

Summary of 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
by Pacific Northwest National Laboratory
under Contract DE-AC05-76RL01830, with
contributions from Boise State University;
CH2M HILL Hanford, Inc.; Fluor Hanford,
Inc.; and Washington Closure Hanford, LLC



Pacific Northwest National Laboratory
Richland, Washington 99352

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or Battelle Memorial Institute.

PACIFIC NORTHWEST NATIONAL LABORATORY

operated by

BATTELLE

for the

UNITED STATES DEPARTMENT OF ENERGY

under Contract DE-AC05-76RL01830

Printed in the United States of America

**Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401.**

**Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161**



This document was printed on recycled paper.

Contents

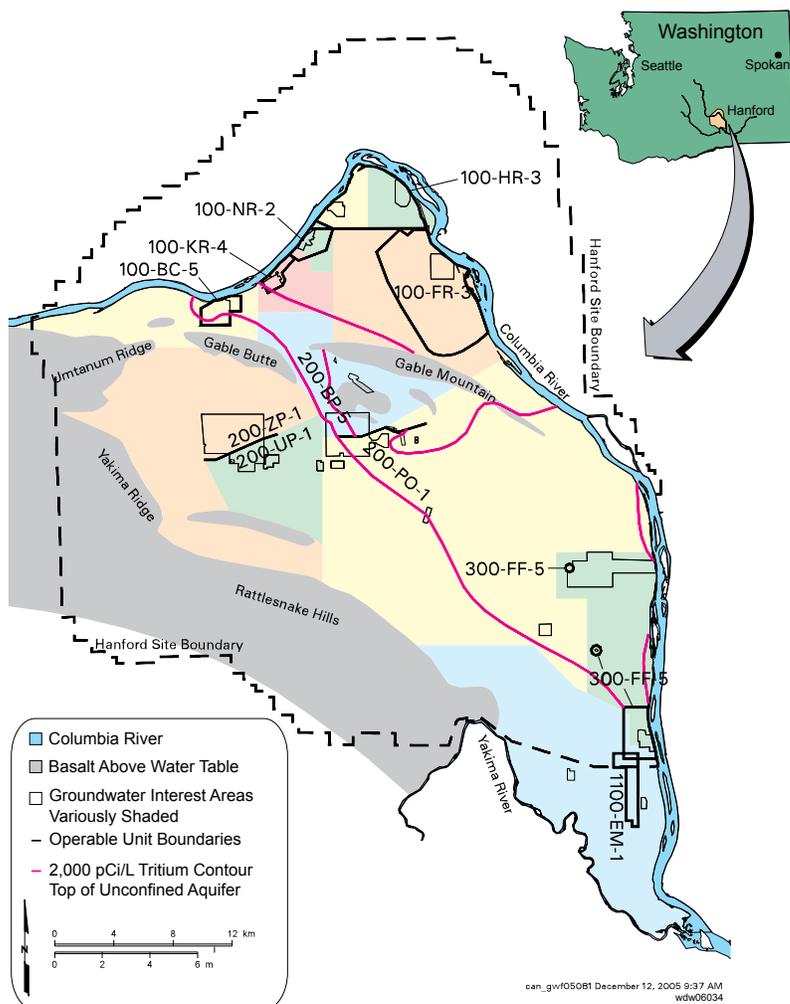
Introduction	1
Emerging Issues	3
Groundwater Flow	4
Groundwater Monitoring and Remediation.....	5
100-BC-5 Operable Unit.....	9
100-KR-4 Operable Unit.....	9
100-NR-2 Operable Unit	11
100-HR-3-D Operable Unit.....	12
100-HR-3-H Operable Unit.....	13
100-FR-3 Operable Unit	14
200-ZP-1 Operable Unit	14
200-UP-1 Operable Unit.....	16
200-BP-5 Operable Unit	18
200-PO-1 Operable Unit.....	19
300-FF-5 Operable Unit.....	21
1100-EM-1 Operable Unit	23
Confined Aquifers	23
Well Installation, Maintenance, and Decommissioning.....	24
Vadose Zone	25
Continued Monitoring.....	27
Glossary	28

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 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.

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

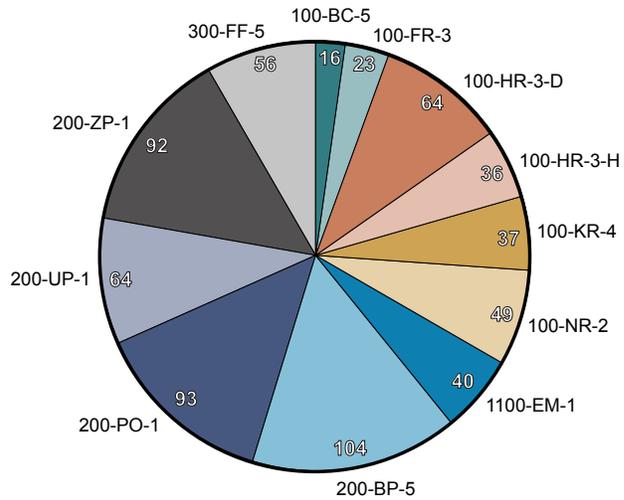


Hanford Site groundwater monitoring is organized by areas of interest, which are informally named after the groundwater operable units. The areas of interest are useful for planning and scheduling groundwater monitoring and interpreting data.

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).

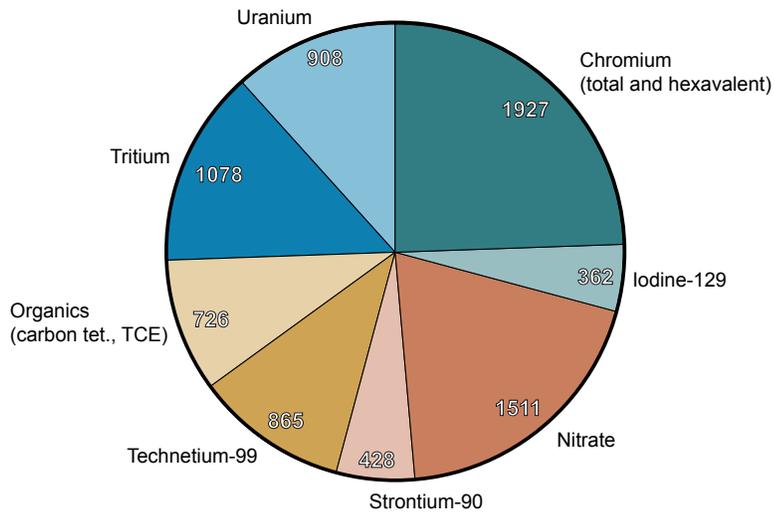
Some contamination reached the Columbia River by moving downward from waste sites through the vadose zone, into the groundwater, and then into the river. The analysis of groundwater samples provides data that help determine the potential fate and transport

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



sbn06001

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



sbn06002

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.

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).

Emerging Issues

This section briefly describes some of the high-priority groundwater topics for FY 2005. Additional details can be found in *Hanford Site Groundwater Monitoring for Fiscal Year 2005*.

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 test plan for a field test in FY 2006. The new approach will pump a form of calcium, along with phosphate, into the soil in the 100-N Area to form a compound called apatite. The calcium compound, similar to that found in tooth enamel, will react with the phosphorus to create an apatite barrier in the soil. Then a chemical reaction between strontium-90 and the apatite will bind the strontium in place for decades, keeping it from the river while radioactive decay renders it nearly harmless. The goal is to create a permeable, reactive barrier near the shoreline that will capture strontium-90 as groundwater flows through a treatment zone.

