable Unit is presented in Section 2.10.3.

Plume areas (square kilometers) above the drinking water standard at the 200-BP-5 Operable Unit:

Iodine-129 — 4.34
Nitrate — 5.36
Strontium-90 — 0.72
Technetium-99 — 2.17
****Tritium — 0.95***
Uranium — 0.30

****Includes entire plume through Gable Gap and between 100-B/C and 100-K Areas.***

2.10.1 Groundwater Contaminants

This section describes the distribution of groundwater contaminants of concern in the 200-BP-5 Operable Unit. Specific information is provided for several CERCLA units (the 216-B-5 reverse well, BY cribs, and Gable Mountain Pond) as well as general information regarding regional contaminant distribution, particularly in the Gable Gap area. Contaminants of concern for this operable unit include tritium, uranium, iodine-129, technetium-99, cobalt-60, cyanide, strontium-90, cesium-137, plutonium-239/240, and nitrate (PNNL-14049).

Plume maps presented in this section are based on annual average values from wells completed at the top of the unconfined aquifer.

2.10.1.1 Tritium

Tritium contamination is widespread throughout the northwest part of the 200 East Area. The contamination extends north through the gap between Gable Mountain and Gable Butte and to the Columbia River and southeast through the 200-PO-1 Operable Unit (see Figure 2.1-5 in Section 2.1). Tritium contamination within the 200-BP-5 Operable Unit has declined greatly because of natural decay and dispersion (Figure 2.10-4). A number of waste disposal facilities in the 200 East Area have contributed to tritium contamination in the operable unit. Wells in the vicinity of the 216-B-5 injection well had concentrations of tritium below the drinking water standard in fiscal year (FY) 2005.

The tritium plume extends northward through Gable Gap.

Tritium at levels above the drinking water standard can be found between Gable Mountain and Gable Butte (see Figure 2.1-5 in Section 2.1) and indicates a preferential flow pathway through Gable Gap of the non-reactive tracer. Concentrations in monitoring well 699-61-62 in Gable Gap continued to decline with a measured value for FY 2005 of 17,000 pCi/L (Figure 2.10-5; see Figure 2.1-2 in Section 2.1 and Figure 2.10-2 for locations of 600 Area wells). Tritium concentrations in wells 699-60-60 (22,000 pCi/L) and 699-64-62 (16,000 pCi/L) also declined somewhat in FY 2005. Well 699-72-73, located between the 100-B/C and 100-K Areas, exceeded the drinking water standard in FY 2001, but tritium concentrations have subsequently declined and a value of 13,500 pCi/L was reported in FY 2005.

Tritium values increased for several years at the south end of Waste Management Area B-BX-BY, but may be starting to decline. The maximum tritium value in this region in FY 2004 was 19,900 pCi/L in well 299-E33-21, but a value of 14,800 pCi/L was reported in the second half of FY 2005 (Section 2.10.3.1).

2.10.1.2 Nitrate

A nitrate plume originating in the 200 East Area extends beyond the boundary fence line northwest toward the Columbia River (see Figure 2.1-6 in Section 2.1) and, like tritium, acts as a tracer delineating a preferential pathway through Gable Gap. The plume within the 200 East Area has two parts: (1) a west plume that extends through the west portion of Low-Level Waste Management Area 1 and (2) an east plume extending from the BY and surrounding cribs toward the northwest (Figure 2.10-6). The two plumes appear to join northwest of the 200 East Area and extend through the gap between Gable Butte and Gable Mountain to the Columbia River at levels less than the drinking water standard (45 mg/L).

The highest nitrate concentrations are in the vicinity of the BY and 216-B-8 cribs.

The west part of the nitrate plume, extending through the west portion of Low-Level Waste Management Area 1, appears to be part of a larger plume extending primarily from the Plutonium-Uranium Extraction (PUREX) facility in the 200-PO-1 Operable Unit. This plume apparently moved to the northwest under past flow conditions during the period of high discharge to 200 East Area facilities and B Pond.

The highest nitrate concentrations are in the vicinity of the BY and 216-B-8 cribs. High concentrations of nitrate are associated with the cobalt-60, cyanide, and technetium-99 plume originating from the BY cribs (PNNL-13080). The highest nitrate concentrations measured in FY 2005, were found in well 299-E33-4 (1,600 mg/L), near the BY cribs. This well is nearly dry and, thus, may not be representative of general aquifer conditions. The highest value for nitrate associated with the 216-B-8 crib during FY 2005 was a concentration of 630 mg/L reported for well 299-E33-16.

Nitrate continued to be detected in wells monitoring Gable Mountain Pond at levels above the drinking water standard (see Figure 2.1-6 in Section 2.1). In FY 2005, a nitrate value of 91 mg/L was measured in well 699-53-47A and a value of 210 mg/L in well 699-53-48A (Figure 2.10-7).

2.10.1.3 Iodine-129

Iodine-129 contamination is present throughout the 200-BP-5 Operable Unit. Like the tritium plume, the iodine-129 plume extends to the northwest toward the Gable Mountain/Gable Butte gap and southeast through the 200-PO-1 Operable Unit (see Figure 2.1-7 in Section 2.1). Unlike tritium, however, levels greater than the iodine-129 drinking water standard (1 pCi/L) have not passed beyond the gap between Gable Mountain and Gable Butte. A band of elevated iodine-129 concentrations (~5 pCi/L) has been present in Waste Management Area B-BX-BY but wells in this area reported <5 pCi/L during FY 2005 (Figure 2.10-8). Interpretation of the iodine-129 configuration in this area is complicated by elevated detection limits that result from laboratory analytical issues. In addition, the current laboratory reporting system produced some values reported as not detected at levels greater than the drinking water standard (1 pCi/L) (Appendix C).

2.10.1.4 Technetium-99

A plume of technetium-99 extends from the area of the BY cribs to beyond the north boundary of 200 East Area. The plume has moved through Gable Gap at levels below the drinking water standards.

A plume of technetium-99 extends from the area of the BY cribs and Waste Management Area B-BX-BY to the northwest (Figure 2.10-9). A significant portion of the plume is north of the 200 East boundary and is interpreted to represent early releases of technetium-99 from the BY cribs (PNNL-13080), but technetium-99 may also have been contributed by tanks or other cribs. Detection of technetium-99 at levels lower than the drinking water standard (900 pCi/L) north of the gap between Gable Mountain and Gable Butte indicates that technetium-99 has moved north into, and through, the gap.

There is considerable uncertainty about the extent of technetium-99 contamination. Technetium-99 was not routinely measured in groundwater prior to the late 1980s, limiting the information on historical trends. In addition, well coverage is limited. Interpretation of the exact configuration and extent of the technetium-99 plume north of the 200 East Area is also complicated by the variable concentrations seen in wells that are relatively close together (see Figure 2.1-2 in Section 2.1 and Figure 2.10-2 for 600 Area well locations). For example, concentrations of technetium-99 less than the drinking water standard have been consistently detected in well 699-49-55A since the early 1990s (16 pCi/L in FY 2001, 249 pCi/L in FY 2004, and 46 pCi/L in FY 2005). This well was used as the injection well in 1995 for pump-and-treat operations and has had low technetium-99 values relative to nearby wells since then (Figure 2.10-9).

Seven wells were successfully sampled in the Gable Gap area north of the 200 East Area boundary in FY 2005 (Figure 2.10-9). Concentrations of technetium-99 were generally similar for FY 2004 and 2005. Concentrations in well 699-49-57A increased from the mid-1990s to 2003 and have remained flat since then (Figure 2.10-10). A new well, 699-50-59, was installed in late FY 2005 (Figure 2.10-2) (DOE/RL-2005-76). Technetium-99 data obtained by sampling of this well in FY 2006 is anticipated to improve our understanding of the distribution of this contaminant in the vicinity of Gable Gap.

In the late 1990s, rising technetium-99 concentrations were seen in the BY crib area in wells 299-E33-7 and 299-E33-38 (Figure 2.10-10). In early 1999, the trends for both wells began to track together and reached an apparent maximum in late 2000. These trends are thought to reflect arrival of contamination from the vadose zone at the BY cribs and relatively recent breakthrough into the saturated zone. In particular, high concentrations of technetium-99 in well 299-E33-38 (average of 12,300 pCi/L in FY 2005) and well 299-E33-4 (average of 19,000 pCi/L in FY 2005) suggest a continuing source of contamination from the vadose zone to groundwater. A general correlation of concentration trends for technetium-99, nitrate, cobalt-60, iron, and cyanide in wells 299-E33-7 and 299-E33-38 and local distribution of these constituents suggests that the primary source of technetium-99 contamination was related to past discharges of ferrocyanide containing waste to the BY cribs (PNNL-13080; PNNL-14049).

2.10.1.5 Cobalt-60 and Cyanide

Cobalt-60 and cyanide continued to be detected in a number of wells in the 200-BP-5 Operable Unit. Cobalt-60 has a relatively short half-life (5.3 years) and is generally found at levels less than the drinking water standard (100 pCi/L). Cyanide is found at levels above the drinking water standard (200 µg/L). These constituents are useful for distinguishing contaminant groups and contaminant sources and were generally associated with ferrocyanide waste streams generated by uranium scavenging operations conducted during the mid-1950s. Thus, cyanide and cobalt-60 are generally found together in this area.

The maximum cyanide concentration in this area in FY 2005 was 859 µg/L from well 299-E33-4 located in the north part of the BY cribs. Well 299-E33-38, located in the south part of the cribs, had a maximum cyanide value of 341 pCi/L in FY 2005. Cyanide contamination trends in wells located at the BY cribs are similar to those of technetium-99, cobalt-60, and nitrate and may be related to past discharges of ferrocyanide waste to the BY cribs (PNNL-13080; PNNL-14049).

The highest cobalt-60 values in FY 2005 also were detected in wells monitoring the BY cribs, and the cribs are believed to be the source of this contamination. The highest cobalt-60 concentration in FY 2005 was in well 299-E33-4 (200 pCi/L) located in the north part of the BY cribs. Well 299-E33-38, located in the south part of the cribs, had a maximum cobalt-60 value of 41.6 pCi/L in FY 2005.

2.10.1.6 Uranium

Uranium contamination in the 200-BP-5 Operable Unit is limited to three isolated areas:

- Wells monitoring Waste Management Area B-BX-BY and BY cribs.
- Wells near the 216-B-5 injection well.
- Wells 299-E28-21 and 299-E28-18 at the 216-B-62 crib.

Wells in all three of these areas exceeded the drinking water standard (30 µg/L) during FY 2005.

Waste Management Area B-BX-BY. The body of evidence indicates that the source for the large uranium groundwater plume in the 200 East Area is from Waste Management Area B-BX-BY. This is based on both the geophysical logging data showing a cluster of high uranium readings in boreholes adjacent to the BX Tank Farm and isotope analysis showing strong similarities between the uranium in the groundwater plume and the BX-102 overfill (PNNL-14187; Christensen et al. 2004). The uranium from the overfill event likely migrated laterally through the vadose zone to the water table. The highest uranium concentrations reported for the 200-BP-5 Operable Unit during the last several years occur within and to the east of the BY Tank Farm (Figure 2.10-11). The contamination is present in a narrow northwest-southeast band. Uranium concentrations have been increasing rapidly in well 699-49-57A in the last several years (11.9 µg/L reported in FY 2005), suggesting that the plume is migrating to the northwest toward the Gable Gap area (Figure 2.10-12). In FY 2005, the highest average uranium concentrations were detected in wells 299-E33-18 (370 µg/L), 299-E33-38 (320 µg/L), and 299-E33-44 (250 µg/L). The maximum reported concentration in FY 2005 was 454 µg/L in well 299-E33-18. Section 2.10.3.1 includes additional discussion

Uranium contamination in the 200-BP-5 Operable Unit is limited to three isolated areas: Waste Management Area B-BX-BY and surrounding cribs, 216-B-5 injection well, and 216-B-62 crib.

of uranium at Waste Management Area B-BX-BY. The lack of uranium in groundwater in the northern part of the BY cribs suggests that the uranium sources are distinct from the source of the majority of the technetium-99.

216-B-5 Injection Well. Uranium contamination is associated with the cesium-137, plutonium, and strontium-90 contamination found at the former 216-B-5 injection well (Figure 2.10-11). The highest uranium concentration detected in FY 2005 at this site was 59.2 μg/L in well 299-E28-23, located only ~1 meter from the injection well. Uranium concentrations are roughly stable in well 299-E28-23. Uranium values were significantly lower in wells 299-E28-24 (18.8 μg/L) and 299-E28-25 (14.6 μg/L) located farther from the injection well. During FY 2005, a uranium value of 36.0 μg/L was reported for well 299-E28-6, located south of the injection well. Uranium concentrations have been generally declining in well 299-E28-6. It is not known if the source of uranium contamination in this well is the 216-B-5 injection well.

216-B-62 Crib. Uranium was detected consistently at levels slightly above the drinking water standard (30 μg/L) in wells monitoring the 216-B-62 crib, located northwest of B Plant (Figure 2.10-11). Uranium concentrations were over 200 μg/L in the mid-1980s, but declined to current levels by the early 1990s. The maximum FY 2005 uranium concentration at the 216-B-62 crib was 32.4 μg/L reported for well 299-E28-18. Uranium also has been found along the west side of Low-Level Waste Management Area 1, but no wells exceeded the drinking water standard in FY 2005. The uranium detected near Low-Level Waste Management Area 1 may have originated at the 216-B-62 crib or its predecessor, the 216-B-12 crib.

Wells near the 216-B-5 injection well have elevated concentrations of low-mobility contaminants including cesium-137, plutonium, and strontium-90.

2.10.1.7 Cesium-137 and Strontium-90

Cesium-137 and strontium-90 have relatively low mobility and are generally found near their source. Several wells near the 216-B-5 injection well have had elevated concentrations of strontium-90. Four wells (299-E28-2, 299-E28-23, 299-E28-24, and 299-E28-25) had concentrations of strontium-90 above the drinking water standard (8.0 pCi/L) in FY 2005. Two of the wells have had strontium-90 concentrations greater than the U.S. Department of Energy (DOE) derived concentration guide (1,000 pCi/L) in past years and in FY 2005 (Figure 2.10-13). The highest strontium-90 concentration was reported for well 299-E28-23, with a value of 3,900 pCi/L in FY 2005. Strontium-90 also exceeded the DOE derived concentration guide in well 299-E28-25, with a value of 1,960 pCi/L reported in FY 2005.

Well 299-E28-23 near the 216-B-5 injection well has consistently had concentrations of cesium-137 greater than the drinking water standard (200 pCi/L) but less than the DOE derived concentration guide (3,000 pCi/L). In FY 2005, a value of 663 pCi/L was reported for this well, which exhibits a generally declining trend. All other wells sampled at this site had cesium-137 concentrations below the drinking water standard in FY 2005.

In several wells near Gable Mountain Pond, strontium-90 concentrations rose in the 1990s and have declined since 2000 but remain above the drinking water standard (Figures 2.10-14 and 2.10-15). Strontium-90 was detected in groundwater at levels above the DOE derived concentration guide in the only well that was sampled at Gable Mountain Pond in FY 2000 (well 699-53-47A), but was below the guide in FY 2003, 2004, and 2005. The concentration in samples from that well was 649 pCi/L in FY 2005 (Figure 2.10-15). Well 699-53-48A sampling indicated an apparent increase in strontium-90 in FY 2005, however, with a reported value of 741 pCi/L versus a value of 288 pCi/L in FY 2004 (Figure 2.10-15).

2.10.1.8 Plutonium

Plutonium-239 and plutonium-240 were detected in past years in samples taken from several wells near the 216-B-5 injection well. Plutonium contamination is relatively immobile and, therefore, is found only near the injection well. The highest reported plutonium concentration in FY 2005 was for well 299-E28-23, which had a filtered value of

6.68 pCi/L and an unfiltered value of 19.4 pCi/L, which are both below the DOE derived concentration guide for plutonium (30 pCi/L). The lower concentration in the filtered versus unfiltered samples suggests that a portion of the plutonium is associated with particulates. The concentration of plutonium in well 299-E28-23 has not exhibited a clear change in trend in recent years. Other wells sampled near the 216-B-5 injection well site have also had plutonium levels below the DOE derived concentration guide in recent years.

2.10.2 Operable Unit Monitoring

CERCLA monitoring requirements in the 200-BP-5 Operable Unit have been defined in the sampling and analysis plan (DOE/RL-2001-49). The sampling and analysis plan was revised in late FY 2004 to integrate *Atomic Energy Act* (AEA) monitoring and make slight modifications in the 200-BP-5 monitoring network. The revised monitoring plan was implemented in FY 2005. CERCLA monitoring includes sampling of the regional plumes, 216-B-5 injection well site, BY cribs, and Gable Mountain Pond. Results of monitoring are discussed in Section 2.10.1. An interim or final record of decision has not been established yet for the 200-BP-5 Operable Unit. This report is the only formal report presently being prepared on a regular basis for the unit.

CERCLA monitoring in the 200-BP-5 Operable Unit includes sampling of the regional plumes, 216-B-5 injection well site, BY cribs, and Gable Mountain Pond.

The 200-BP-5 monitoring network and analytes are listed in Appendix A. In FY 2005, sampling was planned for 60 wells. Of these, 59 wells were successfully sampled during FY 2005. Well 699-47-60, however, could not be sampled until October 2005 because of scheduling constraints.

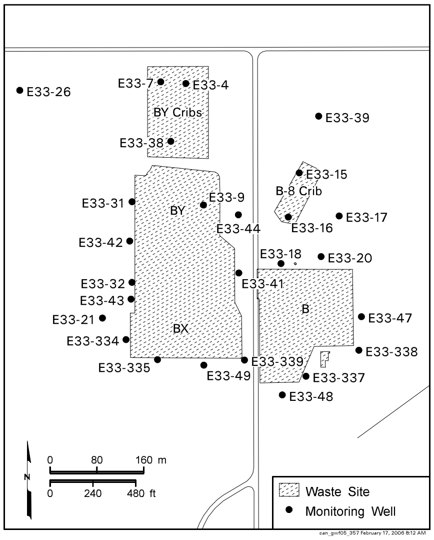
A new well, 699-50-59, was installed in late FY 2005 south of Gable Gap (Figure 2.10-2). This well was installed on the west margin of the technetium-99 plume and should serve to better define plume extent and geometry. Installation of the new well in this area is also important from a hydrogeological standpoint because it will provide information regarding groundwater flow (based on the gradient of the water table). Data obtained during drilling of this well has served to better define the elevation of the top of the basalt in this area and the geometry of the anticlinal structure in the gap. The latter information is needed to support predictions of future groundwater flow and contaminant migration through Gable Gap. The aquifer is thin at this location (~0.6 meter saturated zone above basalt), but good flow rates were achieved during well development activities.

2.10.3 Facility Monitoring

This section describes results of monitoring at individual units such as treatment, storage, and disposal units or tank farms. Some of these facilities are monitored under the requirements of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 2.1, 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 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.

The 200-BP-5 Operable Unit contains six RCRA sites with groundwater monitoring requirements: Waste Management Area B-BX-BY, 216-B-63 trench, Low-Level Waste Management Areas 1 and 2, Liquid Effluent Retention Facility, and Waste Management Area C. This section summarizes results of statistical comparisons, assessment studies, and other developments for FY 2005. Groundwater data are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

2.10.3.1 Waste Management Area B-BX-BY



The B, BX, and BY Tank Farms, located in the northwest part of the 200 East Area and consisting of single-shell tanks along with ancillary waste transfer lines and diversion boxes, comprise Waste Management Area B-BX-BY. The waste management area is monitored under the requirements of RCRA, CERCLA, and AEA. The site was placed in a RCRA groundwater quality assessment program in 1996 (40 CFR 265.93(d) as referenced by WAC 173-303-400) when specific conductance at a downgradient well became elevated above the critical mean. In a first determination assessment report (PNNL-11826), published in 1998, it was shown that residual waste in the vadose zone related to an overfill at tank BX-102 in 1951 had, most likely, been driven to the groundwater close to well 299-E33-41 by recent fresh water flooding from leaking water lines. Based on 40 CFR 265.93(d) paragraph (7), the site must continue in quarterly monitoring to determine contaminant levels and the rate/extent of migration until final facility closure (PNNL-11826).

RCRA wells close to the waste management area boundaries were sampled quarterly to assess the rate and extent of groundwater contamination associated with Waste Management Area B-BX-BY (Appendix B). One exception is well 299-E33-9, located in the BY Tank Farm. This well has not been sampled since March 2004 because of limited tank farm access related to health concerns. This well has marked the highest concentration of a uranium plume with a maximum value of 678 μg/L in FY 2001. Well 299-E33-4 also was not sampled as scheduled in August 2005. Outlying wells were sampled semiannually to annually to provide groundwater data under surrounding past-practice liquid effluent disposal facilities. These data help distinguish non-tank farm sources that may have affected groundwater quality from tank-related sources. Radionuclides are monitored under CERCLA and AEA at the site. Appendix B includes a well location map, a list of wells, and the constituents monitored for Waste Management Area B-BX-BY.

In summary, assessment studies have identified several distinct groups of contaminants based on chemical associations. A brief description of these contaminants groups is provided in the following paragraphs (for a more complete discussion, see PNNL-15070; PNNL-13116; PNNL-14187; PNNL-14548; PNNL-SA-39825; PNNL-13788):

Assessment studies at Waste Management Area B-BX-BY have identified several distinct groups of contaminants.

- ***Technetium-99, nitrate, sulfate, uranium, and nitrite***. These contaminants are centered under and southeast of the BY Tank Farm. Technetium-99, nitrate, and uranium are found above the drinking water standard of 900 pCi/L, 45 mg/L, and 30 μg/L, respectively. Although this area has the highest levels of uranium in the 200 East Area, the concentrations of co-varying mobile contaminants are not the highest levels seen in the area. Until recently, this is the only area that has had elevated nitrite, but it is now also observed to the east in well 299-E33-16 (PNNL-13788; PNNL-14187; PNNL-SA-39825). Past leaks of processing waste from the tank farms have left contaminated soil under the farms, which are most likely a source of groundwater contamination. Further assessment of these contaminants is ongoing.
- ***Tritium***. This contaminant is found on the southwest corner and along the south border of the waste management area and is part of a linear trend extending to the northwest and southeast. The tritium concentration increased from the local background value of ~1,800 pCi/L to over 16,000 pCi/L in seven wells at nearly the same time beginning in early 1999. The sharply rising trends indicate the wells are close to the area where the tritium is entering the groundwater (see Figure 2.10-12 in PNNL-15070). Movement through the vadose zone from a perched water table with elevated tritium located ~4.5 meters above the water table under the BX Tank Farm is, most likely, the source

of this contamination. The tritium in this perched water table may be related to tank condensate from the B evaporator and from liquids that came from the tanks and were diverted to holding tanks. These waste streams were discharged to the B-50 and B-57 cribs.

- ***Technetium-99, nitrate, sulfate, cobalt-60, and cyanide***. These contaminants, found under and around the BY cribs, comprise the bulk of the contamination in the groundwater near Waste Management Area B-BX-BY. High levels of technetium-99 (23,100 pCi/L), nitrate (1,590 mg/L), tritium (118,000 pCi/L), cyanide (859 µg/L), sulfate (520 mg/L), and cobalt-60 (200 pCi/L) continue to be found in the groundwater under the BY cribs. These contaminants are attributed to residual waste in the vadose zone associated with the original discharges of uranium recovery waste to the BY cribs in the mid-1950s.
- ***Nitrate and technetium-99***. Located under the 216-B-8 crib is another unique group of contaminants. Until recently, this was the location of the maximum nitrate concentration (695 mg/L in November 2000) found in the area. In FY 2005, however, there were three distinct locations for high nitrate: well 299-E33-34, the BY cribs, and the 216-B-8 cribs. Groundwater in the vicinity of the 216-B-8 crib lacks the cyanide and cobalt-60 found under the BY cribs and the high levels of uranium and nitrite associated with the contamination under the BY Tank Farm and, thus, can be distinguished from these sources. The contaminant signature has a distinctly different nitrate-to-technetium-99 ratio signature than the other groups. Residual waste left in the vadose zone under and around the 216-B-8 crib is, most likely, the source for groundwater contamination in this location and is not associated with the waste management area.

The first contaminant group is attributed to the tank farms. Consequently, the following discussion, which covers the FY 2005 assessment monitoring, focuses on contamination associated with the B-BX-BY Tank Farms. References to the other groups are made, as necessary, to distinguish between the sources.

Sources within Waste Management Area B-BX-BY may have contributed to groundwater contamination.

Hydrology at Waste Management Area B-BX-BY. Because the hydraulic gradient is nearly flat across the 200 East Area, small inaccuracies in water elevations are important when estimating flow direction and rate. These inaccuracies are caused by measurement errors, deviations from vertical of the borehole, small differences between elevation references from different surveys, and pressure effects associated with changing weather conditions (PNNL-12086; PNNL-13116; PNNL-13022; PNNL-13023; and PNNL-13078). Consequently, considerable uncertainty remains in flow directions surrounding the waste management area.

The region of the aquifer near the basalt subcrop is slowly receding back to pre-Hanford water levels, which will eventually leave most of the area under Waste Management Area B-BX-BY and the Low-Level Waste Management Area 2 devoid of an unconfined aquifer. Structural highs in the basalt likely affect local flow directions in the vicinity of Waste Management Area B-BX-BY, especially where the aquifer is thin.

Estimated flow rates, based on hydraulic conductivities from slug tests (PNNL-14186; PNL-6820) and calculated using the Darcy equation, range from 0.005 to 0.18 meters/day assuming a hydraulic gradient of 0.00002 (Appendix B, Table B.1). The average water-table decline beneath the waste management area was 10 centimeters in FY 2005, based on water-elevation data from wells 299-E33-31, 299-E33-32, 299-E33-33, 299-E33-334, 299-E33-38, 299-E33-39, 299-33-41, 299-E33-42, 299-E33-43, and 299-E33-44.

Since the initial assessment investigation (PNNL-11826), a further determination was conducted to identify the source of rising contamination observed in the vicinity of the BY Tank Farm. Results of this investigation, presented in PNNL-SA-39825 and PNNL-14187, show that some of the contamination observed in downgradient wells around Waste Management Area B-BX-BY is associated with remobilization of residual waste left in the soil under the tank farms by fresh-water recharge. Although the source of the water and the vadose zone migration pathways, especially lateral migration, are not clearly understood, the source of the water appears to be related to long-term natural recharge and to releases of fresh water at the surface, both intentional and unintentional (PNNL-14187).

Recent Contaminant Trends. Results from 10 years of groundwater sampling suggest a long-term increasing trend in nitrate across the waste management area. As shown in wells 299-E33-32, 299-E33-42, 299-E33-44, 299-E33-38, and 299-E33-7 (Figure 2.10-16), nitrate ranged from over 800 mg/L in the north to 122 mg/L in the south. The highest value was found in the BY cribs at 1,340 mg/L at well 299-E33-4. This well is nearly dry and, thus, may not be representative of conditions deeper in the aquifer. The area east of the BY Tank Farm also shows increasing nitrate over the years, ranging from 664 to 219 mg/L in FY 2005. This contamination is part of a larger nitrate plume that is believed to have multiple sources.

Contamination from the vadose zone appears to be moving down to groundwater.

Technetium-99 also shows a generally increasing trend across the waste management area. The highest level in the BY cribs was 17,500 pCi/L in well 299-E33-4 while a value of 13,700 pCi/L was observed in the south part of the BY cribs. This well only samples an interval near the top of the aquifer because it is nearly dry. A long-term increasing trend is found in well 299-E33-21 (Figure 2.10-17), located southwest of the waste management area. Technetium-99 concentration also increased in well 299-E33-339 along the south boundary of the waste management area (Figure 2.10-17) where values are currently over 200 pCi/L.

Although uranium continued to increase slowly north of the BY Tank Farm during FY 2005, uranium concentrations increased markedly to the southeast. Figure 2.10-18 compares uranium trends between well 299-E33-9, the highest concentration well within the uranium plume in 2000, with the increasing trend observed in well 299-E33-18. Uranium concentrations increased in FY 2005 from 227 to 454 µg/L in well 299-E33-18, located southeast of BY Tank Farm. However, east of the BY Tank Farm in well 299-E33-44, uranium decreased from 350 µg/L in 2004 to 207 µg/L at the end of FY 2005. Unlike well 299-E33-44, where nitrate and technetium-99 have been increasing while the uranium has been decreasing, nitrate, technetium-99, and uranium have been rising at well 299-E33-18. This lack of co-variation in the concentrations of the mobile contaminants and uranium east of the BY Tank Farm may indicate movement of contamination from the BY cribs toward well 299-E33-44, which has lower levels of uranium but high nitrate and technetium-99, while contamination under the BY Tank Farms spreads southward to well 299-E33-18.

Contaminant Sources. The 1951 overfill event at tank BX-102 appears to be the major source of the uranium plume extending northwest from the vicinity of Waste Management Area B-BX-BY, as discussed in Section 2.10.1.6. However, several observations have yet to be explained by this scenario. First, the highest groundwater concentrations of uranium observed are north of tank BX-102, at well 299-E33-9 in the BY Tank Farm, although the southeast limit of the groundwater plume is around well 299-E33-18, north of the B Tank Farm. The area where the contamination enters groundwater has not been completely defined.

The historical discharge of effluent to the ground in and around Waste Management Area B-BX-BY resulted in complex patterns of groundwater contamination.

A comparison of uranium trends under the BY cribs (well 299-E33-38) and uranium found to the west (well 299-E33-26) also shows that uranium impacts both wells at nearly the same time (Figure 2.10-19). A value of 105 µg/L was observed in the groundwater to the west at the same time 329 µg/L was found under the BY cribs. Comparing trends in well 299-E33-26 with a well from the uranium plume farther to the west (well 299-E33-34) also shows very little offset in the arrival of the uranium between the locations (Figure 2.10-19). When the same comparisons are made for nitrate and technetium between the two locations (Figure 2.10-20), the trends are nearly coincident. A definitive explanation for the almost simultaneous incursion of contamination into the unconfined aquifer over such a broad area has not yet been presented.

One other constituent that may provide insight on contaminant movement is the distribution of cyanide that was discharged to the ground primarily under the BY cribs during the 1950s. Although the record is incomplete for cyanide in groundwater, the maximum concentration found in FY 2005 was 859 µg/L under the BY cribs. Cyanide was found at 45 µg/L in well 299-E33-26 but at the significantly higher value of 358 µg/L in well 299-E33-34.

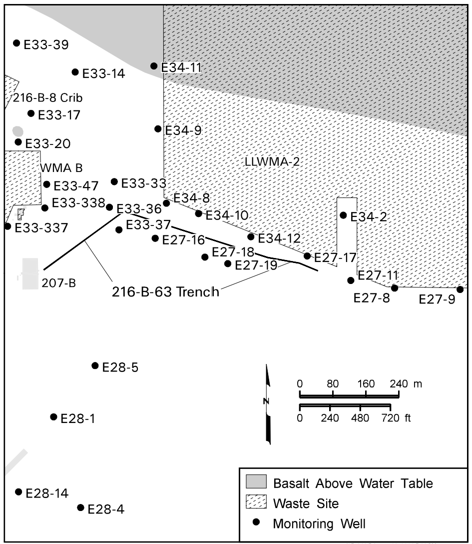
Other waste sources in the vicinity of Waste Management Area B-BX-BY have not been completely ruled out as current or possible future contributors to the uranium groundwater contamination and are believed to be contributors to other radionuclide and chemical contamination. Source and groundwater investigations are ongoing to further refine our understanding of contamination in this area.

The historical discharge of effluent to the ground in and around Waste Management Area B-BX-BY resulted in complex patterns of groundwater contamination. The highest level of technetium-99, located beneath the BY cribs to the north, is attributed to discharges to the cribs in the mid-1950s. Associated with high concentrations of nitrate, sulfate, tritium, cyanide, and some cobalt-60, this contamination forms a plume that possibly affects the groundwater under an area greater than the cribs and may be the main contaminant source for plumes extending to the south and west from the cribs. Elevated uranium with technetium-99, nitrate, sulfate, and nitrite is found beneath the BY Tank Farm while a small tritium plume exists along the south margin of the waste management area. Evidence discussed in PNNL-14187 and presented above suggests the contamination seen in and around Waste Management Area B-BX-BY may be entering the groundwater in multiple areas from the vadose zone and is sourced in the contaminated soils under both the tank farms and the surrounding cribs. Residual waste left in the vadose zone from the 1951 BX-102 tank overfill event and possibly other releases associated with the waste management area is, most likely, contributing to the uranium, nitrate, technetium-99, and other contamination in the vicinity of Waste Management Area B-BX-BY (PNNL-14187). Quarterly monitoring of the groundwater at Waste Management Area B-BX-BY will continue.

Sampling results for the 216-B-63 trench have historically supported the interpretation that waste from the facility has not affected groundwater.

2.10.3.2 216-B-63 Trench

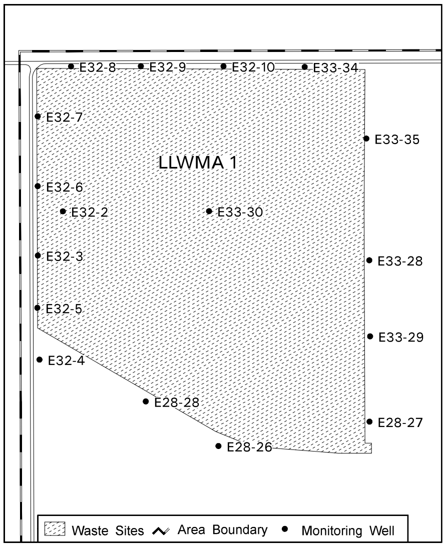
This RCRA unit continued to be monitored under an interim status detection program (40 CFR 265.93(b) as referenced by WAC 173-303-400) in FY 2005. The monitoring network was sampled twice, as scheduled, for 12 wells during the year (PNNL-14112, Appendix B). Total organic halide results reported for the April 2005 sampling exhibited high variability. Wells 299-E34-10, 299-E27-9, and 299-E27-18 all had replicate values that exceeded the limit of quantitation for total organic halide at the 216-B-63 trench (12.7 µg/L at the time of reporting). Only downgradient well 299-E27-18 was resampled for verification. Subsequent sampling failed to reproduce the same concentration levels that triggered the exceedance. Total organic halide data from the April 2005 event have been flagged as suspect in the Hanford Environmental Information System. Also, the limit of quantitation applied to the results at the time of reporting was too low based on recalculation of data from quality control blanks. The recalculated value of 21.1 µg/L should have been used as the basis for comparing the total organic halide data in the April to June 2005 timeframe. Thus, no further action is required with respect to this issue.



Specific conductance has risen in all of the 216-B-63 trench wells since they were installed (Figure 2.10-21). These changes have been attributed to a progressive rise in cations and anions in groundwater. The specific conductance trends for all but well 299-E27-9 show small, incremental increases or decreases. Groundwater quality parameter sampling, performed annually at the 216-B-63 trench, indicate that anion and cation concentrations have also changed little in the last fiscal year. Although there has been a slow, progressive rise in most constituents such as sodium and calcium, the only results that indicate a marked elevated rise in concentration in most of the 216-B-63 trench network are for sulfate (Figure 2.10-22). There does not appear to be a particular pattern in the distribution of wells that have increasing concentrations of sulfate versus increases for other constituents. The only conclusion that can be drawn from the increase in sulfate in these wells is that it appears to be part of a general increase in the constituent throughout the 200 East Area.

The monitoring well network for the 216-B-63 trench is shared with both the Low-Level Waste Management Area 2 and the B-BX-BY Tank Farms. Samples are gathered twice a year in spring and fall (see Appendix B). Due to the low hydraulic gradient in the 200 East Area, the rate of groundwater movement near the 216-B-63 trench is relatively low for the Hanford formation, ~0.1 meter/day (see Appendix B). Present data are insufficient to define a dominant flow direction. A southwest flow direction is assumed, however, in accordance with the interim status designation of upgradient and downgradient wells until a stable flow direction is re-established. The monitoring network for the 216-B-63 trench currently meets RCRA requirements as defined in the monitoring plan.

2.10.3.3 Low-Level Waste Management Area 1



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Groundwater at Low-Level Waste Management Area 1 continued to be monitored under RCRA and AEA. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (WHC-SD-EN-AP-015; DOE/RL-2000-72; Appendix B). All 17 wells were successfully sampled during both samplings; however, 2 wells were sampled late for the June 2005 round due to sampling problems. One of the wells was sampled in July and the other in August 2005.

An application was submitted to the Washington State Department of Ecology (Ecology) in June 2002 to incorporate the low-level burial grounds into the Hanford Facility RCRA Permit (Ecology 1994a). This would have the effect of changing the groundwater monitoring requirements for the burial grounds from interim status monitoring to final status monitoring. As part of the application, new groundwater monitoring constituents and statistical evaluations were proposed. No new wells were proposed at Low-Level Waste Management Area 1 and none have been included in recent versions of the Tri-Party Agreement M-24 milestone.

The groundwater gradient in this part of the 200 East Area is almost flat making the determination of groundwater flow direction difficult (Figure 2.10-3). Based on contaminant plumes, flow direction to the northwest in the past is indicated (Figures 2.10-4 through 2.10-9). Past analysis of water-level data also indicate flow toward the northwest. Trend surface analysis performed on FY 2003 through FY 2005 water-level data indicated highly variable flow direction. No meaningful flow rate could be calculated, given the variability and low gradient. The data are insufficient to define a dominant flow direction. For this reason, no attempt will be made to update the interim status designation of upgradient and downgradient wells until a stable flow direction is re-established.

Specific conductance continued to exceed the statistical upgradient/downgradient comparison value (critical mean) in downgradient well 299-E33-34, with values ranging from 1,293 to 1,376 µS/cm. This was an increase from FY 2004. In FY 2004 and the second half of FY 2005, well 299-E32-10, west of well 299-E33-34, also exceeded the statistical comparison value. The comparison value has been increasing due to increasing specific conductance in background wells. The specific conductance exceedance is related to a regional nitrate plume (Figure 2.10-6). DOE notified Ecology of the exceedance in 1999.

The average of the June results for total organic halides (20.4 µg/L) in well 299-E33-34 was greater than the previously calculated statistical comparison value of 17.4 µg/L, based on the most recent limit of quantitation. The well was resampled, and the exceedance was not confirmed. When the limit of quantitation was recalculated at the end of the quarter, the limit was 21.1 µg/L. It appears the original elevated results were due to analytical errors, and no action will be taken. See Appendix C for further discussion of widespread total organic halide analytical issues. Other indicator parameters remained below critical mean values in downgradient wells. Statistical comparison values to be used for indicator parameters in FY 2006 are listed in Appendix B.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 1 is designed to complement the RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level Waste Management Area 1 is to gather data to assess changes in concentrations at downgradient wells using statistical tests and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), only technetium-99 is monitored specifically for performance assessment.

Contaminant characteristics at Low-Level Waste Management Area 1 include the following:

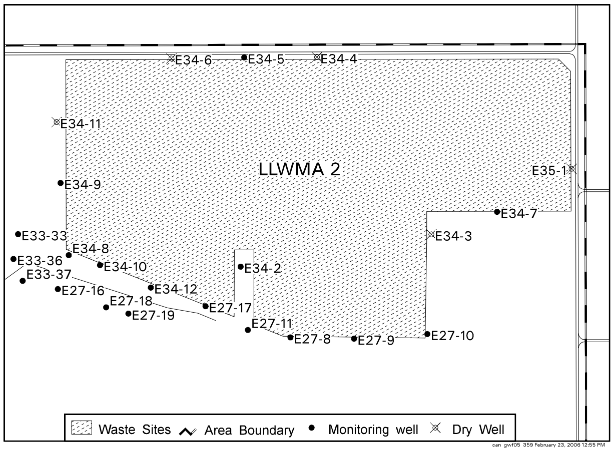
- Technetium 99 concentrations continued to be elevated in several wells (299-E33-34, 299-E32-10, 299-E33-35) near the northeast corner of Low-Level Waste Management Area 1. Concentrations in FY 2005 (maximum of 7,860 pCi/L in well 299-E33-34) were lower than the maximum concentration seen in 2001 (8,170 pCi/L in well 299-E33-34). The contamination levels are consistent with regional plumes that appear to have originated in the vicinity of the BY cribs (Figure 2.10-9). Two wells (299-E32-2 and 299-E32-6) near the west boundary of Low Level Waste Management Area 1 have also shown generally increasing technetium-99 concentrations in recent years. However, levels remained <60 pCi/L and were only slightly higher than surrounding and upgradient wells.
- Uranium values remained relatively steady in well 299-E33-34 in the northeast corner of the waste management area after a steep increase in 2002. This is associated with a relatively recent plume originating in the vicinity of Waste Management Area B-BX-BY (Figure 2.10-11). The uranium plume has impacted other wells surrounding this part of the waste management area (e.g., wells 299-E32-10 and 299-E33-35), but concentrations are not as high.
- Uranium levels stayed fairly stable in most wells on the west side of Low-Level Waste Management Area 1 in FY 2005. Levels remained below the drinking water standard. The history of uranium contamination prior to regular monitoring of the burial ground wells is difficult to establish but the source may have been cribs west of B Plant and south of the waste management area.
- Tritium contamination is also believed to be from regional plumes, not related to the burial grounds (Figure 2.10-4). Tritium concentrations were less than the drinking water standard in FY 2005. Concentrations are increasing along the north and east side of the waste management area. This appears to be due to a slight shift in the regional plumes.
- Iodine-129 contamination in this area is consistent with regional plumes and believed to be from liquid waste facilities (Figure 2.10-8).
- Nitrate contamination at Low-Level Waste Management Area 1 is mapped as two separate plumes at the drinking water standard, both extending from areas outside of the burial ground. The contours shown in Figure 2.10-6 are similar to those from previous years. The highest concentrations are in the northeast plume, approximately coincident with the technetium-99 plume. Thus, the northeast nitrate plume has a likely source in the BY cribs, the 216-B-8 crib, and other nearby waste sites.

Contaminant levels beneath Low-Level Waste Management Area 1 are consistent with regional plumes.

- Low levels of chromium contamination continue to be seen in filtered samples from well 299-E33-34, in the northeast corner of Low-Level Waste Management Area 1. The FY 2005 average chromium concentration was 22 µg/L. The drinking water standard for chromium is 100 µg/L. From the plume contours, the sources appear to be the same as for nitrate.

2.10.3.4 Low-Level Waste Management Area 2

Groundwater at Low-Level Waste Management Area 2 continued to be monitored under RCRA and AEA. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (WHC-SD-EN-AP-015; DOE/RL-2000-72; Appendix B). The well network was sampled twice for indicator and site-specific parameters. Sampling was successful at 11 wells for both sampling rounds. Other wells in the unit have gone dry in recent years. Two wells (299-E34-5 and 299-E34-7) went dry after FY 2005 sampling was completed.



An application was submitted to Ecology in June 2002 to incorporate the low-level burial grounds into the Hanford Facility RCRA Permit (Ecology 1994a). This would have the effect of changing the groundwater monitoring requirements for the burial grounds from interim status monitoring to final status monitoring. As part of the application, new groundwater monitoring constituents and statistical evaluations are proposed. No new wells were proposed and none have been included in recent versions of the Tri-Party Agreement M-24 milestone, in spite of wells going dry, because the water-table elevation is receding below the top of the basalt. Deeper aquifers are isolated from the burial grounds by the low-permeability basalts (see as-built diagrams in Appendix B, PNL-6820).

The groundwater gradient in this part of the 200 East Area is almost flat, making the determination of groundwater flow direction difficult. Groundwater flow appears to be generally to the west based on small differences in head at wells along the south boundary of Low-Level Waste Management Area 2. Flow to the southwest is indicated by the movement of the nitrate plume from well 299-E34-7 to well 299-E27-10 (discussed further in the following paragraphs). For this reason, no attempt will be made to update upgradient well designations used in the statistical tests until a stable flow direction is evident. The basalt surface above the water table in the north part of Low-Level Waste Management Area 2 constrains possible flow directions for the unconfined aquifer. However, it is possible that the flow is influenced by continued drainage of the unsaturated sediment and recharge moving laterally on the basalt surface to the saturated aquifer sediment. The gradient calculated from wells along the south boundary of the burial ground was 0.00007, using the March 2005 data set. Using this gradient, the estimated flow rate at Low-Level Waste Management Area 2 is 0.1 to 1.4 meter/day (Appendix B).

The total organic halide statistical comparison value appeared to be exceeded in the April 2005 sampling of downgradient wells 299-E27-9 and 299-E34-10, based on the previous quarter's limit of quantitation. The average results were 17.3 µg/L and 32.8 µg/L respectively. The results were not confirmed by resampling in August. When the limit of quantitation for total organic halides was recalculated for the quarter, it increased to 20.1 µg/L; therefore, the original result for well 299-E27-9 did not exceed the value. It appears the original elevated results were due to analytical errors and no action will be taken. See Appendix C for further discussion of widespread total organic halide analytical issues. Statistical comparison values for other indicator parameters were not exceeded for any downgradient wells in FY 2005. Upgradient well 299-E34-7, however, is no longer used to calculate critical mean values because of the anomalous chemistry in this well. Appendix B lists the initial statistical comparison values to be used in FY 2006 based on data for the other upgradient wells. Well 299-E34-7 went dry in early FY 2006 and has been removed from the sample schedule.

Well 299-E34-7 has high specific conductance, total organic carbons, and total organic halides. The major contributors to the elevated specific conductance are sulfate, chloride, nitrate, and calcium. The source of the elevated specific conductance is not known. The specific conductance in FY 2005 remained close to FY 2004 levels but below the peak readings in FY 2002 and FY 2003 (Figure 2.10-23).

The cause of the elevated levels of total organic carbon and total organic halides is also not known. Total organic carbon levels declined slightly from FY 2004. The FY 2005 average total organic carbon concentration was 3,200 µg/L. The average total organic halide concentration was 16.7 µg/L, lower than in FY 2003. FY 2003 through 2005 samples from well 299-E34-7 were analyzed for an extensive list of constituents and other possible contaminants identified in 40 CFR 264, Appendix IX. No organic constituents were detected consistently and those detected were at low levels, often associated with blank contamination that appears to be false-positive results (Table 2.10-1). The levels of Appendix IX (40 CFR 264) constituents are far lower than the total organic carbon.

Levels of specific conductance, total organic carbon, and total organic halides in an upgradient well at Low-Level Waste Management Area 2 were elevated. The source is unknown.

The constituents causing the increased specific conductance in well 299-E34-7 are impacting wells farther southwest, well 299-E27-10 and well 299-E27-9. Sulfate, chloride, nitrate, and calcium are all increasing in these wells but remain at lower concentrations than seen in well 299-E34-7. The concentrations in well 299-E27-10 are higher than in well 299-E27-9, indicating the plume is spreading toward the southwest and west. The nitrate trend for these three wells is shown in Figure 2.10-24 as an example of the increases.

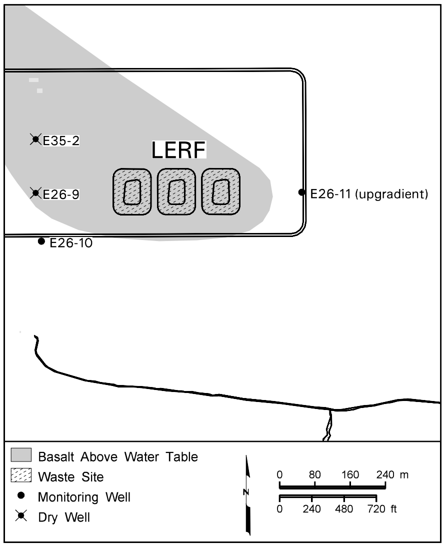
Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 2 is designed to complement the RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level Waste Management Area 2 is to gather data to assess changes in concentrations at downgradient wells using statistical tests and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, and uranium are monitored specifically for performance assessment.

Contaminant characteristics at Low-Level Waste Management Area 2 include the following:

- Technetium-99 concentration continued to increase in upgradient well 299-E27-10 southeast of Waste Management Area 2, where the concentration reached 79 pCi/L in FY 2005. This contamination is believed to be from past disposal of liquid waste in the 200 East Area and unrelated to Low-Level Waste Management Area 2 because this is an upgradient well. Other wells in the monitoring network have lower technetium-99 concentrations.
- Tritium contamination was found at levels less than the drinking water standard. The tritium concentrations were consistent with regional plumes (Figure 2.10-4 and Section 2.10.1.1).
- Iodine-129 concentrations were <5 pCi/L in Low-Level Waste Management Area 2 wells. The levels were consistent with the regional iodine-129 plume (Figure 2.10-8 and Section 2.10.1.3) and do not appear to be related to a burial ground source.
- Uranium concentrations in Low-Level Waste Management Area 2 samples were <5 µg/L and do not indicate a burial ground source.
- Nitrate contamination at levels above the drinking water standard were restricted to upgradient wells on the east side of Low-Level Waste Management Area 2.

2.10.3.5 Liquid Effluent Retention Facility

The Liquid Effluent Retention Facility is an active, lined facility that is identified in the Hanford Facility RCRA Permit (Ecology 1994a). Groundwater at this facility is monitored to meet requirements of RCRA under 40 CFR 265.93(b) as referenced by WAC 173-303-400. A RCRA final status detection-monitoring program was in place at the Liquid Effluent Retention Facility until June 1999 when downgradient well 299-E26-9 no longer provided representative groundwater information (i.e., went dry). Ecology granted a variance in September 1999 to allow DOE to operate the remaining network wells as the compliance system. This variance gave DOE 18 months, or until the next downgradient well became non-functional, to develop and deploy an alternative monitoring system. Ecology rescinded the variance in January 2001 when downgradient well 299-E35-2 no longer produced representative samples. A letter from Ecology directed DOE[a] to discontinue statistical evaluation of groundwater sample results effective January 14, 2001. Since that time, DOE has continued to sample the remaining wells according to WHC-SD-EN-AP-024, but no longer performs statistical evaluations of the results. The groundwater monitoring network is not compliant with the groundwater monitoring requirements of WAC 173-303-645. DOE and Ecology are exploring alternative approaches to environmental groundwater monitoring at the facility to meet compliance with hazardous waste regulations.

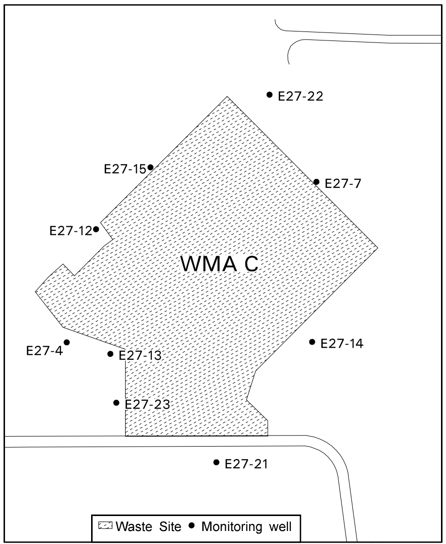


Two wells were successfully sampled semiannually at the Liquid Effluent Retention Facility in FY 2005 (Appendix B). Results for specific conductance (consisting largely of elevated levels of sulfate) have been rising in concentration since 1994 mirroring a regional trend (PNNL-14187). The FY 2005 increase in specific conductance and sulfate was not as dramatic as in past fiscal year sampling efforts. No other contamination indicator parameters increased over FY 2005.

The Liquid Effluent Retention Facility is monitored by two wells.

2.10.3.6 Waste Management Area C

Located in the northeast part of the 200 East Area, Waste Management Area C consists of the C Tank Farm, the 244-CR vault, ancillary waste transfer lines, and seven diversion boxes. Groundwater at this waste management area is monitored to meet requirements of RCRA under 40 CFR 265.93(b) as referenced by WAC 173-303-400 and AEA. The objective of RCRA monitoring is to detect if dangerous waste constituents associated with the facility have compromised groundwater quality. Monitoring continued under an interim status indicator evaluation program in FY 2005 (40 CFR 265.93(b) as referenced by WAC 173-303-400). Although only semiannual sampling is required, wells are sampled quarterly per a request from Ecology related to monitoring of single-shell tanks following retrieval of waste. The required semiannual sampling, conducted twice per year for indicator parameters, confirmed there were no exceedances of critical means. Appendix B includes a well location map, a list of wells, the critical means used for upgradient/downgradient comparisons, and the site-specific constituents monitored for Waste Management Area C. Radionuclides are tracked under AEA monitoring at the site. The following discussion covers monitoring conducted during FY 2005 and the local hydrogeology of the waste management area.



In summary, the increase in groundwater contamination, which began between 1995 and 1998 depending on the location, slowed during FY 2005. Contamination

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(a) Letter from D Goswami and F Jamison (Washington State Department of Ecology) to K Leary and M Thompson (U.S. Department of Energy), *Liquid Effluent Retention Facility (LERF) Unsaturated Zone Monitoring Alternatives Evaluation, Suspension of Groundwater Monitoring Statistical Evaluation Requirements, LERF RCRA Permit Modification, and Leachate Monitoring Performance Criteria*, dated January 24, 2001.

consists primarily of elevated nitrate, technetium-99, sulfate, and, sporadically, low levels of cyanide. Upgradient well 299-E27-7, which is close to the northeast fence line and to ancillary equipment used for farm activities, has elevated contaminant levels making upgradient/downgradient comparisons difficult. The new upgradient well (299-E27-22), located further to the northeast, along with the three new downgradient wells (wells 299-E27-4, 299-E27-21, and 299-E27-23) have improved the monitoring network. Upgradient values of sulfate and to some extent nitrate, indicate an upgradient source for these contaminants. Although high levels of technetium-99 have been observed upgradient in the past, the plume is currently impacting only downgradient wells above the drinking water standards of 900 pCi/L.

A general flow direction toward the southwest to south-southwest has been determined for this site using in situ flow measurements with the colloidal borescope, plume tracking, and water elevations corrected for borehole deviations from vertical (PNNL-13788). Hydrographs confirm the flow direction remains to the southwest, which is consistent with the regional water-table map (see Figure 2.10-19 in PNNL-15070). The rate of groundwater flow, based on hydraulic conductivities calculated from a multi-stress slug test, ranges from 0.7 to 2.4 meters/day (Appendix B). These values were calculated using the Darcy equation. Estimated conductivity values ranged from 1,890 to 6,888 meters/day, as expected for the highly permeable lower Hanford formation sediments found in the aquifer at Waste Management Area C. The rate of water-table decline beneath Waste Management Area C was 9 to 10 centimeters, the same as FY 2004. If this rate continues, replacement of the older wells in the network will need to be considered in ~5 to 6 years.

The increase in contaminant concentrations, including technetium-99, in groundwater at Waste Management Area C slowed during FY 2005.

Elevated specific conductance is found at Waste Management Area C with values in FY 2005 ranging from 583 to 663 µS/cm upgradient to 779 µS/cm downgradient on the southeast side. The increasing specific conductance is caused primarily by rising sulfate and calcium along with some nitrate (PNNL-14187). Sulfate dominates the specific conductance signature with values ranging from 66 to 205 mg/L across the site. Rising sulfate concentrations are primarily from an upgradient source near the basalt subcrop where the value has been as high as 671 mg/L. However, in downgradient well 299-E27-14, there is a good correlation between sulfate and increasing technetium-99 (see Figure 2.10-21 in PNNL-15070). Thus, downgradient of the site, part of the rising specific conductance may be related to a chemical nuclear processing source.

Further insight can be gained by comparing nitrate to technetium-99 values across the site. Figure 2.10-25 shows the distribution of nitrate for June 2005. Although nitrate is elevated above the Hanford site-wide background value of 12.4 mg/L (WHC-EP-0595) in most wells, both upgradient and downgradient, the highest value is found in well 299-E27-14. Trends in nitrate correlates with sulfate and technetium-99 in this well. Trends in technetium-99, shown in Figure 2.10-26, show a high pulse of technetium-99 (2,760 pCi/L FY 2002) in upgradient well 299-E27-7 that has declined to current values below 100 pCi/L. Downgradient technetium-99 continued to increase in FY 2005 to over 2,000 pCi/L. Migration of this technetium-99 plume from northeast to southwest can be seen in Figure 2.10-27, which compares the technetium-99 distribution in FY 2002 to FY 2005. However, with the installation of the new downgradient wells in FY 2003, the highest technetium-99 is found at well 299-E27-4. The level dropped from the June 2005 value of 7,070 pCi/L to 4,310 pCi/L in September 2005. This elevated technetium-99 is found with low levels of nitrate (Figure 2.10-25). The nitrate to technetium-99 ratio at well 299-E27-4 is 2.8, indicating the source of this contaminated groundwater may be tank-related, the same as nearby well 299-E27-13 (PNNL-14187 and PNNL-14548). In general, nitrate to technetium-99 ratios lower than 10 suggest the source of contamination for this well may be related to residual tank waste left in the vadose zone from past operations.

Although detected sporadically at several locations in the groundwater at Waste Management Area C, cyanide levels were steady in upgradient well 299-E27-7 in FY 2005, with values ranging from 41.7 to 24.8 µg/L (the drinking water standard is 200 µg/L). The presence of cyanide in the groundwater also suggests a source associated with tank-related waste left in the vadose zone, because the C Tank Farm is the only known local source for cyanide (HNF-SD-WM-TI-740). Additionally, the sharp rise and fall of the technetium-99 peak at well 299-E27-7 (Figure 2.10-26) indicated a short travel distance from the point of entry into the groundwater to the well (PNNL-14548) implying the source was close to the farm. Continued monitoring at this waste management area will provide more information on contaminant sources.

Table 2.10-1. Organic Constituents Reported in Well 299-E34-7, Low-Level Waste Management Area 2, FY 2005

Constituent	Number of Detects	Number of Results	Maximum Reported (µg/L)	Notes
1,2,3,4,6,7,8-Heptachlorodibenzodioxin	1	2	0.000016	Contamination in associated blank; not all qualitative identification criteria met
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1	2	0.000002	Contamination in associated blank; not all qualitative identification criteria met
Bromomethane	1	2	0.61	
Dicamba	1	2	0.17	Spike sample recovery out of limits
Heptachlorodibenzo-p-dioxins	1	2	0.00003	Contamination in associated blank; not all qualitative identification criteria met
Heptachlorodibenzofurans	1	2	0.0000033	Contamination in associated blank; not all qualitative identification criteria met
Hexachlorodibenzo-p-dioxin	1	2	0.0000043	Contamination in associated blank; not all qualitative identification criteria met
Octachlorodibenzo-p-dioxin	1	2	0.00018	Contamination in associated blank
Octachlorodibenzofuran	1	2	0.0000078	Contamination in associated blank
Pentachlorodibenzo-p-dioxins	1	2	0.0000024	Contamination in associated blank; not all qualitative identification criteria met

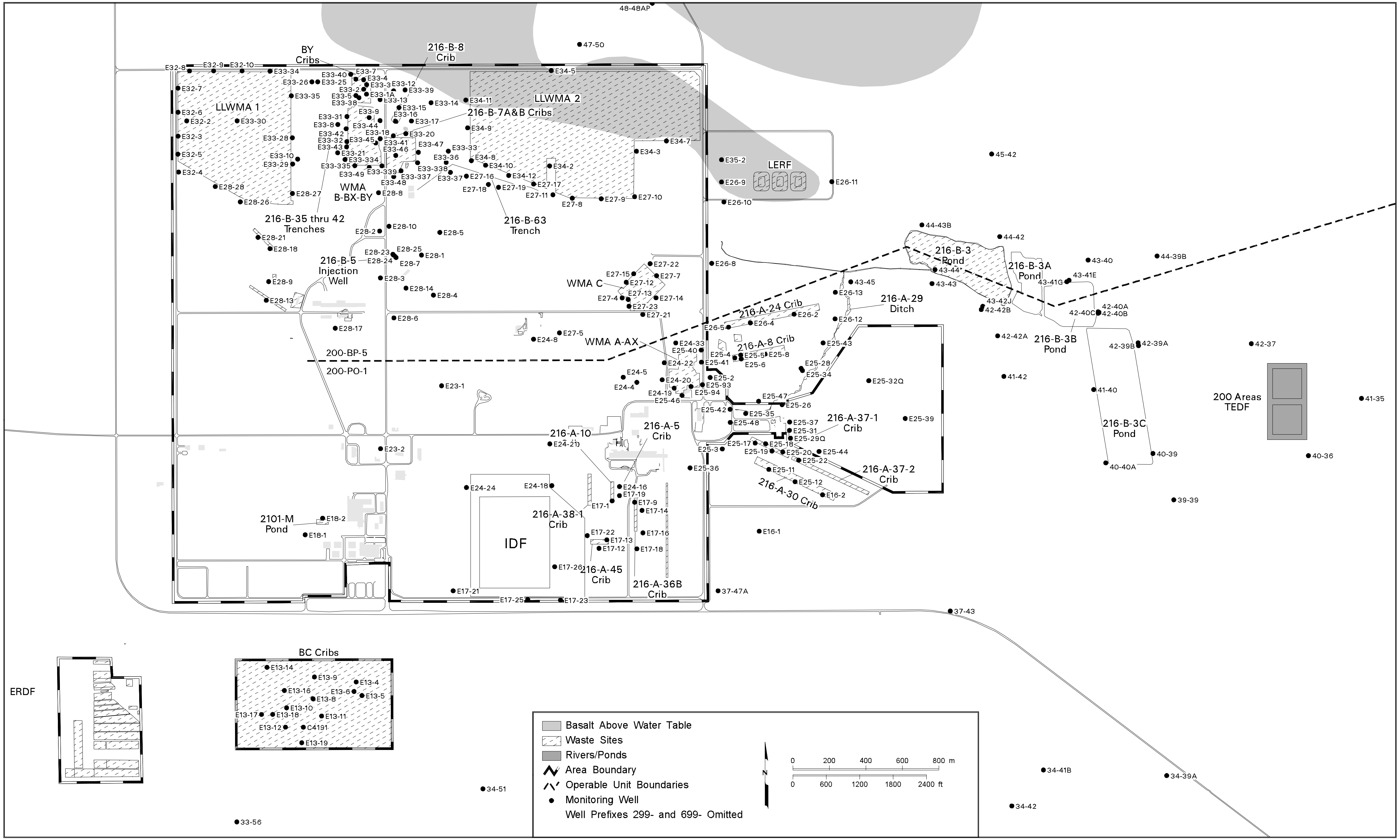

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Figure 2.10-1. Groundwater Wells Monitored in the 200 East Area, 2001 through 2005

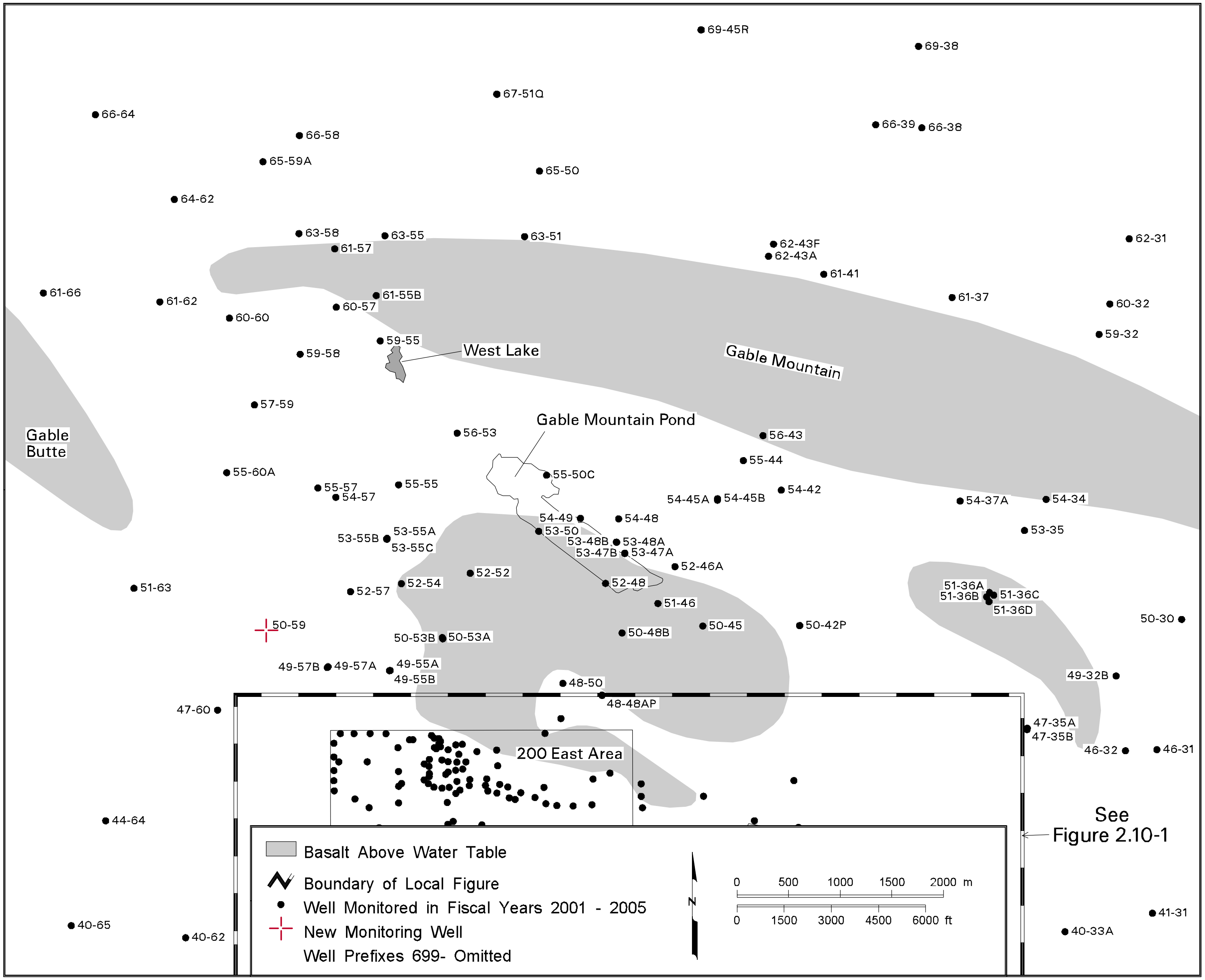

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Figure 2.10-2. Groundwater Monitoring Wells Located in the 600 Area Associated with the 200-BP-5 Operable Unit

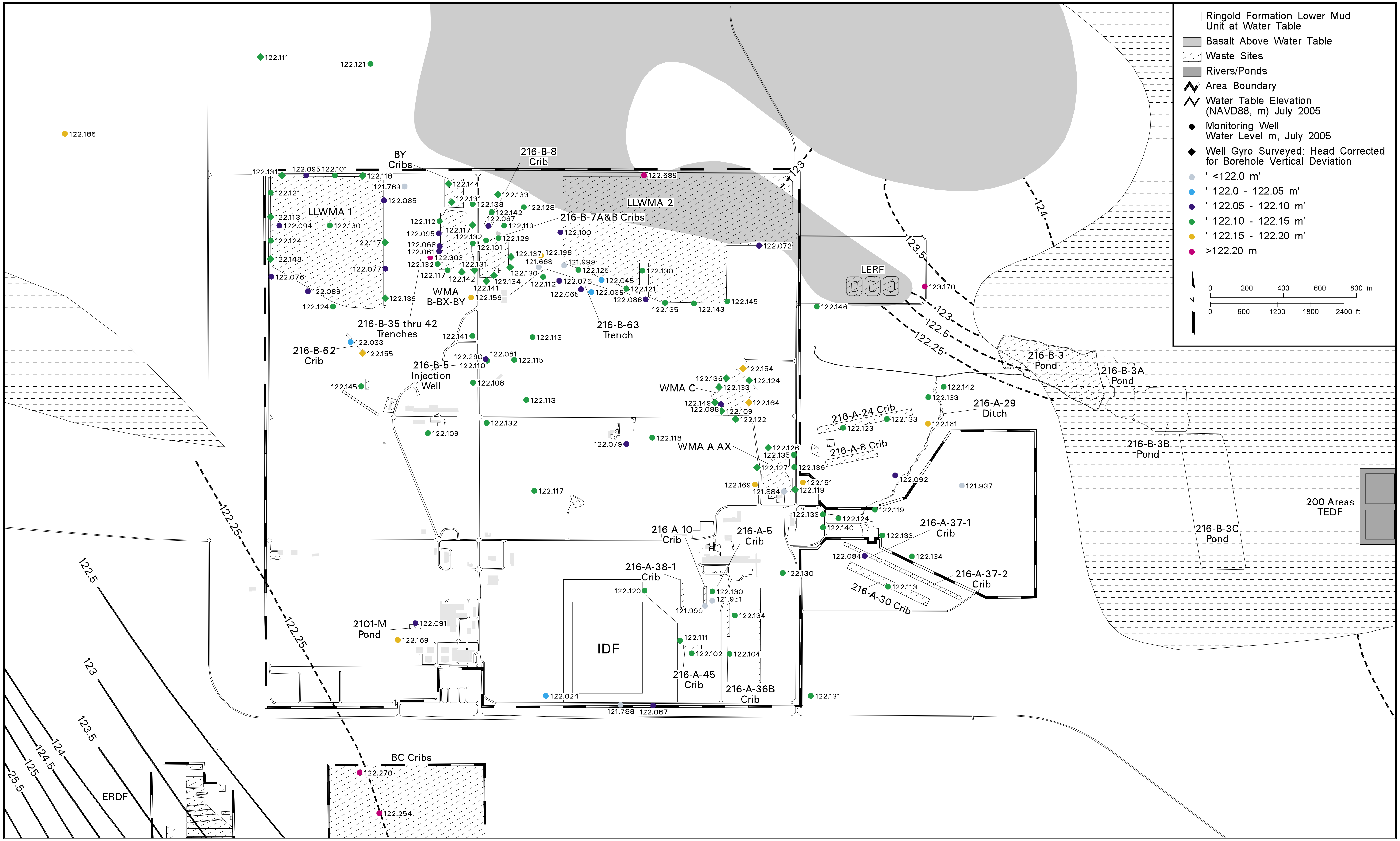

Figure 2.10-3. 200 East Area Water-Table Map, July 2005

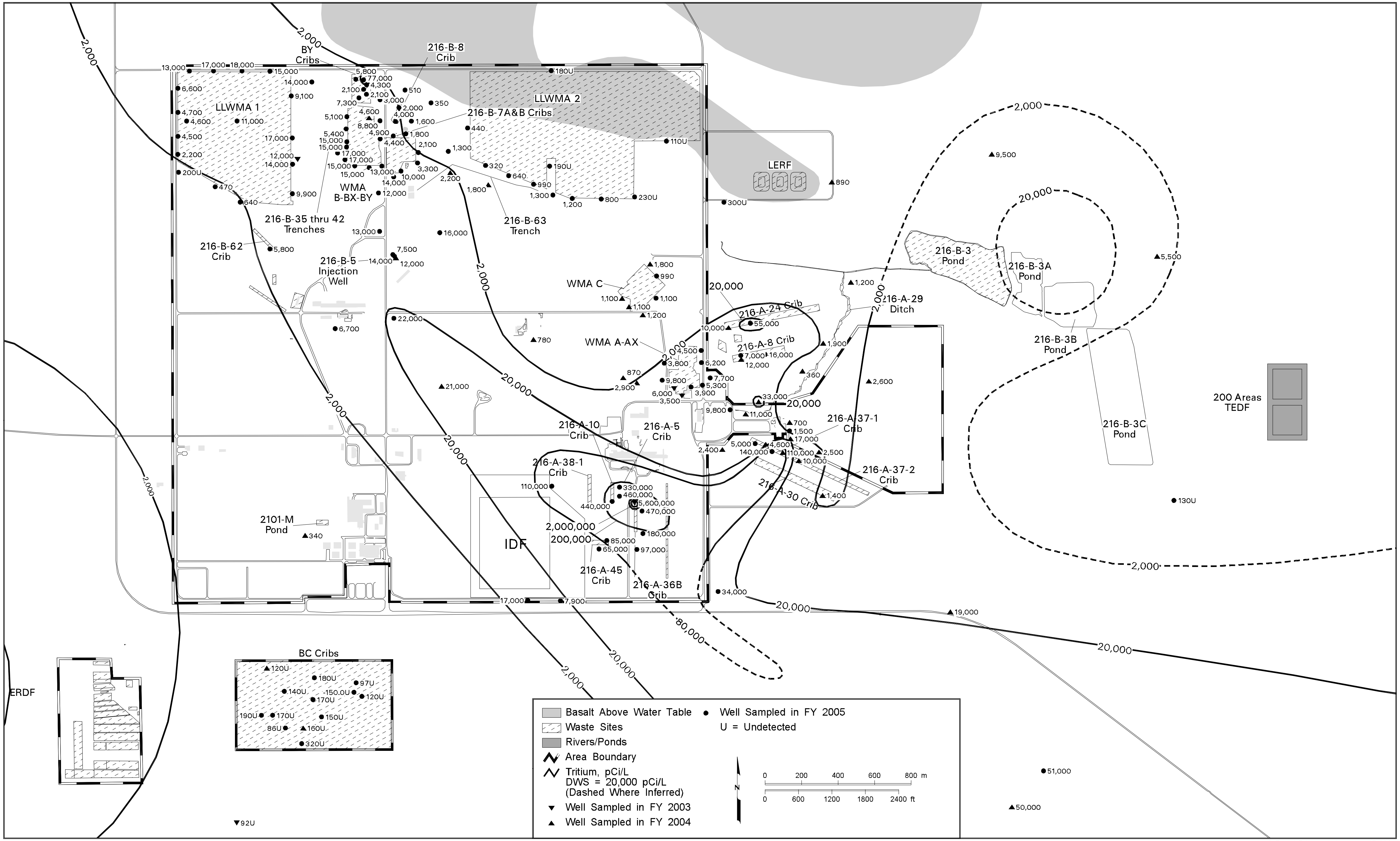

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Figure 2.10-4. Average Tritium Concentrations in the 200 East Area, Top of Unconfined Aquifer

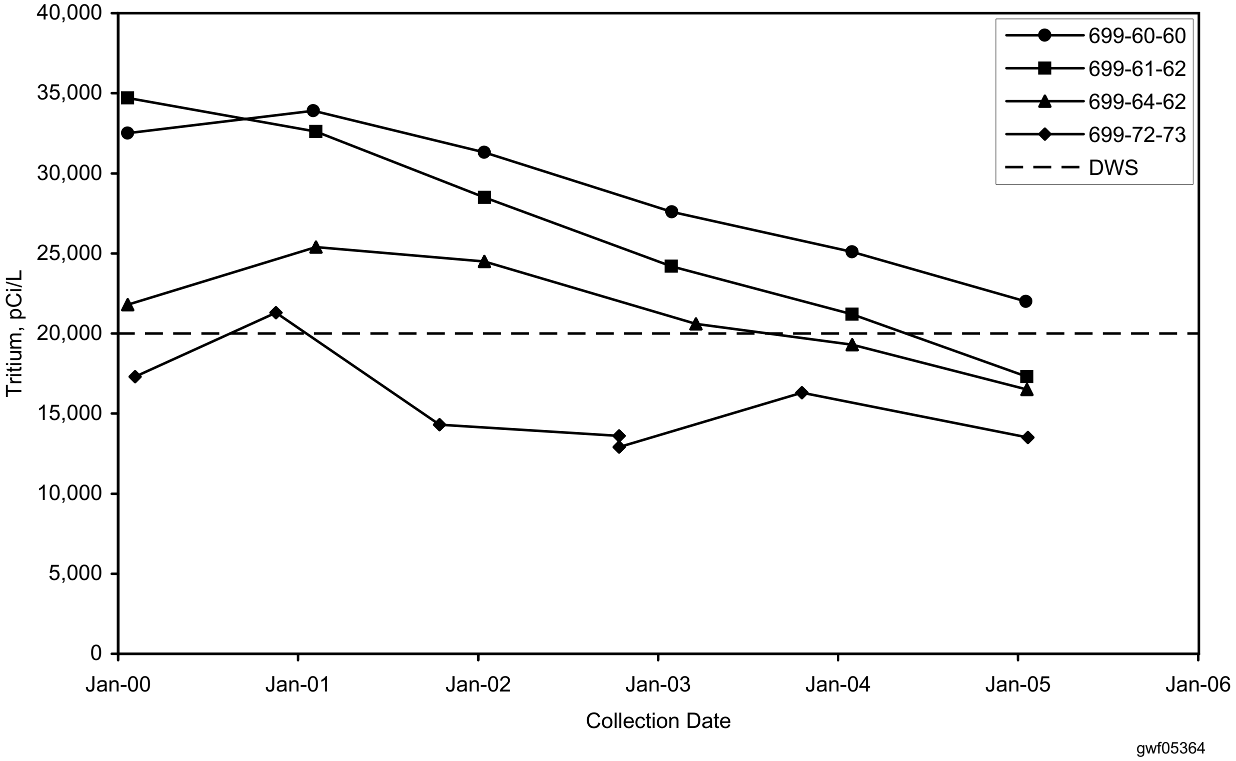

Figure 2.10-5. Tritium Concentrations in Wells Located in Gable Gap Area, Top of Unconfined Aquifer

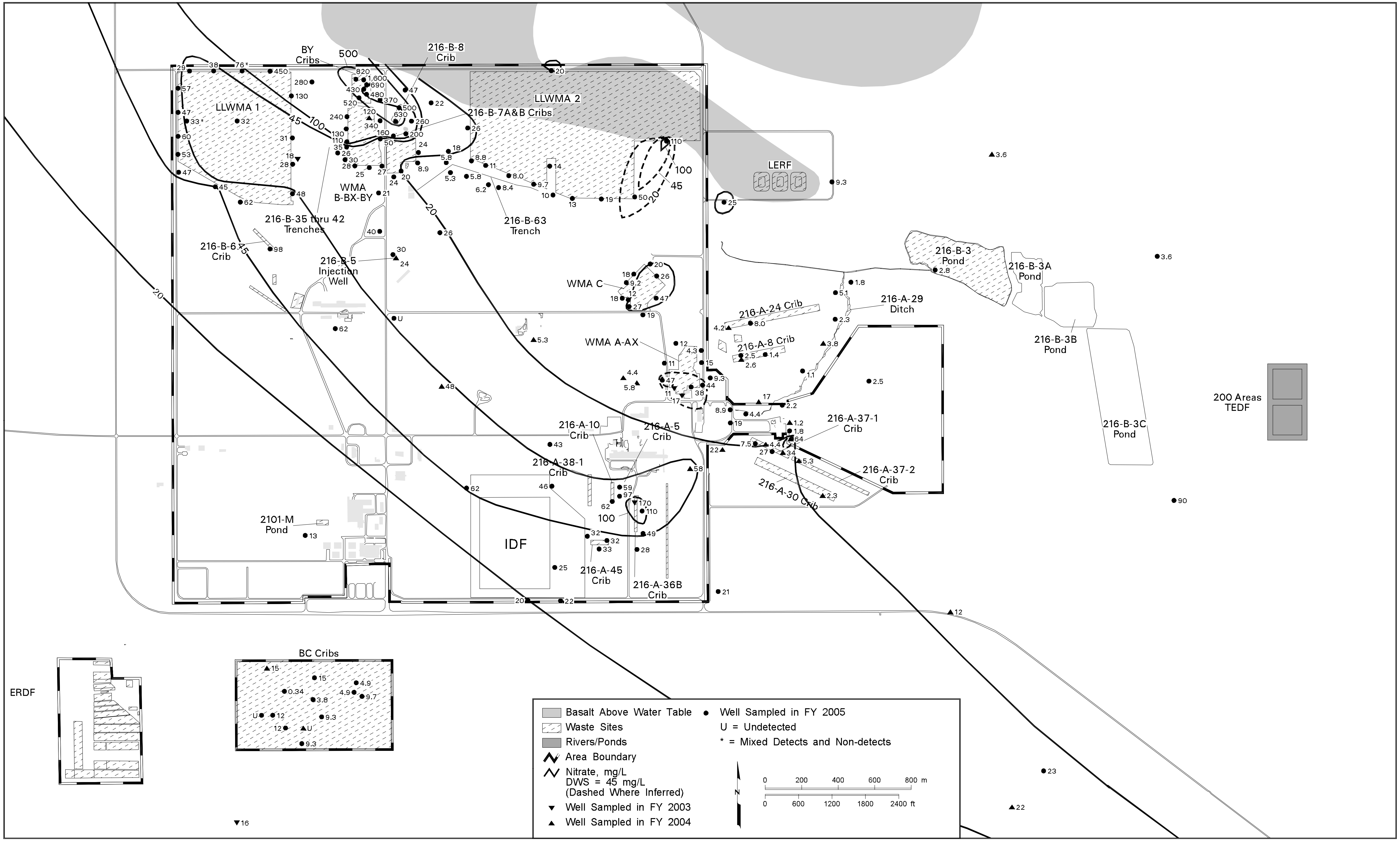

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Figure 2.10-6. Average Nitrate Concentrations in the 200 East Area, Top of Unconfined Aquifer

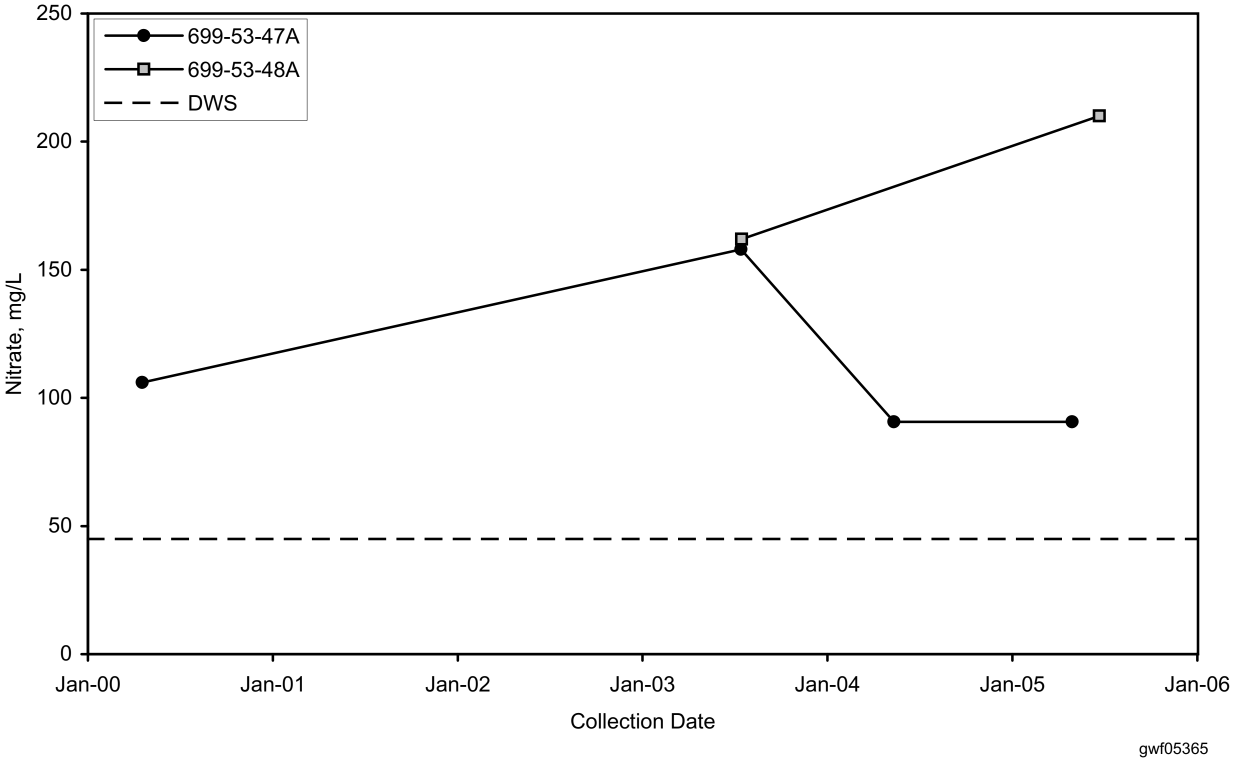

Figure 2.10-7. Nitrate Concentrations in Wells 699-53-47A and 699-53-48A at Gable Mountain Pond, Top of Unconfined Aquifer

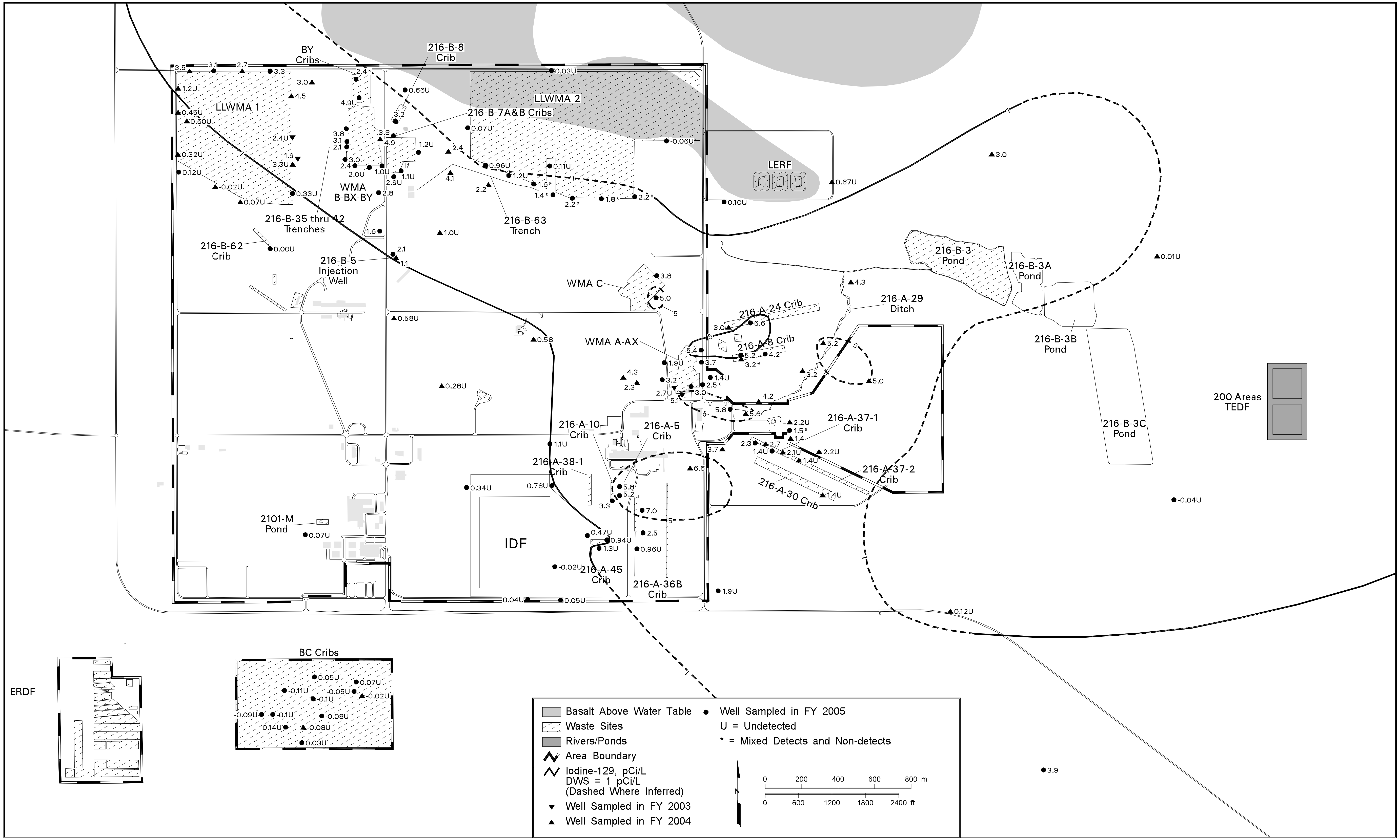

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Figure 2.10-8. Average Iodine-129 Concentrations in the 200 East Area, Top of Unconfined Aquifer

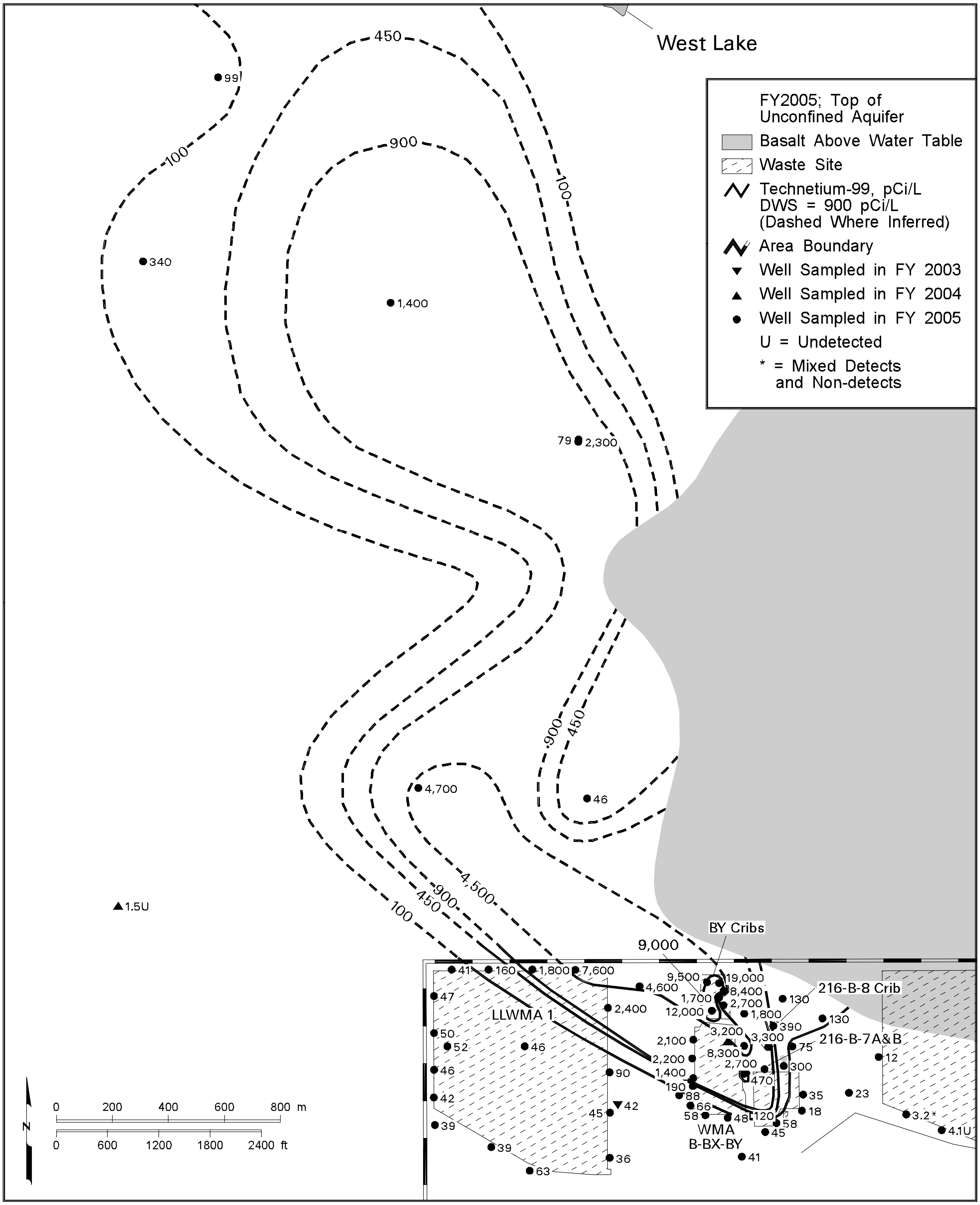

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Figure 2.10-9. Average Technetium-99 Concentrations in the North 200 East Area, Top of Unconfined Aquifer

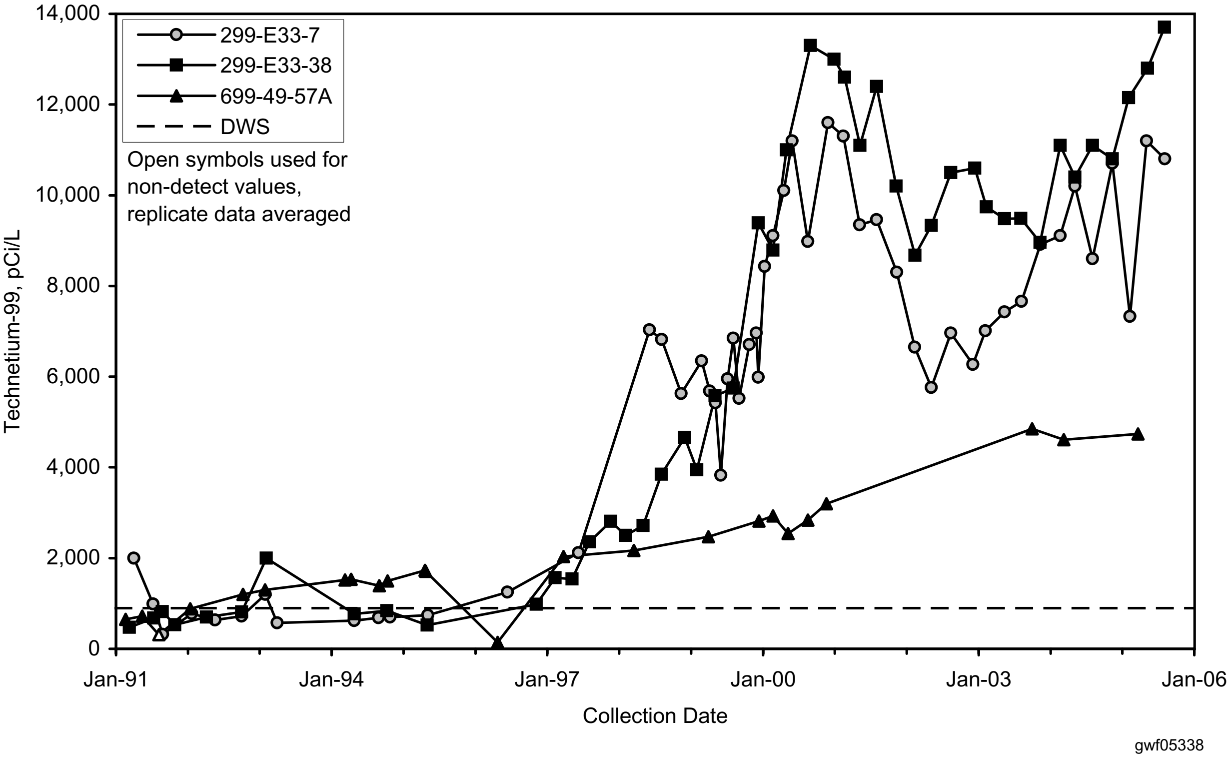

Figure 2.10-10. Technetium-99 Concentrations in Wells 299-E33-7 and 299-E33-38 at the BY Cribs and Well 699-49-57A North of 200 East Area

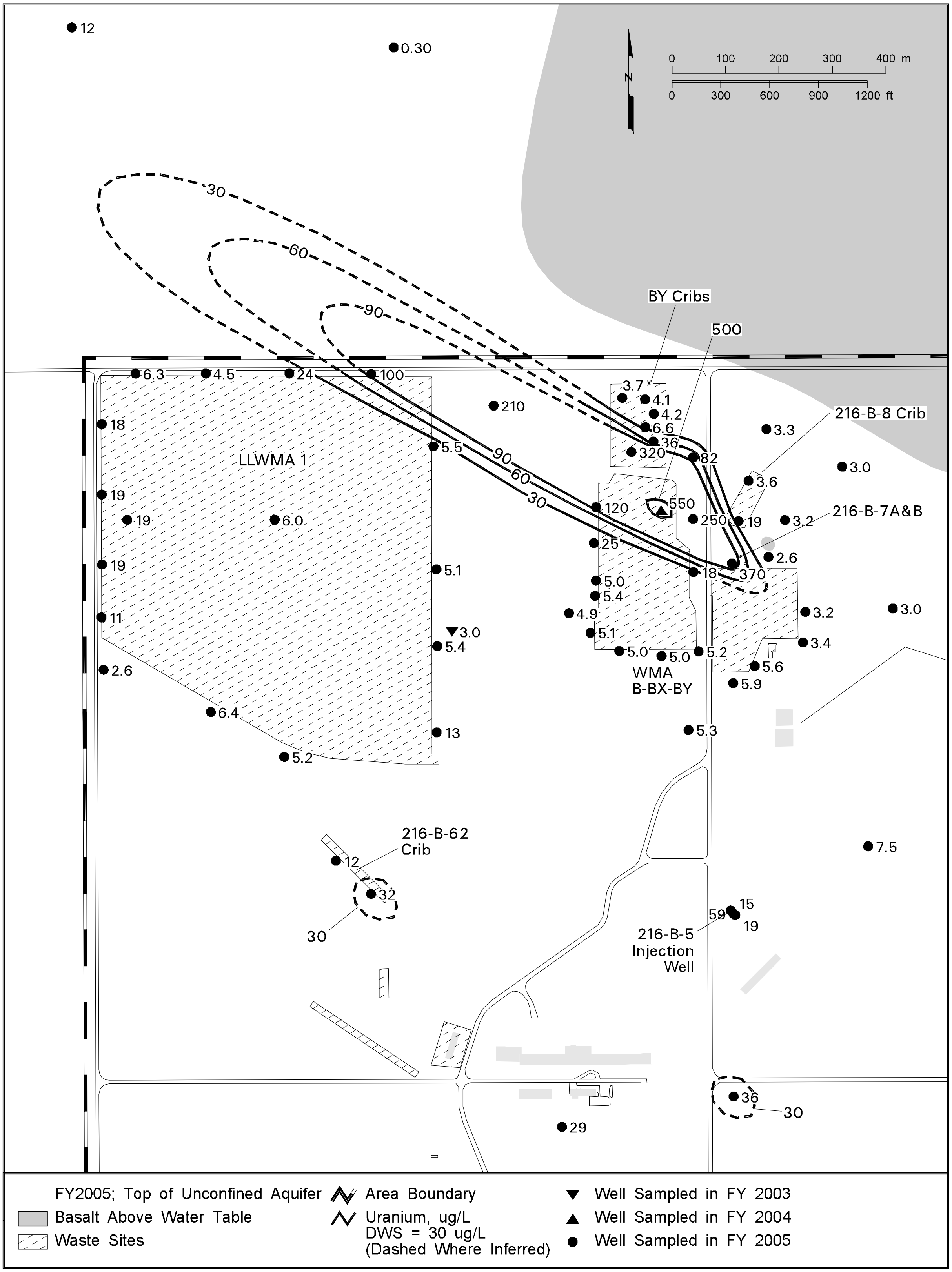

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Figure 2.10-11. Average Uranium Concentrations in the Northwest 200 East Area, Top of Unconfined Aquifer

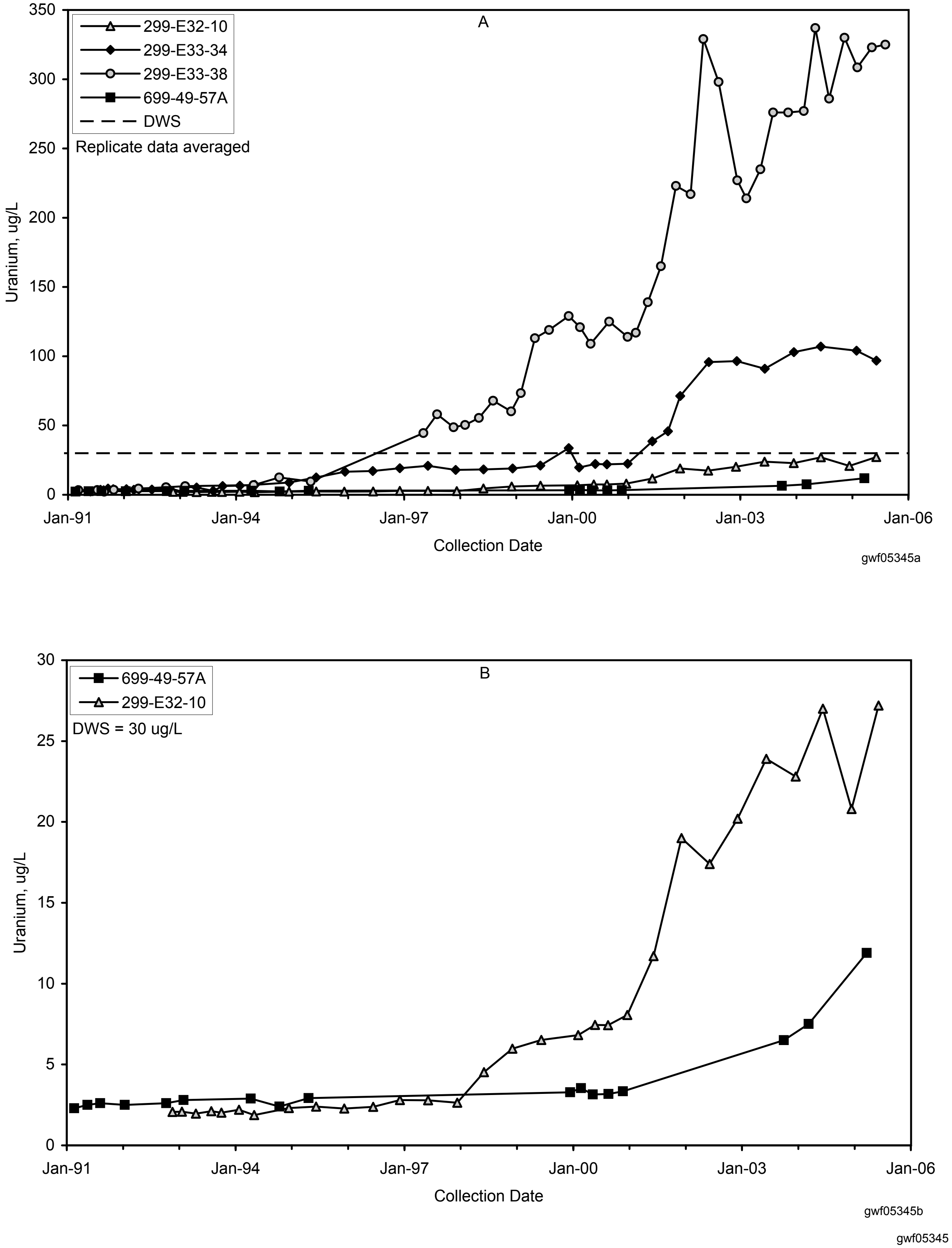


Figure 2.10-12. Uranium Concentrations in Wells in the Northwest 200 East Area, Top of Unconfined Aquifer

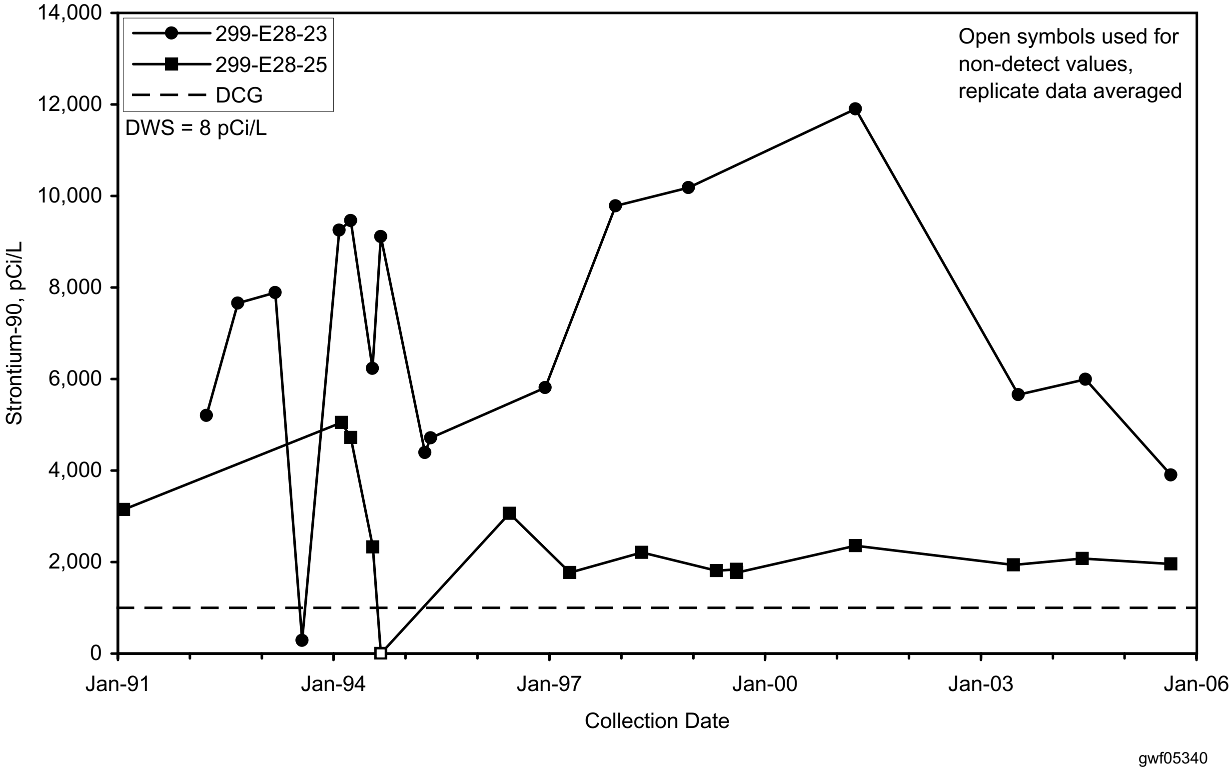


Figure 2.10-13. Strontium-90 Concentrations in Wells 299-E28-23 and 299-E28-25 at the 216-B-5 Injection Well Site, Top of Unconfined Aquifer

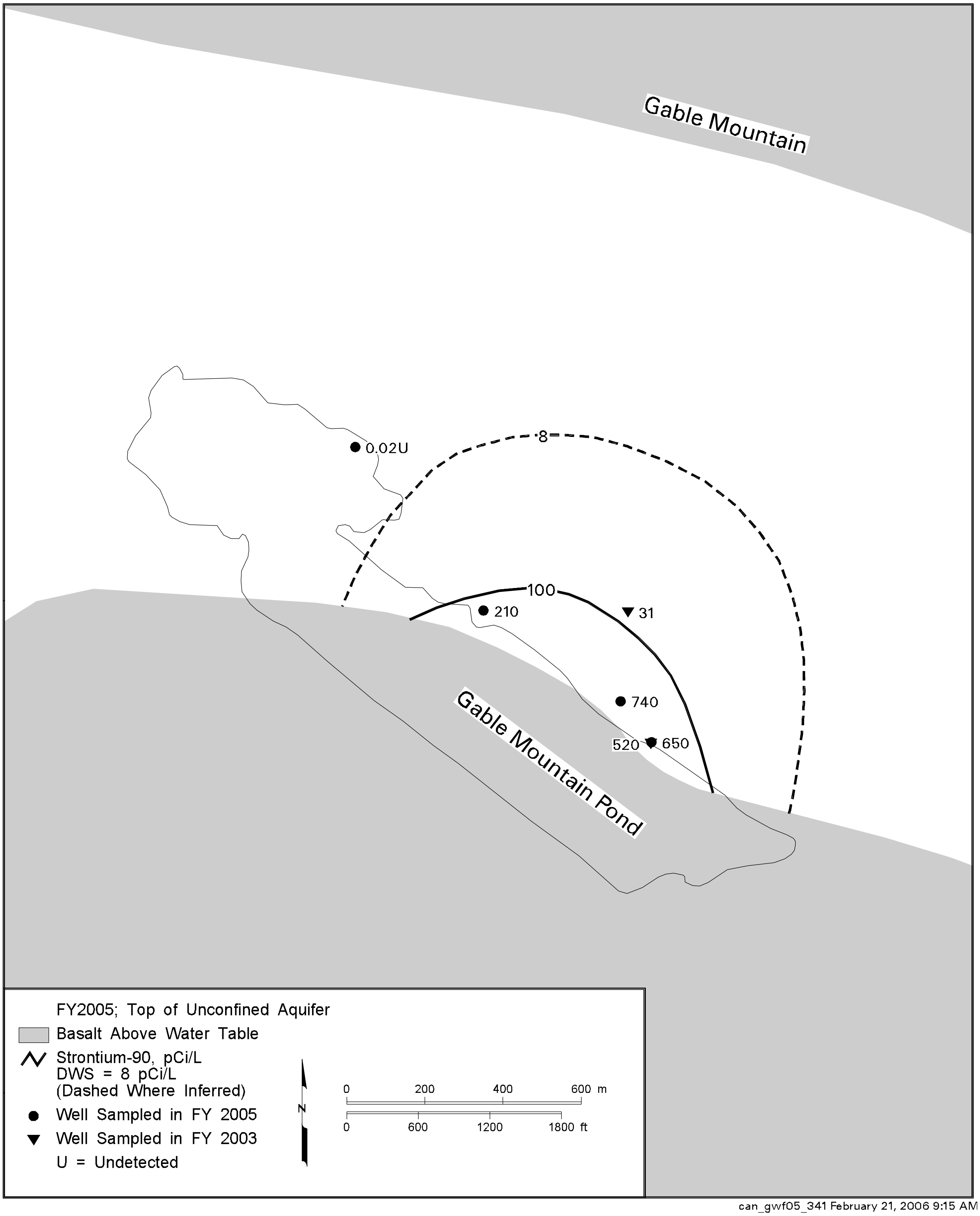


Figure 2.10-14. Strontium-90 Concentrations at Gable Mountain Pond, Top of Unconfined Aquifer

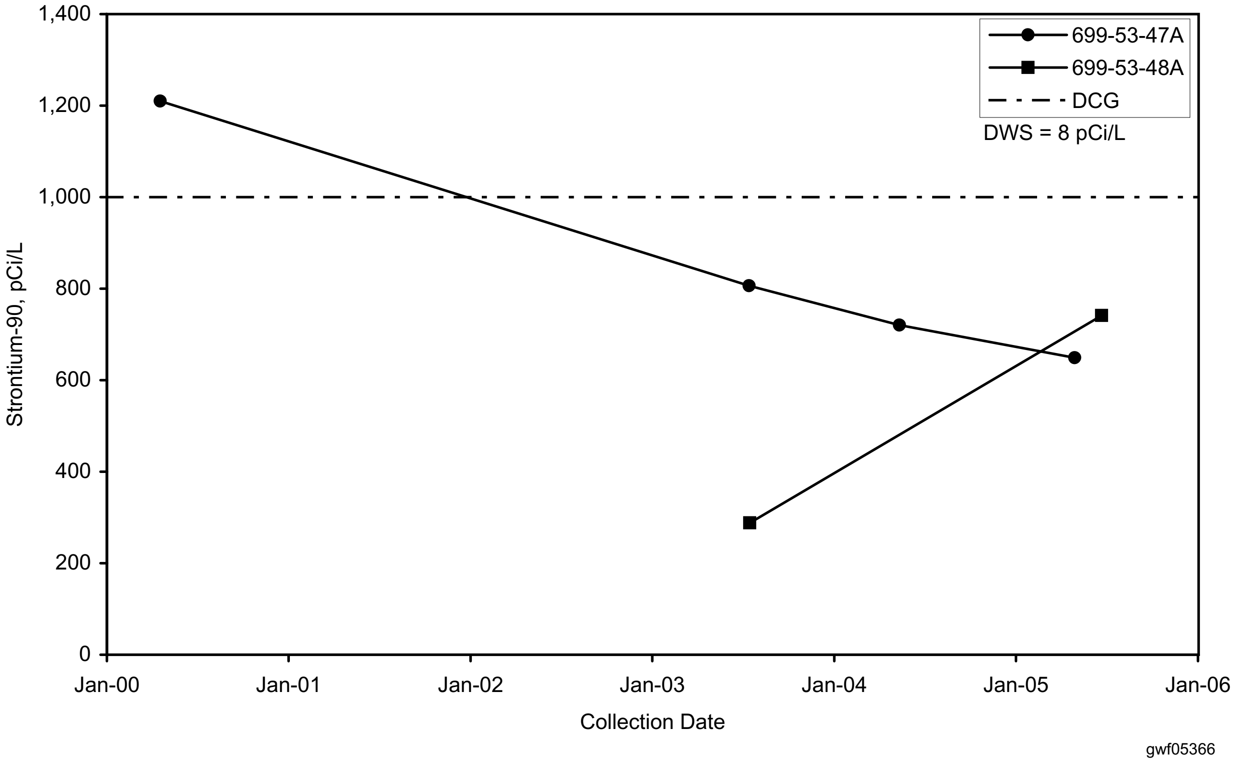


Figure 2.10-15. Strontium-90 Concentrations in Wells 699-53-47A and 699-53-48A at Gable Mountain Pond, Top of Unconfined Aquifer

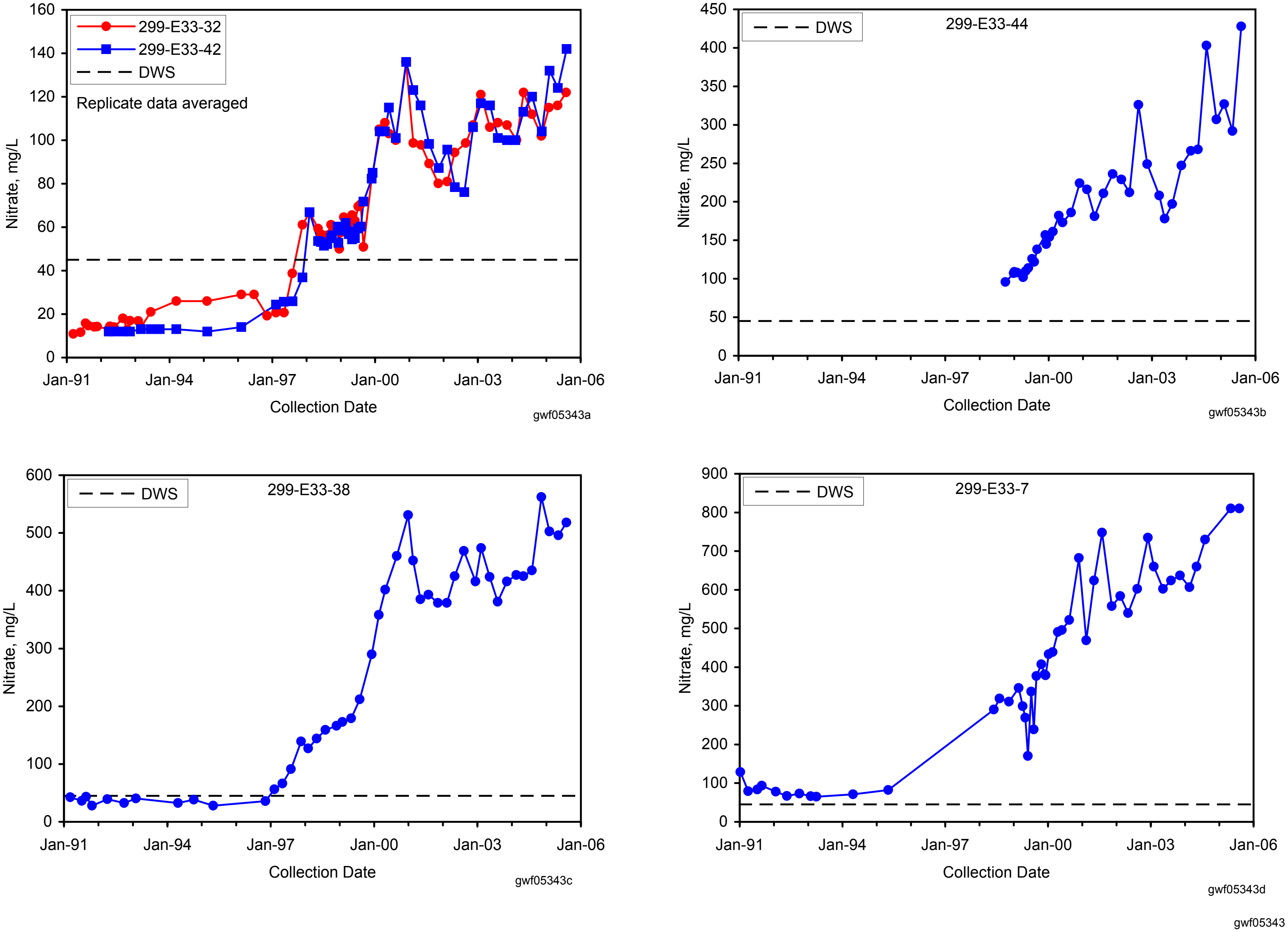


Figure 2.10-16. Trend Plots of Nitrate for Wells at Waste Management Area B-BX-BY and BY Cribs

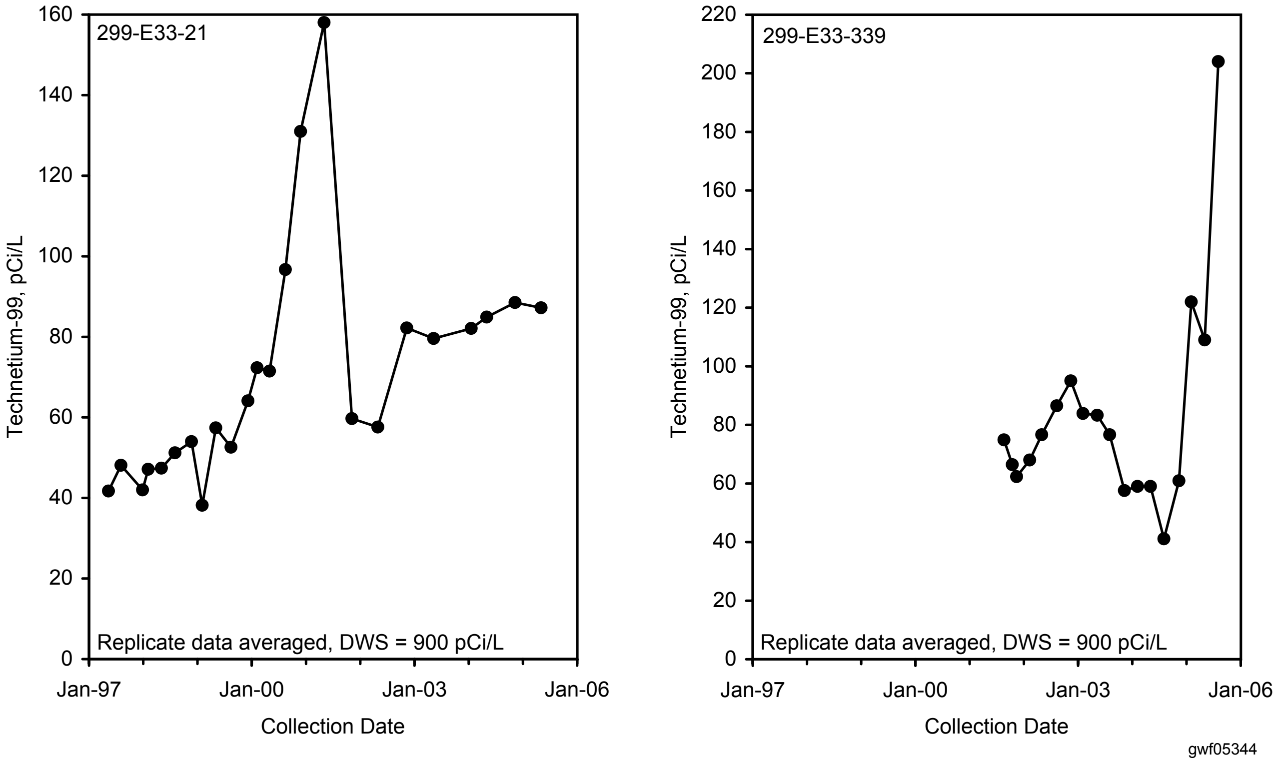


Figure 2.10-17. Technetium-99 Concentrations Southwest (well 299-E33-21) and South (well 299-E33-339) of Waste Management Area B-BX-BY

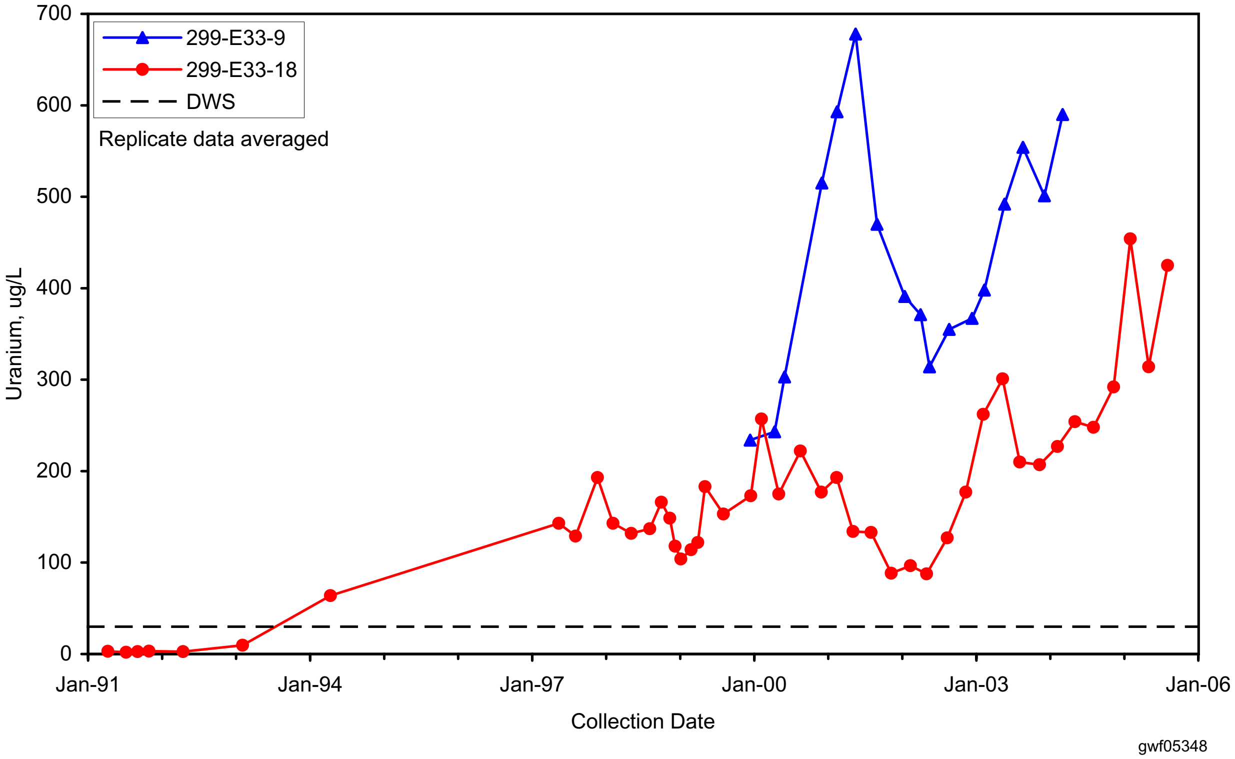
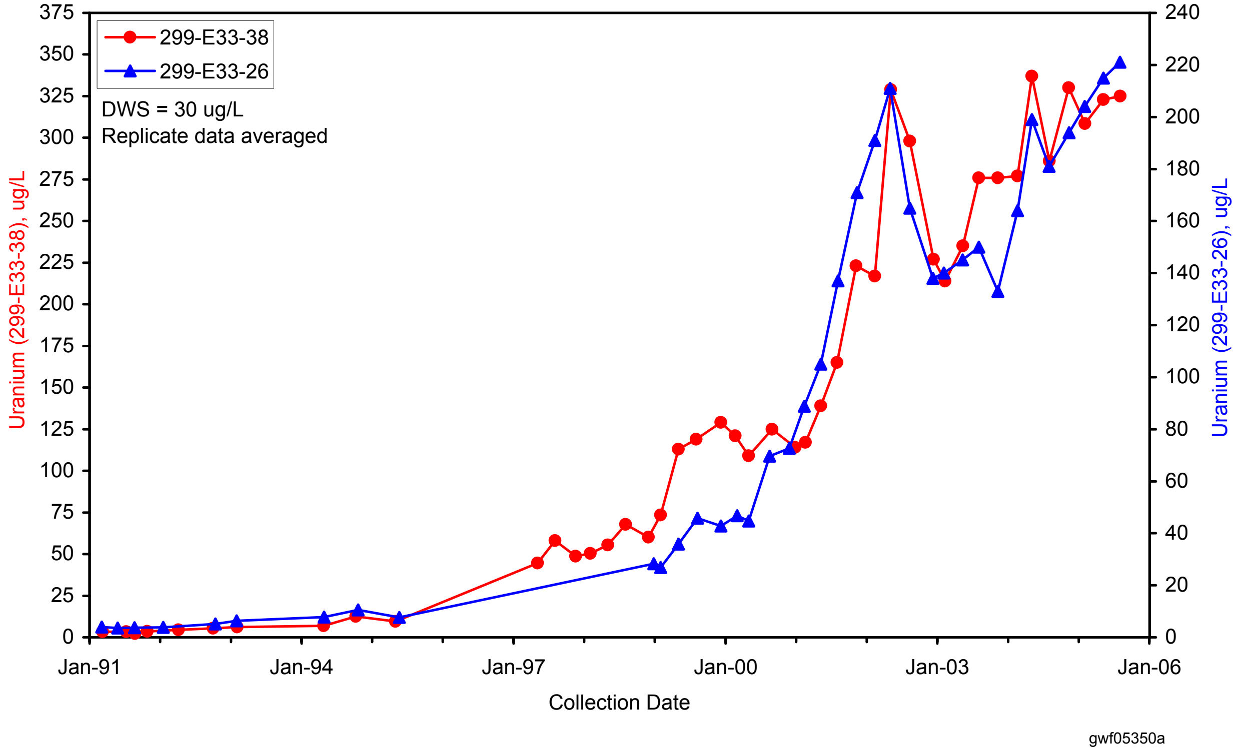


Figure 2.10-18. Uranium Concentrations Under BY Tank Farm at Well 299-E33-9 and Downgradient Well 299-E33-18



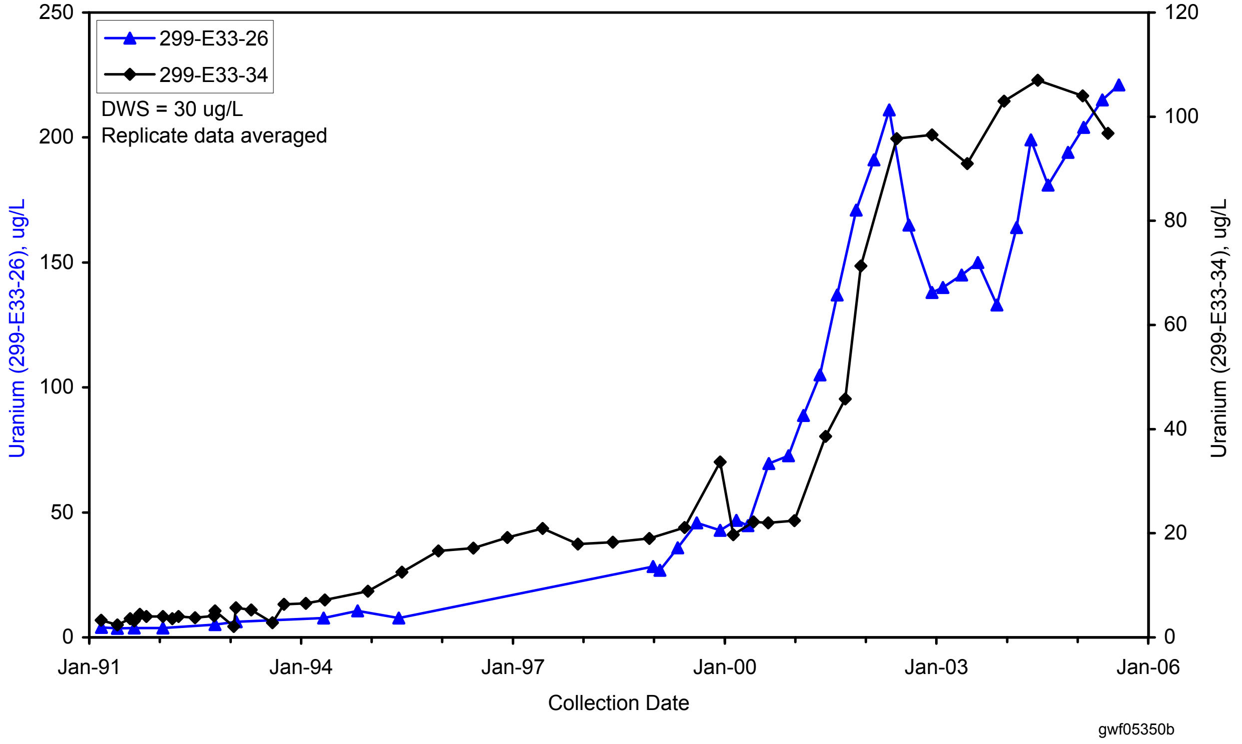


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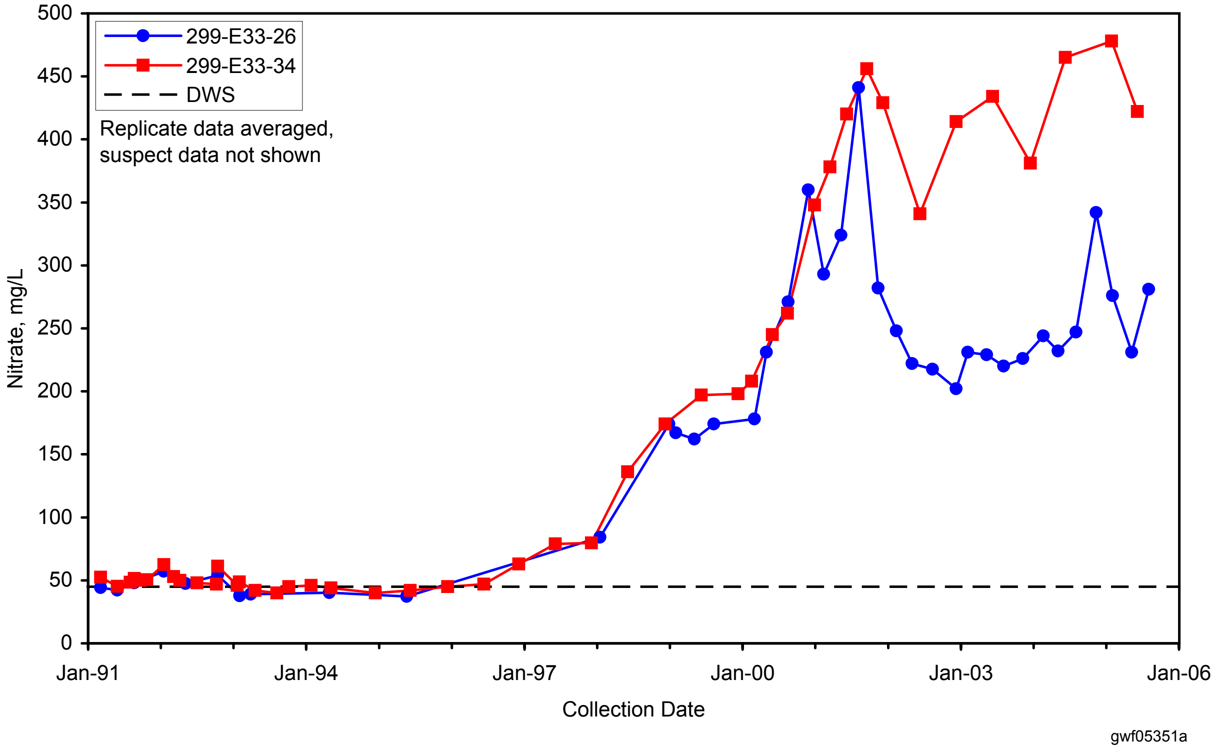
Figure 2.10-19. Uranium Trends Under BY Cribs (Well 299-E33-38) and to the West. Uranium impacted these wells at nearly the same time.



