8.7 Groundwater Monitoring

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DOE has monitored groundwater on the Hanford Site since the 1940s to help determine what chemical and radiological contaminants have made their way into the groundwater. An evaluation of groundwater quality of the Hanford Site is documented in an annual groundwater monitoring report (PNNL-15070).

Plutonium production activities on the Hanford Site produced contaminants that reached the Columbia River by moving down through the vadose zone, into the groundwater, and then into the river. The analysis of groundwater samples helps determine the potential effects that contaminants could have on human health and the environment. DOE works with regulatory agencies, such as EPA and the Washington State Department of Ecology, to make groundwater-cleanup decisions based on sound technical information and the technical capabilities available.

8.7.1 Highlights and Emerging Issues

DOE's major accomplishments related to groundwater monitoring in 2004, and emerging issues of potential concern, are outlined in the following paragraphs.

8.7.1.1 Groundwater Monitoring Highlights

Number of Wells Sampled in 2004. Workers sampled 727 monitoring wells and 154 shoreline aquifer tubes in 2004 to determine the distribution and movement of contaminants in Hanford Site groundwater. Many of the wells were sampled multiple times during the year.

Number of Sample Analyses in 2004. Two thousand one hundred and sixty-five samples of Hanford groundwater were analyzed for chromium, 1,514 for nitrate, and 1,146 for tritium. Other constituents frequently analyzed for included carbon tetrachloride analyzed in 653 samples, technetium-99 analyzed in 779 samples, and uranium analyzed in 732 samples. Summaries that account for the number of all groundwater wells monitored and the number of analyses performed on samples from the wells during 2004 according to groundwater interest area and monitoring purpose are provided in Tables 8.7.1 and 8.7.2, respectively.

Monitoring Tritium in Groundwater at the KE Basin. Tritium levels began to rise in January 2003 in a well downgradient of the KE Basin, exceeding 100,000 pCi/L (3,700 Bq/L) in October 2003 and subsequently declining to approximately 40,000 pCi/L (1,500 Bq/L) in October 2004. (The drinking water standard for tritium is 20,000 pCi/L [740 Bq/L].) Because there are multiple sources of tritium in the area, no mobile co-contaminants such as technetium-99 are found with the tritium, and there is no evidence of measurable water losses from the KE Basin, scientists cannot conclude with certainty that the recent rise in tritium is a result of current loss of KE Basin shielding water to the ground. Other potential sources of tritium include remobilization of tritium in the soil from a 1993 basin leak and remobilization of tritium in the soil from the remediation of condensate cribs. Cracks have been found in the concrete basins that still contain sludge and shielding water contaminated with tritium and other radionuclides. The extent of the cracking and possible impact on groundwater are being investigated. The frequency of groundwater sample collection downgradient of the KE Basin has been increased.

Monitoring Technetium-99 in Groundwater at Waste Management Area T. Concentrations of technetium-99 continued to increase in wells on the east side (downgradient) of the T Tank Farm in 2004. Water from well

Table 8.7.1. Summary of Hanford Site Groundwater Performance Assessment Project by Groundwater Interest Area, 2004

	Hanford Site	100-BC-5	100-FR-3	100-HR-3-D	100-HR-3-H	100-KR-4	100-NR-2
Number of wells and aquifer tubes	881	41	46	110	58	49	54
Number of sampling events	2,233	51	62	345	168	191	170
Number of analyses	25,835	379	560	2,569	1,072	1,189	2,066
Number of results	79,093	693	2,214	4,758	2,548	2,832	4,748
Percent of non-detected results	49	26	50	21	28	32	35
	1100-EM-1	**200-BP-5**	**200-PO-1**	**200-UP-1**	**200-ZP-1**	**300-FF-5**	
Number of wells	58	109	132	67	89	68	
Number of sampling events	81	239	230	207	296	193	
Number of analyses	678	5,302	4,065	2,612	3,558	1,785	
Number of results	1,921	13,354	11,367	11,453	15,702	7,503	
Percent of non-detected results	54	45	49	58	59	65	

Table 8.7.2. Summary of Hanford Site Groundwater Performance Assessment Project by Monitoring Purpose,[a] 2004

	Restoration[b]	Waste Management[c]	Environmental Surveillance[d]
Number of wells	565	243	329
Number of sampling events	1,476	743	855
Number of analyses	13,862	13,076	8,411
Number of results	44,395	38,359	24,950
Percent of non-detected results	51	48	49

(a) Because of the co-sampling among groundwater monitoring programs, the wells monitored, sampling events, analyses, results, and non-detectable results overlap between monitoring purposes.
(b) Wells associated with remediation activities.
(c) Wells sampled to determine impact, if any, to a waste management unit (e.g., RCRA) on groundwater.
(d) Wells sampled to detect impact, if any, of site operations on groundwater over the entire Hanford Site and adjacent offsite areas.

299-W11-39, near the northeast corner of the waste management area, had a technetium-99 concentration of 21,400 pCi/L (790 Bq/L) in 2004, more than double the 2003 concentration of 9,140 pCi/L (338 Bq/L). (The drinking water standard for technetium-99 is 900 pCi/L [33 Bq/L].) Preliminary data from a new well installed in early 2005 east of Waste Management Area T showed a technetium-99 concentration in well water of 182,000 pCi/L (673 Bq/L) at approximately 10 meters (33 feet) below the water table. DOE will work with the regulatory agencies to develop actions in response to the technetium-99 increases.

Well Spacing at Hanford Site Low-Level Burial Grounds. DOE and the Washington State Department of Ecology have been holding workshops regarding some aspects of groundwater monitoring at the low-level (low-activity waste) burial grounds, which are located in the 200-West and 200-East Areas. One of the issues to be resolved is the spacing and number of groundwater monitoring wells to be installed at these burial grounds to meet RCRA groundwater monitoring requirements.

Alternative Statistics for Evaluating Data from RCRA Sites. DOE completed data collection and evaluation of an alternative statistical method for evaluating groundwater monitoring data to determine if a site has affected groundwater quality. This method, using control charts (a graphical tool for monitoring changes), has been proposed to the Washington State Department of Ecology for use in RCRA groundwater monitoring. It is hoped that discussions with the Washington State Department of Ecology in the next year will resolve the applicability of this method.

Well Decommissioning. DOE has accelerated the rate at which at-risk and unused Hanford Site wells are being decommissioned. This activity will continue to be a high priority for DOE to prevent unused wells from acting as a potential pathway for vertical movement of groundwater contaminants.

Cleanup Feasibility Studies. DOE began a focused feasibility study for cleanup of the 300-FF-5 Operable Unit, which will lead to final remediation decisions. A similar study is scheduled to begin for the 200-BP-5 Operable Unit in 2005.

8.7.1.2 Groundwater Monitoring at Operable Units

CERCLA-related groundwater monitoring continued at 11 operable units during 2004 (Figure 8.7.1).

Monitored Natural Attenuation. Average trichloroethene concentrations in monitoring wells in the 1100-EM-1 Operable Unit (in the former 1100 Area; Figure 8.7.1) remained below the 5-µg/L (0.005 parts per million) drinking water standard. This contaminant has been attenuating naturally. Average trichloroethene concentrations also remained below the drinking water standard in the 300-FF-5 Operable Unit (300 Area). Uranium, another contaminant of concern in the 300 Area, is slow to attenuate and DOE is investigating alternative remedial actions.

Working Toward Final Groundwater Remediation Decisions. Final decisions for groundwater remediation have been made only for the 1100-EM-1 Operable Unit. During 2004, DOE and the regulatory agencies continued the process to determine what information is needed to make final decisions for the 100-BC-5, 100-FR-3, 200-BP-5, 200-UP-1, 200-ZP-1, 200-PO-1, and 300-FF-5 Operable Units (Figure 8.7.1).

8.7.1.3 Groundwater Monitoring at Waste Facilities

Monitoring at RCRA Units. Monitoring continued in 2004 at 24 RCRA units (or waste management areas) on the Hanford Site (Table 8.7.3 and Figure 8.7.2). At the end of 2004, 15 RCRA waste management areas were monitored to detect whether they were contaminating groundwater with hazardous constituents. Seven waste management areas were monitored to assess the extent of known contaminants, and two were monitored to determine the progress of corrective action for groundwater contamination. The facilities monitored under RCRA are scheduled for closure under the Hanford Site Part B RCRA Permit except for the Liquid Effluent Retention Facility, low-level burial grounds (Waste Management Areas 1 to 4), and the planned Integrated Disposal Facility; these will receive permits as operating facilities.

Monitoring at Other Regulated Units. Groundwater monitoring was required for four regulated, non-RCRA waste facilities in 2004 (Table 8.7.3). The 200 Area Treated Effluent Disposal Facility and State-Approved Land Disposal Site are monitored under state discharge permits (WAC 173-216). The Solid Waste Landfill is monitored for the requirements of WAC 173-304, *Minimum Functional Standards for Solid Waste Handling*. The Environmental Restoration Disposal Facility is a low-level, mixed waste facility where waste from surface remedial actions on the Hanford Site is disposed. Groundwater monitoring is conducted in accordance with a CERCLA record of decision. These facilities are monitored for waste constituents specified in their permits or other regulatory agreements.

8.7.2 Groundwater Flow and Movement

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 distributions of contaminants.

General directions of groundwater flow are illustrated on the map for March 2004 (Figure 8.7.3). Beneath the reactor areas, groundwater flows generally toward the Columbia River. Farther inland, north of Gable Mountain, flow is toward the northeast and east. Groundwater flows eastward beneath the 200 Areas and then flows to the southeast or north through the gap between Gable Butte and Gable Mountain. Groundwater converges on the 300 Area from the northwest, west, and southwest and discharges into the Columbia River to the east. Groundwater in the area south of the Hanford Site flows generally eastward to the Columbia River.

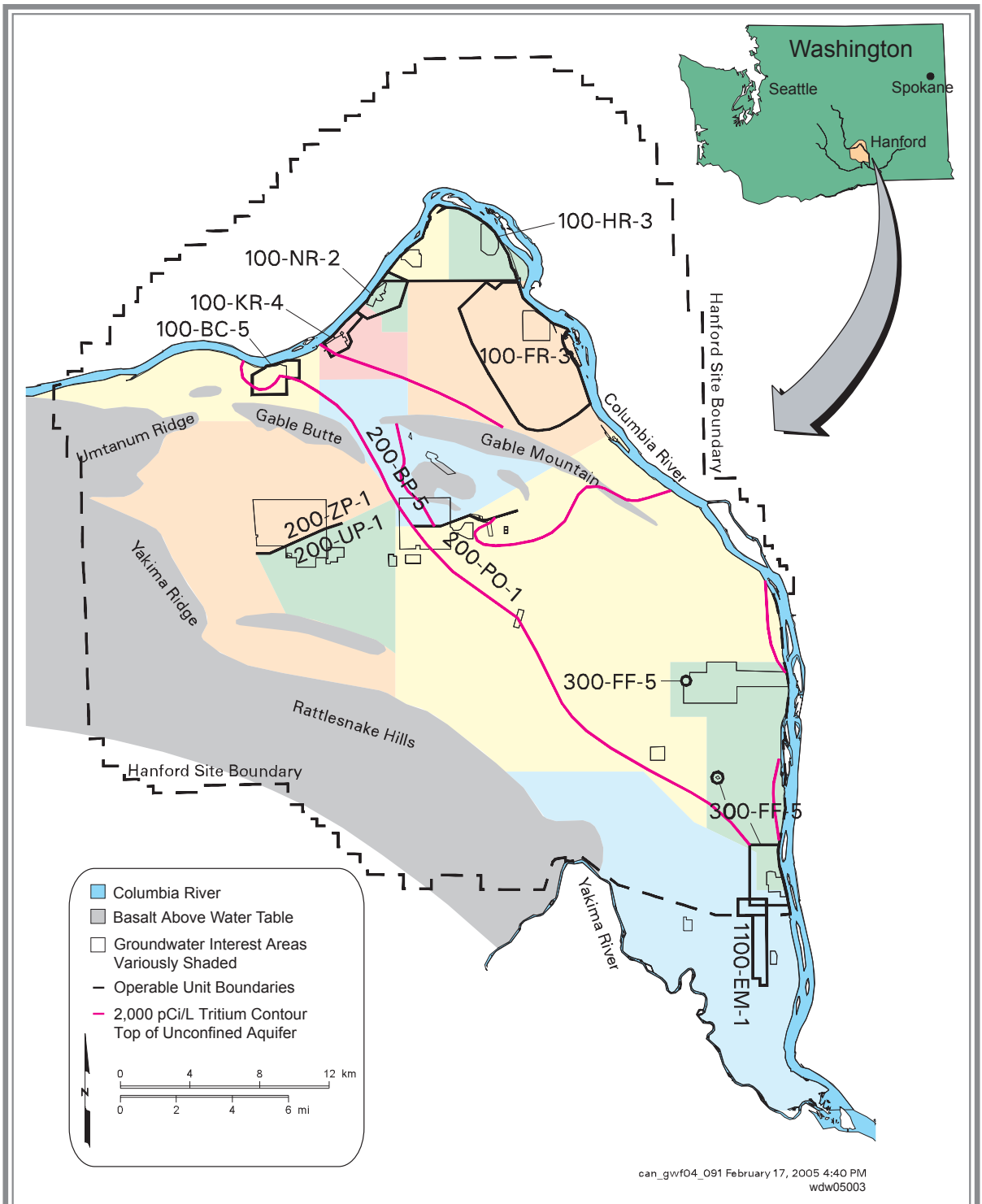

Figure 8.7.1. Groundwater Interest Areas on the Hanford Site in 2004

Table 8.7.3 Regulated Units Requiring Groundwater Monitoring on the Hanford Site, 2004

Site or Waste Management Area	Type of Monitoring Program	Regulated Under	2004 Highlights
	RCRA Regulated Units		
116-N-1 (1301-N) facility	Final status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
116-N-3 (1325-N) facility	Final status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
120-N-1, 120-N-2 (1324-N/NA) facilities	Final status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
116-H-6 (183-H) evaporation basins	Final status corrective action	WAC 173-303-645(11)(g)	Monitoring during CERCLA interim action; chromium, nitrate, technetium-99, uranium
216-A-29 ditch	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
216-B-3 pond	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Reverted to conventional statistics
216-S-10 pond and ditch	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection;[a] only two shallow and one deep downgradient wells remain
216-U-12 crib	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment; only two downgradient wells, no upgradient wells remain
316-5 process trenches	Final status corrective action	WAC 173-303-645(11)(g)	Monitoring during CERCLA natural attenuation interim action; uranium and organics
Integrated Disposal Facility	Pending completion of network	WAC 173-303-645	Planned facility; 5 of 8 wells in place
Liquid Effluent Retention Facility	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Insufficient wells; no statistical comparisons
Low-Level Waste Management Area 1	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
Low-Level Waste Management Area 2	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection;[a] north wells dry; no unconfined aquifer
Low-Level Waste Management Area 3	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection;[a] three wells went dry
Low-Level Waste Management Area 4	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a] until last shallow downgradient well went dry
Nonradioactive Dangerous Waste Landfill	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
PUREX cribs	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment; iodine-129, nitrate, and tritium
SST Waste Management Area A-AX	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection;[a] two corroded wells decommissioned; two new wells installed
SST Waste Management Area B-BX-BY	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment; nitrate, nitrite, technetium-99, uranium; 3 wells installed.
SST Waste Management Area C	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Temporarily ceased upgradient/ downgradient comparisons
SST Waste Management Area S-SX	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment; chromium, technetium-99; new well planned

Table 8.7.3 (cont'd)

Site or Waste Management Area	Type of Monitoring Program	Regulated Under	2004 Highlights
SST Waste Management Area T	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment; technetium-99; 3 new wells planned
SST Waste Management Area TX-TY	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment; chromium, technetium-99; new well planned
SST Waste Management Area U	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment; nitrate, technetium-99; one well installed
Other Regulated Units			
200 Area Treated Effluent Disposal Facility	Compliance with permit	WAC 173-216	No influence on upper aquifer
Environmental Restoration Disposal Facility	Similar to RCRA detection	ROD 1995	No impact on groundwater
State Approved Land Disposal Site	Compliance with permit	WAC 173-216	No permit limits exceeded; 2 dry wells
Solid Waste Landfill	Compliance with permit	WAC 173-304	Five constituents exceeded background or standards; low levels of organics

(a) Analysis of RCRA CIP provided no evidence of groundwater contamination with hazardous constituents from the unit.
CIP = Contamination indicator parameters.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*.
CFR = *Code of Federal Regulations*.
PUREX = Plutonium-Uranium Extraction Plant.
RCRA = *Resource Conservation and Recovery Act*.
ROD = Record of decision.
SST = Single-shell tank.
WAC = *Washington Administrative Code*.

