

Executive Summary

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Executive Summary – Introduction

The Hanford Site, part of the U.S. Department of Energy (DOE) nuclear weapons complex, encompasses ~1,500 square kilometers along the Columbia River in southeastern Washington State. In 1943, the federal government took possession of the Site to build the world’s first large-scale plutonium production reactor, which was used to make plutonium for the Trinity Test and the “Fat Man” bomb that was dropped on Nagasaki, Japan in 1945. During the Cold War period (1945 to 1991), the government built a total of nine reactors for the production of weapons-grade plutonium.

During reactor operations, chemical and radioactive waste was released into the environment and contaminated the soil and groundwater beneath portions of the Hanford Site, mostly in the 200 East Area, 200 West Area, 300 Areas, 1100 Area, and reactor areas along the river (e.g., 100-BC, 100-K) (Figure ES.1). Since the 1990s, DOE has worked to remediate this contamination. DOE developed a plan to address groundwater and vadose zone contamination in consultation with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). Key elements associated with managing the Hanford Site’s groundwater and vadose zone contamination are to: (1) protect the Columbia River and groundwater, (2) develop a cleanup decision process, and (3) achieve final cleanup.

Groundwater occurs in an unconfined aquifer within unconsolidated gravel and sand units. Groundwater in the unconfined aquifer generally flows from upland areas in the west toward the regional discharge areas along the Columbia River (Figure ES.2). The flow of water divides beneath the 200 East Area, with some water flowing toward the north through Gable Gap and some flowing southeast. Maximum concentrations of key groundwater contaminants are presented in Tables ES.1 and 2; time series of cumulative plume areas for selected contaminants in Hanford groundwater are shown in Figure ES.16.

DOE has taken the following actions to protect the Columbia River from contaminated groundwater:

- Ceasing discharge of all unpermitted liquids in the central Hanford Site.
- Remediating former waste sites in the 100 and 300 Areas to reduce the potential for future groundwater contamination.
- Containing groundwater plumes and reducing the mass of primary contaminants through remedial actions such as pump-and-treat (P&T).

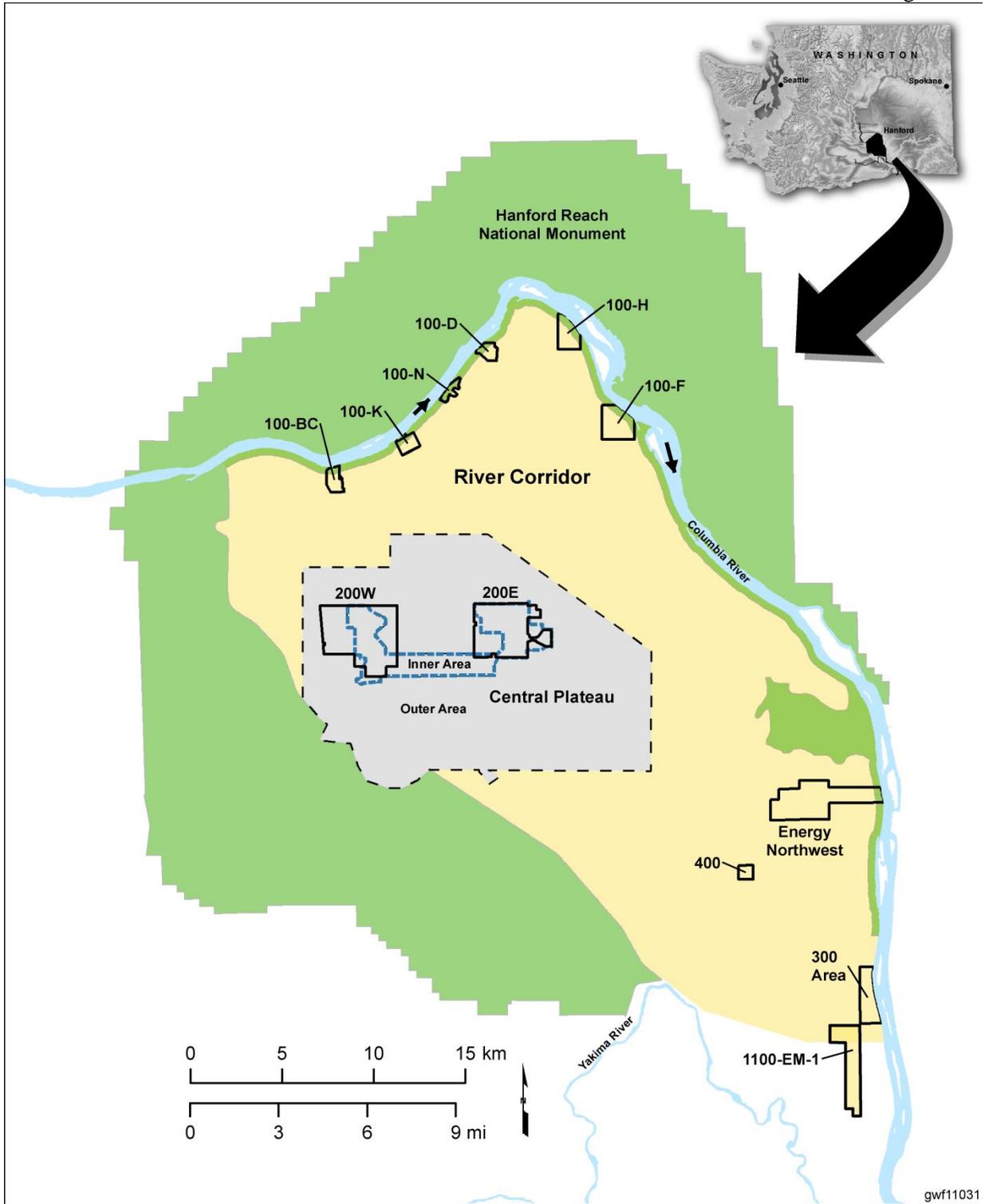


Figure ES.1 Regions of the Hanford Site

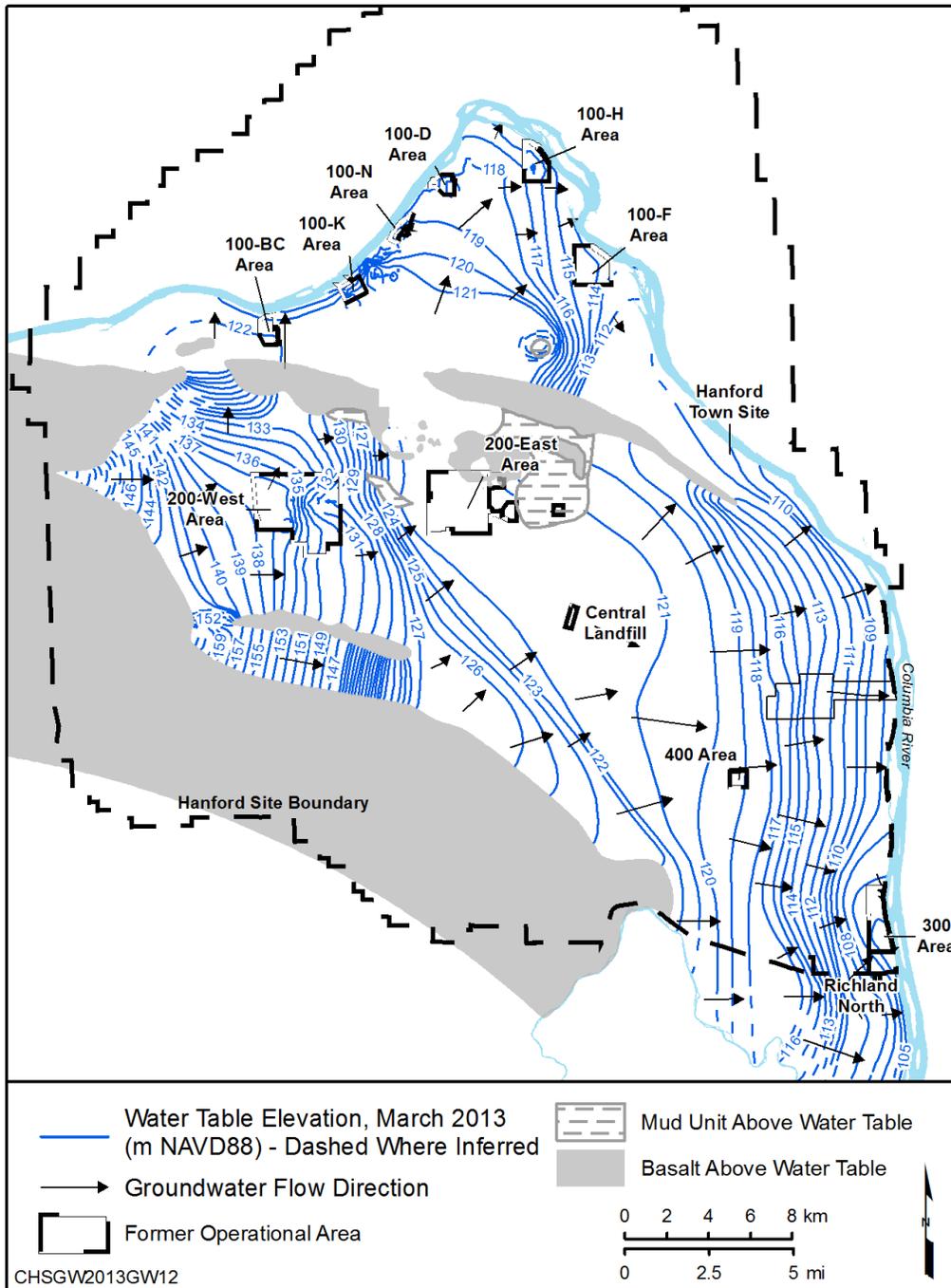


Figure ES.2 Hanford Site Water Table and Directions of Groundwater Flow

Table ES.1 Overview of the River Corridor Groundwater Interest Areas Contaminant Concentrations.

Interest Area	Primary Operations	Status of Waste Site Cleanup ^(a)	Groundwater Interim Remedial Action	Groundwater Contamination: Maximum Concentration and Plume Area						
				Carbon-14 (pCi/L)	Hex. Chromium (µg/L)	Nitrate (mg/L)	Strontium-90 (pCi/L)	Trichloroethene (µg/L)	Tritium (pCi/L)	Uranium (µg/L)
100-BC	Reactor operations -- B Reactor 1944-69; C Reactor 1952-69	92% complete	None	N	62.5	<DWS	53	<DWS	<DWS	<DWS
100-KR	Reactor operations -- KE Reactor 1955-71; KW Reactor 1955-70	59% complete	Cr(VI) -- P&T 1997 - present	39,500 ^b	3,280	64	13,200 ^b	8.3	76,000	<DWS
100-NR	Reactor operations -- N Reactor 1963-87	79% complete	Sr-90 -- P&T: 1995-2006; Apatite barrier: 2006 - present	<DWS	(c)	168	14,000	<DWS	120,000	<DWS
100-HR	Reactor operations -- D Reactor 1944-67; DR Reactor 1950-64; H Reactor 1949-65	77% complete	Cr(VI) -- P&T 1997 - present; ISRM: 2000-present	<DWS	5,392	70	31	<DWS	≤DWS	<DWS
100-FR	F Reactor 1945-65; Biological experiments until 1976	98% complete	None	N	25.5	189	180	15	<DWS	<DWS
300-FF	Nuclear fuel fabrication and research -- 1940s-1960s	90% complete	Final ROD: Uranium & others -- enhanced attenuation & MNA	N	N	(d)	<DWS	430 ^e	1,000,000	462
1100-EM	Vehicle maintenance, 1954-85; solid waste landfill --1950s-1970	100% (final ROD)	Final ROD:TCE - MNA, 1996-present	N	N	(d)	N	<DWS	<DWS	(d)
Standards				2000 pCi/L	10 µg/L	45 mg/L	8 pCi/L	5 µg/L	20,000 pCi/L	30 µg/L
Mobility in subsurface				High	High to Moderate	High	Slight	Moderate	High	Moderate
Legend										
Colors indicate maximum concentration in 2013					Height of bar indicates plume area above standard (km²)					
NOTES										
(a) Percentage by number of sites classified as closed, interim closed, no action, rejected, or not accepted (end of 2013).										
(b) Based on extrapolated concentrations. Detected concentrations lower.										
(c) Chromium plume in 100-NR originates in 100-KR so plume area not shown										
(d) Contaminants from offsite sources excluded										
(e) TCE only exceeds the DWS in deep aquifer tubes; no plume map constructed										
ABBREVIATIONS										
DWS Drinking water standard			ISRM In situ redox manipulation							
N Not detected or not analyzed			ROD Record of decision			TCE Trichloroethene				

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Table ES.2 Overview of Central Plateau Groundwater Interest Areas Contaminant Concentrations.