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.

DOE continued to study a new approach to treat strontium-90 contamination, sequestration by apatite, in FY 2005. A field test is planned for FY 2006.

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.

**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.**

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.

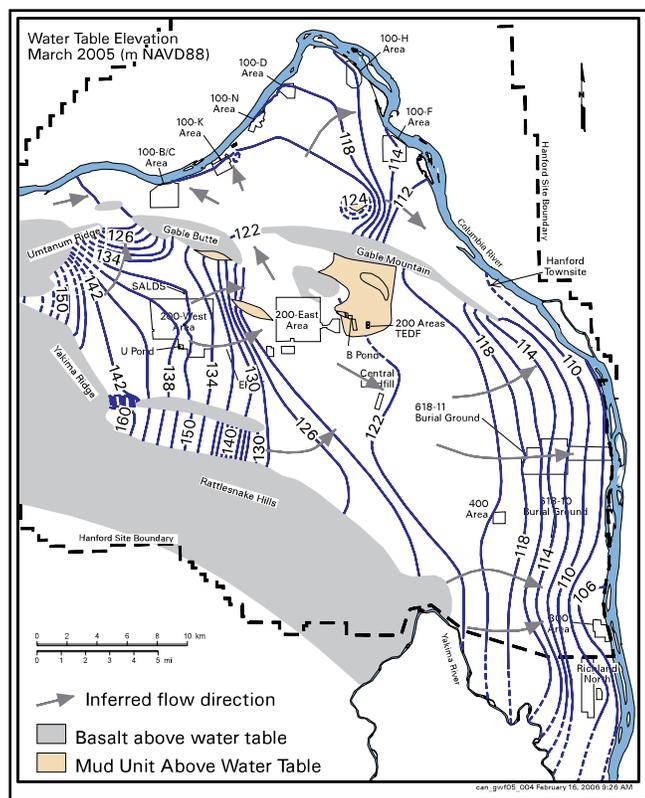
Vertical Distribution of Contaminants in 200 West Area. In recent years, depth-discrete sampling in existing wells, and sampling during drilling of new wells, have provided new information on how contaminant concentrations change with depth in the unconfined aquifer. At some locations in the carbon tetrachloride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

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.



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.

Groundwater Flow

Groundwater in the unconfined aquifer generally flows from west to east across the Hanford Site to discharge areas

(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.

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.

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.

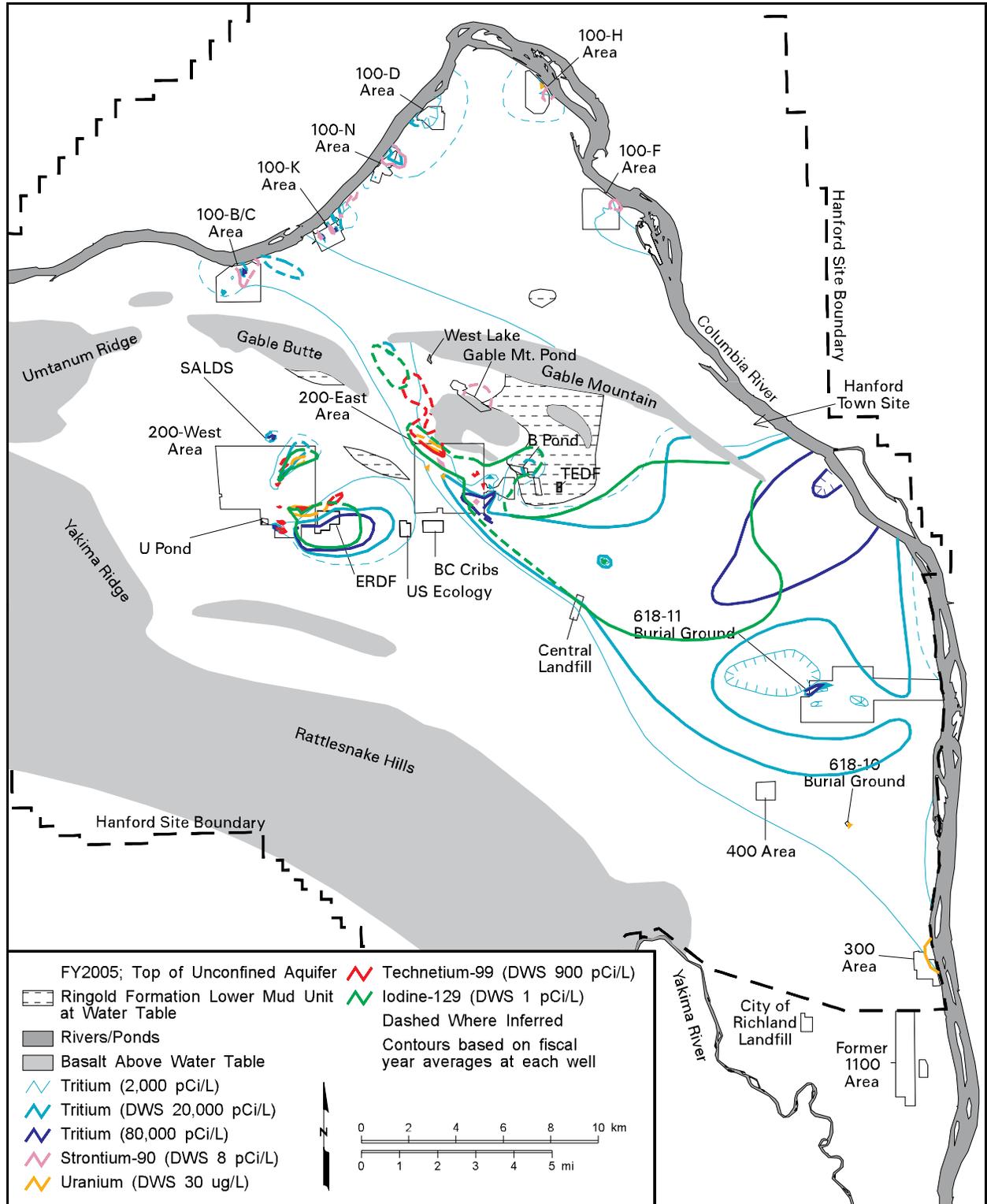
East of the 200 East Area, a fine-grained confining unit creates a barrier to groundwater movement in the surrounding unconfined aquifer. Beneath this confining unit, the uppermost aquifer is a permeable unit in the Ringold Formation. Groundwater flow in this locally confined aquifer still is influenced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

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.

