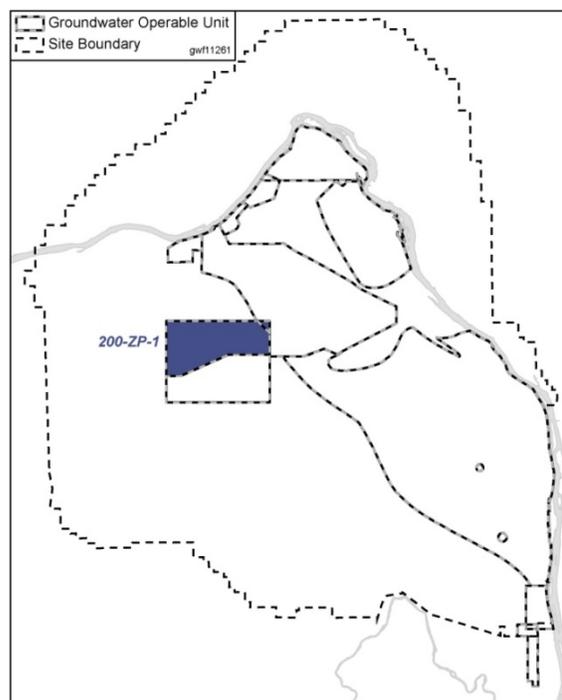


3.2 200-ZP-1

S.A. Simmons

Activities within the 200-ZP-1 Operable Unit focus on monitoring and remediation of groundwater contaminant plumes beneath the northern and central portions of the 200 West Area and nearby portions of the 600 Area. The operable unit lies within the larger 200-ZP-1 groundwater interest area, which was established for ease of management and work planning (Figure 3.1-1 in Section 3.1). Figure 3.2-1 shows the boundaries of the operable unit, some of the more prominent facilities that are present, and groundwater monitoring, extraction, and injection wells.

Groundwater is monitored to assess the performance of two interim action pump-and-treat systems. One of these pump-and-treat systems uses air stripping to remove carbon tetrachloride from groundwater. A second system that targets a technetium-99 plume near WMA T and transports the contaminated groundwater to the Effluent Treatment Facility where contaminants are removed by ion exchange, reverse osmosis, and ultraviolet light/oxidation. Groundwater monitoring is performed to track the movement of nitrate, iodine-129, chromium, trichloroethene,¹ and tritium plumes, as well as to support groundwater monitoring at four RCRA units and the State-Approved Land Disposal Site (SALDS). Data from facility-specific monitoring are used to support performance evaluations for CERCLA groundwater remediation activities. Radionuclide monitoring is performed in accordance with the AEA.



The primary sections that comprise this chapter are organized as follows:

- Sections 3.2.1 through 3.2.8 describe groundwater contaminants and monitoring results in 2011.
- Section 3.2.9 summarizes the CERCLA remediation activities and soil vapor extraction activities.
- Section 3.2.10 addresses groundwater monitoring of RCRA facilities and the SALDS.

The main contaminant of concern within 200-ZP-1 is carbon tetrachloride associated with discharges to the 216-Z-1A, 216-Z-9, and 216-Z-18 Trenches.

Carbon tetrachloride is the main contaminant of concern within 200-ZP-1, forming a plume >13 square kilometers in an area extending north and east from the source areas. The primary source is associated with discharges of liquid waste from the Plutonium Finishing Plant's processes to the 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs and Trenches. The other contaminant plumes within 200-ZP-1

¹ Trichloroethene is also known as trichloroethylene, the contaminant of concern identified in the final ROD.

are much smaller and are contained within the boundaries of the carbon tetrachloride plume (Figure 3.2-2).

Monitoring activities in the past focused on the upper 15 meters of the aquifer, primarily to track water quality changes associated with vadose zone discharges and possible unplanned releases. More recent groundwater investigations revealed that, in some cases, higher concentrations are found much deeper within the aquifer. These findings are being incorporated into remedial action designs and compliance monitoring strategies.

The Columbia River Basalt Group forms the bedrock beneath 200-ZP-1. The uppermost basalt flow is the Elephant Mountain Member of the Saddle Mountains Basalt. Geologic units above the basalt (in ascending sequence) are the semiconsolidated sand and gravel of the Ringold Formation unit A, the silt and clay of the Ringold lower mud unit, the semiconsolidated sand and gravel of Ringold unit E, the fine- to coarse-grained Cold Creek unit, and unconsolidated sand and gravel of the Hanford formation (Section 3.1 and Appendix E). Groundwater occurs as an unconfined aquifer, as well as under locally confining conditions beneath the Ringold lower mud unit (Ringold confined aquifer), and within and between the basalt flows (upper basalt-confined aquifer and the lower basalt aquifers). The groundwater in the suprabasalt sediments is the only aquifer directly impacted by waste disposal operations in the central and northern 200 West Area. In those areas where the Ringold lower mud unit is missing in the stratigraphic sequence (Figure 3.2-3), carbon tetrachloride migrated below the mud unit and into the confined aquifer.

Depths from land surface to the water table range from 64 to 106 meters, with the greater depths occurring in the eastern portion of the interest area. The thickness of the unconfined aquifer within the interest area ranges from 8 to 68 meters on the east side and north side respectively (Section 3.1 of PNNL-13858). Moving east of the 200 West Area, the aquifer transitions into the more transmissive Hanford formation. The lower mud unit rises to the northeast and eventually is above the water table.

200-ZP-1 at a Glance

T Plant Operations: 1944 to 1956 (Plutonium Separation)			
Plutonium Finishing Plant Operations: 1949 to 1989			
2011 Groundwater Monitoring			
Contaminant	Drinking Water Standard	Maximum Concentration	Plume Area^a (km²)
Carbon Tetrachloride	5 µg/L	3,900 µg/L	10.8/13.3 ^b
Nitrate	45 mg/L	2,740 mg/L	8.3
Iodine-129	1 pCi/L	22.5 pCi/L	0.50
Tritium	20,000 pCi/L	420,000 pCi/L	0.39
Chromium	100/48 µg/L ^{c, d}	522 µg/L ^e	0.20/0.07
Trichloroethene	5 µg/L	11 µg/L	0.20
Technetium-99	900 pCi/L	7,600 pCi/L	0.08
Remediation			
Groundwater pump-and-treat (interim action):			
<ul style="list-style-type: none"> • 1996–2011, removed 13,503 kg carbon tetrachloride 			
Soil vapor extraction (expedited response action):			
<ul style="list-style-type: none"> • 1991–2011, removed 79,945 kg carbon tetrachloride 			
Final action record of decision issued in 2008.			
Groundwater pump-and-treat (final action):			
<ul style="list-style-type: none"> • Scheduled to begin operating in 2012 			

- a. Estimated area above listed drinking water standard.
- b. Area in upper part of unconfined aquifer/Area of full plume footprint, all depths in unconfined aquifer.
- c. 100 µg/L federal drinking water standard for total chromium.
- d. 48 µg/L groundwater cleanup standard for hexavalent chromium.
- e. Value is for unfiltered total chromium.

The water table within 200-ZP-1 has continued to decline since discharge of wastewater was terminated in the 1990s. The current rate of decline ranges from ~0.21 to 0.4 meter per year.

Groundwater in the northern 200 West Area flowed east-northeast over the past decade, but is locally influenced by the 200-ZP-1 interim pump-and-treat system and effluent discharges to the SALDS (Figure 3.2-4). Groundwater flow rates in 200-ZP-1 range from 0.0001 meter per day in fine-texture, low-permeability Ringold sediments to 0.5 meter per day in coarse-texture, higher-permeability Hanford sediments (SGW-38815).

Flow in the southern portion of 200-ZP-1 is strongly influenced by the operation of the interim pump-and-treat system's 14 extraction wells (Figure 3.2-1). The treatment system removes carbon tetrachloride and other volatile organic compounds. Treated effluent is injected into the aquifer through five wells upgradient of the plume. A small groundwater mound is present at the injection wells, while a cone of depression occurs near the extraction wells, setting up a recirculation zone between the two areas. The injection wells are positioned due west of LLWMA-4, affecting groundwater flow direction and contaminant concentrations beneath the surrounding sites.

3.2.1 Carbon Tetrachloride

Carbon tetrachloride is found at levels greater than the drinking water standard of 5 µg/L under most of the 200 West Area (Figure 3.2-5). Initially, carbon tetrachloride concentrations exceeding 2,000 µg/L were located beneath the PFP. After 15 years of pump-and-treat operations, the areal extent of the >2,000 µg/L contour in the upper portion of the aquifer has been reduced from 530,000 square meters in 1996 to 293,000 square meters consisting of several small, isolated areas in 2011. Areal extent of the plume was determined by sample analyses results across the operable unit. Sample results from wells in the upper 15 meters of the unconfined aquifer are indicated on Figure 3.2-5. Specific requirements for the interim action are outlined in *Record of Decision for the USDOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure* (EPA/ROD/R10-95/114).

200-ZP-1 interim pump-and-treat remedial actions successfully reduced maximum concentrations and the number of wells with carbon tetrachloride concentrations exceeding 2,000 µg/L.

Continued investigations during drilling of new groundwater monitoring, extraction, and injection wells revealed carbon tetrachloride concentrations greater than 1,000 µg/L throughout the entire thickness of the aquifer, rather than just in the upper 15 meters. Figure 3.2-6 shows the carbon tetrachloride distribution throughout the unconfined aquifer and includes depth-discrete sample results obtained during installation of recent wells. Figure 3.2-7 provides a visual "slice" through a three-dimensional conceptual model of the carbon tetrachloride plume. The data supporting this figure were derived from groundwater samples collected for all wells screened above the basalt within the unconfined aquifer along the A to A' transect shown on Figure 3.2-8. Both of these figures show carbon tetrachloride extending to the east and vertically downward from the source areas. Except for monitoring well 699-48-71, concentrations at a distance from the source are declining because of dispersion and degradation. During 2011, carbon tetrachloride concentrations increased in well 699-48-71 (located northeast and outside of the 200 West Area) to ~110 µg/L (Figure 3.2-9). Since 2002, carbon tetrachloride concentrations exceeded the DWS in this well. The steady increase in carbon tetrachloride in well 699-48-71 is the result of contaminated groundwater from central 200-ZP-1 migrating toward this well. The 200 West pump-and-treat well network is designed to capture and contain contamination within 200-ZP-1. The new extraction wells are large diameter (20 cm) with long screens (>30 meters) placed to within 3 meters of the bottom of each well. Spacing of extraction wells was determined through aquifer testing to be sufficient to capture contamination throughout the aquifer underlying 200-ZP-1. Contamination in the

vicinity of well 699-48-71 will be captured in the new 200 West pump-and-treat extraction well located south of well 699-48-71. Prior to 200-ZP-1 interim actions in 1996, 17 extraction wells and 23 monitoring wells exceeded 2,000 µg/L of carbon tetrachloride. In 2011, only five extraction wells and four monitoring wells showed carbon tetrachloride concentrations at or above 2,000 µg/L (Figure 3.2-10). Groundwater wells 299-W15-50, 299-W15-40, and 299-W15-765, located south and west of WMA TX-TY, had the highest 2011 carbon tetrachloride concentrations at 3,900 µg/L, 3,700 µg/L, and 2,800 µg/L, respectively. The remaining six wells are located south of WMA TX-TY and west and east of WMA T. Maximum concentrations in 200-ZP-1 extraction wells in 2011 averaged 63 percent less than the maximum concentrations recorded prior to the interim action. For the two extraction wells located east of WMA T (299-W11-45 and 299-W11-46), maximum concentrations in 2011 (1,200 µg/L in both wells) averaged 56 percent less than their maximum prior to startup operations in 2007 (3,900 µg/L and 2,100 µg/L, respectively). The significant decline in both maximum carbon tetrachloride concentration (from 8,700 µg/L in 1990 to 3,900 µg/L in 2011) and in the number of wells exceeding the RAO of 2,000 µg/L (from 40 wells to 9) demonstrates the effectiveness of the interim actions in reducing contamination in the area of highest concentration of carbon tetrachloride in groundwater.

3.2.2 Trichloroethene

Trichloroethene in 200-ZP-1 is detected at levels above the drinking water standard (5 µg/L) in two discrete plumes: (1) beneath WMA TX-TY, co-located with the high-concentration portion of the carbon tetrachloride plume; and (2) beneath WMA T and directly east of WMA T. Each of these plumes is along the centerline of the carbon tetrachloride plume (Figure 3.2-11).

The maximum trichloroethene concentration reported during 2011 was 11 µg/L in 299-W15-44, an increase from a maximum concentration of 7 µg/L in this well in 2010. The increase in trichloroethene concentration in monitoring well 299-W15-44 is due to the influence of groundwater flow by nearby extraction well 299-W15-225, which has been operating at 946 liters per minute (250 gpm) since July 2010. The high flow rate in this well diverts the groundwater flow direction, effectively capturing contamination in the southern portion of WMA TX-TY.

The trichloroethene plume beneath and east of WMA T is also located within the capture zone of the two pump-and-treat extraction wells downgradient of WMA T. Figure 3.2-12 depicts the 2011 maximum trichloroethene concentration in wells adjacent to both WMAs compared to maximum trichloroethene concentrations recorded prior to 2011. With three exceptions (wells 299-W11-40, 299-W11-41, and 299-W10-28), trichloroethene concentrations in wells adjacent to WMA T declined an average of 39 percent and, with two exceptions (299-W10-26 and 299-W14-13), trichloroethene concentrations in wells adjacent to WMA TX-TY declined an average of 51 percent because of remediation activities.

The increase in trichloroethene concentration in the three WMA T wells is due to the influence of the two extraction wells effectively drawing in trichloroethene contamination from the surrounding area. The increase in trichloroethene concentration in the two WMA TX-TY wells is due to the east-northeast flow of contaminant/groundwater beneath the WMA.

3.2.3 Nitrate

Nitrate concentrations are above the drinking water standard (45 mg/L, as nitrate) beneath much of 200-ZP-1 (Figure 3.2-13). Sources of nitrate include liquid waste disposal from PFP processes to the cribs near WMA T and the 216-Z Cribs and Trenches. Two discrete, high concentration plumes are discernible: (1) a plume located beneath WMA T and WMA TX-TY, and (2) a diminishing plume observed at well 299-W18-16 (near the 216-Z Cribs and Trenches). These plumes merge above the 45 mg/L contour extending from the 216-Z Cribs and Trenches to beyond the 200 West Area boundary to the northeast. The size and concentration of contours in 2011 are similar to those reported in 2010.

The high-concentration plume beneath WMA T is located within the capture zone of WMA T pump-and-treat wells 299-W11-45 and 299-W11-46. The highest concentration at the WMA T wells for 2011 was 2,740 mg/L at well 299-W10-4, a 74 percent decrease in nitrate concentration from the

maximum concentration reported for this well of 7,610 mg/L in 2004, confirming remediation of this plume. The nitrate concentration in well 299-W18-16 in the southern high-concentration plume is also declining. The maximum nitrate concentration for this well in 2011 was 314 mg/L, a 70 percent decrease from the maximum concentration of 1,060 mg/L reported in 2006. Figure 3.2-14 illustrates the decrease in maximum nitrate concentrations in WMA T and WMA TX-TY wells.

3.2.4 Chromium

Chromium contamination is found at levels above the drinking water standard (100 µg/L for total chromium and 48 µg/L for hexavalent chromium) beneath the single-shell tanks at WMA T and at WMA TX-TY (Figure 3.2-15). Sources of chromium contamination include past leaks from single-shell tanks containing metal and liquid waste from chemical processing of uranium-bearing, irradiated reactor fuel rods, the bismuth phosphate process, uranium-recovery process, and from REDOX and PUREX plant operations (DOE/RL-2009-66, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*; DOE/RL-2009-67, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*). For groundwater plume analysis, total chromium is used to characterize concentrations and plume extent; total chromium in filtered samples represents hexavalent chromium (Section 1.7) because the hexavalent form of chromium is soluble and mobile in water. In 2011, the 200-ZP-1 maximum chromium concentration of 522 µg/L was found at well 299-W10-4, a 28 percent decrease from the maximum chromium concentration of 722 µg/L measured in this well in 2004 (prior to remediation activities).

The highest concentration reported in WMA T extraction wells 299-W11-45 and 299-W11-46 during 2011 was 149 µg/L and 121 µg/L, respectively. Chromium contamination in the northeastern corner of WMA T is within the capture zone of the extraction wells. Maximum chromium concentrations decreased an average of 41 percent in WMA T wells and decreased an average of 42 percent in WMA TX-TY wells. Figure 3.2-16 illustrates the decrease in maximum chromium concentrations in WMA T and WMA TX-TY wells. In 2011, chromium concentrations in WMA T extraction wells are significantly less compared to values reported before remediation operations (from a maximum chromium concentration of 708 µg/L in 2007 to a maximum of 149 µg/L in 2011).

3.2.5 Tritium

Tritium concentrations exceeded the drinking water standard of 20,000 pCi/L within 200-ZP-1 at two locations: (1) adjacent to WMA T and WMA TX-TY and (2) adjacent to the SALDS. Active permitted discharges at the SALDS are an ongoing source of tritium to groundwater in 200-ZP-1. Other sources of contamination are the liquid wastes from plutonium processing to disposal facilities, including 216-T-25 Trench, and past leaks from tanks and pipelines adjacent to WMA TX-TY.

Tritium concentrations exceed the 20,000 pCi/L drinking water standard at wells adjacent to WMA T, WMA TX-TY, and near the SALDS. The plumes near WMA T and TX-TY are shrinking.

Figure 3.2-17 shows the geometry and extent of the tritium plumes, with contaminant levels greater than 20,000 pCi/L in wells south of WMA TX-TY to contaminant levels greater than 400,000 pCi/L east of WMA TX-TY. In 2011, the highest tritium concentration found in 200-ZP-1 measured 420,000 pCi/L at well 299-W14-13 located east of WMA TX-TY. Tritium concentrations at wells near the WMAs are declining (from a maximum tritium concentration of 2,940,000 pCi/L in 2000 to 420,000 pCi/L in 2011—an 86 percent decrease), suggesting that less contamination is moving from the vadose zone to groundwater. In addition, the area of the plume northeast of WMA T has gotten smaller, based on declining concentrations in wells downgradient of WMA T.

The tritium plume near the SALDS varies with discharge volumes and based on the concentration loading received from the Effluent Treatment Facility (ETF). In 2011, the highest tritium concentration in wells 699-48-77A, 699-48-77C, and 699-48-77D were 110,000 pCi/L, 155,000 pCi/L, and 160,000 pCi/L, respectively. The 2011 maximum concentrations are significantly less than past years' maximum concentrations in these three wells: 2,000,000 pCi/L in 1997 compared to 110,000 pCi/L in 2011 in well 699-48-77A (a 94.5 percent decrease); 980,000 pCi/L in 2001 in 699-48-77C compared to 155,000 pCi/L in 2011 (an 84 percent decrease); and 2,100,000 pCi/L in 1998 in 699-48-77D compared to 160,000 pCi/L in 2011 (a 92 percent decrease). Tritium concentrations are also declining in downgradient monitoring well 699-48-71: from a maximum concentration of 70,000 pCi/L in 1962 to 1,300 pCi/L in 2011—a 98 percent decrease.