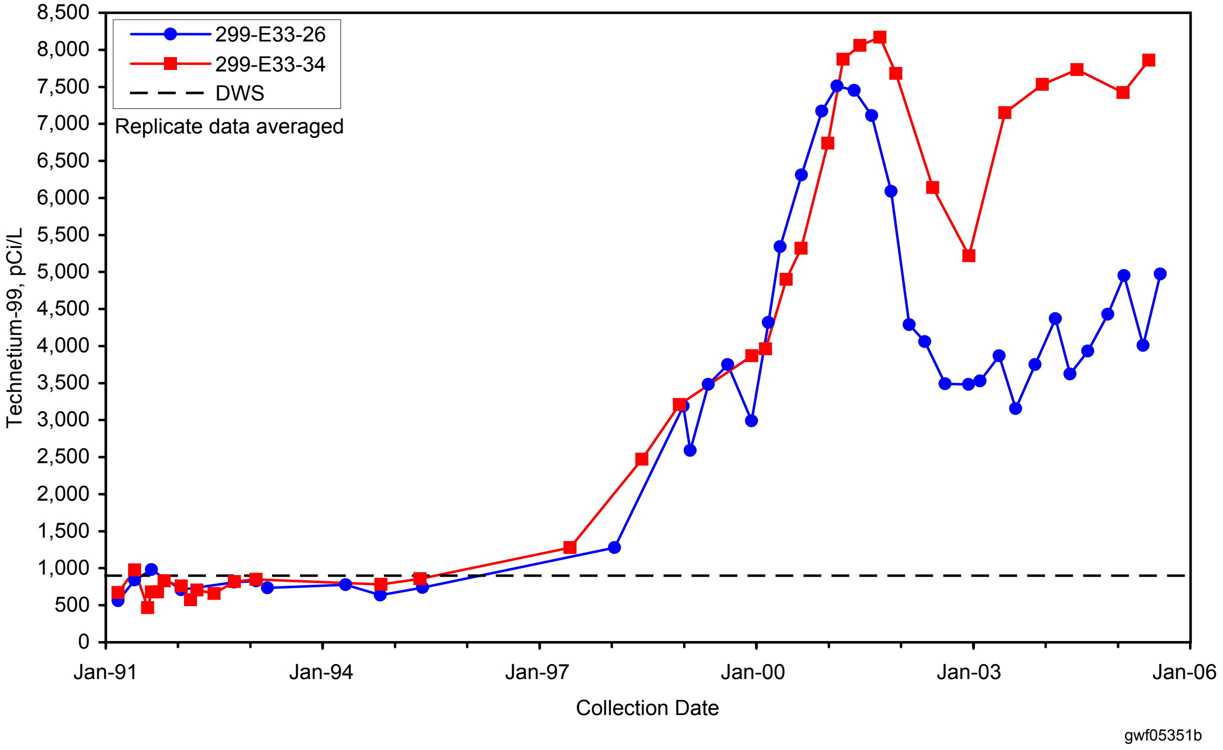


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Figure 2.10-20. Nitrate and Technetium-99 Concentrations West of the BY Cribs. These contaminants impacted the wells at nearly the same time.

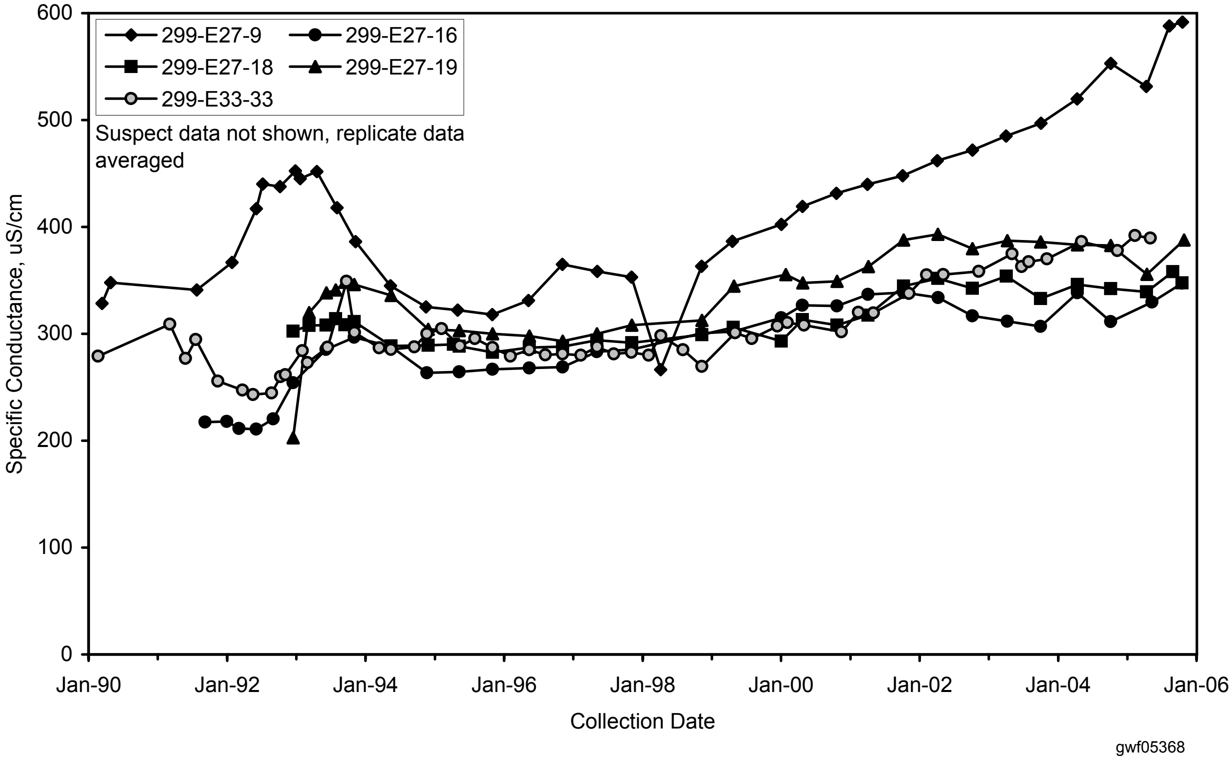

Figure 2.10-21. Specific Conductance in Wells at the 216-B-63 Trench

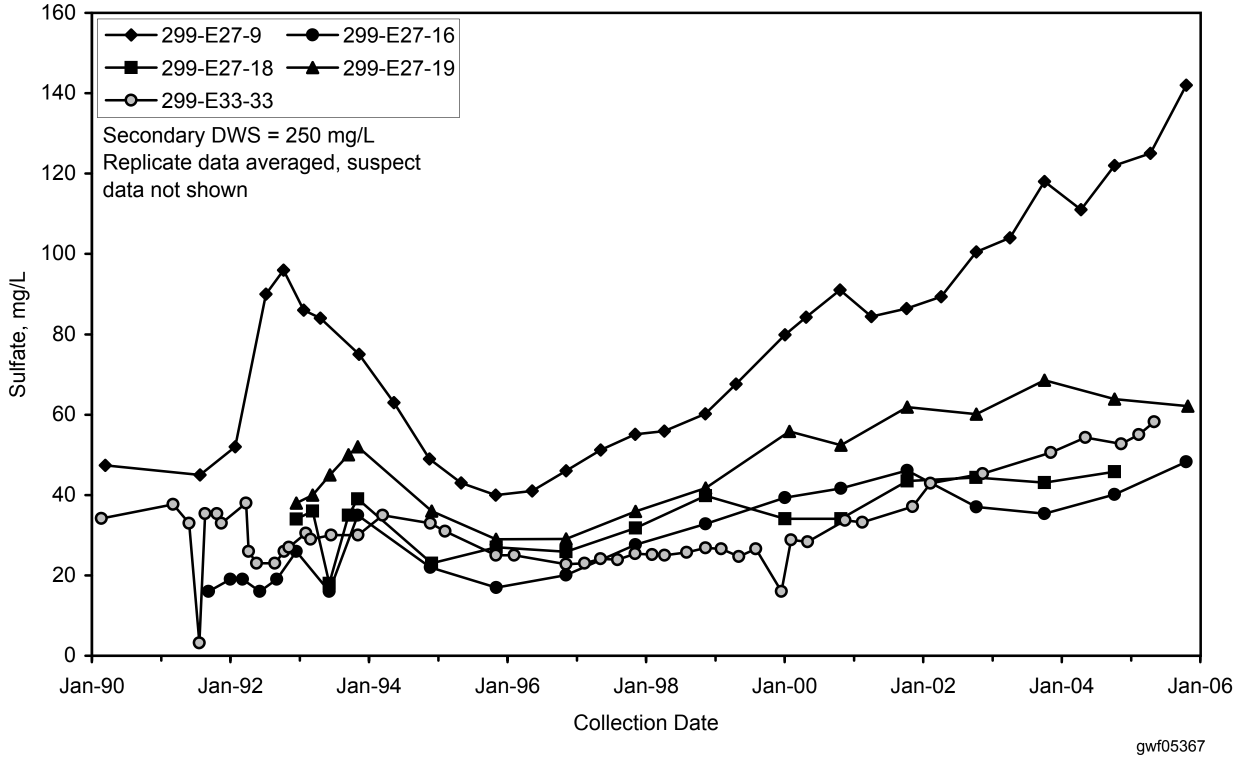

Figure 2.10-22. Sulfate Concentrations in Wells at the 216-B-63 Trench

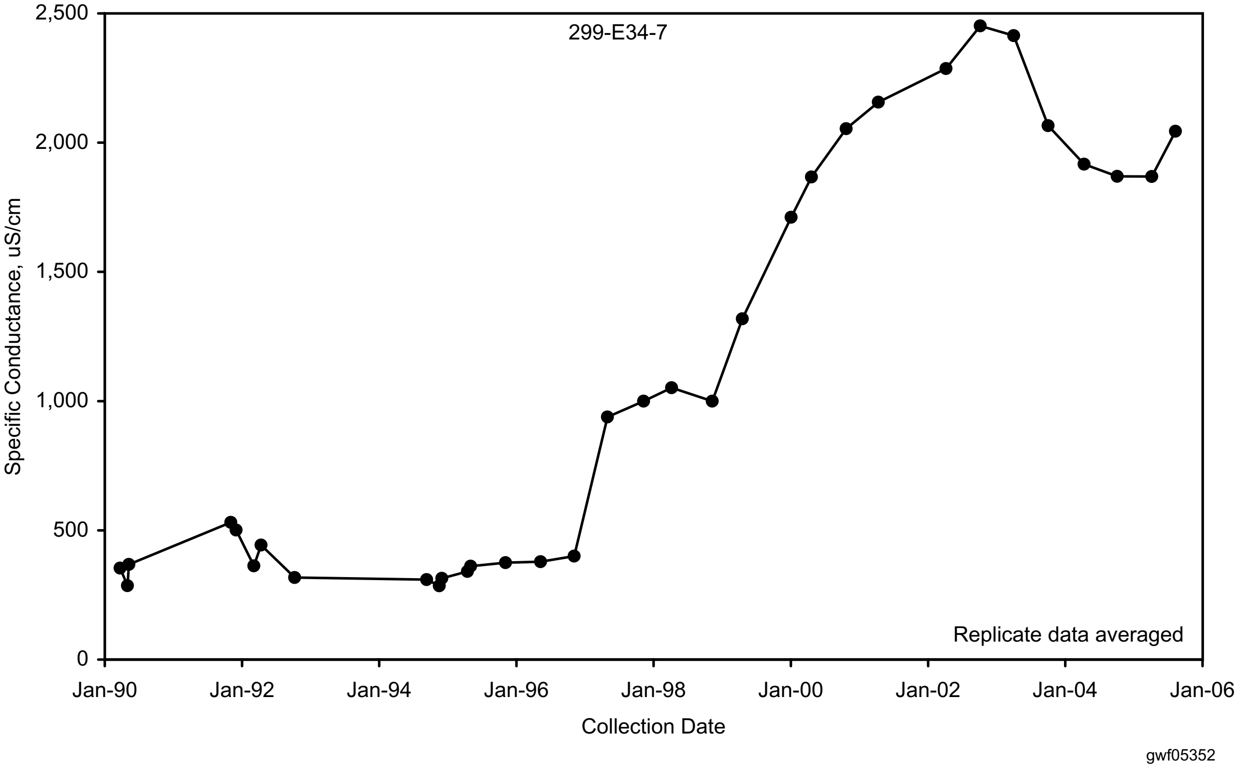

Figure 2.10-23. Specific Conductance versus Time in Well 299-E34-7 at Low-Level Waste Management Area 2

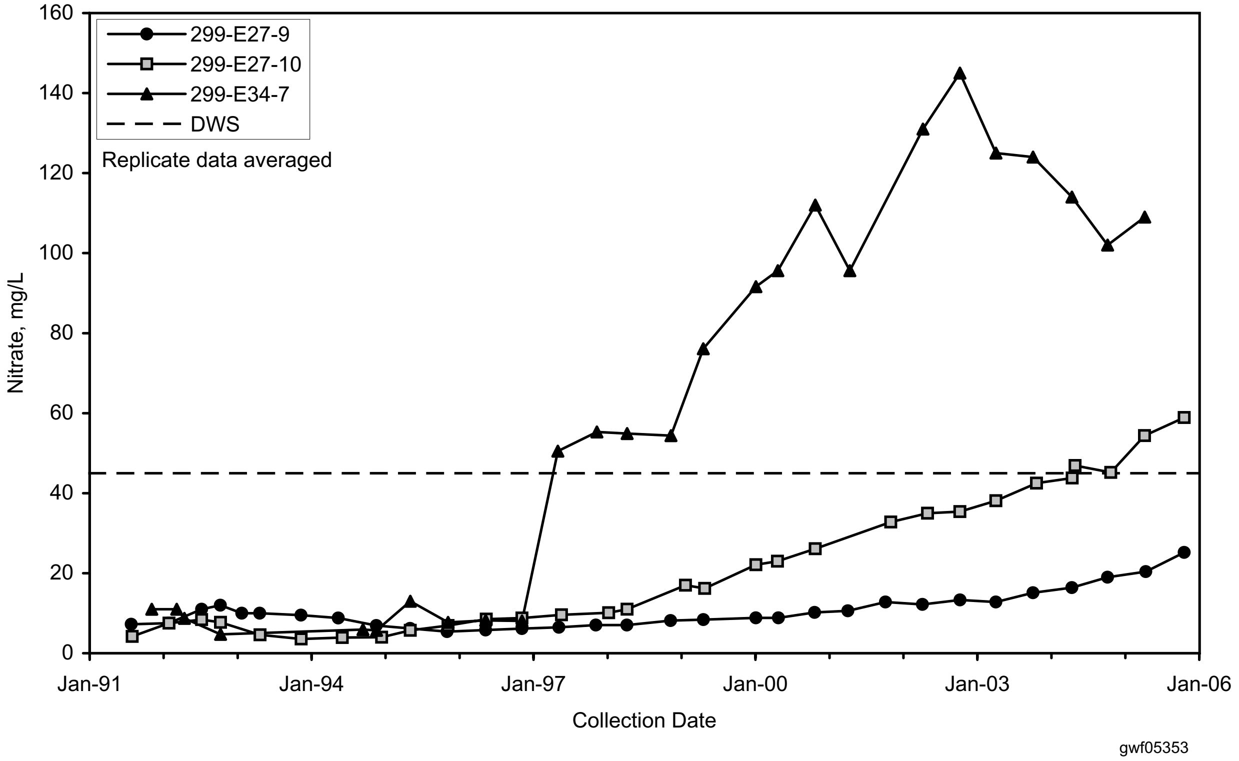

Figure 2.10-24. Nitrate Concentrations in Low-Level Waste Management Area 2 Wells 299-E34-7, 299-E27-10, and 299-E27-9

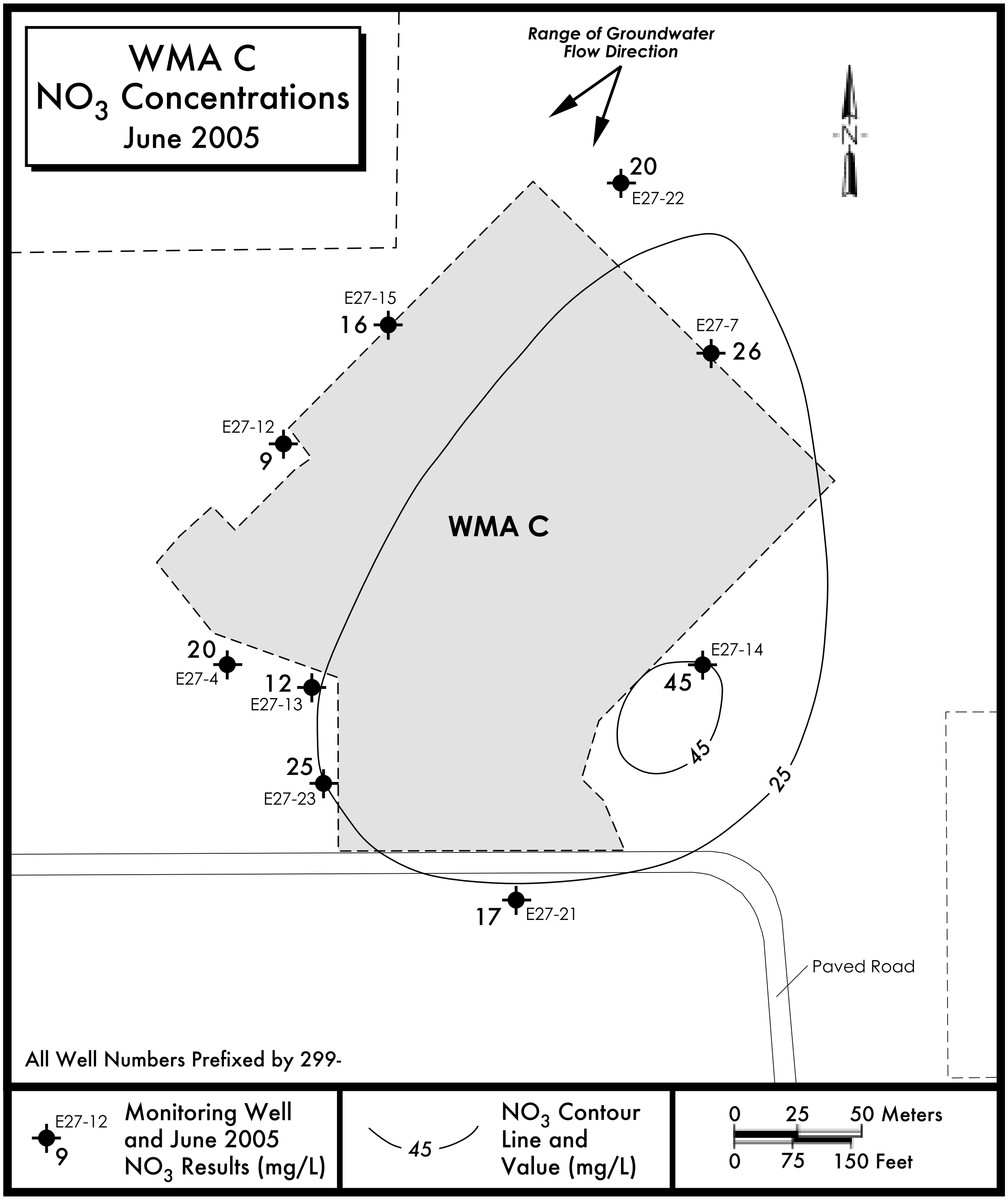

Figure 2.10-25. Nitrate Concentrations at Waste Management C Mapped for Data from the June 2005 Sampling Event

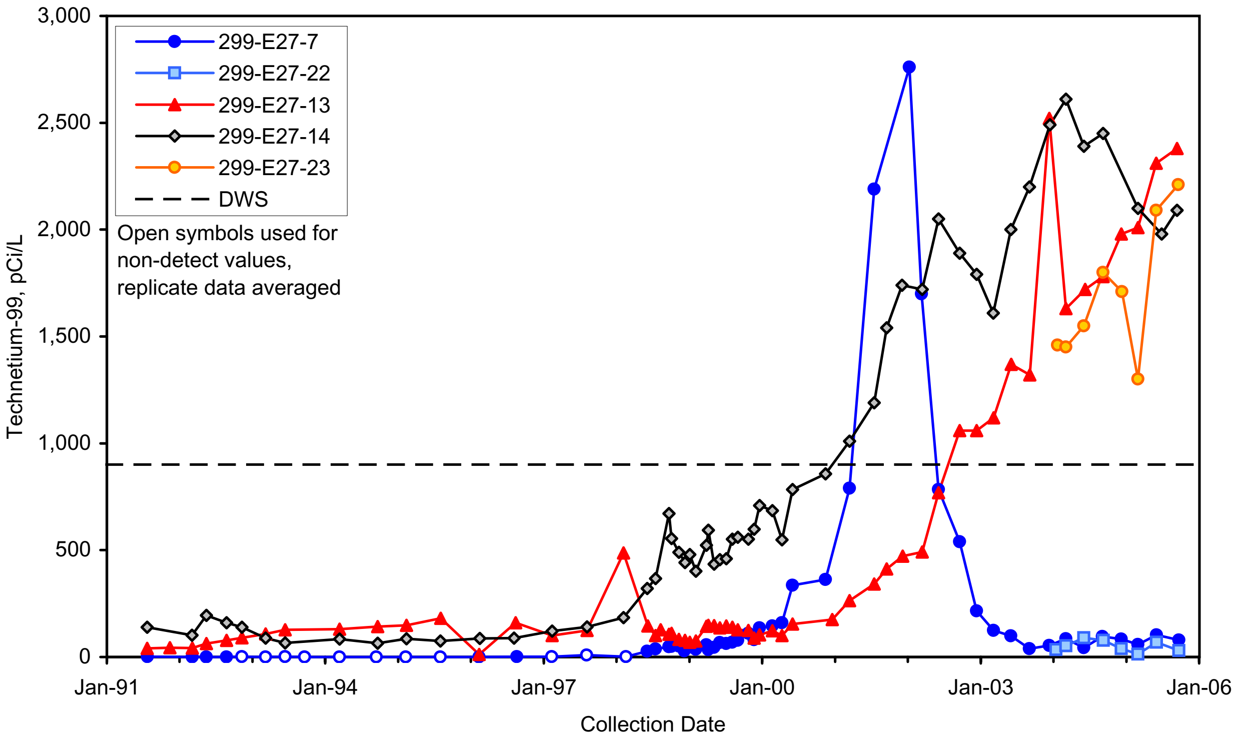

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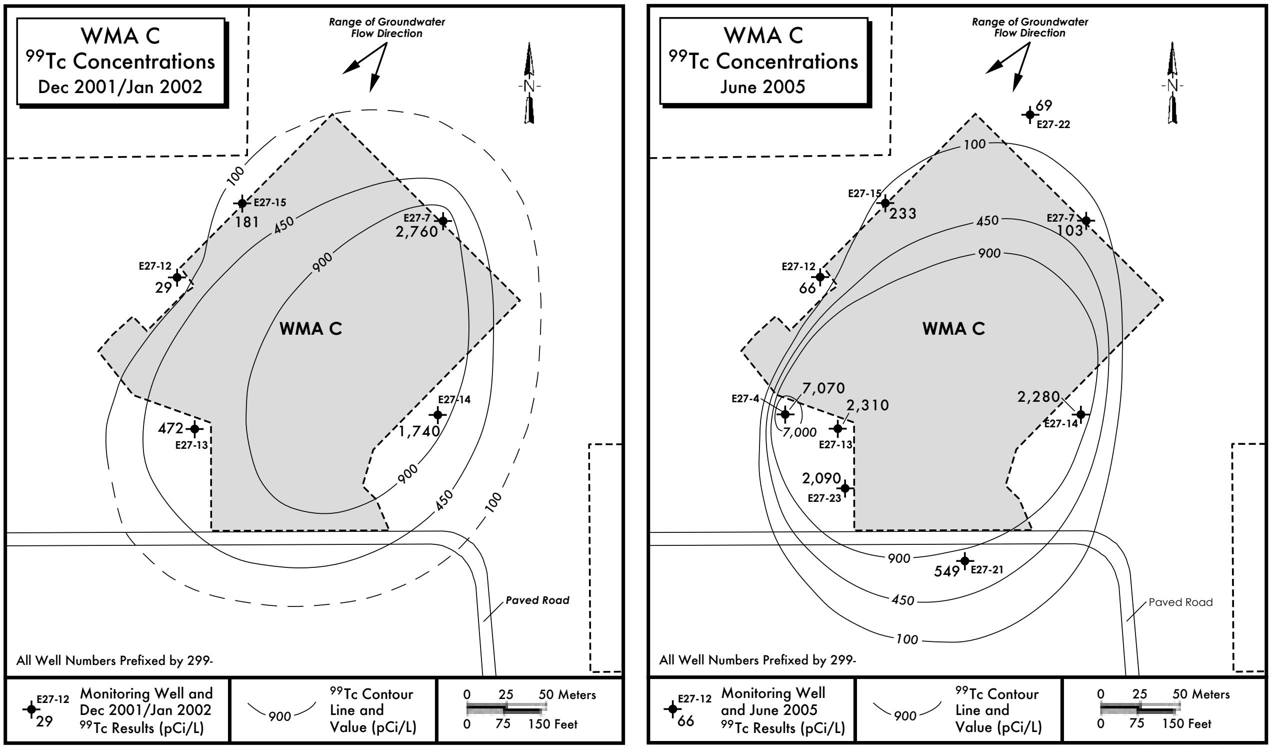
Figure 2.10-26. Trend Plot of Technetium-99 Values at Waste Management Area C



2006/DCL/C/001 (02/17)

2006/DCL/C/002 (02/20)

Figure 2.10-27. Technetium-99 Distributions from FY 2002 to FY 2005

2.11 200-PO-1 Operable Unit

J. W. Lindberg, S. M. Narbutovskih, M. D. Sweeney, D. B. Barnett, D. G. Horton, and E. C. Thornton

The scope of this section is the 200-PO-1 groundwater interest area, which includes the 200-PO-1 Operable Unit (Figure 2.1-1 in Section 2.1). This area encompasses the south portion of the 200 East Area and a large triangle-shaped portion of the Hanford Site extending to the Hanford town site to the east and the 300-FF-5 groundwater interest area to the southeast. The 216-B-3 pond (B Pond) straddles two operable units but is considered part of the 200-PO-1 interest area. The Groundwater Performance Assessment Project (groundwater project) established the interest areas to aid in planning, scheduling, and interpretation. Figure 2.11-1 shows facilities and near-field wells. Figure 2.1-2 in Section 2.1 and Figure 2.11-2 shows the locations of 600 Area wells including 200-PO-1 Operable Unit far-field wells and shoreline monitoring sites in this region. Tritium, nitrate, and iodine-129 are the contaminants of greatest significance in groundwater. Other contaminants of concern include strontium-90 and technetium-99. Contaminants of potential concern include arsenic, chromium, manganese, vanadium, cobalt-60, cyanide, and uranium.

Tritium, nitrate, and iodine-129 are the contaminants of greatest significance in this operable unit.

The primary monitoring objective is to meet the groundwater monitoring requirements for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), *Resource Conservation and Recovery Act* (RCRA), Washington Administrative Code (WAC), and the *Atomic Energy Act* (AEA) as directed in U.S. Department of Energy (DOE) Orders.

Groundwater monitoring in the 200-PO-1 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring

- ***One-hundred-nineteen wells and six aquifer sampling tube sites (along the Columbia River) are sampled annually to triennially for tritium, nitrate, and iodine-129 plus other constituents depending on location.***
- ***In FY 2005, six wells and the six aquifer sampling tubes were not sampled as scheduled (see Appendix A for details).***

Facility Monitoring

- ***Groundwater monitoring of seven wells at the Integrated Disposal Facility started in FY 2005.***
- ***Eleven near-field wells are sampled quarterly to semiannually at the RCRA PUREX cribs facility for RCRA monitoring. Seventy-nine far-field wells are co-sampled with the 200-PO-1 Operable Unit.***
- ***Eight wells at the single-shell tank Waste Management Area A-AX are monitored semiannually for RCRA monitoring.***
- ***Nine wells are sampled semiannually at the 216-A-29 ditch for RCRA monitoring.***
- ***Four wells are sampled semiannually at the 216-B-3 pond (B Pond) for RCRA monitoring.***
- ***Three wells are sampled quarterly at the 200 Area Treated Effluent Disposal Facility under a Washington State waste discharge permit (WAC 173-216).***
- ***Nine wells are sampled semiannually at the Nonradioactive Dangerous Waste Landfill for RCRA monitoring.***
- ***Ten wells at the Solid Waste Landfill are sampled quarterly under a Washington State solid waste landfill permit (WAC 173-304).***
- ***Three water supply wells at the 400 Area are sampled quarterly to annually for AEA.***
- ***Wells not sampled as planned included two wells in which a sampling event was missed because of decreasing water levels, two wells in which sampling was delayed for one or more months, and two wells in which constituents analyzed in collected samples were not as planned (see Appendix B for details).***

The goal for the 200-PO-1 Operable Unit is to monitor the contaminants of concern until final clean-up decisions are made. Included within the operable unit are six RCRA units including the Plutonium-Uranium Extraction (PUREX) cribs (called the RCRA PUREX cribs), Waste Management Area A-AX (single-shell tanks), 216-A-29 ditch, Integrated Disposal Facility, B Pond, and the Non-Radioactive Dangerous Waste Landfill. Two other facilities that are not regulated under RCRA but are subject to WAC requirements are the 200 Area Treated Effluent Disposal Facility and Solid Waste Landfill. Water supply wells in the 400 Area are monitored primarily for tritium under AEA.

Groundwater in the 200-PO-1 Operable Unit flows to the southeast and east.

Groundwater in the unconfined aquifer generally flows southeastward in the west portion of the operable unit and northeastward, eastward, and southeastward in the east portions of the operable unit as groundwater approaches the Columbia River (see Figure 2.1-3 in Section 2.1). A detailed discussion of 200 East Area hydrogeology can be found in PNNL-12261. Further discussion of more local groundwater flow characteristics are found in Section 2.11.3.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under CERCLA, RCRA, AEA, and WAC monitoring.

2.11.1 Groundwater Contaminants

This section describes the major contaminants of concern within the 200-PO-1 Operable Unit including tritium, nitrate, iodine-129, strontium-90, and technetium-99, and other contaminants of potential concern. Greater details at various RCRA or WAC facilities are discussed in Section 2.11.3.

2.11.1.1 Tritium

The source for the large tritium plume that extends from the southeast portion of the 200 East Area to the Columbia River (see Figure 2.1-5 in Section 2.1) is in the vicinity of the PUREX cribs.[a] The highest concentrations of tritium (drinking water standard 20,000 pCi/L) in this plume remain near these cribs (see Figure 2.10-4 in Section 2.10). The highest reported level of tritium during fiscal year (FY) 2005 was 578,000 pCi/L for a sampled collected October 2004 at well 299-E17-14 near the 216-A-36B crib. (Note: The 200-PO-1 Operable Unit well with the highest tritium concentrations in recent years was well 299-E17-9 near the 216-A-36B crib. This well went dry in FY 2003. The last tritium analysis from this well in October 2002 was 5.6 million pCi/L.)

Concentrations of tritium continue to decline as the plume is attenuating naturally.

Concentrations of tritium continued to decline as the plume attenuates naturally due to radioactive decay and dispersion combined with the general decreasing source that resulted from the termination of PUREX Plant operations. Wells in the east portion of the 200-PO-1 Operable Unit have tritium concentrations above 80,000 pCi/L (see Figure 2.1-5 in Section 2.1) from an early period of discharge to the PUREX cribs (PNNL-11141). These wells are expected to continue to experience decreasing concentrations as portions of the plume with higher concentrations (representing the two periods of PUREX Plant operations) move beyond the wells into the river or decay and disperse. These wells more distant from the source are sampled once every 3 years, and most were sampled during FY 2004. Wells in the south of the 200-PO-1 Operable Unit, immediately north of the 300 Area, also have decreasing tritium concentrations indicating that the southward migration of the plume has stopped due to the dispersion and radioactive decay (see more about tritium near the 300 Area in Section 2.12.1.5).

Wells near the PUREX cribs generally show a steady to decreasing trend as demonstrated in the trend plot for well 299-E17-14 (Figure 2.11-3) located near the 216-A-36B crib (see

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[a] The term “PUREX cribs” refers to all the cribs in the southeast part of the 200 Area and east of the 200 East Area where PUREX wastewater was discharged. Three of these cribs are monitored under RCRA and are termed RCRA PUREX cribs (see Section 2.11.3.2).

Figure 2.11-1 for locations of cribs and wells). However, two show slightly increasing trends since 2003 as demonstrated in the trend plot for well 299-E24-16 (also in Figure 2.11-3) located near the 216-A-10 crib. The wells with increasing trends do not have the highest tritium concentrations. The increasing trends may be caused by shifting groundwater flow patterns.

The zone of lower tritium concentration near Energy Northwest (Figure 2.1-5 in Section 2.1) may be due to a zone of lower hydraulic conductivity in the unconfined aquifer. At that site, the water table is within the upper portion of the Ringold Formation that locally may have a greater degree of cementation. Tritium at the 618-11 burial grounds located just west of Energy Northwest is discussed in Section 2.12.1.5.

A few wells in the 200-PO-1 Operable Unit that were sampled in FY 2005 monitor deeper within the unconfined and confined aquifers. Wells at B Pond and the 200 Area Treated Effluent Disposal Facility had tritium results that ranged from below 30 pCi/L at the Treated Effluent Disposal Facility to near the drinking water standard (20,000 pCi/L) near B Pond. These wells are screened at the first occurrence of groundwater below the Ringold Formation lower mud unit. Therefore, they are locally confined (i.e., potentiometric surface is within the lower mud unit). Similarly, well 699-S11-E12AP north of the 300 Area is screened at a level that is confined locally in the lower portions of the Ringold Formation. Tritium levels there continue to be below the detection level of the groundwater analysis method (usually <100 pCi/L). Well 499-S1-8J in the 400 Area (a water supply well) is screened in the lower portions of the Ringold Formation (but not confined) and had tritium levels during FY 2005 that ranged between 2,100 and 2,800 pCi/L. These results are similar to other wells in the 400 Area that are screened at the water table. Typically wells in this area affected by the large tritium plume from the 200 East Area have tritium levels ranging from 2,000 to 20,000 pCi/L (see Figure 2.1-5 in Section 2.1). Tritium was not detected (below 72 pCi/L) in the Laser Interferometer Gravitational Wave Observatory well (well 699-S2-34B), which is screened in a basalt-confined aquifer, in a sample taken during March 2005. Other wells sampling groundwater in basalt-confined aquifers are on a triennial sampling schedule and will be sampled again in FY 2006.

The iodine-129 plume is dispersing, but at a very slow rate.

2.11.1.2 Iodine-129

The iodine-129 plume (Figure 2.1-7 in Section 2.1) extends southeast into the 600 Area from the 200 East Area and appears to coincide with the tritium and nitrate plumes (see Figures 2.1-5 and 2.1-6 in Section 2.1). Very little difference has been observed between this year's map and the corresponding map in last year's groundwater annual report (PNNL-15070, Figure 2.1-7). The iodine-129 plume is dispersing at a very slow rate. During FY 2005, the highest concentrations of the iodine-129 plume were near the sources of the plume, i.e., the PUREX cribs, where concentrations varied between 5 and 10 pCi/L (see Figure 2.10-8 in Section 2.10). The well with the highest concentration during FY 2005 was well 299-E17-14 (near the 216-A-36B crib) with a result of 9.2 pCi/L for a sample collected in January 2005. The gradually decreasing trend for iodine-129 at this well (Figure 2.11-4) is typical of the gradually decreasing trend for iodine-129 in the vicinity of the PUREX cribs. Iodine-129 was not detected during FY 2005 in the few wells that sample deeper in the unconfined aquifer and confined aquifers.

The nitrate plume appears to have receded slightly over previous years throughout most of its extent.

2.11.1.3 Nitrate

The extent of the nitrate plume that originated in the 200 East Area (Figure 2.1-6 in Section 2.1) is nearly identical to the tritium plume. However, the area with nitrate concentration above the drinking water standard (>45 mg/L) is more restricted than the area with tritium above its drinking water standard of 20,000 pCi/L. Nitrate at levels above the drinking water standard north of the 400 Area and at Energy Northwest, within the area impacted by the PUREX cribs, can be attributed to wastewater disposal activities in those areas. The highest reported concentration of nitrate during FY 2005 within the 200-PO-1 interest area was at well 299-E17-14 (at the 216-A-36B crib; see Figure 2.10-6 in Section 2.10) with a reported value of 134 mg/L in July 2005. The overall nitrate plume (see Figure 2.1-6 in Section 2.1) appears to have receded slightly over previous years throughout most of its extent except for the south – most portions of the plume near the 300 Area (Section 2.12.1.4) and in the immediate vicinity of the PUREX cribs (PNNL-14548; PNNL-15070).

Wells near the PUREX cribs in the southeast portion of the 200 East Area generally showed stable or increasing nitrate trends during FY 2005. The trend at well 299-E17-19 is typical of the increasing trend (Figure 2.11-5). The increase in nitrate concentration was also observed at upgradient wells 299-E24-18 and 299-E23-1 (Figure 2.11-6), located west and northwest of PUREX cribs, respectively, and near Waste Management Area A-AX (see Section 2.11.3.3). This increase in nitrate at many of the wells in the southeast portion of the 200 East Area most likely is due to changing groundwater flow conditions related to the cessation of wastewater discharges at B Pond. Nitrate-contaminated groundwater in the central portion of the 200 East Area (near well 299-E23-1) with concentrations near the drinking water standard (45 mg/L) may be moving into the area of the PUREX cribs and causing increases in nitrate concentration in the upgradient well (299-E24-18) for the RCRA PUREX cribs and some of the wells near the 216-A-10 crib.

One well at Waste Management Area A-AX had technetium-99 levels ranging from 5,230 to 8,580 pCi/L during FY 2005, which is a decrease from FY 2004.

Nitrate was detected at depth in a few wells that are deeper in the unconfined aquifer or in a lower confined aquifer. However, none of the deeper wells had reported nitrate concentrations as high as the drinking water standard (45 mg/L). At the Nonradioactive Dangerous Waste Landfill, nitrate concentrations were as high as 4.5 mg/L in well 699-26-35C, which is a well screened at the top of the low permeability unit (the bottom of the unconfined aquifer there) in the upper Ringold Formation. Beneath the Ringold Formation lower mud unit at B Pond and the 200 Area Treated Effluent Disposal Facility (the uppermost aquifer there), nitrate concentrations continue to be very low (near the detection level, below 0.05 mg/L). In the lower portions of the unconfined aquifer beneath the 216-A-29 ditch (well 299-E25-28), the nitrate concentration was ~0.35 mg/L, and north of the 300 Area (well 699-S11-E12AP), it was not detected. In the water supply wells at the 400 Area (e.g., well 499-S1-8J), which are screened in the lower portion of the Ringold Formation, the nitrate levels continue to be non-detected. Nitrate also remains undetected in the Laser Interferometer Gravitational Wave Observatory well (699-S2-34B), which is screened in a lower basalt aquifer.

2.11.1.4 Strontium-90

A small plume of strontium-90 (a beta emitter) exists near the 216-A-10 and 216-A-36B cribs. Well 299-E17-14 was the only well with strontium-90 concentration above the drinking water standard (8 pCi/L) during FY 2005, with a maximum of 21 pCi/L. The trend for strontium-90 in well 299-E17-14 shows an increasing trend from 1997 to 2001, and then a decrease (Figure 2.11-7). The impact is localized because of the low mobility of strontium-90 compared to tritium, iodine-129, and nitrate. This result is consistent, in part, with an elevated gross beta concentration of 66 pCi/L in the same well.

2.11.1.5 Technetium-99

Technetium-99 (a beta emitter) continues to be detected at Waste Management Area A-AX in concentrations far above the drinking water standard (900 pCi/L) and was detected indirectly (by gross beta) at the PUREX cribs. Although most wells at Waste Management Area A-AX had technetium-99 concentrations below the drinking water standard, groundwater samples collected from well 299-E25-93 had technetium-99 concentrations ranging from 5,230 to 8,580 pCi/L during FY 2005. Concentrations were down slightly from FY 2004 when they were as high as 13,100 pCi/L at that well (Figure 2.11-8). (For more information about technetium-99 at Waste Management Area A-AX, refer to Section 2.11.3.3).

The result for the gross beta concentration level (66 pCi/L) at well 299-E17-14 (at the 216-A-36B crib) is more than can be accounted for from the strontium-90 result (21 pCi/L) in the same well. If strontium-90 were the only beta emitter present,

Plume areas (square kilometers) above the drinking water standard at the 200-PO-1 Operable Unit:

Iodine-129 — 65.75
Nitrate — 1.03
Strontium-90 — 0.01
Technetium-99 — <0.01
**Tritium — 126.23*

**Includes portion of plume beneath 300-FF-5 Operable Unit.*

gross beta would be ~42 pCi/L. Therefore, the 66-pCi/L gross beta result must include another beta emitter. The higher result is most likely due to technetium-99, another beta emitter. The last technetium-99 result from well 299-E17-14 was 209 pCi/L in FY 1994. Technetium-99 is no longer routinely analyzed in PUREX cribs well samples because previous results were significantly less than the drinking water standard (900 pCi/L), and gross beta analysis could be used as a screening tool for technetium-99 and other beta emitters.

2.11.1.6 Other Constituents

Other constituents such as arsenic, chromium, manganese, and vanadium are also contaminants of concern at various facilities within the 200-PO-1 Operable Unit (DOE/RL-2003-04, Rev. 0). Chromium, cobalt-60, cyanide, and uranium are potential contaminants of concern at the BC cribs (see Section 2.11.2 for more groundwater contaminant information at the BC cribs). Filtered arsenic was detected at the wells near the PUREX cribs and Waste Management Area A-AX in concentrations ranging from 3 to 11 µg/L during FY 2005. However, these concentrations are consistent with Hanford groundwater background values (DOE/RL-96-61).

One well (299-E25-40) at Waste Management Area A-AX had filtered chromium results as high as 34 µg/L and another well (299-E13-9) at the BC cribs had a filtered chromium result of 44 µg/L, but no wells within the 200-PO-1 Operable Unit had a result that exceeded the drinking water standard (100 µg/L).

Two wells at Waste Management Area A-AX had filtered manganese results that exceeded the secondary drinking water standard (50 µg/L). Well 299-E25-40 (the same well that had the elevated filtered chromium results) had an elevated filtered manganese result of 166 µg/L. This well has had elevated manganese results earlier but the occurrences were erratic, supporting the suggestion that these spurious occurrences were possibly related to corrosion of the well casing or screen. The other well at Waste Management Area A-AX with elevated filtered manganese was the newly installed well 299-E25-94. Filtered manganese results immediately after the well was installed were as high as 55 µg/L; however, later in FY 2005, the concentration had dropped to 20 µg/L. Elevated manganese values are common in some wells soon after installation.

Filtered manganese was the only contaminant discovered above drinking water standards in groundwater samples collected from an exploratory borehole at the BC cribs area.

Although uranium (an alpha emitter) is a groundwater contaminant of concern in the BC cribs area, it was not detected there above background concentrations during FY 2005. However, in recent years, gross alpha at well 299-E24-16 near the PUREX cribs had been increasing in concentration (Figure 2.11-9 – gross alpha at wells 299-E24-16 and 299-E24-18). Groundwater samples from wells near the PUREX cribs were not routinely analyzed for uranium previously because uranium levels were relatively low and gross alpha provided a cost efficient indicator parameter. To confirm that uranium was responsible for the elevated gross alpha results, samples from wells 299-24-16, 299-E17-14, and 299-E17-16 were analyzed for uranium as well as gross alpha in FY 2005. Uranium was detected in these samples above background levels but not exceeding the drinking water standard (30 µg/L). The well with the highest levels of gross alpha and uranium was well 299-E24-16. During FY 2005, uranium at well 299-E24-16 ranged from 24 to 26 µg/L and gross alpha ranged from 10 to 17 pCi/L. The source of the uranium is unknown, but it may be from an area upgradient. Well 299-E24-18 (an upgradient well for the PUREX cribs) experienced a plume of gross alpha that passed by the well with a concentration peak in 1994 to 1996 (Figure 2.11-9). The highest concentration during the 1994 to 1996 period at that well was ~17 pCi/L, which compares well with the recent detected high of 17 pCi/L at well 299-E24-16.

The highest concentrations of vanadium in 200-PO-1 Operable Unit groundwater were in the vicinity of the PUREX cribs and Waste Management Area A-AX in the southeast portion of the 200 East Area. Concentrations ranged there between 13 and 30 µg/L during FY 2005. In the PUREX cribs area, vanadium concentrations are generally decreasing. At Waste Management Area A-AX, the trends are variable. There is no maximum contaminant level for vanadium.

2.11.2 Operable Unit Monitoring

The 200-PO-1 Operable Unit contains a large section of the Hanford Site (see Figure 2.1-1 in Section 2.1 and Figure 2.11-2). Its boundaries are generally defined by the largest contamination plume of the operable unit, tritium. The north boundary is the line separating the 200-BP-5 Operable Unit with the 200-PO-1 Operable Unit in the 200 East Area and the 2,000-pCi/L tritium contour line that extends eastward to the Columbia River. The southwest boundary is the 2,000-pCi/L tritium contour line. The south boundary coincides with the north boundary of the 300-FF-5 Operable Unit, and the east boundary is the Columbia River. The BC cribs, located south of the 200 East Area (see Figure 2.11-1), are included in the 200-PO-1 Operable Unit because of their location, although the majority of waste disposed there came from U Plant in the 200 West Area.

The 200-PO-1 sampling and analysis plan was revised during FY 2005. The overall approach remained the same, but changes were made in sampling frequency and constituents sampled at some wells.

Groundwater monitoring at the 200-PO-1 Operable Unit makes certain that requirements for CERCLA and AEA are met. The goal is to monitor the groundwater contaminants of concern until final cleanup decisions are made. A record of decision has not been written for this operable unit. The results of 200-PO-1 Operable Unit groundwater monitoring for FY 2005 included in this report constitute the official report for FY 2005. There is no separate report as there would be for an operable unit with a record of decision and an operation and maintenance or ongoing remediation.

Groundwater monitoring in the 200-PO-1 Operable Unit continued during FY 2005 under DOE/RL-2003-04, Rev. 0, which was based on an earlier study of data quality objectives for groundwater monitoring in the operable unit (PNNL-14049). Major groundwater contaminants of concern were tritium, nitrate, and iodine-129. Minor groundwater contaminants of concern (or potential concern) were arsenic, chromium, cyanide, manganese, strontium-90, technetium-99, and vanadium (see Section 2.11.1 for maps and descriptions of plumes and trends).

The 200-PO-1 Operable Unit sampling and analysis plan (DOE/RL-2003-04, Rev. 0) was revised during FY 2005 (DOE/RL-2003-04, Rev. 1) and will be implemented in FY 2006. While the overall approach remained the same, changes in sampling frequency and constituents have been made to reflect data collected and evaluated after publication of the first version. Eighteen of the near-field wells were changed to an annual sampling frequency from triennial in order to more rapidly detect changes in groundwater chemistry in areas near the sources of 200-PO-1 Operable Unit groundwater contamination. Eleven of these wells that were changed to annual sampling status were already sampled annually or semiannually under RCRA groundwater monitoring plans. Total organic carbon and total organic halides analyses were replaced with volatile organic analyses in transect well samples (see paragraphs later in this section) to provide more reliable screening for volatile organic compounds. Miscellaneous analyses such as gross alpha and beta, arsenic, gamma scan, lead, mercury, metals, strontium-90, and technetium-99 of groundwater samples from 22 general far-field wells were dropped because they were beyond what was determined necessary by the data quality objectives analysis (PNNL-14049).

During FY 2005, another data quality objectives process was started with the goal of defining data quality objectives for selecting operable unit remediation activities. The first step in the data quality objectives process was to meet with interested parties (including regulatory agencies, affected Indian tribes, and others) to inform them of what is currently known about the operable unit and to set the schedule for site remediation studies (including the data quality objectives process). In FY 2005, groundwater project staff interviewed one or more representative from each of the interested parties to learn of their concerns and ideas about 200-PO-1 Operable Unit groundwater contamination cleanup. With the information derived from the interviews and from existing knowledge about the operable unit, a report will be written in FY 2006 summarizing the results of the data quality objectives process.

Many of the wells surrounding the BC cribs and trenches are older wells that are scheduled for decommissioning because they are not compliant with WAC 173-160 and are not being used (these wells are numbered 299-E13-xx; Figure 2.11-1). Prior to decommissioning, they were sampled one more time to be sure there were no detectable groundwater contaminants there because most of these wells had not been sampled for 15 years. Most of the submersible pumps installed in those wells were no longer serviceable so the wells had to be bailed. Samples from these wells (and the routinely sampled well 299-E13-5) were analyzed for anions, tritium, iodine-129, gross alpha and beta, cyanide, gamma scan, metals, strontium-90, technetium-99, and uranium. Sampling was successful at 10 of the 13 wells scheduled for decommissioning. Results of the groundwater analyses showed that only filtered iron, manganese, and zinc exceeded their respective (secondary) drinking water standards in four wells (299-E13-16, 299-E13-11, 299-E13-5, and 299-E13-17). Elevated levels of these metals are common in older, non-WAC-compliant, carbon steel wells and do not necessarily indicate groundwater contamination from nearby liquid waste facilities. Technetium-99 was not detected, and the other radionuclides were similar to background levels. Table 2.11-1 lists the FY 2005 groundwater analysis results that exceeded secondary drinking water standards.

Prior to decommissioning, ten wells were sampled at the BC cribs area; results showed that only filtered iron, manganese, and zinc exceeded drinking water standards.

The 200-PO-1 Operable Unit sampling and analysis plan (DOE/RL-2003-04, Rev. 0) specifies sampling two lines of "guard wells" annually to screen for a comprehensive list of analyses. One of the lines of guard wells (the Southeast Transect) is located southeast of the 200 East Area (Figure 2.11-2) and ensures that unexpected contaminants do not migrate out of the 200 East Area undetected. The other line (the River Transect) is located along the Columbia River (Figure 2.11-2). Its purpose is to assess the concentrations of any groundwater contamination that may reach the river. The comprehensive list of analytes include alkalinity, gross alpha and beta, anions, gamma scan, iodine-129, metals, strontium-90, technetium-99, total organic halides, total organic carbon, and tritium.

Results of monitoring the Southeast Transect during FY 2005 indicated that the only groundwater contaminants exceeding drinking water standards were tritium and iodine-129, corresponding to the large plumes emanating from the 200 East Area. The secondary drinking water standard for iron (300 µg/L) was exceeded at well 699-24-46 with a result of 361 µg/L (filtered sample), but elevated levels of iron are common in the older, non-WAC-compliant wells at the Hanford Site. In River Transect wells, the only reported results exceeding drinking water standards during FY 2005 were tritium (63,500 pCi/L) at well 699-41-1A and pH (9.2) at well 699-20-E12O (see Figure 2.11-2 for well locations). The reason for the slightly rising trend for pH at well 699-20-E12O is unknown, but the rising pH trend is accompanied by decreased specific conductance, alkalinity, and nitrate over previous levels. This well is an older, complex well with multiple piezometers. It is possible that there is communication between piezometers. The trends will be closely monitored in the future to determine the cause of this pH anomaly.

Tritium and iodine-129 were the only groundwater constituents that exceeded drinking water standards during FY 2005 in Southeast Transect wells.

2.11.3 Facility Monitoring

This section describes results of monitoring individual facilities such as treatment, storage, or disposal units or tank farms. Groundwater at some of these facilities is monitored under the requirements of RCRA for hazardous waste constituents and AEA for radionuclides including source, special nuclear, and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations for each facility. As discussed in Section 2.1, 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 DOE acting pursuant to its AEA authority. Groundwater data for these facilities are available in the Hanford Environmental

Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

The 200-PO-1 Operable Unit contains six RCRA sites, two sites regulated by WAC, and one site regulated exclusively under AEA groundwater requirements.

The 200-PO-1 Operable Unit contains six RCRA sites, two sites regulated by WAC, and one site regulated exclusively under AEA groundwater requirements (Figure 2.11-1):

Sites Regulated under RCRA

- Integrated Disposal Facility (not yet operational).
- PUREX cribs (216-A-10, 216-A-36B, and 216-A-37-1).
- Single-shell tanks at Waste Management Area A-AX.
- 216-A-29 ditch.
- 216-B-3 pond (B Pond).
- Nonradioactive Dangerous Waste Landfill (see Figure 2.1-2 in Section 2.1).

Sites Regulated under WAC

- Solid Waste Landfill.
- Treated Effluent Disposal Facility.

Sites Regulated under AEA

- 400 Area Water Supply Wells (see Figure 2.1-2 in Section 2.1).

This section summarizes results of statistical comparisons, assessment studies, and other developments for FY 2005. Groundwater data are available in the Hanford Environmental Information System and in the data files accompanying this report.

2.11.3.1 Integrated Disposal Facility

Construction of the Integrated Disposal Facility began in September 2004. DOE submitted a Part B RCRA permit application to the Washington State Department of Ecology (Ecology), and it will be incorporated into the Hanford Facility RCRA Permit after approval. The Integrated Disposal Facility is schedule to receive its first waste in early 2007.

Although waste has not yet been disposed in the Integrated Disposal Facility, collection of groundwater background data began in June 2005.

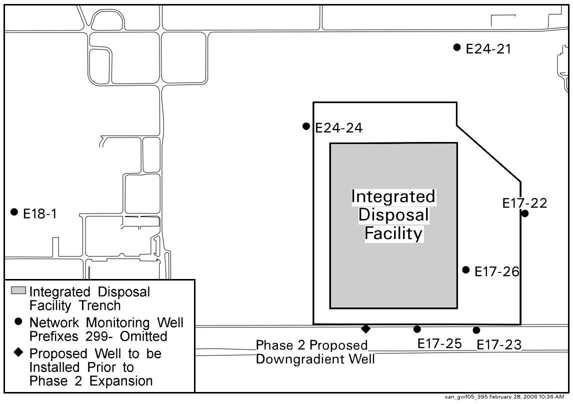
The objective of RCRA and operational monitoring at the Integrated Disposal Facility is to determine whether the facility has impacted groundwater quality. The facility is not yet operational, and the current monitoring is directed at obtaining background values for monitoring constituents. The current groundwater monitoring network consists of three upgradient wells and four downgradient wells (Appendix B). One new well remains to be installed at a future date when required by facility expansion.

The Integrated Disposal Facility consists of an expandable, lined landfill covering ~25 hectares located in the south-central part of 200 East Area (see Figure 2.11-1 for location of the site and Appendix B for a list of network wells, their locations, and groundwater constituents monitored). The landfill will be divided lengthwise into two distinct cells, one for the disposal of low-level radioactive waste and the other for the disposal of mixed waste. The facility will be a RCRA-compliant landfill (i.e., a double-lined trench with leachate collection system) that is ~442 meters wide by 555 meters in length and up to 15 meters deep. The landfill will contain four layers of waste container separate vertically by 0.9 meter of soil. The approximate volume of waste to be deposited will be 900,000 cubic meters. The waste will be segregated into a RCRA-permitted side and a non-RCRA-permitted side.

The water table in south-central 200 East Area is extremely flat making groundwater flow directions and water-table gradients difficult to estimate from water-level data. Based on the geometry of existing contaminant plumes and on regional water-level measurements, the groundwater flow direction is estimated to be toward the southeast at rates between 0.002 to 0.0075 meter/day.

The collection of background groundwater data began in June 2005 and will continue until May 2006 at which time the critical mean values for indicator parameters will be determined and routine, semiannual monitoring will begin. The indicator parameters that will be routinely monitored are chromium, specific conductance (field), total organic carbon, total organic halides, and pH (field). Supplemental groundwater quality parameters will also be measured and include alkalinity, anions, metals, temperature, and turbidity (Appendix B). The supplemental parameters aid in data interpretation and quality control.

The Integrated Disposal Facility operational monitoring plan was published in 2005 (RPP-PLAN-26534). That plan called for analyses of gross alpha, gross beta, technetium-99, and iodine-129 in groundwater. Therefore, these constituents have been added to the list of RCRA indicator parameters and supplemental groundwater quality parameters for analysis. Finally, each well was sampled and analyzed for the entire Appendix IX constituent list (WAC 173-303-9905) once when it was first sampled. The complete sampling schedule including all constituents and sampling frequency is in Appendix B.



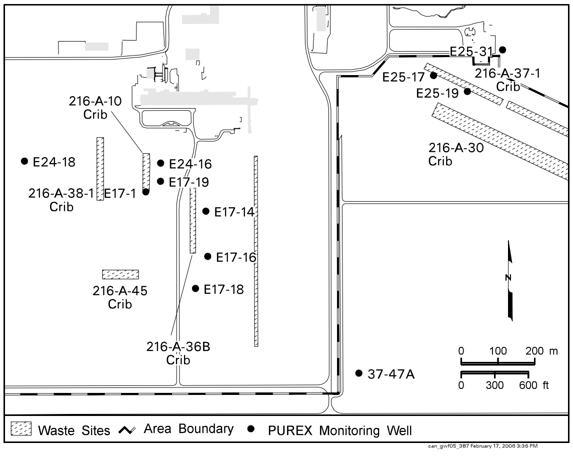
The Integrated Disposal Facility monitoring wells were sampled in June, July, and September during FY 2005. One analytical result for iron, one result for aluminum, and two results for nitrate were the only data to exceed drinking water standards. Numerous aluminum exceedances occurred during the fiscal year in wells throughout the Hanford Site and are considered to result from laboratory problems (see Appendix C). The iron concentration was 460 μg/L in the July filtered sample from well 299-E18-1. (The secondary drinking water standard is 300 μg/L.) However, the iron concentration in the unfiltered sample collected at the same time was 74.3 μg/L, well within the natural range for iron concentration in Hanford Site groundwater. The iron exceedance is not considered representative of groundwater beneath the Integrated Disposal Facility and was flagged as suspect in the database. It is likely that the filtered and unfiltered samples were exchanged inadvertently.

Nitrate exceeded the drinking water standard (45 mg/L) in the July and September samples from well 299-E24-24. The highest nitrate concentration was 64.6 mg/L. Well 299-E24-24 is located in the regional nitrate plume that is presumed to originate from the PUREX cribs east of the Integrated Disposal Facility (see Section 2.11.1).

2.11.3.2 RCRA PUREX Cribs

The RCRA PUREX cribs are located in the southeast part of the 200 East Area and include three cribs (216-A-10, 216-A-36B, and 216-A-37-1; see Figure 2.11-1) monitored under RCRA interim status to assess groundwater quality. Other nearby cribs also received PUREX waste (e.g., 216-A-45 crib) but are not regulated as RCRA treatment, storage, and disposal units. They are monitored collectively under the 200-PO-1 Operable Unit.

The objective of RCRA monitoring at these cribs is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer [40 CFR 265-93(d) as referenced by WAC 173-303-400]. Groundwater monitoring under AEA tracks radionuclides at the cribs and surrounding vicinity. Appendix B includes a well location map and list of wells and constituents monitored for the RCRA PUREX cribs.



During FY 2005, nitrate exceeded the drinking water standard in wells monitoring the RCRA PUREX cribs.

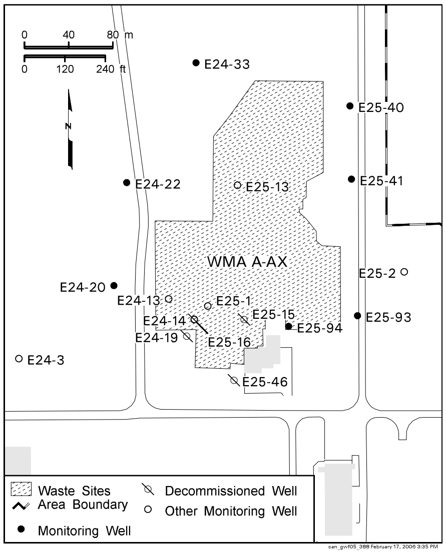
Groundwater flow for the two west cribs (216-A-10 and 216-A-36B) is most likely toward the southeast; for the 216-A-37-1 crib, it is south or southwest. (See Appendix B for more information on flow direction and rate.) The RCRA PUREX cribs are located in a region where several groundwater contamination plumes contain constituents that exceed drinking water standards. The similarities in effluent constituents disposed to these cribs, as well as the 216-A-45 crib, make determining the contribution of the RCRA PUREX cribs difficult. During FY 2005, tritium, iodine-129, nitrate, strontium-90 (a beta emitter), and gross beta exceeded drinking water standards in RCRA PUREX cribs wells (see Sections 2.11.1.1 to 2.11.1.6 for more information on these constituents).

The RCRA PUREX cribs groundwater monitoring plan (PNNL-11523) was revised during FY 2005 to bring the plan up to date with sampling, analysis, quality assurance, and data management and reporting protocols in practice for the groundwater project. Groundwater constituents analyzed in groundwater samples remained the same except that arsenic and radioactive constituents (e.g., tritium, iodine-129, and strontium-90) were discontinued. Arsenic levels in groundwater near the RCRA PUREX cribs have declined to the level of being indistinguishable from background. Both arsenic and radioactive constituents will continue to be contaminants of concern (or of potential concern) in the 200-PO-1 Operable Unit sampling and analysis plan (DOE/RL-2003-04, Rev. 1).

Nitrate continued to exceed its drinking water standard beneath and downgradient of the RCRA PUREX cribs. It is the only dangerous waste constituent exceeding drinking water standards at the RCRA PUREX cribs. The nitrate plume continues to generally attenuate in much of its downgradient extent in the 600 Area between the 200 East Area and the Columbia River. However, several of the wells near the RCRA PUREX cribs are showing increases in nitrate concentration (see Section 2.11.1.3). The reason for the increased concentration is not known. It may be related to residual nitrate contamination in the vadose zone that continues to enter to the saturated zone. However, the increases could also be related to changes in groundwater flow paths due to the decreased amount of groundwater flow from B Pond and a greater contribution of groundwater flow from the northwest.

2.11.3.3 Single-Shell Tank Waste Management Area A-AX

Located along the east border of the 200 East Area, Waste Management Area A-AX consists of the A Tank Farm, AX Tank Farm, 244-AR vault, ancillary waste transfer lines, and seven diversion boxes. Until recently, groundwater beneath this waste management area was monitored under an interim status detection-level indicator evaluation program in accordance with RCRA, as described in 40 CFR 265, Subpart F, by reference of WAC 173-303-400(3). The interim status monitoring plans in the past were designed to meet interim status requirements for Waste Management Area A-AX (PNNL-13023; WHC-SD-EN-AP-012).



Results from the interim status RCRA semiannual sampling in June 2005 at one downgradient well, 299-E25-93, showed an average specific conductance value of 536 µS/cm. This exceeded the critical mean value of 522 µS/cm. Results from verification sampling confirmed that the specific conductance was above the critical mean with a value of 538 µS/cm. Thus, the monitoring at Waste Management Area A-AX has been elevated into RCRA assessment.

A first determination, as allowed under 40 CFR 265.93(d)(5), provides the owner/operator of a facility the opportunity to determine whether dangerous waste or dangerous waste constituents from the regulated unit have compromised groundwater quality. A groundwater quality assessment plan was prepared in FY 2005 and will be published in FY 2006. The plan is intended to comply with this initial first determination investigation. Radionuclides are tracked under AEA monitoring at the site. A well location map with a list of network wells and the site-specific constituents used for the assessment monitoring is available in Appendix B.

The local groundwater flow direction, determined from water levels (in wells) and in situ flow measurements with the colloidal borescope, is interpreted to be east southeast to southeast (PNNL-14187). The saturated screen interval ranges from 1.6 to 10 meters in RCRA network wells while the aquifer thickness is ~27 meters. The average rate of water-table decline was 8 centimeters in 2005. Some of the older RCRA-compliant wells may need replacing in 6 to 7 years when the water level drops below the screened interval. The estimated flow rate at Waste Management Area A-AX was calculated with the Darcy equation and ranges from 0.77 to 1.0 meter/day (see Appendix B, Table B.2). The monitoring network includes two monitoring wells installed in FY 2004, two installed in FY 2003, and five older wells. One additional downgradient well is scheduled for installation in FY 2007, which will complete that monitoring network as designed in PNNL-13023.

Groundwater monitoring at Waste Management Area A-AX was changed to a RCRA groundwater quality assessment program during FY 2005 because the critical mean for specific conductance was exceeded at one downgradient well.

Several wells were recently decommissioned after it was confirmed that casing corrosion was causing local elevation of chromium in the groundwater. A recent borehole survey has shown that well 299-E25-40, which has begun to show low levels of chromium in the groundwater, also has casing and screen corrosion. This well may need replacement in the near future. Further discussion of this problem at Waste Management Area A-AX can be found in PNNL-13788, PNNL-14187, PNNL-14548, and PNNL-15070.

The first semiannual RCRA sampling event for FY 2005 was conducted in December 2004. A specific conductance value of 535 µS/cm was observed at well 299-E25-93, a downgradient well installed in 2003 and located on the southeast corner of the A Tank Farm (Appendix B). During January 2005, verification sampling at this well was performed, but the exceedance of the critical mean was not confirmed when a value of 506 µS/cm was found in the groundwater (Figure 2.11-10). The next regular semiannual RCRA sampling event was in June 2005. Once again, at downgradient well 299-E25-93, the critical mean was exceeded with a specific conductance value of 536 µS/cm. Verification sampling was performed in July 2005. Results confirmed that the specific conductance is above the critical mean with a value of 538 µS/cm. These are the data that prompted placing Waste Management Area A-AX into RCRA assessment.

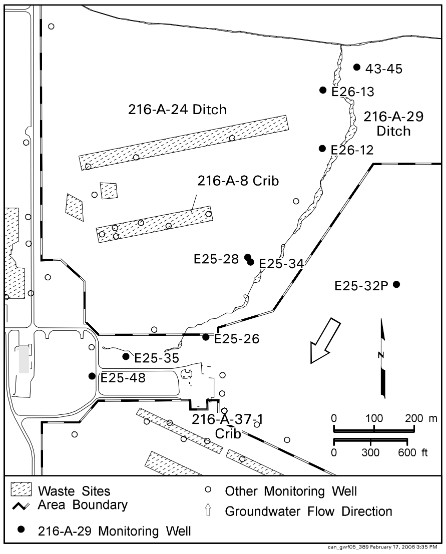
Along with the elevated specific conductance in downgradient well 299-E25-93, the sulfate was elevated at 94 mg/L and nitrate at 40 mg/L for June 2005 (Figures 2.11-11 and 2.11-12). The drinking water standard is 250 mg/L for sulfate and 45 mg/L for nitrate. Upgradient the June 2005 sulfate values ranged from 46 to 71 mg/L, while the nitrate values ranged from 12 to 51 mg/L. The elevated sulfate concentrations may be mostly responsible for the elevated specific conductance in well 299-E25-93, but nitrate has been above the drinking water standard in the recent past. These anions are the main source of the elevated specific conductance. The associated cations are primarily calcium and sodium.

Sulfate and nitrate concentrations are shown in Figures 2.11-13 and 2.11-14. Both sulfate and nitrate appear to increasing regionally across the 200 East Area. For example, a sulfate value as high as 671 mg/L was detected upgradient near the basalt subcrop. The source of this contaminant at Waste Management Area A-AX may be upgradient of the site (Figure 2.11-13). Furthermore, Figure 2.11-14 shows there is elevated nitrate above the drinking water standard of 45 mg/L in upgradient well 299-E24-20 (51 mg/L). This rising nitrate may be part of the regional increasing trend in nitrate moving into the area around Waste Management Area A-AX from well 299-E28-17 (66.4 mg/L 2004).

Nitrate and technetium-99 exceeded drinking water standards in the new downgradient well 299-E25-93 at Waste Management Area A-AX.

Along with the elevated levels of sulfate and nitrate, technetium-99 is found above the drinking water standard of 900 pCi/L in downgradient well 299-E25-93 (see Figure 2.11-8). A maximum value of 13,100 pCi/L was observed in FY 2003; since that time, levels have dropped to the current value of 8,350 pCi/L. The distribution of technetium-99 in June 2005 is shown in Figure 2.11-15. Technetium-99 concentrations were elevated at 697 pCi/L in upgradient well 299-E24-33 and in downgradient well 299-E25-94. The data from these wells are too sparse at present to determine long-terms trends relationships between the anions and technetium-99.

2.11.3.4 216-A-29 Ditch



The groundwater beneath the 216-A-29 ditch is monitored for evidence of hazardous waste migration as required by interim status RCRA regulations (40 CFR 265.93(b) as referenced by WAC 173-303-400). The groundwater monitoring network at this facility is sampled twice annually for constituents that include contamination indicator parameters, and annually for groundwater quality parameters and site-specific constituents (PNNL-13047; see Appendix B for list of network wells, their locations, and groundwater constituents monitored). The well network is adequate for the current groundwater flow directions.

Specific conductance exceeded its critical mean value in two downgradient wells during FY 2005 (299-E25-48 and 299-E25-35). The reason for the exceedance at these wells, which lie at the head end of the 216-A-29 ditch, is the high sulfate concentrations in groundwater associated with discharges of sulfuric acid. Only well 299-E25-28 continues to exhibit an increasing trend. Elevated sulfate levels have been shown to increase specific conductance at the 216-A-29 ditch in the past (WHC-SD-EN-EV-032).

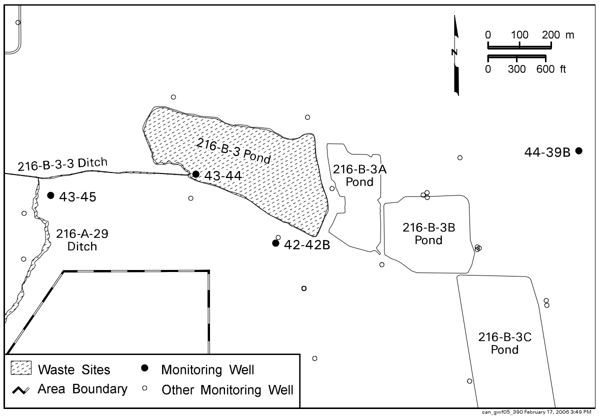
Total organic halides exceeded the limit of quantitation for the 216-A-29 ditch (17.1 µg/L) in April 2005. The elevated results were accompanied by high variability in the replicates for each well. For well 299-E25-35, the highest replicate concentration (32.6 µg/L) is nearly ten times that of the lowest value (3.2 µg/L). This variability among replicates was also observed in wells 299-E25-26, 299-E26-12, 299-E25-32P, and 299-E25-48. Confirmation sampling of wells exceeding the limit of quantitation (299-E25-32P and 299-E35-48) was performed and the results indicated that the April 2005 results were in error. The results are flagged as suspect in the Hanford Environmental Information System.

Two downgradient wells at the 216-A-29 ditch continue to have exceedances of specific conductance critical mean.

The direction of groundwater flow near the 216-A-29 ditch is generally to the south-southwest, and the gradient is largely flat. The lower mud unit of the Ringold Formation inhibits flow to the east near the 216-A-29 ditch and groundwater is, therefore, forced to the south. The estimated groundwater flow rate is ~0.1 meter/day.

2.11.3.5 216-B-3 Pond Facility (B Pond)

The original B Pond system included the main pond and three expansion ponds. The main pond and an adjacent portion of 216-B-3-3 ditch are regulated now under RCRA and require groundwater monitoring under 40 CFR 265.93(b) as referenced by WAC 173-303-400. These features are the regulated remnants of a more expansive system of ponds and ditches, most of which have been clean closed. The B Pond system continued in an interim status, detection monitoring mode during FY 2005. The monitoring plan, including the well network, constituents of concern, sampling and analysis procedure, and a conceptual model is described by PNNL-15479. The plan was revised in FY 2005, but the well network and groundwater constituents to be analyzed were not changed.



The current network wells and hydraulic gradient configuration allows upgradient/downgradient comparisons as prescribed by RCRA and WAC procedures for interim status facilities. The groundwater monitoring well network for the B Pond system consists of a total of four wells (see Appendix B). Well 699-44-39B is located in an area currently upgradient of the B Pond with three wells (699-42-42B, 699-43-44, and 699-43-45) located at the downgradient edges of the main pond and 216-B-3-3 ditch.

In FY 2005, no averaged replicate results exceeded the limits of quantitation for indicator parameters total organic halides and total organic carbon. Isolated, elevated replicate results were received for total organic halides in samples from all four B Pond wells during FY 2005, but these are attributed to a general analytical problem currently under investigation (see Appendix C). Field parameters pH and specific conductance were well within historical ranges. Both pH and specific conductance in wells 699-43-45 and 699-42-42B have displayed a slight upward trend over the past several years, and probably represent a gradual return to pre-operational conditions in the aquifer following dilution by waste disposal made up of river water. Specific conductance is below site-wide background (DOE/RL-96-61) in all B Pond network wells. Nitrate, which has shown recent upward trends, was unchanged during FY 2005 in well 699-42-42B and up slightly in well 699-43-45. Likewise, sulfate has trended upward in these two wells in recent years. However, both nitrate (maximum 1.8 mg/L in well 699-43-45) and sulfate (maximum 21.7 mg/L in well 699-42-42B) are far below estimates of site-wide groundwater background concentrations (42 and 55 mg/L, respectively).

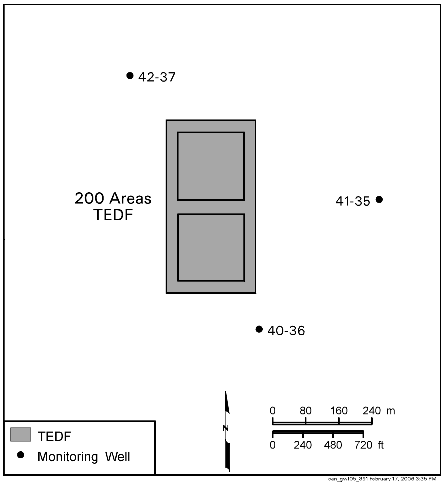
During FY 2005, groundwater indicator parameters remained below their critical mean values in B Pond monitoring wells.

Based on 2005 water-level measurements, groundwater flow directions, which were calculated using several wells in the B Pond network and vicinity, varied from west-southwest east of the main pond to south-southeast immediately beneath the pond. Both of these locations are interpreted to lie within the confined portions of the uppermost aquifer (PNNL-12261). At the western extremity of the main pond, and near the 216-B-3-3 ditch, the hydraulic gradient is extremely slight and flow direction is difficult to determine. Based on a July 2005 gradient of 0.003 between wells 699-44-39B (upgradient well) and 699-42-42B, an average hydraulic conductivity of 1.0 meter/day, and an estimated effective porosity of 0.25, the average linear flow velocity of groundwater is estimated at 0.012 meter/day (Appendix B). Head measurements in vertically separated wells 699-43-41E and 699-43-41G indicated that a downward flow potential still exists near the main pond, although it continues to diminish. The head difference between these two wells, as determined by September 2005 water levels, was ~0.5 meter.

2.11.3.6 200 Area Treated Effluent Disposal Facility

The 200 Area Treated Effluent Disposal Facility is located southeast of the B Pond RCRA facility and has received effluent since June 1995. Groundwater beneath the facility is monitored under a Washington State waste discharge permit (WAC 173-216; PNNL-13032). Three wells, 699-40-36, 699-41-35, and 699-42-37, monitor groundwater beneath the facility.

Because there was no unconfined aquifer beneath the 200 Area Treated Effluent Disposal Facility at the time of construction, the groundwater monitoring wells were installed in the Ringold Formation confined aquifer, which was the uppermost aquifer beneath the facility (see also Section 2.14). Thus, these three wells are isolated from the effects of the effluent by the relatively impermeable Ringold Formation unit 8 (the lower mud unit) silt and clay stratum (PNNL-14098). The quarterly analytical results from the wells are used to demonstrate continuation of the isolation.



Based on hydraulic head calculations for March 2005, and estimates of effective porosity and hydraulic conductivity, groundwater flow potential in the confined aquifer beneath the 200 Area Treated Effluent is directed southwest at ~0.0004 meter/day. Historically, major ionic composition and extremely low tritium concentrations have suggested that groundwater in the confined Ringold Formation beneath this facility is isolated from groundwater in the adjacent unconfined aquifer, and thus its water quality is largely unaffected by Hanford Site operations. Results of annual low-level tritium analyses confirm this assumption. However, hydraulic head continues to decline in all three wells at the Treated Effluent Disposal Facility, as a result of the dissipating pressure effects of historical discharges at the nearby B Pond facility.

Groundwater samples are collected quarterly from wells for a list of constituents required by the state waste-discharge permit ST-4502 (Ecology 2000). Three of the constituents (cadmium, lead, and pH) are compared with specific enforcement

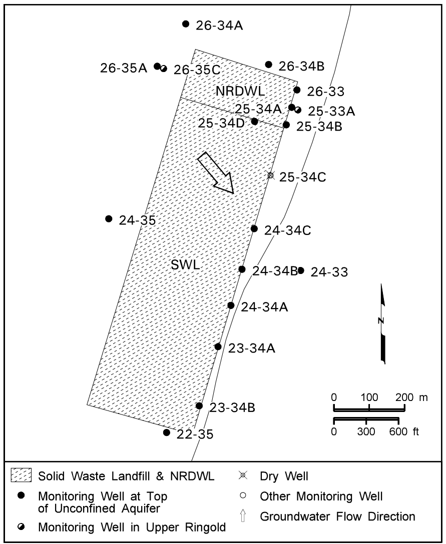
At the 200 Area Treated Effluent Disposal Facility, all scheduled groundwater samples were collected during FY 2005 and no enforcement limits were exceeded.

limits set by the permit (see Appendix B). All scheduled samples were collected during FY 2005, and no enforcement limits were exceeded. Most results for anions, metals, and radionuclide indicators have been below Hanford Site groundwater background levels (e.g., WHC-EP-0595 and DOE/RL-96-61) since monitoring began at the site.

2.11.3.7 Nonradioactive Dangerous Waste Landfill

The Nonradioactive Dangerous Waste Landfill is located southeast of the 200 East Area next to the Solid Waste Landfill. The two landfills are collectively called the Central Landfill (Figure 2.1-2 in Section 2.1). The objective of RCRA monitoring at the Nonradioactive Dangerous Waste Landfill is to determine if hazardous waste constituents from the landfill have contaminated groundwater (40 CFR 265.93(b) as referenced by WAC 173-303-400). Groundwater monitoring under AEA tracks radionuclides (from upgradient areas) in groundwater at the landfill and surrounding area. Appendix B includes a well location map and lists of wells and constituents monitored for the landfill.

Monitoring of the Nonradioactive Dangerous Waste Landfill focuses on the RCRA interim status indicator parameters: pH, specific conductance, total organic carbon, and total organic halides (PNNL-11523; Appendix B). Volatile organic compounds are monitored because they may represent groundwater contamination originating from this landfill. Nitrate is present in groundwater and has a source in the 200 East Area (see Section 2.11.1.3). The groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate) are required analytes but during FY 2005 were either not detected or were reported in concentrations not significantly above background concentrations.



Wells at the Nonradioactive Dangerous Waste Landfill (Appendix B) are sampled semiannually, usually in February and August. During FY 2005 all of the Nonradioactive Dangerous Waste Landfill network wells were sampled as scheduled except the February 2005 sampling at well 699-25-34D was delayed until June 2005, and the August 2005 sampling at wells 699-25-34D and 699-26-33 was delayed until October 2005. Although there were sampling difficulties at these two wells during FY 2005, all the wells of the network are functional, and there are no changes planned for the well network.

Drinking water standards of the groundwater quality parameters and volatile organic compounds were not exceeded at Nonradioactive Dangerous Waste Landfill network wells during FY 2005. Three of the four indicator parameters (pH, total organic halides, and total organic carbon) did not exceed their critical means where valid upgradient/downgradient comparisons could be made. However, the critical mean of specific conductance (572 µS/cm) was exceeded at four downgradient wells during FY 2005. The four wells with the exceedances were 699-25-34A, 699-25-34B, 699-25-34D, and 699-26-33. Specific conductance at these four wells ranged from 596 to 634 µS/cm. Exceedances of the specific conductance critical mean has occurred in prior years and were interpreted to be due to increases in the concentrations of non-hazardous constituents (bicarbonate, sulfate, and magnesium) at the Solid Waste Landfill to the south. It was first discovered and reported in FY 2000. An assessment plan and assessment report were submitted to Ecology at that time. During FY 2005, specific conductance at Solid Waste Landfill wells ranged from 550 µS/cm at an upgradient well to 831 µS/cm in a downgradient well. Furthermore, specific conductance results at the Nonradioactive Dangerous Waste Landfill were similar to the reported results of specific conductance in the adjacent portions of the Solid Waste Landfill (see Section 2.11.3.8 for more information about groundwater sampling results at the Solid Waste Landfill).

The critical mean value for specific conductance continues to be exceeded at the Nonradioactive Dangerous Waste Landfill and is most likely due to the influence of the nearby Solid Waste Landfill.

2.11.3.8 Solid Waste Landfill

The Solid Waste Landfill is located with the Nonradioactive Dangerous Waste Landfill at the Central Landfill (Figure 2.1-2 in Section 2.1). It is regulated by Ecology under

WAC 173-304. WAC 173-304 constituents and site-specific constituents (including volatile organic compounds and filtered arsenic) are analyzed on groundwater samples collected quarterly (PNNL-13014; Appendix B). Compliance is determined by comparing results from monitoring downgradient wells with statistically derived background threshold values from upgradient wells. Groundwater flow direction is southeast as determined from the general direction of movement of major 200 East Area plumes (see beginning of Section 2.11). The well network for the Solid Waste Landfill includes two upgradient and seven downgradient wells and is shown in Appendix B.

Disposed waste at the Solid Waste Landfill has impacted groundwater including minor volatile organic compound contamination.

Disposed waste at the Solid Waste Landfill has impacted groundwater including minor chlorinated hydrocarbon contamination (Table 2.11-2). The only chlorinated hydrocarbon consistently exceeding its WAC 173-200-40 limit (0.8 µg/L) was tetrachloroethene. The highest reported tetrachloroethene result during FY 2005 was 1.8 µg/L at the downgradient well 699-24-33. In recent years, the trend for tetrachloroethene has been stable to slightly decreasing in concentration at Solid Waste Landfill wells. However, during FY 2005, many of the Solid Waste Landfill wells showed a slight increase in reported tetrachloroethene concentration over FY 2004. This recent increasing trend was not observed in other chlorinated hydrocarbons monitored at the Solid Waste Landfill during FY 2005.

Some downgradient wells continue to show higher chemical oxygen demand, chloride, coliform bacteria, specific conductance, and sulfate, and lower pH than upgradient wells. The lower pH apparently is a result of high concentrations of carbon dioxide in the vadose zone resulting from the degradation of sewage material disposed to the Solid Waste Landfill (see Section 5.3 of DOE/RL-93-88; PNL-7147; WHC-SD-EN-TI-199). The elevated chemical oxygen demand, coliform bacteria, and possibly the specific conductance, may also be related to the disposed sewage material.

WAC 173-304 Parameters. Each WAC 173-304 parameter is discussed separately in the following paragraphs. See Appendix B for a complete list of all results for required constituents at the Solid Waste Landfill during FY 2005. Table 2.11-2 shows the results for the chlorinated hydrocarbons during the same period.

- *Ammonium* – Results for ammonium ion in all Solid Waste Landfill wells during FY 2005 were below the method detection limit (5.8 µg/L). Background threshold value for nitrate was 118 µg/L. See Appendix B for a total list of FY 2005 background threshold values for WAC 173-304 required parameters.
- *Chemical Oxygen Demand* – Chemical oxygen demand at Solid Waste Landfill wells during FY 2005 ranged from 3.0 mg/L (the method detection limit) to 57 mg/L. The background threshold value (10 mg/L) was exceeded at all the Solid Waste Landfill wells during FY 2005, including the two upgradient wells. Historically, chemical oxygen demand results have been mostly below the method detection limit with the exception of a few spurious values. Now that all the wells appear to have elevated chemical oxygen demand, it indicates a clear increase in the overall trend at the Solid Waste Landfill. Elevated chemical oxygen demand values could be an indication of groundwater contaminated by sewage, which was known to be discharged to Solid Waste Landfill trenches.
- *Chloride* – The May 2005 result for well 699-24-33 (7.9 mg/L) was the only one during FY 2005 to exceed the background threshold value for chloride (7.8 mg/L). Chloride concentrations have been increasing at this well since 2002.
- *Coliform Bacteria* – Four downgradient wells and one upgradient well had reported results that exceeded the background threshold value (1.0 colonies/100 milliliters). The highest value reported during FY 2005 was 80.9 colonies/100 milliliters at downgradient well 699-23-34A. Elevated results for coliform bacteria at Solid Waste Landfill wells have historically been random and sporadic and, therefore, suspicious. However, like chemical oxygen demand, elevated levels of coliform bacteria are expected in groundwater contaminated when sewage was known to be disposed at the Solid Waste Landfill.

The background threshold value for chemical oxygen demand was exceeded at all the Solid Waste Landfill wells during FY 2005.

- *Filtered Iron* – With the exception of one spurious elevated result of 161 µg/L at well 699-22-35, the range of filtered iron values during FY 2005 was below the method detection limit (6.9 µg/L) at several Solid Waste Landfill wells during the October 2004 sampling event to 90.2 µg/L in downgradient well 699-24-34A in May 2005. The background threshold value of 160 µg/L was surpassed by the one spurious value at well 699-22-35, but this result was out of trend for this well and was most likely a sampling or analysis error.
- *Filtered Manganese* – Reported values for filtered manganese during FY 2005 ranged from below 0.84 µg/L (the method detection limit) to 6.2 µg/L at well 699-22-35. The background threshold value of 10 µg/L was not exceeded by any of the Solid Waste Landfill wells during FY 2005.
- *Nitrate* – Nitrate concentrations in Solid Waste Landfill wells during FY 2005 ranged from 2.3 to 3.8 mg/L. The background threshold value of 29 mg/L was not exceeded.
- *Nitrite* – Nitrite was not detected in any Solid Waste Landfill well during FY 2005. The method detection limit was 6.1 µg/L. Background threshold value for nitrite was 59 µg/L.
- *Field pH* – Measured values in network wells ranged from 6.58 to 7.73 during FY 2005. Reported results were lower than the background threshold range (6.68 to 7.84) in three downgradient wells: 699-23-34A, 699-23-34B, and 699-24-34B.
- *Specific Conductance* – Specific conductance measurements on samples taken from all downgradient wells during FY 2005 continued to exceed the background threshold value of 583 µS/cm. The range in downgradient wells was 691 to 831 µS/cm. Six of the seven downgradient wells also exceeded the maximum contaminant level (700 µS/cm; WAC 246-290-310) in FY 2005. Since 2001, the trend for specific conductance in Solid Waste Landfill wells has been relatively steady. Elevated specific conductance may be due to increased concentrations of sulfate and other anions at the Solid Waste Landfill.

The background threshold value for specific conductance (583 µS/cm) was exceeded at all downgradient Solid Waste Landfill wells during FY 2005.

- *Sulfate* – Reported results in downgradient wells ranged from 40 to 62 mg/L. The background threshold value was 47 mg/L and was exceeded at six downgradient wells. Sulfate trends are holding steady in some wells and rising in others since 1998 in downgradient Solid Waste Landfill wells.
- *Temperature* – Groundwater temperatures measured during sampling in downgradient wells of the Solid Waste Landfill network ranged from 17.0°C to 20.1°C. None of the Solid Waste Landfill wells had temperatures that exceeded the 20.7°C background threshold value.
- *Total Organic Carbon* – The only reported results that exceeded the background threshold value (1.51 mg/L) during FY 2005 were 9.1 mg/L in one sample collected from well 699-24-33 and 5.5 mg/L in another sample from well 699-24-34C. These results are not consistent with historical trends at these two wells. In previous years, spurious values for total organic carbon have been reported in Solid Waste Landfill wells. However, elevated total organic carbon is consistent with what might be expected when groundwater is contaminated with sewage as it has at the Solid Waste Landfill.
- *Filtered Zinc* – Reported values for filtered zinc during FY 2005 ranged from less than the analytical method detection limit (<1.5 µg/L) to 19.1 µg/L in downgradient wells. The background threshold value was 42.3 µg/L, and none of the results exceeded it during FY 2005.

Site-Specific Parameters. Site-specific parameters at the Solid Waste Landfill include chlorinated hydrocarbons and two other constituents (1,4-dioxane and filtered arsenic) detected by the leachate collection system beneath the trenches at the landfill. Slightly elevated concentrations of chlorinated hydrocarbons continued to be detected at the Solid Waste Landfill during FY 2005. Tetrachloroethene and filtered arsenic exceeded the groundwater criteria set forth in WAC 173-200. The range of reported concentrations of chlorinated hydrocarbons is given in Table 2.11-2.

Chlorinated hydrocarbons were detected in all Solid Waste Landfill network wells, including the upgradient wells. The chlorinated hydrocarbons detected included 1,1,1-trichloroethane, carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene. Three chlorinated hydrocarbons detected in FY 2004 were not detected in FY 2005: 1,2-dichloroethane, 1,4-dichlorobenzene, and cis-1,2-dichloroethene. Furthermore, those that were detected show decreasing trends in Solid Waste Landfill wells. Two anomalous results included 8.1 µg/L of 1,4-dioxane at well 699-24-33 and 0.97 µg/L of carbon tetrachloride at well 699-24-34C. The reported 1,4-dioxane at well 699-24-33 was detected in both the associated quality control blank and in the sample. The carbon tetrachloride reported at well 699-24-34C was an isolated occurrence and is inconsistent with results previously and later. Therefore, the reported 1,4-dioxane and carbon tetrachloride are suspicious and are not considered reliable or representative of the aquifer conditions.

Of those chlorinated hydrocarbons detected, only tetrachloroethene exceeded the WAC 173-200 concentration limit of 0.8 µg/L during FY 2005, and the exceedance was at all seven of the downgradient wells and one of the upgradient wells. The highest concentration recorded was at well 699-24-33 with a value of 1.9 µg/L. The historical trend at all of the downgradient wells in generally downward, and this trend continued during FY 2005. None of the reported results for tetrachloroethene (or any chlorinated hydrocarbons) exceeded drinking water standards.

The tetrachloroethene (WAC 173-200) concentration limit (0.8 µg/L) was exceeded at all the Solid Waste Landfill wells during FY 2005.

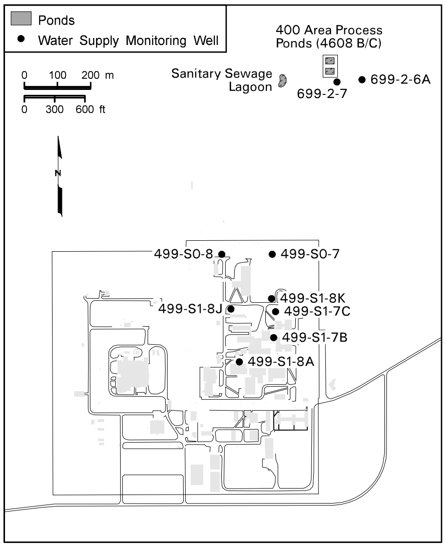
A potential cause of the widespread, low-level chlorinated hydrocarbon contamination at the Solid Waste Landfill, including the upgradient wells and the adjacent Nonradioactive Dangerous Waste Landfill wells, is the dissolution of vadose zone vapors into groundwater. However, the source of the vapors is uncertain. Other possible sources include chlorinated hydrocarbons dissolved in the liquid sewage or the catch tank liquid from the 1100 Area heavy equipment garage and bus shop that were disposed to the Solid Waste Landfill (PNNL-13014).

Filtered arsenic (drinking water standard 10 µg/L; WAC 173-200 limit 0.05 µg/L) was detected at all Solid Waste Landfill wells, especially in the May and August 2005 sampling events when the method detection limit was lowered to 0.28 µg/L. The highest concentration detected was 3.8 µg/L in well 699-24-34A. Although filtered arsenic was discovered in the leachate collection system at the trenches, the occurrence of arsenic in groundwater at the Solid Waste Landfill is probably due to natural processes (i.e., occurs naturally in Hanford Site groundwater – Hanford Site background is ~10 µg/L; DOE/RL-92-23), or there is an upgradient source (e.g., 200 East Area).

During FY 2003, sampling difficulties at well 699-25-34C became severe enough that it was dropped from the sampling schedule. Later it was discovered that the well was dry. With the loss of this well, the number of downgradient wells decreased from eight to seven. Well 699-24-33 is downgradient of the dry well 699-25-34C and eliminates the need for a replacement well. Sampling difficulties also occurred at well 699-24-34A during the February 2005 sampling event, and samples were not collected. The well appeared to be dry. However, the pump was lowered later, and the May and August 2005 samples were collected from that well without difficulty.

2.11.3.9 400 Area Water Supply Wells

The 400 Area on the Hanford Site is the location of the Fast Flux Test Facility, a liquid-metal (sodium) cooled test reactor. At the writing of this report, all sodium systems at the Fast Flux Test Facility have been drained except for the Interim Decay Storage vessel, which is scheduled for draining by September 2006. The completion of sodium removal from fuel and the disassembly of fuel are on schedule for the March/April 2006 time frame.



Primary groundwater monitoring activities in the 400 Area involve monitoring of the 400 Area water supply wells. Monitoring is also conducted to provide information needed to describe the nature and extent of site-wide contamination (primarily nitrate, tritium, and iodine-129). This section discusses the monitoring of the 400 Area water supply wells, specifically tritium, and general aspects of groundwater chemistry in the 400 Area. The water supply wells were sampled quarterly as scheduled in FY 2005.

The Hanford Site water-table map (Figure 2.1-3 in Section 2.1) indicates that flow is generally to the east-southeast across the 400 Area. The water table is located near the contact of the Ringold Formation and Hanford formation, which is ~49 meters below ground surface (WHC-EP-0587). Hanford formation sediment dominates groundwater flow in the 400 Area because of its relatively high permeability compared to that of sediment in the Ringold Formation.

Tritium and nitrate concentrations in all samples from 400 Area water supply wells were below the drinking water standard in FY 2005.

Elevated levels of tritium associated with the groundwater plume originating from the vicinity of the PUREX Plant in the 200 East Area were identified in 400 Area wells as in previous years (see Figure 2.1-6 in Section 2.1). The lower concentrations of tritium north of the 400 Area are probably related to former discharges at the process ponds. Groundwater tritium levels are relevant to the water supply wells, which provide drinking water and emergency supply water for the 400 Area. Well 499-S1-8J serves as the main water supply well, while wells 499-S0-7 and 499-S0-8 are backup supply wells. Well 499-S1-8J has lower tritium concentrations because it is screened at a greater depth than the other two water supply wells. The tritium concentrations in wells 499-S0-7, 499-S0-8, and 499-S1-8J are compared in Figure 2.11-16 to that of the 400 Area drinking water supply. Tritium was measured at levels below the drinking water standard (20,000 pCi/L) in all three of the water supply wells in FY 2005. Tritium levels in well 499-S1-8J (the main water supply well) during FY 2005 ranged from 2,120 to 2,830 pCi/L.

Tritium remained below the drinking water standard (20,000 pCi/L) and the 4-millirem/year dose equivalent in the drinking water supply, sampled at a tap, for all sampling events in FY 2005 (Figure 2.11-16). Nitrate remained below the drinking water standard in FY 2005 for the water supply wells. Data from FY 2005 and earlier from these wells indicate no other constituents are present at levels above their drinking water standards.

Table 2.11-1. FY 2005 Groundwater Analysis Results from Wells at BC Cribs Where Results Exceeded Secondary Drinking Water Standards

Wells	Filtered Iron, µg/L (300)	Filtered Manganese, µg/L (50)	Filtered Zinc, µg/L (5,000)
299-E13-16	**54,000**	**4,000**	**49,700**
299-E13-11	**1,210**	**89**	5
299-E13-5	**390**	6	10
299-E13-17	32	**56**	7

Results in **bold** print exceed secondary drinking water standards.
Secondary drinking water standards indicated in parentheses.

Table 2.11-2. Ranges of Reported Chlorinated Hydrocarbon Concentrations in Solid Waste Landfill Wells during FY 2005

Constituent	Limit (µg/L)	699-22-35	699-23-34A	699-23-34B	699-24-33	699-24-34A
1,1,1-Trichloroethane	WAC 200	1.3-1.9	1.2-1.8	1.2-1.8	0.51-1.4	1.0-1.3
1,1,2-Trichloroethane	MCL 5.0	<0.21	<0.21	<0.21	<0.21	<0.21
1,2-Dichloroethane	WAC 0.5	<0.21	<0.21	<0.21	<0.21	<0.21
1,4-Dichlorobenzene	WAC 4.0	<0.11	<0.11	<0.11-0.2B	<0.11	<0.11
1,4-Dioxane	WAC 7.0	<2.6	<2.6	<2.6	<2.6-**8.1B**	<2.6
Carbon tetrachloride	WAC 0.3	<0.1	<0.1	<0.1-0.24	<0.1	<0.1
Chloroform	WAC 7.0	0.27-0.47	0.29-0.39	0.62-0.74	<0.11-0.11	<0.11-0.15
cis-1,2-Dichloroethene	MCL 70	<0.27	<0.27	<0.27	<0.27	<0.27
Tetrachloroethene	WAC 0.8	0.56-**0.88**	**0.84-1.3**	0.5-**0.88**	0.73-**1.8**	**0.93-1.4**
Trans-1,2-dichloroethene	MCL 100	<0.09	<0.09	<0.09	<0.09	<0.09
Trichloroethene	WAC 3.0	0.36-0.48	0.46-0.53	0.33-0.48	0.33-0.93	0.45-0.64

Constituent	Limit (µg/L)	699-24-34B	699-24-34C	699-24-35	699-26-35A
1,1,1-Trichloroethane	WAC 200	0.62-1.5	0.47-1.2	0.61-1.4	<0.07-1.0
1,1,2-Trichloroethane	MCL 5.0	<0.21	<0.21	<0.21	<0.21
1,2-Dichloroethane	WAC 0.5	<0.21	<0.21	<0.21	<0.21
1,4-Dichlorobenzene	WAC 4.0	<0.11	<0.11	<0.11	<0.11
1,4-Dioxane	WAC 7.0	<2.6	<2.6	<2.6	<2.6
Carbon tetrachloride	WAC 0.3	<0.1	<0.1-**0.97**	<0.1	<0.1
Chloroform	WAC 7.0	<0.11-0.12	<0.11	<0.11	<0.11-0.16
cis-1,2-Dichloroethene	MCL 70	<0.27	<0.27	<0.27	<0.27
Tetrachloroethene	WAC 0.8	0.71-**1.7**	0.7-**1.7**	0.47-**0.86**	<0.08-0.72
Trans-1,2-dichloroethene	MCL 100	<0.09	<0.09	<0.09	<0.09
Trichloroethene	WAC 3.0	0.33-0.74	0.31-0.78	0.19-0.43	0.18-1.1

Values in **bold** equal or exceed WAC 173-200-40.
B = The analyte was detected in both the associated QC blank and in the sample.
MCL = Maximum contaminant level (Federal drinking water standard).
QC = Quality control.
WAC = Washington Administrative Code (WAC 173-200-40).

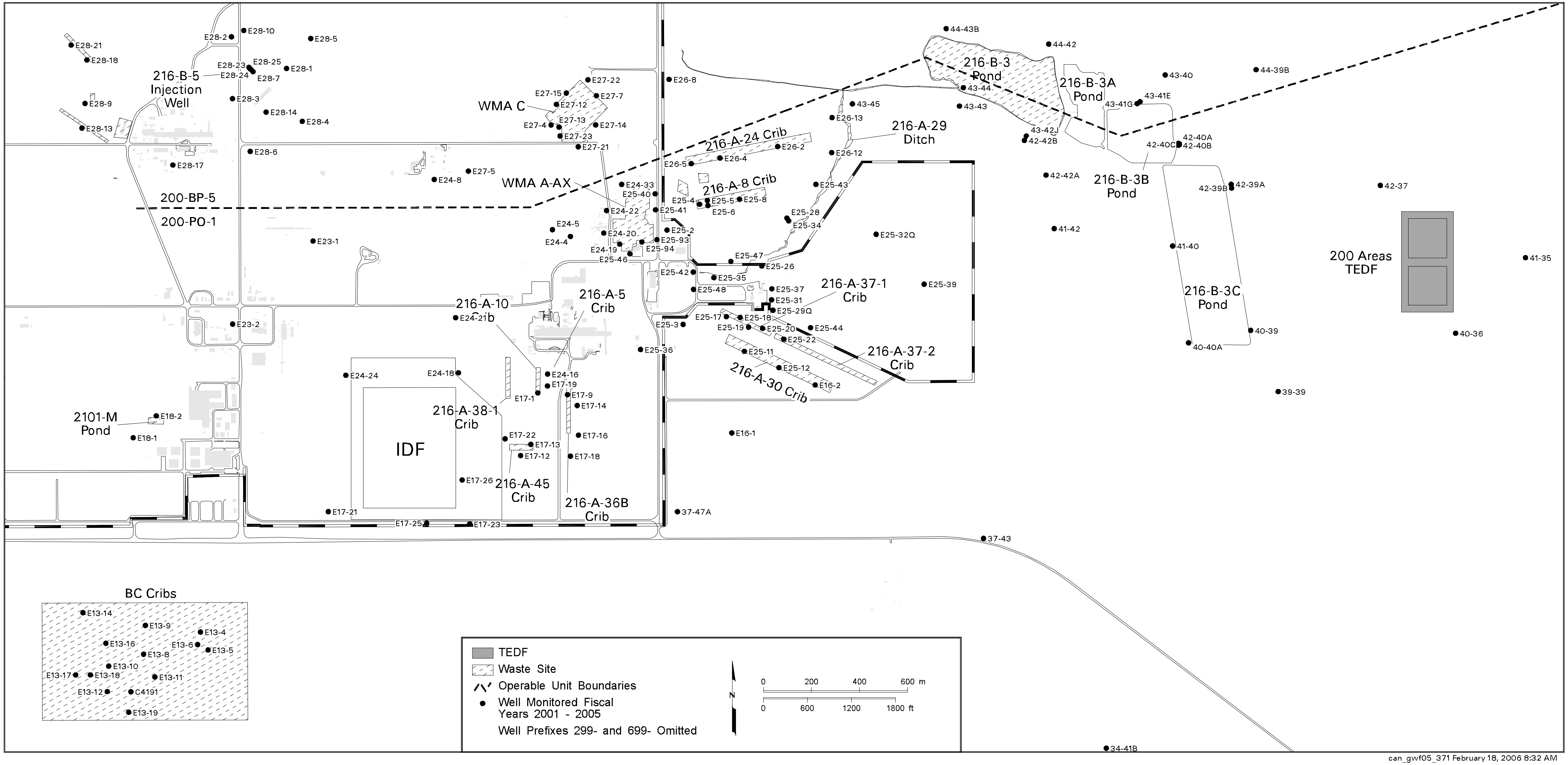


Figure 2.11-1. Facilities and Groundwater Monitoring Wells in the North Portion of 200-PO-1 Operable Unit

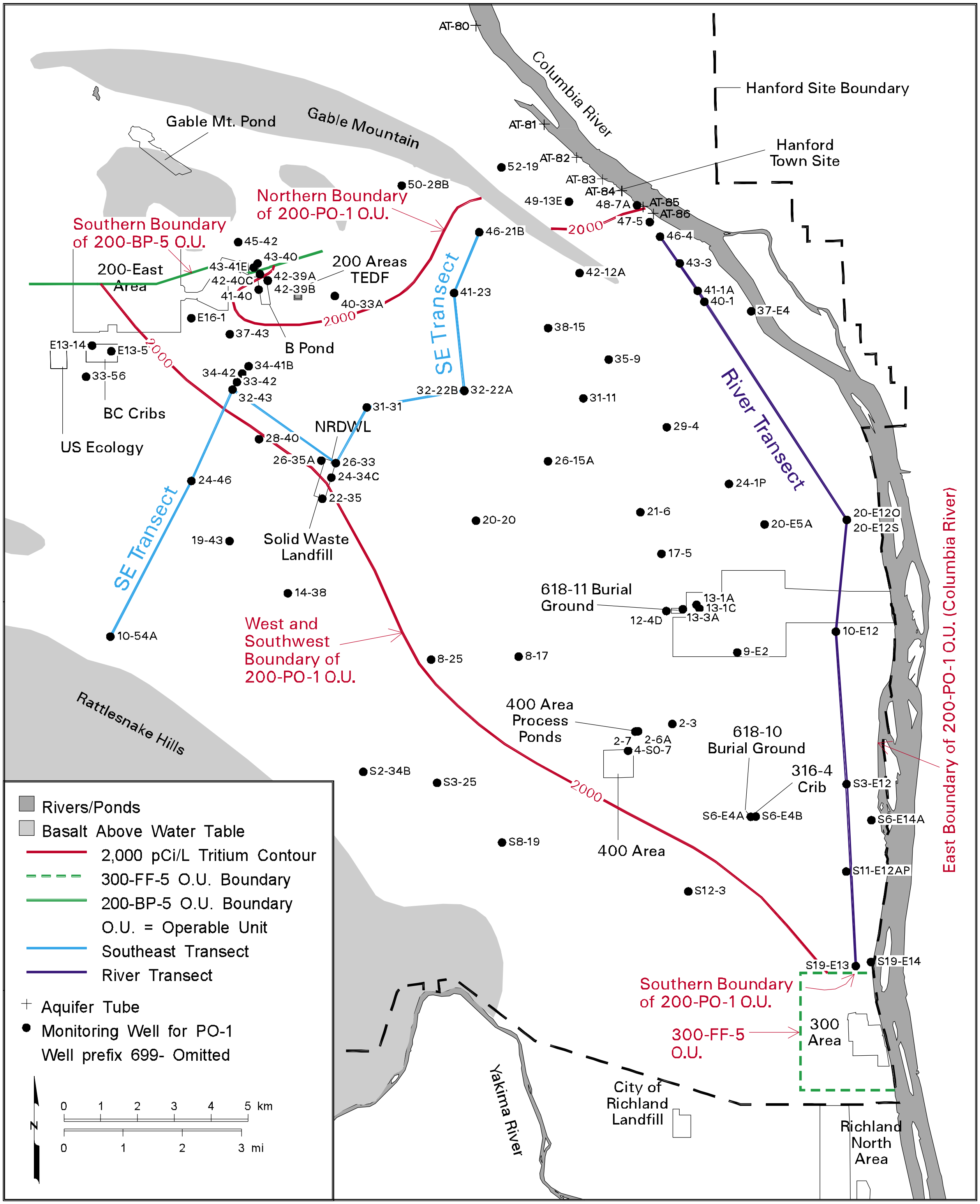


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Figure 2.11-2. Far-Field Monitoring Wells

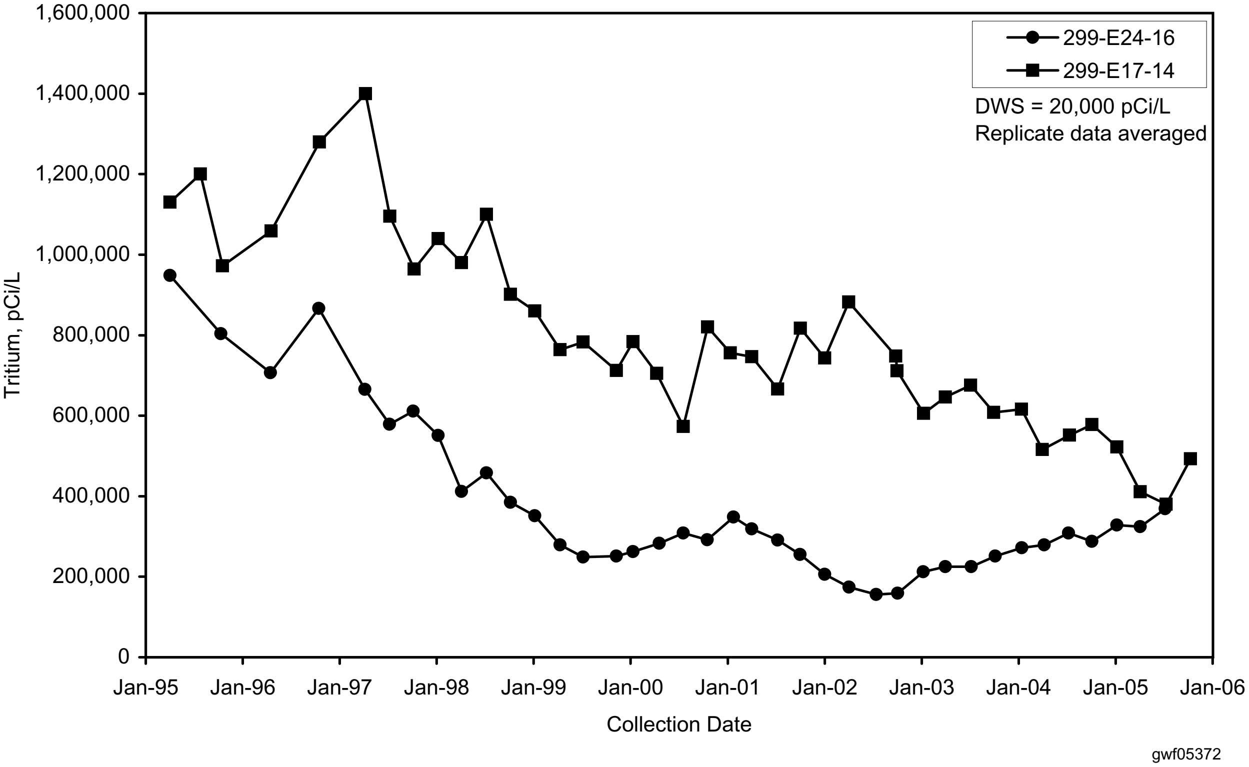

Figure 2.11-3. Tritium Concentrations at Wells 299-E24-16 and 299-E17-14

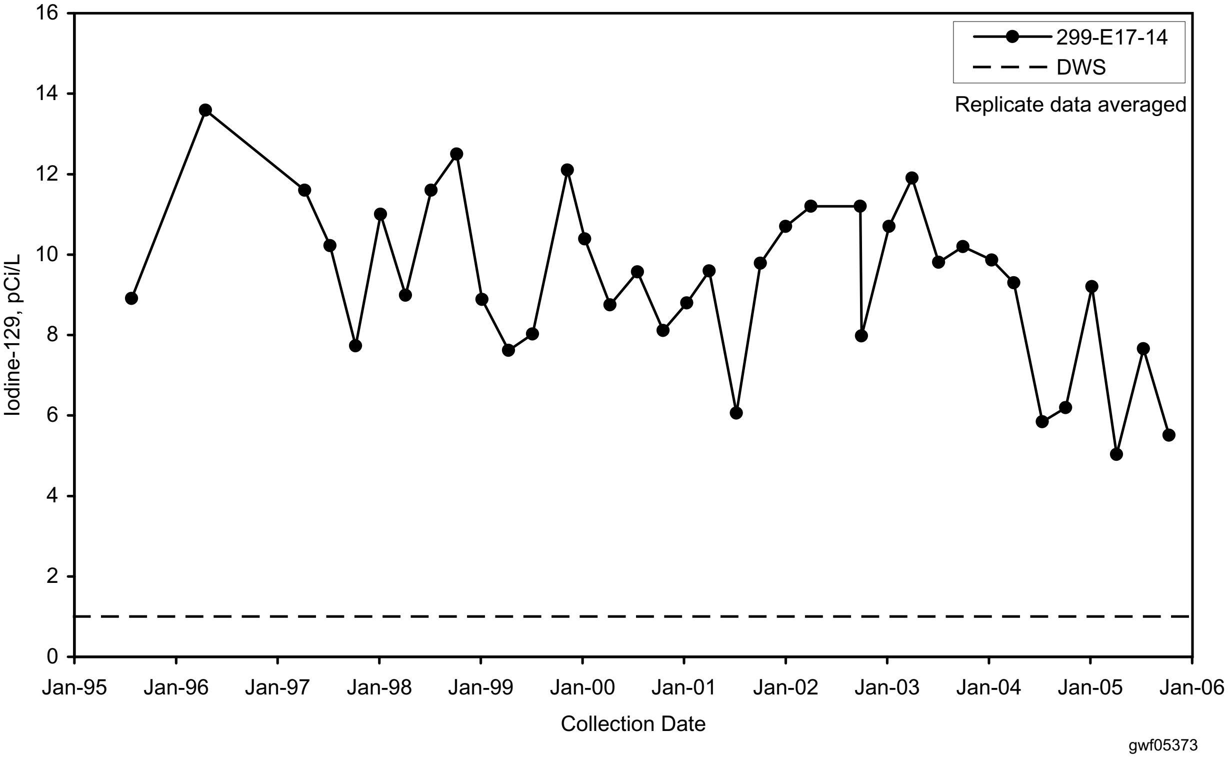

Figure 2.11-4. Iodine-129 Concentrations in Well 299-E17-14 at the 216-A-36B Crib

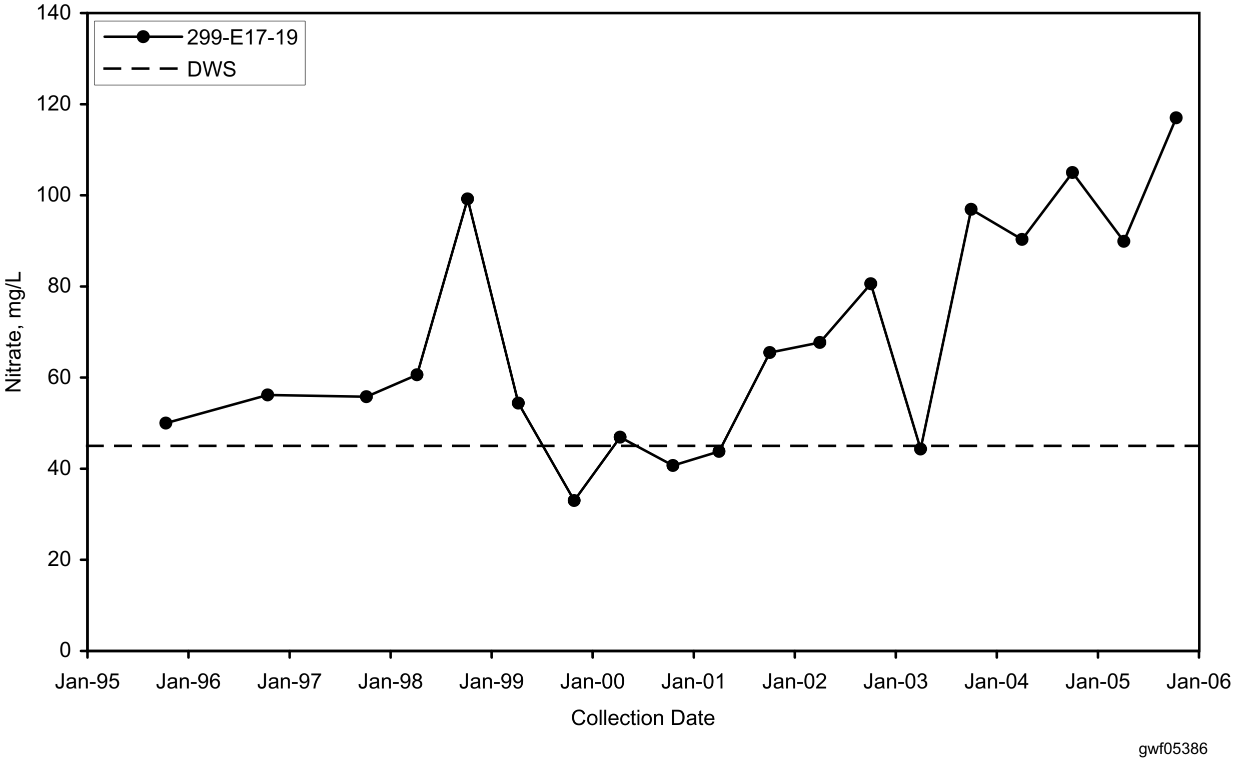

Figure 2.11-5. Nitrate Concentrations at the 216-A-10 Crib

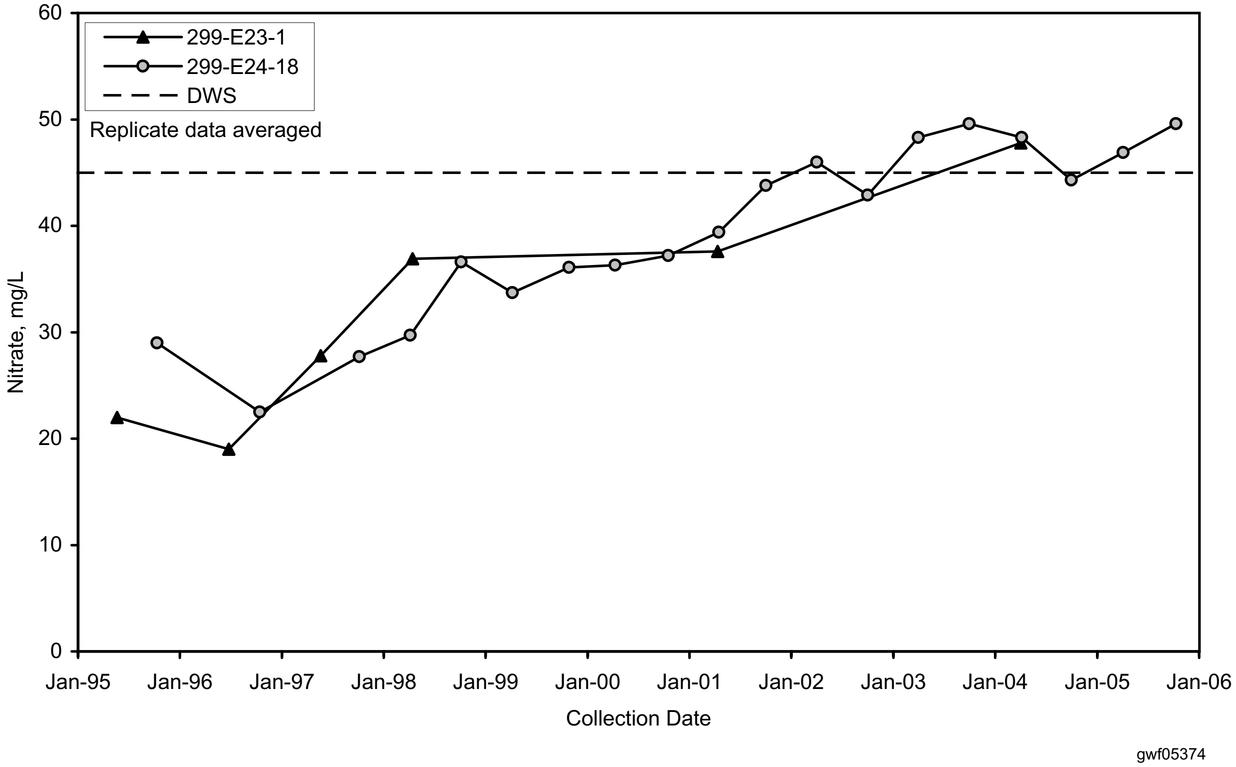

Figure 2.11-6. Nitrate Concentrations at Upgradient Wells 299-E24-18 and 299-E23-1 for the RCRA PUREX Cribs

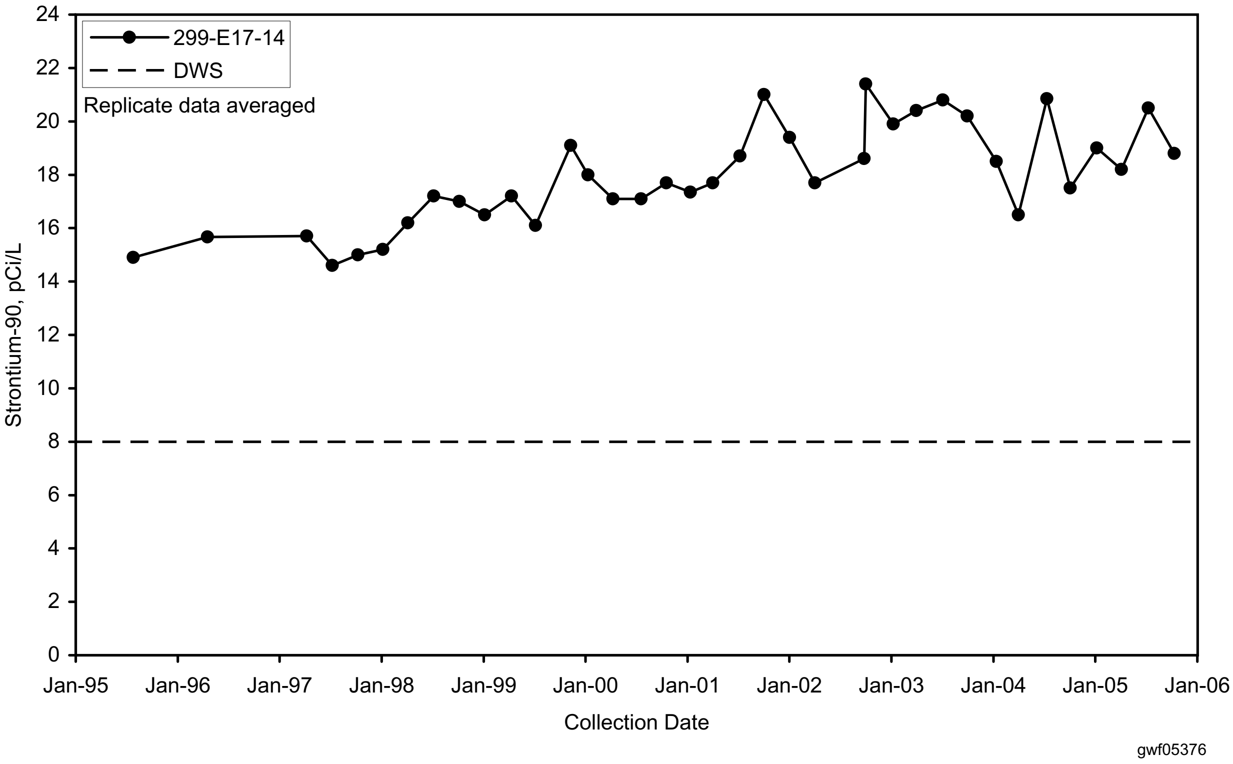

Figure 2.11-7. Strontium-90 Concentrations in Well 299-E17-14 at 216-A-36B Crib

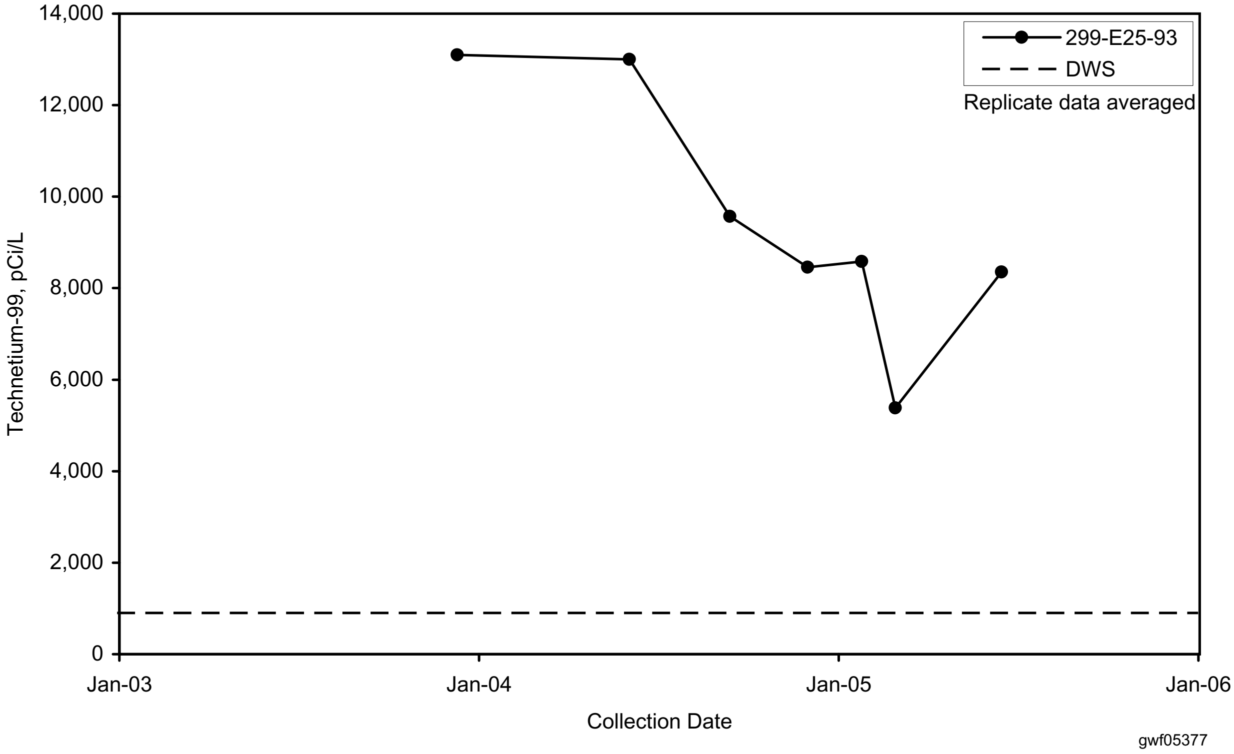

Figure 2.11-8. Technetium-99 Concentrations in Well 299-E25-93 at Waste Management Area A-AX

