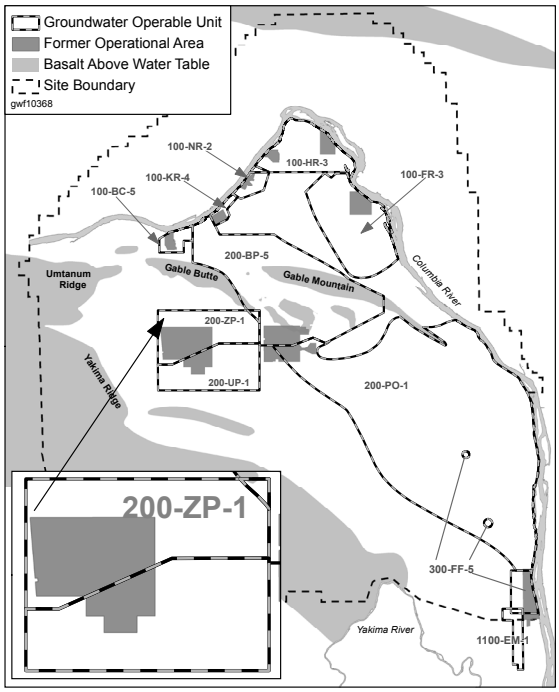
12.0 200-ZP-1 Operable Unit

E.J. Freeman

The 200-ZP-1 Operable Unit (OU) activities focus on monitoring and remediation of groundwater contaminant plumes beneath the northern and central portions of the 200 West Area and the 600 Area (adjacent to the 200 West Area). The OU lies within the larger 200-ZP-1 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (Figure 1-4 in Chapter 1.0). Figure 12-1 shows the extent of the OU, the facilities, and wells.



Groundwater is monitored to assess the performance of the interim action pump-and-treat system for carbon tetrachloride and technetium-99, to track other contaminant plumes, and to support four *Resource Conservation and Recovery Act of 1976* (RCRA) units and the State-Approved Land Disposal Site (SALDS). Data from facility-specific monitoring are also integrated into the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) groundwater investigations. Radionuclide monitoring for facilities is performed in accordance with the *Atomic Energy Act of 1954* (AEA).

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

- Section 12.1 describes the waste facilities, hydrogeology, and groundwater flow characteristics for the 200-ZP-1 OU.
- Section 12.2 describes groundwater contaminants and compliance monitoring during the reporting period.
- Section 12.3 summarizes the CERCLA groundwater interim remedial action system performance for effective capture of carbon tetrachloride and technetium-99 within the OU.
- Section 12.4 addresses groundwater monitoring of RCRA facilities and the SALDS.
- Section 12.5 provides the conclusions and recommendations for the OU.

This chapter presents the calendar year (CY) 2010 activity for the 200-ZP-1 OU, from January 1, 2010, through December 31, 2010.

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

12.1 Conceptual Model

This section provides a brief discussion of the conceptual site model, which affects estimates of contaminant distributions and migration rates and pathways. Elements that contribute to the conceptual model include waste site operations, hydrogeologic framework, and groundwater characteristics. Additional details on the conceptual model for the 200-ZP-1 OU can be found in Chapters 2 and 4 of the *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24)

Carbon tetrachloride is the primary contaminant of concern (COC) present in groundwater in the OU. The primary source of this COC is associated with discharges to the 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs and Trenches. The contaminant

plume extends out from these waste sites along the primary flow direction to the north, northeast, and east, with the highest concentrations beneath the TX-TY Tank Farms. To a lesser extent, some migration of carbon tetrachloride has occurred to the south and southeast. Additional COCs within the 200-ZP-1 OU include trichloroethylene, technetium-99, chromium, nitrate, tritium, and iodine-129. Monitoring and remediation activities in the past have focused on wells screened in the upper 15 meters of the aquifer. Recent deeper drilling and well installations have confirmed the presence of relatively high contaminant concentrations at depth. This information is being incorporated into well designs and the remedial action process.

The Columbia River Basalt Group forms the bedrock beneath the 200-ZP-1 groundwater interest area. 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 9, the silt and clay of the Ringold lower mud unit 8, the semiconsolidated sand and gravel of Ringold unit 5, the fine- to coarse-grained Cold Creek unit (CCU), and unconsolidated sand and gravel of the Hanford formation. Groundwater within the interest area occurs as an unconfined aquifer, as well as under locally confining conditions, and as present beneath the Ringold lower mud unit (Ringold confined aquifer) and in the basalt flows and interbeds. 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 unit 8 is missing in the stratigraphic sequence, carbon tetrachloride has migrated below the elevation of the lower mud unit and into the confined aquifer.

The unconfined aquifer is contained within Ringold Formation sediments at the 200-ZP-1 OU and has been directly impacted by waste disposal operations in the central and northern 200 West Area. In particular, the aquifer occupies Ringold unit 5 and its base is generally the fine-grained Ringold lower mud unit, although in some areas the mud unit is missing and the bottom of the aquifer occurs at the top of the basalt. Depths from land surface to the water table range from 64 to 106 meters, with the greater depths occurring in the northeastern portion of the interest area. The thickness of the unconfined aquifer within the interest area is variable (PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*). Moving east of the 200 West Area, the aquifer transitions into the Hanford formation, which is a much more transmissive unit. The lower mud unit rises to the northeast and subcrops above the water table.

Groundwater in the northern portion of the 200 West Area predominantly flows toward the east-northeast but is locally influenced by the 200-ZP-1 pump-and-treat system and from effluent discharges to the SALDS (Figure 12-2) just north of the 200 West Area. The groundwater flow rates, calculated using the Darcy relationship (SGW-38815, *Water-Level Monitoring Plan for Hanford Site Soil and Groundwater Remediation Project*), typically range from 0.0001 meter per day in fine-texture, low-permeability material to 0.5 meter per day in coarse-texture, higher permeability material within the 200-ZP-1 groundwater interest area. The water table was impacted by Hanford Site operations in the 200 West Area due to past discharge of wastewater to ponds, ditches, and trenches. Cessation of these discharges has resulted in the water table declining at a rate of ~0.21 to 0.35 meters per year (Figure 12-3). The flow direction in the northern portion of the groundwater interest area has shifted over the past decade, from a north-northeastern direction to a more easterly direction as the water table decline approaches new equilibrium groundwater levels.

Flow in the central portion of the 200 West Area (southern portion of the 200-ZP-1 groundwater interest area) is strongly influenced by operation of the 200-ZP-1 pump-and-treat system. The 200-ZP-1 pump-and-treat system currently has fourteen extraction wells located north of the 216-Z Cribs and Trenches and west of Waste Management Area (WMA) TX-TY (Figure 12-1). The treatment system removes carbon tetrachloride and other volatile organic compounds. Treated effluent is injected into the aquifer to the west of the area. A small groundwater mound is present in the area of the injection wells, while a region of drawdown occurs near the extraction wells, setting up a recirculation zone between the two areas. The injection wells are due west of Low-Level Waste Management Area 4 (LLWMA-4) and have affected groundwater flow direction and contaminant concentrations beneath that WMA.

12.2 Groundwater Contaminants

This section describes the major COCs for the 200-ZP-1 OU: carbon tetrachloride, trichloroethylene, nitrate, total chromium, hexavalent chromium, tritium, iodine-129, and technetium-99. Cribs, trenches, and underground tanks are the principal sources of groundwater contamination. Most of the sampling and analytical results that are used to define the contaminant plume are from monitoring and extraction wells completed in the upper 15 meters of the aquifer. As a result, previous plume maps have been biased toward the top of the unconfined aquifer. The plume maps discussed in this section represent the annual average concentration calculated from all sampling events at each well during the reporting period.

Plume areas (square kilometers) in the 200-ZP-1 Operable Unit:

Carbon Tetrachloride*, 5 µg/L — 11.459
Chromium, 100 µg/L — 0.05
Iodine-129, 1 pCi/L — 0.74
Nitrate, 45 mg/L — 5.808
Technetium-99, 900 pCi/L — 0.073
Trichloroethene, 5 µg/L — 0.107
Tritium, 20,000 pCi/L — 0.532
Uranium, 30 µg/L — 0

**** Also includes plume area beneath the 200-UP-1 Operable Unit***

The predominant COC in the 200-ZP-1 OU is carbon tetrachloride. By 2010, the 1,000 µg/L plume contour within the upper 15 meters of the aquifer had decreased in area from 0.53 square kilometers to 0.43 square kilometers. Carbon tetrachloride is purported to exist only in a soluble liquid phase (dissolved). Field studies conducted in 2006 and 2007 (DOE/RL-2006-58, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid [DNAPL] Source Term Interim Characterization Report*; and DOE/RL-2007-22, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid [DNAPL] Source Term Characterization Report Addendum*) investigated whether carbon tetrachloride was present as a free-phase, dense nonaqueous-phase liquid product. In both studies, only the water-soluble component was detected; therefore, it is believed that carbon tetrachloride no longer or minimally exists in free-phase, dense nonaqueous-phase form at the former disposal sites. Consequently, any current downward migration of this contaminant is thought to be the results of lithologic controls and/or a vertical hydraulic gradient induced by past liquid waste disposal operations.

Depth-discrete sampling of volatile organic analytes at new extraction wells in the 200-ZP-1 OU exhibit carbon tetrachloride reduction-oxidation degradation and chloroform accumulation at the contact between coarse and fine sediments.

12.2.1 Carbon Tetrachloride

Carbon tetrachloride is the principal COC for the 200-ZP-1 OU and is found at levels greater than the drinking water standard (DWS) (5 µg/L) under most of the 200 West Area (Figures 12-4 and 12-5). The main sources of carbon tetrachloride are the 216-Z Cribs and Trenches (three facilities) that received waste from the Plutonium Finishing Plant (PFP). Interim remediation of this plume began in 1994. The remedial action objectives for cleanup of the plume are described in the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA/ROD/R10-95/114).

The initial targeted capture zone for the interim action was an area where carbon tetrachloride concentrations were greater than 2,000 µg/L.

The extent of the shallow unconfined carbon tetrachloride plume is depicted in Figure 12-4. The 2,000 µg/L mass in the upper 15 meters is currently located along the western edge of WMA TX-TY. In the mid-1990s, the plume was centered in the area of the PFP. Within and adjacent to this area, fourteen extraction wells are operating to remove contaminated groundwater for subsequent treatment at the 200-ZP-1 interim treatment facility (Figure 12-1). After treatment for volatile organics, the remediated water is injected through a line of five wells oriented north to south, located west of LLWMA-4. The plume area at the 5 µg/L DWS extends to the boundaries of the 200 West Area to the north, south, and east. The main plume orientation indicates overall migration predominantly northeast to east. The overall extent of the plume for CY 2010 is similar to that observed in 2009 (~11.5 square kilometers).

In addition to shallow carbon tetrachloride contamination (upper 15 meters) in the unconfined aquifer (Figure 12-4), the distribution throughout the full extent of the unconfined aquifer is shown in Figure 12-5. This figure represents a revision of Figure 7-5 from the *Hanford Site Groundwater Monitoring and Performance Report 2009* (DOE/RL-2010-11). Figure 12-5 incorporates additional data from recent depth-discrete sampling during drilling, removes data older than 2005 from the analysis, accounts for spatially varying properties of the plume, and takes into consideration depositional characteristics of the sediments. These changes provide a similar configuration but a somewhat more contorted plume than the smoother plume presented in DOE/RL-2010-11. Also, the carbon tetrachloride that accounts for the greater than 2,000 µg/L area appears as fragmented zones rather than a large, coherent mass in the aquifer. This new conceptualization is consistent with the principles of groundwater flow in heterogeneous porous media.

During CY 2010, two monitoring wells and five extraction wells in the 200-ZP-1 performance monitoring network exceeded 2,000 µg/L. Groundwater wells 299-W15-40, 299-W15-11, and 299-W15-765 had the highest recorded concentrations at ~2,900 µg/L for CY 2010. Monitoring well 299-W15-50 averaged ~2,600 µg/L. Since 2002, well 699-48-71 (northeast and outside of the 200 West Area) has shown a continuing increase in carbon tetrachloride concentration. The concentration has exceeded the DWS since 2002 and is currently ~94 µg/L (Figure 12-6).

The carbon tetrachloride concentration distribution for the 200-ZP-1 OU plume map (Figure 12-4) has been based on groundwater wells in the upper 15 meters of the unconfined aquifer. As a result of drilling new groundwater extraction wells, carbon tetrachloride concentrations greater than 1,000 µg/L have recently been observed at depths greater than 15 meters at wells downgradient from the source zone. Figure 12-7 provides a visual "slice" through a three-dimensional conceptual model of the carbon tetrachloride plume at 94 m elevation above mean sea level. This "slice" is derived from concentrations measured in all groundwater wells screened above the basalt within the unconfined aquifer. The vertical distribution of carbon tetrachloride is developed from 200-ZP-1 groundwater wells along the A to A' transect shown in Figure 12-7. The vertical and laterally continuous carbon tetrachloride plume is represented in Figure 12-8. Both of these plume maps show that carbon tetrachloride has moved toward the east and vertically downward at increasing distances from the source zone. Additionally, overall concentrations are declining at greater distances due to dispersion and degradation.

Depth-discrete sampling is currently performed during the construction phase while drilling new groundwater injection and extraction wells. By the end of CY 2010, fourteen new extraction and four new injection wells were completed to support future operations of the 200 West Area pump-and-treat groundwater processing facility. The wells are oriented in a staggered line from west of WMA TX-TY to the eastern boundary of the 200 West Area (Figure 12-5) and are designed to locate the extraction wells within the greater than 1,000 µg/L carbon tetrachloride contour.

12.2.2 Trichloroethylene

Trichloroethylene is detected at levels above the DWS (5 µg/L) in the 200-ZP-1 groundwater interest area. The main trichloroethylene plume (Figure 12-9) is located north from the source area at the 216-Z Cribs and Trenches. There are three discrete plume lobes with concentrations above the DWS located (1) beneath WMA TX-TY, co-located with the high-concentration portion of the carbon tetrachloride plume; (2) beneath WMA T; and (3) directly east of WMA T. Each of these plumes is downgradient, along the centerline of the carbon tetrachloride plume. Trichloroethylene exceeded the DWS in sixteen performance monitoring wells, including six extraction wells (four wells adjacent to WMA TX-TY and two wells east of WMA T). The maximum reported concentration during CY 2010 was 12 µg/L east of WMA TX-TY at extraction well 299-W15-45. At well 299-W11-34P, ~300 meters east of WMA T, the trichloroethylene concentration was 10 µg/L for most of the reporting period. The trichloroethene plumes for both WMA TX-TY and WMA T are located within the capture zones for their respective interim pump-and-treat systems. The plume east of WMA T is downgradient and lies outside of any capture zone. However, this plume shows a declining trend and is also in the capture zone for the final remedy pump-and-treat extraction wells.

12.2.3 Nitrate

Nitrate concentrations were above the DWS (45 mg/L, as nitrate) beneath much of the 200-ZP-1 groundwater OU (Figure 12-10). Multiple sources of nitrate likely exist in this area, including the cribs near WMA T and the 216-Z Cribs and Trenches. Two discrete, high-concentration plumes (greater than 400 mg/L) are discernible in the 200-ZP-1 OU: (1) a plume located beneath WMA T, and (2) a diminishing plume centered at well 299-W18-16 (near the 216-Z Cribs and Trenches) (Figure 12-10). The 45 mg/L contour extends from the 216-Z Cribs and Trenches at the southwest to beyond the 200 West Area boundary to the northeast.

The northern high-concentration plume is located, in part, within the capture zone of the current WMA T pump-and-treat wells. The highest concentration at the WMA T wells for the reporting period was 2,830 mg/L at well 299-W10-4. The high value reported for the southern plume at well 299-W18-16 has declined from 708 mg/L in 2009 to 411 mg/L in 2010. In general, the nitrate plume remained stable during CY 2010 compared to 2009.

12.2.4 Chromium

Chromium contamination is found at levels above the DWS (100 µg/L) beneath the single-shell tank farms WMA T and WMA TX-TY (Figure 12-11). The hexavalent form of chromium is soluble and mobile in water. For the groundwater plume analysis, total chromium is used to characterize concentrations and plume extent. The maximum concentration during CY 2010 was ~731 µg/L at tank farm well 299-W14-13. The maximum concentration reported at CERCLA well 299-W10-4, south of WMA T, was 465 µg/L. The chromium plume path is oriented toward the northeast. A total of ten performance monitoring wells exceeded

the chromium DWS in CY 2010, and nine of these wells were adjacent to WMA T. The chromium-contaminated wells in the northeastern corner of WMA T are within the capture zone for the pump-and-treat system. The concentration in the extraction wells immediately downgradient of WMA T at the end of CY 2010 were 146 µg/L in well 299-W11-45 and 121 µg/L in well 299-W11-46. In general, the chromium plume remained stable during CY 2010 compared to values observed in 2009.

12.2.5 Tritium

Tritium concentrations exceed the 20,000 pCi/L DWS only at wells northeast of WMA T, WMA TX-TY, and near the SALDS.

Tritium concentrations exceeded the DWS of 20,000 pCi/L within the 200-ZP-1 OU at two locations: (1) adjacent to WMA T and WMA TX-TY, and (2) adjacent to the SALDS. The geometry and extent of the tritium plumes are shown in Figure 12-12. The highest concentrations occur east of WMA TX-TY at well 299-W14-13. The tritium concentration at this well was measured at 1.6 million pCi/L. The general configuration of the plume shows the tritium oriented along a northeast flow path. Possible sources include surface wastewater disposal sites and facilities associated with the tank farms. The main source of the tritium plume near WMA TX-TY and WMA T is unknown. Tritium concentrations at wells near the WMAs appear to be declining over the years, which suggest that the tritium source may be depleted. Another explanation may be a shift in the hydraulic gradient that is diverting the higher concentration part of the plume away from the observations wells.

The second source of tritium is associated with the active wastewater discharge site at the SALDS. These discharges are known to contain tritium and are permitted by the State of Washington (Permit ST 4500 [Ecology, 2000a]). The highest tritium concentrations in groundwater wells 299-48-77A, 299-48-77C, and 299-48-77D were 7,500 pCi/L, 88,000 pCi/L, and 180,000 pCi/L, respectively. The tritium is expected to decay below the DWS as it moves downgradient from this facility.

The tritium plume near the SALDS varies with discharge volumes and correlates to concentration loading received from the Effluent Treatment Facility (ETF).

12.2.6 Iodine-129

Iodine-129 concentrations at the 200-ZP-1 OU exceeded the 1 pCi/L DWS at four wells during CY 2010. The extent and geometry of the iodine-129 plume is shown in Figure 12-13. The maximum concentration of 39.6 pCi/L was at well 299-W14-13, adjacent to WMA TX-TY. Concentrations exceeded the DWS at wells 299-W11-34P, 299-W11-37, and 299-W11-7. The flow path of the iodine-129 plume can be traced to downgradient wells along a northeast trend. The highest iodine-129 concentrations associated with extraction wells occurred in wells 299-W11-45 and 299-W11-46 with concentrations of 0.95 pCi/L and 0.99 pCi/L, respectively. The detection limit for iodine-129 is ~0.5 pCi/L. In general, the iodine-129 plume remains stable compared to 2009 at ~0.74 square kilometers.

12.2.7 Technetium-99

The technetium-99 maximum concentration has steadily declined in extraction well 299-W11-46, from a high of 113,000 pCi/L in 2007 to 4,500 pCi/L in CY 2010.

Technetium-99 exceeded the 900 pCi/L DWS at eleven of the 200-ZP-1 OU groundwater wells. The highest concentration measured during CY 2010 was 10,000 pCi/L at well 299-W11-40, located at the east side of WMA T. Three distinct plumes are shown in Figure 12-14, which are centered at (1) the south end of WMA TX-TY, (2) the north end of WMA TX-TY, and (3) beneath WMA T. The second highest measured technetium-99 concentration during CY 2010 of 6,900 pCi/L was measured at well 299-W14-13, located on the east side of WMA TX-TY, at the north end. This well also accounted for the highest iodine-129 and highest tritium concentrations measured at the OU. The highest technetium-99

concentrations at extraction wells included 299-W15-765 (5,600 pCi/L), 299-W11-46 (5,000 pCi/L), and 299-W11-45 (4,000 pCi/L). Well 299-W15-3 had a concentration of 40,000 pCi/L when it was last measured in 2009.

The plume beneath WMA T has the same northeast trend as other contaminant plumes in the OU. The north plume is distinct at WMA TX-TY in that it appears to be oriented to the southeast. The reason for the plume's orientation is unknown. The southern WMA TX-TY plume does not show a discernible trend of flow direction. Overall technetium-99 concentrations at the monitoring wells remain stable in comparison to the observations for 2009.