3.2.6 Iodine-129

Iodine-129 concentrations exceed the 1 pCi/L drinking water standard in wells east of WMA T and WMA TX-TY. Sources of iodine-129 include past leaks from single-shell tanks containing metal and liquid waste from chemical processing and plant operations to liquid waste disposal facilities (for example, cribs and trenches) adjacent to the tank farms. Figure 3.2-18 shows the extent and geometry of the iodine-129 plume at the 1 pCi/L drinking water standard. In 2011, the maximum reported concentration of 22.5 pCi/L was at well 299-W14-13, adjacent to and east of WMA TX-TY. Concentrations also exceeded the drinking water standard at 299-W14-11, 299-W14-15, 299-W11-34P, and 299-W11-37.

Figure 3.2-19 depicts the decline in iodine-129 concentration in 200-ZP-1 wells prior to 2011 and during 2011, suggesting less contamination is moving from the vadose zone to groundwater. The flow path of the iodine-129 plume can be traced to downgradient wells along a northeast trend. The highest iodine-129 concentrations found in WMA T extraction wells 299-W11-45 and 299-W11-46 measured 0.803 pCi/L and 0.802 pCi/L, respectively. The detection limit for iodine-129 is ~0.5 pCi/L. Iodine-129 concentrations declined compared to 2010 data.

3.2.7 Technetium-99

Technetium-99 exceeded the 900 pCi/L drinking water standard at fourteen 200-ZP-1 groundwater wells in 2011. Sources of technetium-99 contamination in 200-ZP-1 were releases from past leaks in single-shell tanks and pipelines in WMA T and TX-TY, and liquid waste disposal from plutonium processing operations to cribs and trenches adjacent to the WMAs. Figure 3.2-20 shows three distinct technetium-99 plumes above the 900 pCi/L drinking water standard, centered at (1) the south end of WMA TX-TY, (2) the north end of WMA TX-TY, and (3) beneath WMA T. The highest concentration was 7,600 pCi/L in monitoring well 299-W11-41, located east (downgradient) of WMA T. High technetium-99 concentrations also occurred in wells 299-W15-765 (6,300 pCi/L), 299-W11-46 (5,120 pCi/L), and 299-W11-45 (2,500 pCi/L). The plume beneath WMA T assumes the same eastward trend as other contaminant plumes in the operable unit. Technetium-99 concentrations are declining compared to sample results prior to 2011 (Figure 3.2-21). Prior to remediation activities (Section 3.2.9.2) in 2007, nineteen wells exceeded the drinking water standard with the maximum technetium-99 concentration of 113,000 pCi/L found in WMA T extraction well 299-W11-46. In 2011, the maximum technetium-99 concentration in that same well measured 5,120 pCi/L—a 95.5 percent reduction in concentration. The same trend occurs in WMA T extraction well 299-W11-45—an 89.4 percent reduction from a maximum concentration of 23,500 pCi/L recorded in 2005 to 2,500 pCi/L in 2011 (Figure 3.2-22). Remediation activities resulted in an average 45 percent decrease in technetium-99 concentration in 200-ZP-1 wells since operations began in 2007.

The maximum technetium-99 concentration is steadily declining in extraction well 299-W11-46, from a high of 113,000 pCi/L in 2007 to 5,120 pCi/L in 2011.

3.2.8 Other Contaminants

In the past, detections of antimony were close to the reported detection limit and sporadic. Most detections before 2011 are believed to be false-positive results. In 2011, more stringent analytical methods with lower detection limits (ICP-MS Metals 6020 and ICP-MS Metals 200.8) were used to analyze for antimony and other metals enabling detection limits below the drinking water standard. Antimony concentrations were below the drinking water standard of 6 µg/L in 2011.

Other constituents detected in groundwater at concentrations above the drinking water standard include arsenic, fluoride, iron, and manganese. Chloroform and methylene chloride are monitored for the groundwater interest area as degradation products of carbon tetrachloride.

In 2011, the annual average chloroform concentrations in 200-ZP-1 groundwater remained below the 80 µg/L drinking water standard (defined for total trihalomethanes). The 2011 maximum chloroform concentration measured 50 µg/L at extraction well 299-W15-225. Concentrations are declining throughout the area. Chloroform sources include biotic and abiotic degradation of carbon tetrachloride and sanitary sewer discharges to the 2607-Z Tile Field.

In 2011, methylene chloride was detected above the drinking water standard (5 µg/L) in one well, new injection well 299-W6-14 (located near the northwestern boundary of 200-ZP-1). The maximum methylene chloride concentration of 24 µg/L was found during drilling. Methylene chloride (dichloromethane) is a degradation product of carbon tetrachloride (tetrachloromethane) and a common laboratory contaminant.

In 2011, arsenic was detected at levels above the 10 µg/L drinking water standard in well 299-W10-4, located southwest of WMA T, and in well 699-48-77A, located east of the SALDS. Maximum arsenic concentrations at these wells were reported at 12.2 and 12.8 µg/L, respectively. These maximum concentrations are slightly higher than the maximum recorded values of 12.0 µg/L at well 299-W10-4 and 10.8 µg/L at well 699-48-77A in 2010 (filtered arsenic). However, the 2011 average arsenic concentration in well 299-W10-4 is 11.1 µg/L and in well 699-48-77A the average is 10.6 µg/L. Average arsenic concentration in both wells are below the Hanford Site filtered groundwater background for arsenic, which is 11.8 µg/L (95th percentile) (DOE/RL-96-61).

Fluoride contamination at levels greater than the primary drinking water standard of 4 mg/L historically occurred in a local area around T Tank Farm. Fluoride concentrations are declining in the T Tank Farm area, from a maximum concentration of 10.5 mg/L at well 299-W10-8 in 2005 to the 2011 maximum fluoride concentration of 4.75 mg/L at well 299-W10-23 (located north of the tank farm). The 2011 maximum fluoride concentration of 4.75 mg/L at well 299-W10-23 is similar to the maximum concentration of 4.5 mg/L at well 299-W10-8 in 2010. The source of the fluoride is the historical surficial releases of lanthanum fluoride used in the bismuth phosphate process, which infiltrated to the unconfined aquifer.

Iron was present at levels above the 300 µg/L secondary drinking water standard (an EPA non-mandatory water quality guideline) in nineteen groundwater monitoring wells. The secondary drinking water standard for iron applies to taste, color, and odor of groundwater, but the iron content is not considered to present a risk to human health or the environment. The maximum reported concentration of 20,200 µg/L (unfiltered) was at well 699-48-77D (the filtered sample to remove sediments measured 118 µg/L). A review of samples collected for multiple years at individual wells indicates that iron concentration fluctuates over a wide range because iron is a naturally occurring component of aquifer sediment and is found in well construction materials. Iron concentration changes with changes in groundwater chemistry, level of turbidity during sampling, and with degradation of well materials. For example, iron concentration in well 699-48-77D fluctuated greatly in 2011 between 19 µg/L and 20,200 µg/L, but the maximum reported before 2011 was 1,390 µg/L (unfiltered) in 2007. The filtered sample in 2007 measured 59 µg/L. The background iron concentration for Hanford Site filtered groundwater is 55.3 µg/L (DOE/RL-96-61).

Manganese (unfiltered) was present at levels above the 50 µg/L secondary drinking water standard (an EPA non-mandatory water quality guideline) in nine groundwater monitoring wells. The secondary drinking water standard for manganese applies to taste, color, and odor of groundwater, but the manganese content is not considered to present a risk to human health or the environment. The maximum reported concentration of 590 µg/L (unfiltered) was at well 299-W7-4 (the filtered sample to remove sediments was undetectable for manganese at the detection limit of 5 µg/L).

3.2.9 CERCLA Groundwater Activities

This section summarizes the CERCLA groundwater performance monitoring and interim remedial measures at the 200-ZP-1 Operable Unit. It also summarizes remediation of the vadose zone by removal of carbon tetrachloride via soil vapor extraction.

Appendix A lists wells, constituents, and sampling frequencies for 200-ZP-1 CERCLA groundwater monitoring in 2011.

3.2.9.1 Final Groundwater Remediation

The plan and schedule for implementing all of the tasks applicable to the 200 West pump-and-treat system, as set forth in the final 200-ZP-1 ROD, were issued in the 200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan (DOE/RL-2008-78) in March 2009.

Based on groundwater characterization activities and interim pump-and-treat operations, the final remedy for the 200-ZP-1 Operable Unit was developed and formalized in the final ROD (EPA et al., 2008). The list of contaminants of concern from the interim action was expanded to include major contaminant plumes exceeding drinking water standards. The contaminants of concern include carbon tetrachloride, trichloroethene, iodine-129, technetium-99, nitrate, hexavalent chromium, total chromium, and tritium.

The remedial action objectives for 200-ZP-1 are as follows (EPA et al., 2008):

- *Return the 200-ZP-1 Operable Unit groundwater to beneficial use.*
- *Apply institutional controls to prevent use of groundwater until the cleanup levels have been attained.*
- *Protect the Columbia River from degradation and unacceptable impacts caused by contamination from the 200-ZP-1 Operable Unit.*
- *The final ROD addresses carbon tetrachloride and seven other groundwater contaminants through the full thickness of the unconfined aquifer.*

The remedial action objectives will be achieved through four remedy components: (1) monitored natural attenuation, (2) institutional controls, (3) flow-path controls, and (4) pump and treat of the contamination. The 200 West pump-and-treat system will begin operations in 2012.

The CERCLA cleanup process for the 200-ZP-1 Operable Unit is described in a series of regulatory documents, including the following:

- Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit (DOE/RL-2003-55), prepared in fiscal 2004 and implemented in fiscal year 2005.
- Remedial Investigation Report for 200-ZP-1 Groundwater Operable Unit (DOE/RL-2006-24), published in October 2006.
- Feasibility Study Report for 200-ZP-1 Groundwater Operable Unit (DOE/RL-2007-28) and Proposed Plan for Remediation of 200-ZP-1 Groundwater Operable Unit (DOE/RL-2007-33), completed in July 2008.
- *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78), for implementing all of the tasks for design, installation, and operation of the 200 West Area Pump-and-Treat system (as set forth in the final 200-ZP-1 ROD), completed in July 2009.
- *200 West Area Groundwater Pump-and-Treat Remedial Design Report* (DOE/RL-2010-13) presents the site-specific data and considerations needed to successfully complete the remedial actions identified in the ROD.
- Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action (DOE/RL-2009-115).

In 2011, tasks performed to execute the final ROD remedial action objectives included the completion of six injection wells to supplement the twenty wells completed in 2009 and 2010. This moves the project closer to a final network of 36 injection and extraction wells. These wells will support the new 200 West pump-and-treat system, which will become operational in 2012. Construction activities for the new groundwater treatment facility were completed in 2011.

3.2.9.2 Interim Groundwater Remediation

The primary contaminants of concern identified for interim remediation are carbon tetrachloride, trichloroethene, and chloroform. The interim RAOs were identified in EPA/ROD/R10-95/114, and the interim remedial action is described in *200-ZP-1 Interim Remedial Measure Remedial Design Report* (DOE/RL-96-07) and DOE/RL-2003-55.

DOE began interim actions in 1996 to remediate carbon tetrachloride, chloroform, and trichloroethene near the 216-Z liquid waste disposal cribs and trenches. Fourteen extraction wells captured the high-concentration (greater than 2,000 µg/L) region of the carbon tetrachloride plume. Carbon tetrachloride, chloroform, and trichloroethene are removed from the waste stream at an interim treatment facility. The treated effluent is pumped back into the upgradient aquifer through five injection

The interim remedial action objectives for the 200-ZP-1 pump-and-treat system are as follows (EPA/ROD/R10-95/114):

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

wells. This action creates a groundwater mound that increases the groundwater gradient of the plume toward the extraction wells.

During 2011, four extraction wells were taken offline because of low water levels that prevented sustainable operation: 299-W15-6, 299-W15-36, 299-W15-40, and 299-W15-765. Extraction well 299-W15-47 was taken offline because of a failed pump. In 2011, injection well 299-W18-37 was taken offline because condensation built up between the inner and outer pipeline, which triggered the leak detector alarm and shut the well down. Maintenance (scheduled for spring of 2012) to seal the outer pipeline needs to be completed prior to bringing the injection well back online.

The performance monitoring network for the interim system is intended to ensure that appropriate data are collected to evaluate remedy performance in the aquifer. Appendix A provides a list of the performance monitoring network wells and sampling frequency. Table 3.2-1 summarizes the performance of the interim action pump-and-treat system. A detailed status of the interim remediation is provided in *Calendar Year 2011 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations* (DOE/RL-2012-03).

Pumping and treating 758 million liters of 200-ZP-1 groundwater from 14 extraction wells removed 791.8 kilograms of carbon tetrachloride in 2011.

Analysis of the interim system's capture zone indicates that it continued to contain the high-concentration portion of the carbon tetrachloride plume ($>2,000 \mu\text{g/L}$) present in the upper 15 meters of the aquifer. The areal extent of the high-concentration plume at the water table has declined by approximately 55 percent over the life of the interim action pump-and-treat system.

In 2011, modifications were made at the 200-ZP-1 interim pump-and-treat system to improve performance. Major highlights of the 200-ZP-1 interim and final remedies for 2011 are as follows:

- Water level transducer cables in extraction wells were replaced with carbon tetrachloride resistant cabling resulting in fewer well shutdowns due to faulty signals from transducers.
- Adjustments were made to the new heater/chiller unit to optimize performance.
- Phase 1 operation of the new 200 West pump-and-treat system per DOE/RL-2008-78 was completed to meet Tri-Party Agreement (Ecology et al., 1989) Milestone M-016-122.
- Construction activities at the 200 West pump and treat system were completed in 2011.
- Six injection wells were drilled with three of them completed in 2011 compared to 11 wells completed in 2010, for a total of 26 wells (18 extraction wells and 8 injection wells).
- Several documents supporting 200-ZP-1 remedy implementation were completed, including the following:
 - *ZP-1 Pump and Treat Facility Layup Plan* (SGW-49761) describes the strategy and basis for the shutdown of the interim ZP-1 Pump-and-Treat facility.
 - *200 West Area Pump and Treat System Startup Plan* (SGW-49168) provides a general description of the 200 West pump-and-treat startup process.
 - *Transition Plan from the Interim 200-ZP-1 Pump-and-Treat System to the Commissioning of the 200 West Groundwater Treatment Facility* (DOE/RL-2011-75) documents the general approach for terminating operations

at the interim pump-and-treat system and startup and operations of the 200 West pump-and-treat facility.

- *Mitigation Action Plan for the 200 West Area Groundwater Remediation Project* (SGW-48726) describes the mitigation process and documents ecological and cultural surveys conducted to assess potential impacts to the environment by the project.
- *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity within the 200 West Area, Hanford Site* (SGW-50907) provides information about 200 West Area monitoring wells currently in use, but expected to become dry within the next 10 years.

Monitoring and interim remediation of technetium-99 and other contaminants from sources within WMA T and WMA TX-TY for both the CERCLA and AEA programs continued in 2011. The interim remediation activity was implemented as part of the remedial guidance for 200-ZP-1, based on EPA/ROD/R10-95/114 and the data quality objectives process (WMP-28389, *T-Area Technetium-99 Data Quality Objectives Summary Report*). Groundwater extracted from wells at WMA T is routed through resins that remove the technetium-99 before treatment for volatile organic compounds (carbon tetrachloride), nitrate, and metals (chromium). Remediation activities at WMA T include pumping of technetium-99-laden groundwater from extraction wells 299-W11-45 and 299-W11-46. Effluent from these wells is transferred to the ETF via a cross-transfer pipeline, where constituents are removed by ion exchange, reverse osmosis, and ultraviolet light/oxidation before the remediated water is discharged at the SALDS. Table 3.2-2 summarizes the 2011 performance for the two WMA T extraction wells.

During 2011, five wells were chosen to sample for plutonium, americium, and their isotopes. The five wells were identified for sampling based on proximity (and downgradient location) to potential sources (Figure 3.2-1): 299-W11-45 (east of WMA T Tank Farm), 299-W14-13 (east of WMA TX/TY Tank Farm), 299-W15-32 (on the north border of 216-Z-9 trench), 299-W15-46 (on the south border of 216-Z-9 trench), and 299-W18-16 (on the east side of 216-Z-1A trench). One well, 299-W15-46, was successfully sampled in 2011. No plutonium or americium was detected in the samples. The remaining four wells are scheduled for sampling in 2012.

3.2.9.3 Soil Vapor Extraction

Soil vapor extraction (SVE) is being used to remove carbon tetrachloride from the vadose zone at the carbon tetrachloride site in the 200-PW-1 Operable Unit overlying the 200-ZP-1 groundwater. The carbon tetrachloride site includes the three waste sites (216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib) used from 1955 through 1973 for disposal of waste liquids containing carbon tetrachloride. The purpose of the remediation using soil vapor extraction is to mitigate the threat to the environment caused by the migration of carbon tetrachloride vapors through the soil column and into the groundwater.

Soil vapor extraction (SVE) was implemented as an interim action in 1992 (Smith and Stanley, 1992, "Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume"). The CERCLA Record of Decision for the 200-PW-1 Operable Unit was finalized in September 2011 (EPA, 2011, *Record of Decision—Hanford 200 Area Superfund Site: 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units, September 30, 2011*). The ROD selected SVE as the final remedial action for vadose zone carbon tetrachloride contamination at these waste sites that received the carbon tetrachloride waste liquids.

During SVE operations, vapor-phase carbon tetrachloride is extracted through vadose zone wells and adsorbed onto granular activated carbon before the treated, clean vapor is released to the atmosphere. Since 1992, soil vapor extraction has been implemented using soil vapor extraction systems with design capacities ranging from 14.2 to 42.5 cubic meters per minute. In 2011, two SVE systems, each with a design capacity of 14.2 cubic meters per minute, were used from March through October to remove carbon tetrachloride from the vadose zone. The systems were maintained in standby mode during the

winter (November through February) to allow time for carbon tetrachloride vapor concentrations to rebound.

In 2011, the two systems removed 195 kilograms of carbon tetrachloride from the vadose zone and treated 3.7 million cubic meters of vapor (Table 3.2-3). Since startup of soil vapor extraction operations in 1992, 79,945 kilograms of carbon tetrachloride have been removed from the vadose zone in 115 million cubic meters of soil vapor (Figure 3.2-23). Each SVE system extracts simultaneously from multiple wells; in 2011, vapor was extracted through 32 well intervals using 24 wells (eight of the wells have two isolated open intervals).