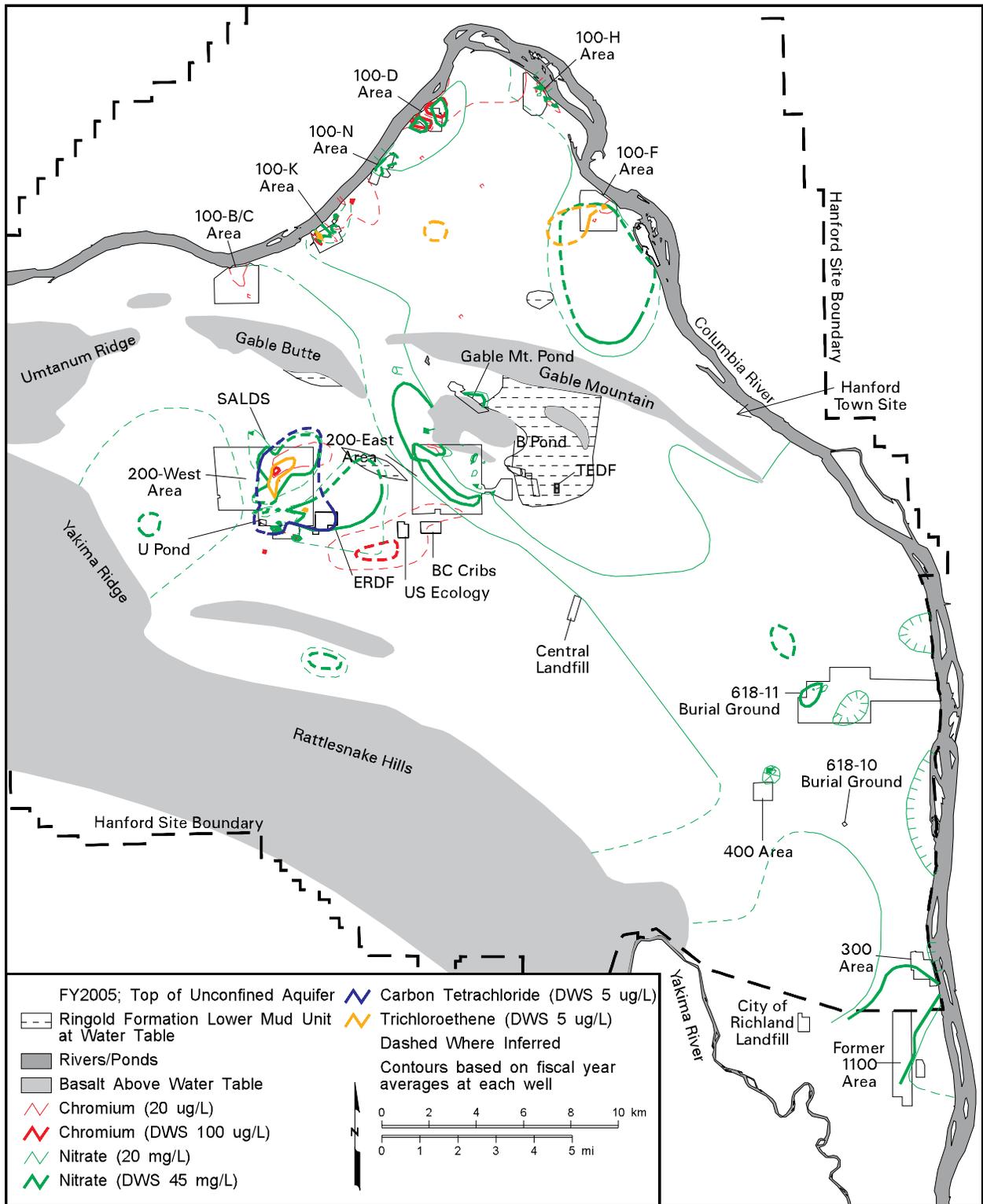
Of the radionuclide plumes, tritium and iodine-129 have the largest areas with concentrations above drinking water standards. The dominant plumes had sources in the 200 East Area and extend toward the east and southeast. Extensive tritium and iodine-129 plumes are also present in 200 West Area. Technetium-99 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

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.



can_gwf05_005 February 21, 2006 11:24 AM

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.

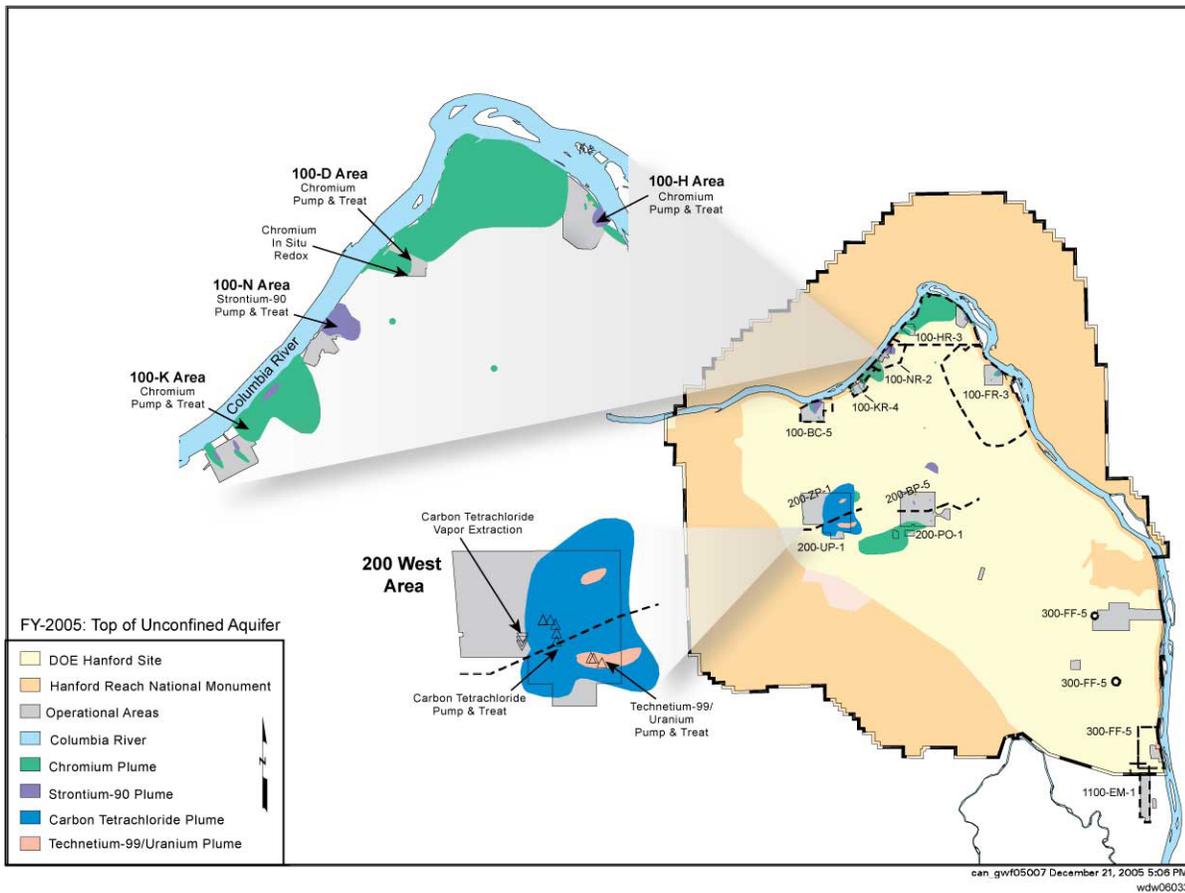


can_gwf05_006 February 21, 2006 11:25 AM

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.



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.

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.

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.

100-BC-5 Operable Unit

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.