The natural pattern of groundwater flow was altered during the Hanford Site's operating years by the formation of mounds in the water table. 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 are disappearing.

East of the 200-East Area, a fine-grained confining unit creates a barrier to 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 confined aquifer still is influenced by a recharge mound.

Groundwater in the upper basalt-confined aquifer generally flows from west to east across the Hanford Site, up through 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. Therefore, there is little potential for contaminants to migrate from the unconfined aquifer into the basalt-confined aquifer, where it could move offsite. Downward gradients are measured beneath the west portion of the Hanford Site and north and east of the Columbia River.

8.7.3 Groundwater Monitoring Results

This section summarizes results of Hanford Site groundwater monitoring for various requirements, including RCRA and CERCLA monitoring.

8.7.3.1 Overview

DOE has developed a plan to accelerate cleanup of Hanford's groundwater, which will return it to its beneficial use where practicable or will at least prevent further degradation (DOE/RL-2002-68). Specific results that can be expected using the accelerated plan include (a) remediating

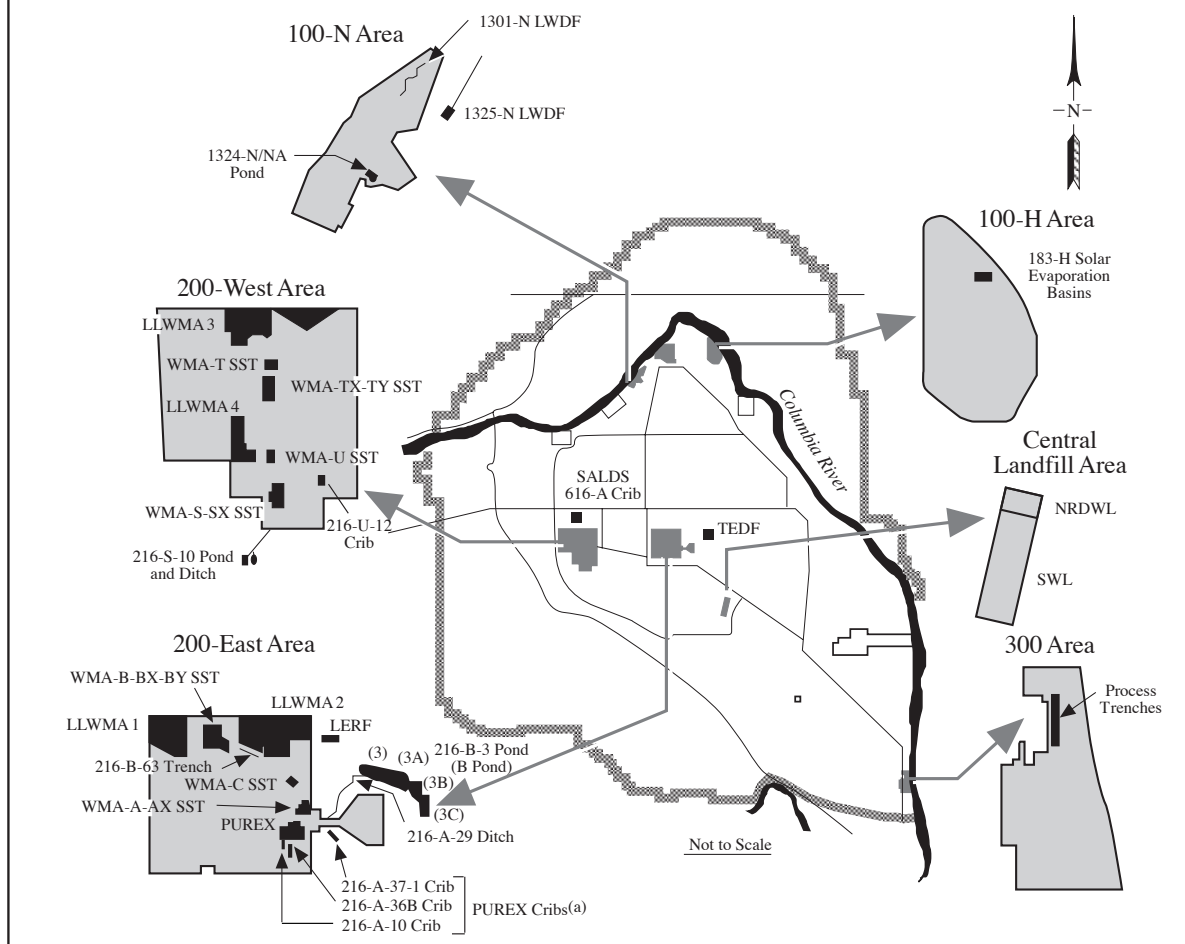

Figure 8.7.2. Locations of the Regulated Waste Management Units on the Hanford Site During 2004

waste sites that pose the highest risk to groundwater, (b) shrinking the contaminated areas, (c) reducing groundwater recharge associated with operational discharges to the ground, (d) remediating groundwater, and (e) monitoring groundwater contaminant levels. Figures 8.7.4 and 8.7.5 show the distribution of nine principal groundwater contaminant plumes.

The total area of radiological and chemical contaminant plumes with contaminant concentrations exceeding drinking water standards was estimated to be approximately 170 square kilometers (66 square miles) during 2004 (Table 8.7.4). This area occupies 11.2% of the total area of the Hanford Site. The tritium and iodine-129 plumes have the largest areas with concentrations exceeding drinking water standards. These 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

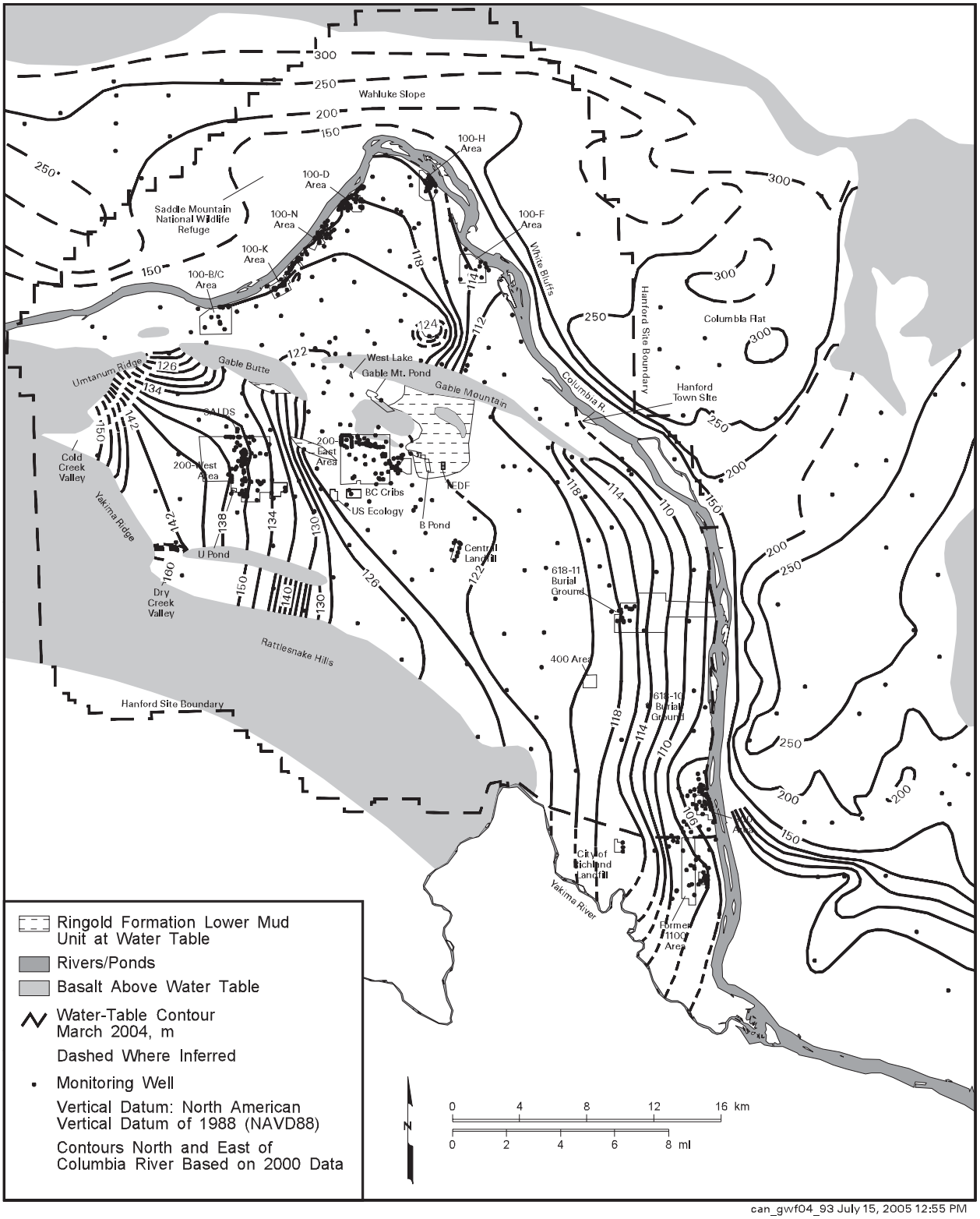

Figure 8.7.3. Water-Table Elevations and Inferred Flow Direction for the Unconfined Aquifer at the Hanford Site, March 2004

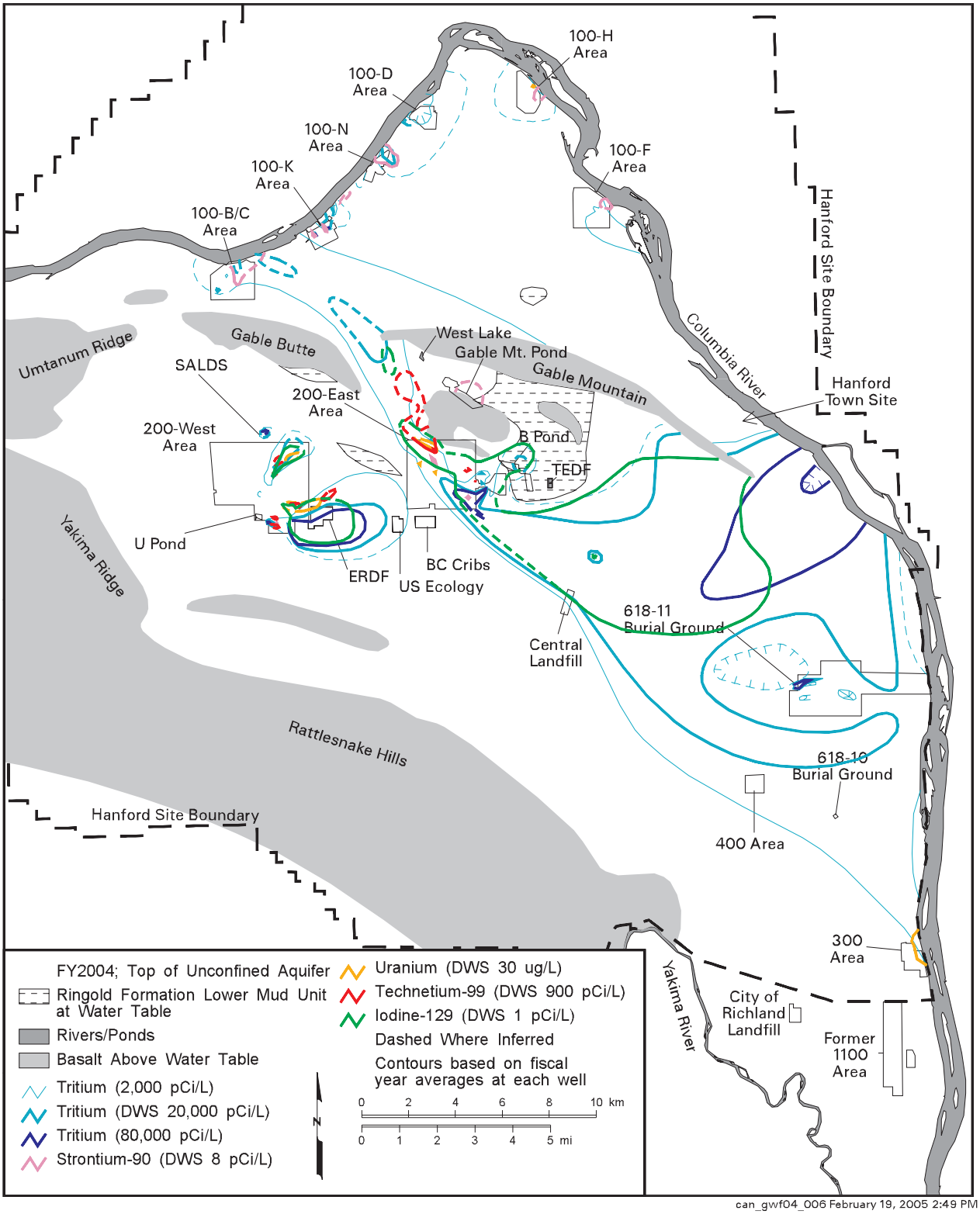

Figure 8.7.4. Distribution of Major Radionuclides in Hanford Site Groundwater at Concentrations Above Drinking Water Standards During 2004