12.2.8 Other Constituents

Other constituents detected in groundwater at concentrations above the preliminary target action levels include fluoride, antimony, arsenic, iron, and manganese. Chloroform and methylene chloride are monitored for the groundwater interest area as degradation products of carbon tetrachloride.

During CY 2010, the annual average chloroform concentrations in the 200-ZP-1 groundwater interest area remained below the 80 µg/L DWS (defined for total trihalomethanes). Concentrations are declining throughout the groundwater interest area. Possible chloroform sources include biodegradation of carbon tetrachloride and sanitary sewer discharges to the 2607-Z Tile Field. Chloroform also is found near WMA TX-TY and WMA T, as well as at depth below the water table to the northeast of these areas.

Uranium is another constituent of interest in groundwater that could potentially exceed the current DWS (30 µg/L). During CY 2010, the maximum uranium concentration of 26.3 µg/L was detected in groundwater well 299-W11-37. This well is located near the T Plant complex, and the uranium concentrations have been steadily declining over time. None of the groundwater wells in the 200-ZP-1 OU exceeded the DWS for uranium during CY 2010.

Fluoride contamination at levels greater than the primary DWS (4 mg/L) has historically occurred in a local area around T Tank Farm. Well 299-W10-8 (located at the northwestern corner of the tank farm) had the CY 2010 maximum fluoride concentration of 4.49 mg/L, which reflects a slight decrease in fluoride from a concentration of 4.89 mg/L in 2009. A possible source for the contamination is the historical surficial releases of lanthanum fluoride used in the bismuth phosphate process. This liquid may have infiltrated to the unconfined aquifer.

Antimony concentrations in several wells exceeded the DWS (6 µg/L) in CY 2010; however, antimony results have been problematic. Detections are typically very close to the reported detection limit and are sporadic. Most of the detections in CY 2010 and previous years are believed to be false-positive results.

During CY 2010, filtered arsenic was detected at levels above the 10 µg/L DWS in well 299-W10-4 located southwest of WMA T. The maximum concentration reported at this well was 12.0 µg/L, which is slightly higher than the maximum of 9.7 µg/L at this well in 2009. The Hanford Site filtered groundwater background for arsenic is 11.8 µg/L (95th percentile) (DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*).

Iron was present at levels above the 300 µg/L secondary DWS in eleven groundwater monitoring wells. The maximum reported concentration of 2,400 µg/L (unfiltered) was at well 299-W10-4. Since well 299-W10-4 was constructed in 1952 and the casing is carbon steel, high iron content in the water may be an artifact of

casing degradation. Review of samples collected for multiple years at individual wells indicates that the iron concentration typically fluctuates over a wide range. The sample results for iron are suspect because iron is also a naturally occurring component of the aquifer sediment and is found in well materials. The background iron concentration for Hanford Site filtered groundwater is 55.3 µg/L (DOE/RL-96-61).

Methylene chloride was detected at levels above the 5 µg/L DWS in one well in the 200-ZP-1 groundwater interest area during CY 2010. The maximum concentration reported was at well 299-W17-1 (eastern boundary of LLWMA-4) at 5.9 µg/L. Methylene chloride (dichloromethane) can be a degradation product or impurity in carbon tetrachloride (tetrachloromethane), but it is also a common laboratory contaminant.

12.3 CERCLA Groundwater Activities

This section summarizes the CERCLA groundwater performance monitoring and interim remedial measures at the 200-ZP-1 OU, as outlined in the interim Record of Decision (ROD) (EPA/ROD/R10-95/114), and as implemented in the *200-ZP-1 Interim Remedial Measure Remedial Design Report* (DOE/RL-96-07) and the *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE/RL-2002-17).

The performance monitoring network is intended to ensure that appropriate data are collected to evaluate remedy performance in the aquifer. A list of the performance monitoring network wells and sampling frequency is provided in Appendix A, Table A-11. The final design, installation, and operation of the remedial action monitoring network and treatment system are discussed in the *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78). Additional tasks performed during CY 2010 in support of the final ROD issued in 2008 (*Declaration of the Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* [EPA et al., 2008]) included the completion of eleven additional wells (seven extraction and four injection), which supplements the seven wells completed in 2009 and moves the project closer to a final network of at least sixteen injection and twenty extraction wells. These wells will support the new groundwater treatment facility, which is anticipated to be operational by December 2012. Construction activities for the new and expanded groundwater treatment facility continued in CY 2010.

Within the 200-ZP-1 OU, interim actions have been implemented to remediate carbon tetrachloride, chloroform, and trichloroethylene in the vicinity of the 216-Z liquid waste disposal cribs and trenches. The final remedy for the 200-ZP-1 OU addressed carbon tetrachloride and the other COCs throughout the vertical extent of the aquifer in accordance with the final ROD (EPA et al., 2008). The *Calendar Year 2010 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable unit Pump-and-Treat Operations* (DOE/RL-2011-26) provides a detailed status of the interim remediation from previous years. Interim remedial measures were implemented through operation of fourteen extraction wells and five injection wells to capture the high-concentration (greater than 2,000 µg/L) region of the carbon tetrachloride plume. Carbon tetrachloride and seven other constituents are removed from the contaminated groundwater at an interim treatment facility in the 200 West Area, and the treated effluent is then pumped back into the aquifer through a group of injection wells. This action creates a groundwater mound that increases the groundwater gradient of the plume toward the extraction wells.

In addition to carbon tetrachloride, monitoring and remediation of technetium-99 from sources within WMA T and WMA TX-TY have been implemented to address this constituent for both CERCLA and AEA programs. Remediation activities at this site include pumping of technetium-99-laden groundwater from wells 299-W11-45 and 299-W11-46. Effluent from these wells is transferred to the ETF via a cross-site transfer pipeline, where constituents are removed before the remediated water is discharged at the SALDS.

The plan and schedule for implementing all of the tasks applicable to the 200 West Area pump-and-treat system, as set forth in the final 200-ZP-1 ROD, were issued in the 200-ZP-1 pump-and-treat remedial design/ remedial action work plan (DOE/RL-2008-78) in March 2009.

12.3.1 CERCLA Decision Documents

The interim remedy for the 200-ZP-1 OU is defined in the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA/ROD/R10-95/114). The purpose of the ROD is to explain the cleanup alternatives that are used at the site. The primary COCs identified for interim remediation are carbon tetrachloride, trichloroethylene, and chloroform. The interim ROD identifies that the three remedial action objectives for the project are to (1) reduce contamination in the areas of highest concentration of the carbon tetrachloride plume, (2) prevent further movement of contaminants from high concentration areas, and (3) provide information to the final remedy that is protective of human health and the environment.

The second CERCLA 5-year review was published in November 2006 (DOE/RL-2006-20, *The Second CERCLA Five-Year Review Report for the Hanford Site*), which provided a comprehensive evaluation of the status of groundwater and source OU investigations and cleanup actions. All findings pertinent to the 200-ZP-1 OU for the 200 Areas National Priority List (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan") were completed in fiscal year (FY) 2007.

Based on groundwater characterization activities and interim pump-and-treat operations, the final remedy for the 200-ZP-1 OU was developed and formalized in the final ROD (EPA et al., 2008). The list of COCs was expanded to include the major contaminant plumes exceeding DWSs. The COCs include carbon tetrachloride, trichloroethylene, iodine-129, technetium-99, nitrate, hexavalent chromium, total chromium, and tritium. The remedial action objectives identified in the ROD include (1) return the 200-ZP-1 OU groundwater to beneficial use, (2) apply institutional controls to prevent use of groundwater until the cleanup levels have been attained, and (3) protect the Columbia River from degradation and unacceptable impacts caused by contamination from the 200-ZP-1 OU. The remedial action objectives are achieved through four remedy components: (1) pump-and-treat of the contamination, (2) monitored natural attenuation, (3) flow-path controls, and (4) institutional controls.

The CERCLA cleanup process for the 200-ZP-1 OU 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 FY 2004 and implemented in FY 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 the *Proposed Plan for Remediation of 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-33), completed in July 2008
- *Declaration of the Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton county, Washington* (EPA et al., 2008)

Carbon tetrachloride mass was reduced through pumping and treating over 570.2 million liters of groundwater from fourteen extraction wells during CY 2010. This resulted in the removal of 700.7 kilograms of carbon tetrachloride. The large increase in mass removed and volume extracted relative to 2009 can be attributed to addition of extraction well 299-W15-225 during CY 2010.

- *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.

12.3.2 Pump-and-Treat System for Carbon Tetrachloride

The main portion of the current 200-ZP-1 OU interim pump-and-treat system is located near the middle of the 200 West Area (Figure 12-1) and it removes carbon tetrachloride as the primary COC, with chloroform and trichloroethylene as secondary COCs. New extraction and injection wells to support the final remedy will cover this area, most of the northern portion of the 200 West Area and outside the 200 West Area to the east (Figure 12-5). The baseline groundwater plume is centered on an area of high carbon tetrachloride concentration that has its source from discharges to three waste sites located immediately south and east of the PFP. One of the remedial action objectives, as defined in the interim ROD (EPA/ROD/R10-95/114) identifies reducing contamination in the area of highest concentrations of carbon tetrachloride. The pump-and-treat system began operation in 1994 and includes fourteen extraction wells and five injection wells as of CY 2010. Groundwater extracted by the well network is processed through the 200-ZP-1 interim treatment system before being pumped back into the aquifer at the five active injection wells. Much of the groundwater beneath the 200 West Area and adjacent 600 Area has carbon tetrachloride concentrations exceeding the DWS of 5 µg/L.

This section provides a summary of the information contained in the annual performance report for 200-ZP-1 OU interim pump-and-treat operations (DOE/RL-2011-26). More detailed discussion can be found in that annual summary report. The production metrics and operational results of the pump-and-treat activities are also included in the following discussion.

12.3.2.1 Changes in 2010

During CY 2010, a range of activities was performed at the 200-ZP-1 pump-and-treat system to improve system operation and provide a better understanding of contaminant distribution and movement. A summary of the 200-ZP-1 pump-and-treat activities and developments for CY 2010 is as follows:

- Extraction well 299-W15-44 was removed from the pump-and-treat system and replaced by well 299-W15-225. The new extraction well increased production by ~946 liters per minute and now accounts for 52% of the water extracted from the fourteen-well network.
- A new heater/chiller unit was installed to moderate temperature variations at the plant. This improvement further enhances the operational efficiency of the system.
- Seven injection and four extraction wells were completed during CY 2010 compared to seven wells completed in CY 2009, for a total of eighteen wells. Ultimately, the pump-and-treat system will consist of at least sixteen injection and twenty extraction wells.
- Construction at the 200 West Area groundwater treatment facility proceeded expeditiously during CY 2010, with progress on the radiological process facility and biological treatment facility ongoing. Construction on this facility is scheduled for completion by the end of 2011.
- The design and balance of plant requirements were completed, as they pertain to the expanded 200 West Area pump-and-treat system, to meet *Hanford Federal*

Facility Agreement and Consent Order (Tri-Party Agreement) Milestone M-016-123 (Ecology et al., 1989).

- Several documents relevant to carbon tetrachloride pump-and-treat operations were completed, including the following:
  - DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*
  - DOE/RL-2009-124, *200 West Area Pump-and-Treat Facility Operations and Maintenance Plan*
  - DOE/RL-2010-13, *200 West Area Groundwater Pump-and-Treat Remedial Design Report*
  - DOE/RL-2010-72, *Sampling and Analysis Plan for Eight Remediation Wells in the 200-ZP-1 Operable Unit in Fiscal Year 2011*
  - DOE/RL-2010-78, *200 West Area Groundwater Pump-and-Treat Facility Extraction and Injection Well Maintenance Plan*
  - PNNL-19681, *Tc-99 Ion Exchange Resin Testing*
  - SGW-47662, *Test Plan for Technetium-99 Adsorption on Selected Resins from Hanford Site 200 West Area Groundwater*
  - SGW-46453, *Testing Guidelines for Technetium-99 Adsorption on Activated Carbon*.

12.3.2.2 Extraction System Performance

During CY 2010, fourteen extraction wells operated over a period of 336 days, with various combinations of extraction wells in operation from 3 to 319 days during the period. The average combined pumping rate was 1,181.9 liters per minute. The extraction system produced 570.2 million liters of contaminated groundwater in CY 2010, which is a 60% increase over the 356.4 million liters in CY 2009. The new extraction well, which is screened across most of the unconfined aquifer, pumped at a daily average rate of 939 liters per minute, which is well above the pumping rates achieved in other shorter screened extraction wells. The total volume of groundwater pumped since startup of the 200-ZP-1 treatment system in 1994 is ~5.0 billion liters.

12.3.2.3 Capture Zone Analysis

Estimates of the extent of the hydraulic capture produced by the 200-ZP-1 extraction wells were calculated using a water-level mapping method for the Hanford Site as described in SGW-42305, *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance*. Capture estimation using water-level maps follows a three-step process: (1) water-level maps are prepared using universal kriging, which enables a deterministic trend to be included in the map; (2) particle tracking is used to define (estimate) the extent of capture; and (3) a capture frequency map is used to depict capture estimates on the basis of numerous alternative water-level maps. A capture frequency map is generated that depicts the frequency with which each theoretical contaminant particle terminates at an extraction well, calculated over alternative water-level maps derived from discrete sampling events throughout the year. A frequency of 1.0 indicates that the particle is captured on every map; a frequency of zero indicates that a particle is not captured on any map; and intermediate frequencies indicate that the particle is captured using some maps and not on others.

Two capture frequency maps were generated: one with the addition of well 299-W15-225 and without operating well 299-W15-44, and one prior to operation

of well 299-W15-225. The addition of well 299-W15-225 in June 2010 increased overall water production by 40%. Figure 12-15(a) and (b) presents two ensemble depictions of capture calculated for each operational period (before and after well 299-W15-225) using capture frequency maps that are superimposed on the carbon tetrachloride plume contour map.

The width of the capture zone during the first period, prior to startup of well 299-W15-225, is wider at the southern lobe and exhibits greater capture at the northern lobe during the second time period. This phenomenon is contingent upon multiple factors, including (1) well screen penetration depth, (2) pumping rate, (3) injection well location relative to the extraction well, and (4) reduced pumping rate at extraction wells to the south of the new extraction well. The shallow extraction wells tend to capture flow over a broader area than deep well 299-W15-225. The development of a steeper gradient and narrower capture zone at the deep extraction well, combined with the orientation of the injection wells, increases and focuses the flow toward the deep well, so the particle capture is more tightly bound to the deep extraction well. The high flow upgradient at the injection wells and downgradient at the deep extraction well tends to dampen the aquifer response at the shallower, less-productive extraction wells. Consequently, the broad capture at the shallow wells is reduced. Further description of screen penetration and Hanford Site-specific effects on capture are discussed in "Variations in Capture-Zone Geometry of a Partially Penetrating Pumping Well in an Unconfined Aquifer" (Bair and Lahm, 1996) and DOE/RL-2011-26.

Figure 12-15(a) and (b) indicates that the current 200-ZP-1 OU extraction wells contain the high-concentration carbon tetrachloride present in the upper 15 meters of the aquifer. The successful retrieval of carbon tetrachloride from well 299-W15-225 with the longer screen interval indicates the presence of significant contamination deeper in the aquifer.

12.3.2.4 Treatment System Performance

The treatment system at the 200-ZP-1 OU uses an air-stripper column to remove carbon tetrachloride from the groundwater by separating it into a vapor phase. The carbon tetrachloride is then captured on granular activated carbon in canisters that are sent offsite for regeneration. Treated groundwater is returned to the aquifer through injection wells located south-southwest of the treatment facility.

The total amount of carbon tetrachloride removed in CY 2010 at the 200-ZP-1 OU was 700.7 kilograms (Table 12-1), which is a 72% increase in mass removed compared to 404.1 kilograms of removed in CY 2009. The increase in mass removal is a direct result of the increase in treated volume from 299-W15-225 in CY 2010 when compared to CY 2009.

Online availability in CY 2010 was 87.2% compared to 62.5% in CY 2009. The better performance measurement for CY 2010 largely relates to system upgrades and increased leak detection alarms in CY 2009 that spuriously caused additional downtime. Total availability was 88.5% in CY 2010. This calculation factors out scheduled downtimes and, therefore, emphasizes the impact of unscheduled outages. Treatment system availability is summarized in Table 12-2.

12.3.2.5 Compliance Monitoring

The areal extent of carbon tetrachloride and trichloroethylene plumes (Figures 12-4 and 12-9, respectively) are based on semiannual (or higher frequency) analytical data. A plume map was not generated for chloroform because the concentration has

not exceeded the 80 µg/L DWS since 1996. The compliance monitoring network consists of twelve active groundwater monitoring wells and the fourteen extraction wells that primarily penetrate the upper 15 meters of the unconfined aquifer. Trend plots for carbon tetrachloride, chloroform, and trichloroethylene concentrations at the monitoring and extraction wells during the current and previous three CYs are shown in Figures 12-16, 12-17, 12-18, and 12-19, respectively.

The CY 2010 contaminant monitoring highlights at the 200-ZP-1 pump-and-treat system for wells located in the upper 15 meters of the aquifer are summarized below:

- **Plume trends:**
  - The high-concentration portion of the carbon tetrachloride plume (greater than 2,000 µg/L to less than 3,000 µg/L) decreased in size and concentration from CY 2009 to CY 2010.
  - The area enclosed by the 1,000 µg/L contour for carbon tetrachloride shrank from 0.53 square kilometers in CY 2009 to 0.43 square kilometers in CY 2010. The most notable change in size occurred in the area near the pump-and-treat wells.
  - Chloroform concentrations declined in the main portion of the carbon tetrachloride plume shown in Figure 12-17. Monitoring wells did not exhibit chloroform concentrations greater than 17 µg/L during CY 2010.
  - The CY 2010 area of the trichloroethylene plume decreased compared to CY 2009. The area with highest concentrations continues to occur at extraction wells that were the original target of the interim action.
- **Extraction wells:**
  - In CY 2010, carbon tetrachloride concentrations in extraction wells generally exhibited a decreasing trend in comparison to CY 2009. Eight wells had measured carbon tetrachloride concentrations at or above 2,000 µg/L during 2009. In 2010, seven wells had concentrations of at least 2,000 µg/L. The maximum concentration reported for 2009 was 3,900 µg/L at pumping well 299-W15-50. The maximum concentration during CY 2010 was 2,900 µg/L at extraction wells 299-W15-40 and 299-W15-765.
  - Well 299-W15-6, which is screened in the lower unconfined aquifer near the 216-Z-9 Crib, has historically had carbon tetrachloride results ranging between 1,500 and 2,000 µg/L. The average CY 2010 concentration was within this range, from 1,725 µg/L to a high of 2,100 µg/L reported in December 2010.
  - Chloroform levels from extraction wells and monitoring wells have not exceeded the 80 µg/L DWS at any well since August 1996. Concentrations did not exceed 16 µg/L in CY 2010. Average trichloroethylene concentrations slightly exceeded the 5 µg/L DWS at three of the fourteen extraction wells, including 299-W15-40 (6.9 µg/L), 299-W15-44 (8.4 µg/L), and 299-W15-765 (5.9 µg/L). The maximum detected concentration was 12 µg/L at extraction well 299-W11-45.
- **Monitoring wells:**
  - The highest carbon tetrachloride concentrations measured in performance monitoring wells within the 200-ZP-1 OU occurred at 299-W15-50 and

299-W10-24, with maximum quarterly concentrations of 2,600 and 2,400 µg/L, respectively.

– The highest average trichloroethylene concentration, measured at monitoring well 299-W11-34P, was 10.0 µg/L.

- **Deep wells:**
  – The highest carbon tetrachloride concentrations were measured in deep wells 299-W13-1 and 299-W11-87, located near the eastern boundary of the 200 West Area. The highest reported value was 1,500 µg/L. These wells are screened deep in the unconfined aquifer, just above the Ringold lower mud unit. Maximum concentrations in the other eight deep monitoring wells ranged from 1 to 1,200 µg/L.
  – Chloroform concentrations at each of the ten deep wells were stable or decreasing, with average concentrations ranging from less than detect to 13 µg/L.
  – Trichloroethylene concentrations measured in the ten deep monitoring wells ranged from 1 to 8.8 µg/L. The 5 µg/L DWS was exceeded only at wells 299-W13-1, 299-W14-72, and 299-W14-71.