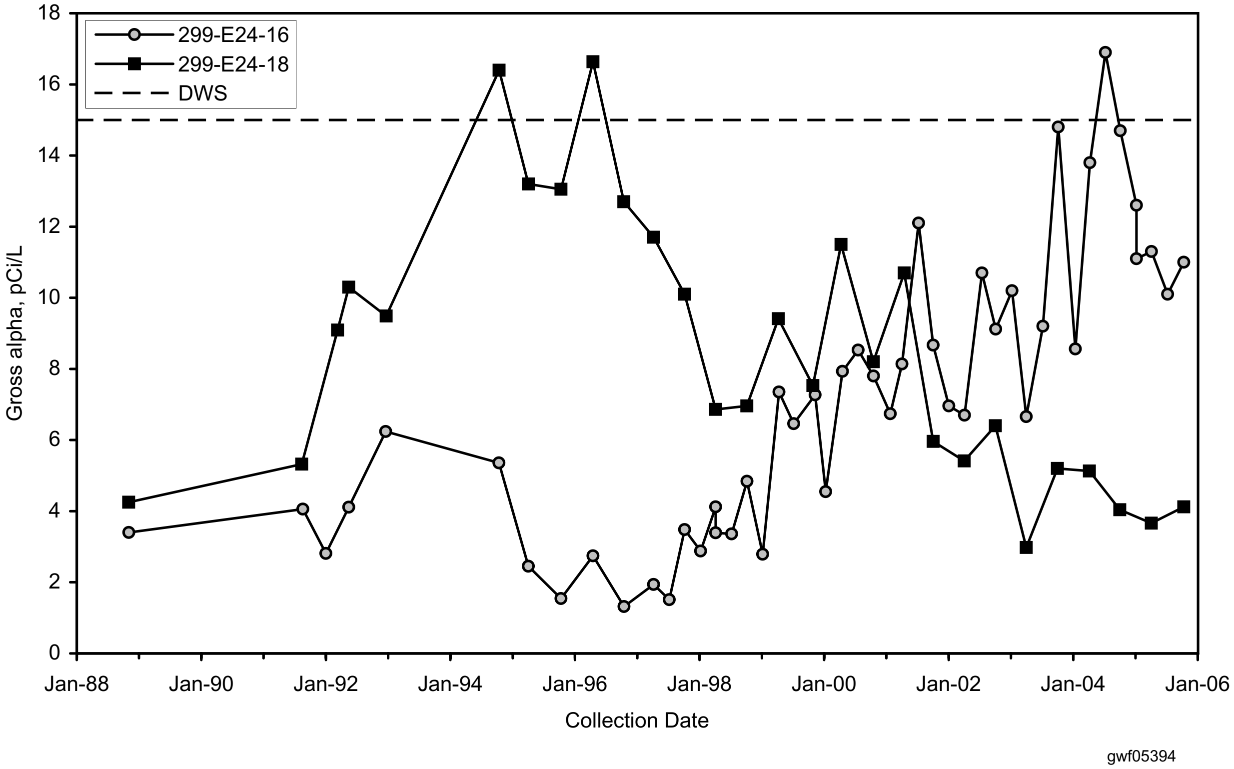

Figure 2.11-9. Gross Alpha Concentrations in Wells Near the PUREX Cribs

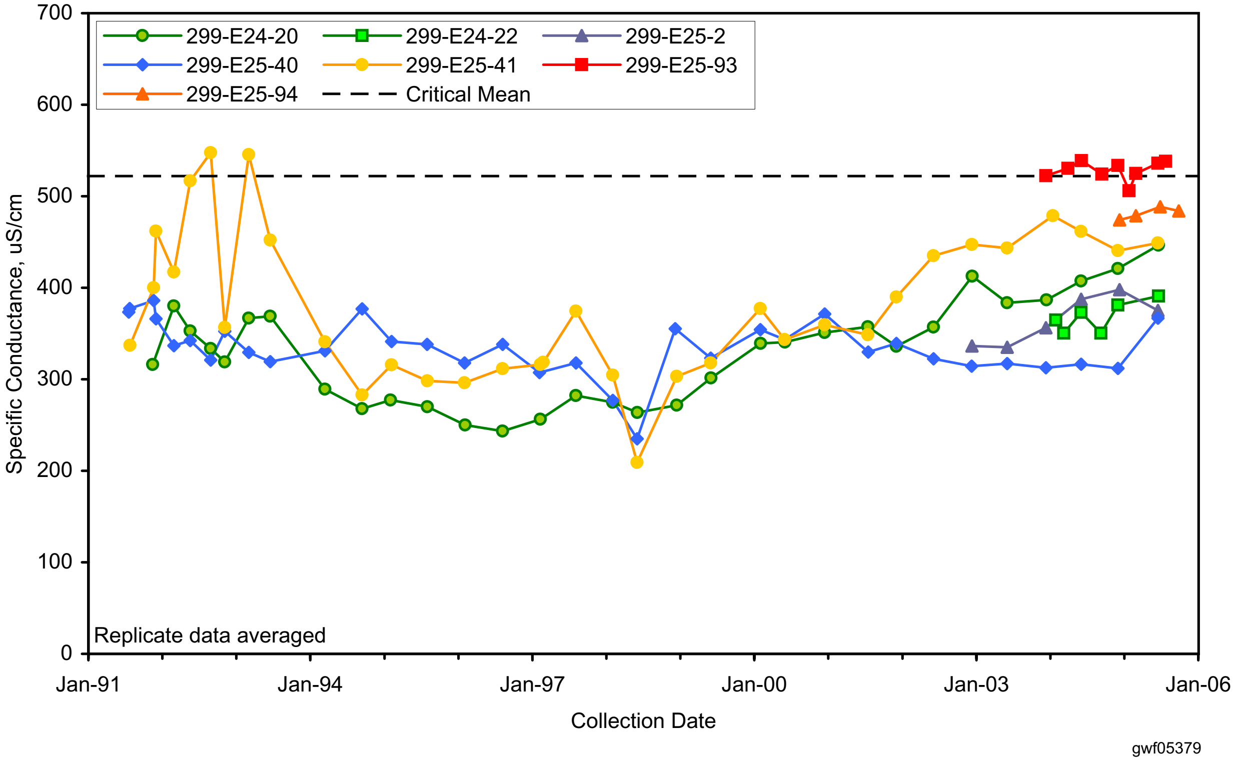

Figure 2.11-10. Specific Conductance at Waste Management Area A-AX

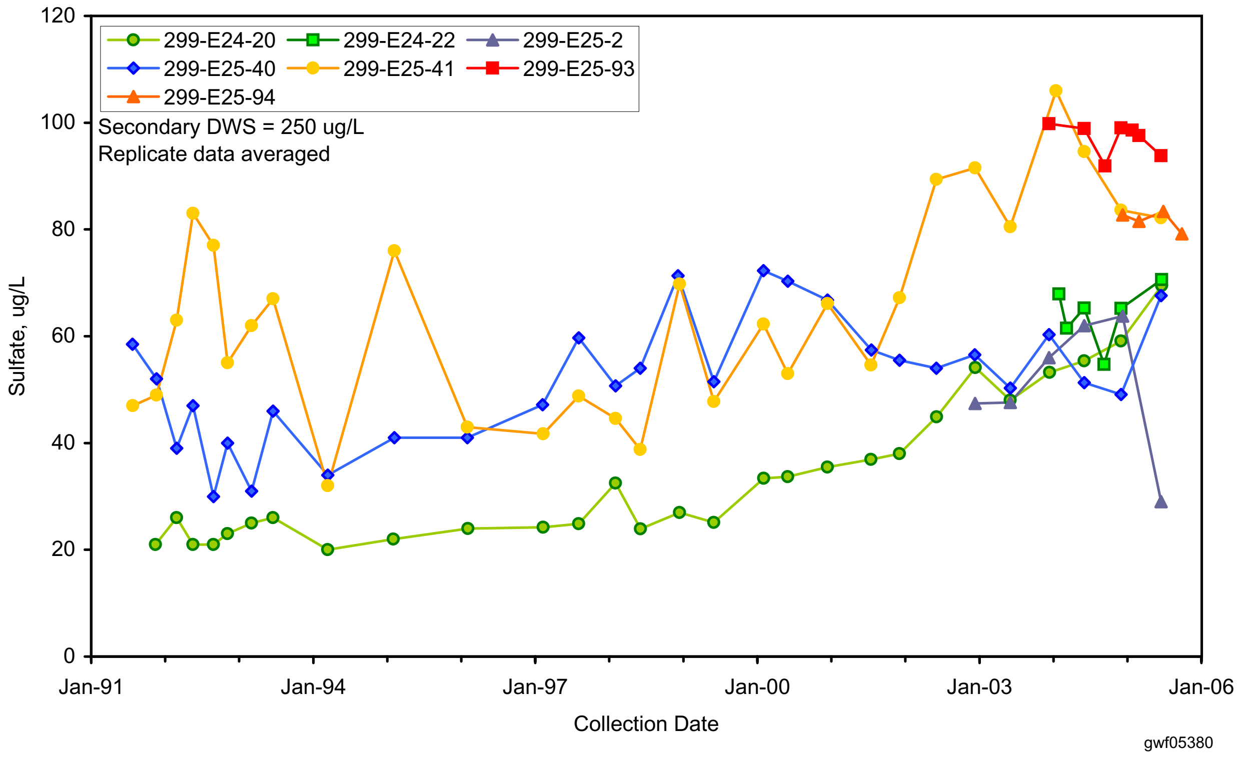

Figure 2.11-11. Sulfate Concentrations at Waste Management Area A-AX

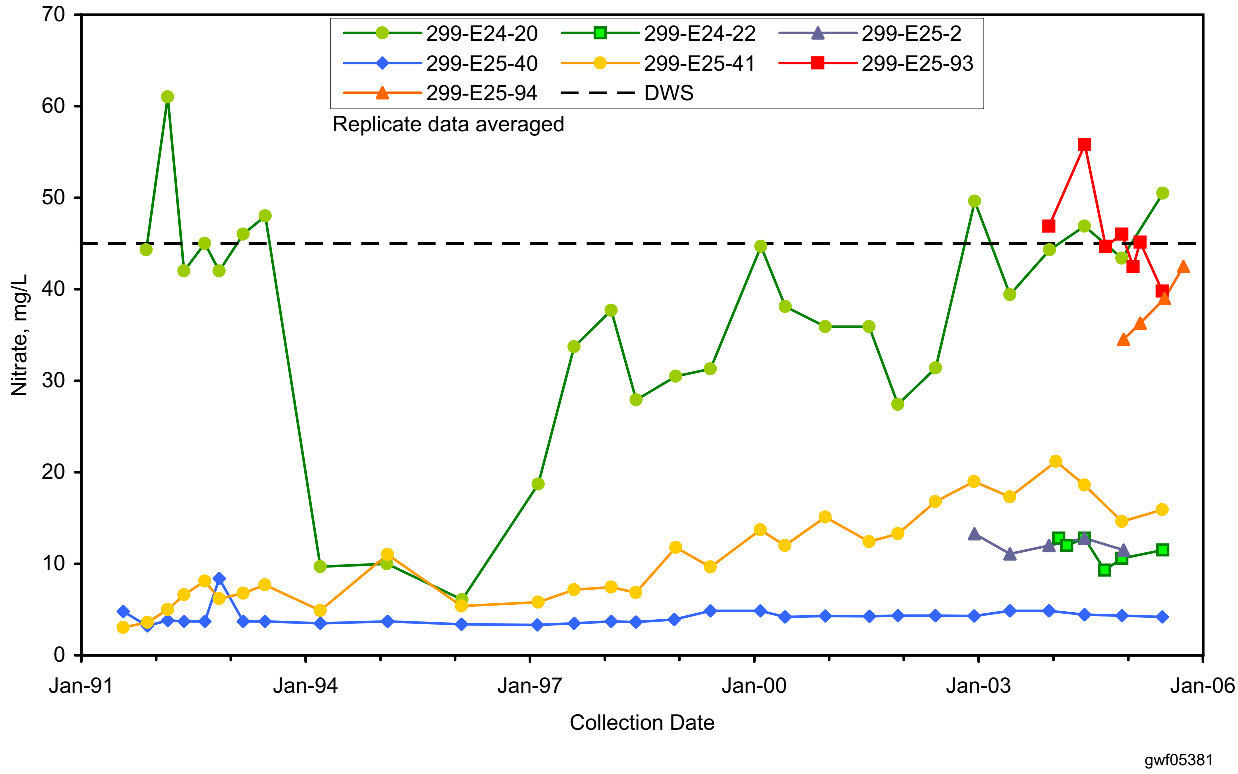

Figure 2.11-12. Nitrate Concentrations at Waste Management Area A-AX

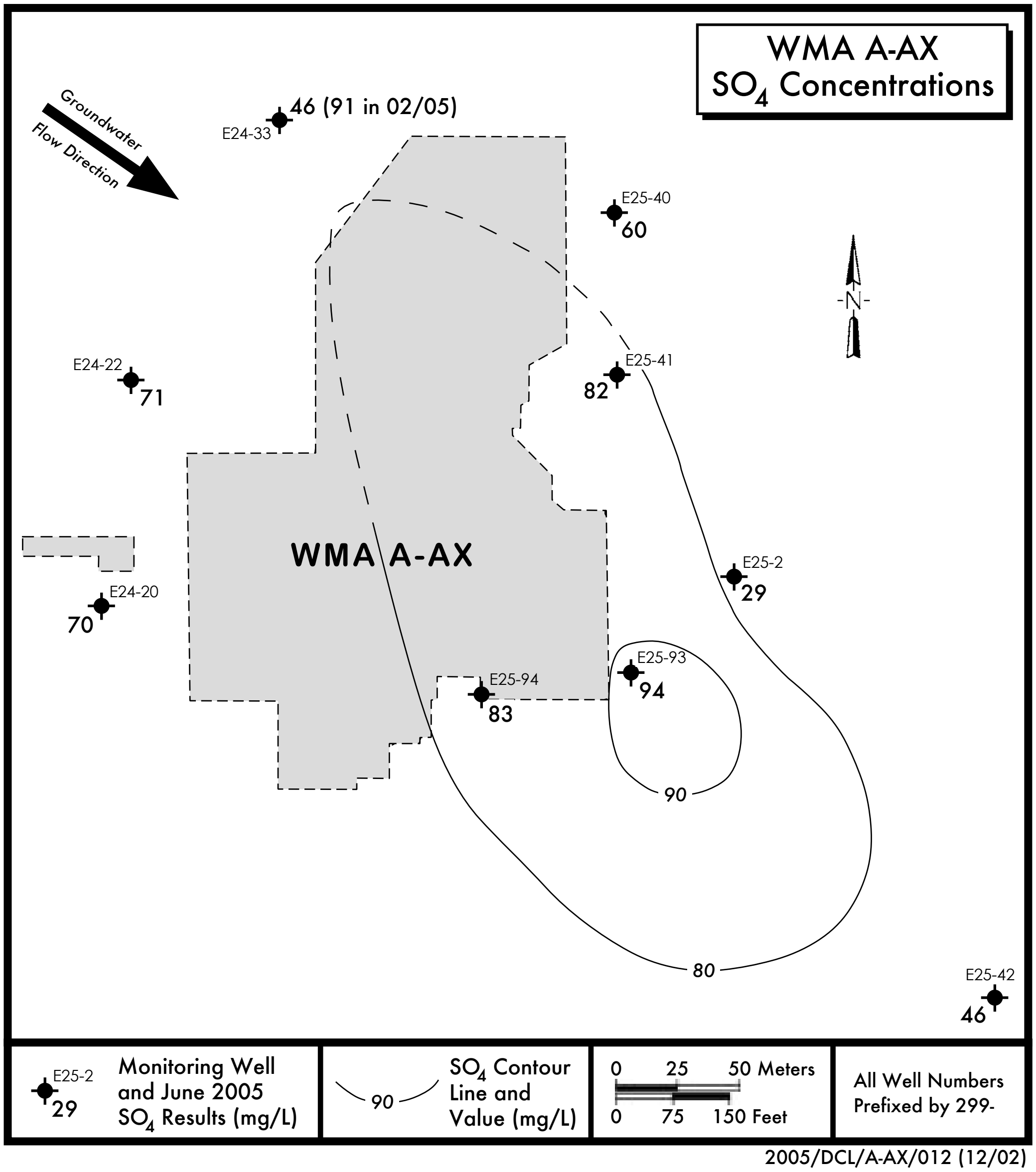

Figure 2.11-13. Contour Map of Sulfate Concentrations in Groundwater at Waste Management Area A-AX

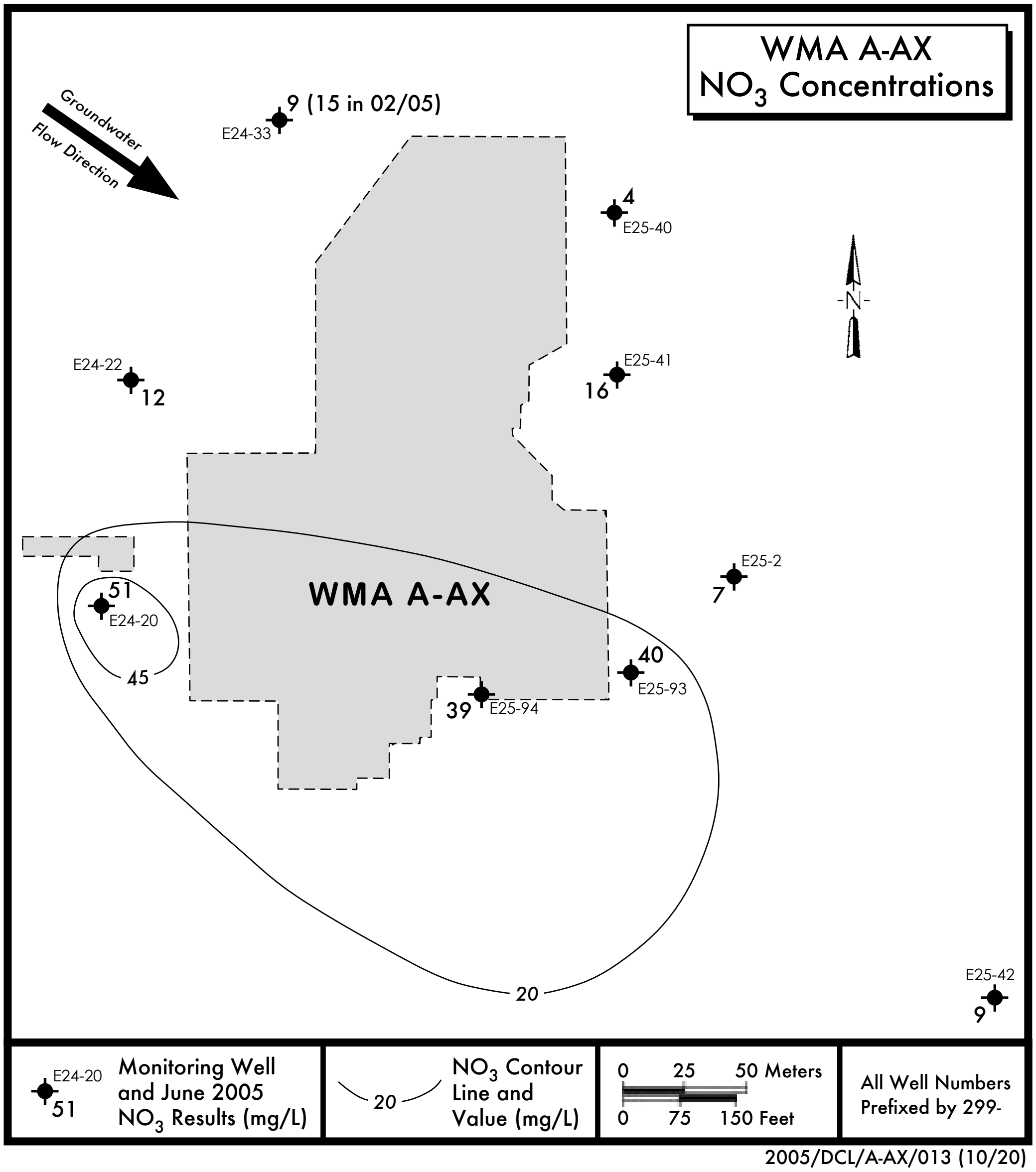

Figure 2.11-14. Contour Map of Nitrate Concentrations in Groundwater at Waste Management Area A-AX

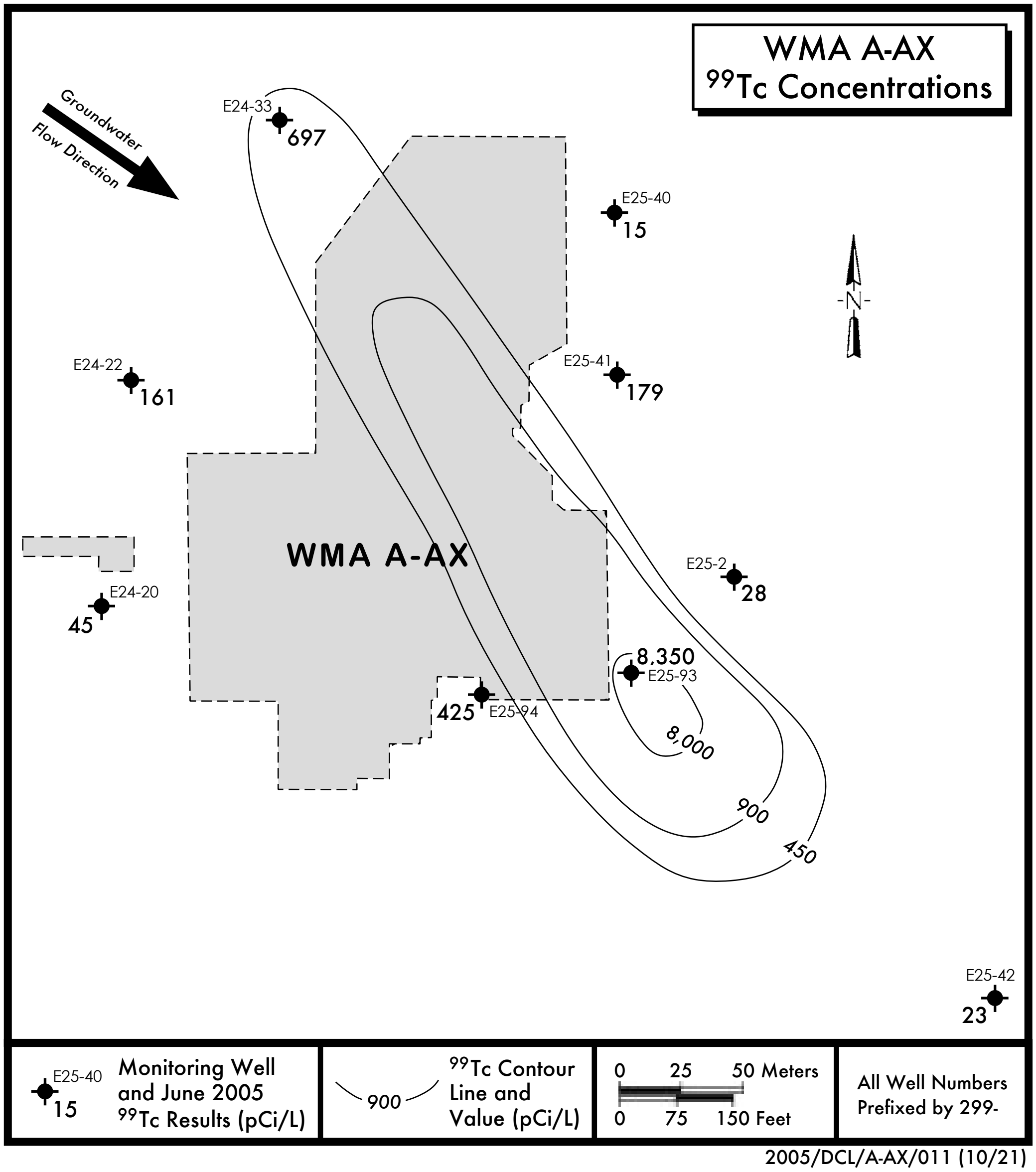

Figure 2.11-15. Contour Map of Technetium-99 Concentrations in Groundwater at Waste Management Area A-AX

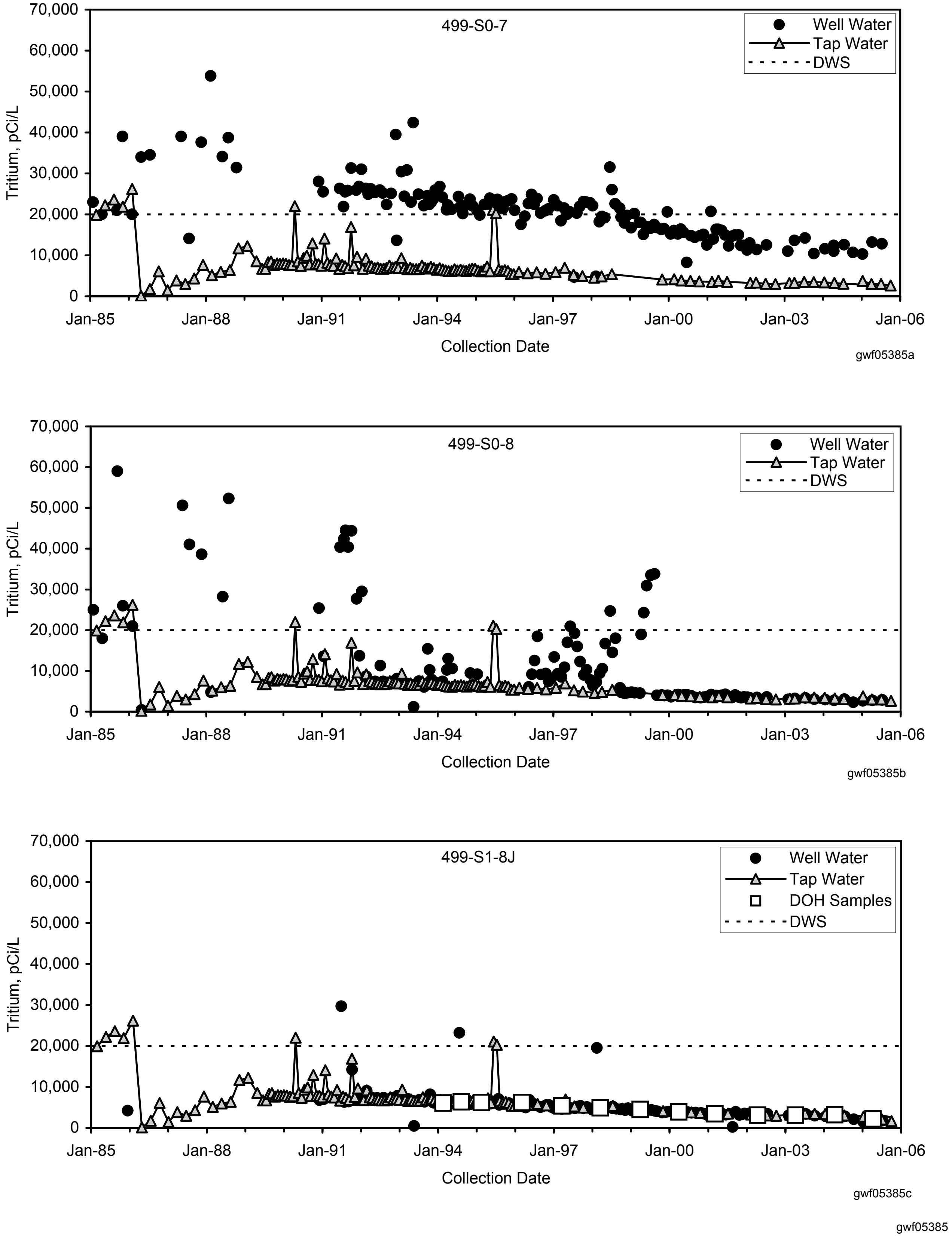

Figure 2.11-16. Tritium Concentrations in 400 Area Water Supply Wells

2.12 300-FF-5 Operable Unit

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The 300-FF-5 Operable Unit includes groundwater affected by releases from all waste sites and burial grounds associated with the 300-FF-1 and 300-FF-2 Operable Units. Primary among these contaminant sources are the liquid waste disposal facilities and burial grounds in the 300 Area, and two outlying subregions, which contain the 618-11 burial ground and the 618-10 burial ground/316-4 crib waste sites. Also, groundwater beneath any newly discovered source waste site will be added to the 300-FF-5 Operable Unit. The operable unit lies within a larger groundwater interest area (see Figure 2.1-1 in Section 2.1), which has been defined by the Groundwater Performance Assessment Project (groundwater project) for scheduling, data evaluation, and interpretation purposes. Groundwater investigations are underway in the operable unit to (a) track changes in the extent of groundwater contaminants and their concentration trends with time, (b) identify natural processes that reduce the levels of contaminants of potential concern, (c) characterize the vertical and horizontal extent of uranium in the vadose zone, and its mobility, and (d) comply with *Resource Conservations and Recovery Act* (RCRA) regulatory requirements associated with the 316-5 process trenches.

The 300-FF-5 Operable Unit subregions are shown in (Figure 2.12-1). The 300 Area contains former nuclear fuel fabrication facilities, fuel research laboratories, liquid effluent disposal sites (e.g., process trenches process ponds), and several solid waste burial grounds. An index map to 300 Area facilities, waste sites, groundwater wells, and shoreline monitoring sites is shown in Figure 2.12-2. Approximately 30 wells and 8 aquifer tube sites along the Columbia River are used to monitor groundwater conditions beneath the 300 Area. The two outlying subregions of the operable unit (i.e., the 618-11 burial ground near Energy Northwest, and the 618-10 burial ground) received primarily solid radioactive waste from the 300 Area during the period 1954 to 1967. The former 316-4 cribs, which are located adjacent to the 618-10 burial ground, received uranium-bearing organic liquid waste during the period 1948 to 1956. An index map to the north 300-FF-5 subregions is provided as Figure 2.12-3. Approximately 11 of the 41 monitoring wells that are in service for the 300-FF-5 Operable Unit are devoted to these two regions (618-11 and 618-10 burial grounds).

Approximately 30 wells and 8 aquifer tube sites along the Columbia River are used to monitor groundwater conditions beneath the 300 Area.

Groundwater monitoring in the 300-FF-5 groundwater interest area includes the following monitoring activities:

CERCLA Long-Term Monitoring

- ***Forty-one wells are sampled semiannually for uranium, volatile organic compounds, and other contaminants.***
- ***Aquifer tubes, riverbank springs, sediment, and associated biota are sampled annually (coordinated with Public Safety and Resource Protection Program monitoring).***
- ***In FY 2005, four wells were not sampled as planned (see Appendix A).***

Facility Corrective Action Monitoring at 316-5 Process Trenches

- ***Eight wells were sampled eight times during FY 2005 for uranium and volatile organic carbons under RCRA.***
- ***Monitoring was coordinated with other programs to avoid duplication.***
- ***In FY 2005, eight wells were sampled as planned.***

AEA Monitoring

- ***Twenty-two wells are sampled annually to supplement CERCLA and RCRA monitoring. Monitoring is coordinated to avoid duplication.***

Groundwater flows toward the east and southeast across the 300-FF-5 interest area and discharges to the Columbia River.

Groundwater flow in the unconfined aquifer beneath the 300-FF-5 groundwater interest area, including the 300 Area, is generally to the east and southeast. Flow into the 300 Area converges from regions to the northwest, west, and southwest, with ultimate discharge to the Columbia River (Figure 2.12-4). During fiscal year (FY) 2005, in the north and central portions of the 300 Area, flow direction was southeast during March 2005 (Figure 2.12-4), and east in the south portion of the 300 Area, as inferred from water-table elevations. These are typical directions for groundwater flow when the river is at low-to-medium stage. As the river stage rises during late May or June, the direction of groundwater flow can temporarily shift to a more southward direction in the north portion of the 300 Area in the vicinity of the process 316-5 process trenches. Changes in river-stage elevation are correlated to changes in water-level elevations at wells located inland as much as 360 meters from the river (PNL-8580).

The remainder of this section describes contaminant plumes and concentration trends for contaminants of potential concern listed in sampling and analysis plans that support *Comprehensive Environmental Resource, Compensation, and Liability Act* (CERCLA) and RCRA requirements.

2.12.1 Groundwater Contaminants

The contaminant of greatest significance in groundwater beneath the 300 Area is uranium, which has persisted as a plume for a long time. Additional contaminants of potential concern from 300 Area sources are volatile organic compounds (cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene) and strontium-90. Constituents from sources outside of the 300 Area that migrate into the region include tritium, nitrate, and trichloroethene.

Plume areas (square kilometers) above the drinking water standard at the 300-FF-5 Operable Unit:

**Nitrate — 0.61*
***Tritium — 0.21*
Uranium — 0.41

** Excludes nitrate from offsite sources.*
*** Excludes tritium from 200-PO-1 Operable Unit.*

For the north 300-FF-5 Operable Unit subregions, the contaminant of greatest significance is tritium at the 618-11 burial ground, where a plume containing high concentrations, but of limited areal extent, is present. This plume lies beneath the Energy Northwest complex. At the 618-10 burial ground and 316-4 cribs to the south of the 618-11 burial ground, the contaminants of potential concern are uranium and tributyl phosphate. These two contaminants are known to have been disposed to the former 316-4 cribs; there is some evidence that uranium may also have been released from waste in the 618-10 burial ground. There is no evidence to date suggesting release of tritium from the 618-10 burial ground, as has occurred at the 618-11 burial ground to the north. Tritium and nitrate migrate into the north 300-FF-5 subregions from upgradient sources in the 200 East Area.

During FY 2004, a detailed evaluation of historical concentration trends for contaminants of potential concern in the 300-FF-5 Operable Unit was undertaken (PNNL-15127). Most contaminants of potential concern, as identified in regulatory decision documents, show either a decrease or relatively constant concentration trend since the initial remedial investigation for the operable unit was conducted in the early 1990s (DOE/RL-94-85).

2.12.1.1 Uranium

Uranium is the contaminant of greatest significance in groundwater at this operable unit.

Uranium is a contaminant of concern in groundwater beneath the 300 Area and beneath the 618-10 burial ground/316-4 cribs subregion. In the 300 Area, it was introduced to groundwater by disposal of fuel fabrication effluent to large infiltration ponds and trenches. At the former 316-4 cribs, it was disposed to open-bottomed infiltration cribs along with liquid effluent containing organic compounds. These cribs were excavated in 2004, and the excavation backfilled; some uranium and tributyl phosphate remains in the soil beneath the excavation. (Note: A final cleanup decision on this site has been deferred until remediation of the adjacent 618-10 burial ground has been completed). Uranium is moderately mobile in groundwater, with some sorption onto sediment particles. The mobility of uranium within waste sites, the underlying vadose zone, and in the aquifer is highly variable and depends on the (a) chemical makeup of the waste effluent and (b) subsurface geochemical environment, especially the carbonate concentration, pH, and surface properties of minerals (PNNL-14022; PNNL-15121).

The persistent uranium plume in the 300 Area, as defined by concentrations exceeding 10 µg/L, covers an area of ~1 square kilometer.

The U.S. Environmental Protection Agency (EPA) maximum contaminant level for uranium in drinking water supplies is 30 µg/L. The standard is based primarily on uranium's chemical toxicity to humans, which is associated with damage to internal organs. Protection standards for freshwater aquatic organisms have not been established by EPA. A recent literature review regarding the chemical toxicity of uranium to non-human biota describes the relationship between toxicity and water hardness (i.e., the amount of calcium and other cations) for aquatic organisms (Sheppard et al. 2005). The range of predicted no-effect concentrations are from 5 µg/L for freshwater plants and invertebrates (without considering of hardness) to 2,800 µg/L for fish (assuming water hardness similar to the Columbia River). Until further regulatory guidance becomes available for the toxicity of uranium to freshwater organisms, the drinking water standard will be used as the criteria for protection along the 300 Area shoreline where contaminated groundwater discharges to the river. Uranium in groundwater is typically monitored using chemical analyses for total uranium in an unfiltered sample. In the river environment, uranium in shoreline media and river water is monitored using analyses for specific isotopes. Results for each type of analysis can be converted to the other to provide comparable data sets.

300 Area Uranium Plume. The persistent uranium plume in the 300 Area, as defined by concentrations exceeding 10 µg/L, covers an area of ~1 square kilometer. Natural background concentrations for uranium in this subregion are in the 5 to 8 µg/L range. The area of the plume where concentrations exceed the drinking water standard (30 µg/L) is ~0.4 square kilometer (Figures 2.12-5 and 2.12-6). Although the areal extent of the plume is quite consistent from year to year, the concentrations of uranium within the plume vary throughout the year. These changes within the plume during various seasons are related to cyclic changes in river stage, which cause the water-table beneath the 300 Area to fluctuate up and down. Near the river, stage fluctuations also result in river water infiltrating the near-river aquifer, which reduces groundwater contaminant concentrations by dilution and by increasing sorption onto aquifer solids. Throughout most of the year (i.e., August through April), the river maintains a relative low-to-moderate stage elevation, while during late May and June, the stage is typically relatively high. Figure 2.12-5 shows the uranium plume indicated by results for samples collected in December 2004, which is considered representative of the August through April time period. Figure 2.12-6 shows the uranium plume during June 2005.

Seasonal river stage conditions cause variability in uranium concentrations in groundwater.

Uranium concentrations in 300 Area groundwater are influenced by fluctuations in water-table elevation, which are, in turn, influenced by river stage fluctuations. Higher concentrations are frequently observed when the water table is elevated above long-term levels, e.g., during the spring river freshet each May and June. These higher concentrations may be the consequence of remobilizing uranium that is sequestered in the lower portion of the vadose zone beneath former liquid waste disposal sites (e.g., the 316-5 process trenches and 316-3 trench). For example, Figure 2.12-7 shows the positive correlation between uranium concentrations and water level at well 399-1-17A, located near the 316-5 process trenches. Closer to the river at well 399-1-16A, uranium concentrations during June are frequently lower than those observed during other seasons. The lower concentrations are caused by infiltrating river water mixing with groundwater, thus diluting the contamination (Figure 2.12-8). There is also the possibility of increased absorption of uranium onto aquifer solids in areas of bank storage, thus reducing the dissolved component of uranium. Investigations of uranium mobility have shown that sorption is increased in a chemical environment that is low in carbonate; river water contains less carbonate than groundwater (PNNL-14022; PNNL-15121).

During June 2005, the elevated river stage was not as pronounced compared to the higher river stages during the spring of 1996 through 1999. Therefore, the uranium plume for June 2005 (Figure 2.12-6) is very similar to the December 2004 plume (Figure 2.12-5). The most obvious difference is well 399-1-21A where the December 2004 uranium value was 31 µg/L and the June 2005 value was 97 µg/L. The increase is likely due to either the cyclical process described in the last two paragraphs or possibly due to surface clean up efforts to the west of the well (near the 313 Building) conducted during FY 2004 and FY 2005. During surface remedial activities, water is sprayed onto the ground for the purpose of suppressing airborne dust. The extra water discharged to the ground could have mobilized an increased amount of uranium from the vadose zone, which, in turn, would have been detected in the downgradient well 399-1-21A.

Uranium contamination is primarily limited to the uppermost part of the unconfined aquifer at the 300 Area.

Concentrations at a well located close to the most recently active waste site (i.e., well 399-1-17A at the 316-5 process trenches) indicate a gradual decline since the middle 1990s (Figure 2.12-9), though levels appear to have remained fairly constant since approximately 2001. At locations farther downgradient for this waste site, concentration trends reveal the passage of a relatively high concentration pulse (Figure 2.12-10), which is related to the high river stage during the spring runoffs of 1996 and 1997 and possibly to extensive source excavation activities that started in the mid-1990s. Concentrations at other locations within the plume show variable trends. Because there is currently no disposal of effluent to waste sites and some past-practice waste sites have been excavated, the most likely influence on long-term concentration trends are (a) plume migration and (b) recharge of the plume by continuing releases from vadose zone sediment and possibly from aquifer solids as well. Short-term variability in concentrations is caused by seasonal changes in water-table elevation and groundwater/river interaction near the shoreline.

The plume maps prepared for this report represent conditions in the upper part of the unconfined aquifer. Several wells in the 300 Area are screened at the bottom of the unconfined aquifer, and uranium concentrations in samples from these wells are generally near background levels, and range from non-detect to 14.8 µg/L (well 399-1-16B) in recent samples. The higher values at this depth are found near the most recently active source, i.e., the 316-5 process trenches. Uranium has not been detected at the few wells that monitor the uppermost confined aquifer.

Aquifer tube results continue to show that the sites with the highest reported uranium values are adjacent to the central core area of the groundwater plume.

Aquifer tubes installed in 2004 at multiple depths along the 300 Area shoreline have now been sampled three times: February 2004, March 2005, and September 2005. The initial samples from these tubes revealed uranium concentrations ranging from 10 to 241 µg/L, with the highest values adjacent to the central core area of the groundwater plume. Subsequent results show that the highest values remain at sites AT-3-3 and AT-3-4 (Figures 2.12-5 and 2.12-6), which is consistent with the central core area of the mapped groundwater plume. The results from the three sampling events also appear to indicate similar uranium concentrations for the groundwater approaching these sites, i.e., the observed differences in concentrations for the three sampling events are primarily caused by variability in the amount of infiltrating river water, which dilutes contaminant concentrations for a particular sampling event. Results for the September 2005 sampling event are shown in Figure 2.12-11, along with concentrations observed in adjacent near-river monitoring wells. Note that concentrations for samples from aquifer tubes represent a much shorter vertical interval (i.e., 0.15 meter) than the interval for a monitoring well (~4.6 meters).

The concentrations observed in samples from tubes are not directly comparable to concentrations observed from wells, because of the difference in screen length (i.e., 15 centimeters for tubes versus 3 to 7 meters for typical wells). However, the relative distribution along the shoreline does help in defining the boundaries of the plume and also reveals information about the vertical distribution of contamination. Additional investigation of the zone of interaction between groundwater and river water using aquifer tube methodology has been underway during FY 2005 as part of the Remedial Action and Closure Science Project. Results from several year of data collection at the shoreline are currently being interpreted.

Uranium Near 618-10 Burial Ground and 316-4 Cribs. Uranium concentrations are elevated above natural background levels (i.e., 5 to 8 µg/L) at several wells near the 618-10 burial ground and former 316-4 cribs. Concentrations at wells 699-S6-E4A and 699-S6-E4L, which are located in the southeast side of the burial ground, ranged from 3.8 to 42 µg/L during FY 2005, slightly exceeding the drinking water standard of 30 µg/L (Figure 2.12-12). The highest concentration was for a sample from well 699-S6-E4A, which is located within the footprint of the excavation associated with removal of the 316-4 cribs and adjacent soil. With that exception, other monitoring results from this well remained below the standard during the removal action at this waste site, even though elevated levels of uranium were found in the soil at the bottom of the excavation.

Uranium concentrations at well 699-S6-E4L have gradually increased since construction of the well in early 2003. The cause for this is unknown. It is possible that the increases seen at wells 699-S6-E4L and at 699-S6-E4A are related to excavation activities associated with the 316-4 waste sites. The differences in trends and concentrations seen at the two wells may reflect the differing vertical positions and depths of the screened interval for each well. Well 699-S6-E4L has the shorter open interval and the higher concentrations that currently are slightly above the drinking water standard. Regardless of what has occurred, uranium concentrations in this area seem to have stabilized with the most recent sampling events and at a level close to the drinking water standard.

Results from research activities involving uranium isotopes in groundwater from wells 699-S6-E4A and 699-S6-E4L suggest two distinct sources for the uranium in groundwater at this location. A known source is the former 316-4 cribs; a second potential source in this subregion is the 618-10 burial ground, where small volume containers of liquid waste containing uranium were placed in trenches (WHC-MR-0415).

2.12.1.2 Organic Compounds

Constituents of concern in groundwater beneath the 300 Area include cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene. Beneath the 618-10 burial ground and 316-4 cribs, organic compounds previously identified as potential concern include tributyl phosphate and petroleum hydrocarbons.

During FY 2005, the only volatile organic compound reliably found to be in concentrations exceeding the drinking water standard (70 µg/L) was cis-1,2-dichloroethene.

300 Area Organic Compounds. During FY 2005, cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene were detected in 300 Area groundwater samples, but only cis-1,2-dichloroethene was reliably found to be in concentrations exceeding the drinking water standard (70 µg/L). Near or downgradient of the 316-5 process trenches, cis-1,2-dichloroethene was detected (>0.27 µg/L) in six wells. Four of the wells are screened (or have perforated well casings) at the water table while two of the wells are screened at the base of the unconfined aquifer. Only well 399-1-16B, screened at the base of the unconfined aquifer, had reported cis-1,2-dichloroethene results that exceeded the drinking water standard (70 µg/L). During FY 2005, the reported values of cis-1,2-dichloroethene ranged from 130 to 230 µg/L at well 399-1-16B with an overall increasing trend throughout the fiscal year (Figure 2.12-13).

Trichloroethene (drinking water standard 5 µg/L) was detected in 23 wells in the 300 Area and also in other wells offsite to the southwest where there is a source of trichloroethene groundwater contamination (Figure 2.12-14). Another source of trichloroethene groundwater contamination is the 316-5 process trenches. Of the 23 wells in the 300 Area where trichloroethene was detected in FY 2005, all but two have open sampling intervals that include the uppermost portion of the unconfined aquifer (i.e., near the water table). The two exceptions (wells 399-1-16B and 399-1-8) have open intervals in the lower portion of the unconfined aquifer; also, both are located downgradient of the 316-5 process trenches. With the exception of a result of 8.3 µg/L at well 399-3-2, which was likely a sampling or laboratory error, the highest reported result for trichloroethene at monitoring wells during FY 2005 in the 300 Area was 3.7 µg/L at well 399-4-12. Well 399-2-2 was close, with a result of 3.6 µg/L. Along the shoreline, values at aquifer tube sites are below the drinking water standard or non-detections.

Tetrachloroethene (drinking water standard 5 µg/L) was detected at very low concentrations in seven wells in the 300 Area during FY 2005. Most of these are downgradient of the 316-5 process trenches, and all are screened at the water table. The range of detected concentrations was 0.12 to 0.45 µg/L. Reported levels of tetrachloroethene in wells downgradient of the 316-5 process trenches have been as high as 38 µg/L (July 1998 in well 399-1-17A) in previous years, but during FY 2005 reported concentrations remained low.

Elsewhere in the 300 Area, contamination by petroleum hydrocarbons was suspected during remedial actions at the 618-4 and 618-5 burial grounds. However, groundwater samples from wells 399-1-15 and 399-1-6 have not revealed petroleum hydrocarbon contamination to date.

Groundwater in the 300 Area and 300-FF-5 North region is contaminated with nitrate from sources outside of the operable unit. Concentrations are generally below the drinking water standard (45 mg/L).

Organic Compounds in the North 300-FF-5 Operable Unit. Tributyl phosphate has been detected in the past at well 699-S6-E4A, which is located within the excavation footprint of the former 316-4 cribs. The cribs received fuels fabrication liquid waste that contained tributyl phosphate and uranium during the period 1948 to 1954. Tributyl phosphate concentrations were elevated in early 2004, along with uranium (Figure 2.12-2), during the period when crib removal actions were underway. Since then, concentrations have remained very low. Samples from nearby wells 699-S6-E4K and 699-S6-E4L indicate non-detections. Tributyl phosphate became of interest in 1996 following refurbishment of well 699-S6-E4A, when contamination in the vadose zone and/or within the well was remobilized. Subsequent monitoring has shown that the occurrence is very localized, as expected. The semivolatile compound tends to bind to soil in the vadose zone, where it slowly degrades with time. It is not very soluble in water and, therefore, not widely dispersed via water transport mechanisms. There is no drinking water standard for tributyl phosphate.

Petroleum hydrocarbons (both diesel and gasoline) were also detected during the refurbishment of well 699-S6-E4A in 1995. The source may have been past leaks or spills from a fuel tank associated with operation of the 316-4 cribs. Monitoring conducted since 1995 has shown non-detections at wells in the general vicinity.

2.12.1.3 Strontium-90

Strontium-90 has been detected as an isolated occurrence at well 399-3-11 in previous years (PNNL-13788). The drinking water standard is 8 pCi/L. Results from well 399-3-11 during FY 2005 were 3.3 and 3.2 pCi/L for samples collected during January and June 2005, respectively. The source for the strontium-90 is not clearly evident, but one candidate is a long-term leak from transfer lines associated with the 307 Retention Basins, which was discovered in 1969 and with an estimated loss of 10 curies of strontium-90 (WIDS Unplanned Release UPR-300-1).

2.12.1.4 Nitrate

Groundwater in the 300-FF-5 Operable Unit is contaminated with nitrate from upgradient sources. In the 300 Area, the source is to the southwest, while in the 618-11 burial ground and 618-10 burial ground and 316-4 cribs region, the source is the 200 East Area (see Section 2.11.1.3).

Nitrate in the 300 Area and Adjacent Area to the South. Nitrate in groundwater beneath the 300 Area is generally present at concentrations less than the drinking water standard of 45 mg/L (Figure 2.12-15). Concentration trends for 300 Area wells during the period 1992 through 2004 are presented in PNNL-15127, Table 2.10. The source for this nitrate is past disposal of liquid effluent during the operating years, and possibly septic systems. Groundwater concentrations were somewhat higher during the 1970s and 1980s, although they never greatly exceeded the drinking water standard. In the region immediately south of the 300 Area (southern extent of the 300-FF-5 Operable Unit), nitrate concentrations are relatively higher and do exceed the drinking water standard, with concentrations at some wells in the 100 to 140 mg/L range during FY 2005. This nitrate originates at sources to the southwest of 300-FF-5, possibly including agricultural activities. Concentrations are gradually increasing in wells and at shoreline sites in the southern part of the 300 Area, as nitrate-laden groundwater from the southwest migrates into the area.

Nitrate in the North 300-FF-5 Operable Unit. The outlying waste sites in the north portion of the 300-FF-5 Operable Unit lie within the large contaminant plume that originates in the 200 East Area. Background levels of nitrate upgradient of the 618-11 burial ground are in the range of 20 to 40 mg/L, while in the vicinity of the 618-11 burial ground the concentrations of nitrate are somewhat higher, with values during FY 2005 at well 699-13-3A (~80 mg/L) and well 699-12-2C (~110 mg/L) exceeding the drinking water standard (45 mg/L). The cause for these higher values is not confirmed; they may reflect the influence of an active septic system operated by Energy Northwest or some hydrogeologic characteristic that has caused retention of more contaminated groundwater from earlier years. Trends for the last several years indicated relatively constant nitrate levels, but with some variability. At the 618-10 burial ground, nitrate concentrations are generally consistent with values expected for the leading edge of the site-wide plume and are below the drinking water standard.

2.12.1.5 Tritium

Tritium contamination in groundwater in the 300-FF-5 Operable Unit has two sources. One is the site-wide tritium plume that originates in the 200 East Area (see Figure 2.1-5 in Section 2.1 and Section 2.11.1.1). The other is the 618-11 burial ground in the north 300-FF-5 Operable Unit. Concentrations attributed to the site-wide plume as it reaches the 300 Area are shown in Figure 2.12-16 and range from 100 to 10,000 pCi/L, depending on location, and were below the drinking water standard (20,000 pCi/L). Wells located toward the northeast have higher concentrations than those toward the southwest. In the region just to the north of the 300 Area (Figure 2.12-16), concentrations are decreasing with time, as the site-wide plume attenuates by radioactive decay and dispersion (see discussion of 200 East Area tritium plume in Section 2.11.1.1).

The very high concentrations of tritium adjacent to the 618-11 burial ground have continued to decline in recent years.

Tritium at 618-11 Burial Ground. The high concentrations of tritium that were detected in early 1999 at well 699-13-3A, which is located immediately to the east of the 618-11 burial ground, have continued to decline in recent years (Figure 2.12-17). The contaminant plume, whose source is the burial ground (PNNL-13675), extends downgradient as a narrow plume of concentrations much higher than the surrounding site-wide plume from 200 East Area (Figure 2.12-18). The trend near the burial ground at well 699-13-3A suggests the possibility that an episodic event may have occurred that caused a release of tritium from buried materials and/or mobilization of tritium in the vadose zone sufficient to impact groundwater. The removal of tritium sources in the 618-11 burial ground is expected to be no later than 2018, per Tri-Party Agreement Milestone M-016-00B.

2.12.2 Operable Unit Monitoring and Interim Action Progress

The geographic extent of the 300-FF-5 Operable Unit includes three subregions: 300 Area, 618-11 burial ground, and the 618-10 burial ground and 316-4 cribs region (Figure 2.12-1). A record of decision for interim action in the 300 Area portion was made in 1996 (ROD 1996b) and subsequently expanded to include the two outlying subregions north of the 300 Area in 2000 (EPA 2000). The interim remedy as described in the record of decision is:

- Continued monitoring of groundwater that is contaminated above health-based levels to ensure that concentrations continue to decrease.
- Institutional controls to ensure that groundwater use is restricted to prevent unacceptable exposures to groundwater contamination.

The CERCLA process includes a requirement to review the effectiveness of records of decision every 5 years, if contamination remains in the operable unit involved. The results of the first 5-year review (EPA 2001) indicated that the remedial actions at 300 Area source waste sites were proceeding in an effective manner to protect human health and the environment. EPA re-affirmed that the cleanup goals and remedy selection for groundwater are still appropriate at the time the first 5-year review was released.

The remedial action objectives for groundwater in the 300-FF-5 Operable Unit (ROD 1996b) are:

- *Protect human and ecological receptors from exposure to contaminants in the soil and debris.*
- *Protect receptors from exposure to contaminants in the groundwater and control the sources of contamination to minimize future impacts to groundwater.*
- *Protect the Columbia River such that contaminants in the groundwater or soil after remediation do not result in an impact to the river that would exceed the Washington State surface water quality standards.*

The record of decision sets the objective concentrations as the drinking water standards for cis-1,2-dichloroethene, trichloroethene, and uranium. In 2000, EPA expanded the record of decision to include groundwater beneath the 300-FF-5 North region (EPA 2000).

While the first 5-year review found the interim remedy to be appropriate, it also found that additional work was needed to better characterize the performance of natural processes in reducing the levels of contaminants of concern. This finding lead to a revised operations and maintenance plan in 2002 (DOE/RL-95-74) that contained increased requirements for monitoring, especially along the 300 Area shoreline, and for analysis of natural processes that lead to attenuation of contaminant levels. An outgrowth of this finding also led to an expanded 300-FF-5 groundwater report for FY 2004 (PNNL-15127), which contains detailed information on historical trends and current conditions for contaminants of potential concern. The format of that report was designed to support the second 5-year review of the record of decision. The second 5-year review is being conducted during the period summer 2005 through spring 2006. The review will be made available to the public by April 2006.

In 2004, activities were renewed on the operable unit's remedial investigation and feasibility studies. A new Tri-Party Agreement milestone (M-016-68) was developed in early 2005 for a Phase III Feasibility Study report on remedial action alternatives and a draft proposed plan. A work plan was prepared (DOE/RL-2005-41) that describes these additional efforts, which include updated computer simulations of groundwater flow and uranium transport; an update to human health and ecological risk assessment in the 300 Area; a limited field investigation involving multiple characterization boreholes (DOE/RL-2005-47); and an assessment of potential remediation technologies for uranium.

2.12.2.1 Monitoring Activities

Along the 300 Area shoreline, sampling and analysis at various sites and of various media are being conducted under several programs, with primarily annual sampling.

In the 300 Area, numerous monitoring wells were in service as part of the CERCLA monitoring effort. In addition, samples were collected from eight aquifer tube sites, two riverbank springs, and from the river along the shoreline. Exceptions to the planned schedule for FY 2005 are listed in Appendix A. Groundwater monitoring included semiannual sampling at monitoring wells during December and June, with the intent of characterizing average seasonal conditions (December) and the spring period of high water-table elevations (June) that are caused by the spring runoff to the Columbia River. Additional samples were collected from wells in support RCRA corrective action monitoring associated with the former 316-5 process trenches (WHC-SD-EN-AP-185; see Section 2.12.3).

Along the 300 Area shoreline, environmental monitoring involving a variety of sites and media is being conducted under several programs, with primarily annual sampling. Under CERCLA, near-river wells, shoreline aquifer tubes, and riverbank springs are sampled to provide data on the distribution and concentration trends of contaminants in groundwater near the point-of-discharge to the river ecosystem. Under the Public Safety and Resource Protection Program, an integrated effort involving the Surface Environmental Surveillance Project and the Ecological Monitoring and Compliance Project is producing additional data on contaminants at the groundwater and river interface. Media sampled include riverbed pore water and sediment, river water, and various aquatic biota. To date, clams have been shown to be good indicators of where uranium-contaminated groundwater discharges to the riverbed (PNNL-13692). Also during 2005, research continued on the interaction between groundwater and surface water at the 300 and 100-N Areas under the Remedial Action and Closure Science Project. Finally, the 300 Area is included as part of the River Corridor Baseline Risk Assessment, which started in 2004 and continued during FY 2005.

At the 618-11 burial ground, monitoring the tritium plume that extends downgradient of the burial ground continued during FY 2005 and wells used to define the plume were primarily sampled quarterly. For wells closest to the burial ground, concentrations show a declining trend (Section 2.12.1.6 and Figure 2.12-17). At other wells, changes in concentrations seem to reflect lateral spreading and gradual migration of the plume to the east.

Groundwater sampling during FY 2005 near the 316-4 cribs has shown that an earlier rise in uranium concentrations was only temporary.

Groundwater monitoring at the 316-4 cribs was interrupted between June 2004 and February 2005 by excavation activities. When groundwater sampling resumed, the monitoring frequency was increased to better detect potential changes associated with the excavation activities. Remedial action associated with the cribs began near the end of FY 2004 with site preparation activities (actual excavation began in October 2004). A rise in uranium concentrations was observed during this time period at two nearby wells (Figure 2.12-12 and Section 2.12.1.1), which raised suspicions that contamination in the vadose zone was being remobilized. Subsequent monitoring during FY 2005 indicates that if this has occurred, it was temporary and did not create a lasting impact on groundwater conditions in the 316-4 cribs region. Starting December 2005, monitoring frequency returns to quarterly at most of the region's monitoring network.

Analytical results for samples of groundwater, surface water, sediment, and biota are stored in the Hanford Environmental Information System database (HEIS 1994). Groundwater data are summarized in an annual report (this document), while results for other media are described in an annual environmental report (e.g., PNNL-15222). Data and interpretations are also presented in topical reports as the need arises.

2.12.2.2 Interim Remedial Action Progress

Implementation of the interim remedy is described in the updated and expanded operations and maintenance plan, as revised in 2002 (DOE/RL-95-73) and a sampling and analysis plan (DOE/RL-2002-11), which was revised in December 2005. Key elements of the remedy include continued monitoring of groundwater to verify previously modeled predictions of contaminant attenuation, and evaluating the need for active remedial measures. Continued monitoring involves sampling and analysis of groundwater collected from wells and shoreline sites, and also developing new information on (1) the recharge of mapped plumes because of release from the vadose zone and/or aquifer solids, (2) the characteristics of discharge from the aquifer to the Columbia River, and (3) dispersal of contaminants in the river environment via biota pathways. This new information is used to maintain an up-to-date conceptual site model for uranium contamination in the 300 Area, as well as conceptual site models for contaminants of potential concern in other subregions of the operable unit. In turn, the conceptual site models provide a basis for developing computer simulations of groundwater flow and contaminant transport, and for evaluating remedial action alternatives (Section 2.12.2.3).

Key elements of the interim remedy include continued monitoring of groundwater to verify previously modeled predictions of contaminant attenuation.

With regard to continued monitoring, the Executive Summary for the operations and maintenance plan (DOE/RL-95-73, as revised) describes specific monitoring objectives for the period of interim action. Contaminants of concern for the operable unit, as identified in the record of decision and explanation of significant difference (ROD 1996b and EPA 2000, respectively), are listed below, along with lists of additional contamination indicators that are being tracked (in parentheses):

- **300 Area**: Uranium, cis-1,2-dichloroethene, and trichloroethene (gross alpha, gross beta, strontium-90, and tritium; nitrate and tetrachloroethene)

- **618-11 burial ground**: Tritium (gross alpha, gross beta, technetium-99, and uranium; nitrate)
- **618-10 burial ground and 316-4 cribs**: Uranium and tributyl phosphate (gross alpha, gross beta, technetium-99, and tritium; nitrate)

The status information provided in the following paragraphs on meeting the operation and maintenance plan (DOE/RL-95-73, as revised) objectives has been extracted from the expanded FY 2004 groundwater report for the 300-FF-5 Operable Unit (PNNL-15127), which contains descriptions of trends since 1992, proposed updates to the lists of contaminants of concern/potential concern, and an analysis of the applicability of monitored natural attenuation as a remedial action alternative for the operable unit. That report also contains descriptions of the conceptual site models for the 300 Area uranium plume and the 618-11 burial ground tritium plume.

1. Objective: Verify that natural attenuation reduces groundwater contamination concentrations to drinking water maximum contaminant levels over a reasonable time period.

    - **300 Area**: Since approximately 1998, uranium concentrations at many 300 Area monitoring wells have shown a declining trend, although not necessarily to the 30-µg/L standard or lower. At other wells, concentrations show a constant value typically lower than the standard. Where concentrations are rising, it appears to be the result of migration of the core of the plume into relatively less contaminated areas. Estimates for changes in the areal extent, contaminated volume, and mass of dissolved uranium reveal considerable variability, probably because of simplifying assumptions made for the calculations. However, they are not inconsistent with the interpretation of an overall declining level of contamination since at least 2001. Natural attenuation because of dispersion via groundwater flow, and a reduction in the rate of uranium recharge from the vadose zone, appear to have the largest effect on the level of uranium contamination in the aquifer. An additional reduction in the amount of uranium in groundwater occurs because of water withdrawal to support the 331 Building aquariums.

      Volatile organic compounds in the 300 Area are generally present at concentrations below the drinking water standard. The exception is cis-1,2-dichloroethene at one well, which remains relatively constant at concentrations approximately twice the standard, with no apparent attenuation. There appears to be greater variability in concentrations at this well since late 2004. Trichloroethene at the same well has shown a declining trend between 1987 and 2001, and then a constant level (~2 µg/L) ever since.

    - **618-11 Burial Ground**: A tritium plume created by releases from the 618-11 burial ground has not changed shape appreciably or migrated a significant distance during FY 2005. Concentrations have decreased at wells nearest the source but remain well above the drinking water standard (20,000 pCi/L). Attenuation appears to be primarily controlled by radioactive decay, aided by dispersion.

      An updated characterization of this tritium plume, including a computer simulation of future plume behavior, was prepared during FY 2005 to support a March 31, 2005 interim deliverable associated with Tri-Party Agreement Milestone M-016-83 (PNNL-15293). The computer simulation revealed that tritium concentrations at downgradient receptor locations, e.g., Energy Northwest water supply wells MW-31 and MW-32, and the Columbia River would not exceed the drinking water standard in the foreseeable future. A key assumption for this prediction is that sustained pumping from the water supply wells will not occur; if it does, the downgradient migration rate for the plume would accelerate, and concentrations at those wells would be higher than predicted.

The largest effect on the level of uranium contamination in the aquifer is from natural attenuation, because of dispersion via groundwater flow, and a reduction in the rate of uranium recharge from the vadose zone.

- **618-10 Burial Ground and 316-4 Cribs**: Uranium near the 316-4 cribs increased during late 2004, with the highest result (42 µg/L) exceeding the drinking water standard (30 µg/L). The cause for this trend is not known, although excavation activities may be a factor. Following the peak value, subsequent monitoring shows reduced concentrations similar to the long-term trend at the waste site, i.e., lower than the drinking water standard. Most volatile organic compounds at the 316-4 cribs remain undetected in groundwater, with the exception of tributyl phosphate, which has been detected during FY 2005 at relatively low concentrations (no drinking water standard has been established for this compound, which has limited mobility in the environment). Significant concentrations of tributyl phosphate and uranium are present in the vadose zone beneath the waste site, as revealed by sampling during excavation activities in fall 2004 and early 2005.

Uranium concentrations remain above the drinking water standard (30 µg/L) at several riverbank spring locations of the 300 Area.

2. Objective: Confirm that contaminant concentrations in the river seeps do not exceed ambient water-quality criteria or established remediation goals (drinking water standards).

   - During FY 2005, expanded monitoring along the 300 Area shoreline continued, with samples being collected from riverbank springs, near-shore river flow, and shallow aquifer tubes at the shoreline. Uranium concentrations remain above the drinking water standard (30 µg/L) at several locations along the shoreline where the core of the groundwater plume meets the river. The gross alpha concentration associated with this uranium also exceeds the drinking water standard (15 pCi/L). Concentrations are exceeded in samples from riverbank springs and aquifer tubes, but not in near-shore river water samples. Volatile organic compounds, such as trichloroethene and cis-1,2-dichloroethene, are generally not detected, although one spring sample and several aquifer tube samples revealed very low levels of trichloroethene during FY 2005 (1.4 and <2 µg/L, respectively). Cis-1,2-dichloroethene was not detected in spring and tube samples. (Note: The cis-1,2-dichloroethene contamination detected in the lower part of the unconfined aquifer [see discussion in Section 2.12.1.2] would not likely be revealed in samples from riverbank springs or existing aquifer tubes.) Nitrate concentrations in shoreline samples from the southern portion of the 300 Area (Figure 2.12-15) occasionally reach and exceed the drinking water standard (45 mg/L). The primary source for this nitrate is agricultural activity to the southwest of the 300 Area.
   - Groundwater contamination associated with the outlying waste sites (i.e., 618-11 burial ground, 618-10 burial ground, and 316-4 cribs) has not been identified in riverbank springs.

3. Objective: Validate contaminant fate and transport conceptual models.

   - **300 Area**: During FY 2005, monitoring was enhanced to provide more field observations that can be used to validate computer simulations for groundwater flow and contaminant transport. A new well (well 699-S20-E10) was installed in the northwest corner of the 300 Area to provide boundary conditions for the three-dimensional model. Hourly water-level measurements are being collected in numerous 300 Area wells to calibrate the flow model. More frequent measurements of uranium and other water quality parameters are being made at sites along the shoreline to better characterize the variability in contaminant concentrations brought on by the Columbia River stage influence.

     A limited field investigation, which involves (a) collecting continuous core throughout the vadose zone and uppermost aquifer and (b) mapping uranium in the capillary fringe zone near the water table throughout the 300 Area, has been planned to provide more detailed information that can be used in simulation models for uranium (see Section 2.12.2.3).

More frequent measurements of uranium and other water quality parameters are being made at sites along the 300 Area shoreline to better characterize the variability in contaminant concentrations brought on by the Columbia River stage influence.

- **618-11 Burial Ground**: Quarterly groundwater sampling is being used to monitor the tritium plume in this region. The quarterly data will also be used to verify the conditions predicted by a recent computer simulation of that plume (PNNL-15293).

2.12.2.3 Remedial Investigation/Phase III Feasibility Study

Numerous activities were initiated during FY 2004 and continued during FY 2005 to provide updated information on contamination in the subsurface at the 300 Area and outlying waste sites. These activities are part of extending the scope of the original remedial investigation and feasibility study to provide more information on what controls the persistence of the 300 Area uranium plume, how contaminant levels have changed during the 10 years since the original record of decision (ROD 1996b), and remedial action alternatives for addressing uranium contamination levels. A work plan describing the additional activities associated with the Phase III feasibility study is provided in DOE/RL-2005-41. Key aspects of FY 2005 activities included laboratory experiments associated with the geochemistry of uranium in 300 Area sediment, three-dimensional computer simulation of groundwater flow and uranium transport for the 300 Area, and planning a limited field investigation that is focused on uranium in the vadose zone. In addition, work was conducted, under other programs, that directly contributes to a better understanding of the subsurface characteristics at the 300 Area including estimating uncertainty in computer simulations of groundwater flow and transport (Meyer et al. 2004) and research along the 300 Area shoreline involving the zone of groundwater/river interaction (hyporheic zone).

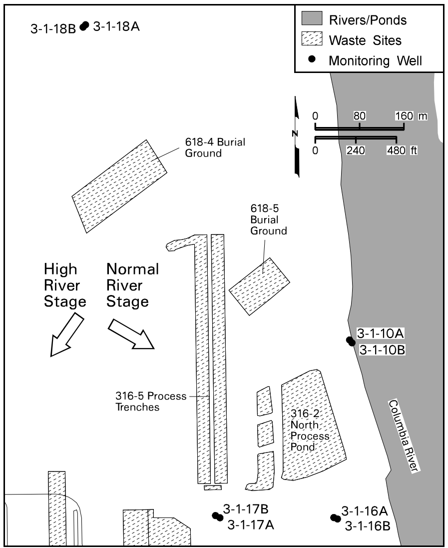
Key aspects of the Phase III feasibility study during FY 2005 included laboratory experiments of uranium geochemistry, three-dimensional computer modeling of groundwater flow and uranium mobility, and planning a limited field investigation.

Reports that have become available during FY 2005 on various topics involving the 300-FF-5 Operable Unit include:

- Evaluation of trends in contaminants of potential concern: PNNL-15127, Section 2.0.
- Updates to conceptual site models: Updated descriptions were prepared for uranium contamination in the 300 Area and tritium contamination in the 618-11 burial ground (PNNL-15127, Sections 3.0 and 4.0, respectively).
- Compilation and summary of research results involving the geochemistry of uranium in the 300 Area: PNNL-15121.
- Two-dimensional simulation of groundwater flow and uranium transport in the vadose zone-aquifer-river system: PNNL-15125.
- Conceptual site model and computer simulation of the tritium plume associated with the 618-11 burial ground: PNNL-15293.

A limited field investigation will get underway in early 2006 that involves drilling four characterization boreholes (to be completed as monitoring wells) and fifteen temporary borings (direct-push) for geophysical logging in the 300 Area (DOE/RL-2005-47). Figure 2.12-19 shows the planned locations for the proposed direct-push and characterization boreholes. The characterization boreholes will include collecting continuous core throughout the vadose zone and into the aquifer (and throughout the entire uppermost aquifer at two of the locations). Geophysical logging in these boreholes will be compared to laboratory results for analyses on core samples to provide calibration data for using spectral gamma logging in the fifteen temporary boreholes. The objectives for the two types of drilling are (a) define in detail the characteristics of uranium in the vadose zone at four representative locations to help design treatability tests and (b) map the distribution of uranium in the vadose zone throughout the area of contamination.

2.12.3 Facility Monitoring — 316-5 Process Trenches



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This section describes results of monitoring groundwater at the former 316-5 process trenches, a RCRA treatment, storage, or disposal unit in the Hanford Facility RCRA Permit (Ecology 1994a). This facility is monitored under the requirements of RCRA for hazardous waste constituents and *Atomic Energy Act* for radionuclides. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for the facility. As discussed in Section 2.1, with respect to RCRA sites, the U.S. Department of Energy (DOE) has the sole and exclusive responsibility and authority to regulate source, special nuclear, and by-product materials at DOE-owned nuclear facilities.

The 316-5 process trenches received effluent discharges of dangerous mixed waste from fuel fabrication and nuclear research laboratories in the 300 Area from 1975 through 1994. The trenches were remediated in 1997 and 1998 by excavation and backfilling with clean soil. Groundwater monitoring at the 316-5 process trenches is conducted in accordance with Washington Administrative Code (WAC) 173-303-645(11), Corrective Action Program, and Part VI, Chapter 1 of the Hanford Facility RCRA Permit (Ecology 1994a). The modified closure plan (DOE/RL-93-73), which is incorporated into the Hanford Facility RCRA Permit, indicates that groundwater remediation is deferred to the CERCLA 300-FF-5 Operable Unit.

During FY 2005, RCRA groundwater monitoring at the 316-5 process trenches was operated under an existing plan (WHC-SD-EN-AP-185) that has been in effect since 1997. Appendix B lists groundwater monitoring wells and constituents monitored for the 316-5 process trenches. Constituents monitored under RCRA are uranium, cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene. (Note: Uranium is not regulated under RCRA but was included in the monitoring plan for completeness and incorporated by reference into the Hanford Facility RCRA Permit [Ecology 1994b].) The characteristics in the groundwater flow affected by discharges to the 316-5 process trenches are discussed in Section 2.12.1. The sampling frequency at the eight wells of the monitoring network is monthly for 8 months of the fiscal year (December, January, February, March, June, July, August, and September). This sampling schedule was designed to accommodate two semiannual sampling periods with four time-independent samples collected during each period. During FY 2005, the March 2005 samples were not collected from two wells (399-1-10A and 399-1-10B) because of well-access problems associated with surface remedial activities in the area. The March 2005 samples at those wells were sampled in April 2005. All other sampling events were accomplished as scheduled.

Two contaminants of concern, uranium and cis-1,2-dichloroethene, remain above drinking water standards downgradient of the former 316-5 process trenches.

Only two contaminants of concern for RCRA monitoring remain above the drinking water standard, uranium and cis-1,2-dichloroethene. Uranium concentrations in well 399-1-17A, the well nearest the process trenches, have decreased or remained relatively constant during recent years (Figure 2.12-9). Further downgradient along the flow path from the process trenches, concentrations increased, then decreased, suggesting the passage of higher concentrations created by high water-table conditions during high river stages of 1997 and 1998 (Figure 2.12-10).

Well 399-1-16B, a well installed at the base of the unconfined aquifer downgradient of the process trenches, is the only network well having reported levels of cis-1,2-dichloroethene above the drinking water standard (70 µg/L). The concentration appeared to be holding steady in recent years, neither significantly increasing nor decreasing in concentration, until FY 2005 when there was an overall increase in concentration (Figure 2.12-13). The most recent result from this well was 230 µg/L for a sample collected in September 2005. Other volatile organic compounds such as trichloroethene and tetrachloroethene continue to be detected in network wells at the 316-5 process trenches but at levels below their respective drinking water standards.

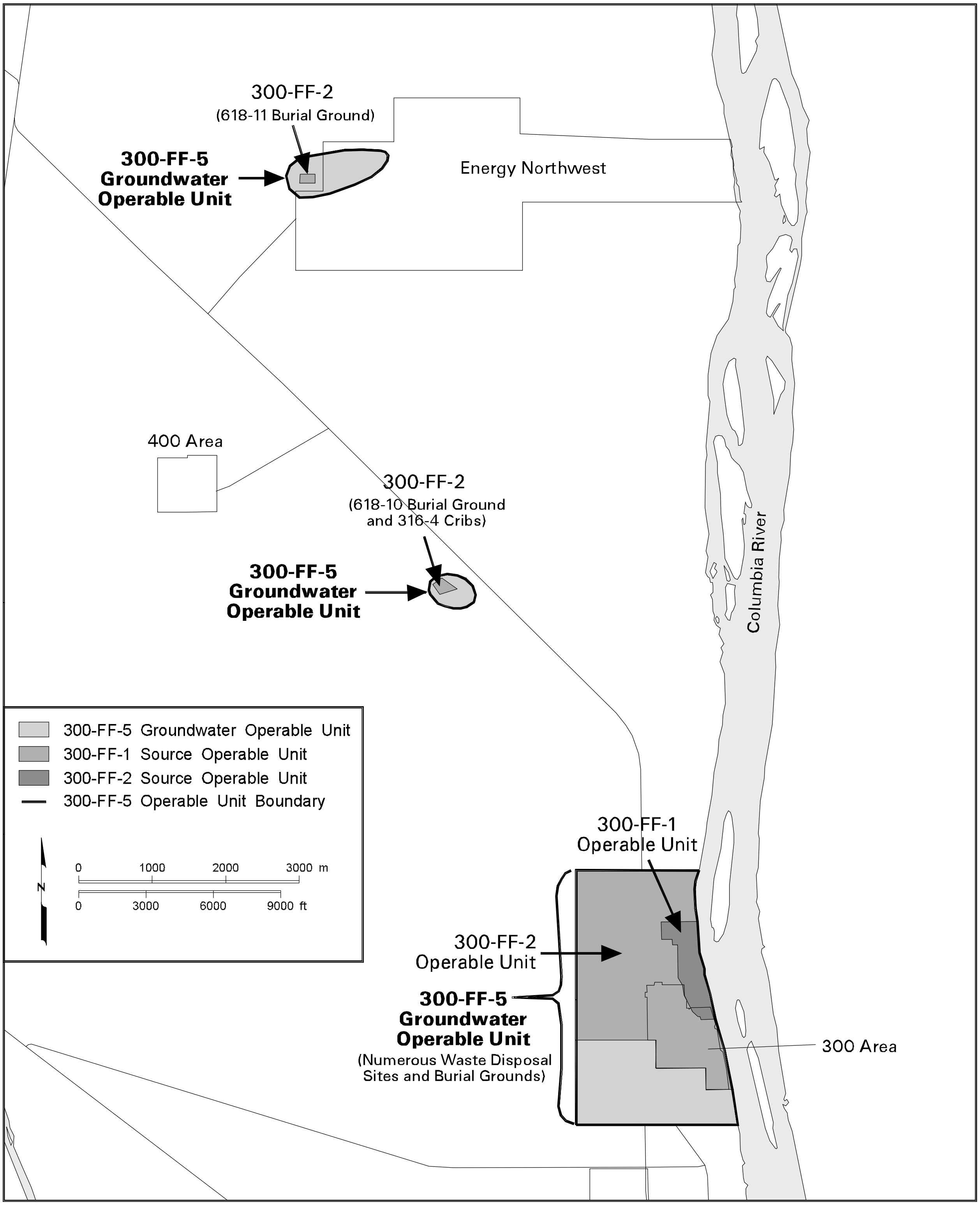

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Figure 2.12-1. Geographical Subdivisions of 300-FF-5 Operable Unit

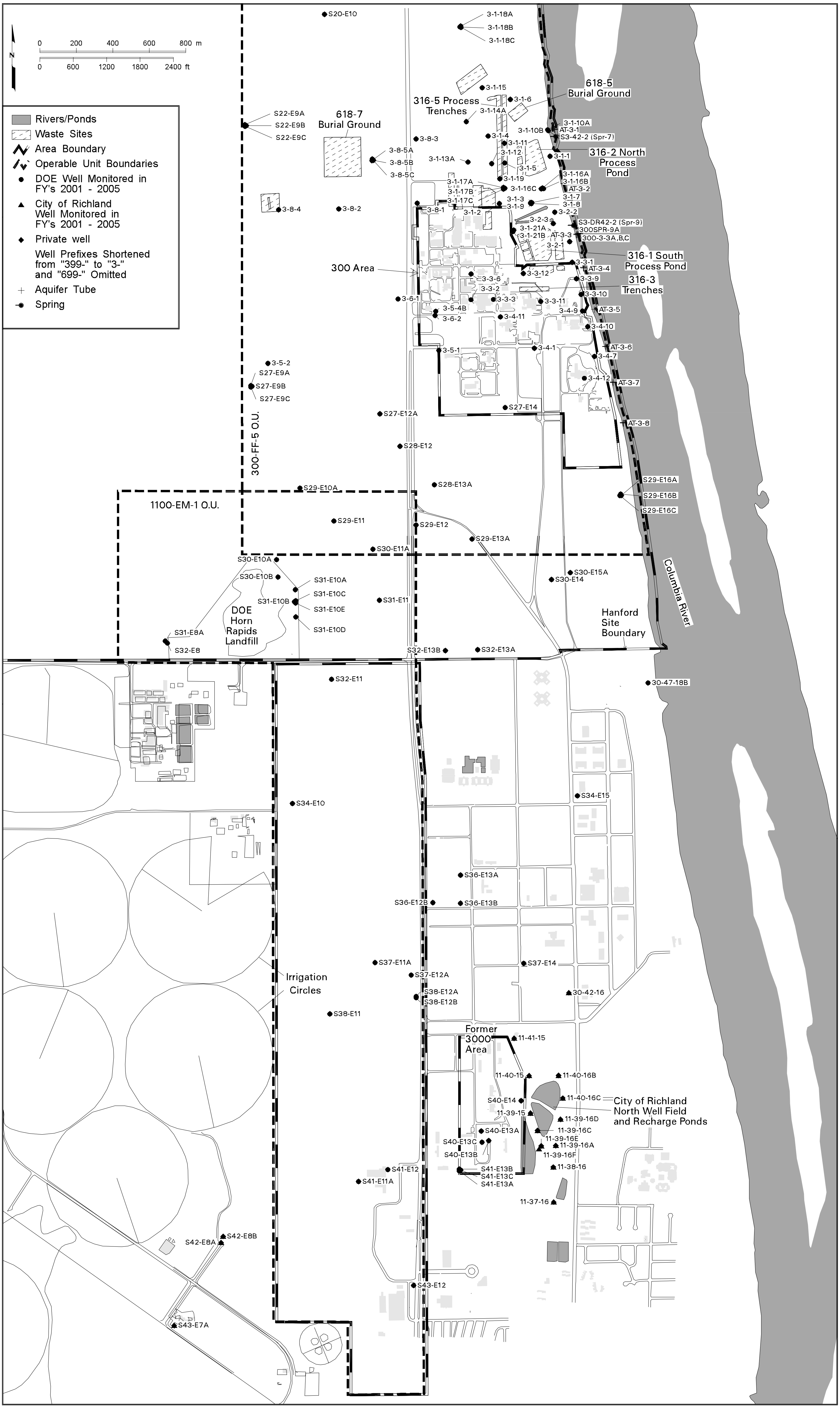

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Figure 2.12-2. Facilities and Groundwater Monitoring Wells in 300 and 1100-EM-1 Areas

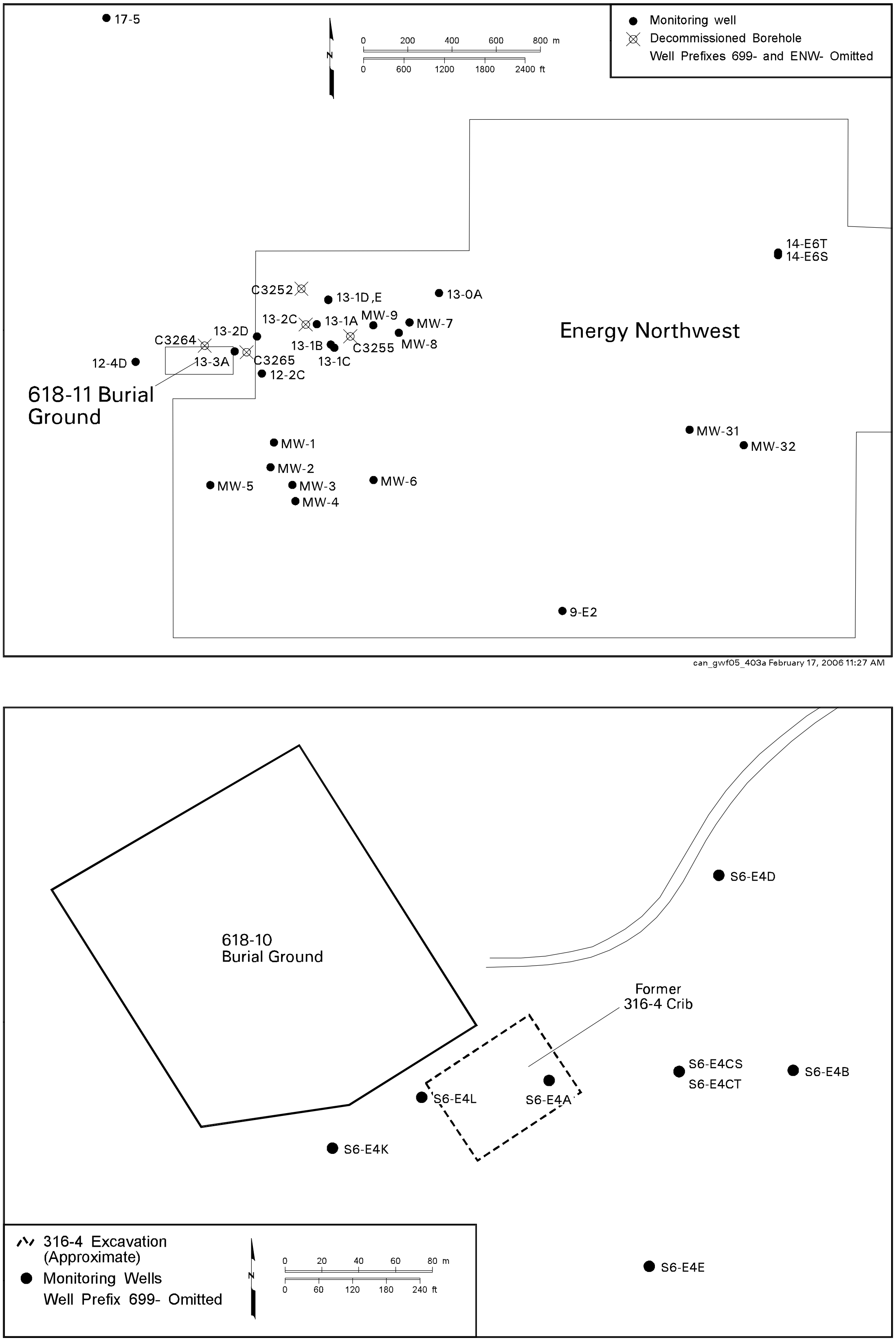

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Figure 2.12-3. Groundwater Monitoring Wells in 300-FF-5 North Subregion

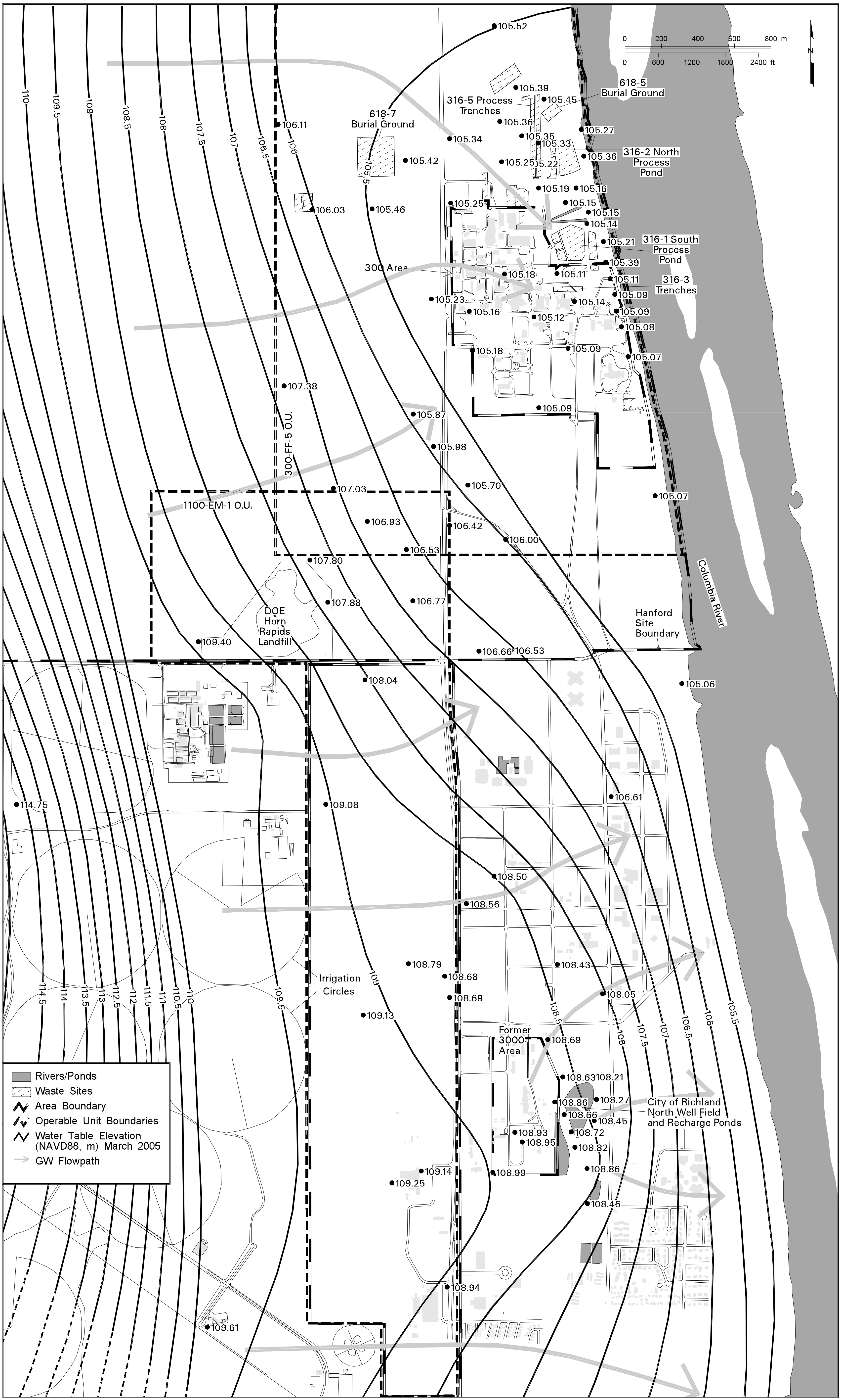

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Figure 2.12-4. Water-Table Map for 300 and 1100-EM-1 Areas, March 2005

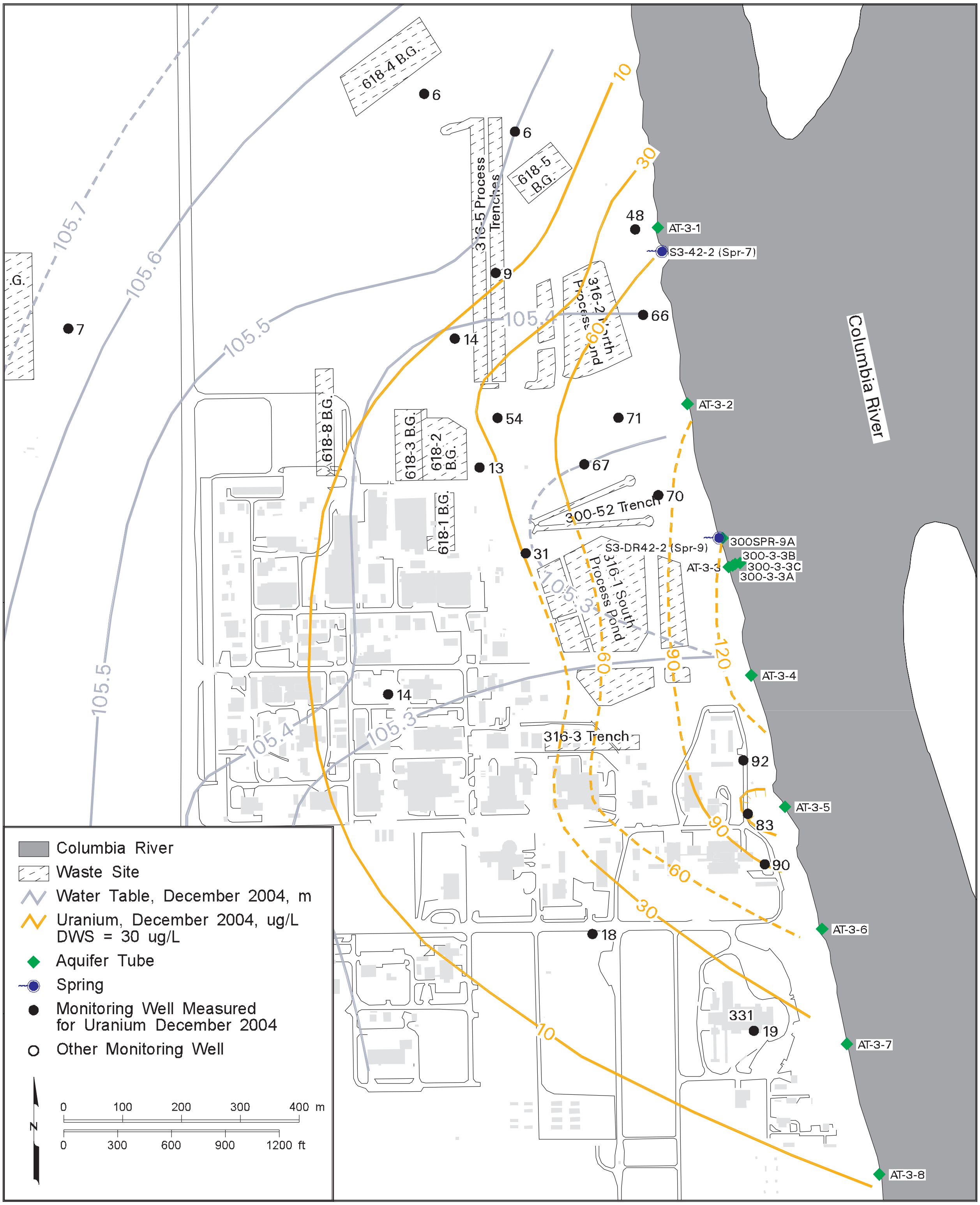

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Figure 2.12-5. Uranium Concentrations at Wells in 300 Area, December 2004, Top of Unconfined Aquifer

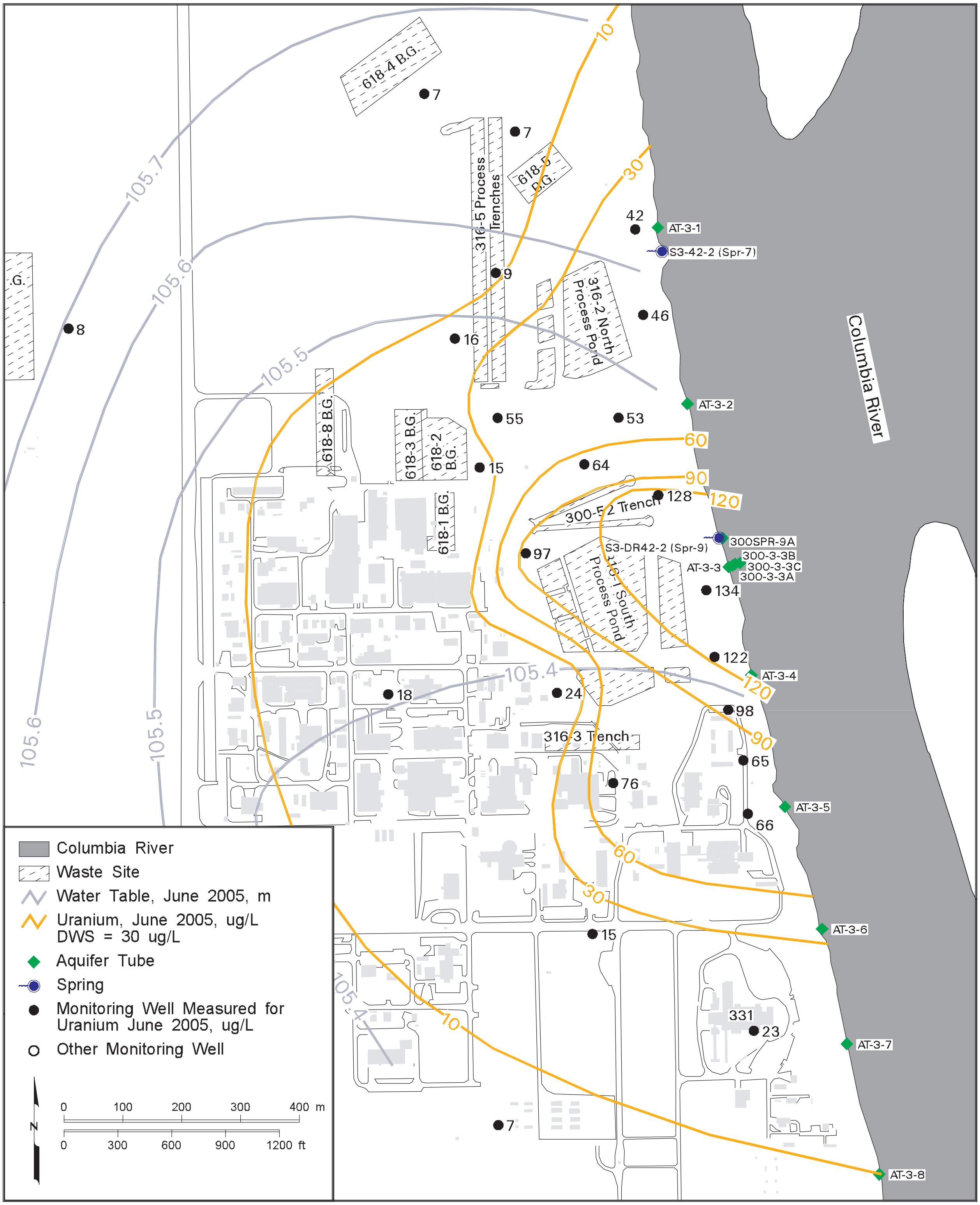

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Figure 2.12-6. Uranium Concentrations at Wells in 300 Area, June 2005, Top of Unconfined Aquifer

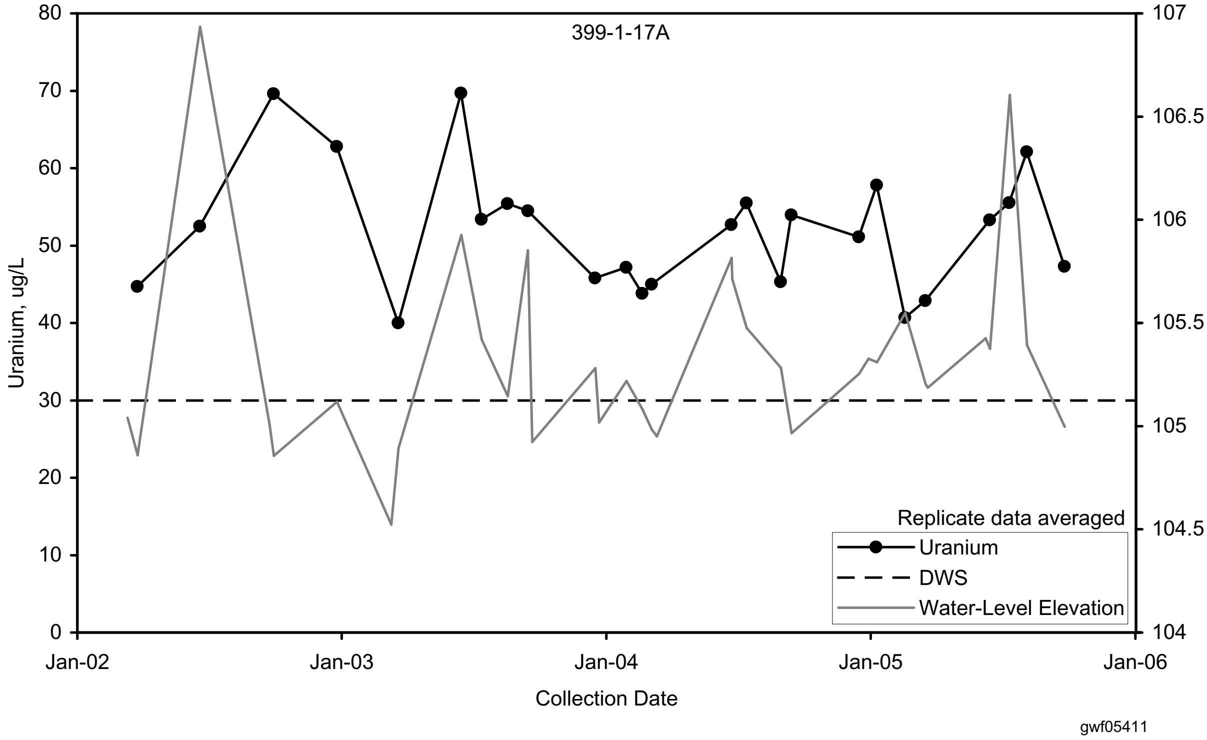

Figure 2.12-7. Correlation Between Uranium Concentrations and Water-Table Elevation at Inland Well. A raised water table remobilizes uranium held in the lower vadose zone.

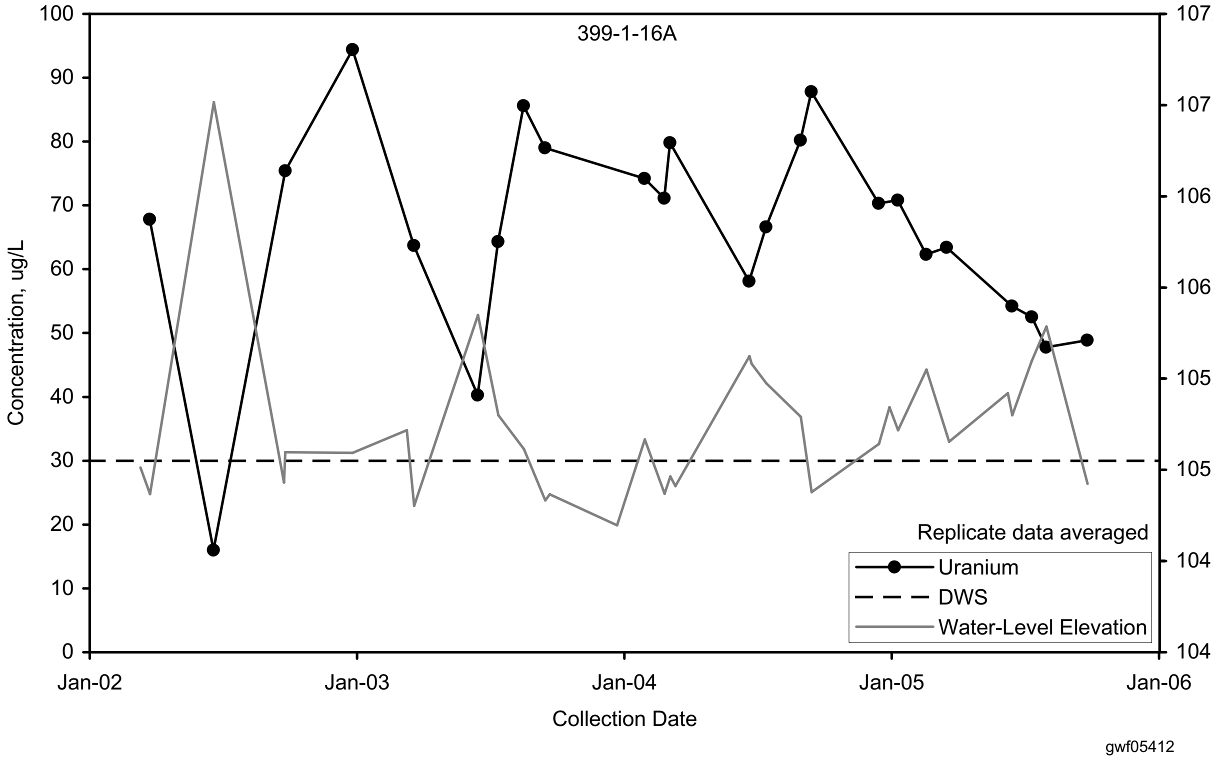

Figure 2.12-8. Correlation Between Uranium Concentrations and Water-Table Elevation at Well Close to Columbia River. Infiltrating river water reduces contaminant levels by dilution.

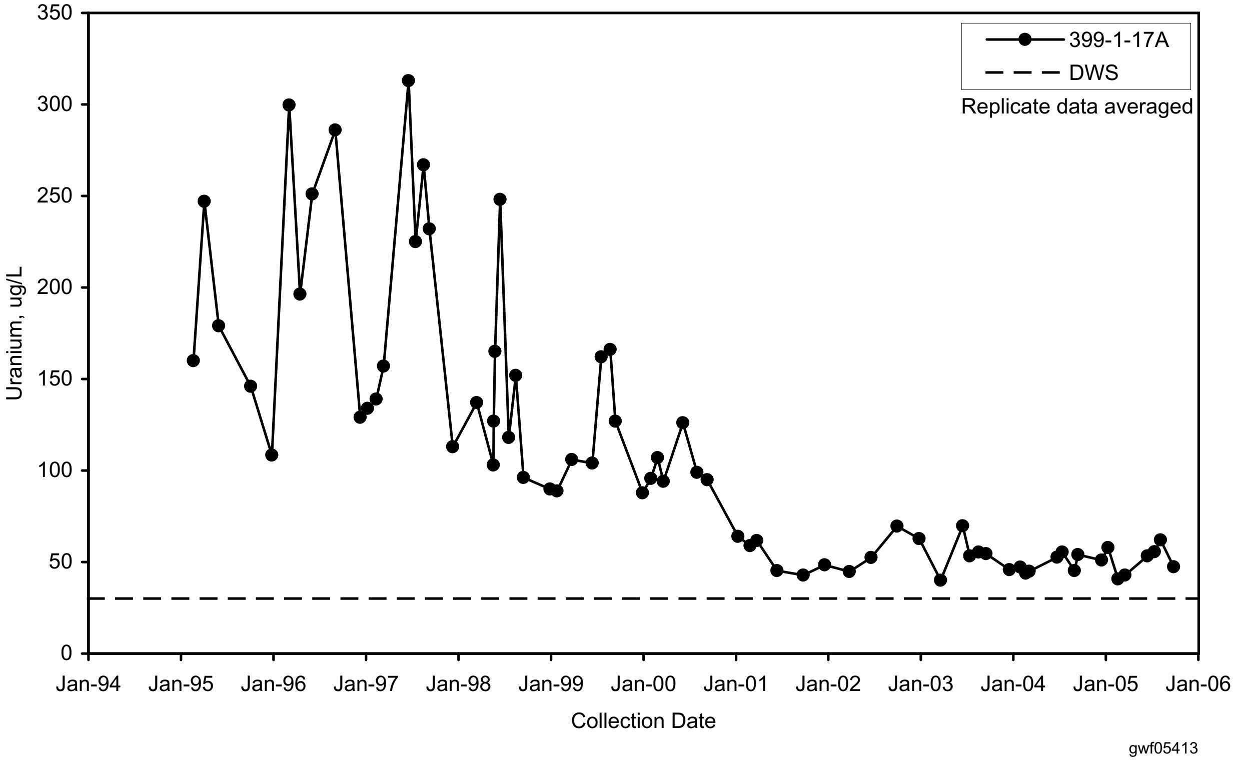

Figure 2.12-9. Uranium Concentrations in Well 399-1-17A Near the 316-5 Process Trenches

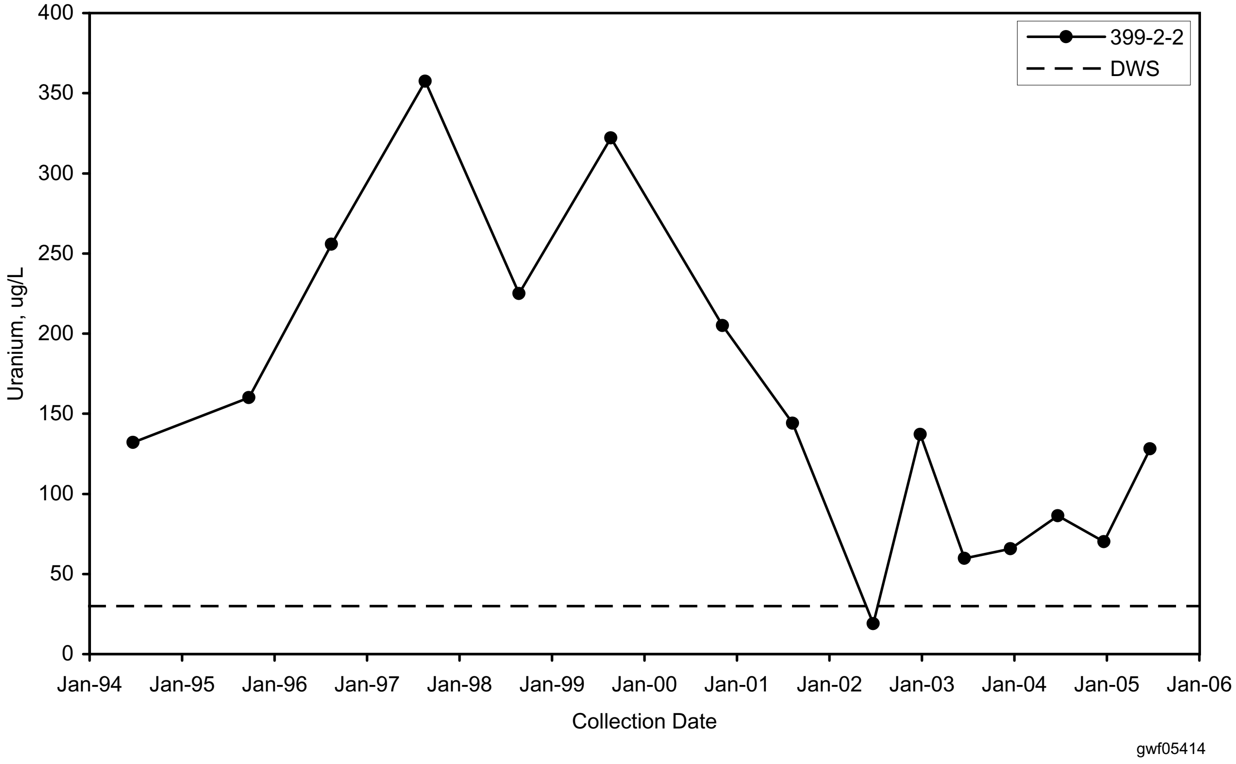

Figure 2.12-10. Uranium Concentrations in Well 399-2-2 in the 300 Area

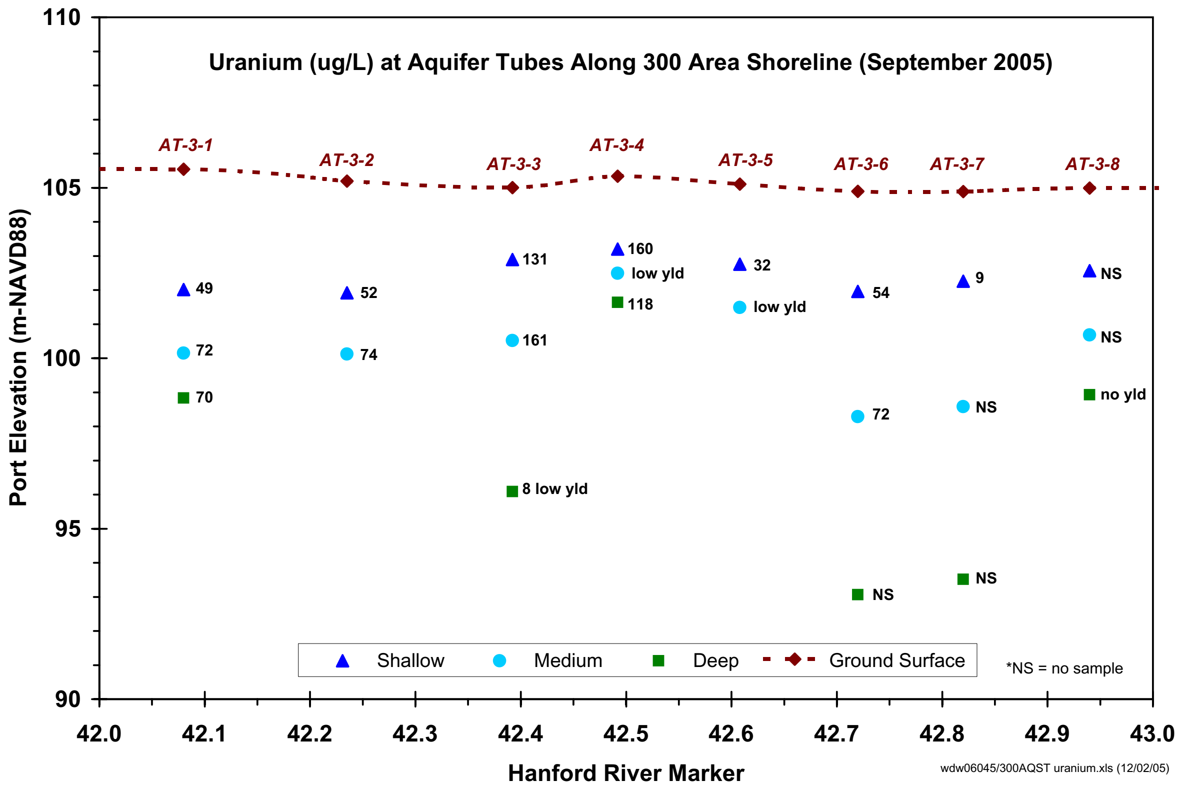

Figure 2.12-11. Uranium Concentrations (µg/L) at Aquifer Tubes Along 300 Area Shoreline (September 2005)

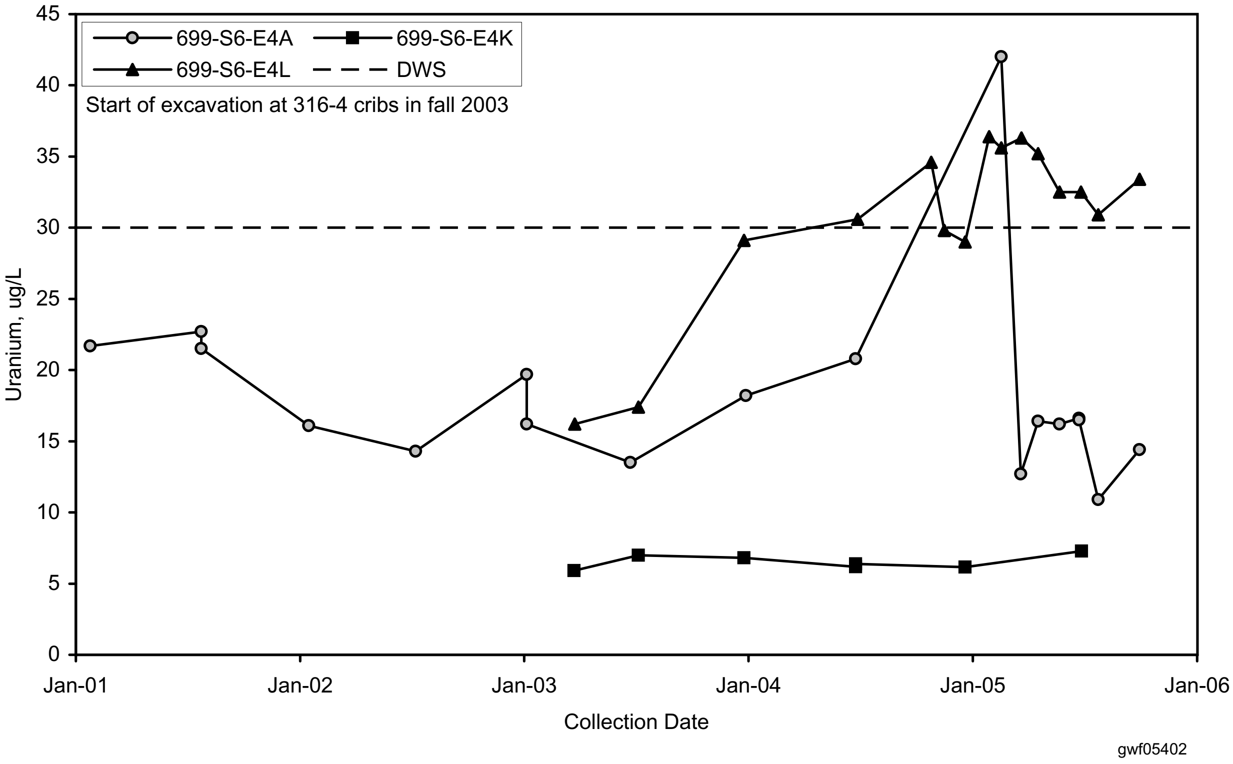

Figure 2.12-12. Uranium Concentrations at Selected Wells Near the 316-4 Cribs Remedial Action Site

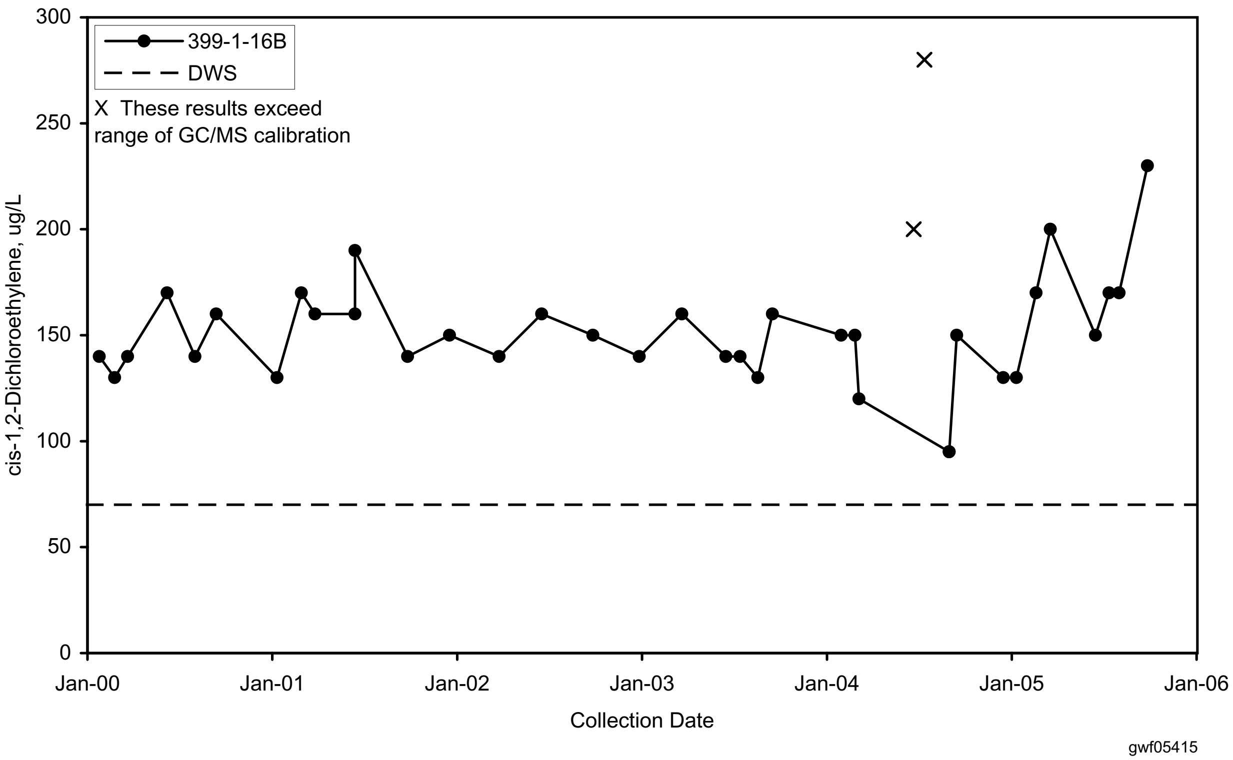

Figure 2.12-13. Concentrations of cis-1,2-Dichloroethene at Well 399-1-16B Near the 316-5 Process Trenches

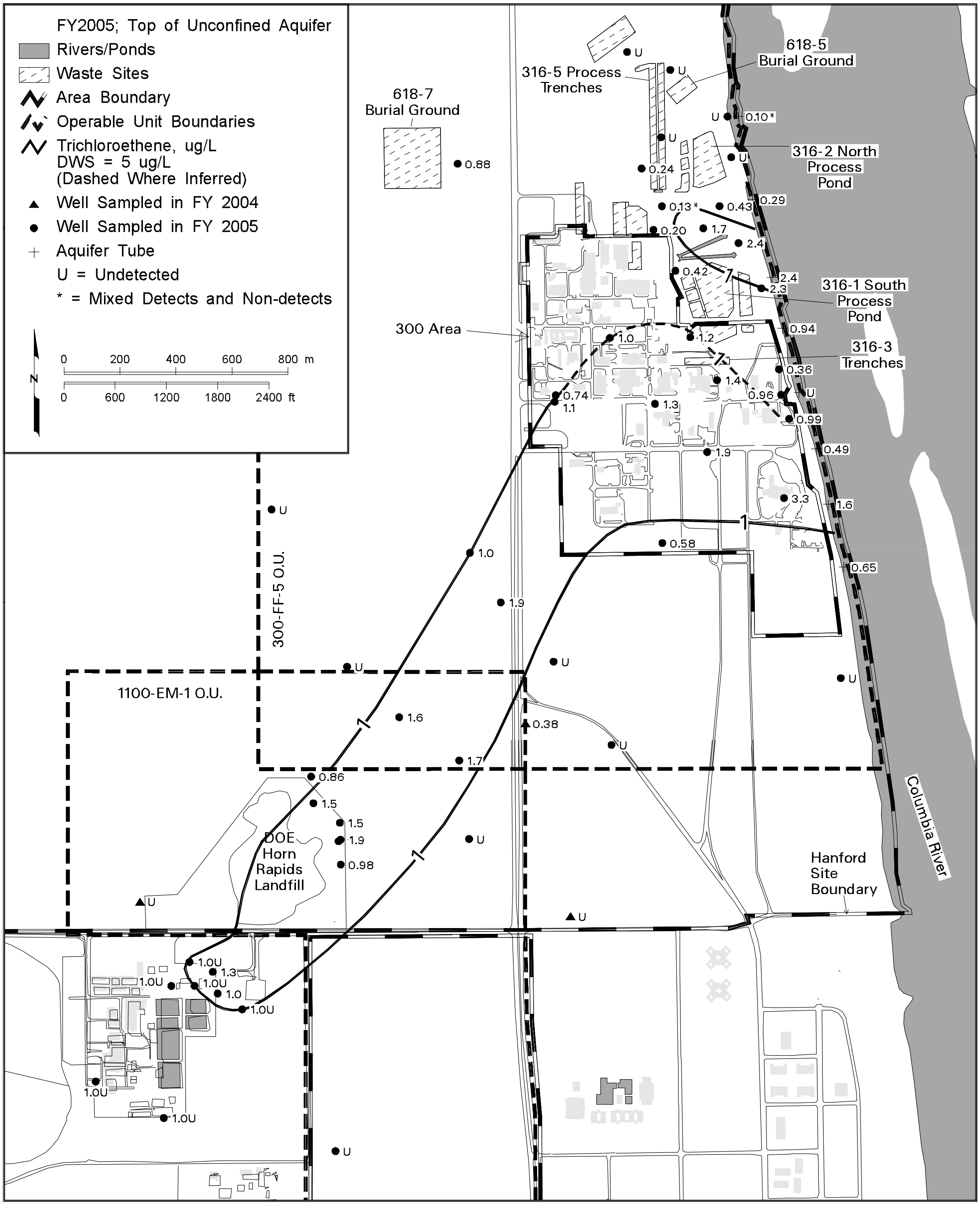

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Figure 2.12-14. Average Trichloroethene Concentrations in 300 and 1100-EM-1 Areas, Top of Unconfined Aquifer

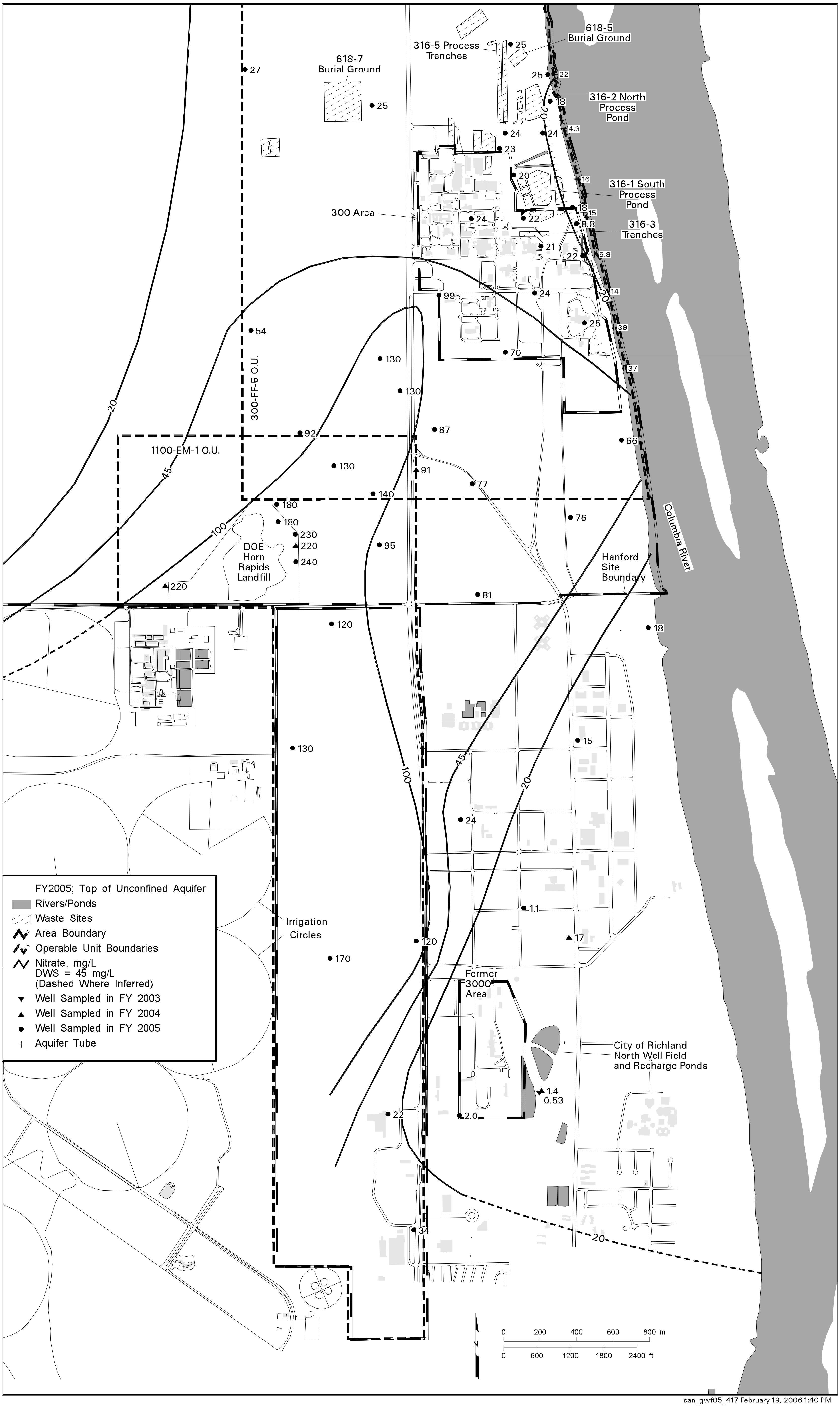

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Figure 2.12-15. Nitrate Concentrations in 300 and 1100-EM-1 Areas, Top of Unconfined Aquifer

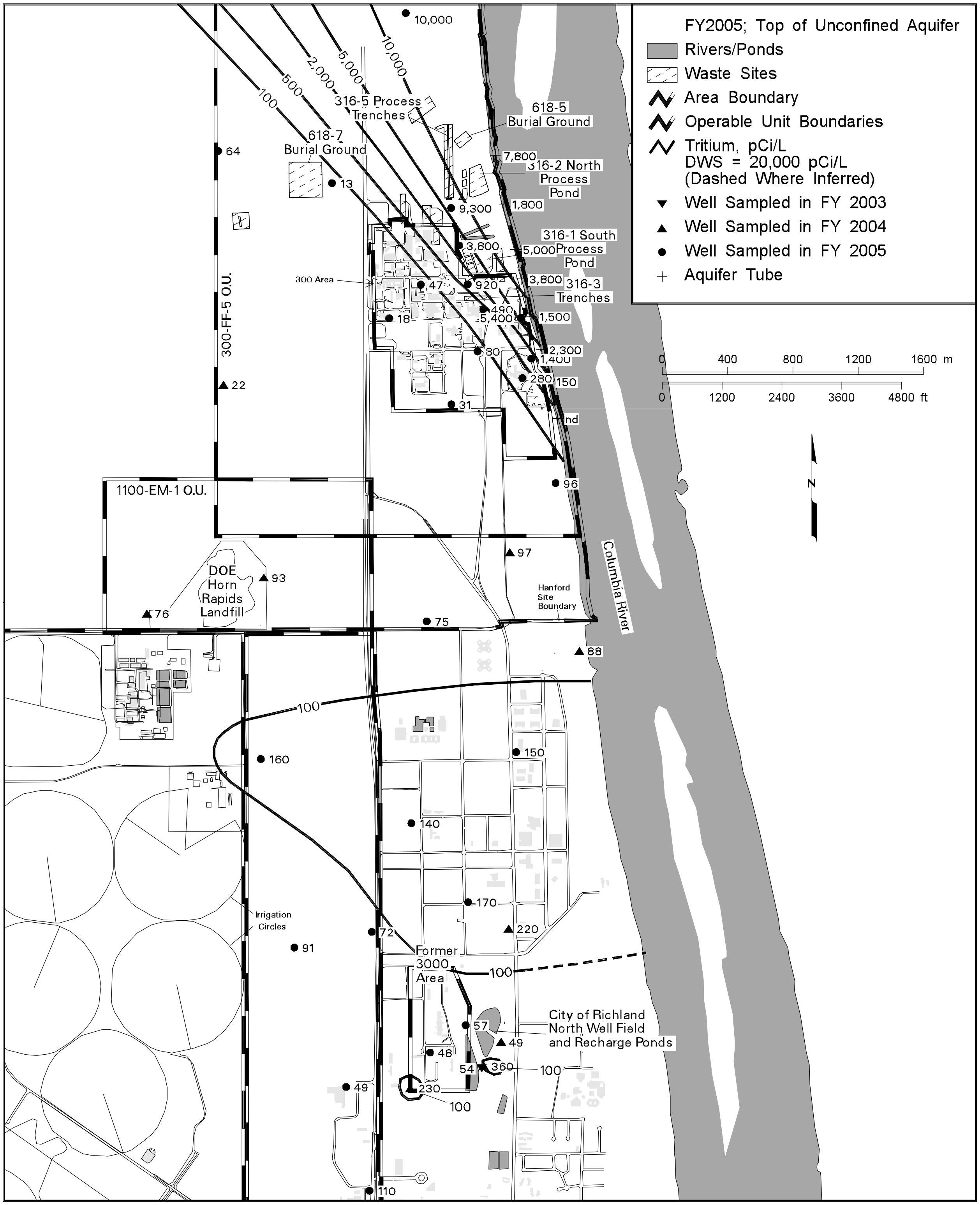

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Figure 2.12-16. Average Tritium Concentrations in Groundwater in 300 and 1100-EM-1 Areas, Top of Unconfined Aquifer

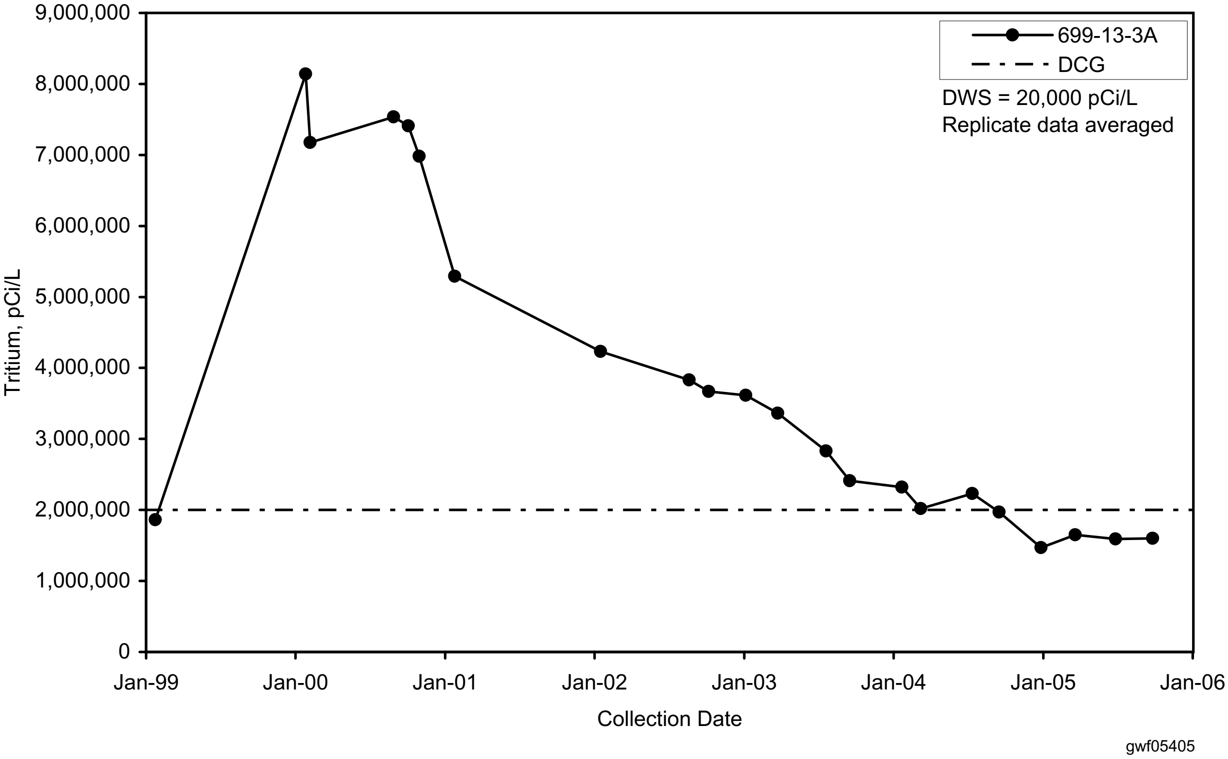

Figure 2.12-17. Tritium Concentrations at Well 699-13-3A Near 618-11 Burial Ground

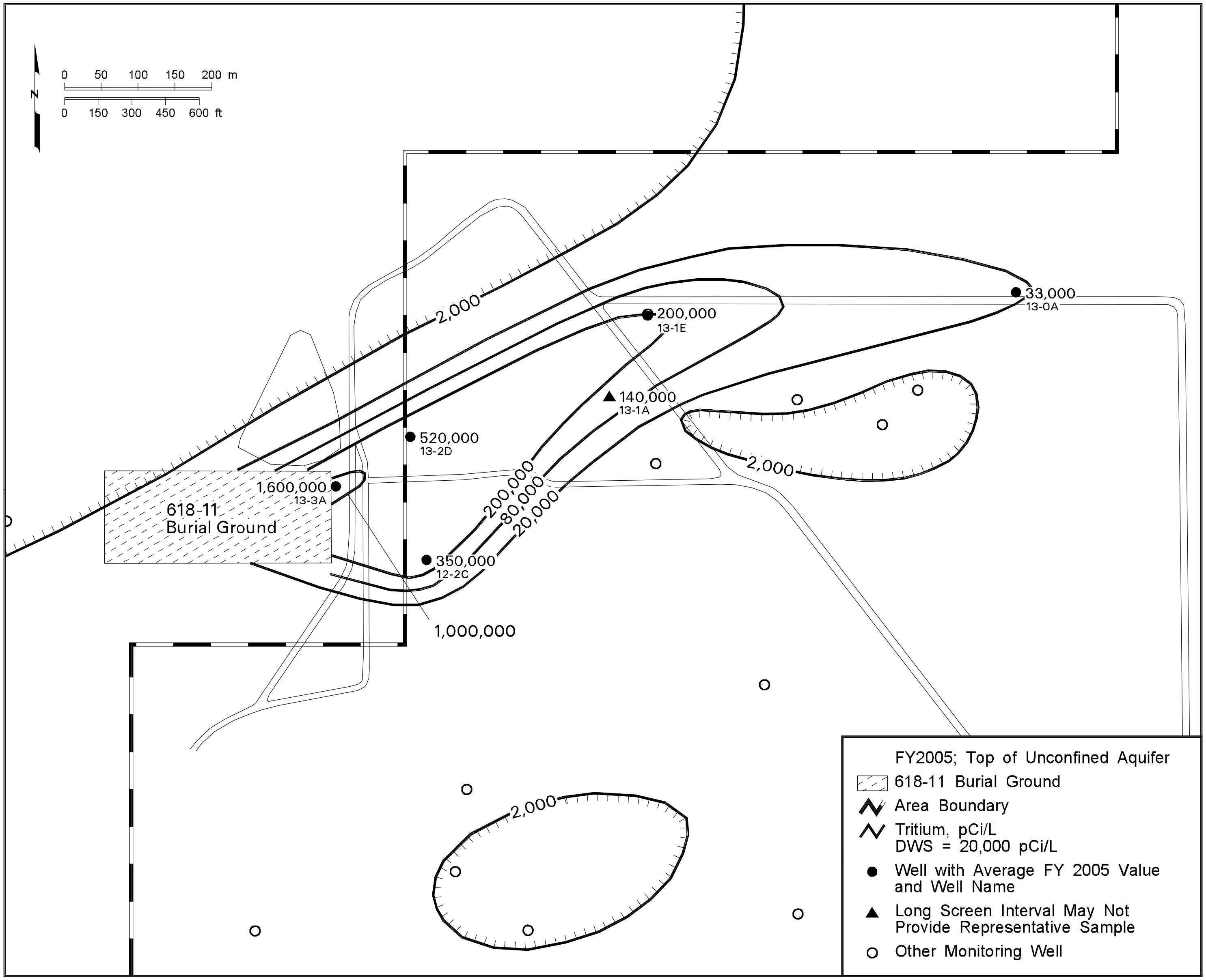

Figure 2.12-18. Tritium Concentrations in Plume from 618-11 Burial Ground, Top of Unconfined Aquifer

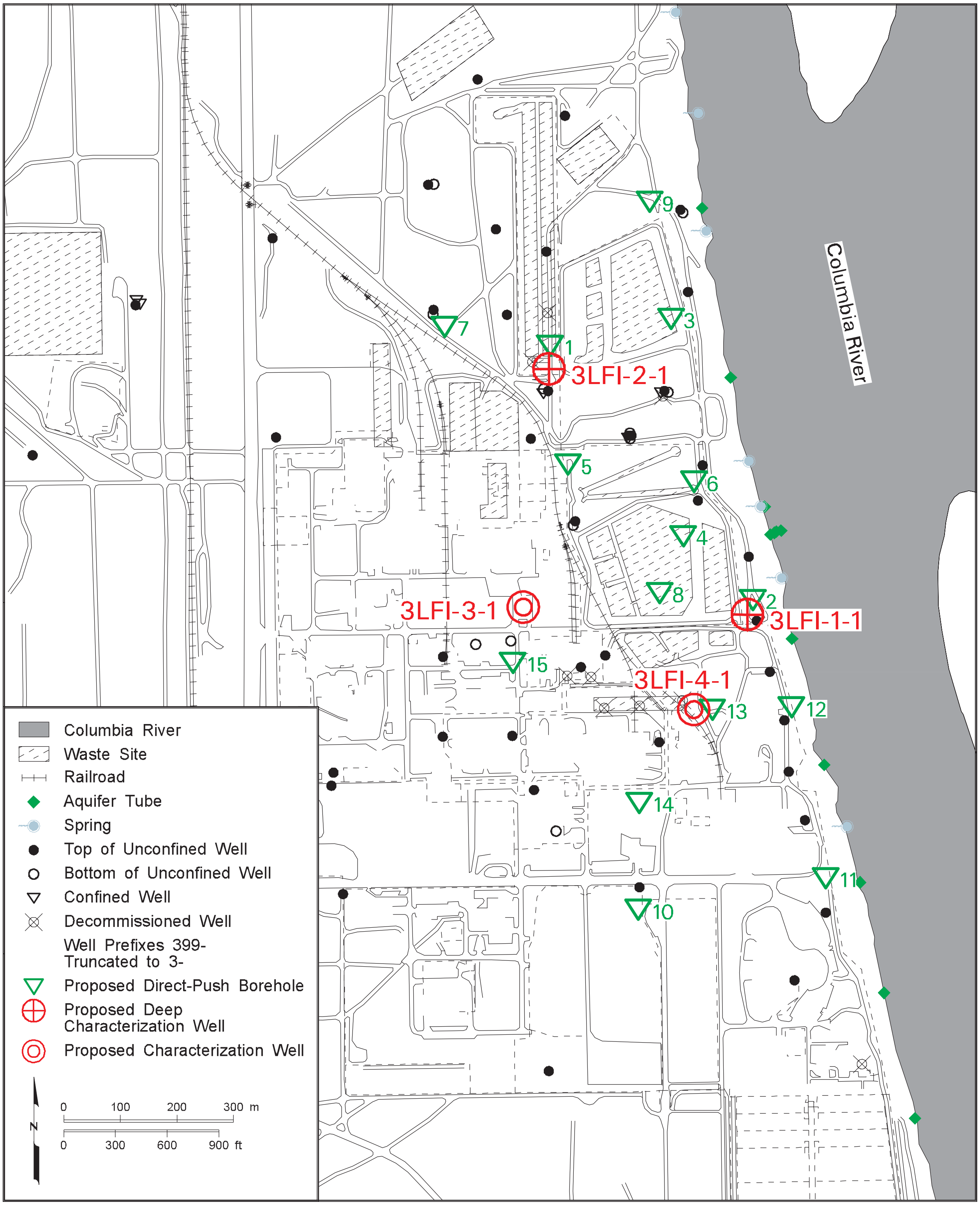

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Figure 2.12-19. Locations of Proposed Direct-Push Boreholes and Characterization Wells in the 300 Area for the 300-FF-5 Operable Unit (DOE/RL-2005-47)

2.13 1100-EM-1 Operable Unit

D. R. Newcomer

The scope of this section is the 1100-EM-1 groundwater interest area, which includes the 1100-EM-1 Operable Unit, a large south portion of the Hanford Site, and the offsite area to the south of the Hanford Site, including the areas formerly designated as the former 1100 and 3000 Areas of the Hanford Site (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) established the groundwater interest areas to aid planning, scheduling, and data interpretation. Figure 2.12-2 in Section 2.12 shows facilities, wells, and shoreline monitoring sites in this region. The focus of this section is the central and east portions of the 1100-EM-1 groundwater interest area near the south boundary of the Hanford Site. Trichloroethene and nitrate are the contaminants of greatest significance in groundwater. Groundwater is monitored to assess the performance of natural attenuation of volatile organic compounds. In addition to the trichloroethene plume, contaminants of concern include breakdown products of trichloroethene (vinyl chloride and 1,1-dichloroethene) and nitrate.