Interest Area	Primary Operations	Status of Groundwater ROD	Groundwater Remedial Action	Groundwater Contamination: Maximum Concentration and Plume Area									
				Carbon Tetrachloride (µg/L)	Chromium (µg/L)	Cyanide (µg/L)	Iodine-129 (pCi/L)	Nitrate (mg/L)	Strontium-90 (pCi/L)	Trichloroethene (µg/L)	Technetium-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)
200-ZP	T Plant (Pu separation) 1944-1956; Pu Finishing Plant: 1949-1989	Signed 2008 (final)	Carbon tet. & others: P&T & MNA: 1995-present; Soil vapor extraction 1991-present	2,600	186	<DWS	3.6	846	<DWS	9.8	8,600	140,000	<DWS
200-UP	REDOX Plant (Pu separation) 1952-1967; U Plant (U recovery) 1952-1957	Signed 2012 (interim)	U plant P&T Tc-99 & U: 1994-2011; S-SX P&T 2012-present	See 200-ZP	907	N	9.14	3,210	<DWS	7.2	62,000	310,000	298
200-BP	B Plant Pu separation: 1945-1952; B Plant Sr and Cs recovery: 1967-1985	Expected 2016	Perched aquifer P&T test: 2011-2013	<DWS	53.9	1,520	7.54	1,680	980	<DWS	36,000	42,000	3,300
200-PO	PUREX Plant Pu separation: 1956-1972 and 1983-1989	Expected 2016	Vadose zone desiccation test: 2011	<DWS	<DWS	N	9.09	126	15	<DWS	4,200	490,000	58.8
Standards				5 µg/L	48 µg/L	200 µg/L	1 pCi/L	45 mg/L	8 pCi/L	5 µg/L	900 pCi/L	20,000 pCi/L	30 µg/L
Mobility in subsurface				Multi-phase	High to Moderate	Moderate	High	High	Slight	Moderate	High	High	Moderate
Legend													
Colors indicate maximum concentration in 2013				Height of bar indicates plume area above standard (km ²)									
ABBREVIATIONS													
DWS Drinking water standard				P&T Pump and treat system									
N Not detected or not analyzed				ROD Record of decision									

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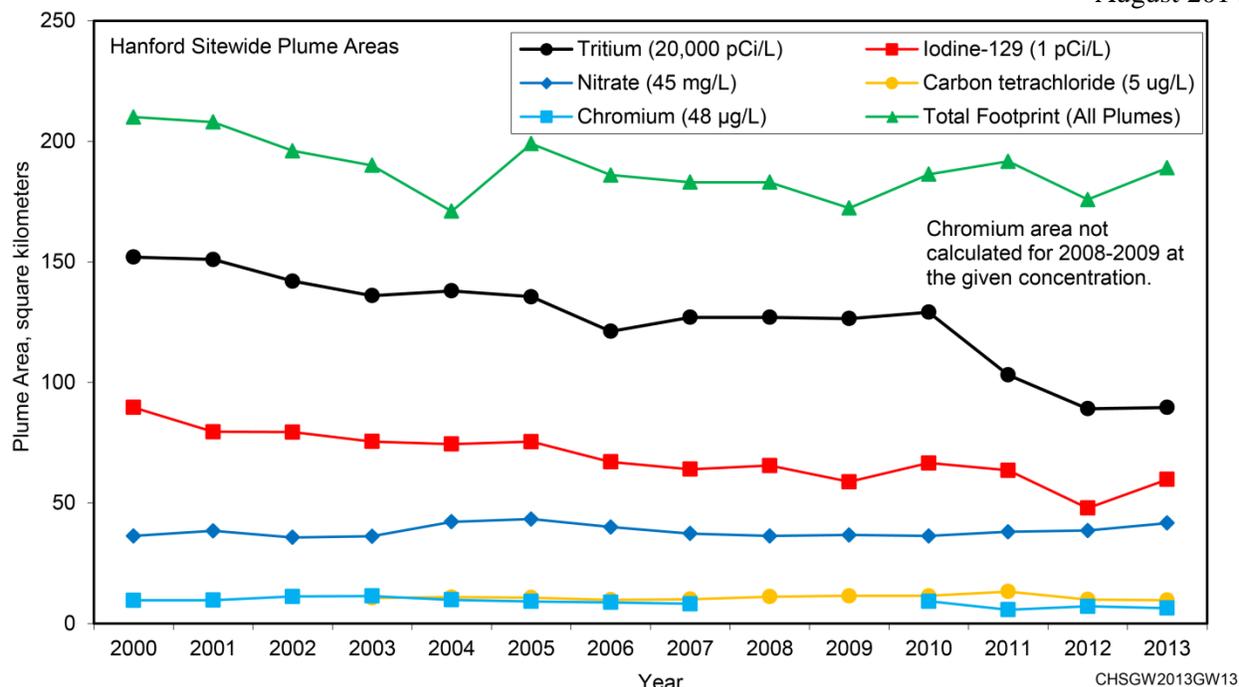


Figure ES.16 Hanford Sitewide Plume Areas

Executive Summary – Highlights

This report is organized by geographic regions known as “groundwater interest areas” that include the River Corridor (100 and 300 Areas) and the Central Plateau (200 Areas). Highlights of 2013 groundwater monitoring include the following:

- **River Corridor**
 - More than 85% of the former waste sites in the River Corridor have been remediated or are classified as not needing remediation under interim Records of Decision (RODs). The rest of the waste sites will be remediated in the next few years. Thus, potential sources of additional groundwater contamination are being removed from the region that poses the most immediate threat to the Columbia River.
 - **100-BC.** New wells and sampling points were installed in 2013 to provide data that will support final decisions about groundwater cleanup in 2016. This includes ongoing, intensive sampling of water in the shallow river bed.
 - **100-KR.** Three P&T systems continued to operate under an interim ROD. In 2013 over 2 billion liters of groundwater was pumped from 36 extraction wells. A total of 1,647 kg of hexavalent chromium have been removed from groundwater to date. The plume area (>20 µg/L) was estimated to be 1.0 km² in 2013, about the same as in 2012. Since 2007 the plume area has decreased by approximately two-thirds. Final cleanup decisions are expected after 2015; additional P&T is proposed.
 - **100-NR.** Under an interim ROD, a permeable reactive barrier is in place along the shoreline to reduce the amount of strontium-90 migrating from groundwater into the river. A draft Remedial Investigation (RI)/Feasibility Study (FS) report was submitted to the lead regulatory agency in 2013 for review. Final cleanup decisions are expected in 2015.
 - **100-HR.** Two P&T systems continued to operate under an interim ROD. In 2013 2.4 billion liters of groundwater were pumped from 72 extraction wells. A total of 2,039 kg of hexavalent chromium have been removed from groundwater to date. The plume area

(>20 µg/L) was estimated to be 4.0 km² in 2013 about the same as in 2012. Since 2005 the plume has shrunk by approximately 50%. Final cleanup decisions are expected in 2015; additional P&T is proposed.

- **100-FR.** Decision documents are being finalized and final cleanup decisions are expected in 2014. Groundwater contaminants are present at relatively low concentrations and do not appear to be impacting the river. Monitored natural attenuation (MNA) of contaminants is proposed.
- **300-FF.** The final record of decision was signed in 2013 and remedial action of groundwater includes enhanced attenuation of uranium using sequestration by phosphate application. MNA is the remedy of choice for other COCs.
- **Central Plateau**
 - Contamination is still present in many parts of the thick vadose zone, and may continue to drain into the groundwater. Remediation of the Central Plateau waste sites and vadose zone will accelerate after River Corridor remediation is complete. Meanwhile, DOE has been remediating groundwater and testing methods to remediate the deep vadose zone.
 - **200-ZP.** The final remedy for groundwater includes an expanded P&T system that continued operating in 2013. Together with the previous, interim P&T system and a soil vapor extraction system, nearly 98,000 kg of carbon tetrachloride has been removed from the ground. In 2013, 18 extraction wells and 16 injection wells were in use, and the treatment plant was operating at a flow rate of 5,300 liters per minute (60 percent of its design capacity), about the same as in 2012. Additional wells were installed in 2013 that will be used to expand the extraction network in the future. Other contaminants of concern being removed by the P&T system include trichloroethene, total chromium, hexavalent chromium, nitrate, technetium-99, iodine-129, and tritium.
 - **200-UP.** Groundwater is being remediated under an interim ROD that was signed in 2012. It includes a P&T near the S-SX single-shell tanks, where high concentrations of technetium-99 and other contaminants are present in groundwater. In 2013, 0.81 Ci of technetium-99 were removed by the system. An additional P&T for uranium and technetium-99 in the U Plant area is currently being designed.
 - **200-BP.** In recent years, high-concentration portions of contaminant plumes have been growing in one portion of this OU. These plumes include the highest concentrations of uranium in Hanford Site groundwater. Concentrations are even higher in a zone of perched water that lies above the water table. In 2013, water continued to be extracted from this perched zone to prevent uranium and other contaminants from continuing to drain to the water table. A RI has been completed, however, final cleanup decisions are yet to be made.
 - **200-PO.** This OU includes the largest contaminant plumes on the Hanford Site, tritium and iodine-129. The tritium plume had an estimated area of 89.8 square kilometers in 2013. Although there is currently no practical treatment technology for tritium, concentrations and plume area have been declining due to radioactive decay and dispersion. The size of the tritium plume has decreased by one-third since 1980 and the maximum concentration has declined 90 percent. A remedial investigation has been completed.

Executive Summary – Groundwater Monitoring Regulations

This document describes 2013 monitoring results for *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal units; for *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) groundwater OUs; and for the *Atomic Energy Act of 1954* (AEA), as required by DOE orders. DOE publishes details on CERCLA remediation activities (for example, P&T operations) in separate reports that are summarized and referenced in this report.

RCRA regulates the management of solid waste, hazardous waste, and certain underground storage tanks. It applies to active or recently-active treatment, storage, and disposal units. Monitoring is required at some units to determine if they are affecting groundwater quality in the uppermost aquifer. The uppermost aquifer is the unconfined aquifer beneath most of the Hanford Site. Groundwater monitoring requirements for the Site's RCRA units fall into one of two broad categories: interim status or final status. A permitted RCRA unit requires final status monitoring, as specified in Washington State's dangerous waste regulations ([WAC 173-303-645](#)). The RCRA units not currently incorporated into a permit require interim status monitoring.

RCRA groundwater monitoring is conducted under one of three possible phases: (1) contaminant indicator evaluation (or detection) monitoring, (2) groundwater quality assessment (or compliance) monitoring, or (3) corrective action monitoring. In the interim-status contaminant indicator evaluation monitoring, four indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) are monitored and evaluated against statistically derived threshold values calculated from upgradient wells. In final status detection monitoring, site-specific indicators are evaluated using statistical methods identified in the respective permit. Groundwater quality assessment (interim status) or compliance (final status) monitoring occurs when a facility appears to have impacted groundwater quality. The objective of the monitoring program shifts from detection to assessing the nature and extent of the problem. Under corrective action monitoring, Ecology has stipulated some form of groundwater remediation. The goal of a corrective action groundwater monitoring program is to determine if the corrective action is effective.