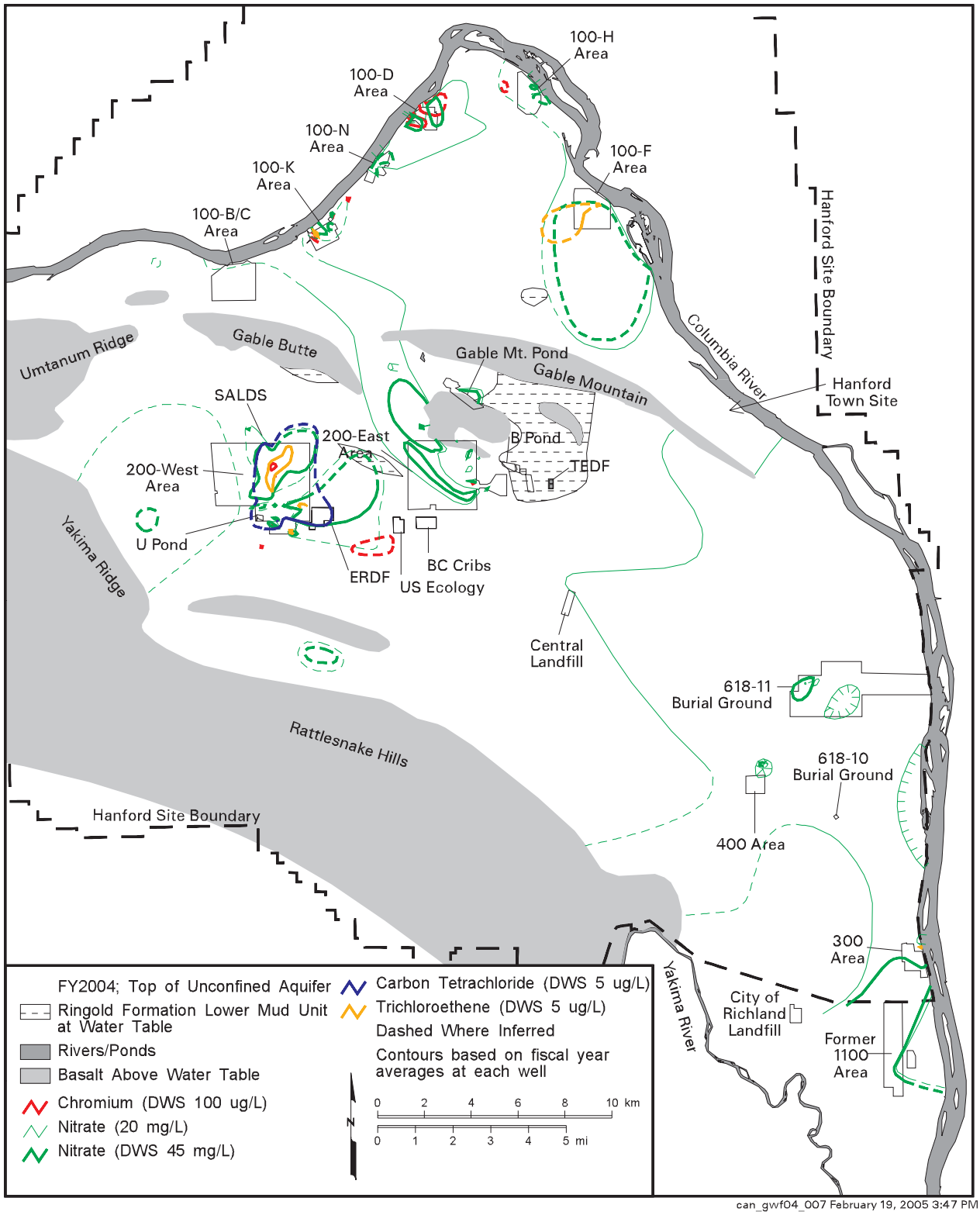

Figure 8.7.5. Distribution of Major Hazardous Chemicals in Hanford Site Groundwater at Concentrations Above Drinking Water Standards During 2004

Table 8.7.4. Areas of Contaminant Plumes on the Hanford Site at Levels Above Drinking Water Standards, 2004

Constituent	Drinking Water Standard	Area (km^2)	Constituent	Drinking Water Standard	Area (km^2)
Tritium	20,000 pCi/L	138	Dissolved chromium	100 µg/L	2.3
Iodine-129	1 pCi/L	74.4	Strontium-90	8 pCi/L	2.6
Nitrate	45 mg/L	42.2	Technetium-99	900 pCi/L	2.4
Carbon tetrachloride	5 µg/L	10.9	Total uranium	30 µg/L	1.3
Trichloroethene	5 µg/L	3.3	Combined plumes		171[(a)]

(a) Total reflects some overlap of contaminant plumes.
1 pCi/L = 0.037 Bq/L.
1 µg/L = 0.001 ppm.
1 mg/L = 1 ppm.

northward from the 200-East Area. Uranium is less mobile than tritium, iodine-129, or technetium-99; smaller uranium plumes are found in the 200-East, 200-West, and 300 Areas. Strontium-90 is not very mobile in groundwater, but it forms a plume in the 100-N Area and exceeds the drinking water standard in each of the 100 Areas. Other radionuclides including cesium-137 and cobalt-60 are even less mobile in the subsurface and rarely exceed drinking water standards in Hanford Site groundwater.

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 the 200-West Area, and trichloroethene. The largest trichloroethene plume is found in the 200-West Area with smaller plumes in the 100-K and 100-F Areas. Chromium contamination underlies portions of the 100-K, 100-D, and 100-H Areas. Smaller plumes of chromium contamination also are present in the 200 Areas, particularly the north part of 200-West Area.

Summaries of maximum concentrations in Hanford Site groundwater for the most widespread contaminants are presented by groundwater interest area in Table 8.7.5 and by monitoring purpose in Table 8.7.6. As expected, most of the maximum concentrations were detected in the 100 and 200 Areas because these areas contain the largest number of waste sites that have affected groundwater quality. For each monitoring purpose, the maximum concentrations detected were greater than the drinking water standards for all of the most widespread contaminants listed in Table 8.7.6. A list of drinking water standards for these contaminants is provided in Table D.2 in Appendix D.

The following text discusses groundwater contamination, monitoring, and remediation in each of the 11 groundwater operable units (Figure 8.7.1) and in the confined aquifers.

8.7.3.2 Groundwater Monitoring Results for the 100-BC-5 Operable Unit

The 100-BC-5 Operable Unit includes the groundwater beneath the 100-B/C Area (Figure 8.7.1). Most of the groundwater contamination in this unit is found in the north portion of the area, beneath former waste trenches and retention basins. In 2004, tritium and strontium-90 exceeded drinking water standards in several wells. Nitrate and chromium were somewhat elevated, but have been below drinking water standards in recent years.

8.7.3.3 Groundwater Monitoring Results for the 100-KR-4 Operable Unit

The principal groundwater issues in the 100-KR-4 Operable Unit include (a) remediation of groundwater beneath a large liquid-waste disposal trench, (b) tracking contaminant plumes from other past-practices sites, and (c) monitoring groundwater contaminants near the KE and KW Basins. Monitoring to detect leaks is underway for

Table 8.7.5. Summary of Maximum Contaminant Concentrations in Hanford Site Groundwater by Groundwater Interest Area, 2004

	Hanford Site	100-BC-5	100-FR-3	100-HR-3-D	100-HR-3-H	100-KR-4	100-NR-2
Tritium (pCi/L)	2,320,000	41,000	12,600	31,900	5,160	636,000	28,600
Iodine-129 (pCi/L)	24.8	NA	NA	NA	NA	NA	NA
Nitrate (mg/L)	7,610	28.8	166	70.8	244	132	270
Carbon tetrachloride (µg/L)	5,600	ND	ND	NA	NA	ND	ND
Trichloroethene (µg/L)	15	NA	9.2	NA	NA	5.5	ND
Filtered chromium (µg/L)	2,864	33	61.1	2,864	132	565	170
Strontium-90 (pCi/L)	7,390	39	22.6	8.2	38.8	2,380	7,390
Technetium-99 (pCi/L)	62,300	124	150	ND	694	148	ND
Total uranium (µg/L)	599	NA	22.7	5.8	93.5	NA	NA

	1100-EM-1	200-BP-5	200-PO-1	200-UP-1	200-ZP-1	300-FF-5
Tritium (pCi/L)	394	45,300	616,000	339,000	1,830,000	2,320,000
Iodine-129 (pCi/L)	ND	5.8	9.9	13.6	24.8	ND
Nitrate (mg/L)	239	1,590	132	522	7,610	111
Carbon tetrachloride (µg/L)	ND	ND	0.29	650	5,600	0.45
Trichloroethene (µg/L)	2.3	ND	1.1	7.1	15	6.8
Dissolved chromium (µg/L)	ND	56.8	73.7	558	733	10.9
Strontium-90 (pCi/L)	ND	6,360	21.1	32	1.4	3.4
Technetium-99 (pCi/L)	24.4	23,100	13,000	62,300	21,400	36.2
Total uranium (µg/L)	19.6	590	7.1	599	250	241

NA = Not analyzed.
ND = Not detected.

Table 8.7.6. Summary of Maximum Contaminant Concentrations in Hanford Site Groundwater by Monitoring Purpose, 2004

	Restoration	Waste Management	Environmental Surveillance
Tritium (pCi/L)	2,320,000	1,830,000	2,320,000
Iodine-129 (pCi/L)	13.6	24.8	7.1
Nitrate (mg/L)	7,610	7,610	730
Carbon tetrachloride (µg/L)	5,600	3,000	1,700
Trichloroethene (µg/L)	15	15	14
Dissolved chromium (µg/L)	2,864	733	2,864
Strontium-90 (pCi/L)	7,390	1,200	7,390
Technetium-99 (pCi/L)	11,100	62,300	11,100
Total uranium (µg/L)	590	590	599

the two basins, which are currently undergoing decontamination and decommissioning. New monitoring capabilities were added during 2004 in the form of additional aquifer tube sites along the 100-K Area shoreline of the Columbia River. Two new groundwater wells were installed in 2004 to support the interim remedial action.

Interim Remedial Action. Groundwater beneath a liquid-waste disposal trench is being pumped and treated to reduce the amount of chromium reaching the Columbia River (see Section 8.7.4). The area of highest contamination has decreased in recent years.

Monitoring at Past-Practices Waste Sites. Contaminants of potential concern in the 100-KR-4 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 years of reactor operations (1955 to 1971). While levels for all contaminants of concern remain above drinking water standards, decisions regarding remedial actions have been deferred until the waste sites are cleaned up. Some recent variability in contaminant concentrations is believed to be caused by remobilization of contaminants held in the vadose zone. Remobilization may result from infiltrating water from the ground surface or because of activities associated with remedial actions (e.g., excavation of waste sites).

Monitoring at K Basins. The KE and KW Basins are integral parts of the KE and KW Reactor buildings. Groundwater monitoring is conducted to help detect and evaluate any potential loss of water from the basins to the ground, because the remaining shielding water in the basins is highly contaminated with radionuclides. The last well-documented leakage of shielding water occurred in 1993 from a construction joint associated with the KE Basin. There has been no documented leakage from the KW Basin.

8.7.3.4 Groundwater Monitoring Results for the 100-NR-2 Operable Unit

The primary contaminant of concern in the 100-NR-2 Operable Unit is strontium-90, which is the focus of a pump-and-treat system that is intended to divert the contaminant from the Columbia River (see Section 8.7.4). Strontium-90 concentrations are variable and the size and shape of the plume have been stable for many years.

Four RCRA units are located in the 100-NR-2 Operable Units: 116-N-1, 116-N-3, 120-N-1, and 120-N-2 (also known as the 1301-N, 1325-N, 1324-N, and 1324-NA facilities). During 2004, these sites remained in detection monitoring programs to determine if the sites have affected groundwater quality with dangerous waste constituents.

8.7.3.5 Groundwater Monitoring Results for the 100-HR-3-D Operable Unit

The 100-HR-3 Operable Unit underlies the 100-D and 100-H Areas and the region between. The informally named 100-HR-3-D groundwater interest area comprises the west part of the 100-HR-3 Operable Unit, which includes the 100-D Area. Chromium is the primary contaminant of concern in the 100-D Area. The source of this contaminant was reactor cooling water treated with sodium dichromate to inhibit corrosion and discharged to cribs and ditches. Chromium is distributed in two plumes that are the targets of interim remedial actions (see Section 8.7.4). In 2004, concentrations of chromium remained above remediation goals in compliance wells. Three new wells and new aquifer tubes were installed in 2004 to support the interim remedial actions in this unit.

Sensor for Detecting Chromium in Groundwater. DOE deployed a sensor for detecting chromium on the 100-D Area Columbia River shoreline in 2004. The purpose of the deployment was to demonstrate the efficacy of such a system in the field. The system can measure chromium concentrations in monitoring wells and aquifer tubes at more frequent intervals than is practical using manual sampling techniques and can record and report results immediately. Results of the limited deployment showed that sensors are suitable for shoreline monitoring at the Hanford Site.

8.7.3.6 Groundwater Monitoring Results for the 100-HR-3-H Operable Unit

The east part of the 100-HR-3 Operable Unit, informally called the 100-HR-3-H groundwater interest area,

underlies the 100-H Area. Chromium is the primary groundwater contaminant of concern in this unit, but the plume is smaller and concentrations are lower than in the 100-D Area chromium plume. Nitrate also is elevated in groundwater here, but concentrations have declined from their peak levels. Strontium-90 concentrations exceed the drinking water standard beneath former wastewater retention basins. Groundwater levels of technetium-99 and uranium are elevated in a small area.

Chromium concentrations have decreased in recent years due to remediation and natural processes (Figure 8.7.6; see Section 8.7.4). However, concentrations in some compliance wells remained above the remediation goal (22 µg/L [0.022 parts per million]). New aquifer tubes were installed in 2004 to improve monitoring coverage along the 100-H Area Columbia River shoreline.

Monitoring at the 116-H-6 (183-H) Evaporation Basins. These former basins compose the only RCRA site in the 100-H Area. Leakage from the basins has contaminated groundwater with chromium, nitrate, and the non-RCRA regulated constituents, technetium-99[(a)] and uranium. The site is being monitored during the post-closure period to track contaminant trends during the operation of the CERCLA interim action (pump-and-treat system) for chromium.