Nitrate and trichloroethene are the contaminants of greatest significance in groundwater at the 1100-EM-1 Operable Unit.

Figure 2.12-4, in Section 2.12, shows the March 2005 water-table elevations and corresponding groundwater flow directions for the east portion of the 1100-EM-1 groundwater interest area. Groundwater in the 1100-EM-1 groundwater interest area generally flows eastward from the Yakima River (see Figure 2.1-3 in Section 2.1) and discharges to the Columbia River. In the northeast part of the 1100-EM-1 groundwater interest area, groundwater flows northeast and converges with groundwater entering the 300 Area before discharging to the Columbia River. In the east-central part of the 1100-EM-1 groundwater interest area, groundwater flow from the west is diverted to the northeast and southeast around a recharge mound created by the city of Richland's North Richland Well Field before discharging to the Columbia River. Agricultural irrigation supplied primarily by the Columbia River recharges the unconfined aquifer between the Yakima and Columbia Rivers.

2.13.1 Groundwater Contaminants

This section describes the distribution of groundwater contaminants in the 1100-EM-1 groundwater interest area. Groundwater contaminants discussed are chlorinated hydrocarbons (primarily trichloroethene), tritium, nitrate, uranium, ammonia, and fluoride.

2.13.1.1 Chlorinated Hydrocarbons

Trichloroethene contamination occurs in the 1100-EM-1 groundwater interest area beneath the U.S. Department of Energy's (DOE's) inactive Horn Rapids Landfill and offsite

Groundwater monitoring in the 1100-EM-1 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring

- *Fourteen compliance wells are sampled annually for trichloroethene, breakdown products, and nitrate.*
- *One well is sampled annually for filtered chromium.*
- *In FY 2005, all 1100-EM-1 monitoring wells were sampled as scheduled (see Appendix A).*

AEA Monitoring

- *Approximately forty wells are sampled annually and semiannually for tritium, volatile organic compounds, nitrate, and general chemistry.*
- *A few isolated wells are sampled annually for uranium, gross alpha, gross beta, technetium-99, and ammonia.*

in AREVA wells (see Figure 2.12-14 in Section 2.12). The distribution of trichloroethene in the upper part of the unconfined aquifer shows that the plume has an elongated configuration. This configuration indicates a northeast flow direction toward the 300 Area. The thickness of the unconfined aquifer in this area is ~6 to 9 meters. The wells used for monitoring trichloroethene have screen intervals that penetrate the upper ~4.5 to 8.5 meters of the unconfined aquifer. One well monitors the lower ~5 meters of the unconfined aquifer.

Quarterly trichloroethene sample concentrations continued to be <5 µg/L in all AREVA wells during the first quarter of fiscal year (FY) 2005 (E06-01-20044Q). AREVA data for the second, third, and fourth quarters of FY 2005 were not published by the time this report was published. The maximum trichloroethene concentration during first quarter was 1.3 µg/L immediately downgradient of the process lagoons. The past use of solvent to install and maintain process lagoon liners at AREVA is the only potential source of trichloroethene identified in the eastern portion of the 1100-EM-1 groundwater interest area (DOE/RL-92-67).

Trichloroethene concentrations have decreased in all plume areas near DOE's Horn Rapids Landfill.

Trichloroethene concentrations have decreased in all the plume areas near DOE's Horn Rapids Landfill. Trichloroethene concentrations decreased by an order of magnitude in this area since monitoring began in 1990 (Figure 2.13-1). In FY 2005, trichloroethene concentrations were all <5 µg/L, ranging from less than detection to 1.9 µg/L downgradient of the landfill. The decreased concentrations in the majority of wells downgradient of DOE's Horn Rapids Landfill suggest that some elements of natural attenuation (e.g., volatilization, passive pumping) may have reduced the plume mass. For a discussion of trichloroethene in the 300 Area, see Section 2.12.1.2.

Potential breakdown products of trichloroethene, including vinyl chloride and 1,1-dichloroethene, continued to show levels less than their respective minimum detection limits during FY 2005.

The city of Richland monitors groundwater in the upper unconfined aquifer quarterly for chemical constituents at their Horn Rapids Sanitary Landfill (formerly Richland Landfill). The landfill is located in the central portion of the 1100-EM-1 groundwater interest area adjacent to the southern boundary of the Hanford Site (refer to Figure 2.1-2 in Section 2.1 for location). Chlorinated hydrocarbons were detected in city landfill monitoring wells between ~1 and 1.5 kilometers south of the Hanford Site boundary at levels above their respective drinking water standards during FY 2005 (City of Richland 2005a, 2005b). The highest concentrations during FY 2005 were 26.5 µg/L 1,1-dichloroethane, 71.3 µg/L cis-1,2-dichloroethene, 66.8 µg/L tetrachloroethene, and 29.3 µg/L trichloroethene. During FY 2005, these constituents were below their respective minimum detection limits at onsite well 699-S31-1 just northeast of the city's sanitary landfill.

Plume areas (square kilometers) above the drinking water standard at the 1100-EM-1 Operable Unit:

****Nitrate — 4.23***

****Also includes portion of plume beneath 300-FF-5 Operable Unit.***

A confined aquifer in the Ringold Formation is monitored for trichloroethene downgradient of the inactive DOE Horn Rapids Landfill. This confined aquifer lies below a clayey silt aquitard, but above the basalt surface, at a depth of ~18 to 21 meters below the water table. Trichloroethene has not been detected in this confined aquifer since monitoring began in 1991, which suggests that the trichloroethene plume in the unconfined aquifer did not migrate downward into the underlying confined aquifer.

2.13.1.2 Tritium

The 200 Area tritium plume extends southward toward the 1100-EM-1 groundwater interest area at levels below 2,000 pCi/L. Tritium continues to be closely monitored because of its potential to the city of Richland's North Well Field (see Figure 2.12-16 in Section 2.12). South of the 300 Area, tritium levels were slightly elevated above background in wells west and north of the city of Richland's North Well Field during FY 2005. The background geometric mean tritium concentration in the upper part of the unconfined aquifer was determined to be 63.9 pCi/L (DOE/RL-96-61). The average tritium concentration from monthly Columbia River samples collected at the Richland Pumphouse was 39.6 pCi/L for the first 11 months of FY 2005. However, these levels are far below the drinking water standard (20,000 pCi/L). Trends in tritium concentrations in wells west and south of the city of Richland's North Well Field have consistently shown fluctuating levels in the last few years, as shown in Figure 2.13-2.

Monitoring data show that the Richland North Well Field is not contaminated by the Hanford Site tritium plume through the groundwater flow system.

Tritium is not migrating in groundwater from the 200 Areas tritium plume to the city of Richland well field. Factors limit the migration of the tritium plume into the east portion of the 1100-EM-1 groundwater interest area:

- Groundwater generally flows from west to east between the Yakima River and the Columbia River.
- Artificial recharge from agricultural irrigation in the west and central portions of the 1100-EM-1 groundwater interest area south of the Hanford Site contributes to the eastward flow.
- Groundwater flow is directed outward from the elevated groundwater levels at the city of Richland's North Well Field because of ponds used to recharge the well field.

These factors produce converging flow lines in the 300 Area and discharge to the Columbia River (see Figure 2.12-4 in Section 2.12). Figure 2.12-16 in Section 2.12 shows a region of low tritium concentrations between the 200 Areas tritium plume and the slightly elevated tritium concentrations near the North Richland Well Field and recharge ponds. Thus, no indication exists that the tritium plume is migrating southward and affecting the well field. Tritium in groundwater in the 300 Area is discussed in Section 2.12.

2.13.1.3 Nitrate

The nitrate distribution in the east portion of the 1100-EM-1 groundwater interest area is shown in Figure 2.12-15 in Section 2.12. Nitrate contamination in this area is likely the result of industrial and agricultural uses off the Hanford Site. Agricultural uses include application of fertilizers onto irrigation circles in the central portion of the 1100-EM-1 groundwater interest area (see Figure 2.12-2 in Section 2.12).

Nitrate contamination in groundwater is the result of industrial and agricultural uses off the Hanford Site.

Nitrate concentrations above the drinking water standard (45 mg/L) are found over much of the east portion of the 1100-EM-1 groundwater interest area and continued to increase in a number of wells in FY 2005 (Figure 2.13-3). Some of the highest nitrate levels occur near an offsite facility (AREVA) and DOE's inactive Horn Rapids Landfill. Elevated nitrate near these areas is likely the result of agricultural activities to the west and southwest. The highest nitrate concentration in this area was 277 mg/L upgradient of the AREVA facility at well SPC-GM-2. Nitrate data for the offsite wells are reported in E06-01-20044Q. Another potential source of nitrate is the ConAgra (Lamb Weston) facility located southwest of the 1100-EM-1 groundwater interest area.

Nitrate concentrations continued to be elevated in wells downgradient of DOE's inactive Horn Rapids Landfill in FY 2005. The highest nitrate concentration was 239 mg/L at well 699-S31-E10D. An example of elevated nitrate concentrations showing an increasing trend occurs immediately downgradient of the landfill (Figure 2.13-3). The shape of the nitrate plume (as defined by the 100-mg/L contour) near the AREVA facility and DOE's inactive Horn Rapids Landfill indicates that nitrate in these areas continues to migrate in a northeast direction toward the 300 Area. Groundwater and aquifer tube sample data, shown on Figure 2.12-15 in Section 2.12, indicates that groundwater with nitrate levels above the drinking water standard discharges to the Columbia River immediately south of the 300 Area.

The remedial action objectives for the 1100-EM-1 Operable Unit (ROD 1993) are:

- ***Attain concentration of <5 µg/L trichloroethene at designated point of compliance.***
- ***Protect environmental receptors in surface waters by reducing groundwater contaminant concentrations in the plume.***

2.13.1.4 Gross Alpha and Uranium

Elevated levels of gross alpha and uranium occur downgradient of an offsite industrial facility (AREVA) near DOE's inactive Horn Rapids Landfill. The highest gross alpha level was 84 pCi/L immediately downgradient of the AREVA facility during FY 2005 (E06-01-20044Q). Several wells downgradient of the AREVA facility showed gross alpha levels that were above the drinking water standard (15 pCi/L), which excludes uranium. However, it is probable that the gross alpha levels are largely attributed to uranium because of industrial uses offsite. If gross alpha is attributed to uranium with natural isotopic abundances, then 84 pCi/L gross alpha is equivalent to 120 µg/L uranium, which is above the drinking water standard (30 µg/L) for uranium.

Uranium contamination is present near DOE's inactive Horn Rapids Landfill, but the source is located offsite.

The distribution of uranium near DOE's inactive Horn Rapids Landfill is shown on Figure 2.13-4. The map shows a small plume of uranium with levels less than the drinking water standard (30 µg/L) near the landfill. Uranium concentrations in wells downgradient of the landfill have been increasing since 1996. Uranium concentrations ranged up to 21.6 µg/L, with the highest concentration immediately downgradient of DOE's Horn Rapids Landfill (Figure 2.13-5). It is probable that elevated uranium downgradient of DOE's inactive Horn Rapids Landfill is attributed to past industrial uses offsite.

2.13.1.5 Other Constituents

Ammonia and gross beta are found at low levels in wells near an offsite industrial facility (AREVA).

Ammonia – Concentrations of ammonia in the AREVA facility wells generally remained steady in FY 2005 (E06-01-20044Q). The highest average concentration detected was 11.3 mg/L (as NH_3) in wells SPC-GM-8. Ammonia is typically absorbed by plants and soil microorganisms or is taken up as an exchangeable ion on soil particles (Hausenbuiller 1972). However, ammonia is usually less stable than nitrate in a biological system like the soil medium and is rapidly converted to nitrate. Ammonia was detected in several wells downgradient of the AREVA facility in FY 2005. The fact that ammonia is found in the groundwater suggests that relatively high concentrations reached the soil column.

Gross Beta – Gross beta continued to be detected in wells downgradient of AREVA during FY 2005 (E06-01-20044Q). The highest average gross beta measurement in FY 2005 was 35 pCi/L in well SPC-GM-8. Low levels of technetium-99, detected near DOE's inactive Horn Rapids Landfill, may be related to the gross beta measurements.

2.13.2 Operable Unit Monitoring

The 1100-EM-1 Operable Unit, which contains DOE's inactive Horn Rapids Landfill, was placed on the National Priorities List in 1989 and de-listed from the National Priorities List in 1996. Results of the CERCLA investigation for this operable unit are presented in the final remedial investigation study (DOE/RL-92-67) and the record of decision (ROD 1993). The selected remedy for groundwater is monitored natural attenuation of volatile organic compounds, with institutional controls on drilling of new water supply wells. Monitoring includes analysis of trichloroethene, its breakdown products (e.g., vinyl chloride and 1,1-dichloroethene), and nitrate in wells downgradient of DOE's inactive Horn Rapids Landfill, as recommended in the sampling plan (PNNL-12220). A list of wells and constituents are provided in Appendix A, Table A.16.

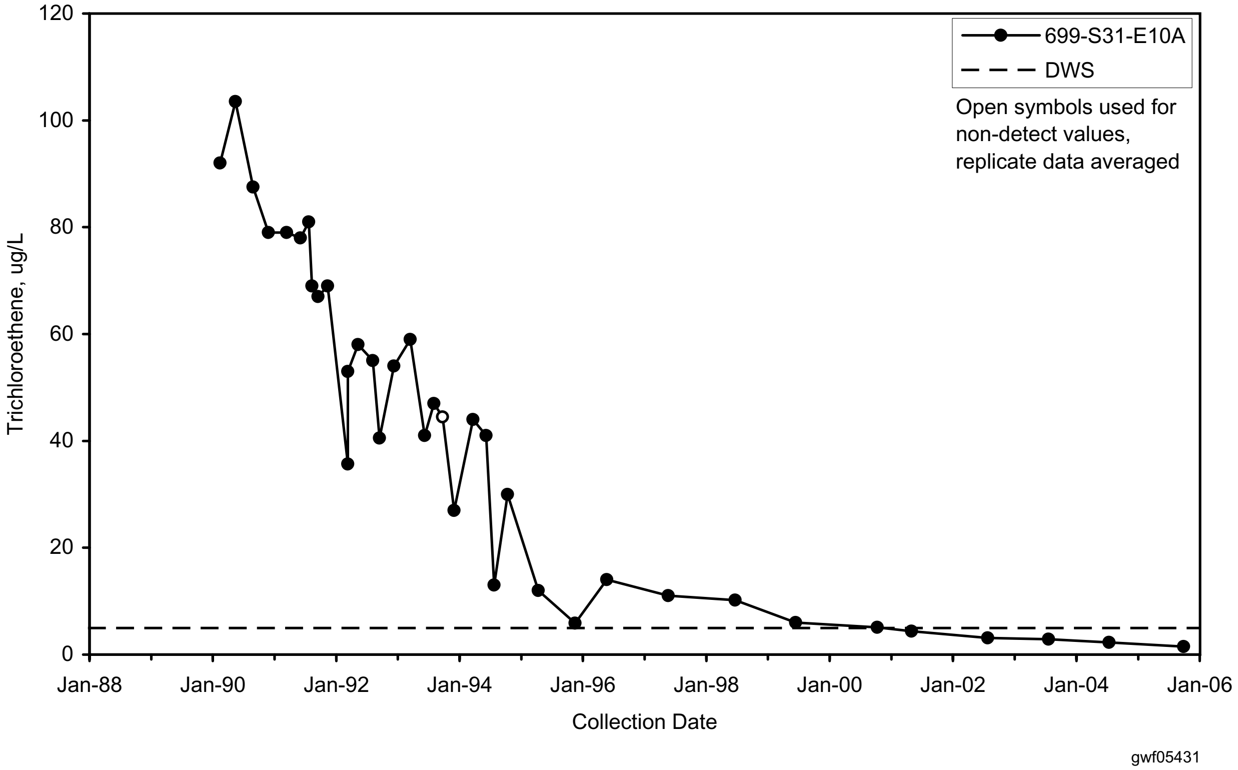

Figure 2.13-1. Trichloroethene Concentrations Near the U.S. Department of Energy's Inactive Horn Rapids Landfill

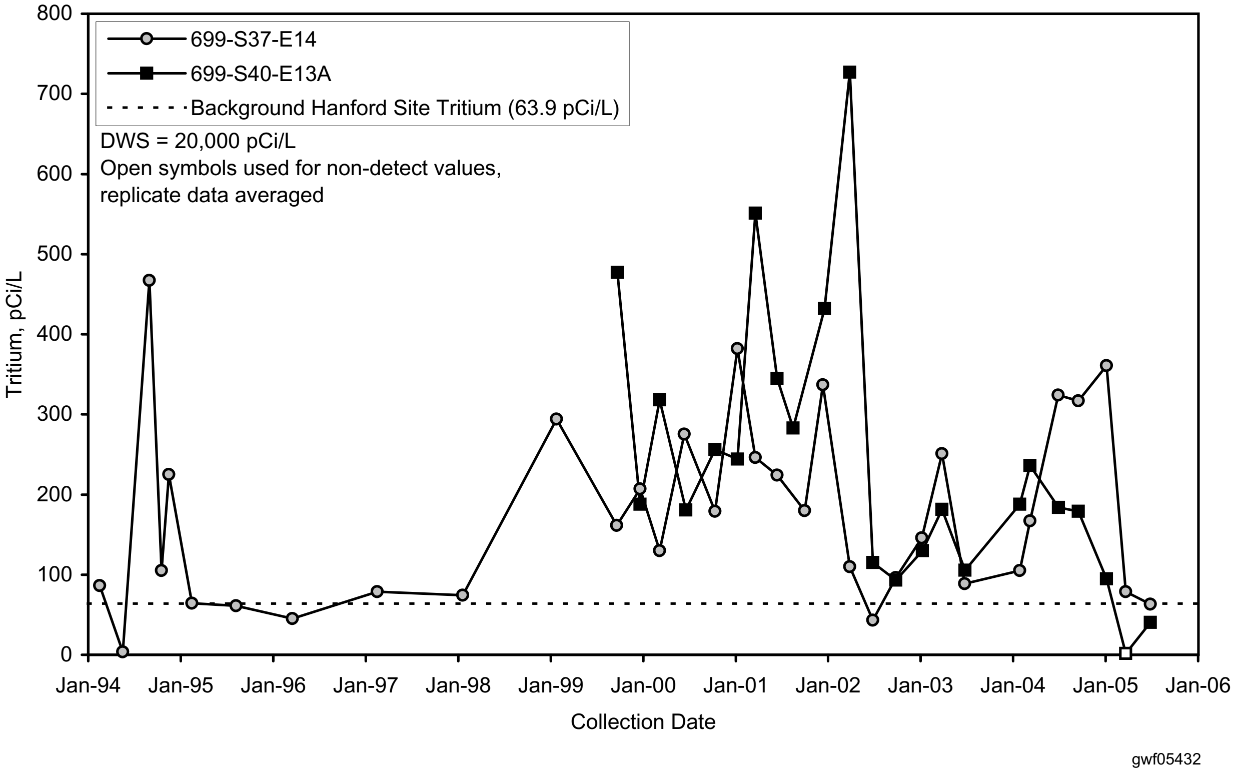

Figure 2.13-2. Tritium Concentrations in Selected Wells in the 1100-EM-1 Groundwater Interest Area

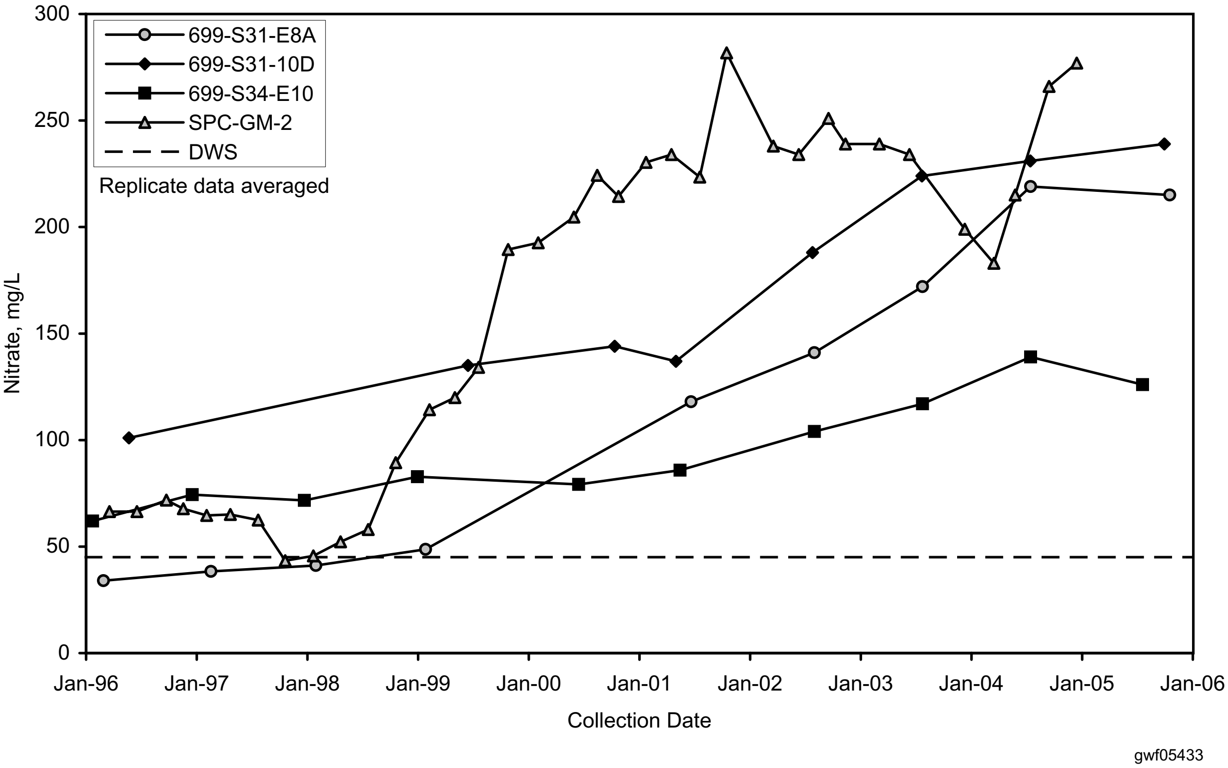

Figure 2.13-3. Nitrate Concentrations in Selected Wells in the 1100-EM-1 Groundwater Interest Area (data for well SPC-GM-2 taken from E06-01-20044Q)

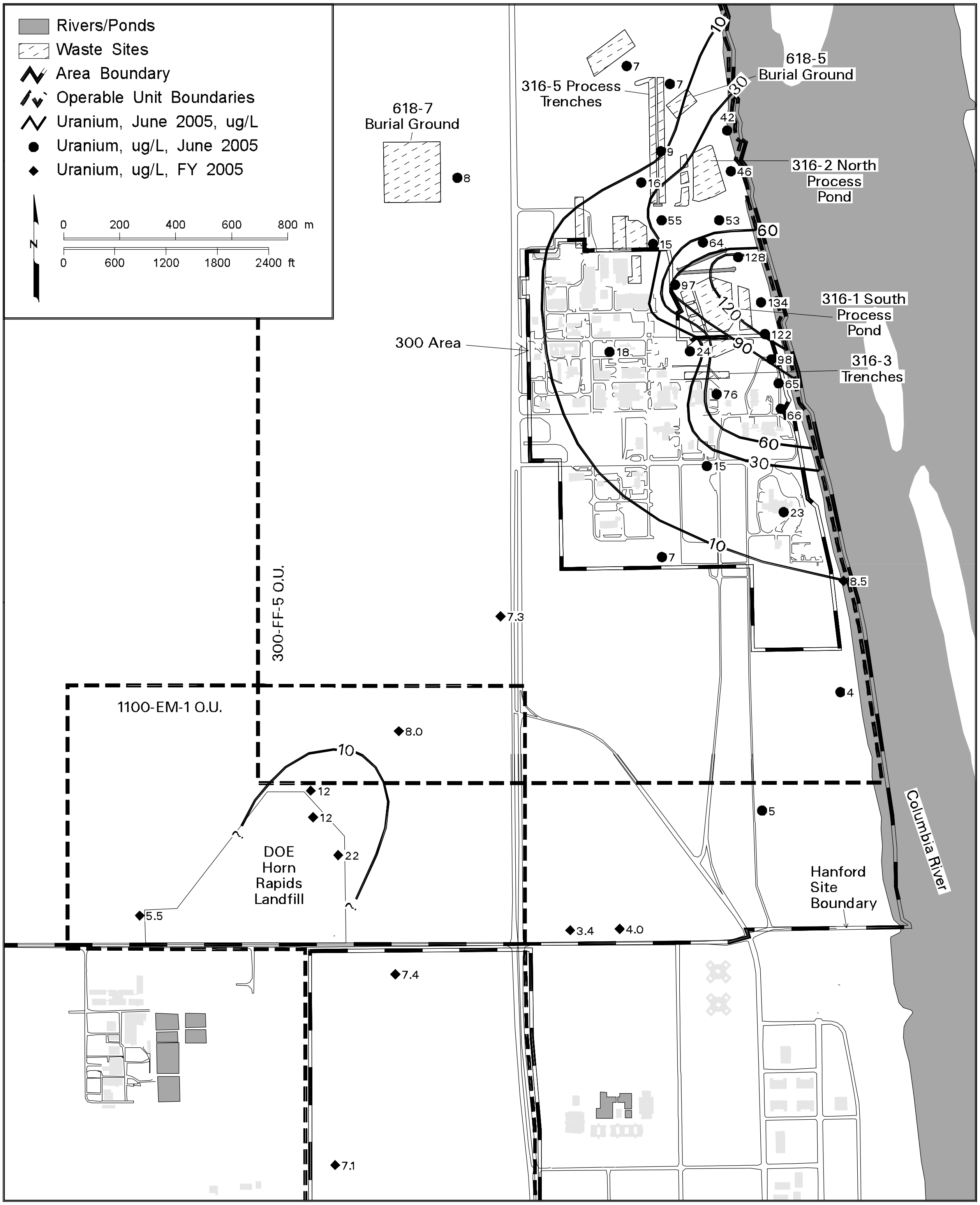

Figure 2.13-4. Uranium Concentrations at Wells in 300 Area, December 2004 to January 2005, Top of Unconfined Aquifer

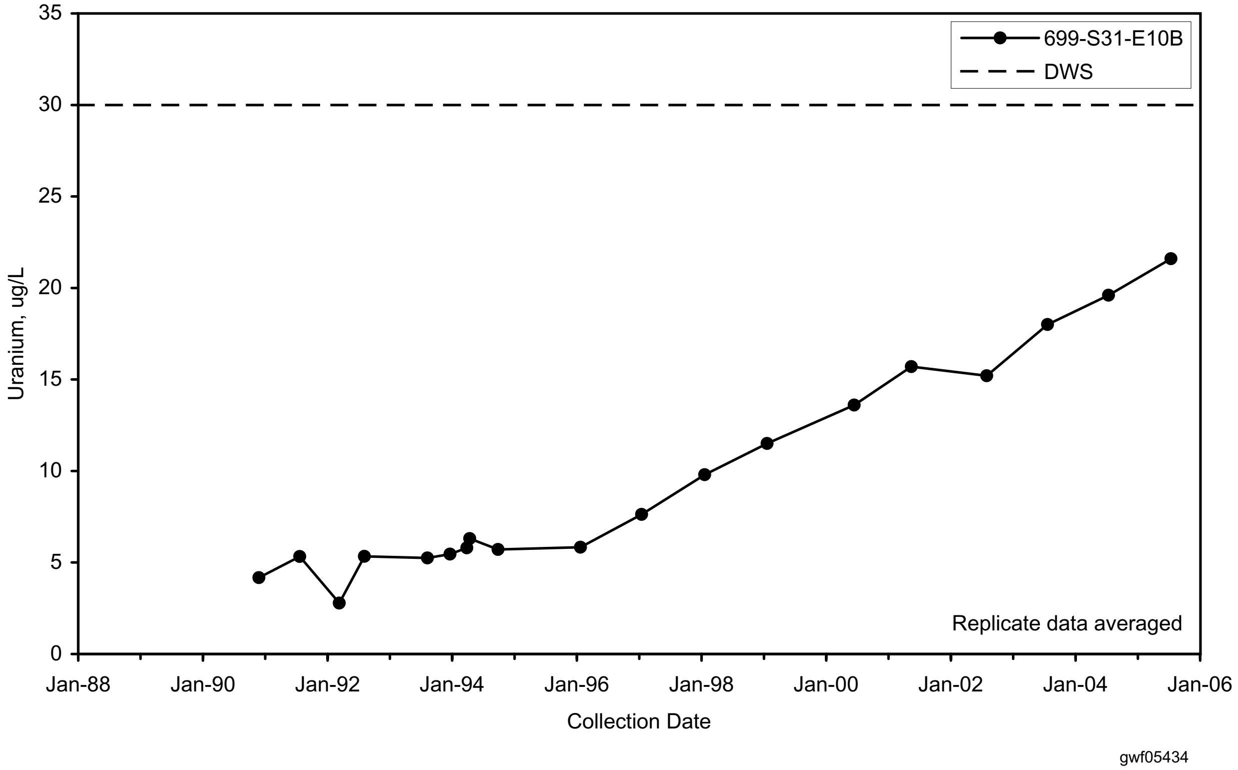

Figure 2.13-5. Uranium Concentrations Near the U.S. Department of Energy's Inactive Horn Rapids Landfill

2.14 Confined Aquifers

D. R. Newcomer and J. P. McDonald

This section describes groundwater flow and quality within the Ringold Formation and upper basalt-confined aquifers. The Ringold Formation confined aquifer is described only for the 200 Areas Central Plateau and the area near the inactive B Pond system because few wells monitor this aquifer. The upper basalt-confined aquifer is described for much of the Hanford Site, primarily the area south of Gable Butte and Gable Mountain.

2.14.1 Ringold Formation Confined Aquifer

Groundwater quality in the Ringold Formation confined aquifer is monitored because of the past and potential future for downward migration of contaminants from the overlying unconfined aquifer.

The Ringold Formation confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of the Ringold Formation (unit 9). It is confined below by basalt and above by the lower mud unit (unit 8).

2.14.1.1 Groundwater Flow in the Ringold Formation Confined Aquifer

Figure 2.14-1 presents the interpreted potentiometric surface for a portion of the confined aquifer in the Ringold Formation. This map is incomplete and subject to uncertainty because only a few wells monitor this aquifer.

Groundwater flow in the Ringold Formation confined aquifer is generally west to east near the 200 West Area and west to east along the south boundary of the aquifer near the Rattlesnake Hills. This flow pattern indicates that recharge occurs west of the 200 West Area from upland areas, the Cold Creek Valley, the Dry Creek Valley, and possibly the Rattlesnake Hills. In the central portion of the aquifer in the vicinity of the 200 East Area, flow converges from the west, south, and east before discharging to the unconfined aquifer where the confining mud unit (unit 8) is absent. Water-level elevation data from well pair 299-E25-28 and 299-E25-34 (Figure 2.14-2), as well as from piezometers 299-E25-32P and 299-E25-32Q, suggest a slight upward gradient in this area. This upward gradient is the evidence suggesting that groundwater discharges from the confined aquifer to the overlying unconfined aquifer, which is then interpreted to flow southeastward over the top of the confining unit.

Groundwater in the Ringold Formation confined aquifer flows generally west to east in the vicinity of the 200 West Area and west to east along the south boundary of the aquifer.

Elevated water levels are present in the Ringold Formation confined aquifer northeast of B Pond as a remnant of past wastewater discharges to this facility. This causes southwest flow beneath B Pond to the 200 East Area. Eastward flow away from the region of elevated water levels does not occur, because the May Junction Fault, located east of B Pond, is thought to be a hydrologic barrier preventing flow to the east (PNNL-12261). South of B Pond, a stagnation point occurs where the flow of water divides with some moving northwest toward the 200 East Area and some moving toward the east or southeast.

The contours on Figure 2.14-1 are similar to the potentiometric surface contours for the upper basalt-confined aquifer (see Section 2.14.2.1), indicating that flow patterns in the central portion of the Hanford Site are similar in both aquifers. The basalt from Gable Gap into the 200 East Area vicinity was significantly eroded by late Pleistocene catastrophic flooding (RHO-BWI-LD-5), which facilitates intercommunication between the unconfined and confined aquifers. The 200 East Area vicinity is a discharge area for both of the confined aquifers, which is why the flow patterns are similar.

Water levels declined in the Ringold Formation confined aquifer during the period from March 2004 to March 2005. The declines in individual wells ranged from 0.05 to

0.38 meter. The potentiometric surface is responding to the curtailment of liquid effluent discharges to ground since the discharge volume peaked in the mid 1980s. As in previous years, the declines were largest in the 200 West Area (up to 0.38 meter) and the B Pond vicinity (up to 0.26 meter).

2.14.1.2 Groundwater Quality in the Ringold Formation Confined Aquifer

The 200 Areas Central Plateau and the area near the inactive B Pond system are the two known areas where contamination can migrate from the unconfined aquifer into the confined Ringold aquifer. Groundwater chemistry data for the Ringold Formation confined aquifer are limited to wells near the 200 Area Treated Effluent Disposal Facility and B Pond facilities. During fiscal year (FY) 2005, four wells were sampled that are completed in the Ringold Formation confined aquifer (Figure 2.14-2). Data for constituents of interest are listed in Table 2.14-1. Iodine-129 in a single well was the only contaminant present in significant concentrations.

2.14.2 Upper Basalt-Confined Aquifer

Groundwater quality in the upper basalt-confined aquifer is monitored because of the potential for downward migration of contaminants from the overlying unconfined aquifer. Contaminants that reach the upper basalt-confined aquifer have the potential to migrate through the aquifer and deeper confined aquifers to areas off the Hanford Site. The upper basalt-confined aquifer is also monitored to assess the potential migration of contaminants onto the Hanford Site from offsite sources. Additional information regarding the potential for contaminants to migrate off the Hanford Site can be found in PNL-10817 and PNNL-14107.

Groundwater quality in the upper basalt-confined aquifer is monitored because of the potential for downward migration of contaminants from the overlying unconfined aquifer.

Within the upper basalt-confined aquifer system, groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds within the upper Saddle Mountains Basalt. The thickest and most widespread sedimentary unit in this system is the Rattlesnake Ridge Interbed, which is present beneath much of the Hanford Site. Groundwater also occurs within the Levey Interbed, which is present only in the south portion of the site. An interflow zone occurs within the Elephant Mountain Member of the upper Saddle Mountains Basalt and also may be significant to the lateral transmission of water. This system is confined by the dense, low-permeability, interior portions of basalt flows and in some places by Ringold Formation silt and clay units overlying the basalt.

Figure 2.14-2 shows the location of the upper basalt-confined aquifer monitoring wells on the Hanford Site. Most of the wells are completed in the Rattlesnake Ridge Interbed near the 200 East Area in the central part of the Hanford Site. A few wells are completed in the Elephant Mountain interflow zone, the Levey Interbed, or a composite of one or more interbeds and/or interflow zones within the upper Saddle Mountains Basalt.

2.14.2.1 Groundwater Flow in the Upper Basalt-Confined Aquifer

Recharge to the upper basalt-confined aquifer system is believed to occur from upland areas along the margins of the Pasco Basin and results from the infiltration of precipitation and surface water where the basalt and interbeds are exposed at or near ground surface. Recharge may also occur through the Hanford/Ringold aquifer system in areas where the hydraulic gradient is downward, and from deeper basalt aquifers where an upward gradient is present. The Yakima River may also be a source of recharge. The Columbia River represents a discharge area for this aquifer system in the south portion of the site, but not for the north portion of the site (PNL-8869). Discharge also occurs to the overlying Hanford/Ringold aquifer system in areas where the hydraulic gradient is upward. Discharge to overlying or underlying aquifers in the vicinity of the Gable Butte/Gable Mountain structural area may occur through erosional windows in the basalt.

Groundwater flow rates within the Rattlesnake Ridge Interbed have been estimated to be between 0.7 and 2.9 meters/year (PNL-10817). This flow rate is considerably slower than most estimates for the overlying unconfined aquifer system. On average, the magnitude of the hydraulic gradient is lower than in the unconfined aquifer. In addition, the sediment comprising the interbed consists mostly of tuffaceous sandstone along with silts and clays, and is less permeable than the sediments in the unconfined aquifer.

Figure 2.14-3 presents an approximation of the March 2005 potentiometric surface for this aquifer system south of Gable Butte and Gable Mountain. The region to the north of Gable Butte and Gable Mountain was not contoured because of insufficient well control. (See PNL-8869 for a generalized potentiometric surface map of this area.) Because the Rattlesnake Ridge interbed is absent, the upper basalt-confined aquifer is interpreted to not exist in Cold Creek Valley and along the west portion of the Gable Mountain/Gable Butte structural area.

South of the Umtanum Ridge/Gable Mountain area, groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site toward the Columbia River. In the vicinity of the 200 East Area, the potentiometric surface in Figure 2.14-3 is similar to the potentiometric surface for the Ringold Formation confined aquifer (compare with Figure 2.14-1). The basalt in this area was significantly eroded by late Pleistocene catastrophic flooding, which facilitates aquifer intercommunication (RHO-BWI-LD-5). In the vicinity of the 200 East Area and to the immediate north, the vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying Hanford/Ringold aquifer system is upward. Therefore, it is likely the upper basalt-confined aquifer system currently discharges to the overlying Hanford/Ringold aquifer system in this region.

Groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site toward the Columbia River.

A downward hydraulic gradient from the Hanford/Ringold aquifer system to the upper basalt-confined aquifer exists in the west portion of the Hanford Site, in the vicinity of the B Pond recharge mound, as well as in the regions north and east of the Columbia River (Figure 2.14-4). In the vicinity of B Pond, the vertical head gradient between the unconfined aquifer system and the upper basalt-confined aquifer system has diminished in recent years but remains downward. In other areas of the Hanford Site, the hydraulic gradient is upward from the upper basalt-confined aquifer to the Hanford/Ringold aquifer system. The May Junction Fault, located east of B Pond and in a north-south trend, acts as a barrier to groundwater flow in the Hanford/Ringold aquifer system (PNNL-12261). It may also impede the movement of water in the upper basalt-confined aquifer system by juxtaposing permeable units opposite impermeable units.

Water levels in the upper basalt-confined aquifer declined over most of the Hanford Site from March 2004 to March 2005. In the 200 East Area and to the immediate north and east (near B Pond), water-level declines in wells ranged from 0.08 to 0.22 meter over the 12-month period. Water-level declines in wells near the 200 West Area ranged from 0.14 to 0.30 meter. The declines are in response to curtailed effluent disposal activities in the 200 Areas and are consistent with water-level declines in the overlying Hanford/Ringold aquifer system.

Water levels in the basalt-confined aquifer along the Columbia River in the east part of the site (i.e., wells 699-13-1C and 699-24-1P) demonstrate long-term increasing trends. This is interpreted to be the result of offsite irrigation east of the Columbia River (PNL-8869). From March 2004 to March 2005, water levels declined in this area for the second straight year (0.11 and 0.21 meter). It is not unusual for these wells to exhibit short-term declines superimposed on the long-term increasing trend.

2.14.2.2 Groundwater Quality in the Upper Basalt-Confined Aquifer

The upper basalt-confined aquifer is affected much less from contamination than the overlying unconfined aquifer system. Contamination found in the upper basalt-confined aquifer is most likely attributed to areas where confining units of basalt have been eroded away or were never deposited and where past disposal of large amounts of wastewater resulted in downward hydraulic gradients. In some areas, wells penetrating the upper basalt-confined aquifer system provided a downward pathway for contaminant migration. Because of these factors, intercommunication between the aquifers permitted groundwater flow from the unconfined aquifer to the underlying confined aquifer, thereby increasing the potential to spread contamination.

The small amount of contamination detected in the upper basalt-confined aquifer is attributed to areas where confining units of basalt are absent or where wells provided a pathway for migration.

An area of intercommunication between the unconfined and upper basalt-confined aquifer systems was first identified in the north part of the 200 East Area (RHO-BWI-ST-5; RHO-RE-ST-12 P). Several confined aquifer wells north and east of the 200 East Area have shown evidence of intercommunication with the overlying unconfined aquifer (PNL-10817). Intercommunication between the unconfined and confined aquifers in this region has been attributed to erosion of the upper Saddle Mountains Basalt and a downward hydraulic gradient that resulted from groundwater mounding associated with past wastewater disposal to the ground. However, the groundwater mound has diminished in recent years (see Section 2.14.1).

Wells completed in the upper basalt-confined aquifer system are routinely sampled on the Hanford Site. Most of these wells are sampled every 3 years, and a few are sampled annually. During FY 2003 through 2005, 21 samples were collected from 17 wells and analyzed for chemical and radiological constituents. Many of the samples were analyzed for tritium, iodine-129, and nitrate because these constituents (1) are the most widespread in the overlying unconfined aquifer, (2) are some of the most mobile constituents in groundwater, and (3) provide an early warning for potential contamination in the upper basalt-confined aquifer system. Groundwater samples from the upper basalt-confined aquifer were also analyzed for anions (besides nitrate), cations, cyanide, gross alpha, gross beta, gamma-emitters, strontium-90, technetium-99, and uranium isotopes. Data for the primary constituents of interest are listed in Table 2.14-2. A full data set is included in the data files that accompany this report.

Distribution of sample results for selected constituents and wells across the Hanford Site for FY 2002 through 2004 is shown in Figure 2.14-5. Tritium at the Hanford Site ranged from less than the detection limits near the discharge area in the east-southeast portion of the Hanford Site to 5,080 pCi/L east of the 200 East Area. Concentrations have been decreasing at this location since 1996 (Figure 2.14-6). This elevated tritium is located in the 200 East Area/Gable Mountain region, an area of intercommunication with the overlying contaminated unconfined aquifer. Nearby wells completed in the Ringold Formation show elevated but declining trends. Near the 618-11 burial ground, where a source of tritium has contaminated the unconfined aquifer at high levels, tritium was detected at a concentration of 31.6 pCi/L in the upper basalt-confined aquifer in FY 2004.

In FY 2005, cyanide, nitrate, and technetium-99 were elevated in one well in the 200 East/ Gable Mountain region, an area of intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer.

In the north part of the 200 East Area, technetium-99 was elevated in the upper basalt-confined aquifer in one well (Figure 2.14-5). The technetium-99 concentration was 1,090 pCi/L in this well (299-E33-12) in 2004. However this level, which exceeds the drinking water standard (900 pCi/L), is slightly lower than concentrations since the early 1990s (Figure 2.14-7). Contamination in this well is attributed to migration of high-salt waste down the borehole during construction when it was open to both the unconfined and confined aquifers (RHO-RE-ST-12 P). This well is located in the vicinity of a technetium-99 plume in the overlying unconfined aquifer (Section 2.10.1).

Cyanide and nitrate are also elevated in the same well (299-E33-12) that technetium-99 is elevated in (Figure 2.14-8). However, these co-contaminants are at levels that do not exceed their respective drinking water standards. Concentrations of cyanide and nitrate have not changed significantly at this well since the early 1990s. Like technetium-99, this contamination is associated with migration of high-salt waste down the borehole during well construction when it was open to both the unconfined and confined aquifers (RHO-RE-ST-12 P). Cyanide and nitrate are co-contaminants with much higher concentrations in the unconfined aquifer in the north part of the 200 East Area.

Nitrate levels in the upper basalt-confined aquifer typically range from less than detectable to ~1 mg/L across the Hanford Site. Higher levels indicate intercommunication with the overlying contaminated unconfined aquifer (RHO-BWI-ST-5; RHO-RE-ST-12 P; PNL-10817). The majority of wells with higher nitrate in the upper basalt-confined aquifer occur near Gable Mountain and the 200 East Area (Table 2.14-2).

Some samples collected from upper basalt-confined aquifer wells were analyzed for iodine-129. These wells are located beneath or near the iodine-129 plume contained within the overlying unconfined aquifer. Iodine-129 was not detected in the upper basalt-confined aquifer during FY 2003 through 2005 (see Table 2.14-2).

A few samples collected from upper basalt-confined aquifer wells were analyzed for gamma-emitting and uranium isotopes. Gamma-emitting isotopes were not detected in the upper basalt-confined aquifer on the Hanford Site, including the Gable Mountain/200 East Area. Uranium isotopes were not detected in this aquifer in one well in the eastern part of the Hanford Site during FY 2003 through 2005 (Figure 2.14-5).

Gamma-emitting isotopes were not detected in the upper basalt-confined aquifer on the Hanford Site

In summary, cyanide, nitrate, and technetium-99 were elevated in an upper basalt-confined aquifer well in the north part of the 200 East Area. Migration of high-salt waste via the well during its construction is responsible for this contamination. Tritium was predominantly detected at low levels or was not detected. One elevated tritium concentration near the 200 East Area is associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer but was less than the drinking water standard. Iodine-129, strontium-90, gamma-emitting isotopes, and uranium isotopes were not detected above the minimum detection limits in the upper basalt-confined aquifer.

Table 2.14-1. Potential Contaminants in Ringold Confined Aquifer, FY 2003 through FY 2005

Well	Sample Date	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Iodine-129 (pCi/L)	Nitrate (mg/L)	Specific Conductance (µS/cm)
699-40-36	10/28/02	2.75	5.2	NA	0.088	NA
699-40-36	02/04/03	1.85	6.1	NA	0.088 B	NA
699-40-36	04/16/03	4.2	6.6	NA	0.12 B	NA
699-40-36	09/02/03	3.1	5.4	NA	0.128 B	NA
699-40-36	10/22/03	1.54 U	9.53	NA	0.102	295
699-40-36	01/21/04	3.03	8.82	NA	0.0974	308
699-40-36	04/01/04	2.65	10.9	NA	0.0487 U	315
699-40-36	07/07/04	2.91	9.23	NA	0.0753 B	316
699-40-36	10/20/04	0.95 U	6.5	NA	0.204 B	309
699-40-36	01/19/05	5	4.1	NA	6.02	314
699-40-36	05/03/05	4.7	5.4	NA	0.0974 U	313
699-40-36	09/21/05	2.2	6.4	NA	0.0797 U	306
699-41-35	10/28/02	2.3	4	NA	0.653	NA
699-41-35	02/04/03	4	6.1	NA	0.537 B	NA
699-41-35	04/16/03	3.5	5.3	NA	0.809	NA
699-41-35	09/02/03	5.4	6.2	NA	1.100	NA
699-41-35	10/22/03	4.51	9.58	NA	0.908	322
699-41-35	01/21/04	2.45	7.44	NA	1.02	323
699-41-35	04/01/04	5.3	11.4	NA	0.974	328
699-41-35	07/07/04	2.95	10.9	NA	0.797	329
699-41-35	10/20/04	2.75	5.85	NA	0.872	324
699-41-35	01/19/05	4.3	6.8	NA	0.930	326
699-41-35	05/03/05	5.4	6.3	NA	0.792	328
699-41-35	09/21/05	3.8	6.5	NA	0.850	321
699-42-37	10/28/02	5.6	4.7	NA	6.273	NA
699-42-37	02/04/03	3.8	3.3	NA	5.675	NA
699-42-37	04/16/03	4	4	NA	6.175	NA
699-42-37	09/02/03	4.2	4	NA	6.240	NA
699-42-37	10/22/03	7.18	7.37	NA	6.200 D	358
699-42-37	01/21/04	5.45	4.85	NA	6.640	359
699-42-37	04/01/04	4.76	10.5	NA	6.640 D	369
699-42-37	07/07/04	6.61	6.89	NA	5.310 D	373
699-42-37	10/20/04	2.9	5.6	NA	6.68	339
699-42-37	01/19/05	3.7	6.6	NA	0.0974 U	368
699-42-37	05/03/05	3.8	6.5	NA	6.33	368
699-42-37	09/21/05	4.2	3.9	NA	6.51	355
699-45-42	07/28/04	NA	NA	2.98	3.59	279

Table 2.14-1. (contd)

Well	Sample Date	Strontium-90 (pCi/L)	Technetium-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)
699-40-36	10/28/02	NA	NA	NA	3.49
699-40-36	02/04/03	NA	NA	NA	3.31
699-40-36	04/16/03	NA	NA	NA	3.43
699-40-36	09/02/03	NA	NA	NA	3.42
699-40-36	10/22/03	NA	NA	NA	NA
699-40-36	01/21/04	NA	NA	NA	NA
699-40-36	04/01/04	NA	NA	NA	NA
699-40-36	07/07/04	NA	NA	NA	NA
699-40-36	10/20/04	NA	NA	8.53 U	3.57
699-40-36	01/19/05	NA	NA	NA	7.56
699-40-36	05/03/05	NA	NA	NA	3.48
699-40-36	09/21/05	NA	NA	NA	3.44
699-41-35	10/28/02	NA	NA	NA	5.38
699-41-35	02/04/03	NA	NA	NA	4.97
699-41-35	04/16/03	NA	NA	NA	5.14
699-41-35	09/02/03	NA	NA	NA	5.25
699-41-35	10/22/03	NA	NA	23.2	NA
699-41-35	01/21/04	NA	NA	NA	NA
699-41-35	04/01/04	NA	NA	NA	NA
699-41-35	07/07/04	NA	NA	NA	NA
699-41-35	10/20/04	NA	NA	13.92	5.61
699-41-35	01/19/05	NA	NA	NA	11.83
699-41-35	05/03/05	NA	NA	NA	5.41
699-41-35	09/21/05	NA	NA	NA	5.32
699-42-37	10/28/02	NA	NA	NA	6.83
699-42-37	02/04/03	NA	NA	NA	6.35
699-42-37	04/16/03	NA	NA	NA	6.66
699-42-37	09/02/03	NA	NA	NA	6.87
699-42-37	10/22/03	NA	NA	13.5	NA
699-42-37	01/21/04	NA	NA	NA	NA
699-42-37	04/01/04	NA	NA	NA	NA
699-42-37	07/07/04	NA	NA	NA	NA
699-42-37	10/20/04	NA	NA	1.82 U	7.09
699-42-37	01/19/05	NA	NA	NA	3.86
699-42-37	05/03/05	NA	NA	NA	6.85
699-42-37	09/21/05	NA	NA	NA	6.70
699-45-42	07/28/04	NA	NA	9,530	NA

B = Analyte detected at a value less than the contract required detection limit.
D = Analyzed at a secondary dilution factor.
NA = Not analyzed.
U = Below detection limit.

Table 2.14-2. Potential Contaminants in Upper Basalt-Confined Aquifer, FY 2003 through 2005

Well	Sample Date	Cesium-137 (pCi/L)	Cobalt-60 (µg/L)	Cyanide (mg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Iodine-129 (pCi/L)
299-E16-1	10/06/03	NA	NA	NA	0.289 U	12.2	NA
299-E26-8	10/02/03	NA	NA	NA	4.32	12.1	NA
299-E33-12	06/21/04	-0.322 U	6.03 U	22.9	3.0	254	0.544 U
399-5-2	06/23/04	NA	NA	NA	8.5	8.66	NA
699-13-1C	10/27/03	NA	NA	NA	1.03 U	3.67	NA
699-32-22B	10/08/03	NA	NA	NA	1.78 U	11.5	-0.0353 U
699-32-22B	10/08/03	NA	NA	NA	1.1 U	12	0.00454 U
699-42-E9B	09/10/03	-0.446 U	-0.696 U	NA	0.862 U	6.52	0.0105 U
699-42-E9B	07/19/04	2.88 U	-1.4 U	NA	0.62 U	11.4	0.0578 U
699-42-40C	10/09/03	NA	NA	NA	1.8	12.6	0.253 U
699-49-57B	03/09/04	0.605 U	-0.488 U	4.7 U	1.61 U	5.72	-0.843 U
699-49-57B	03/21/05	0.423 U	-1.2 U	2 U, N	NA	NA	-0.0396 U
699-50-53B	10/08/03	NA	NA	NA	NA	NA	0.0922 U
699-52-46A	06/30/04	NA	NA	NA	4.74	8.83	NA
699-54-34	07/01/04	NA	NA	NA	1.51 U	6.68	NA
699-56-43	10/09/03	NA	NA	NA	2.47	6.33	NA
699-56-53	10/08/03	NA	NA	NA	2.41	8.41	NA
699-S11-E12AP	02/03/04	NA	NA	NA	NA	NA	NA
699-S11-E12AP	02/01/05	NA	NA	NA	NA	NA	NA
699-S2-34B	01/21/04	NA	NA	NA	NA	NA	NA
699-S2-34B	03/31/05	NA	NA	NA	NA	NA	-0.0308 U
699-S24-19P	07/13/04	NA	NA	NA	NA	NA	NA

Table 2.14-2. (contd)

Well	Sample Date	Nitrate (mg/L)	Specific Conductance (µS/cm)	Strontium-90 (pCi/L)	Technetium-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)
299-E16-1	10/06/03	0.0487 U	307	NA	NA	9.11	NA
299-E26-8	10/02/03	3.67	307	NA	NA	16.3	NA
299-E33-12	06/21/04	36.7 D	342	NA	1,090	153	2.96
399-5-2	06/23/04	0.0394 B	361	NA	NA	5.22 U	NA
699-13-1C	10/27/03	0.0974 C	251	NA	NA	31.6	NA
699-32-22B	10/08/03	0.0487 U	395	NA	NA	6.08 U	NA
699-32-22B	10/08/03	0.0487 U	395	NA	NA	12.5	NA
699-42-E9B	09/10/03	0.328	425	NA	NA	NA	NA
699-42-E9B	07/19/04	0.0177 U	431	NA	NA	0.168 U	NA
699-42-40C	10/09/03	4.87 D	324	NA	NA	5,080	NA
699-49-57B	03/09/04	1.15	302	NA	-2.39 U	-28.5 U	NA
699-49-57B	03/21/05	1.06 N	304	NA	1.35 U	14.3 U	NA
699-50-53B	10/08/03	10.6 D	360	NA	1.38 U	-92.8 U	NA
699-52-46A	06/30/04	1.86	338	0.16 U	NA	10.7	NA
699-54-34	07/01/04	12.4 D	291	NA	NA	5.17 U	NA
699-56-43	10/09/03	4.43 D	320	NA	NA	15.9	NA
699-56-53	10/08/03	0.930	368	NA	NA	16.9 U	NA
699-S11-E12AP	02/03/04	0.0487 U	335	NA	NA	-22.9 U	NA
699-S11-E12AP	02/01/05	NA	362	NA	NA	-0.298 U	NA
699-S2-34B	01/21/04	0.0487 U	591	NA	NA	-75 U	NA
699-S2-34B	03/31/05	0.0177 U	604	NA	NA	72.7 U	NA
699-S24-19P	07/13/04	0.708	285	NA	NA	13.5	NA

Negative values occur when a sample has a lower count than the background.

B = Analyte detected at a value less than the contract required detection limit.
C = Analyte detected in both the sample and the associated quality control blank.
D = Analyzed at a secondary dilution factor.
N = Spike sample recovery is outside control limits.
NA = Not analyzed.
U = Below detection limit.

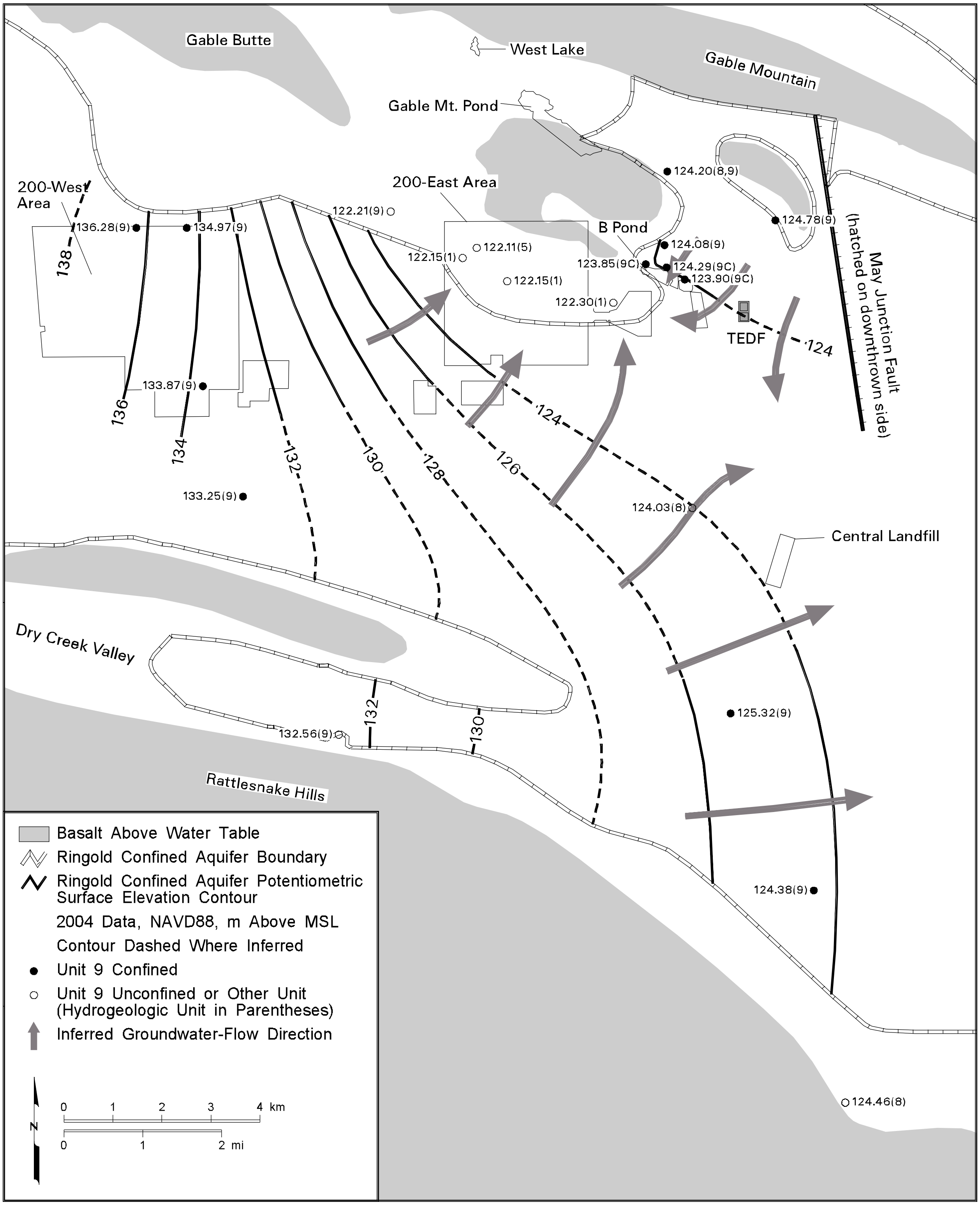

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Figure 2.14-1. Potentiometric Surface Map of Ringold Formation Confined Aquifer (Unit 9), Central Hanford Site, March 2005

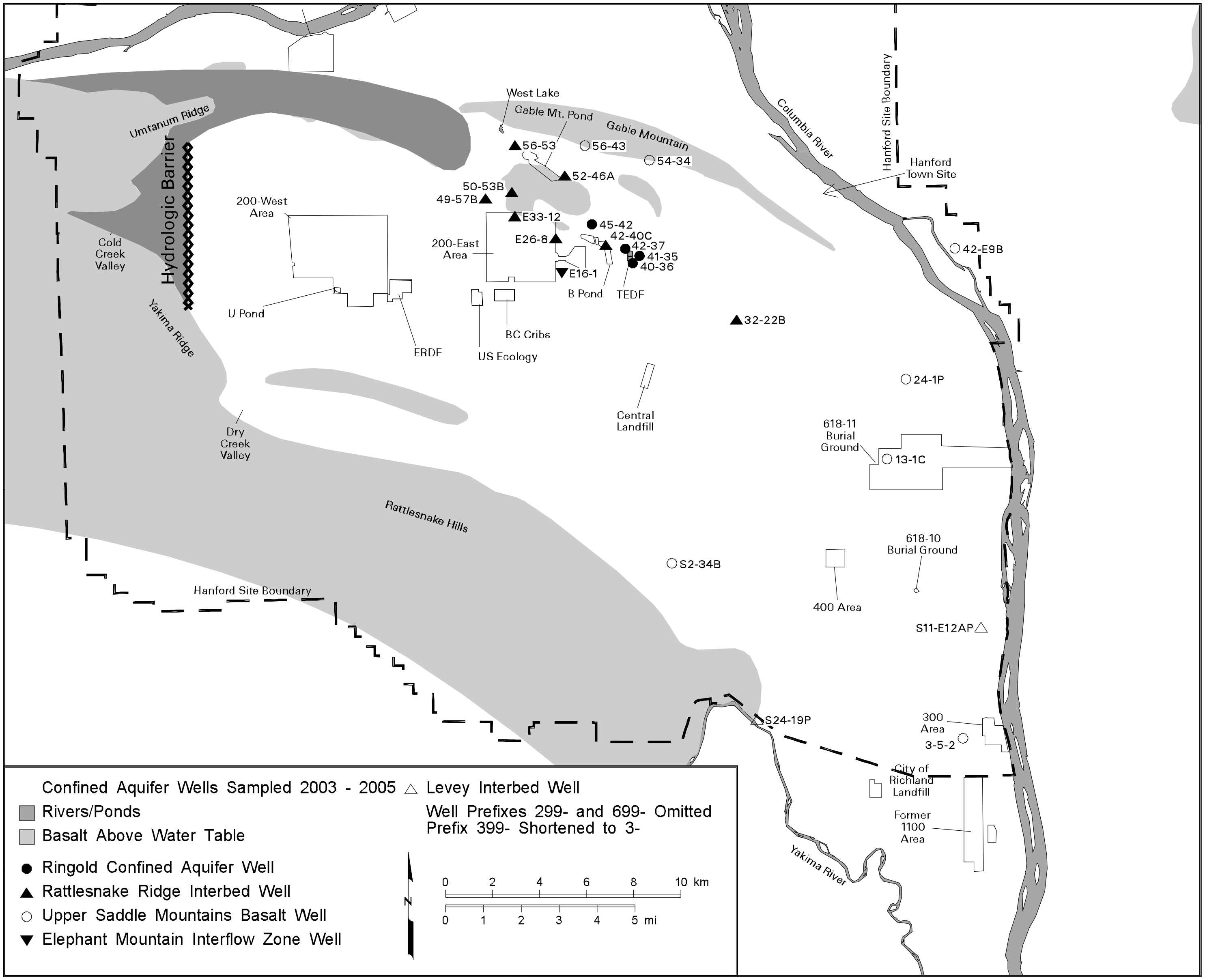
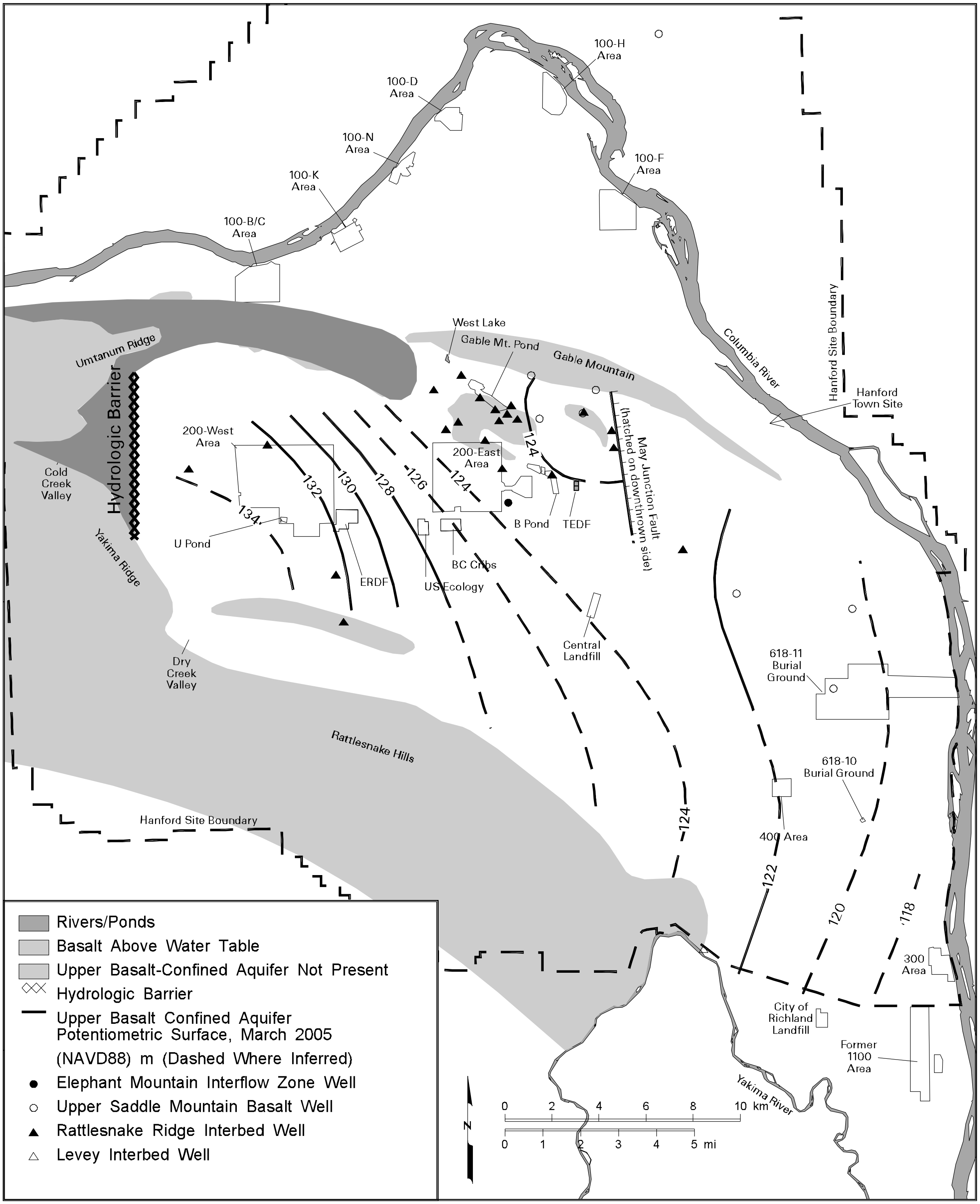


Figure 2.14-2. Groundwater Monitoring Wells Sampled in the Ringold Confined and the Upper Basalt-Confined Aquifers, FY 2003 through 2005



can_gwf05_453 February 15, 2006 3:37 PM

Figure 2.14-3. Potentiometric Surface Map of Upper Basalt-Confined Aquifer System, March 2005

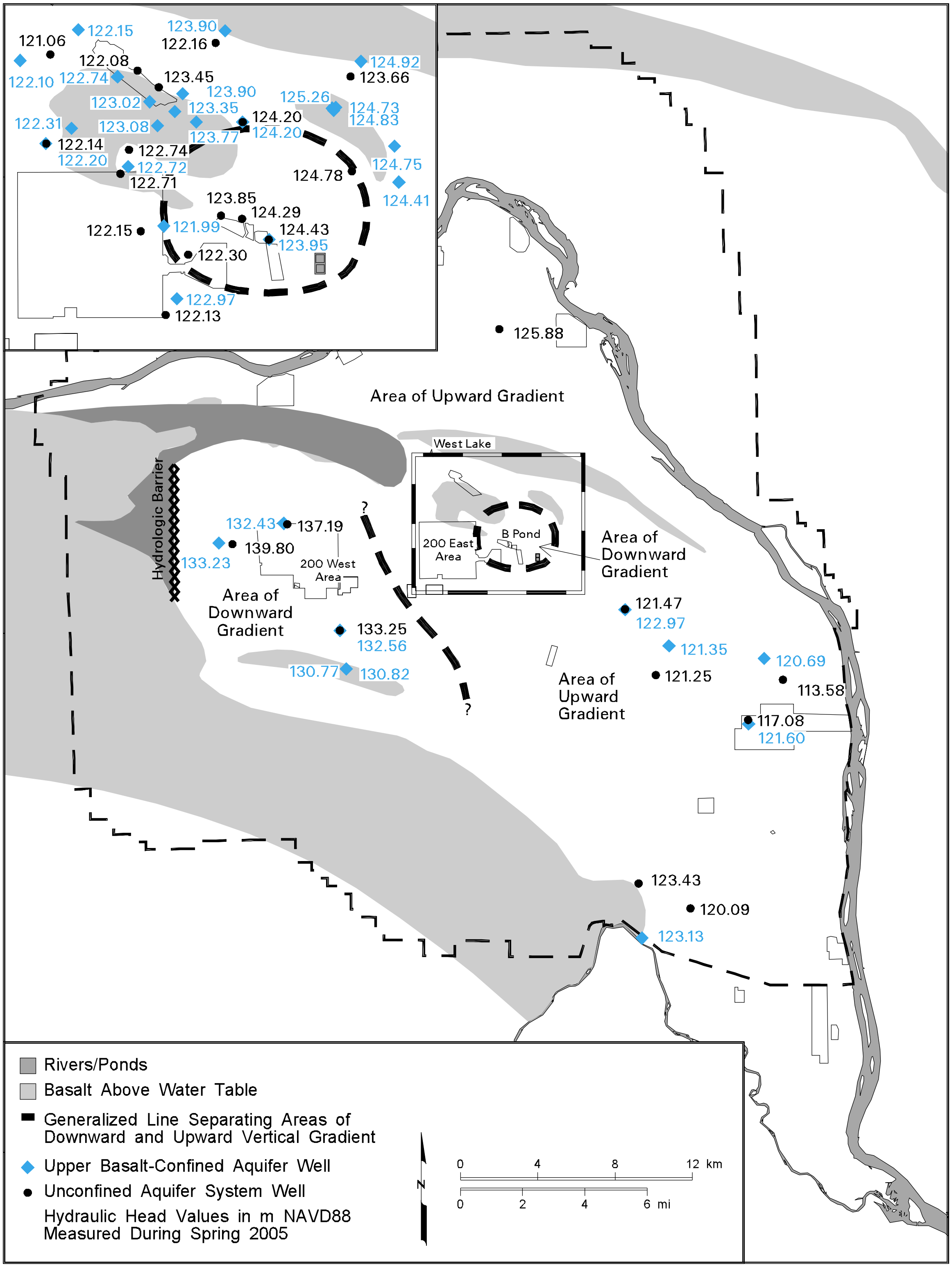


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Figure 2.14-4. Comparison of Observed Heads for the Upper Basalt-Confined Aquifer and Overlying Unconfined Aquifer

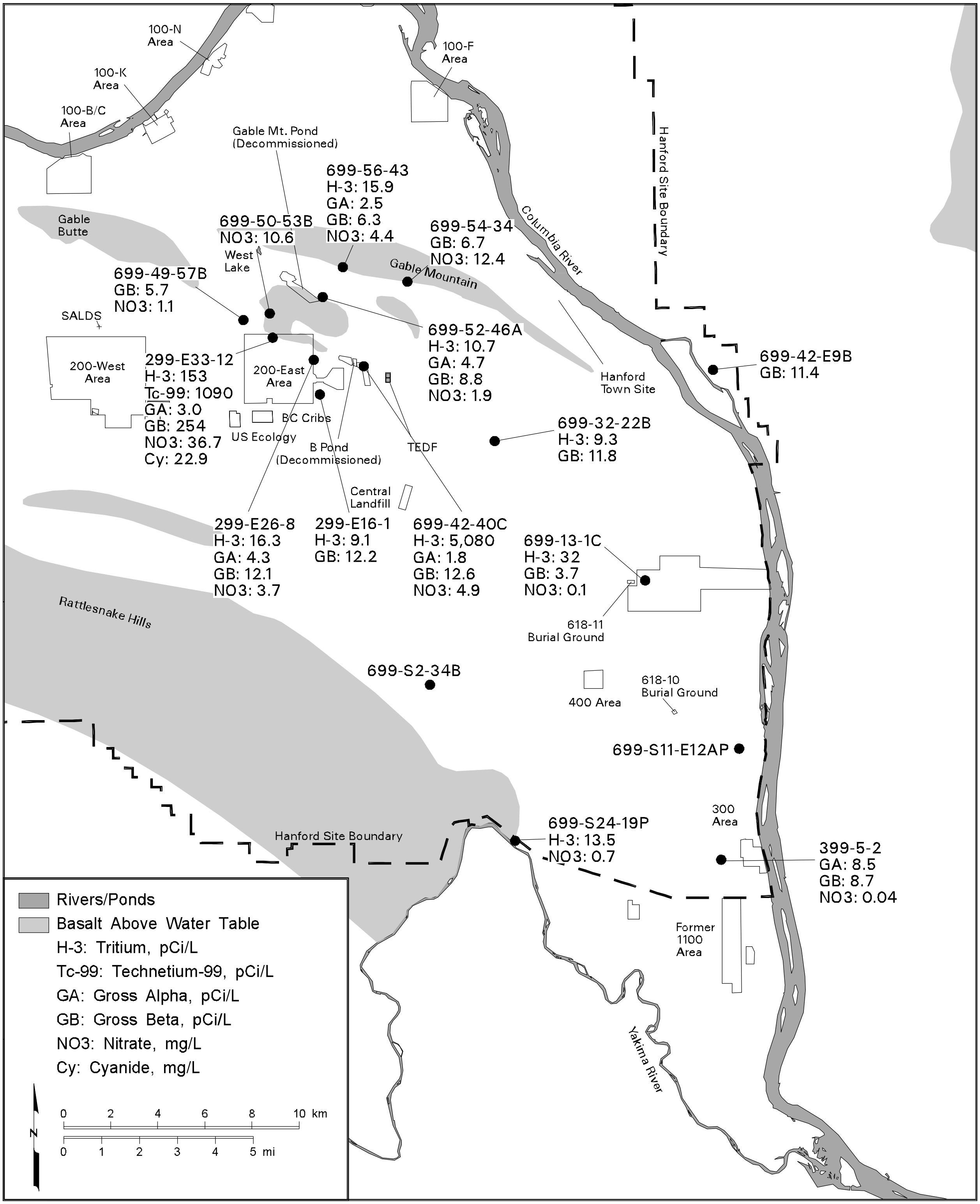

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Figure 2.14-5. Distribution of Chemical and Radiological Constituents in the Upper Basalt-Confined Aquifer, FY 2003 through 2005

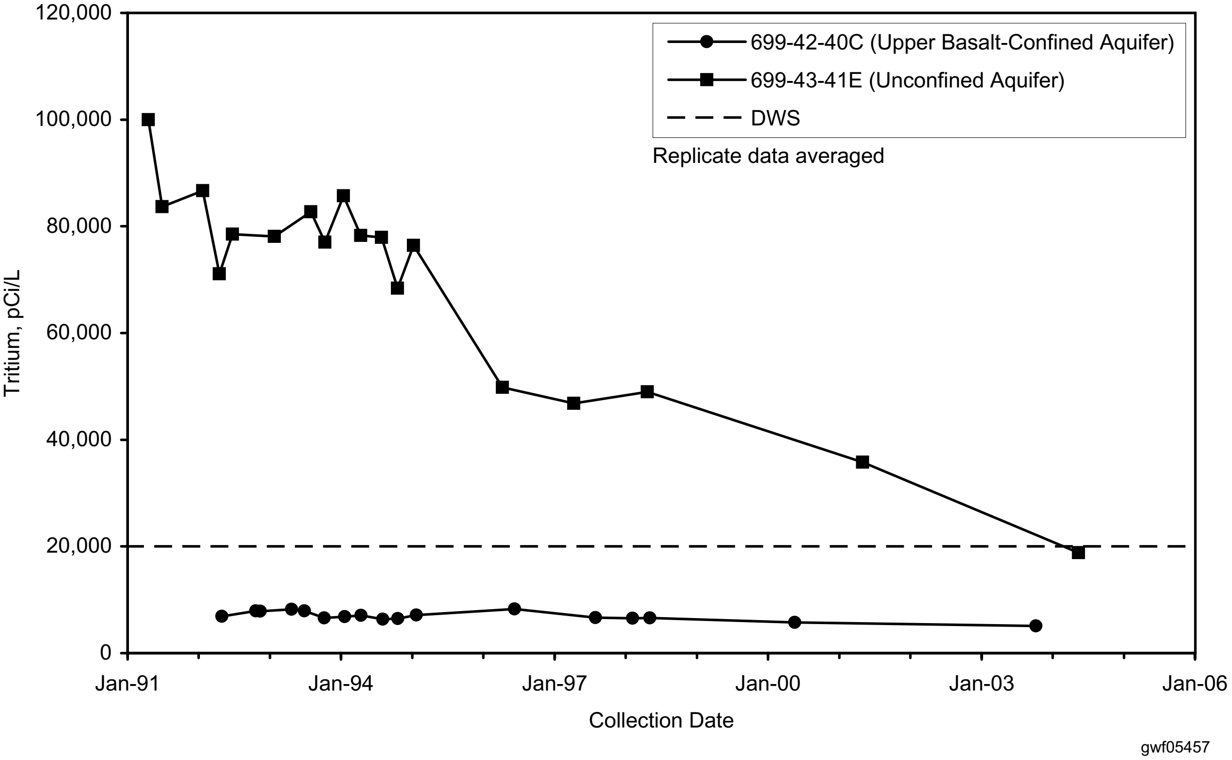


Figure 2.14-6. Tritium Concentrations in Wells 699-42-40C (Upper Basalt-Confined Aquifer) and 699-43-41E (Unconfined Aquifer)

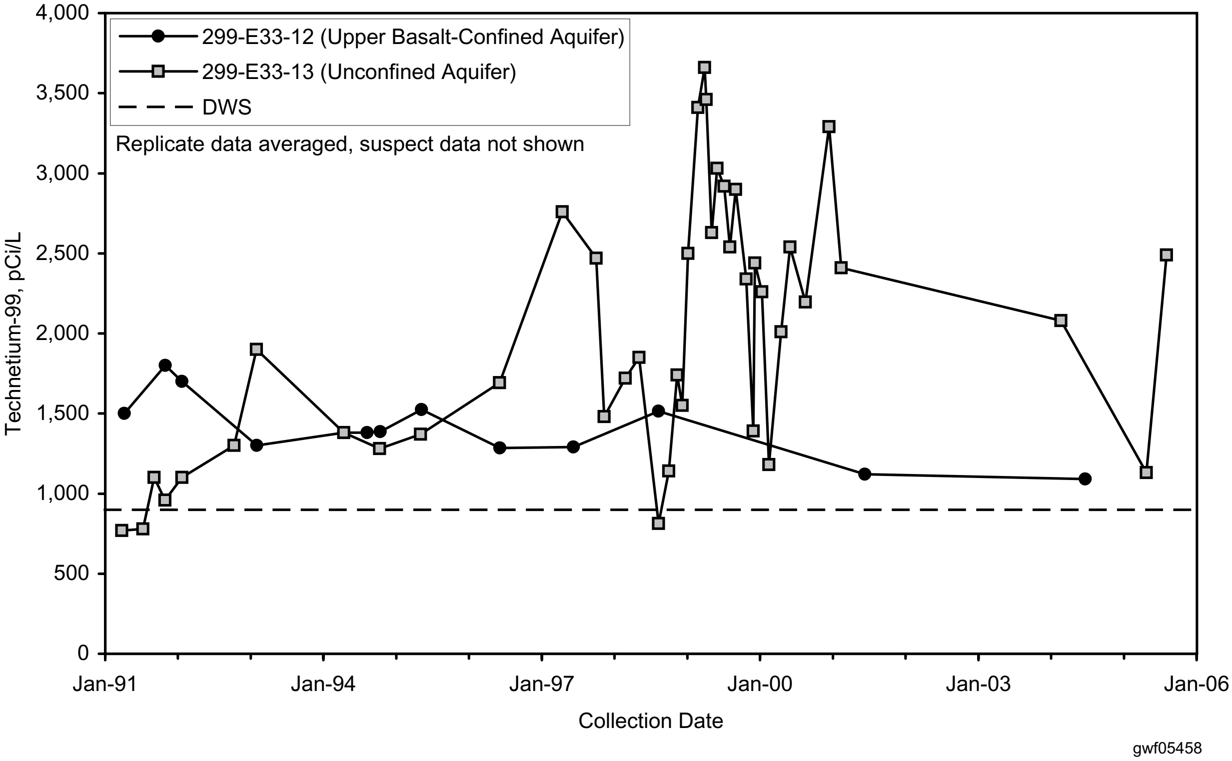


Figure 2.14-7. Technetium-99 Concentrations in Wells 299-E33-12 (Upper Basalt-Confined Aquifer) and 299-E33-13 (Unconfined Aquifer)

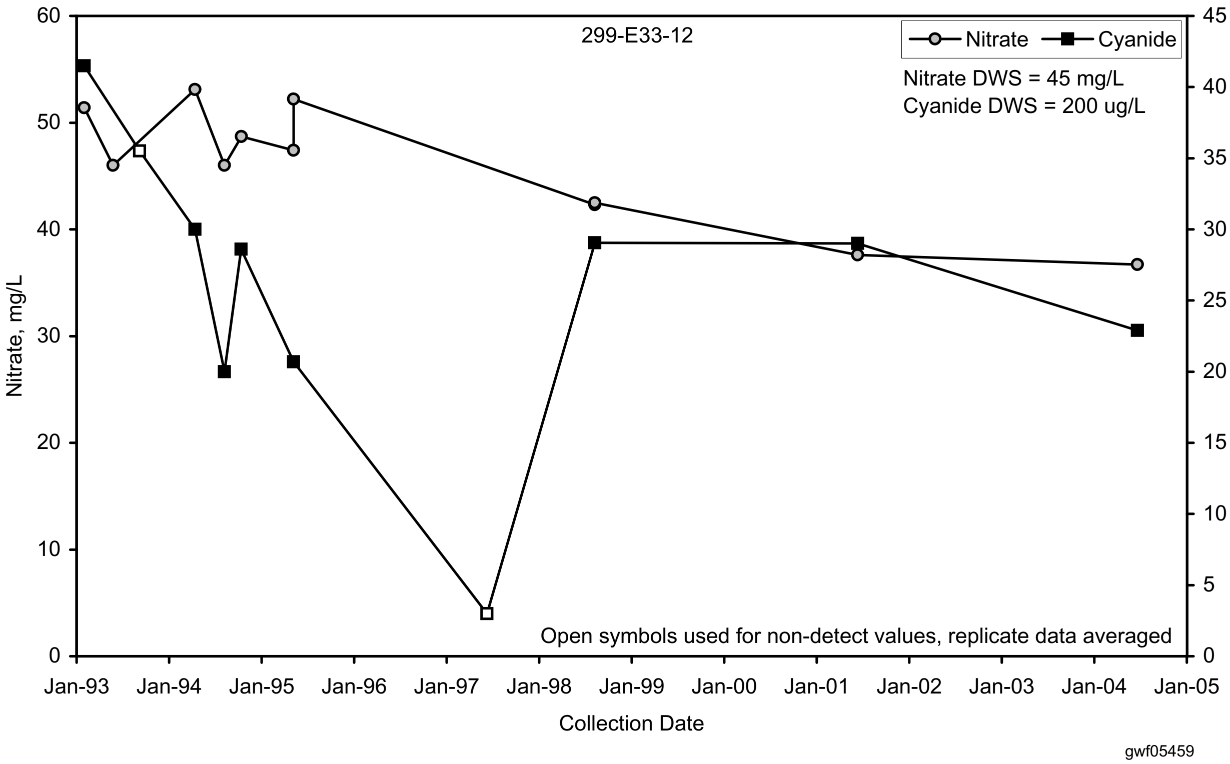


Figure 2.14-8. Cyanide and Nitrate Concentrations in Well 299-E33-12

3.0 Vadose Zone

D. G. Horton

At the Hanford Site, radioactive and hazardous waste in the soil column from past intentional liquid waste disposal, unplanned leaks, solid waste burial grounds, and underground tanks are potential sources of continuing and future vadose zone and groundwater contamination. Characterization of the subsurface and vadose zone monitoring were conducted during fiscal year (FY) 2005 to better understand the distribution of subsurface contaminants and to track the movement of vadose zone contamination. Also, several technical studies were completed; the results of these studies could lead to new understandings of moisture and contaminant movement in the vadose zone, contaminant interactions with the soil column, and new and improved methods to characterize and monitor the vadose zone.

This chapter summarizes major findings from those efforts, focused primarily on vadose zone soil contamination associated with past single-shell tank leaks and liquid disposal to ground as a result of spent fuel processing.

An overview of major soil sources of groundwater contamination is provided in PNNL-13080. This chapter discusses vadose zone contamination that could affect groundwater in the future. An overall evaluation depends, to a large degree, on integration of vadose zone and groundwater monitoring and characterization data to present a comprehensive picture of contaminant fate and transport. Significant FY 2005 vadose zone results are summarized here. However, the bulk of the data interpretation on the effect to groundwater is presented and discussed in Chapter 2 of this document.

3.1 Vadose Zone Monitoring

D. G. Horton

Vadose zone monitoring occurred at four major areas on the Hanford Site in fiscal year (FY) 2005. Leachate and soil-gas monitoring continued at the Solid Waste Landfill and the Environmental Restoration Disposal Facility. Also, soil-gas monitoring at the carbon tetrachloride expedited-response-action site continued during FY 2005. Finally, long-term barrier performance and water balance continued to be monitored at the 200-BP-1 surface barrier. Surface barriers are an integral part of the U.S. Department of Energy's (DOE's) waste management strategy.

3.1.1 Leachate Monitoring at the Environmental Restoration Disposal Facility

D. A. St. John and R. L. Weiss

Concentrations of some constituents have been increasing in leachate from the Environmental Restoration Disposal Facility over the past 2 to 3 years.

Washington Closure Hanford (formerly Bechtel Hanford, Inc.) operates the Environmental Restoration Disposal Facility to dispose of radioactive and mixed waste generated during waste management and remediation activities at the Hanford Site. In FY 2005, Bechtel Hanford, Inc. published the results of groundwater and leachate monitoring and sampling at the Environmental Restoration Disposal Facility during the calendar year 2004 (BHI-01777). The groundwater results are discussed in Section 2.9; this section summarizes the vadose zone results.

The Environmental Restoration Disposal Facility began operation in July 1996. Located between the 200 East and 200 West Areas (see Figure 2.9-1 in Section 2.9), the facility is currently operating two disposal cells that became active during FY 2005. Throughout calendar year 2004, ~556,965 metric tons of remediation waste were disposed at the facility. A total of ~4.77 million metric tons of remediation waste have been placed in the Environmental Restoration Disposal Facility from initial operations start-up through calendar year 2004.

Each cell was constructed with a double liner system to collect leachate resulting from water added as a dust suppressant and natural precipitation. The liners deliver the leachate to sumps beneath the cells where it is sampled. A composite sample of leachate was collected in duplicate in June and December of calendar year 2004 from the sumps associated with the upper liners of cells 1 through 4. The samples were analyzed for selected metals, anions, organic compounds, total dissolved solids, gross alpha, gross beta, and selected radionuclides. The purposes of the leachate monitoring are to provide data for leachate delisting analyses and to assess whether additional analytes should be added to the routine groundwater monitoring program at the Environmental Restoration Disposal Facility.

The composite leachate samples contained detectable concentrations of common metals, anions, and mobile radionuclides. Constituents that were generally increasing in concentration include chromium, potassium, specific conductance, bromide, and nitrate. Gross alpha and total uranium had been increasing until calendar year 2004. The following is a summary of those analytes with increasing trends:

- Chromium concentration has been slowly increasing at a stable rate over the past 3 years. The chromium concentration averaged 33.7 µg/L in December 2004, up from 22.4 µg/L in December 2002.
- Potassium is monitored only once every 2 years. The December 2004 potassium concentration averaged 27,650 µg/L, up from 18,250 µg/L in December 2002.

- Specific conductance remained fairly stable from June 2002 to December 2004 at which time a fairly significant increase was observed. The December 2004 specific conductance was 3,500 µS/cm, up from 2,360 µS/cm in June 2004. Additional data are needed to determine whether the December 2004 result represents an increasing trend.
- Bromide was not detected in leachate samples until June 2004 (735 µg/L) and increased in December 2004 (990 µg/L). Future sampling data are necessary to confirm this apparent increasing trend.
- Nitrate concentrations have continued to increase at a fairly steady rate over the past 3 years. The most recent (December 2004) average nitrate concentration was 492 mg/L.

Groundwater monitoring data for chromium, potassium, bromide, nitrate, gross alpha, and uranium were examined to determine whether the Environmental Restoration Disposal Facility has affected groundwater. In all cases, groundwater concentrations for these constituents remained stable. Based on this comparison, it appears that the Environmental Restoration Disposal Facility leachate has not affected groundwater.

The target constituents for the groundwater monitoring program are consistent with the leachate monitoring program. Based on that evaluation, no additional constituents are recommended for addition to the groundwater monitoring program at the Environmental Restoration Disposal Facility landfill.

3.1.2 Leachate and Soil-Gas Monitoring at the Solid Waste Landfill

B. B. Nelson-Maki and B. J. Dixon

Leachate is collected beneath part of the Solid Waste Landfill. The volume of leachate decreased in FY 2005 because of decreased precipitation.

The Solid Waste Landfill is a disposal facility in the center of the Hanford Site (part of the Central Landfill illustrated on Figure 2.1-2 in Section 2.1). The Solid Waste Landfill covers an area of ~26.7 hectares and began operating in 1973 to receive non-hazardous, non-radioactive sanitary waste generated from Hanford Site operations. The Solid Waste Landfill stopped receiving waste in 1996 and an "interim cover" consisting of 0.6 to 1.2 meters of soil was placed over all trenches. Current monitoring at the Solid Waste Landfill consists of quarterly sampling of groundwater, soil gas, and leachate. Recent groundwater monitoring results are discussed in Section 2.11. This section summarizes leachate and soil-gas monitoring results. The results are forwarded annually to Washington State Department of Ecology (Ecology).

In all, the Solid Waste Landfill consists of ~70 single trenches and 14 double trenches. Based on trench geometry and the thickness of the waste layer, the capacity of a trench per linear foot is 8.4 cubic meters for the single trenches and ~30.6 cubic meters for the double trenches. Based on this estimate, total design capacity of the Solid Waste Landfill is ~596,400 cubic meters.

One of the double trenches overlies a lined, basin lysimeter designed to collect leachate generated by infiltration through the overlying refuse. (All other trenches are unlined). This lysimeter covers an area of ~88 square meters. A discharge pipe continuously drains leachate by gravity flow from the basin to a nearby collection pump. However, leachate collected from this lysimeter may not be representative of leachate drainage throughout the entire landfill area because the lysimeter only collects leachate from 1 of 84 trenches and is installed under one of the newer trenches built after implementation of regulations that restrict land disposal practices. Still, the lysimeter provides some indication of the rate of infiltration and some of the contaminants that may be released to the vadose zone beneath the site.

Leachate is collected from the basin lysimeter every 10 to 14 days. Figure 3.1-1 shows the rate of leachate generated over the past 9 years. Prior to calendar year 2003, the generation rate was consistently between 4 to 8 liters/day. However, during FY 2003 and 2004, the generation rate increased significantly to ~19 liters/day. This increase mainly was attributed to above average rainfall recorded at the Hanford Site during the winter of 2003/2004. Drainage from the winter rainfall started arriving in the lysimeter collection tank in late April 2004.

For the reporting period between July 2004 through June 2005, the leachate generation rate decreased to ~16 liters/day (Figure 3.1-1). This was about a 12% decrease in leachate generation over the previous year. This decrease is attributed mainly to lower than normal precipitation recorded at the Hanford Site during the 2004/2005 winter. The Hanford Meteorological Station recorded 3.4 centimeters of rain during the December through February period, which is 50% of normal (i.e., 6.8 centimeters).

Leachate is sampled and tested quarterly for indicator parameters listed in WAC 173-304-490 and annually for site-specific constituents, which cover a complete range of metals and organics. Concentrations measured during July 2004 through June 2005 are similar to previous concentrations and did not identify any areas of concern. Some of the indicator parameters and some organic constituents and metals continued to be above WAC 173-200 groundwater quality criteria and/or drinking water standards established in WAC 246-290-310. However, no constituent was above the maximum contaminant level at the point of compliance, which is the groundwater at the Solid Waste Landfill boundary (see Section 2.11.3.8). Table 3.1-1 shows analytical results for key constituents in the Solid Waste Landfill leachate.

Monitoring the soil gas at the Solid Waste Landfill is to demonstrate that the air quality performance standards are met. Soil-gas monitoring at the Solid Waste Landfill uses eight shallow monitoring stations located around the perimeter of the landfill. Each station consists of two soil-gas probes at depths of ~2.75 and 4.6 meters. Soil gas is monitored quarterly to determine concentrations of oxygen, carbon dioxide, methane, and several key volatile organic compounds. During the reporting period, between July 2004 and June 2005, results were consistent with results for monitoring during previous years. Contaminants of concern were either not detected or were at or near detection limits.

3.1.3 Carbon Tetrachloride Monitoring and Remediation

V. J. Rohay

Soil-vapor extraction is being used to remove carbon tetrachloride from the vadose zone in the 200 West Area.

Soil-vapor extraction is being used to remove carbon tetrachloride from the vadose zone in the 200 West Area. The U.S. Environmental Protection Agency (EPA) and Ecology authorized DOE to initiate this remediation in 1992 as a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) expedited response action. The following discussion summarizes FY 2005 activities associated with the carbon tetrachloride removal. Detailed results will be published in FY 2006. For descriptions of past work, see BHI-00720, WMP-21327, WMP-26178, and Section 3.2.4 in PNNL-14548. WMP-26178 describes the soil-vapor extraction system and the well fields. See Figure 3.1-2 for locations of vapor extraction wells.

The 14.2-cubic-meter/minute soil-vapor extraction system was operated at the 216-Z-9 well field from March 31 through July 26, 2005. The soil-vapor extraction system was operated at the 216-Z-1A well field from July 29 through October 18, 2005. The system was maintained in standby mode from November 1, 2004 through March 30, 2005. The 28.3- and 42.5-cubic-meter/minute soil-vapor extraction systems did not operate and were not maintained during FY 2005. Temporarily suspending soil-vapor extraction operations at each well field allows the carbon tetrachloride concentrations to recharge and be more economically extracted when operations resume.

To track the effectiveness of the remediation effort, soil-vapor concentrations of carbon tetrachloride were monitored at the inlet to the soil-vapor extraction system and at individual online extraction wells during the 7-month operating period. To assess the impact of the soil-vapor extraction system on subsurface concentrations, soil-vapor concentrations of carbon tetrachloride were monitored at off-line wells and probes during the entire fiscal year.

Remediation efforts during FY 2005 also included passive soil-vapor extraction.

3.1.3.1 Soil-Vapor Extraction

Approximately 78,600 kilograms of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

Soil-vapor extraction to remove carbon tetrachloride from the vadose zone resumed March 31, 2005, at the 216-Z-9 well field. Initial extraction was from wells close to the 216-Z-9 trench. As extraction continued, additional wells close to the trench and farther away from the trench were brought online. Extraction wells open near the less-permeable Cold Creek unit, where the highest carbon tetrachloride concentrations have consistently been detected in the past, were selected to optimize mass removal of contaminant. Extraction wells open near the groundwater also were selected. During the 17 weeks of extraction in FY 2005, the maximum carbon tetrachloride concentration measured at the soil-vapor extraction system inlet was ~87 ppmv (Figure 3.1-3). This concentration was significantly lower than the maximum concentration (172 ppmv) measured when the soil-vapor extraction system last operated at this site in 2004. However, the 2005 maximum concentration was similar to the maximum concentration (109 ppmv) measured in 2002. (The soil-vapor extraction system did not operate at the 216-Z-9 site in 2003). The increased carbon tetrachloride concentrations in 2004 reflected the build-up of vapors containing carbon tetrachloride that occurred during the 27 months that vapor extraction was not operated at the 216-Z-9 site between 2002 and 2004.

Soil-vapor extraction resumed July 29, 2005, at the 216-Z-1A well field. Initial online wells were selected within the perimeter of the 216-Z-1A tile field. As extraction continued, wells farther away from the tile field were brought online. Extraction wells open near the less-permeable Cold Creek unit, where the highest carbon tetrachloride concentrations have consistently been detected in the past, were selected to optimize mass removal of contaminant. Initial carbon tetrachloride concentrations measured at the soil-vapor extraction inlet were ~25 ppmv (Figure 3.1-3). This concentration was similar to the maximum concentration (20 ppmv) measured when the soil-vapor extraction system last operated at this site in 2004.

As of October 2005, ~78,700 kilograms of carbon tetrachloride had been removed from the vadose zone since extraction operations started in 1991 (Table 3.1-2). The mass of carbon tetrachloride removed in FY 2005 was 362 kilograms. WMP-26178 provides the amounts of carbon tetrachloride removed per year between 1991 and 2004. Since initiation, the extraction systems are estimated to have removed 7% of the residual mass at 216-Z-1A/216-Z-12/216-Z-18 well field and 23% of the mass at 216-Z-9 well field. This estimate assumes that all of the mass that has not been lost to the atmosphere (21% of the original inventory), dissolved in groundwater (2% of the original inventory), or biodegraded (1% of the original inventory) was still available in the vadose zone as residual mass in 1991 when extraction operation began (WMP-26178; WHC-SD-EN-TI-101).

3.1.3.2 Monitoring at Off-Line Wells and Probes

During FY 2005, soil-vapor concentrations of carbon tetrachloride were monitored near the ground surface, near the Cold Creek unit (~40 meters below ground surface [bgs]), and near groundwater (~66 meters bgs). Soil-vapor concentrations were monitored near the ground surface and groundwater to evaluate whether non-operation of the soil-vapor extraction system negatively affects the atmosphere or groundwater. The maximum concentration detected near the ground surface (between 2 and 10 meters bgs) was 11 ppmv. Near the groundwater, at a depth of 55 meters bgs, the maximum concentration was 23 ppmv. Soil-vapor concentrations also were monitored above and within the Cold Creek unit to provide an indication of concentrations that could be expected during restart of the soil-vapor extraction system. The maximum concentration detected near the Cold Creek unit (between 25 and 44 meters bgs) was 374 ppmv in well 299-W15-217 (35 meters bgs) adjacent to the 216-Z-9 trench. During monitoring in FY 1997, 1998, 1999, 2000, 2001, 2003, and 2004, the highest carbon tetrachloride concentrations also were detected in this well. South of the 216-Z-9 trench ~90 meters, the maximum carbon tetrachloride concentration detected was 246 ppmv at soil-vapor probe CPT-28 (27 meters bgs). North of the 216-Z-9 trench ~200 meters, the maximum carbon tetrachloride concentration detected was 54 ppmv at soil vapor probe CPT-9A (15 meters bgs). The maximum carbon tetrachloride concentration detected in the vadose zone overlying the Cold Creek unit (between 11 and 23 meters bgs) was 170 ppmv at soil vapor probe CPT-21A (20 meters bgs) near the 216-Z-9 trench.

At the combined 216-Z-1A/216-Z-12/216-Z-18 well field, the maximum carbon tetrachloride concentration detected near the Cold Creek unit was 249 ppmv in well 299-W18-248 (40 meters bgs) at the 216-Z-1A tile field. During monitoring in FY 1997 through 2004, the highest carbon tetrachloride concentrations in the 216-Z-1A/216-Z-12/216-Z-18 well field also were detected in wells at the 216-Z-1A tile field.

The temporary suspension of soil-vapor extraction in FY 2005 appears to have caused minimal detectable vertical transport of carbon tetrachloride through the soil surface to the atmosphere. This interpretation is supported by data that show carbon tetrachloride concentrations did not increase significantly at the near-surface monitoring probes. In addition, suspending operations of the soil-vapor extraction system appears to have had no negative impact on groundwater quality, because carbon tetrachloride concentrations did not increase significantly near the water table during that time.

Passive soil-vapor extraction uses naturally induced pressure gradients to drive soil vapor to the surface.

3.1.3.3 Passive Soil-Vapor Extraction

Passive soil-vapor extraction is a remediation technology that uses naturally induced pressure gradients between the subsurface and the surface to drive soil vapor to the surface. In general, falling atmospheric pressure causes subsurface vapor to move to the atmosphere through wells, whereas rising atmospheric pressure causes atmospheric air to move into the subsurface. Passive soil-vapor extraction systems are designed to use this phenomenon to remove carbon tetrachloride from the vadose zone.

Passive soil-vapor extraction systems were installed at the end of FY 1999 at eight boreholes that are open near the vadose-groundwater interface at the 216-Z-1A/216-Z-12/216-Z-18 well field. The passive systems are outfitted with check valves that only allow soil-vapor flow out of the borehole (i.e., one-way movement), and canisters holding granular activated carbon that adsorbs carbon tetrachloride upstream of the check valves before the soil vapor is vented to the atmosphere. The check valve prohibits flow of atmospheric air into the borehole during a reverse barometric pressure gradient, which tends to dilute and spread carbon tetrachloride vapors in the subsurface.

The wells are sampled periodically upstream of the granular activated carbon canisters when atmospheric pressure is falling and the wells are venting. The maximum carbon tetrachloride concentrations measured at the four wells (299-W18-6, 299-W18-7, 299-W18-246, and 299-W18-252) in the vicinity of the 216-Z-1A tile field ranged from 18 to 25 ppmv. The maximum carbon tetrachloride concentrations measured at the four wells (299-W18-10, 299-W18-11, 299-W18-12, and 299-W18-247) in the vicinity of the 216-Z-18 crib ranged from 9 to 12 ppmv.

3.1.4 Long-Term Hydrologic Performance of the 200-BP-1 Surface Barrier

A. L. Ward, J. M. Keller, and C. E. Strickland

Groundwater remediation may include the use of surface barriers. Surface barriers are an integral part of DOE's waste management strategy.

A multilayered, vegetated capillary barrier was constructed over the 216-B-57 crib in Hanford's 200-BP-1 Operable Unit in August 1994 in an effort to understand the long-term performance of field-scale surface barriers. A CERCLA treatability test was conducted between November 1994 and September 1998 to evaluate barrier stability, resistance to erosion and bio-intrusion, vegetation dynamics, and the key components of water balance. Since 1998, monitoring has focused on barrier stability and the water balance. Performance data are currently being used to guide the design of final barriers for other waste management areas and in model validation. This section provides a summary of the results of water balance measurements made at the prototype barrier from September 1994 through September 2005. These measurements included precipitation, runoff, water storage, and drainage with evapotranspiration determined as the difference between measured inputs and outputs. Details of the monitoring methods are given in PNNL-14960.

Precipitation. Precipitation in FY 2005 totaled 119.88 millimeters, only 68% of the normal 177.29 millimeters. FY 2005 also saw major shifts in the seasonal distribution relative to the normal distribution. The winter of FY 2005 (December 2004 through February 2005) was relatively dry with only 34.04 millimeters compared to the normal 67.56 millimeters occurring during the 3-month period. Precipitation in the spring (March through May 2005) was close to normal with 34.54 millimeters recorded compared to the normal 40.13 millimeters. Like the winter precipitation, summer precipitation (June through August 2005) was very dry with only 5.33 millimeters occurring compared to the normal 24.13 millimeters. These differences translated into significant deceases in the amount of water stored in the fine-soil profile and decreased drainage amounts from the side slopes during the course of the year compared to previous years. The cumulative amount of water received by the barrier from November 1, 1994, through the end of September 2005, was 2,679.47 millimeters on the north half (formerly irrigated) and 2,006.60 millimeters on the south (non-irrigated) half.

Water storage in the Hanford barrier has never exceeded design capacity even during irrigation treatability tests.

Water Storage. Regular water storage measurements were made every year except FY 1999. These data show a well-defined annual cycle in water storage during the 3 years of the treatability test (November 1994 through October 1997). Although plants in both the irrigated and non-irrigated parts of the barrier were able to recycle most of the water intercepted by the barrier, the data show a divergence in the storage values at the end of each summer. On the south side, which was never irrigated, plants removed water to essentially the same minimum each year. Even though the plants on the irrigated north side were able to remove all of the water received, the lower limit of storage increased over time and was larger than the non-irrigated side. This may indicate a reduced ability of the irrigated plants to recycle water. This discrepancy between the north and south sides persisted for ~2 years after the cessation of irrigation. Nevertheless, the system has shown a complete recovery and the differences between the two sides have essentially disappeared. At the end of FY 2005, water storage on the north side was 109.45 ± 3.78 millimeters compared to 99.98 ± 3.14 millimeters in FY 2004. Storage on the south side was 105.84 ± 3.65 millimeters compared to 95.59 ± 3.53 millimeters in FY 2004. The lower storage at the end of FY 2005 reflects the reduced precipitation during the year. Nevertheless, these results are consistent with previous measurements with the storage at the end of the fiscal year being on the order of 100 millimeters. They also provide insight into the factors controlling performance. The prototype Hanford barrier was designed with a 2-meter silt-loam layer capable of storing ~600 millimeters of water, which is more than three times the long-term average precipitation (160 millimeters/year) for the Hanford Site. This capacity has never been exceeded by the barrier, even during treatability tests when the prototype barrier was irrigated. Results also emphasize the importance of choosing the right vegetation to enhance the function of capillary barriers. Native species are particularly resilient and appear capable of recovering from short-term stresses, such as those imposed by elevated precipitation.

Drainage. Figure 3.1-4 shows the cumulative drainage for the period November 1994 through September 2005 for the side-slope plots and Figure 3.1-5 shows the drainage from the silt-loam plots. In general, the north side-slope plots accounted for most of the drainage. Since 1994, the north (formerly irrigated) gravel plot has drained 21.83% of the total precipitation, essentially the same as the north rip-rap slope that drained 21.82%. In contrast, the south (non-irrigated) plots drained somewhat less. For the same period, the south gravel plot drained 18.82% of the total precipitation whereas the south rip-rap slope drained only 14.89%. Given the difference in precipitation treatments, the difference between the north and south plots is understandable. However, the difference in drainage between the non-irrigated, south plots is less intuitive given that both received essentially the same precipitation amounts and were exposed to the same meteorological situation. The discrepancy is attributed to water loss from the rip-rap slope due to wind action within the rock slope. The effect of low humidity air impacting the side slope is to evaporate water from the rock surfaces and pore space resulting in a reduced amount of water available for drainage. Perhaps a more important observation is the extremely low amounts of drainage from the soil-covered plots. From 1994 through September 2005, the soil-covered plots generated an average of 0.10 ± 0.08 millimeters/year drainage. This is in contrast to the 0.25 millimeters/year drainage criterion established for the prototype barrier. In contrast, the long-term rate from the north gravel and rip-rap plots was ~52 millimeters/year, over 200 times the drainage criterion. The effective rate on the non-irrigated gravel was 33.6 millimeters/year whereas the effective rate on the non-irrigated rip-rap slope was only 26.5 millimeters/year. Even then, none of this water would have entered the waste zone because of the presence of the asphalt layer at the base of the cover in the Hanford design.

The use of low-permeability layers and diversion layers in a surface barrier effectively reduces recharge to underlying waste.

These results clearly show the effectiveness of the soil-covered section in eliminating recharge and provide insight into the potential problems in the design of protective side slopes for above-grade barriers. The use of protective side slopes without an underlying low-permeability layer or a diversion layer will result in significant recharge to the underlying waste.

Table 3.1-1. Leachate Monitoring Results – Key Constituents

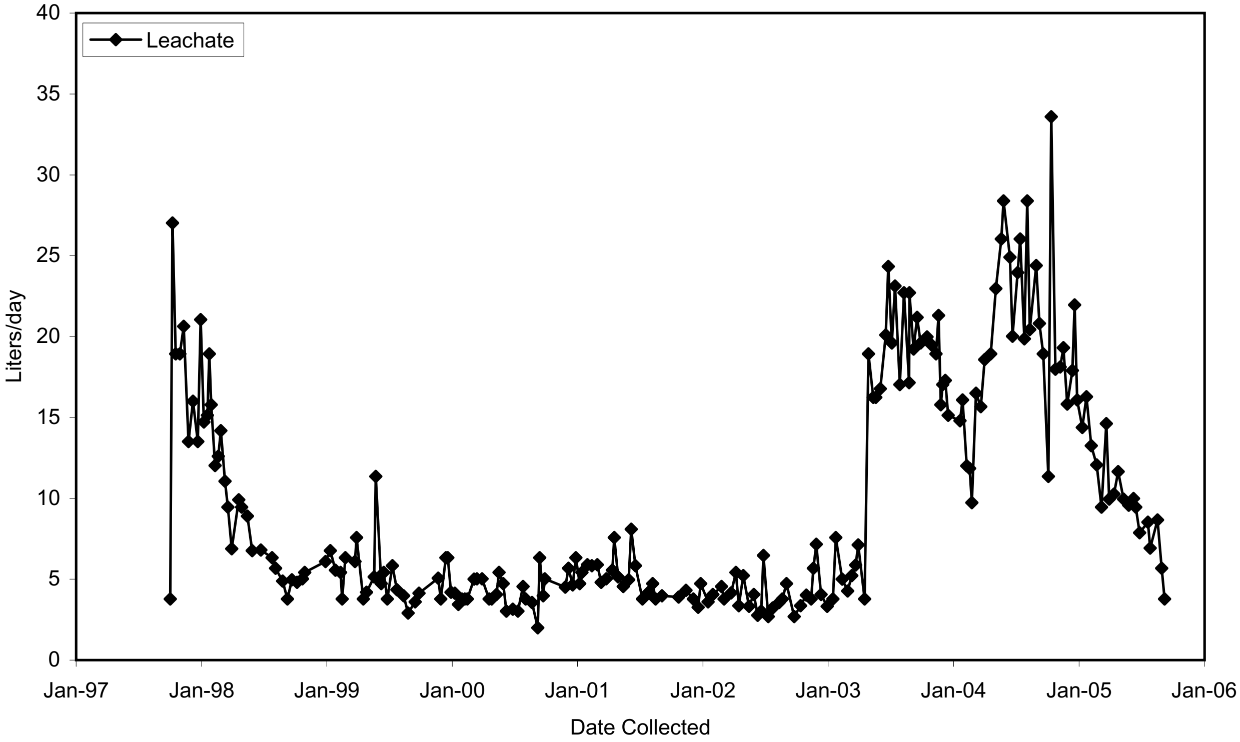
Parameter	Results by Quarter July-September 2004	October-December 2004	January-March 2005	April-June 2005
pH	6.96	6.79	6.97	7.0
Conductivity (µS/cm)	1,920	1,800	1,860	1,920
Sulfate (mg/L)	2.85	2.31	<1.50	<7.65
Chloride (mg/L)	227	245	231	214
Fluoride (mg/L)	0.325	<0.900	<0.180	0.918
Total dissolved solids (mg/L)	NT	NT	1,330	NT
Arsenic (µg/L)	NT	40.7	61	NT
Barium (µg/L)	572	481	519	NT
Manganese (µg/L)	1,340	1,320	1,380	1,380
Nickel (µg/L)	128	110	118	NT
Cadmium (µg/L)	NT	1.30	0.800	NT
Copper (µg/L)	NT	<3.30	<3.30	NT
Selenium (µg/L)	NT	<18.0	29.3	NT
Zinc (µg/L)	345	<3.0	1,360	<3.0
Iron (µg/L)	11,900	10,400	11,700	9,770
1,4-Dioxane (µg/L)	NT	NT	<10.0	NT
1,4-Dichlorobenzene (µg/L)	NT	NT	15.0	NT
Methylene chloride (µg/L)	NT	NT	1.80	NT
Tetrachloroethene (µg/L)	NT	NT	<1.0	NT

NT = Not tested.