Executive Order 12580 assigns DOE the responsibility and authority (under CERCLA Section 104) to conduct cleanup of contamination at the Hanford Site, and CERCLA Section 120 gives EPA an oversight role at Hanford and other Federal facilities placed on the CERCLA National Priorities List. Cleanup decisions are based on the results of environmental investigations that include the vadose zone and groundwater. CERCLA groundwater monitoring on the Hanford Site includes monitoring of contaminants and water levels, and monitoring the effectiveness of groundwater remedial actions, such as P&T systems.

DOE orders implement requirements of the AEA at DOE sites. These requirements include groundwater monitoring to detect, characterize, and respond to releases of radionuclides. This AEA monitoring is integrated with CERCLA and RCRA monitoring on the Hanford Site.

DOE operates an extensive groundwater monitoring program on the Hanford Site, collecting thousands of samples from hundreds of wells each year. Figure ES.3 compares maximum concentrations of the major groundwater contaminants in various parts of the Site in 2013. These contaminants are discussed further in the remaining sections of this Executive Summary.

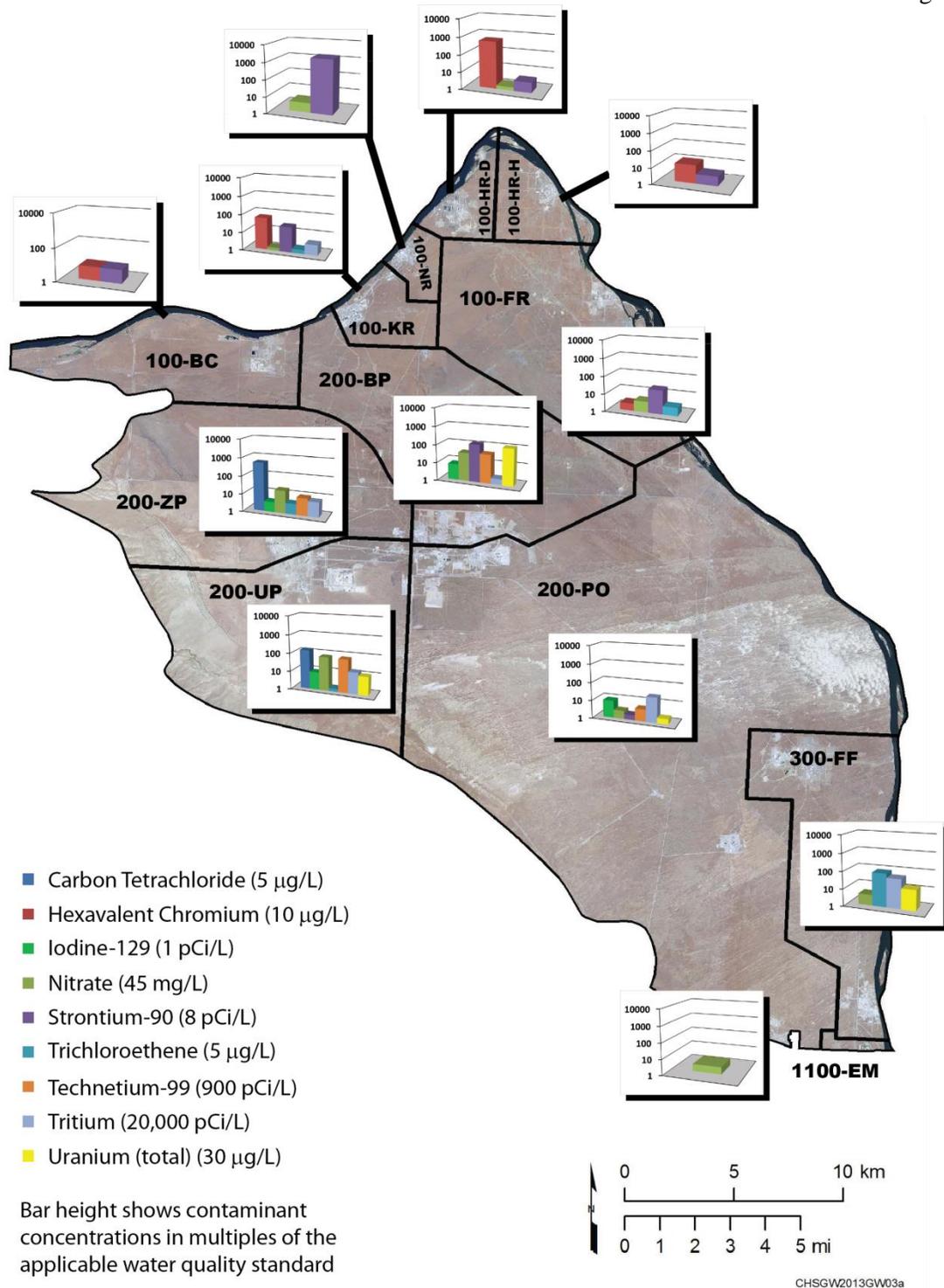


Figure ES.3 Exceedance Ratios of Groundwater Contaminants

This map shows the maximum concentrations of groundwater contaminants in each groundwater interest area in 2013. The heights of the bars represent multiples of the applicable water quality standards. For example, if the maximum strontium-90 concentration was 80 pCi/L, the bar is 10 units high because the DWS is 8 pCi/L.

Executive Summary – River Corridor

The River Corridor comprises the region of the Hanford Site along the shoreline of the Columbia River, which includes the 100, 300, and 1100 Areas. In the 100 Area, groundwater contamination is related to past disposal of waste associated with water-cooled nuclear reactors. The primary groundwater contaminants are hexavalent chromium, strontium-90, nitrate, and tritium (Figure ES.4). Sources of hexavalent chromium contamination included the routine disposal of reactor cooling water, which contained the corrosion inhibitor sodium dichromate, and unplanned spills and leaks of the high-concentration sodium dichromate stock solution. In 300-FF uranium and tritium are the primary groundwater contaminants. Table ES.1 provides a summary of the River Corridor groundwater interest areas and associated contamination plumes.

Since the 1990s DOE has been remediating waste sites and groundwater in the River Corridor under interim RODs. Removal of contaminated soil has reduced the potential for future groundwater contamination and, by the end of 2013, more than 85 percent of the waste sites near the river had been remediated or classified as not requiring remediation. Cleanup of the remaining sites is underway. Groundwater remediation systems in the 100 Area are limiting the amount of contamination reaching the Columbia River and reducing the mass of contaminants in the groundwater. Interim cleanup of the River Corridor has achieved a considerable level of cleanup and final remedies are being developed. EPA and DOE signed a final ROD for 300-FF waste sites and groundwater in 2013, and final RODs for the other portions of the River Corridor are expected to be developed in the next few years.

100-BC

Groundwater contaminants in 100-BC include hexavalent chromium and strontium-90. Tritium concentrations declined below the drinking water standard (DWS) in 2013. Former waste sites in 100-BC have been remediated under an interim action ROD, so contaminant levels in groundwater are expected to continue to decline.

DOE began conducting additional studies in 100-BC in 2013 to reduce uncertainties relating to (1) the completion of waste site remediation; (2) short term changes in groundwater contaminants related to waste site remediation; (3) modeling results predicting that it will take a long time for the hexavalent chromium plume to attenuate; and (4) the level of risk associated with variable contaminant concentrations in Columbia River pore water. In 2013, DOE installed and began monitoring 18 shallow aquifer tubes in the Columbia River. Eight new monitoring wells were installed in late 2013 and early 2014.

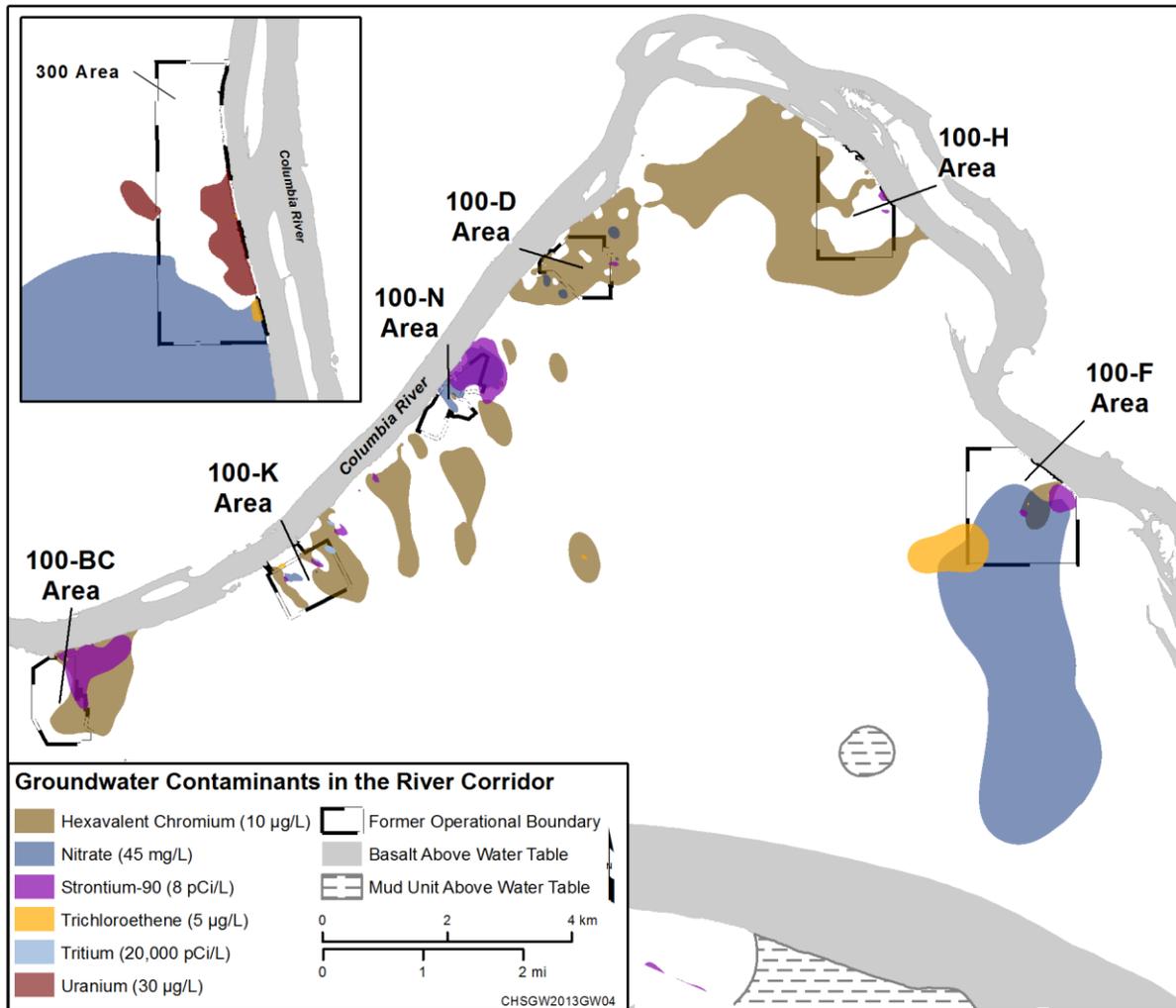


Figure ES.4 Groundwater Contaminants in the River Corridor

100-KR

The principal groundwater activities for 100-KR are cleaning up hexavalent chromium in the groundwater, tracking contaminant plumes, and monitoring groundwater near the former KE Fuel Storage Basins and the KW Fuel Storage Basins. The concrete KE and KW Basins were integral parts of each reactor building. Until 2004, the water-filled basins were used to store irradiated fuel from the last run of N Reactor, as well as miscellaneous fuel fragments recovered during remedial actions at other reactor areas. Leaks at and around the basins have contaminated groundwater in the past.