12.3.2.6 Vertical Distribution of Contamination Throughout the Unconfined Aquifer Sediments

The recent installation of wells supporting the final ROD and expansion of the pump-and-treat system has provided more detailed information on the vertical distribution of carbon tetrachloride. The new extraction and injection wells are installed using a drill-and-test procedure, which provides data on the contaminant concentrations down to the top of the basalt. These data provide a different perspective on the vertical distribution of carbon tetrachloride than the initial perspective when the interim action ROD was issued in 1994. A summary of this new information is as follows:

- Carbon tetrachloride concentrations appear widely distributed at depth.
- The deeper plume extends further northeast than had been previously mapped.
- Two high-concentration areas appear to be separated by a low concentration area in Figure 12-7. This separation is believed to be caused by dilution by leakage from the former 216-U-14 wastewater ditch, which is oriented north to south.

Using the carbon tetrachloride concentration from multiple wells that were sampled at regular vertical intervals, a three-dimensional conceptualization of the contaminant distribution was generated. Figure 12-7 provides the carbon tetrachloride plume in plan view for a “slice” through the conceptual plume at an elevation of 94 meters above mean sea level. This image shows the plume location relative to a new extraction well network and injection wells. The extraction wells are distributed within the carbon tetrachloride plume, along the flow direction; the injection wells are arranged along the perimeter of the plume, upgradient and downgradient to provide hydraulic containment. The transect line A-A’ is the trace of a vertical profile through the carbon tetrachloride plume and is represented in Figure 12-8. In the vertical profile, the carbon tetrachloride has been shown to have migrated downgradient through an erosional window in the Ringold lower mud unit and is present beneath the mud unit at the eastern extent of the plume. The plume appears to be situated in the upper portion of the aquifer at wells to the west than at wells further downgradient, which suggests that the carbon tetrachloride

moved deeper into the aquifer as it moved to the east. The increasing depth to the east was likely caused by a downward hydraulic gradient, which is likely the result of surface discharges in the past (infiltration) to cribs, ditches and ponds, and/or through lithologic controls (flowing along higher hydraulic conductivity pathways). The plume depicted in Figures 12-7 and 12-8 shows regions of high concentration and changes in concentration out to 100 µg/L. The 100 µg/L concentration signifies the expected concentration to be achieved over the entire area to remove 95% of the carbon tetrachloride mass in groundwater.

12.3.2.7 Historical Plume Trends

The current carbon tetrachloride plume configuration indicates that the 200-ZP-1 pump-and-treat activities in CY 2010 and previous years were successful in reducing mass and the overall distribution of carbon tetrachloride in the upper 15 meters of the unconfined aquifer.

As has been the case for the previous few years, the southern end of the plume (historically defined by the 1,000 µg/L contour) was stable in CY 2010. A detailed discussion of changes in the size of the carbon tetrachloride plume since inception of the pump-and-treat remedy is provided in Appendix H of DOE/RL-2011-26.

12.3.3 Pump-and-Treat System for Technetium-99

A pump-and-treat test system specifically targeting technetium-99 began operating in September 2007 as part of a designed interim remedial activity. These wells are located on the eastern side of WMA T. The interim remedial activity was implemented as part of the general remedial guidance for the 200-ZP-1 OU based on the interim ROD (EPA/ROD/R10-95/114) and the *Technetium-99 Pump-and-Treat System to Support the 200-ZP-1 CERCLA Remedial Investigation/Feasibility Study Process* (DOE/RL-2007-23). The pump-and-treat test system at WMA T currently consists of two extraction wells (299-W11-45 and 299-W11-46) that deliver groundwater via a cross-site transfer line to the 200 Area Liquid Effluent Retention Facility (LERF). The contaminated groundwater is treated at the ETF. Treated groundwater is then transported by pipeline and disposed at the SALDS surface discharge site north of the 200 West Area. Groundwater monitoring well and extraction well trend plots for the technetium-99 plume in the area of WMA T are shown in Figures 12-20 and 12-21, respectively, for a 7-year interval through the end of 2010. The figures show that technetium-99 is below the DWS at the selected monitoring wells but remains above the DWS at the extraction wells.

Technetium-99 mass was reduced in the area of highest concentrations through pumping and treating more than 52.2 million liters of groundwater from two extraction wells during CY 2010. This resulted in the removal of 22,959 kilograms of nitrate, 16.35 grams of technetium-99, 6.25 kilograms of chromium, and 27.86 kilograms of carbon tetrachloride.

Technetium-99 is most commonly found in the 200 West Area in groundwater downgradient of the tank farms and the liquid disposal waste sites associated with tank farm or evaporator processes. Potential sources for technetium-99 include the 216-T-21 through 216-T-28 Cribs; the 242-T evaporator; and the T, TX, and TY Tank Farms. The following subsections address CY 2010 activities in regard to technetium-99 groundwater contamination at the 200-ZP-1 OU.

12.3.3.1 Changes in 2010

No major changes occurred in regard to the WMA T pump-and-treat system during CY 2010. The system operated throughout the year with occasional stoppages for maintenance and cross-site transfers from other facilities.

12.3.3.2 Extraction System Performance

During CY 2010, the two extraction wells produced 52.2 million liters of groundwater at a combined average annual rate of 99.3 liters per minute. The two extraction wells operated from February 17, 2010, through December 31, 2010.

Both wells were offline from January 1, 2010, through February 17, 2010, due to maintenance at the ETF. Well 299-W11-45 was online for 257 days, or 70.4% availability. Well 299-W11-46 was online for 289 days, for 79.1% availability. The monthly operational availability is listed in Table 12-3.

12.3.3.3 Capture Zone Analysis

Estimates of the extent of the hydraulic capture produced by the two technetium-99 extraction wells were calculated using a water-level mapping method at the Hanford site as described in SGW-42305. Capture estimation using water-level maps follows a three-step process: (1) water-level maps are prepared using universal kriging, which enables a deterministic trend to be included in the map; (2) particle tracking is used to define (estimate) the extent of capture; and (3) a capture frequency map is used to depict capture estimates on the basis of numerous alternative water-level maps. A capture frequency map is generated that depicts the frequency with which each theoretical contaminant particle terminates at an extraction well, calculated from alternative water-level maps derived from discrete sampling events throughout the year. A frequency of 1.0 indicates that the particle is captured on every map; a frequency of zero indicates that a particle is not captured on any map; and intermediate frequencies indicate that the particle is captured using some maps and not on others.

The two extraction wells adjacent to WMA T operated throughout CY 2010, with the exception of stoppages for maintenance and cross-site transfers from other facilities. The capture frequency map for these wells corresponds to the smaller northern plume near WMA T shown in Figure 12-15. The capture frequency map for the first half of the year in Figure 12-15(a) shows a much lower capture frequency than the capture frequency calculated for the second half of the year (Figure 12-15[b]). The difference between the two capture configurations is attributed to extraction well 299-W15-225 being brought online. Operation of this well increased drawdown to the south of WMA T and slightly changed groundwater flow direction in the northern portion of the 200 West Area. This change in hydraulic conditions helped to improve the overall capture of the WMA T extraction wells.

12.3.3.4 Treatment System Performance

Treatment of groundwater pumped from the two WMA T extraction wells resulted in removal of 16.35 grams of technetium-99, 27.86 kilograms of carbon tetrachloride, 22,959 kilograms of nitrate, 6.25 kilograms of chromium, and 245 grams of trichloroethylene. Table 12-4 summarizes the CY 2010 production data for the pump-and-treat system.

12.3.3.5 Compliance Monitoring

Technetium-99 within the 200-ZP-1 OU is found at levels significantly above the DWS (900 pCi/L) on the eastern (downgradient) side of WMA T and in two areas near WMA TX-TY (Figure 12-14). The size of the plume associated with WMA TX-TY appears to have expanded along the eastern margin of the tank farm, although concentrations have not concurrently increased. In fact, concentrations along the eastern margin of the WMA T have decreased somewhat due to groundwater extraction at pumping wells 299-W11-45 and 299-W11-46.

The maximum average concentration observed within the plume in CY 2010 was 7,833 pCi/L at monitoring well 299-W11-40, which is one of five wells located near WMA T. The other four wells ranged from 1,024 to 6,640 pCi/L in CY 2010. Concentrations in the extraction wells have been decreasing since pumping began in late CY 2007. Maximum concentrations recorded in CY 2010 were 4,000 pCi/L

at well 299-W11-45 and 5,000 pCi/L at well 299-W11-46. In both cases, the concentrations were lower than the highest concentrations observed in CY 2009 for these two wells, which were 6,400 and 8,600 pCi/L, respectively.

The technetium-99 plume on the north side of WMA TX-TY had a maximum annual concentration of 6,900 pCi/L. The concentration is higher than the CY 2009 values of 5,400 pCi/L. The small plume at the southern end of WMA TX-TY had a maximum average concentration of 2,233 pCi/L, which was observed at performance monitoring well 299-W15-41. Both of these plumes remained relatively stable from CY 2009 to CY 2010.

12.3.4 Vertical Distribution of Technetium-99 Throughout the Unconfined Aquifer Sediments

Data collected at uniform vertical locations during drilling of new injection and extraction wells included technetium-99 concentration data. A three-dimensional conceptual model of the technetium-99 distribution was developed using these data derived from drilling logs. Figure 12-22 shows a plan view of the plume for a "slice" through the plume at 127 meters above mean sea level. The figure shows multiple discrete lobes that originate from near each of the tank farms. Transect line A-A' represents the trace of a vertical profile oriented southwest to northeast through the northern plume near WMA TX-TY and WMA T. A second perspective is given in Figure 12-23 where the vertical extent of technetium-99 contamination is displayed through the slice plane. The technetium-99 plume appears to move deeper as it migrates further downgradient from the source. The leading edge of the plume at the water table appears to be moving out faster than contamination deeper in the aquifer. One explanation for this behavior is that as contamination reaches the groundwater table first and moves both vertically and laterally from there. As the technetium-99 migrates deeper into the aquifer, it starts moving laterally. In essence the deep contamination is following a longer flow path. The well traces shown in Figure 12-23 represent the position of each well relative to the plume, but only concentration data from wells within 500 meters of the section line (Figure 12-22) are used to describe the vertical distribution of the plume at this slice. The technetium-99 plume does not appear to be as significantly affected by vertical migration, as was the case for the carbon tetrachloride plume.

12.4 Facility Monitoring

This section describes the results of monitoring at individual units such as treatment, storage, and disposal units or tank farms (monitored under RCRA), as well as the SALDS (monitored under a state waste discharge permit). Some of the units monitored under RCRA requirements for dangerous waste constituents are also monitored under AEA for source, special nuclear, and byproduct materials. Data from facility-specific monitoring are also integrated into CERCLA groundwater investigations. The AEA and CERCLA monitoring results and discussions are addressed in Section 12.2 and are separate from the following RCRA-focused sections that satisfy RCRA reporting requirements.

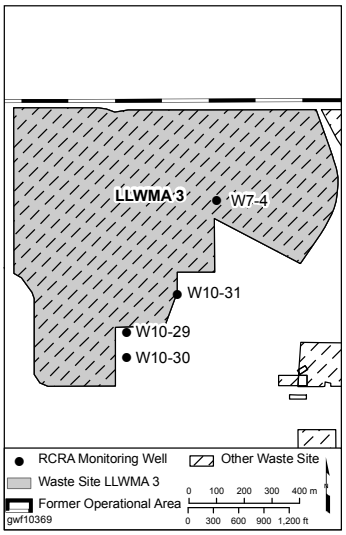
The 200-ZP-1 OU contains four RCRA sites with groundwater monitoring requirements: LLWMA-3, LLWMA-4, WMA T, and WMA TX-TY. The following discussion summarizes the results of statistical comparisons, assessment studies, and other developments for the reporting period. Groundwater data are available in the Hanford Environmental Information System database and in data files accompanying

this report. Additional information (including well and constituent lists, maps, flow rates, and statistical tables) is included in Appendix B.

12.4.1 Low-Level Waste Management Area 3

D.A. Gamon

Groundwater at LLWMA-3, located in the north-central corner of the 200 West Area, continued to be monitored under RCRA and AEA requirements. The LLWMA-3 consists of the 218-W-3A Burial Ground (20.4 hectares), 218-W-3AE Burial Ground (20 hectares), and 218-W-5 Burial Ground (37.2 hectares).



The 218-W-3A Burial Ground contains 57 unlined trenches that vary in length from 120 to 285 meters. The burial ground began operating in 1970 and has not received waste since 1998.

The 218-W-3AE Burial Ground contains eight unlined trenches varying in length from 325 to 380 meters, with bottom widths between 5 and 6 meters. The burial ground began operating in 1981 and received waste until July 2004.

The 218-W-5 Burial Ground contains ten unlined trenches and two lined trenches. The unlined trenches are between 160 and 350 meters long, 4.5 to 12 meters wide, and 5 to 6 meters deep. The lined trenches were constructed in 2000 and are 36 meters wide at the bottom, 9.1 meters deep, and 230 meters long. The burial ground began operating in 1986, and the two double-lined mixed waste trenches are the only trenches that continue to receive waste. All filled trenches are thought to contain 2.4 meters of soil cover.

In accordance with 40 CFR 265.93(b) ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response"), as referenced by WAC 173-303-400 ("Dangerous Waste Regulations," "Interim Status Facility Standards"), the well network was sampled semiannually for RCRA indicator and site-specific parameters (PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*; DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*). The controlling interim status groundwater monitoring document was updated midway through CY 2010 with the release of DOE/RL-2009-68, which replaced PNNL-14859. All of the wells were successfully sampled during the reporting period, except 299-W7-4, which was added back into the monitoring network in the latter part of CY 2010 after access and safety issues were resolved.

Appendix B, Table B-23 includes a list of wells and constituents monitored. The following subsections provide the annual evaluation requirements for the monitoring network, groundwater results, and compliance status.

12.4.1.1 Hydrogeology

The LLWMA-3 is underlain from the ground surface to the top of the basalt by the Hanford formation, the CCU, and the Ringold Formation. The Ringold Formation at this location is mostly sand and gravel, with minor units of finer grained sediment. The top of the water table is situated in the Ringold Formation and depth to groundwater is ~74 to 78 meters below land surface. The Ringold lower mud unit is absent beneath the northernmost portion of the area. Underlying the sedimentary deposits is the Elephant Mountain Member of the Saddle Mountains Basalt. The suprabasalt sediments range in thickness from 145 to 160 meters, of which 60 meters (south area) to 75 meters (north area) is saturated. The CCU dips

gently to the south and rises to within 6 meters of the surface along the northern boundary of LLWMA-3.

The water table continued to decline beneath LLWMA-3 during the reporting period at ~0.3 meter per year in response to the greatly reduced discharge of wastewater to surface facilities around the 200 West Area. The groundwater flow direction in this portion of 200 West Area is northeast across LLWMA-3 based on the March 2010 water-level data (Figure 12-2).

The hydraulic conductivity in the unconfined aquifer beneath LLWMA-3 is on the order of 2.5 to 10 meters per day and the hydraulic gradient is ~0.0016. Using these values and assuming an average effective porosity of aquifer materials of 0.1, the groundwater flow rate is calculated at 0.04 to 0.16 meters per day (see Appendix B, Table B-1). A current groundwater map that includes LLWMA-3 is shown in Figure 12-2.

12.4.1.2 Network Evaluation

A new upgradient well, 299-W9-2, is planned to be constructed by mid- to late CY 2011, which will allow statistical evaluations to resume.

Groundwater monitoring activities at LLWMA-3 currently consist of water-level monitoring and chemical constituent monitoring. The LLWMA-3 is sampled semiannually from a network of four wells. Samples are analyzed for indicator parameters and supporting constituents semiannually and for anions, metals, and phenols 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.

The groundwater monitoring network at LLWMA-3 consists of four wells along the southeastern boundary (Figure 12-1). The network wells are screened at the water table. Due to water-level decline, the only previously existing upgradient well on the western side of the WMA (299-W9-1) did not have enough water in the screened interval and was technically dry by 2000; the LLWMA-3 has not had upgradient monitoring wells since that time. Three out of the four monitoring wells have adequate water columns in the screened interval (over 9 meters). Well 299-W7-4 has ~1 meter of water column available and will be sampled using a bailer method; it is estimated this well can be sampled for several years using this method.

New upgradient well 299-W9-2 is planned to be constructed by mid- to late CY 2011, which will allow statistical evaluations to resume. No other new downgradient wells are expected at LLWMA-3 until the effects on groundwater flow direction of the expanded 200-ZP-1 OU pump-and-treat system are known.

Appendix B, Figure B-12 shows the location of wells in the LLWMA-3 monitoring network. All wells were sampled as scheduled during the reporting period, except for well 299-W7-4, which was added back into the monitoring network under the new groundwater plan (DOE/RL-2009-68) too late to collect a sample during CY 2010.

12.4.1.3 Compliance Status

Interim status indicator evaluation groundwater monitoring at LLWMA-3 will continue in CY 2011. Statistical evaluations at LLWMA-3 are currently suspended but will resume after new upgradient well 299-W9-2 is constructed and sampled as per requirements.

12.4.1.4 Groundwater Contaminants

Groundwater at LLWMA-3 is monitored under RCRA and AEA requirements. This section addresses only the RCRA requirements in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. The well network was sampled semiannually

for indicator and site-specific parameters (PNNL-14859; DOE/RL-2009-68). Based on the results presented below, there is no evidence of LLWMA-3 contaminating groundwater downgradient of the WMA.

Indicator parameters are pH, specific conductance, total organic carbon, and total organic halides, which were sampled for semiannually at each network well during the reporting period.

The wells were on trend for pH during the reporting period. Well 299-W10-31 continued its increasing trend for specific conductance from 434 µS/cm in 2009 and 514 µS/cm in CY 2010. This increase may be related to increasing nitrate concentrations at this well likely caused by movement of the regional nitrate plume.

The highest annual average total organic carbon value was in well 299-W10-30 (2,058.8 µg/L), which was an increase from the previous year's sample results. During CY 2010, total organic carbon concentrations increased in well 299-W10-29 from 1,360 to 2,170 µg/L and decreased slightly in well 299-W10-31.

The highest annual average total organic halides value was in well 299-W10-31 (50 µg/L), which was a decrease from the previous year. Total organic halide values in the other network wells remained on trend.

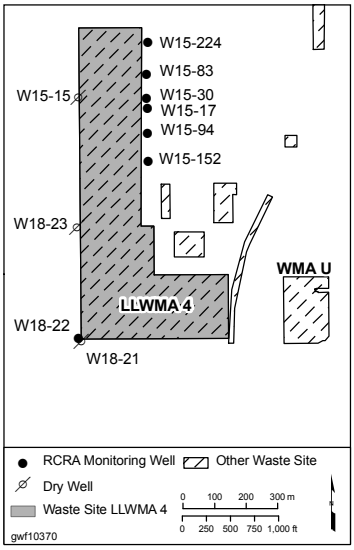
Carbon tetrachloride and associated trichloroethylene and chloroform concentrations in LLWMA-3 wells are consistent with those observed in regional plumes. Only carbon tetrachloride was detected at levels above the DWS. The highest annual average concentration was 85.0 µg/L in well 299-W10-31. Carbon tetrachloride concentrations in well 299-W10-31 have shown a decreasing trend since the well was constructed in FY 2006.

The nitrate distribution at LLWMA-3 is consistent with regional plumes (Section 12.2.3). The maximum annual average concentration during the reporting period (55.0 mg/L) was in well 299-W10-31. This value was an increase from 41.5 mg/L at the end of 2009, a continuation of the increasing trend for this well.

12.4.2 Low-Level Waste Management Area 4

D.A. Gamon

The LLWMA-4 is located in the 200 West Area, just west of the PFP and the U Tank Farm. The LLWMA-4 consists of the 218-W-4B and 218-W-4C Burial Grounds, which contain 28 unlined trenches. The 218-W-4B Burial Ground also contains twelve below-grade caissons at the southern end of the facility. The LLWMA-4 was used for disposal of low-level radioactive wastes and low-level mixed wastes beginning in 1967. The caissons in the 218-W-4B Burial Ground contain remote-handled, low-level waste, and retrievable transuranic waste. 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.



In accordance with 40 CFR 265.93(b) (as referenced by WAC 173-303-400), the well network was sampled semiannually for contamination indicator parameters and supporting constituents (PNNL-14859; DOE/RL-2009-69, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*). DOE/RL-2009-69 replaced PNNL-14859 midway through CY 2010 as the current and updated interim status groundwater monitoring plan. All of the wells were successfully sampled during the reporting period.

Appendix B, Table B-24 includes a list of wells, constituents monitored and the indicator parameter comparison values for CY 2011 are provided in Table B-25. The

following subsections provide annual evaluation requirements for the monitoring network, groundwater results, and compliance status.