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

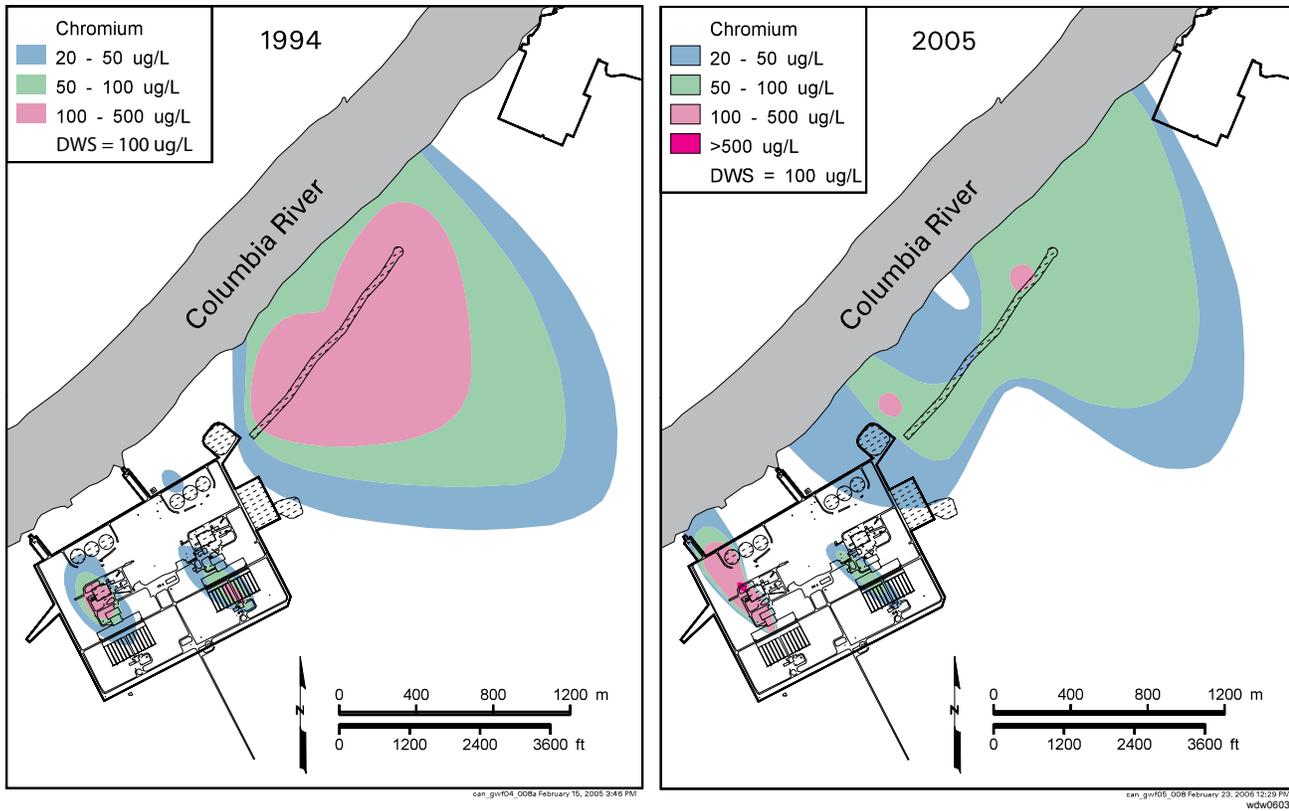
The principal groundwater issues in this operable unit include (a) remediation of groundwater beneath a large liquid-waste disposal trench; (b) tracking plumes from other past-practices sites; and (c) monitoring groundwater near the KE and KW Basins. Interim remedial action involves a pump-and-treat 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.

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.

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



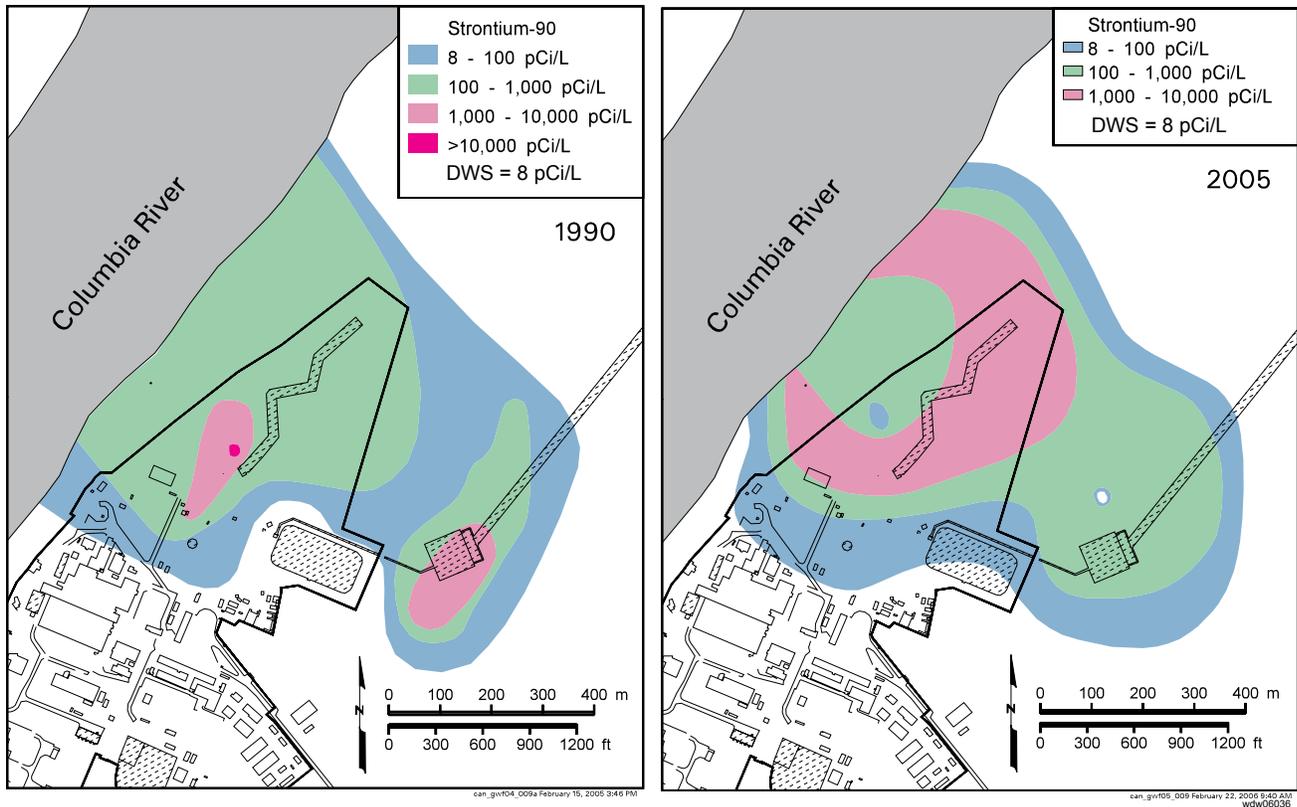
These maps show chromium in the upper part of the unconfined aquifer in the 100-K Area. A pump-and-treat system reduces the amount of chromium entering the Columbia River. Concentrations decreased in most areas since 1994.

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

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 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.

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



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.

in tritium concentrations near KW Reactor is believed to be caused by remobilization of contaminants held in the vadose zone.