8.7.3.7 Groundwater Monitoring Results for the 100-FR-3 Operable Unit

Nitrate concentrations exceed the drinking water standard in groundwater beneath much of the 100-F Area and

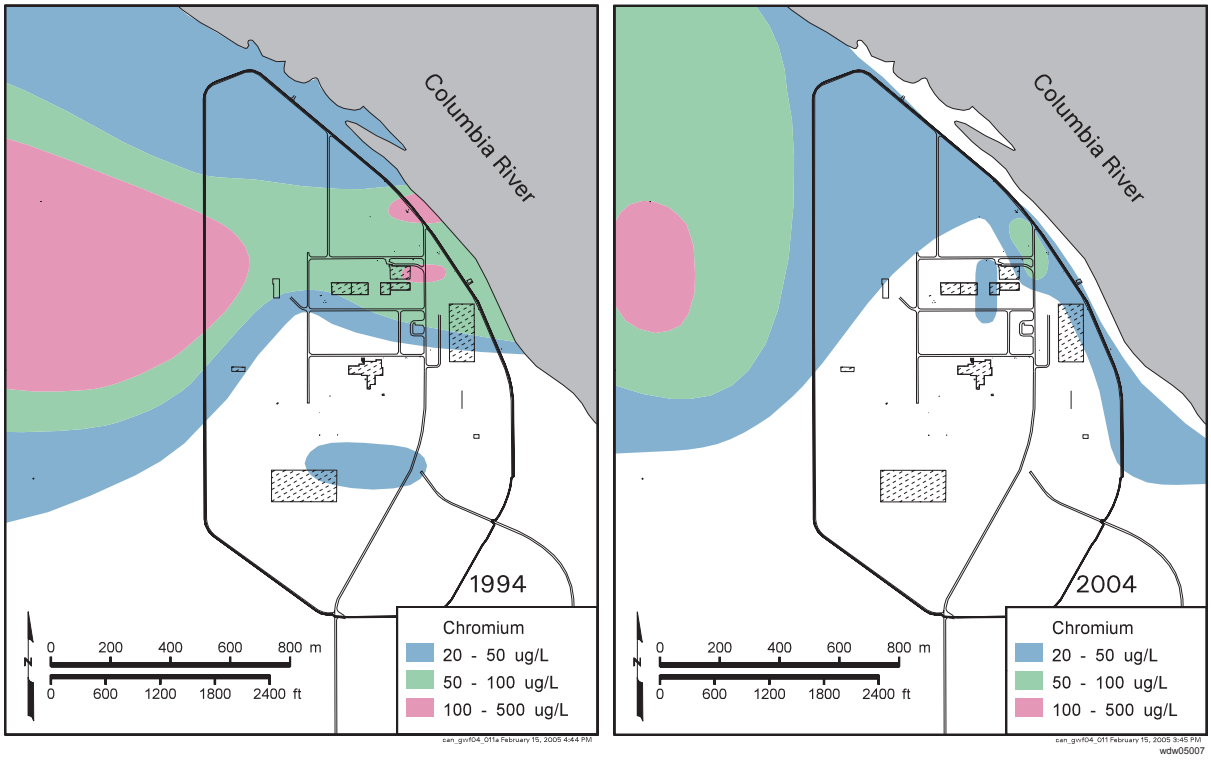

Figure 8.7.6. Influence of Pump-and-Treat Remediation and Natural Processes on Chromium Concentrations in Groundwater Beneath the Hanford Site's 100-H Area, 1994 Compared to 2004

(a) 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 the *Atomic Energy Act* and/or CERCLA. Please note that pursuant to RCRA, the source, special nuclear, and by-product material components of radioactive mixed waste are not regulated under RCRA and are regulated by the DOE acting pursuant to its *Atomic Energy Act* 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 or other RCRA regulatory requirements.

the downgradient region. Other groundwater contaminants include strontium-90 and trichloroethene. New aquifer tubes were installed in 2004 to improve monitoring coverage in this unit at the Columbia River shoreline.

A record of decision has not yet been developed for the 100-FR-3 Operable Unit (Figure 8.7.1), and no active remediation of groundwater is underway. The monitoring of groundwater contaminants in this unit has continued since the initial remedial investigation.

8.7.3.8 Groundwater Monitoring Results for the 200-ZP-1 Operable Unit

The 200-ZP-1 Operable Unit encompasses the northern portion of the 200-West Area (Figure 8.7.1). The primary groundwater contaminant of concern is carbon tetrachloride, which forms the largest plume of chlorinated hydrocarbons on the Hanford Site and is the target of an interim remedial action (see Section 8.7.4). The carbon tetrachloride contamination had sources associated with past 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 200-ZP-1 Operable Unit groundwater include tritium, nitrate, chromium, fluoride, iodine-129, technetium-99, and uranium.

Carbon tetrachloride has migrated vertically and laterally farther in the aquifer than expected. The distribution of carbon tetrachloride is complex because it may travel as a dense, non-aqueous phase liquid, in the gaseous state, and dissolved in water. Most wells in the 200-West Area are screened at the top of the aquifer, but in recent years DOE has begun to study carbon tetrachloride deeper in the aquifer. In 2004, depth-discrete data collected during drilling of a well in the east-central region of the 200-West Area showed carbon tetrachloride concentrations of 32 μg/L (0.032 parts per million) near the water table and 1,300 μg/L (1.3 parts per million) at the bottom of the unconfined aquifer. Samples collected from the Ringold confined aquifer had lower concentrations, declining to 132 μg/L (0.132 parts per million) at the top of the basalt. Similar distribution with depth has been observed in other wells but not ubiquitously. DOE will continue to study the nature and extent of carbon tetrachloride contamination.

The 200-ZP-1 Operable Unit contains four facilities monitored under RCRA and the *Atomic Energy Act* and one site permitted by the state of Washington for waste discharge.

Monitoring at Low-Level Waste Management Areas 3 and 4. RCRA groundwater monitoring in Low-Level Waste Management Areas 3 and 4 (burial grounds) continued under interim status requirements in 2004. Monitoring networks for both of these waste management areas contain fewer than the optimal number of wells for groundwater monitoring because many wells have gone dry. DOE is working with the Washington State Department of Ecology to correct the deficiencies.

In June 2002, DOE submitted an application to incorporate the burial grounds into the Hanford Facility RCRA Permit (Ecology 1994). As part of the application, a groundwater monitoring program was proposed that included adding new wells, monitoring more constituents, and using a different method of statistically evaluating data to determine if the site is affecting groundwater quality. Workshops with the Washington State Department of Ecology to address their comments (i.e., Notice of Deficiency) on this application began in 2003 and continued through 2004.

Monitoring at Waste Management Area T. Results of a RCRA assessment and *Atomic Energy Act* monitoring indicate that Waste Management Area T probably has introduced technetium-99 and other contaminants from underground waste storage tanks to the uppermost aquifer in the area. Additional contamination (carbon tetrachloride, trichloroethene, chromium, and nitrate) from other facilities is likely also present in groundwater beneath the waste management area.

Monitoring at Waste Management Area TX-TY. Results of a RCRA assessment and *Atomic Energy Act* monitoring continued to indicate that groundwater in Waste Management Area TX-TY has been contaminated with chromium and other constituents from underground waste storage tanks. Other nearby sources of contamination make specific source determinations uncertain for some contaminants. Technetium-99, iodine-129, nitrate, and tritium are elevated in groundwater beneath this waste management area.

Monitoring at the State-Approved Land Disposal Site. This active disposal facility is regulated under a Washington State waste discharge permit. The State-Approved Land Disposal Site is located just north of the 200-West Area. Groundwater beneath this facility is monitored for tritium and 15 other constituents. Concentrations in monitoring wells did not exceed permit enforcement limits during 2004.

8.7.3.9 Groundwater Monitoring Results for the 200-UP-1 Operable Unit

The 200-UP-1 Operable Unit underlies the south portion of the 200-West Area (Figure 8.7.1). The primary groundwater contaminants of concern in this operable unit are technetium-99 and uranium, which are the target of an interim remedial action (see Section 8.7.4). Tritium, iodine-129, and nitrate plumes also have sources in this operable unit. Sources of carbon tetrachloride were within the 200-ZP-1 Operable Unit, and the contamination underlies the 200-UP-1 Operable Unit as well.

There are four facilities monitored under RCRA and the *Atomic Energy Act*, one CERCLA interim action, and a CERCLA disposal site in the 200-UP-1 Operable Unit. Monitoring activities are summarized below.

Monitoring at the 216-U-12 Crib. A RCRA assessment and *Atomic Energy Act* monitoring continued at the 216-U-12 crib in 2004 (Figure 8.7.2). 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 regulations. The monitoring network contains just two usable, downgradient wells and no upgradient wells because some wells have gone dry.

Monitoring at the 216-S-10 Pond and Ditch. The 216-S-10 facility continued to be monitored under a RCRA interim status detection program in 2004 (Figure 8.7.2). The current RCRA monitoring network consists of only two downgradient wells because other wells have gone dry.

Monitoring at Waste Management Area S-SX. A RCRA assessment and *Atomic Energy Act* monitoring continued at Waste Management Area S-SX in 2004 (Figure 8.7.2). Groundwater beneath this waste management area is contaminated with nitrate, chromium, and technetium-99 attributed to two general source areas within the waste management area. One well with very high technetium-99 concentrations continued to be purged at least 3,785 liters (1,000 gallons) after each quarterly sampling event in 2004, as the Washington State Department of Ecology requested beginning in 2003.

Monitoring at Waste Management Area U. A RCRA assessment and *Atomic Energy Act* monitoring continued at Waste Management Area U in 2004 (Figure 8.7.2). This 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 chromium, nitrate, and technetium-99. One new well was installed at this waste management area in 2004.

Monitoring at the 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 at the Environmental Restoration Disposal Facility continued to indicate that the facility has not adversely affected groundwater quality. Concentrations of gross beta emissions and chromium in groundwater at this facility declined in 2004 from those observed in 2003.

8.7.3.10 Groundwater Monitoring Results for the 200-BP-5 Operable Unit

The 200-BP-5 Operable Unit (Figure 8.7.1) includes groundwater beneath the north portion of the 200-East Area. Technetium-99 and tritium plumes extend northward between Gable Mountain and Gable Butte. Other contaminants include cesium-137, cobalt-60, cyanide, iodine-129, nitrate, plutonium, strontium-90, and uranium.

Groundwater monitoring under CERCLA continued in 2004. The sampling and analysis plan was revised to integrate *Atomic Energy Act* monitoring with CERCLA monitoring. There is no active groundwater remediation in this operable unit and final remediation decisions are yet to be made.

There are five facilities in the 200-BP-5 Operable Unit that are monitored under RCRA and the *Atomic Energy Act*. Monitoring activities are summarized below.

Monitoring at Waste Management Area B-BX-BY. A RCRA assessment and *Atomic Energy Act* monitoring continued at Waste Management Area B-BX-BY in 2004. Uranium, technetium-99, nitrate, nitrite, and sulfate contamination observed in downgradient wells near this waste management area is believed to result from vertical movement of residual waste left in the soil under the B, BX, and BY Tank Farms. Three new wells were installed at this waste management area in 2004.

Monitoring at Waste Management Area C. Waste Management Area C (Figure 8.7.2) continued to be monitored under the *Atomic Energy Act* and an interim status RCRA detection program in 2004. Technetium-99 and nitrate are elevated in groundwater beneath the waste management area and may have originated in the C Tank Farm.

Monitoring at 216-B-63 Trench. The 216-B-63 trench (Figure 8.7.2) continued to be monitored under an interim status RCRA detection monitoring program in 2004. The average value for total organic carbon in one downgradient well near the 216-B-63 trench was higher in April 2004 than in previous samples. However, the value was below the limit of quantitation, so the results did not trigger assessment monitoring. The limit of quantitation is the level above which quantitative results may be obtained with a specified degree of confidence. The well was sampled in October 2004 and no total organic carbon was detected.

Monitoring at Low-Level Waste Management Areas 1 and 2. Low-Level Waste Management Areas 1 and 2 (Figure 8.7.2) continued to be monitored under RCRA interim status requirements and the *Atomic Energy Act* in 2004. 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 the burial grounds. Most wells in the north part of Low-Level Waste Management Area 2 are dry because of a declining water table.

In June 2002, DOE submitted an application to incorporate the low-level burial grounds into the Hanford Facility RCRA Permit (Ecology 1994). As part of the application, a groundwater monitoring program was proposed that included adding new wells, monitoring more constituents, and using a different method of statistically evaluating data to determine if the site is affecting groundwater quality. Workshops with the Washington State Department of Ecology to address comments (i.e., Notice of Deficiency) on this application began in 2003 and continued through 2004.

Monitoring at the Liquid Effluent Retention Facility. A 2001 letter from the Washington State Department of Ecology directed DOE to discontinue statistical evaluation of groundwater sample results at the Liquid Effluent Retention Facility (Figure 8.7.2) because all but two wells had gone dry and a 1999 variance to allow DOE to operate the remaining wells until an alternative monitoring system could be deployed had expired. DOE has continued to sample the two remaining wells at this facility but is not conducting statistical analyses of the analytical results. DOE and the Washington State Department of Ecology are exploring alternative approaches for monitoring groundwater at this facility.

8.7.3.11 Groundwater Monitoring Results for the 200-PO-1 Operable Unit

The 200-PO-1 Operable Unit (Figure 8.7.1) encompasses the south portion of the 200-East Area and a large portion of the Hanford Site extending to the east and southeast. This operable unit is contaminated with widespread plumes of tritium, nitrate, and iodine-129. Concentrations of tritium continued to decline as the plume attenuates naturally because of radioactive decay and dispersion (Figure 8.7.7). Other contaminants in this unit include strontium-90 and technetium-99, but these are limited to very small areas. CERCLA groundwater monitoring at the 200-PO-1 Operable Unit continued in 2004. There is no active groundwater remediation in this operable unit and final remediation decisions are yet to be made.

There are 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.