Table 3.1-2. Carbon Tetrachloride Inventory in Primary Disposal Sites

Well Field	Estimated Mass Discharged, 1955 to 1973[(a)] (kg)	Estimated Mass Lost to Atmosphere, 1955 to 1990[(b)] (kg)	Mass Removed Using Soil-Vapor Extraction, 1991 to October 2005 (kg)
216-Z-1A	270,000	56,700	24,525[(c)]
216-Z-9	130,000 to 480,000	27,300 to 100,800	54,183
216-Z-18	170,000	35,700	--
Total	570,000 to 920,000	119,700 to 196,800	78,700

(a) Based on DOE/RL-91-32.
(b) Based on WHC-SD-EN-TI-101.
(c) Includes mass removed from 216-Z-18 site; reported as a combined value because the well fields overlap.



gwf05501

Figure 3.1-1. Leachate Collection Volumes at the Solid Waste Landfill

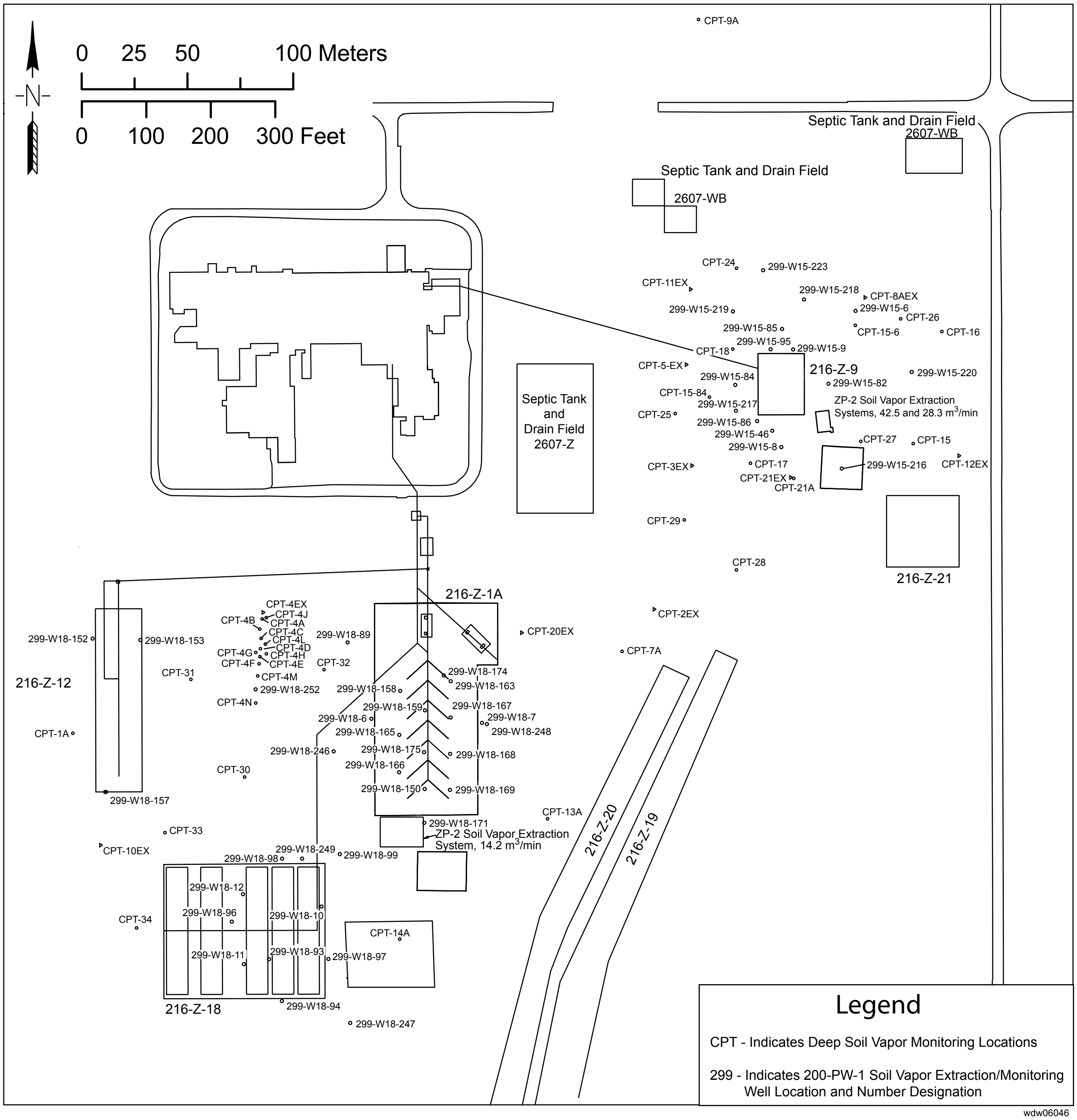


Figure 3.1-2. Locations of Carbon Tetrachloride Vapor-Extraction Wells at the 216-Z-1A/216-Z-12/216-Z-18 and the 216-Z-9 Well Fields

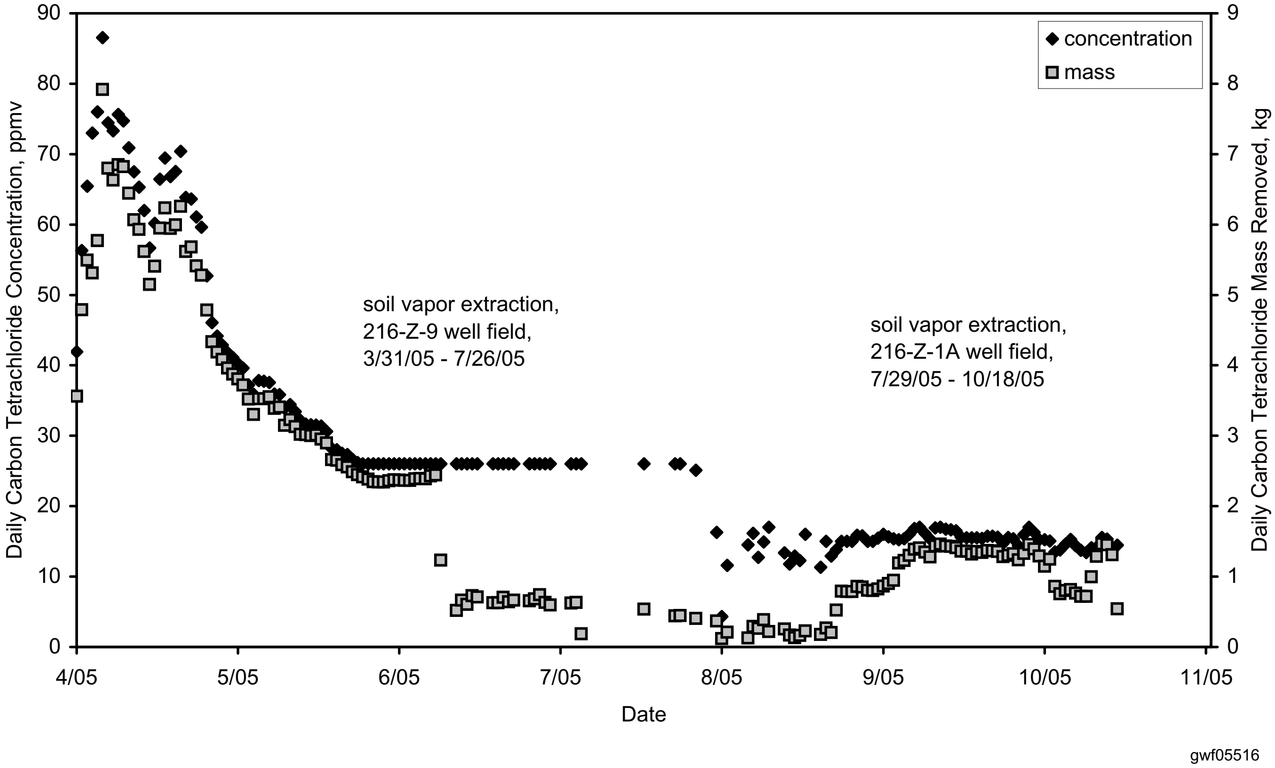


Figure 3.1-3. Time Series Concentrations and Mass of Carbon Tetrachloride in Soil Vapor Extracted from the 216-Z-1A/216-Z-12/216-Z-18 and the 216-Z-9 Well Fields

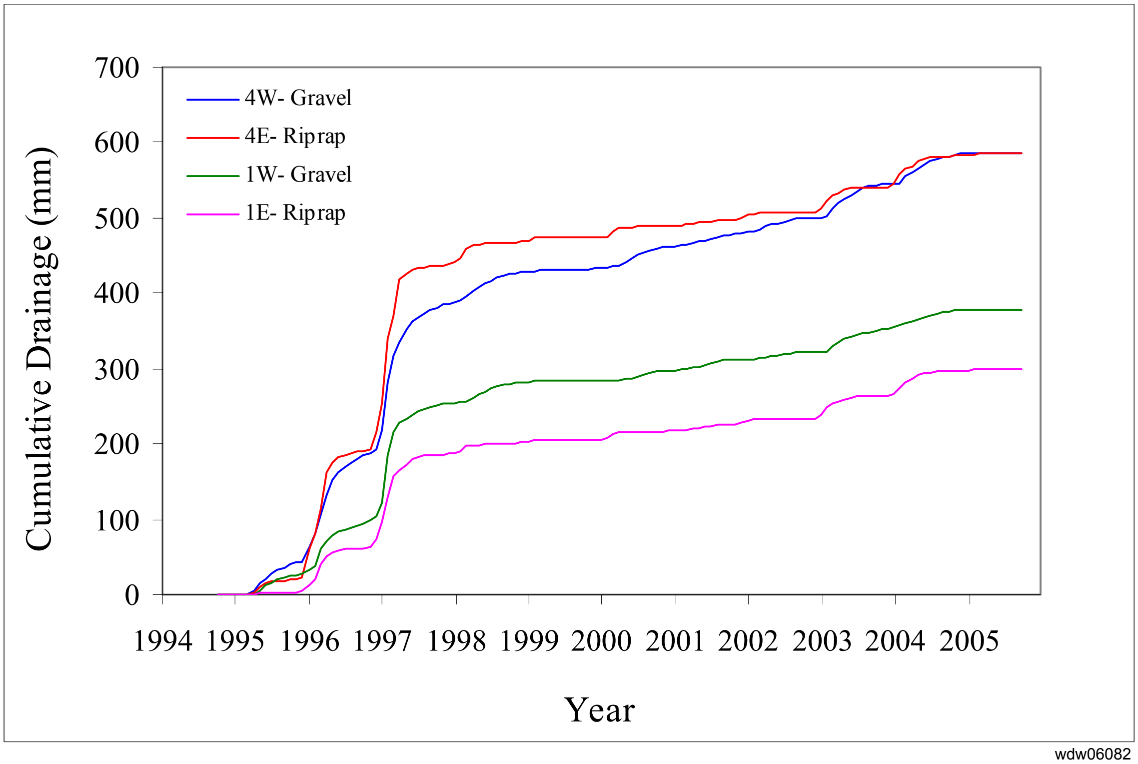
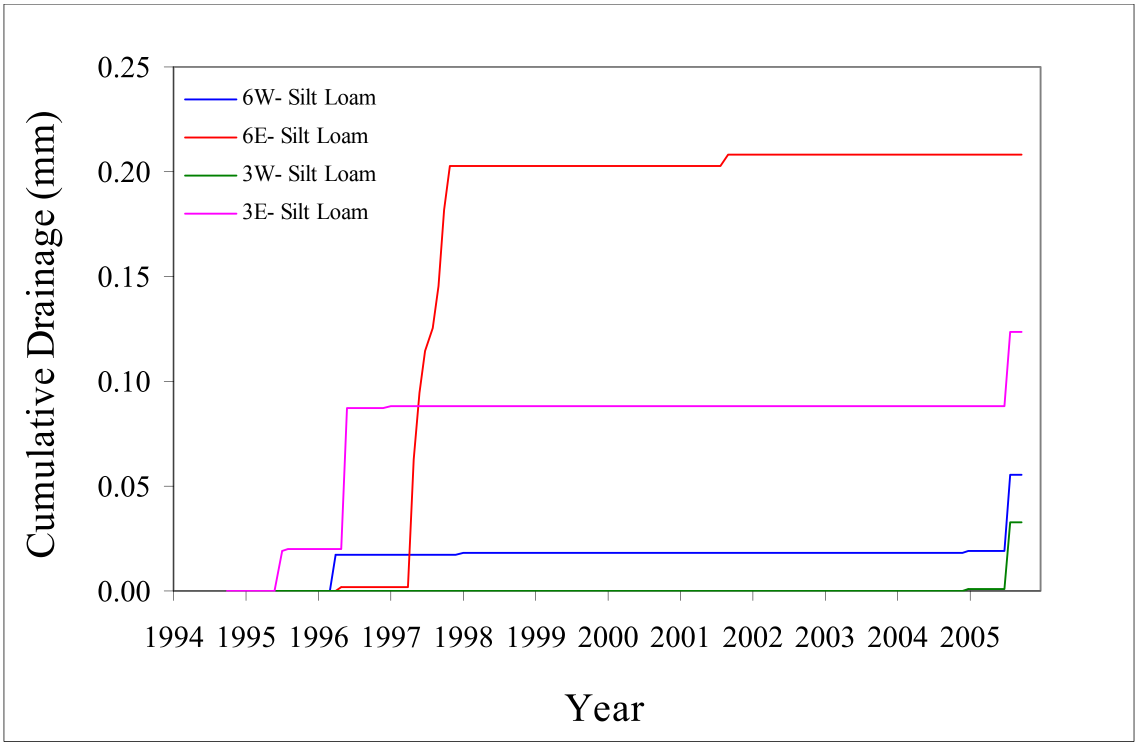


Figure 3.1-4. Cumulative Amounts of Water Diverted by the Asphalt Pad (drainage) from the Side-Slope Plots at the Prototype Hanford Barrier for the Period September 1994 through September 2005



wdw06083

Figure 3.1-5. Cumulative Amounts of Water Diverted by the Asphalt Pad (drainage) from the Soil-Covered Plots at the Prototype Hanford Barrier for the Period September 1994 through September 2005

3.2 Vadose Zone Characterization

D. G. Horton

This section describes characterization activities that occurred in fiscal year (FY) 2005. These characterization activities were done to further the understanding of physical and chemical properties of the vadose zone and vadose zone contamination and to delimit existing vadose zone contamination.

3.2.1 Tank Farm Vadose Zone Project Characterization Activities for FY 2005

D. A. Myers

Geophysical exploration of the T Tank Farm and surrounding areas was carried out to determine the extent to which surface resistivity techniques could be applied in the electrically complex tank farm environment. High resolution resistivity methods had been demonstrated in the 216-BC cribs area south of the 200 East Area. Extension of the technique to the tank farms holds promise of a cost-effective means of characterizing large areas. Initial results confirmed the electrical complexity of the tank farm but pointed toward supplemental work that holds promise for deconvoluting the data.

Characterization activities further the understanding of physical and chemical properties of the vadose zone. High resolution resistivity methods may prove effective for characterizing the vadose zone beneath single-shell tank farms.

A new approach to collecting vadose zone samples and providing access to geophysical logging tools was developed and implemented during investigations of the C and TY Tank Farms. This method uses a backhoe mounted hydraulic hammer to drive and rotate a nominal 7.6-centimeter, outside diameter, drill string to depth. Small-diameter gamma detectors are then lowered down the casing to determine the presence and distribution of gamma-emitting contaminants. The maximum depth to which this system is able to penetrate has not yet been determined, but depths of 21 meters have been reached. A second hole is driven to collect a single depth-specific sample for laboratory analysis. Work to be conducted during FY 2006 includes an assessment of this system's ability to drill at angles significantly off vertical.

Laterals beneath tanks in the A and SX Tank Farms were geophysically logged for the first time since 1988. A segmented string of small diameter gamma detectors was deployed to the ends of the laterals using a Pipe Explorer™ system to assure that the tools remained uncontaminated. Of special interest was the finding that several of the tanks suspected to be leaking had no indication of gamma-emitting radionuclides in the soils interrogated by the laterals. The results of the surveys are documented in RPP-RPR-27605.

A Field Investigation Report for Waste Management Areas T and TX-TY (RPP-23752) was prepared describing characterization efforts conducted by the CH2M Hill's Vadose Zone Project.

3.2.2 Geophysical Characterization at the BC Cribs and Trenches

M. D. Sweeney

Characterization of the BC cribs and trenches began in FY 2004 and continued in FY 2005 to support the 200-TW-1 Scavenged Waste Operable Unit feasibility study. The purpose of the characterization is to find the concentration and extent of subsurface contamination in the area. The location of the BC cribs is shown in Figure 2.10-1 in Section 2.10.

Geophysical surveys were completed by hydroGEOPHYSICS, Inc. and Pacific Northwest National Laboratory (PNNL) in two phases between March and April 2005. Several surface geophysical methods were used to map subsurface features within the BC cribs and trenches area. These methods included magnetic gradiometry, electromagnetic induction, high resolution resistivity, and induced polarization. A full report of the geophysical surveys and their results will be issued in the future. A summary is presented in the following paragraphs.

Characterization studies at the BC cribs and trenches help to determine the concentration and extent of subsurface contamination in the area.

The magnetic gradiometry and electromagnetic induction data showed several localized anomalies that were unrelated to any natural geologic phenomena. In particular, large responses were seen in both total field and magnetic gradient near monitoring wells. These wells had casings that could be identified at the surface. Other features could not be identified with certainty, but were expected to be abandoned pipeline networks that delivered liquid, mixed waste from the 200 East Area to the north part of the BC crib site. A specific goal for the electromagnetic survey was to delineate any shallow, electrically conductive soil that might interfere with the application or interpretation of the high resolution resistivity survey.

A total of 42 high resolution resistivity lines were acquired in and around the BC cribs and trenches site, totaling ~19 line-kilometers of coverage. The majority of the data were collected parallel and perpendicular to waste disposal sites that included sixteen trenches and six cribs. High resolution resistivity lines were extended south of the site to test a hypothesis that disposal of liquid waste, or migration of liquid waste, occurred outside of the disposal site boundaries. No evidence of waste migration outside of the site boundaries was discovered, but the high resolution resistivity data did provide geologic information about the uncontaminated natural sediments.

All of the resistivity data were compiled into two-dimensional contour plots and evaluated on a line-by-line basis in order to understand the characteristics of the changes in subsurface resistivity. Each high resolution resistivity line in the BC cribs area showed a marked decrease in apparent resistivity that could not be explained by the natural environment, especially considering the data collected outside of the site. The range of apparent resistivity data for measurements outside of the BC cribs area, from the surface to 60 meters below ground surface (bgs), was 600 to 1600 ohm meters. The values measured directly beneath the disposal units exhibited a large conductivity contrast that created a sharp anomaly with the background values measured outside of the BC cribs area. An inorganic plume that resulted from liquid waste disposal activities is the most likely explanation for the resistivity anomalies.

High resolution resistivity surveys at the BC cribs and trenches showed no evidence that waste has migrated outside the area boundary in the vadose zone.

Resistivity data collected directly over and parallel to waste disposal sites showed a plume that migrated vertically within the subsurface. The center of mass for the plume was ~30 meters bgs for each survey line. The results also showed that the plume had higher conductivity directly under the waste trenches or cribs and lower conductively away from a trench. High resolution resistivity data collected along lines perpendicular to trenches confirmed this observation. Zones of higher conductivity are seen to reach near-surface directly beneath a trench.

The data acquisition strategy included the idea that many closely-spaced high resolution resistivity lines could be combined to form a single pseudo-three dimensional plume of resistivity. Parallel lines were spaced ~15 meters apart to allow high spatial resolution so that interpolation could be completed with high confidence. Additionally, sufficient background data were collected immediately adjacent to the site so that the plume's geometry could be identified with accuracy. The resistivity data were first combined into two-dimensional slices at several depths using a kriging algorithm. Variogram analysis was completed to ensure that interpolation between high resolution resistivity lines was conducted with the best linear unbiased estimator. A horizontal slice at 32 meters bgs showed that the plume had spread to 8.09 hectares at approximately the 160 ohm-meter contour. It is believed that the majority of the conductive plume is bound by the 160 to 175 ohm-meter contours.

The three-dimensional interpolation was completed with an inverse distance algorithm. Volume estimates of the resistivity plume showed that an isopach between ~160 and 175 ohm meters would effectively represent the total effluent disposal volume of 118,000 cubic meters of liquid assuming a site-wide change in volumetric water content of 0.06 cm^3 cm^{-3}.

The mass of nitrate estimated from high resolution resistivity agrees well with the known disposed mass.

Soil samples, collected through the center of and near the 216-B-26 trench, were analyzed for soil moisture, electrical conductivity, inorganic chemicals, and a few radionuclides to verify the resistivity data. The highest spatial resolution came from borehole C4191, where soil samples were analyzed at intervals of 0.76 meter from the surface to the water table. These analyses were obtained from 1:1 soil:water extracts that, when corrected for moisture content, represented material within the pore space. The analytical data were compared to co-located high resolution resistivity data and relationships were developed to translate apparent resistivity to nitrate concentration.

The process for comparing resistivity to nitrate concentrations first involved compiling the resistivity data into a three-dimensional data set. Regression analysis of coincident resistivity and borehole C4191 data, as described above, provided the parameters to relate high resolution resistivity data to nitrate concentrations. An isopach map of the converted concentrations was plotted and each cell in the plot domain was converted to nitrate mass. That nitrate mass was calculated using the known plot cell volume, an assumed moisture content, and the derived nitrate concentration from the regression analysis. The calculated mass from this process was compared to reported discharge volumes. The modeled plume volumes agreed well with the known discharge volumes.

3.3 Vadose Zone Studies — Fiscal Year 2005

D. G. Horton

This section summarizes the activities and results of several technical studies done at the Hanford Site in fiscal year (FY) 2005 to better understand the vadose zone sediment, vadose zone hydrology, and contamination. These studies are designed to result in new, innovative methods for cleanup and monitoring at the Hanford Site. These studies included modeling of contaminants beneath specific past-practice disposal facilities and comparison of the modeling results with data derived from characterization efforts; experiments and modeling to improve estimations of infiltration and recharge at the Hanford Site; and laboratory experiments of potential remediation methods for immobilizing contaminants in the vadose zone.

Many of the inputs to this section have been edited somewhat to address a broad audience. The reader interested in more experimental or theoretical detail is encouraged to contact the individual authors.

Vadose zone studies are designed to result in new, innovative methods for cleanup and monitoring.

3.3.1 Conceptual Model for Vadose Zone Transport of Technetium-99 at the BC Trench Site

A. L. Ward

The BC cribs and trenches in the Hanford Site's 200 East Area are believed to have received ~113.5 million liters of scavenged tank waste containing an estimated 400 curies of technetium-99 as well as large quantities of nitrate and uranium-238 mostly between 1956 and 1957. The lack of strong evidence for these contaminants having reached the groundwater raised concerns about the accuracy of the inventory as well as the conceptual model for migration of the discharged waste fluids and contaminants. These issues had to be resolved before a remediation plan could be developed and evaluated. Resolution of these issues was accomplished by conducting a detailed analysis of transport at the site, which requires development of an accurate conceptual model. The purpose of this study was to develop a conceptual model for contaminant fate and transport at the 216-B-26 trench site to allow interpretation of the current contaminant distributions and to support identification, development, and evaluation of remediation alternatives.

A conceptual model was developed to help identify technetium-99 distribution beneath the BC cribs and trenches in the 200 East Area.

In developing the conceptual model, the presence of large concentrations of technetium-99 and nitrate high above the water table, inferred from borehole C4191, implicated stratigraphy as an important control of downward contaminant migration (see Section 3.2.2). The resulting conceptual model, therefore, included (1) small-scale stratigraphy and changes in physical and chemical properties, (2) tilted layers to accommodate the natural slope of the formation, and (3) lateral spreading along multiple strata with contrasting physical properties. Flow and transport properties were derived using physically based pedotransfer functions that were coupled with high-resolution neutron moisture logs taken on a vertical spacing of 7.6 centimeters. Heterogeneity in the longitudinal and transverse horizontal directions was incorporated by using geostatistical methods to overlay the spatial correlation structure of flow variables from the well-characterized 299-E24-111 test site, also in the 200 East Area, onto the simulation domain. The Subsurface Transport Over Multiple Phases (STOMP) simulator was used to predict infiltration and redistribution of wastewater and dissolved contaminants transported through the vadose zone and into a 5-meter-thick unconfined aquifer during transient multidimensional flow.

Model simulations showed that small-scale stratigraphic differences led to considerable anisotropy in flow in the vadose zone with much of the discharged water and contaminants spreading laterally in the shallow subsurface. Simulations were in agreement with field observations that showed the peak concentrations in technetium-99 between 25 and

45 meters below ground surface (bgs). A non-invasive geophysical survey using high resolution resistivity showed a zone of low electrical resistivity (high conductivity), which can be interpreted as a high pore-water concentration of an ionic salt such as nitrate, in the same depth interval (see Section 3.2.2). Nitrate and technetium-99 are both very mobile in geologic media and have been reported to migrate at similar rates. Thus, it is quite reasonable to conclude that the region of high electrical conductivity is also indicative of high pore-water concentrations of technetium-99. Figure 3.3-1 shows the STOMP predicted technetium-99 distribution resulting from discharges to the seven trenches 216-B-23 through 216-B-28 and 216-B-52. Spatial moment analysis shows the center of mass of the predicted technetium-99 plume at the location of well C4191 (at trench 216-B-26) is essentially the same as predicted from the field observations. A band of elevated technetium-99 was at a depth of 20 to 40 meters. A peak concentration of 2×10^6 pCi/L occurred at around 30 meters bgs in both the observed and predicted profiles. (For comparison, the water table is at ~100 to 105 meters bgs.) Figure 3.3-1 shows an overlay of the measured distribution of electrical conductivity, associated with nitrate. Resistivity ranged from ~80 to 140 ohm meters, also in a depth interval of 20 to 40 meters bgs. Qualitatively, the predicted technetium-99 and resistivity distributions are in very good agreement.

Having successfully predicted the current distribution of the contaminant plume, the model was then used to predict future migration and evaluate remedial options. Simulations were performed to compare a no-action alternative, assuming current estimates of recharge rate, with a capping remedy in which a surface barrier would be put in place by 2010 to limit recharge 0.1 millimeter/year. Predictions showed that future leachate concentrations reaching the water table would exceed the drinking water standard under a no-action alternative. Capping would successfully reduce the threat to groundwater through an increase in residence time of technetium-99 in the vadose zone and a reduction in mass flux to the water table. The reduction in mass flux coupled with dispersion in the groundwater will reduce concentrations reaching a hypothetical downgradient receptor well to values below the maximum contaminant level.

Chloride mass balance has been used at the Hanford Site to estimate recharge rates.

3.3.2 Use of Chloride Mass Balance to Estimate Recharge at the Hanford Site: Recommended Procedures

G. W. Gee, J. M. Keller, Z. F. Zhang, and R. J. Serne

For nearly two decades, chloride mass balance has been used at the Hanford Site to estimate recharge rates. Chloride is a good tracer for recharge because it is readily found in rainwater and atmospheric fallout, and it is an easy element to analyze and can be removed from soil samples through simple extraction methods. Soil samples are brought into the laboratory where the chloride is extracted in a water extract that is typically 1:1 (water: soil) and then subsequently analyzed for chloride. In the past, where samples were high in chloride, the water extracts were diluted to keep the chloride within the calibration range of the analytical instrument. Extracts in the range of 2:1 and 3:1 have been reported in the literature. Results from this study show that high dilutions may be a source of error and suggest that coarse sand samples at Hanford never be extracted at levels beyond 1:1. Several other recommendations for standardizing the chloride mass balance method are made.

Many Hanford formation soil samples have field water contents in the range of 0.025 to 0.05 g/g. At a water content of 0.025 g/g, the dilution factor of a 1:1 extract is 40. This means that the extract chloride concentration must then be multiplied by 40 to get the pore water chloride concentration. A 2:1 extract would have a dilution factor of 80 and a 3:1 extract would have a dilution factor of 120. In a case where the actual pore-water concentration of a sample is 1 mg/L, a 1:1 extract would make the chloride concentration in the extract approach the detection limit of the analytical instrument used in most studies at the Hanford Site. Any extracts more dilute than 1:1 (i.e., 2:1 or 3:1) would clearly push chloride below the instrument detection limit.

The use of pore-water extracts works best at high-chloride concentrations and low recharge rates because, as the chloride concentration approaches the detection limit of the analytical method, analytical errors significantly increase the uncertainty of the recharge estimate (Tyler et al. 1999). Also, at low concentrations, systematic contamination of sample and extracts can become an important source of error. In addition, treatment of a soil low in chloride with deionized water used in the extract process can potentially dissolve mineral chloride (Murphy et al. 1996). Another consideration for soil with significant clay content is the possibility of anion exclusion, which could adversely affect the recharge estimate (Gee and Hillel 1988). The impact is greatest when the water content is lowest. For clay-rich soils, pore-water samples obtained from direct extraction (e.g., centrifugation) would be affected the most.

Two suites of tests were performed in FY 2005 to understand the causes of variability in chloride contents that have been measured in water extracts of Hanford Site sediment. Although the key parameter desired is the concentration of chloride in vadose zone pore water, this study focused on measuring the total water extractable chloride because this value is not dependent on the moisture content of the sample. This avoids complications caused by drying during sampling in the field, during storage, and during preparation of the water extract tests.

Two groups of tests were performed in FY 2005 to understand the causes of variability in chloride contents that have been measured in water extracts of Hanford Site sediment.

In the first suite of tests, aliquots of sediment from the Hanford Site 300-N lysimeter were tested in three moisture states: as received (3.94%wt ± 0.03%wt), air-dried (1.16%wt ± 0.02%wt) and oven dried. A large, old oven with high air circulation was used for oven drying 300-N lysimeter sediment used in the suite 1 tests.

Chloride was extracted from aliquots of each sediment with deionized water at a solution-to-solid ratio of 1:1 for 1 day [1-day tests]. The samples were then gently shaken for one hour and settled overnight before filtering for analysis. Some of the air dried sediment was also extracted at 2:1 and 3:1 water:soil ratios. Also, some samples were extracted at longer contact periods where they were shaken for several hours and settled for ~40 to 44 hours [called 2-day test] or for ~166 hours [called 7-day test]. In addition, some of the 300-N lysimeter sediment was placed in special two balanced UFA cells and ultracentrifuged to extract actual pore water.

The same 300-N lysimeter sediment was used for the second suite of tests with two moisture contents: 3.42%wt ± 0.13%wt moisture and oven dried in a new and clean oven. The oven dried samples were added to the second suite because of suspected contamination from the old oven used in the first suite. The only solution used was deionized water and two solution-to-solid ratios were studied for the as-received sediment, 0.5:1 and the standard 1:1. The contact times were the standard 1-day test, a 3-day test, and a 6-day test. A commercial quartz sand, sieved to be <50 and >70 mesh and with air-dry moisture content of ~<0.05%wt moisture was included in the second suite.

Oven drying of the sediment appears to have caused the release of significantly larger amounts of chloride from the sediments than found for field moist and air dried sediment for the 1-day tests (Figure 3.3-2). The field moist and air dried samples released about the same amount of chloride given the variability in the replicates (see error bars in Figure 3.3-2). After 1 day of contact, the effects of varying the solution-to-solid ratio were not significant (Figure 3.3-2). There does appear to be significantly more (~44% more) chloride extracted from the 3:1 sample after 7 days of contact time (Figure 3.3-3).

The second suite of tests evaluated whether the impact of oven drying observed in the first suite of tests was real or could be attributed to contamination from the drying oven. All the oven dried sediments used in the second suite of tests were dried in the new oven.

Figure 3.3-4 shows the data for water extractions of the 300-N lysimeter sediment in the second suite of tests. The arrows represent one standard deviation uncertainty in triplicate measurements. There is no clear trend between the field moist sediments for the two different solution-to-solid extractions given the variability in replicates. There also is no statistically significant trend in the contact time for the extractions. Again, oven drying does seem to lead to higher amounts of extracted chloride, although the differences are less than for the first suite of tests.

Figure 3.3-5 shows the chloride extracted from the commercial quartz sand. There does not appear to be any significant difference in extractable chloride as a function of extraction time but, again, oven drying leads to higher extractable chloride concentrations. Figure 3.3-6 shows the extractable chloride from quartz for both oven corrected and non-corrected samples.(a) The data in Figure 3.3-6 suggest that there may be a true difference between the amounts of chloride extracted from oven-dried quartz and air-dried quartz even after correction for oven "contamination." The reason for this difference is not known.

Based on this study, oven drying sediment prior to chloride extraction is not recommended for the chloride mass balance method.

Figure 3.3-7 combines the data sets from suites 1 and 2 tests. Given the variability in data for replicates, there does not appear to be any significant statistical differences in extractable chloride resulting from different solution-to-solid ratios. Contact time also does not seem to be a significant factor in chloride extraction. Oven drying of both 300-N lysimeter soil and commercial quartz seems to cause larger concentrations of extractable chloride than air dried treatment and the reason for the differences remains unknown.

The recharge rate at the 300-N lysimeter was determined from the chloride content of pore water in the suites 1 and 2 sediments assuming an average precipitation of 190 millimeters/year and an average chloride input of 0.225 mg/L. The average recharge rate predicted by the chloride mass balance method is ~13 millimeters/year for suite 1 samples (Table 3.3-1) and ~11 millimeter/year for suite 2 samples (Table 3.3-2). The measured lysimeter drainage (recharge) was ~62 millimeters/year. The ratio of measured to predicted recharges ranged from 3 to 13. The pore water chloride concentration required to achieve a recharge rate of 62 millimeters/year is 0.7 mg/L, while the average measured pore-water chloride was 4.7 mg/L and 3.9 mg/L for Tables 3.3-1 and 3.3-2.

Based on the results of this study, the following steps should be standardized and be part of the procedure when applying the chloride mass balance method for determining recharge rates:

- Special care should be taken to accurately measure field moisture content and to preserve the sediment samples to be used for chloride extraction.
- The containers to be used to store the sediment must be "moisture proof" and chloride-free.
- The extraction containers should be pre-cleaned to remove any incidental chloride contamination.
- Field and laboratory personnel should be careful not to touch the sediment with their hands to avoid adding chloride.
- Oven drying the sediment prior to performing water extractions is not recommended.

The ideal solution-to-solid ratio for chloride extraction was not determined by this study; however, for sediment similar to 300-N lysimeter sediment where recharge has been quite high, the concentration of chloride found in 1:1 soil extracts was ~0.12 μg/mL and procedure blanks were ~0.024 to 0.03 μg/mL. The instrument detection limit is ~0.02 μg/mL. A

(a) The oven correction was made by evaporating 5 milliliters of deionized water from clean beakers in each oven. The beakers were then rinsed with 5 milliliters of deionized water and the rinsate analyzed for chloride. The chloride content of the rinsate was used as the correction factor.

solution-to-water ratio larger than 1:1 is not recommended because greater dilutions could bring the chloride concentration below the detection limit. It is also recommended that the contact time for sediment in the water be kept to 3 days or less and that the slurry be gently shaken for periods of time that allow for settling overnight before filtration.

For sediments with suspected recharge rates larger than the 300-N lysimeter, it may be necessary to use clean-room protocols such as laminar flow hoods, pre-cleaned containers, and use of clean (chloride free) gloves and masks by the workers to avoid adding chloride to the samples or containers used in the extractions.

For sediments with much lower recharge rates than found at 300-N lysimeter, the typical chloride peak within the top 50 meters of the sediment may require some further study to determine the optimum solution-to-solid ratio, slurry shake time, and total contact time to remove pore water chloride. It appears that for lower recharge sediments, the chloride procedure blank, pre-cleaning of containers, and use of clean-room techniques may not be necessary because the pore water chloride peak is much larger than the few parts per million found in the 300-N lysimeter sediments, and corrections become immaterial to the measured peak chloride concentrations.

3.3.3 Correcting Hydraulic Properties for the Effects of Gravel

Z. F. Zhang, A. L. Ward, and J. M. Keller

Gravel and cobbles make up significant portions of Hanford Site sediment and are suspected to be partly responsible for the differences between the hydraulic and geochemical properties measured in the laboratory and in the field as well as properties measured on whole versus repacked sediments. The discrepancy is due mostly to the fact that laboratory measurements are typically made on sediment fractions that pass through a 2-millimeter sieve. Over the years, there have been several attempts to correct physical, hydraulic, and geochemical properties for gravel content. The approach currently used at the Hanford Site is one that assumes that the porosity, saturated hydraulic conductivity, the distribution coefficient (k_d), and cation exchange capacity all decrease linearly with increasing gravel content and that gravel has no effect on the hydraulic properties. However, there is increasing evidence that this assumption is only valid if the gravel content is less than a critical value.

This study shows that there is a critical fraction of gravel at which saturated hydraulic conductivity and porosity reach a minimum.

During FY 2005, a number of experiments were conducted to quantify the effect of gravel on the physical and hydraulic properties. Bulk density, porosity, saturated hydraulic conductivity, and water retention properties were measured on samples composed of both coarse- and fine-grained sediments representative of mixtures of Hanford Site gravel and the sediment passing a 2-millimeter sieve. In place of the current linear correction, a mixing model was proposed to describe the mixing level of the binary system. Based on these results, equations were derived to determine the porosity of the mixtures. A power-averaging method was developed, with the power being a function of gravel content, to determine the effective grain size and further to predict the saturated hydraulic conductivity of a mixture of two components.

The results showed that there exists a critical gravel content, f_c, that determines whether a sediment mixture is gravel supported, i.e., a coarse-grained network with very few fine grains, or matrix supported, i.e., very few particles with a diameter >2 millimeters dispersed in a fine-grained matrix. When the gravel content is less than f_c, the bulk saturated hydraulic conductivity decreases slightly with the increasing gravel content due to a decrease in porosity; when the gravel content is greater than f_c, the bulk saturated hydraulic conductivity increases sharply by as much as a few orders of magnitude with increasing gravel content.

The proposed gravel correction method can also accurately predict the bulk saturated hydraulic conductivity for the full range of gravel contents, a limitation of current models.

Figure 3.3-8 shows the measured and predicted porosities and saturated hydraulic conductivity of mixtures of 5-millimeter glass beads and 20-30 mesh Accusand. As observed in the data, there is a critical fraction of gravel at which saturated hydraulic conductivity and porosity reach a minimum. This fraction also corresponds to a maximum in bulk density. These data clearly show that the widely used linear correction is inappropriate for the majority of Hanford Site sediments. The incomplete mixing model is able to predict the desired properties over the entire range of mixtures. At present, this approach is applicable to the ROCSAN database that reports a mud fraction and a coarse-grained fraction. Work is ongoing to extend this approach to handle tertiary mixtures, which would be applicable to the typical sand, silt, and clay contents determined from traditional particle size distributions and to quaternary mixtures that would consider gravel in addition to the sand, silt, and clay fractions.

3.3.4 Estimation of the Hydraulic Properties of the Hanford Site's Grass Site Using STOMP-W-I

Z. F. Zhang, A. L. Ward, and M. D. White

A new method to relate field-measured hydraulic parameters to the scale typically used in modeling reduces errors in vadose zone flow and transport model.

Accurate field-scale predictions of flow and transport through the Hanford Site vadose zone have often been hampered by insufficient and uncertain hydraulic property information. Part of the uncertainty is due to a disparity between the typical scale at which hydraulic properties are measured (10^{-3} m^2) and the typical model grid block (1 m^2) to which these measurements are applied. Inverse modeling of field-scale experiments have proven useful for estimating field-scale parameters with the resulting parameters incorporating all of the local heterogeneities that are ignored in applying laboratory measurements directly to the model grid block. However, determination of the soil hydraulic parameters of layered soil remains a challenge since inverting too many parameters can lead to non-uniqueness of parameter values. A parameter scaling method is proposed that reduces the number of parameters to be estimated. Parameter scaling factors are determined using local-scale parameter values. By assigning scaling factors to the corresponding soil textures in the field, the reference hydraulic parameter values at the field scale can be estimated through inverse modeling of well-designed field experiments. Parameters for individual soil textures are then obtained through inverse scaling of the reference values using relationships between reference values and the specific values for each texture.

The proposed method was applied to estimate the hydraulic properties of the Hanford Site's grass site, located in the 300 Area, using data from an infiltration-drainage experiment conducted in the 1980s. A new tool to estimate parameters was developed by creating an inverse extension to the water operational mode of the STOMP simulator. This extension is designated as STOMP-W-I and uses the inverse modeling program, UCODE, for parameter estimation from flow and transport measurements. Field-scale parameters derived from inverting the data from the field experiment were then compared to laboratory-measured properties for predicting field-scale flow with STOMP-W. The results show that simulation errors were significantly reduced after applying parameter scaling and inverse modeling. When compared to the use of local-scale parameters, parameter scaling reduced the sum of squared weighted residuals by 96%. A comparison of the observations and the predictions of water content and pressure head using the field-scale parameter values determined inversely based on the parameter scaling concept is shown in Figure 3.3-9.

3.3.5 Sparse Vegetation Evapotranspiration Model for STOMP-WAE

A. L. Ward, M. D. White and Z. F. Zhang

The tight coupling of transport processes between the atmosphere and the soil surface and between the soil surface and the subsurface complicates the design and analysis of field-scale vegetated engineered barriers. Long-term performance analysis based on uncoupled or loosely coupled models can introduce significant uncertainty, particularly when trying to optimize the amount of fine-grained soil needed for the storage layer. Undoubtedly, such uncertainty is compounded when the uncertainty in climatic conditions and characteristics of the sites to be covered are taken into account. Over the last few years, work has been ongoing to develop a barrier extension to the water-air-energy mode of the STOMP simulator for applications to barrier design and performance assessment. The ideal model should be capable of supporting barrier design and performance assessment within the complex interaction of physical, hydrologic, and biotic processes at the site of interest. The existing STOMP water-air-energy (STOMP-WAE) version was modified to simulate barrier performance by including a soil-vegetation-atmosphere-transfer scheme (SVAT) based on a sparse vegetation evapotranspiration model. This extension, water-air-energy-barriers (STOMP-WAE-B) provides the needed scientific tool to design and evaluate candidate barriers for the Hanford Site.

During FY 2005, a barrier extension was added to the water-air-energy mode of the STOMP computer simulator. This new scientific tool will help scientists design and evaluate surface barriers for the Hanford Site.

In FY 2005, the final release of version 1.0 was made available to users along with a user's guide that includes a suite of verification problems and a benchmark simulation in which STOMP-WAE was compared with seven public domain codes currently being used for barrier design and performance assessment. This section provides a brief overview of the main features of the code and compares simulation results with field observations from an experimental site located in the Hanford Site 300 Area near the 300-N lysimeter facility.

The modifications made to STOMP can calculate water mass, air mass, and thermal energy across a boundary surface and the root-water transport between the subsurface and canopy and between the canopy and the atmosphere. The model solves sets of nonlinear conservation equations for water mass, air mass and thermal energy at the ground surface, plant leaves, and canopy. The subsurface equations are coupled to the surface evapotranspiration equations as a boundary condition, whose effects affect deeper subsurface nodes according to the distribution of plant roots. The sets of equations differ, depending on whether the ground surface is bare or vegetated. The model can also account for the rainfall interception and condensation on the canopy. When these processes are included, the water mass conservation equation at the plant leaves changes from steady-flow to transient, including plant-leaf storage of water.

For model validation, a series of eleven verification problems related to infiltration, redistribution, evaporation, and transpiration in homogeneous and layered soils was simulated. Comparison of simulation results with published analytical and numerical solutions and experimental results demonstrates that STOMP is able to describe the dynamics of mass and energy transport over a range of meteorological and soil conditions with or without plants present. The model was also used to simulate the water balance at the grass site located in the Hanford Site 300 Area. Water balance measurements were made at this site starting in 1983 and the vegetation was characterized with respect to ground cover and root characteristics in 1986 and 1987. The site was simulated with a one-dimensional soil domain assumed to be comprised of four layers. Thermal properties were estimated using particle size distributions and the water retention function using published pedotransfer functions. Soil albedo was estimated using the soil Munsell color approach and the dependence of soil albedo on moisture was simulated using an algorithm that considers the solar altitude and aqueous water saturation. For this simulation, the Cass et al. (1984) thermal conductivity model with enhanced isothermal and thermal vapor diffusion was used.

Figure 3.3-10 compares the simulated and observed water storage in the 0 to 1 meter soil depth in 1983. In general, predicted water storage shows very good agreement with the field observations in terms of the temporal distribution and the absolute values. The discrepancy between the predicted and observed results during the first 50 days or so of the simulation is due perhaps to the lack of a feedback mechanism between atmospheric and hydrologic conditions and plant growth. The underestimation in the model predictions of storage in the first 30 days could be due to a combination of factors. These include higher predicted evaporation rates and a more gradual start to actual plant water uptake. For this simulation, we specified the beginning of plant activity to be day 55 with a step change in leaf area index and water uptake. Qualitatively, it appears that a later start in the plant developmental cycle coupled with a gradual increase in the leaf area index rather than the currently assumed step increase would eliminate the discrepancy during the first 130 days. Plant growth ceased around day 160 with the plants going into flowering-induced dormancy. The decline in storage was similar to that of the field observations reaching a minimum of 5.55 centimeters by day 287. Both the values and their timing agree well with the observed increase in water accumulation which occurred around day 294 (October 21) when the storage was 5.04 centimeters. The onset of fall and winter led to a sharp increase in water storage. This increase is consistent with increasing precipitation, reduced evaporation, and the cessation of transpiration by plants. Given the lack of precise data on the root distributions and canopy structure, the agreement between the measured and predicted water storage is quite remarkable.

Model results highlight the importance of having site-specific plant and hydraulic property data.

Figure 3.3-11 shows the water balance components for the site. The total precipitation for the year was 278.4 millimeters and over 50 millimeters of drainage was calculated from changes in measured water storage. This value compares well with the predicted 53.19 millimeters, which is equivalent to 19% of total precipitation. Cumulative actual evaporation was 229.5 millimeters, or 82% of precipitation, while cumulative actual transpiration accounted for 34.5 millimeters or 12.4% of precipitation. These results show that even though precipitation was almost 70% more than normal, only a small fraction penetrated beyond the root zone to become percolation. These simulations were conducted without any calibration beyond the depth to which hydraulic properties were estimated from field measurements. Nevertheless, these results indicate that STOMP-WAE adequately incorporates the mechanisms to allow simulation of the field water balance from basic meteorological, soil, and plant data. These results highlight the importance of having site specific plant and hydraulic property data in order to accurately represent site water balance. Cheatgrass and Sandberg's blue grass were most active when available water was highest and the structure of the root systems allowed them to maximize water uptake following precipitation events. The grasses were limited in their ability to extract water from deep in the profile and as a result there was deep drainage from the root zone. There is considerable evidence from the 200-BP-1 prototype Hanford barrier that a combination of shallow-rooted grasses and deep-rooted shrubs are needed for effective control of deep percolation.

3.3.6 Image Analysis for Detecting Change in Vegetation Cover

A. L. Ward and G. H. Seedahmed

Plant type, percent ground cover, and plant leaf area per unit of ground area are important characteristics of shrub-steppe ecosystems needed to predict the transport of water, gas, and energy between the subsurface and atmosphere in arid environments such as the Hanford Site. This information, along with meteorological data and site-specific lithostratigraphy, can be used with numerical models of water mass and thermal energy transport to predict recharge rates in waste management areas. The STOMP-WAE operational mode was recently extended to allow prediction of recharge rates using site-specific meteorological and plant data as inputs. This approach can provide information about recharge rates, prior to waste site operations, that is needed to establish the initial conditions for transport models.

However, plant input data for pre-waste site operation are mostly unavailable. One solution to this problem is to characterize plant distributions using remotely sensed data such as aerial or satellite images. Aerial photography is a well understood technology that is often the only accurate historical record of the conditions at waste sites. In relation to vegetation characteristics, image texture is correlated with canopy structure, but factors such as differences in canopy closure, shadows, and plant density are complicating factors in this type of analysis. The objective of this study was to investigate the feasibility of estimating the amount of vegetation from aerial photographs. High-resolution aerial photographs of the Hanford Site are perhaps the only unbiased records of surface changes at waste sites over the years. During FY 2005, a study was undertaken to develop an algorithm that could use aerial photos to identify shrubs and to calculate the number of plants per unit ground surface.

The algorithm, based on a combination of scale-space and mutual information, characterizes the statistical relationships between neighboring pixels of aerial photos. Scale-space analysis is a method for the multi-scale representation of an image from which the scale-dependence of texture can be inferred. First order (maximum, minimum, mean, range, and standard deviation) and second order (correlation, variance, angular second moment) measures of texture can also be determined. To test this algorithm, we used aerial photos from the 200-BP-1 prototype Hanford barrier (Figure 3.3-12). For this analysis, the surface was divided into four equal quadrants, each of which was treated as a sub-image.

Aerial photography can be used to estimate vegetative ground cover for input to water balance models and recharge prediction.

Each sub-image was processed and the image texture used to distinguish shrubs from bare ground, grass, and shadows. Figure 3.3-13 shows the results for the sub-image of the top right quadrant. These results show that the algorithm is capable of differentiating shrubs from bare ground and in so doing, also delineate the canopy. The latter is an important step in estimating leaf area per unit ground area, an index that is needed for models simulating the effects of plant water uptake on recharge.

To evaluate the accuracy of the new photogrammetric method, the estimated shrub cover was compared to manual measurements of ground cover (Table 3.3-3). In general, there was good agreement between the texture-based estimate and the manual measurements. For example, on the northeast plot, the textured-based method estimated a ground cover of 29% compared to a measured value of 33%. The mean cover for the entire north (formerly irrigated) section of the 200-BP-1 barrier was 31.2 ± 3.0% from the image-based method compared to 36.78 ± 17.96% for the manual method. On the south side of the 200-BP-1 barrier, which has received only ambient precipitation, shrub cover was 27.5 ± 1.3% from the textured-based method compared to 33.75 ± 16.57% from the manual method.

The texture-based method appears to underestimate shrub cover relative to the manual method but this is not necessarily indicative of an error in the texture method. Manual surveys at the barrier are based on the Daubenmire method in which canopy cover is visually estimated as a vertical projection of a polygon drawn around the extremities of each plant. This method has been reported in the literature to overestimate ground cover. A unique feature of the texture-based method compared to other automated methods is the ability to suppress the shadow induced by differences in plant heights and lighting. This allows automatic differentiation between the actual plant and the shadow.

Aerial photography has proven to be a useful tool to retrieve historical data about waste sites. These results show that such photographs can also be used to estimate vegetative ground cover needed for input into water balance models used to predict recharge. Application of an automatic texture segmentation algorithm to such images yields very consistent estimates of vegetative cover that overcome most of the shortcomings observed in previous algorithms. The method is currently being applied to the 300-FF-5, 100-N, and BC trenches to document vegetation changes over time and to estimate ground cover for use in recharge predictions.

3.3.7 Use of Ground Penetrating Radar to Delineate Subsurface Heterogeneity in the 300-FF-5 Operable Unit

A. L. Ward and W. P. Clement

Heterogeneity and anisotropy in natural sediments are caused by depositional processes. The resulting sedimentary facies are three-dimensional bodies with distinct textural, structural, and lithologic features that reflect changes in sediment transport and depositional mechanisms. Thus, subsurface formations, such as those in the Hanford Site's 300-FF-5 Operable Unit, are highly variable with heterogeneities at scales ranging from millimeters to tens of meters. Variations in lithology and stratigraphy are typically accompanied by a wide range in mean grain diameter and grain sorting, both of which are known to control hydraulic and geochemical properties. Thus, a particularly difficult challenge in modeling contaminant transport in operable units like 300-FF-5 is identification of the lithostratigraphic facies across the range of spatial scales that adequately characterize the heterogeneity in hydraulic properties. Past geologic and hydrologic characterization were done mostly at the scale of geologic layers and relied mostly on borehole data such as high-resolution geophysical logs, with sediment cores collected less frequently. Because borehole data are one-dimensional, they provide very limited information about the three-dimensional relationships between lithofacies and the hydraulic properties needed to develop realistic lithostratigraphic maps for transport modeling.

Ground penetrating radar can help identify lithologic features in the subsurface that may affect the movement of contamination.

Surface-based geophysical methods like ground penetrating radar, high resolution resistivity, seismic methods, and spectral induced polarization are capable of providing dense spatial coverage with responses that are related to lithostratigraphy; hydraulic properties (e.g., porosity, permeability, pore fluid type); and sorption properties such as specific surface and cation exchange capacity. It has been suggested that the geostatistical analysis of the spatial variation in reflected ground penetrating radar energy is representative of the spatial variation of flow variables and hydraulic properties (Rea and Knight 1998), which are essentially controlled by variability in grain size distributions. More recently, it was shown that radar images of the subsurface can change drastically with application of signal processing or by changing the signal frequency (Oldenborger et al. 2003). Thus, experimental variograms appear to be controlled by the antenna frequency and the data processing protocol. An alternate approach was proposed in which the geologic structure is inferred from the radar stack velocity rather than the reflected energy. This approach is potentially more accurate as there is a more fundamental relationship between hydrogeologic properties and velocity.

In FY 2005, a ground penetrating radar survey was done at the 300-FF-5 Operable Unit to developing an improved lithostratigraphic model and identify preferential paths that could be controlling the migration of contaminants towards the Columbia River. Ground penetrating radar data were collected along three lines located just south of the 300 Area process trenches. All the lines were acquired with 50 MHz antennas to maximize signal penetration depth. Each line was acquired with 0.5-meter trace spacing and 2-meter antenna separation. The sampling frequency in time was 1.6 nanoseconds. Data acquisition on Line 1 started with a time window of 800 nanoseconds and 8 stacks per trace to speed up acquisition. Because of poor signal penetration, acquisition was switched to 32 stacks for Line 2 in an attempt to increase the energy penetration. However, this had little effect on the penetration depth. In collecting data for Line 3, 64 stacks were initially used but the time window was decreased to 400 nanoseconds to keep the speed of acquisition relatively fast. Because of the poor signal penetration, there was little concern about recording deeper events.

The data were processed using a simple three-step procedure. First, low frequency electromagnetic interference was removed. Next, the data were filtered to remove unwanted noise. Finally, an automatic gain control was applied to enhance low signal reflections.

Figures 3.3-14 through 3.3-16 show plots of the resulting radarfacies. As the plots indicate, energy penetration was generally <100 nanoseconds for the three lines. Line 1 showed two strong reflection events that extended across the 55-meter-long profile (Figure 3.3-14). The first reflection occurred between 30 and 40 nanoseconds whereas the second reflection started at ~75 nanoseconds at the start of the transect (0 meters) and increased to ~100 nanoseconds at ~12 meters.

Line 2 also showed two strong reflections in the which the shallower reflection started at ~30 nanoseconds at the start of the transect, decreased to ~20 nanoseconds at 25 meters, and then increased to ~40 nanoseconds at 90 meters (Figure 3.3-15). Between 80 to 100 meters, a shallower reflection emerged at ~20 nanoseconds and continued along the rest of the transect. The later reflection is incoherent between 0 to 60 meters. This incoherent energy seems to change into a more coherent, lower frequency reflection at ~65 meters and 80 nanoseconds. This event increased in time to ~90 nanoseconds; then at 100 meters, the event abruptly decreased travel time to ~70 nanoseconds. The scattered energy of the later event between 0 and 60 meters may indicate large cobbles in the subsurface. The change in reflection character at 100 meters may indicate a change in the subsurface geologic structure. The bifurcation at ~30 nanoseconds time may be the result of changes in the geology due to a change in the depth of the reflecting sediment layer or an increase in velocity of the overlying sediments.

At the 300-FF-5 Operable Unit, ground penetrating radar was not able to penetrate the depths needed to describe the geology required for flow modeling through the vadose zone.

Line 3 showed a reflection at ~30 nanoseconds (Figure 3.3-16). This reflection was disrupted between 55 and 85 meters, most likely due to small changes in the continuity of the reflecting sediment layer. A later arriving reflection is apparent along the transect between 70 and 90 nanosecond travel time and is more disrupted than the earlier reflection. Again, these disruptions are indicative of physical breaks in the reflecting sediment layer or changes in velocity of the overlying sediments. Line 3 also showed a strong hyperbolic reflection near the start of the transect. The event started at 50 nanosecond travel time at 0 meters and continued to 300 nanoseconds at ~45 meters. This event is most likely the reflection from a nearby metal tower. A similar feature was observed at ~110 nanoseconds at the start of the transect and is most likely due to a second more distant metal tower.

The depth, z, of an event was calculated simply as $z = v\ t/2$, where the t is the two-way travel time measured on the time axis in nanoseconds and v is the velocity in meters/nanoseconds. Assuming a velocity of 0.10 meter/nanosecond, the depth of the deepest reflector detected at the site was ~5 meters, much shallower than the desired 15 to 20 meters penetration depth. The limited penetration depth at the 300-FF-5 Operable Unit was somewhat surprising compared to other surveys on the Hanford Site where penetration depths in excess of 15 meters have been observed. These areas appear to have a similar geologic history and to consist of similar materials. Whereas the 5-meter depth is shallow compared to other sites, it is similar to that observed in a ground penetrating radar survey conducted in 1993. In that study (WHC-SD-EN-TI-069), ground penetrating radar was very successful at mapping the thickness of eolian sand dunes and the Holocene horizon. Several shallower drainage features were also identified.

The most common cause for limited penetration depths in ground penetrating radar surveys is elevated electrical conductivity of the sediments, which causes attenuation of the signal. Given the nature of the waste fluids discharged in the 300 Area process ponds, it is very likely that elevated salt content in the sediments may be responsible for the reduced signal penetration. In general, each line showed two identifiable reflections at ~30 and ~100 nanoseconds. The 100 nanosecond travel time corresponds to a signal penetration of ~5-meter depth. Clearly, ground penetrating radar is incapable of delineating aquifer lithologic heterogeneity at this site on the scale needed for model construction. There are other geophysical methods that may be able to overcome these limitations and image greater depths at the 300-FF-5 Operable Unit. These include seismic reflection or refraction and electromagnetic methods such as DC resistivity. During the next fiscal year, electromagnetic methods will be investigated.

3.3.8 Laboratory Evaluation of Uranium Immobilization in the Vadose Zone by Hydrogen Sulfide Gaseous Reduction of Hanford Formation Sediment

L. Zhong and E. C. Thornton

Uranium present in the vadose zone usually is a long-term source for groundwater contamination, as the infiltration of rain water and fluctuations of the water table transfer uranium from the vadose zone to the underlying aquifer. In places at the Hanford Site, there is a thick vadose zone interval containing significant uranium that releases contamination to the aquifer.

In situ gaseous reduction treatment of vadose zone sediment with diluted hydrogen sulfide is a potential way to immobilize contaminants that show substantially lower mobility in their reduced form (e.g., technetium-99, uranium, and chromium). The in situ gaseous reduction approach might be able to create permeable reactive barriers. Mixtures of hydrogen sulfide diluted in nitrogen, passed through the vadose zone, might produce zones of reduced sediment. The reduced phases (ferrous oxyhydroxides and ferrous sulfide) would create a permeable reactive barrier that could immobilize possible future releases of contaminants from surface facilities or waste sites.

Uranium contamination in the vadose zone may be a long-term source for groundwater contamination.

Hydrogen sulfide treatment and hexavalent uranium immobilization experiments were conducted with Hanford formation sediment to investigate whether the in situ gaseous reduction approach can effectively immobilize uranium in aqueous solutions under vadose zone conditions.

Two types of tests were done: batch tests and column sorption tests. For the batch tests, Hanford formation sediment was mixed with deionized water or with simulated groundwater in a 0.033 ratio. The sediment/water mixture was agitated for 7 days before extracting the solution for analysis of uranium.

Four types of column tests were done (Table 3.3-4). Two of the tests were done with untreated sediment; one test was done with sediment pretreated with a 200 parts per million hydrogen sulfide in nitrogen mixture, and one test with nitrogen saturated with water vapor (100% humidity). Tests were done using solutions of both deionized water and simulated groundwater.

The uranium concentration as a function of hydrogen sulfide pore volume and flow rates is presented in Figure 3.3-17. This figure shows that, for the dry gas treatment, the hydrogen sulfide breakthrough required a greater number of pore volumes when the gas flow rate was lower. When the gas mixture was humidified, the hydrogen sulfide breakthrough of the humidified gas required more pore volumes than for the dry gas treatment, even though the flow rate was higher for the humidified treatment. This indicates that more hydrogen sulfide was consumed and the reduction of the soil was enhanced when moisture was present.

The hydrogen sulfide consumption by the sediment was calculated for both the dry and moist tests based on the reaction $2Fe(OH)_3 + 3H_2S = 2FeS + S + 6H_2O$ (Table 3.3-5). Both hydrogen sulfide consumption and Fe(III) reduction were significantly higher for soil treated with moisturized gas.

Immobilization of hexavalent uranium by pristine Hanford formation sediment in deionized water and in Hanford Site simulated groundwater was studied to evaluate the influence of water chemistry. Also, untreated soil, dry hydrogen sulfide-nitrogen gas treated soil, and moisturized gas reduced soil were used in column tests to investigate the impact of soil treatment on uranium immobilization.

Sorption of hexavalent uranium in deionized water to the untreated Hanford formation sediment is strong. In the column test, no hexavalent uranium breakthrough was observed after >180 pore volumes (Figure 3.3-18) while the inflow uranium concentration was 300 parts per billion. However, for hexavalent uranium in groundwater, the breakthrough was immediate for untreated soil. At ~25 pore volumes, the effluent uranium concentration reached the inflow concentration, and no more uranium was adsorbed to the soil.

The sorption of hexavalent uranium to the untreated soil from deionized water and simulated pore water was compared in batch tests. The sorption isotherms are displayed in Figure 3.3-19. Much more hexavalent uranium was sorbed to the soil from the deionized water solution. The average distribution coefficient was 25.57 cm^3/g for uranium in deionized water and 7.37 cm^3/g for uranium in groundwater. A linear isotherm is formed for uranium in deionized water, implying the relative attraction of the sediment for uranium remains the same at all tested concentrations of uranium in the sediment. The sorption of hexavalent uranium from groundwater, suggests that as specific sites on the sediment become filled with uranium, the remaining sites are less attractive to uranium sorption. The change in the sorption behavior from deionized water to simulated groundwater may be related to the aqueous speciation of uranium and other constituents associated with these solutions. The batch test results verify the column test observation that immobilization of hexavalent uranium from deionized water is much stronger than that from groundwater.

In situ gaseous reduction of Hanford Site sediment was effective in immobilizing hexavalent uranium and may provide the basis for future remediation.

The impact of soil treatment on uranium immobilization is demonstrated in Figure 3.3-20. Uranium in simulated groundwater at a concentration of ~300 parts per billion was used as the influent for all the tests. The uranium breakthrough was immediate with the untreated soil (Test U-Col-II). At 10 and 25 pore volumes, the normalized effluent uranium concentration (C/C_0) reached 0.70 and 1.00, respectively. In the test of soil treated with dry hydrogen sulfide-nitrogen gas mixture (Test U-Col-III), the breakthrough was slower. The normalized effluent uranium concentration at 10 and 25 pore volumes was 0.16 and 0.70, respectively. Breakthrough of uranium in the test with the moisturized gas-treated soil (Test U-Col-V) took the longest time. At 10 and 25 pore volumes, the normalized hexavalent uranium concentration was ~0.08 and 0.42, respectively.

The effluent oxygen concentration is also shown in Figure 3.3-20. For the untreated sediment, the effluent oxygen concentration was approximately equal to the inflow oxygen concentration indicating that the sediment in the column did not consume any oxygen. For the hydrogen sulfide reduced sediments, no oxygen was detected in the effluent at the beginning of the tests. Oxygen breakthrough occurred at 14 pore volumes in the column treated with dry gas mixture, and breakthrough was not seen until 70 pore volumes from the column treated with the moisturized gas mixture.

The difference in effluent uranium concentration among the tests shown in Figure 3.3-20 at the same pore volume is related to uranium immobilization attributed to sediment reduction. From the data in Figure 3.3-20, it is determined that from 25% up to 89% of hexavalent uranium was immobilized by reduction for the first 30 pore volumes in tests U-Col-III and U-Col-V. The soil treated with moisturized gas mixture (U-Col-V) had a higher immobilization capacity than the soil treated with dry gas mixture (U-Col-II). This result agrees with the observation that, at the same gas flow rate and pore volume, the soil is more reduced when the moisturized gas mixture was applied during treatment (Figure 3.3-17; Table 3.3-5).

In U-Col-III test, no oxygen was detected in the first 14 pore volumes even though uranium had started to exit the column (Figure 3.3-20). The same phenomenon was seen in U-Col-V test for the first 30 pore volumes. This suggests that when oxygen and hexavalent uranium compete for the reducing regent in the sediment, oxygen is reduced before uranium. Also, the reduction of uranium in the column may be controlled by kinetic processes; the resident time of the uranium solution in the column may not have been long enough for complete uranium reduction, even though there was no oxygen to compete for the reducing reagent.

There probably are several mechanisms involved in uranium immobilization. The first is reduction of uranium. Hexavalent uranium is reduced to quadravalent uranium and precipitates from solution. A second mechanism is enhanced sorption of uranium to re-oxidized sediment. Ferrous iron generated from sediment reduction by hydrogen sulfide is reoxidized when oxygen is introduced to the column. The initial oxidation product may be poorly crystallized, hydrated ferric oxide (Kukkapapu et al. 2006). Hydrated amorphous ferric oxides or iron oxides are reported to strongly adsorb and immobilize uranium (Zhong et al. 2005). In the sediment treated with moisturized gas, more ferric iron was reduced and reoxidation generated more hydrated amorphous ferric oxide, which provided enhanced uranium immobilization by sorption. Note that no indication of remobilization of uranium is present in Figure 3.3-20. This suggests that uranium release does not occur upon reoxidation, at least in the short-term.

In summary, in situ gaseous reduction treated Hanford formation sediment is capable of effectively immobilizing hexavalent uranium from simulated groundwater. The immobilization is further enhanced by sediment treatment with a moisturized hydrogen sulfide-nitrogen gas mixture. During the first 20 pore volumes, >80% of the mobile uranium was still immobilized. The breakthrough of the hexavalent uranium occurred well before the breakthrough of oxygen, however. Hexavalent uranium was able to move through a partially reduced environment, indicating that the reduction of uranium may be a kinetic process.

Results of this study indicate that immobilization of hexavalent uranium in a vadose zone permeable reactive barrier created by in situ gaseous reduction is a possible remediation approach. The lifetime of the barrier will primarily be related to the rate of reoxidation. It is believed that release of uranium from the barrier will be low because of the adsorption or incorporation of uranium into the amorphous ferric oxidation product. Even temporary immobilization and slow release on reoxidation could have an effective impact for the long-term treatment and ultimate risk of a site, however, since it would delay the release of uranium and reduce the peak concentration during breakthrough.

Table 3.3-1. Pore-Water Chloride and Recharge Estimates from Suite 1 Samples of Hanford Site Sand from 300-N Lysimeter

Sample Identification Suite 1	Pore Water Chloride (mg/L)	Pore Water Chloride[(a)] (mg/L)	Recharge (mm/yr)	Recharge[(a)] (mm/yr)
1:1 field moist	2.9	2.3	14.7	18.6
1:1 air dry	3.2	2.7	13.4	15.8
1:1 oven dry	9.7	9.1	4.4	4.7
2:1 air dry	3.2	--	13.3	--
3:1 air dry	3.6	--	11.9	--
3:1 (2 day)	3.8	--	11.2	--
3:1 (7 day)	4.6	--	9.3	--

(a) Corrected for chloride concentration in the blank.
-- = Values not calculated due to uncertain correction.

Table 3.3-2. Pore-Water Chloride and Recharge Estimates from Suite 2 Samples of Hanford Site Sand from 300-N Lysimeter

Sample Identification Suite 2	Pore Water Chloride (mg/L)	Pore Water Chloride[(a)] (mg/L)	Recharge (mm/yr)	Recharge[(a)] (mm/yr)
1:1 field moist (fm)	4.6	3.8	9.3	11.3
1:1 fm (3-day)	4.3	3.5	9.9	12.2
1:1 fm (6-day)	4.9	4.1	8.7	10.4
1:05 field moist	3.6	3.2	11.9	13.4
1:05 (3-day)	4.4	4.0	9.7	10.7
1:05 (6-day)	3.5	3.0	12.2	14.2
1:1 oven dry (3-day)	5.5	4.7	7.8	9.1
1:1 oven dry (6-day)	5.6	4.9	7.6	8.7

(a) Corrected for blank chloride addition.

Table 3.3-3. A Comparison of Automated and Manual Measures of Shrub Cover at the 200-BP-1 Barrier

Sub-Image	Image-Based	Manual	Difference
Northwest Corner	33.3	41.64	8.34
Northeast Corner	29.0	33.31	4.31
Southwest Corner	28.4	35.0	6.6
Southeast Corner	26.5	32.9	6.4
Mean (North)	31.2 ± 3.0	36.78 ± 17.96	5.58
Mean (South)	27.5 ± 1.3	33.75 ± 16.57	6.25
Mean (Combined)	29.3 ± 2.87	35.08 ± 17.23	5.78

Table 3.3-4. Parameters for Immobilization Column Tests

Test Name	Soil, Weight (g)	Pore Volume (ml)	Fluid
U-Col-I	Untreated, 300.52	52.01	Hexavalent uranium in deionized water
U-Col-II	Untreated, 294.41	54.40	Hexavalent uranium in simulated groundwater
U-Col-III	Pretreated with hydrogen sulfide/ nitrogen mixture, 306.86	49.62	Hexavalent uranium in simulated groundwater
U-Col-V	Pretreated with saturated nitrogen, 300.71	52.01	Hexavalent uranium in simulated groundwater

Table 3.3-5. Hydrogen Sulfide Consumed and Ferric Iron Reduced at 30,000 Pore Volumes

Test ID	Hydrogen Sulfide Flow Rate (ml/min)	Hydrogen Sulfide Consumed (g/kg soil)	mol of Fe(III) Reduced
U-Col-III (dry)	300	4.26E-01	2.35E-03
U-Col-V (w/moisture)	245	6.84E-01	3.78E-03

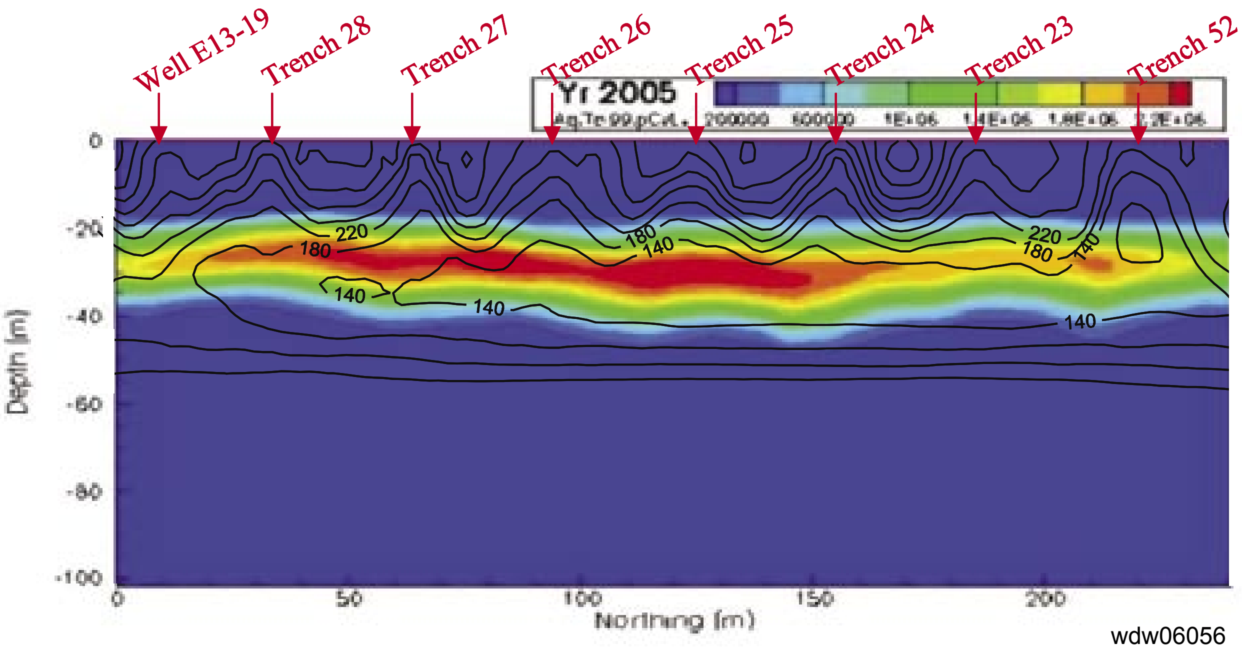


Figure 3.3-1. Calculated Distributions of Technetium-99 in 2005 (color contours). The black contour lines represent the resistivity distribution as measured by high-resolution resistivity.

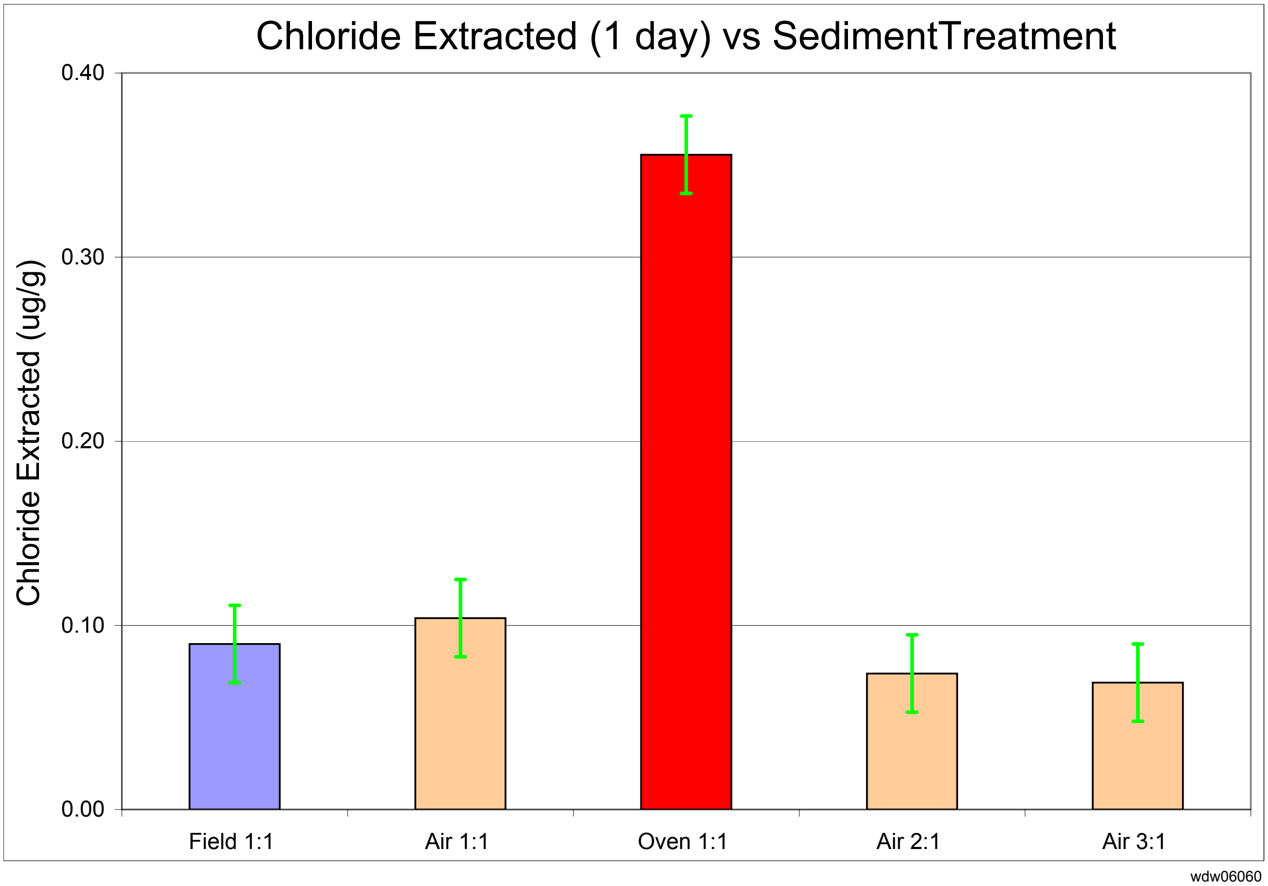


Figure 3.3-2. Extractable Chloride versus Treatment for 1 Day Contact Time for the First Suite of Tests (error bars = ±1 standard deviation)

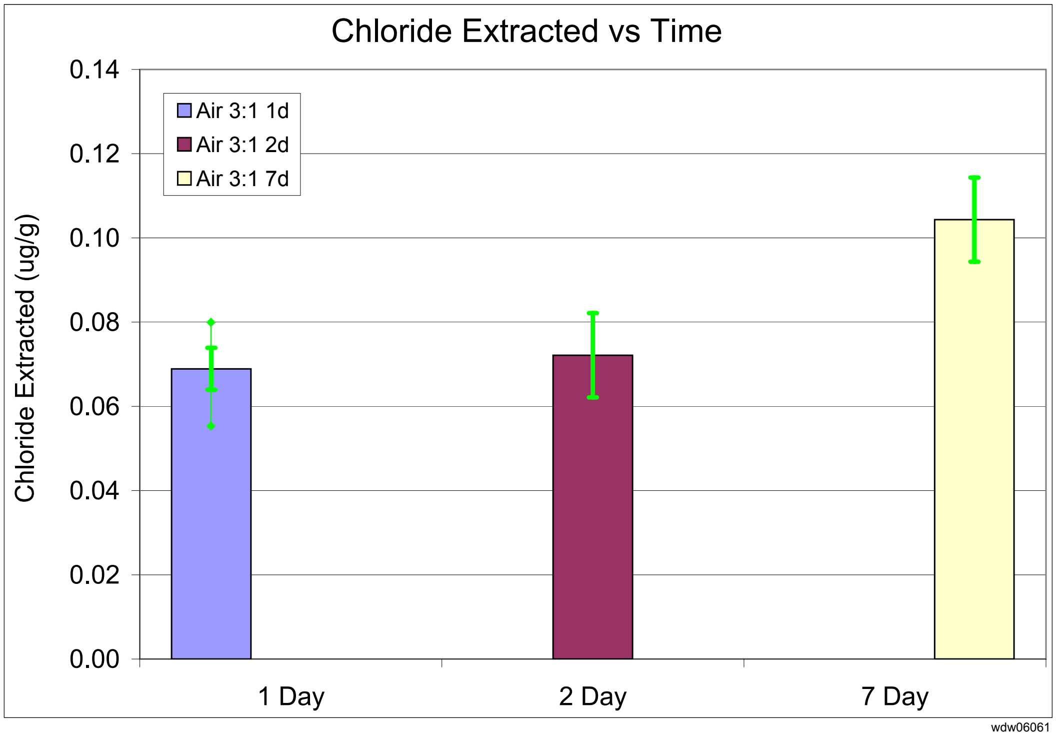


Figure 3.3-3. Effect of Extraction Time on Amount of Chloride Removed from Air Dried, 3:1 Solution-to-Solid Tests (first suite of tests)

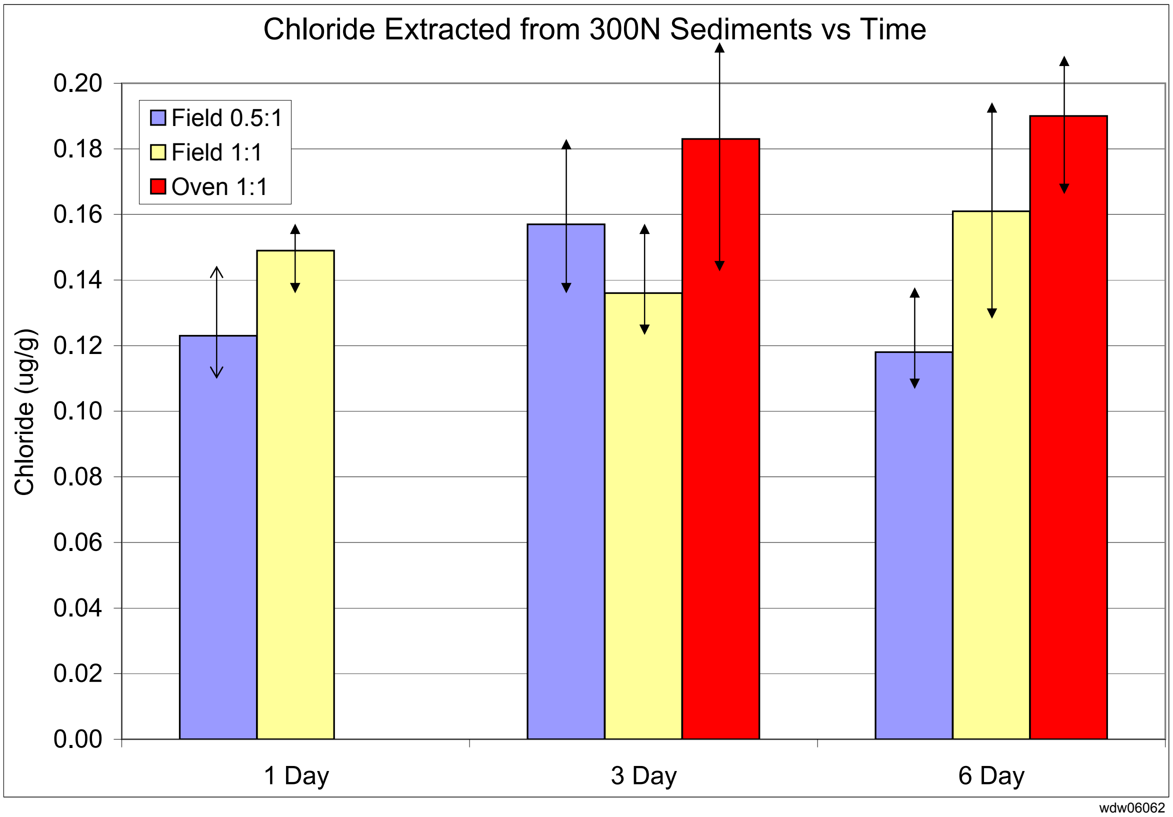


Figure 3.3-4. Extractable Chloride versus Time, Treatment, and Solution-to-Solid for the Second Suite of Tests

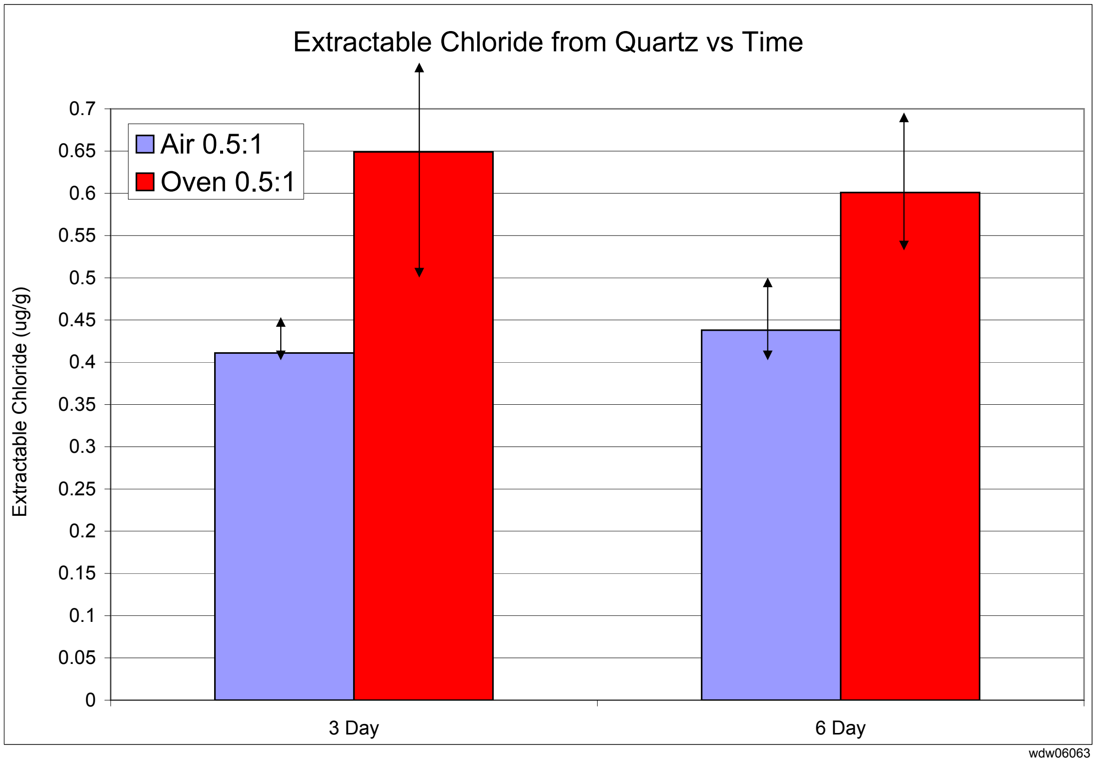


Figure 3.3-5. Extractable Chloride from Quartz versus Time. The arrow lines represent 1 standard deviation of triplicate tests.

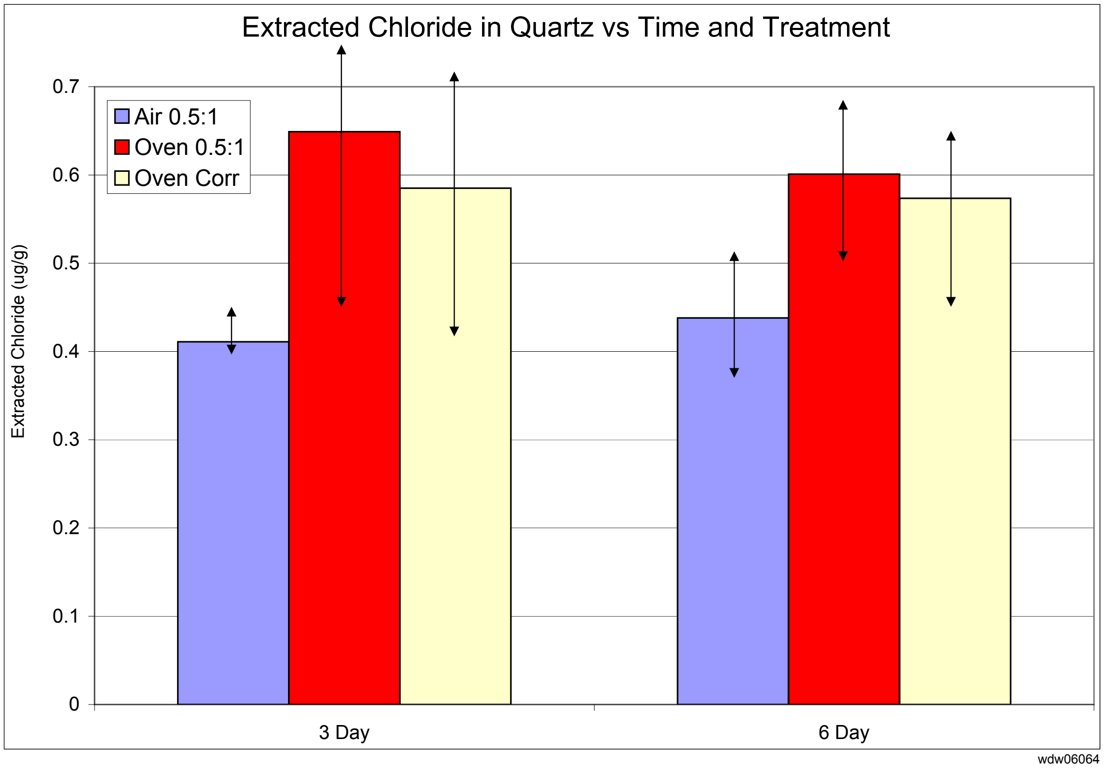
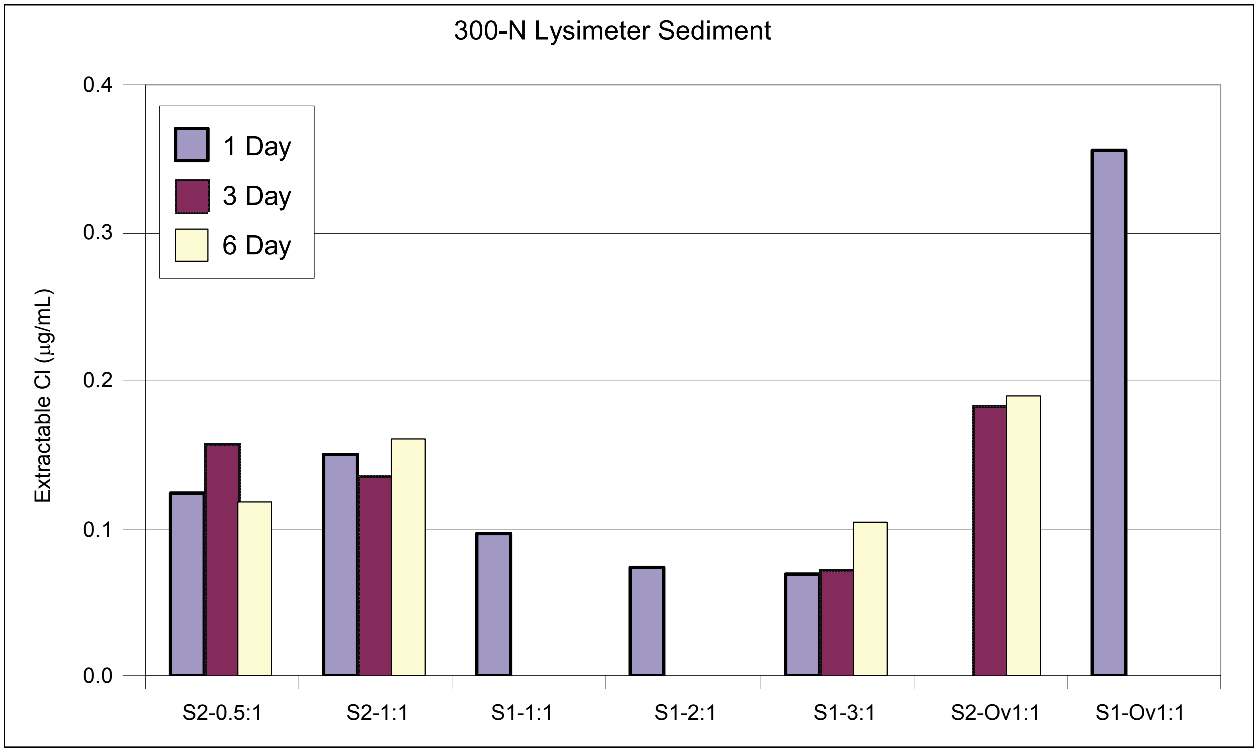
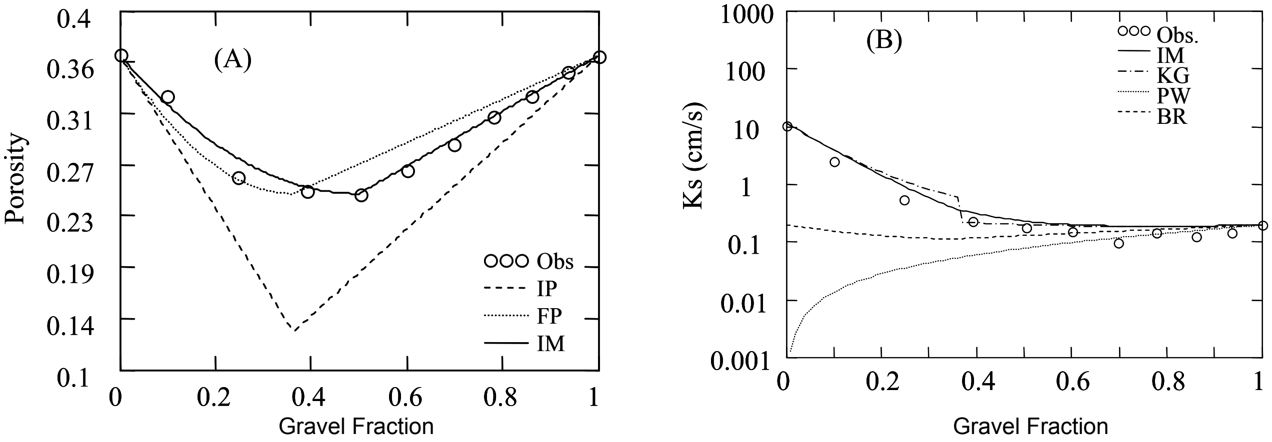


Figure 3.3-6. Extractable Chloride from Quartz versus Time Before and After Oven Correction



wdw06065

Figure 3.3-7. Combined Data Sets for 300-N Lysimeter Sediment (combined field moist and air dried; and combined 2-3 day and 6-7 day contact times into 3 and 6 days for plotting). S1 = Suite 1 and S2 = Suite 2. OV = Oven. Solution-to-solid ratios shown on the absissa (0.5:1; 1:1, 2:1, 3:1).



wdw06059

Figure 3.3-8. Measured (circles) and Predicted (lines) (A) Porosity and (B) Saturated Hydraulic Conductivity for a Mixture of 5 mm Glass Beads and 20-30 Mesh Accusand. Obs = Observations; IP = Ideal packing; FP = Fractional packing; IM = Incomplete mixing; KG = Koltermann and Gorelick (1995) method; PW = Peck and Watson (1979) method; and BR = Bouwer and Rice (1976) method.

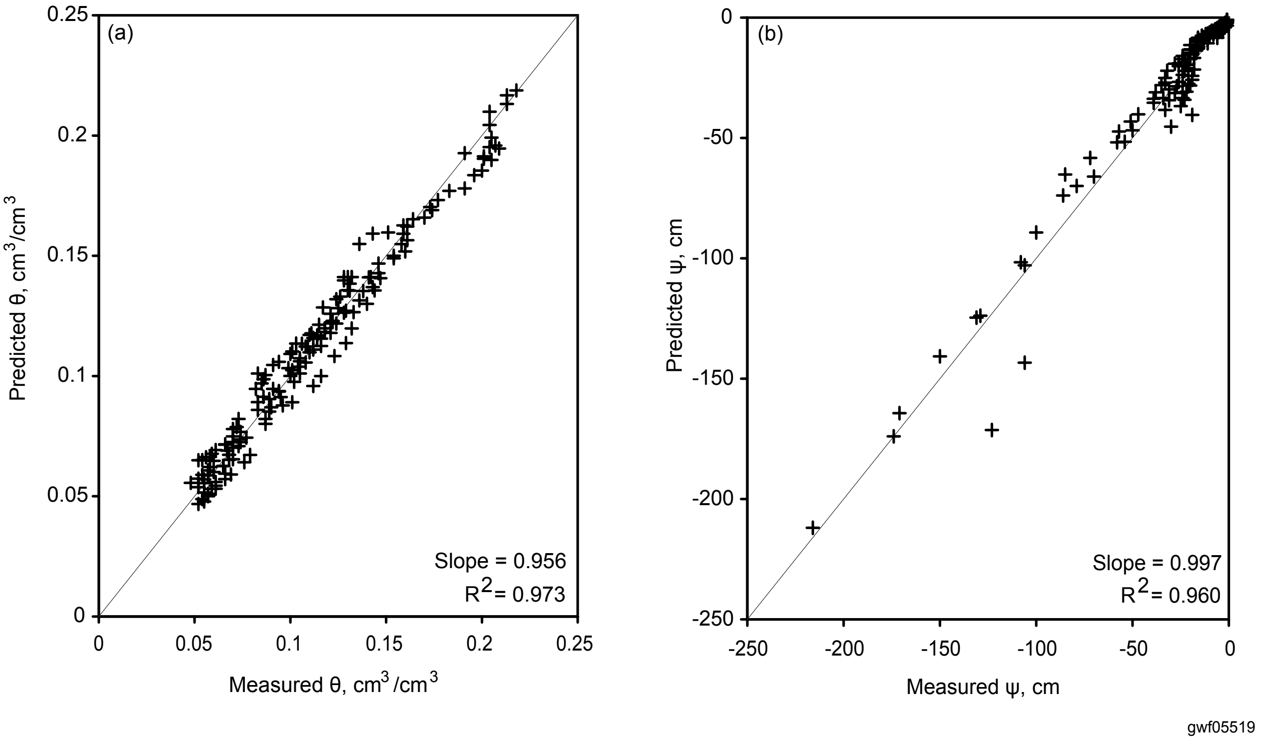


Figure 3.3-9. Comparison of the Observations and the Predictions of Water Content and Pressure Head Using the Field-Scale Parameter Values Based on the Parameter Scaling Concept

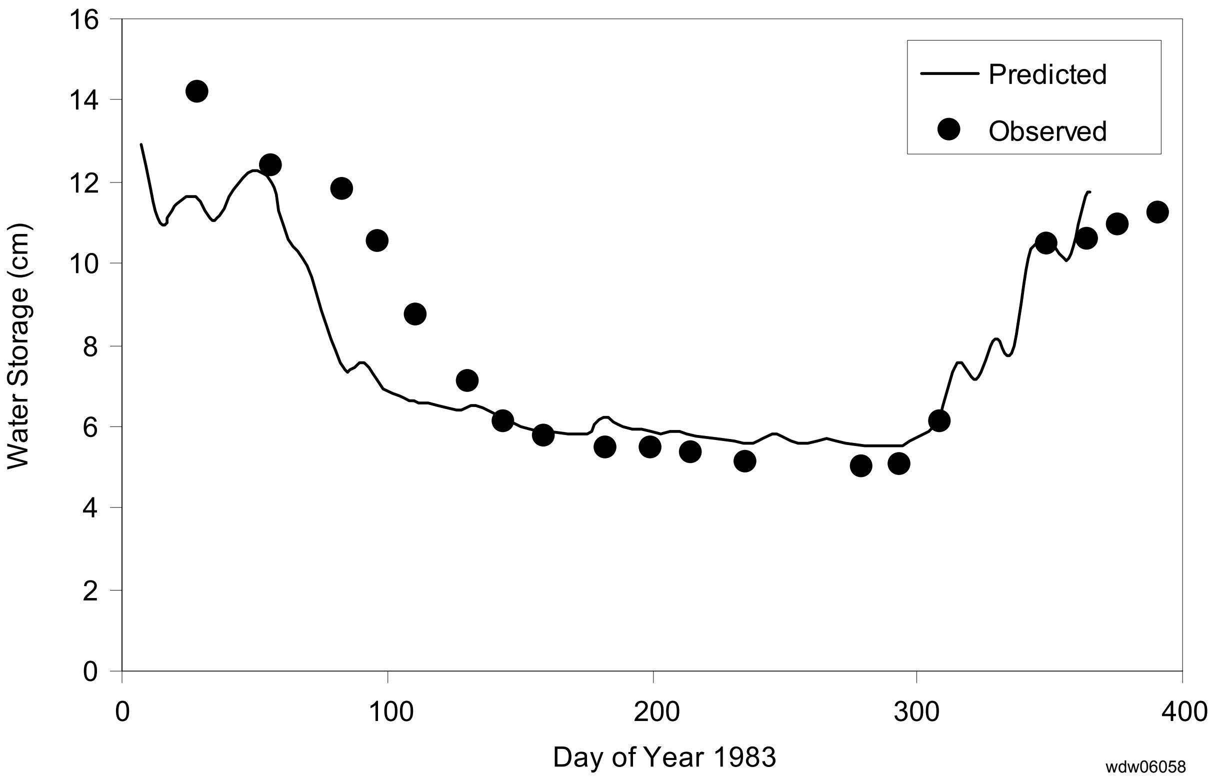


Figure 3.3-10. Temporal Response of Soil Water Storage in the 0 to 1 Meter Depth

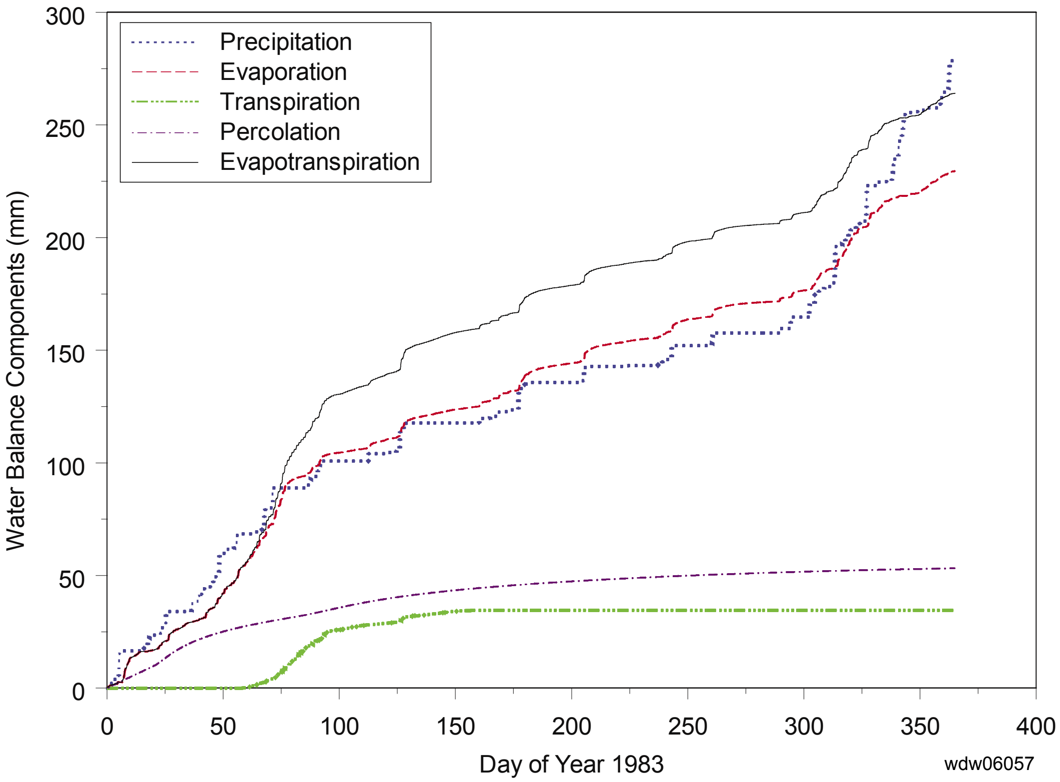


Figure 3.3-11. Predicted Water Balance Components

wdw06055

Figure 3.3-12. Aerial Photograph of the 200-BP-1 Prototype Barrier Taken in 2004. The surface is divided in four quadrants for sub-images selection.

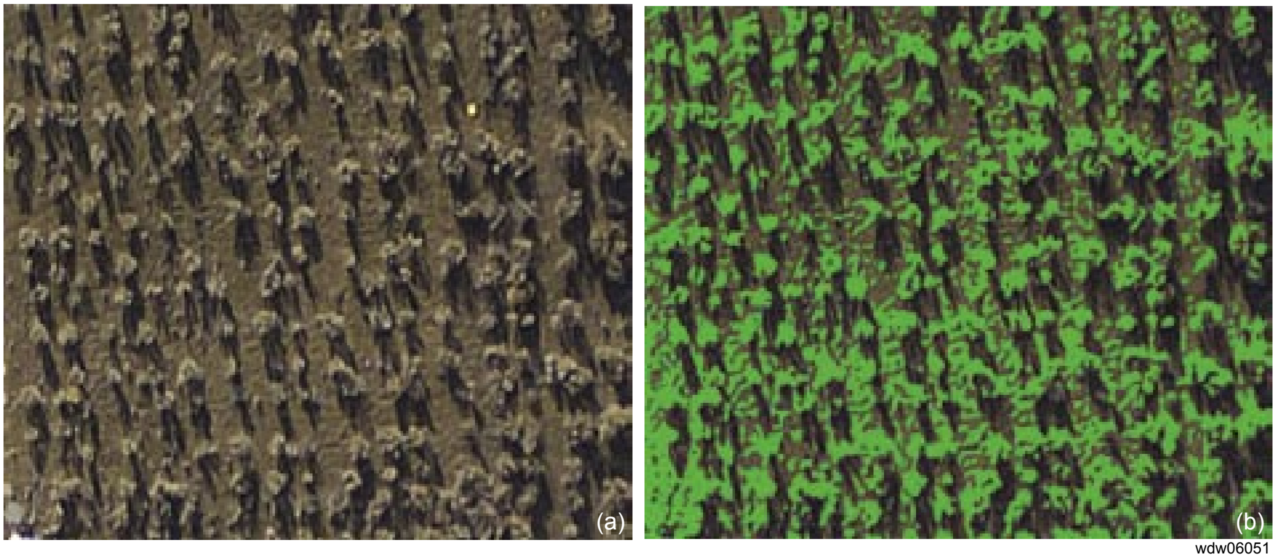


Figure 3.3-13. Segmentation of an Image from the 200-BP-1 Barrier (a) sub-image from the upper right (northeast) corner of the image in Figure 3.3-12 and (b) resulting vegetation extraction

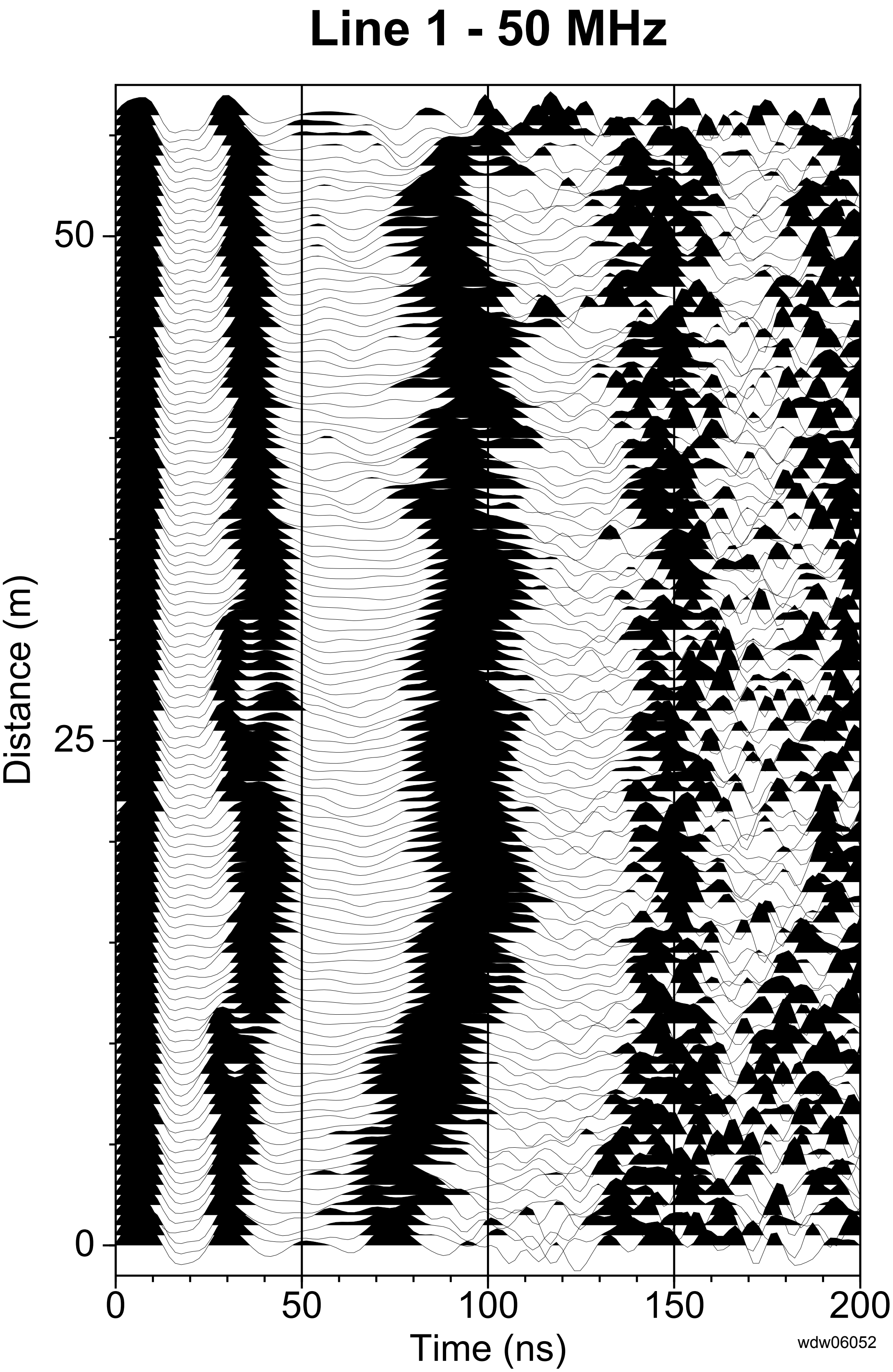


Figure 3.3-14. Automatic Gained Radar Section for Line 1

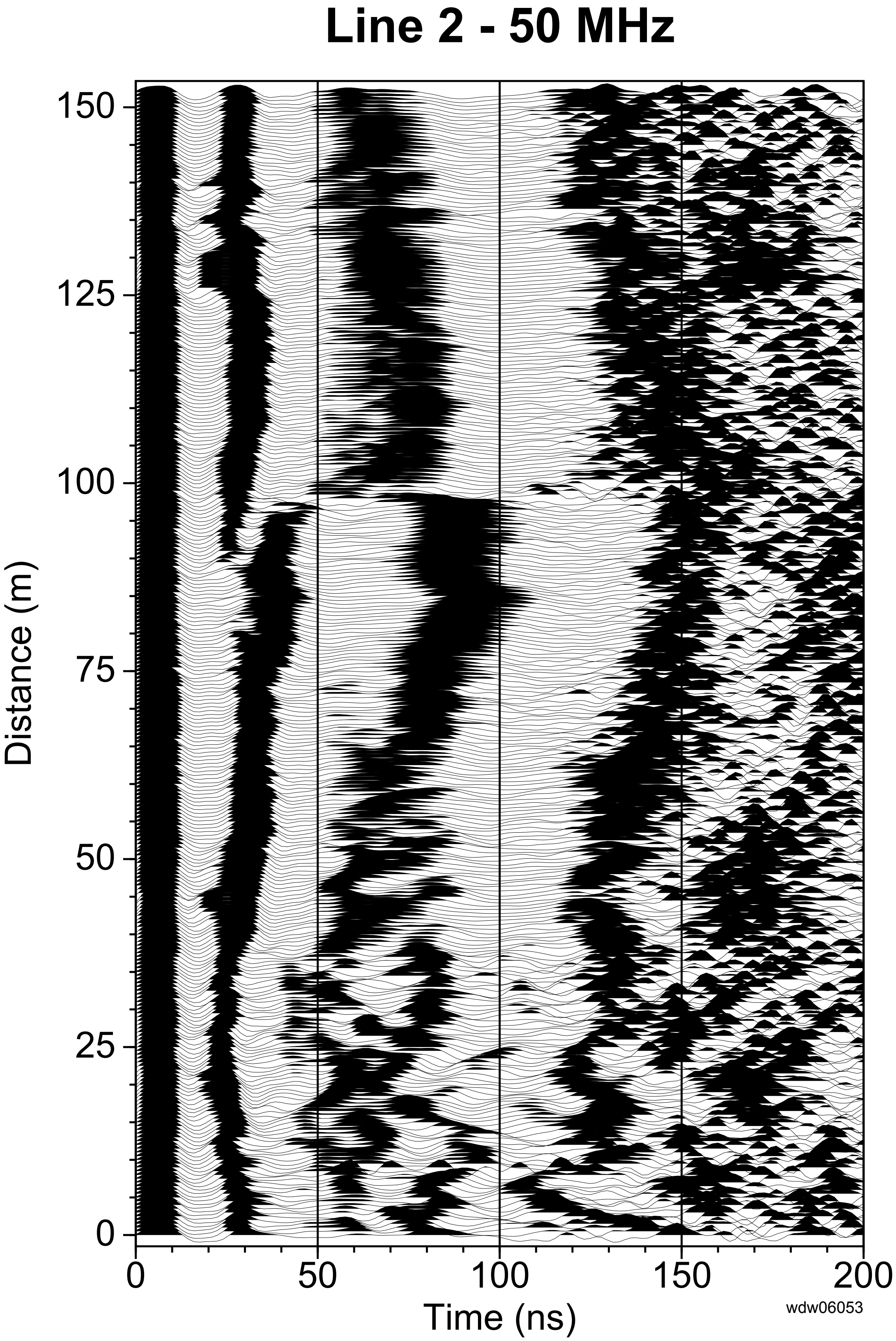


Figure 3.3-15. Automatic Gained Radar Section for Line 2

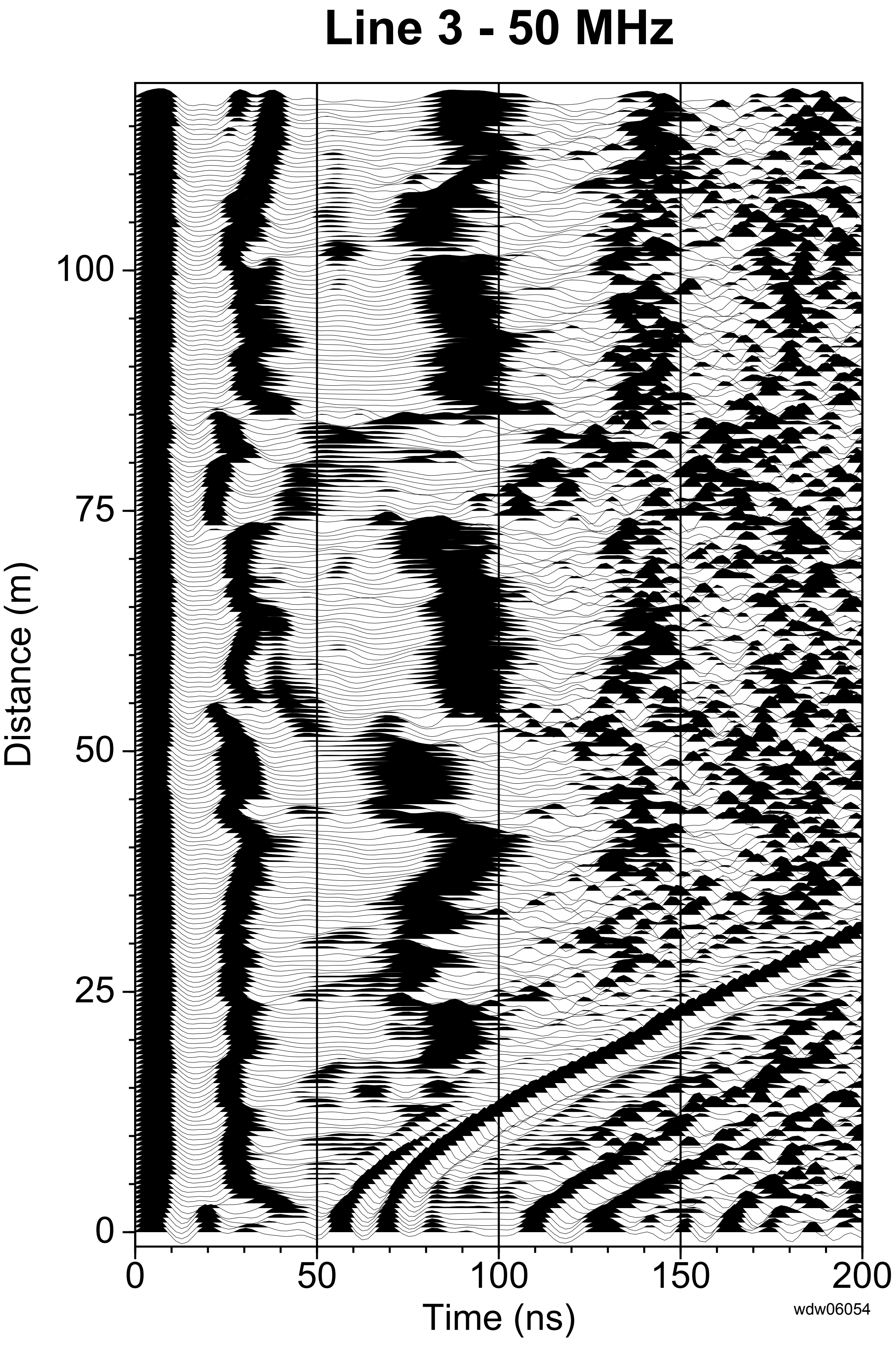


Figure 3.3-16. Automatic Gained Radar Section for Line 3

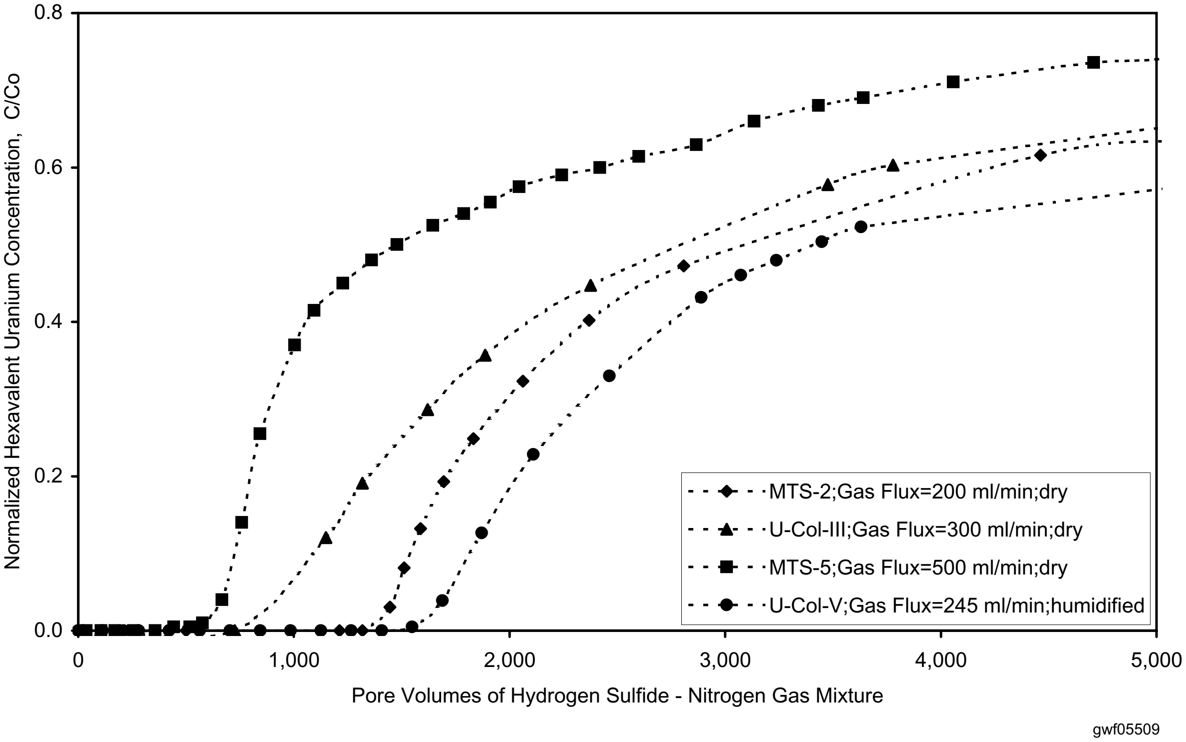


Figure 3.3-17. Hydrogen Sulfide Concentration versus Pore Volume for Three Dry and One Humidified Tests. MTS indicates results from previously reported experiments (PNNL-15070)

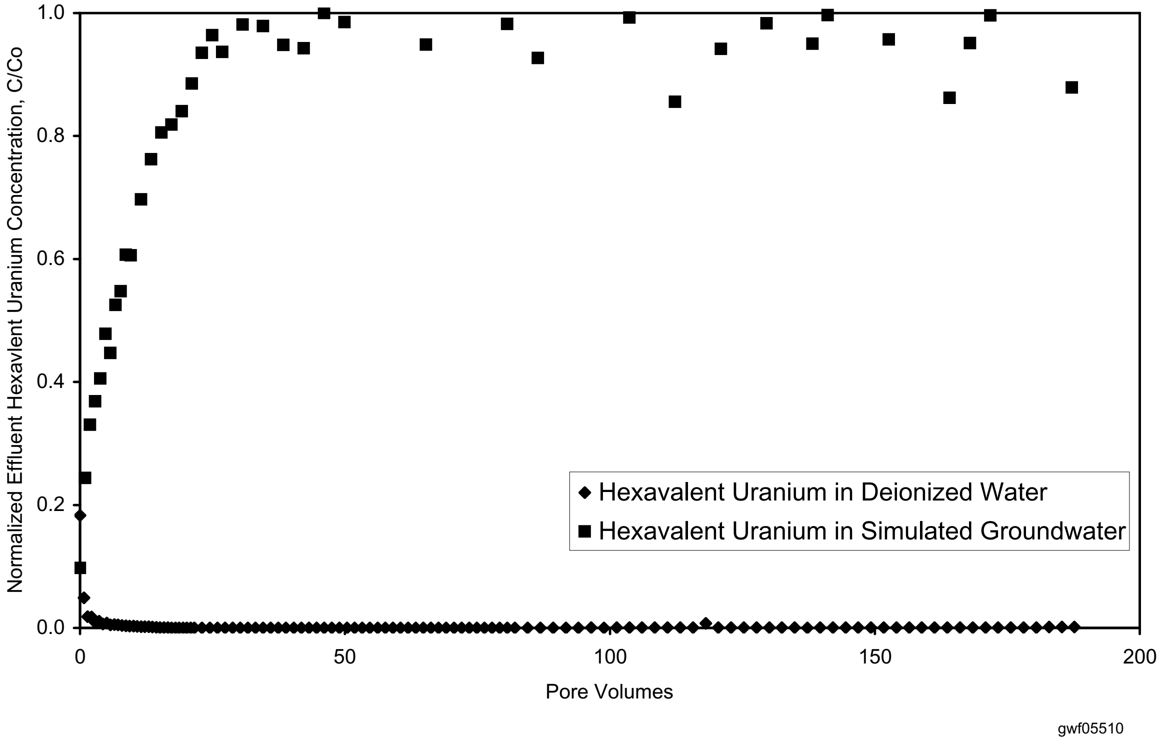


Figure 3.3-18. Hexavalent Uranium Concentrations Normalized by Inflow Concentration in Column Tests Using Deionized Water and Simulated Groundwater

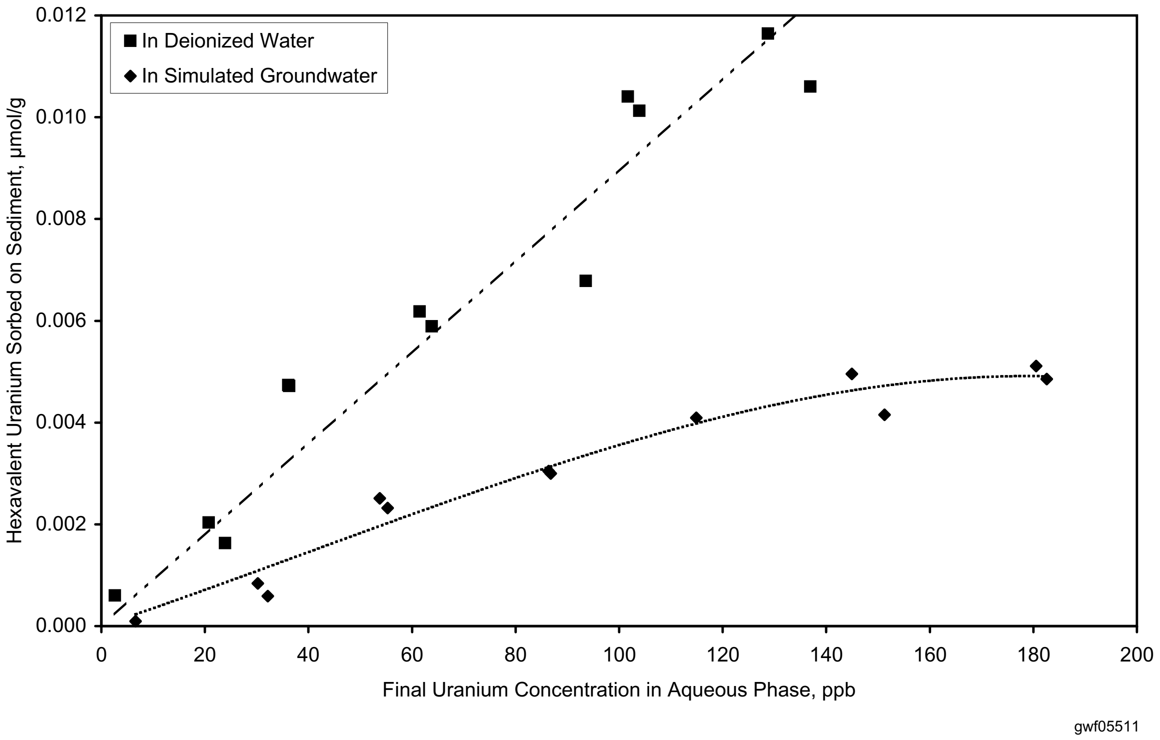


Figure 3.3-19. Sorption Isotherms for Hexavalent Uranium in Deionized Water and in Groundwater Sorbed to Untreated Hanford Formation Sediment

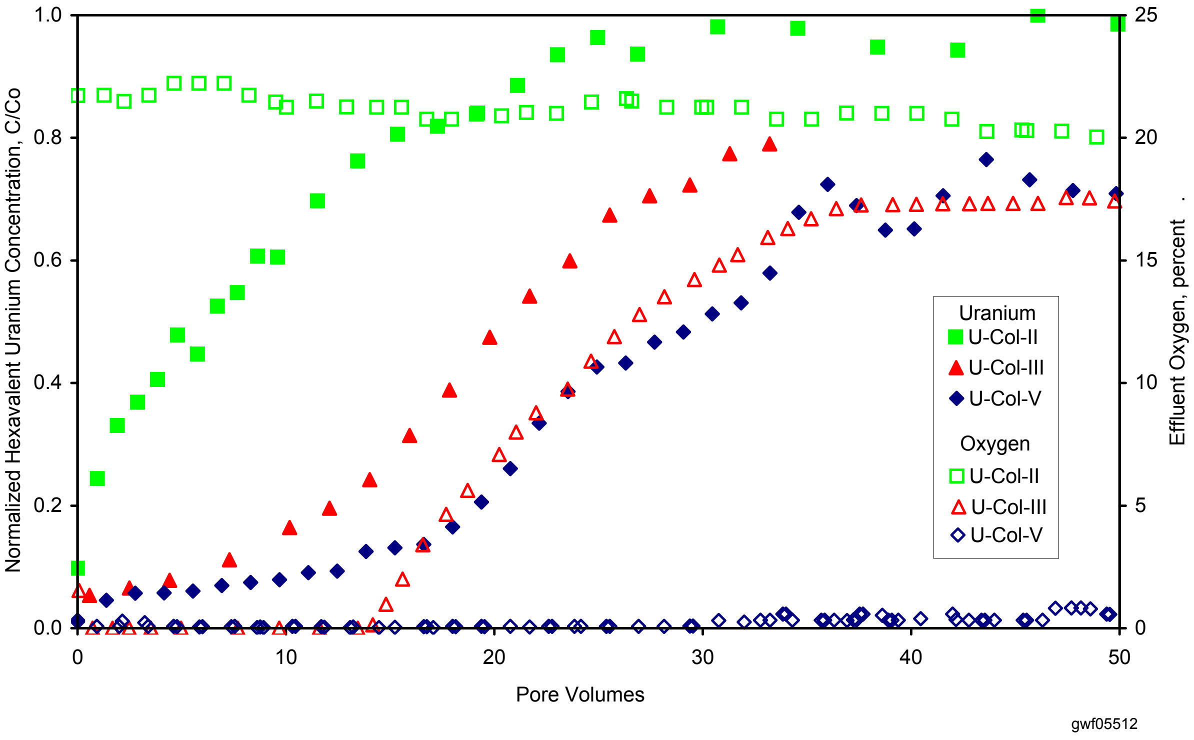


Figure 3.3-20. Effluent Hexavalent Uranium and Oxygen Concentrations in Column Tests. The dissolved oxygen concentration in the inflow was the equilibrium concentration of water in contact with air containing 21.5% of oxygen. The effluent O_2 concentration is expressed in the percentage of oxygen in the air in equilibrium with water at the measured dissolved-oxygen level.

3.4 Related Vadose Zone Studies Published in Fiscal Year 2005

D. G. Horton

In addition to the studies described in Section 3.3, the results of several other studies were published during fiscal year (FY) 2005. These studies are summarized in this section by way of reproducing the abstract or summary directly from the report. The complete citation to the report is given and the interested reader is encouraged to consult the entire report or the authors of the report to learn more about the individual activities.

3.4.1 Investigation of Accelerated Casing Corrosion in Two Wells at Waste Management Area A-AX

Brown, CF, RJ Serne, HT Schaef, BA Williams, MM Valenta, VL LeGore, MJ Lindberg, KN Geiszler, SR Baum, IV Kutnyakov, TS Vickerman, and RE Clayton. 2005. *Investigation of Accelerated Casing Corrosion in Two Wells at Waste Management Area A-AX*. PNNL-15141, Pacific Northwest National Laboratory, Richland, Washington.

Note: After this report was published, well 299-E25-40 began showing signs of casing and screen corrosion. The following information is excerpted directly from PNNL-15141:

> **Executive Summary**. An overall goal of the Groundwater Performance Assessment Project, led by Pacific Northwest National Laboratory (PNNL) and per guidance in DOE Order 5400.1, includes characterizing and defining trends in the physical, chemical, and biological condition of the environment. To meet these goals, numerous Resource Conservation and Recovery Act (RCRA) monitoring wells have been installed throughout the Hanford Site. In 2003, it was determined that two RCRA monitoring wells (299-E24-19 and 299-E25-46) in Waste Management Area (WMA) A-AX failed due to rapid corrosion of the stainless steel casing over a significant length of the wells. Complete casing corrosion occurred between 276.6 and 277.7 feet below ground surface (bgs) in well 299-E24-19 and from 274.4 to 278.6 feet bgs in well 299-E25-46. CH2M HILL Hanford Group, Inc., asked scientists from PNNL to perform detailed analyses of vadose zone sediment samples collected in the vicinity of the WMA A-AX from depths comparable to those where the rapid corrosion occurred in hopes of ascertaining the cause of the rapid corrosion.
>
> This report contains the geochemical and selected physical characterization data collected on (1) archived vadose zone sediment recovered during the early 1990s installation of four RCRA monitoring wells 299-E24-19, 299-E24-20, 299-E24-22, and 299-E25-46; (2) a sample of bentonite material; (3) sidewall core samples collected during the decommissioning (in 2004) of wells 299-E24-19 and 299-E25-46; (4) splitspoon core samples collected during the installation (in 2004) of two RCRA monitoring wells 299-E24-33 and 299-E25-95; and (5) a perched water sample collected during the installation of well 299-E24-33. Laboratory tests were conducted to characterize the sediment and to identify water-leachable constituents. The laboratory tests provided the following conclusions regarding the cause of rapid corrosion:
>
> 1. Archived Samples – Because of sample preservation problems, the moisture content of samples was artificially low and resulted in an exaggeration of the true chloride concentration. Therefore, it is unlikely that any of the archived sediment samples tested could generate pore waters with a sufficient chloride content to initiate corrosion of the well casing.

2. Bentonite Material – The bentonite sample had considerably high water-extractable concentrations of sodium, chloride, fluoride, sulfate, and alkalinity (measured as calcium carbonate). Interpretation of the laboratory data indicated that the Wyoming bentonite test sample was capable of generating localized vadose zone pore water with chloride concentrations in excess of 700 mg/L. However, the vadose zone at the Hanford Site is primarily composed of coarse-grained sands with an in situ moisture content ranging from 5 to 12%. Therefore, it is doubtful enough moisture will be available throughout the majority of the vadose zone to sufficiently "wet" the bentonite and leach chloride from the material. Consequently, Wyoming bentonite material should be suitable as an annulus filling agent in all low-moisture zones and those regions that lack the potential to accumulate perched water.

3. Sidewall Core Samples – Findings from analysis of these samples demonstrate that the vadose zone chemistry in the vicinity of the two failed wells has been affected or compromised by a Hanford Site waste stream. Clearly, the sidewall core samples tested were capable of generating pore waters with sufficient chloride concentrations to cause corrosion of the stainless steel well casing. Furthermore, analysis of the sidewall core samples yielded a clear relationship between chloride concentration and well casing corrosion. It is likely that chloride leached from the bentonite material and/or chloride carried as a constituent of the liquid waste stream caused the advanced well casing corrosion found at wells 299-E24-19 and 299-E25-46 via crevice corrosion and stress corrosion cracking.

4. Splitspoon Core Samples – Samples were collected during the recent installation of two RCRA monitoring wells and were characterized to assess the current vadose zone geochemical conditions in WMA A-AX. Analysis of these samples showed that common Hanford sediment constituents were present at concentrations typically observed in uncontaminated vadose zone sediments. The dissolved chloride concentrations in the samples makes it doubtful that they could lead to the advanced corrosion found in wells 299-E24-19 and 299-E25-46.

5. Perched Water Sample – The results support the assessment that the archived sediment samples were compromised via moisture loss during storage and, therefore, are not suitable for estimating the true pore-water concentration of chemical constituents.

Based on the findings of this study, we recommend using Portland cement as an annulus sealing agent in groundwater monitoring wells in zones with high moisture contents or that have the potential to accumulate perched water.

3.4.2 Uranium Geochemistry in Vadose Zone and Aquifer Sediments from the 300 Area Uranium Plume

Zachara, JM (ed.). 2005. *Uranium Geochemistry in Vadose Zone and Aquifer Sediments from the 300 Area Uranium Plume*. PNNL-15121, Pacific Northwest National Laboratory, Richland, Washington.

The following information is excerpted directly from PNNL-15121:

Summary. In 1996, an interim record of decision was issued for the 300-FF-5 Operable Unit on the Hanford Site in southeast Washington State. The record of decision specified the interim remedy as (1) continued monitoring of groundwater and (2) institutional controls to restrict groundwater use. This record of decision was based on a remedial investigation that suggested levels of uranium would decrease with time because of natural geochemical and hydrologic processes.

A prediction was made that concentrations of uranium would decrease to the proposed drinking water standard or lower (20 µg/L) in 3 to 10 years from 1993. This prediction has not been realized, prompting investigations and update of the conceptual model for uranium in the 300 Area.