SVE Operations have removed 79,945 kilograms of carbon tetrachloride from 115 million cubic meters of soil vapor since startup in 1992.

Passive SVE systems were installed in 2001 at eight wells near the 216-Z-1A Tile Field and 216-Z-18 Crib. Passive soil vapor extraction is a naturally occurring process driven by barometric pressure fluctuations and is often referred to as “barometric pumping.” These eight passive SVE systems operated throughout 2011 and removed approximately 4 kilograms of carbon tetrachloride. Since 2001, the passive systems have removed approximately 104 kilograms of carbon tetrachloride from the vadose zone.

Additional details for soil vapor extraction system operations and vadose zone monitoring for 2011 are available in SGW-51807, Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Operable Unit Carbon Tetrachloride Site, Calendar Year 2011. The performance evaluation report also provides a general overview of the entire operating period from February 25, 1992, through December 31, 2011 and a list of reports that contain detailed information on previous SVE operating periods.

Pacific Northwest National Laboratory conducted a treatability test in 2011 using one of the SVE systems and associated vadose zone wells (DOE/RL-2010-79, *Treatability Test Plan for Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-Z-9 Site*). The purpose of the test was to evaluate the flux of carbon tetrachloride from the vadose zone to the groundwater under site-specific conditions and to refine the conceptual site model of the location of the remaining carbon tetrachloride in the vadose zone. The testing involved testing one interval within an extraction well at a time. Many of the extraction wells have two screened (or perforated) intervals within one steel-cased well (one casing string). The intervals are isolated from each other by a packer placed in the well between the screens. The screened intervals are referred to as U (upper, above the Cold Creek unit) and L (lower, below the Cold Creek unit). So, for example, the upper screened extraction interval (299-W15-9U) in well 299-W15-9 was tested on one day and the lower screened extraction interval (299-W15-9L) was tested on a different day. During the test, which was conducted in August and September, 22 extraction well intervals were added online sequentially for single-well testing. The data and the evaluation of the results will be provided in a separate report in 2012.

3.2.10 RCRA and Other Facility Monitoring

This section describes the results of monitoring at individual RCRA treatment, storage, and disposal units or tank farms, as well as the SALDS. Some of these units are monitored under RCRA requirements for dangerous waste constituents, and under AEA for source, special nuclear, and byproduct materials.

The 200-ZP-1 Operable Unit contains four RCRA sites with groundwater monitoring requirements: WMA T, WMA TX-TY, LLWMA-3, and LLWMA-4. Interim status groundwater quality assessment monitoring was conducted at WMA T and WMA TX-TY (40 CFR 265.93[d], as referenced by WAC 173-303-400). Interim status indicator parameter evaluation monitoring was conducted at the LLWMA-3 and LLWMA-4 (40 CFR 265.92, “Interim Status Standards for Owners and Operators of Hazardous

Waste Treatment, Storage, and Disposal Facilities,” “Sampling and Analysis;” and 40 CFR 265.93[b], as referenced by WAC 173-303-400). The following discussion summarizes the results of statistical comparisons, assessment studies, and other developments for the reporting period. LLWMA-3 and LLWMA-4 also have AEA monitoring conducted under a performance assessment monitoring plan (DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*).

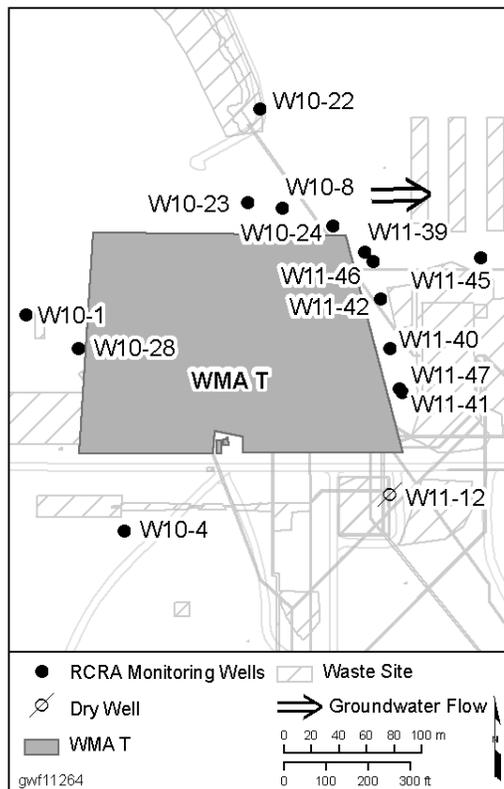
Groundwater data are available in the HEIS database and in the appendices accompanying this report. The database is available at: <http://environet.hanford.gov/eda/>. Appendix B includes additional information (including well and constituent lists, maps, flow rates, and statistical tables).

3.2.10.1 Waste Management Area T

The WMA T, which includes the T Tank Farm, is located in the northern portion of the 200 West Area and was used for interim storage of radioactive waste from chemical processing of reactor fuel for plutonium production. In 2008, an interim corrective measure, consisting of surface barrier emplacement over a portion of the farm, was designed and constructed to reduce infiltration and the subsequent migration of contaminants through the vadose zone to groundwater. Sections 3.2.6 and 3.2.7 discuss the distribution of the non-RCRA constituents iodine-129 and technetium-99 near WMA T.

WMA T is in assessment monitoring due to concentrations of the dangerous constituent chromium exceeding the drinking water standard of 100 µg/L in downgradient wells. The well network was sampled quarterly in some wells, semiannually and annually in others for waste constituents and indicator parameters in the groundwater (DOE/RL-2009-66). Appendix B includes a list of wells and constituents monitored.

The water table declined beneath WMA T ~0.3 meter in 2011. This was in response to the cessation of wastewater discharges to surface facilities around the 200 West Area. Figure 3.2-4 provides a current groundwater map including WMA T. Estimates of groundwater/contaminant flow beneath WMA T (using the Darcy relationship) range from 0.12 to 0.19 meter per day. Appendix B contains calculations of groundwater flow rates and gradients.



The primary dangerous waste constituents found beneath WMA T in 2011 are chromium, carbon tetrachloride, and trichloroethene. Of these, only chromium originated at WMA T.

The WMA T monitoring well network consists of two upgradient, two assessment, one far-field, and seven downgradient monitoring wells (299-W11-12 went dry in 2010 and extraction well 299-W11-46 is no longer online). The two assessment wells are not directly upgradient or downgradient, and are used to help distinguish other contaminant plumes impinging on WMA T. The well network complies with RCRA groundwater monitoring requirements. The direction of groundwater flow is not expected to change until the new 200 West pump-and-treat system becomes operational. However, the magnitude and direction of these changes will not be known until after performance monitoring and assessment of the

system is completed, as defined in DOE/RL-2009-115. The groundwater flow direction in this portion of the 200 West Area is eastward, but is locally variable because of the pump-and-treat effects. Appendix B, Figure B-17, shows the location of wells in the WMA monitoring network.

The primary dangerous waste constituents found beneath WMA T during the reporting period were chromium, carbon tetrachloride, and trichloroethene. Carbon tetrachloride and trichloroethene contamination are not related to WMA T, but are associated with liquid disposal processes at the PFP (Section 3.2.1). These constituents are monitored as part of the 200-ZP-1 Operable Unit. Chromium is a dangerous constituent monitored under the RCRA assessment program. From 1944 to 1980, the WMA received metal and first-cycle waste from chemical processing including the bismuth phosphate process, tributyl phosphate process, and REDOX process. Past leaks from single-shell tanks and waste pipelines within the WMA are the sources of the chromium contamination.

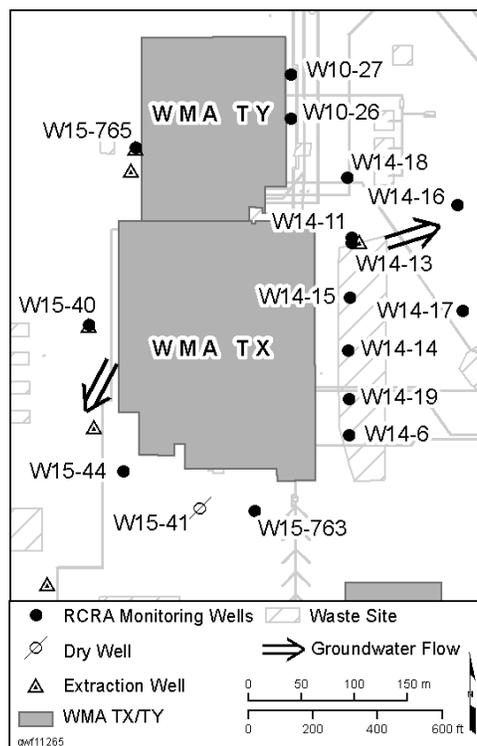
In 2011, the highest chromium concentration in the upper portion of the aquifer was in assessment well 299-W10-4 (522 µg/L), located at the southwest corner of the WMA. The highest chromium concentration found in wells screened deeper within the upper portion of the aquifer (above the Ringold lower mud unit) in WMA T was 106 µg/L in downgradient well 299-W11-47 (screened between 7.5 and 17 meters below the water table). The highest chromium concentrations in downgradient extraction wells 299-W11-46 (screened between 6 and 12 meters below the water table) and 299-W11-45 (screened between 8.5 and 13 meters below the water table) were 120 µg/L and 137 µg/L, respectively. The highest chromium concentration in adjacent downgradient well 299-W11-39 (screened at the water table) was 62 µg/L. The higher concentrations in the deeper-screened wells show that the chromium plume at WMA T extends relatively deep in the aquifer downgradient of WMA T and is present laterally at least 80 meters downgradient (eastward) at concentrations above the drinking water standard of 100 µg/L (Figure 3.2-15). However, as a result of remediation activities at WMA T, chromium concentrations are declining, and the plume extent is shrinking.

Nitrate is also found in the groundwater beneath the WMA from the same source as chromium. A nitrate plume beneath WMA T is located within the regional nitrate plume and is consistent with the configuration in 2010 (Figure 3.2-13). During the reporting period, the highest nitrate concentrations were in upgradient wells 299-W10-4 (2,740 mg/L) and 299-W10-28 (1,760 mg/L). The nitrate concentrations above the drinking water standard in the remaining WMA T wells were between 115 and 695 mg/L. While WMA T is a source of nitrate, other upgradient sources are larger contributors.

3.2.10.2 Waste Management Area TX-TY

WMA TX-TY, which includes the TX and TY Tank Farms, is located in the northern portion of the 200 West Area and was used for interim storage of radioactive waste from chemical processing of reactor fuel for plutonium production. The WMA is regulated under RCRA and its implementing requirements in WAC 173-303-400. Sections 3.2.6 and 3.2.7 discuss the distribution of the non-RCRA constituents iodine-129 and technetium-99 near WMA TX-TY.

In 2011, the water table declined beneath WMA TX-TY ~0.4 meter due to cessation of artificial recharge from liquid waste disposal operations. The 200-ZP-1 pump-and-treat extraction wells on the west and south sides of the WMA altered the flow direction and hydraulic gradients, shifting the flow south-southwest in the southern portion of the WMA. This change in groundwater flow direction also shifts contaminant distribution in the uppermost aquifer beneath



WMA TX-TY to the south.

The WMA TX-TY well network currently consists of two upgradient, two mid-field, and eleven downgradient monitoring wells. The well network complies with RCRA groundwater monitoring requirements. Once operational, the new 200 West pump-and-treat system will influence and change groundwater flow direction and velocity at WMA TX-TY. The magnitude and direction of the changes will not be known until after the new system becomes operational and performance monitoring and assessment of the system is completed as defined in DOE/RL-2009-115.

Technetium-99, iodine-129, nitrate, and chromium showed the same declining trend during the reporting period. This may indicate that all four contaminants shared a common source.

The WMA TX-TY well network was sampled quarterly and semiannually for contamination indicator parameters and supporting constituents (DOE/RL-2009-67). Appendix B includes a map of wells in the WMA monitoring network and a list of wells and constituents monitored in 2011. Some wells were not sampled as scheduled during the reporting period as follows:

- Well 299-W14-13 was not sampled during the first and second quarters of 2011 because the pump required lowering by well maintenance staff. The pump was lowered and successfully sampled in the third and fourth quarterly events.
- Well 299-W15-765 has not been sampled since the March 2011 event because of a failed pump. This extraction well has subsequently been taken offline because of low water.
- Well 299-W15-41 was not sampled in 2011 because the well is dry.

Well 299-W15-765 is being converted to a monitoring well to restore its status as a WMA TX-TY upgradient monitoring well. Downgradient wells 299-W15-44 and 299-W15-763 (in the vicinity of 299-W15-41) continue to be monitored for contaminant movement. While there are replacement monitoring wells (for dry wells) planned for in future years, the locations for these wells will not be defined until the effects of the 200 West pump-and-treat system are known.

The dangerous waste constituent chromium was monitored under the RCRA assessment program in WMA TX-TY during the reporting period. Other dangerous waste constituents found at the WMA during the reporting period included carbon tetrachloride and trichloroethene, which come from other sources associated with PFP operations. Nitrate and fluoride are also found in the groundwater beneath the WMA.

In 2011, chromium was detected above the 100 µg/L drinking water standard in three wells monitoring WMA TX-TY (Figure 3.2-16). The highest chromium concentration was 374 µg/L in downgradient well 299-W14-13, which was a decrease from 732 µg/L in 2010. The highest chromium concentration in 299-W14-11 was 112 µg/L, which was lower than the 2010 high concentration of 178 µg/L. The highest chromium concentration in 299-W10-27 was 119 µg/L, which was higher than the 83 µg/L recorded in 2010. The source for the chromium was past leaks from tanks and pipelines at WMA TX-TY. During 2011, nitrate concentrations exceeded the drinking water standard (45 mg/L) in all wells in the monitoring network (Figure 3.2-13). Nitrate concentrations decreased from the highest concentration found at 299-W14-11 (3,600 mg/L) during drilling in 2005 to the highest concentration found in 2011 at 299-W10-27 (832 mg/L). Nitrate concentrations in other WMA TX-TY wells ranged between 48.3 mg/L (299-W14-14) and 562 mg/L (299-W15-763). Most of the nitrate contamination is attributed to PFP operations, as well as past-practice disposal to cribs and trenches in the area.

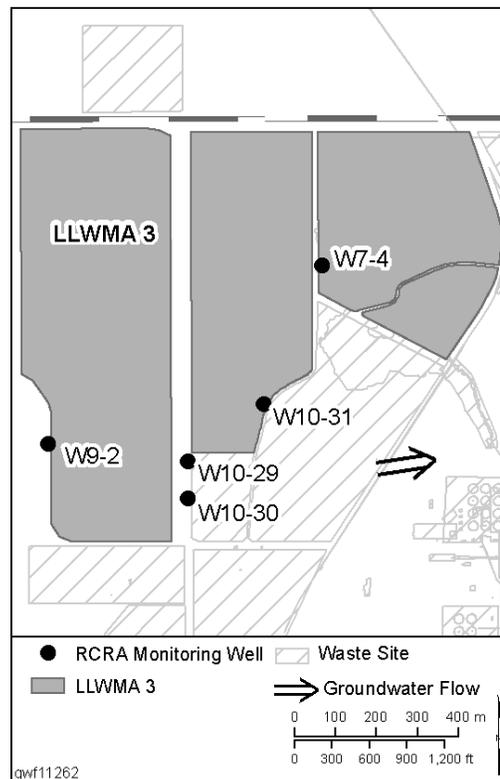
Nitrate (Figure 3.2-14) and chromium (Figure 3.2-16), and the non-RCRA constituents iodine-129 (Section 3.2.6; Figure 3.2-19) and technetium-99 (Section 3.2.7; Figure 3.2-21) showed a declining trend during 2011 indicating that all four contaminants may share a common source.

3.2.10.3 Low-Level Waste Management Area 3

The LLWMA-3, located in the northwest corner of the 200 West Area, consists of the 218-W-3A Burial Ground, 218-W-3AE Burial Ground, and 218-W-5 Burial Ground. The 218-W-3A Burial Ground (20.4 hectares) contains 57 unlined trenches operated between 1970 and 1998. The 218-W-3AE Burial Ground (20 hectares) contains eight unlined trenches operated between 1981 and July 2004. The 218-W-5 Burial Ground (37.2 hectares) contains ten unlined trenches and two lined trenches. This burial ground began operating in 1986, and the two double-lined mixed waste trenches are the only trenches continuing to receive waste.

The LLWMA-3 well network was sampled semiannually for RCRA indicator and site-specific parameters (DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*). All of the wells were sampled in 2011. Well 299-W7-4 was sampled only once because it went dry. Appendix B includes a list of wells and constituents monitored.

The water table declined ~0.3 meter beneath LLWMA-3 during 2011. This is consistent with regional water table declines resulting from the cessation of Hanford Site discharges. The groundwater flow direction across LLWMA-3 is east-northeast at a calculated rate (using the Darcy relationship) of 0.04 to 0.15 meter per day.



DOE installed a new upgradient well for LLWMA-3 in 2011, which will allow statistical evaluations to resume.

The LLWMA-3 wells are sampled semiannually and annually from a network of four wells. Samples are analyzed for indicator parameters and supporting constituents semiannually. Anions, metals, and phenols are sampled annually. Water-level measurements are taken each time a groundwater sample is collected, and site-wide water-level measurements are collected annually, usually during the month of March.

As RCRA monitoring wells, the network is screened at the water table. Because of water-level decline, the only previously upgradient well on the western side of the WMA (299-W9-1) went dry in 2000. Without sample data from an upgradient well to provide background groundwater quality data, statistical evaluations between background and downgradient groundwater quality could not be performed. DOE drilled and installed a new upgradient well, 299-W9-2, in 2011. Data from this well (sampled quarterly to establish background levels more quickly) will be used to calculate new critical mean values, so statistical evaluations can resume. The well network complies with RCRA groundwater monitoring requirements. No other wells are expected to be installed at LLWMA-3 until the effects on groundwater flow direction from the new 200 West pump-and-treat system are known.

Appendix B includes a map showing the location of wells in the LLWMA-3 monitoring network. During the reporting period, all wells except 299-W7-4 were sampled as scheduled for indicator parameters: pH, specific conductance, total organic carbon, and total organic halides. Well 299-W7-4 went dry in 2011. Appendix B includes a table with indicator parameter averages for LLWMA-3 downgradient wells in 2011 and 2010. Indicator parameter averages are similar to 2010 except for total

organic carbon, which decreased significantly in 299-W10-29 (from 1,766 µg/L in 2010 to 436 µg/L in 2011) and 299-W10-30 (from 2,059 µg/L to 1,696 µg/L) but increased slightly in 299-W10-31 (from 463 µg/L to 615 µg/L).

DOE monitors the LLWMAs for AEA radionuclides, as described in DOE/RL-2000-72. Constituents iodine-129, technetium-99, and uranium are monitored semiannually. Both iodine-129 and technetium-99 were undetected in all three wells. Uranium was detected in all three wells with a maximum concentration of 1.21 µg/L (background level) in 299-W10-31.