12.4.2.1 Hydrogeology

The LLWMA-4 is underlain from the ground surface to the top of the basalt by the Hanford formation, the CCU, and the Ringold Formation. The vadose zone beneath LLWMA-4 is ~68 to 76 meters thick and consists of the Hanford formation, the CCU, the member of Taylor Flat of the Ringold Formation (lower unit 4), and the upper portion of unit 5 of the member of Wooded Island of the Ringold Formation. The water table is at ~136 to 137 meters in elevation and is entirely within Ringold unit 5. The Ringold lower mud unit is present everywhere beneath the LLWMA-4 and forms the bottom of the unconfined aquifer. The saturated thickness of the unconfined aquifer is ~69 meters in the south (at well 299-W18-22) and ~59 meters in the north (at well 299-W15-17). The thickness of the aquifer, as well as the groundwater flow direction and flow rate, are influenced by the 200-ZP-1 OU pump-and-treat system injection wells to the west of the LLWMA and the extraction wells located northeast of the LLWMA.

The water table continued to decline beneath the LLWMA-4 during the reporting period at ~0.3 meters per year in response to the greatly reduced discharge of wastewater to surface facilities around the 200 West Area. Previously, water levels in upgradient wells declined slower than levels in downgradient wells due to the effects of the upgradient 200-ZP-1 pump-and-treat system injection wells. The groundwater flow direction in this portion of 200 West Area is generally east but can be locally variable due to the effects of the 200-ZP-1 pump-and-treat system (Figure 12-1).

The hydraulic conductivity in the unconfined aquifer beneath LLWMA-4 is on the order of 2.5 to 10 meters per day and the hydraulic gradient is ~0.004. Using these values and assuming an average effective porosity of aquifer materials between 0.1 and 0.3, the groundwater flow rate is calculated at 0.1 to 0.4 meters per day (see Appendix B, Table B-1). A current groundwater map that includes LLWMA-4 is shown in Figure 12-2.

12.4.2.2 Network Evaluation

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

The monitoring network at LLWMA-4 currently does not include any upgradient wells but does include six downgradient wells. Upgradient wells 299-W15-15 and 299-W18-23 went dry in 2008, and upgradient well 299-W18-21 went dry in early 2010. 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 has caused groundwater to flow toward the southeast at the location of this well, which is no longer upgradient of the facility in relation to the existing downgradient wells located northeast of this well. No new wells are expected at LLWMA-4 until the effects of the enhanced 200-ZP-1 OU pump-and-treat system are known.

All other wells in the network, except for downgradient deep screened monitoring well 299-W15-17, are screened across or at the top of the water table. These water table wells all have adequate water columns in the screened interval (from 4 to 8 meters) available for sampling. The LLWMA-4 is sampled semiannually and analyzed for indicator parameters and supporting constituents. Anions, metals, and phenols are sampled for and analyzed annually. Site-wide water-level measurements

are collected annually, usually during the month of March. Water-level measurements are also taken at network monitoring wells during groundwater sample collection.

Appendix B, Figure B-13 provides the location of wells in the LLWMA-4 monitoring network. All wells were sampled as scheduled during the reporting period, except for well 299-W18-21, which went dry in early 2010.

12.4.2.3 Compliance Status

Interim status indicator parameter evaluation groundwater monitoring at LLWMA-4 will continue in CY 2011. Statistical evaluations will proceed for this reporting period using critical means calculated from the most recent data from well 299-W18-21 encompassing several previous years. Construction of an upgradient well is not expected until the effects of the enhanced 200-ZP-1 OU pump-and-treat system are known.

12.4.2.4 Groundwater Contaminants

Groundwater at LLWMA-4 is monitored under RCRA and AEA requirements. This section addresses only RCRA requirements in accordance with 40 CFR 265.93(b), as referenced by WAC 173-303-400. The well network was sampled semiannually for indicator and site-specific parameters (PNNL-14859; DOE/RL-2009-69). The indicator parameters are pH, specific conductance, total organic carbon, and total organic halides, which were sampled semiannually at each network well during the reporting period.

The wells were below the critical mean for pH during the reporting period, with well 299-W15-30 having the highest average value during the reporting period at 8.6. Specific conductance ranged from 366 to 559 µS/cm, and all wells were under the critical mean.

As in previous years, downgradient wells continued to exceed the statistical comparison value (critical mean) for total organic halides in most samples during the reporting period. The U.S. Department of Energy (DOE) previously reported the exceedance of the critical mean in well 299-W15-16 (now dry) to the U.S. Environmental Protection Agency and the Washington State Department of Ecology in August 1999. Well 299-W15-30 replaced 299-W15-16, and exceedance of the critical mean for total organic halides continued. These exceedances have also been iterated in previous annual groundwater reports. The elevated total organic halide concentrations are consistent with observed levels of carbon tetrachloride in the aquifer (Section 12.2.1).

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 during CY 2010. However in July 2010, the average total organic carbon concentration in this well increased moderately to 887 µg/L, indicating that the unknown local organic source of carbon is still present. A current hypothesis for the source of organic carbon is that some type of microbial processes may be occurring in the monitoring wells not coming from other sources to include the monitored facility. This hypothesis will be further investigated in CY 2011.

Nitrate continued to exceed the DWS at all monitoring wells except deep downgradient well 299-W15-17 (24.5 mg/L) and deep upgradient well 299-W18-22 (18.7 mg/L). During CY 2010, concentrations ranged from 18.7 to 120 mg/L, with the maximum concentration in downgradient well 299-W15-152. Nitrate

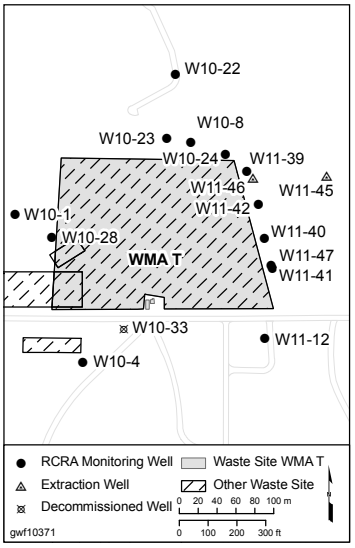
contamination is likely unrelated to waste disposal at the burial grounds. Some of the nitrate contamination is related to injection of treated water upgradient of the burial ground. The treatment system does not remove nitrate from the water, causing treated water with relatively high nitrate concentrations to mix with upgradient groundwater that is normally lower in nitrate. The nitrate plume observed at the LLWMA-4 monitoring wells reflects a cyclical process where nitrate is captured at the downgradient extraction wells and reinjected at the injection wells. The final remedy pump-and-treat facility scheduled to come online at the end of 2011 will remove nitrate from the waste stream.

Carbon tetrachloride concentrations display downward or stable trends in all wells in the network when compared with the historical data available. During the reporting period, carbon tetrachloride concentrations continued to decline in network wells. Well 299-W15-94 declined from 170 µg/L in FY 2009 to 75 µg/L in CY 2010. The maximum concentration of 100 µg/L was in downgradient well 299-W15-30. Known sources of carbon tetrachloride include the 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib (DOE/RL-2006-20). Chloroform and trichloroethylene concentrations remained below the DWS in all LLWMA-4 wells. None of the wells had trichloroethylene concentrations above detection limits.

12.4.3 Waste Management Area T

D.A. Gamon

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. The WMA is regulated under RCRA and its implementing requirements in WAC 173-303-400.



The WMA T was placed in assessment monitoring in 1993 because of elevated specific conductance (a RCRA indicator parameter) in one downgradient well. Assessment monitoring has continued at WMA T since that time and is currently controlled by *RCRA Assessment Plan for Single-Shell Tank Waste Management Area T* (PNNL-15301). Currently, WMA T is in assessment monitoring due to concentrations of the dangerous constituent chromium exceeding the DWS in downgradient wells. The objectives for the continued assessment of groundwater quality at WMA T, as required by 40 CFR 265.93(d)(7)(i), are to determine the concentration and the rate and extent of migration of the hazardous waste or hazardous waste constituents in the groundwater. Appendix B, Table B-36 includes a list of wells and constituents monitored, and Table B-37 shows the indicator parameter comparison values for CY 2011. The following subsections provide annual evaluation requirements for the monitoring network, groundwater results, and compliance status. In 2008, an interim corrective measure, consisting of a surface barrier over a portion of the farm, was designed and constructed to reduce infiltration and subsequently migration of contaminants beneath the tank farm.

12.4.3.1 Hydrogeology

The vadose zone beneath WMA T is between ~70 and 76 meters thick and from ground surface to top of the underlying basalt consists of the Hanford formation, the CCU, the member of Taylor Flat of the Ringold Formation (the lower portion of unit 4), and the upper portion of unit 5 (the member of Wooded Island of the Ringold Formation). The water table is ~134.5 meters in elevation (March 2010). The unconfined aquifer beneath WMA T is estimated to be ~48 to 51 meters thick based on water levels and the depth of the Ringold lower mud unit, which serves as a

confining or semiconfining layer separating the unconfined aquifer from a confined, or partly confined, aquifer in the underlying Ringold unit 9.

Water levels in the unconfined aquifer increased as much as 13.5 meters (above the pre-Hanford natural water table) beneath WMA T due to artificial recharge from liquid waste disposal operations between the mid-1940s and 1995. During that time, the groundwater flow direction changed from eastward (the pre-Hanford direction) to southward, then northward, and finally back toward the east as a result of changes in waste management practices. More recently, two monitoring wells east of WMA T were converted to extraction wells to remove technetium-99 in the 200-ZP-1 OU, which will tend to enhance the eastward flow of groundwater. The shifts in groundwater flow direction have implications for contaminant distribution in the uppermost aquifer beneath WMA T as contaminant plumes react and adjust to the new hydraulic regime created by the local extraction wells

The water table continued to decline beneath WMA T monitoring wells during the reporting period at ~0.3 meter per year in response to the greatly reduced discharge of wastewater to surface facilities around the 200 West Area. The hydraulic conductivity in the unconfined aquifer beneath WMA T is on the order of 6.1 to 9.7 meters per day and the hydraulic gradient is ~0.002. Using these values and assuming an average effective porosity of aquifer materials of 0.1, the groundwater flow rate is calculated at 0.12 to 0.19 meters per day (see Appendix B, Table B-1). A time series depicting the water-level decline at select 200-ZP-1 groundwater wells is provided in Figure 12-3. An interim corrective measure, consisting of a surface barrier over a portion of the tank farm is designed to reduce infiltration and subsequently migration of contaminants beneath the tank farm.

The primary dangerous waste constituents found beneath WMA T in 2010 are chromium, carbon tetrachloride, and trichloroethylene. The source for the carbon tetrachloride and trichloroethylene was liquid disposal associated with processes at the PFP and not WMA T.

12.4.3.2 Network Evaluation

The network currently consists of two upgradient, two assessment, one far-field, and nine downgradient monitoring wells. The two assessment wells are not directly upgradient or downgradient and are used to help distinguish other contaminant plumes impinging on WMA T. Some of the wells in the monitoring network are also sampled for the 200-ZP-1 OU performance monitoring program. Sampling for WMA T and 200-ZP-1 OU is coordinated to eliminate duplicate well trips and analytes. Appendix B, Table B-34 lists the constituents at each well in the network to be analyzed for RCRA monitoring. The wells are sampled quarterly, semiannually, or annually each year. Appendix B, Table B-34 also indicates the purpose of each well and identifies whether the wells meet WAC requirements.

Water-level measurements are collected before each sampling event. A more comprehensive set of water-level measurements is made annually in the northern 200 West Area. Wells in the WMA T monitoring network are not expected to go dry for several years, as water columns in the screened intervals range from 1.5 to 17 meters. The well with only 1.5 meters of water column (299-W11-12) may be the exception, because it is an older well that was filling in with sediments and casing debris caused by the construction technique and well casing corrosion. The well recently underwent maintenance to clean out sediment and debris from the bottom of the well and scrub the perforated interval to allow better flow into the well. The well will be sampled via the bailer method for as long as possible.

The direction of groundwater flow is not expected to change greatly in the near future (CY 2011). However, with expansion of the 200-ZP-1 pump-and-treat system in the 200 West Area, groundwater flow direction and velocity at WMA T will be impacted. However, the magnitude and direction of these changes will not be known

until after the expanded system becomes operational and a 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 generally east but can be locally variable due to the effects of the active pump-and-treat systems.

Appendix B, Figure B-17 shows the location of wells in the WMA monitoring network. Some wells were not sampled as scheduled during the reporting period, including the following:

- Quarterly scheduled monitoring of well 299-W10-4 was not performed in April 2010 due to pump performance issues that required repairs to the well.
- Quarterly scheduled monitoring of well 299-W10-8 was not performed in October 2010 due to the site-wide sampling work stoppage (September 27 to November 8, 2010).
- Semiannually scheduled wells 299-W10-22 and 299-W11-7 were removed from the new groundwater assessment plan beginning CY 2010. Well 299-W10-22 is no longer downgradient of the WMA, and well 299-W11-7 is a far-field downgradient well not in the direct path of existing plumes. The new groundwater assessment plan (DOE/RL-2009-66, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T)* will be implemented beginning in CY 2011.
- Quarterly scheduled monitoring well 299-W11-12 was not sampled during the January 2010 event due to falling water levels, which required the pump to be removed and debris in the well screen to be cleaned out. The well was not sampled for the October scheduled quarterly event due to the site-wide sampling work stoppage that occurred. Since that time, the well is being sampled using the bailer method.
- Extraction well/monitoring well 299-W11-45 was not sampled during the July scheduled quarterly event due to mechanical issues that required maintenance. The well was not sampled as scheduled during the October scheduled quarterly event due to the site-wide sampling work stoppage.

12.4.3.3 Compliance Status

Assessment status groundwater monitoring at WMA T will continue in CY 2011. A new assessment monitoring plan for WMA T was issued in February 2011 (DOE/RL-2009-66).

12.4.3.4 Groundwater Contaminants

An indicator evaluation groundwater monitoring program began at WMA T in 1989 (WHC-SD-EN-AP-012, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*). As stated in Section 12.4.3, the WMA was placed in assessment monitoring in 1993 when specific conductance values in downgradient well 299-W10-15 exceeded the upgradient critical mean value (WHC-SD-EN-AP-132). Elevated specific conductance in the well, principally resulting from elevated sodium and nitrate from an upgradient source, dropped below the critical mean in 1994. However, before the WMA could be returned to an indicator evaluation monitoring program, specific conductance in well 299-W11-27 (decommissioned) began to rapidly increase in late 1995 and exceeded the critical mean in early 1996. In well 299-W11-27, the increased specific conductance was accompanied by elevated nitrate, calcium, magnesium, sulfate, chromium, and total organic carbon.

The primary dangerous waste constituents found beneath WMA T during the reporting period were chromium, carbon tetrachloride, and trichloroethylene. The source for the carbon tetrachloride and trichloroethylene contamination was liquid waste disposal associated with processes at the PFP and not releases from WMA T (Sections 12.2.1 and 12.2.2); these constituents are monitored as part of the 200-ZP-1 OU. Nitrate and fluoride are also found in the groundwater beneath the WMA. Chromium is a dangerous constituent monitored under the RCRA assessment program.

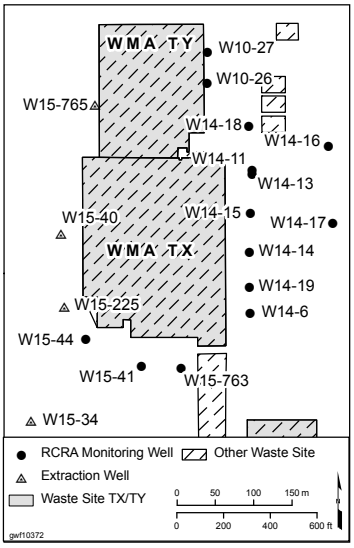
The highest chromium concentration in the upper portion of the aquifer during the reporting period was in assessment well 299-W10-4 (576 µg/L), located at the southwestern corner of the WMA. The highest chromium concentration found in wells screened deeper within the aquifer in WMA T was 168 µg/L in downgradient well 299-W11-47 (screened between 7.5 and 17 meters below the water table). The highest chromium concentration in downgradient extraction well 299-W11-46 (screened between 6 and 12 meters below the water table) was 124 µg/L. The highest chromium concentration in adjacent downgradient well 299-W11-39 (screened at the water table) was 56 µg/L.

Downgradient extraction well 299-W11-45 is ~80 meters downgradient of well 299-W11-46 and is screened between 8.5 and 13 meters below the water table. The highest chromium concentration for this well during the reporting period was 146 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 DWS of 100 µg/L.

A local nitrate plume is located within the regional nitrate plume beneath WMA T (Figure 12-10). The plume retained the same general configuration as in CY 2009. During the reporting period, the highest average nitrate concentrations were in upgradient wells 299-W10-28 (1,458 mg/L) and 299-W10-4 (2,617 mg/L). The nitrate concentrations above the DWS in downgradient wells were between 82 and 695 mg/L. More than one source, including the WMA T, likely contributed to the nitrate plume beneath the WMA, but the higher upgradient concentrations indicate greater contributions from other sources.

12.4.4 Waste Management Area TX-TY

D.A. Gamon



The 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.

The WMA was placed in assessment monitoring in 1993 because specific conductance values in downgradient wells 299-W10-17 and 299-W14-12 exceeded the upgradient background (critical mean) value (WHC-SD-EN-AP-132). The first assessment report (PNNL-11809, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas T and TX-TY at the Hanford Site*) concluded the following: (1) elevated contamination in well 299-W14-12 was consistent with a source within the WMA, and (2) an upgradient source (the 216-T-25 Trench) was possible. Subsequent drilling and sampling of well 299-W15-40, located between the 216-T-25 Trench and the WMA, eliminated the 216-T-25 Trench as a possible source of high-level contamination upgradient

of the WMA. The second assessment report (PNNL-14004, *RCRA Groundwater Quality Assessment Report for Single-Shell Tank Waste Management Area TX-TY [January 1998 through December 2001]*) was not able to eliminate the WMA TX-TY as a source for the downgradient contamination. Continuation of the groundwater assessment was required, and PNNL-14004 describes the activities for continued assessment. The dangerous constituent monitored in this assessment program is chromium.

The objectives for the continued assessment of groundwater quality at WMA TX-TY, as required by 40 CFR 265.93(d)(7)(i), are to determine the rate and extent of migration of the dangerous waste or dangerous waste constituents in the groundwater and the concentrations of the hazardous waste or hazardous waste constituents in the groundwater. Appendix B, Table B-37 provides a list of wells, constituents monitored, and the indicator parameter comparison values for 2011 are presented in Table B-38. The following subsections provide annual evaluation requirements for the monitoring network, groundwater results, and compliance status.

12.4.4.1 Hydrogeology

The vadose zone beneath WMA TX-TY is between ~66 and 70 meters thick. The sediments from ground surface to top of the underlying basalt, in descending sequence, consist of the Hanford formation, the CCU, the member of Taylor Flat of the Ringold Formation (lower portion of unit 4), and the upper portion of unit 5 (the member of Wooded Island of the Ringold Formation). The water table is between ~134 and 134.5 meters in elevation based on CY 2010 water table elevations. The unconfined aquifer beneath WMA TX-TY is estimated to be between 48.5 and 56.5 meters thick, estimated from water levels and the depth of the Ringold lower mud unit, which serves as a confining or semiconfining layer separating the unconfined aquifer from a confined (or partly confined) aquifer in the underlying Ringold unit 9.

Water levels in the unconfined aquifer increased as much as 14 meters above the pre-Hanford natural water table beneath WMA TX-TY due to artificial recharge from liquid waste disposal operations active between the mid-1940s and 1995. During that time, the groundwater flow direction changed from eastward (the pre-Hanford direction) to southward, then northward, and finally back toward the east as a result of changes in waste management practices. Local groundwater levels continue to decline at a rate of ~0.4 meter per year due to cessation of artificial recharge from liquid waste disposal operations in the area.

More recently, extraction wells for the 200-ZP-1 OU pump-and-treat system have altered the flow direction and local hydraulic gradients. In 2005, upgradient wells were converted to extraction wells, shifting the flow southward in the southern portion of the WMA and likely shifting flow toward the northwest in the northern portion of the WMA. Possible stagnation points exist in the middle portion of the WMA east of the extraction wells, and some flow is currently eastward in the middle of the WMA. Therefore, it must be assumed the water table gradient is variable beneath WMA TX-TY due to influences from pump-and-treat system extraction wells. The shifts in groundwater flow direction have implications for contaminant distribution in the uppermost aquifer beneath WMA TX-TY.

12.4.4.2 Network Evaluation

The network currently consists of two upgradient, two mid-field, and eleven downgradient monitoring wells. Some of the wells in the monitoring network are also sampled for the 200-ZP-1 OU under CERCLA. Sampling for WMA TX-TY and the 200-ZP-1 OU is coordinated to eliminate duplicate well trips and analytes.