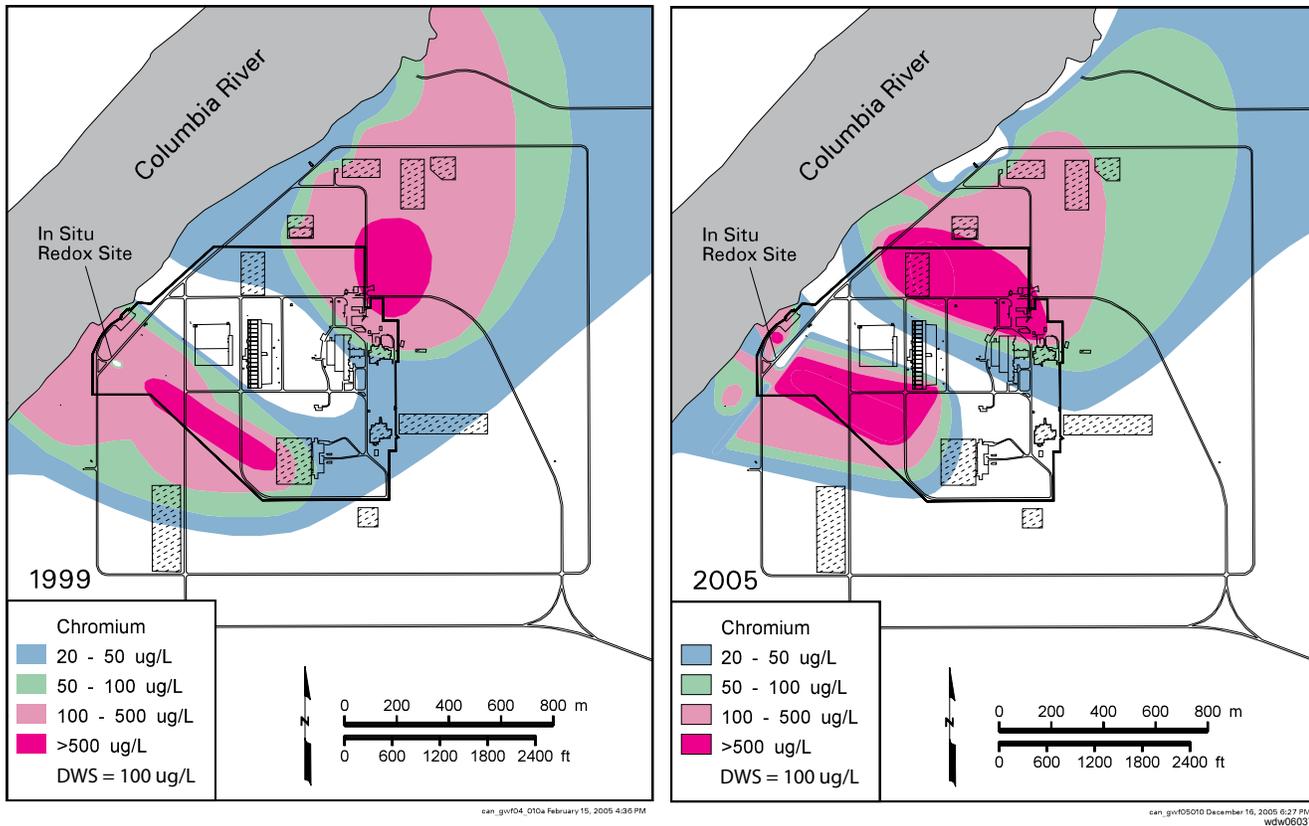
K Basins. The KE and KW Basins are integral parts of each reactor building. Since the late 1970s, they have been used to store irradiated fuel from the last run of N Reactor, as well as miscellaneous fuel fragments recovered from cleanup at other reactor areas. DOE has removed the fuel and is currently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

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

Data from aquifer tubes along the shoreline helped define the details of the strontium-90 plume at 100-N Area.



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.

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.

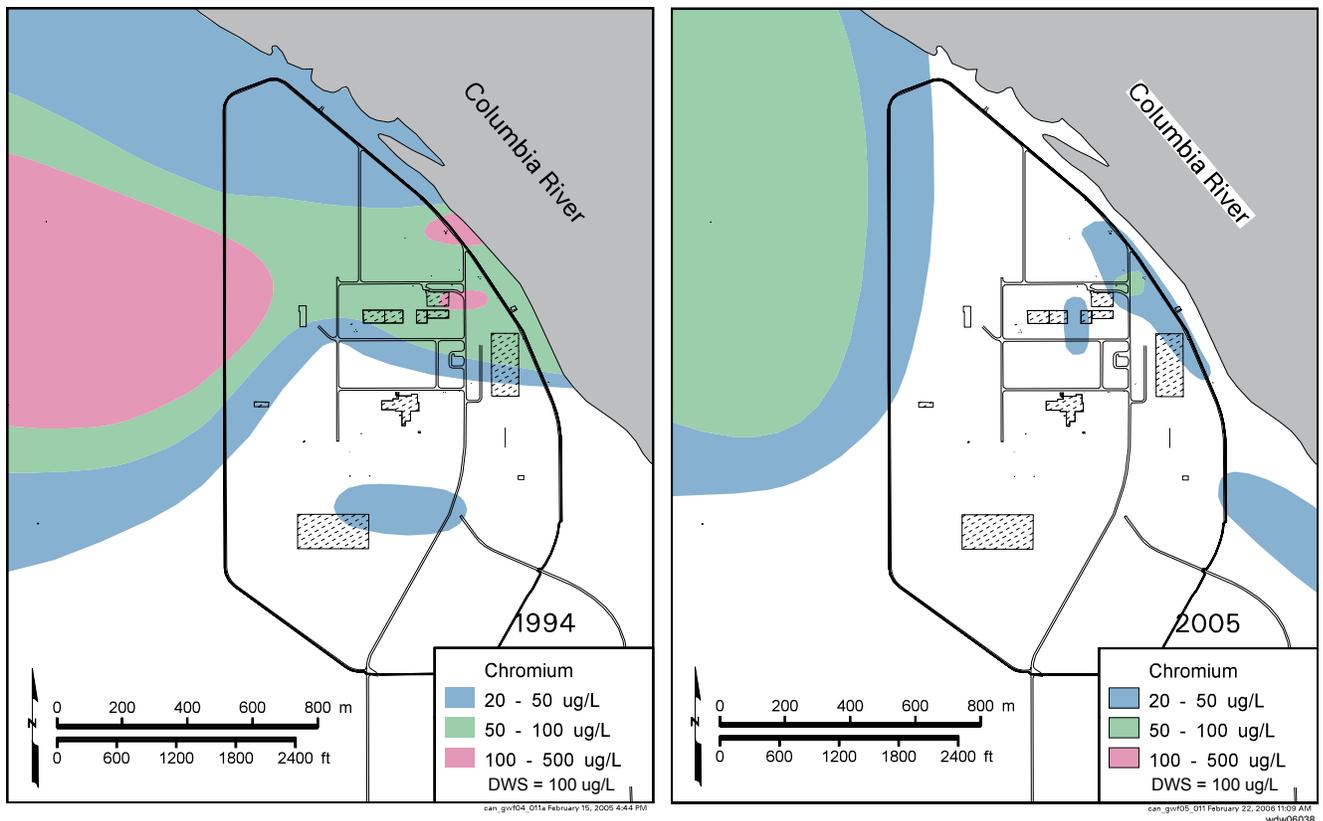
aquifer. Therefore, DOE is evaluating alternative treatment methods. Laboratory studies of strontium-90 sequestration by apatite continued during FY 2005. Favorable results for one approach led to the decision to prepare a treatability test plan for a field test and install a 91-meter barrier in FY 2006. The goal is to create a permeable, reactive barrier near the 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). 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.



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.

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 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.