3.2.10.4 Low-Level Waste Management Area 4

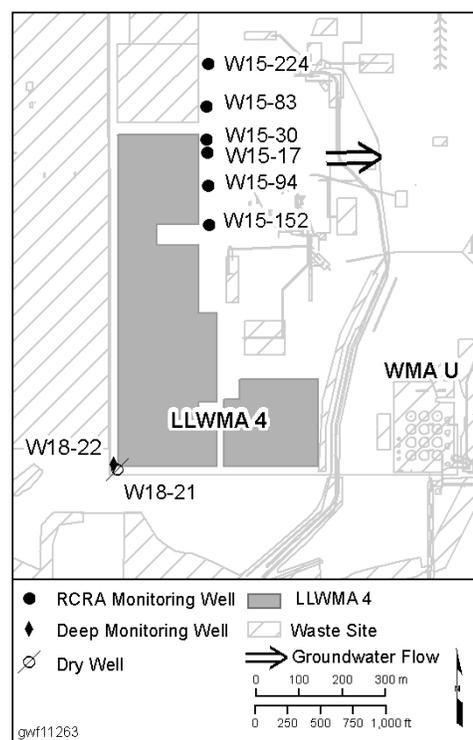
LLWMA-4 consists of the 218-W-4B and 218-W-4C Burial Grounds, and contains 28 unlined trenches used for disposal of low-level radioactive wastes and low-level mixed wastes since 1967. The 218-W-4B Burial Ground also contains twelve below-grade caissons at the southern end of the facility. The caissons in the 218-W-4B Burial Ground contain remote-handled, low-level waste, and retrievable transuranic waste. Burial Ground 218-W-4B was closed in 1990, and 218-W-4C was closed in 2004. The dangerous chemicals in the low-level mixed waste portions of LLWMA-4 are regulated under RCRA and its implementing requirements (WAC 173-303-400).

The LLWMA-4 well network was sampled semiannually for contamination indicator parameters and supporting constituents (DOE/RL-2009-69, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*). Appendix B includes lists of wells and the indicator parameter comparison values to be used in 2012.

The water table declined ~0.3 meter beneath the LLWMA-4 in 2011. This decline is in response to the cessation of discharges of wastewater to surface facilities around the 200 West Area. Water levels in upgradient wells declined more slowly than levels in downgradient wells as a result of the effects of the upgradient 200-ZP-1 pump-and-treat system injection wells. The groundwater flow direction in this portion of the 200 West Area is generally east-northeast, but can be locally variable because of the effects of the 200-ZP-1 pump-and-treat system. Groundwater flows (using the Darcy relationship) at a rate of 0.08 to 0.32 meter per day beneath this WMA.

The monitoring network at LLWMA-4 includes six downgradient wells and one upgradient well, 299-W18-21. Upgradient wells 299-W15-15 and 299-W18-23 went sample dry in 2008. Upgradient well 299-W18-22 (screened at the bottom of the unconfined aquifer) is located at the southwestern corner of LLWMA-4 and currently is not truly upgradient; the well was upgradient until the 200-ZP-1 pump-and-treat system began injecting water into five injection wells located just west (upgradient) of the LLWMA. This injection caused groundwater to flow toward the southeast at the location of this well. The well network complies with RCRA groundwater monitoring requirements. No new wells are expected at LLWMA-4 until the effects of the new 200 West pump-and-treat system are known.

Except for downgradient, deep-screened well 299-W15-17, all other wells in the network are screened across the water table. These water table wells have adequate water columns in the screened interval (from 4 to 8 meters) available for sampling.



The groundwater flow to the east at LLWMA-4 is largely affected by injection wells to the west and extraction wells to the east.

The well network was sampled semiannually for indicator and site-specific parameters including: pH, specific conductance, total organic carbon, and total organic halides. All wells, except 299-W15-224, were successfully sampled. Well 299-W15-224 was sampled only once because of electrical problems with the well pump. Appendix B includes a table with indicator parameter averages for LLWMA-4 wells in 2011 and 2010. Total organic halides and total organic carbon results declined in 2011 compared to 2010 results. Indicator parameter averages for pH and specific conductance are similar to 2010. Specific conductance, pH, and total organic carbons in downgradient wells remained below their critical mean values (Appendix B).

As in previous years, downgradient wells continued to exceed the statistical comparison value (critical mean) for total organic halides (24.3 µg/L for 2011) in samples during the reporting period. The critical mean value for 2011 was based on sampling events from January 2007 through July 2007 for upgradient well 299-W15-15, from January 2007 through February 2010 of upgradient well 299-W18-21, and from February 2007 through May 2008 for upgradient well 299-W18-23. DOE previously reported the exceedance of the critical mean in 299-W15-16 (now dry) to the EPA and Ecology in August 1999. These exceedances have been reported in annual groundwater reports since 2001. Well 299-W15-30 replaced 299-W15-16, and exceedance of the critical mean for total organic halides continued. In 2011, 299-W15-30 (with 46 µg/L) and 299-W15-224 (with 26 µg/L) exceeded the critical mean. All LLWMA-4 wells declined in total organic halide concentration in 2011. The elevated total organic halide concentrations do not indicate contamination from LLWMA-4 and are consistent with observed levels of carbon tetrachloride in the aquifer (Section 3.2.1).

Total organic carbon did not exceed the critical mean in any of the network monitoring wells during the reporting period. Well 299-W15-224, which exceeded the critical mean in 2009, had total organic carbon concentrations decrease drastically from the 2009 high of 2,210 µg/L to a low of 540 µg/L in 2010. The decline continued in this well to an average of 269 µg/L total organic carbon in 2011.

DOE monitors the LLWMAs for AEA radionuclides, as described in DOE/RL-2000-72. Constituents iodine-129, technetium-99, and uranium are monitored semiannually. Iodine-129 was undetected in all wells, technetium-99 was undetected in wells 299-W15-17 and 299-W18-22 and detected at very low levels in the remaining five wells (maximum detected was 260 pCi/L in 299-W15-224), and uranium was detected in all wells with a maximum of 1.87 µg/L (background level) in 299-W15-152. Detection of technetium-99 is consistent with observed levels in the aquifer and does not indicate contamination from LLWMA-4.

3.2.10.5 State-Approved Land Disposal Site

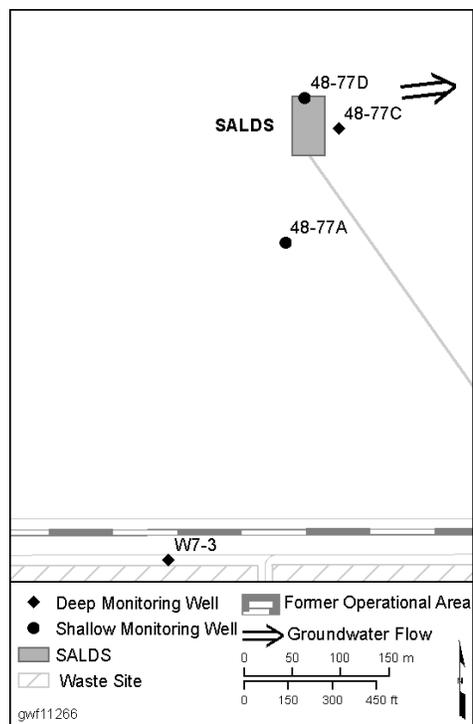
J.P. McDonald

The ETF processes aqueous wastes from various Hanford Site facilities. Treated water from the ETF is discharged to SALDS, which is authorized to receive the effluent by *State Waste Discharge Permit Number ST 4500* (Ecology, 2000a; hereinafter referred to as the “permit”). The permit (Ecology, 2000a) was issued in June 1995, and the site began operating in December 1995. The SALDS is located 400 meters outside the northern boundary of the 200 West Area (Figure 3.2-1) and consists of a 35 meter by 61 meter drain field. During 2011, 75.2 million liters of water were discharged to the SALDS, which is a slight increase to the 71.4 million liters discharged during 2010.

A total of 75.2 million liters of effluent containing 1.35 curies of tritium was discharged to the SALDS during 2011.

Much of the effluent disposed to the SALDS contains tritium because there is no cost-effective treatment technology to remove tritium from wastewater. The 2011 releases contained a total of 1.35 curies of tritium, and monthly average concentrations in the effluent ranged from 7,400 to 131,000 pCi/L. No releases occurred during August and September. These releases resulted in a tritium plume in groundwater beneath the facility.

DOE monitors groundwater in the SALDS vicinity to track the migration of the tritium plume and to compare concentrations of other constituents to permit limits. Groundwater monitoring requirements are described in *Groundwater Monitoring and Tritium-Tracking Plan for the 200 Area State-Approved Land Disposal Site* (PNNL-13121). Quarterly sampling is required for three wells proximal to the SALDS facility and both annual and semiannual sampling is required for a set of tritium-tracking wells located farther afield. Appendix B includes a well location map and a list of wells and constituents sampled for the SALDS. Except for proximal well 699-48-77A and tritium-tracking well 299-W8-1, both of which became dry during 2011, all wells were sampled as planned. Monitoring results for the SALDS are reported in annual reports (on a fiscal-year basis), most recently in *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2011* (SGW-51085). The permit (Ecology, 2000a) also specifies that periodic numerical modeling of the tritium plume be performed to predict future plume migration. The model was updated during 2011 and the results are described in SGW-51085.



Water-Level and Well Network Evaluation. Discharges from the SALDS form a small groundwater mound, causing a localized area of radial flow beneath the facility. The center of the mound is offset from the facility to the south because the southward dip of the Cold Creek unit diverts the effluent while it infiltrates through the vadose zone. Water table mapping indicates that the regional groundwater flow direction in the SALDS vicinity is currently towards the east-northeast (Figure 3.2-4).

Between March 2010 and March 2011, the water table in the SALDS vicinity declined by 0.33 meter (SGW-51085). The ongoing decline of the water table has caused 11 of the 19 tritium-tracking wells listed in the monitoring plan (PNNL-13121) to become dry, including 299-W8-1, which became dry during 2011. Two attempts were made to sample proximal well 699-48-77A during the fourth quarter of 2011, but both were unsuccessful because of a lack of water. The same issue is also affecting proximal well 699-48-77D. The first attempt to sample this well during the fourth quarter was not successful because of a lack of water, but a second attempt was successful because the water level had increased in response to effluent discharges to the SALDS during November and December. The third proximal well, 699-48-77C, is completed deeper in the unconfined aquifer and is not in danger of becoming dry. The permit (Ecology, 2000a) is due to be renewed, and the issue of the proximal wells becoming dry will be addressed during the renewal process.

The declining water table has caused several of the groundwater wells used for monitoring the SALDS to become dry over the years, including two additional wells during 2011.

Sampling Results. The proximal wells are sampled for 17 constituents/parameters, as listed in the permit (Ecology, 2000a), which sets concentration limits for acetone, benzene, cadmium (total), chloroform, copper (total), lead (total), mercury (total), field pH, sulfate, tetrahydrofuran, and total dissolved solids. Sampling of gross alpha, gross beta, strontium-90, and tritium is also required by the permit (Ecology, 2000a), but these constituents are not assigned permit limits. All groundwater sampling results from the SALDS proximal wells were within permit compliance limits during 2011.

All groundwater sample results from the SALDS wells during 2011 were within permit concentration limits.

Tritium concentrations in the proximal wells are affected by releases from the SALDS. Concentrations exhibit a correlation with the activity of tritium released, although the concentration response in the deeper well, 699-48-77C, exhibits a time lag of several years. During 2011, concentrations increased, and then declined in 699-48-77A, fluctuated in 699-48-77D, and generally increased in the deeper well 699-48-77C (Figure 3.2-24). Concentration changes in the shallow wells are attributed to increases in the activity of tritium discharged between August and December 2010. Changes in the deeper well 699-48-77C are probably due to tritium releases during 2006 and 2007. Peak tritium concentrations in 2011 were 110,000 pCi/L, 155,000 pCi/L, and 160,000 pCi/L in wells 699-48-77A, 699-48-77C, and 699-48-77D, respectively.

Figure 3.2-17 shows the tritium plume beneath the SALDS. To date, tritium from the SALDS has not been detected in any of the tritium tracking wells, and this observation is consistent with numerical model predictions (SGW-51085). The low levels of tritium observed in wells 299-W6-11, 299-W6-12, and 699-48-71 is interpreted to have originated from past wastewater releases from other 200 West Area sources to the south (Figure 3.2-17).

Table 3.2-1. 200-ZP-1 Operable Unit Interim Action Pump-and-Treat, Performance in 2011 and Since Startup

Performance	2011	Since Startup (March 1994)
Total groundwater processed (L)	758.0 million	5.8 billion
Total mass of carbon tetrachloride removed (kg)	791.8	13,503.4
Average mass removal efficiency mass [(influent – effluent) ÷ (influent)] × 100	99%	99%
System availability	97%	95%
Plume area at 2,000 µg/L (km ²)	0.29	0.53
Wells	End of 2011	Change from 2010
Extraction Wells	9	-5
Injection Wells	4	-1

Table 3.2-2. WMA T Extraction Well Performance in 2011

Performance^a	299-W11-45	299-W11-46
Total groundwater processed (L)	18.8 million	39.4 million
Total mass of carbon tetrachloride removed (kg)	22.4	35.5
Total mass removed chromium (kg)	2.5	4.4
Total mass removed nitrate (kg)	6,815	16,209
Total mass removed technetium-99 (g) [Ci] ^b	2.5 [0.044]	10.8 [0.187]
Total mass removed trichloroethene (g)	175.3	229.9
System availability	89.9%	80.7%
Average mass removal efficiency mass [(influent – effluent) ÷ (influent)] × 100	99%	99%

a. Mass removed is calculated from volume extracted, not volume treated.

b. Technetium-99 in Curies converted to grams from activity 58.7 g/Ci.

Table 3.2-3. Soil Vapor Extraction Performance in 2011 and Since Startup

Performance	2011	Since Startup (February 1992^a)
Total soil vapor processed (cubic meters)	3,718,000	115,246,000
Total mass of carbon tetrachloride removed (kg) ^b	195	79,945
System availability	74% ^c	(d)

a. Includes the pilot test operations in April 1991.

b. Does not include the mass removed by the passive soil vapor extraction systems.

c. Average of the availability of two soil vapor extraction systems operating from March through October.

d. Not calculated.

Figure 3.2-1. Facilities and Groundwater Monitoring Wells in 200-ZP-1



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Figure 3.2-2. Changes in 200-ZP-1 Plume Areas

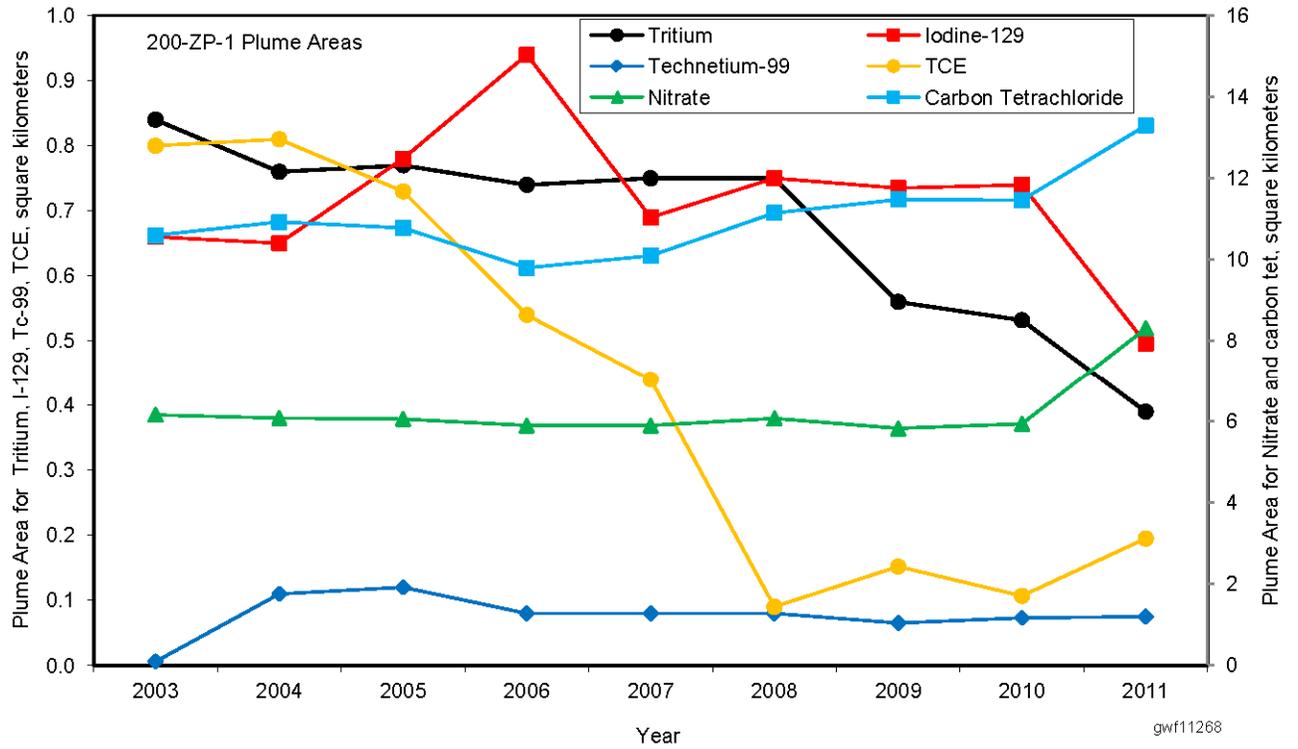


Figure 3.2-3. Ringold Formation Lower Mud Unit Extent Areas across the Central Plateau