The KE Basin was demolished, but some contaminated soil remains. The KW Basin has been emptied of fuel rods but remains a depository for contaminated sludge from the KE and KW Basins. The KW Basin and the 116-KW-2 Crib are scheduled for removal. Groundwater monitoring in 2013 did not show new groundwater impacts from the basins. Remediation of waste sites continued in 2013.

Groundwater contaminant plumes in 100-KR are decreasing in size due to remediation and natural processes including dispersion, discharge to the Columbia River in areas without hydraulic containment, degradation, and radioactive decay.

Hexavalent chromium is the primary contaminant of concern for groundwater. Three P&T systems operate as interim actions to remove hexavalent chromium from the groundwater. Changes in the hexavalent chromium plume over time are shown in Figure ES.5. Between 1997 and 2013, 747 kilograms of hexavalent chromium have been removed. Smaller plumes of carbon-14, tritium, strontium-90, nitrate, and trichloroethene also are present in 100-KR groundwater. Cleanup actions for these other contaminants will be defined in the ROD.

The CERCLA process is underway to make final cleanup decisions for 100-KR. DOE has proposed P&T for hexavalent chromium as part of a preferred alternative for groundwater remediation. The draft RI/FS and Proposed Plan underwent review in 2012 and DOE will incorporate the results of supplemental source characterization activities.



Figure ES.5 100-KR Hexavalent Chromium Plume in 1996 (Before Interim Action) Compared to 2013 (During Interim Action)

100-NR

Principal groundwater activities for 100-NR include RCRA monitoring and remediation of strontium-90 and total petroleum hydrocarbons. The major liquid waste disposal sites have been remediated, and excavation is continuing at remaining waste sites. Other groundwater contaminants include nitrate and tritium.

The primary groundwater contaminant is strontium-90, which originated at the 116-N-1 and 116-N-3 waste sites. Since Strontium-90 binds to sediment the shape and size of the plume (Figure ES.6) has not changed significantly since 1996. P&T technology was found to be ineffective in cleaning up strontium-90, so DOE is now applying an in situ technology remedy called strontium-90 sequestration, using an apatite chemical solution. The goal is to create a reactive zone in the aquifer that captures strontium-90 as groundwater flows through it to the Columbia River. Apatite chemicals were injected into a line of wells along the river shoreline several times between 2006 and 2011. As the injected chemicals reacted with the aquifer and sediments, strontium-90 levels temporarily increased in groundwater wells and aquifer tubes between the apatite barrier and the river. Subsequently, strontium-90 and gross beta concentrations declined, as predicted.

In 2013, RCRA monitoring continued under final status detection programs at the 1301-N, 1324-N/NA, and 1325-N facilities (waste sites 116-N-1, 120-N-1, 120-N-2, and 116-N-3). Results indicated no releases of dangerous waste constituents from the RCRA units.

DOE submitted a draft RI/FS Report and Proposed Plan to Ecology for review in 2013. The RI/FS Report and Proposed Plan will be used to develop a ROD, documenting decisions for remediation of waste sites and groundwater in the coming year.

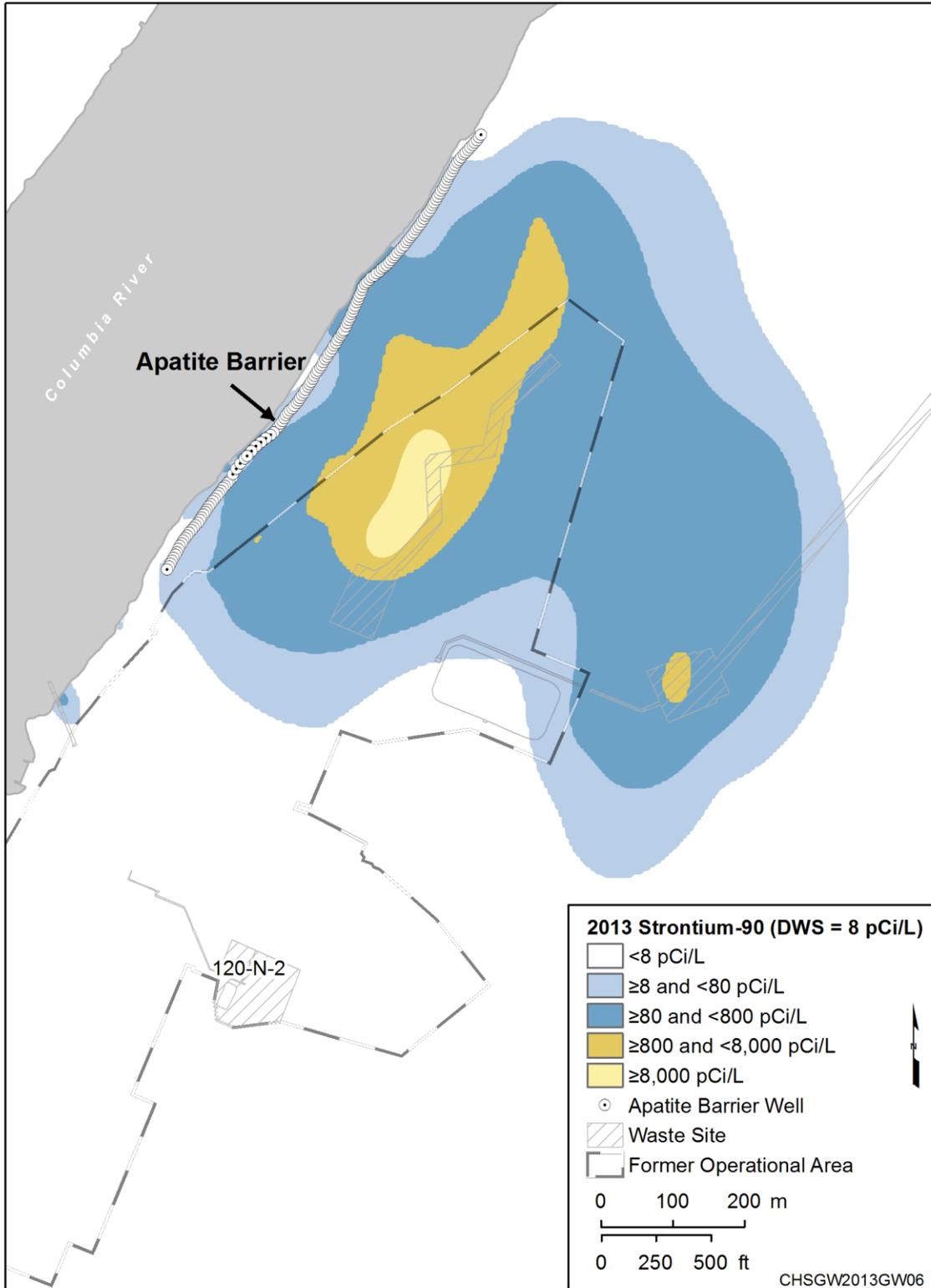


Figure ES.6 100-NR Strontium-90 Plume

100-HR

The 100-HR-3 groundwater OU in the northern Hanford Site includes the 100-HR-D and 100-HR-H groundwater interest areas. Remediation of waste sites continued in 2013. Hexavalent chromium is the primary contaminant of concern for groundwater, and is the target of two groundwater P&T systems. Hexavalent chromium also was detected at relatively high levels within the Ringold upper mud unit (RUM) beneath portions of 100-HR, unlike elsewhere in the 100 Areas. Additional groundwater contaminants include strontium-90 and nitrate (Figure ES.4).

P&T systems remove hexavalent chromium contamination from the groundwater as part of an interim action. Between 1997 and 2013, these systems removed 2,038 kilograms of hexavalent chromium. Investigation of groundwater conditions at 100-HR greatly changed the understanding of the extent of chromium contamination during this time, primarily because many more wells were installed. In 1997, 95 wells were sampled, and in 2013, over 300 wells were sampled. The added wells identified areas of higher chromium concentrations at 100-D and in the Horn. Even with areas of high levels of contamination being identified, the overall aerial extent of the plume has decreased as a result of remediation (Figure ES.7).

The CERCLA process is underway to make final cleanup decisions for 100-HR. DOE submitted Draft A of an RI/FS and Proposed Plan in 2012. Starting in 2013 and continuing in 2014, DOE and Ecology have been working through the comment resolution process. After comments are incorporated, the document will undergo a public comment period and then a ROD will be issued that identifies the final remedial alternatives. DOE has proposed ongoing P&T as the preferred alternative for remediating hexavalent chromium in groundwater. The P&T system will capture the other contaminants of concern.

The former 183-H solar evaporation basins (waste site 116-H-6) constitute the only RCRA site in 100-HR. The site is monitored in accordance with RCRA corrective action requirements during the post-closure period to track contaminant trends during operation of the CERCLA interim action for chromium. Monitoring well 199-H4-3 was decommissioned in April 2013 due to ongoing CERCLA remediation activities and replaced in the permit by well 199-H4-84.

100-FR

Groundwater contamination in 100-FR originated from disposal of solid and liquid waste associated with operation of the water-cooled F Reactor and biological experiments. Nitrate concentrations in groundwater exceed the DWS beneath much of the 100-F Area and the plume extends southward approximately 5 kilometers. Smaller plumes of hexavalent chromium, strontium-90, and trichloroethene are present. Contaminant concentrations are below applicable standards near the river and are declining overall.

Former waste sites have been excavated and backfilled under a ROD for interim action. In 2013 DOE incorporated EPA's review comments into a draft RI/FS and Proposed Plan. In 2014 the Proposed Plan will undergo a public comment period and then a ROD will be issued that identifies the final remedial alternatives. DOE has proposed monitored natural attenuation (MNA) as the preferred alternative for groundwater remediation.