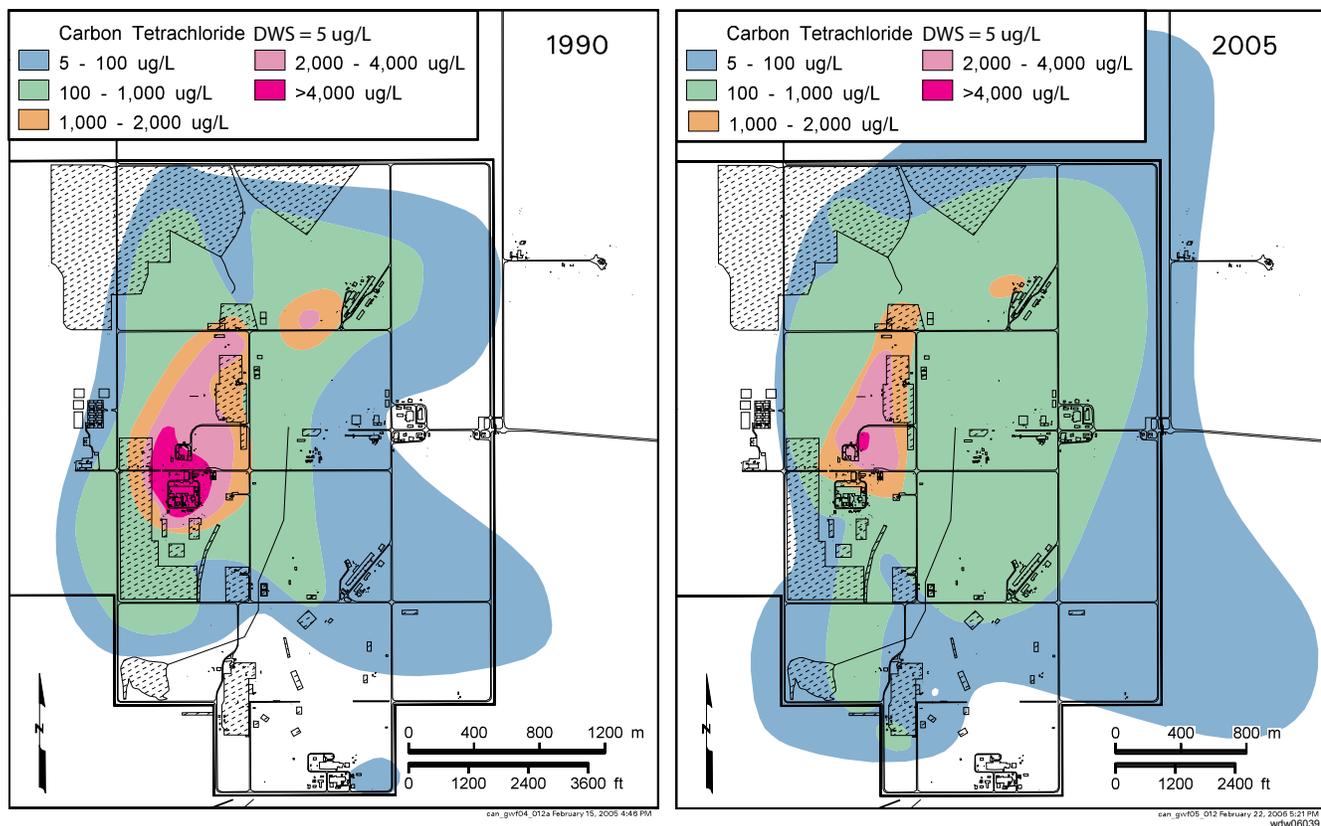
100-HR-3-H Operable Unit

The east part of the 100-HR-3 Operable Unit (100-HR-3-H) underlies the 100-H Area. 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.

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,

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



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.

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.

nitrate, technetium-99, and uranium. The site is monitored during the post-closure period to 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.

100-FR-3 Operable Unit

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

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.

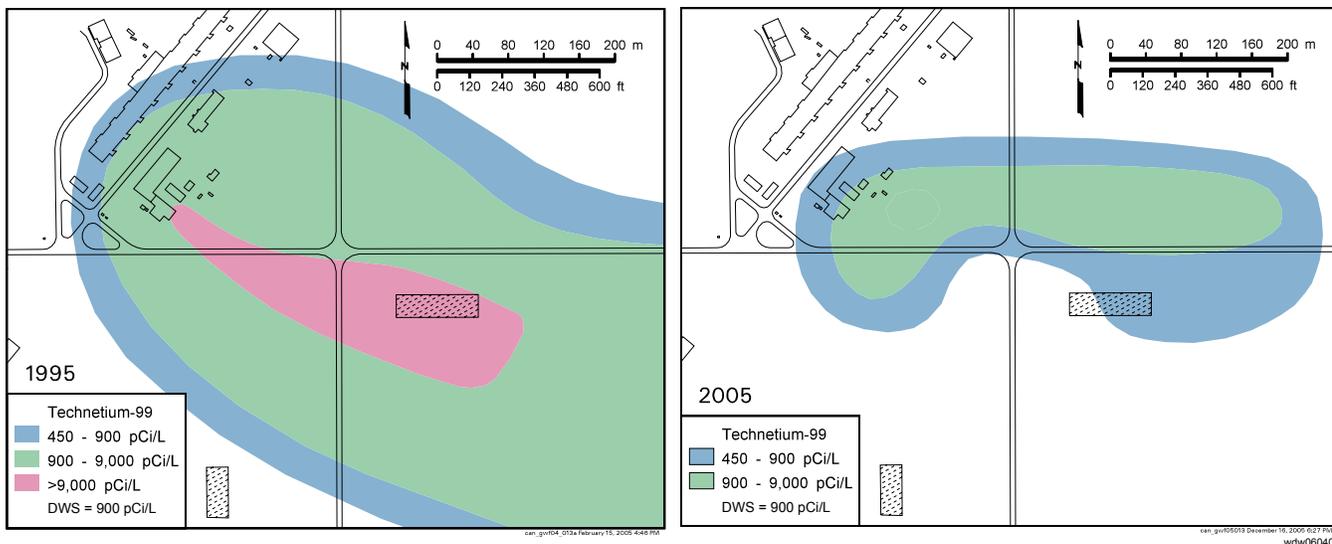
Soil-Vapor Extraction. Soil vapor is extracted from the vadose zone and treated to remove carbon tetrachloride. As of October 2005, ~78,600 kilograms of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

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.				
<u>Fiscal Year</u>	<u>200 West</u>	<u>200 East</u>	<u>Other Areas</u>	<u>Total</u>
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



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.

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

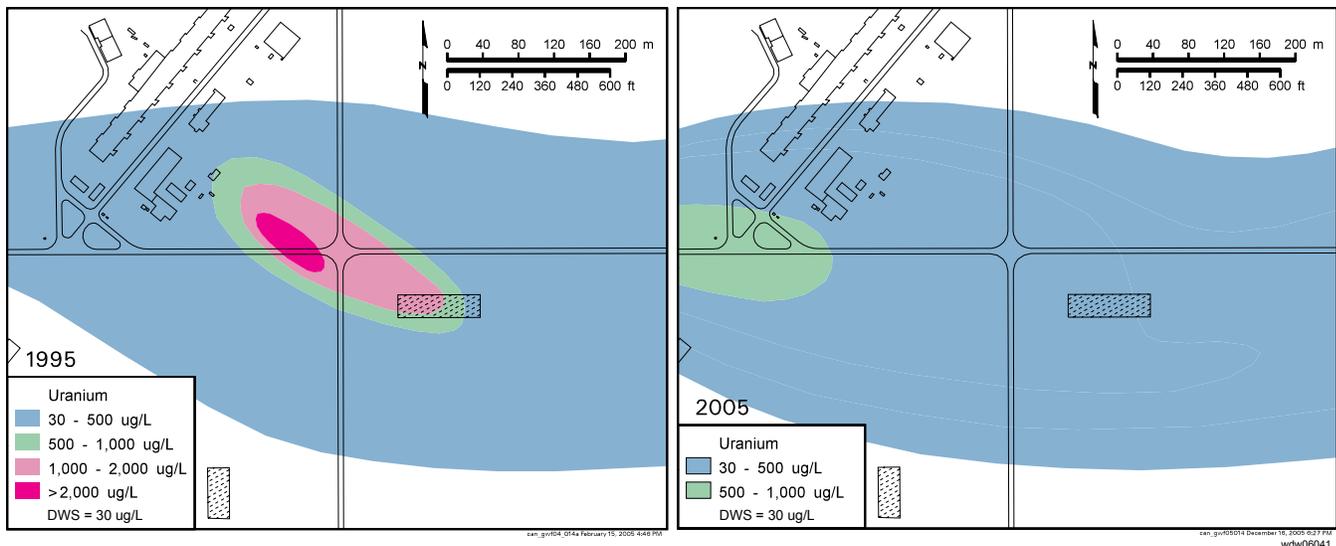
This operable unit underlies the south portion of 200 West Area. The primary contaminants of concern are technetium-99 and uranium. Tritium, chromium, iodine-129, and nitrate plumes also have sources in this operable unit. Carbon tetrachloride in the 200-UP-1 Operable Unit originated from sources in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

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,

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



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.