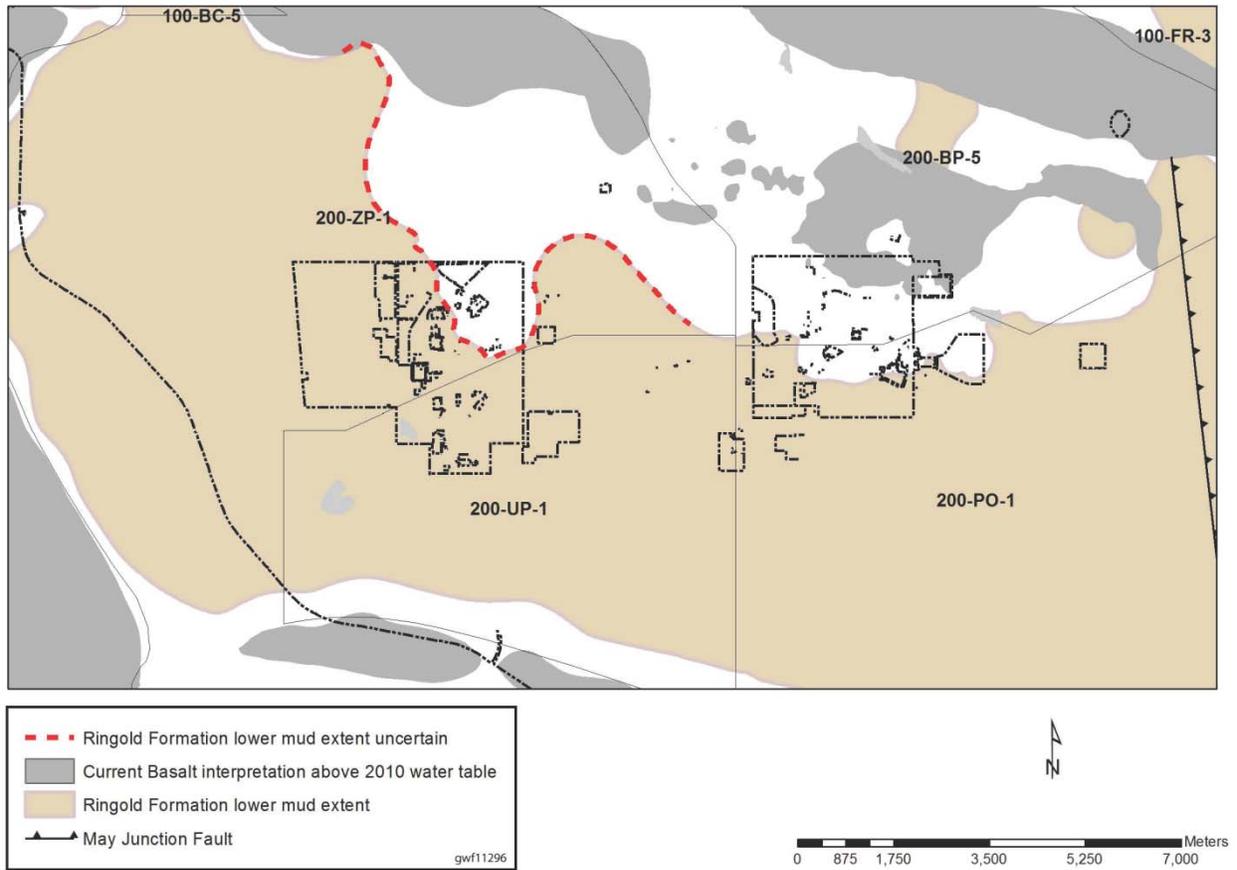


Figure 3.2-4. 200-ZP-1 Water Table, March 2011

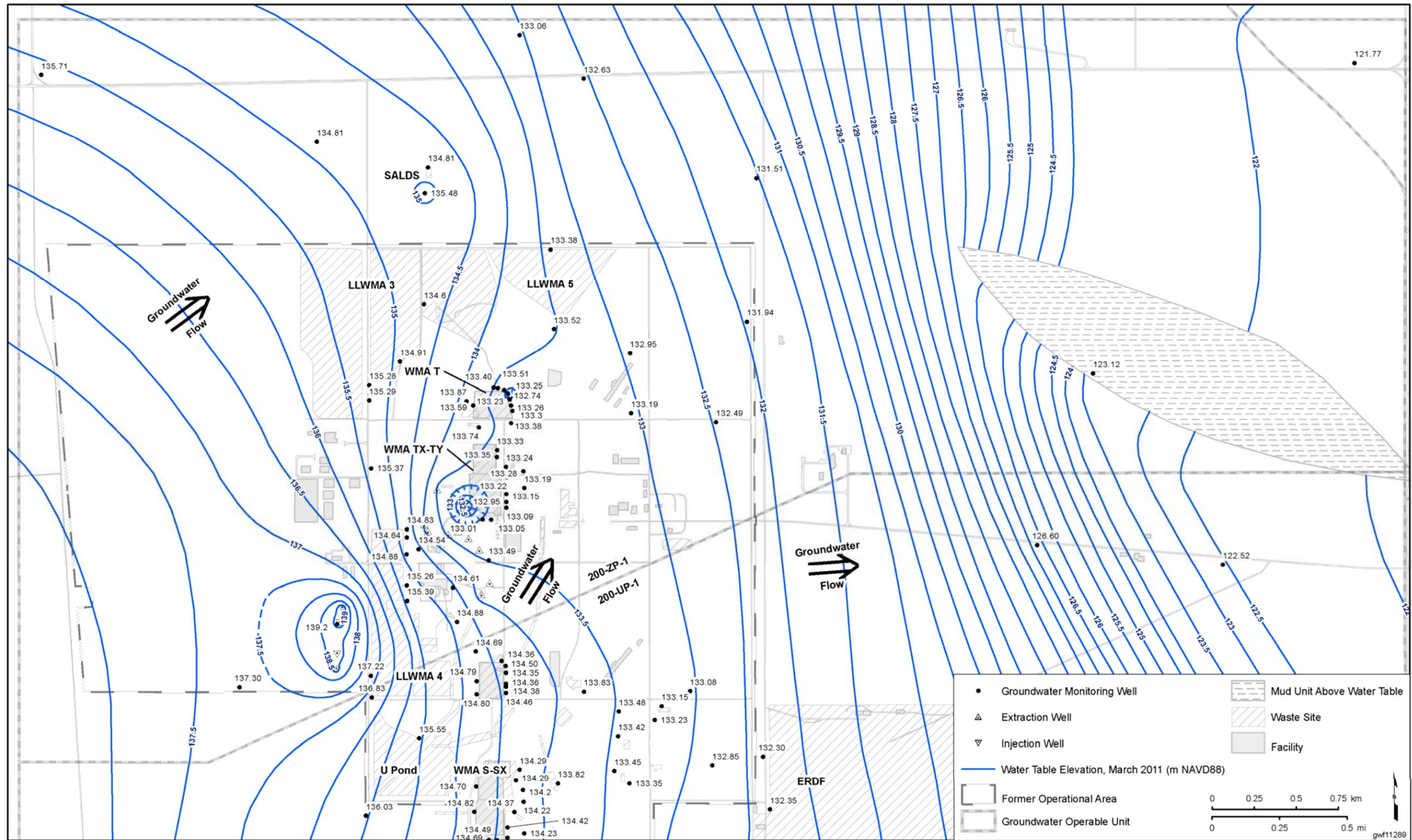


Figure 3.2-5. Average Carbon Tetrachloride Concentrations in the 200 West Area and Vicinity, Upper Part of Unconfined Aquifer, 2011

3.2-28

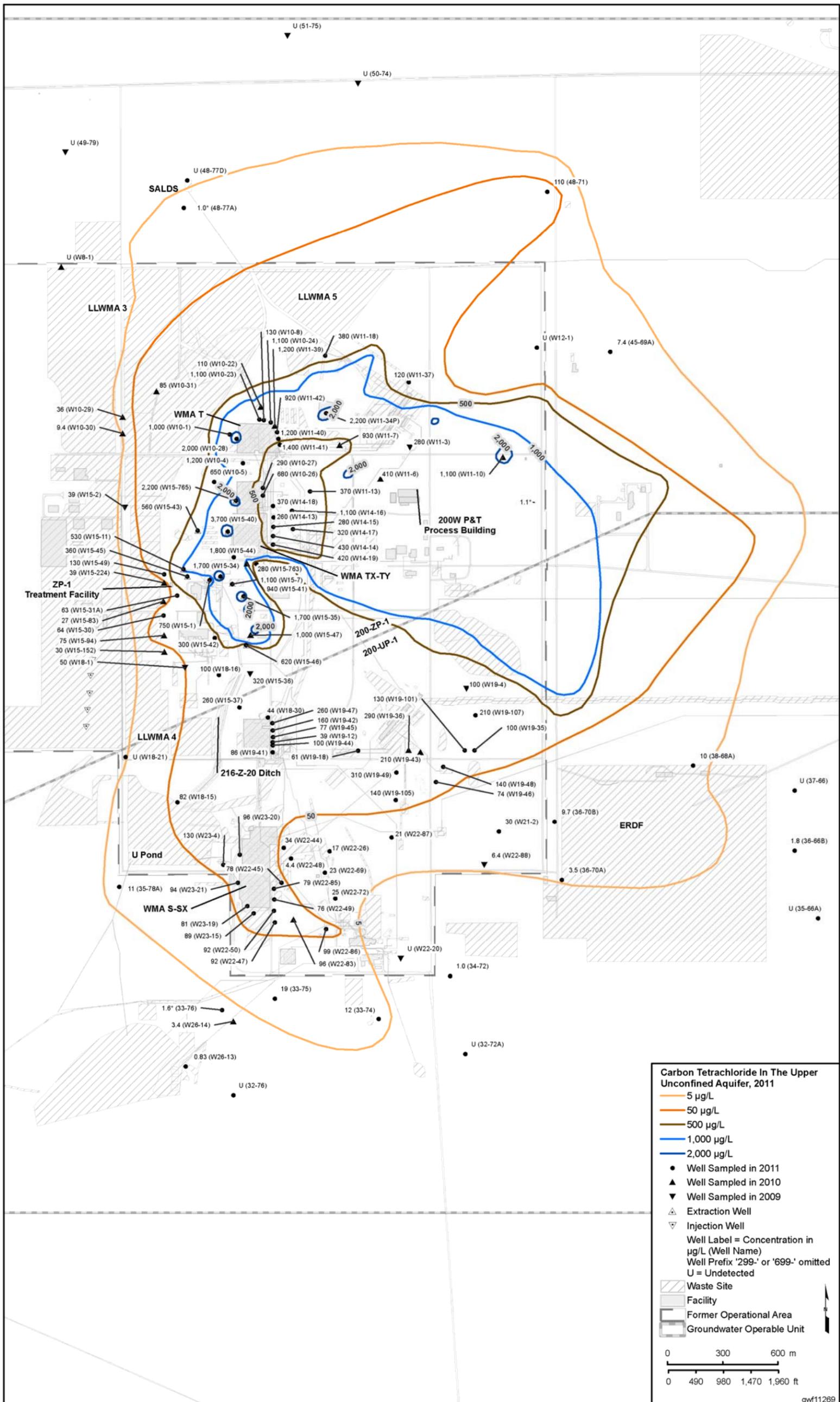
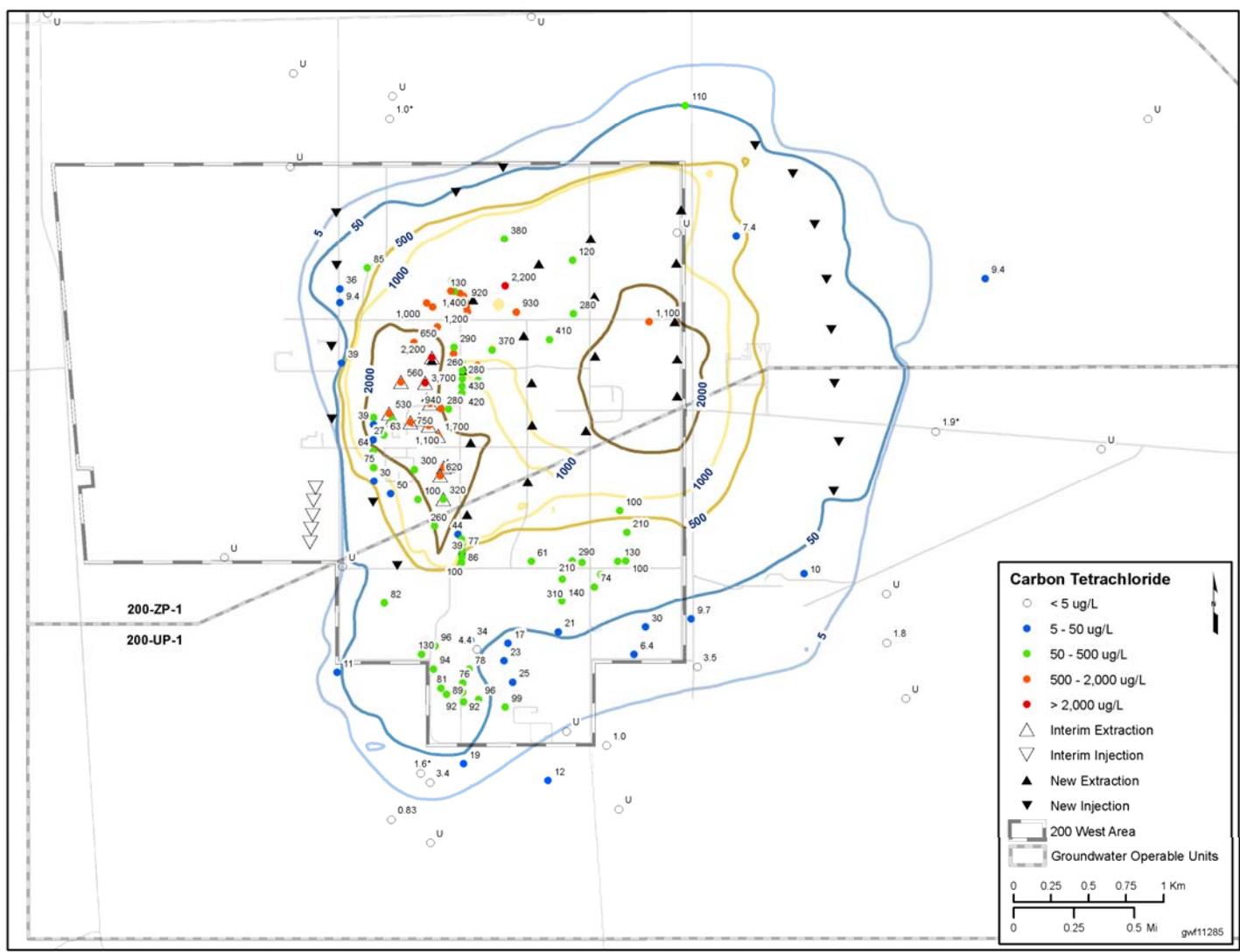


Figure 3.2-6. Average Carbon Tetrachloride Concentrations in 200 West Area throughout the Unconfined Aquifer and Locations of the Final Remedy Extraction and Injection Wells



3.2-29

Figure 3.2-7. 200-ZP-1 Carbon Tetrachloride Plume Cross Section A-A'

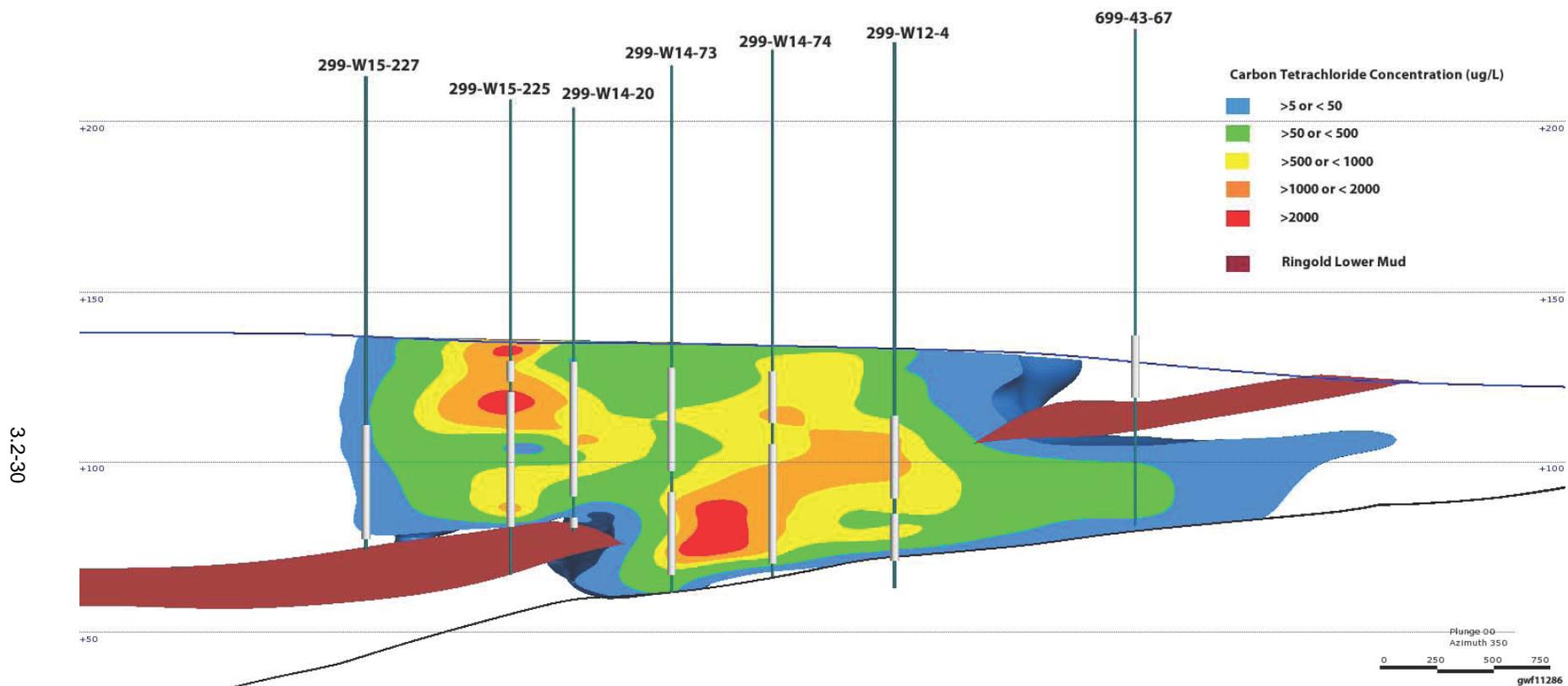


Figure 3.2-8. 200-ZP-1 Groundwater Operable Unit Carbon Tetrachloride Concentration Plan View and Transect through Cross Section A-A'