In June 2002, the U.S. Department of Energy (DOE) asked scientists at Pacific Northwest National Laboratory's (PNNL) Remediation and Closure Science (RCS) Project to begin research on the 300 Area uranium plume, in collaboration with a small team of investigators from the Environmental Management Science Program, currently funded through the U.S. Department of Energy Office of Biological and Environmental Research. The study completed by the RCS Project, and summarized in this report, will be used to improve the conceptual model of the 300 Area uranium plume and develop a final record of decision for the 300-FF-5 Operable Unit.

Significant progress has been made on planned research and is summarized in this report. The information in this report is of a technical nature and is intended to provide the scientific basis for re-evaluation of the 300-FF-5 record of decision. The following are important conclusions and implications:

1. Residual hexavalent uranium U(VI) concentrations observed beneath the north and south process ponds (NPP and SPP) are heterogeneous and display no marked trend with depth. An average of 37.5% of the residual, sorbed uranium appears accessible to dissolution/desorption, but variation in this number between sediments is large. Dissolution/desorption extent was found to decrease with decreasing water content and at 21% water saturation was only 1 to 3% of total uranium.

2. Both precipitated and adsorbed U(VI) existed in the sediments. No evidence was found for precipitated U(IV) or metallic uranium. A precise demarcation of precipitated and adsorbed forms, and their relative concentrations is difficult. Adsorbed U(VI) predominates in sediments with total uranium <25 mg/kg.

3. The vadose zone sediments beneath both SPP and NPP will remain as potential source terms to maintain groundwater U(VI) concentrations at or above the drinking water standard. Their ultimate impact will be controlled by moisture flux rates through the vadose zone and their bicarbonate concentrations. Increasing groundwater levels at high river stage will solubilize sorbed U(VI) from the capillary fringe and lower vadose zone.

4. The extent of adsorption decreases with increasing aqueous bicarbonate concentration. U(VI) is adsorbed by 300 Area vadose zone and aquifer sediments more strongly than previously recognized. Travel times for adsorption and desorption fronts through the aquifer will consequently be longer by factors of 2 to 5, or even more.

5. The intrusion of river water into the aquifer during periods of high river stage has two different effects: (1) River water dilutes the total ion composition of near shore groundwater and decreases its bicarbonate concentration. This dilution increases U(VI) adsorption to aquifer solids, which further decreases aqueous U(VI) concentrations below the dilution value. Increased adsorption slows the dissipation of the U(VI) groundwater plume and reduces the discharge of U(VI) from the groundwater plume to the Columbia River. (2) Farther inland, a pressure front advances many meters from the river shoreline into the aquifer that raises the groundwater level into the lower vadose zone. Deep vadose zone sediments below the process ponds and trenches contain sorbed U(VI) that desorbs slowly as water levels rise into them, resulting in higher dissolved U(VI) concentrations in waters near the surface of the aquifer. These higher U(VI) concentrations are released into the aquifer proper as water levels drop in response to changing river

stage. Thus, rising and falling river stage provides a hydrologic mechanism to mobilize U(VI) from the vadose zone and transport it to groundwater.

6. The vadose zone and aquifer sediments beneath the SPP and NPP differ significantly in sorption properties for uranium. A single value of Kd is therefore unlikely to yield realistic simulations of U(VI) geochemical behavior in the 300 Area plume given heterogeneity in sediment properties and the apparent importance of kinetic processes. Reactive transport modeling of the future dynamics of the plume will consider these issues.

7. The dissolution of U(VI) containing solids and the desorption of U(VI) surface complexes in the contaminated sediments are slow. Equilibrium-based models don't capture the slow release and have led to shorter predictions of the time required for plume dissipation to the maximum contaminant level.

8. A significant amount of copper was disposed to the 300 Area process ponds along with uranium. Total copper concentrations in vadose zone sediments correlated closely with total uranium, but copper concentrations were generally one hundred times larger. In contrast, total copper concentrations in the groundwater fines were smaller than U(VI). Microscopic and spectroscopic measurements showed that copper had precipitated on vadose zone mineral grain surfaces, apparently as a result of neutralization of waste fluid pH. The copper is currently immobilized and has shown low water solubility. Continued low solubility is expected under the current geochemical conditions. The future migration potential of the precipitated copper is low unless the pH decreases for unexpected reasons.

3.4.3 Silt Borrow Source Field Investigation Report

Petersen, SW. 2005. *Silt Borrow Source Field Investigation Report*. D&D-25575, Fluor Hanford, Richland, Washington.

The following information is excerpted directly from D&D-25575:

> **Abstract**. This report presents information on the predominately fine-grained soils that occur southwest of State Highway 240 near its intersection with Beloit Avenue, an area here called the borrow site. These soils are within a 926 ha (2287 acre) zone that is explicitly identified in the *Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999) for use as conservation (mining) (Figure 3.4-1). The soils in this area are intended to be used for topsoil and evapotranspiration layers in engineered surface barriers, which are planned to be installed over a number of waste sites on the Hanford Site's Central Plateau.
>
> A critical component of the barriers is the evapotranspiration layer, which acts like a "sponge" to keep water from migrating downward into the waste site and potentially carrying contamination to the water table. Water in the evapotranspiration layer is removed by direct evaporation into the air and transpiration by plants. Soil texture is the primary physical property that influences water absorption and retention; aspects of texture that need to be determined include grain size distribution and particle density. Hydrologic properties that quantify the capacity of a sample to hold water include water storage capacity, porosity, and hydraulic conductivity. For barrier design, several engineering properties are needed. These include standard compaction (Proctor) tests, shear strength, and Atterberg limits. The soil also must be able to support plant growth for transpiration of moisture out of the upper portion of the barrier and for erosion control.

The borrow site was sampled with split-spoon samplers driven through hollow-stem augers in 34 locations, to an average depth of 18.5 ft. Only the eastern portion of the borrow site was investigated because a previous study showed it potentially has the greatest volume of silt-loam.

The physical and chemical tests show that the silt material in the Borrow Site has the properties necessary for use in evapotranspiration barriers. There are over 8 million m^3 (10 million yd^3) of silt in the area investigated that have a water storage capacity greater than 180 mm/year, which is the average amount of precipitation over the past 57 winter seasons plus one standard deviation. The largest contiguous body of silt occurs in the southwestern portion of the study area. Total thickness of silt here is consistently over 4 meters, and totals ~4 million m^3 (5 million yd^3). The chemical tests show that the soil is slightly alkaline, but suitable for supporting native and non-native plant growth.

3.4.4 A Catalog of Geologic Data for the Hanford Site

Horton, DG, GV Last, TJ Gilmore, BN Bjornstad, and RD Mackley. 2005. *A Catalog of Geologic Data for the Hanford Site*. PNNL-13653, Rev. 2, Pacific Northwest National Laboratory, Richland, Washington.

The following information is excerpted directly from PNNL-13653, Rev. 2. The appendices referenced in the following summary are included in the PNNL-13653, Rev. 2 document and do not correspond to the appendices in this annual report.

Summary. The purpose of this report is to update the previous version of the geologic data catalog (Horton et al. 2002). The earlier catalog gathered sources of existing borehole geologic data for the Hanford Site, focusing on the 100, 200, and 300 Areas, with a particular emphasis on the 200 Areas. Over 2,600 boreholes were included in the previous catalog. This revision of the geologic data catalog incorporates new boreholes drilled after September 2002 as well as other older wells, particularly from the 600 Area, omitted from the earlier catalogs. Additionally, a description of available borehole geophysical log data has been included in the catalog.

This version of the geologic data catalog now contains 3,519 boreholes and is current with boreholes drilled as of November 2004. However, the data catalog (Appendix A) is by no means complete. Many individuals have been involved in geologic studies through the years, and the extent of unpublished data retained in their files is unknown. The geologic data catalog is estimated to represent the majority of borehole geologic data currently available from the Hanford Site, but will continued to evolve as additional boreholes and data are added to the database from other areas.

The data catalog in Appendix A identifies the majority of existing lithologic data available for the Hanford Site. Appendix B is an annotated bibliography of references given in Appendix A. Some, but not all of the references in Appendix B, describe the procedures used to collect the data and/or the pedigree of the data if known.

This geologic data catalog is not a database. Instead, it is a listing of the types of existing data and places where the data can be found (e.g., published documents, formal databases, or informal databases). Most of the data were generated during characterization and remediation activities by Bechtel Hanford, Inc.; the waste management and environmental programs of Rockwell Hanford Operations, Westinghouse Hanford Company, and Fluor Hanford, Inc.; the characterization and monitoring activities done by Pacific Northwest National Laboratory (PNNL); and studies done by independent contractors. The geologic data catalog is intended for the subject matter expert who has a need for existing geologic data. The data catalog also can be used to identify data gaps and technical needs.

3.4.5 Development of an Integrated Borehole Geologic Information System for the Hanford Site

Last, GV, VR Saripalli, DA Bush, and RD Mackley. Abs. 2005. 5th Washington Hydrogeology Symposium, Program with Abstracts, p. 76.

The following information is excerpted directly from the symposium program:

> Borehole data are the cornerstone of subsurface characterization, monitoring, and performance assessment programs. These data often take great effort and expense to generate. Yet, historically they have been managed in an ad hoc fashion, using a wide variety of formats (generally non-digital) and scattered across individual project records. Additionally, data collection procedures have varied over time and are often poorly documented, making it difficult to evaluate, integrate, and apply the data. A number of database, borehole log, and mapping tools are commercially available to help manage and interpret borehole data. However, none of these tools can take advantage of existing databases that contain data collected over the last 60 years at the Hanford Site. Thus, the Groundwater Remediation Project is developing an integrated borehole geology data management and interpretation system to maximize the value of these data. HBGIS (Hanford Borehole Geologic Information System) is a secure online web application supported by Microsoft SQL Serverâ as a back end database. It is designed to support the Hanford Site community with a user friendly GUI (graphical user interface) that provides a comprehensive information management system for archival, retrieval, and interpretation of data from over 4000 boreholes. HBGIS's unique feature is its ability to connect directly to different databases to get the relevant borehole information rather than storing duplicate data available in other Hanford databases. HBGIS data transformation option allows exporting data into graphical data processing software such as LogPlot™ and SoilVision.

3.4.6 Hanford Borehole Geologic Information System (HBGIS)

Last, GV, RD Mackley, and RR Saripalli. 2005. *Hanford Borehole Geologic Information System (HBGIS)*. PNNL-15362, Pacific Northwest National Laboratory, Richland, Washington.

The following information is excerpted directly from PNNL-15362:

> **Summary**. This report provides detailed information regarding the web-based graphical user interface (GUI) for the Hanford Borehole Geologic Information System (HBGIS). This GUI has been improved and enhanced over the last year to provide an effective front end to viewing and downloading borehole geologic data. The HBGIS is being developed as part of the Remediation Decision Support Task of the Groundwater Remediation Project, managed by Fluor Hanford, Inc., Richland, Washington. It is being developed in parallel with related databases such as the Vadose Zone Hydraulic Properties Database (Freeman and Last, 2003) and the Hanford Contaminant Distribution Coefficient Database (Cantrell et. al. 2003). The HBGIS is intended to provide the necessary raw geologic data sets (and secondary data sets) to support the various remedial investigation and performance assessment programs for the Hanford Site.

> The purpose and scope of this document is to provide the reader with a user's guide for disseminating borehole geologic data through this web-based interface. A data dictionary for tables and fields containing borehole geologic data, as well as instructions for viewing and downloading borehole geologic data are provided in this document.

3.4.7 Standard Practices for the Development of Vadose Zone Physical and Hydraulic Properties Data for the Hanford Site, Washington

Freeman, EJ. 2005. *Standard Practices for the Development of Vadose Zone Physical and Hydraulic Properties Data for the Hanford Site, Washington*. PNNL-15398, Pacific Northwest National Laboratory, Richland, Washington.

The following information is excerpted directly from PNNL-15398:

> The purpose of the vadose hydraulic properties task of the Remediation Design Support program (formerly the Characterization of Systems task) is to provide reliable, consistent, reproducible, and defensible physical and hydraulic parameters and conceptual models that are used as input to numerical models for use by site-wide and site-specific modeling efforts. The report describes the processes that are followed starting with sample collection and ending with a conceptual model and calculated parameters that are input into the numerical models used at Hanford.

3.4.8 Three-Dimensional Modeling of DNAPL in the Subsurface of the 216-Z-9 Trench at the Hanford Site

Oostrom, M, ML Rockhold, PD Thorne, GV Last, and MJ Truex. 2004. *Three-Dimensional Modeling of DNAPL in the Subsurface of the 216-Z-9 Trench at the Hanford Site*. PNNL-14895, Pacific Northwest National Laboratory, Richland, Washington.

The following information is excerpted directly from PNNL-14895:

> **Summary**. Carbon tetrachloride (CT) was discharged to waste sites that are included in the 200-PW-1 Operable Unit in Hanford 200 West Area. Fluor Hanford, Inc. is conducting a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial investigation/feasibility study (RI/FS) for the 200-PW-1 Operable Unit. The RI/FS process and remedial investigations for the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units are described in the Plutonium/Organic-Rich Process Condensate/Process Waste Groups Operable Unit RI/FS Work Plan. As part of this overall effort, Pacific Northwest National Laboratory was contracted to improve the conceptual model of how CT is distributed in the Hanford 200 West Area subsurface through use of numerical flow and transport modeling. This work supports the U.S. Department of Energy's (DOE's) efforts to characterize the nature and distribution of CT in the 200 West Area and subsequently select an appropriate final remedy.
>
> Three-dimensional modeling was conducted to enhance the conceptual model of CT distribution in the vertical and lateral direction beneath the 216-Z-9 trench. Simulations targeted migration of dense, nonaqueous phase liquid (DNAPL) consisting of CT and co-disposed organics in the subsurface beneath the 216-Z-9 trench as a function of the properties and distribution of subsurface sediments and of the properties and disposal history of the waste. The geological representation of the computational domain was extracted from a larger Earthvision^{TM} geologic model

of the 200 West Area subsurface developed during fiscal year 2002. Simulations of CT migration were conducted using the Subsurface Transport Over Multiple Phases (STOMP) simulator, a multi-fluid flow and transport code developed by Pacific Northwest National Laboratory.

A total of 23 three-dimensional simulations were conducted to examine infiltration and redistribution of CT in the subsurface prior to implementation of remediation activities in 1993. The simulations consisted of one Base Case simulation and 22 sensitivity analysis simulations. The sensitivity simulations investigated the effects of variations in 1) fluid composition; 2) disposal rate, area, and volume; 3) fluid retention; 4) permeability; 5) anisotropy; 6) sorption; 7) porosity; and 8) residual saturation formation on the movement and redistribution of DNAPL. Additional simulations were conducted to investigate the effect of soil-vapor extraction (SVE) on the distribution of CT in the subsurface of the 216-Z-9 trench.

The simulation results indicate that the Cold Creek unit accumulated CT and has a large impact on DNAPL movement and the resulting distribution of CT in the subsurface. The Cold Creek unit is a relatively thin, laterally continuous unit comprised of a silt layer and a cemented carbonaceous layer located ~40 m below ground surface and ~50 m above the water table. The simulations also show that the lateral extent of the vapor-phase plume in the vadose zone was much more extensive than the lateral extent of the DNAPL. Density-driven vapor flow caused the CT vapor to move downward until the plume contacted relatively impermeable units (e.g., the Cold Creek unit) or the water table. At these interfaces, the vapor plume moved laterally. The vapor plume also partitioned into the water and onto the solid phase as it moved. The CT present in the Cold Creek unit can continue to volatilize over time and move downward to layers where it could be removed by SVE or deeper where groundwater contamination could take place. The simulation results also clearly demonstrated that DNAPL CT has not moved laterally away from the footprint of the disposal facility. In most simulations, CT was predicted to enter the water table as a separate phase or in the aqueous phase directly beneath the disposal area or through gaseous transport and subsequent partitioning into the aqueous phase over a wide-spread area.

In summary, the modeling results led to the following conclusions that can be used to update the conceptual model of CT distribution in the subsurface.

- *Where is CT expected to accumulate?* CT DNAPL accumulates in the finer-grain layers of the vadose zone but does not appear to pool on top of these layers.

- *Where would continuing liquid CT sources to groundwater be suspected?* Migration of DNAPL CT tends to be preferentially vertically downward below the disposal area. Lateral movement of DNAPL CT is not likely. However, significant lateral migration of vapor CT occurs.

- *Where would DNAPL contamination in groundwater be suspected?* Sufficient CT and co-disposed liquids were introduced to the subsurface for DNAPL CT to migrate at least through the Cold Creek unit and, in some sensitivity cases, to migrate across the water table. For the Base Case simulation, 43% of the original DNAPL inventory (450,000 kg) was still present in the vadose zone as a DNAPL in 1993. Most of this DNAPL was located just above and within the Cold Creek units. At 1993, ~27,000 kg (6% of the inventory) of DNAPL had moved across the water table.

- *What is the estimated distribution and state of CT in the vadose zone?* The amount of DNAPL CT that accumulated in the vadose zone by 1993 ranges from 19% to 65% of the total disposed in the sensitivity simulations. The majority of the mass at 1993 was typically a DNAPL or sorbed phase. The center of mass for CT in the vadose zone was typically directly beneath the disposal area and within the Cold Creek unit.

- *How does SVE affect the distribution of CT in the vadose zone?* SVE effectively removes CT from the permeable layers of the vadose zone. SVE previously applied in the 216-Z-9 trench area has likely removed a large portion of CT initially present in the permeable layers within the large radius of influence of the extraction wells. Finer grain layers with more moisture content are less affected by SVE and contain the CT remaining in the vadose zone.

3.4.9 Review of Geophysical Techniques to Define the Spatial Distribution of Subsurface Properties or Contaminants

Murray, CJ, GV Last, and MJ Truex. 2005. *Review of Geophysical Techniques to Define the Spatial Distribution of Subsurface Properties or Contaminants*. PNNL-15305, Pacific Northwest National Laboratory, Richland, Washington.

The following information is excerpted directly from PNNL-15305:

> **Summary**. The purpose of this report is to summarize the state-of-the-art, minimally intrusive geophysical techniques that can be used to elucidate subsurface geology, structure, moisture, and chemical composition. The term "minimally intrusive" is used here to mean technologies that can be installed in the shallow (<0.3048 meter [1 foot]) surface, can use pre-existing monitoring wells, or can use inexpensive subsurface access.
>
> A significant amount of characterization will be needed at Hanford in the future to support remediation decisions and implementation of remedies. Due to the large volume of contaminated soil in the subsurface, geophysical characterization techniques may be desirable because they can provide data that directly estimates the spatial distribution of subsurface properties or contaminants. In contrast, many currently used techniques rely on discrete samples, and spatial distributions must be interpolated between the sample locations. In addition, the use of geophysical techniques will minimize the amount of intrusive characterization (e.g., boreholes) and the resulting waste management costs that will be needed in the future.
>
> The choice of geophysical technology is site specific, and it may be useful to consider combinations of technologies and combined data analysis techniques as a means to enhance the characterization effort. Our analyses of the geophysical techniques, provides the following information for consideration:
>
> - For characterizing contamination, there are technologies that may be useful for metals, other organics, and nonaqueous phase liquid (NAPL) contamination.
> - Dissolved- and vapor-phase contamination are not readily characterized by geophysical techniques.
> - Subsurface properties including stratigraphy, moisture, hydraulic conductivity, and porosity can be characterized with geophysical techniques. However, geophysical techniques are not as suitable for characterizing grain size, geochemistry, and flow patterns.
> - In conjunction with the geophysical technologies for characterizing contaminant distribution and subsurface properties, widely available magnetometer and electromagnetic metal detectors are useful to identify cultural features that can affect the performance of geophysical technologies.

3.4.10 Additional Papers Published in Fiscal Year 2005

In addition to the vadose zone studies described in the preceding sections, the results of several other vadose zone studies, pertinent to the Hanford Site, were published in peer reviewed journals in FY 2005. Citations to those articles are listed in this section. The reader is encouraged to consult the appropriate journal or the authors to learn more about the research.

Bush, DA, CJ Murray, and GV Last. Abs., 2005. *3-D Geostatistical Lithofacies Mapping of Ice-Flood Deposits in a Portion of the Hanford Nuclear Site*. Geological Society America, Abstracts with Programs, v. 37, n. 7, p. 148.

Gee, GW, JM Keller, and AL Ward. 2005. "Measurement and Prediction of Deep Drainage from Bare Sediments at a Semiarid Site." *Vadose Zone Journal* 4(1):32-40.

Gee, GW, ZF Zhang, SW Tyler, WH Albright, and MJ Singleton. 2005. "Chloride-Mass-Balance: Cautions in Predicting Increased Recharge Rates." *Vadose Zone Journal* 4:72-78.

Last, GV, CJ Murray, ML Rockhold, PD Thorn, BN Bjornstad, RD Mackley, MJ Truex, and M Oostrom. 2005. *Lithofacies Mapping at the Hanford Site – Data Management, Analysis, and Visualization*. Geological Society America, Abstracts with Programs, v. 37, no. 4, p. 75.

Nicholes, WE, GV Last, and CT Kincaid. 2005. *Vadose Zone Modeling of Dispersed Waste Sites in the Framework of an Integrated Stochastic Environmental Transport and Impacts Assessment Code for the Hanford Site*. Stochastic Environmental Research and Risk Assessment. Vol. 19, p. 24-32. Springer-Verlag New York Inc., Secaucus, New Jersey.

Qafoku, N, JM Zachera, C Liu, PL Gassman, O Qafoku, and SC Smith. 2005. "Kinetic Desorption and Sorption of U(VI) during Reactive Transport in a Contaminated Hanford Sediment." *Environmental Science and Technology* 39(9):3157-3165.

Um, W, RJ Serne, SB Yabusaki, and AT Owen. 2005. "Enhanced Radionuclide Immobilization and Flow Path Modifications by Dissolution and Secondary Precipitates." *Journal of Environmental Quality* 34(4):1404-1414.

Wang, Z, JM Zachera, PL Gassman, C Liu, O Qafoku, W Yantasee, and JG Catalano. 2005. "Fluorescence Spectroscopy of U(VI)-Silicates and U(VI)-Contaminated Hanford Sediment." *Geochimica et Cosmochimica Acta* 69(6):1391-1403.

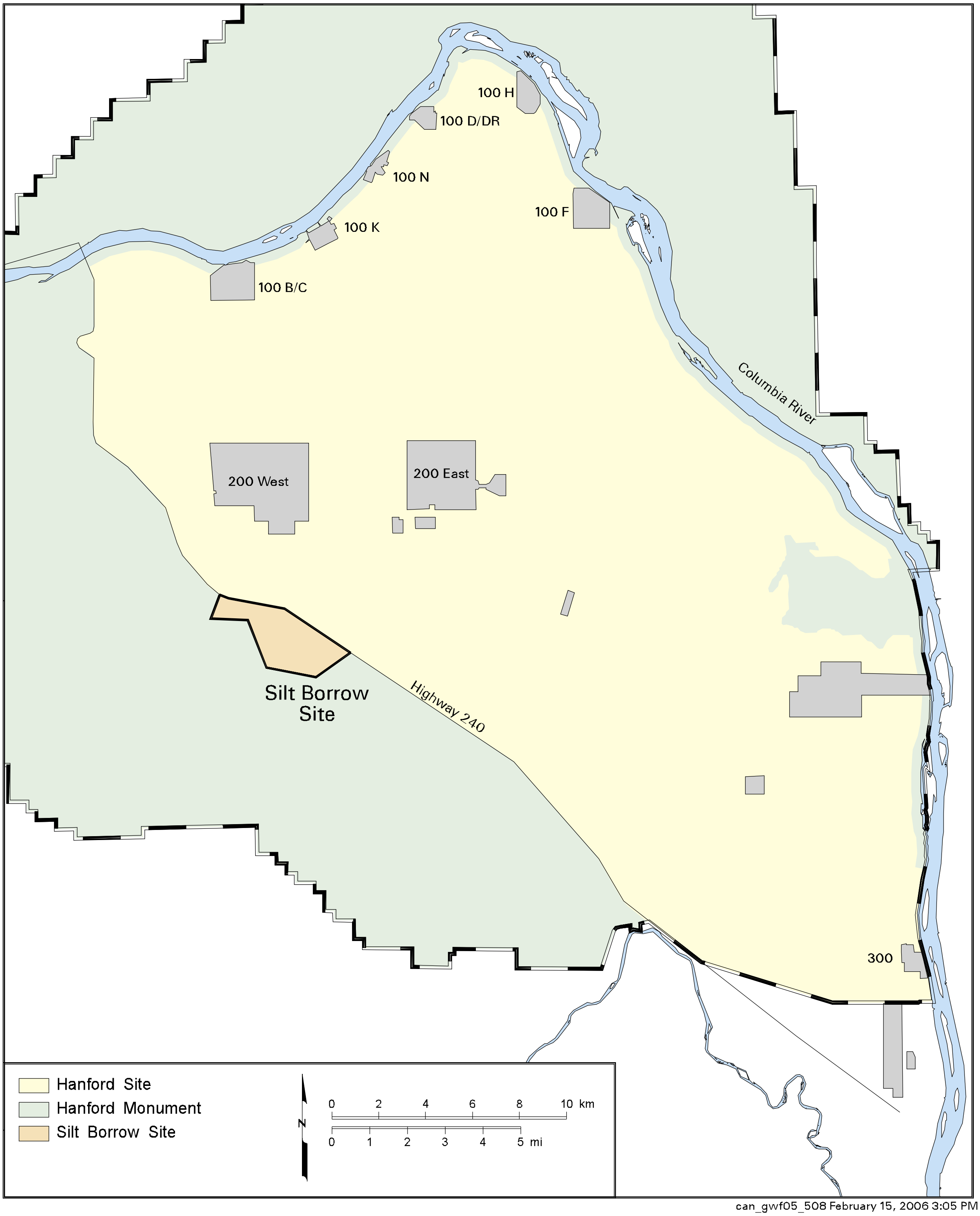


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Figure 3.4-1. Hanford Comprehensive Land Use (from DOE 1999) Showing the Silt Borrow Site (Area C) and Other Borrow Sites Previously Investigated

4.0 Well Installation, Maintenance, and Decommissioning

B. A. Williams and G. G. Kelty

This section describes new well installation activities conducted on the Hanford Site during calendar year 2005. Well maintenance and decommissioning activities are summarized for fiscal year (FY) 2005. In addition, FY 2005 characterization borehole installation activities are summarized.

Approximately 6,562 wells have been identified within the Hanford Site. To date, 2,587 of these wells, or ~39% of the total identified wells, have been decommissioned. During FY 2005, 1,382 wells were in use and 115 wells were physically decommissioned. In addition in FY 2005, records management administratively decommissioned 756 temporary boreholes and subsurface installations, meaning that the wells have previously been taken out of service and decommissioned, and no physical well remains to be located. There were 27 new monitoring wells installed during calendar year 2005.

Each year the Groundwater Performance Assessment and Groundwater Remediation Projects review the need for new monitoring wells. In FY 2005, 27 new wells were installed.

4.1 Well Installation

The Groundwater Performance Assessment Project (groundwater project) along with the Groundwater Remediation Project defines the need for new wells at Hanford. Each year, the groundwater project identifies new wells to meet the requirements of the *Resource Conservation and Recovery Act* (RCRA) detection and assessment groundwater monitoring requirements; characterization and monitoring for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA); and long-term monitoring of regional groundwater plumes under U.S. Department of Energy (DOE) Orders based on the *Atomic Energy Act* (AEA). These efforts include ongoing RCRA assessment of groundwater contamination, replacement of monitoring wells that go dry because of the declining regional water table, replacement of wells that need to be decommissioned, improvement of spatial coverage of the detection monitoring networks or for plume monitoring, and vertical characterization of groundwater contamination.

The Groundwater Remediation Project, managed by Fluor Hanford, Inc., determines the need for new remediation (i.e., pump-and-treat and treatability testing), performance assessment monitoring, and plume characterization wells annually to fulfill obligations of

Based on groundwater monitoring requirements, DOE, EPA, and Ecology agree on new wells needed and prioritize the requirements of RCRA, CERCLA, and AEA. During calendar year 2005, 27 new wells were installed on the Hanford Site:

- ***Seventeen for CERCLA/RCRA monitoring (fulfilling Tri-Party Agreement Milestone M-24-57 commitments).***
- ***Ten in support of groundwater contaminant barrier studies, treatability testing, and ongoing groundwater investigations.***

Well maintenance is performed to support groundwater sampling. Non-routine maintenance varies and depends on specific problems identified in the field. During FY 2005, 197 wells received non-routine maintenance.

Wells are decommissioned when they are no longer used; they are in poor condition; they pose an environmental, safety, or health hazard; or are "in the way." During FY 2005, 115 wells were decommissioned. Another 756 wells were administratively decommissioned during FY 2005.

CERCLA. Other projects may also request new wells based on specific needs (i.e., vadose investigations, seismic investigations, and other research (in situ reduction-oxidation [redox] manipulation, N-Barrier, etc.).

New RCRA, CERCLA, and AEA well proposals are reviewed, prioritized, and approved annually as defined under the Tri-Party Agreement Milestone M-24. All new wells are constructed and decommissioned in accordance with the provisions of WAC 173-160. Well needs are integrated and documented via the data quality objectives process (e.g., CP-15329). This process integrates the borehole and well data needs of the various Hanford Site regulatory driven projects (i.e., CERCLA, RCRA, and AEA). Based on the data quality objectives documentation process, the Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), and DOE (the Tri-Parties) annually negotiate an integrated well drilling list that coordinates and prioritizes the requirements of RCRA, CERCLA, and AEA under Tri-Party Agreement (Ecology et al. 1989) Milestone M-24-57. In 2004, the Tri-Parties renegotiated the milestone and prioritized and scheduled the installation of 60 wells over 4 years between calendar years 2003 to 2006 at a minimum rate of installation of 15 wells per year.

The revised Tri-Party Agreement milestone includes a prioritized list and schedule for installation of 60 wells over 4 years.

During calendar year 2005, a total of 27 new wells were installed at the Hanford Site (Table 4.1-1), which are shown on Figure 4.1-1. Tri-Party Agreement Milestone M-24-57 approved the installation of 17 of these wells, which include 9 RCRA wells and 8 CERCLA wells. Ten non-Tri-Party Agreement wells were also installed in calendar year 2005 including two wells installed at 100-N Area to support monitoring at the 100-NR-2 Operable Unit (N-Barrier), four wells installed in the 100-D Area to support 100-HR-3 Operable Unit in situ redox manipulation treatability testing, and four wells installed in the 100-K Area in support of the 100-KR-4 Operable Unit chromium treatability testing.

Four of the nine RCRA wells were drilled in the 200 West Area around single-shell tank Waste Management Areas S-SX (one well), TX-TY (one well), and T (two wells). These wells are for continued site-specific assessment of groundwater contaminants downgradient of the tank farms. Three other wells were installed downgradient of Low-Level Waste

Obtaining a water-level measurement during new well acceptance inspection.

Management Area 4 as interim-status indicator-parameter wells. The remaining two RCRA wells were installed in the 200 East Area to monitor the Integrated Disposal Facility.

The eight CERCLA wells include one well in the 300-FF-5 Operable Unit within the 300 Area which serves as an upgradient monitoring well and provided continuous sediment sample data in support of groundwater flow and contaminant transport simulations; one well in the 200-BP-5 Operable Unit was installed to investigate aquifer conditions (i.e., hydrogeology and groundwater chemistry) and groundwater flow through the Gable Gap area; four wells for the 200-ZP-1 Operable Unit (200 West Area) as part of the ongoing carbon tetrachloride investigation; and two wells for the 200-UP-1 Operable Unit (200 West Area) technetium-99 investigation.

Water well reports for all new wells, as required in WAC 173-160, are submitted to Ecology. Data packages for new wells installed during calendar year 2005 will provide detailed information about the wells including the detailed geologic and geophysical descriptions and a listing of characterization activities (i.e., sediment and groundwater sampling, aquifer testing, geophysical logging, etc.). Detailed drilling and construction records for the new wells are also electronically stored in the drilling contractor database.

Three new aquifer sampling tubes were installed along the Columbia River shore during calendar year 2005. The aquifer tubes were installed along the 100-N Area shoreline (N-Springs) to expand shoreline monitoring capabilities. In addition, 21 monitoring points were installed in the 100-N Area along the Columbia River shore during FY 2005 (see Section 2.4.1.1). The new monitoring points are similar to aquifer tubes monitored elsewhere on the Hanford Site shoreline and range in depth from 0.8 to 2.4 meters. The new tubes are part of a study of the 100-N Area shoreline to evaluate alternative remedial actions for groundwater remediation.

During FY 2005, many vadose characterization boreholes (temporary boreholes) were installed around the Hanford Site in support of various projects. These boreholes, while temporary, are more cost-effective and can be used to supplement data collected during installation of permanent monitoring wells and in areas that are more difficult for the larger drill rig to access. The temporary boreholes are installed for subsurface characterization of radiological constituents, volatile organics (e.g., carbon tetrachloride), hydrogeologic property determination (e.g., moisture, grain size distribution), and etc. During FY 2005, 261 temporary boreholes (i.e., cone penetrometer, Geoprobe push boreholes, auger, and drilled boreholes) were installed. Table 4.1-2 provides a summary of the number, program, and general location of these temporary boreholes. All of the temporary boreholes were decommissioned after data acquisition was completed. Chapter 3 provides more details about vadose characterization studies conducted during FY 2005.

4.2 Well Maintenance

Well maintenance activities include casing repairs, repairing and replacing sampling pumps, pump and equipment retrieval, and tubing replacement.

Maintenance of groundwater wells is performed to meet regulatory requirements (e.g., Ecology 1994a, Condition II.F.2) in response to non-routine problems identified in the field. During FY 2005, non-routine maintenance was funded and work was completed in 197 wells. A summary of non-routine maintenance activities by regulatory program is presented in Table 4.2-1.

Routine maintenance is planned based on a 5-year cycle to support groundwater sampling and to minimize non-routine maintenance activities. During FY 2005, no routine maintenance was performed. At a minimum, routine maintenance includes the following tasks:

- Removing groundwater sampling pump systems or aquifer-testing equipment.
- Inspecting and repairing or replacing sampling pump systems or aquifer-testing equipment.

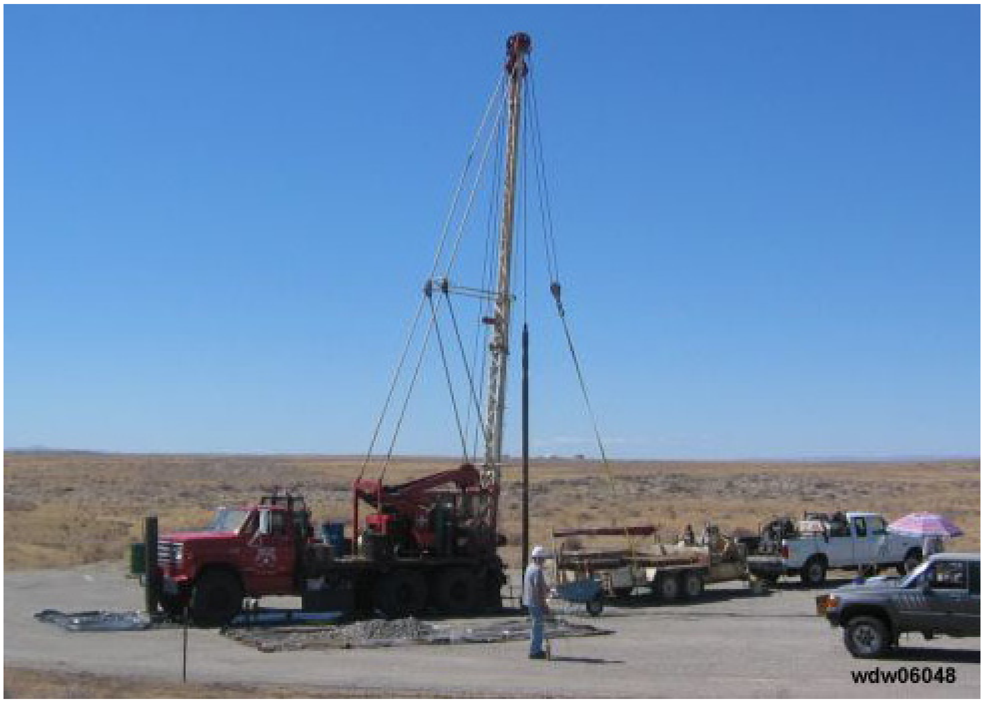
These photos show cable tool drilling of new wells in the 300 Area on the Hanford Site.

- Brushing or cleaning of well casing perforations or well screens.
- Removing debris and fill material.
- Developing the well.
- Performing borehole video camera survey.
- Re-installing sampling pumps and/or aquifer-testing instrumentation/equipment.
- Documenting well conditions and maintenance activities.

Non-routine maintenance tasks are varied and depend on the specific problem encountered at a well; these tasks include both surface and subsurface tasks. Surface tasks include conducting field inspections, well labeling, maintenance and replacement of locking well caps, casing repairs, diagnosis and repair of surface electrical, and pump-discharge fitting. Subsurface tasks include repairing and replacing sampling pumps, performing camera surveys, pump and equipment retrieval, and tubing replacement.

4.3 Well Decommissioning

A well becomes a candidate for decommissioning if (1) its use has been permanently discontinued (i.e., it has gone dry); (2) its condition is so poor that its continued use is impractical; (3) it is in the path of intended remediation/excavation/construction activities; or (4) it poses an environmental, safety, or public health hazard (e.g., casing corrosion). At this time, decommissioning is generally driven by the long-range environmental restoration schedule (DOE/RL-96-105), available funding, and provisions of WAC 173-160. In addition, the list of candidate decommissioning wells is expanded to include wells identified in the Hanford well database that have been removed from the groundwater project's well maintenance list (an indication of no further well use). However, all candidate wells must be reviewed and approved for decommissioning by the contractors and other potential well users prior to actual decommissioning.



Two years ago, in FY 2004, ~6,277 wells reportedly had been identified within the Hanford Site boundary. This number reflected all known subsurface installations, both permanent and temporary, on the Hanford Site. In FY 2005, improved data tracking allowed the project to differentiate permanent well installations from temporary ones. Temporary wells, or more appropriately investigation or characterization boreholes, include Geoprobe or direct push technology boreholes, seismic testing boreholes, or soil-gas tubes that are usually decommissioned immediately following completion and data collection.

After further analysis in FY 2005, only 3,975 permanent well structures were identified within the Hanford Site. Of these permanent structures, 1,382 wells are designated as in-use monitoring wells (includes 1,046 monitoring wells plus 336 special project wells [i.e., in situ redox manipulation, N-Barrier]). Also, there are an additional 836 vadose monitoring boreholes within tank farms available for use. Approximately 1,750 out of the total 3,975 wells (not including tank farms) have been identified as potential candidates for decommissioning.

Wells are filled with grout if they are in poor condition, interfere with surface construction activities, or are no longer used.

During FY 2005, 115 permanent well installations were decommissioned (Table 4.3-1 and Figure 4.3-1). Another 756 unique well identification numbers were administratively decommissioned. For example, in some instances, Hanford well identification numbers (Well ID's) were obtained to drill wells, but drilling was subsequently cancelled. In other instances, the wells were drilled but the casings (if present) were pulled as the holes were backfilled. Other wells were completed and in use for a period of time and then decommissioned, but the administrative record of their decommissioning unfortunately was not filed at the time of their decommissioning. To date, 2,587 unique well identification numbers (~39% of the total Hanford Site well installations, both permanent and temporary) have been either administratively removed from the well inventory or physically decommissioned.

Decommissioning activities result in the permanent removal of a well, borehole, or piezometer from service and from the Hanford Site active well inventory. Decommissioning is performed in accordance with Ecology standards (WAC 173-160), applicable variances, and conditions defined in the Hanford Facility RCRA Permit (Ecology 1994a, Condition II.F.2). Decommissioning involves backfilling a well with impermeable material to prevent vertical

Cable tool drilling of new groundwater monitoring wells in the 300 Area of the Hanford Site.

movement of water and/or contaminants. For resource protection wells, decommissioning typically is performed by placing sand across the screen interval and filling the casing with an impermeable material (e.g., bentonite or cement grout). For older, non-compliant wells, the casing(s) is perforated and pressure grouted. The sealing of the annular space between the casing(s) and formation is intended to minimize the creation of preferential pathways. Where possible, the casing is removed and a brass survey marker identifying the well is set in grout at the surface and over the well location. If the casing cannot be removed, the casing is generally cut ~1 meter below ground surface and the identifying brass survey marker is set in the grout below land surface; the hole is then backfilled to grade.

Table 4.1-1. Well Installations for Calendar Year 2005

Well Name	Well ID	Program	Facility
199-D4-90	C4686	ISRM	100-D, DR
199-D4-91	C4687	ISRM	100-D, DR
199-D4-92	C4688	ISRM	100-D, DR
199-D4-93	C4689	ISRM	100-D, DR
199-K-133	C4734	CTT	100-KR-4-OU
199-K-134	C4735	CTT	100-KR-4-OU
199-K-135	C4736	CTT	100-KR-4-OU
199-K-136	C4737	CTT	100-KR-4-OU
199-N-122	C4954	N-Barrier	100-NR-2-OU
199-N-123	C4955	N-Barrier	100-NR-2-OU
299-E17-26	C4648	RCRA	Integrated Disposal Facility
299-E24-24	C4647	RCRA	Integrated Disposal Facility
299-W11-43	C4694	CERCLA	200-ZP-1-OU
299-W11-45	C4948	RCRA	SST WMA T/200-ZP-1-OU
299-W11-46	C4950	RCRA	SST WMA T/200-ZP-1-OU
299-W14-11	C4668	RCRA	SST WMA TX-TY/200-ZP-1-OU
299-W15-152	C4685	RCRA	LLBG WMA-4 TSD
299-W15-46	C3426	CERCLA	200-ZP-1-OU
299-W15-50	C4302	CERCLA	200-ZP-1-OU
299-W15-83	C4683	RCRA	LLBG WMA-4 TSD
299-W15-94	C4684	RCRA	LLBG WMA-4 TSD
299-W19-101	C4966	CERCLA	200-UP-1-OU
299-W19-49	C4695	CERCLA	200-UP-1-OU
299-W22-47	C4667	RCRA	SST WMA S-SX/200-UP-1-OU
699-50-59	C4882	CERCLA	200-BP-5-OU
699-50-74	C4697	CERCLA	200-ZP-1-OU
699-S20-E10	C4855	CERCLA	300-FF-5-OU

Shaded cells are wells installed as required under Tri-Party Agreement Milestone M-24-57.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act.*
CTT = Chromium treatability testing.
ISRM = In situ redox manipulation treatability testing.
LLBG = Low-level burial ground.
OU = Operable unit.
RCRA = *Resource Conservation and Recovery Act.*
SST = Single-shell tank.
WMA = Waste management area.

Table 4.1-2. Characterization Boreholes, Soil-Gas Probes, and GeoProbe/Push Installation for FY 2005

WELL_ID	Program	Facility	Location
C4401	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4403	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4404	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4405	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4406	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4407	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4408	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4409	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4410	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4411	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4412	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4413	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4414	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4415	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4416	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4417	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4418	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4419	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4420	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4421	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4422	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4425	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4426	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4427	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4428	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4429	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4430	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4431	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4432	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4433	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4434	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4435	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4436	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4437	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4438	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4439	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4440	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4445	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4447	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4448	DOE-ORP Tank Farm Vadose	SST WMA C	200 East Area
C4545	PW-1/PW-3 Program.	10 Geoprobes	200 West Area
C4545	PW-1/PW-3 Program.	2 boreholes	200 West Area
C4557	CERCLA/200-UP-1 OU	216-S-7 Crib	200 West Area

Table 4.1-2. (contd)

WELL_ID	Program	Facility	Location
C4558	CERCLA/200-BP-5 OU	2 for 216-A-4 Crib	200 East Area
C4559	CERCLA/200-UP-1 OU	2 for 216-U-3 French Drain	200 West Area
C4603	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4604	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4605	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4607	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4609	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4611	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4613	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4615	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4619	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4621	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4629	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4631	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4635	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4698	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4699	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4700	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4701	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4702	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4703	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4704	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4705	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4706	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4707	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4708	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4709	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4710	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4711	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4712	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4713	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4714	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4715	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4716	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4717	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4718	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4719	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4720	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4721	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4722	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4723	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4724	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4725	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area

Table 4.1-2. (contd)

WELL_ID	Program	Facility	Location
C4726	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4727	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4728	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4729	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4730	CERCLA/200-UP-1 OU	Various U area facilities	200 West Area
C4738	Entered wrong status (DEC-N)	Replacement for C4558 at 216-T-33, hole abandoned due to obstruction.	
C4743	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4744	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4745	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4746	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4747	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4748	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4749	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4750	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4751	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4752	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4753	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4754	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4755	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4756	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4757	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4758	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4759	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4760	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4761	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4762	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4763	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4764	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4765	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4766	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4767	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4768	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4769	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4770	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4771	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4772	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4773	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4774	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4775	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4776	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4777	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4778	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area

Table 4.1-2. (contd)

WELL_ID	Program	Facility	Location
C4779	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4780	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4781	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4782	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4783	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4784	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4785	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4786	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4787	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4788	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4789	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4790	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4791	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4792	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4793	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4794	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4795	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4796	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4797	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4798	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4799	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4800	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4801	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4802	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4803	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4804	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4805	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4806	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4807	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4808	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4809	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4810	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4811	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4812	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4813	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4854	CERCLA/200-BP-5 OU	200-E-4 French Drain, 200-MW-1	200 West Area
C4856	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4857	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4858	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4859	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4860	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4861	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4862	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area

Table 4.1-2. (contd)

WELL_ID	Program	Facility	Location
C4863	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4864	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4865	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4866	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4867	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4868	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4869	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4870	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4871	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4872	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4873	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4874	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4875	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4876	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4877	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4878	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4879	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4880	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4895	DOE-ORP Tank Farm Vadose	SST WMA TX-TY	200 West Area
C4897	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4898	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4899	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4900	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4901	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4902	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4903	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4904	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4905	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4906	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4907	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4908	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4909	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4910	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4911	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4912	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4913	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4914	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4915	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4916	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4917	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4918	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4919	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4920	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area

Table 4.1-2. (contd)

WELL_ID	Program	Facility	Location
C4921	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4922	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4923	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4924	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4925	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4926	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4927	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4928	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4929	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4930	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4931	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4932	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4933	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4934	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4935	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4936	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4939	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4940	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4941	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4942	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4943	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4944	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4945	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4946	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4947	CERCLA/100-BC Hex chrom investigation	100 B/C Area	100-B/C Area
C4956	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4957	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4958	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4959	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4960	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4961	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4962	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4963	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area
C4964	CERCLA/200-ZP OU Carbon Tetrachloride	Multiple site investigation	200 West Area

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CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act.*
DOE = U.S. Department of Energy.
ORP = Office of River Protection.
OU = Operable unit.
SST = Single-shell tank.
WMA = Waste management area.

Table 4.2-1. Well Maintenance Summary for FY 2005

Program	Routine	Non-Routine
CERCLA	0	186
RCRA	0	11
Total	**0**	**197**

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act.*
RCRA = *Resource Conservation and Recovery Act.*

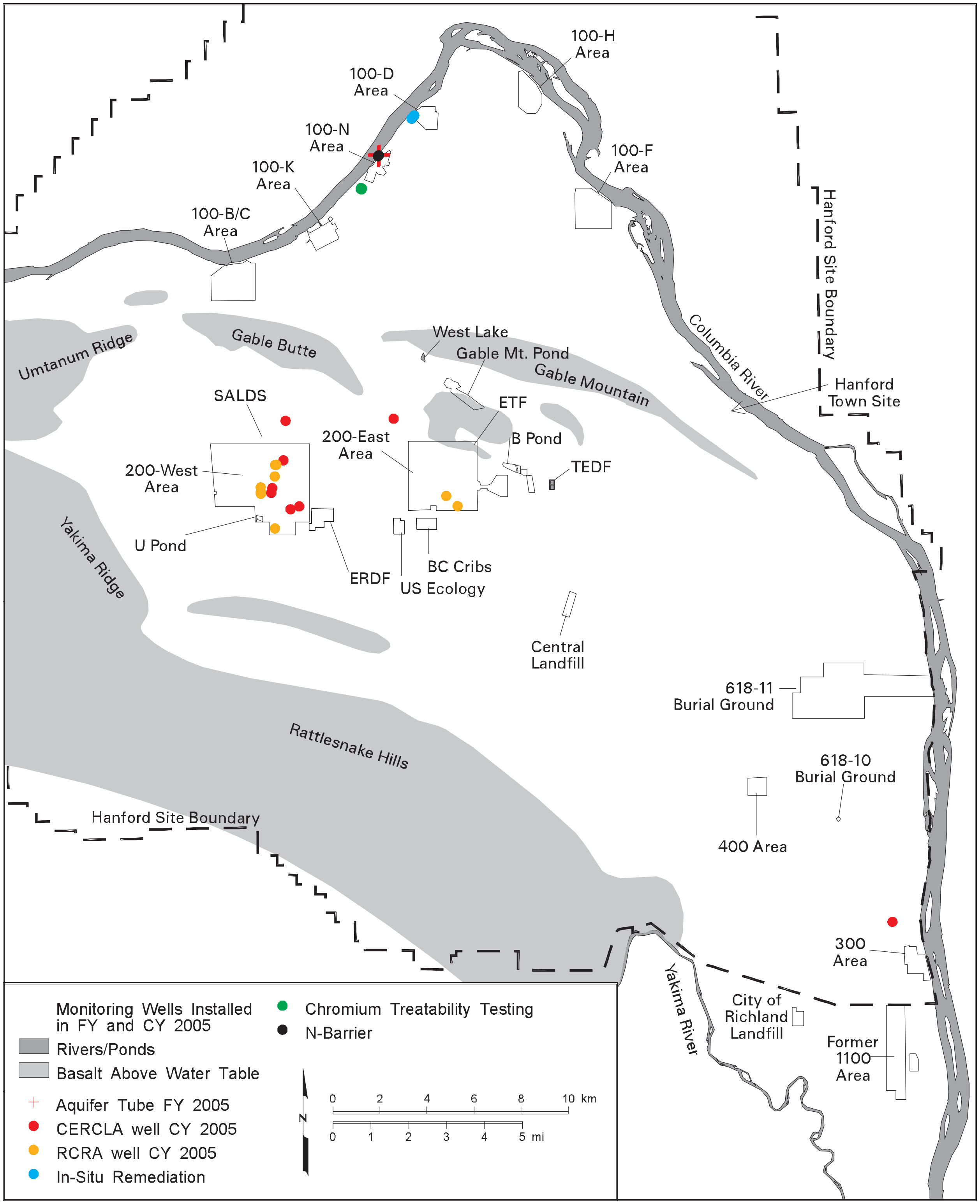
Table 4.3-1. Wells Decommissioned during FY 2005

Well Name	HEIS Well ID
299-E13-54	A5869
299-E13-55	A5870
299-E13-56	A5871
299-E13-57	A5872
299-E17-10	A4729
299-E17-11	A5883
299-E17-2	A5879
299-E17-4	A5881
299-E17-5	A4739
299-E17-6	A4740
299-E17-7	A5882
299-E17-8	A4741
299-E19-1	A5889
299-E24-1	A5896
299-E24-10	A5902
299-E24-11	A5903
299-E24-12	A5904
299-E24-2	A4755
299-E24-9	A5901
299-E26-3	A6640
299-E27-3	A6671
299-E27-3O	A9460
299-E27-3P	A9461
299-E28-10	A6789
299-E28-12	A4819
299-E28-16	A6794
299-E28-19	A6795
299-E28-20	A6796
299-E28-22	A6798
299-E33-19	A4845
299-E33-22	A6856
299-E33-23	A6857
299-E33-336	B8908
299-E33-6	A6852
299-E33-71	A6879
299-E34-1	A4874
299-W11-11	A7280
299-W14-1	A4913
299-W14-10	A7334
299-W14-2	A7328
299-W14-3	A7329
299-W14-4	A7330
299-W14-7	A5467
299-W14-8A	A7332
299-W14-8B	A7333
299-W14-9	A4915
299-W15-102	A7401
299-W15-202	A7500
299-W15-4	A4929
299-W15-53	A7354
299-W15-54	A7355
299-W15-55	A7356
299-W15-56	A7357
299-W15-57	A7358
299-W15-59	A7360
299-W15-60	A7361
299-W15-61	A7362
299-W15-62	A7363
299-W15-63	A7364
299-W15-76	A7377
299-W15-78	A7379
299-W15-81	A7382
299-W18-19	A7532
299-W18-8	A7525
299-W19-10	A7738
299-W19-11	A7739
299-W19-13	A7740
299-W19-14	A4946
299-W19-15	A4947
299-W19-16	A7741
299-W19-17	A7742
299-W19-21	A4950
299-W19-3	A7733
299-W19-70	A7770
299-W19-71	A7771
299-W19-72	A7772
299-W19-73	A7773
299-W19-8O	C4691
299-W19-8P	C4692
299-W19-8Q	C4693

Table 4.3-1. (contd)

Well Name	HEIS Well ID
299-W19-9	A7737
299-W22-1	A7827
299-W22-11	A7836
299-W22-12	A7837
299-W22-13	A7838
299-W22-14	A7839
299-W22-15	A7840
299-W22-16	A7841
299-W22-17	A4964
299-W22-18	A7842
299-W22-19	A4965
299-W22-2	A7828
299-W22-27	A7847
299-W22-27O	A9573
299-W22-27P	A9574
299-W22-27Q	A9575
299-W22-27R	A9576
299-W22-27S	A9577
299-W22-29	A7848
299-W22-30	A7849
299-W22-31	A7850
299-W22-32	A7851
299-W22-33	A7852
299-W22-34	A7853
299-W22-35	A7854
299-W22-36	A7855
299-W22-5	A7831
299-W22-6	A7832
299-W22-75	A7879
299-W23-6	A4989
299-W26-2	A8058
699-37-82A	A5147
699-50-48A	A8812
699-50-53A	A5227
699-55-60B	A8869

HEIS = Hanford Environmental Information System.
ID = Identification.



can_gwf05_555 February 24, 2006 9:26 AM

Figure 4.1-1. Groundwater Monitoring Wells and Aquifer Tubes Installed in Calendar Year 2005

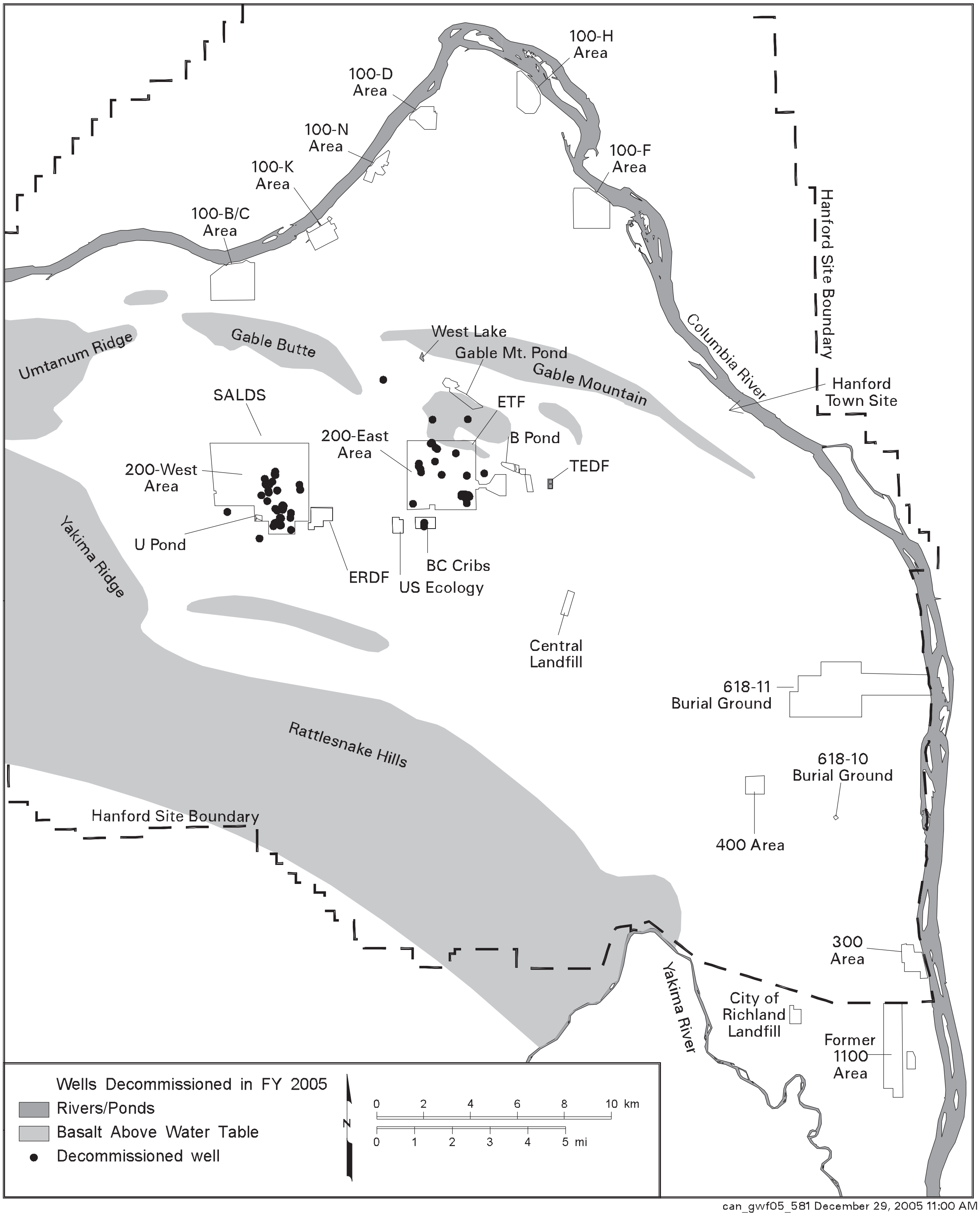


Figure 4.3-1. Groundwater Monitoring Wells Decommissioned During FY 2005

5.0 References

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Appendix A

Supporting Information for CERCLA Groundwater Operable Units

Contents

Tables

Appendix A

Supporting Information for CERCLA Groundwater Operable Units

The groundwater and vadose zone beneath contaminated portions of the Hanford Site are divided into 11 groundwater operable units. Figure 2.1-1 in Section 2.1 of the main text shows the locations of these units and related groundwater interest areas on the Hanford Site. The groundwater project defined the interest areas informally to aid in planning, scheduling, and data interpretation.

Tables A.1 through A.16 list the constituents, monitoring wells, and the frequency of sampling for each operable units required by sampling and analysis plans or other documentation. The tables also indicate whether the wells were sampled as scheduled during fiscal year 2005.

In many cases, wells are sampled for additional constituents not strictly required by the plans. Those constituents are not listed in the tables of this appendix, but data files accompanying this report include all required and supplemental data.

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Table A.1. Monitoring Wells and Constituents for the 100-BC-5 Operable Unit (adapted from DOE/RL-2003-38)

Well	Alkalinity	Alpha	Anions	Beta	Hexavalent Chromium	Metals	Strontium-90	Tritium	Technetium-99	Sampled as Scheduled in FY 2005
199-B2-12	BO	BO	BO	BO		BO	BO	A		Yes
199-B2-13	A	BE	A	BE		A	BE	BE		Yes
199-B3-1	A		A		A	A	A	A		Yes
199-B3-46	BO		BO		A	BO	A	A		Yes
199-B3-47	A	A	A	A	A	A	A	A		Yes
199-B4-1	BE	BE	BE	BE	BE	BE	BE	BE		Not scheduled
199-B4-4		BE		BE			BE	BE		Not scheduled
199-B4-5										Water level only
199-B4-6										Water level only
199-B4-7	BO	BO	BO	BO		BO	BO	BO		Yes
199-B4-8	A	BE	A	BE		A	BE	BE		Yes
199-B5-1	A	A	A	A	A	A	BE	A		Yes
199-B5-2		BO		BO	A		BO	A		Yes
199-B8-6	BO	BO	BO	BO		BO	BO	A		No alkalinity, metals, anions (scheduling error)
199-B9-2		BE		BE			BE	BE		Not scheduled
199-B9-3	BO	BO	BO	BO		BO	BO	BO		Yes
699-63-90	BE	BE	BE	BE		BE		BE		Not scheduled
699-65-72	BE		BE			BE		BE		Not scheduled
699-65-83								BE		Not scheduled
699-66-103								BE		Not scheduled
699-67-86								BO		Yes
699-68-105	BO		BO			BO		BO		Yes
699-71-77	BO		BO			BO		BO	BO	No technetium-99 (scheduling error)
699-72-73	A		A			A		A	BO	No technetium-99 (scheduling error)
699-72-92	BO		BO			BO		BO		Yes
AT-01					A			A		Yes
AT-03					A			A		Yes
AT-04			A		A			A		Yes
AT-05		A	A	A	A		A	A		Yes
AT-06		A	A	A	A		A	A		Yes
AT-07		A	A	A	A			A		No (scheduling error)
AT-11		A		A	A			A	A	No
AT-12		A		A	A			A	A	No
AT-B-1					A			A		Yes
AT-B-2					A			A		Yes
AT-B-3		A	A	A	A		A	A		Yes
AT-B-4		A	A	A	A			A		Yes
AT-B-5		A	A	A	A		A	A	A	Yes
AT-B-7		A	A	A	A		A	A		No alpha, beta, anions, tritium (collection error)
Seep 037-1		A		A	A			A		Yes
Seep 039-2		A		A	A			A		Yes

A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.

Table A.2. Monitoring Wells and Constituents for 100-KR-4 Pump-and-Treat System[(a)]

Well	Frequency	Sampled as Scheduled in FY 2005
199-K-114A	M	Converted to extraction well
199-K-117A	M	Yes
199-K-130	M	Frequency reduced; sampled 5 times
199-K-131	M	Yes
199-K-18	M	Yes
199-K-19	SA	Yes
199-K-20	M	Yes
199-K-21	SA	Yes
199-K-22	SA	Yes
199-K-37	SA	Yes

(a) Table based on requirements transmitted to the Groundwater Performance Assessment Project via letter FH-0402972 from RG Gallagher (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005* , dated October 7, 2004.

FY = Fiscal year.

M = To be sampled monthly.

SA = To be sampled semiannually.

Table A.3. Monitoring Wells and Constituents for 100-KR-4 Operable Unit Long-Term Monitoring(a)

Well	Frequency	Sampled as Scheduled in FY 2005
199-K-106A	BE	Not scheduled
199-K-107A	Q	Yes
199-K-108A	Q	Yes
199-K-109A	A	Yes
199-K-11	BO	Yes
199-K-110A	BE	Not scheduled
199-K-111A	A	Yes
199-K-18	A	Yes
199-K-19	A	Yes
199-K-20	A	Yes
199-K-21	A	Yes
199-K-22	A	Yes
199-K-23	BO	Yes
199-K-27	Q	Yes
199-K-30	Q	Yes
199-K-31	A	Yes
199-K-32A	A	Yes
199-K-32B	A	Yes
199-K-34	BO	Yes
199-K-35	BO	Yes
199-K-36	Q	Yes
199-K-37	A	Yes
699-70-68	BE	Not scheduled
699-73-61	BE	Not scheduled
699-78-62	BE	Not scheduled
SK-057-3	A	No
SK-077-1	A	Yes
SK-082-2	A	No

(a) Table based on requirements transmitted to the Groundwater Performance Assessment Project via letter FH-0402972 from RG Gallagher (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.

A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.
Q = To be sampled quarterly.

Table A.4. Monitoring Wells and Constituents for 100-NR-2 Interim Action[(a)]

Well	Frequency	Sampled as Scheduled in FY 2005
199-N-14	SA	Yes
199-N-16	A	Yes
199-N-18	A	Yes
199-N-2	A	Yes
199-N-21	A	Yes
199-N-27	A	Delayed until 10/2005
199-N-3	SA	Yes
199-N-32	SA	Missed one; access restrictions
199-N-50	A	Yes
199-N-51	A	Yes
199-N-64	A	Delayed until 11/2005
199-N-67	SA	Yes
199-N-70	A	Yes
199-N-74	A	Yes
199-N-75	SA	Yes
199-N-76	SA	Yes
199-N-80	A	Yes
199-N-81	A	Yes
199-N-92A	A	Yes
199-N-96A	A	Yes
199-N-99A	A	Yes

(a) Table based on requirements transmitted to the Groundwater Performance Assessment Project via letter FH-0402972 from RG Gallagher (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.
A = To be sampled annually.
FY = Fiscal year.
SA = To be sampled semiannually.

Table A.5. Monitoring Wells and Constituents for 100-NR-2 Baseline Monitoring

Well	Alkalinity	Alpha	Anions	Beta	Gamma	Metals	Strontium-90	Tritium	Sampled as Scheduled in FY 2005
199-N-46	Q	Q	Q	M	Q	Q	Q	Q	Yes
199-N-67	Q	Q	Q	M	Q	Q	Q	Q	Missed 12/2004
199-N-92A	A	A	A	A	A	A	A	A	Yes
199-N-96A	Q	Q	Q	M	Q	Q	Q	Q	Yes
199-N-99A	Q	Q	Q	M	Q	Q	Q	Q	Yes
199-N-119	Q	Q	Q	M	Q	Q	Q	Q	Yes
199-N-120	Q	Q	Q	M	Q	Q	Q	Q	Yes
199-N-121	Q	Q	Q	M	Q	Q	Q	Q	Yes
NS-2A-23cm	Q	Q	Q	M	Q	Q	Q	Q	Missed 11/2004(a) and 09/2005
NS-2A-87cm	Q	Q	Q	M	Q	Q	Q	Q	Missed 11/2004(a) and 07/2005
NS-2A-168cm	Q	Q	Q	M	Q	Q	Q	Q	Missed 11/2004(a)
NS-3A-10cm	Q	Q	Q	M	Q	Q	Q	Q	Missed 11/2004(a) and 09/2005
NS-3A-87cm	Q	Q	Q	M	Q	Q	Q	Q	Missed 11/2004(a)
NS-3A-176cm	Q	Q	Q	M	Q	Q	Q	Q	Missed 11/2004(a) and 03/2005
NS-4A-17cm	Q	Q	Q	M	Q	Q	Q	Q	Missed 11/2004(a)
NS-4A-138cm	Q	Q	Q	M	Q	Q	Q	Q	Missed 10/2004, 11/2004,(a) and 09/2005
NS-2	Q	Q	Q	M	Q	Q	Q	Q	Sampled twice
NS-3	Q	Q	Q	M	Q	Q	Q	Q	Sampled twice
NS-4	Q	Q	Q	M	Q	Q	Q	Q	Sampled twice

(a) October 2004 sample collected at end of month; skipped November sample.
A = To be sampled annually.
FY = Fiscal year.
M = To be sampled monthly.
Q = To be sampled quarterly.

Table A.6. Monitoring Wells and Constituents for 100-HR-3 Operable Unit In Situ Redox System (100-D Area)[(a)]

Well	Frequency	Sampled as Scheduled in FY 2005
199-D2-6	Q	Yes
199-D2-8	Q	Yes
199-D3-2	Q	Yes
199-D4-1	Q	Yes
199-D4-15	M	Yes
199-D4-20	Q	Yes
199-D4-22	Q	Yes
199-D4-23	Q	Yes
199-D4-26	Q	Yes
199-D4-31	Q	Yes
199-D4-32	Q	Yes
199-D4-36	Q	Yes
199-D4-38	Q	Yes
199-D4-39	Q	Yes
199-D4-4	Q	Yes
199-D4-48	Q	Yes
199-D4-5	Q	Yes
199-D4-6	Q	Yes
199-D4-62	Q	Yes
199-D4-7	Q	Yes
199-D4-78	Q	Fourth delayed until 10/2005
199-D4-83	Q	Yes
199-D4-84	Q	Yes
199-D4-85	Q	Yes
199-D4-86	Q	Yes
199-D5-36	Q	Yes
199-D5-38	M	Yes
199-D5-39	M	Missed 12/2004; frozen line; converted to extraction well summer 2005
199-D5-43	M	Missed 12/2004; frozen line

(a) Table based on requirements transmitted to the Groundwater Performance Assessment Project via letter FH-0402972 from RG Gallagher (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.

FY = Fiscal year.

M = To be sampled monthly.

Q = To be sampled quarterly.

Table A.7. Monitoring Wells and Constituents for 100-HR-3 Pump-and-Treat Systems (100-D and 100-H Areas)[(a)]

Well	Frequency	Sampled as Scheduled in FY 2005
199-D5-92	M	Sampled 7 times; converted to extraction well
199-D8-54B	SA	Yes
199-D8-69	M	Yes
199-D8-70	M	Yes
199-D8-71	SA	Yes
199-D8-73	M	Yes
199-D8-88	M	Yes
199-H4-10	SA	Yes
199-H4-12B	SA	Yes
199-H4-12C	SA	Yes
199-H4-13	SA	Yes
199-H4-14	SA	Yes
199-H4-15B	SA	Yes
199-H4-15CS	SA	Yes
199-H4-16	SA	Yes
199-H4-17	SA	Yes
199-H4-18	SA	Sampled once; converted to injection well
199-H4-3	SA	Yes
199-H4-4	M	Yes
199-H4-46	SA	Yes
199-H4-48	SA	Yes
199-H4-49	SA	Yes
199-H4-5	M	Yes
199-H4-6	SA	Yes
199-H4-63	M	Yes
199-H4-64	M	Yes
199-H4-8	SA	Yes
199-H5-1A	SA	Yes

(a) Table based on requirements transmitted to the Groundwater Performance Assessment Project via letter FH-0402972 from RG Gallagher (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.
FY = Fiscal year.
M = To be sampled monthly.
SA = To be sampled semiannually.

Table A.8. Monitoring Wells and Constituents for 100-HR-3 Operable Unit Long-Term Monitoring (100-D and 100-H Area)[(a)]

Well	Frequency	Sampled as Scheduled in FY 2005
199-D2-6	Q	Yes
199-D3-2	Q	Yes
199-D4-13	Q	Yes
199-D4-14	Q	Yes
199-D4-15	M	Yes
199-D4-19	Q	Yes
199-D4-20	Q	Yes
199-D4-22	Q	Yes
199-D4-23	Q	Yes
199-D5-13	Q	Yes
199-D5-14	Q	Yes
199-D5-15	Q	Yes
199-D5-16	Q	Yes
199-D5-17	A	Yes
199-D5-18	BO	Yes
199-D5-19	BO	Yes
199-D5-20	A	Yes
199-D5-33	Q	Yes
199-D5-34	Q	Yes
199-D5-36	Q	Yes
199-D5-37	Q	Yes
199-D5-38	M	Yes
199-D5-39	M	Missed 12/2004; frozen line; converted to extraction well summer 2005
199-D5-40	Q	Yes
199-D5-41	Q	Fourth delayed until 10/2005
199-D5-43	M	Yes
199-D5-44	Q	Yes
199-D8-4	A	Yes
199-D8-55	Q	Yes
199-H3-2A	A	Yes
199-H3-2C	BO	Yes
199-H4-10	A	Yes
199-H4-12C	A	Yes
199-H4-13	A	Yes
199-H4-14	BO	Yes
199-H4-16	BO	Yes
199-H4-17	BO	Yes
199-H4-18	A	Yes
199-H4-3	A	Yes
199-H4-4	A	Yes
199-H4-45	A	No access
199-H4-46	BO	Yes
199-H4-47	BE	Not scheduled
199-H4-48	BE	Not scheduled
199-H4-49	BE	Not scheduled
199-H4-5	A	Yes

Table A.8. (contd)

Well	Frequency	Sampled as Scheduled in FY 2005
199-H4-6	BO	Yes
199-H4-63	A	Yes
199-H4-64	A	Yes
199-H4-8	BO	Yes
199-H4-9	BE	Not scheduled
199-H5-1A	BE	Not scheduled
199-H6-1	A	Yes
699-91-46A	BE	Not scheduled
699-93-48A	BE	Not scheduled
699-96-43	BO	Yes
699-96-49	BO	Yes
699-97-43	BE	Not scheduled
699-97-51A	A	Yes
SD-102-1	A	Yes
SD-110-1	A	Yes
SD-110-2	A	No
SD-98-1	A	No
SH-144-1	A	No
SH-145-1	A	Yes
SH-150-1	A	No
SH-152-2	A	No
SH-153-1	A	Yes

(a) Table based on requirements transmitted to the Groundwater Performance Assessment Project via letter FH-0402972 from RG Gallagher (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.
A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.
M = To be sampled monthly.
Q = To be sampled quarterly.

Table A.9. Monitoring Wells, Aquifer Tubes, and Constituents for the 100-FR-3 Operable Unit (adapted from DOE/RL-2003-49)

Well	Alkalinity	Alpha	Anions	Hexavalent Chromium	Metals	Strontium-90	Tritium	TCE (VOA)	Uranium	Sampled as Scheduled in FY 2005
199-F1-2	BO		BO		BO					Yes
199-F5-1	A	BE	A		A	BE	BE			Yes
199-F5-4	A	BO	A		A		BO	BO		Yes
199-F5-42	BO	BO	BO		BO	BO	BO			Yes
199-F5-43A	BE	BE	BE		BE	BE	BE			Not scheduled
199-F5-43B	BE	BE	BE		BE	BE				Not scheduled
199-F5-44	BE	BE	BE		BE	BE	BE			Not scheduled
199-F5-45	BO	BO	BO		BO	BO	BO	BO	BO	Yes
199-F5-46	BE	A	BE		BE	BE	A	BE	A	No alpha; scheduling error
199-F5-47	A	BE	A		A		A		A	Yes
199-F5-48	BO	BO	BO		BO		BO		BO	Yes
199-F5-6	A	BE	A		A	BE	BE			Yes
199-F6-1	BO	BO	BO		BO	BO	BO			Yes
199-F7-1	BE		BE		BE			BE		Not scheduled
199-F7-2	BE	BE	BE		BE		BE	BE		Not scheduled
199-F7-3	BE	BE	BE		BE		BE	BE		Not scheduled
199-F8-2	BO	BO	BO		BO		BO		BO	Yes
199-F8-3	BO	A	BO		BO		A	BO	A	Yes
199-F8-4	BE	A	BE		BE		BE		A	Yes
699-58-24	BE		BE		BE					Not scheduled
699-60-32	BO		BO		BO					Yes
699-62-31	BO		BO		BO					Yes
699-62-43F	A		A		A		A			Yes
699-63-25A	BO		BO		BO		BO			Yes
699-63-55	BO		BO		BO		A			Yes
699-64-27	BE		BE		BE					Not scheduled
699-66-23	BE		BE		BE		BE			Not scheduled
699-67-51	BO		BO		BO		BO			Yes
699-71-30	BO	BO	BO		BO		BO			Yes
699-74-44	BO		BO		BO			BO		Yes
699-77-36	BE		BE		BE			BE		Not scheduled
699-77-54	BO		BO		BO					Yes
699-81-38	BE		BE		BE					Not scheduled
699-83-47	BE		BE		BE			BE		Not scheduled
AT-62	A		A	A	A					Yes
AT-63	A		A	A	A					Yes
AT-64	A		A	A	A	A				Yes
AT-65	A		A	A	A	A				Yes
AT-66	A		A	A	A	A		A		Yes
AT-67	A		A	A	A					Yes
AT-68	A		A	A	A		A			Yes
AT-72	A		A	A	A		A			Yes
AT-73	A		A	A	A		A			No; tube under water
AT-74	A		A	A	A		A			Yes
AT-75	A		A	A	A		A			Yes

Table A.9. (contd)

Well	Alkalinity	Alpha	Anions	Hexavalent Chromium	Metals	Strontium-90	Tritium	TCE (VOA)	Uranium	Sampled as Scheduled in FY 2005
AT-76	A		A	A	A		A			Yes
AT-77	A		A	A	A					Yes
AT-78	A		A	A	A					No; tube under water
AT-80	A		A	A	A					No; low priority site
AT-F-1	A		A	A	A	A				Yes
AT-F-2	A		A	A	A		A	A		Yes
AT-F-3	A		A	A	A		A	A		Yes
AT-F-4	A		A	A	A		A			No; tube under water
SF-187-1	A		A	A	A		A			No; low priority site
SF-190-4	A		A	A	A		A			No; low priority site
SF-207-1	A		A	A	A		A			No alkalinity

A = To be sampled annually.
BE = To be sampled biennially, even fiscal year (e.g., FY 2004).
BO = To be sampled biennially, odd fiscal year (e.g., FY 2005).
FY = Fiscal year.
TCE = Trichloroethene.
VOA = Volatile organic analyses.

Table A.10. Monitoring Wells and Constituents for the 200-ZP-1 Operable Unit[(a)]

Well	Frequency	Sampled as Scheduled in FY 2005
299-W10-1	A	Yes
299-W10-13	BO	Dry
299-W10-20	BO	Yes
299-W10-21	SA	Yes
299-W10-22	A	Yes
299-W10-23	A	Yes
299-W10-4	SA	Yes
299-W10-5	A	Yes
299-W11-10	SA	Yes
299-W11-13	SA	Yes
299-W11-14	SA	Dry
299-W11-18	A	Yes
299-W11-3	SA	Yes
299-W11-37	SA	Yes
299-W11-6	SA	Yes
299-W11-7	A	Yes
299-W12-1	A	Yes
299-W14-14	A	Yes
299-W14-16	A	Yes
299-W15-1	SA	Yes
299-W15-11	SA	Yes
299-W15-15	A	Yes
299-W15-17	SA	Yes
299-W15-2	A	Yes
299-W15-30	SA	Yes
299-W15-31A	SA	Yes
299-W15-34	A	Yes
299-W15-35	A	Yes
299-W15-36	A	Yes
299-W15-38	A	Yes
299-W15-39	SA	Yes
299-W15-40	SA	Yes
299-W15-41	SA	Second delayed until 10/2005
299-W15-42	SA	Yes
299-W15-43	SA	Yes
299-W15-44	SA	Yes
299-W15-45	Q	Yes
299-W15-46	Q	Yes
299-W15-47	Q	Yes
299-W15-7	SA	Yes
299-W18-1	SA	Second delayed until 10/2005
299-W18-23	A	Yes
299-W18-27	A	Dry
299-W6-10	A	Yes

Table A.10. (contd)

Well	Frequency	Sampled as Scheduled in FY 2005
299-W7-12	BO	Yes
299-W7-4	A	Yes
299-W8-1	BE	Not scheduled
699-43-89	BO	Delayed until 10/2005
699-44-64	BO	Delayed until 10/2005
699-45-69A	BO	Delayed until 10/2005
699-47-60	BO	Delayed until 10/2005
699-48-71	SA	Yes
699-48-77A	BO	Yes
699-55-60A	BO	Delayed until 10/2005

(a) Table based on requirements transmitted to the Groundwater Performance Assessment Project via letter FH-0402972 from RG Gallagher (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.

A = To be sampled annually.

BE = To be sampled biennially, even fiscal year.

BO = To be sampled biennially, odd fiscal year.

FY = Fiscal year.

SA = To be sampled semiannually.

Table A.11. Monitoring Wells and Constituents for the 200-UP-1 Operable Unit[(a)]

Well	Frequency	Sampled as Scheduled in FY 2005
299-W15-37	A	Delayed until 10/2005
299-W18-15	SA	Yes
299-W18-21	A	Yes
299-W18-22	A	Yes
299-W18-30	A	Yes
299-W18-33	A	Yes
299-W19-34A	A	Yes
299-W19-34B	BE	Not scheduled
299-W19-35	SA	Yes
299-W19-36	A	Yes
299-W19-37	SA	Yes
299-W19-39	SA	Yes
299-W19-4	BO	Yes
299-W19-40	A	Yes
299-W19-43	SA	Yes
299-W19-46	SA	Yes
299-W22-20	A	Delayed until 10/2005
299-W22-26	A	Yes
299-W22-45	A	Yes
299-W22-48	SA	Second delayed until 10/2005
299-W22-49	SA	Yes
299-W22-83	Q	Yes
299-W22-9	BO	Delayed until 12/2005
299-W23-10	SA	Yes
299-W23-15	SA	Yes
299-W23-21	Q	Yes
299-W23-4	SA	Yes
299-W23-9	A	No water
299-W26-13	BO	Yes
299-W26-14	SA	Yes
699-32-62	BO	Delayed until 10/2005
699-32-72A	BO	Delayed until 10/2005
699-35-66A	BO	Yes
699-35-70	BO	Delayed until 10/2005
699-35-78A	A	Delayed until 10/2005
699-36-70A	A	Yes
699-38-65	A	Delayed until 10/2005
699-38-68A	BO	Yes
699-38-70	A	Delayed until 10/2005
699-40-62	BO	Delayed until 11/2005

(a) Table based on requirements transmitted to the Groundwater Performance Assessment Project via letter FH-0402972 from RG Gallagher (Fluor Hanford, Inc.) to DL Stewart (Pacific Northwest National Laboratory), *Tables Specifying Fluor Hanford Performance Sampling Requirements for Fiscal Year 2005*, dated October 7, 2004.

A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.
Q = To be sampled quarterly.
SA = To be sampled semiannually.

Table A.12. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit (adapted from DOE/RL-2001-49)

Well Name	Contaminants of Concern										Supporting Constituents/Measurements							Sampled as Scheduled in FY 2005
	Technetium-99	Tritium	Nitrate	Iodine-129	Cyanide	Cobalt-60	Uranium	Strontium-90	Cesium-137	Plutonium-239/240	Alkalinity	Americium-241	Arsenic	Gross Alpha/Beta	Metals (filtered)	Neptunium-237	TOC/TOX	
299-E24-8		3-07	3-07	3-07		3-07			3-07				3-07	3-07				Not scheduled
299-E26-10		A	A	A														Yes
299-E26-11		3-07	3-07	3-07									3-07					Not scheduled
299-E27-10		3-07	3-07	3-07									3-07					Not scheduled
299-E27-14	A	A	A	A														Yes
299-E27-15	A		A								A				A			Yes
299-E27-17		3-07	3-07	3-07									3-07					Not scheduled
299-E27-18		3-07	3-07	3-07									3-07					Not scheduled
299-E27-7	A	A	A	A									A					Yes
299-E28-13		3-07	3-07	3-07			3-07	3-07						3-07				Not scheduled
299-E28-17			A				A	A	A	A								Yes
299-E28-18		A	A	A			A						A	A				Yes
299-E28-2	A	A	A	A				A	A	A	A			A	A			Yes
299-E28-21							A											Yes
299-E28-23							A	A	A	A		A		A		A		Yes
299-E28-24		A					A	A	A	A		A		A		A		Yes
299-E28-25		A	A	A			A	A	A	A		A	A	A		A		Yes
299-E28-26	A	3-07	A	3-07			A						3-07					Yes
299-E28-27	A	3-07	A	A			A	A	A	A								Yes
299-E28-28		3-07	3-07	3-07														Not scheduled
299-E28-5		3-07	3-07	3-07			A	A	A	A			3-07	3-07				Yes
299-E28-6		3-07	3-07	3-07		A	A	A	A	A			3-07	3-07				Yes
299-E28-8	A						A	A	A	A								Yes
299-E32-10	A	3-07	3-07	3-07	A	A	A						3-07					Yes
299-E32-2		3-07	3-07	3-07														Not scheduled

Table A.12. (contd)

Well Name	Contaminants of Concern										Supporting Constituents/Measurements							Sampled as Scheduled in FY 2005
	Technetium-99	Tritium	Nitrate	Iodine-129	Cyanide	Cobalt-60	Uranium	Strontium-90	Cesium-137	Plutonium-239/240	Alkalinity	Americium-241	Arsenic	Gross Alpha/Beta	Metals (filtered)	Neptunium-237	TOC/TOX	
299-E32-4	A	A	A	A														Yes
299-E32-5		3-07	3-07	3-07			3-07											Not scheduled
299-E32-6	A	3-07	A	3-07			3-07											Yes
299-E32-7		3-07	3-07	3-07														Not scheduled
299-E32-8		3-07	3-07	3-07														Not scheduled
299-E32-9		3-07	A	A	3-07													Yes
299-E33-12	3-07																	Not scheduled
299-E33-13					A		A											Yes
299-E33-15	A		A															Yes
299-E33-16	A		A	A			A											Yes
299-E33-18	A		A	A			A											Yes
299-E33-26	A	3-07	3-07	3-07	A	A	A							3-07				Yes
299-E33-28	A		A															Yes
299-E33-29	3-07	3-07	3-07	3-07														Not scheduled
299-E33-30	A		A															Yes
299-E33-32	3-07	3-07	3-07	3-07														Not scheduled
299-E33-33		3-07	3-07	3-07			3-07						3-07					Not scheduled
299-E33-334	A		A				A											Yes
299-E33-335	A									A								Yes
299-E33-338	A						A											Yes
299-E33-34	A	A	A	A	A	A	A											Yes
299-E33-35	A	3-07	A	3-07	A	3-07	A		3-07									Yes
299-E33-37		3-07	3-07	3-07														Not scheduled
299-E33-38	A	A	A	A	A	A	A	A		A			A	A				Yes
299-E33-39	A	A	A	A	A		A											Yes

Table A.12. (contd)

Well Name	Contaminants of Concern										Supporting Constituents/Measurements							Sampled as Scheduled in FY 2005
	Technetium-99	Tritium	Nitrate	Iodine-129	Cyanide	Cobalt-60	Uranium	Strontium-90	Cesium-137	Plutonium-239/240	Alkalinity	Americium-241	Arsenic	Gross Alpha/Beta	Metals (filtered)	Neptunium-237	TOC/TOX	
299-E33-41	A	3-07	3-07	3-07	3-07	3-07	A		3-07									Yes
299-E33-42	A			A			A											Yes
299-E33-43	A			A			A											Yes
299-E33-44	A					A	A											Yes
299-E33-7	A	A	A	A	A	A	A		A					A				Yes
299-E34-2		A	A	A														Yes
299-E34-5		3-07	3-07	3-07														Not scheduled
299-E34-7		A	A											A				Yes
299-E34-9		3-07	3-07	3-07														Not scheduled
699-44-39B		3-07	3-07	3-07														Not scheduled
699-45-42		3-07	3-07	3-07														Not scheduled
699-47-60	A	A	A	A														Delayed until 10/2005
699-49-55A	A	A	A	A	A	A	A	A	A	A				A				Yes
699-49-57A	A	A	A	A	A	A	A		A				A					Yes
699-49-57B	A	A	A	A	A	A			A									Yes
699-50-59	3-06		3-06	3-06		3-06	3-06				3-06				3-06			New well; delayed until 12/2005
699-53-47A		A	A					A						A				Yes
699-53-47B			3-06					3-06										Not scheduled
699-53-48A		A	A	A				A						A	A			Yes
699-53-55A	A	A	A		A	A												Yes
699-53-55B	A	A	A		A	A												Yes
699-53-55C	A	A	A	A	A	A												Yes

Table A.12. (contd)

Well Name	Contaminants of Concern										Supporting Constituents/Measurements							Sampled as Scheduled in FY 2005
	Technetium-99	Tritium	Nitrate	Iodine-129	Cyanide	Cobalt-60	Uranium	Strontium-90	Cesium-137	Plutonium-239/240	Alkalinity	Americium-241	Arsenic	Gross Alpha/Beta	Metals (filtered)	Neptunium-237	TOC/TOX	
699-54-45A			3-06															Not scheduled
699-54-45B			3-06															Not scheduled
699-54-48								3-06										Not scheduled
699-54-49		A	A					A						A				Yes
699-55-50C	A	A	A	A				A										Yes
699-55-57	A	A	A	A	A	A												Yes
699-55-60A	A	A	A	A	A	A												Yes
699-57-59	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-59-58	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-60-60	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-61-62	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-61-66	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-64-62	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-65-50	3-07																	Not scheduled
699-65-72		3-07																Not scheduled
699-66-58	3-07	3-07																Not scheduled
699-66-64	3-07	3-07																Not scheduled
699-70-68	3-07	3-07																Not scheduled
699-72-73	3-07	3-07	3-07															Not scheduled
699-73-61		3-07																Not scheduled

3-xx = To be sampled triennially (every three years); xx indicates the first fiscal year of sampling for specified analyte in accordance with this revised sampling plan.
A = To be sampled annually.
FY = Fiscal year.
TOC = Total organic carbon.
TOX = Total organic halides.

Table A.13. Monitoring Wells, Aquifer Tubes, and Constituents for the 200-PO-1 Operable Unit (adapted from DOE/RL-2003-04)

Well	Alkalinity	Alpha	Ammonia	Anions	Arsenic	Beta	Coliform	Cyanide	Gamma	Hexavalent Chromium	Iodine-129	ICP	Metals-Mercury	Metals-Lead	Oil/Grease	Phenols	Plutonium	SVOA	Strontium-90	Technetium-99	TDS	TOC	TOX	TPH	Tritium	Uranium	VOA	Sampled as Scheduled in FY 2005
299-E13-5		A		A		A		A	A			A							A	A					A	A		Yes
299-E16-1	3-06	3-06		3-06		3-06					3-06	3-06													3-06			Not scheduled
299-E16-2				3-07	3-07						3-07														3-07			Not scheduled
299-E17-12		A		A	A	A					A	A													A			Yes
299-E17-13	A	A		A	A	A					A	A							A						A			Yes
299-E17-14				3-07	3-07						3-07														3-07			Not scheduled
299-E17-16				3-07	3-07						3-07														3-07			Not scheduled
299-E17-18				3-07	3-07						3-07														3-07			Not scheduled
299-E17-19				3-07	3-07						3-07														3-07			Not scheduled
299-E23-1				3-07	3-07						3-07														3-07			Not scheduled
299-E24-18				3-07	3-07						3-07														3-07			Not scheduled
299-E24-19		A		A		A																						No; casing corroded; removed from network
299-E24-20				3-07	3-07						3-07														3-07			Not scheduled
299-E24-5				3-07	3-07						3-07														3-07			Not scheduled
299-E25-17				3-07	3-07						3-07														3-07			Not scheduled
299-E25-18				3-07	3-07						3-07														3-07			Not scheduled
299-E25-19				3-07	3-07						3-07														3-07			Not scheduled
299-E25-20				3-07	3-07						3-07														3-07			Not scheduled
299-E25-22				3-07	3-07						3-07														3-07			Not scheduled
299-E25-28				3-07	3-07						3-07														3-07			Not scheduled
299-E25-29P				3-07	3-07						3-07														3-07			Not scheduled
299-E25-29Q				3-07	3-07						3-07														3-07			Not scheduled
299-E25-3				3-07	3-07						3-07														3-07			Not scheduled
299-E25-32P				3-07	3-07						3-07														3-07			Not scheduled
299-E25-32Q	3-07			3-07	3-07						3-07	3-07													3-07			Not scheduled
299-E25-34				3-07	3-07						3-07														3-07			Not scheduled
299-E25-35				3-07	3-07						3-07														3-07			Not scheduled
299-E25-36				3-07	3-07						3-07														3-07			Not scheduled
299-E25-37				3-07	3-07						3-07														3-07			Not scheduled
299-E25-41				3-07	3-07						3-07														3-07			Not scheduled
299-E25-42				3-07	3-07						3-07														3-07			Not scheduled
299-E25-43				3-07							3-07														3-07			Not scheduled
299-E25-44											3-07														3-07			Not scheduled
299-E25-46				3-07							3-07														3-07			Casing corroded; removed from network
299-E25-47				3-07							3-07														3-07			Not scheduled
299-E25-6		3-07		3-07	3-07	3-07			3-07		3-07									3-07					3-07	3-07		Not scheduled
299-E26-4		A		A	A	A			A		A	A													A			Yes
499-S0-7	A	A	A	A		A					A	A													Q			Yes
499-S0-8	A	A		A		A					A	A													Q			Yes

Table A.13. (contd)

Well	Alkalinity	Alpha	Ammonia	Anions	Arsenic	Beta	Coliform	Cyanide	Gamma	Hexavalent Chromium	Iodine-129	ICP	Metals-Mercury	Metals-Lead	Oil/Grease	Phenols	Plutonium	SVOA	Strontium-90	Technetium-99	TDS	TOC	TOX	TPH	Tritium	Uranium	VOA	Sampled as Scheduled in FY 2005
499-S1-8J		A	A	A		A			A		A	A							A	A					Q	A	A	Yes
699-10-54A	3-07								3-07			3-07							3-07	3-07		3-07	3-07					Not scheduled
699-10-E12	A	A		A		A			A			A							A			A	A		A			Yes
699-12-4D				3-07							3-07														3-07			Not scheduled
699-13-1A		3-07		3-07		3-07					3-07														3-07			Not scheduled
699-13-1C	3-06	3-06		3-06		3-06						3-06													3-06			Not scheduled
699-13-3A									A																		A	Yes
699-14-38				3-07								3-07													3-07			Not scheduled
699-17-5	3-07	3-07		3-07		3-07			3-07		3-07	3-07							3-07	3-07					3-07		3-07	Not scheduled
699-19-43				3-07							3-07	3-07													3-07			Not scheduled
699-20-20		3-07		3-07		3-07			3-07		3-07	3-07								3-07					3-07			Not scheduled
699-20-E12O	A	A		A		A			A		A	A							A	A		A	A		A			Yes
699-20-E12S	3-07			3-07																					3-07			Not scheduled
699-20-E5A				3-07																					3-07			Not scheduled
699-21-6				3-07							3-07														3-07			Not scheduled
699-2-3				3-07							3-07														3-07			Not scheduled
699-24-1P	3-07	3-07		3-07		3-07						3-07													3-07			Not scheduled
699-24-34C				3-07							3-07														3-07			Not scheduled
699-24-46	A	A		A		A			A		3-07	A							A	A		A	A		A			Yes
699-26-15A				3-07							3-07														3-07			Not scheduled
699-26-33	A	A		A		A			A		A	A							A	A		A	A		A			Yes
699-26-35A				3-07							3-07														3-07			Not scheduled
699-2-6A	Q	A		Q		A	A					A	A	A								Q			A			Yes
699-2-7	Q	A		Q		A	A					A	A	A								Q			A			Yes
699-27-8				3-07							3-07														3-07			Dry; removed from network
699-28-40				3-07							3-07	3-07													3-07			Not scheduled
699-29-4				3-07							3-07														3-07			Not scheduled
699-31-11				3-07							3-07														3-07			Not scheduled
699-31-31	A	A		A		A			A		A	A							A	A		A	A		A			Yes
699-31-31P				3-07							3-07														3-07			Not scheduled
699-32-22A	A	A		A		A			A		A	A							A	A		A	A		A			Yes
699-32-22B	3-06	3-06		3-06		3-06					3-06	3-06													3-06			Not scheduled
699-32-43	A	A		A		A			A		A	A							A	A		A	A		A			Yes
699-33-42				3-07							3-07	3-07													3-07			Not scheduled
699-34-41B				A							A														A			Yes
699-34-42				3-07							3-07														3-07			Not scheduled
699-35-9				3-07							3-07														3-07			Not scheduled
699-37-43				3-07							3-07														3-07			Not scheduled

Table A.13. (contd)

Well	Alkalinity	Alpha	Ammonia	Anions	Arsenic	Beta	Coliform	Cyanide	Gamma	Hexavalent Chromium	Iodine-129	ICP	Metals-Mercury	Metals-Lead	Oil/Grease	Phenols	Plutonium	SVOA	Strontium-90	Technetium-99	TDS	TOC	TOX	TPH	Tritium	Uranium	VOA	Sampled as Scheduled in FY 2005
699-37-47A				3-07	3-07						3-07														3-07			Not scheduled
699-37-E4	3-07			3-07							3-07	3-07													3-07			Not scheduled
699-38-15				3-07							3-07														3-07			Not scheduled
699-39-39				3-07							3-07														3-07			Not scheduled
699-40-1				3-07							3-07														3-07			Not scheduled
699-40-33A				3-07							3-07														3-07			Not scheduled
699-41-1A	A	A		A		A			A		A	A							A	A		A	A		A			Yes
699-41-23	3-07	A		A		A			3-07		A	3-07							3-07	3-07		3-07	3-07		A			Yes
699-41-40	3-07	3-07		3-07		3-07					3-07														3-07			Not scheduled
699-42-12A				3-07							3-07														3-07			Not scheduled
699-42-39A				3-07							3-07														3-07			Not scheduled
699-42-39B	3-07			3-07							3-07														3-07			Not scheduled
699-42-40C	3-06	3-06		3-06		3-06					3-06	3-06													3-06			Not scheduled
699-42-41				3-07	3-07						3-07														3-07			Decommissioned
699-42-42B	3-07			3-07							3-07														3-07			Not scheduled
699-43-3				3-07							3-07														3-07			Not scheduled
699-43-40				3-07	3-07						3-07														3-07			Dry
699-43-41E				3-07	3-07						3-07														3-07			Not scheduled
699-43-43				3-07	3-07						3-07														3-07			Decommissioned
699-43-45				3-07	3-07						3-07														3-07			Not scheduled
699-44-39B				3-07							3-07														3-07			Not scheduled
699-45-42				3-07							3-07														3-07			Not scheduled
699-46-21B	3-07	A		A		A			3-07		3-07	3-07							3-07	3-07		3-07	3-07		A			Yes
699-46-4	A	A		A		A			A		A	A							A	A		A	A		A			Delayed until 10/2005
699-47-5				3-07							3-07														3-07			Not scheduled
699-48-7A																									3-07			Not scheduled
699-49-13E		3-07		3-07		3-07			3-07		3-07														3-07			Not scheduled
699-50-28B				3-07							3-07														3-07			Not scheduled
699-8-17	Q	A		Q		A	A				A	A	A	A								Q			A			Yes
699-8-25				3-07							3-07														3-07			Not scheduled
699-9-E2		3-07		3-07		3-07			3-07		3-07														3-07			Not scheduled
699-S11-E12AP																									A			Yes
699-S12-3				3-07																					3-07			Not scheduled
699-S19-E13	SA	A		SA		A			A			A							A	A		A	A		SA			Changed to annual for all constituents
699-S19-E14				3-07																					3-07			Not scheduled
699-S2-34B	A			A							A	A									A				A			Yes

Table A.13. (contd)

Well	Alkalinity	Alpha	Ammonia	Anions	Arsenic	Beta	Coliform	Cyanide	Gamma	Hexavalent Chromium	Iodine-129	ICP	Metals-Mercury	Metals-Lead	Oil/Grease	Phenols	Plutonium	Semi-VOA	Strontium-90	Technetium-99	TDS	TOC	TOX	TPH	Tritium	Uranium	VOA	Sampled as Scheduled in FY 2005
699-S3-25				3-07																					3-07			Yes
699-S3-E12	A	A		A		A			A			A							A	A		A	A		A			Yes
699-S6-E14A		3-07		3-07		3-07			3-07																3-07			Not scheduled
699-S6-E4A	A			A					A						SA	SA	A	SA	A					SA		SA	SA	No stronium-90, plutonium
699-S6-E4B		3-07		3-07		3-07			3-07																3-07			Not scheduled
699-S8-19				3-07																					3-07			Not scheduled
AT-81		A		A		A				A	A									A					A			No(a)
AT-82		A		A		A				A	A									A					A			No(a)
AT-83		A		A		A				A	A									A					A			No(a)
AT-84		A		A		A				A	A									A					A			No(a)
AT-85		A		A		A				A	A									A					A			No(a)
AT-86		A		A		A				A	A									A					A			No(a)

(a) Tube sampling limited by river stage.
3-06 = Sampled triennially; next scheduled for FY 2006.
3-07 = Sampled triennially; next scheduled for FY 2007.
A = To be sampled annually.
FY = Fiscal year.
ICP = Inductively coupled plasma.
Semi-VOA = Semivolatile organic analyses.
TDS = Total dissolved solids.
TOC = Total organic carbon.
TOX = Total organic halides.
TPH = Total petroleum hydrocarbons.
VOA = Volatile organic analyses.

Table A.14. Monitoring Wells, Aquifer Tubes, and Constituents for the 300-FF-5 Operable Unit, 300 Area (adapted from DOE/RL-2002-11)

Well	Alkalinity	Alpha	Anions	Beta	ICP Metals	Strontium-90	TPH	Tritium	Uranium	VOA	Sampled as Scheduled in FY 2005
399-1-1	SA		SA						SA	SA	Yes
399-1-10A	SA		SA						SA	SA	Yes
399-1-10B	SA							SA	SA	SA	Yes
399-1-11	SA								SA	SA	Yes
399-1-12	SA								SA	SA	Yes
399-1-15	SA	SA		SA					SA	SA	Yes
399-1-16A	SA		SA						SA	SA	Yes
399-1-16B	SA								SA	SA	Yes
399-1-17A	SA	SA	SA	SA				SA	SA	SA	Yes
399-1-17B	SA								SA	SA	Yes
399-1-18A	SA		SA								Yes
399-1-18B	SA							SA			Yes
399-1-2	SA		SA						SA	SA	Yes
399-1-21A	SA							SA	SA	SA	Yes
399-1-21B	SA								SA	SA	Yes
399-1-6	SA		SA						SA	SA	Yes
399-1-7	SA								SA	SA	Yes
399-1-8	SA								SA	SA	Yes
399-2-1	SA								SA	SA	Missed one; pump problem
399-2-2	SA								SA	SA	Yes
399-3-10	SA								SA	SA	Yes
399-3-11	SA	SA	SA	SA		SA		SA	SA	SA	Yes
399-3-12	SA		SA					SA	SA	SA	Yes
399-3-2	SA									SA	Missed one; pump problem
399-3-6	SA		SA					SA	SA	SA	Yes
399-4-1	SA		SA					SA	SA	SA	Yes
399-4-12	SA		SA					SA	SA	SA	Yes
399-4-9	SA		SA					SA	SA	SA	Yes
399-5-4B	SA							SA		SA	Yes
399-8-5A	SA	SA	SA	SA				SA	SA	SA	Yes
AT-3-1	A		A		A				A	A	Yes
AT-3-2	A		A		A				A	A	Yes
AT-3-3	A		A		A				A	A	Yes
AT-3-4	A		A		A				A	A	Yes
AT-3-5	A		A		A				A	A	Yes
AT-3-6	A		A		A				A	A	Yes
AT-3-7	A		A		A				A	A	Yes
AT-3-8	A		A		A				A	A	Yes

A = To be sampled annually.
FY = Fiscal year.
ICP = Inductively coupled plasma.
SA = To be sampled semiannually.
TPH = Total petroleum hydrocarbons.
VOA = Volatile organic analyses.

Table A.15. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, North (adapted from DOE/RL-2002-11)

Well	Alkalinity	Alpha	Anions	Beta	Gamma	Iodine-129	Metals	TPH	Technetium-99	Tritium	Uranium	VOA and SVOA	Sampled as Scheduled in FY 2005
699-12-2C	SA	Q	SA	Q	Q	SA	A			Q	Q	A	Yes
699-13-0A	SA	Q	SA	Q	Q	SA	A			Q	Q	A	Yes
699-13-1E	SA	Q	SA	Q	Q	SA	A			Q	Q	A	Yes
699-13-2D	SA	Q	SA	Q	Q	SA	A			Q	Q	A	Yes
699-13-3A	SA	Q	SA	Q	Q	SA	A		A	Q	Q	A	Yes
699-S6-E4A	SA	SA	SA	SA	SA		SA	A		SA	SA	SA	Yes
699-S6-E4B	SA	A		A	A					SA	A		Second delayed until 10/2005
699-S6-E4D	A	A		A	A				A	A	A		Yes
699-S6-E4E	SA	A		A	A					A	A		Second delayed until 10/2005
699-S6-E4K	SA	SA	SA	SA	SA		SA	SA	SA	SA	SA	SA	Yes
699-S6-E4L	SA	SA	SA	SA	SA		SA	SA	SA	SA	SA	SA	Yes

A = To be sampled annually.
FY = Fiscal year.
Q = To be sampled quarterly.
SA = To be sampled semiannually.
SVOA = Semivolatile organic analyses.
TPH = Total petroleum hydrocarbons.
VOA = Volatile organic analyses.

Table A.16. Monitoring Wells and Constituents for the 1100-EM-1 Operable Unit (adapted from PNNL-12220)

Well	Anions	Metals	VOA	Sampled as Scheduled in FY 2005
699-S27-E12A	A		A	Yes
699-S28-E12	A		A	Yes
699-S28-E13A	A		A	Yes
699-S29-E10A	A		A	Yes
699-S29-E11	A		A	Yes
699-S29-E12	A		A	Delayed until 11/2005
699-S29-E13A	A		A	Yes
699-S30-E10A	A		A	Yes
699-S30-E10B	A		A	Yes
699-S30-E11A	A		A	Yes
699-S31-E10A	A		A	Yes
699-S31-E10C	A		A	Yes
699-S31-E10D	A		A	Yes
699-S31-E11	A		A	Yes
699-S41-E12		A		Yes

A = To be sampled annually.
FY = Fiscal year.
VOA = Volatile organic analyses.

Appendix B

Supporting Information for Monitored Facilities

Contents

Tables

Figures

Appendix B

Supporting Information for Monitored Facilities

This appendix provides supplemental information for *Resource Conservation and Recovery Act* (RCRA) and other regulated units on the Hanford Site that require groundwater monitoring excluding *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) units (discussed in Appendix A). Site-specific discussions for each facility in Appendix B are found in the body of the document under the respective operable unit in which the facility lies (see Figure 2.1-1 in the main text for operable units).

RCRA groundwater monitoring continued during fiscal year (FY) 2005 at 26 waste management areas (Figure B.1). Estimates of groundwater velocity, hydrologic properties, and associated references are shown in Table B.1 for all RCRA sites and the Solid Waste Landfill. Table B.2 lists upgradient/downgradient comparison values used for statistical comparisons at RCRA sites monitored under indicator parameter programs in FY 2005. Tables B.3 through B.41 provide supporting information for the RCRA sites and Figures B.2 through B.18 show locations of monitoring wells.

This appendix also provides constituent lists, well network configurations, and other ancillary information for regulated facilities that fall outside of RCRA programs except CERCLA units. Some network wells in these facilities are shared with RCRA facilities. Figure B.19 shows the general locations of these facilities. Locations of monitoring wells are shown in Figures B.20 through B.23 and Figure B.15. Tables B.38 through B.44 list the constituents list and/or results summaries for the facilities.

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WHC-SD-EN-EV-002. 1990. *Interim Hydrogeologic Characterization Report for the 216-B-3 Pond.* Westinghouse Hanford Company, Richland, Washington.

Table B.1. Estimates of Groundwater Flow Rates at Hanford Site Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/d) (source)	Effective Porosity[a]	Gradient[b]	Comments
116-N-1 LWDF	NW	0.06 to 1.0	Darcy	6.1 to 37 (PNL-8335)		0.0028	Gradient calculated between wells 199-N-66 and 199-N-2.
120-N-1 and 120-N-2	NW	0.06 to 1.0	Darcy	6.1 to 37 (PNL-8335)		0.0027	Gradient calculated between wells 199-N-72 and 199-N-26.
116-N-3 LWDF	N	0.04 to 0.68	Darcy	6.1 to 37 (PNL-8335)		0.0018	Gradient calculated between wells 199-N-28 and 199-N-81.
116-H-6 evaporation basins	E	0.14 to 4.0	Darcy	15 to 140 (PNL-6728)		0.0028	Gradient calculated between wells 199-H4-14 and 199-H4-3.
216-A-29 ditch	WSW	~0.01 to ~0.04	Darcy	18 (WHC-SD-EN-DP-047)		~0.0002	Gradient calculated from water-table map.
216-B-3 pond	WSW to SSE	0.012	Darcy	1.0 (WHC-SD-EN-EV-002; PNL-10195)	0.25	0.004	Gradient calculated between wells 699-44-39B and 699-42-42B.
216-B-63 trench	SW	0.03 to 0.4	Darcy	52 to 200 (WHC-SD-EN-EV-002)		~0.0002	Gradient calculated from water-table map.
216-S-10 pond	ESE	0.075 to 2.25	Darcy	10 (WHC-SD-EN-DP-052) 12 to 150 (BNWL-1709)	0.1 to 0.2	0.0015	Wells are dry. Gradient calculated using regional water-table maps.
216-U-12 crib	ESE	0.027 to 0.07	Darcy	4.2 to 5.4 (PNNL-13378)	0.1 to 0.2	0.0013	Gradient calculated between wells 299-W22-79 and 699-36-70A.
316-5 process trenches	SE	10.7 (PNL-5408)	Movement of PCE spill				
	SE	0.54 to 54	Darcy	150 to 15,000 (PNL-6716)	0.25	0.0009	Gradient calculated from December 2004 water-table map.
IDF	SE	0.002 to 0.0075	Darcy	68 to 75 (PNNL-13652; PNNL-11957)		0.00001	Uncertainty in gradient and rate of flow. Flow direction inferred from plume maps.
LERF	W	0.04 to 2.4	Darcy	6.1 to 120 (PNNL-11620)		0.002	Gradient calculated from water-table map.

Table B.1. (contd)

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/d) (source)	Effective Porosity[a]	Gradient[b]	Comments
LLWMA 1	NW	Undetermined					Uncertain of flow direction. Gradient too low to determine flow rate.
LLWMA 2	W to SW	0.1 to 1.4	Darcy	430 to 2,000 (PNL-6820)		~0.00007	Uncertainty with flow direction, rate, and gradient.
LLWMA 3	75° E of N	0.00008 to 0.12	Darcy	0.02 to 9.8 (PNL-6820)		0.0012	Flow direction from trend-surface analysis.
LLWMA 4	E	0.2 to 1.0	Darcy	24 (PNL-6820)		0.0025 to 0.004	Flow direction is variable due to effects of pump-and-treat system.
NRDWL	125° E of N (based on plume maps)	0.015 to 0.02	Darcy	518 to 1,524 (WHC-EP-0021)		0.00001	Uncertainty with gradient and rate of flow. Flow direction inferred from plume maps.
PUREX cribs	SE	0.0006 to 0.3	Darcy	18 to 3,000 (PNNL-11523; PNNL-11523-ICN-1)		0.00001	Uncertainty with gradient and rate of flow. Flow direction inferred from plume maps.
SWL	125° E of N (based on plume maps)	0.013 to 0.02	Darcy	640 to 1,280 (PNL-6820)		0.00001	Uncertainty with gradient and rate of flow. Flow direction inferred from plume maps.
WMA A-AX	SE	0.8 to 1.0	Darcy	1,981	0.3 to 0.4	0.00016	Gradient and flow rate calculated between wells 299-E24-20 and 299-E25-93.
WMA B-BX-BY	WSW (north half) SSE to SE (south half)	0.005 to 0.17	Darcy	73 to 2,520 (PNNL-6820)	0.3	0.00002	Flow rate uncertain. Maximum hydraulic conductivity based on aquifer test data.[c]
WMA C	SW	0.7 to 2.4	Darcy	1,890 to 6,888 (PNNL-14656)	0.3	0.0001	Gradient and flow rate calculated between wells 299-E27-7 and 299-E27-13. Hydraulic conductivity based on a multi-stress slug test performed on well 299-E27-22 and reported in PNNL-14656.
WMA S-SX	E to ESE	0.07 to 0.14	Contaminant travel time (PNNL-13441)	NA	NA	NA	Based on inferred contaminant travel time between 216-S-25 crib and downgradient wells 299-W23-15 and 299-W22-46, and between wells 299-W22-46 and 299-W22-83.
		0.009 to 0.36	Darcy	0.58 to 17.2 (aquifer test data)	0.09 to 0.12	0.0018 to 0.0019	Based on aquifer tests (PNNL-13514 and PNNL-14113).

Table B.1. (contd)

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/d) (source)	Effective Porosity[(a)]	Gradient[(b)]	Comments
WMA T	85° to 98° E of N	0.0007 to 0.028 0.022 to 0.029	Darcy Tracer tests	1 to 28 (PNNL-13378; PNNL-14113; PNNL-14186)	0.04 to 1.1	0.001	Flow direction based on trend surface analysis: PNNL-14113, PNNL-13378.
WMA TX-TY (north part)	108° E of N	0.0007 to 2.46 0.122 to 1.1	Darcy Tracer test	0.05 to 4.9 (PNNL-13378; PNNL-14113; PNNL-14186)	0.002 to 1	0.009	Flow direction based on trend surface analysis: PNNL-14113, PNNL-13378, and PNNL-14186.
WMA TX-TY (south part)	South to southwest	0.29 0.374	Darcy Tracer test	14.2 to 19.9 (PNNL-13378; PNNL-14113; PNNL-14186)	0.068	0.001	Flow direction based on water-table evaluations; Flow rate and direction affected by 200-ZP-1 pump-and treat in south part of WMA. PNNL-13514.
WMA U	E	0.08	Darcy	6.12 (PNNL-13378)	0.17	0.0021	Average gradient between upgradient and downgradient wells.

(a) Effective porosity assumed to be between 0.1 and 0.3, a representative range for the unconfined aquifer system, unless otherwise noted.

(b) March 2005 unless noted otherwise.

(c) Letter report from FA Spane and DR Newcomer, Pacific Northwest National Laboratory, to JV Borghese, Fluor Hanford, Inc., *Slug Test Characterization Results for Multi-Test/Depth Intervals Conducted During the Drilling of WMA B-BX-BY Well 299-E33-49 (C4261)*, dated October 8, 2004.

IDF = Integrated Disposal Facility.
LERF = Liquid effluent retention facility.
LLWMA = Low-level waste management area.
LWDF = Liquid waste disposal facility.
NA = Not applicable.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PCE = Tetrachloroethene.
PUREX = Plutonium-Uranium Extraction (Plant).
SWL = Solid Waste Landfill.
WMA = Waste management area.

Table B.2. Upgradient/Downgradient Comparison Values[a] Used for Statistical Comparisons at RCRA Sites in FY 2005

Quarter	Specific Conductance Critical Mean (µS/cm)	pH Critical Range	TOC Critical Mean[b]/LOQ (µg/L)	TOX Critical Mean/LOQ (µg/L)	Comments
116-N-1 (1301-N) Facility					
Jan-Mar 2005	1,118	[6.65, 8.85]	**1,680**/1,630	**17.8**/17.4	
Jul-Sep 2005	1,118	[6.65, 8.85]	1,680/**2,240**	17.8/**23.9**	
120-N-1 and 120-N-2 (1324-N/NA) Facilities					
Jan-Mar 2005	454	[7.70, 8.52]	1,590/**1,630**	**21.8**/17.4	
Apr-Jun 2005	454	[7.70, 8.52]	1,590/**1,940**	**21.8**/21.1	Sampling schedule altered.
116-N-3 (1325-N) Facility					
Jan-Mar 2005	404	[7.61, 8.58]	NC[c]/**1,630**	**24.2**/17.4	Critical means recalculated because one downgradient well could not be sampled this quarter.
Jul-Sep 2005	407	[7.58, 8.61]	NC[c]/**2,240**	**25.6**/23.9	
216-A-29 Ditch					
Oct-Dec 2004	312	[7.14, 9.65]	**2,980**/1,550	**17.1**/14.8	
Apr-Jun 2005	312	[7.14, 9.65]	**2,980**/1,940	17.1/**21.1**	
216-B-3 Pond					
Jan-Mar 2005	318	[7.83, 8.48]	**2,450**/1,630	NC[c]/**17.4**	
Jul-Sep 2005	318	[7.83, 8.48]	**2,450**/2,240	NC[c]/**23.9**	
216-B-63 Ditch					
Oct-Dec 2004	593	[7.75, 8.40]	1,340/**1,550**	NC[c]/**14.8**	
Apr-Jun 2005	593	[7.75, 8.40]	1,340/**1,940**	NC[c] /**21.1**	
216-S-10 Pond and Ditch					
Oct-Dec 2004	296	[7.49, 8.73]	1,300/**1,550**	NC[c] /**14.8**	
Apr-Jun 2005	296	[7.49, 8.73]	1,300/**1,940**	NC[c] /**21.1**	
Low-Level Waste Management Area 1					
Oct-Dec 2004	711	[7.43, 8.62]	1,260/**1,550**	NC[c] /**14.8**	
Apr-Jun 2005	710	[7.43, 8.62]	1,260/**1,940**	NC[c] /**21.1**	Critical means revised because one downgradient well could not be sampled this quarter.
Low-Level Waste Management Area 2					
Oct-Dec 2004	1,337	[7.03, 8.72]	**3,980**/1,550	**15.7**/14.8	
Apr-Jun 2005	1,337	[7.03, 8.72]	**3,980**/1,940	15.7/**21.1**	
Low-Level Waste Management Area 3					
No statistical comparisons until new baseline established					
Low-Level Waste Management Area 4					
Jan-Mar 2005	875	[7.31, 8.58]	1,360/**1,630**	**99.0**/17.4	
Jul-Sep 2005	875	[7.31, 8.58]	1,360/**2,240**	**99.0**/23.9	
Nonradioactive Dangerous Waste Landfill					
Jan-Mar 2005	573	[6.84, 7.60]	NC[c] /**1,630**	NC[c]/**17.4**	Critical means revised because one downgradient well could not be sampled this quarter.
Jul-Sep 2005	574	[6.83, 7.61]	NC[c] /**2,240**	NC[c]/**23.9**	
Waste Management Area A-AX					
Oct-Dec 2004	522	[7.60, 8.55]	**1,570**/1,550	**23.1**/14.8	
Apr-Jun 2005	522	[7.60, 8.55]	1,570/**1,940**	**23.1**/21.1	

Table B.2. (contd)

Quarter	Specific Conductance Critical Mean (µS/cm)	pH Critical Range	TOC Critical Mean[b]/LOQ (µg/L)	TOX Critical Mean/LOQ (µg/L)	Comments
Waste Management Area C					
Oct-Dec 2004	859	[6.88, 9.38]	**2,880**/1,550	**28.3**/14.8	Critical means revised because one downgradient well could not be sampled this quarter.
Apr-Jun 2005	867	[6.85, 9.41]	**2,960**/1,940	**29.0**/21.1	

(a) Upgradient/Downgradient comparison values (in **bold**) for TOC and TOX are the larger of calculated critical mean value and limit of quantitation for the respective quarter.
(b) Reported values rounded to the nearest 10 µg/L.
(c) Not calculated. Critical mean value could not be calculated because essentially all measurements were below vendor specified method detection limit.
LOQ = Limit of quantitation; based on field blanks collected and analyzed in the previous four quarters.
TOC = Total organic carbon.
TOX = Total organic halides.

Table B.3. Monitoring Wells and Constituents for 100-N Area Units (adapted from PNNL-13914)

			Contamination Indicator Parameters				Other Parameters				
Well Number(a)	Comment	WAC Compliant	Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Alpha(b)	Anions	Metals (filtered)	Sampled as Scheduled in FY 2005?
116-N-1 (1301-N) Liquid Waste Disposal Facility											
199-N-105A	Extraction well	C	S	S	S	S	A		A	A	Yes
199-N-2		P	S	S	S	S	A		A	A	Yes
199-N-3		P	S	S	S	S	A		A	A	Yes
199-N-34		P	S	S	S	S	A		A	A	Yes
199-N-57		C	S	S	S	S	A		A	A	Yes
120-N-1 and 120-N-2 (1324-N/NA) Facilities											
199-N-59		C	S	S	S	S	A	A	A	A	No; insufficient water
199-N-71		C	S	S	S	S	A		A	A	Yes
199-N-72		C	S	S	S	S	A		A	A	Yes
199-N-73		C	S	S	S	S	A		A	A	Yes
199-N-77	Bottom of aquifer; no statistics	C	S	S	S	S	A	S	A	A	Yes
116-N-3 (1325-N) Liquid Waste Disposal Facility											
199-N-28	Information only; no statistics	P	S	S	S	S	A		A	A	Yes
199-N-32		P	S	S	S	S	S		S	S	Missed one; access restrictions
199-N-41		P	S	S	S	S	A		A	A	Yes
199-N-74		C	S	S	S	S	A		A	A	Yes
199-N-81		C	S	S	S	S	A		A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.

(a) ***Bold italic*** = Upgradient well.

(b) Monitored for *Atomic Energy Act*.

A = To be sampled annually.

C = Well is constructed as a resource protection well under WAC 173-160.

FY = Fiscal year.

P = Constructed prior to WAC requirements.

S = To be sampled semiannually.

Spec. Cond. = Specific conductance.

WAC = Washington Administrative Code.

Table B.4. Critical Means for 116-N-1 (1301-N) Liquid Waste Disposal Facility for FY 2006 Comparisons(a)

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	9	8	5.0420	537.5	118.8	1,169	1,169
Field pH	9	8	5.6180	7.69	0.203	[6.49, 8.90]	[6.49, 8.90]
Total organic carbon,(b) µg/L	9	8	5.0420	543.8	274.1	2,001	2,240(c)
Total organic halides,(b) µg/L	8(d)	7	5.4079	7.28	4.81	34.9	34.9

(a) Based on semiannual sampling events from March 2004 to September 2005 for upgradient well 199-N-57 and from September 2003 to September 2005 for upgradient well 199-N-34.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
(d) Excluded suspected values on samples collected in September 2005 from upgradient well 199-N-34.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 20 comparisons.

Table B.5. Critical Means for 120-N-1 and 120-N-2 (1324-N/NA) Liquid Waste Disposal Facilities for FY 2006 Comparisons(a)

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	5	4	7.5288	377.8	12.8	483	483
Field pH	5	4	9.0294	8.06	0.05	[7.57, 8.56]	[7.57, 8.56]
Total organic carbon,(b) µg/L	5	4	7.5288	412.2	211.9	2,160	2,240(c)
Total organic halides,(b) µg/L	5	4	7.5288	8.0	2.78	30.9	30.9

(a) Based on semiannual sampling events from September 2003 to June 2005 for upgradient well 199-N-71.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 12 comparisons.

Table B.6. Critical Means for 116-N-3 (1325-N) Liquid Waste Disposal Facility for FY 2006 Comparisons[(a)]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	5	4	8.1216	369.4	3.7	403	403
Field pH	5	4	9.7291	8.08	0.026	[7.80, 8.35]	[7.80, 8.35]
Total organic carbon,[(b)] µg/L	5	4	8.1216	415.0	201.8	2,210	2,240[(c)]
Total organic halides,[(b)] µg/L	5	4	8.1216	6.24	1.73	21.7	23.9[(c)]

(a) Based on semiannual sampling events from September 2003 to September 2005 for upgradient well 199-N-74.

(b) Critical means calculated from values reported below vendor's specified method detection limit.

(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).

df = Degrees of freedom (n-1).

n = Number of background replicate averages.

t_c = Bonferroni critical t-value for appropriate df and 16 comparisons.

Table B.7. Monitoring Wells and Constituents for 116-H-6 (183-H) Evaporation Basins (adapted from PNNL-11573)

			Permit-Specified				Other Parameters			
Well Number	Comment	WAC Compliant	Hex Cr (filtered)	Nitrate	Technetium-99[(a)]	Uranium[(a)]	Alkalinity	Anions	Metals (filtered)	Sampled as Scheduled in FY 2005?
199-H4-12A	Extraction well	C	A	A	A	A	A	A	A	Yes
199-H4-12C	Mid-depth unconfined	C	A	A	A	A	A	A	A	Yes
199-H4-3	Converted to extraction well August 2005	P	A	A	A	A	A	A	A	Yes
199-H4-7	Extraction well; converted to injection well August 2005	C	A	A	A	A	A	A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.

(a) Radionuclides not typically subject to RCRA monitoring, but included in the current Hanford Facility RCRA Permit (Ecology 1994) for this facility.

A = To be sampled annually.

C = Well is constructed as a resource protection well under WAC 173-160.

FY = Fiscal year.

Hex Cr = Hexavalent chromium.

P = Constructed prior to WAC requirements.

RCRA = *Resource Conservation and Recovery Act*.

WAC = Washington Administrative Code.

Table B.8. Monitoring Wells and Constituents for 216-A-29 Ditch (adapted from PNNL-13047)

			Contamination Indicator Parameters				Other Parameters				
Well Number[(a)]	Comment	WAC Compliant	Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Phenols	Sampled as Scheduled in FY 2005?
299-E25-26	Upper unconfined	C	S	S	S	S	S	S	A	A	No phenols; scheduling error
299-E25-28	Deep unconfined; no statistics	C	S	S	S	S	S	S	A	A	TOC and TOX only once; scheduling error
299-E25-32P		C	S	S	S	S	S	S	A	A	Yes
299-E25-34		C	S	S	S	S	S	S	A	A	Yes
299-E25-35		C	S	S	S	S	S	S	A	A	Yes
299-E25-48		C	S	S	S	S	S	S	A	A	Yes
299-E26-12		C	S	S	S	S	S	S	A	A	Yes
299-E26-13		C	S	S	S	S	S	S	A	A	Yes
699-43-45		C	S	S	S	S	S	S	A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
TOC = Total organic carbon.
TOX = Total organic halides.
WAC = Washington Administrative Code.

Table B.9. Critical Means for 216-A-29 Ditch for FY 2006 Comparisons[(a)]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	5	4	9.729	241.8	2.97	273	273
Field pH	7	6	7.4012	8.40	0.175	[7.02, 9.79]	[7.02, 9.79]
Total organic carbon,[(b)] µg/L	5	4	9.729	397.2	121.1	1,688	2,240[(c)]
Total organic halides,[(b)] µg/L	5	4	9.729	3.14	1.42	18.3	23.9[(c)]

(a) Based on quarterly sampling events from July 2004 to July 2005 (January 2004 to July 2005 for pH) for upgradient well 699-43-45.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 32 comparisons.

Table B.10. Monitoring Wells and Constituents for 216-B-3 Pond (adapted from PNNL-15479)

			Contamination Indicator Parameters				Other Parameters						
Well Number[a]	Comment	WAC Compliant	Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Alpha[b]	Anions	Beta[b]	Metals (filtered, unfiltered)	Phenols	Sampled as Scheduled in FY 2005?
699-42-42B	Bottom of aquifer	C	S	S	S	S	A	S	A	S	A	A	Yes
699-43-44		C	S	S	S	S	A	S	A	S	A	A	Yes
699-43-45		C	S	S	S	S	A	S	A	S	A	A	Yes
699-44-39B		C	S	S	S	S	A	S	A	S	A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act*.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.11. Critical Means for 216-B-3 Pond for FY 2006 Comparisons[(a)]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	5	4	8.1216	259.0	8.9	338	338
Field pH	5	4	9.7291	8.14	0.04	[7.70, 8.58]	[7.70, 8.58]
Total organic carbon,[(b)] µg/L	5	4	8.1216	402.5	202.5	2,204	2,240[(c)]
Total organic halides,[(b)] µg/L	5	4	8.1216	2.87	2.73	27.2	27.2

(a) Based on semiannual sampling events from June 2003 to July 2005 for specific conductance and field pH and from June 2001 to July 2005 for total organic carbon and total organic halides from upgradient well 699-44-39B.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 16 comparisons.

Table B.12. Monitoring Wells and Constituents for 216-B-63 Trench (adapted from PNNL-14112)

Well Number(a)	WAC Compliant	Contamination Indicator Parameters				Other Parameters						Sampled as Scheduled in FY 2005?
		Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Alpha(b)	Anions	Beta(b)	Metals (filtered)	Phenols	
299-E27-8	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-9	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-11	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-16	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-17	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-18	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-19	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E33-33	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E33-36	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E33-37	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E34-8	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E34-10	C	S	S	S	S	A	S	A	S	A	A	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act*.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.13. Critical Means for 216-B-63 Trench for FY 2006 Comparisons(a)

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	23	22	4.152	439.2	57.1	681	681
Field pH	23	22	4.435	8.04	0.076	[7.70, 8.38]	[7.70, 8.38]
Total organic carbon,(b) µg/L	21	20	4.224	524.3	92.34	924	2,240(c)
Total organic halides,(b) µg/L	21(d)	20	4.224	4.3	3.43	19.1	23.9(c)

(a) Based on semiannual sampling events from October 2003 to April 2005 for upgradient wells 299-E27-8, 299-E27-11, 299-E27-17, and 299-E34-10 and from October 2003 to August 2005 for upgradient well 299-E27-9.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
(d) Excluded erroneous analytical results on samples collected in April 2005 from wells 299-E27-9 and 299-E34-10.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 48 comparisons.

Table B.14. Monitoring Wells and Constituents for 216-S-10 Pond and Ditch (adapted from PNNL-14070 and PNNL-14070-ICN-1)

			Contamination Indicator Parameters				Other Parameters						
Well Number	Comment	WAC Compliant	Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Hex Cr (filtered)	Metals (filtered)	Phenols	Volatile Organic Analyses	Sampled as Scheduled in FY 2005?
299-W26-13		C	S	S	S	S	A	A	S	A	A	S	Yes
299-W26-14		C	S	S	S	S	A	A	S	A	A	S	Yes
299-W27-2	Bottom of aquifer; no statistics	C	S	S			A	A	S	A		S	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Hex Cr = Hexavalent chromium.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.15. Critical Means for 216-S-10 Pond and Ditch for FY 2006 Comparisons[(a)]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	4	3	10.8689	269.8	2.2	296	296
Field pH	4	3	13.745	8.11	0.04	[7.49, 8.73]	[7.49, 8.73]
Total organic carbon,[(b)] µg/L	4	3	10.8689	195.6	90.9	1,300	2,240[(c)]
Total organic halides,[(d)] µg/L	4	3	10.8689	NC	NC	NC	23.9[(c)]

(a) Based on semiannual sampling events from December 2001 to June 2003 for upgradient well 299-W26-7, which went dry in 2003. Background levels will be revised when data from a new upgradient well are available.
(b) Critical mean calculated from values reported below vendor's specified method detection limit.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
(d) Critical mean cannot be calculated because essentially all measurements are below vendor's specified detection limit.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
NC = Not calculated.
t_c = Bonferroni critical t-value for appropriate df and 12 comparisons.