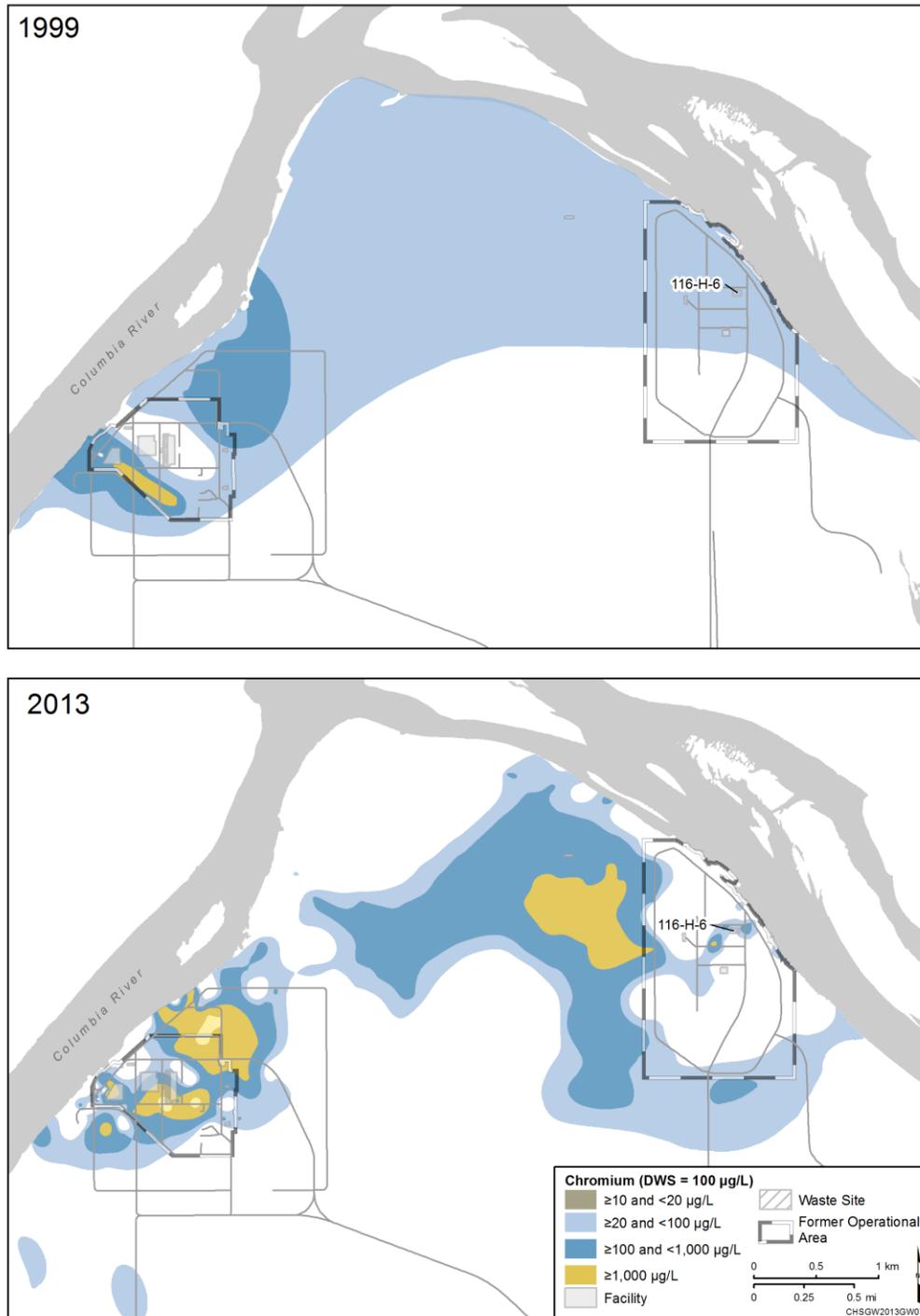


Figure ES.7 100-HR-3 Hexavalent Chromium Plume in 1999 (Early in Interim Action Period) Compared to 2013 (During Interim Action)

The changes in plume delineation and concentrations in 100-D and 100-H reflect the addition of new wells over time, which identified areas of higher concentration.

300-FF

Three geographic regions comprise 300-FF: the 300 Area Industrial Complex, the 618-11 Burial Ground region, and a region including the 618-10 Burial Ground and 316-4 Cribs. Most of the former waste sites have been remediated or classified as not requiring remediation under an interim ROD.

EPA and DOE signed a ROD for the 300-FF-5 groundwater OU in 2013. The contaminants of concern are uranium, gross alpha, trichloroethene, and cis-1,2-dichloroethene at the 300 Area Industrial Complex and tritium and nitrate at the 618-11 Burial Ground.

Uranium concentrations remain above the cleanup level (30 µg/L) in groundwater in the 300 Area Industrial Complex (Figure ES.8). Concentrations vary with changes in water table elevation, which relate to the stage of the Columbia River. When the water table is high, uranium concentrations decline in wells near the river and increase in inland wells.

Another area of uranium contamination developed downgradient from the 618-7 Burial Ground when it was remediated in 2007 and 2008. The contaminant plume resulted from the infiltration of dust control water and soil fixatives used during remediation activities. The contamination migrates toward the Columbia River and merges with the uranium plume in the 300 Area Industrial Complex.

Trichloroethene concentrations did not exceed the cleanup level (4 µg/L) in any 300-FF monitoring wells in 2013. Trichloroethene was detected at concentrations above the cleanup level at some aquifer tubes that are screened proximal to, or within, a finer-grained interval of Ringold Unit E sediment.

Groundwater associated with the 618-11 Burial Ground contains a high-concentration tritium plume originating from irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from a peak value of 8,140,000 pCi/L in January 2000 to a level concentration of 900,000 from 2007 to 2013, and the plume has maintained its basic shape since its discovery in 1999. Relatively constant tritium concentrations immediately adjacent to the site suggest that buried materials are providing an ongoing source of tritium to groundwater. However, the conceptual model for the plume, including a simulation of plume evolution over time, indicates that tritium concentrations will be below the DWS when the plume reaches the Columbia River.

Nitrate concentrations near the 618-11 Burial Ground continue to exceed the cleanup level (45 mg/L). Concentrations of nitrate above 45 mg/L are also present in groundwater beneath part of the 300 Area Industrial Complex, from sources off the Hanford Site.

RCRA groundwater monitoring continued at the 300 Area Process Trenches (waste site 316-5). The unit is monitored in accordance with post-closure corrective action requirements (WAC 173-303-645[11]). Uranium and cis-1,2-dichloroethene continued to exceed permit limits in 2013. Site remediation will be coordinated under the 300-FF-5 Groundwater OU as part of the Remedial Design (RD)/Remedial Action (RA) work plan.

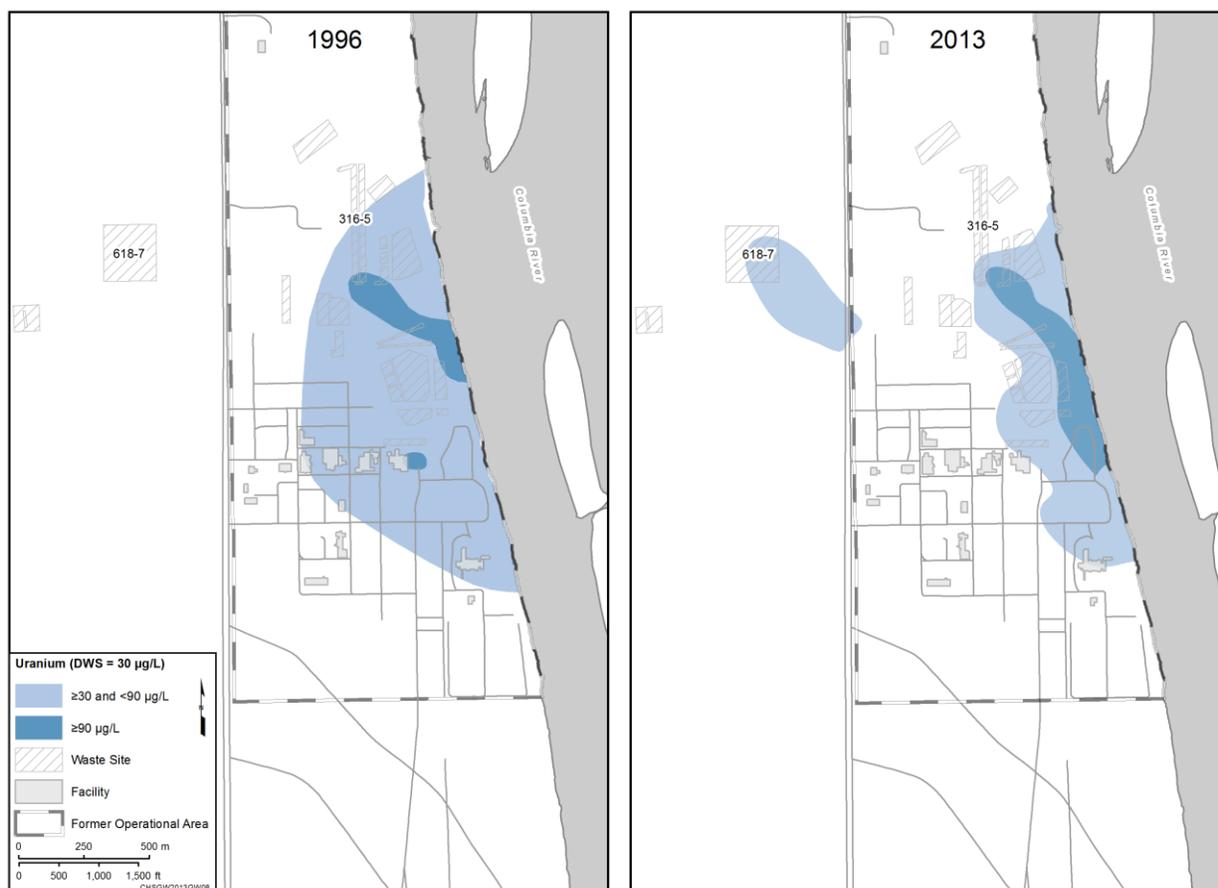


Figure ES.8 300-FF-5 Uranium Plume in 1996 Compared to 2013

1100-EM and Richland North

The 1100-EM-1 groundwater OU was removed from the “National Priorities List” (40 CFR 300, Appendix B) in 1996. The selected remedy was MNA of volatile organic compounds, with institutional controls (ICs) on drilling of new water supply wells. Trichloroethene was the primary contaminant of concern, but concentrations have remained below the cleanup level since 2001.

Wells in the North Richland Well Field are monitored frequently to detect any changes in potential Hanford Site contaminants near these wells. Tritium associated with the plume originating from sources in the 200 East Area has not been detected in these wells.

Uranium concentrations in Hanford Site wells in the vicinity of DOE’s inactive Horn Rapids Landfill have increased gradually since 1996, exceeding the DWS in 2012 and dropping slightly below the standard in January 2014. The presence of uranium at these locations is likely associated with the plume moving northeast from an offsite facility.

Columbia River

DOE samples Columbia River water, river sediment, and riverbank seeps to determine the extent of Hanford Site contaminants. The data provide a historical record of radionuclides and chemicals in the environment. Concentrations of tritium and uranium in river water downstream of the Site are slightly higher than upstream of the Site (tritium detected at 108 pCi/L downstream versus 26 pCi/L upstream; uranium-234 detected at 0.31 pCi/L downstream and 0.27 pCi/L upstream), but they meet water quality standards. Concentrations of other contaminants are no higher in downstream samples.

Two DOE studies addressed the entire River Corridor in order to support the multiple River Corridor RI/FS documents. The 100 Area and 300 Area component of DOE's River Corridor baseline risk assessment addresses post-remediation, residual contaminant concentrations in these areas, as well as the Hanford and White Bluffs town sites. The assessment also investigated the risks related to the potential transport of Hanford Site contaminants into Columbia River riparian and near-shore environments adjacent to the operational areas.

DOE completed an investigation of Hanford Site contaminant releases in the Columbia River in 2010 ([DOE/RL-2010-117](#)). Samples were collected of pore water (i.e., groundwater discharge into the river bottom sediment), river sediment, river water, fish, and island soil. Pore water in some 100 Area samples had concentrations of hexavalent chromium above the aquatic standard, and strontium-90 exceeded the DWS in some 100-N Area samples. Tritium concentrations exceeded the DWS in some pore water samples near the former Hanford town site, and uranium exceeded the DWS near the 300 Area. The information obtained from this investigation will ultimately be used to help make final cleanup decisions for each of the River Corridor units.

Executive Summary – Central Plateau

When the Hanford Site was operating as a plutonium production facility, irradiated fuel reprocessing, isotope recovery, and associated waste management activities occurred in the 200 East and 200 West Areas in the central portion of the Site. Ponds, cribs, and ditches used for disposal of liquid waste were primary sources of groundwater contamination. There are also seven single-shell tank waste management areas (WMAs) in the 200 Area. Some of these tanks have leaked, contaminating the vadose zone and groundwater beneath the tanks. Remediation of the Central Plateau waste sites is expected to accelerate after River Corridor remediation is complete. Currently, cleanup activities on the Central Plateau focus on completing decision documents, remediating groundwater plumes, and decontaminating and decommissioning facilities.

Groundwater contaminant plumes of tritium, nitrate, and iodine-129 formed when the waste discharged to ponds and cribs reached the aquifer. These contaminants form regional plumes originating on the Central Plateau. The tritium and nitrate plumes have decreased in area over the years as a result of dispersion and radioactive decay (tritium only); the area of iodine-129 has remained stable. A large carbon tetrachloride plume originated in the 200 West Area. Other groundwater contaminants in the Central Plateau include technetium-99, uranium, strontium-90, trichloroethene, cyanide, and other dangerous waste constituents (Table ES.3 and Figure ES.9).