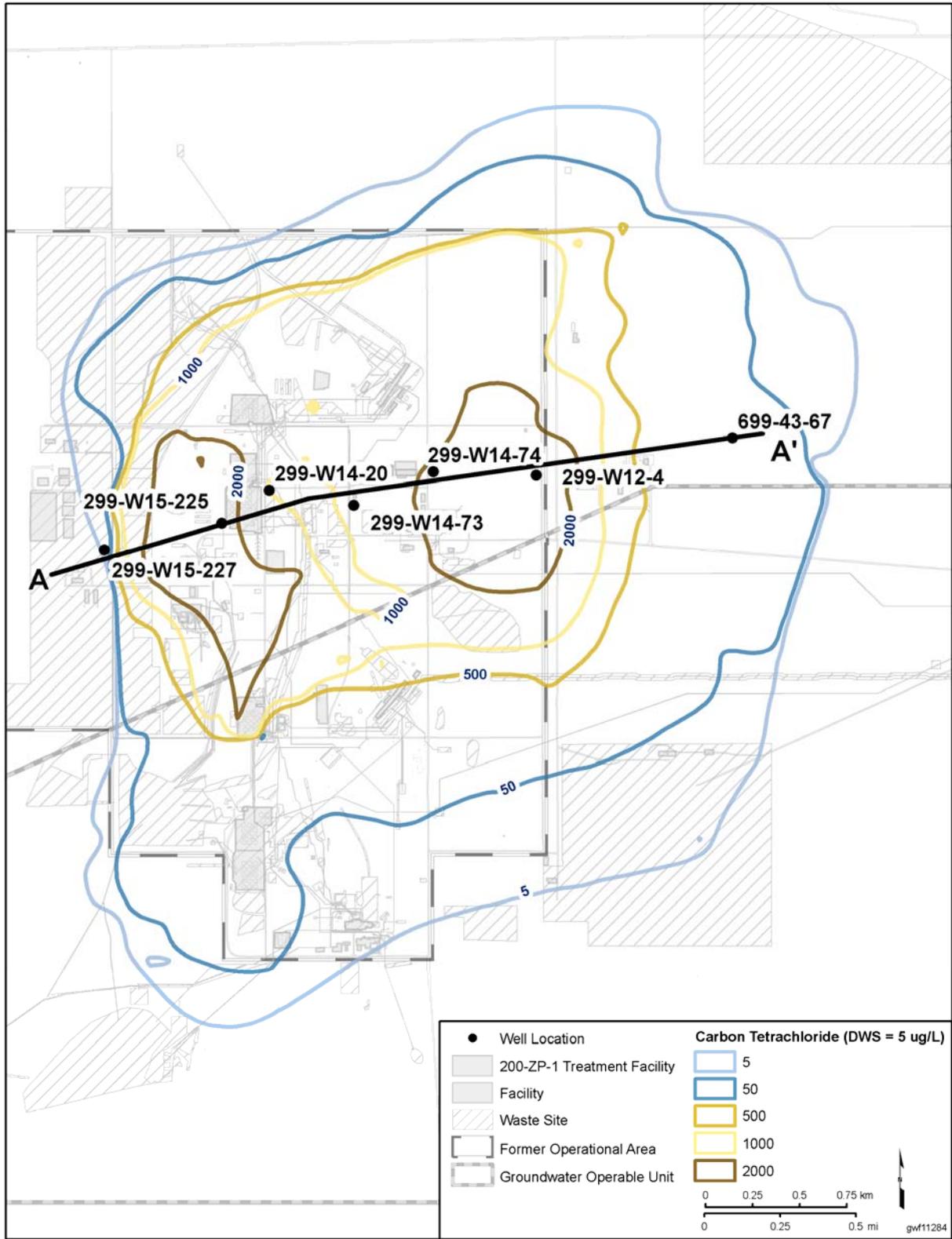


Figure 3.2-9. Carbon Tetrachloride Concentrations in Well 699-48-71, Northeast of 200 West Area

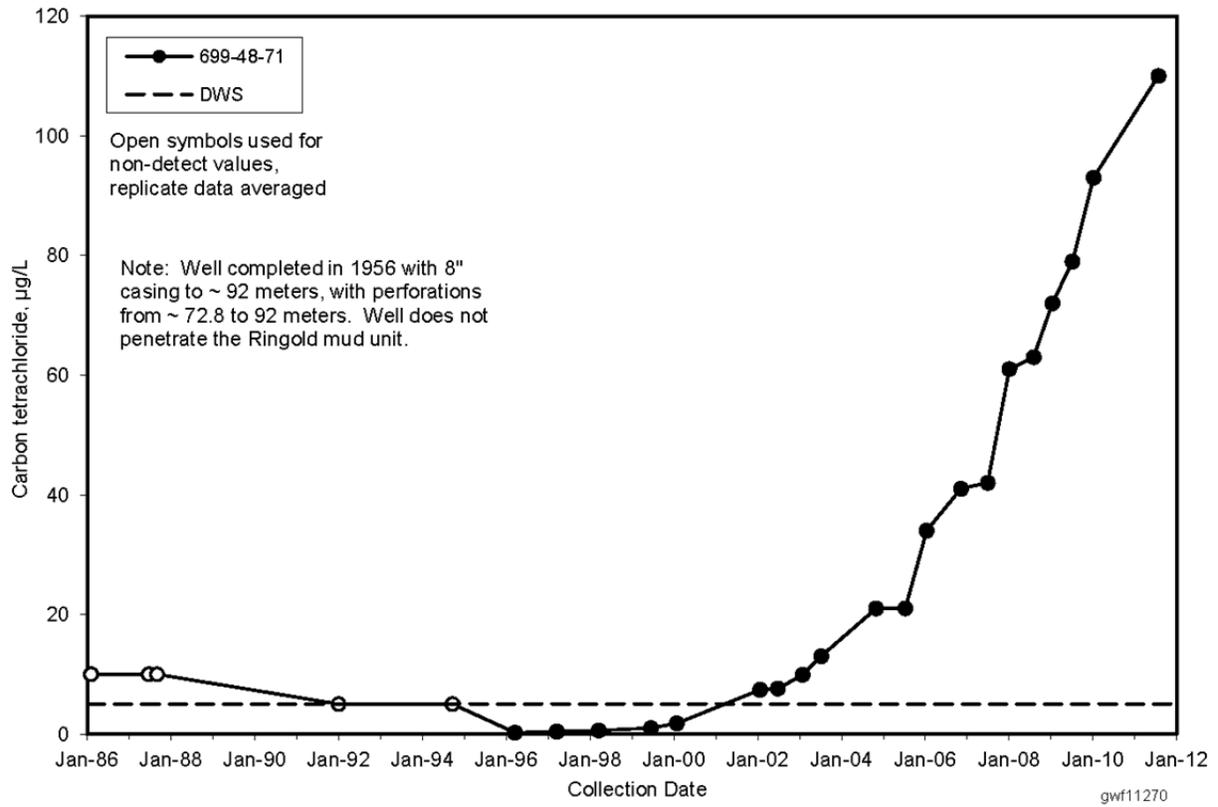
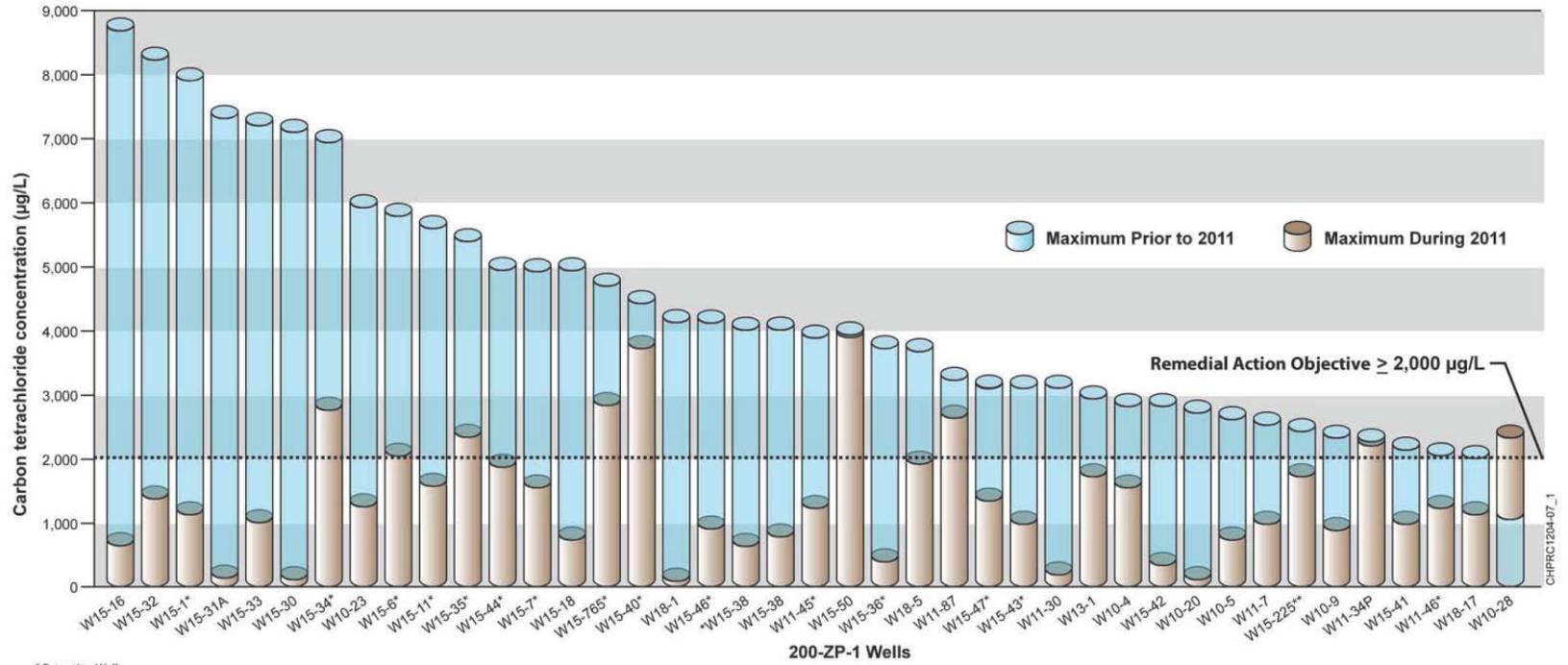


Figure 3.2-10. 200-ZP-1 Wells Exceeding 2,000 µg/L Carbon Tetrachloride prior to 2011 and during 2011

200-ZP-1 Wells Exceeding 2,000 µg/L Carbon Tetrachloride Prior to 2011 and During 2011



* Extraction Well

200-ZP-1 Wells

gwf11290

3.2-33

Figure 3.2-11. Average Trichloroethene Concentrations in 200-UP-1, Upper Part of Unconfirmed Aquifer, 2011

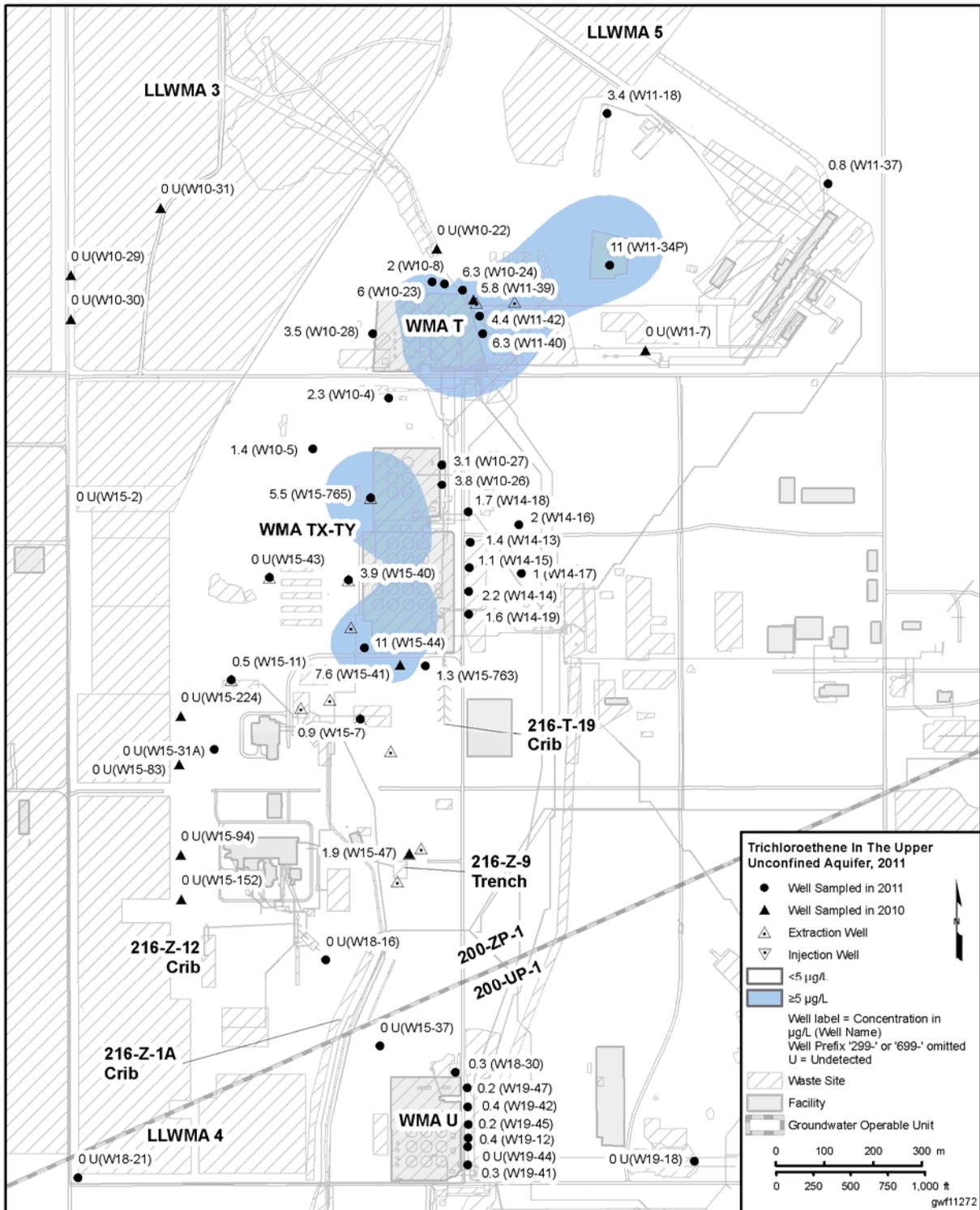
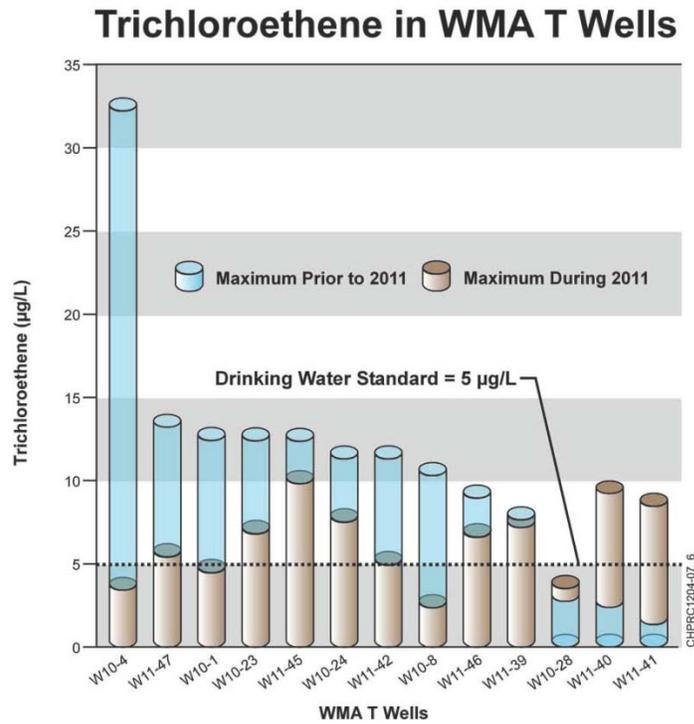
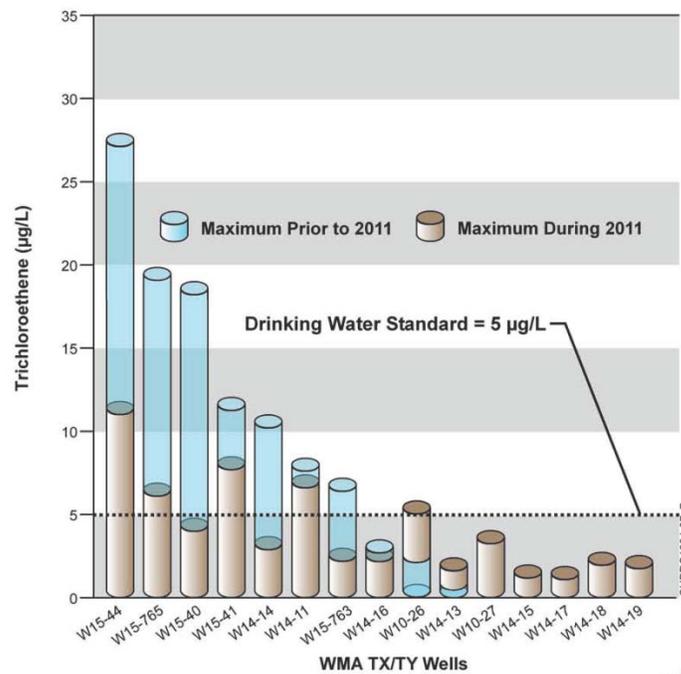


Figure 3.2-12. Maximum Trichloroethene Concentrations in WMA T and TX-TY Wells in 2011 and prior to 2011



Trichloroethene in WMA TX/TY Wells



gw11291

Figure 3.2-13. Average Nitrate Concentrations in 200-ZP-1, Upper Part of Unconfined Aquifer, 2011

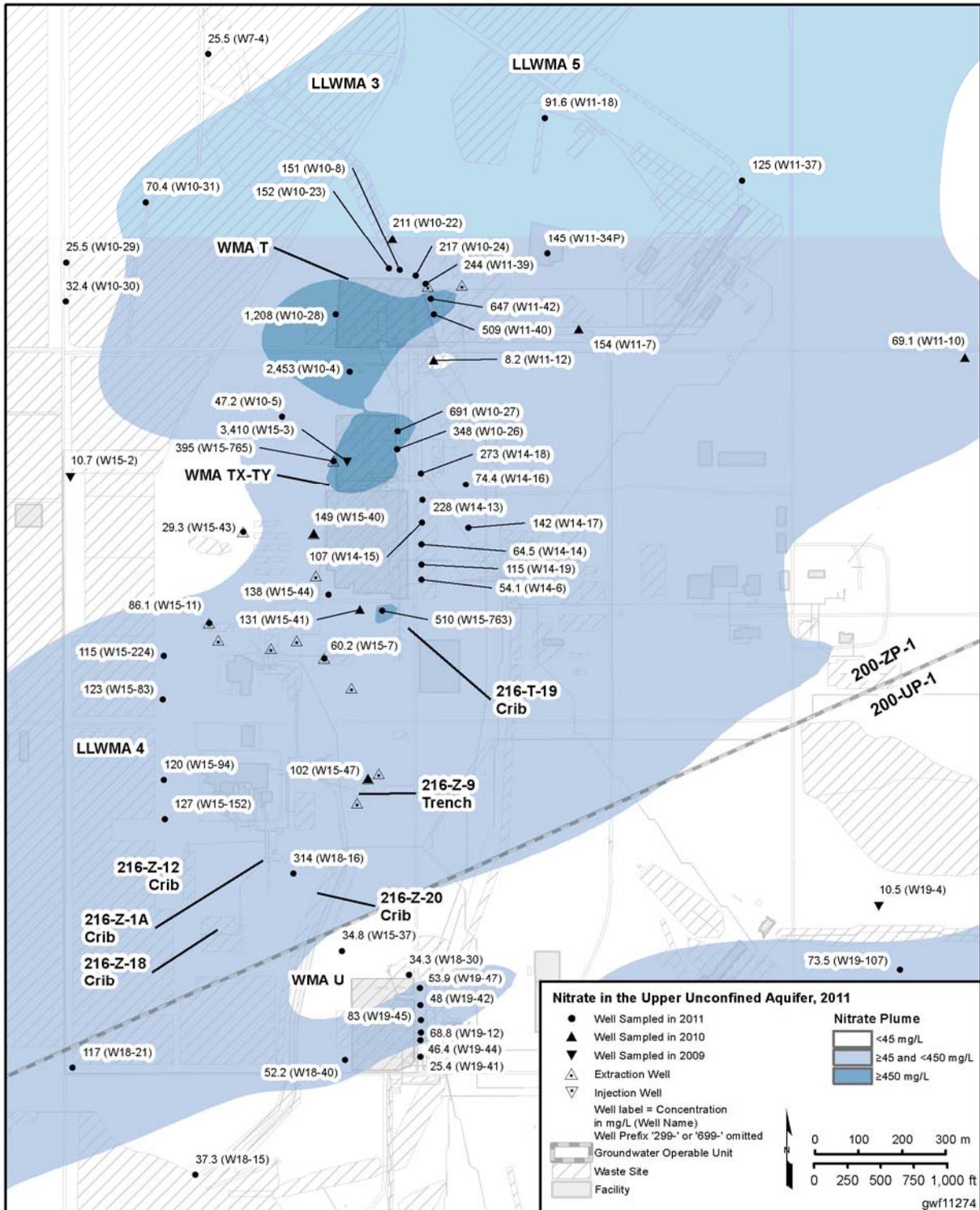


Figure 3.2-14. Maximum Nitrate Concentrations in WMA T and TX-TY Wells in 2011 and prior to 2011