Table B.16. Monitoring Wells and Constituents for 216-U-12 Crib (adapted from WHC-SD-EN-AP-108, PNNL-14301, and PNNL-14301-ICN-1)

Well Number(a)	Comment	WAC Compliant	Alkalinity	Anions	Arsenic (filtered)	Metals (filtered)	Total Dissolved Solids	Technetium-99(b)	Sampled as Scheduled in FY 2005?
299-W21-2	Adding to network starting FY 2006	C	A	Q	A	A	A	Q	Not scheduled
299-W22-26		P	A	Q	A	A	A	Q	Not scheduled
299-W22-79		C	A	Q	A	A	A	Q	Yes
699-36-70A		C	A	Q	A	A	A	Q	Yes

New monitoring plan takes effect in FY 2006: PNNL-14301, Rev. 2.
Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act*.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
WAC = Washington Administrative Code.

Table B.17. Monitoring Wells and Constituents for 316-5 Process Trenches (adapted from WHC-SD-EN-AP-185)

Well Number	Comment	WAC Compliant	cis-1,2-dichloroethene	Tetrachloroethene	Trichloroethene	Uranium(a)	Sampled as Scheduled in FY 2005?
399-1-10A		C	S	S	S	S	Yes
399-1-10B	Bottom of aquifer	C	S	S	S	S	Yes
399-1-16A		C	S	S	S	S	Yes
399-1-16B	Bottom of aquifer	C	S	S	S	S	Yes
399-1-17A		C	S	S	S	S	Yes
399-1-17B	Bottom of aquifer	C	S	S	S	S	Yes
399-1-18A		C	S	S	S	S	Yes
399-1-18B	Bottom of aquifer	C	S	S	S	S	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) Radionuclides not typically subject to RCRA monitoring, but included in the current Hanford Facility RCRA Permit (Ecology 1994) for this facility.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
RCRA = *Resource Conservation and Recovery Act*.
S = Sampled four consecutive months, twice per year (semiannually).
WAC = Washington Administrative Code.

Table B.18. Monitoring Wells and Constituents for Integrated Disposal Facility (adapted from DOE/RL-2003-12 and RPP-PLAN-26534)

Well Number(a)	WAC Compliant	Appendix IX(b)	Indicator Parameters					Other Parameters							Sampled as Scheduled in FY 2005?(e)
			Chromium (filtered, unfiltered)(c)	Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Alpha(d)	Beta(d)	Iodine-129(d)	Technetium-99(d)	
299-E17-22	C	1	(f)	(f)	(f)	(f)	(f)	S	S	S	S	S	S	S	Yes
299-E17-23	C	1	(f)	(f)	(f)	(f)	(f)	S	S	S	S	S	S	S	Yes
299-E17-25	C	1	(f)	(f)	(f)	(f)	(f)	S	S	S	S	S	S	S	Yes
299-E17-26	C	1	(f)	(f)	(f)	(f)	(f)	S	S	S	S	S	S	S	Yes
299-E18-1	C	1	(f)	(f)	(f)	(f)	(f)	S	S	S	S	S	S	S	Yes
299-E24-21	C	1	(f)	(f)	(f)	(f)	(f)	S	S	S	S	S	S	S	Yes
299-E24-24	C	1	(f)	(f)	(f)	(f)	(f)	S	S	S	S	S	S	S	Yes
Proposed downgradient well	C	1	(f)	(f)	(f)	(f)	(f)	S	S	S	S	S	S	S	Not applicable

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) 40 CFR 264, Appendix IX constituent list, sampled one time per well.
(c) Filtered and unfiltered samples for one year after background established; filtered only thereafter.
(d) Operational parameters monitored for supplemental information.
(e) Sampling began fourth quarter of FY 2005.
(f) Sampled two times per quarter for one year to establish background, then four times semiannually (total of eight times per well per year) thereafter.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.19. Monitoring Wells and Constituents for Liquid Effluent Retention Facility (adapted from WHC-SD-EN-AP-024)

Well Number(a)	WAC Compliant	Alkalinity	Alpha(b)	Ammonia	Anions	Beta(b)	Metals (filtered)	Phenols	Volatile Organic Analyses	Sampled as Scheduled in FY 2005?
299-E26-10	C	A	S	S	A	S	A	A	S	Yes
299-E26-11	C	A	S	S	A	S	A	A	S	Yes

Wells completed at the top of the unconfined aquifer.
Statistical evaluations suspended in 2001 because only one downgradient well is not dry.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act*.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
WAC = Washington Administrative Code.

Table B.20. Monitoring Wells and Constituents for Low-Level Waste Management Area 1 (adapted from PNNL-14859 and DOE/RL-2000-72)

		Contamination Indicator Parameters				Other Chemical Parameters						AEA Parameters					
Well Number(a)	WAC Compliant	pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Mercury (filtered)	Lead (filtered)	Phenols	Alpha	Beta	Technetium-99(b)	Tritium	Uranium	Sampled as Scheduled in FY 2005?
299-E28-26	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E28-27	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E28-28	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-2	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-3	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-4	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-5	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-6	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-7	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-8	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-9	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E32-10	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E33-28	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E33-29	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E33-30	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E33-34	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes
299-E33-35	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Performance assessment parameter.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.21. Critical Means for Low-Level Waste Management Area 1 for FY 2006 Comparisons(a)

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	28	27	4.1542	505.6	64.5	778	778
Field pH	28	27	4.4138	8.02	0.15	[7.34, 8.70]	[7.34, 8.70]
Total organic carbon,(b) µg/L	28	27	4.1542	523.3	193.4	1,341	2,240(c)
Total organic halides,(b) µg/L	28	27	4.1542	4.19	3.55	19.2	23.9(c)

(a) Based on semiannual sampling events from December 2003 to June/July 2005 for upgradient wells 299-E28-26, 299-E28-28, 299-E32-4, 299-E33-28, 299-E33-29, and 299-E33-35 and from December 2003 to August 2005 for upgradient well 299-E28-27.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 68 comparisons.

Table B.22. Monitoring Wells and Constituents for Low-Level Waste Management Area 2 (adapted from PNNL-14859 and DOE/RL-2000-72)

			Contamination Indicator Parameters				Other Chemical Parameters								AEA Parameters						
Well Number[(a)]	Comment	WAC Compliant	pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Mercury (filtered)	Lead (filtered)	Polychlorinated Biphenyls	Phenols	Organics[(b)]	Alpha	Beta	Iodine-129[(c)]	Technetium-99[(c)]	Tritium	Uranium[(c)]	Sampled as Scheduled in FY 2005?
299-E27-8		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes
299-E27-9		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes
299-E27-10		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes
299-E27-11		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes
299-E27-17		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes
299-E34-2		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes
299-E34-5	Information only; no statistics	C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes, but dry in FY 2006
299-E34-7		C	S	S	S	S	S	S	S	S	S	S	A	A	S	S	S	S	S	S	Yes, but dry in FY 2006
299-E34-9		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes
299-E34-10		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes
299-E34-12		C	S	S	S	S	S	S	S	S	S	S	A		S	S	S	S	S	S	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Volatile and semivolatile organics, oil and grease, total petroleum hydrocarbons, coliform.
(c) Performance assessment parameter.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.23. Critical Means for Low-Level Waste Management Area 2 for FY 2006 Comparisons[(a)]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	6	5	7.7980	892.7	56.9	1,372	1,372
Field pH	6	5	9.0330	7.76	0.096	[6.83, 8.70]	[6.83, 8.70]
Total organic carbon,[(b)] µg/L	6	5	7.7980	737.3	431.6	4,373	4,370[(c)]
Total organic halides,[(b)] µg/L	6	5	7.7980	7.49	6.78	64.6	64.6

(a) Based on semiannual sampling events from April 2003 to April 2005 for upgradient well 299-E27-10. Data from upgradient well 299-E34-7 are excluded due to elevated levels of all indicator parameters.
(b) Critical means calculated from values below vendor's specified method detection limit.
(c) Rounded to the nearest 10 µg/L.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 36 comparisons.

Table B.24. Monitoring Wells and Constituents for Low-Level Waste Management Area 3 (adapted from PNNL-14859 and DOE/RL-2000-72)

Well Number[a]	Comment	WAC Compliant	Contamination Indicator Parameters				Other Chemical Parameters							AEA Parameters						Sampled as Scheduled in FY 2005?
			pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Mercury (filtered)	Lead (filtered)	Phenols	Volatile Organic Analyses	Alpha	Beta	Iodine-129[b]	Technetium-99[b]	Tritium	Uranium[b]	
299-W7-3	Deep unconfined; no statistics	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W7-4		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W7-5		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampled once; Dry 09/2005
299-W7-12		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W8-1		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W10-14	Deep unconfined; no statistics	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W10-20		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W10-21		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampled once; Dry 09/2005
299-W10-25	Planned	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampling to begin after completion
299-W10-29	Planned	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampling to begin after completion
299-W10-30	Planned	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampling to begin after completion

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Performance assessment parameter.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.25. Monitoring Wells and Constituents for Low-Level Waste Management Area 4 (adapted from PNNL-14859 and DOE/RL-2000-72)

			Contamination Indicator Parameters				Other Chemical Parameters							AEA Parameters						
Well Number(a)	Comment	WAC Compliant	pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Mercury (filtered)	Lead (filtered)	Phenols	Volatile Organic Analyses	Alpha	Beta	Iodine-129(b)	Technetium-99(b)	Tritium	Uranium(b)	Sampled as Scheduled in FY 2005?
299-W15-15		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W15-17	Deep unconfined; no statistics	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W15-30		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W15-83	Drilled FY 2005	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampling to begin in FY 2006
299-W15-94	Drilled FY 2005	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampling to begin in FY 2006
299-W15-152	Planned	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampling to begin after completion
299-W15-224	Planned	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Sampling to begin after completion
299-W18-21		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W18-22	Deep unconfined; no statistics	C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-W18-23		C	S	S	S	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Performance assessment parameter.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.26. Critical Means for Low-Level Waste Management Area 4 for FY 2006 Comparisons(a)

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	12	11	4.7248	507.5	62.2	813	813
Field pH	12	11	5.1621	7.93	0.117	[7.30, 8.56]	[7.30, 8.56]
Total organic carbon,(b) µg/L	12	11	4.7248	489.5	187.74	1,413	2,240(c)
Total organic halides, µg/L	12	11	4.7248	14.48	5.99	43.9	43.9

(a) Based on semiannual sampling events from January 2004 to July 2005 for upgradient wells 299-W15-15, 299-W18-21, and 299-W18-23.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 32 comparisons.

Table B.27. Monitoring Wells and Constituents for Nonradioactive Dangerous Waste Landfill (adapted from PNNL-12227 and PNNL-12227-ICN-1)

Well Number[a]	Comment	WAC Compliant	Contamination Indicator Parameters				Other Parameters				Sampled as Scheduled in FY 2005?
			pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Anions	Metals (filtered)	Phenols	Volatile Organic Analyses	
699-25-33A	Top of LPU; no statistics	C	S	S	S	S	S	A	A	S	Yes
699-25-34A		C	S	S	S	S	S	A	A	S	Yes
699-25-34B		C	S	S	S	S	S	A	A	S	Yes
699-25-34D		C	S	S	S	S	S	A	A	S	Second delayed until 10/2005
699-26-33		C	S	S	S	S	S	A	A	S	Second delayed until 10/2005
699-26-34A		C	S	S	S	S	S	A	A	S	Yes
699-26-34B		C	S	S	S	S	S	A	A	S	Yes
699-26-35A		C	S	S	S	S	S	A	A	S	Yes
699-26-35C	Top of LPU; no statistics	C	S	S	S	S	S	A	A	S	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
LPU = Low-permeability in upper Ringold Formation.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.28. Critical Means for Nonradioactive Dangerous Waste Landfill for FY 2006 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	8	7	5.7282	550.6	8.0	599	599
Field pH	8	7	6.4295	7.21	0.073	[6.71, 7.71]	[6.71, 7.71]
Total organic carbon,[b] µg/L	7[c]	6	6.3510	299.8	114.8	1,079	2,240[d]
Total organic halides,[b] µg/L	8	7	5.7282	4.07	2.97	22.1	23.9[d]

(a) Based on semiannual sampling events from February 2004 to August 2005 for upgradient wells 699-26-34A and 699-26-35A.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Excluded suspected total organic carbon values collected in August 2005 from well 699-26-34A.
(d) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 28 comparisons.

Table B.29. Monitoring Wells and Constituents for PUREX Cribs 216-A-10, 216-A-36B, and 216-A-37-1 (adapted from PNNL-11523 and PNNL-11523-ICN-1)

			Primary RCRA Constit.	Supporting Parameters						AEA Parameters					
Well Number	Comment	WAC Compliant	Nitrate	Alkalinity	Ammonia	Anions	Metals (filtered)	Arsenic (filtered)	Phenols	Alpha	Beta	Iodine-129	Strontium-90	Tritium	Sampled as Scheduled in FY 2005?
299-E17-1	216-A-10	P	S	S	S	S	S	S	S	S	S	S	S	S	Yes
299-E17-14	216-A-36B	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E17-16	216-A-36B	C	S	S	S	S	S	S	S	S	S	S	S	S	Yes
299-E17-18	216-A-36B	C	S	S	S	S	S	S	S	S	S	S	S	S	Yes
299-E17-19	216-A-10	C	S	S	S	S	S	S	S	S	S	S	S	S	Yes
299-E24-16	216-A-10	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E24-18	Upgradient	C	S	S	S	S	S	S	S	S	S	S	S	S	Yes
299-E25-17	216-A-37-1	P	S	S	S	S	S	S	S	S	S	S	S	S	Yes
299-E25-19	216-A-37-1	P	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-31	Upgradient	C	S	S	S	S	S	S	S	S	S	S	S	S	Yes
699-37-47A	216-A-37-1	C	S	S	S	S	S	S	S	S	S	S	S	S	Yes
79 Wells	Far-field		(a)			(a)						(a)		(a)	See Appendix A for 200-PO-1

New monitoring plan took effect in FY 2006: PNNL-11523, Rev. 1.
Wells completed at the top of the unconfined aquifer.
(a) Far-field wells sampled annually to triennially for the constituents indicated, in conjunction with 200-PO-1 Operable Unit.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
S = To be sampled semiannually.
WAC = Washington Administrative Code.

Table B.30. Monitoring Wells and Constituents for Waste Management Area A-AX (adapted from PNNL-13023-ICN-1)

		Contamination Indicator Parameters				Other Chemical Parameters						AEA Parameters							
Well Number[(a)]	WAC Compliant	pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Coliform	Metals (filtered)	Arsenic (filtered)	Phenols	Beta	Gamma	Iodine-129	Strontium-90	Technetium-99	Tritium	Uranium	Sampled as Scheduled in FY 2005?
299-E24-20	C	S	S	S	S	S	S	S	S	S	A	S	A	A	A	A	A	A	Yes
299-E24-22	C	S	S	S	S	S	S	S	S	S	A	S	A	A	A	A	A	A	Yes
299-E24-33[(b)]	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q				S			Missed first quarter, construction zone; fourth quarter delayed until 11/2005
299-E25-2	P	S	S	S	S	S	S	S	S	S	A	S	A	A	A	A	A	A	Yes
299-E25-40	C	S	S	S	S	S	S	S	S	S	A	S	A	A	A	A	A	A	Yes
299-E25-41	C	S	S	S	S	S	S	S	S	S	A	S	A	A	A	A	A	A	Yes
299-E25-93	C	S	S	S	S	S	S	S	S	S	A	S	A	A	A	A	A	A	Yes
299-E25-94	C	S	S	S	S	S	S	S	S	S	A	S	A	A	A	A	A	A	Yes

Site entered assessment. New monitoring plan implemented in FY 2006: PNNL-15315.
Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Also analyzed for 40 CFR 264, Appendix IX constituent list quarterly for one year.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.31. Monitoring Wells and Constituents for Waste Management Area B-BX-BY (adapted from PNNL-13022, PNNL-13022-ICN-1, and PNNL-13022-ICN-2)

Well Number[(a)]	WAC Compliant	RCRA Parameters					AEA Parameters								Sampled as Scheduled in FY 2005?
		Alkalinity	Anions	Cyanide	Metals (filtered)	Total Organic Carbon	Alpha	Beta	Gamma	Iodine-129	Strontium-90	Technetium-99	Tritium	Uranium	
Near-Field Wells															
299-E33-9	P	Q	Q	Q	Q	A	Q	Q	Q		A	Q	Q	Q	No; tank farm access restrictions
299-E33-15	P	S	S	S	S			S	S			S	S	S	Yes
299-E33-16	P	Q	Q	Q	Q			Q	Q			Q	Q	Q	Yes
299-E33-17	P	S	S	S	S			A				S	S	S	Yes
299-E33-18	P	Q	Q	Q	Q		Q	Q				Q	Q	Q	Yes
299-E33-20	P	S	S	S	S							S	S	S	Yes
299-E33-21	P	S	S	S	S							S	S	S	Yes
299-E33-31	C	Q	Q	Q	Q	A	Q	Q	Q		A	Q	Q	Q	Yes
299-E33-32	C	Q	Q	Q	Q	A		Q	Q	A	A	Q	Q	Q	Yes
299-E33-38	C	Q	Q	Q	Q	A	Q	Q	Q			Q	Q	Q	Yes
299-E33-39	C	Q	Q	Q	Q	A						Q	Q	Q	Yes
299-E33-41	C	Q	Q	Q	Q	A	Q	Q	Q		A	Q	Q	Q	Yes
299-E33-42	C	Q	Q	Q	Q	A	Q	Q	Q		A	Q	Q	Q	Yes
299-E33-43	C	Q	Q	Q	Q	A		Q		A	A	Q	Q	Q	Yes
299-E33-44	C	Q	Q	Q	Q	A	Q	Q	Q		A	Q	Q	Q	Yes
299-E33-47	C	Q	Q	Q	Q	A				A	A	Q	Q	Q	Yes
299-E33-48	C	Q	Q	Q	Q	A				A	A	Q	Q	Q	Yes
299-E33-49	C	Q	Q	Q	Q	A				A	A	Q	Q	Q	Yes
299-E33-334	C	Q	Q	Q	Q	A				A		Q	Q	Q	Yes
299-E33-335	C	Q	Q	Q	Q	A				A		Q	Q	Q	Yes
299-E33-337	C	Q	Q	Q	Q	A				A	A	Q	Q	Q	Yes
299-E33-338	C	Q	Q	Q	Q	A					A	Q	Q	Q	Yes
299-E33-339	C	Q	Q	Q	Q	A				A	A	Q	Q	Q	Yes
Far-Field Wells															
299-E28-8	P	Q	Q	S	Q				S	A		Q	Q	S	Yes
299-E33-1A	P	Q	Q	Q	Q	A	Q	Q	Q			Q	Q	Q	Yes
299-E33-2	P	Q	Q	Q	Q	A	Q	Q	Q			Q	Q	Q	Yes
299-E33-3	P	Q	Q	Q	Q	A	Q	Q	Q			Q	Q	Q	Yes
299-E33-4	P	Q	Q	Q	Q	A	Q	Q	Q			Q	Q	Q	Low water 08/2005; will attempt in FY 2006
299-E33-7	P	Q	Q	Q	Q		Q	Q	Q			Q	Q	Q	Yes
299-E33-26	C	Q	Q	Q	Q		Q	Q	Q			Q	Q	Q	Yes
299-E33-28	C	S	S	A	S		S	S				S	S	S	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
S = To be sampled semiannually.
WAC = Washington Administrative Code.

Table B.32. Monitoring Wells and Constituents for Waste Management Area C (adapted from PNNL-13024-ICN-1, PNNL-13024-ICN-2, PNNL-13024-ICN-3, and PNNL-13024-ICN-4)

Well Number[a]	WAC Compliant	Contamination Indicator Parameters				Other Chemical Parameters						AEA Parameters				Sampled as Scheduled in FY 2005?
		pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Cyanide	Metals (filtered)	Arsenic (filtered)	Phenols	Alpha/Beta	Gamma	Technetium-99	Uranium	
299-E27-4	C	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-7	P	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-12	C	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-13	C	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-14	C	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-15	C	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-21	C	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-22	C	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-23	C	Q	Q	S	S	Q	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.33. Critical Means for Waste Management Area C for FY 2006 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	8	7	5.7282	584.6	59.0	943	943
Field pH	8	7	6.4295	8.12	0.197	[6.77, 9.46]	[6.77, 9.46]
Total organic carbon,[b] µg/L	7	6	6.3510	609.5	330.7	2,855	2,860[c]
Total organic halides,[b] µg/L	6[d]	5	7.3884	7.08	4.00	39.0	39.0

(a) Based on quarterly/semiannual sampling events from June 2004 to June 2005 for upgradient wells 299-E27-22 and 299-E27-7.
(b) Critical means calculated from values reported below vendor's specified method detection limit.
(c) Rounded to the nearest 10 µg/L.
(d) Excluded suspected values on samples collected in June 2005.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 28 comparisons.

Table B.34. Monitoring Wells and Constituents for Waste Management Area S-SX (adapted from PNNL-12114-ICN-1 and PNNL-12114-ICN-2)

		RCRA Parameters					AEA Parameters				
Well Number[(a)]	WAC Compliant	Alkalinity	Anions	Beta	Gamma	Metals (filtered)	Technetium-99	Tritium	Uranium	Volatile Organic Analyses	Sampled as Scheduled in FY 2005?
299-W22-44	C	Q	Q			Q	Q	Q	Q		No tritium
299-W22-45	C	Q	Q			Q	Q	Q	Q		Yes
299-W22-46	C	Q	Q			Q	Q	Q	Q		Sampled twice; went dry 06/2005. No tritium
299-W22-47	C	Q	Q	Q		Q	Q	Q	Q	Q	Began sampling April 2005. No tritium
299-W22-48	C	Q	Q			Q	Q	Q	Q		Yes
299-W22-49	C	Q	Q			Q	Q	Q	Q		Missed one quarter; pump problems
299-W22-50	C	Q	Q			Q	Q	Q	Q		Yes
299-W22-80	C	Q	Q			Q	Q	Q	Q		No tritium
299-W22-81	C	Q	Q			Q	Q	Q	Q		No tritium
299-W22-82	C	Q	Q			Q	Q	Q	Q		No tritium
299-W22-83	C	Q	Q			Q	Q	Q	Q		No tritium
299-W22-84	C	Q	Q			Q	Q	Q	Q		No tritium
299-W22-85	C	Q	Q			Q	Q	Q	Q		Yes
299-W23-15	C	Q	Q			Q	Q	Q	Q		Yes
299-W23-19	C	Q	Q	Q	A	Q	Q	Q	Q		Yes
299-W23-20	C	Q	Q			Q	Q	Q	Q		No tritium
299-W23-21	C	Q	Q			Q	Q	Q	Q		No tritium

Wells completed at the top of the unconfined aquifer.
Tritium Q all wells in plan but only scheduled for one well in FY 2005.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
WAC = Washington Administrative Code.

Table B.35. Monitoring Wells and Constituents for Waste Management Area T (adapted from PNNL-12057-ICN-1)

			RCRA Parameters			AEA Parameters						
Well Number(a)	Comment	WAC Compliant	Alkalinity	Anions	Metals (filtered)	Alpha	Beta	Gamma	Iodine-129	Technetium-99	Tritium	Sampled as Scheduled in FY 2005?
299-W10-1		P	Q	Q	Q	A	A			Q	Q	Yes
299-W10-4		P	Q	Q	Q	A	A	A		Q	Q	Yes
299-W10-8		P	Q	Q	Q	A	A			Q	Q	Yes
299-W10-22		C	S	S	S					S	S	Yes
299-W10-23		C	Q	Q	Q	A	A			Q	Q	Yes
299-W10-24		C	Q	Q	Q	S	S	S		Q	Q	Yes
299-W10-28		C	Q	Q	Q	A	A			Q	Q	Yes
299-W11-7		P	S	S	S					S	S	Yes
299-W11-12		P	Q	Q	Q	A	A			Q	Q	Yes
299-W11-39		C	Q	Q	Q	S	S	S		Q	Q	Yes
299-W11-40		C	Q	Q	Q	A	A			Q	Q	Yes
299-W11-41		C	Q	Q	Q	S	S	S	A	Q	Q	Yes
299-W11-42		C	Q	Q	Q	S	S	S		Q	Q	Yes
299-W11-45	Screened 8.5 to 13 m below water table	C	Q	Q	Q	A	A	A		Q	Q	New well; began sampling FY 2006
299-W11-46	Screened 6 to 12 m below water table	C	Q	Q	Q	A	A	A		Q	Q	New well; began sampling FY 2006

New monitoring plan to be implemented in FY 2006: PNNL-15301.
Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
S = To be sampled semiannually.
WAC = Washington Administrative Code.

Table B.36. Monitoring Wells and Constituents for Waste Management Area TX-TY (adapted from PNNL-12072-ICN-1)

			RCRA Parameters			AEA Parameters							
Well Number[(a)]	Comment	WAC Compliant	Alkalinity	Anions	Metals (filtered)	Alpha	Beta	Gamma	Iodine-129	Strontium-90	Technetium-99	Tritium	Sampled as Scheduled in FY 2005?
299-W10-26		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W10-27		C	Q	Q	Q	A	A	S			Q	Q	Yes
299-W14-6		P	Q	Q	Q	A	A				Q	Q	Yes
299-W14-11	Screened 11 to 14.6 m below water table	C	Q	Q	Q	S	S	S	Q	A	Q	Q	Began sampling 05/2005
299-W14-13		C	Q	Q	Q	S	S	S	Q	A	Q	Q	Yes
299-W14-14		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W14-15		C	Q	Q	Q	A	A	A	Q		Q	Q	Missed one; pump problem
299-W14-16		C	Q	Q	Q				Q		Q	Q	Yes
299-W14-17		C	Q	Q	Q	S	S		Q		Q	Q	Yes
299-W14-18		C	Q	Q	Q	A	A	A	Q		Q	Q	Yes
299-W14-19		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W15-40	Converted to extraction well 07/2005	C	Q	Q	Q	A	A				Q	Q	Yes
299-W15-41		C	Q	Q	Q	A	A	A	S		Q	Q	Yes
299-W15-44	Converted to extraction well 07/2005	C	Q	Q	Q	A	A	A	S		Q	Q	Yes
299-W15-763		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W15-765	Converted to extraction well 07/2005	C	Q	Q	Q	A	A		S		Q	Q	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
S = To be sampled semiannually.
WAC = Washington Administrative Code.

Table B.37. Monitoring Wells and Constituents for Waste Management Area U (adapted from PNNL-13612 and PNNL-13612-ICN-1)

		RCRA Parameters			AEA Parameters				
Well Number[(a)]	WAC Compliant	Alkalinity	Anions	Metals (filtered)	Alpha	Beta	Gamma	Technetium-99	Sampled as Scheduled in FY 2005?
299-W18-30	C	Q	Q	Q	A	A	A	Q	Yes
299-W18-31	C	Q	Q	Q	A	A	A	Q	Yes
299-W18-40	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-12	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-41	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-42	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-44	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-45	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-47	C	Q	Q	Q	Q	Q	Q	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
WAC = Washington Administrative Code.

Table B.38. Monitoring Wells and Constituents for KE and KW Basins (adapted from PNNL-14033)

Well Number	Comment	WAC Compliant	Alpha	Anions	Beta	Carbon-14	Metals (filtered)	Strontium-90	Technetium-99	Tritium	Uranium	Volatile Organic Analyses	Sampled as Scheduled in FY 2005?
KE Basin													
199-K-27	Changed quarterly to monthly 01/2005	P	M	Q	M		S		A	M	M		Yes
199-K-29	Changed quarterly to monthly 01/2005	P	M	Q	M	A	A		A	M	M		Yes
199-K-30		P	Q	Q	Q	A	S			Q			Yes
199-K-32A		C	Q	Q	Q	A	A		A	Q			Yes
199-K-109A	Changed quarterly to monthly 01/2005	C	M	Q	M	A	S	A	Q	M	M		Yes
199-K-110A		C	S	S	S		A			S			Yes
199-K-111A		C	Q	Q	Q	A	A		A	Q			Yes
KW Basin													
199-K-34		C	Q	Q	Q	A	S	A	A	Q			Yes
199-K-106A		C	Q	Q	Q	A	S		A	Q		A	Missed anions one quarter
199-K-107A		C	Q	Q	Q	A	S	A	A	Q			Yes
199-K-108A		C	S	S	S		S			S			Yes
199-K-132	New well	C	Q	Q	Q	Q	Q	Q	Q	Q		Q	Began sampling 01/2005

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
M = To be sampled monthly.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
S = To be sampled semiannually.
WAC = Washington Administrative Code.

Table B.39. Monitoring Wells, Constituents, and Enforcement Limits for 200 Area Treated Effluent Disposal Facility (adapted from PNNL-13032)

Well[(a)]	WAC Compliant	Constituents with Enforcement Limits			Other Constituents								Sampled as Scheduled in FY 2005?
		pH (6.5 - 8.5)	Cadmium[(b)] (5 µg/L)	Lead[(b)] (10 µg/L)	Alkalinity	Alpha	Anions	Beta	Metals[(b)]	Total Dissolved Solids	Trace Metals[(b)]	Tritium	
699-40-36	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	A	Yes
699-41-35	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	A	Yes
699-42-37	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	A	Yes

All wells completed at the top of the Ringold confined aquifer.
(a) Bold italic = Upgradient well.
(b) Filtered and unfiltered samples.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Q = To be sampled quarterly.
WAC = Washington Administrative Code.

Table B.40. Monitoring Wells and Constituents for Environmental Restoration Disposal Facility (adapted from BHI-00873)

Well Number[(a)]	WAC Compliant	Alkalinity	Alpha	Anions	Beta	Carbon-14	Iodine-129	Metals (filtered, unfiltered)	Radium[(b)]	Total Dissolved Solids	Technetium-99	Total Organic Halides	Uranium	Volatile Organic Analyses	Sampled as Scheduled in FY 2005?
699-35-66A	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Second delayed until 10/2005
699-36-67	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Second delayed until 10/2005
699-36-70A	P	S	S	S	S	S	S	S	S	S	S	S	S	S	Second delayed until 10/2005
699-37-68	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Second delayed until 10/2005

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) No radium was scheduled in FY 2005.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
S = To be sampled semiannually.
WAC = Washington Administrative Code.

Table B.41. Monitoring Wells and Constituents for Solid Waste Landfill (adapted from PNNL-13014)

			Required Parameters (WAC 173-304-490)														Other Parameters				
Well Number[(a)]	Comment	WAC Compliant	Ammonia	Chemical Oxygen Demand	Chloride	Iron (filtered)	Manganese (filtered)	Zinc (filtered)	Nitrate	Nitrite	pH (field)	Spec. Cond. (field)	Sulfate	Temperature (field)	Coliform	Total Organic Carbon	Anions	Metals (filtered)	Arsenic (filtered)	Volatile Organic Analyses	Sampled as Scheduled in FY 2005?
699-22-35		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-23-34A		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-23-34B		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-33	Information only; no statistics	P	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-34A		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Missed one; pump needed lowering
699-24-34B		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-34C		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-35		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-26-35A		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
Spec. Cond. = Specific conductance.
WAC = Washington Administrative Code.

Table B.42. Analytical Results for Required Constituents(a) at Solid Waste Landfill

Constituent, unit	Value(b)	Date	Well 699-22-35	Well 699-23-34A	Well 699-23-34B	Well 699-24-33	Well 699-24-34A	Well 699-24-34B	Well 699-24-34C	Well 699-24-35	Well 699-26-35A
Ammonium, µg/L	118	October 2004	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8
		February 2005	<5.8	<5.8	<5.8	<5.8	c	<5.8	<5.8	<5.8	<5.8
		May 2005	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8
		August 2005	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8
Chemical oxygen demand, mg/L	10	October 2004	<3	<3	<3	<3	<3	<3	<3	<3	<3
		February 2005	**11**	**18**	9	9	(c)	**14**	**15**	**10**	8
		May 2005	**17**	**24**	**13**	**15**	<7.1	**14**	**18**	**23**	**57**
		August 2005	<7.1	**11**	**12**	9	**18**	**30**	<7.1	8	<7.1
Chloride, mg/L	7.82	October 2004	6.1	6.4	6.1	6.5	6.1	6.2	6.4	5.9	6.8
		February 2005	6.8	6.9	6.1	6.6	(c)	6.9	6.9	6.4	7.1
		May 2005	7.3	7.6	7.2	**7.9**	7.8	7.5	7.5	7.1	7.8
		August 2005	5.6	7.4	5.4	6.5	7.4	7.1	7	6	7.4
Coliform bacteria, Col/100ml	1	October 2004	0	0	0	0	**14.6**	0	**1**	0	0
		February 2005	0	0	0	0	(c)	0	0	0	0
		May 2005	0	0	0	0	**5.2**	**1**	0	0	0
		August 2005	<1	**80.9**	<1	<1	**10**	<1	<1	**9.8**	<1
Iron, filtered, µg/L	160	October 2004	21.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9
		February 2005	38.5	40.9	53.4	41.7	(c)	36.1	38.2	33.5	19.9
		May 2005	**161**	39.4	53.6	35.9	90.2	51.1	87.5	49	30.1
		August 2005	73.3	40.3	50	39.5	72.3	47.1	54.4	41.4	23.6
Manganese, filtered, µg/L	10	October 2004	1.4	<0.99	<0.99	2.3	1.4	<0.99	<0.99	<0.99	1.4
		February 2005	<0.99	<0.99	<0.99	1.1	(c)	<0.99	<0.99	<0.99	1
		May 2005	6.2	<0.84	<0.84	<0.84	2.1	1.5	1	1	1.6
		August 2005	1.9	1.1	<0.84	<0.84	4.4	1.1	<0.84	1.7	<0.84
Nitrate, mg/L	29	October 2004	3.1	3.2	3.1	2.7	2.4	2.6	2.7	2.3	3.3
		February 2005	3.6	3.7	3.5	3	(c)	3	3.1	3.5	3.7
		May 2005	3.8	3.8	3.7	3.3	2.9	3.3	3.1	2.7	3.7
		August 2005	3.7	3.7	3.5	3.1	2.9	3.3	2.8	2.9	3.4
Nitrite, mg/L	0.059	October 2004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
		February 2005	0.004	0.004	0.004	0.004	(c)	0.004	0.004	0.004	0.004
		May 2005	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061
		August 2005	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061

Table B.42. (contd)

Constituent, unit	Value(b)	Date	Well 699-22-35	Well 699-23-34A	Well 699-23-34B	Well 699-24-33	Well 699-24-34A	Well 699-24-34B	Well 699-24-34C	Well 699-24-35	Well 699-26-35A
Field pH	6.68-7.84	October 2004	6.91	**6.58**	**6.65**	6.98	6.76	**6.65**	6.84	7.73	7.2
		February 2005	6.94	**6.62**	**6.65**	6.82	(c)	**6.68**	6.92	6.87	7.12
		May 2005	6.93	**6.55**	6.76	6.85	6.75	6.69	6.91	6.82	7.05
		August 2005	7.02	6.6	6.75	6.96	6.71	6.71	6.96	6.88	7.18
Specific conductance, µS/cm	583	October 2004	**831**	**767**	**799**	**785**	**697**	**719**	**762**	**616**	557
		February 2005	**821**	**754**	**797**	**786**	(c)	**732**	**764**	**588**	555
		May 2005	**826**	**770**	**815**	**787**	**693**	**703**	**752**	**599**	550
		August 2005	**824**	**764**	**791**	**774**	**691**	**752**	**769**	**604**	557
Sulfate, mg/L	47.2	October 2004	43.4	47.1	43.7	41.7	43.9	44.6	40	43.3	36.2
		February 2005	43.5	**47.4**	43.2	41.7	(c)	47.1	40.2	43.2	36.7
		May 2005	**51.1**	**54.3**	**50.1**	**51.7**	**51.5**	**59.5**	47	**50.5**	41.8
		August 2005	45.9	**51.2**	45	45.4	**47.8**	**61.9**	43.1	**48**	37.3
Temperature, °C	20.7	October 2004	18	17.8	17.6	19.2	18.5	18.6	18.8	17.6	18.8
		February 2005	17.9	17.4	17.5	18.7	(c)	17.7	17	16.3	19
		May 2005	18.4	19.6	19.6	19	18.9	18.9	18.9	18.1	18.9
		August 2005	19	18.8	18.8	19.7	19.7	19.6	20.1	18.4	19.7
Total organic carbon, mg/L	1.51	October 2004	0.39	0.39	0.39	0.39	0.39	0.39	0.44	0.39	0.39
		February 2005	0.54	0.49	0.6	0.43	(c)	0.44	0.43	0.57	0.43
		May 2005	0.44	1	1	**9.084(d)**	1	1	**5.521(d)**	1	1
		August 2005	0.72	0.71	0.65	0.66	0.7	0.52	0.68	0.78	0.54
Zinc, filtered, µg/L	42.3	October 2004	<1.5	1.7	1.8	19.1	2.8	2	10.6	4.4	5.6
		February 2005	1.6	3.9	3.2	12.8	(c)	2	11.2	5.6	6.6
		May 2005	5.7	5.7	4.5	10.2	4.9	3.6	14	7.5	7.6
		August 2005	4.9	4.8	3.2	13.1	5.9	6.7	13.8	6.4	7

(a) WAC 173-304.
(b) Number obtained from Table B.43 of last year's annual groundwater report (PNNL-15070).
(c) Sample not collected.
(d) Result not typical of historical trend for this well. Likely an error.
Results in **bold** exceed background threshold value.

Table B.43. Results of Shapiro and Francia Test for Normality and Background Threshold Values for Solid Waste Landfill

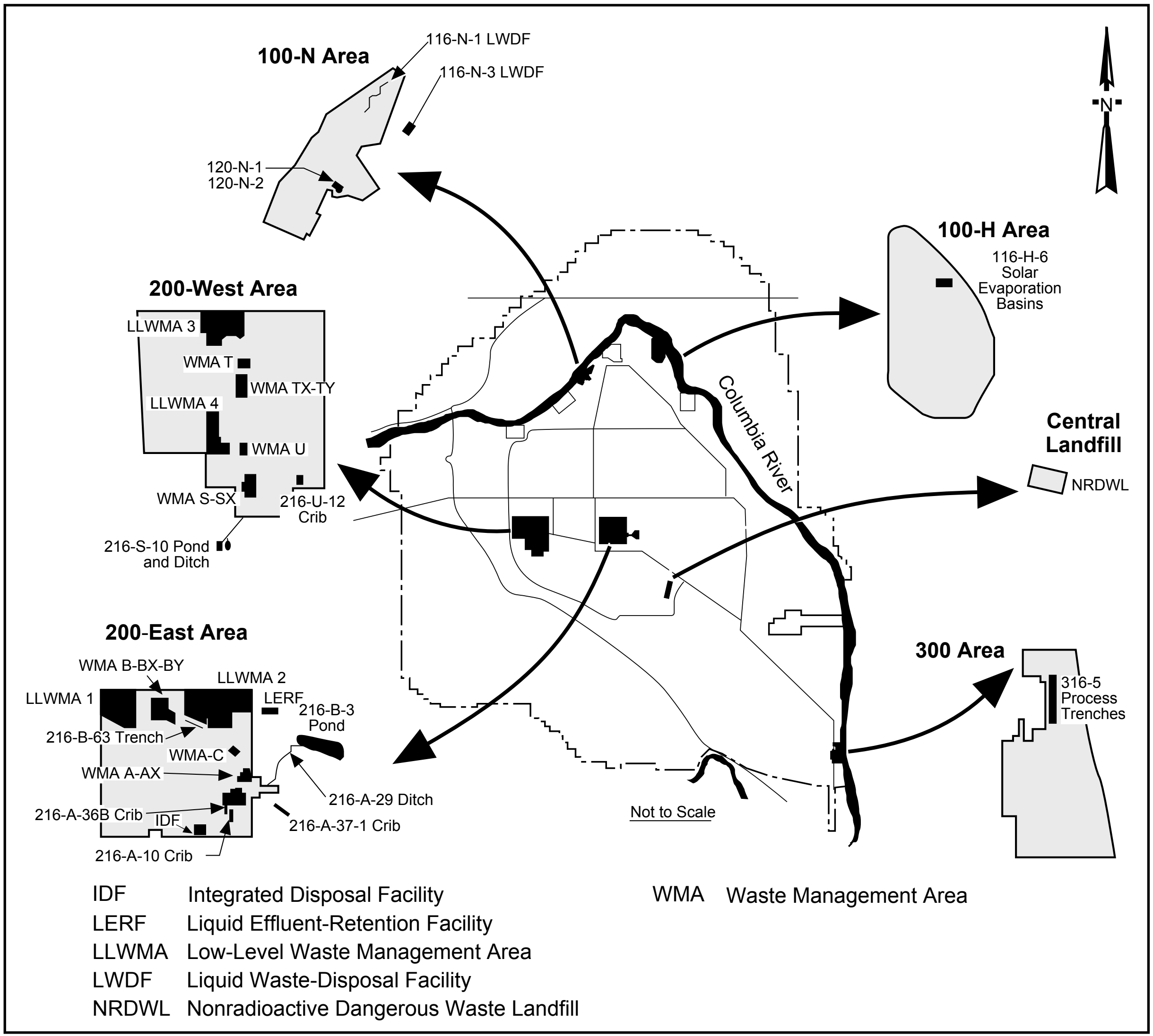
Constituent,(a) unit	W-test Statistic,(b) (log value)	W-test Statistic,(b) (raw data)	W-test(b) Critical Value, Wα(c)	Upper Tolerance Limit	Background Threshold Value
Temperature, °C	0.953 s	0.961 s	0.963	20.7(d)	20.7
Specific conductance, µS/cm	0.978 ns	NA	0.960	583(e)	583
Field pH	0.988 ns	NA	0.963	[6.68, 7.84](e)	[6.68, 7.84]
Total organic carbon, µg/L	NC	NC	NC	842(d) 2,240(f)	2,240
Chloride, µg/L	0.954 s	0.962 s	0.963	7,820(d)	7,820
Nitrate (as NO_3^-), µg/L	0.833 s	0.844 s	0.963	29,000(d)	29,000
Nitrite (as NO_2^-), µg/L	NC	NC	NC	89(f)	89
Ammonium (as NH_3^-), µg/L	NC	NC	NC	90(d) 32(f)	90
Sulfate, µg/L	0.983 ns	NA	0.963	47,200(e)	47,200
Iron, dissolved, µg/L	0.960 s	0.802 s	0.962	160(d) 56.7(f)	160
Zinc, dissolved, µg/L	NC	NC	NC	42.3(d) 5.4(f)	42.3
Manganese, dissolved, µg/L	NC	NC	NC	10(d) 4(f)	10
Coliform bacteria, colonies/100 ml	NC	NC	NC	1(g)	1
Chemical oxygen demand, µg/L	NC	NC	NC	10,000(g)	10,000

(a) Constituents are specified in WAC 173-304-490(2)(d). Data collected from March 1993 to May 2000 from upgradient wells 699-24-35 and 699-26-35A.
(b) Shapiro and Francia (1972).
(c) Obtained from Table A-9 (Shapiro 1980) for α = 5%.
(d) Maximum value reported.
(e) Based on log-normal distribution.
(f) Based on limit of quantitation using method detection limit.
(g) Based on laboratory lowest detected result.
NA = Not applicable.
NC = Not calculated; insufficient measured values.
ns = Not significant at 0.05 level of significance.
s = Significant at 0.05 level of significance.

Table B.44. Monitoring Wells, Constituents, and Enforcement Limits for State-Approved Land Disposal Site (adapted from PNNL-13121)

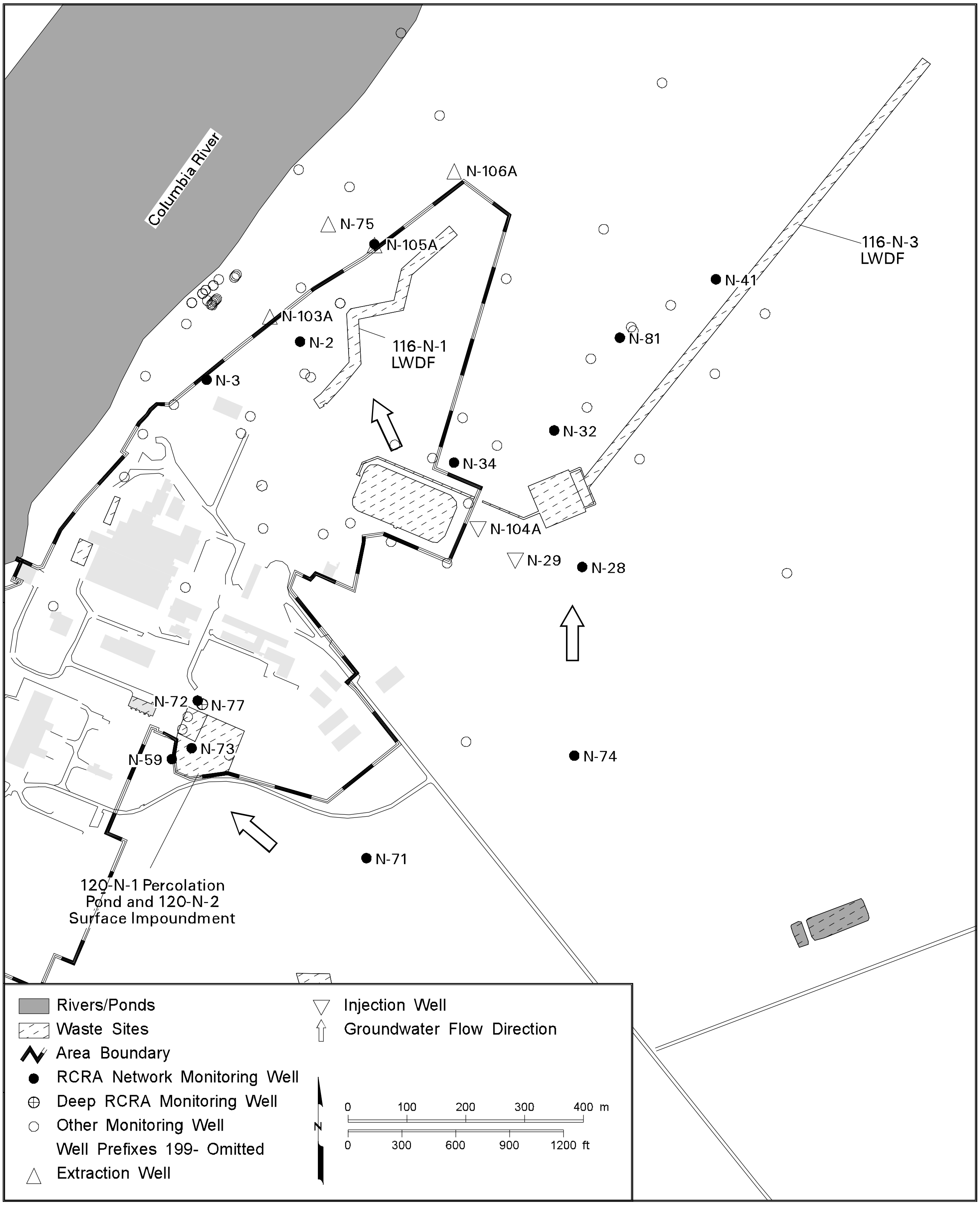
			Constituents with Enforcement Limits											Other Constituents				
Well	Comment	WAC Compliant	pH (6.5 - 8.5)	Acetone (160 µg/L)	Benzene (5 µg/L)	Cadmium(a) (5 µg/L)	Chloroform (6.2 µg/L)	Copper(a) (70 µg/L)	Lead(a) (10 µg/L)	Mercury(a) (2 µg/L)	Sulfate (250 mg/L)	Tetrahydrofuran (100 µg/L)	Total Dissolved Solids (500 mg/L)	Alpha	Beta	Strontium-90	Tritium	Sampled as Scheduled in FY 2005?
299-W6-6	Bottom of unconfined	C															A	Yes
299-W6-11		C															A	Yes
299-W6-12		C															A	Yes
299-W7-3	Bottom of unconfined	C															S	Yes
299-W7-5		C															S	Sampled once; dry 09/2005
299-W7-12		C															A	Yes
299-W8-1		C															A	Yes
699-48-71	Unconfined	P															A	Yes
699-48-77A	Ringold E, upper	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-48-77C	Ringold E, mid to lower	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-48-77D	Ringold E, upper	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-49-79		P															A	Yes
699-51-75		P															S	Yes
699-51-75P	Lower unconfined	P															A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) Filtered samples.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
S = To be sampled semiannually.
WAC = Washington Administrative Code.



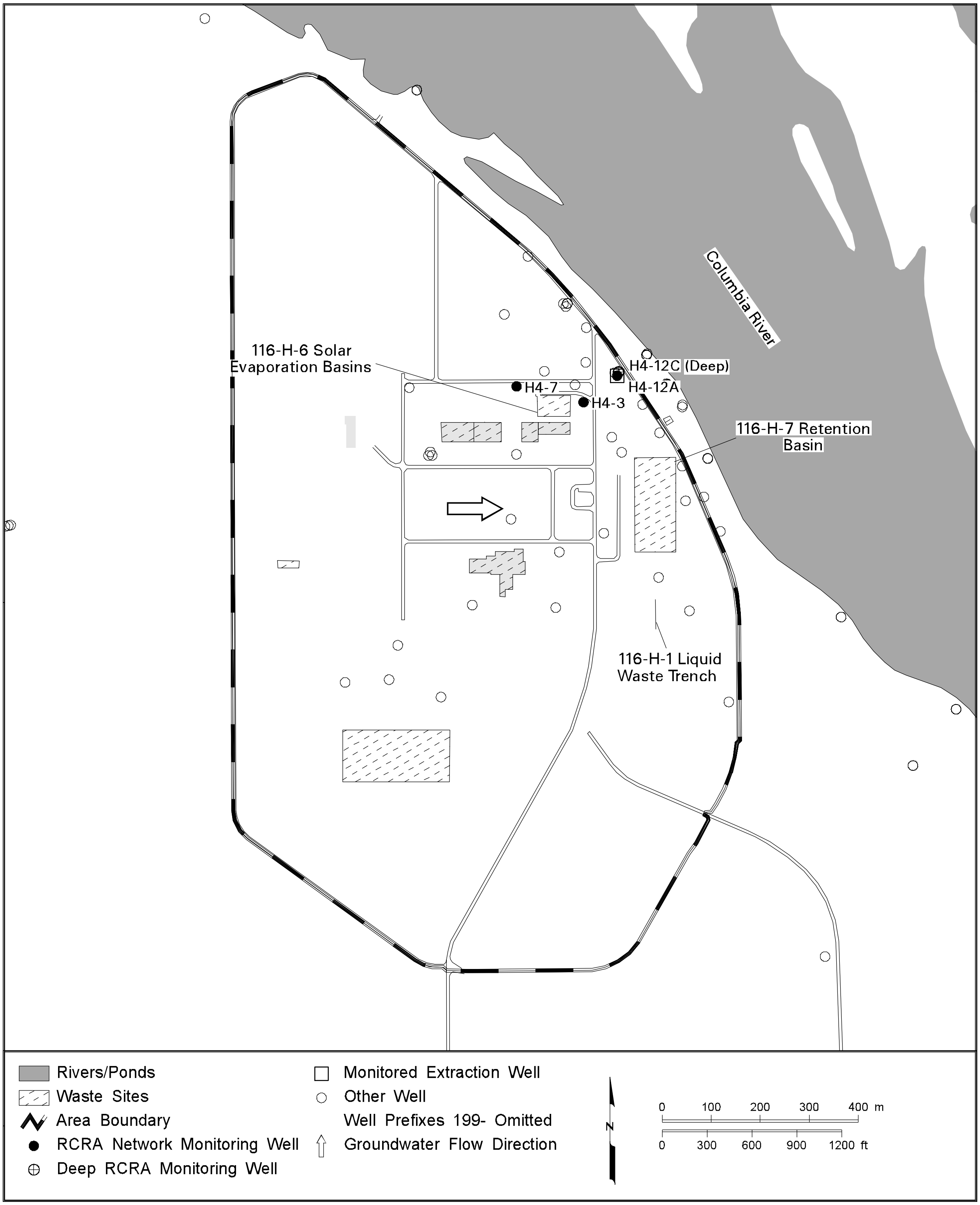
wdw06081/ecs05003/G00080088.3

Figure B.1. RCRA Units on the Hanford Site Requiring Groundwater Monitoring. (The 216-A-10, 216-A-36B, and 216-A-37-1 cribs are monitored as a single waste management unit, PUREX Cribs.)



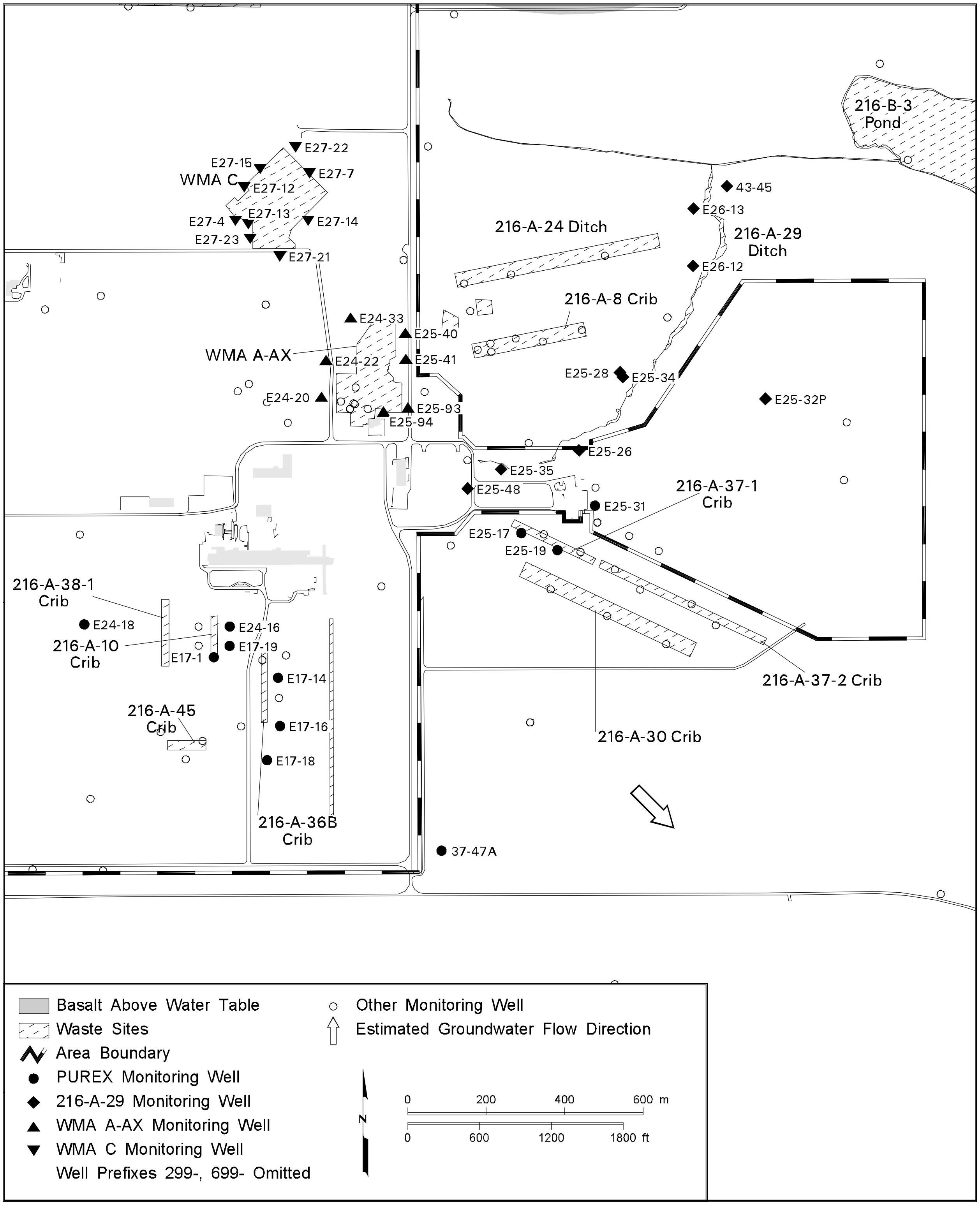
can_gwf05_612 December 28, 2005 10:36 AM

Figure B.2. Groundwater Monitoring Wells for 100-N Area RCRA Sites



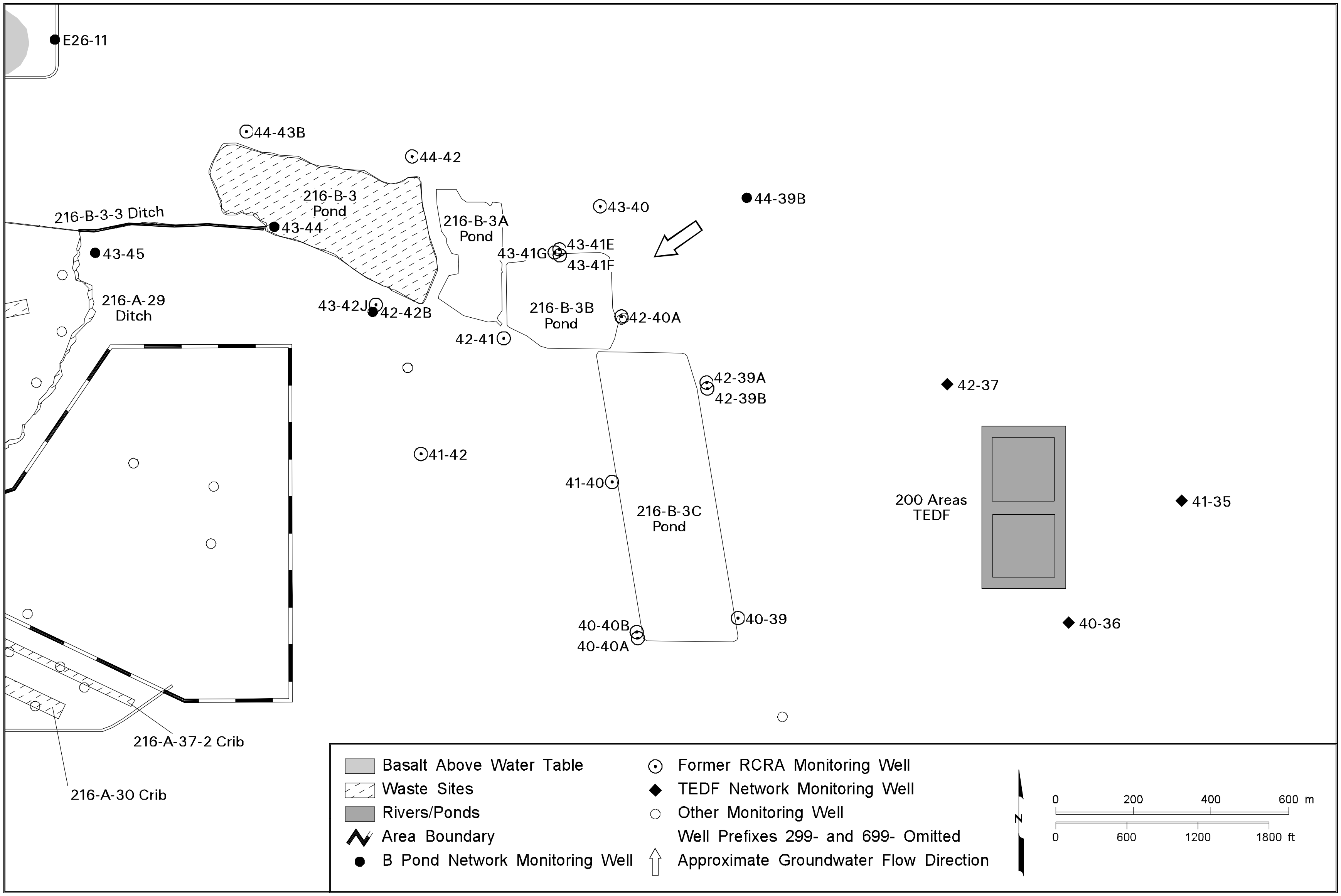
can_gwf05_613 December 28, 2005 10:36 AM

Figure B.3. Groundwater Monitoring Wells at 116-H-6 (183-H) Evaporation Basins



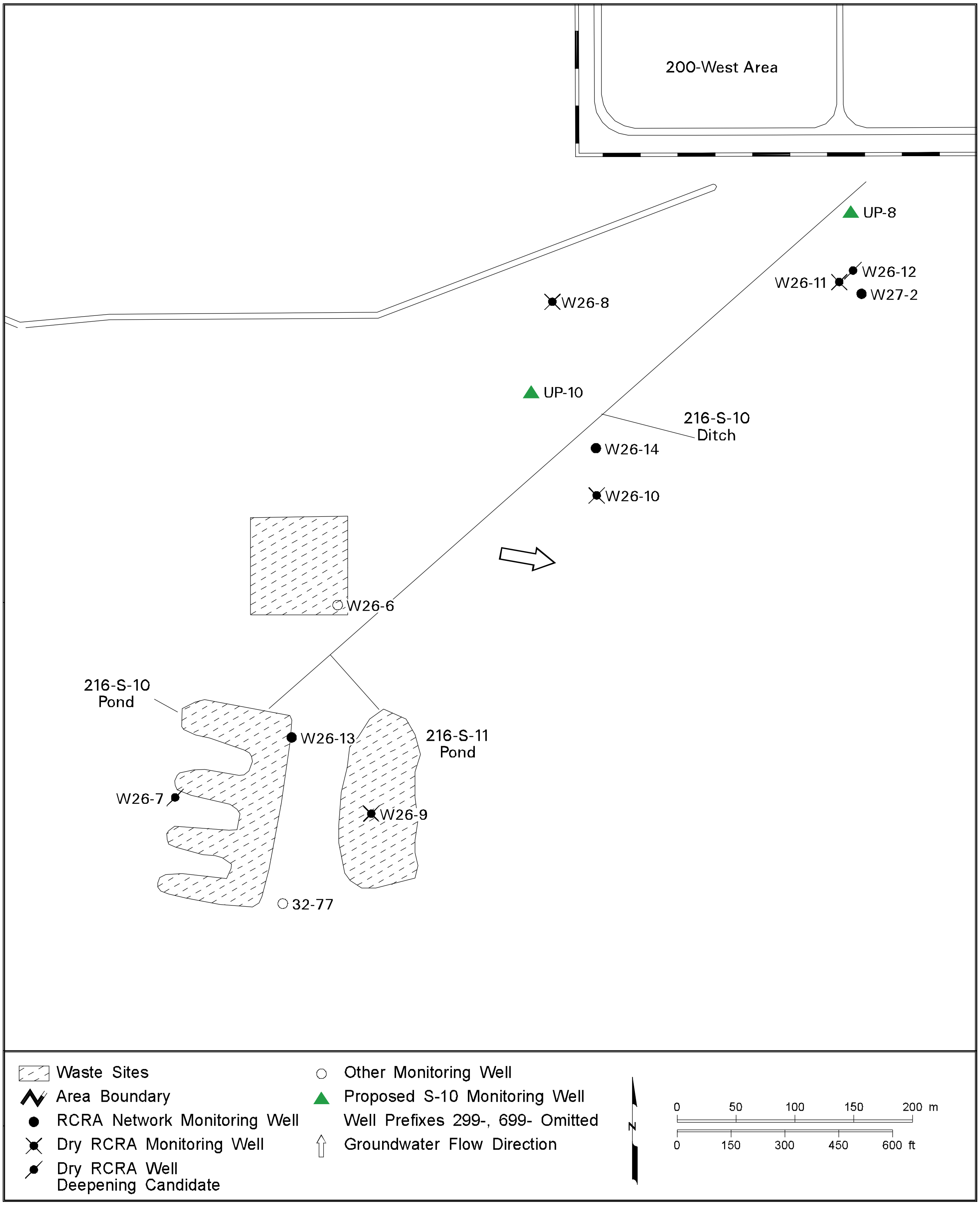
can_gwf05_614 February 21, 2006 11:19 AM

Figure B.4. Groundwater Monitoring Wells at 216-A-29 Ditch, PUREX Cribs, and Waste Management Areas A-AX and C



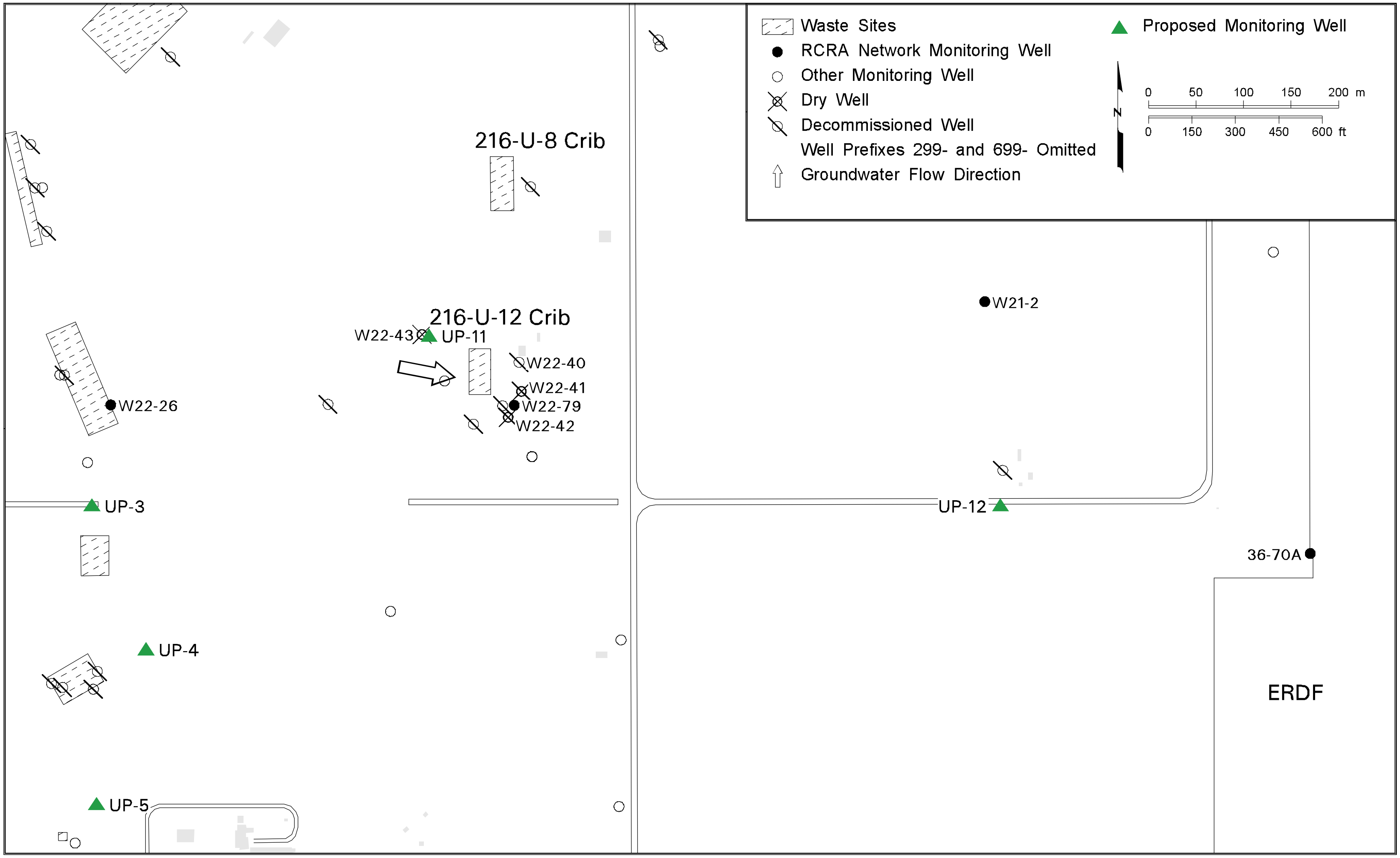
can_gwf05_615 December 28, 2005 12:45 PM

Figure B.5. Groundwater Monitoring Wells at 216-B-3 Pond and 200 Area Treated Effluent Disposal Facility



can_gwf05_617 February 21, 2006 11:10 AM

Figure B.6. Groundwater Monitoring Wells at 216-S-10 Pond and Ditch



can_gwf05_618 January 05, 2006 9:35 AM

Figure B.7. Groundwater Monitoring Wells at 216-U-12 Crib

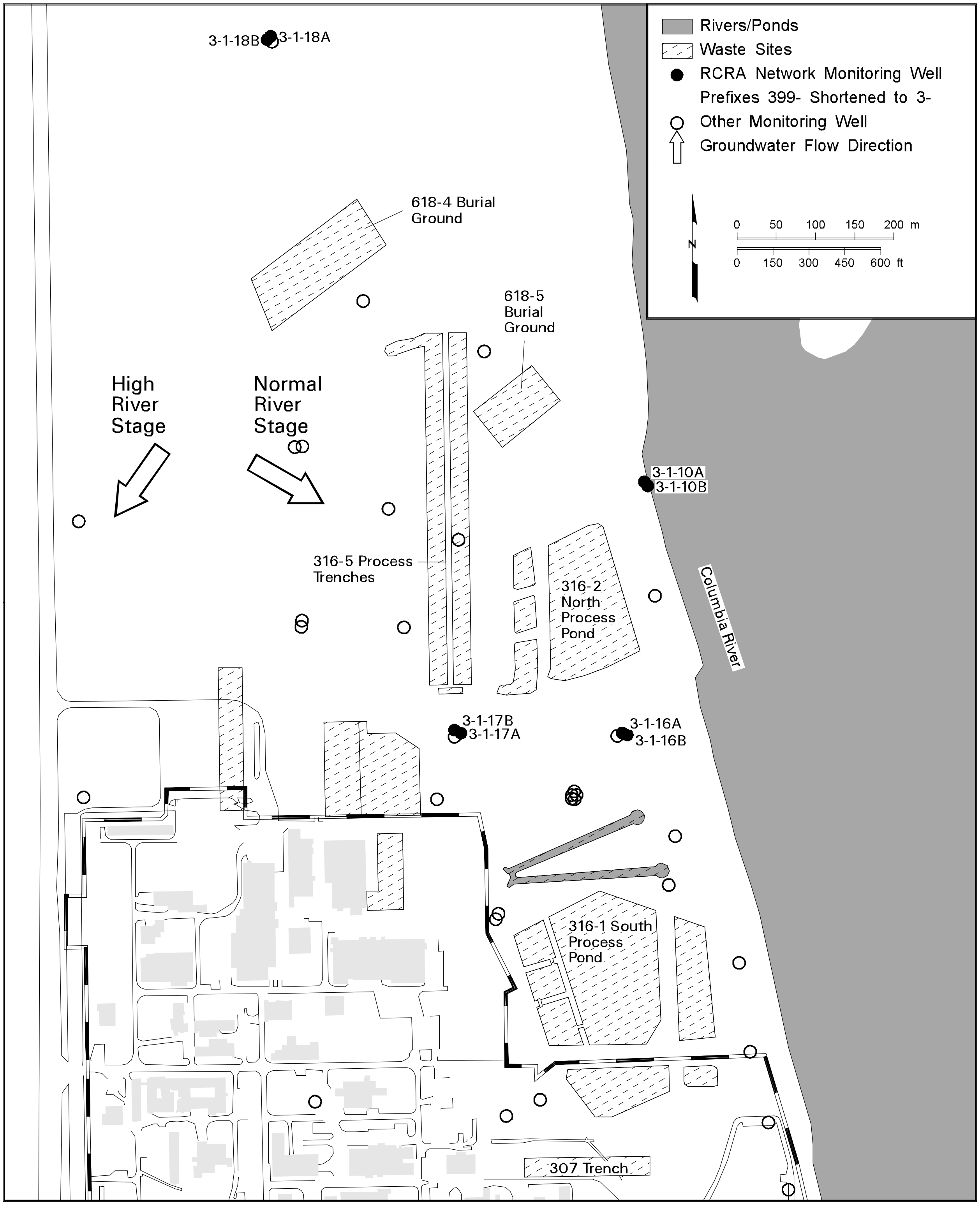
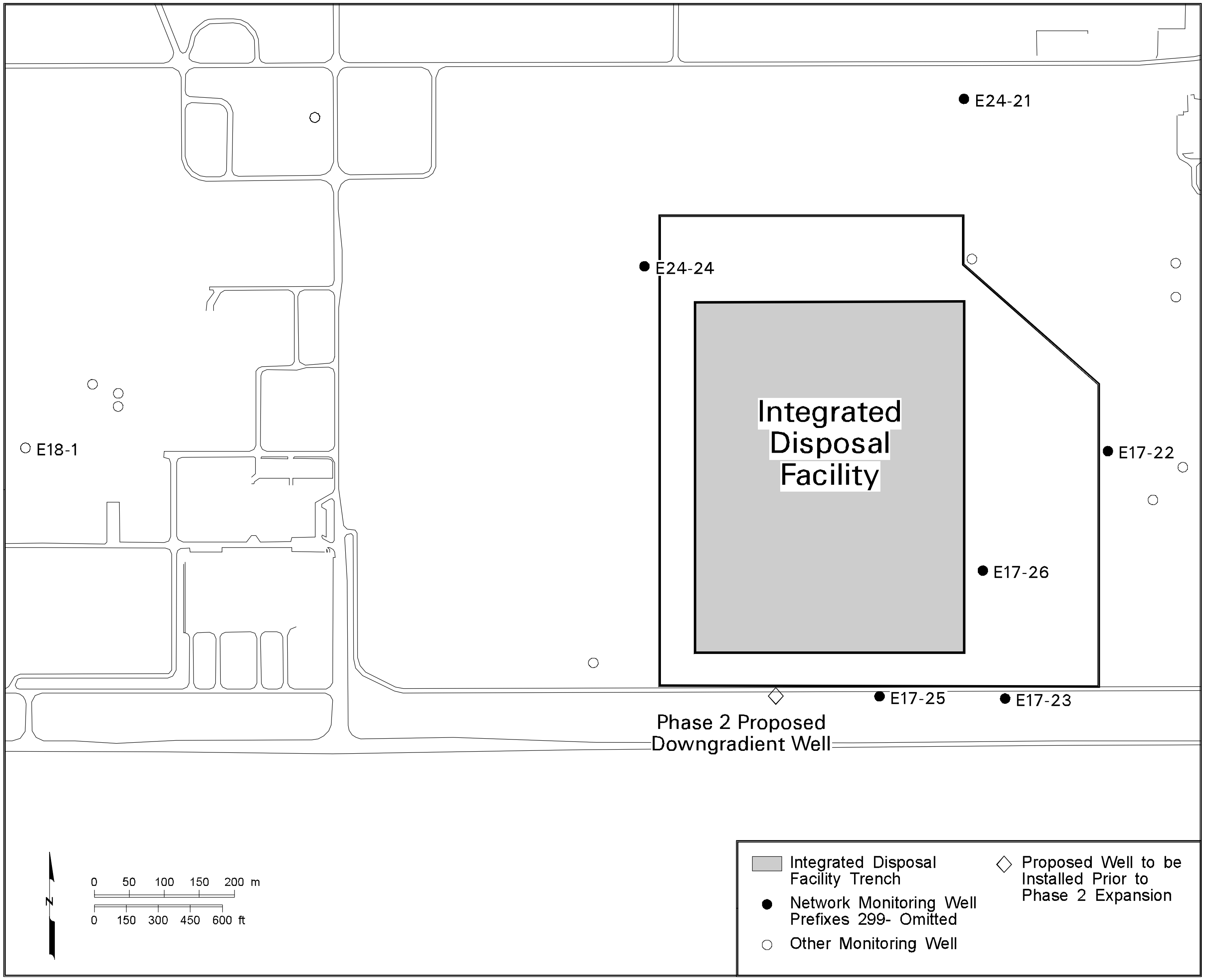
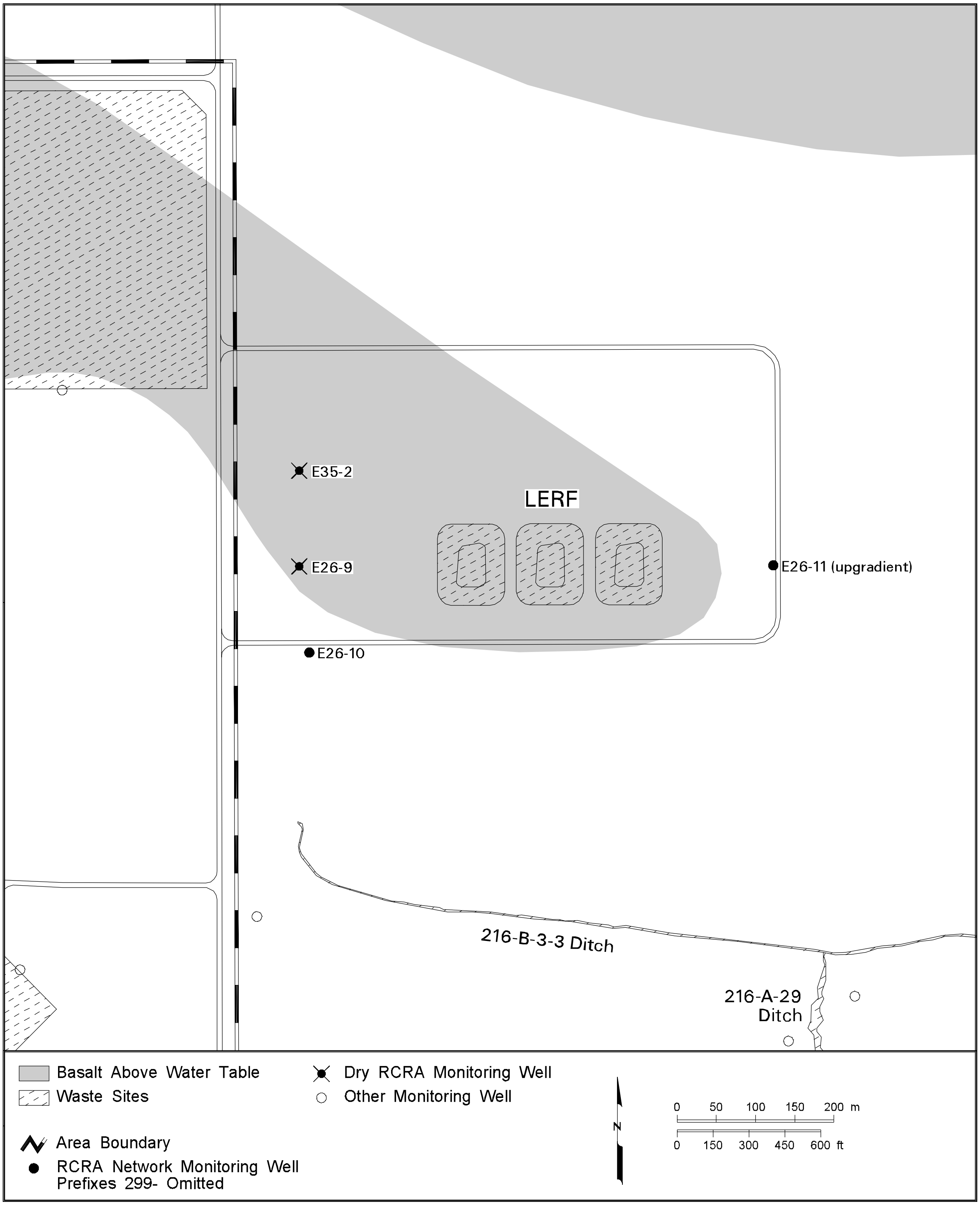


Figure B.8. Groundwater Monitoring Wells at 316-5 Process Trenches



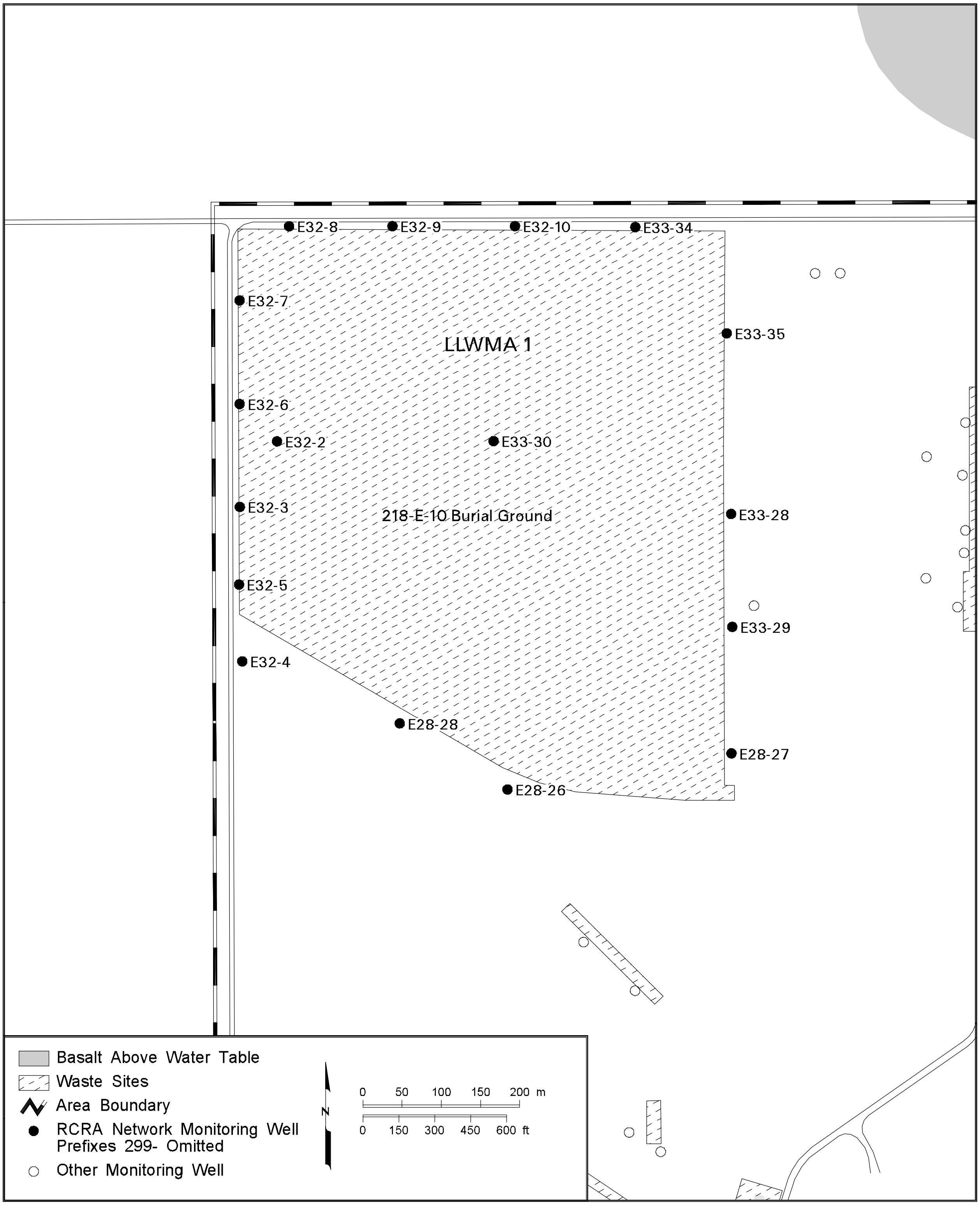
can_gwf05_620 December 28, 2005 1:10 PM

Figure B.9. Groundwater Monitoring Wells at Integrated Disposal Facility



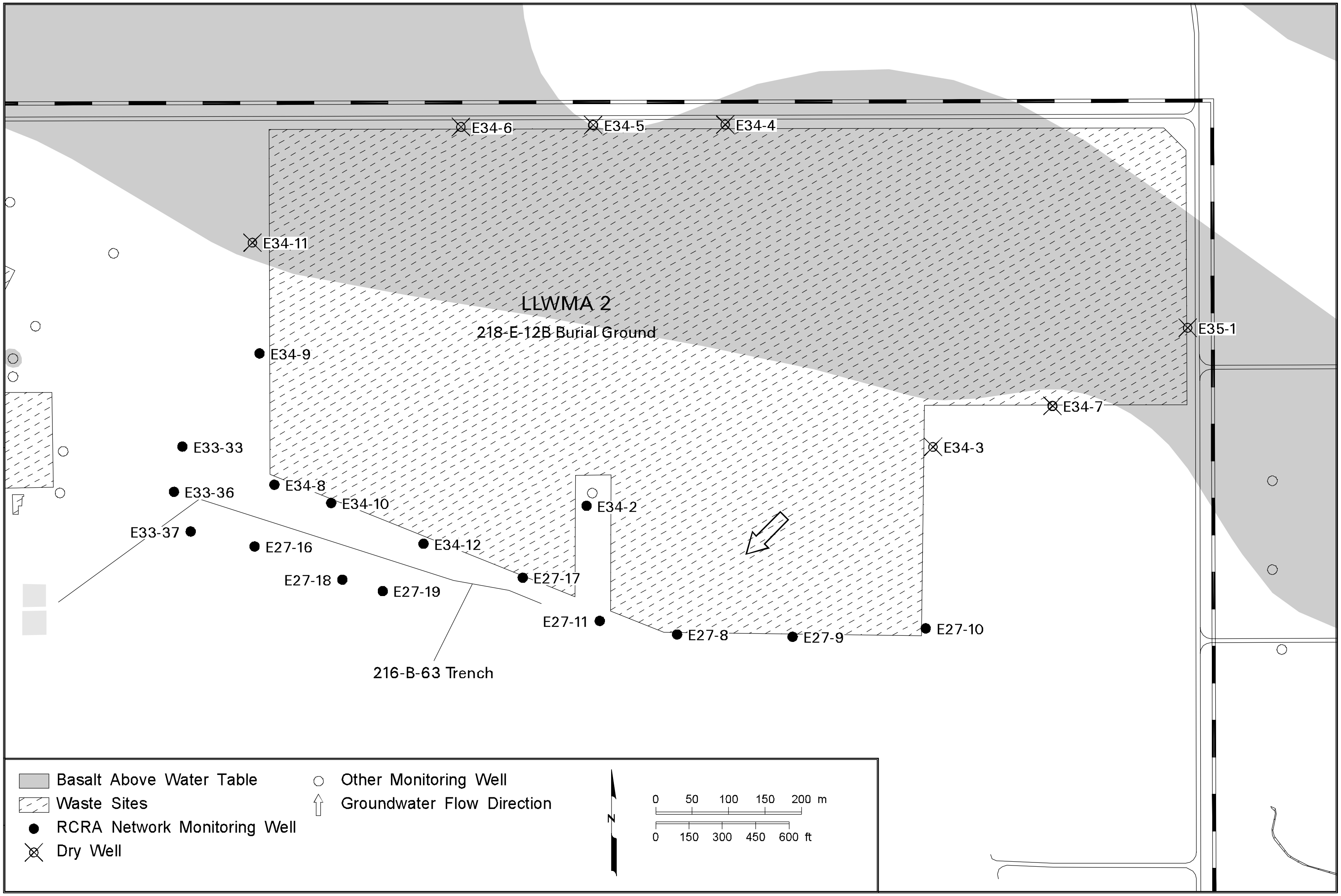
can_gwf05_621 December 30, 2005 11:57 AM

Figure B.10. Groundwater Monitoring Wells at Liquid Effluent Retention Facility



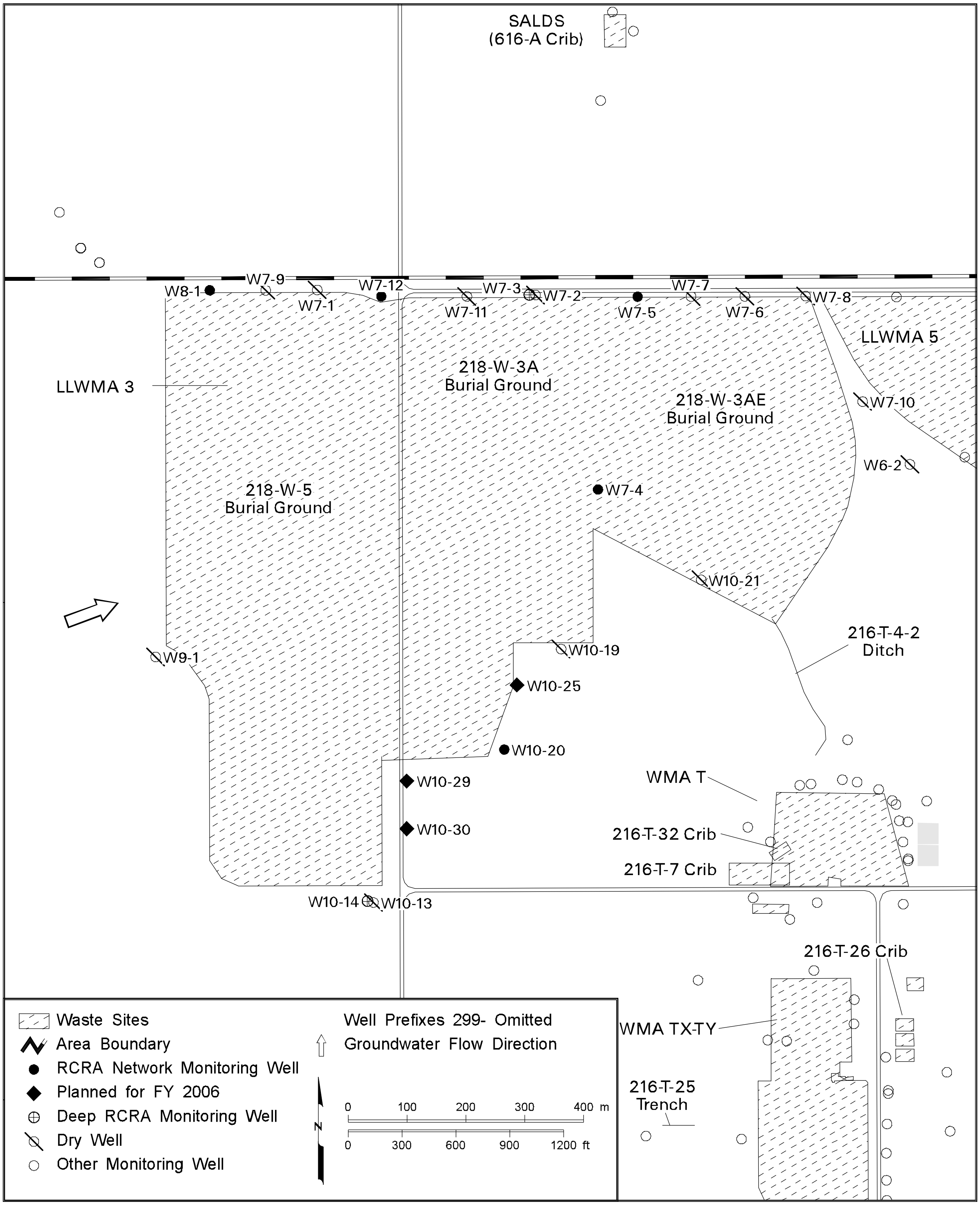
can_gwf05_622 February 20, 2006 3:02 PM

Figure B.11. Groundwater Monitoring Wells at Low-Level Waste Management Area 1



can_gwf05_616 February 15, 2006 2:56 PM

Figure B.12. Groundwater Monitoring Wells at 216-B-63 Trench and Low-Level Waste Management Area 2



can_gwf05_623 February 19, 2006 3:38 PM

Figure B.13. Groundwater Monitoring Wells at Low-Level Waste Management Area 3

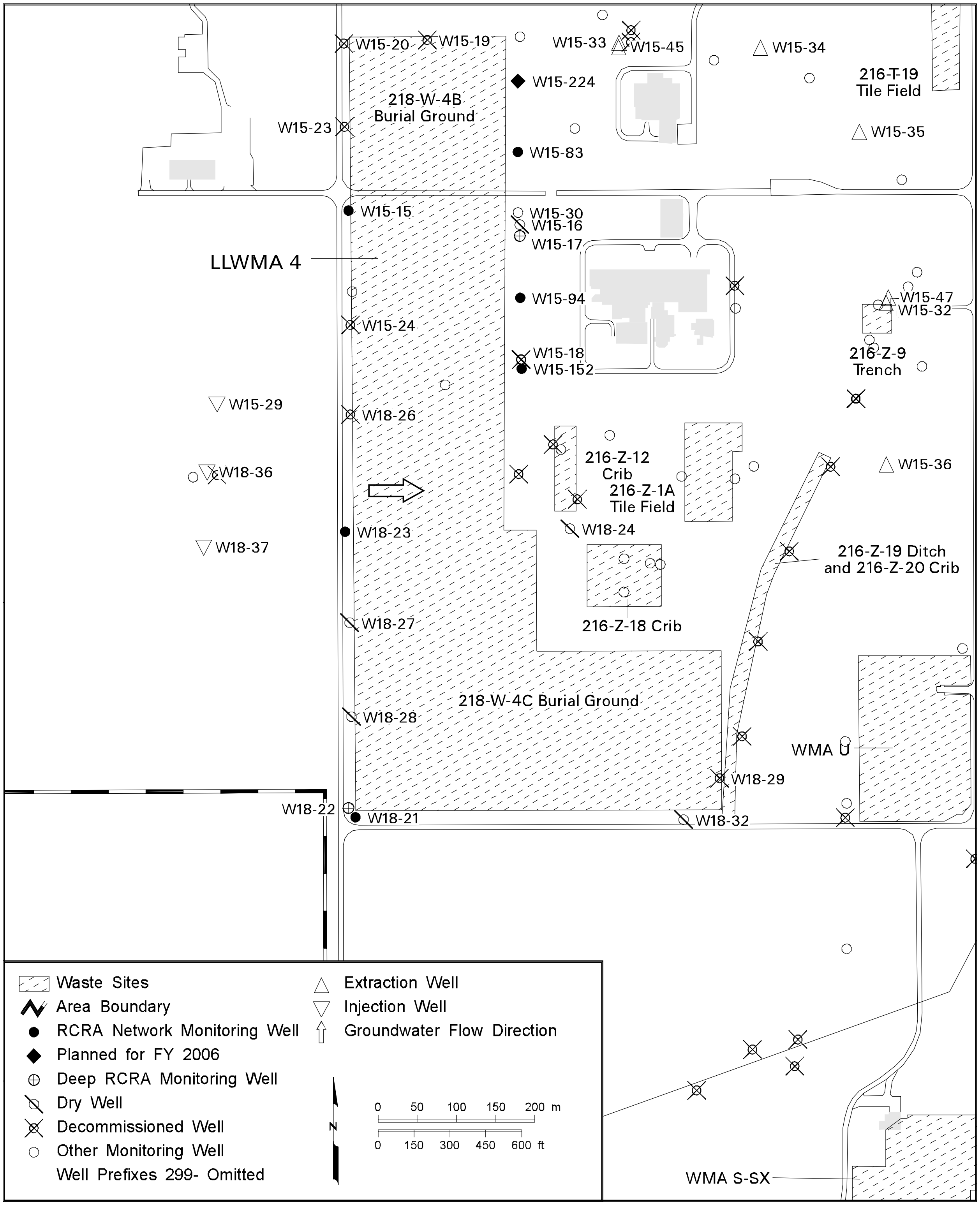
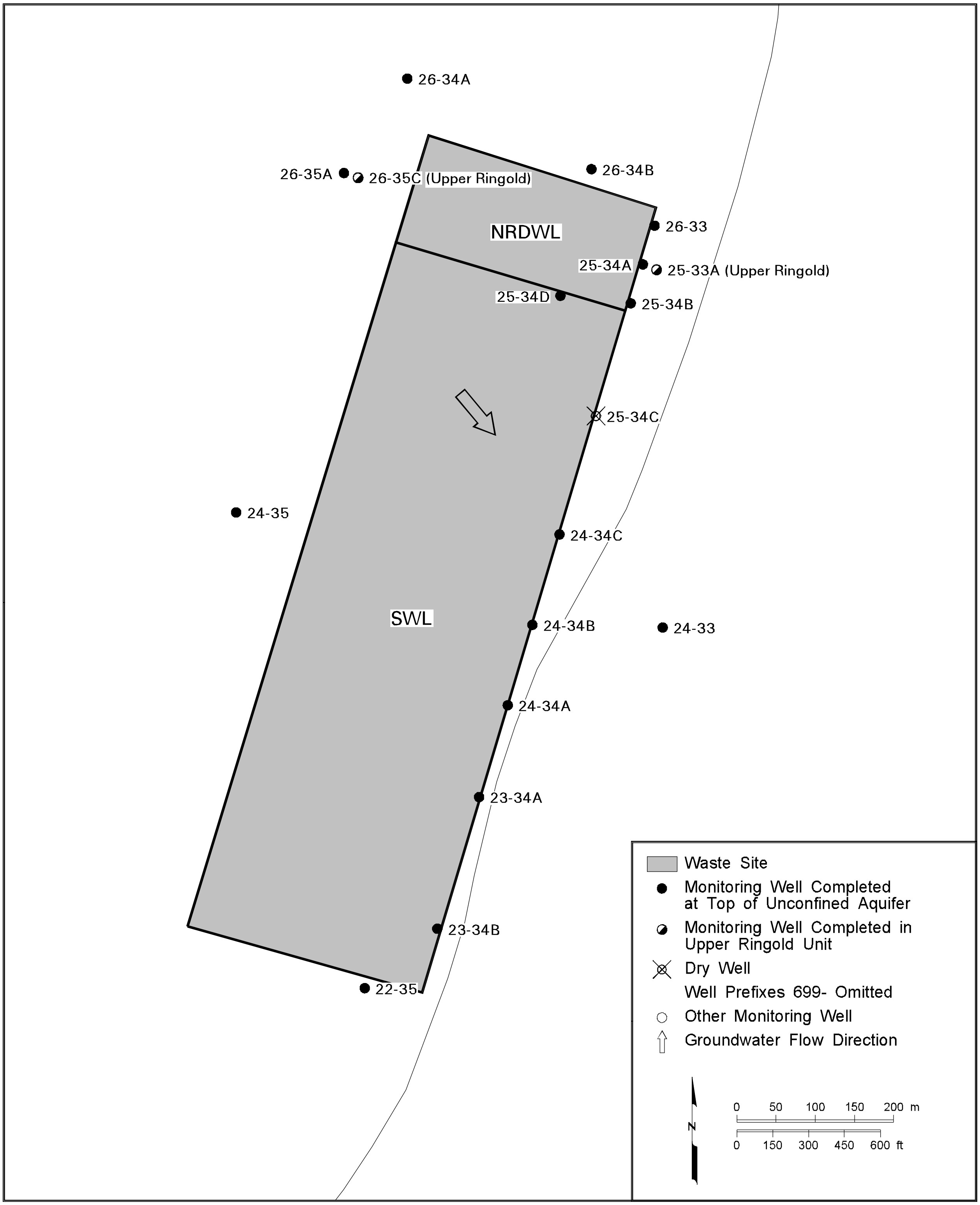
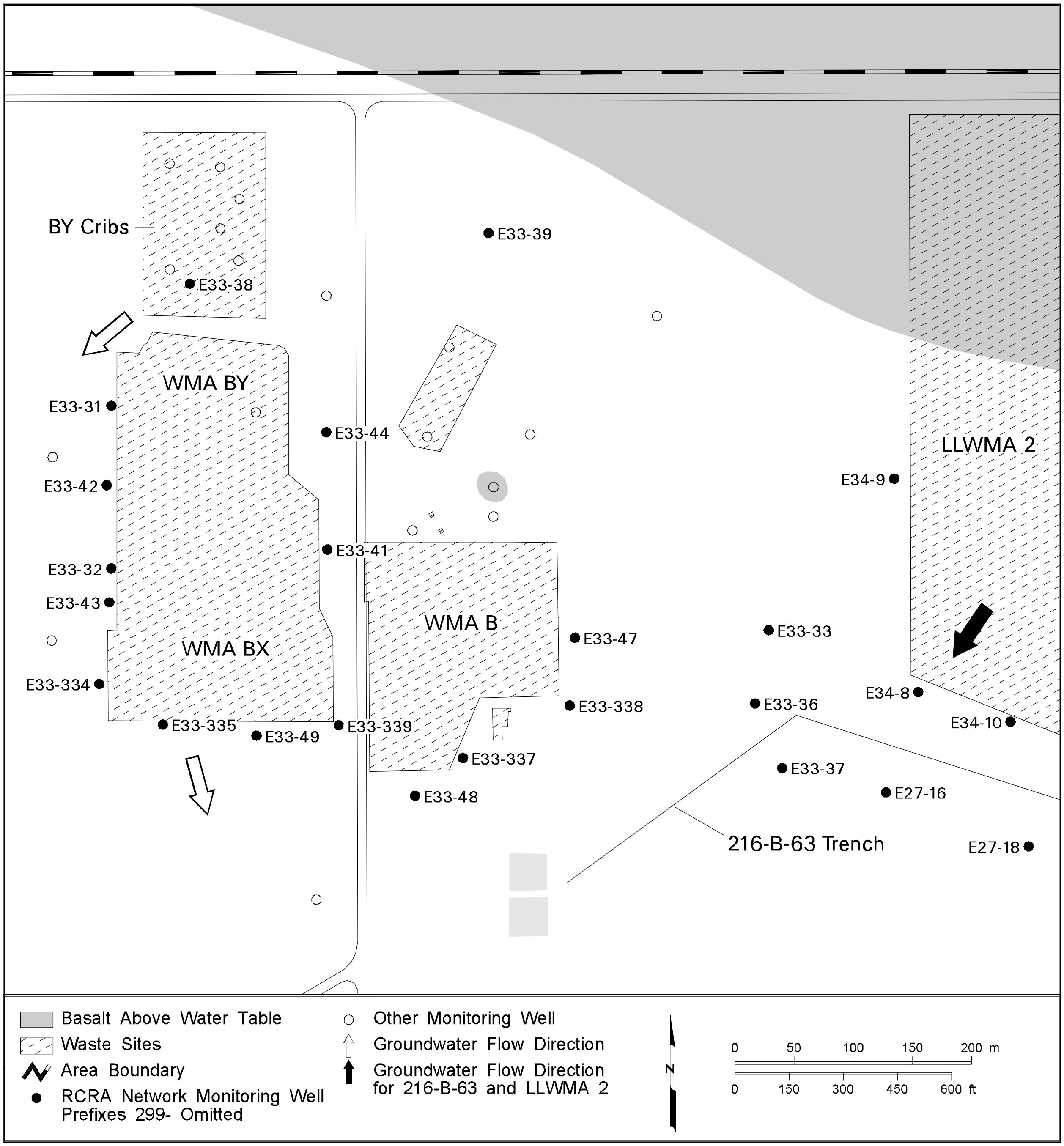


Figure B.14. Groundwater Monitoring Wells at Low-Level Waste Management Area 4



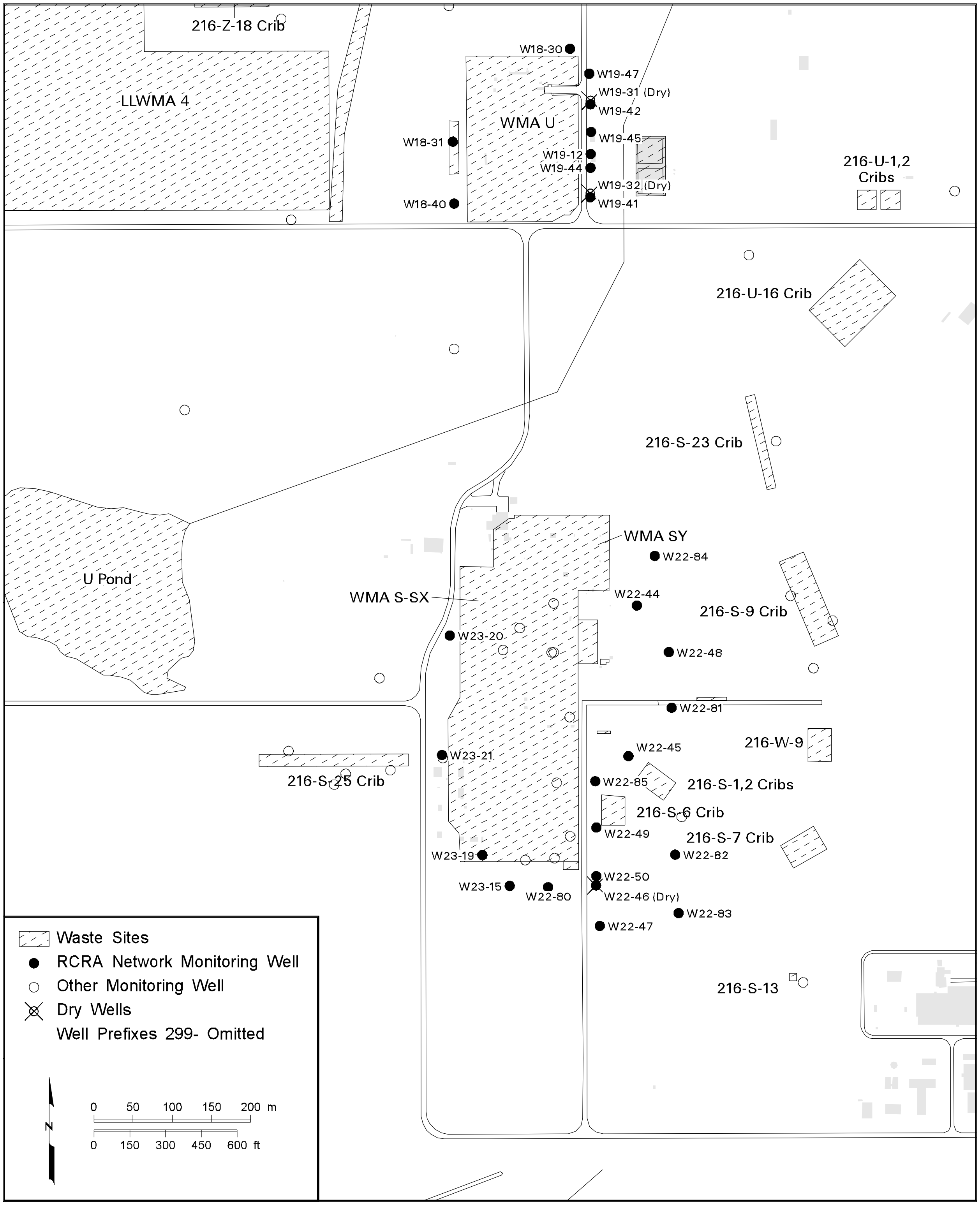
can_gwf05_625 December 28, 2005 2:15 PM

Figure B.15. Groundwater Monitoring Wells at Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill



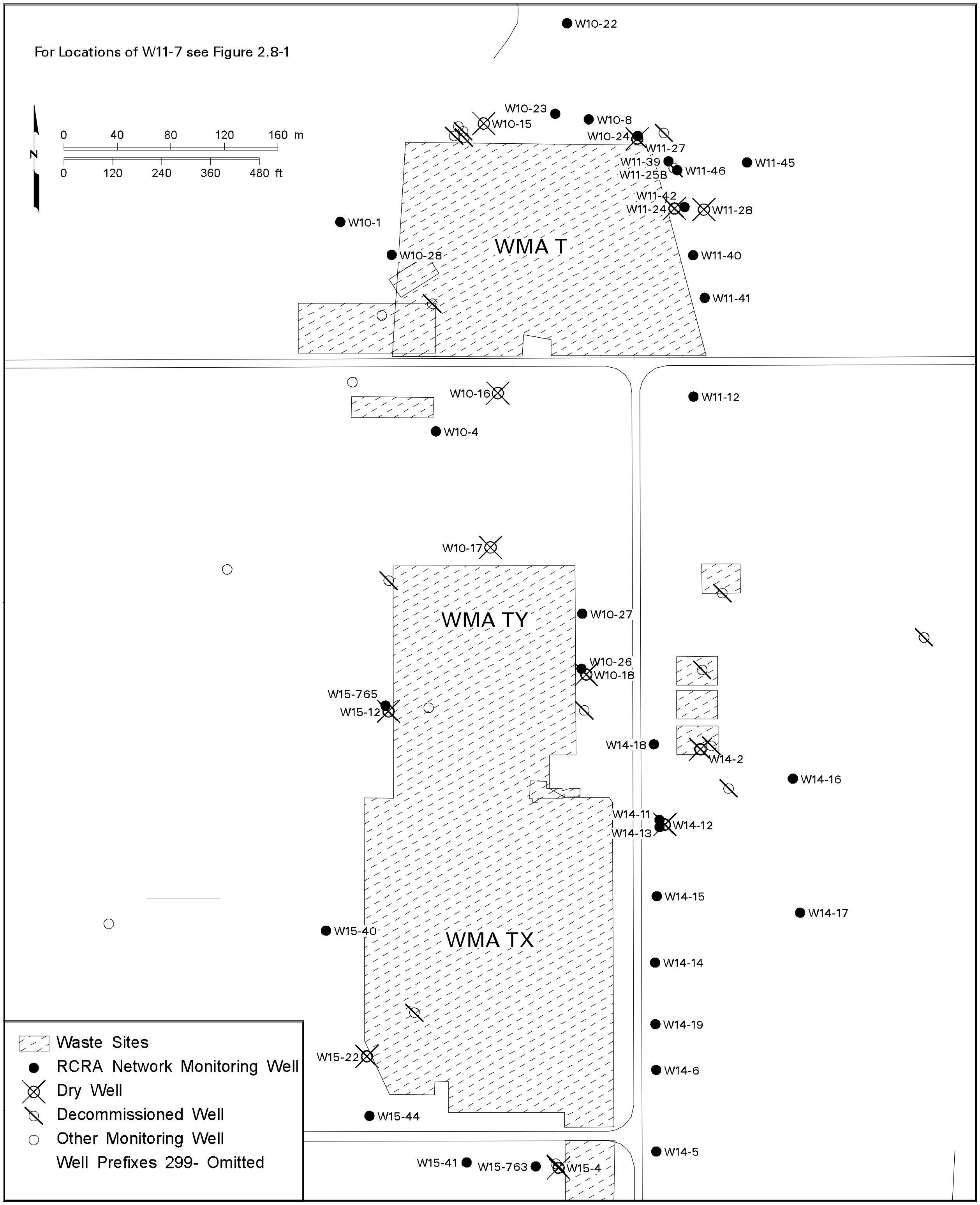
can_gwf05627 December 22, 2005 5:26 PM

Figure B.16. Groundwater Monitoring Wells at Waste Management Area B-BX-BY



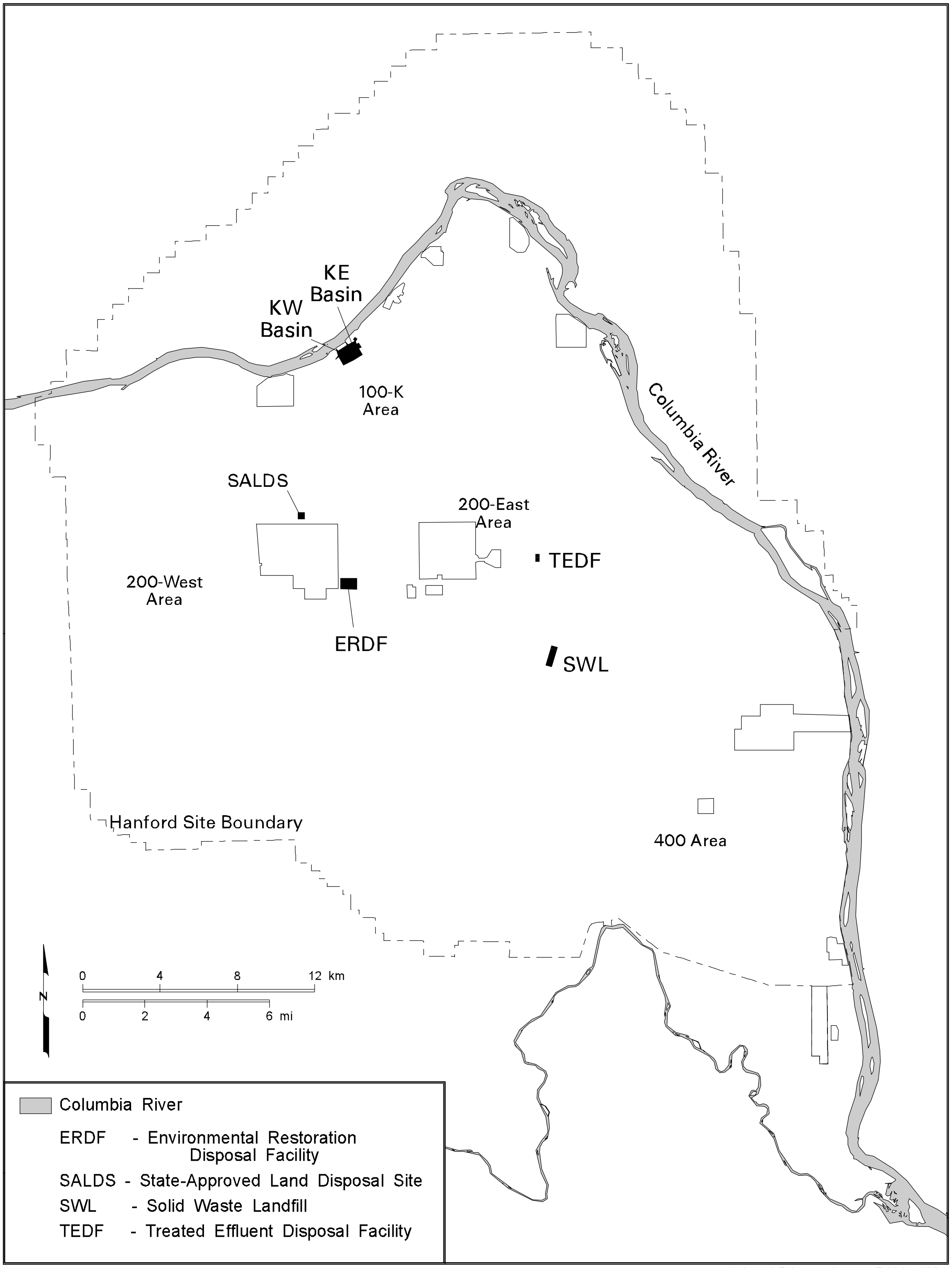
can_gwf05_629 December 28, 2005 2:11 PM

Figure B.17. Groundwater Monitoring Wells at Waste Management Areas S-SX and U



can_gwf05_630 December 28, 2005 3:27 PM

Figure B.18. Groundwater Monitoring Wells at Waste Management Areas T and TX-TY



can_gwf04_631 February 12, 2005 11:18 AM

Figure B.19. Regulated Units (other than RCRA units) on the Hanford Site Requiring Groundwater Monitoring

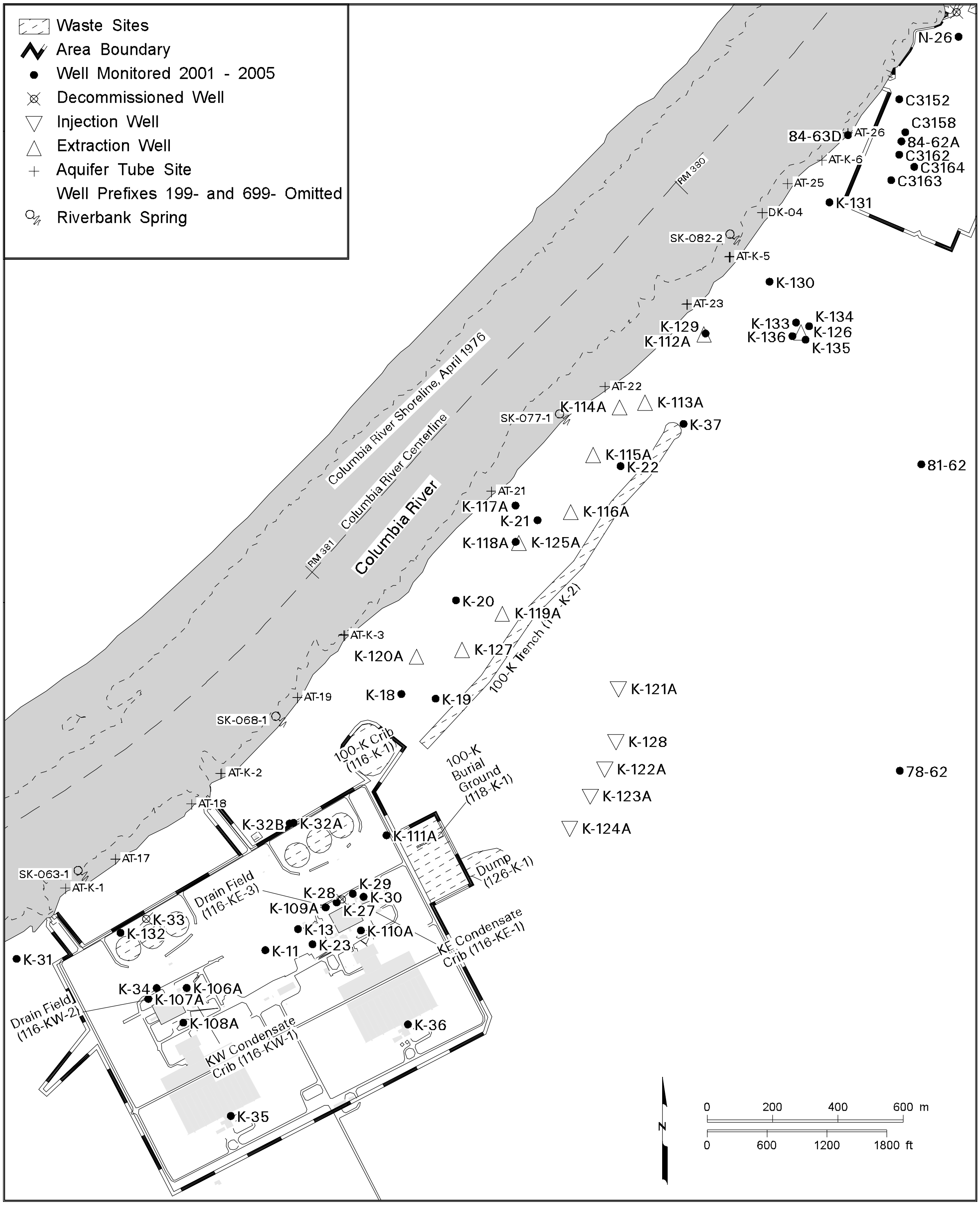


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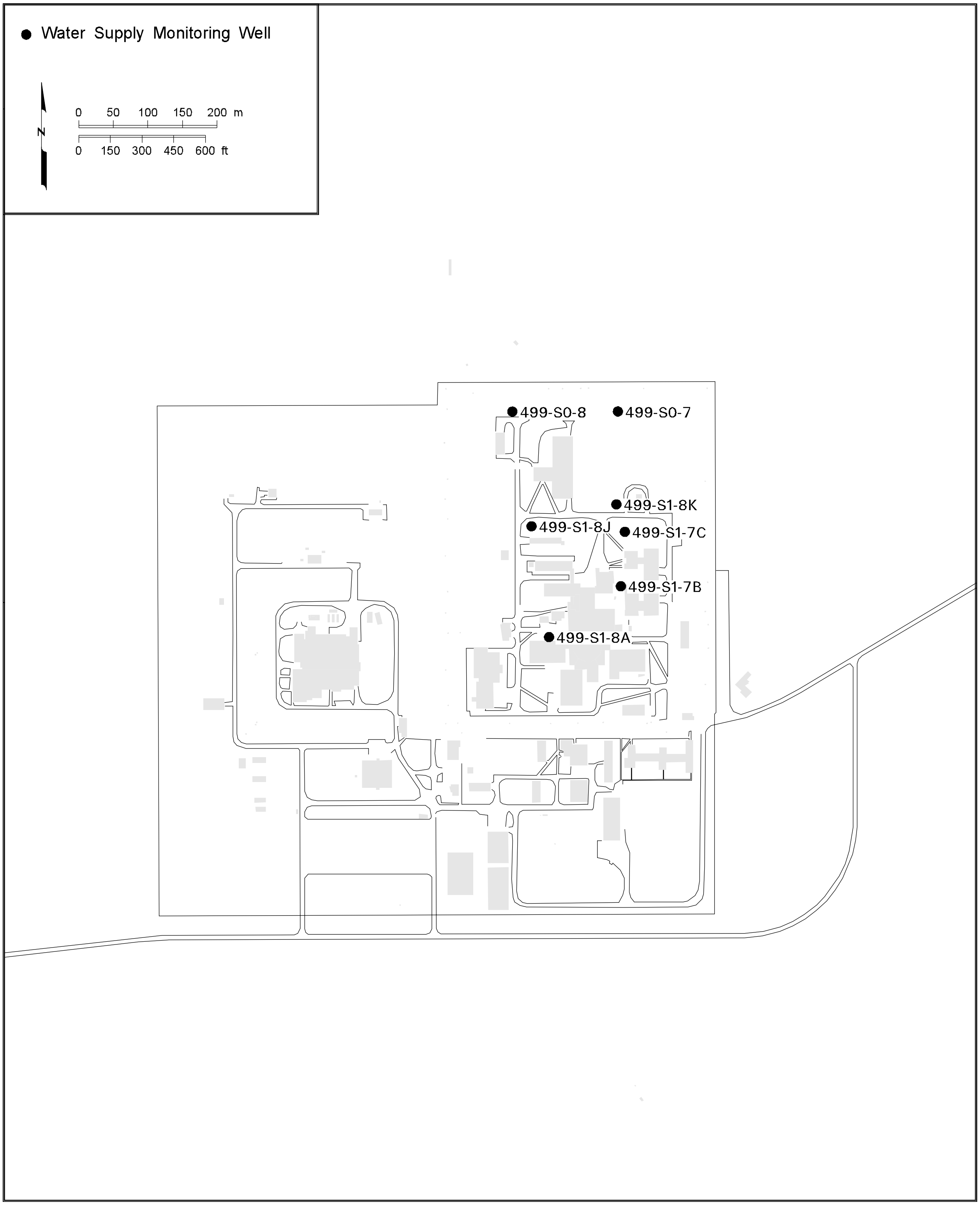
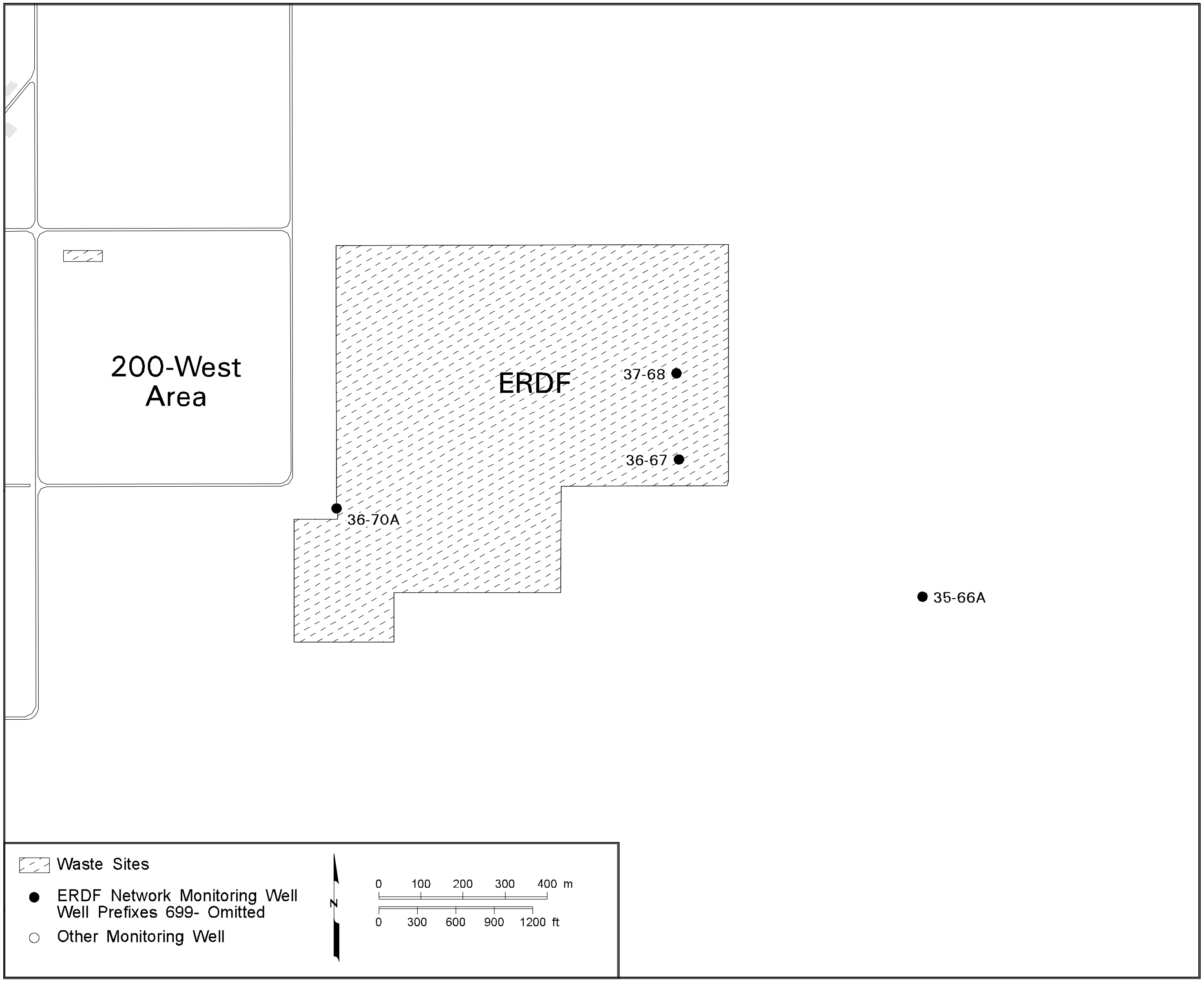
Figure B.20. Groundwater Monitoring Wells at 100-K Basins



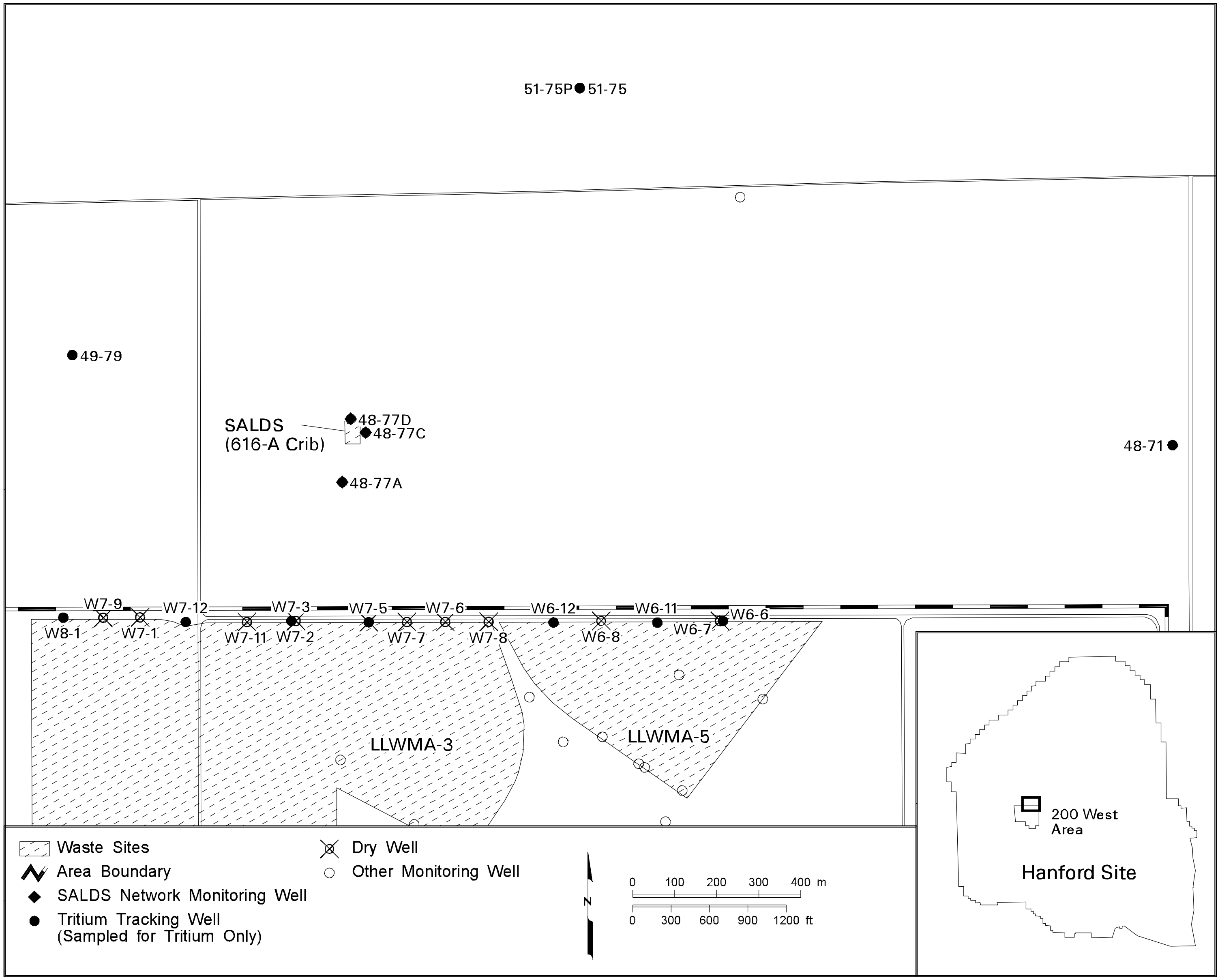
jpm_gwf04_634 December 30, 2004 4:43 PM

Figure B.21. Water-Supply Monitoring Wells in 400 Area



can_gwf04_635 February 14, 2005 9:29 AM

Figure B.22. Groundwater Monitoring Wells at Environmental Restoration Disposal Facility



can gwf05 637 December 28, 2005 5:03 PM

Figure B.23. Groundwater Monitoring Wells at State-Approved Land Disposal Site

Appendix C

Quality Assurance and Quality Control

Contents

Tables

Appendix C

Quality Assurance and Quality Control

C. J. Thompson

This appendix presents fiscal year (FY) 2005 quality assurance/quality control (QA/QC) information for long-term and interim action groundwater monitoring at the Hanford Site. The phrase "long-term monitoring" refers to monitoring performed to meet the requirements of the *Resource Conservation and Recovery Act* (RCRA) and the *Atomic Energy Act* (AEA). Long-term monitoring also includes monitoring performed at *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) sites with no active groundwater remediation. Pacific Northwest National Laboratory (PNNL) manages long-term monitoring via the Groundwater Performance Assessment Project (groundwater project). Interim action monitoring encompasses monitoring at sites with active groundwater remediation under CERCLA. Fluor Hanford, Inc. provided oversight for interim action groundwater monitoring during FY 2005. For both categories of groundwater monitoring, PNNL managed sample scheduling, sample collection, analytical work, and entry of associated information into the Hanford Environmental Information System (HEIS) database (HEIS 1994).