Table ES.3 New Wells and Aquifer Tubes Completed in 2013

Groundwater Interest Area	Wells	Aquifer Tubes
100-BC	0	18
100-HR-D	6	0
100-HR-H	4	0
200-UP	2	0
200-ZP	4	0
Total	16	18

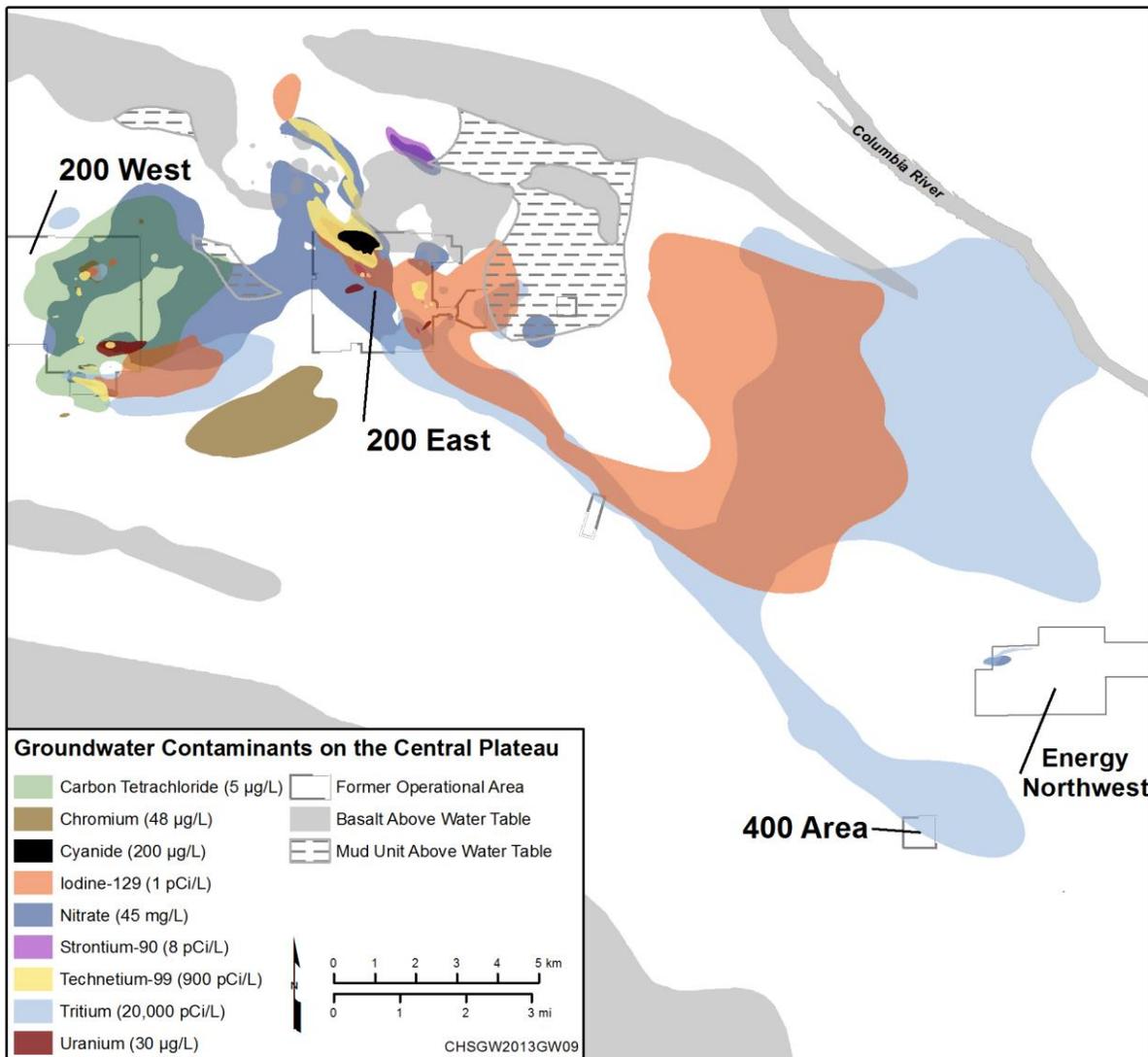


Figure ES.9 Groundwater Contaminants in the Central Plateau

200-ZP

Contaminant sources in 200-ZP, located in the 200 West Area, included cribs, ponds, and single-shell storage tanks. A final ROD for 200-ZP-1 groundwater identified carbon tetrachloride as the primary contaminant of concern. This plume is expanding at the edges but is currently contained within the 200 West area and vicinity. A P&T system has reduced the high-concentration core area (Figure ES.10). Other contaminants of concern are trichloroethene, iodine-129, technetium-99, nitrate, chromium, and tritium.

In July 2012, DOE began to operate a large, final action P&T system to remediate the entire thickness of the unconfined aquifer. In 2013, the system processed 747 million liters of groundwater and removed 3,049 kilograms of carbon tetrachloride, 195,051 kilograms of nitrate, and other contaminants from groundwater. Combined, the final action system and the interim action system, which operated from 1996 through 2012, has removed a total of 17,491 kilograms of carbon tetrachloride from groundwater. In addition, a final-action soil vapor extraction system and the interim action system that operated from 1992 through 2011 removed a total of 80,107,000 kilograms of carbon tetrachloride from the vadose zone. Figure ES.11 illustrates the total mass removed from the subsurface.

Two Low-Level Waste Management Areas (LLWMA-3 and LLWMA-4) in 200-ZP are monitored under RCRA interim-status, contaminant indicator parameter programs. Monitoring results showed no indication that either of these LLWMAs is contaminating groundwater.

RCRA assessment monitoring continued at WMA T and WMA TX-TY. Due to CERCLA remediation activities (operation of the 200 West P&T system) near WMA T, chromium concentrations are declining and the plume extents at both WMAs are shrinking.

The State-Approved Land Disposal Site (SALDS) receives treated water from the Hanford Site's Effluent Treatment Facility. It is regulated under a state waste discharge permit and has created a local tritium plume. All groundwater sampling results from the SALDS proximal wells were within permit compliance limits during 2013.

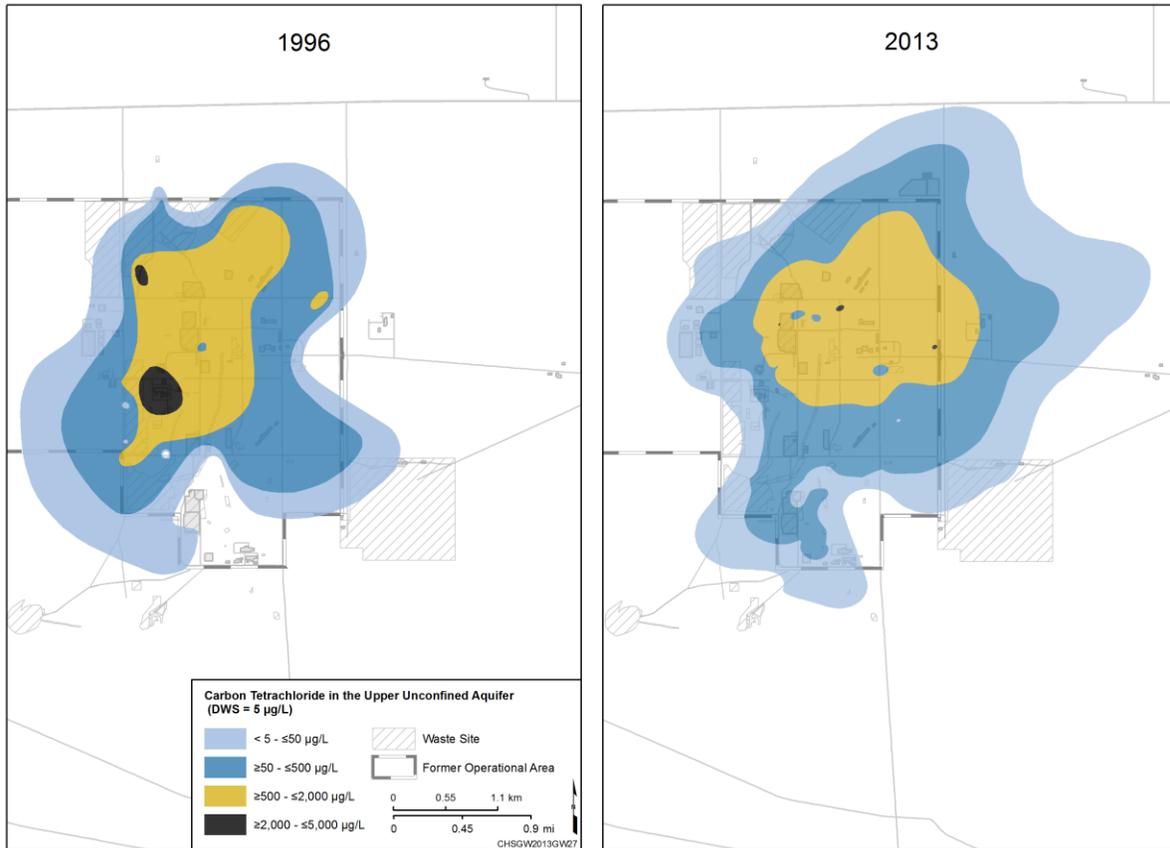


Figure ES.10 200-West Carbon Tetrachloride Plume in 1996 (Upper Part of Unconfined Aquifer) Compared to 2013 (Including Available Vertical Interval Data)

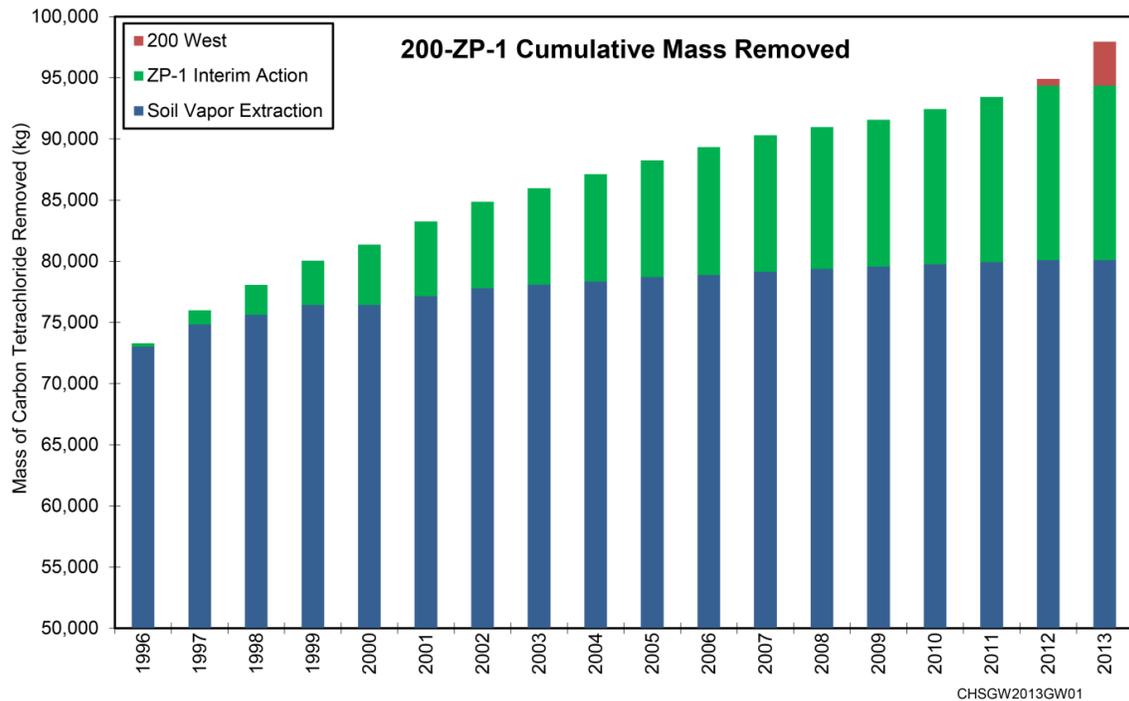


Figure ES.11 200-ZP Carbon Tetrachloride Mass Removed by Final Pump-and-Treat, Interim Pump-and-Treat, and Soil Vapor Extraction

200-UP

The southern portion of the 200 West Area and adjacent areas to the east and south comprise 200-UP. Contaminant sources included cribs, ponds, and single-shell tanks. Carbon tetrachloride, technetium-99, uranium, tritium, iodine-129, nitrate, and chromium plumes are present in groundwater. Carbon tetrachloride in this region originated from sources in 200-ZP.