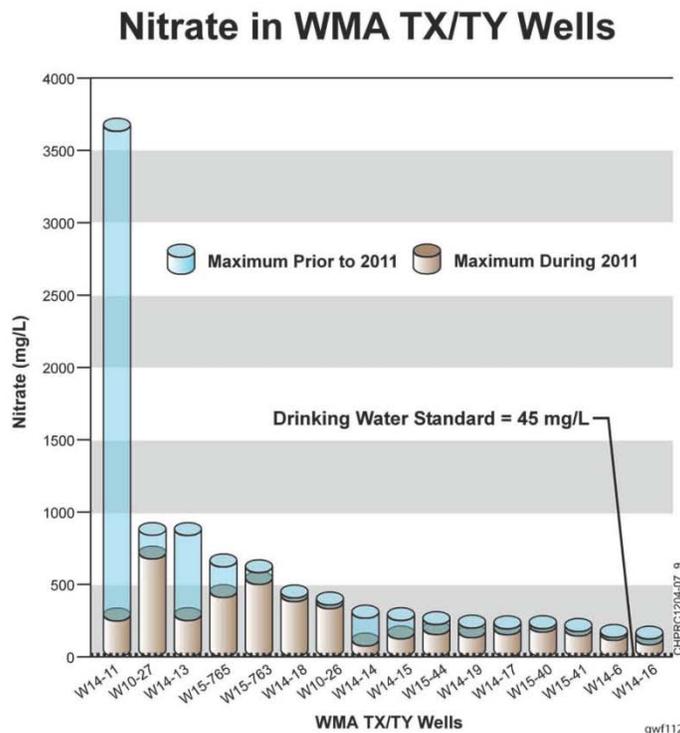
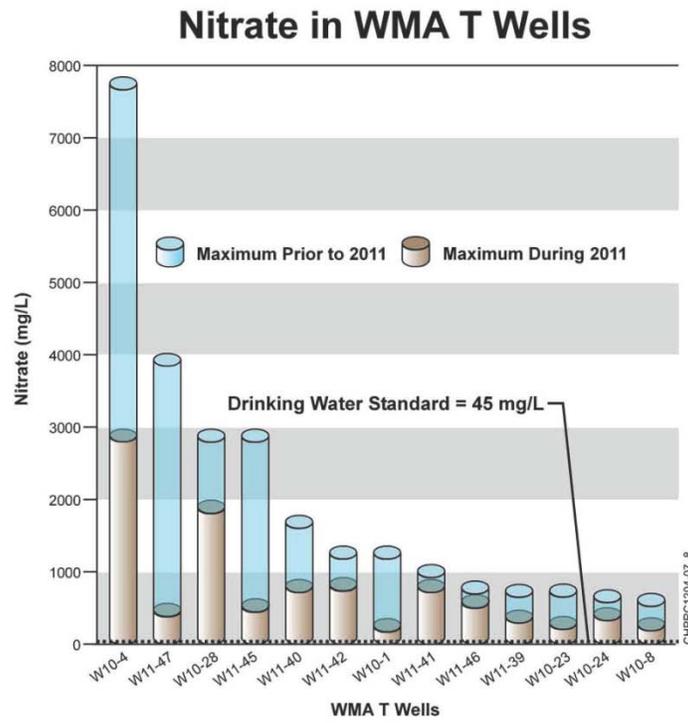


Figure 3.2-15. Average Chromium Concentrations in 200-ZP-1, Upper Part of Unconfined Aquifer, 2011

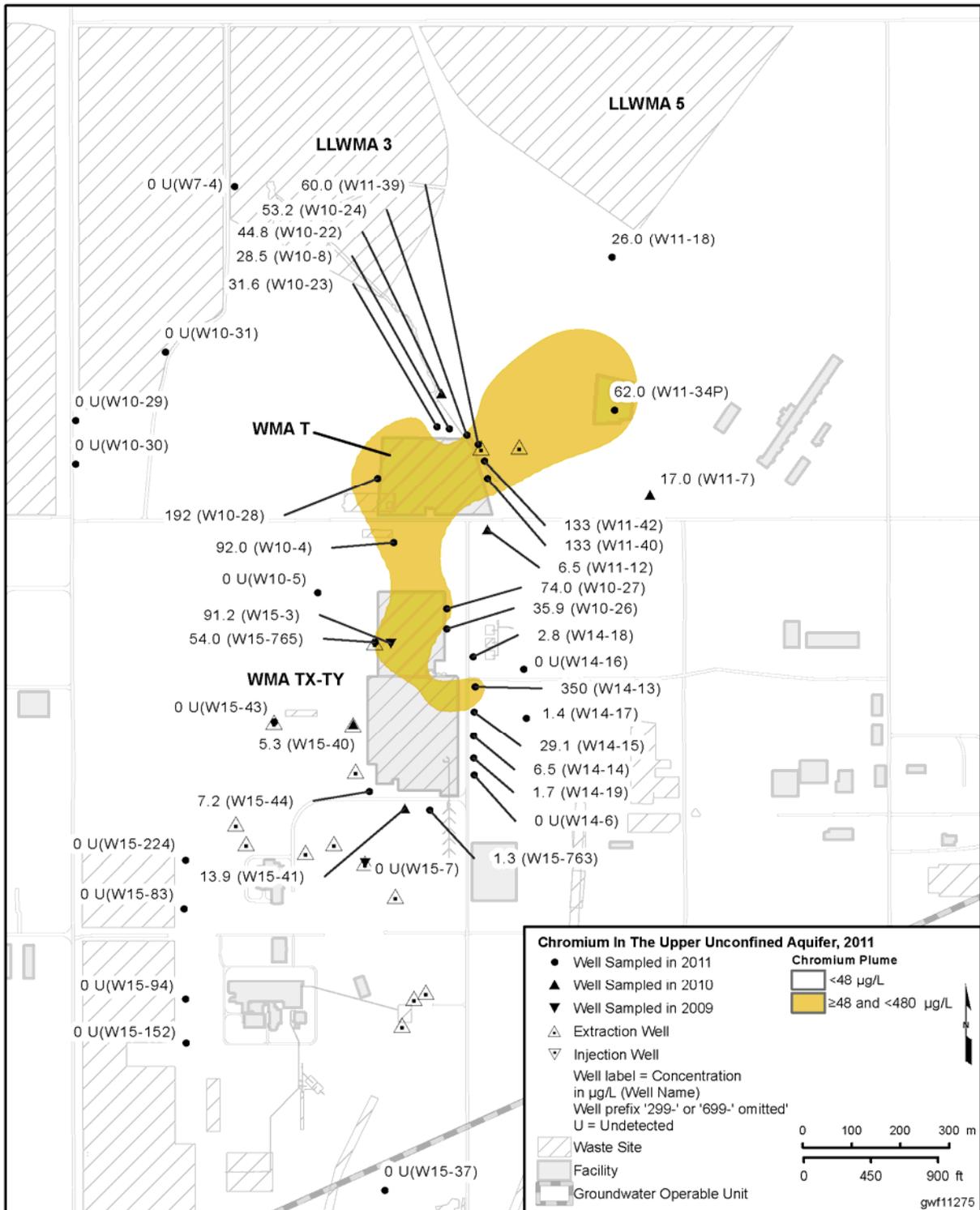
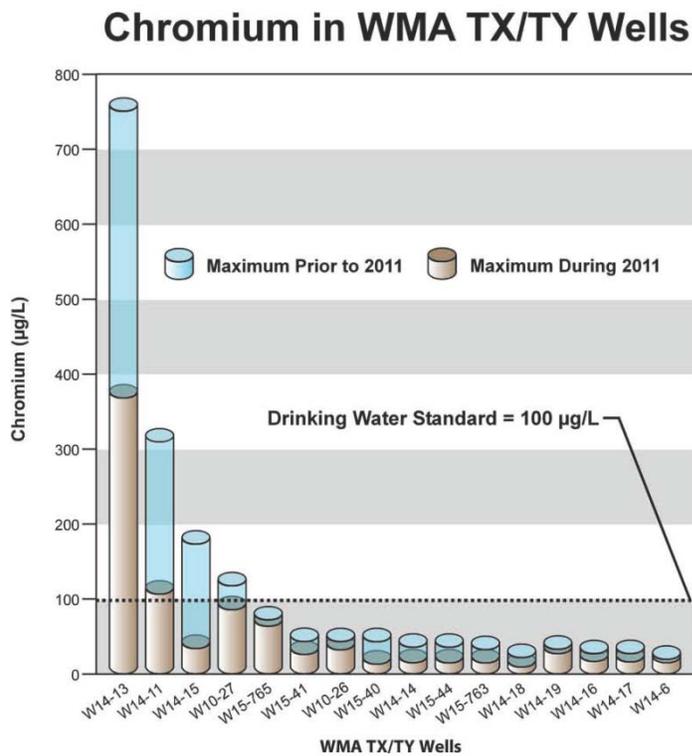
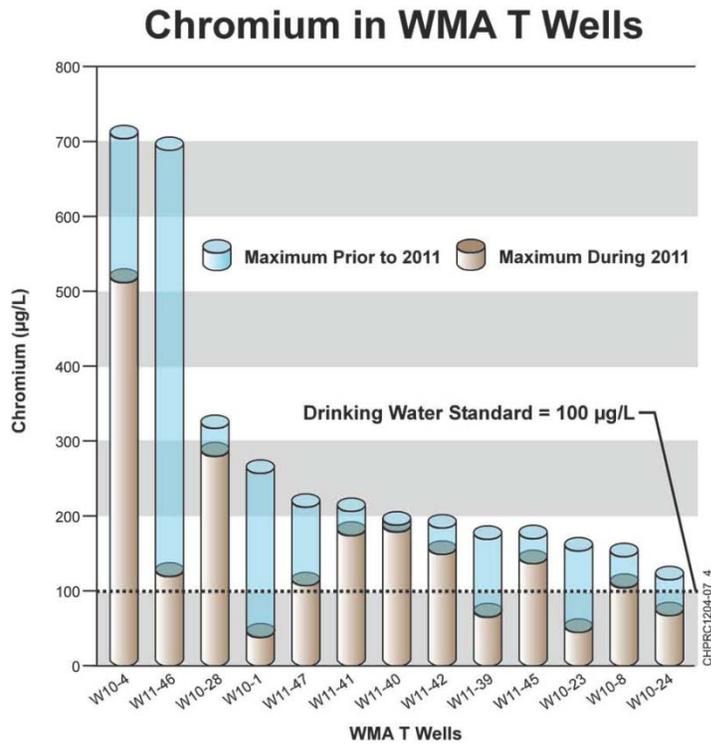


Figure 3.2-16. Maximum Chromium Concentrations in WMA T and TX-TY Wells in 2011 and prior to 2011



gwf11293

Figure 3.2-17. Average Tritium Concentrations in 200-ZP-1, Upper Part of Unconfined Aquifer, 2011

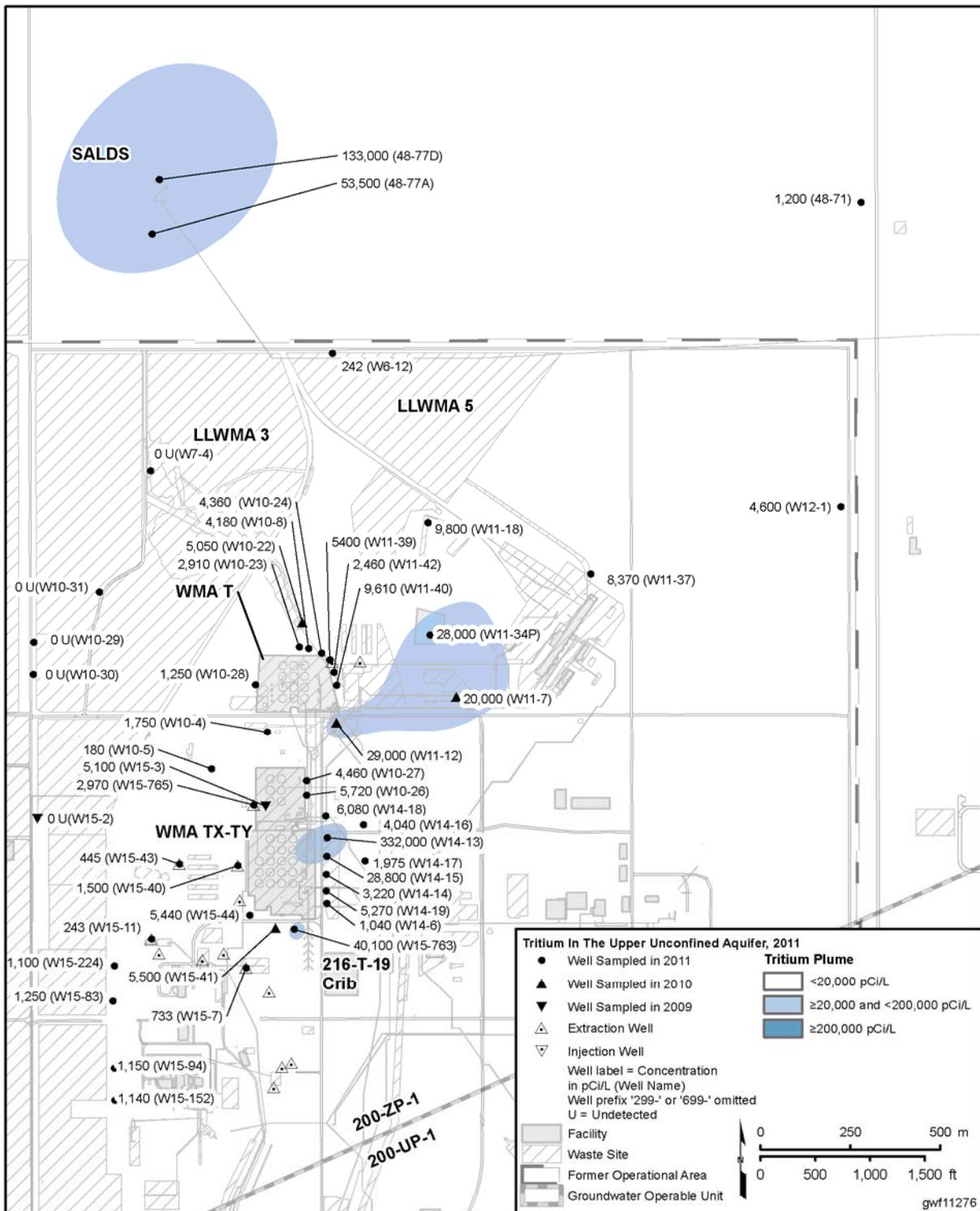


Figure 3.2-18. Average Iodine-129 Concentrations in 200-ZP-1, Upper Part of Unconfined Aquifer, 2011