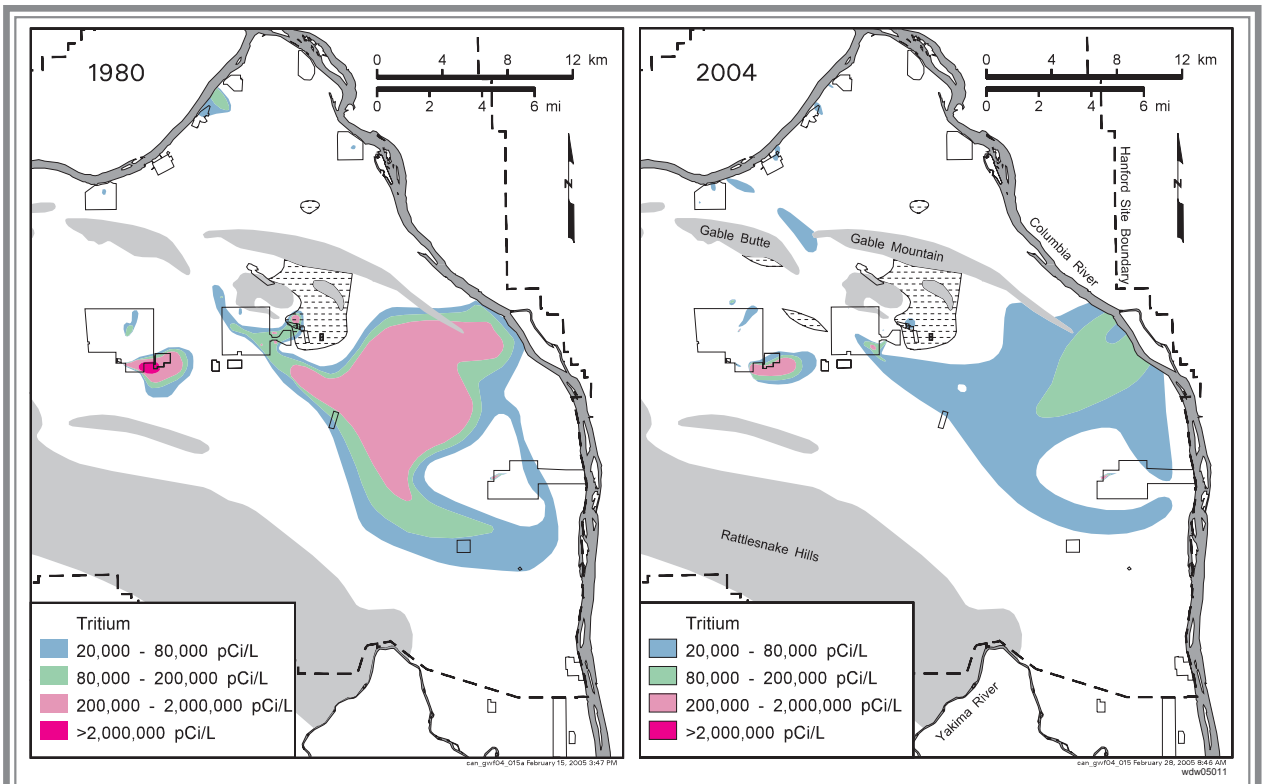

Figure 8.7.7. Tritium Concentrations in Hanford Site Groundwater, 1980 Compared to 2004

Monitoring at the Plutonium-Uranium Extraction (PUREX) Plant Cribs. Three cribs (216-A-10, 216-A-36B, and 216-A-37-1) are monitored at the Plutonium-Uranium Extraction (PUREX) Plant under a RCRA interim status assessment program and the *Atomic Energy Act*. The cribs have contributed to widespread contaminant plumes in the area, including nitrate, tritium, and iodine-129. Data show that over time the nitrate and tritium plumes are generally attenuating throughout most of their area. However, in recent years, the concentration of nitrate in wells near the Plutonium-Uranium Extraction (PUREX) Plant cribs has either held steady or increased.

Monitoring at Waste Management Area A-AX. Waste Management Area A-AX continued to be monitored under a RCRA interim status indicator evaluation program and the *Atomic Energy Act* in 2004. In 2004, one additional upgradient well and a replacement downgradient well were installed at this waste management area. Two downgradient wells formerly monitored for this site were decommissioned after it was confirmed with a borehole-video survey that each well suffered from extensive corrosion of the casing. Data in 2004 from a downgradient well installed in 2003 showed elevated nitrate and technetium-99. DOE is conducting additional studies to determine if the source of the contamination is the waste management area.

Monitoring at the 216-A-29 Ditch. The groundwater beneath the 216-A-29 ditch (Figure 8.7.2) continued to be monitored as required by RCRA interim status detection regulations. Specific conductance is increasing in three downgradient wells as groundwater quality returns to ambient conditions in response to the cessation of effluent disposal at B Pond (which has been decommissioned). Groundwater quality beneath the ditch closely resembles regional patterns.

Monitoring at the Integrated Disposal Facility. The Integrated Disposal Facility will be an expandable, lined, RCRA-compliant landfill. The groundwater monitoring network for this facility will consist of three upgradient wells and five downgradient wells. Three wells remain to be installed at the Integrated Disposal Facility; two will be installed in 2005 and the third will be installed at a future date when required by facility expansion.

Monitoring at the 216-B-3 Pond. Monitoring for the 216-B-3 pond (B Pond) returned to a conventional RCRA interim status detection monitoring program in 2004. This change marked the end of a trial period for an alternate approach to groundwater monitoring and statistical data analysis at the site.

Monitoring at the Nonradioactive Dangerous Waste Landfill. The Nonradioactive Dangerous Waste Landfill is located in the 600 Area (Figure 8.7.2), within the footprint of the 200-PO-1 Operable Unit regional plume (Figure 8.7.1). Interim status detection monitoring continued 2004.

Monitoring at the Solid Waste Landfill. The Solid Waste Landfill (Figure 8.7.2) is adjacent to the Nonradioactive Dangerous Waste Landfill and is regulated under state solid waste regulations. In 2004, temperature, specific conductance, pH, total organic carbon, chemical oxygen demand, chloride, sulfate, and coliform bacteria exceeded their background threshold levels (Table B.43 in PNNL-15070) in one or more samples.

Monitoring at the 200 Area Treated Effluent Disposal Facility. A state waste discharge permit governs groundwater sampling and analysis in the three monitoring wells at the 200 Area Treated Effluent Disposal Facility. No permit criteria for constituents in groundwater were exceeded in 2004. The groundwater monitoring network continues to show that effluent disposed to the ground at this facility is not affecting the uppermost aquifer, which is confined.

8.7.3.12 Groundwater Monitoring Results for the 300-FF-5 Operable Unit

The 300-FF-5 Operable Unit (Figure 8.7.1) is subdivided into three geographic regions: the 300 Area, the 618-11 burial ground region, and the 316-4 cribs and 618-10 burial ground region. The latter two regions are referred to informally as "300-FF-5 North." The operable unit is currently regulated under a record of decision that calls for continued monitoring of groundwater conditions and interim actions to help minimize the potential for human exposure to contaminants in groundwater (institutional controls) until contaminant source remedial actions are complete. The operable unit includes groundwater associated with a former liquid waste disposal site, where groundwater is also 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 beneath approximately half of the 300 Area. The decrease in uranium concentrations predicted by modeling during the initial remedial investigation has not occurred as expected, so DOE has supported additional investigation of natural processes that lead to reduced concentrations as well as more detailed groundwater modeling. An update to the focused feasibility study for remedial action alternatives for uranium is also underway. The new information developed by these activities will be used to guide future remedial action decisions.

Groundwater downgradient of the 618-11 burial ground is contaminated by a high-concentration tritium plume, whose origin is believed to be materials in the burial ground. The concentration of tritium at a well adjacent to the burial ground has decreased since maximum values were measured in 2000 but is still the highest observed on the Hanford Site. Continued characterization and modeling are underway to predict the future movement of the narrow plume, which extends approximately 1 kilometer (0.62 mile) to the east of the waste site.

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 during fall 2004. Current concentrations of uranium in the area are generally below the drinking water standard, although there is some suggestion that excavation activities may have remobilized vadose zone contamination. Tributyl phosphate has been undetected in recent samples. There is no evidence for impact to groundwater caused by contaminant releases from the 618-10 burial ground.

Monitoring at the 316-5 Process Trenches. This liquid waste disposal site, monitored under RCRA, was the last in the 300 Area to receive uranium-bearing effluent, with discharges ending in the early 1990s (Figure 8.7.2). The

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 this waste site, although concentrations appear to be decreasing with time. Cis-1,2,dichloroethene exceeds the standard at only one downgradient well.

8.7.3.13 Groundwater Monitoring Results for the 1100-EM-1 Operable Unit

The 1100-EM-1 Operable Unit (Figure 8.7.1) includes a small, narrow plume of trichloroethene, which is attenuating naturally. Annual average concentrations have remained below the drinking water standard since 2001. Contaminants also flow into the unit from offsite sources (e.g., nitrate from agriculture and industry).

The city of Richland maintains a well field in the 1100-EM-1 groundwater interest area, which includes a much broader area than the operable unit. Wells near the well field are monitored frequently to detect any changes in Hanford contaminants near the city's wells. The tritium plume from the 200-East Area has not been detected in these wells. Low levels of tritium, similar to levels in Columbia River water, continued to be detected.

The selected remedy for cleaning up 1100-EM-1 Operable Unit groundwater is to continue to monitor the natural attenuation of volatile organic compounds.

8.7.3.14 Groundwater Monitoring Results for the 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 migration of contamination offsite through the basalt-confined aquifer.

The Ringold Formation confined aquifer occurs within fluvial sand and gravel composing 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 converges on the 200-East Area from the west, south, and east. Groundwater discharges from the confined aquifer into the overlying unconfined aquifer near the 200-East Area.

While effluent disposal was occurring at the B Pond system, which consists of 216-B-3, 216-B-3A, 216-B-3B, and 216-B-3C ponds, groundwater mounding forced groundwater and any associated contamination a limited distance into the Ringold Formation confined aquifer. Groundwater analyses for 2004 at the 200 Area Treated Effluent Disposal Facility continued to demonstrate that the confined aquifer has not been influenced by disposal activities at this facility.

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 system 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 west of the 200-East Area, near B Pond, and north and east of the Columbia River.

Results of sampling basalt-confined groundwater show that tritium was detected in some wells at very low levels, while iodine-129, strontium-90, gamma-emitting isotopes, and uranium isotopes were not detected. Cyanide, nitrate, and technetium-99 were elevated in one well in the north part of the 200-East Area, but contaminant migration during well construction is responsible for this contamination. Contaminants on the Hanford Site have not migrated through the upper basalt-confined aquifer system to offsite sampling locations south and southeast of the Hanford Site.

8.7.4 Groundwater and Vadose Zone Remediation

The overall objectives of groundwater and vadose zone remediation at sites adjacent to the Hanford Reach are to protect aquatic receptors in the river bottom substrate from contaminants in the groundwater entering the

Columbia River, reduce levels of contamination in the areas of highest concentration, prevent further movement of contamination, and protect human health and the environment.

8.7.4.1 Groundwater Remediation Using Pump-and-Treat Systems and In Situ Redox Manipulation Technology

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Pump-and-treat systems continued to operate at five operable units, an in situ remediation system continued to operate at one operable unit, and a soil-gas vapor extraction system continued to operate at one operable unit during 2004 (Figure 8.7.8). A second pump-and-treat system was installed at the 100-HR-3 Operable Unit in 2004 to treat contaminated groundwater in the central part of the 100-D Area. Summary descriptions of groundwater remediation activities are provided in the following paragraphs. A summary of groundwater remediation activities at the Hanford Site is provided in Table 8.7.7.

Chromium. Groundwater contaminated with chromium underlies portions of the 100-D, 100-H, and 100-K Areas (the 100-HR-3 and 100-KR-4 Operable Units). Chromium is of concern because of its potential to affect the ecosystem of the Hanford Reach. Low levels of chromium are toxic to aquatic organisms, particularly those that use the riverbed sediment as habitat (DOE/RL-94-102; DOE/RL-94-113). The relevant standard for protection of freshwater aquatic life is 10 µg/L (0.01 parts per million) of chromium (WAC 173-201A). Chromium concentrations exceeding 600 µg/L (0.6 parts per million) have been measured in the porewater of riverbed sediment adjacent to the 100-D Area (BHI-00778). Background chromium concentrations are usually less than 1 µg/L (1 part per billion) in the river.

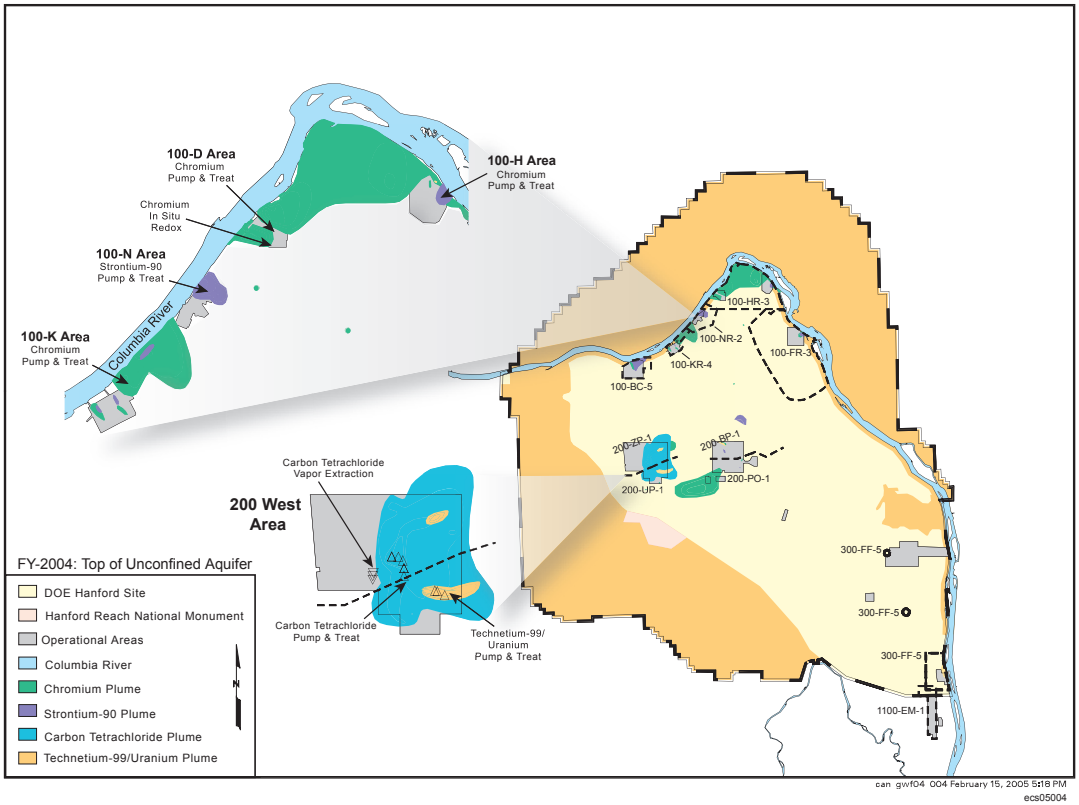

Figure 8.7.8. Pump-and-Treat, In Situ Remediation, and Soil-Gas Extraction Systems Operating on the Hanford Site in 2004

Table 8.7.7. Summary of Groundwater Remediation Activities at the Hanford Site, 2004

Remedial Action Site	Start-up Date	Progress from Startup through December 2004	Progress for 2004
100-K Area 100-KR-4 Pump-and-Treat	1997	Decreases chromium to river; 257.6 kilograms (568 pounds) chromium removed.	29.6 kilograms (65.3 pounds) chromium removed
100-N Area 100-NR-2 Pump-and-Treat	1995	Diverts strontium-90 from river; 1.63 curies (60.3 GBq) strontium-90 removed; ~12 curies (444 GBq) decayed naturally.	0.15 curies (5.55 GBq) strontium-90 removed
100-D Area 100-HR-3 Pump-and-Treat	1997	Decreases chromium to river; 199 kilograms (438.8 pounds) chromium removed.	30.1 kilograms (66.4 pounds) chromium removed
100-D Area 100-HR-3 In Situ Redox	1999	Decreases chromium concentration downgradient of barrier.	
100-H Area 100-HR-3 Pump-and-Treat	1997	Decreases chromium to river; 38.6 kilograms (85.1 pounds) chromium removed.	3.5 kilograms (7.7 pounds) chromium removed
200-West Area 200-ZP-1 Pump-and-Treat	1994	Prevents high-concentration portion of carbon tetrachloride plume from spreading; 8,764.4 kilograms (19,325.5 pounds) removed.	898.3 kilograms (1,969.7 pounds) carbon tetrachloride removed
200-West Area Soil-Vapor Extraction	1991	Prevents carbon tetrachloride movement to groundwater; 78,300 kilograms (172,651.5 pounds) removed from vadose zone.	256 kilograms (564.5 pounds) carbon tetrachloride removed
200-West Area 200-UP-1 Pump-and-Treat	1994	Decreases migration of contaminants; 116.1 grams (3.73 ounces) technetium-99 and 206.8 kilograms (456 pounds) uranium removed.	25 kilograms (55.1 pounds) uranium removed 12.8 grams (0.41 ounce) technetium-99 removed 6.67 kilograms (14.7 pounds) carbon tetrachloride removed 5,401 kilograms (11,909 pounds) nitrate removed
Waste Management Area S-SX Well 299-W23-19 Pump-and-Treat	2003	0.00211 curies (78.07 MBq) technetium-99 removed.	0.033 grams (0.001 ounce) technetium-99 removed
300-FF-5 Natural Attenuation	NA	Average trichloroethene concentrations below target level; uranium concentrations above target level.	
1100-EM-1 Natural Attenuation	NA	Average trichloroethene concentrations below 5 µg/L (0.005 ppm) since 2001.	