Given the current rate of water table decline (0.3 to 0.4 meter per year), well 299-W14-6 was expected to be dry in 2010 and in fact became "sample dry" in late CY 2010 (fourth quarter). Sample dry is when some groundwater remains in contact with the screened interval but a sample pump or bailer is unable to adequately remove water from the bottom of the well to ground surface for collection. Well 299-W15-41 has ~1.5 meters of water column available in the screened interval and should not go dry for several years. The remainder of the WMA TX-TY network wells have adequate water columns ranging from 6 to 14 meters.

The 200-ZP-1 OU pump-and-treat system is in the process of adding 36 extraction and injection wells. Once operational, this system is expected to further 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 expanded system becomes operational in 2012 and performance monitoring and assessment of the system is completed as defined in DOE/RL-2009-115.

Appendix B, Figure B-17 shows the location of wells in the WMA monitoring network. Some wells were not sampled as scheduled during the reporting period as follows:

- Quarterly scheduled monitoring well 299-W14-13 was not sampled during the April 2010 and the July 2010 due to pump performance issues requiring repairs by well maintenance staff. The well was not repaired before the October scheduled quarterly event due to the site-wide sampling work stoppage that occurred from September 27 through November 8, 2010.
- Quarterly scheduled monitoring well 299-W14-17 was not sampled during the April 2010 event due to pump performance issues that required repairs. The well was not sampled as scheduled during the October quarterly event due to the site-wide sampling work stoppage.
- Quarterly scheduled monitoring well 299-W14-18 was not sampled during the April event due to pump performance issues that required repairs.
- Quarterly scheduled monitoring well 299-W14-19 was not sampled during the April event due to pump performance issues that required repairs.
- Quarterly scheduled monitoring well/remedial extraction well 299-W15-44 was not sampled during the January and April 2010 events. The well was taken out of service as an extraction well (replaced by new extraction well 299-W15-225) and converted into a monitoring well.
- Quarterly scheduled monitoring well/remedial extraction well 299-W15-765 was not sampled during the April 2010 event. The well was nonoperational from March 27 to August 31, 2010. From March to May, aquifer testing occurred in the local area. From June to August, pump performance issues required troubleshooting and repairs to be made. The well was successfully sampled in early September to satisfy the July scheduled event.

12.4.4.3 Compliance Status

Assessment status groundwater monitoring at WMA TX-TY will continue in CY 2011. The new assessment monitoring plan for WMA TX-TY was finalized in January 2011 and will go into effect for CY 2011 (DOE/RL-2009-67, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*).

12.4.4.4 Groundwater Contaminants

As stated in Section 12.4.4, the WMA was placed in assessment monitoring in 1993 because specific conductance values in downgradient wells 299-W10-17 and 299-W14-12 exceeded the upgradient critical mean value. For well 299-W14-12, the increased specific conductance was accompanied by elevated concentrations of calcium, magnesium, chromium, nitrate, and sulfate.

The dangerous waste constituent found in groundwater beneath WMA TX-TY during the reporting period is chromium. Other dangerous constituents found at the WMA during the reporting period included carbon tetrachloride and trichloroethylene, which are attributed to other waste sites (Sections 12.2.1 and 12.2.2). Nitrate and fluoride are also found in the groundwater beneath the WMA. Chromium is the dangerous constituent monitored under the RCRA assessment program.

Special sampling of well 299-W15-3 was performed in May 2009 at the request of the project scientist. This well was not sampled in CY 2010 but is included as pertinent information to assist in defining current groundwater contamination conditions at WMA TX-TY. The well is located in the TY Tank Farm, adjacent to tank TY-106 and ~32 meters due east of extraction well 299-W15-765. The well was drilled in 1952, is constructed of carbon steel, and is perforated from 61 to 72 meters below ground surface. Well 299-W15-3 was last sampled in 1991, with the results indicating that groundwater from the well has extremely high concentrations of most major and minor cations and anions, as well as some contaminants.

Of particular note from the CY 2009 sampling event was the technetium-99 concentration, which was 40,000 pCi/L and the highest technetium-99 concentration that has been found at WMA TX-TY. The nitrate concentration was also extremely high at 3,410 mg/L, which is just slightly less than the highest concentration found at well 299-W14-11 (3,600 mg/L) during drilling in CY 2005. The nitrate concentration in 1991 at well 299-W15-3 was only117 mg/L. Also noted were the very low tritium (5,100 pCi/L) and iodine-129 (0.42 pCi/L) concentrations and a relatively low chromium concentration (91.2 µg/L filtered). The tritium concentration has decreased in this well, as the concentration reported in 1991 was 45,000 pCi/L. Iodine-129 and chromium were not sampled historically at this well; therefore, comparison to the current values is not possible.

Tank TY-106 was declared a leaker in 1959 with a revised estimated amount leaked of 68,000 liters of tributyl phosphate process waste. Tank TY-106 is next to tank TY-105, which was declared a leaker in 1960 with a revised estimated leak amount ranging from 114,000 to 163,000 liters (RPP-RPT-42296, *Hanford TY-Farm Leak Assessments Report*) of tributyl phosphate process waste. Either one or both of these tanks could be a partial source of high contaminant concentrations in well 299-W15-3. The effects of the nearby extraction well may be concentrating contaminants as the hydraulic gradient is reversed and water levels decrease under the tanks.

During the reporting period, nitrate concentrations exceeded the DWS (45 mg/L) in all wells in the monitoring network. Figure 12-10 shows a plume map for nitrate in the area. Overall, the nitrate concentrations remain stable in most wells in WMA TX-TY. The highest nitrate concentration at the WMA during the reporting period was 593 mg/L in downgradient well 299-W10-27. The dissolved oxygen concentrations in this well have been decreasing since January 2010 (6.1 mg/L), down to 2.6 mg/L by August. This decreasing trend is being analyzed for evidence of possible changes in local contaminant plume behavior due to mixing of new contamination with existing groundwater, groundwater chemistry responses to

changes in the pump-and-treat operations schedule, natural attenuation, or other chemical reactions changing local groundwater chemistry.

The nitrate concentration in other downgradient wells was between 54 mg/L (299-W14-14) and 417 mg/L (299-W14-13). Much of the nitrate contamination is attributed to PFP operations, as well as past practice disposal to cribs and trenches in the area. Some nitrate contamination may be from WMA TX-TY, although distinguishing the different sources is difficult. Section 12.2.3 provides information on nitrate in the north-central 200 West Area.

In CY 2010, chromium was detected above the 100 µg/L DWS in some wells monitoring WMA TX-TY. The highest chromium concentration was 732 µg/L in downgradient well 299-W14-13, which was a slight decrease from CY 2009 concentrations (736 µg/L). The chromium concentration has been elevated in this well since it was drilled in 1998 and was elevated in the early 1990s in adjacent (but now dry) well 299-W14-12.

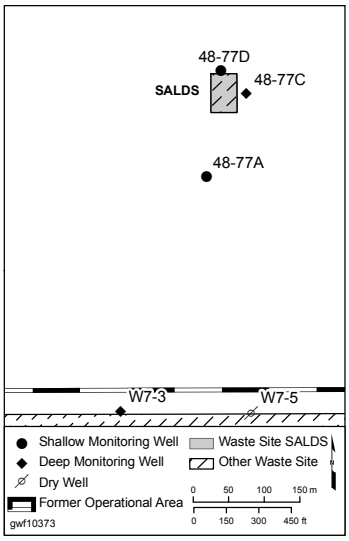
Well 299-W14-11 is located next to well 299-W14-13 but is screened between 11.6 and 14.6 meters below the water table. The highest chromium concentration in well 299-W14-11 was 178 µg/L, indicating that significant chromium contamination may exist deeper in the aquifer than shown by wells screened at the water table, although the highest concentrations appear to be near the water table in this area. The source for the chromium is assumed to be WMA TX-TY by default because no alternative sources have been identified.

Well 299-W14-15 is located south of well 299-W14-13, and its highest chromium concentration during the reporting period was 62.9 µg/L. Historically, chromium concentrations decrease rapidly in monitoring wells south of this well, and this observation continued during CY 2010.

Nitrate, technetium-99, and iodine-129 accompanied chromium, and all four contaminants showed the same trend during the reporting period (Figure 12-24). This may indicate that all four contaminants shared a common source and that part of the plume began passing through these wells between the end of FY 2009 and beginning of CY 2010 (Figure 12-24). Because well 299-W14-13 was offline for maintenance beginning in March, this trend could not be evaluated throughout the reporting period.

12.4.5 State-Approved Land Disposal Site

E.J. Freeman



The ETF processes contaminated aqueous waste from various Hanford Site facilities. The treated wastewater contains tritium that cannot be removed and is discharged to the SALDS. The SALDS operates on a state FY basis (i.e., September 1 to August 30), not on a federal FY basis (i.e., October 1 to September 30, which is observed by DOE). During CY 2010, 71.4 million liters of water were discharged to the SALDS compared to 82.6 million liters in CY 2009. The smaller volume in 2010 is the result of a lower ETF discharge rate when processing K Basin wastewater, which was not processed in CY 2009.

A state waste discharge permit *State Waste Discharge Permit ST 4500* (Ecology, 2000a) requires the monitoring of groundwater at this site. Quarterly monitoring is required for three wells proximal to the SALDS facility. The permit was issued in June 1995, and the site began operation in December 1995. Groundwater monitoring requirements are described in *Groundwater Monitoring and Tritium Tracking Plan for the 200 Area State-Approved Land Disposal Site* (PNNL-13121).

A total of 71.4 million liters of tritiated water was discharge to SALDS during CY 2010 in compliance with State Waste Discharge Permit ST 4500.

For all of the monitoring wells, the hydraulic head has declined an average of 0.38 meters per year. The average rate of decline includes increasing water levels at the three proximal wells adjacent to the SALDS area between March 2008 and March 2009. A less biased rate of decline can be calculated if water-level changes in the proximal wells are excluded. Numerical flow and transport modeling at this site was performed during FY 2009 (SGW-42604, *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State-Approved Land Disposal Site Fiscal Year 2009*). The results of the modeling show that tritium will not reach downgradient wells before 2025; furthermore, tritium will decay before reaching the Columbia River.

12.4.5.1 Hydrogeology

The lithologic sequence beneath the SALDS facility is a major feature that regulates how effluent moves from the facility into the groundwater. The sediments at the surface consist of ~5 meters of highly permeable eolian sand. Beneath this sand is the CCU, which is sandy silty sediment that is also highly cemented. This unit has low permeability and is ~16 meters thick. Next in the sequence is the Ringold Formation, which comprises ~84% of the sediments beneath the SALDS. These sediments are moderately consolidated fluvial sand and gravel deposits through which effluent from the SALDS migrates for ~50 meters before contacting the water table. Beneath the Ringold sediments is the Elephant Mountain Member of the Saddle Mountains Basalt at ~132 meters, which serves as the base of the unconfined aquifer. The basalt and overlying sediments dip at ~3 degrees to the south.

Discharges from the SALDS facility drain through the eolian sands and are diverted to the south along the sloping CCU layer. The first arrival of tritium contamination was observed at well 699-48-77A, which is upgradient from the SALDS relative to the regional groundwater system. About one year after the first arrival of the tritium pulse at this well, the contaminant pulse (depicted as concentration at discrete times in Figure 12-25) moved from south to the northern wells downgradient in the flow system.

12.4.5.2 Network Evaluation

The state waste discharge permit stipulates the requirements for groundwater monitoring and establishes enforcement limits for concentrations of eleven constituents in three additional wells immediately surrounding the facility (Appendix B, Table B-43). Groundwater monitoring for tritium was conducted in twelve additional wells around the facility (Appendix B, Figure B-20).

Wells immediately surrounding the SALDS facility were sampled four times during CY 2010. Tritium-tracking wells were sampled annually or semiannually. Many of the wells in the tritium-tracking network south of the SALDS have gone dry since discharge began in 1995. Water-level measurements in the three wells nearest the facility indicated a small, localized groundwater mound centered on well 699-48-77A. Mounding is the result of treated effluent discharge that originates from the SALDS. This mound results in outward radial flow before the regional northeastward flow becomes dominant. This condition also places several wells south of the SALDS hydraulically downgradient from the facility.

12.4.5.3 Groundwater Contaminants

The primary COC at the SALDS is tritium. Additional parameters sampled include pH, specific conductance, metals, anions, total dissolved solids, and volatile organic analytes. A complete list of the SALDS monitoring wells sampled and

contaminant concentrations is provided in Appendix A of *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2010* (SGW-47923).

The maximum tritium activities decreased by an order of magnitude at well 699-48-77A, from 77,000 pCi/L in 2009 to 7,400 pCi/L at the end of 2010. Tritium concentration increased in well 699-48-77C from 67,000 pCi/L in 2009 to 88,000 pCi/L in 2010 and showed a slight decline at well 699-48-77D from 180,000 pCi/L at the end of 2009 to 150,000 pCi/L at the end of 2010. The decline in tritium concentration at well 699-48-77A and subsequent increases at the other proximal wells (Figure 12-25) signify migration of the plume through subsequent down-gradient wells after high-concentration discharges associated with ETF treatment of K Basins wastewater in FY 2007 moved through the groundwater. Concentrations of all chemical constituents with permit limits were within or below detection limits during the entire reporting period. Acetone, benzene, cadmium, chloroform, and tetrahydrofuran were below method detection limits in all samples. Three target metals were found at or near detection concentrations in well 699-48-77A. Maximum concentrations of lead, copper, and mercury were present at 0.171 µg/L, 4.19 µg/L, and less than detection, respectively. Concentrations of major anions and cations continued to be below the background levels observed prior to facility operation. The low concentrations are due, in part, to mixing with clean water discharged by the SALDS.

The decline in tritium concentration at well 699-48-77A showed a return to normal levels after a high-concentration discharge event associated with activities at the K Basins during FY 2008.

12.4.5.4 Compliance Status

Monitoring activities included those for tritium and additional constituents at twelve wells subject to *State Waste Discharge Permit ST 4500* (Ecology, 2000a). Groundwater contaminant data reported for CY 2010 confirmed that the SALDS was in compliance with the terms described in the state waste discharge permit.

12.5 Conclusions and Recommendations

The conclusions and recommendations for the 200-ZP-1 OU are presented in the following sections.

12.5.1 Conclusions

The 200-ZP-1 OU covers the northern and central region of the 200 West Area and the adjacent 600 Area. The 200-ZP-1 OU is tasked with performance monitoring and remedial actions for past-practice waste streams that have contaminated groundwater. The activities at the 200-ZP-1 OU are subject to regulatory compliance in accordance with RCRA, CERCLA, and the AEA. Activities covered by CERCLA include remediation and performance monitoring of the contaminant plume in groundwater that is subject to remediation. Within the OU, specific facilities that are regulated under RCRA include LLWMA-4, LLWMA-3, WMA T, and WMA TX-TY. The SALDS, which is a liquid waste disposal facility, is monitored in compliance with WAC 173-216, "State Waste Discharge Permit Program."

Pump-and-treat operations for the 200-ZP-1 OU include two remedial systems. One system that addresses volatile organic compound contamination, consists of fourteen extraction wells, a treatment plant, and five injection wells at the west side of LLWMA-4. The primary COCs are carbon tetrachloride, chloroform, and trichloroethylene. The second system that addresses high technetium-99 contamination consists of two extraction wells located at the northeast corner of WMA T that discharge wastewater to the LERF for storage before contaminants are

removed at the ETF. The primary COC from this waste stream is technetium-99. The effluent stream is treated for all known contaminants, except for tritium, which cannot be removed at the ETF. The tritiated waste stream is then discharged at the SALDS facility.

Operations at the 200-ZP-1 pump-and-treat interim action site removed 570.2 million liters of contaminated groundwater. The average pumping rate for the extraction well field during CY 2010 was 1,180 liters per minute. During the reporting period, extraction well 299-W15-44 was removed from the extraction network and was converted to a monitoring well; concurrently, new extraction well 299-W15-225 was connected to the extraction system. The addition of well 299-W15-225 increased pumping capacity by an average of 949 liters per minute and accounted for 52% of the total production. The total carbon tetrachloride mass removed by the pump-and-treat system during CY 2010 was 700.7 kilograms. During CY 2010, the system had a cumulative availability of 87%.

Pump-and-treat operations at the WMA T pump-and-treat system removed 52.2 million liters of contaminated groundwater. The average pumping rate for the two wells that make up this system was 99.3 liters per minute. Contaminant mass removed during CY 2010 included 16.35 grams of technetium-99; 27.86 kilograms of carbon tetrachloride; 22,959 kilograms of nitrate; and 6.25 kilograms of chromium. During CY 2010, the availability for well 299-W11-45 was 70% and well 299-W11-46 was 89%.

The 200-ZP-1 interim pump-and-treat system was designed to remediate contamination in the upper 15 meters of the unconfined aquifer to address the high-concentration area around the PFP. Performance monitoring for wells in this region of the aquifer show that the plume has decreased around the original targeted area. In general, the high-concentrations of the carbon tetrachloride plume also showed a decline in concentration.

Construction of a final remedy pump-and-treat system, which will extract COCs over a broader area and capture deeper contamination, is currently in progress. During CY 2010, four new injection and eleven new extraction wells were installed. Additionally, construction of the new treatment plant is well underway and will continue through the end of 2011, when the treatment facility is scheduled to become operational. The new pump-and-treat facility is expected to increase treatment capacity over the current system by five times.

Performance monitoring at the RCRA facilities indicates that conditions at these facilities remained stable during CY 2010. Both LLWMA-3 and LLWMA-4 remain in indicator evaluation monitoring, and WMA T and WMA TX-TY are in assessment monitoring. Waste streams released at the SALDS facility are in compliance with limits set forth in State Permit ST-4500.

Measurable progress was made during the reporting period to meet specific remedial action objectives specific to the interim ROD (Section 12.3.1). The results for each remedial action objective are discussed below:

- **Remedial action objective #1:** Prevent further movement of contaminants from the highest concentration area of the baseline plume.

  The shallow portion of the aquifer (upper 15 meters) in the area of the baseline carbon tetrachloride plume continues to be captured by the 200-ZP-1 pump-and-treat system. The pump-and-treat configuration was designed specifically to capture the high-concentration portion of the carbon tetrachloride plume in the area of the Z Plant. Five extraction wells are currently operating

within the 2,000 µg/L portion of the plume. Carbon tetrachloride north of the high-concentration area is generally moving to the northeast. The interim remedy does not explicitly address capture of carbon tetrachloride deeper than 15 meters below the water table or at concentrations less than 1,000 µg/L in the upper aquifer. Remediation of the broader plume is addressed by actions required under the final ROD for the 200-ZP-1 OU (EPA et al., 2008). The pump-and-treat system will be installed and operational by 2011 for remediating the broader plume.

- **Remedial action objective #2:** Reduce contamination in the areas of highest concentration of carbon tetrachloride.

  During CY 2010, 700.7 kilograms of carbon tetrachloride were removed from 570.2 million liters of groundwater. Since startup of the pump-and-treat operations, ~12,663 kilograms of carbon tetrachloride have been removed from over 4.9 billion liters of groundwater. The volume of water treated in CY 2010 was ~60% more than FY 2009. Reduction in carbon tetrachloride contamination within the highest concentration portion of the contaminant plume has been demonstrated by the contaminant removal volumes and a decrease in the extent of the high-level targeted area over the last 12 years.

- **Remedial action objective #3:** Provide information that will lead to development of a final remedy that will be protective of human health and the environment.

  The remedial design/remedial action work plan (DOE/RL-2008-78) was issued during CY 2009. The selected remedy for the 200-ZP-1 OU combines pump-and-treat, monitored natural attenuation, flow-path control, and institutional controls. The *Sampling and Analysis Plan for the First Set of Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2008-57) was issued to support this final remedy. Data collected over the previous 12 years of pump-and-treat system operation were used to develop the final ROD (EPA et al., 2008).

12.5.2 Recommendations

The recommendations for the 200-ZP-1 OU are as follows:

- Perform aquifer testing in the new extraction well(s) to be installed to support the 200 West Area pump-and-treat system. Aquifer testing will improve estimates of hydraulic properties, help define optimum well spacing of future extraction wells, and provide better estimates for optimum design and operation of the remediation system.
- Collect additional depth-discrete groundwater samples during installation of new wells to assist in further defining the vertical distribution of contamination, appropriate length of well screens, and proper positioning of the screens within the aquifer.
- Apply modeling tools to assess the effectiveness of the current pump-and-treat well configuration to continue to support plume capture and assess efficiency of sampling frequency for the monitoring well network.
- Evaluate all extraction wells to determine any degradation in well efficiency. If well performance is found to have declined due to scale buildup on the screen and/or in the filter pack, well rehabilitation should be planned.
- Review the current performance monitoring well network to determine if sufficient coverage exists to detect plume extents. Many wells in the monitoring

well network have gone dry due to the regionally declining water table, and additional wells will go dry over the next 10 years. As the number of available wells decreases, the ability to effectively monitor remediation, contaminant concentrations, and changes in the plume configuration will be significantly impaired.