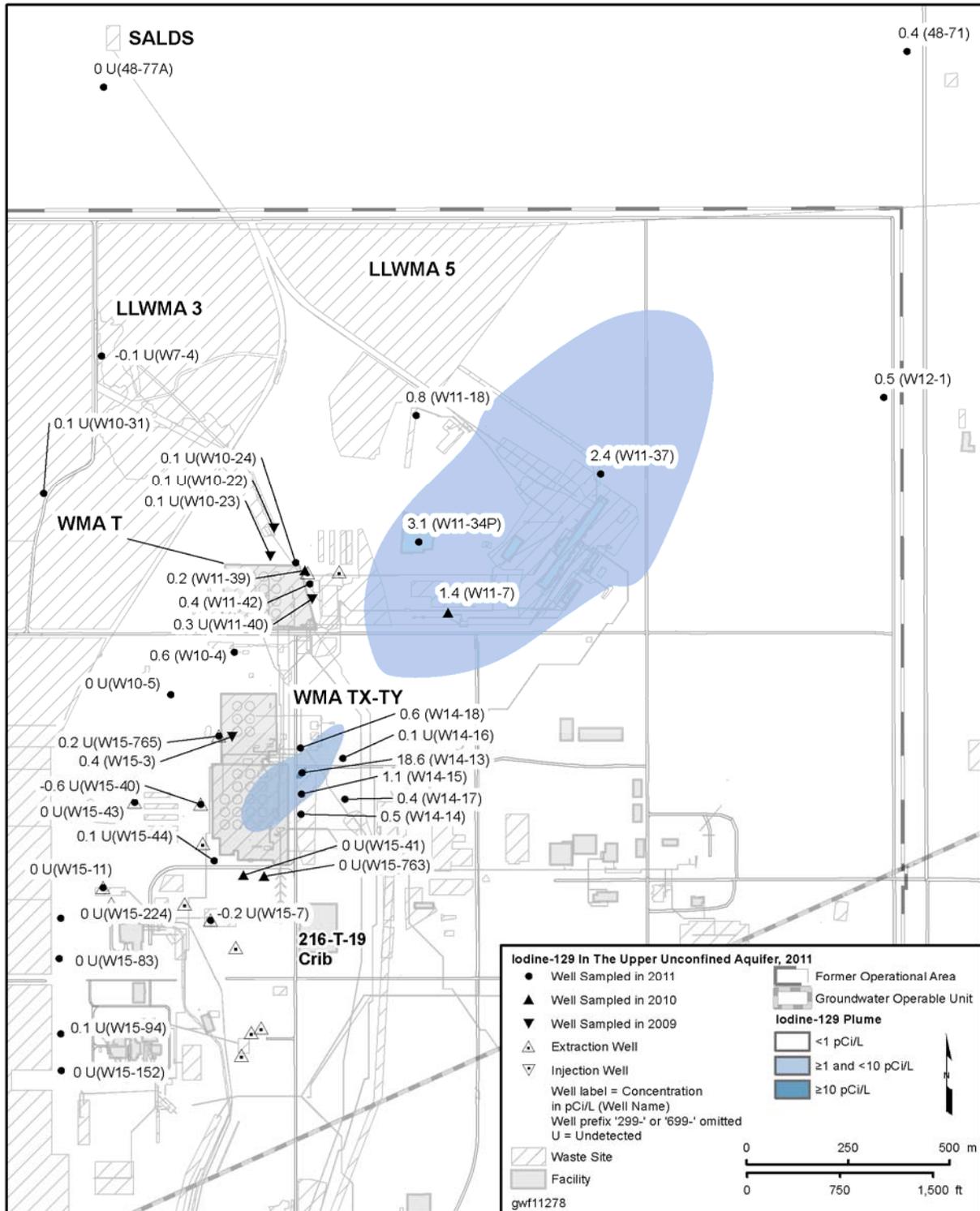
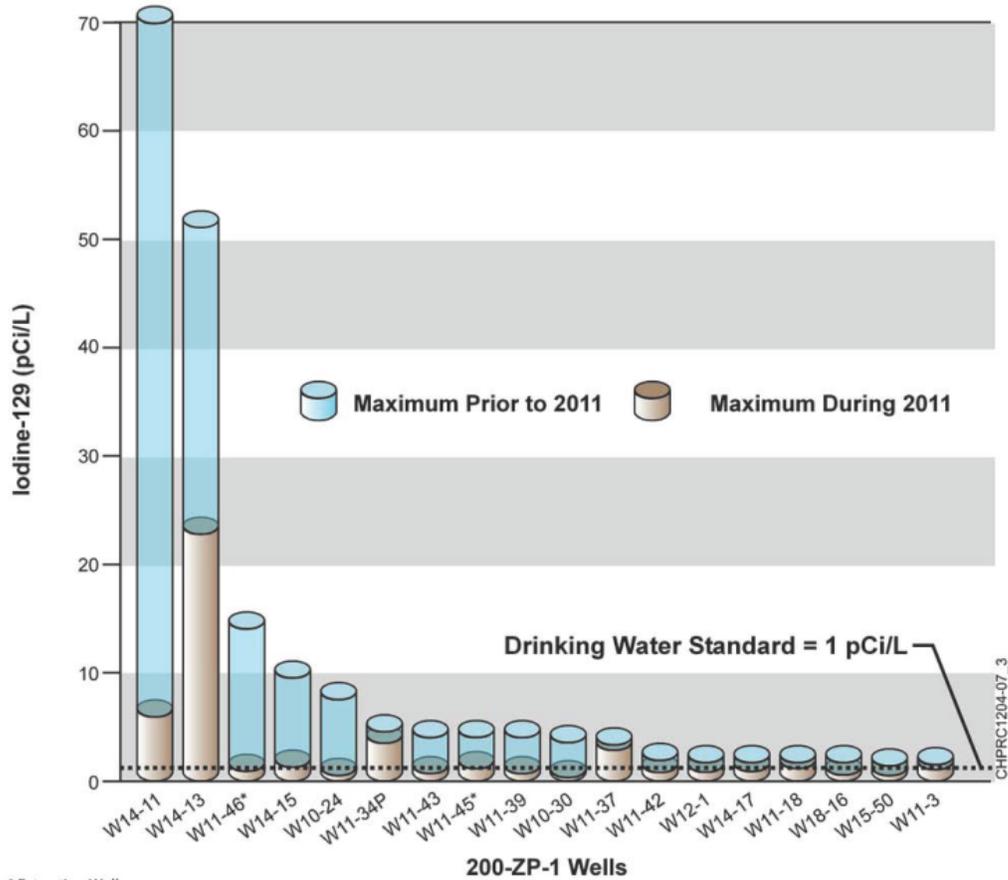


Figure 3.2-19. Maximum Iodine-129 Concentrations in 200-UP-1 Wells in 2011 and prior to 2011

200-ZP-1 Wells Exceeding 1 pCi/L Iodine-129 Prior to 2011 and During 2011



* Extraction Well

gwf11294

Figure 3.2-20. Average Technetium-99 Concentrations in 200-ZP-1, Upper Part of Unconfined Aquifer, 2011

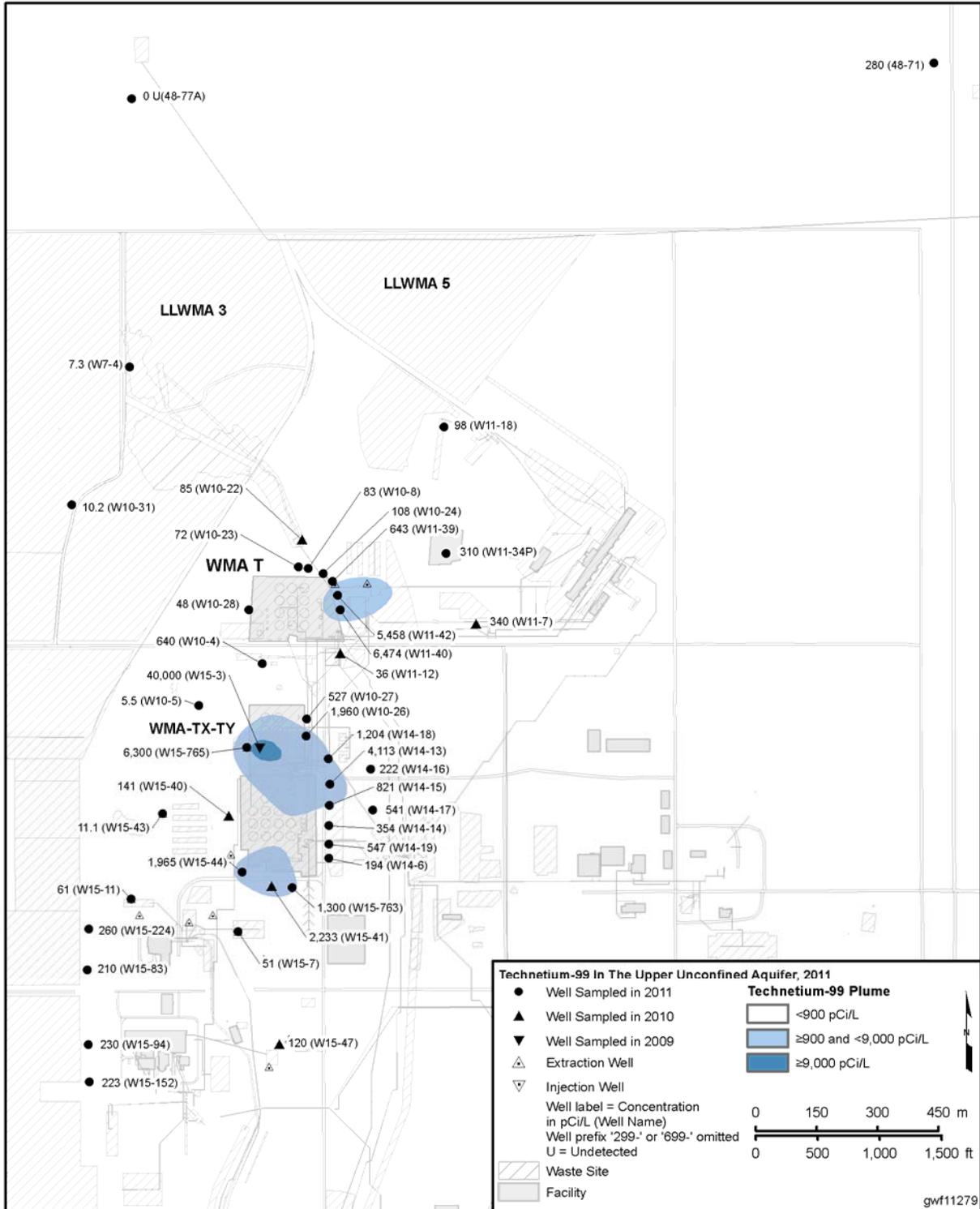


Figure 3.2-21. Maximum Technetium-99 Concentrations in 200-ZP-1 Wells in 2011 and prior to 2011

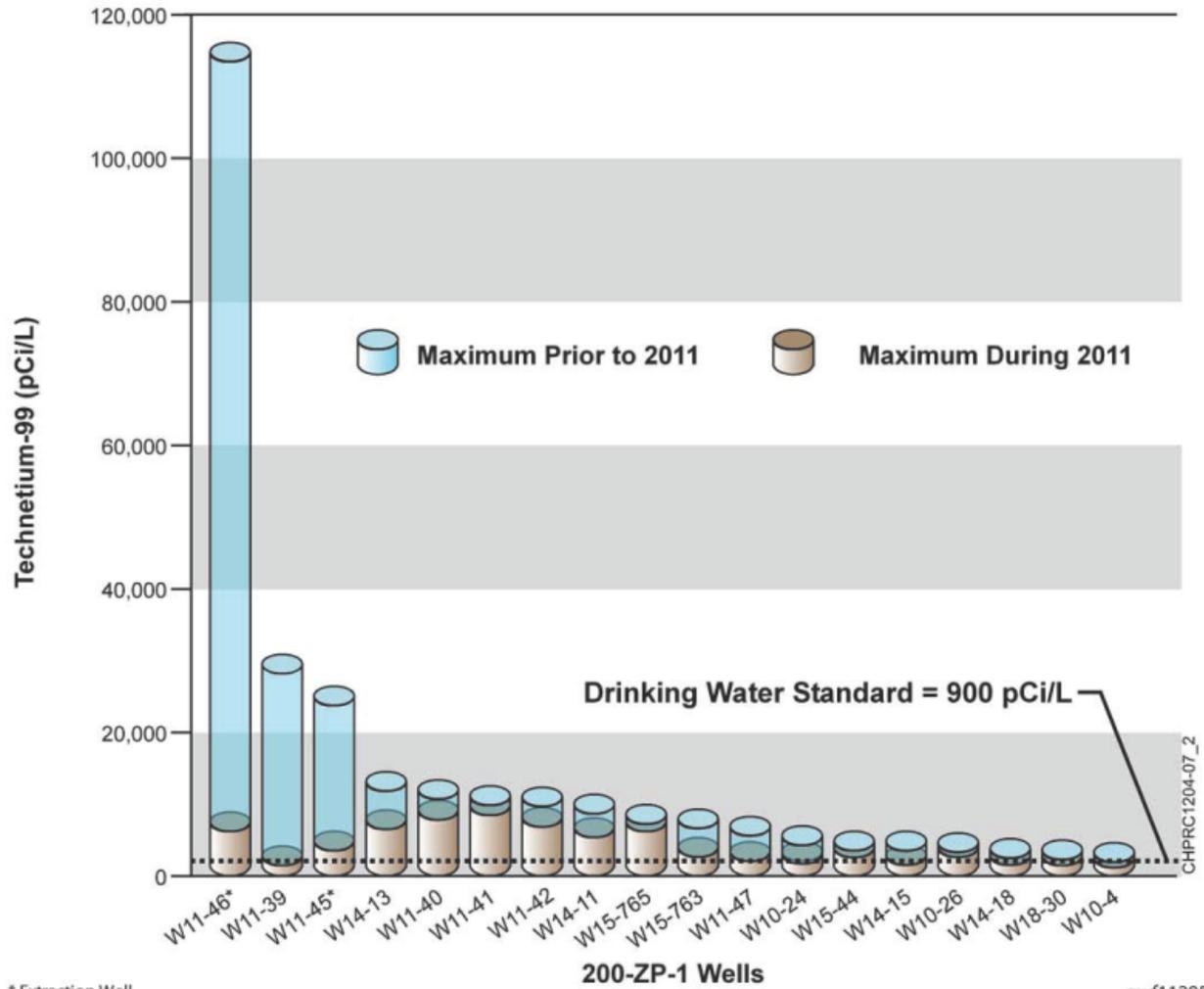


Figure 3.2-22. Technetium-99 Trends in WMA T Extraction Wells

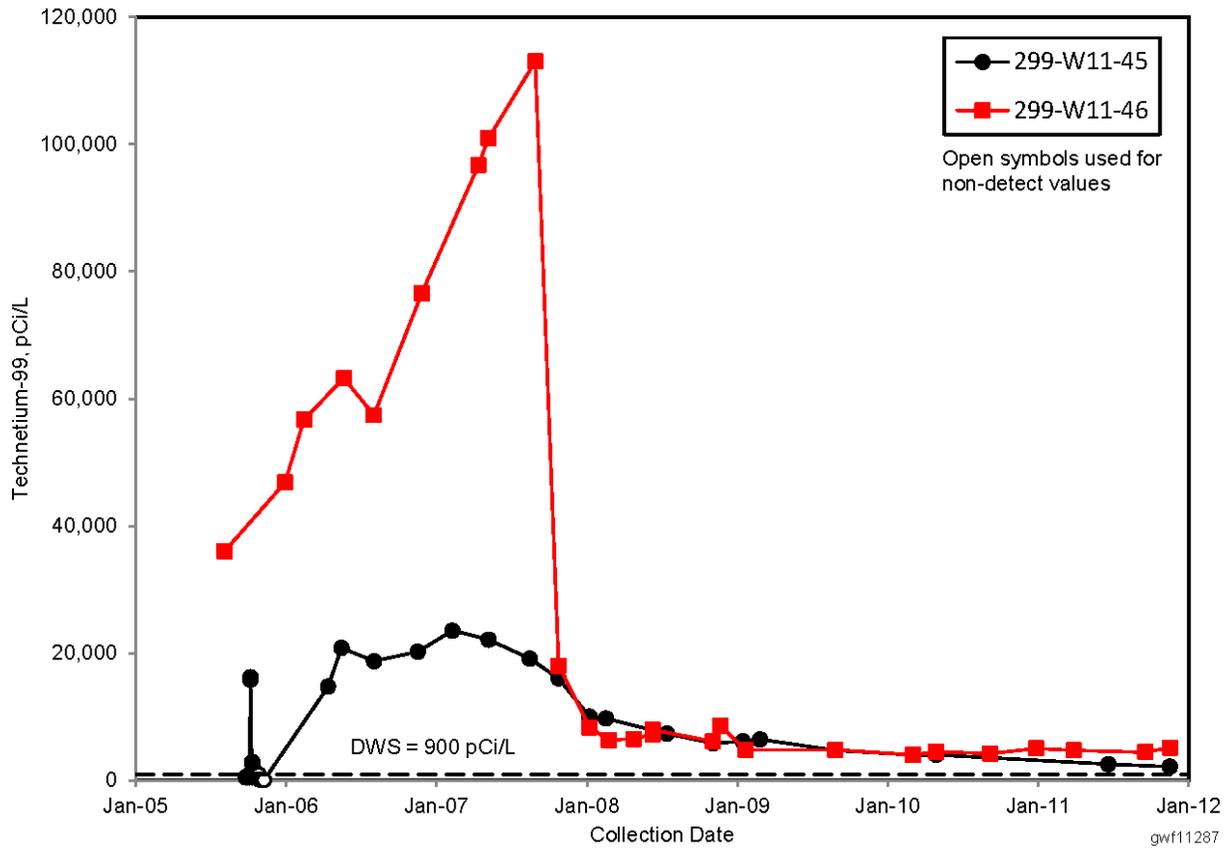


Figure 3.2-23. Mass of Carbon Tetrachloride Removed from 200-ZP-1 Vadose Zone

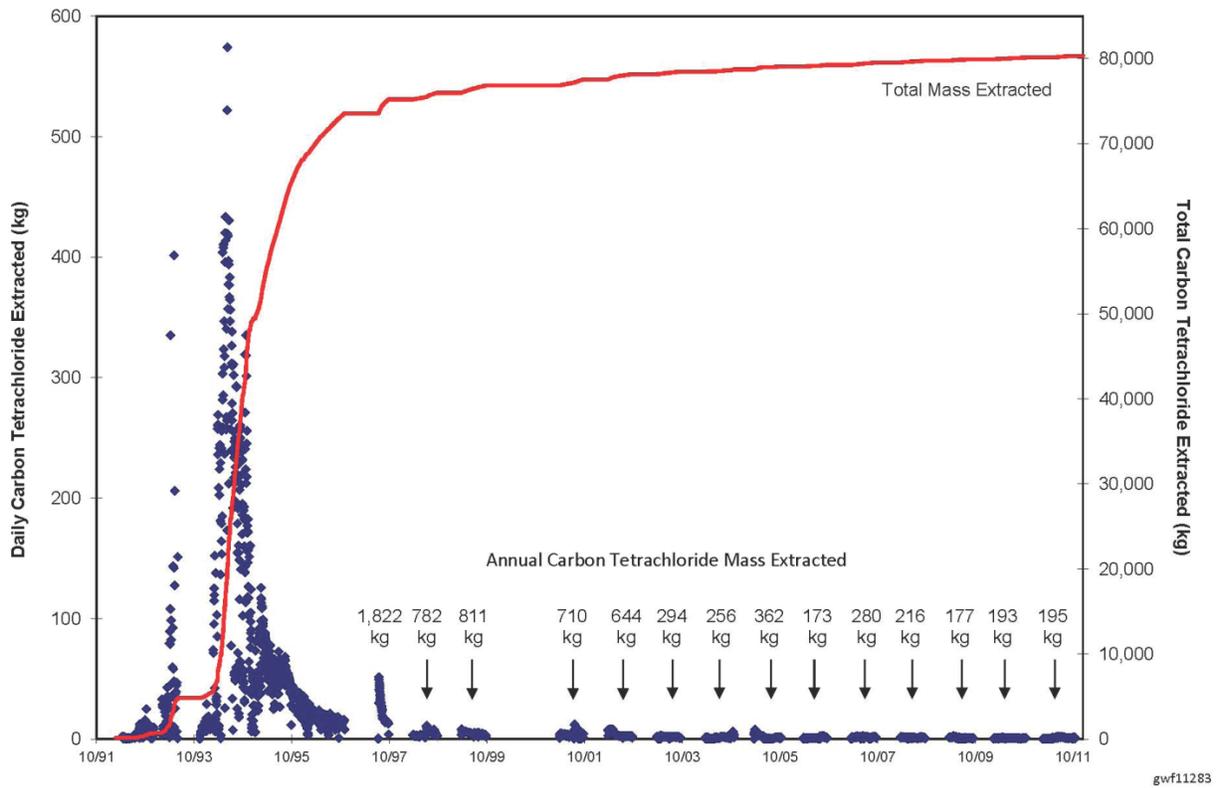


Figure 3.2-24. Tritium Trends in Wells Monitoring the State-Approved Land Disposal Site