NA = Not applicable.

100-KR-4 Operable Unit. A pump-and-treat system is being used to remove chromium from the aquifer beneath a large, liquid-waste disposal trench in the 100-KR-4 Operable Unit. The purpose of the interim action is to reduce the amount of chromium entering the Columbia River at the 100-K Area (Figure 8.7.9). During 2004, the 100-KR-4 pump-and-treat system treated 493.3 million liters (130.3 million gallons) of groundwater and removed 29.2 kilograms (64.2 pounds) of chromium. Total chromium removed since operations began in 1997 is 249.9 kilograms (549.8 pounds) through treatment of 2.7 billion liters (713.3 million gallons) of water. Treated groundwater is re-injected into the aquifer upgradient from the 100-KR-4 extraction wells. Although the mapped extent of contamination has remained fairly constant during the past 10 years, the area of highest concentration has decreased markedly. The interim remedial action concentration goal for groundwater near the Columbia River is 22 µg/L (0.022 parts per million) chromium.

100-HR-3 Operable Unit Pump-and-Treat Systems. During 1994, a pilot-scale groundwater extraction system was installed in the 100-D Area to test chromium removal from groundwater using ion exchange technology. Following the issuance of a record of decision in 1996 (EPA 1996a), full scale pump-and-treat systems were constructed in the 100-D, 100-H, and 100-K Areas (Figure 8.7.8). The objective of these systems is to remove chromium contamination from the groundwater and, thus, prevent or reduce the movement of chromium to the Columbia River.

During 2004, 310.5 million liters (82 million gallons) of groundwater were treated by pump-and-treat systems in the 100-D and 100-H Areas, and approximately 32.6 kilograms (71.8 pounds) of chromium were removed. Since 1997, more than 2.26 billion liters (596.7 million gallons) of groundwater have been treated, with 236.6 kilograms (520.6 pounds) of chromium removed. Treated groundwater is re-injected into the aquifer upgradient from the 100-H Area extraction wells. Groundwater from both the 100-D and 100-H Areas is treated in the 100-H Area using separate treatment systems.

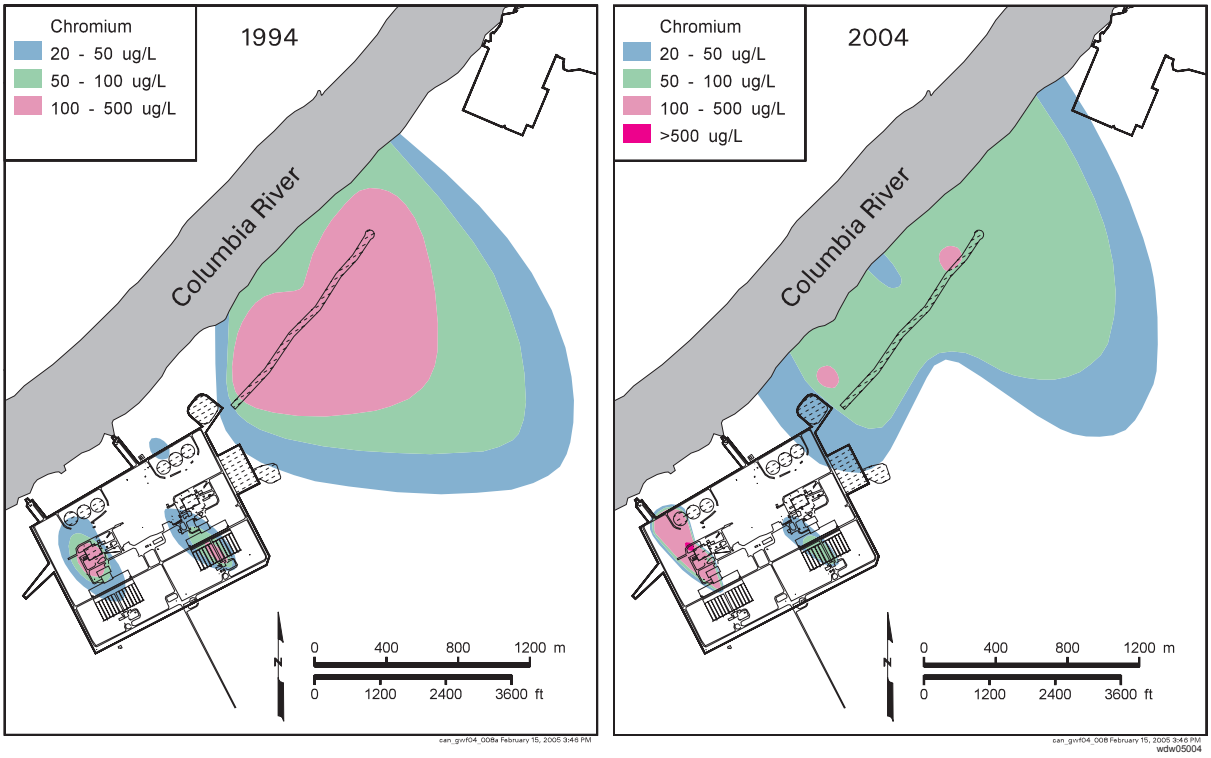

Figure 8.7.9. The Effect of Pump-and-Treat System on Groundwater Chromium Concentrations in the Hanford Site's 100-K Area, 1994 Compared to 2004

A new, 189 L/min (50 gpm), ion exchange pump-and-treat system, 100-DR-5, was brought on line in the 100-D Area in June 2004 to intercept groundwater in the central 100-D Area near the Columbia River shoreline, where chromium concentrations had increased in recent years (Figure 8.7.10). Water is extracted at three downgradient wells at a combined rate of approximately 142 L/min (37.5 gpm), treated, and re-injected into an upgradient well. To date, 2.09 million liters (551,765 gallons) of water have been extracted and an estimated 1.9 kilograms (4.2 pounds) of chromium removed. This system is designed to capture a recently identified lobe of the chromium plume that is not contained by either the existing 100-D Area pump-and-treat system or an in situ redox manipulation barrier. This segment of the plume is suspected to have been mobilized by water leaks at the 182-D reservoir. The leaks were found to result when basin water depth exceeded 2.44 meters (8 feet); institutional controls no longer allow greater storage capacity. Monitoring wells were installed around the reservoir and delineated a significant water mound within the larger chromium plume. The leaks created a low-chromium concentration divide, forming two lobes initially. Since cessation of leaks, the two plumes appear to be merging.

100-HR-3 Operable Unit In Situ Redox Manipulation. In addition to pump-and-treat remediation, use of in situ redox manipulation technology continued in the southwest portion of the 100-D Area to treat hexavalent chromium contamination in groundwater. This technology immobilizes hexavalent chromium by reducing the soluble, more toxic, chromate ion to highly insoluble, less toxic, chromic hydroxide or to a chromic-ferric hydroxide complex. This is accomplished by injecting a chemical-reducing agent into closely spaced wells to form a permeable reactive barrier. Following reduction, the reagent and reaction products are pumped out of the wells. Chromium is immobilized as groundwater naturally flows through the barrier. This groundwater cleanup technique was tested during 1997 through 1999 in five injection wells and then expanded to include additional injection wells in 2000, 2001, 2002, and 2003. During 2004, no additions were made to the system.

Past monitoring has shown that chromium concentrations in wells along the barrier axis are, generally, less than

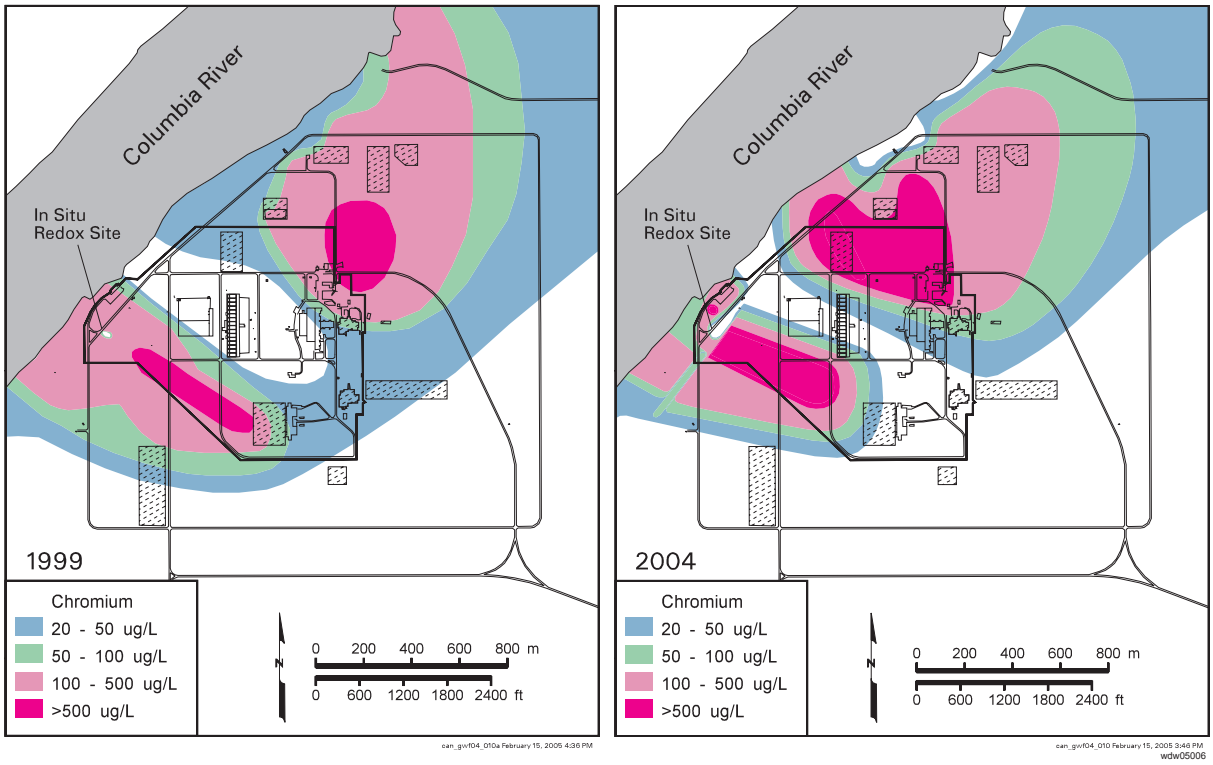

Figure 8.7.10. Chromium Concentrations in Hanford Site's Central 100-D Area Groundwater, 1999 Compared to 2004

20 µg/L (0.02 parts per million) except in 14 barrier wells where concentrations have increased to as high as 980 µg/L (0.98 parts per million). Compliance wells to the west of the barrier still have high concentrations ranging from 5 to 950 µg/L (0.005 to 0.95 parts per million). The barrier is 680 meters (2,230 feet) long and approximately 15 meters (48 feet) wide.

Bioremediation Research. DOE conducted field tests near the 100-H Area in 2004 to demonstrate the feasibility of a remediation technology to immobilize hexavalent chromium in the aquifer. Researchers identified several types of bacteria in the sediment including species that are known to reduce or sorb hexavalent chromium. The natural microbial population is likely insufficient for direct chromium reduction, but the population was successfully stimulated during the field tests.

Strontium-90. The primary groundwater contaminant in the 100-N Area is strontium-90, which originated at two former liquid waste disposal cribs. The extent of the strontium-90 plume has changed little in over 12 years; however, concentrations increased during the 1990s because of changing groundwater levels caused by fluctuating Columbia River levels.

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 (Figure 8.7.11). The pump-and-treat system creates a hydraulic barrier to flow, thereby, decreasing groundwater flow into the Columbia River. Approximately 107.2 million liters (28.3 million gallons) of water were processed during 2004. During that period, 0.15 curies (5.55 gigabecquerels) of strontium-90 were removed from the groundwater. More than 1.009 billion liters (266.7 million gallons) of groundwater have been processed since the system began operation in 1995, removing 1.63 curies (60.3 gigabecquerels) of strontium-90. Concentrations remained far above the 8-pCi/L (0.3-Bq/L) drinking water standard in 2004.