Table 12-1. 200-ZP-1 Operable Unit Pump-and-Treat Performance Summary, CY 2010

Total processed groundwater:	
Total groundwater processed in CY 2010 (L)	570,220,143
Total groundwater processed since startup (March 1994) (billions of L)	5.02
Carbon tetrachloride mass removed:	
Total mass of carbon tetrachloride removed in CY 2010 (kg)	700.7
Total mass of carbon tetrachloride removed since startup (March 1994) (kg)	12,646.8
Summary of FY 2008 operational parameters:	
Removal efficiency % by mass, average for year – [(influent – effluent) ÷ (influent)] x 100	99.9%

Table 12-2. 200-ZP-1 Operable Unit Treatment System Availability, CY 2010

Total possible hours run in a year	8,760
Scheduled outages (e.g., connecting new wells, maintenance, etc.) (hours)	127.8
Unscheduled outages (primarily shutdowns due to leak detection alarm shutdowns) (hours)	991
Total time on-line (hours)	7,641.2
Online availability ({total hours - total outage hours} ÷ total hours) x 100	87.2%
Total availability {total hours - total outage hours} ÷ {total hours – scheduled outage hours} x 100	88.5%

Table 12-3. Waste Management Area T Treatment System Availability, CY 2010

Month	Possible Hours	299-W11-45 Online Hours	299-W11-46 Online Hours	299-W11-45 Downtime Hours	299-W11-46 Downtime Hours	299-W11-45 Monthly Online Operational Percentages	299-W11-46 Monthly Online Operational Percentages
January 2010	744	0	336	744	408	0%	45%
February 2010	672	216	636	456	36	32%	95%
March 2010	744	720	720	24	24	97%	97%
April 2010	720	540	660	180	60	75%	93%
May 2010	744	720	696	24	48	97%	94%
June 2010	720	684	600	36	120	95%	83%
July 2010	744	696	696	48	48	94%	94%
August 2010	744	408	720	336	24	55%	97%
September 2010	720	36	624	684	96	5%	87%
October 2010	744	720	672	24	72	97%	90%
November 2010	720	696	684	24	36	97%	95%
December 2010	744	744	744	0	0	100%	100%
Total	**8,760**	**6,180**	**7,812**	**2,580**	**972**	**70.5%**	**89.2%***

* Average annual percentage.

Table 12-4. Waste Management Area T Pump-and-Treat Performance Summary, CY 2010

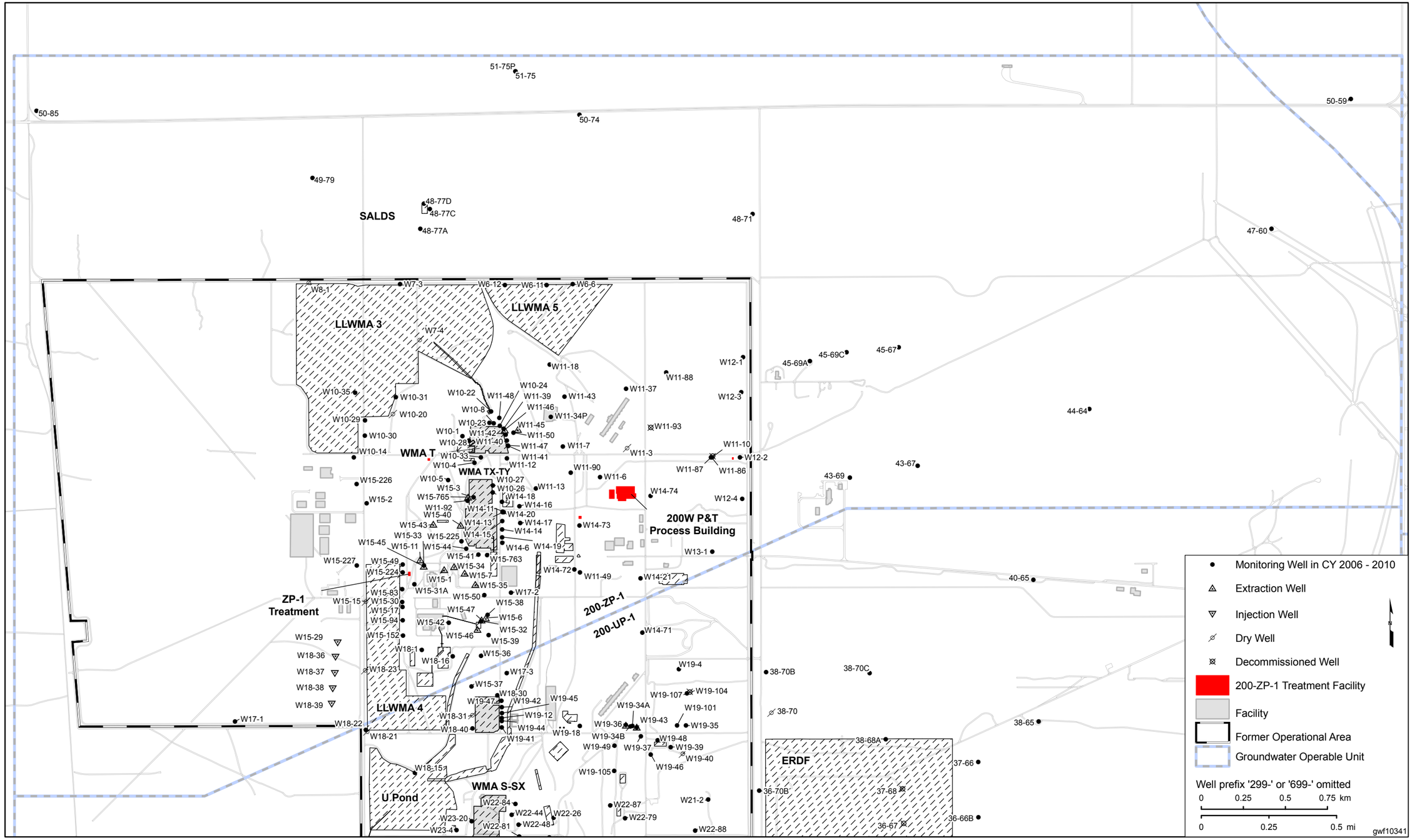
Total processed groundwater:						
Total groundwater processed in CY 2010 (L)					52,176,235	
Total groundwater processed since startup (July 2007) (millions of L)					174,753,016	
Reporting Period	**Extracted Volume (L)**	**Contaminants**				
		Tc-99 (kg)[a]	**Carbon Tetrachloride (kg)[a]**	**Nitrate (kg)[a]**	**Chromium (kg)[a,b]**	**TCE (g)[a]**
CY 2010						
January – March	9,704,187	6.75	9.30	4,496	0.84	37.04
April – June	13,570,205	3.93	5.33	5,858	1.77	121.67
July – September	12,578,147	0.62	7.25	5,613	1.66	17.27
October – December	16,323,926	5.05	5.98	6,992	1.98	69.05
Totals	**52,176,465**	**16.35**	**27.86**	**22,959**	**6.25**	**245.03**

a. Mass removed by the ETF is reported for both of the 200-UP-1 and 200-ZP-1 (241-T) OU pump-and-treat systems. Previously, an estimated mass removed was calculated using the most recent pre-treatment tank concentrations reported, multiplied by the gallons pumped at each well. Since more gallons were pumped than were treated, the percentage per pump-and-treat system was calculated and multiplied by the ETF mass removed to compute mass removed for each system. For CY 2010, it was determined that a more accurate method for determining mass removed was to multiply liters removed by the quarterly average concentration from each extraction well. Exceptions are for carbon tetrachloride, where the ETF values are used instead of calculated values as considerable volatilization takes place prior to treatment. In addition, where quarterly analytical data are not present, annual averages are used as a proxy to calculate masses.

b. Note that all hexavalent chromium is attributed to the 200-ZP-1/241-T extraction system. Chromium is not a target analyte at the 200-UP-1 OU.

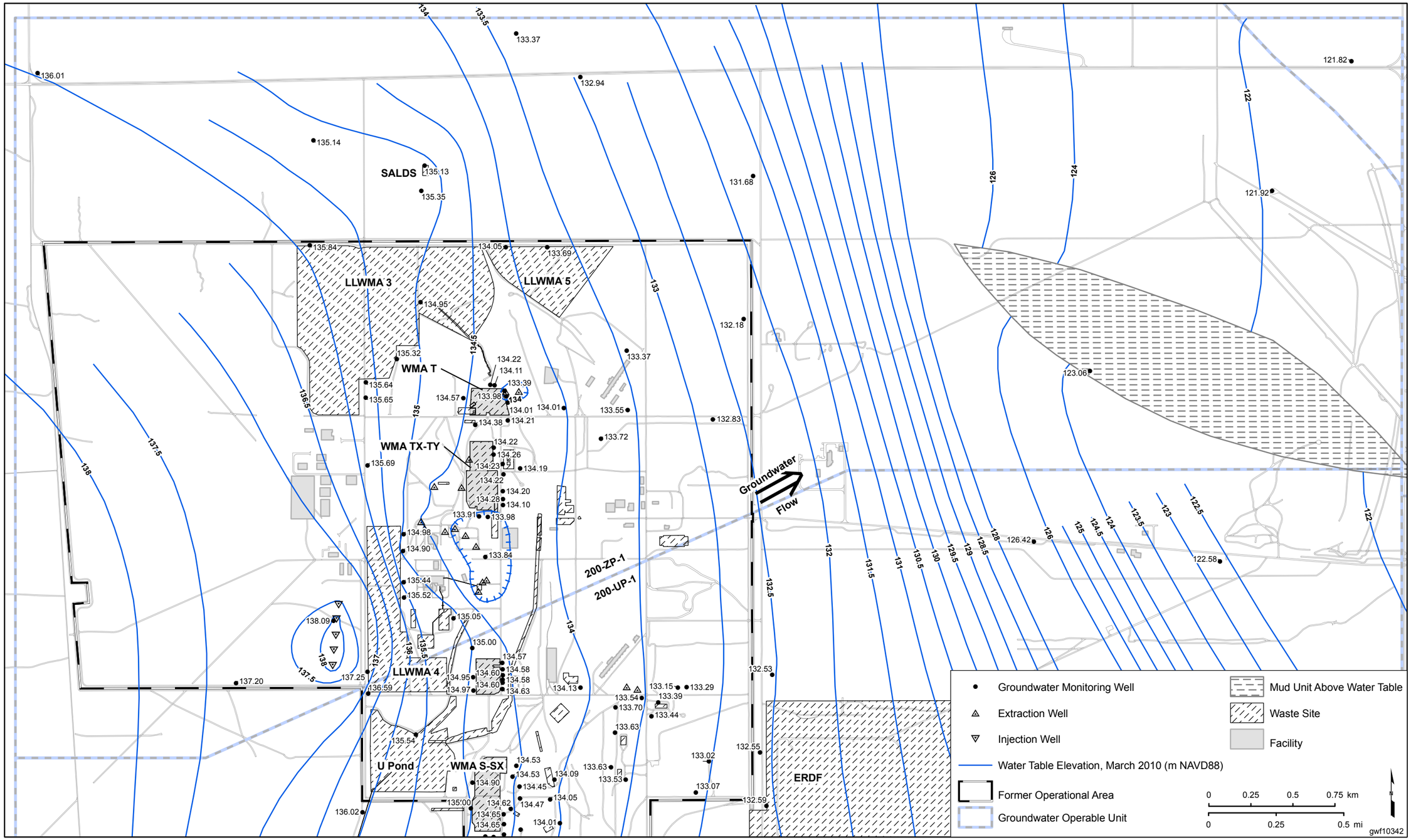
This page intentionally left blank.

Figure 12-1. Facilities and Groundwater Monitoring Wells in the 200-ZP-1 Operable Unit



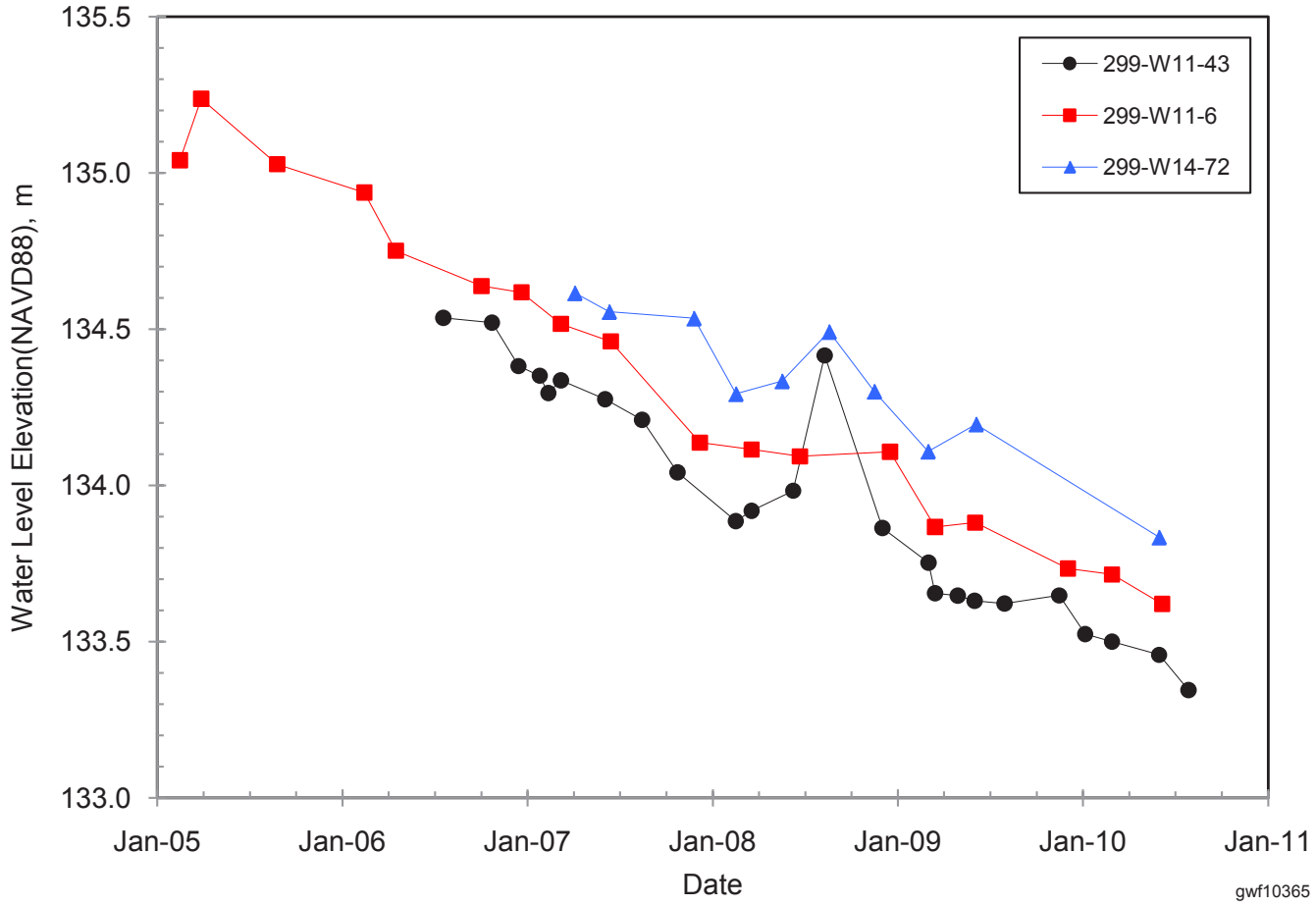
This page intentionally left blank.

Figure 12-2. 200 West Area Water Table Map, CY 2010



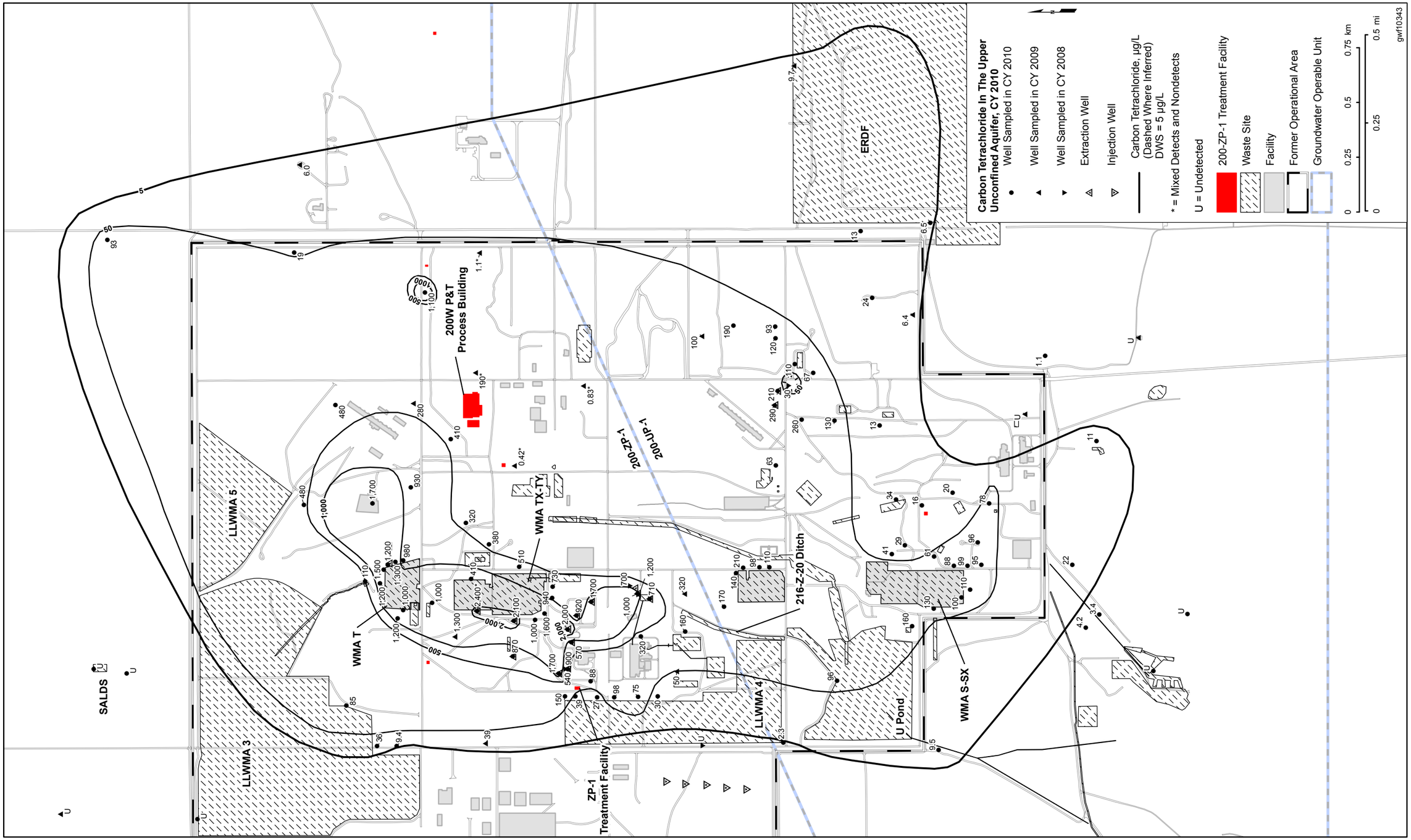
This page intentionally left blank.

Figure 12-3. Hydrograph for Selected Wells in Northern Portion of 200 West Area



This page intentionally left blank.

Figure 12-4. Average Carbon Tetrachloride Concentration in the 200 West Area, Upper Portion of Unconfined Aquifer



This page intentionally left blank.