The QA/QC practices used by the groundwater project assess and enhance the reliability and validity of field and laboratory measurements conducted to support these programs. Accuracy, precision, and detection are the primary parameters used to assess data quality (Mitchell et al. 1985). Representativeness, completeness, and comparability may also be evaluated for overall quality. These parameters are evaluated through laboratory QC checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analysis, analysis of blind standards and blanks, and interlaboratory comparisons. Acceptance criteria have been established for each of these parameters. When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence.

The QA/QC practices for RCRA samples are based on guidance from the U.S. Environmental Protection Agency (EPA) (EPA 1986a [OSWER-9950.1] and 1986b [SW 846]). U.S. Department of Energy (DOE) Orders and internal requirements provide the guidance for the collection and analysis of samples for other long-term monitoring. The QA/QC practices for the groundwater project are described in the project-specific QA plan (PNNL-15014). Guidance for interim action monitoring QA/QC practices is provided in project-specific documents (e.g., DOE/RL-90-08; DOE/RL-91-03; DOE/RL-91-46; DOE/RL-92-76; DOE/RL-96-07; DOE/RL-96-90; DOE/RL-97-36; DOE/RL-2002-10; DOE/RL-2002-17). A glossary of QA/QC terms is provided in PNNL-13080. Additional information about the QA/QC program and FY 2005 data (e.g., results of individual QC samples and/or associated groundwater samples) is available on request.

C.1 Sample Collection and Analysis

C. J. Thompson and D. L. Stewart

Duratek Federal Services, Inc. conducted groundwater sampling for FY 2005. Their tasks included bottle preparation, sample set coordination, field measurements, sample collection, sample shipping, well pumping, and coordination of purgewater containment and disposal. Duratek's statement of work[a] defines quality requirements for sampling activities. Groundwater project staff review all sampling procedures before the procedures are implemented.

Groundwater project staff periodically reviewed sample collection activities performed by nuclear chemical operators from Fluor Hanford, Inc. under the supervision of Duratek Federal Services, Inc. The purpose of the surveillances was to ensure that samples were collected and submitted to the laboratories in accordance with high-quality standards. Ten surveillances were conducted in the following areas: sample packaging, shipping, and storage; measurement of groundwater levels; sample collection (two events); water-purification system maintenance; decontamination of sampling equipment; training and associated documentation; and quality records management and storage. Minor procedural

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[a] SOW-409744-A-B3. 2001. Statement of Work between Pacific Northwest National Laboratory and Duratek Federal Services, Inc., Richland, Washington.

deviations were identified. Corrective actions for all of these surveillances have been received and accepted. Three surveillances remain open pending completion of the corrective actions. The open surveillances related to procedural modifications, lack of a procedure, and minor reporting issues related to calibration of electronic tapes used for water-level measurements.

During FY 2005, Severn Trent Laboratories, Incorporated, St. Louis, Missouri (STL St. Louis), performed most of the routine analyses of Hanford groundwater samples for hazardous and non-hazardous chemicals. Severn Trent Laboratories, Incorporated, Knoxville, Tennessee analyzed a limited number (25) of groundwater samples for dioxins. Lionville Laboratory, Incorporated, Lionville, Pennsylvania (Lionville Laboratory), served as a secondary laboratory for chemical analyses of split samples and blind standards.

Severn Trent Laboratories, Incorporated, Richland, Washington (STL Richland) performed the majority of radiological analyses on Hanford groundwater samples. Eberline Services, Richmond, California, also analyzed samples for radiological constituents.

Standard methods from EPA and American Society for Testing and Materials (ASTM) were used for the analysis of chemical constituents. Methods employed for radiological constituents were developed by the analyzing laboratories and are recognized as acceptable within the radiochemical industry. Descriptions of the analytical methods used are provided in PNNL-13080.

C.2 Data Review and Validation

M. J. Hartman, H. Hampt, and C. J. Thompson

Groundwater project staff review and validate groundwater data according to an established procedure. Validation produces an electronic data set that is useable by the groundwater project and others, with suspect or erroneous data corrected or flagged. The validation process includes the following activities:

- Review of sampling documents and analytical data verification.
- Quality control evaluation.
- Project scientists' evaluation.
- Statistical evaluation.
- Resolution of data issues that arose during the evaluation.

Sampling documents include the groundwater sampling record, chain of custody forms, field logbook pages, and other paperwork associated with sampling and shipping. Project staff review these forms to determine if the documents are filled out completely, signed appropriately, and legible. Staff also verify that analytical data from the laboratories are complete and reported correctly. Moreover, staff review lab documents to check the condition of the samples upon receipt at the lab and determine if problems arose during analysis that may have affected the data.

A quarterly evaluation of QC data is conducted as part of the validation process. Groundwater project staff assess the laboratories' internal QC practices and submit field QC samples and blind standards to the laboratories on a regular basis. QC results are then summarized for project scientists, DOE, and other data users.

Data management staff generate a series of routine data reports that project scientists review. Among these are biweekly data reports, which are generated twice each month and include analytical data that were loaded into the HEIS database since the previous reporting period. The tables are organized by groundwater interest area, RCRA site, or special project (e.g., confined aquifer data). As soon as practical after receiving a report, the project scientists review the data, typically by viewing trend plots, to determine (a) if there are significant changes in contaminant concentrations or distribution and (b) if there are data points that appear erroneous.

Project scientists also review quarterly compilations of the data. The quarterly review provides a method for project staff to check whether there were problems with sampling, all requested analyses were received, and the data seem to represent actual groundwater quality. Unlike the biweekly reports, the quarterly reports usually include a full data set (i.e., all the data from the wells sampled during the previous quarter have been received and loaded into HEIS). This review also includes water-level data, preliminary maps of selected analytical data, and a partial listing of sampling comments. When specific questions arise regarding field measurements, analytical results, dates of analysis or sampling, or sample or well numbers, the project scientist requests a formal data review. The process for data reviews is described in Section C.2.1.

Each quarter, the project statistician evaluates RCRA indicator parameter data, recalculates critical mean values if necessary, and updates limits of detection and quantitation for total organic carbon and total organic halides. Together with the project scientists, the statistician compares downgradient results to background values (or limits of quantitation) for RCRA sites monitored under detection programs.

C.2.1 Requests for Data Review

Requests for Data Reviews (RDRs) are the formal mechanism used by the groundwater project to resolve specific issues with data that appear to have problems. When potential anomalies are encountered during a review of analytical data or water-level measurements, the project scientist reviewing the data will initiate an RDR. Depending upon the type of data issue, project staff will then do some or all of the following: request a laboratory recheck, recount, or reanalysis, review hard copy laboratory data, review sampling documents for data-entry errors or other problems, and/or flag the affected data with one of the review codes described in Table C.1.

When a laboratory reanalysis or recount is requested, the laboratory reanalyzes or recounts the original sample and reports the new results. If there is a discrepancy between the original and new results, groundwater staff will determine which results appear to be more representative and assign an appropriate review code to the results that are loaded into HEIS. Laboratory rechecks involve an internal laboratory review of the data. When discrepancies are discovered by the laboratory, the data are re-reported. The re-reported data are loaded into HEIS and flagged appropriately. A review of the sampling documents and/or the hard copy data from the laboratory can sometimes provide an explanation for unusual results (e.g., data entry errors or swapped samples in the field).

RDRs are most commonly resolved by assigning Y, G, or R review codes to the data in HEIS; however, all of the review codes help define limitations on the data. If a review determines that the result is valid, the result is flagged with a G. If there is clear, documented evidence that a result is erroneous, the result is flagged with an R. The Y code is used when a review did not show if a result was valid or invalid, but the result appears suspect. Data flagged with a Y or R are typically excluded from statistical evaluations, maps, and other interpretations, but are not deleted from HEIS. Occasionally, an RDR is submitted on data that are not managed by the groundwater project (e.g., data associated with active remediation projects). In those cases, the data owner is notified, but no further action is taken by the groundwater project.

Table C.2 lists the number of analytical and water-level results that were flagged during FY 2005 as a result of the RDR process. As of February 14, 2006, the resolution of a number of RDRs is pending, and additional RDRs may yet be filed on FY 2005 data. RDRs have been filed on 919 out of 57,907 analytical results (1.6%). Similarly, ~3% (107 out of 3,581) water-level results were associated with RDRs in FY 2005.

C.3 Data Completeness

C. J. Thompson

Data judged to be complete are data that are not suspect, rejected, associated with a missed holding time, out-of-limit field duplicate or field blank, or qualified to indicate laboratory blank contamination. During FY 2005, 85% of the groundwater data (both long-term and interim action monitoring) were considered complete. The percentages of potentially invalid data were 2.0% for field QC problems, 0.8% for exceeded holding times, 0.0% for rejected results, 0.8% for suspect values, and 12.4% for laboratory blank contamination. These values are similar to the percentages observed in FY 2004, although the relative number of suspect results increased due to several anomalous aluminum and total organic halides results (discussed in Sections C.4.1 and C.6.4, respectively).

C.4 Field Quality Control Samples

D. S. Sklarew, S. J. Trent, and C. J. Thompson

Field QC samples include field duplicates, split samples, and three types of field blanks. The three types of field blanks are full trip, field transfer, and equipment blanks. Field duplicates are used to assess sampling and measurement precision. Split samples are used to confirm out-of-trend results and for interlaboratory comparisons. Field blanks provide an overall measure of contamination introduced during the sampling and analysis process.

C.4.1 Long-Term Monitoring (Groundwater Performance Assessment Project)

The groundwater project's criteria for evaluating the analytical results of field QC samples are as follows:

- Field Duplicates – Results of field duplicates must have precision within 20%, as measured by the relative percent difference. Only those field duplicates with at least one result greater than five times the method detection limit or minimum detectable activity are evaluated.
- Split Samples – Results must have a relative percent difference <20%. Only those results that are greater than five times the method detection limit or minimum detectable activity at both laboratories are evaluated.
- Field Blanks – For most chemical constituents, results above two times the method detection limit are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the limit is five times the method detection limit. Results for metals are flagged if they exceed two times the instrument or method detection limit. For radiological data, blank results are flagged if they are greater than two times the total minimum detectable activity.

If a field blank does not meet the established criteria, it is assumed that there are potential problems with the data for all associated samples. For full-trip and field-transfer blanks, an associated sample is one that was collected on the same day and analyzed by the same method as a full-trip or field-transfer blank. For equipment blanks, an associated sample is one that has all of the following in common with an equipment blank:

- Collection date.
- Collection method/sampling equipment.
- Analysis method.

Data associated with out-of-limit field blanks are flagged with a Q in the database to indicate a potential contamination problem. A Q is also applied to both duplicate results when their precision exceeds the QC limits.

The percentages of acceptable field blank (4,459/4,615 = 97%) and duplicate (2,139/2,182 = 98%) results evaluated in FY 2005 were high, indicating little problem with contamination and good precision overall. A limited number of split samples were collected during the year for aluminum and for total organic halides. The analyzing laboratories demonstrated reasonable agreement for aluminum, but both laboratories demonstrated poor precision in the total organic halide results at the low levels found in the samples.

Tables C.3 through C.6 summarize the field blank and field duplicate results that exceeded QC limits. To assist with their evaluation, the tables are divided into the following categories, where applicable: general chemical parameters, ammonia and anions, metals, volatile organic compounds, semivolatile organic compounds, and radiological parameters. Constituents not listed in the tables had 100% acceptable field blanks and/or field duplicates. Table C.7 summarizes the split results for total organic halides.

With the exception of semivolatile organic compounds, all classes of constituents had results that were flagged as potentially contaminated because of out-of-limit field blank results. A few constituents such as calcium, chloride, and sodium had several quantifiable field blank results, but the concentrations were much lower than the levels of these constituents in almost all groundwater samples.

Compared to FY 2004, the number of elevated field blank results for total organic halides increased significantly (4.9% to 21.3%). The unacceptable results were within a factor of 3 of the QC limits. Laboratory blank results did not show a significant corresponding increase. However, because a number of total organic halides quadruplicates also failed to meet the evaluation criteria, a number of split samples were collected (see last paragraph of Section C.4.1).

Relative to FY 2004, the number of field blank results for sulfate that exceeded the QC limits decreased significantly (15.8% to 0%), though the number for chloride increased (8.2% to 15.9%).

Forty-four field blank results for metals exceeded the QC limits, which is considerably more than the number (12) from last year. However, the laboratory changed the reporting limits for metals from instrument detection limits to method detection limits halfway through the fiscal year. For several metals, the method detection limits were lower than the corresponding instrument detection limits. This makes it difficult to compare results from previous years. Most of the unacceptable results were within a factor of 5 of the detection limits. All of the metals with out-of-limit field blank results had one or more comparable method-blank results, suggesting that some of the elevated field blank values were caused by false detections or laboratory contamination.

Elevated results for aluminum were observed at several wells across the site during the past 1½ years. Although aluminum is not a primary constituent of concern, the results are considered significant because many of the detected values exceeded the lower end of the secondary drinking water standard (50 to 200 µg/L). The questionable data were discussed with the analyzing laboratory (STL St. Louis), but laboratory personnel were not able to identify any procedural or instrument changes that might be responsible for the data trends. Aluminum has been detected in ~20% of method and field blanks this year, but the blank detections do not always correlate with elevated sample results. Other laboratory QC parameters such as laboratory control samples and matrix spikes have consistently been within the acceptance limits. In response to PNNL's concerns, STL St. Louis performed an extensive cleaning of the laboratory used to prepare samples for metals analysis, and they replaced overhead ventilation ductwork to reduce the possibility of sample contamination. Split samples analyzed for aluminum by STL St. Louis and Lionville Laboratory had some higher results determined by STL. However, the data were inconclusive due to the low sample concentrations and the fact that the detection limit from Lionville was less than half that from STL St. Louis. STL St. Louis analyzed a special set of blind standards containing aluminum, and the results were biased high. These results, combined with some elevated blank results, suggest that the problem may be caused by a high instrument background at STL St. Louis. Aluminum results by the method used (EPA Method 6010B, EPA 1986b) do not appear to be reliable at the low levels found in most of the groundwater samples. A more sensitive method (EPA Method 6020, EPA 1986b) will be used in the future for any samples in which aluminum is a constituent of concern.

Concentrations of seven volatile organic compounds exceeded the QC limits in one or more field blanks. Methylene chloride was the predominant volatile contaminant, accounting for 67% of the out-of-limit results. Levels of acetone were also out-of-limits in nine field blanks. Laboratory contamination is the suspected source of these common contaminants, because similar concentrations were also measured in several method blanks. Trace levels of several other volatile organic compounds also were measured in field blanks (Tables C.3 and C.4). All these compounds had low frequencies of detection (i.e., <8%) in field blanks, and the overall impact on the data is believed to be minor.

Gross alpha, potassium-40, technetium-99, tritium, and uranium were the only radiological constituents with out-of-limit field blank results. Although their field blank concentrations were low, they were greater than levels of these constituents in some of the associated groundwater samples. Potassium-40 and uranium were also measured in one or more laboratory method blanks at concentrations similar to the field blank values.

Duplicate results were flagged for all constituent classes (Table C.6). Overall, the relative number of flagged duplicate results was very low (<2%), but the percentages of unacceptable results were high for several constituents based on the number of duplicates that met the evaluation criteria. Most of the associated samples in the radiological parameters category were unfiltered; thus, suspended solids in heterogeneous sample fractions may have caused some of the discrepancies in the results. The majority of the out-of-limit duplicate results appear to be anomalous instances of poor precision based on other QC indicators such as the results from the blind standards and laboratory duplicates (discussed in Sections C.5.2 and C.5.3). In several cases, the laboratory was asked to re-analyze or investigate duplicate results with a very high relative percent difference, but the checks did not reveal the source of the problem. Especially poor agreement was observed between several pairs of results for nitrogen in nitrite (non-detect and 328 µg/L, non-detect and 361 µg/L, 723 and 2,500 µg/L) and for iron (49.6 and 689 µg/L), manganese (0.99 and 10 µg/L), zinc (1.5 and 12.9 µg/L), and tritium (70.3 and 180 pCi/L). Swapped samples or procedural deviations at the laboratory may have caused the unmatched results.

During the third quarter of FY 2005, seven sets of split samples were collected from seven wells and analyzed to investigate anomalous total organic halide results at several wells across the site. Each set was collected in quadruplicate (i.e., four samples were submitted to both STL St. Louis and Lionville Laboratory), as is typical for total organic halide samples, so that the precision of this indicator analysis may be determined. The results for the two laboratories were highly variable (Table C.7). An analysis of variance indicated that the factor that contributed most to the variability in the data was the lack of analytical precision (i.e., the spread of results determined for each group of four samples) rather than the difference in the means determined by the two laboratories. A more detailed discussion of the total organic halides problem and its subsequent investigation is presented in Section C.6.4.

C.4.2 Interim Action Monitoring

Trained staff collected samples in accordance with approved procedures. Field QC samples consisted of field duplicates, splits, equipment blanks, and trip blanks. Field QC data are evaluated as necessary to make decisions that may modify or terminate a remedial action. In FY 2005, no evaluations were necessary for decision-making purposes.

Field QC data were examined to monitor laboratory operations and to identify potential problem areas where improvements were necessary. Evaluation criteria were essentially the same as those used for the long-term monitoring program identified in Section C.4.1.

For field blank samples, 91% of all reviewed results were returned as non-detected. This was a small decline in performance from the FY 2004 evaluation (95% non-detect). Organic compounds, the metals aluminum, beryllium, iron, and zinc, and the anion chloride showed the greatest inclination to exceed the acceptable QC criteria. Seventy-five percent of the volatile organic field blank QC exceedances were due to acetone and methylene chloride. These two compounds are well-known laboratory contaminants, and it is likely that most of the acetone and methylene chloride detections are associated with contamination introduced during analysis of the samples. Field blank QC exceedances for beryllium, iron, zinc, and chloride are more difficult to explain. The presence of these constituents possibly reflects inadequate cleaning of sampling equipment, although no definite trend or pattern of contamination is apparent from the data. Overall, evaluation of field blank sample results showed no evidence of routine contamination of blanks in the field, although the performance was not as good as FY 2004. The constituents and levels of contamination found should have no impact on decision making for interim action monitoring. Blank detects are summarized in Table C.8.

Field duplicate results showed 6% exceeding the criteria used for evaluation. This performance was on par with the field duplicate performance from FY 2004. Field duplicate evaluations are summarized in Table C.9. In general, field duplicate QC issues are minimal and do not indicate significant laboratory or sample collection problems.

Approximately 9% of split sample results did not meet the acceptance criteria. Split sample performance was comparable with the performance from FY 2004. Table C.10 summarizes the out-of-limit results. The percentage of tritium sample splits exceeding the evaluation criteria was among the highest for all monitored constituents and continued a trend from FY 2004. Of the six split sample pairs collected for tritium analysis, the relative percent difference for three pairs fell outside the acceptance limit. The reason for this discrepancy is not readily apparent, although potential differences in laboratory sample processing procedures could be a factor in the relative difference in split sample results for tritium. This possible cause is supported by the observation that in all evaluated tritium splits, the split laboratory tritium values were higher than corresponding primary laboratory tritium values.

The criteria used to evaluate split samples are likely more restrictive than necessary because they are based on similar criteria for laboratory replicate evaluation (i.e., analysis of multiple aliquots from the same sample container by the same laboratory in the same analytical batch). Even with this additional conservatism, evaluation of the split sample data showed no major quality problems exist with either the primary or split laboratories.

Overall, field QC results for FY 2005 appear to be good and comparable with FY 2004 evaluation, although a small decline in field blank QC performance was noted. The evaluation indicated no significant issues associated with the sampling services or analytical service providing support to the DOE Groundwater Remediation Project managed by Fluor Hanford, Inc.

C.5 Holding Times

C. J. Thompson

Holding time is the elapsed time period between sample collection and analysis. Samples should be analyzed within recommended holding times to minimize the possibility of changes in constituent concentrations caused by volatilization, decomposition, or other chemical alterations. Samples are also refrigerated to slow potential chemical reactions within the sample matrix. Maximum recommended holding times for constituents frequently analyzed for the groundwater project are listed in Table C.11. Radiological constituents do not have recommended maximum holding times because these constituents are not typically lost under ambient temperatures when appropriate preservatives are used. Results of radionuclide analysis are corrected for decay from sampling date to analysis date.

During FY 2005, recommended holding times were exceeded for 231 out of 8,018 (2.9%) non-radiological sample analysis requests (both long-term and interim action monitoring). A sample analysis request is defined as a sample that is submitted for analysis by a particular analytical method. In general, the missed holding times should not have a significant impact on the data. Results for samples with missed holding times are flagged with an H in the database. STL St. Louis exceeded the holding times for 209 out of 7,364 (2.8%) sample analysis requests, a decrease from FY 2004 (4.7%). The constituents with the most missed holding times were alkalinity (24 samples), anions by EPA Method 300.0 (119 samples), cyanide (12 samples), total organic carbon (13 samples), and volatile organic compounds (17 samples). STL Richland exceeded holding times for 1 out of 62 hexavalent chromium analyses, but all 86 of the laboratory's coliform analyses were performed within the recommended 24-hour holding time. Lionville Laboratory missed holding times for 13 out of 92 sample analyses. Anions and total organic carbon were the affected constituents. Fluor Hanford, Inc. and PNNL analyzed 318 samples on-site for hexavalent chromium; seven of the measurements were performed after the holding time had expired.

Several factors caused holding times to be exceeded during FY 2005, including sample shipping delays, re-analyses triggered by QC failures, the need to dilute some samples, and oversight by laboratory staff. Periodically, missed holding times were discussed with the laboratories to help identify areas where improvements are needed.

C.6 Laboratory Performance

C. J. Thompson, D. S. Sklarew, and D. L. Stewart

Laboratory performance is measured by several indicators, including national performance evaluation studies, double-blind standard analyses, laboratory audits, and internal laboratory QA/QC programs. This section provides a detailed discussion of the performance indicators for STL St. Louis and STL Richland. Brief summaries of performance measures for Lionville Laboratory and Eberline Services also are presented throughout this section. The majority of the laboratory's results were within the acceptance limits indicating good performance overall.

C.6.1 National Performance Evaluation Studies

During FY 2005, Environmental Resources Associates and DOE conducted national studies to evaluate laboratory performance for chemical and radiological constituents. STL St. Louis and Lionville Laboratory participated in the EPA sanctioned Water Pollution and Water Supply Performance Evaluation studies conducted by Environmental Resources Associates. STL Richland and Eberline participated in the Environmental Resources Associates' InterLaB RadCheM Proficiency Testing Program. Eberline participated in the Environmental Resources Associates' Multi-Media Radiochemistry Proficiency Testing. All four laboratories took part in DOE's Mixed Analyte Performance Evaluation Program. Results of those studies related to groundwater monitoring at the Hanford Site are described in this section.

C.6.1.1 Water Pollution Studies

The purpose of water pollution studies is to evaluate the performance of laboratories in analyzing selected organic and inorganic compounds. An accredited agency such as Environmental Resource Associates distributes standard water samples to participating laboratories. These samples contain specific organic and inorganic analytes at concentrations unknown to the participating laboratories. After analysis, the laboratories submit results to the accredited agency, which uses regression equations to determine acceptance and warning limits for the study participants. The results of these studies, expressed in this report as a percentage of the results that the accredited agency found acceptable, independently verify the level of laboratory performance.

For the two water pollution studies (ERA WP-121 and 126) in which STL St. Louis participated this year, the percentage of results within acceptance limits submitted to the groundwater project ranged from 95% to 97% (Table C.12). Twenty different constituents had unacceptable results, but only orthophosphate as phosphorus and grease and oil (gravimetric) were out of limits in both studies. Several semivolatile organic compounds and metals were out of limits in one out of two studies. The laboratory provided information about possible causes for some of the unacceptable results and suggested corrective actions where appropriate. The constituents that were out of limits in more than one study last year were within limits this year, with the exception of total Kjeldahl nitrogen; however, total Kjeldahl nitrogen is not used for Hanford groundwater samples. Samples that were out of limits in only one study during FY 2004 were within limits in FY 2005, with the exception of orthophosphate as phosphorus, total phosphorus as phosphorus, ammonia as nitrogen, fluoride, and acenaphthene. Overall, the unacceptable results should not have a significant impact on the interpretation of Hanford groundwater data.

Lionville Laboratory participated in two water pollution studies this year (ERA WP-120 and 121). The second study had a limited number of analytes. For the results submitted to the groundwater project, the percentage of Lionville's results within acceptance limits ranged from 95% to 100% (Table C.13). Of the 20 different constituents with unacceptable results in WP-120, four were re-examined in WP-121 because they had failed twice before. All four (calcium, magnesium, chemical oxygen demand, and fluoride) passed in WP-121. In general, the unacceptable results should not have a significant impact on the interpretation of Hanford groundwater data.

C.6.1.2 DOE Mixed Analyte Performance Evaluation Programs

DOE's Mixed Analyte Performance Evaluation Program examines laboratory performance in the analysis of soil and water samples containing metals, volatile and semivolatile organic compounds, and radionuclides. This report considers only water samples. The program is conducted at the Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho. DOE evaluates the accuracy of the Mixed Analyte Performance Evaluation Program results for radiological and inorganic samples by determining if they fall within a 30% bias of the reference value.

Two studies were available for FY 2005 (MAPEP-05-MaW13&OrW13&GrW13 and MAPEP-05-MaW14&OrW14&GrW14). Six results were unacceptable for STL St. Louis: iron-55, nickel-63, strontium-90, mercury, heptachlor, and 4,4'-DDT; one other result was acceptable with warning (Table C.14). Seven results were unacceptable for STL Richland: cesium-134, cesium-137, cobalt-57, cobalt-60, manganese-54, nickel-63, and zinc-65. One nickel-63 result was unacceptable for Eberline Services. All results for Lionville Laboratory were acceptable (Table C.15).

C.6.1.3 InterLaB RadCheM and Multi-Media Radiochemistry Proficiency Testing Program Studies

The purpose of the InterLaB RadCheM and Multi-Media Radiochemistry Proficiency Testing Programs, conducted by Environmental Resources Associates, is to evaluate the performance of laboratories in analyzing selected radionuclides. The InterLaB RadCheM program provides blind standards that contain specific amounts of one or more radionuclides in a water matrix to participating laboratories. Environmental Resources Associates standards were prepared for the following radionuclides/parameters: barium-133, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, iodine-131, radium-226, radium-228, strontium-89, strontium-90, tritium, uranium, uranium mass, and zinc-65. After sample analysis, the results were forwarded to Environmental Resources Associates for comparison with known values and with results from other laboratories. Environmental Resources Associates bases its control limits on the EPA's National Standards for Water Proficiency Testing Studies Criteria Document (NERL-Ci-0045).

In the one study in which STL Richland participated this year (RAD-59), 14 constituents were analyzed. All of the results were acceptable (Table C.14).

Eberline Services participated in two studies this year (RAD-61 and 62); six constituents were analyzed. All of the results were acceptable (Table C.15).

The Multi-Media Radiochemistry Proficiency Testing Program provides blind standards that contain specific amounts of one or more radionuclides in water, soil, vegetation, and air filter samples to participating laboratories. This report considers only water samples. Environmental Resources Associates standards were prepared for the following radionuclides/parameters in water: americium-241, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, iron-55, plutonium-238, plutonium-239, strontium-90, uranium-234, uranium-238, uranium, and uranium mass. After sample analysis, the results were forwarded to Environmental Resources Associates for comparison with known values and with results from other laboratories. Environmental Resources Associates bases its control limits on the DOE report, *Analysis of Environmental Measurements Laboratory (EML) Quality Assessment Program (QAP) Data Determination of Operational Criteria and Control Limits for Performance Evaluation Purposes* (EML-564).

In the one study in which Eberline Services participated this year (MRAD-002), 14 constituents were analyzed. All were acceptable (Table C.15).

C.6.2 Double-Blind Standard Evaluation

The groundwater project forwarded blind QC standards to STL Richland and St. Louis, Lionville Laboratory, Eberline Services, and a PNNL facility in the 300 Area during FY 2005. Blind spiked standards were generally prepared in triplicate and submitted to the laboratories to check the accuracy and precision of analyses. For most constituents, the standards were prepared in a groundwater matrix from a background well. Standards for specific conductance were commercially prepared in deionized water. In all cases, the standards were submitted to the laboratories in double-blind fashion (i.e., the standards were disguised as regular groundwater samples). After analysis, the laboratory's results were compared with the spiked concentrations, and a set of control limits were used to determine if the data were acceptable. Generally, if a result was out of limits, the data were reviewed for errors. In situations where several results for the same method were unacceptable, the results were discussed with the laboratory, potential problems were investigated, and corrective actions were taken if appropriate.

Tables C.16 and C.17 list the number and types of most of the blind standards used in FY 2005 along with the control limits for each constituent. Not included in the tables are three technetium-99 results that were analyzed by PNNL using inductively coupled plasma-mass spectrometry (ICP-MS). All three of the PNNL results were within the ±30% acceptance limits. Overall, 83% of the blind spike determinations were acceptable. This was slightly lower than the percentage from FY 2004 (90%). A total of 36 results were out of limits for STL Richland and St. Louis. Total organic carbon, total organic halides, cyanide, fluoride, aluminum, carbon tetrachloride, trichloroethene, gross alpha, plutonium-239, and tritium were the constituents with out-of-limit results. Lionville Laboratory had eight unacceptable results for total organic carbon. All of Eberline Services' results for gross beta were within the acceptance limits.

Half of the total organic carbon results from STL St. Louis were unacceptably high. All of the questionable values (127% to 168% recoveries) were from the second and third quarters (January through March and April through June). The second quarter standards were spiked at ~1,000 µg/L, which is the laboratory's practical quantitation limit for this method. Lower precision is expected for samples spiked near or below the practical quantitation limit. The laboratories performed reanalyses of the third quarter standards, which were spiked at 1,500 µg/L, but the reanalysis results were similar to the original values. PNNL performed in-house verification analyses on a duplicate, third-quarter sample, and the results (1,700 to 2,200 µg/L) suggested that the standards were prepared at a higher concentration than anticipated. However, a limited number (14) of routine groundwater samples were flagged as suspect during the second and third quarters, which may indicate that the laboratory was experiencing some sporadic problems with the analysis during this period.

For total organic halides, 10 out of 34 of STL St. Louis' results were out of limits. Three of the unacceptable results were for third-quarter standards (April through June) spiked with 2,4,5-trichlophenol. The reported values for these standards were ~6 to 8 times greater than the expected concentration (14 µg/L), suggesting that a preparation or calculation error occurred. Results for the standards spiked with volatile organic compounds were highly variable; seven were out-of-limits. In previous years, low recoveries for the volatile standards have been observed, and the low bias was attributed to volatilization or weak retention of the volatile compounds on the charcoal cartridges used in the analysis. While some of this year's results had low recoveries, four results from the third and fourth quarter were biased high, with recoveries ranging from 129% to 151%. Several actions were taken to investigate the anomalous results for the blind standards and regular groundwater samples, as discussed in Section C.6.4. Among these was the submission of an extra set of low-level (15 µg/L) blind standards to STL St. Louis during the fourth quarter. The laboratory performance was improved during the last quarter (July through September); only 1 out of 13 results was unacceptable, and the out-of-limit result (132% recovery) was not unreasonable for a sample spiked at such a low concentration (i.e., within a factor of 5 of the method detection limit). Continued use of blind standards is planned for FY 2006 to closely monitor the performance of this important indicator analysis.

STL St. Louis had one out-of-limit result for cyanide; the recovery was 56%. Loss of cyanide during the distillation step of the analysis is the suspected cause of the low result.

All of STL St. Louis' first quarter fluoride results were biased high, with recoveries of 130%. PNNL analysis of a duplicate standard suggested that the samples had been spiked at higher concentrations than anticipated. Based on the in-house concentration, STL St. Louis' results would have been acceptable. All of the STL St. Louis' fluoride results from the last three quarters were acceptable.

During the second quarter (January through March), three standards spiked with 100 µg/L of aluminum were submitted to STL St. Louis to help investigate some elevated results that had been observed in routine groundwater samples from many wells across the Hanford site. The samples were analyzed by inductively coupled plasma/atomic emission spectrometry (EPA Method 6010B), and the results had recoveries of ~175%. STL St. Louis reanalyzed the samples, and the reanalysis results ranged from 123 to 126 µg/L. One of the samples was also analyzed by the more sensitive ICP-MS method (EPA Method 6020), and the result was 101 µg/L. As noted in Section C.4.1, the ICP-MS method will be used in the future for wells that require low-level monitoring of aluminum concentrations.

STL St. Louis had four out of limit results for carbon tetrachloride and two unacceptable results for trichloroethene. In most of these cases, the recoveries were between 70% and 74%. Reasons for the low bias are unknown.

In general, STL Richland performed well on the analysis of radiological blind standards. Seven results were outside the QC limits. Two of the unacceptable results were for gross alpha. In both cases, the standards were spiked within a factor of 4 of the minimum detectable activity. All three of the first-quarter results for tritium were high by a factor of ~2.5. A calculation or procedural error at the laboratory may have caused the elevated values. One result for plutonium-239 was unacceptable, with a recovery of 132%. Additionally, one technetium-99 was out of limits with a recovery of 58%. Since all of the other results for these constituents were acceptable, procedural errors are the suspected cause of the anomalous results.

Lionville Laboratory's results for total organic carbon were similar to those from STL St. Louis. Half of the results were out of limits with a positive bias, and all of unacceptable values were from the second and third quarters. As noted earlier, the second quarter standards were spiked at a relatively low concentration, and the third quarter standards appear to have contained a greater concentration of organic carbon than was intended. The impact of these out-of-limit results is minimal, because Lionville Laboratory did not analyze many routine groundwater samples for total organic carbon during FY 2005.

Eberline Services analyzed 12 blind standards for gross beta, and all of the results were acceptable.

Fluor Hanford, Inc. sent no blind standards as part of interim action monitoring to the commercial laboratories in FY 2005. The great similarity of matrices between the long-term and interim action monitoring samples and common use of the same laboratories make additional analysis of blind standards redundant.

C.6.3 Laboratory Internal QA/QC Programs

STL Richland, STL St. Louis, Eberline Services, and Lionville Laboratory maintain internal QA/QC programs that generate data on analytical performance by analyzing method blanks, laboratory control samples, matrix spikes and matrix spike duplicates, matrix duplicates, and surrogates (see PNNL-13080 for definitions of these terms). This information provides a means to assess laboratory performance and the suitability of a method for a particular sample matrix. Laboratory QC data are not currently used for in-house validation of individual sample results unless the lab is experiencing unusual performance problems with an analytical method. An assessment of the laboratory QC data for FY 2005 is summarized in this section. STL data are discussed in detail first. Table C.18 provides a summary of the STL QC data by listing the percentage of QC results that were out of limits for each analyte category and QC parameter. Additional details are presented in Tables C.19 through C.22. Constituents not listed in these tables did not exceed STL's QC limits. A brief summary of Lionville Laboratory and Eberline Services data is presented at the end of the section.

Most of this year's laboratory QC results were within acceptance limits, suggesting that the analyses were in control and reliable data were generated. Nevertheless, a number of parameters had unacceptable results.

Evaluation of results for method blanks was based on the frequency of detection above the blank QC limits. In general, these limits are two times the method detection limit for chemical constituents and two times the total propagated error for radiochemistry parameters. For common laboratory contaminants such as 2-butanone, acetone, methylene chloride, phthalate esters, and toluene, the QC limit is five times the method detection limit.

Table C.19 summarizes method blank results from STL Richland and St. Louis. The ammonia and anions and metal categories had the greatest percentages of method blank results exceeding the QC limits. The following parameters had >10% of method blank results outside the QC limits: chloride, phosphate, aluminum, arsenic, calcium, lithium, zinc, acetone, bromomethane, and methylene chloride. The out-of-limit method blank results for sodium are not a significant problem because the values are typically much lower than the levels measured in Hanford Site groundwater. Similarly, the highest method blank results for chloride (0.19 mg/L), sulfate (0.15 mg/L), barium (0.92 µg/L), and calcium (120 µg/L) are typically lower than the respective levels measured in Hanford groundwater. The percentage of out-of-limit method blanks decreased significantly compared to FY 2004 for sulfate, beryllium, manganese, 1,4-dichlorobenzene, benzyl alcohol, diethylphthalate, strontium-90, and tritium, while the percentage increased for bromide, chloride, fluoride, nitrogen in nitrite, phosphate, aluminum, arsenic, calcium, zinc, methylene chloride, and potassium-40. Some of the changes in the results for metals may have been an effect of the change by the laboratory in the metals reporting limits from instrument detection limits to method detection limits halfway through this fiscal year.

Table C.20 summarizes results for the laboratory control samples from STL Richland and St. Louis. Only volatile organic compounds and semivolatile organic compounds had >2% of their measurements outside the QC limits. The ammonia and anions category had an increased percentage of results outside the QC limits compared to FY 2004 results (0.2% to 1.7%). Specific compounds with >10% of out-of-limit laboratory control samples included selenium, 1,2-dibromo-3-chloropropane, ethyl methacrylate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 2,2'-oxybis(1-chloropropane), 2,4-D, 2,4-dinitrotoluene, 2,6-dinitrotoluene, 2-methylnaphthalene, 2-nitroaniline, 2-secbutyl-4,6-dinitrophenol, 3,3'-dichlorobenzidine, 3-nitroaniline, 4-bromophenylphenyl ether, 4-chloroaniline, 4-chlorophenylphenyl ether, 4-nitroaniline, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, isophorone, nitrobenzene, N-Nitroso-di-n-dipropylamine, N-Nitrosodiphenylamine, a series of polycyclic aromatic hydrocarbons (PAHs), and a series of phthalates. In all of these cases except 2-secbutyl-4,6-dinitrophenol, the number of QC samples analyzed was limited (<20). Many of these constituents are not routinely monitored in Hanford groundwater.

Table C.21 summarizes results for the matrix spikes and matrix spike duplicates from STL Richland and St. Louis. The ammonia and anions and volatile organic compounds categories had the greatest percentage of matrix spikes/spike duplicates exceeding the QC limits. This represents an increase compared to FY 2004 results for the ammonia and anions category (8.6% to 13.3%). The percentage of out-of-limit results increased significantly compared to FY 2004 for cyanide, nitrogen in nitrite, sulfate, tetrachloroethene, and trans-1,2-dichloroethylene. The semivolatile organic compounds and radiochemistry parameters categories showed a decrease in the number of results out of limits compared to FY 2004 results (9.3% to 2.4 % and 7.5% to 3.2%, respectively). For both FY 2005 and FY 2004, fewer than 2% of the matrix spikes or matrix spike duplicates for general chemistry parameters and metals were out of limits.

Matrix duplicates were evaluated by comparing the relative percent difference to the QC limit for results that were five times greater than the method detection limit or the minimum detectable activity. Table C.22 lists the constituents that exceeded the relative percent difference limits. The volatile and semivolatile organic compound categories had the greatest percentage of matrix duplicates exceeding the QC limits. However, both categories showed a decrease in the number of results out of limits compared to FY 2004 results (5.5% to 3.1% and 21.2% to 9.4%, respectively). All other categories had fewer than 3% of their measurements outside the QC limits.

Surrogate data that were out of limits included five compounds for volatile organics and seven for semivolatile organics. For volatile organic compounds, 4.5% of the surrogate results were outside of QC limits. The semivolatile organic surrogates showed a decrease in the number of results out of limits compared to FY 2004 results (6.3% to 1.5%).

QC data for Eberline Services and Lionville Laboratory were limited for FY 2005 because these laboratories did not analyze many samples for routine long-term or interim action groundwater monitoring. Lionville Laboratory analyzed method blanks, laboratory control samples, matrix spikes, and matrix duplicates for total organic carbon (4 QC samples), total organic halides (4 QC samples), seven anions by ion chromatography (10 QC samples), sulfate by ion chromatography (2 QC samples) and 18 metals by inductively coupled plasma - atomic emission spectroscopy (11 QC samples). For several of the metal analyses, the only element of interest was aluminum. All of the QC data for total organic carbon were within limits. Method blanks for several metals (aluminum, barium, calcium, cadmium, copper, iron, magnesium, potassium, sodium, and zinc) were out of limits in one or two instances. The method blank for sodium was out of limits in eight analyses, but the levels were much lower than those measured in the groundwater samples. Duplicates for several metals (aluminum, chromium, copper, iron, manganese, nickel, zinc) and one anion (chloride) were also out of limits one to three times. Matrix spikes were out of limits for total organic halides and phosphate in one or two cases. Eberline Services QC data were limited to gross alpha, gross beta, radionuclides by gamma spectroscopy, strontium-90, and tritium. All of the QC data except two matrix spikes for tritium were within limits.

C.6.3.1 Issue Resolution

Issue resolution forms are documents used to record and resolve problems encountered with sample receipt, sample analysis, missed holding times, and data reporting (e.g., broken bottles or QC problems). The laboratories generate these forms and forward the documents to the groundwater project as soon as possible after a potential problem is identified. The forms provide a means for the project to give direction to the laboratory on resolution with the issues. The documentation is intended to identify occurrences, deficiencies, and/or issues that may potentially have an adverse effect on data integrity. During FY 2005, 46 issue resolution forms were submitted by STL Richland and St. Louis.

Table C.23 indicates the specific issues identified in FY 2005 and the number of analytical requests that were affected. The number of analytical requests affected was small compared to the total number of analytical requests submitted (~13,900, consisting of ~23,900 bottles). Relative to FY 2004, the frequencies of the individual issues were less than last year's in most categories prior to receipt at the laboratory with the exception of temperature variation. Similarly, the frequencies of issues after receipt at the laboratory were less than the previous year. The number of holding time issues was primarily related to shipping delays. A small percentage of the holding time issues were related to laboratory delays. The out-of-limit laboratory QC issues were due to analytical problems that occurred mostly with radiological constituents and a few volatile organics and total organic halides.

C.6.3.2 Laboratory Audits/Assessments

Laboratory activities are regularly assessed by surveillance and auditing processes to make certain that quality problems are prevented and/or detected. Regular assessment supports continuous process improvement. Eight assessments of the commercial analytical laboratories were performed. Five of these audits were conducted by the DOE Consolidated Assessment Program (DOECAP), and three audits were conducted by Bechtel Hanford, Inc. (BHI), representatives.

The goal of DOECAP is to design and implement a program to consolidate site audits of commercial and DOE environmental laboratories providing services to DOE Environmental Management. The specific objectives of the DOECAP audit were to assess the ability of the laboratories to produce data of acceptable and documented quality through analytical operations that follow approved methods and the handling of DOE samples and associated waste in a manner that protects human health and the environment.

Five DOECAP audits were performed at the following laboratories: STL Knoxville, Tennessee, November 18-19, 2004; STL St. Louis, Missouri, April 26-28, 2005; Eberline Services, Richmond, California, April 12-14, 2005; Lionville Laboratory, Lionville, Pennsylvania, May 17-19, 2005; and STL Richland, Washington, July 11-14, 2005. The assessment scope of the DOECAP audits included the following specific functional areas: (1) QA management systems and general laboratory practices, (2) data quality for organic analyses, (3) data quality for inorganic and wet chemistry analyses, (4) data quality for radiochemistry analysis, (5) hazardous and radioactive materials management, and (6) verification of corrective-action implementation from previous audit findings.

Three BHI audits were performed at the following laboratories: Eberline Services, Richmond, California, February 15-17, 2005; STL Richland, Washington, June 21-23, 2005; and Lionville Laboratory, Lionville, Pennsylvania, July 19-21, 2005. The purpose of the BHI audits was to evaluate the continued support of analytical services to Hanford Site contractors as specified in the statement of work between Fluor Hanford, Inc. and STL and Eberline Services.[b] The audits were based on the analytical and QA requirements for both groundwater and multi-media samples as specified in the statement of work. The primary areas of focus were personnel training, procedure compliance, sample receipt and tracking, instrument operation and calibration, equipment maintenance, instrumentation records and logbooks, implementation of STL's QA Management Plan in accordance with Hanford Analytical Services Quality Assurance Document (HASQARD, Volumes 1 and 4, DOE/RL-96-68), and the implementation of corrective actions for deficiencies identified in previous audits.

A total of 31 findings and 51 observations were noted for the 5 DOECAP audits, and 10 findings and 9 observations were identified by the three BHI audits. Results of each of these audits are summarized in Table C.24. Corrective actions have been accepted for all audits, and verification of the corrective actions will be performed in future audits. All laboratories have been qualified to continue to provide analytical services for samples generated at DOE sites.

In addition to many of the past audit findings being closed, proficiencies for many of the laboratories were noted this year, indicating that the laboratories are improving their processes and continuing to provide quality analytical services. Continued assessments of the laboratories are planned for the upcoming year to further evaluate performance and to ensure those corrective actions for the past findings and observations have been implemented.

C.6.4 Concerns about Total Organic Halides Results

In July, PNNL staff observed increased concentrations of total organic halides at several wells across the Hanford Site. The data were also characterized by poor agreement among quadruplicate samples. For example, wells such as 299-W8-1 and 299-E25-48 that previously had a history of non-detected or trace-level results began having variable results >50 µg/L. Several of the field blank results for the third quarter (April through June) also had unusually high concentrations (up to

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(b) RFSH-SOW-93-0003, Rev. 6. 1999. *Environmental and Waste Characterization of Analytical Services*. Statement of Work between Fluor Daniel Hanford, Inc. and Severn Trent Laboratories, Richland, Washington, and Eberline Services, Richmond, California.

19 µg/L). The problem appeared to become widespread in April and continued into the fourth quarter (July through September). Because total organic halides is a key parameter for RCRA detection monitoring, several actions were taken to investigate the problem. The questionable data were discussed with the analyzing laboratory (STL St. Louis), and the laboratory was asked if they were aware of any procedural or instrument changes that might be responsible for the data trends. Laboratory staff were not aware of any factors that might explain the anomalous values. Review of the method blank and laboratory control sample results did not show any significant changes in performance between 2004 and 2005. The laboratory analyzed several low-concentration check standards in response to PNNL's concerns, and the results were within ~10% of the expected concentrations, indicating reasonable method performance. As noted in Sections C.4.1 and C.6.2, split samples and special blind standards were submitted to the laboratory during the third and fourth quarters. The third quarter split results showed poor analytical precision at both STL St. Louis and Lionville Laboratory. However, STL St. Louis' results on the fourth quarter blind standards were generally acceptable (92% were within the acceptance limits). Improvements were also observed in the fourth quarter field blanks; most were non-detected, and the detected concentrations were within a factor of 2 of the method detection limit (3.2 µg/L). At the time of this report, the reasons for the elevated results remain unknown. Sporadic sample contamination (e.g., from sample containers) is a possible explanation. PNNL has flagged many of the suspect results in HEIS. Improved results from the fourth quarter suggest that the issue may have been resolved. However, special field blanks and blind standards will be used in FY 2006, if necessary, to help identify and resolve the problem.

C.7 Limit of Detection, Limit of Quantitation, and Method Detection Limit

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Detection and quantitation limits are essential to evaluate data quality and usefulness because they provide the limits of a method's measurement. The detection limit is the lower limit at which a measurement can be differentiated from background. The quantitation limit is the lower limit where a measurement becomes quantifiably meaningful. The limit of detection, limit of quantitation, and method detection limit are useful for evaluating groundwater data.

The limit of detection is defined as the lowest concentration level statistically different from a blank (Currie 1988). The concentration at which an analyte can be detected depends on the variability of the blank response. For the purpose of this discussion, the blank is taken to be a method blank.

In general, the limit of detection is calculated as the mean concentration in the blank plus three standard deviations of that concentration (EPA/540/P-87/001, OSWER 9355.0-14). The blank-corrected limit of detection is simply three times the blank standard deviation. At three standard deviations from the blank mean, the false-positive and the false-negative error rates are each ~7% (Miller and Miller 1988). A false-positive error is an instance when an analyte is declared present but is, in fact, absent. A false-negative error is an instance when an analyte is declared absent but is, in fact, present.

The limit of detection for a radionuclide is typically computed from the counting error associated with each reported result (e.g., EPA 520/1-80-012) and represents instrumental or background conditions at the time of analysis. In contrast, the limit of detection and limit of quantitation for the radionuclides shown in Table C.25 are based on variabilities that result from both counting errors and uncertainties introduced by sample handling. In the latter case, distilled water, submitted as a sample, is processed as if it were an actual sample. Thus, any random cross-contamination of the blank during sample processing will be included in the overall error, and the values shown in Table C.25 are most useful for assessing long-term variability in the overall process.

The limit of quantitation is defined as the level above which quantitative results may be obtained with a specified degree of confidence (Keith 1991). The limit of quantitation is calculated as the blank mean plus 10 standard deviations of the blank (EPA/540/P-87/001, OSWER 9355.0-14). The blank-corrected limit of quantitation is simply 10 times the blank standard deviation. The limit of quantitation is most useful for defining the lower limit of the useful range of concentration measurement technology. When the analyte signal is 10 times larger than the standard deviation of the blank measurements, there is a 95% probability that the true concentration of the analyte is within ±25% of the measured concentration.

The method detection limit is defined as the minimum concentration of a substance that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero. The method detection limit is determined from analysis of a sample in a given matrix containing the analyte (Currie 1988). The method detection limit is 3.14 times the standard deviation of the results of seven replicates of a low-level standard. Note that the method detection limit, as defined above, is based on the variability of the response of low-level standards rather than on the variability of the blank response.

For this report, total organic carbon, total organic halides, and radionuclide field blank data are available for limit of detection and limit of quantitation determinations. The field blanks are QC samples that are introduced into a process to monitor the performance of the system. The use of field blanks to calculate the limit of detection and the limit of quantitation is preferred over the use of laboratory blanks because field blanks include error contributions from sample preparation and handling, in addition to analytical uncertainties. Methods to calculate the limit of detection and the limit of quantitation are described in detail in Appendix A of DOE/RL-91-03. The results of the limit of detection and limit of quantitation determinations are listed in Table C.25.

Because of the lack of blank data for other constituents of concern, it was necessary to calculate approximate limit of detection and limit of quantitation values by using variability information obtained from low-level standards. The data from the low-level standards are obtained from laboratory method detection limit studies. If low-level standards are used, the variability of the difference between the sample and blank response is increased by a factor of 2 (Currie 1988, p. 84). The formulas are summarized below:

$$\mathrm{MDL} = 3.14 \cdot s$$

$$\begin{aligned}\mathrm{LOD} &= 3\left(\sqrt{2} \cdot s\right) \\ &= 4.24 \cdot s\end{aligned}$$

$$\begin{aligned}\mathrm{LOQ} &= 10\left(\sqrt{2} \cdot s\right) \\ &= 14.14 \cdot s\end{aligned}$$

where s = standard deviation from the seven replicates of the low-level standard.

The results of limit of detection, limit of quantitation, and method detection limit calculations for most non-radiological constituents of concern (besides total organic carbon and total organic halides) are listed in Table C.26. The values in the table apply to STL St. Louis only.

Specific evaluation of detection-limit issues for the interim action groundwater monitoring was not performed for this report. Detection limit issues are primarily assessed as part of site-specific validation activities. No validation activities were performed on interim action groundwater monitoring data in FY 2005.

C.8 Conclusions

Overall, assessments of FY 2005 QA/QC information indicated that groundwater monitoring data are reliable and defensible. Sampling was conducted in accordance with reviewed procedures. Few contamination or other sampling-related problems were encountered that affected data integrity. Likewise, laboratory performance was excellent in most respects, based on the large percentages of acceptable field and laboratory QC results. Satisfactory laboratory audits and generally acceptable results in nationally-based performance evaluation studies also demonstrated good laboratory performance. However, the following areas of concern were identified and should be considered when interpreting groundwater monitoring results:

- Anomalous total organic halide results were observed at several wells across the site during the third quarter (April through June). Field QC samples, including blanks, splits, and blind standards also showed poor precision and elevated concentrations during this time. Suspect data were flagged in the database. The cause of the problem has not been identified, but results for the last quarter of the year showed significant improvement.
- A few QC samples were probably swapped in the field or at the laboratory based on a small number of unusually high field-blank results and duplicate results with poor precision. The same problem likely occurred for a small number of groundwater samples. Mismatched results for key constituents are identified during data review and flagged when appropriate.

- Several indicator parameters, anions, metals, volatile organic compounds, and radiological parameters were detected at low levels in field and/or laboratory method blanks. The most significant contaminants were acetone, aluminum, arsenic, bromide, carbon tetrachloride, fluoride, methylene chloride, nitrogen in nitrate, potassium-40, and zinc.
- Maximum recommended holding times were exceeded for ~2.9% of groundwater monitoring samples that were analyzed by non-radiological methods. Anions were primarily affected, though the data impacts are considered minor.
- Laboratory performance on blind standards was good overall: 83% of the results were acceptable. Constituents with out-of-limit results from STL (St. Louis and Richland) were aluminum, carbon tetrachloride, cyanide, fluoride, gross alpha, plutonium-239, total organic carbon, total organic halides, trichloroethene, and tritium. Lionville Laboratory had out-of-limits for total organic carbon. All of PNNL's and Eberline Services' results were acceptable.

C.9 References

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Table C.1. Data Review Codes

Code	Definition
D	Result is associated with a documented laboratory nonconformance.
F	Result is being reviewed as part of the RDR process. This flag is assigned when an RDR is initiated.
G	Result is valid according to further review.
H	Laboratory holding time exceeded before the sample was analyzed.
P	Potential problem. Collection/analysis circumstances make value questionable.
Q	Associated quality control sample is out of limits.
R	Result is not valid according to further review.
Y	Result is suspect. Review had insufficient evidence to show result valid or invalid.
Z	Miscellaneous circumstance exists. See project file.
RDR = Requests for Data Review.	

Table C.2. Requests for Data Review for FY 2005 Data

Flag G	Flag Y	Flag R	Flag Z	Notify Owner	Other Action	Pending	Number of Results with an Assigned RDR
Analytical Results							
131	636	28	--	67	19	38	919
Water-Level Measurements							
30	56	2	2	--	--	17	107
RDR = Requests for Data Review.							

Table C.3. Long-Term Monitoring Full Trip Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
General Chemical Parameters					
Chemical oxygen demand	1	3	33.3	6,000 – 14,200 µg/L	21,000 µg/L
Total organic carbon	3	76	3.9	780 – 860µg/L	870 – 2,300 µg/L
Total organic halides	13	61	21.3	6.4 µg/L	6.6 – 18.9 µg/L
Ammonia and Anions					
Chloride	10	63	15.9	50 – 86 µg/L	51 – 210 µg/L
Nitrogen in nitrate	6	64	9.4	35.4 – 88.6 µg/L	38.1 – 664 µg/L
Metals					
Aluminum	10	51	19.6	33.2 – 91.0 µg/L	36.5 – 171 µg/L
Beryllium	1	51	2.0	0.36 – 0.58 µg/L	0.91 µg/L
Calcium	9	51	17.6	21.4 – 222 µg/L	22 – 113 µg/L
Iron	3	51	5.9	13.8 – 25.2 µg/L	20.9 – 31 µg/L
Manganese	1	51	2.0	1.68 – 1.98 µg/L	2.1 µg/L
Mercury	1	9	11.1	0.092 – 0.2 µg/L	0.094 µg/L
Sodium	3	51	5.9	188.6 – 760 µg/L	277 – 397 µg/L
Zinc	16	51	31.4	2.4 – 3 µg/L	2.5 – 5.6 µg/L
Volatile Organic Compounds					
1,4-Dichlorobenzene	1	15	6.7	0.18 – 0.22 µg/L	0.31 µg/L
Acetone	1	15	6.7	1.05 µg/L	2.2 µg/L
Methylene chloride	4	15	26.7	0.6 – 0.85 µg/L	1 – 1.7 µg/L
Trichloroethene	1	15	6.7	0.18 – 0.26 µg/L	0.43 µg/L
Xylenes (total)	1	15	6.7	0.26 – 0.68 µg/L	0.35 µg/L
Radiological Parameters					
Gross alpha	1	37	2.7	1.796 pCi/L[b]	3.16 pCi/L
Potassium-40	2	19	10.5	63.8 – 96.2 pCi/L[b]	82.4 – 111 pCi/L
Technetium-99	2	38	5.3	16.56 – 22.6 pCi/L[b]	22.4 – 5,880 pCi/L
Tritium	2	43	4.7	11.4 – 11.44 pCi/L[b]	52.8 – 58.9 pCi/L
Uranium	1	32	3.1	0.02 – 0.42 µg/L	0.171 µg/L

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.
(b) The limit for radiological analyses is determined by the sample-specific total propagated uncertainty.
QC = Quality control.

Table C.4. Long-Term Monitoring Field Transfer Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[(a)] (μg/L)	Range of Out-of-Limit Results (μg/L)
1,4-Dichlorobenzene	3	70	4.3	0.18 – 0.22	0.26
Acetone	8	70	11.4	1.05	1.6 – 5.3
Carbon tetrachloride	5	70	7.1	0.18 – 0.2	0.25 – 21
Chloroform	1	70	1.4	0.14 – 0.22	28
Methylene chloride	42	70	60.0	0.6 – 0.85	0.65 – 5.1
Trichloroethene	1	70	1.4	0.18 – 0.26	12
Xylenes (total)	1	70	1.4	0.26 – 0.68	0.36

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.

QC = Quality control

Table C.5. Long-Term Monitoring Equipment Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[(a)] (μg/L)	Range of Out-of-Limit Results (μg/L)
Ammonia and Anions					
Nitrogen in nitrate	1	1	100	35.4	226
Metals					
Zinc	1	1	100	3.0	3.5

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.

QC = Quality control

Table C.6. Long-Term Monitoring Field Duplicates Exceeding Quality Control Limits

Constituent	Total Number of Duplicates	Number of Duplicates Evaluated[(a)]	Number Out of Limits	Percent Out of Limits	Range of Relative Percent Differences[(b)]
General Chemistry Parameters					
Coliform bacteria	5	1	1	100	79.5
Ammonia and Anions					
Bromide	1	1	1	100	151.9
Cyanide	13	3	1	33.3	34.0
Fluoride	49	48	1	2.1	22.7
Nitrogen in nitrate	49	49	1	2.0	34.0
Nitrogen in nitrite	49	7	5	71.4	33.1 – 186.0
Metals					
Arsenic	11	3	2	66.7	24 – 50.8
Copper	42	1	1	100	161.7
Iron	42	11	4	36.4	25.1 – 173.1
Manganese	42	9	4	44.4	22.0 – 164.0
Zinc	42	14	5	35.7	28.0 – 158.3
Volatile Organic Compounds					
Acetone	17	3	3	100	83.7 – 158.2
Methylene chloride	17	1	1	100	40.0
Semivolatile Organic Compounds					
TPH-diesel	4	1	1	100	162.5
Radiological Parameters					
Gross alpha	30	4	2	50.0	29.7 – 30.6
Gross beta	41	29	4	13.8	27.4 – 69.2
Iodine-129	17	5	2	40.0	20.3 – 38.3
Technetium-99	30	18	1	5.6	21.4
Tritium	43	30	2	6.7	20.5 – 91.1
Uranium	31	25	1	4.0	21.2

(a) Duplicates with both results less than five times the method detection limit or minimum detectable activity were excluded from the evaluation.

(b) In cases where a non-detected result was compared with a measured value, the method detection limit or minimum detectable activity was used for the non-detected concentration.

QC = Quality control.

TPH = Total petroleum hydrocarbons.

Table C.7. Long-Term Monitoring Total Organic Halides Split Samples

Well	STL St. Louis		Lionville Laboratory		Percent of Variability Contributed by Analysis/Laboratory(c)
	Average Result(a) (µg/L)	Standard Deviation (µg/L)	Average Result(a) (µg/L)	Standard Deviation (µg/L)	
299-E25-32P	13.3	9.9	5.1	3.5	73/27
299-E25-48	13.0	5.7	2.5	0.0	24/76
299-E27-9	8.3	11.2	6.4	3.7	100/0
299-E33-34	3.8	2.5	11.2	15.5	100/0
299-E34-7	19.2	9.6	21.3	7.9	100/0
299-E34-10	8.7	10.7	3.3	1.6	98/2
699-E25-34B	7.6	4.3	11.4	11.7	100/0

(a) Average was calculated using one-half the method detection limit value for non-detects.
(b) Method detection limit was 3.2 µg/L at STL St. Louis and 5 µg/L at Lionville Laboratory.
(c) Analysis of variance estimate of the variability contributed by the analysis (precision) and the laboratory (mean).

Table C.8. Interim Action Monitoring Field Blank Detections

Constituent	Number of Detects	Number of Analyses	Percent Out of Limits	Range of QC Limits[(a)]	Range of Out-of-Limit Results
Anions					
Chloride	7	12	58	43 – 250 µg/L	56 – 5,300 µg/L
Fluoride	1	12	8	5.1 µg/L	100 µg/L
Nitrogen in nitrate	3	12	25	17.7 µg/L	93 – 137 µg/L
Nitrogen in nitrite	1	12	8	13.1 µg/L	1,180 µg/L
Sulfate	1	13	8	37 µg/L	40 µg/L
Metals					
Aluminum	13	18	27	45.5 µg/L	46.2 – 272 µg/L
Beryllium	12	18	67	0.29 µg/L	0.40 – 0.74 µg/L
Calcium	2	18	11	111 µg/L	280 – 414 µg/L
Chromium (total)	1	18	6	3.3 µg/L	9 µg/L
Copper	1	18	6	2.4 µg/L	4 µg/L
Iron	9	18	50	6.9 µg/L	8.5 – 51.5 µg/L
Magnesium	3	18	17	125 µg/L	131 – 152 µg/L
Manganese	5	18	28	0.99 µg/L	1.2 – 14.5 µg/L
Nickel	1	18	6	8.6 µg/L	59 µg/L
Sodium	6	18	33	94.3 µg/L	103 – 705 µg/L
Strontium	3	18	17	0.72 µg/L	0.77 – 2.2 µg/L
Vanadium	2	18	11	5 µg/L	7.3 – 7.8 µg/L
Zinc	15	18	83	1.5 µg/L	1.7 – 8.3 µg/L
Semivolatile Compounds					
Phenol	1	2	50	121 µg/L	230 µg/L
Volatile Organic Compounds					
1,4-Dichlorobenzene	2	34	6	0.11 µg/L	0.19 µg/L
Acetone	9	33	27	0.21 µg/L	0.24 – 3.0 µg/L
Carbon tetrachloride	8	33	24	0.09 – 0.1 µg/L	0.21 – 0.68 µg/L
Chloromethane	1	1	100	0.19 µg/L	0.42 µg/L
Methylene chloride	27	33	82	0.12 – 0.17 µg/L	0.21 – 7.7 µg/L
n-Butylbenzene	1	1	100	0.12 µg/L	0.31 µg/L
Radiological Parameters					
Total beta radiostrontium	1	5	20	0.32 pCi/L	1.17 pCi/L
Tritium	1	11	9	384 pCi/L	334 pCi/L
Field Analyses					
Sulfate	2	13	15	--	1,000 µg/L

(a) Because method detection limits may change throughout the year, some limits are presented as a range.
QC = Quality control.

Table C.9. Interim Action Monitoring Field Duplicates Exceeding Quality Control Limits

Constituent	Total Number of Duplicates	Number of Duplicates Evaluated[(a)]	Number out of Limits	Percent Out of Limits	Range of Relative Percent Differences
Wet Chemistry					
Chloride	19	19	2	10	0 – 37.0
Fluoride	19	19	1	5	0 – 44.1
Nitrate	19	19	1	5	0 – 60.3
Nitrite	19	1	1	100	196
Sulfate	19	19	1	5	0 – 61.6
Hexavalent chromium	1	1	0	0	0
Metals					
Aluminum	23	2	1	0	3.1 – 128
Barium	23	23	0	0	0.44 – 5.25
Calcium	23	23	0	0	0.12 – 5.50
Chromium	23	12	0	0	0 – 17.1
Iron	23	8	3	38	0.88 – 89.1
Magnesium	23	23	0	0	0 – 5.71
Manganese	23	4	0	0	0.50 – 9.87
Potassium	23	2	0	0	0.21 – 5.94
Sodium	23	23	0	0	0 – 6.61
Strontium	23	23	0	0	0 – 5.11
Vanadium	23	3	0	0	0.45 – 2.97
Zinc	23	7	2	29	0.68 – 96.4
Volatile Organic Parameters					
Acetone	7	3	2	67	0 - 147
Carbon disulfide	7	1	1	100	156
Carbon tetrachloride	6	5	0	0	3.68 – 19.0
Chloroform	7	6	0	0	3.03 – 11.8
Tetrachloroethene	7	1	0	0	0
Trichloroethene	7	3	0	0	0 – 2.74
Radiological Parameters					
Gross beta	10	4	0	0	2.41 – 8.49
Carbon-14	2	1	0	0	8.42
Tritium	19	10	0	0	0.59 – 6.43
Potassium-40	3	2	2	100	197 – 284
Uranium	7	6	0	0	0.66 – 11.3
Technetium-99	4	1	0	0	0.90
Total beta radiostrontium	7	4	1	25	1.52 – 25.5
Field Analyses					
Hexavalent chromium	45	45	1	2	0 – 57.1
Sulfate	15	15	1	7	0 – 21.4

(a) Duplicates with both results less than five times the method detection limit or minimum detectable activity were excluded from the evaluation.

Table C.10. Interim Action Monitoring Interlaboratory Splits Exceeding Quality Control Limits

Constituent	Total Number of Splits	Number of Splits Evaluated[(a)]	Number Out of Limits	Percent Out of Limits	Range of Relative Percent Differences
Anions					
Chloride	9	9	2	22	3.90 – 80.1
Sulfate	9	9	0	0	1.52 – 19.1
Metals					
Barium	17	17	0	0	0.17 – 16.5
Calcium	17	17	1	6	1.07 – 20.3
Chromium	17	13	0	0	0.77 – 13.4
Iron	17	3	2	67	13.8 – 51.7
Magnesium	17	17	0	0	1.07 – 18.0
Manganese	17	1	0	0	7.48
Sodium	17	17	0	0	0 – 18.3
Strontium	4	4	0	0	4.63 – 5.65
Vanadium	17	2	0	0	6.64 – 7.63
Zinc	17	11	2	18	0 – 135
Radiological Parameters					
Tritium	8	6	3	50	17.3 – 31.8
Gross beta	8	1	0	0	5.85
Total beta radiostrontium	5	1	1	100	29.2
Fixed Laboratory-Field Analyses					
Hexavalent chromium	44	39	2	5	0 – 166
Sulfate	14	14	4	29	2.8 – 30.1

(a) Split sample pairs with both results <5 times the method detection limit or minimum detectable activity were excluded from the evaluation.

Table C.11. Groundwater Performance Assessment Project Maximum Recommended Holding Times

Method	Constituent	Holding Time
8260 (SW-846)	Volatile organics	14 days
8270 (SW-846)	Semivolatile organics	7 days before extraction; 40 days after extraction
8081 (SW-846)	Pesticides	7 days before extraction; 40 days after extraction
8082 (SW-846)	Polychlorinated biphenyls	7 days before extraction; 40 days after extraction
8040 (SW-846)	Phenols	7 days before extraction; 40 days after extraction
6010 (SW-846)	Inductively coupled plasma metals	6 months
6020 (SW-846)	Inductively coupled plasma-mass spectrometry metals	6 months
7060 (SW-846)	Arsenic	6 months
7196 (SW-846)	Hexavalent chromium	24 hours
7421 (SW-846)	Lead	6 months
7470 (SW-846)	Mercury	28 days
9012 (SW-846)	Cyanide	14 days
9020 (SW-846)	Total organic halides	28 days
9030 (SW-846)	Sulfides	7 days
9060 (SW-846)	Total organic carbon	28 days
9223 (APHA/AWWA/WEF)	Coliform	24 hours
120.1 (EPA-600/4-81-004)	Conductivity	28 days
160.1 (EPA-600/4-81-004)	Total dissolved solids	7 days
300.0 (EPA-600/4-81-004)	Bromide	28 days
300.0 (EPA-600/4-81-004)	Chloride	28 days
300.0 (EPA-600/4-81-004)	Fluoride	28 days
300.0 (EPA-600/4-81-004)	Nitrate	48 hours
300.0 (EPA-600/4-81-004)	Nitrite	48 hours
300.0 (EPA-600/4-81-004)	Phosphate	48 hours
300.0 (EPA-600/4-81-004)	Sulfate	28 days
310.1 (EPA-600/4-81-004)	Alkalinity	14 days
350.1 (EPA-600/4-81-004)	Ammonia	28 days
410.4 (EPA-600/4-81-004)	Chemical oxygen demand	28 days

Table C.12. Summary of Severn Trent St. Louis Water Pollution (WP) Performance Evaluation Studies

Accreditation Laboratory	WP-121 April 2005 Acceptable Results/Total	WP-126 September 2005 Acceptable Results/Total
Environmental Resource Associates	246/269[(a)]	268/287[(b)]

(a) Unacceptable results were for ammonia as N, total Kjeldahl nitrogen, orthophosphate as P, total phosphorus as P, fluoride, hexavalent chromium, 2-butanone, 4-methyl-2-pentanone, bis(2-chloroisopropyl)ether, grease and oil (gravimetric), copper, zinc, and acenaphthene.

(b) Unacceptable results were for total organic carbon, orthophosphate as P, total phenolics, Aroclor 1260, benzo(g,h,i)perylene, grease & oil (gravimetric), barium, iron, and manganese.

Table C.13. Summary of Lionville Laboratory Water Pollution (WP) Performance Evaluation Studies

Accreditation Laboratory	WP-120 March 2005 Acceptable Results/Total	WP-121 April 2005 Acceptable Results/Total
Environmental Resource Associates	457/489[(a)]	4/4

(a) Unacceptable results were for total suspended solids, calcium, magnesium, calcium hardness ($CaCO_3$), total hardness ($CaCO_3$), chemical oxygen demand, total organic carbon, total solids at 105ºC, endosulfan I, technical chlordane, bis(2-chloroethyl)ether, fluoride, ethylbenzene, tetrachloroethylene, total xylenes, and acenaphthene.

Table C.14. Summary of Severn Trent Interlaboratory Performance, FY 2005

Constituent	Number of Results Reported for Each	Number Within Acceptable Control Limits
DOE Mixed Analyte Performance Evaluation Program (MAPEP-05-MaW13&OrW13&GrW13, MAPEP-05-MaW14&OrW14&GrW14) **Radiological and Environmental Sciences Laboratory**		
Americium-241, plutonium-238, plutonium-239/240, technetium-99, tritium, uranium-234/233, uranium-238, gross alpha, gross beta	4(a,b)	4
Cesium-134, cesium-137, cobalt-57, cobalt-60, iron-55, manganese-54, strontium-90, zinc-65	4(a,b)	3(c,d)
Nickel-63	4(a,b)	2(c,d,e)
Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, nickel, selenium, thallium, vanadium, zinc	2(b)	2
Mercury	2(b)	1(d)
Silver	1(b)	1
1,3-Dichlorobenzene, 2,4-dimethylphenol, 1,2,4-trichlorobenzene, naphthalene, hexachlorobutadiene, 2,6-dichlorophenol, 2,6-dinitrotoluene, 2,4-dinitrotoluene, diethylphthalate, hexachlorobenzene, anthracene, 1,3-dinitrobenzene, pyrene, benzo(a)anthracene, heptachlor, 4,4'-DDT	2(b)	2(e)
2-Chlorophenol, 1,4-dichlorobenzene, hexachloroethane, nitrobenzene, 2-methylphenol, 4-nitrophenol, fluoranthene, dieldrin, 4,4'-DDE	1(b)	1
ERA InterLaB RadCheM Proficiency Testing Program (RAD 59) **Environmental Resource Associates**		
Barium-133, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, iodine-131, radium-226, radium-228, strontium-89, strontium-90, tritium, uranium, zinc-65	1(a)	1(f)

(a) Results from STL Richland.
(b) Results from STL St. Louis.
(c) Result(s) from STL Richland were not acceptable.
(d) Result(s) from STL St. Louis were not acceptable.
(e) One result each for nickel-63 and 2,4-dinitrotoluene was acceptable but outside warning limits.
(f) Control limits from National Standards for Water Proficiency Testing Studies Criteria Document.

Table C.15. Summary of Eberline Services and Lionville Laboratory Interlaboratory Performance, FY 2005

Radionuclides		Number of Results Reported for Each		Number Within Acceptable Control Limits
DOE Mixed Analyte Performance Evaluation Program (MAPEP-05-MaW13&OrW13&GrW13, MAPEP-05-MaW14&OrW14&GrW14) **Radiological and Environmental Sciences Laboratory**				
Americium-241, cesium-134, cesium-137, cobalt-57, cobalt-60, iron-55, manganese-54, plutonium-238, plutonium-239/240, strontium-90, technetium-99, tritium, uranium-234/233, uranium-238, zinc-65, gross alpha, gross beta		2(a)		2
Nickel-63		2(a)		1
Arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc		2(b)		2
Antimony, silver, thallium		1(b)		1
1,3-Dichlorobenzene, 2,4-dimethylphenol, 1,2,4-trichlorobenzene, naphthalene, hexachlorobutadiene, 2,6-dichlorophenol, 2,6-dinitrotoluene, 2,4-dinitrotoluene, diethylphthalate, hexachlorobenzene, anthracene, 1,3-dinitrobenzene, pyrene, benzo(a)anthracene		2(b)		2
2-Chlorophenol, 1,4-dichlorobenzene, , hexachloroethane, nitrobenzene, 2-methylphenol, 4-nitrophenol, fluoranthene, dieldrin		1(b)		1
Heptachlor, 4,4'-DDT		1(b)		0
ERA InterLaB RadCheM Proficiency Testing Program (RAD 61, 62) **Environmental Resource Associates**				
Radium-226, radium-228, strontium-89, strontium-90, tritium, uranium, uranium mass		2(a)		2(c)
ERA Multi-Media Radiochemistry Proficiency Testing Program (MRAD-002) **Environmental Resource Associates**				
Americium-241, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, iron-55, plutonium-238, plutonium-239, strontium-90, uranium-234, uranium-238, uranium, uranium mass		1(a)		1(d)

(a) Results from Eberline Services.
(b) Results from Lionville Laboratory.
(c) Control limits from National Standards for Water Proficiency Testing Studies Criteria Document.
(d) Control limits from EML-564.

Table C.16. Summary of Severn Trent Laboratories Double-Blind Spike Determinations

Constituent	Laboratory	Sample Frequency	Number of Results Reported[(a)]	Number of Results Outside QC Limits[(b)]	Control Limits[(c)] (%)
General Chemical Parameters					
Specific conductance	St. Louis	Quarterly	12	0	±25
Total organic carbon (potassium hydrogen phthalate spike)	St. Louis	Quarterly	16	8	±25
Total organic halides (2,4,5-trichlorophenol spike)	St. Louis	Quarterly	17	3	±25
Total organic halides (carbon tetrachloride, chloroform, and trichloroethene spike)	St. Louis	Quarterly	17	7	±25
Ammonia and Anions					
Cyanide	St. Louis	Quarterly	12	1	±25
Fluoride	St. Louis	Quarterly	12	3	±25
Nitrate as N	St. Louis	Quarterly	12	0	±25
Metals					
Aluminum	St. Louis	Annually	3	1	±25
Chromium	St. Louis	Annually	3	0	±20
Volatile Organic Compounds					
Carbon tetrachloride	St. Louis	Quarterly	12	4	±25
Chloroform	St. Louis	Quarterly	12	0	±25
Trichloroethene	St. Louis	Quarterly	12	2	±25
Radiological Parameters					
Gross alpha (plutonium-239 spike)	Richland	Quarterly	12	2	±30
Gross beta (strontium-90 spike)	Richland	Quarterly	12	0	±30
Cesium-137	Richland	Annually	3	0	±30
Cobalt-60	Richland	Annually	3	0	±30
Iodine-129	Richland	Semiannually	6	0	±30
Plutonium-239	Richland	Quarterly	12	1	±30
Strontium-90	Richland	Semiannually	6	0	±30
Technetium-99	Richland	Quarterly	12	1	±30
Tritium	Richland	Annually	3	3	±30
Tritium (low level)	Richland	Annually	3	0	±30
Uranium-238	Richland	Quarterly	12	0	±30

(a) Blind standards were generally submitted in duplicate, triplicate, or quadruplicate.
(b) Quality control limits are given in the Groundwater Performance Assessment Project's QA plan (PNNL-15014).
(c) Each result must be within the specified percentage of the known value to be acceptable.
QA = Quality assurance.
QC = Quality control.

Table C.17. Summary of Lionville Laboratory, Inc. and Eberline Services Double-Blind Spike Determinations

Constituent	Sample Frequency	Number of Results Reported[(a)]	Number of Results Outside QC Limits[(b)]	Control Limits[(c)] (%)
General Chemical Parameters				
Total organic carbon (potassium hydrogen phthalate spike)	Quarterly	16	8	±25
Radiological Parameters				
Gross beta (strontium-90 spike)	Quarterly	12	0	±30

(a) Blind standards were submitted in triplicate or quadruplicate.
(b) Quality control limits are given in the Groundwater Performance Assessment Project's QA plan (PNNL-15014).
(c) Each result must be within the specified percentage of the known value to be acceptable.
QA = Quality assurance.
QC = Quality control.

Table C.18. Percentage of Out-of-Limit Quality Control Results by Category, Severn Trent Laboratories (Richland and St. Louis)

QC Parameter	General Chemistry Parameters	Ammonia and Anions	Metals	VOC	SVOC	Radiological Parameters	Total
Method blanks	0.3	6.0	4.0	1.4	0	0.5	2.0
Laboratory control samples	0.3	1.7	0.2	2.5	5.0	1.1	1.9
Matrix spikes	2.0	13.3	0.2	7.4	2.4	3.2	4.0
Matrix duplicates	1.3	2.1	0	3.1	9.4	1.5	2.5
Surrogates	--	--	--	4.5	1.5	--	3.7

QC = Quality control.
SVOC = Semivolatile organic compound.
VOC = Volatile organic compound.

Table C.19. Method Blank Results, Severn Trent Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit[a]	Number of Analyses	Concentration Range of Out-of-Limit Results
General Chemistry Parameters			
Total general chemistry parameters	1	339	--
Total organic halides	1	120	11.7 µg/L
Ammonia and Anions			
Total ammonia and anions	6.0	1,148	--
Bromide	9.5	21	0.081 – 0.095 mg/L
Chloride	17.8	213	0.051 – 0.19 mg /L
Fluoride	7.1	211	0.016 – 0.053 mg/L
Nitrogen in nitrate	0.9	211	0.01 – 0.018 mg/L
Nitrogen in nitrite	2.4	211	0.011 – 0.019 mg/L
Phosphate	66.7	3	0.17 – 0.29 mg/L
Sulfate	2.4	211	0.089 – 0.15 mg/L
Metals			
Total metals	4.0	2,764	--
Aluminum	17.3	139	33.6 – 152 µg/L
Arsenic	15.4	39	0.85 – 1.8 µg/L
Barium	2.2	137	0.74 – 0.92 µg/L
Beryllium	2.2	137	0.59 – 0.91 µg/L
Calcium	19.0	137	22.3 – 120 µg/L
Iron	3.6	138	19.8 – 154 µg/L
Lithium	33.3	3	12 µg/L
Manganese	0.7	137	2.4 µg/L
Mercury	3.8	26	0.18 µg/L
Sodium	2.2	137	209 – 3590 µg/L
Zinc	27.0	137	2.5 – 31.2 µg/L
Volatile Organic Compounds			
Total volatile organic compounds	1.4	3,947	--
1,4-Dichlorobenzene	0.7	147	0.19 µg/L
1,4-Dioxane	0.9	111	12 µg/L
Acetone[b]	14.2	127	1.3 – 3.6 µg/L
Bromomethane	15.0	20	0.68 – 1.2 µg/L
Chloroform	1.6	128	0.2 – 0.23 µg/L
Methylene chloride[b]	22.8	127	0.65 – 4.8 µg/L
Trichloroethene	1.6	127	0.27 – 0.92 µg/L
Xylenes (total)	0.8	127	3.2 µg/L
Semivolatile Organic Compounds			
Total semivolatile organic compounds	0	2,115	--
Radiochemistry Parameters			
Total radiochemistry parameters	0.5	1,779	--
Gross beta	0.8	125	5.21 pCi/L
Potassium-40	6.3	80	90 – 133 pCi/L
Uranium	1.7	120	0.0612 – 0.381 µg/L

(a) Quality control limits are twice the method detection limit.
(b) Quality control limits are five times the method detection limit.

Table C.20. Laboratory Control Samples, Severn Trent Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total general chemistry parameters	0.3	333
Total organic carbon	1.0	97
Ammonia and Anions		
Total ammonia and anions	1.7	1,148
Bromide	4.8	21
Chloride	0.5	213
Cyanide	7.0	43
Nitrogen in nitrate	2.4	211
Nitrogen in nitrite	4.3	211
Sulfate	0.5	211
Metals		
Total metals	0.2	2,765
Aluminum	2.9	139
Iron	0.7	138
Selenium	33.3	3
Volatile Organic Compounds		
Total volatile organic compounds	2.5	3,040
1,1,1-Trichloroethane	2.3	128
1,1,2-Trichloroethane	0.8	128
1,1-Dichloroethane	1.6	128
1,1-Dichloroethene	4.5	110
1,2-Dibromo-3-chloropropane	15.4	13
1,2-Dichloroethane	0.8	128
1,4-Dichlorobenzene	3.1	128
2-Butanone	2.3	128
4-Methyl-2-pentanone	2.3	128
Acetone	9.4	128
Benzene	3.9	128
Bromoform	4.3	23
Carbon disulfide	5.5	128
Carbon tetrachloride	1.4	146
Chloroform	0.8	129
cis-1,3-Dichloropropene	8.7	23
Dibromochloromethane	4.3	23
Ethyl methacrylate	15.4	13
Methylene chloride	3.1	128
Tetrachloroethene	8.6	128
Toluene	1.6	128
Trichloroethene	0.8	128
Vinyl chloride	1.6	128
Semivolatile Organic Compounds		
Total semivolatile organic compounds	5.0	1,490
1,2,4-Trichlorobenzene	12.5	8
1,2-Dichlorobenzene	11.1	9
1,3-Dichlorobenzene	11.1	9
2,2’-Oxybis(1-chloropropane)	12.5	8
2,4,5-Trichlorophenol	2.6	38

Table C.20. (contd)

Constituent	Percent Out of Limit	Number of Analyses
2,4,6-Trichlorophenol	2.6	38
2,4-D	12.5	8
2,4-Dichlorophenol	3.6	56
2,4-Dimethylphenol	7.9	38
2,4-Dinitrotoluene	12.5	8
2,6-Dichlorophenol	3.3	30
2,6-Dinitrotoluene	12.5	8
2-Chlorophenol	2.6	38
2-Methylnaphthalene	12.5	8
2-Methylphenol	3.6	56
2-Nitroaniline	12.5	8
2-Nitrophenol	1.8	56
2-Secbutyl-4,6-dinitrophenol	13.2	38
3,3'-Dichlorobenzidine	12.5	8
3-+4-Methylphenol	2.7	37
3-Nitroaniline	12.5	8
4,6-Dinitro-2-methylphenol	2.6	38
4-Bromophenylphenyl ether	12.5	8
4-Chloro-3-methylphenol	5.3	38
4-Chloroaniline	12.5	8
4-Chlorophenylphenyl ether	12.5	8
4-Nitroaniline	12.5	8
4-Nitrophenol	2.6	38
Acenaphthene	12.5	8
Acenaphthylene	12.5	8
Anthracene	12.5	8
Benzo(a)anthracene	12.5	8
Benzo(a)pyrene	12.5	8
Benzo(b)fluoranthene	12.5	8
Benzo(ghi)perylene	12.5	8
Benzo(k)fluoranthene	12.5	8
Bis(2-chloroethoxy)methane	12.5	8
Bis(2-chloroethyl) ether	12.5	8
Bis(2-ethylhexyl)phthalate	3.8	26
Butylbenzylphthalate	12.5	8
Carbazole	33.3	3
Chrysene	12.5	8
Dibenz[a,h]anthracene	12.5	8
Dibenzofuran	12.5	8
Diethylphthalate	12.5	8
Dimethylphthalate	12.5	8
Di-n-butylphthalate	12.5	8
Di-n-octylphthalate	12.5	8
Fluoranthene	12.5	8
Fluorene	12.5	8
Hexachlorobenzene	12.5	8
Hexachlorobutadiene	12.5	8
Hexachloroethane	12.5	8
Indeno(1,2,3-cd)pyrene	12.5	8
Isophorone	12.5	8
Naphthalene	3.8	26
Nitrobenzene	12.5	8

Table C.20. (contd)

Constituent	Percent Out of Limit	Number of Analyses
N-Nitroso-di-n-dipropylamine	12.5	8
N-Nitrosodiphenylamine	12.5	8
Oil and grease	8.3	12
Pentachlorophenol	3.6	56
Phenanthrene	12.5	8
Phenol	1.7	60
Pyrene	12.5	8
Radiochemistry Parameters		
Total radiochemistry parameters	1.1	1,316
Cesium-137	2.5	80
Gross alpha	1.8	111
Iodine-129	5.5	91
Tritium	1.1	267
Uranium	0.8	236

Table C.21. Matrix Spikes and Matrix Spike Duplicates, Severn Trent Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total general chemistry parameters	2.0	352
Alkalinity	3.0	67
Conductivity	12.5	8
Total organic carbon	0.8	131
Total organic halides	2.1	140
Ammonia and Anions		
Total ammonia and anions	13.3	1,251
Chloride	1.3	229
Cyanide	22.6	53
Fluoride	1.7	230
Nitrogen in ammonia	20.0	20
Nitrogen in nitrate	6.5	230
Nitrogen in nitrite	48.9	229
Sulfate	6.5	233
Sulfide	14.3	7
Metals		
Total metals	0.2	6,397
Arsenic	2.1	96
Calcium	0.3	318
Hexavalent chromium	2.0	101
Lead	3.1	64
Mercury	1.8	56
Potassium	0.6	318
Sodium	0.3	318
Volatile Organic Compounds		
Total volatile organic compounds	7.4	4,999
1,1,1-Trichloroethane	4.6	218
1,1,2-Trichloroethane	0.9	217
1,1-Dichloroethane	10.1	217
1,1-Dichloroethene	7.8	192
1,2-Dichloroethane	4.6	217
1,2-Dichloropropane	5.0	40
1,4-Dichlorobenzene	6.4	220
2-Butanone	5.5	217
2-Hexanone	2.6	39
4-Methyl-2-pentanone	2.3	217
Acetone	8.8	217
Benzene	12.9	217
Bromomethane	2.5	40
Carbon disulfide	8.8	215
Carbon tetrachloride	21.5	237
Chloroform	10.5	219
Chloromethane	10.5	40
cis-1,2-Dichloroethylene	5.3	132
cis-1,3-Dichloropropene	5.1	40
Dichlorodifluoromethane	5.0	20
Ethylbenzene	2.4	206

Table C.21. (contd)

Constituent	Percent Out of Limit	Number of Analyses
Methylene chloride	18.6	218
Styrene	5.0	40
Tetrachloroethene	17.0	212
Toluene	2.8	217
TPH gasoline	5.0	42
trans-1,2-Dichloroethylene	15.2	132
Trichloroethene	3.2	217
Vinyl chloride	3.2	217
Semivolatile Organic Compounds		
Total semivolatile organic compounds	2.4	2,457
2,4,5-T	7.1	14
2,4-Dichlorophenol	2.7	110
2,6-Dichlorophenol	1.6	62
2-Chlorophenol	4.2	72
2-Methylphenol	3.6	110
2-Nitrophenol	2.7	110
2-Secbutyl-4,6-dinitrophenol	9.2	76
3+4-Methylphenol	1.4	70
Bis(2-ethylhexyl)phthalate	6.3	48
Dicamba	14.3	14
Endosulfan I	27.8	18
Endosulfan II	33.3	18
Heptachlor epoxide	11.1	18
Hexachlorocyclopentadiene	10.0	10
Naphthalene	2.1	48
Oil and grease	37.5	16
Pentachlorophenol	0.9	110
Phenol	1.8	114
TPH diesel	15.4	39
Radiochemistry Parameters		
Total radiochemistry parameters	3.2	251
Technetium-99	4.5	133
Uranium	1.7	118

Table C.22. Matrix Duplicates, Severn Trent Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total general chemistry parameters	1.3	549
Total organic carbon	0.5	215
Total organic halides	5.1	118
Ammonia and Anions		
Total ammonia and anions	2.1	2,272
Bromide	5.3	38
Chloride	1.6	427
Cyanide	8.5	47
Fluoride	3.7	428
Nitrogen in nitrate	1.2	426
Nitrogen in nitrite	1.9	431
Sulfate	1.2	425
Metals		
Total metals	0.0	3,242
Volatile Organic Compounds		
Total volatile organic compounds	3.1	3,246
1,1,1-Trichloroethane	2.8	144
1,1,2-Trichloroethane	1.4	144
1,1-Dichloroethane	1.4	144
1,1-Dichloroethene	1.6	127
1,2-Dichloroethane	1.4	144
1,4-Dichlorobenzene	2.1	141
2-Butanone	11.7	145
2-Hexanone	10.5	19
4-Methyl-2-pentanone	4.2	144
Acetone	18.8	144
Benzene	1.4	144
Bromomethane	10.5	19
Carbon disulfide	1.4	144
Carbon tetrachloride	3.9	154
Chloroform	2.1	144
Chloromethane	5.3	19
cis-1,2-Dichloroethylene	1.3	78
Ethylbenzene	1.5	135
Methylene chloride	2.1	144
Tetrachloroethene	1.4	144
Toluene	1.4	144
trans-1,2-Dichloroethylene	1.3	78
Trichloroethene	1.4	144
Vinyl chloride	4.2	144
Semivolatile Organic Compounds		
Total semivolatile organic compounds	9.4	1,449
1,2-Dichlorobenzene	11.1	9
1,3-Dichlorobenzene	11.1	9
2,2-Dichloropropionic acid	12.5	8
2,3,4,6-Tetrachlorophenol	19.4	31
2,4,5-T	12.5	8
2,4,5-Trichlorophenol	18.4	38
2,4,6-Trichlorophenol	15.8	38

Table C.22. (contd)

Constituent	Percent Out of Limit	Number of Analyses
2,4-Dichlorophenol	13.2	53
2,4-Dimethylphenol	18.4	38
2,4-Dinitrophenol	15.8	38
2,6-Dichlorophenol	19.4	31
2-Chlorophenol	15.8	38
2-Methylphenol	13.2	53
2-Nitrophenol	11.3	53
2-Secbutyl-4,6-dinitrophenol	12.8	39
3,3'-Dichlorobenzidine	14.3	7
3-+4-Methylphenol	20.0	35
4.4'-DDT	9.1	11
4,6-Dinitro-2-methylphenol	13.2	38
4-Chloro-3-methylphenol	18.4	38
4-Chloroaniline	14.3	7
4-Nitrophenol	18.4	38
Aldrin	9.1	11
alpha-BHC	9.1	11
Aroclor 1016	9.1	11
Benzo(ghi)perylene	14.3	7
Benzo(k)fluoranthene	14.3	7
beta-BHC	9.1	11
Bis(2-ethylhexyl)phthalate	4.5	22
Dibenz[a,h]anthracene	14.3	7
Di-n-octylphthalate	14.3	7
gamma-BHC (lindane)	9.1	11
Hexachlorobutadiene	14.3	7
Hexachlorocyclopentadiene	25.0	8
Hexachloroethane	14.3	7
Indeno(1,2,3-cd)pyrene	14.3	7
Methoxychlor	10.0	10
Pentachlorophenol	9.4	53
Phenol	17.5	57
TPH diesel	12.0	25
Radiochemistry Parameters		
Total radiochemistry parameters	1.5	1,639
Carbon-14	20.0	15
Gross alpha	1.8	109
Gross beta	1.7	117
Iodine-129	5.8	86
Plutonium-239/240	17.6	17
Strontium-90	1.3	76
Technetium-99	5.2	134
Tritium	0.7	143

Table C.23. Summary of Issue Resolution Forms Received from Severn Trent Laboratories (Richland and St. Louis) for FY 2005

Issue Category	Number of Analyses Impacted	
	Prior to Receipt at the Laboratory	After Receipt at the Laboratory
Hold time missed	135	21
Broken bottles	4	0
Missing samples	1	0
Temperature deviation	39	0
pH variance	7	--
Bottle size/type (insufficient volume)	0	--
Chain-of-custody forms incomplete	4	--
Laboratory QC out-of-limits	--	38
Analytical preparation deviations	--	3
Method failures/discontinued analyses	--	0

QC = Quality control.

Table C.24. Results of Laboratory Assessments

Laboratory	Audit Team	Findings	Observations	Summary of Results
Severn Trent, Inc., St. Louis, MO	DOECAP	15	21	Findings related to lack of procedures or incomplete procedures for verification of electronic data deliverables to hard copy and for identifying performance limits; inconsistent implementation of procedures as they pertain to sample receipt, logbook documentation, daily monitoring of laboratory water purification system, and waste handling. Observations related to inconsistent general laboratory practices related primarily to rad analyses, rad monitoring, and waste handling.
Eberline Services-Richmond, CA	DOECAP	4	6	Findings related to lack of procedure to address LIMS raw-data change control; non compliance to procedure for calibration of thermometers, inadequate documentation on waste handling activities; and lack of monitoring of workers to assure that annual limits are not exceeded. Observations related to inconsistent laboratory practices related to daily monitoring, documentation of checks on samples, and waste handling and training.
Lionville Laboratory, Inc.-Lionville, PA	DOECAP	5	9	Findings related to lack of periodic reviews of procedures, lack of timely internal audits, lack of calibration verification per procedure, and incomplete documentation on waste handling. Observations related to incomplete procedures, lack of training and calibration documentation, and inconsistent general practices within the laboratory.
Severn Trent, Inc.-Richland, WA	DOECAP	4	14	Findings related to non compliance to sample-receipt procedures, out of date waste profiles, and inadequate tagging of broken equipment. Observations related to inconsistent general laboratory practices such as waste handling, procedural review, and documentation.
Severn Trent, Inc.-Knoxville, TN	DOECAP	3	1	Findings related to inadequate waste management program and hearing conservation program; and non-compliance to laboratory policy as it pertains to refrigerated storage units. The observation related an incorrect reference being used in the laboratory Safety Manual.
Severn Trent, Inc.-Richland, WA	BHI	0	5	No findings were noted. Observations related to inconsistent general laboratory practices, lack of documenting revisions of the STL Quality Assurance Manual (QAM), and not implementing the preventive maintenance schedule identified in the STL QAM
Eberline Services,-Richmond, CA	BHI	5	1	Findings related to inconsistencies between HASQARD and laboratory procedures as they pertain to logbook change control, updating procedures to reflect current regulatory methods, performing data quality assessments, out of date calibration for lab balances and radiological standards; and non-compliance to the laboratory QAM for updating organization structure and responsibilities. The observation related to lack of consistency and completeness across laboratory procedures.
Lionville Laboratory, Inc. Lionville, PA	BHI	5	3	Findings related to inadequate compliance to laboratory procedures for performing audits and for sample log-in; non compliance to HASQARD requirements for updating organization structure and responsibilities, for providing trend and summary reports related to quality, and for inadequate reviewing of notebooks and log books. Observations related to incomplete training records, lack of approval on procedures, and insufficient data review.

BHI = Bechtel Hanford, Inc.
DOECAP = Department of Energy Consolidated Assessment Program.
HASQARD = Hanford Analytical Services Quality Assurance Document (DOE/RL-96-68).
LIMS = Laboratory Information Management System.
STL = Severn Trent Laboratories, Incorporated.

Table C.25. Summary of Analytical Laboratory Detection/Quantitation Limits Determined from Field Blanks Data, Severn Trent Laboratories (Richland and St. Louis)

Period(a)	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
Constituent: Total Organic Carbon, µg/L					
01/15/04 - 12/13/04	71(b)	239.8	154.6	460(c)	1,550(c)
04/07/04 - 03/16/05	76(b)	265.8	163.0	490	1,630
07/21/04 - 06/16/05	82(b)	298.5	193.8	580	1,940
10/05/04 - 08/08/05	75(b)	378.6	223.8	670	2,240
Summary	75(b)	378.6	223.8	670	2,240
Constituent: Total Organic Halides, µg/L					
01/15/04 - 12/13/04	75(b)	0.94	1.48	4.4(c)	14.8(c)
04/07/04 - 03/16/05	69(b)	1.09	1.74	5.2	17.4
07/21/04 - 06/16/05	68(b)	1.87	2.11	6.3	21.1
10/05/04 - 08/08/05	52(b)	2.31	2.39	7.2	23.9
Summary	52(b)	2.31	2.39	7.2	23.9
Constituent: Cesium-137, pCi/L					
10/15/04 - 12/20/04	7	-0.09	0.78	2.34(c)	7.81(c)
01/17/05 - 03/21/05	8	0.07	0.77	2.32	7.73
05/09/05 - 06/27/05	2	0.15	0.71	2.13	7.11
08/05/05 - 09/12/05	3	0.05	0.78	2.33	7.77
Summary	20	0.02	0.77	2.32	7.73
Constituent: Cobalt-60, pCi/L					
10/15/04 - 12/20/04	7	-0.07	0.75	2.24(c)	7.48(c)
01/17/05 - 03/21/05	8	0.13	0.94	2.83	9.43
05/09/05 - 06/27/05	2	0.41	0.11	0.33	1.10
08/05/05 - 09/12/05	3	0.94	0.51	1.53	5.12
Summary	20	0.21	0.80	2.39	7.95
Constituent: Europium-152, pCi/L					
10/15/04 - 12/20/04	7	-0.47	1.72	5.17(c)	17.24(c)
01/17/05 - 03/21/05	8	-1.37	2.95	8.85	29.50
05/09/05 - 06/27/05	2	2.04	2.54	7.63	25.45
08/05/05 - 09/12/05	3	-0.59	4.70	14.09	46.97
Summary	20	-0.59	2.84	8.53	28.43
Constituent: Europium-154, pCi/L					
10/15/04 - 12/20/04	7	-0.81	3.01	9.03(c)	30.11(c)
01/17/05 - 03/21/05	8	-1.42	3.68	11.03	36.77
05/09/05 - 06/27/05	2	7.49	2.48	7.45	24.82
08/05/05 - 09/12/05	3	-1.03	3.08	9.24	30.81
Summary	20	-0.26	3.30	9.90	32.99
Constituent: Europium-155, pCi/L					
10/15/04 - 12/20/04	7	0.40	1.00	3.01(c)	10.03(c)
01/17/05 - 03/21/05	8	0.87	2.11	6.33	21.09
05/09/05 - 06/27/05	2	1.48	0.08	0.25	0.85
08/05/05 - 09/12/05	3	-0.40	0.49	1.48	4.94
Summary	20	0.57	1.53	4.60	15.34
Constituent: Gross Alpha, pCi/L					
10/05/04 - 12/20/04	13(b)	0.09	0.28	0.85(c)	2.82(c)
01/13/05 - 03/17/05	11	0.01	0.16	0.48	1.59
04/05/05 - 06/27/05	9	0.08	0.14	0.43	1.45
07/11/05 - 09/09/05	8	0.09	0.17	0.50	1.67
Summary	41(b)	0.07	0.21	0.62	2.06

Table C.25. (contd)

Period(a)	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
Constituent: Gross Beta, pCi/L					
10/05/04 - 12/20/04	13(b)	0.73	0.65	1.96(c)	6.53(c)
01/13/05 - 03/17/05	12	0.57	0.67	2.01	6.70
04/05/05 - 06/27/05	9	0.84	0.39	1.16	3.88
07/11/05 - 09/12/05	8(b)	0.55	0.50	1.49	4.98
Summary	42(b)	0.67	0.58	1.75	5.85
Constituent: Iodine-129, pCi/L					
10/05/04 - 12/07/04	5	0.01	0.14	0.42(c)	1.42(c)
01/17/05 - 03/21/05	3	0.01	0.07	0.20	0.65
04/05/05 - 04/06/05	2	0.00	0.10	0.30	1.01
07/11/05 - 08/12/05	3	-0.06	0.06	0.17	0.55
Summary	13	-0.01	0.11	0.32	1.08
Constituent: Strontium-90, pCi/L					
10/05/04 - 12/16/04	4	0.11	0.05	0.15(c)	0.51(c)
01/17/05 - 03/03/05	2	0.26	0.006	0.02	0.06
04/06/05 - 06/16/05	2	0.10	0.08	0.24	0.80
07/11/05 - 09/09/05	2	0.14	0.09	0.27	0.91
Summary	10	0.15	0.06	0.18	0.62
Constituent: Technetium-99, pCi/L					
10/05/04 - 12/20/04	12	2.15	5.59	16.8(c)	55.9(c)
01/17/05 - 03/21/05	9(b)	-0.67	3.71	11.1	37.1
04/06/05 - 06/27/05	7(b)	0.91	2.69	8.1	26.9
07/20/05 - 09/12/05	7	-1.32	3.52	10.6	35.2
Summary	35(b)	0.48	4.29	12.9	42.9
Constituent: Tritium, (pCi/L)					
10/05/04 - 12/20/04	16	132.9	103.8	312(c)	1,038(c)
01/17/05 - 03/21/05	11	107.0	95.2	286	952
04/05/05 - 06/27/05	8	18.6	95.8	288	958
07/11/05 - 09/09/05	7(b)	75.2	58.2	175	582
Summary	42(b)	94.7	94.2	283	942
Constituent: Tritium, Low-Level Method, pCi/L					
12/27/04 - 06/14/05	4	29.4	30.6	92(c)	306(c)
Constituent: Uranium, µg/L					
10/05/04 - 12/27/04	9(b)	0.019	0.029	0.107(d)	0.312(d)
01/17/05 - 03/16/05	8	-0.001	0.006	0.018	0.062
04/06/05 - 06/27/05	5(b)	0.011	0.018	0.066	0.196
07/14/05 - 09/12/05	6	0.008	0.011	0.042	0.120
Summary	28(b)	0.009	0.020	0.068	0.205

(a) Time period covered for total organic carbon and total organic halides is a moving average of four quarters.

(b) Excluded outliers.

(c) Limit of detection (blank corrected) equals 3 times the blank standard deviation; limit of quantitation (blank corrected) equals 10 times the blank standard deviation. Numbers are rounded.

(d) Limit of detection equals the mean blank concentration plus 3 standard deviations; limit of quantitation equals the mean blank concentration plus 10 standard deviations. Numbers are rounded.

Table C.26. Summary of Detection and Quantitation Limits, Severn Trent Laboratory (St. Louis)

Method	Constituent	Initial MDL(a) (μg/L)	Initial LOD (μg/L)	Initial LOQ (μg/L)	Ending Values, Effective Date	Ending MDL(a) (μg/L)	Ending LOD (μg/L)	Ending LOQ (μg/L)
General Chemical Parameters								
EPA-600/4-81-004, 120.1	Conductivity(b)	0.49	0.66	2.20	10/22/2005	0.22	0.30	0.99
EPA-600/4-81-004, 160.1	Total dissolved solids	3,500	4,700	16,000	11/23/2004	3,600	4,900	16,000
EPA-600/4-81-004, 310.1	Alkalinity	1,200	1,600	5,400	10/11/2004	1,800	2,400	8,100
EPA-600/4-81-004, 410.4	Chemical oxygen demand	3,000	4,000	13,000	10/04/2004	7,100	9,600	32,000
EPA-600/4-81-004, 413.1	Oil and grease	5,000	6,800	22,500				
Ammonia and Anions								
EPA-600/4-81-004, 300.0(c)	Bromide	20	27	90	05/19/2005	26	35	117
EPA-600/4-81-004, 300.0(c)	Chloride	43	58	194	04/21/2005	25	34	113
EPA-600/4-81-004, 300.0(c)	Fluoride	10	14	45	04/21/2005	5.1	7	23
EPA-600/4-81-004, 300.0(c)	Nitrogen in nitrate	4	5	18	04/21/2005	10	18	61
EPA-600/4-81-004, 300.0(c)	Nitrogen in nitrite(d)	4	5	18	04/21/2005	6	8	27
EPA-600/4-81-004, 300.0(c)	Phosphate	50	68	225				
EPA-600/4-81-004, 300.0(c)	Sulfate(d)	37	50	167	04/21/2005	61	82	275
EPA-600/4-81-004, 350.1	Nitrogen in ammonia	21.6	29.2	97.3	10/08/2004	5.8	7.8	26.1
SW-846, 9012	Cyanide	4.7	6.3	21.2	11/16/2004	2	2.7	9.0
Metals								
SW-846, 6010	Aluminum(e)	45.5	61.4	205	04/01/2005	16.6	22.4	74.8
SW-846, 6010	Antimony(e)	21.3	29	96	04/01/2005	23.0	31.1	104
SW-846, 6010	Barium(e)	3.7	5.0	17	04/01/2005	0.32	0.43	1.4
SW-846, 6010	Beryllium(e)	0.29	0.39	1.31	04/01/2005	0.18	0.24	0.81
SW-846, 6010	Cadmium(e)	2	3	9	04/01/2005	0.86	1.16	3.87
SW-846, 6010	Calcium(e)	111	150	500	04/01/2005	10.7	14	48
SW-846, 6010	Chromium(e)	3.3	4	15	04/01/2005	1.91	2.58	8.60
SW-846, 6010	Cobalt(e)	3.3	4	15	04/01/2005	1.66	2.24	7.48
SW-846, 6010	Copper(e)	2.4	3.2	10.8	04/01/2005	4.27	5.77	19.23
SW-846, 6010	Iron(e)	6.9	9.3	31.1	04/01/2005	12.6	17.0	56.7
SW-846, 6010	Lead(e)	30.2	41	136	04/01/2005	17.9	24.2	80.6
SW-846, 6010	Magnesium(e)	125	169	563	04/01/2005	137	185	617
SW-846, 6010	Manganese(e)	0.99	1.3	4.5	04/01/2005	0.84	1	4
SW-846, 6010	Nickel(e)	8.6	12	39	04/01/2005	4	5	18
SW-846, 6010	Potassium(e)	1,470	1,985	6,620	04/01/2005	1,610	2,174	7,250

Table C.26. (contd)

Method	Constituent	Initial MDL[(a)] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[(a)] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 6010	Silver[(e)]	4.1	6	18	04/01/2005	2.2	3.0	9.9
SW-846, 6010	Sodium[(e)]	83	112	374	04/01/2005	380	513	1711
SW-846, 6010	Strontium (elemental)[(e)]	0.72	1.0	3.2	04/01/2005	0.66	0.89	2.97
SW-846, 6010	Tin[(e)]	34.3	46.3	154.5	04/01/2005	2	3	9
SW-846, 6010	Vanadium[(e)]	5	6.8	22.5	04/01/2005	1.4	1.9	6.3
SW-846, 6010	Zinc[(e)]	1.5	2.0	6.8	04/01/2005	1.2	1.62	5.40
SW-846, 6020[(f)]	Arsenic	0.28	0.38	1.26				
SW-846, 6020[(f)]	Lead	0.57	0.77	2.57				
SW-846, 6020[(f)]	Selenium	0.57	0.77	2.57				
SW-846, 6020[(f)]	Thallium	0.22	0.30	0.99				
SW-846, 7060[(f)]	Arsenic	2.5	3.38	11.26				
SW-846, 7131[(f)]	Cadmium	0.078	0.11	0.35				
SW-846, 7191[(f)]	Chromium	0.36	0.49	1.64				
SW-846, 7421[(f)]	Lead	1.3	1.76	5.85				
SW-846, 7470[(f)]	Mercury	0.1	0.1	0.5	10/21/2004	0.046	0.06	0.21
SW-846, 7740[(f)]	Selenium	1.65	2.23	7.44				
SW-846, 7841[(f)]	Thallium	1.30	1.75	5.85				
Volatile Organic Compounds								
SW-846, 8260	1,1,1,2-Tetrachloroethane	0.04	0.05	0.18	01/13/2005	0.09	0.12	0.41
SW-846, 8260	1,1,1-Trichloroethane	0.17	0.23	0.77	01/13/2005	0.08	0.1	0.4
SW-846, 8260	1,1,2,2-Tetrachloroethane	0.17	0.23	0.77	01/13/2005	0.08	0.1	0.4
SW-846, 8260	1,1,2-Trichloroethane	0.05	0.07	0.23	01/13/2005	0.07	0.09	0.32
SW-846, 8260	1,1-Dichloroethane	0.2	0.3	0.9	01/13/2005	0.07	0.09	0.32
SW-846, 8260	1,1-Dichloroethylene	0.16	0.22	0.72	01/13/2005	0.04	0.1	0.2
SW-846, 8260	1,2,3-Trichloropropane	0.15	0.20	0.68	01/13/2005	0.11	0.15	0.50
SW-846, 8260	1,2-Dibromoethane	0.06	0.08	0.27	01/13/2005	0.07	0.1	0.3
SW-846, 8260	1,2-Dichloroethane	0.08	0.1	0.4	01/13/2005	0.09	0.12	0.41
SW-846, 8260	1,2-Dichloroethylene (total)	0.17	0.23	0.77	01/13/2005	0.26	0.35	1.17
SW-846, 8260	1,2-Dichloropropane	0.24	0.32	1.08	01/13/2005	0.1	0.14	0.45
SW-846, 8260	1,4-Dichlorobenzene	0.11	0.15	0.50	01/13/2005	0.09	0.12	0.41
SW-846, 8260	1,4-Dioxane	11	15	50	01/13/2005	2.6	4	12
SW-846, 8260	1-Butanol	4.6	6.2	20.7	01/13/2005	1.1	1	5
SW-846, 8260	2-Butanone	0.29	0.39	1.31	01/13/2005	0.33	0.4	1.5
SW-846, 8260	2-Hexanone	0.14	0.19	0.63	01/13/2005	0.2	0.27	0.90

Table C.26. (contd)

Method	Constituent	Initial MDL(a) (μg/L)	Initial LOD (μg/L)	Initial LOQ (μg/L)	Ending Values, Effective Date	Ending MDL(a) (μg/L)	Ending LOD (μg/L)	Ending LOQ (μg/L)
SW-846, 8260	4-Methyl-2-pentanone	0.35	0.47	1.58	01/13/2005	0.1	0.14	0.45
SW-846, 8260	Acetone	0.66	0.89	2.97	01/13/2005	0.21	0.28	0.95
SW-846, 8260	Acetonitrile	2.7	3.6	12.2	01/13/2005	0.21	0.28	0.95
SW-846, 8260	Acrolein	2.1	2.8	9.5	01/13/2005	2.8	3.8	12.6
SW-846, 8260	Benzene	0.07	0.09	0.32	01/13/2005	0.05	0.07	0.23
SW-846, 8260	Bromodichloromethane	0.18	0.24	0.81	01/13/2005	0.08	0.1	0.4
SW-846, 8260	Bromoform	0.2	0.3	0.9	01/13/2005	0.17	0.2	0.8
SW-846, 8260	Bromomethane	0.61	0.82	2.75	01/13/2005	0.23	0.3	1.0
SW-846, 8260	Carbon disulfide	0.43	0.58	1.94	01/13/2005	0.25	0.3	1.1
SW-846, 8260	Carbon tetrachloride	0.15	0.20	0.68	01/13/2005	0.09	0.1	0.4
SW-846, 8260	Chlorobenzene	0.08	0.1	0.4	01/13/2005	0.05	0.07	0.23
SW-846, 8260	Chloroethane	0.32	0.43	1.44	01/13/2005	0.11	0.1	0.5
SW-846, 8260	Chloroform	0.07	0.09	0.32	01/13/2005	0.07	0.09	0.32
SW-846, 8260	Chloromethane	0.2	0.3	0.9	01/13/2005	0.19	0.3	0.9
SW-846, 8260	cis-1,2-Dichloroethylene	0.06	0.08	0.27	01/13/2005	0.27	0.4	1.2
SW-846, 8260	cis-1,3-Dichloropropene	0.24	0.32	1.08	01/13/2005	0.13	0.18	0.59
SW-846, 8260	Dichlorodifluoromethane	0.32	0.43	1.44	01/13/2005	0.14	0.2	0.6
SW-846, 8260	Ethyl cyanide	2	2.7	9.0	01/13/2005	0.88	1.2	4.0
SW-846, 8260	Ethylbenzene	0.14	0.19	0.63	01/13/2005	0.07	0.1	0.3
SW-846, 8260	Methylenechloride	0.3	0.4	1.4	01/13/2005	0.12	0.16	0.54
SW-846, 8260	Styrene	0.07	0.09	0.32	01/13/2005	0.13	0.18	0.59
SW-846, 8260	Tetrachloroethylene	0.17	0.23	0.77	01/13/2005	0.1	0.1	0.5
SW-846, 8260	Tetrahydrofuran	1.74	2.35	7.84	01/13/2005	1.15	1.55	5.18
SW-846, 8260	Toluene	0.12	0.16	0.54	01/13/2005	0.08	0.1	0.4
SW-846, 8260	trans-1,2-Dichloroethylene	0.17	0.23	0.77	01/13/2005	0.08	0.1	0.4
SW-846, 8260	trans-1,3-Dichloropropene	0.05	0.07	0.23	01/13/2005	0.07	0.09	0.32
SW-846, 8260	Trichloroethene	0.16	0.22	0.72	01/13/2005	0.13	0.2	0.6
SW-846, 8260	Vinyl acetate	0.2	0.3	0.9	01/13/2005	0.2	0.27	0.90
SW-846, 8260	Vinyl chloride	0.25	0.34	1.13	01/13/2005	0.07	0.1	0.3
SW-846, 8260	Xylenes (total)	0.28	0.38	1.26	01/13/2005	0.13	0.18	0.59
WTPH_Gasoline	TPH, gasoline fraction	29	39	131	10/26/2004	20	27	90
Semivolatile Organic Compounds								
SW-846, 8015	TPH, diesel fraction	50	68	225				
SW-846, 8040	2,3,4,6-Tetrachlorophenol	4.8	6.5	21.6	12/15/2004	2.8	3.8	12.6

Table C.26. (contd)

Method	Constituent	Initial MDL(a) (μg/L)	Initial LOD (μg/L)	Initial LOQ (μg/L)	Ending Values, Effective Date	Ending MDL(a) (μg/L)	Ending LOD (μg/L)	Ending LOQ (μg/L)
SW-846, 8040	2,4,5-Trichlorophenol	4.6	6.2	20.7	12/05/2004	3	4.1	13.5
SW-846, 8040	2,4,6-Trichlorophenol	4.1	5.5	18.5	12/15/2004	3.2	4.3	14.4
SW-846, 8040	2,4-Dichlorophenol	3	4	14	12/15/2004	3.1	4.2	14.0
SW-846, 8040	2,4-Dimethylphenol	2.8	3.8	12.6	12/15/2004	2.9	3.9	13.1
SW-846, 8040	2,4-Dinitrophenol	3.4	4.6	15.3	12/15/2004	2.9	3.9	13.1
SW-846, 8040	2,6-Dichlorophenol	3.3	4.5	14.9	12/15/2004	3.1	4.2	14.0
SW-846, 8040	2-Chlorophenol	3.2	4.3	14.4	12/15/2004	2.9	3.9	13.1
SW-846, 8040	2-Methylphenol (cresol, o-)	4	5	18	12/15/2004	3	4.1	13.5
SW-846, 8040	2-Nitrophenol	3.2	4.32	14.41	12/15/2004	3.3	4.5	14.9
SW-846, 8040	2-Secbutyl-4,6-dinitrophenol (DNBP)	4.2	5.7	18.9	12/15/2004	3.7	5.0	16.7
SW-846, 8040	3-+4-Methyl phenol	2.8	3.8	12.6	12/15/2004	2.9	3.9	13.1
SW-846, 8040	4,6-Dinitro-2methyl phenol	4	5	18	12/15/2004	2.6	3.5	11.7
SW-846, 8040	4-Chloro-3-methylphenol	2.8	3.8	12.6	12/15/2004	3.2	4.3	14.4
SW-846, 8040	4-Nitrophenol	2.8	3.8	12.6	12/15/2004	2.3	3.1	10.4
SW-846, 8040	Pentachlorophenol	4.3	5.8	19.4	12/15/2004	2.8	3.8	12.6
SW-846, 8040	Phenol	3	4	14	12/15/2004	2.8	3.8	12.6
SW-846, 8082	Aroclor-1016	0.22	0.30	0.99	07/23/2005	0.22	0.30	0.99
SW-846, 8082	Aroclor-1221	0.22	0.30	0.99	07/23/2005	0.22	0.30	0.99
SW-846, 8082	Aroclor-1232	0.49	0.66	2.21	07/23/2005	0.22	0.30	0.99
SW-846, 8082	Aroclor-1242	0.2	0.27	0.90	07/23/2005	0.22	0.3	1.0
SW-846, 8082	Aroclor-1248	0.14	0.19	0.63	07/23/2005	0.22	0.30	0.99
SW-846, 8082	Aroclor-1254	0.38	0.51	1.71	07/23/2005	0.14	0.19	0.63
SW-846, 8082	Aroclor-1260	0.19	0.26	0.86	07/23/2005	0.14	0.19	0.63
SW-846, 8270	1,2,4,5-Tetrachlorobenzene	0.21	0.28	0.95	10/20/2004	0.4	0.5	1.8
SW-846, 8270	1,2,4-Trichlorobenzene(d)	0.45	0.61	2.03	07/14/2005	2.1	2.8	9.5
SW-846, 8270	1,2-Dichlorobenzene(d)	0.28	0.38	1.26	07/14/2005	2	3	9
SW-846, 8270	1,3-Dichlorobenzene(d)	0.29	0.39	1.31	07/14/2005	2.3	3.1	10.4
SW-846, 8270	2,4,5-Trichlorophenol(d)	0.64	0.86	2.88	07/14/2005	1.4	1.9	6.3
SW-846, 8270	2,4,6-Trichlorophenol	0.44	0.59	2.0	07/14/2005	1.5	2.0	6.8
SW-846, 8270	2,4-Dichlorophenol(d)	0.27	0.36	1.2	05/05/2005	1.6	2.2	7.2
SW-846, 8270	2,4-Dimethylphenol(d)	5.3	7.2	23.9	07/14/2005	1.6	2.2	7.2
SW-846, 8270	2,4-Dinitrophenol(d)	1.7	2.3	7.7	10/20/2004	6.7	9.0	30.2
SW-846, 8270	2,4-Dinitrotoluene(d)	4	5	18	12/29/2004	0.62	0.84	2.79
SW-846, 8270	2,6-Dinitrotoluene(d)	0.68	0.92	3.1	07/14/2005	1.7	2.3	7.7

Table C.26. (contd)

Method	Constituent	Initial MDL(a) (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL(a) (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8270	2-Chloronaphthalene(d)	0.28	0.38	1.3	07/14/2005	1.8	2.4	8.1
SW-846, 8270	2-Chlorophenol(d)	0.25	0.34	1.1	07/14/2005	1.6	2.2	7.2
SW-846, 8270	2-Methylnaphthalene(d)	0.37	0.50	1.7	07/14/2005	2.2	3.0	9.9
SW-846, 8270	2-Methylphenol (cresol, o-)(d)	0.24	0.32	1.1	05/05/2005	1.2	1.6	5.4
SW-846, 8270	2-Nitroaniline(d)	0.65	0.88	2.93	7/14/2005	1.7	2.3	7.7
SW-846, 8270	2-Nitrophenol	0.64	0.86	2.88	05/05/2005	1.6	2.2	7.2
SW-846, 8270	3,3'-Dichlorobenzidine(d)	1.3	1.8	5.9	07/14/2005	2.4	3.2	10.8
SW-846, 8270	3-Nitroaniline(d)	0.56	0.76	2.5	07/14/2005	1.7	2.3	7.7
SW-846, 8270	4,6-Dinitro-2methyl phenol(d)	0.53	0.72	2.4	07/14/2005	1.3	1.8	5.9
SW-846, 8270	4-Bromophenylphenyl ether(d)	0.42	0.57	1.89	07/14/2005	1.9	2.6	8.6
SW-846, 8270	4-Chloro-3-methylphenol(d)	0.37	0.50	1.7	07/14/2005	1.6	2.16	7.21
SW-846, 8270	4-Chloroaniline(d)	1.1	1.5	5.0	07/14/2005	1.8	2.4	8.1
SW-846, 8270	4-Chlorophenylphenyl ether(d)	0.44	0.59	2.0	07/14/2005	2	2.7	9.0
SW-846, 8270	4-Methylphenol (cresol, p-)(d)	7.1	9.59	32.0	10/20/2004	1.5	2.0	6.8
SW-846, 8270	4-Nitroaniline(d)	1	1.4	4.5	07/14/2005	1.9	2.6	8.6
SW-846, 8270	4-Nitrophenol(d)	0.81	1.1	3.6	10/20/2004	3.2	4.3	14
SW-846, 8270	Acenaphthene(d)	0.35	0.47	1.6	07/14/2005	1.9	2.6	8.6
SW-846, 8270	Acenaphthylene(d)	0.34	0.46	1.5	07/14/2005	1.8	2.4	8.1
SW-846, 8270	Aniline(d)	0.29	0.39	1.3	07/14/2005	1.4	1.9	6.3
SW-846, 8270	Anthracene(d)	0.39	0.53	1.8	07/14/2005	2.2	3.0	9.9
SW-846, 8270	Benzo(a)anthracene(d)	0.47	0.63	2.1	07/14/2005	2.3	3.1	10
SW-846, 8270	Benzo(a)pyrene(d)	1.1	1.5	5.0	07/14/2005	2.2	3.0	9.9
SW-846, 8270	Benzo(b)fluoranthene(d)	0.83	1.1	3.7	07/14/2005	2.2	3.0	9.9
SW-846, 8270	Benzo(ghi)perylene(d)	1.2	1.6	5.4	07/14/2005	2.4	3.2	11
SW-846, 8270	Benzo(k)fluoranthene(d)	1.5	2.0	6.8	07/14/2005	2.5	3.4	11
SW-846, 8270	Benzyl alcohol(d)	0.33	0.45	1.5	07/14/2005	0.59	0.80	2.7
SW-846, 8270	Bis(2-chloroethoxy)methane(d)	0.37	0.50	1.7	07/14/2005	1.8	2.4	8.1
SW-846, 8270	Bis(2-chloroethyl) ether(d)	0.43	0.58	1.9	07/14/2005	1.9	2.6	8.6
SW-846, 8270	Bis(2-ethylhexyl) phthalate(d)	2.7	3.6	12.2	05/05/2005	2.6	3.5	12
SW-846, 8270	Butylbenzylphthalate(d)	0.55	0.74	2.5	07/14/2005	2.9	3.9	13
SW-846, 8270	Chrysene(d)	0.6	0.81	2.7	07/14/2005	2.3	3.1	10
SW-846, 8270	Di-n-butylphthalate(d)	0.47	0.63	2.1	07/14/2005	3.6	4.9	16
SW-846, 8270	Di-n-octylphthalate(d)	5.1	6.9	23	07/14/2005	2.3	3.1	10
SW-846, 8270	Dibenz[a,h]anthracene(d)	1.4	1.9	6.3	07/14/2005	2.4	3.2	11

Table C.26. (contd)

Method	Constituent	Initial MDL(a) (μg/L)	Initial LOD (μg/L)	Initial LOQ (μg/L)	Ending Values, Effective Date	Ending MDL(a) (μg/L)	Ending LOD (μg/L)	Ending LOQ (μg/L)
SW-846, 8270	Dibenzofuran(d)	0.36	0.49	1.6	07/14/2005	2	3	9
SW-846, 8270	Diethylphthalate(d)	0.24	0.32	1.1	07/14/2005	2.3	3.1	10
SW-846, 8270	Dimethyl phthalate(d)	0.68	0.92	3.1	07/14/2005	1.9	2.6	8.6
SW-846, 8270	Fluoranthene(d)	0.44	0.59	2.0	07/14/2005	2.4	3.2	10.8
SW-846, 8270	Fluorene(d)	0.38	0.51	1.7	07/14/2005	2	2.7	9.0
SW-846, 8270	Hexachlorobenzene(d)	0.47	0.63	2.1	07/14/2005	1.8	2.4	8.1
SW-846, 8270	Hexachlorobutadiene(d)	0.41	0.55	1.8	07/14/2005	0.29	0.4	1.3
SW-846, 8270	Hexachlorocyclopentadiene	2.4	3.2	11	01/14/2004	2.5	3.4	11
SW-846, 8270	Hexachloroethane(d)	0.24	0.32	1.1	07/14/2005	2.4	3.2	11
SW-846, 8270	Indeno(1,2,3-cd)pyrene(d)	1.2	1.6	5.4	07/14/2005	1.9	2.6	8.6
SW-846, 8270	Isophorone(d)	0.23	0.31	1.0	07/14/2005	1.8	2.4	8.1
SW-846, 8270	N-Nitroso-di-n-propylamine(d)	0.89	1.2	4.0	07/14/2005	2	2.7	9.0
SW-846, 8270	N-Nitrosodimethylamine(d)	0.46	0.62	2.07	10/20/2004	0.73	0.99	3.29
SW-846, 8270	N-Nitrosodiphenylamine(d)	0.45	0.61	2.0	07/14/2005	2.1	2.8	9.5
SW-846, 8270	Naphthalene(d)	0.3	0.4	1.4	05/05/2005	2	3	9
SW-846, 8270	Pentachlorophenol(d)	0.58	0.78	2.61	05/05/2005	1.4	1.9	6.3
SW-846, 8270	Phenanthrene(d)	0.4	0.5	2	07/14/2005	2.2	3.0	9.9
SW-846, 8270	Phenol	0.26	0.35	1.2	10/20/2004	0.52	0.70	2.3
SW-846, 8270	Pyrene(d)	0.46	0.62	2.1	7/14/2005	2.3	3.1	10

(a) MDLs for many constituents changed during the fiscal year. For these constituents, the initial MDL, LOD, and LOQ were in effect until the date the values were updated (ending values, effective date). In cases where the MDL did not change, no ending values are listed.
(b) μMhos/cm.
(c) Units for this method are mg/L.
(d) Additional MDLs were used briefly during the year for these compounds.
(e) Two instruments (standard and trace level) were used for samples analyzed by method 6010. MDL values for the standard instrument were included in this table.
(f) During FY 2005, most projects began ordering GFAA metals by SW-846, 6020.
LOD = Limit of detection.
LOQ = Limit of quantitation.
MDL = Method detection limit.

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