An interim action ROD addressing all of the major contaminant plumes within the 200-UP-1 OU was published in 2012. The selected remedy in the ROD consists of a combination of P&T, MNA, hydraulic containment, and institutional controls.

A work plan released during September 2013 addressed the approach to be used to design P&T systems for uranium and technetium-99 near U Plant, a P&T system for the chromium plume southeast of 200 West Area, and an injection well system for hydraulic control of the iodine-129 plume while treatment technologies are investigated. The work plan also addressed continued operation of the groundwater extraction system at WMA S-SX.

Wells near WMA S-SX continued to show the highest technetium-99 concentrations on the Hanford Site in 2013. The plume has grown in recent years (Figure ES.12) and a P&T system began operating in July 2012 to remove contamination. In 2012 and 2013 the system removed a total of 1.03 Curie of technetium-99, 9,560 kilograms of nitrate, 17.9 kilograms of chromium, and 121 kilograms of carbon tetrachloride from groundwater.

The 200 West P&T system (discussed in the 200-ZP section) is affecting groundwater flow in the northern part of 200-UP near U Plant. Contaminant concentrations have declined in some wells and increased in other wells because of changing directions of groundwater flow. A groundwater extraction system to remediate the uranium and technetium-99 plumes in the U Plant area is currently being designed.

RCRA monitoring in 200-UP includes interim status groundwater quality assessment monitoring at WMA S-SX and WMA U, and interim status indicator parameter evaluation monitoring at the 216-S-10 Pond and Ditch. WMA S-SX has contaminated groundwater with chromium and nitrate. Water levels have declined at WMA S-SX due to groundwater extraction. Two monitoring wells went dry in 2013, two new wells were installed, and an additional replacement well is planned. Sources within WMA U have contaminated groundwater with nitrate and chromium. The groundwater beneath this tank farm is within the capture zone of a nearby extraction well. Indicator parameters did not exceed statistical comparison values at the 216-S-10 Pond and Ditch during 2013.

The Environmental Restoration Disposal Facility (ERDF) is a CERCLA disposal facility used for disposal of low-level radioactive mixed waste generated by remedial actions on the Hanford Site. The results of groundwater monitoring in 2013 continued to indicate that the facility has not adversely affected groundwater quality.

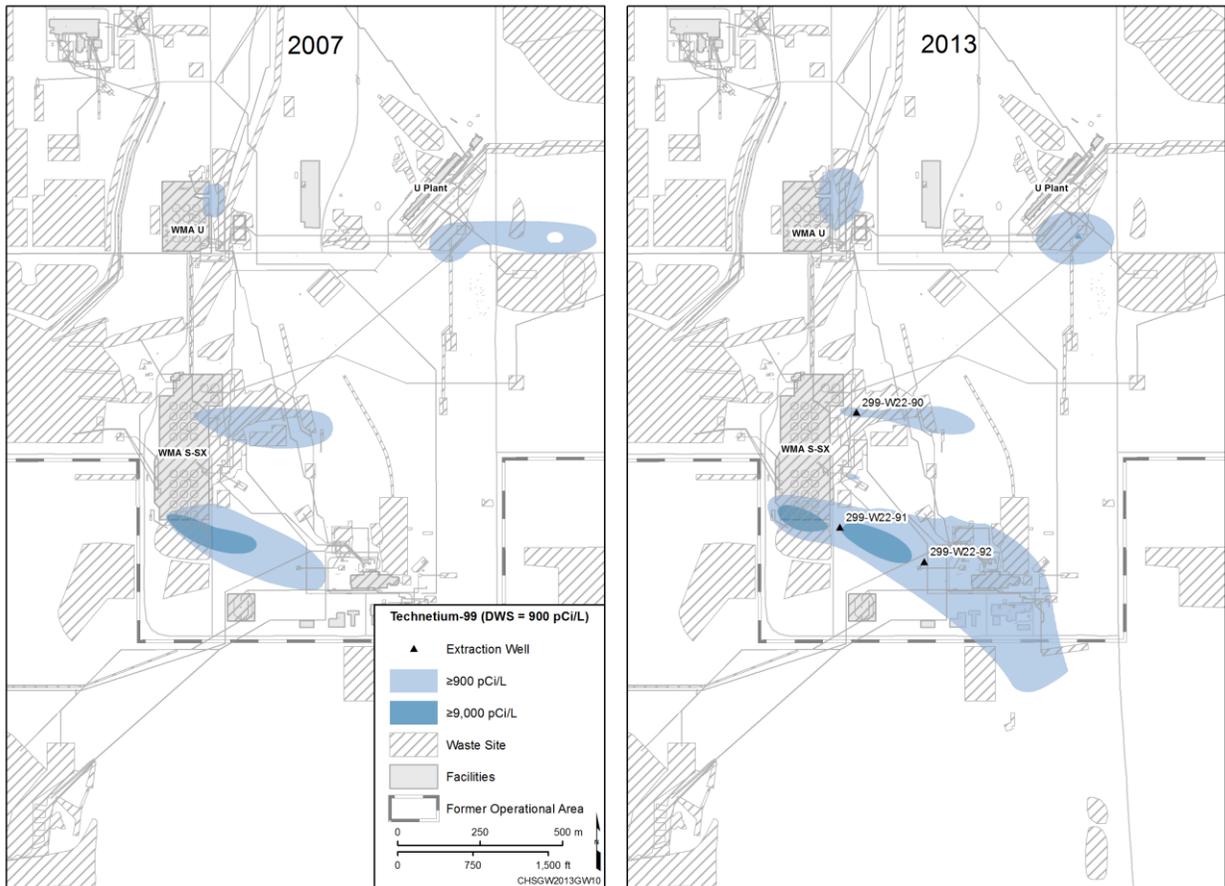


Figure ES.12 WMA S-SX Technetium-99 Plume

200-BP

The 200-BP groundwater interest area includes groundwater beneath the northern 200 East Area and the region to the northwest where mobile contaminants have migrated between Gable Mountain and Gable Butte. Most of the groundwater contamination is concentrated beneath WMA B-BX-BY and adjacent waste sites in the northwestern portion of the 200 East Area. Cleanup decisions for 200-BP are yet to be made.

Nitrate, iodine-129, and technetium-99 form the largest contaminant plumes in 200-BP. These mobile contaminants have migrated to the northwest as a result of past groundwater flow. The high-concentration cores of these plumes have grown in size since 2007 due to continued drainage of contaminated water from the vadose zone into the aquifer (Figure ES.13). Smaller plumes of uranium, cyanide, strontium 90, and tritium also exceed their respective DWSs. Cesium-137 and plutonium-239/240 contamination is limited to one or two wells.

A fine-grained geologic unit beneath the B Plant region has created an area of saturated sediments (a “perched” aquifer) in the deep vadose zone above the regional water table. This perched water is contaminated with uranium and other contaminants at concentrations higher than in the underlying aquifer. Beginning in 2011 and continuing through 2013, DOE operated a pumping test to remove this perched water before it reached groundwater. Approximately 32 kg of uranium were removed through the end of 2013. DOE has proposed continuing the extraction of contaminated perched water as a non-time-critical removal action under CERCLA.

Six RCRA sites with groundwater monitoring requirements are located in 200-BP. RCRA groundwater quality assessment monitoring at WMA B-BX-BY and WMA C indicates that the dangerous waste constituent cyanide in groundwater originated in the WMAs. Because of the continued migration of this dangerous waste constituent an additional well is planned to be installed at WMA B-BX-BY in 2014 to provide control of monitoring the extent. RCRA contamination indicator parameter monitoring continued at the 216-B-63 Trench, LLWMA-1, and LLWMA-2 in 2013. Results continued to show that these units have not adversely affected groundwater quality. DOE monitors the Liquid Effluent Retention Facility (LERF) under a RCRA final-status detection program. Results showed no indication that the site has affected groundwater. In 2013, DOE prepared a class 2 modification of the permit including a new groundwater monitoring plan. This plan is going through public comment in early 2014 and may be implemented in late 2014.

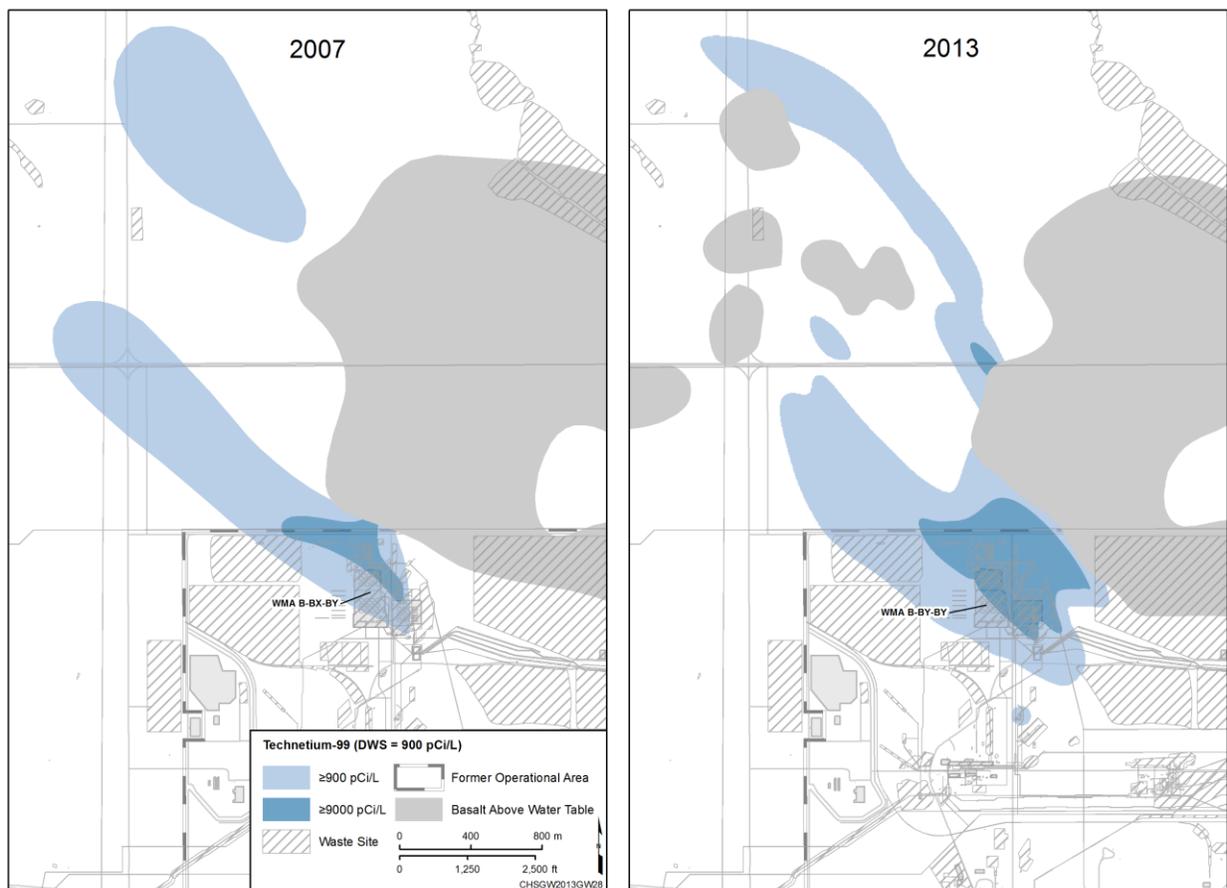


Figure ES.13 200-BP Technetium-99 Plume in 2007 Compared to 2013

200-PO

The southern portion of the 200 East Area and a large region of the Hanford Site to the east and southeast comprise 200-PO. Disposal of large volumes of liquid waste created regional groundwater plumes of tritium, iodine-129, and nitrate. Concentrations of tritium are declining as the groundwater plume attenuates naturally as a result of radioactive decay and dispersion. The size of the tritium plume has decreased in area by one-third since 1980 (Figure ES.14) and the maximum concentration has declined 90 percent. The area of the iodine-129 plume above the 1 pCi/L contour has decreased slightly over the past decade, and maximum concentrations have declined as a result of dispersion. Radioactive decay has not decreased the level of iodine-129 contamination noticeably because this isotope has a half-life of 15.7 million years. The nitrate plume covers a large area, with concentrations above background but mostly below the DWS. Other contaminants in 200-PO include strontium-90, technetium-99, and uranium in smaller areas near their sources.