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.

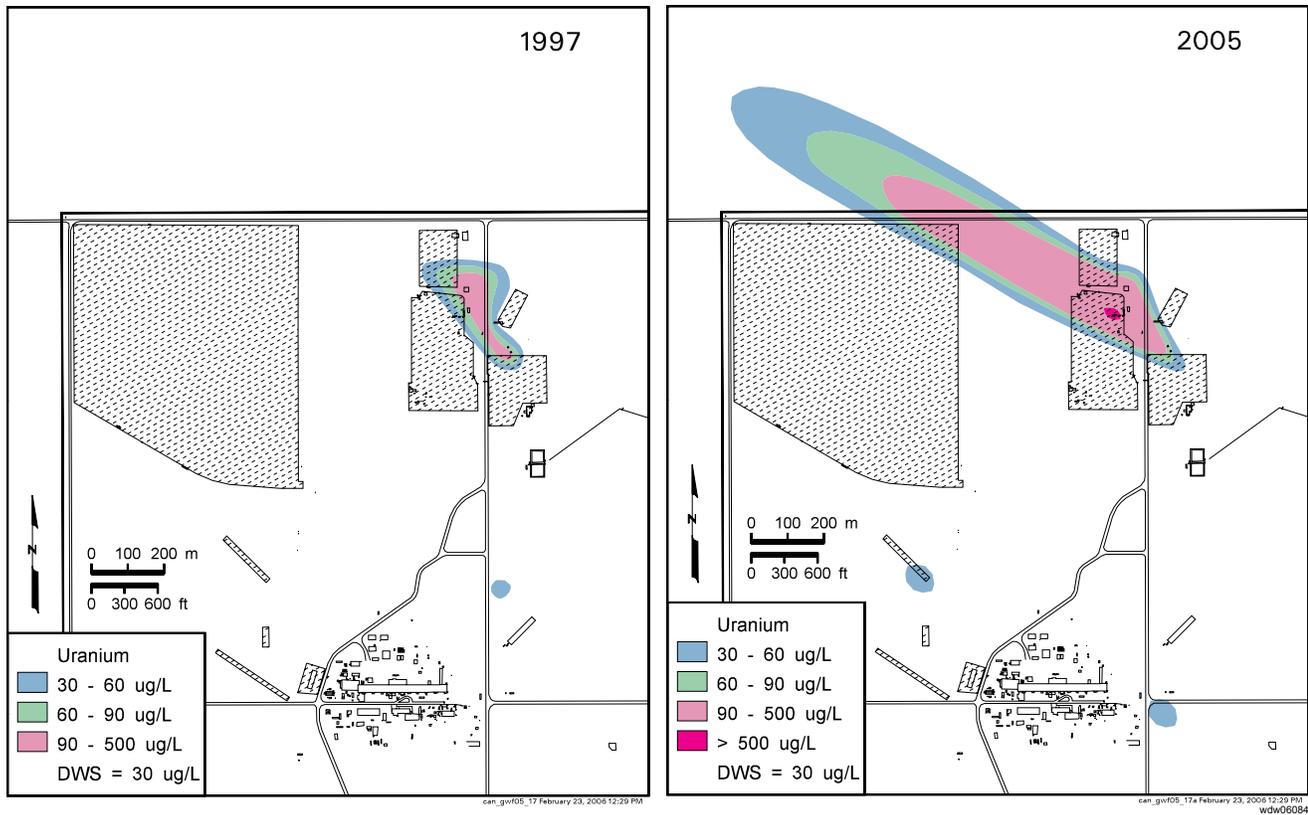
Waste Management Area S-SX. RCRA assessment monitoring continued in FY 2005. Groundwater beneath this waste management area is contaminated with nitrate, hexavalent chromium, and technetium-99 attributed to two general source areas within the waste management area. Technetium-99, nitrate, and chromium 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 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.

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.



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.

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

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

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.

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.

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.

<u>Site</u>	<u>Downgradient</u>	<u>Upgradient</u>	<u>Comments</u>
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	

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

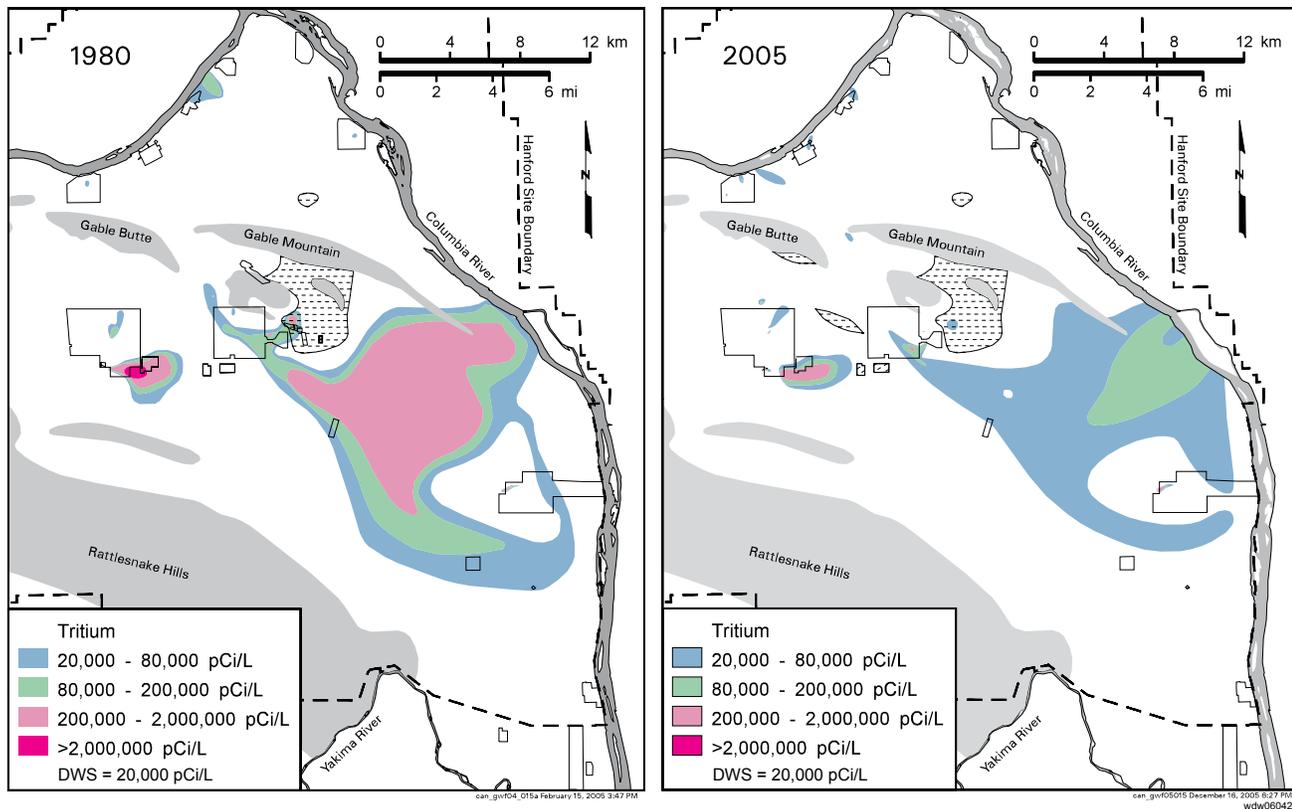
This operable unit encompasses the south portion of the 200 East Area and a large portion of the Hanford Site extending to the east and southeast that is contaminated with plumes of tritium, nitrate, and iodine-129 that exceed drinking water standards. Concentrations of tritium continued to decline as 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.