Pump-and-treat technology has proven to be an ineffective way to remediate strontium-90 contamination because strontium-90 binds to sediment grains. DOE is considering alternative technologies for remediating the

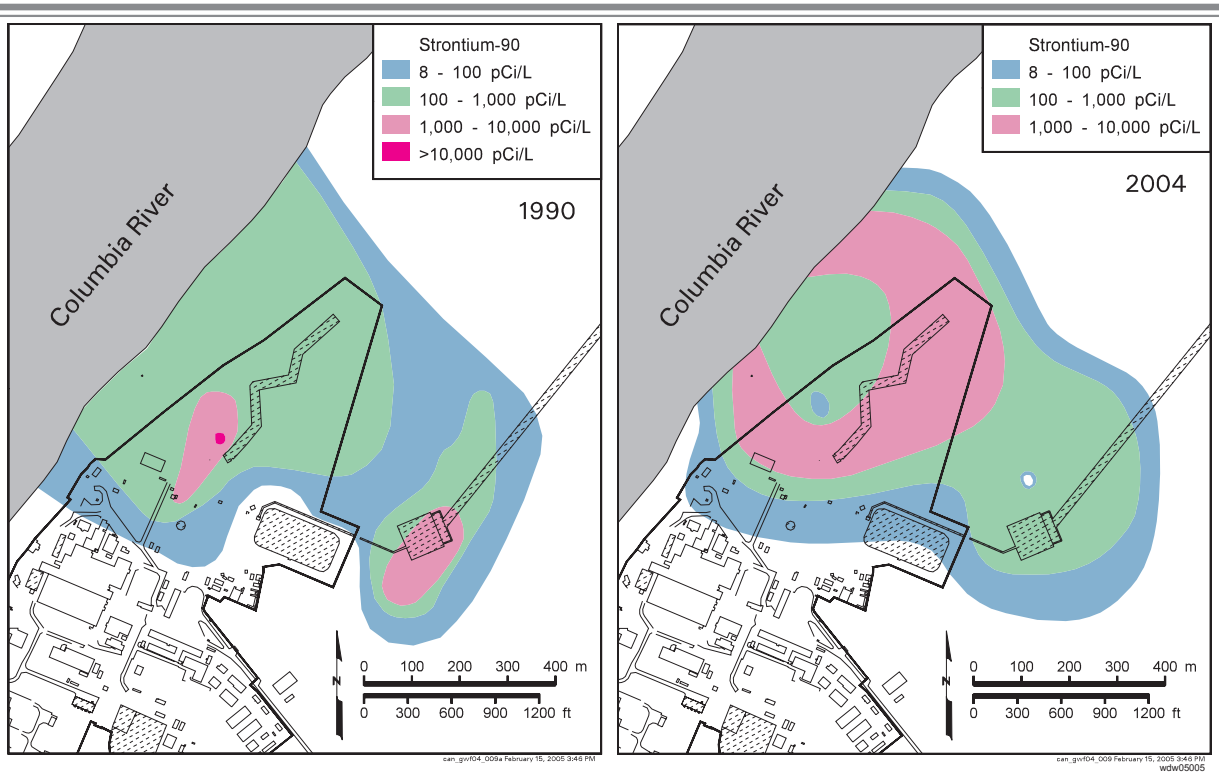

Figure 8.7.11. Strontium-90 Concentrations in the Hanford Site's 100-N Area Groundwater, 1990 Compared to 2004

strontium-90 plume in this area. DOE has developed a treatability test plan to evaluate the effectiveness of one technology, sequestration, where chemicals injected into the aquifer immobilize strontium-90 so it does not flow with the groundwater into the Columbia River. The plan includes a contingency provision for a permeable reactive barrier installation to meet the same objective if sequestration fails. The test will also evaluate phytoremediation to enhance strontium-90 recovery along the Columbia River shoreline. Phytoremediation is a technology that uses plants to remove (take up) contaminants from groundwater. DOE has recommended temporarily suspending operation of the pump-and-treat system while they collect data to evaluate the alternative technologies. Sampling frequency was increased along the Columbia River shoreline in anticipation of suspending the pump-and-treat operations. Three new monitoring wells and new aquifer tubes along the 100-N Area shoreline of the Columbia River were installed to collect baseline data. DOE also recommends monitoring natural attenuation for that portion of the plume that is not expected to reach the Columbia River.

Carbon Tetrachloride. The carbon tetrachloride plume in the 200-West Area (originating in the 200-ZP-1 Operable Unit) covers over 11 square kilometers (4.2 square miles) (Figure 8.7.12). The 200-ZP-1 pump-and-treat system operated as a pilot-scale treatability test from 1994 to 1996, with full-scale operation beginning in 1996. A total of 2.48 billion liters (653.9 million gallons) of groundwater have been processed since startup, removing 8,746.4 kilograms (19,242 pounds) of carbon tetrachloride. During 2004, 264.9 million liters (70.0 million gallons) of groundwater were treated, removing 898.3 kilograms (1,976.3 pounds) of carbon tetrachloride. The 2004 treated volume increased through the replacement of two extraction wells with two new wells. Following replacement, the extraction rate increased by approximately 379 L/min (100 gpm).

Plans are being developed to expand the pump-and-treat system at 200-ZP-1 to existing monitoring wells west and southwest of the TX-TY Tank Farms. An extension to the 2,000-µg/L plume was recognized recently north of the extraction well system installed to treat the 1996 baseline

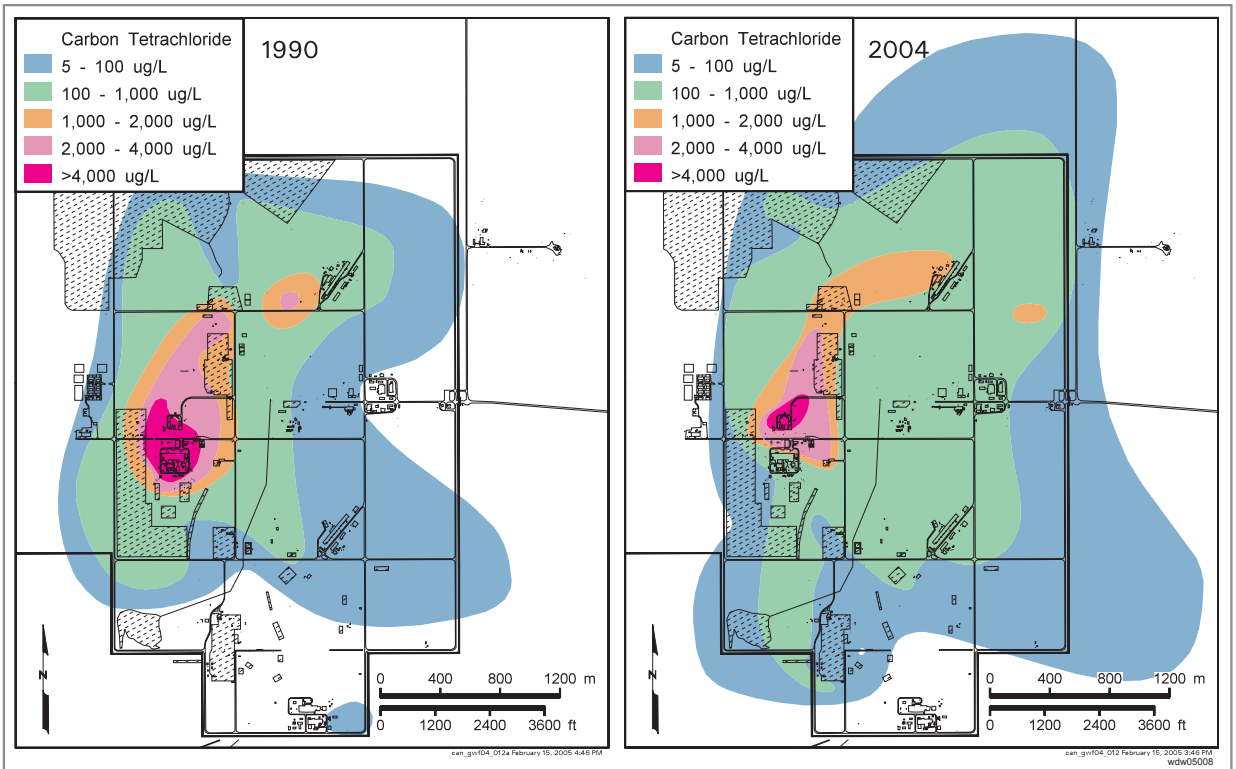

Figure 8.7.12. Influence of a Pump-and-Treat System on Carbon Tetrachloride Concentrations Beneath the Hanford Site's 200-West Area, 1990 Compared to 2004

plume. Four monitoring wells will be converted to extraction wells and connected to the 200-ZP-1 treatment system. Extraction rates are expected to increase by approximately 379 L/min (100 gpm).

Uranium, Technetium-99, Carbon Tetrachloride, and Nitrate. Treatment of the groundwater plume underlying the 200-UP-1 Operable Unit in the 200-West Area continued throughout 2004. The contaminant plume contains uranium, technetium-99, carbon tetrachloride, and nitrate. A pump-and-treat system has operated since 1994 to contain the high-concentration area of the uranium and technetium-99 plume. During early operations, groundwater was treated using ion-exchange resin to remove the uranium and technetium-99, and granular activated carbon was used to remove carbon tetrachloride. Since 1997, contaminated groundwater has been transferred by pipeline to basin 43 at the 200 Area Effluent Treatment Facility. Sophisticated treatment technology at the Effluent Treatment Facility removes all four contaminants. Treated groundwater is then discharged north of the 200-West Area at the State-Approved Land Disposal Site.

The pump-and-treat system operated continually during 2004, at rates at or above 189 L/min (50 gpm). Three extraction wells were used during the year. The primary extraction well ran continuously and was supplemented with smaller amounts of more contaminated water from two upgradient wells in the high-concentration part of the plume.

In 2004, the Effluent Treatment Facility treated 103.5 million liters (27.3 million gallons) of groundwater. Treatment of groundwater removed 12.8 grams (0.0282 pound) of technetium-99, 25.0 kilograms (55 pounds) of uranium, 6.67 kilograms (14.7 pounds) of carbon tetrachloride, and 5,401 kilograms (11,882 pounds) of nitrate. To date, the system has treated 822.9 million liters (217.4 million gallons) of water, removing 116.1 grams (0.256 pound) of technetium-99 and 206.8 kilograms (454 pounds) of uranium.

The pump-and-treat operation made significant progress toward reducing uranium and technetium-99 to below required cleanup concentration levels (Figures 8.7.13 and 8.7.14). During 2004, concentrations in all monitoring and extraction wells were below the remedial action objectives of 9,000 pCi/L (333 Bq/L) for technetium-99 and 480 µg/L for uranium. In 2004, a rebound study was agreed to between the DOE Richland Operations Office and Washington State Department of Ecology to test the effects of treatment. A rebound study assesses how well contaminants have been removed by the pump-and-treat system. Pumping is stopped, allowing groundwater flows to return to equilibrium and contaminants in the sediment

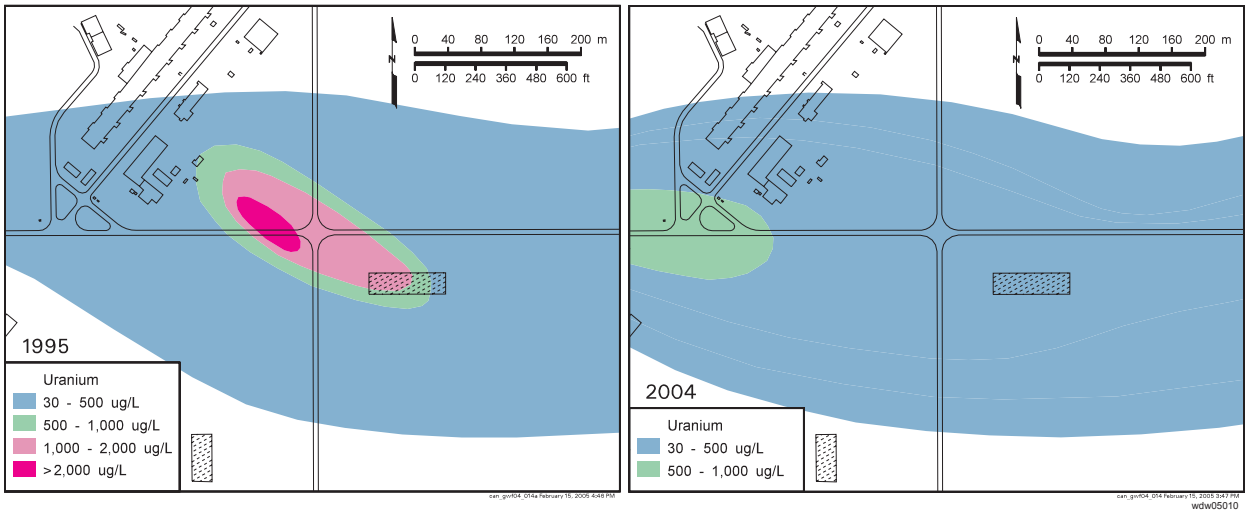

Figure 8.7.13. Influence of a Pump-and-Treat System at the Hanford Site's 200-UP-1 Operable Unit (200-West Area) on Uranium Concentrations in Groundwater, 1995 Compared to 2004

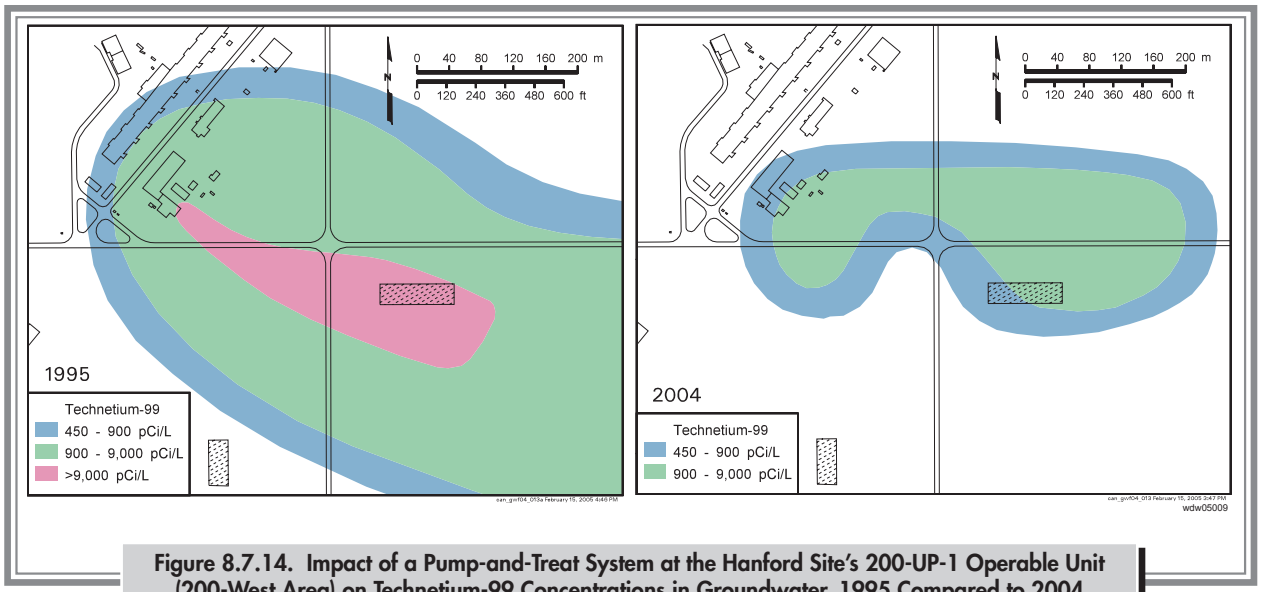

Figure 8.7.14. Impact of a Pump-and-Treat System at the Hanford Site's 200-UP-1 Operable Unit (200-West Area) on Technetium-99 Concentrations in Groundwater, 1995 Compared to 2004

to dissolve back into the groundwater. The concentrations of contaminants in groundwater then reflect concentrations in soil and, thus, indicate if enough contamination has been removed to prevent future exceedences above the remedial action objective. The rebound test started on January 25, 2005.