DOE conducted a CERCLA RI for 200-PO-1 in 2008 and 2009 and submitted an RI report to Ecology in 2012. In 2013, a RI report supplement was started to update the risk assessment using additional data collected since the RI report was completed. The report recommended that the next step in the CERCLA process should be a FS to develop remedies to address the groundwater contamination associated with the OU.

In 2013, RCRA assessment monitoring continued at WMA A-AX and interim-status indicator parameter programs continued at the 216-A-36B Crib, 216-A-37-1 Crib, 216-A-29 Ditch, 216-B-3 Pond, and Nonradioactive Dangerous Waste Landfill (NRDWL). One monitoring well with casing corrosion associated with WMA A/AX was decommissioned in 2013 and is scheduled to be replaced. Monitoring results provided no indication of releases from these facilities to groundwater. The Integrated Disposal Facility is an expandable, double-lined landfill that is regulated under RCRA and the AEA. It is not yet in use, and current groundwater monitoring is directed at obtaining baseline data.

The Solid Waste Landfill is regulated under Washington State solid waste handling regulations. As in previous years, some of the monitoring wells showed higher concentrations of regulated constituents than the statistically calculated background threshold values. Background threshold values exceeded during 2013 included specific conductance, nitrite, sulfate, and total organic carbon. One monitoring well went dry in 2013.

Three water supply wells provide drinking water and serve as an emergency water supply for the 400 Area, which is in the footprint of 200-PO. Because the 400 Area is in the path of the Hanford Site-wide tritium plume, DOE routinely monitors the wells for tritium. These wells are screened deep in the unconfined aquifer, just above the Ringold lower mud unit, where tritium concentrations are lower than at the top of the aquifer.

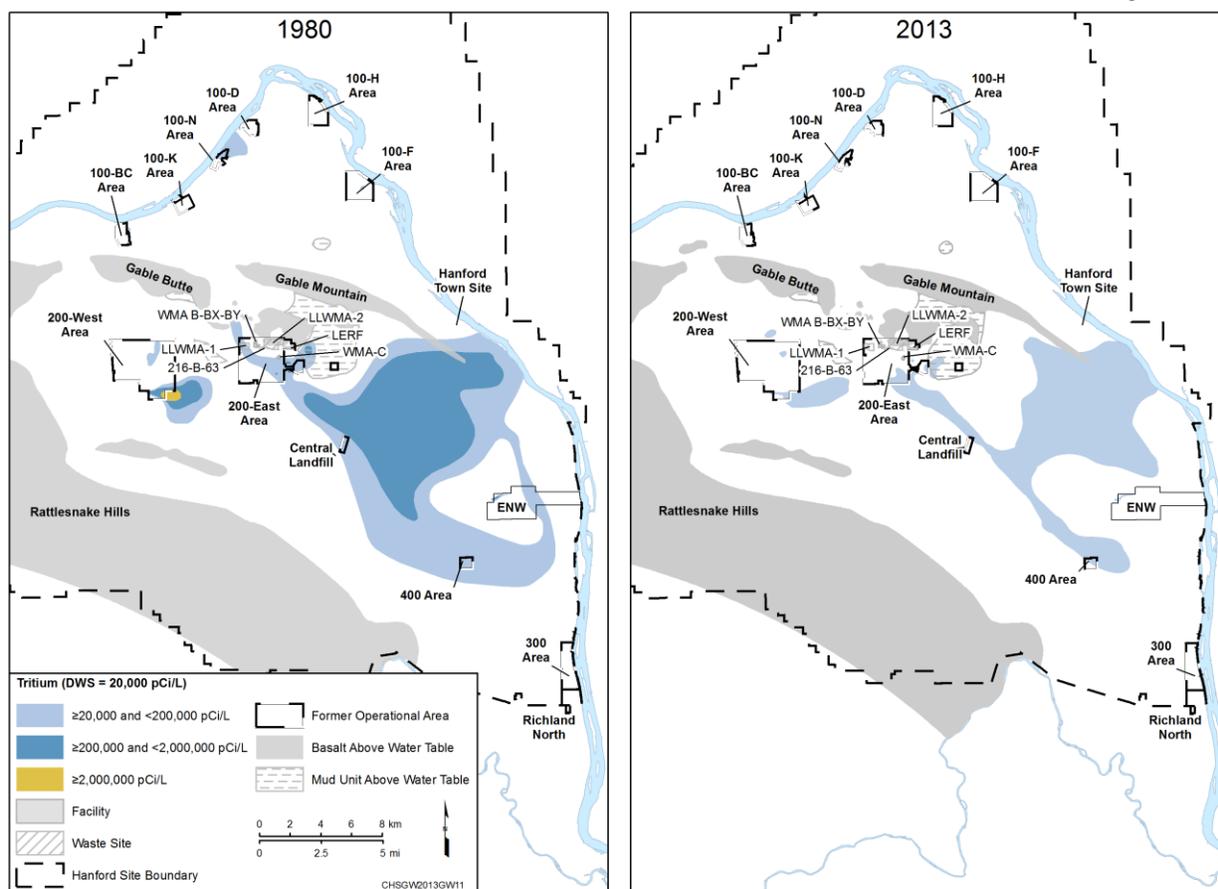


Figure ES.14 Hanford Site Tritium Plumes in 1980 Compared to 2013

Executive Summary – Confined Aquifers

Although most Hanford Site groundwater contamination is found in the unconfined aquifer, DOE monitors wells in deeper aquifers because of potential downward movement of contamination and potential migration of that contamination off site through the confined aquifers. There is no evidence of offsite migration via the confined aquifers. Appendix D includes more detailed information about confined aquifer monitoring.

One confined aquifer occurs within sand and gravel at the base of the Ringold Formation. Carbon tetrachloride, nitrate, and technetium-99 have contaminated this unit in a portion of 200 West Area where the upper confining unit is absent. New wells have been installed in recent years to monitor and remediate this contamination. The Ringold confined aquifer is the uppermost aquifer in a region east of 200 East (within portions of 200-BP and 200-PO). Iodine-129 and tritium are detected in wells at this location, but the contamination has not migrated farther to the east and/or southeast.

In the northern Hanford Site, fine-grained sedimentary units, informally called the RUM, confine deeper sediments in the Ringold Formation. In some parts of 100-HR this unit is contaminated with hexavalent chromium at concentrations up to 133 $\mu\text{g/L}$.

Groundwater within basalt fractures and joints, interflow contacts, and sedimentary interbeds make up the upper basalt-confined aquifer system. No significant contamination is detected in the basalt-confined aquifer, except in the northwestern 200 East Area, where poor well construction and

temporary drilling effects allowed local migration of groundwater from the overlying unconfined aquifer.

Executive Summary - Wells

Over the lifetime of the Hanford Site, DOE has installed thousands of wells to monitor and remediate groundwater and provide geologic data. Figure ES.15 illustrates the number of wells installed during the past ten years. During 2013, DOE installed sixteen new wells and eighteen new aquifer tubes (Table ES.3).

DOE identifies wells, boreholes, or other subsurface installations for decommissioning when they are no longer needed. In 2013, eight wells were physically decommissioned. This involved sealing the wells in compliance with Washington State groundwater protection laws ([WAC 173-160](#)).

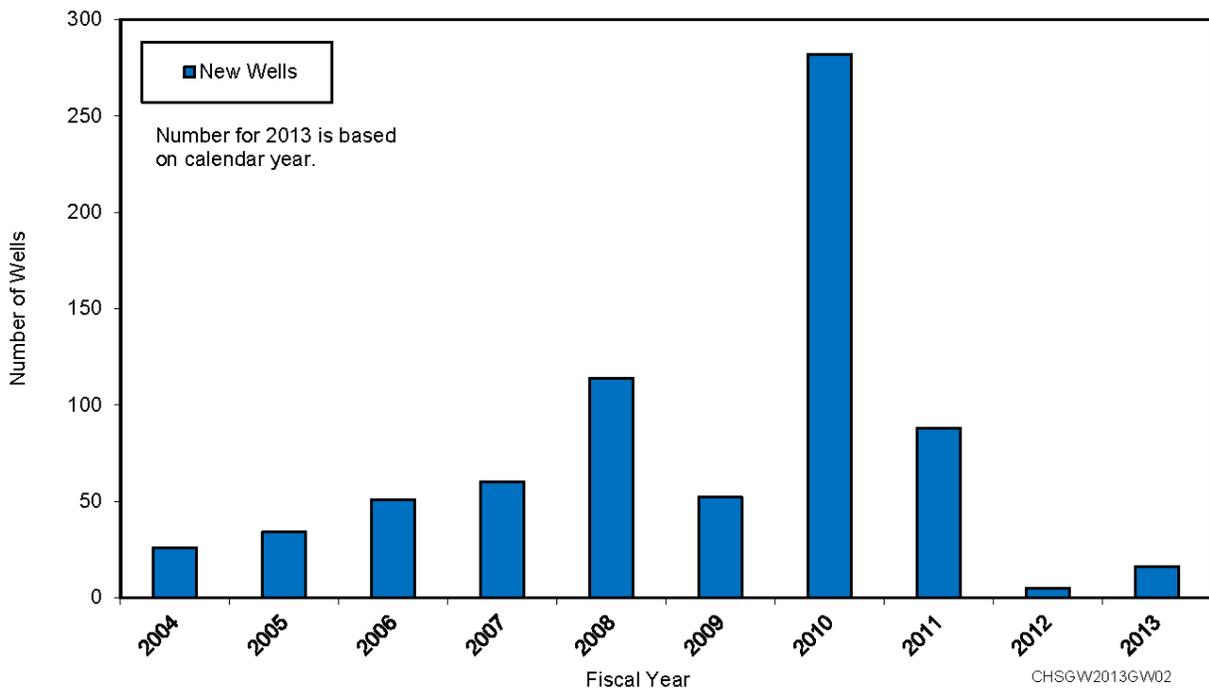


Figure ES.15 New Wells Installed on the Hanford Site, 2004 to 2013
(note: 2013 value is calendar year total)

Executive Summary – Additional Information

The data presented in this report—and information on monitoring well locations, construction details, and screened intervals—can be found through the DOE Environmental Dashboard Application at <http://environet.hanford.gov/EDA/>, in the interactive version of this document, or on the PHOENIX website at <http://phoenix.pnnl.gov>.