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 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

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



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.

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.

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.

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.

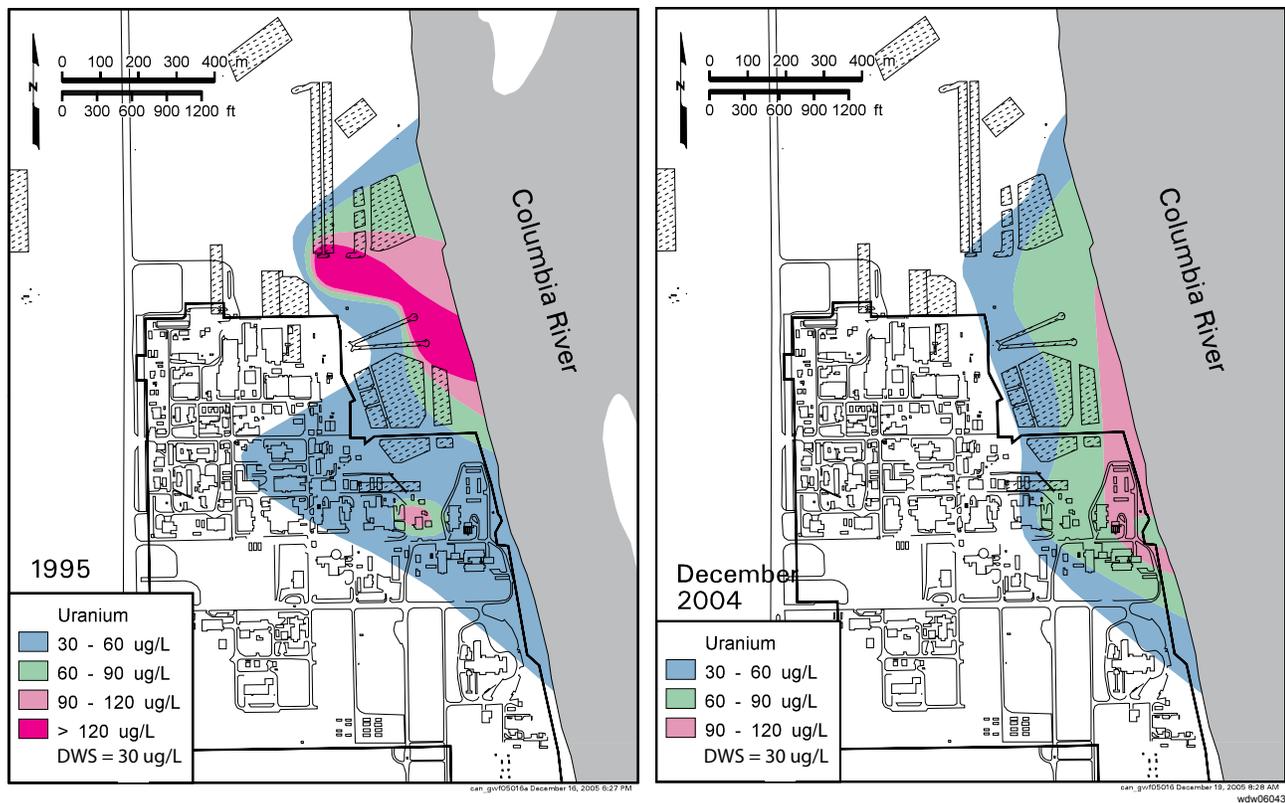
300-FF-5 Operable Unit

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



This photo shows cable tool drilling of new wells in the 300 Area on the Hanford Site.

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



The uranium plume in the 300 Area, at the 30- $\mu\text{g/L}$ level, is attenuating very slowly. DOE is investigating alternatives for more rapid remediation.

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 $\mu\text{g/L}$) 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.

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

Contaminants of concern in 300 Area groundwater are uranium, trichloroethene, and cis-1,2-dichloroethene.

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.

1100-EM-1 Operable Unit

Trichloroethene was the primary contaminant of concern at the 1100-EM-1 Operable Unit, located in the south part of the Hanford Site. 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

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

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

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

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.

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

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.

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.

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



Twenty-seven new wells were drilled on the Hanford Site in CY 2005. Some of them are monitoring wells to replace dry wells or to gather additional information (shown above). Other wells support groundwater remediation.

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.

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.

Vadose zone studies help determine new, innovative methods for cleanup and monitoring.

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.

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



Workers measure water-levels during new well acceptance inspection. Water-level monitoring helps determine groundwater flow beneath the Hanford Site.

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.

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.

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.

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/>.

Glossary

Aquifer – A water-bearing, geologic formation below the surface of the earth that can supply water for a well or spring.

CERCLA – *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (42 USC 9601 et seq. as amended); federal law, enacted in 1980 and amended in 1986, that governs the cleanup of hazardous, toxic, and radioactive substances.

Confined aquifer – An aquifer bounded above and below by less-permeable layers. Groundwater in the confined aquifer is under a pressure greater than atmospheric pressure. Aquifers within the Columbia River Basalt underlying the Hanford Site are confined aquifers.

Groundwater – Groundwater is water that occurs below the earth's surface. It is found within the pores of sand and gravel or the cracks of fractured rock beneath the land and is invisible to the naked eye. Gravity causes groundwater under the Hanford Site to move toward the Columbia River. In this manner, groundwater may carry contamination from Hanford into the river.

Pore water – Water in the minute spaces of the substrate that forms the bottom of the Columbia River; for example, groundwater in springs between rocks.

RCRA – *Resource Conservation and Recovery Act of 1976* (42 USC 6901 et seq. as amended, Public Law 94-580); federal law enacted in 1976 to address the treatment, storage, and disposal of hazardous waste.

Unconfined aquifer – An aquifer containing groundwater that is not confined above by relatively impermeable rocks. The pressure at the top of the unconfined aquifer is equal to that of the atmosphere. At Hanford, the unconfined aquifer is the uppermost aquifer and is most susceptible to contamination from site operations.

Vadose zone – The hydrogeologic region between the surface of the land and the water table.

Water table – Theoretical surface represented by the elevation of water surfaces in wells penetrating only a short distance into the unconfined aquifer.

Inquiries regarding this report and the main *Hanford Site Groundwater Monitoring Report for Fiscal Year 2005* may be directed to M. J. Hartman, Pacific Northwest National Laboratory, P.O. Box 999, K6-96, Richland, Washington, 99352; or send inquiries by electronic mail to mary.hartman@pnl.gov