Elevated concentrations of technetium-99 were observed at a well in the 200 Areas that was drilled in 2002 at the S-SX Tank Farm. The high values led to an agreement that this well should be extensively purged during sampling. The Washington State Department of Ecology and DOE agreed that, for each quarterly sample, more than 3,785 liters (1,000 gallons) of water should be contained and taken to the Effluent Treatment Facility for treatment. After completing a field evaluation and pipe extension modification, purging and treatment were implemented starting in March 2003 (RPP-10757). During 2003, and prior to the first purging, technetium-99 concentrations peaked at 188,000 pCi/L (6,956 Bq/L) at the S-SX Tank Farm then began a steep decline. In 2004, concentrations ranged between 41,800 and 62,300 pCi/L (1,547 and 2,305 Bq/L). Through 2004, at least 31,479 liters (8,304 gallons) of water have been treated at the Effluent Treatment Facility, yielding 0.00211 curies (78.07 megabecquerels) of technetium-99. Further actions will depend on how concentrations change in the future.

8.7.4.2 Vadose Zone Remediation Using Soil-Vapor Extraction Systems

V. J. Rohay

Soil-vapor extraction systems designed to remove carbon tetrachloride vapor from the vadose zone beneath the 200-West Area began operating during 1992 and continued through 2004. Soil-vapor extraction has been conducted in the vicinity of three historical carbon tetrachloride disposal sites: the 216-Z-1A tile field, the 216-Z-9 trench, and the 216-Z-18 crib. Extracted soil vapor is pumped through granular activated carbon, which absorbs carbon tetrachloride. The granular activated carbon is then shipped offsite for treatment. Three soil-vapor extraction systems have operated at three different flow rates: 14.2 cubic meters (500 cubic feet) per minute, 28.3 cubic meters (1,000 cubic feet) per minute, and 42.5 cubic meters (1,500 cubic feet) per minute. However, only the 14.2 cubic meters (500 cubic feet) per minute system operated during 2004; the other two systems are no longer operational. In 2004, 256 kilograms (564 pounds) of carbon tetrachloride were removed. Since operations began, soil-vapor extraction has removed 78,348 kilograms (172,728 pounds) of carbon tetrachloride from the vadose zone. Passive soil-vapor extraction systems, which use atmospheric pressure fluctuations to pump carbon

tetrachloride vapor from the vadose zone, were installed at wells near the 216-Z-1A tile field and 216-Z-18 crib during 1999. These passive systems operated throughout 2004.

8.7.5 Well Installation, Maintenance, and Decommissioning

DOE installs new wells when needed for monitoring or characterization, maintains wells to prevent or repair problems, and decommissions wells that are no longer needed. The Washington State Department of Ecology, EPA, and DOE worked together to develop a prioritized list of new wells needed to meet requirements of various groundwater monitoring regulations. During 2004, a total of 25 new wells were installed at the Hanford Site. This total included 6 RCRA wells and 19 CERCLA wells. In the 200 Areas, 51 vadose characterization holes were installed to support remediation and they were decommissioned after soil sampling was completed. A total of 278 wells received maintenance, and 98 were decommissioned (filled with grout) because they were no longer needed, were in poor condition, or were in the way of remediation activities. In 2004, a total of 108 new aquifer tubes were installed along the Columbia River shoreline of the 100 and 300 Areas.

8.7.6 Groundwater Modeling

Computer simulations of groundwater flow and contaminant movement help predict future conditions and assess the effects of remediation systems. A site-wide numerical model has been developed and is being improved and refined. During 2004, the pattern of geologic zones within the Hanford formation and Ringold Formation gravel units of the model has evolved in a continuing effort to improve the calibration of the model. The calibration involves adjusting the zonation configuration, the hydraulic conductivities associated with the geologic zones, and the amounts of recharge to the system in an effort to match historical changes in water-table elevation and the historical movement of tritium. Changes were also made to the configuration of hydrogeologic units in the model based on new well data and reinterpretation of geological contacts at some locations.

DOE applied the site-wide groundwater model to specific waste-site assessments in 2004:

- modeling the movement of tritium disposed to the State-Approved Land Disposal Site north of 200-West Area
- site-wide groundwater flow and transport calculations supporting the performance assessment for the Integrated Disposal Facility and the preliminary performance assessment for closure of single-shell waste tank farms
- site-wide modeling of dissolved carbon tetrachloride migration from the 200-West Area through the groundwater considering different source conditions and various degrees of sorption and natural degradation.

Local-scale simulations of the movement of dense, non-aqueous liquid (carbon tetrachloride) at the 216-Z-9 trench in the 200-West Area were performed in 2004. The purpose of this work was to better understand carbon tetrachloride movement in the subsurface beneath the trench to support remediation decisions. The modeling indicated the following results:

- The Cold Creek hydrogeologic unit has a large impact on the modeled migration of carbon tetrachloride through the vadose zone.
- The lateral extent of the modeled dense, non-aqueous liquid has not moved outside the footprint of the disposal facility.
- The lateral extent of the modeled vapor-phase plume was much greater than the lateral extent of the dense, non-aqueous liquid.
- The vapor-phase plume caused some contamination of underlying groundwater in the model.

8.7.6.1 An Assessment Tool for Estimating the Impact of Groundwater Contaminants

R. W. Bryce and C. T. Kincaid

During 1999, DOE initiated development of an assessment tool, the System Assessment Capability, that will enable users to model the movement of contaminants from all waste sites at Hanford through the vadose zone, groundwater, and the Columbia River and estimate the

impact of contaminants on human health, the ecology, local cultures, and the local economy. An assessment was completed during 2002 with the System Assessment Capability that demonstrated its functionality. The results of that assessment were presented in *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability* (PNNL-14027).

During 2004, the System Assessment Capability was used to update Hanford's Composite Analysis. A composite analysis is required by DOE Order 435.1, *Radioactive Waste Management*, to ensure public safety through the management of active and planned low-level radioactive waste disposal facilities associated with the Hanford Site. A composite analysis is defined in the Order as "a reasonably conservative assessment of the cumulative impact from active and planned low-level waste disposal facilities, and all other sources from radioactive contamination that could interact with the low-level waste disposal facility to affect the dose to future members of the public." A composite analysis was first performed for Hanford in 1998 (PNNL-11800).

During 2004, the *Technical Scope and Approach for the 2004 Composite Analysis of Low-Level Waste Disposal at the Hanford Site* (PNNL-14372) was published. This document describes the scope of the updated assessment, the region to be analyzed, the waste sites and contaminants to be included, the time period of the assessment, and the process followed to identify those aspects of the assessment. It also describes the technical approach taken for each element of the analysis, the models to be used, and the interaction between the composite analysis and other assessments being performed at Hanford. Calculations were also initiated during 2004 to support the update to the composite analysis.

Table 8.7.8 lists the contaminants to be examined in this assessment of the impact of radioactive wastes. Two key questions formed the basis for selecting these contaminants:

- What contaminants have been observed in the environment and have the potential to affect human or ecological health?
- What contaminants have sufficient inventory in waste sites and have the potential to affect human and/or ecological health as indicated through previous assessments?

Table 8.7.8. Radioactive Contaminants Investigated in the Composite Analysis and Hazardous Chemical Contaminants Chosen for Future Evaluations

Radioactive Contaminants	
Tritium	Europium-152
Carbon-14	Radium-226
Chlorine-36	Protactinium-231
Selenium-79	Uranium-233
Strontium-90	Uranium-234
Technetium-99	Uranium-235
Iodine-129	Neptunium-237
Cesium-137	Uranium-238
Hazardous Chemical Contaminants	
Chromium	Nitrate
Carbon Tetrachloride	

DOE has recently established a Configuration Management Group to review each assessment planned at Hanford, provide guidance to assure consistency among assessments, and ultimately approve the approach to be taken. The group is expected to review the plans for the composite analysis early in 2005 and may provide guidance that results in a change to the assessment and a rerun of simulations performed in 2004.

8.7.6.2 New Science and Technology

M. D. Freshley

The Groundwater Remediation Project includes a science and technology effort to provide data, tools, and scientific understanding to make remediation and site closure decisions. These activities are accomplished under the Remediation and Closure Science Project. During 2004, the project focused on updating soil inventory estimates to support the composite analysis, updating conceptual models for key waste sites, and continuing biological uptake studies.

Soil Inventories. During 2004, the Soil Inventory Model was applied to estimate contaminant inventories for Plutonium Finishing Plant waste sites and provided results to the Hanford Site-Wide Assessments Project. The Soil Inventory Model is continuing to be updated to provide data for additional waste sites and constituents to support the composite analysis.

Conceptual Model Updates. Efforts during 2004 focused on updating the conceptual models of the 300 Area, 100-N Area, carbon tetrachloride transport in Hanford sediment, and the B-26 trench in the 200 Areas.

During 2004, experiments were completed on vadose zone, capillary fringe (the region of the vadose zone composed of sediment that is saturated or nearly saturated near the water table that gradually decreases in water content with increasing elevation above the water table), and aquifer sediment for the 300 Area to update the conceptual model of uranium(VI) fate and transport. These experimental results collectively provide scientific explanations of why the 300 Area uranium plume has been slow to disperse. These results also provide the basis for reactive transport models that are currently under development to forecast future behavior.

Three boreholes were drilled and completed at the 100-N Area along the Columbia River as part of the Remediation and Closure Science Project. These wells will allow the collection of depth-dependent concentration data to determine the distribution of strontium-90 concentrations and strontium-90 flux to the river. Samples from these boreholes are being evaluated in the laboratory to provide data for a reactive transport model of strontium-90 at the 100-N Area. This model will be used to evaluate remediation alternatives to the pump-and-treat system currently in operation in the 100-N Area.

A new theory for residual non-aqueous phase liquid carbon tetrachloride was developed during 2004. This theory was based on intermediate-scale experiments performed by the Remediation and Closure Science Project. The residual non-aqueous phase liquid theory was implemented in the Subsurface Transport Over Multiple Phases computer code and used to successfully simulate the soil-vapor extraction system in the 200-West Area. These simulations are being used to guide field characterization and remediation of the carbon tetrachloride plume.

Results from the Vadose Zone Transport Field Study were used to develop a method for incorporating small-scale heterogeneity into field-scale simulations. This approach was used to simulate moisture flow and contaminant transport beneath the B-26 trench. Predicted moisture contents and technetium-99 concentrations matched observed field data from a borehole drilled through the vadose zone and results from a high-resolution resistivity geophysical survey applied to the vadose zone. High-resolution resistivity was first applied at Hanford as part of the Vadose Zone Transport Field Study. The results of both modeling and subsurface geophysics show the potential extent of the lateral spreading of contaminants. The flow and transport modeling is being used to assist with remedial design.

Biological Uptake of Strontium-90. During 2004, the Remediation and Closure Science Project continued laboratory experiments to determine the uptake of strontium-90 by aquatic species via the food pathway. The goal of these experiments was to determine the rate at which uptake occurred and the total uptake amount. The results are being incorporated into ecological risk assessment modules for use in Hanford site-wide assessments.

8.7.7 Groundwater Remediation Project: Strategic Planning, Public Involvement, and Database Management

T. W. Fogwell

During 2004, the Groundwater Remediation Project continued to closely align the scope of project work with similar site-wide DOE work and align the project with end-state goals and remedial actions. Throughout the year, Groundwater Remediation Project personnel worked closely with the DOE and Hanford regulatory agencies to characterize, protect, remediate, and monitor Hanford Site groundwater. Project staff continued to coordinate and perform scientific research and development to support decision-making activities at Hanford and to manage Hanford's modeling and assessment capabilities aimed at cleaning up groundwater. The Integration Management team organized and coordinated several scientific and technology workshops that resulted in better scientific methods and technological advances being applied to the remediation of the Hanford Site. Also, the Data Access Network prototype was demonstrated. This tool allows for efficient retrieval and visualization of much of the data pertinent to writing reports and other documents at the Hanford Site.

Strategic Planning. The Groundwater Remediation Project team worked throughout 2004 to complete work in the project's master plan, *Hanford's Groundwater Plan: Accelerated Cleanup and Protection* (DOE/RL-2002-68). The plan describes how and when accelerated cleanup work will be accomplished. Project personnel also worked to revise the *Optimization Strategy for Central Plateau Closure* (WMP-18061) and to complete a more detailed *Plan for Central Plateau Closure* (CP-22319).

Public Involvement. During 2004, open meetings, held the first Monday of every month, gave the public, Tribal Nations, regulatory agencies, DOE, and other stakeholders an opportunity to discuss and resolve issues and identify upcoming events. Groundwater project staff also provided regular information to the Hanford Advisory Board and its subcommittees and held several information sessions and workshops concerning specific program events and activities. The project's internet website (http://www.hanford.gov/cp/gpp/) provided information about the project's missions, a calendar of upcoming events, and links to a variety of valuable resources.

Database Management. The Groundwater Remediation Project manages several Hanford Site environmental databases. The Hanford Environmental Information System, as managed by the Groundwater Remediation Project, provides and integrates environmental databases. The environmental databases are required by the Tri-Party Agreement.

The Hanford environmental databases include the Hanford Environmental Information System, Hanford Well Information Data System, Waste Information Data System, and Hanford Geographic Information System. These databases document and track the progress of Hanford Site cleanup. The Hanford Environmental Information System contains the date, time, location, and results from samples taken during activities such as field investigations and groundwater monitoring. The Hanford Well Information Data System contains the details (well history, survey information, as-built information, well construction, and well maintenance records) of the wells and boreholes on the site. The Waste Information Data System tracks the waste sites from discovery through cleanup. The Hanford Geographic Information System keeps track of the locations for waste sites, wells and boreholes, and other sampling site locations. Each of the databases is supported by several software applications for entering or retrieving information.

Database integration supports the sample and data management needs of the Groundwater Remediation Project and waste site remediation. Additionally, the Sample and Data Management Group provides support to Pacific Northwest National Laboratory and the Liquids Effluent Monitoring Information System, and support is currently being planned for the Plutonium Finishing Plant. Sample and data management personnel track samples and data from approval of a sample authorization form to loading of the analytical results from the laboratories into the Hanford Environmental Information System database. The project-specific database stores the data taken from the pump-and-treat and in situ redox manipulation facilities managed by the Groundwater Remediation Project. The data in the Hanford Environmental Information System and the project-specific databases are used by engineers and scientists to prepare the reports required by records of decision and Tri-Party Agreement milestones.

The virtual library portion of database integration makes available the information needed to estimate contamination migration and impact across the Hanford Site. In addition to providing easier user access to the Hanford Environmental Information System, the virtual library includes inventory, geophysical, geochemical, hydrological, and other relevant data. Much of the existing information of this nature is currently scattered throughout several sources, some of which are not available across the Hanford Site. In addition, Fluor Hanford, Inc. and Pacific Northwest National Laboratory generate new information from their science and characterization activities. Key portions of this information are made available through the virtual library.