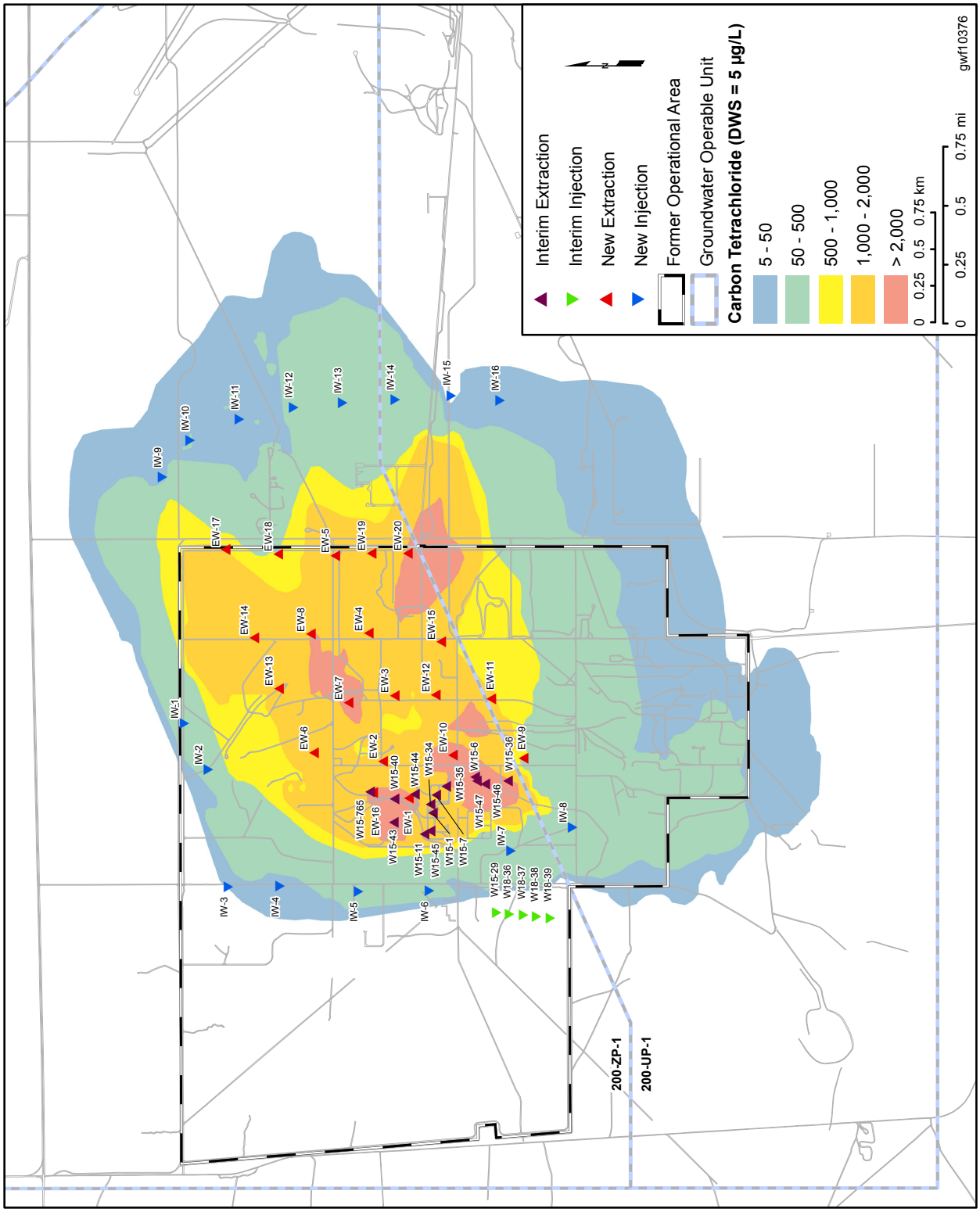
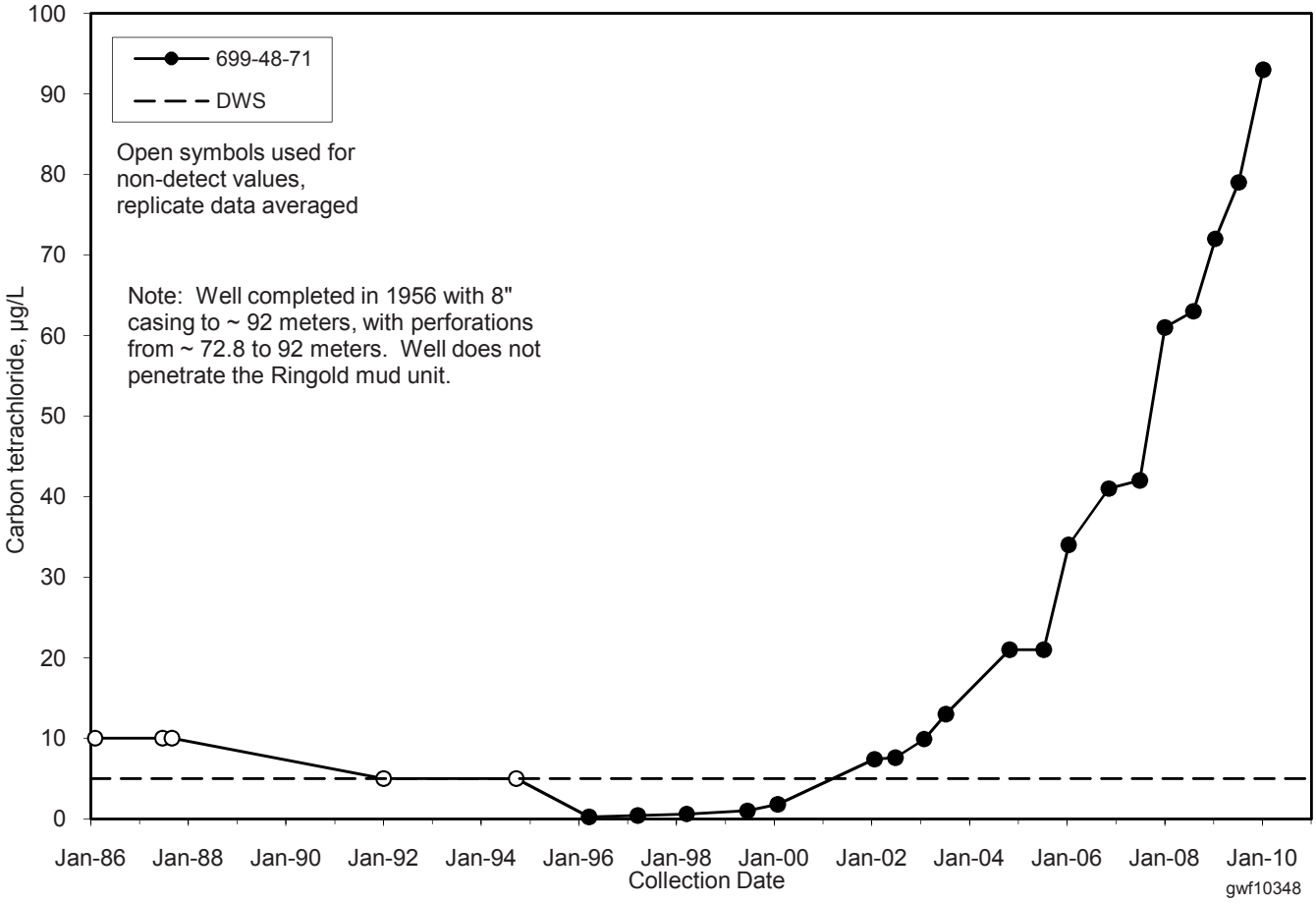


Figure 12-5. Average Carbon Tetrachloride Concentration in 200 West Area Throughout the Unconfined Aquifer and Locations of the Final Remedy Extraction and Injection Wells

Figure 12-6. Carbon Tetrachloride Concentration in Well 699-48-71, Northeast of 200 West Area



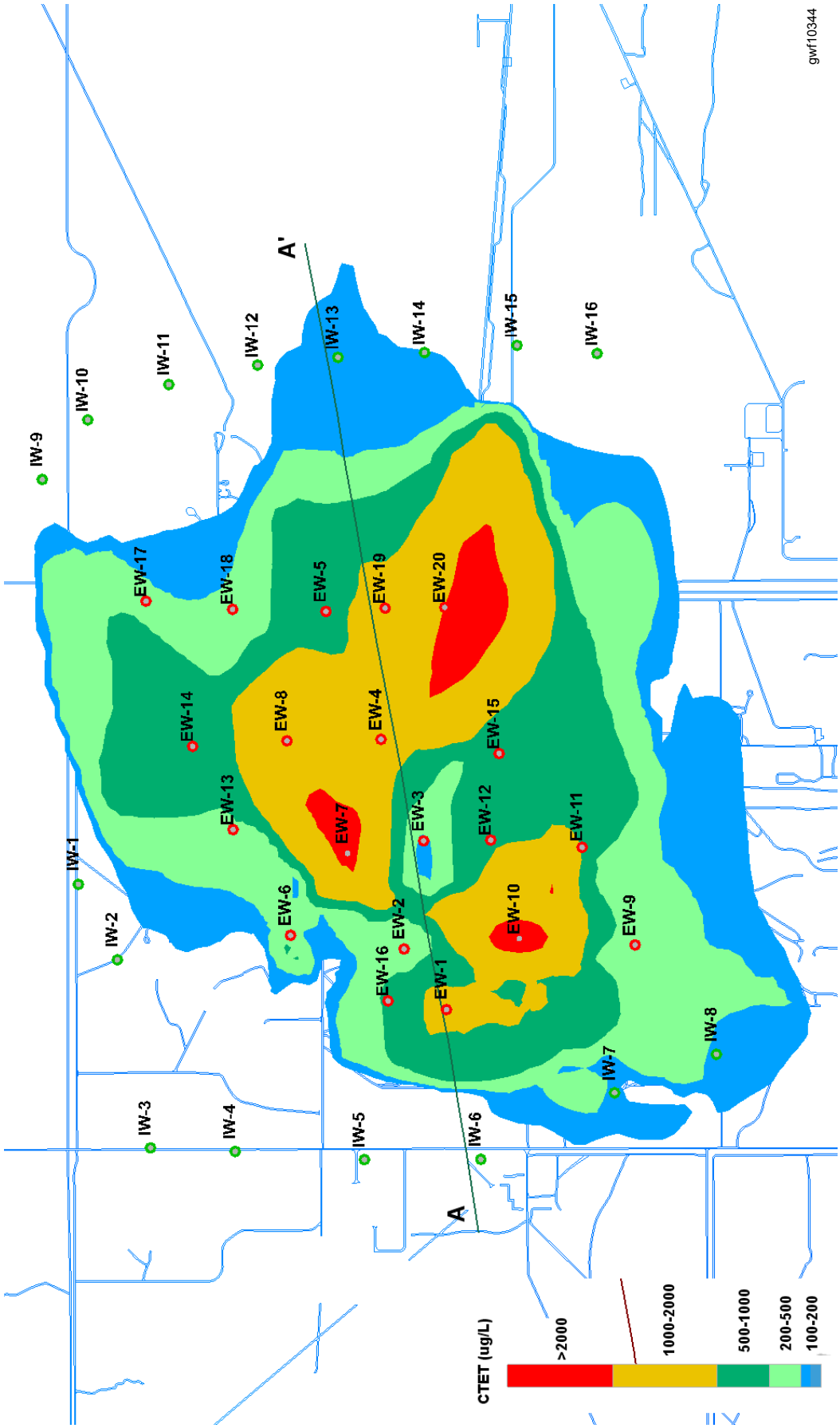


Figure 12-7. 200-ZP-1 Groundwater Operable Unit Carbon Tetrachloride Concentration Plan View at 94 m Elevation Above Mean Sea Level and Cross Section A A'

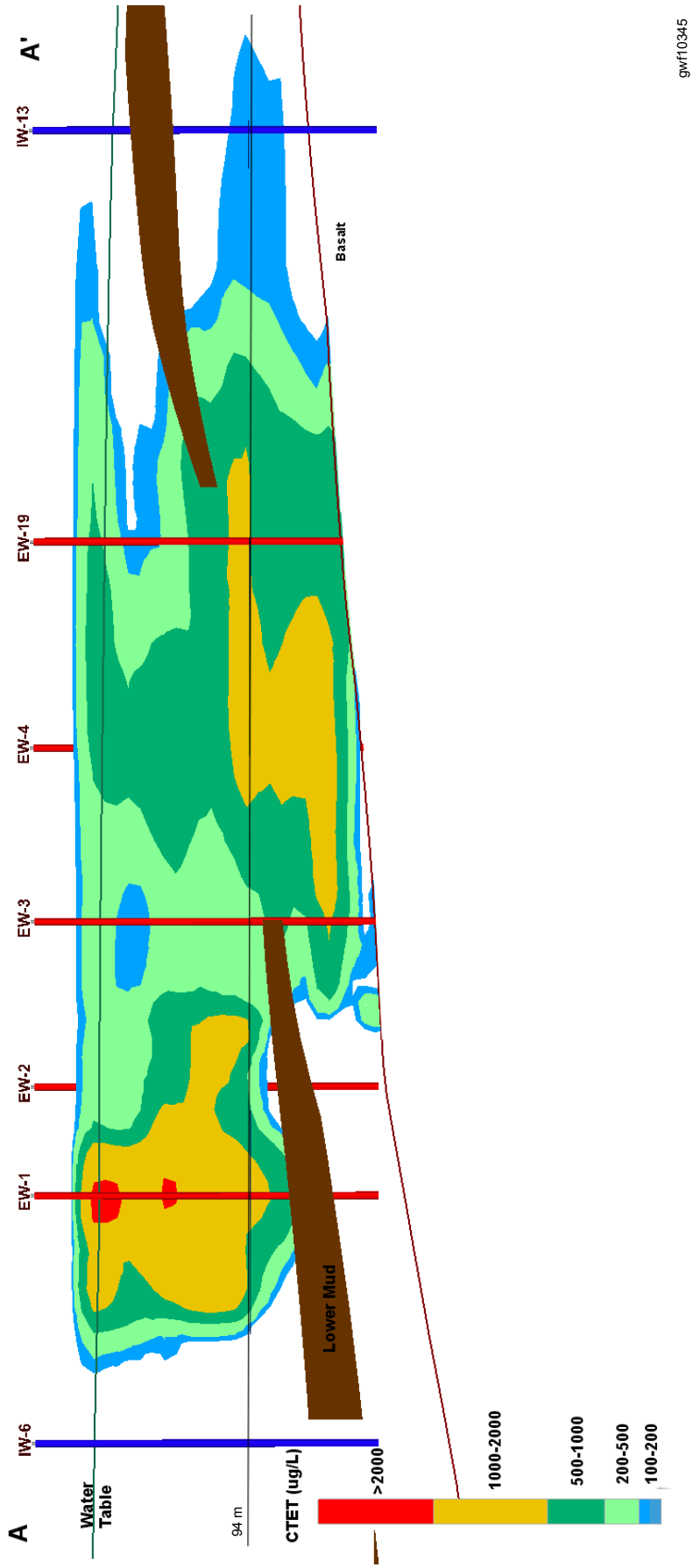


Figure 12-8. 200-ZP-1 Groundwater Operable Unit Carbon Tetrachloride Plume Cross-Section A-A'

Figure 12-9. Average Trichloroethylene Concentration in Central and Northern 200 West Area, Upper Portion of Unconfined Aquifer

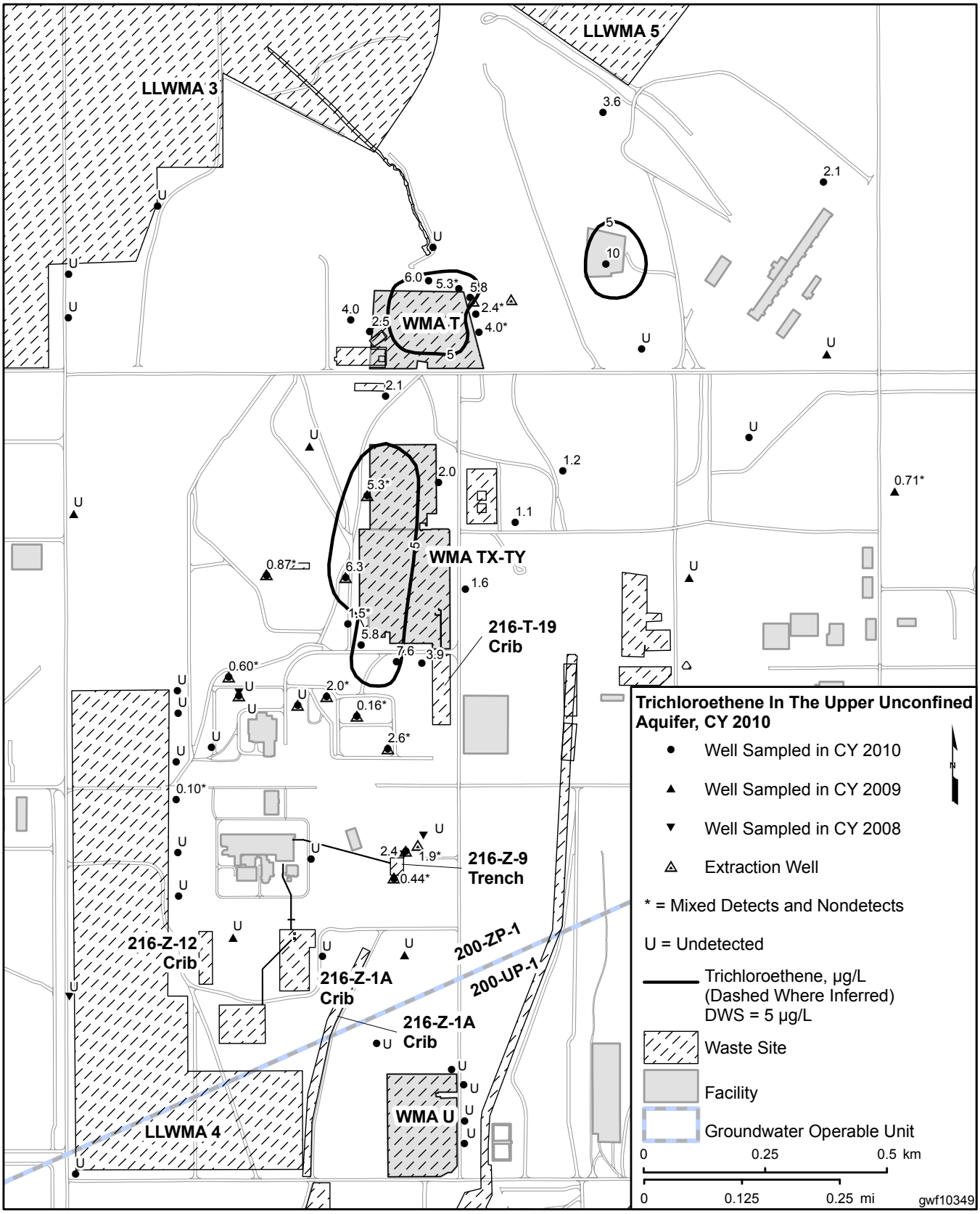


Figure 12-10. Average Nitrate Concentration in Central and Northern 200 West Area, Upper Portion of the Unconfined Aquifer

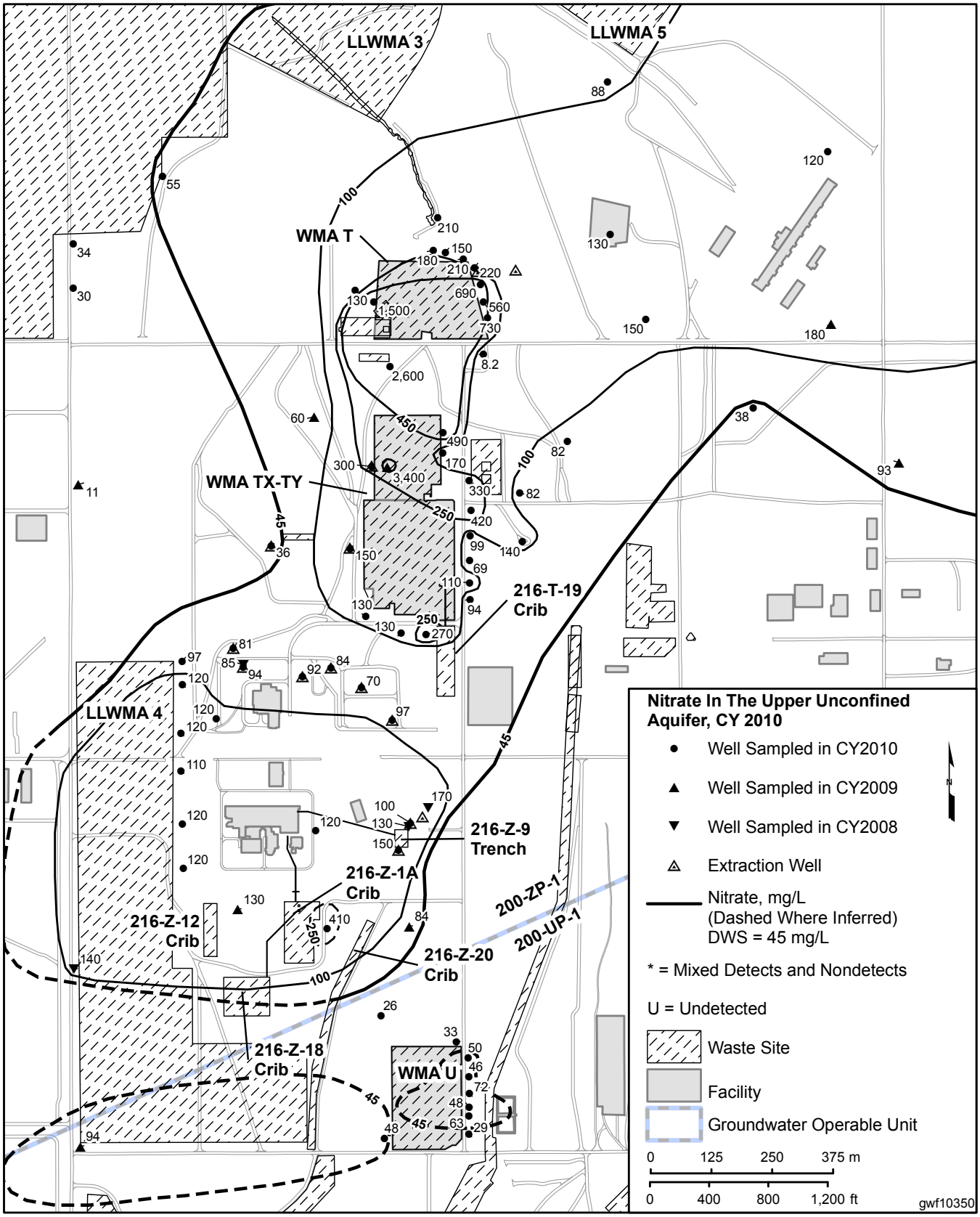


Figure 12-11. Average Filtered Chromium Concentration Northern 200 West Area, Upper Portion of Aquifer

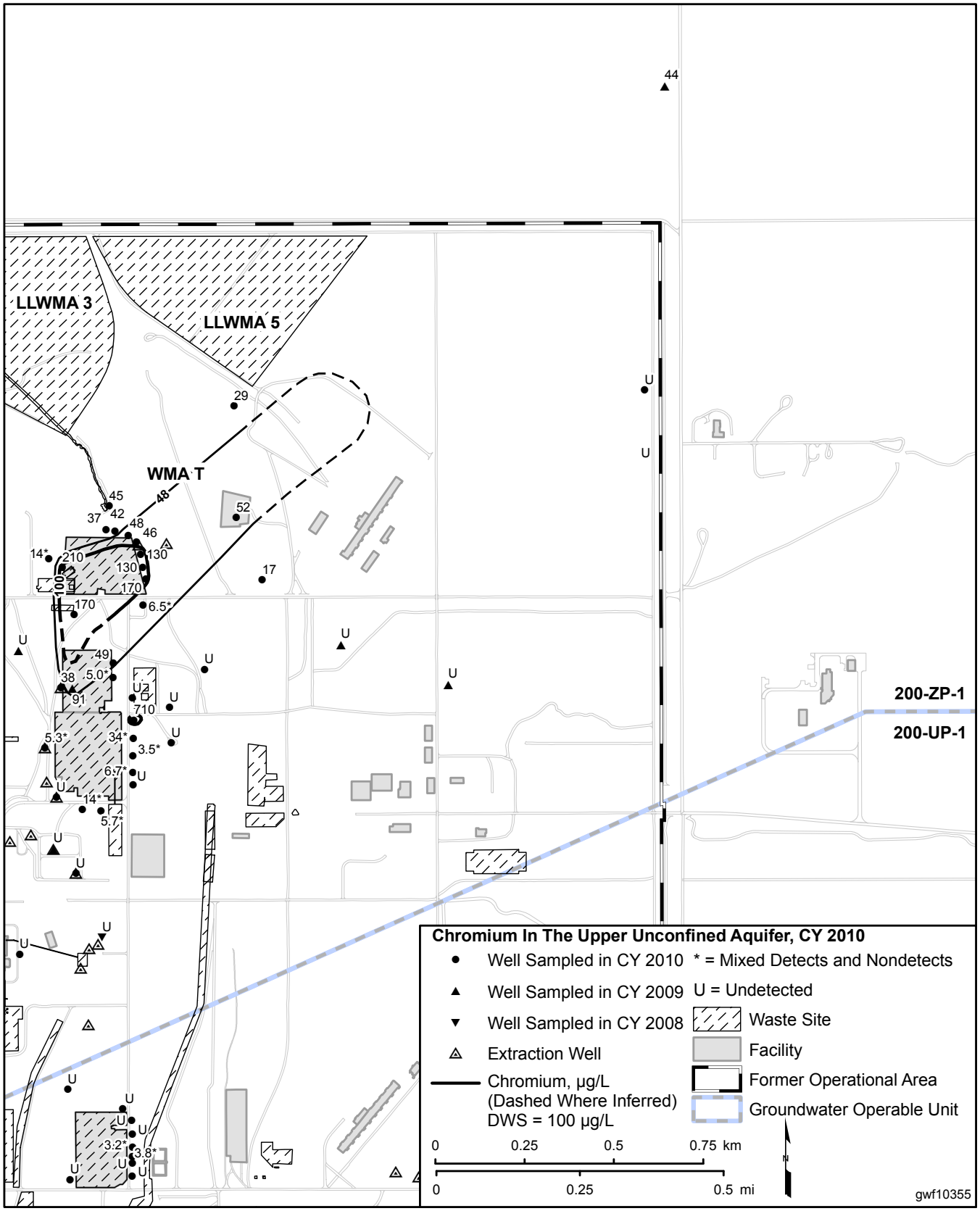


Figure 12-12. Average Tritium Concentration in Central and Northern 200 West Area, Upper Portion of Unconfined Aquifer

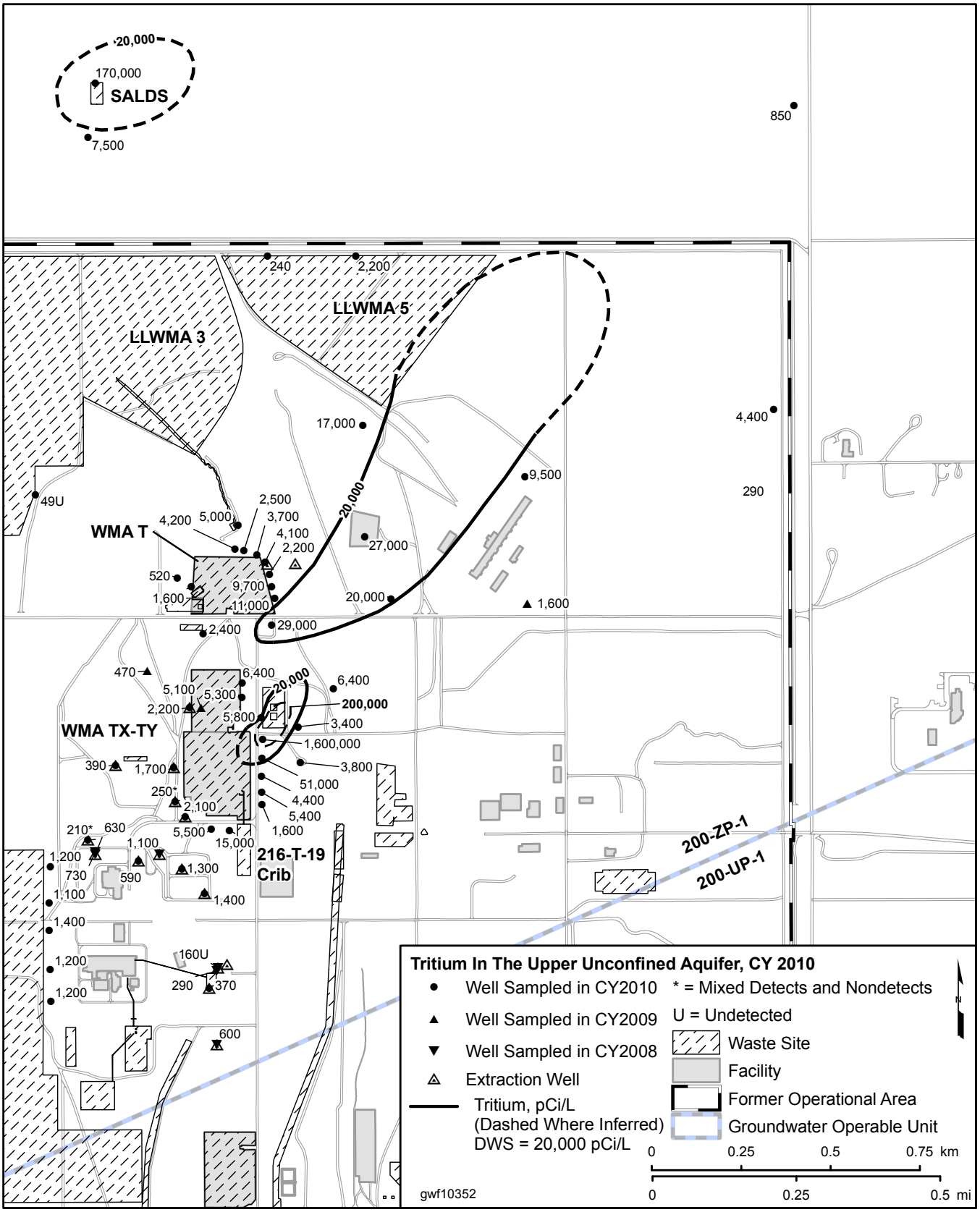


Figure 12-13. Average Iodine-129 Concentration in Central and Northern 200 West Area, Upper Portion of Unconfined Aquifer

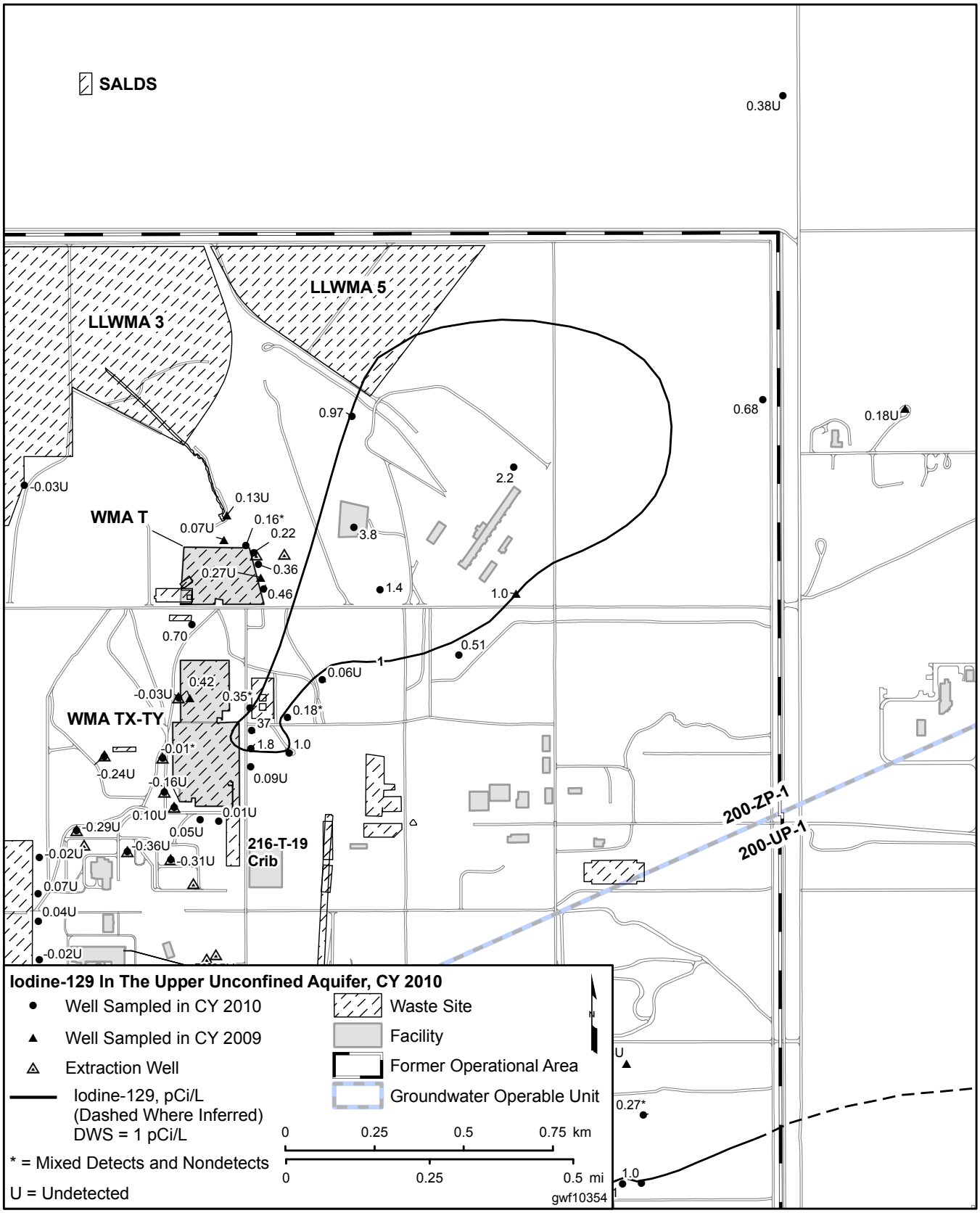


Figure 12-14. Average Technetium-99 Concentration in Central and Northern 200 West Area, Upper Portion of Unconfined Aquifer

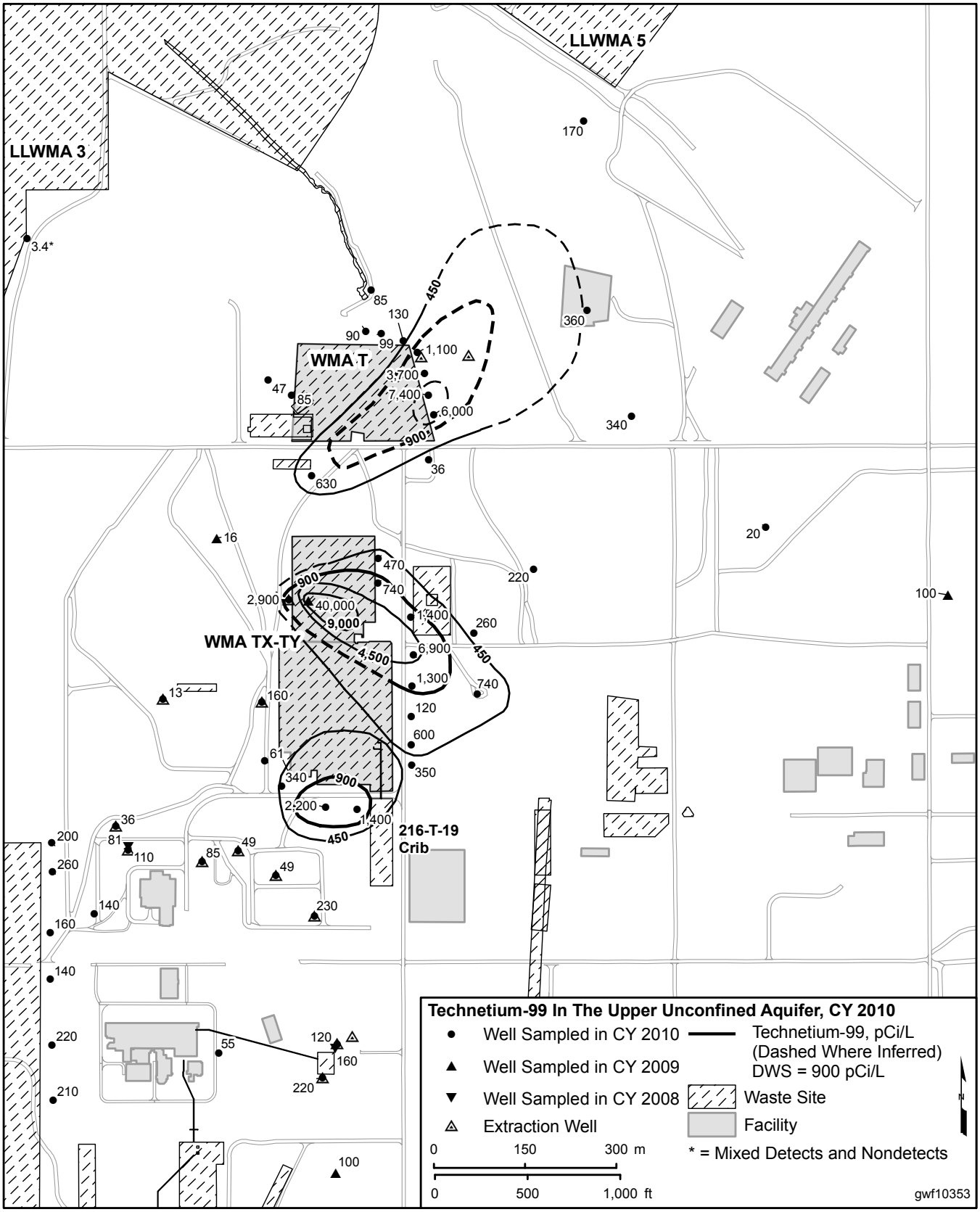


Figure 12-15. 200-ZP-1 Operable Unit Approximate Extent of Capture Overlaid with Contoured Extent of Carbon Tetrachloride, CY 2010

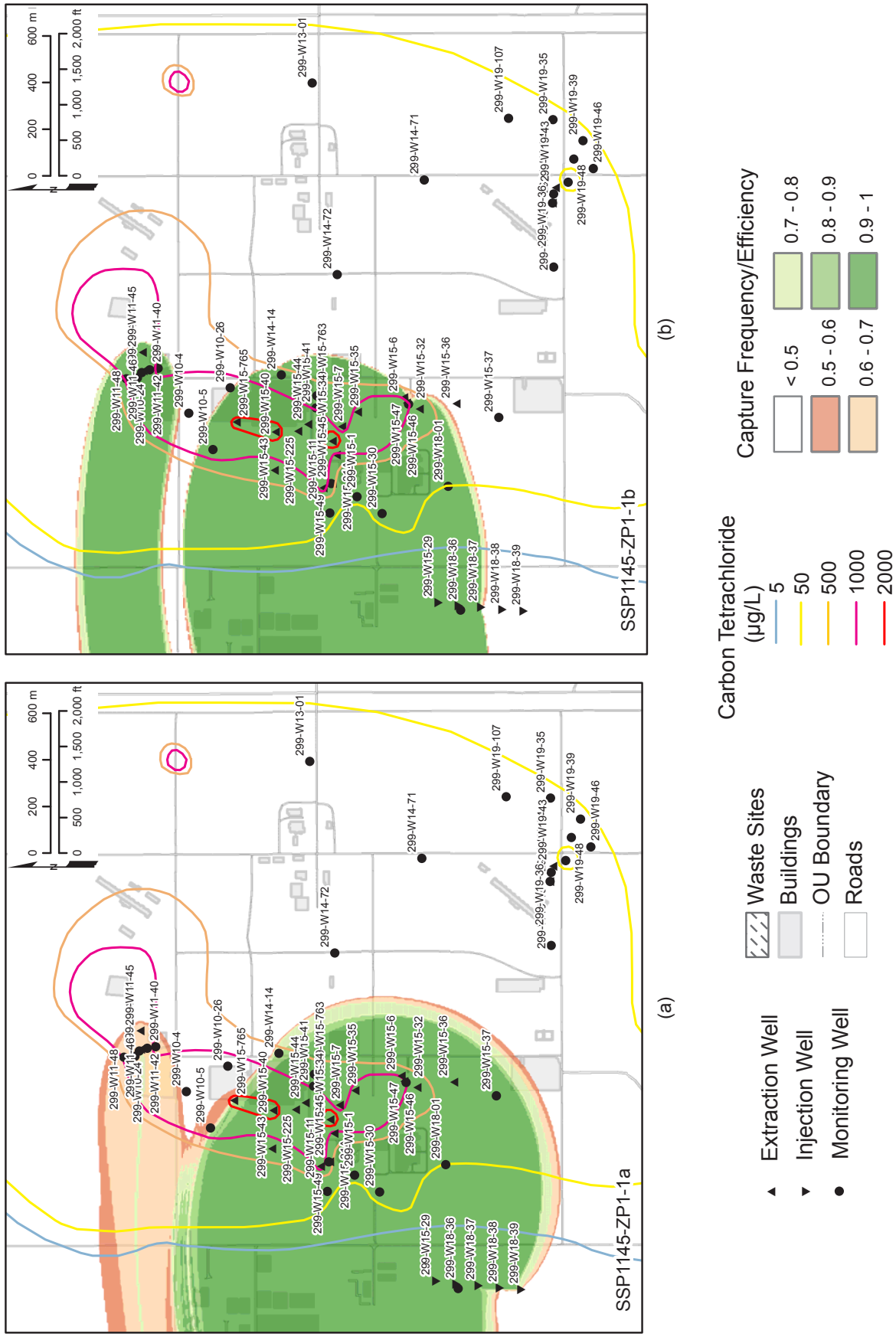
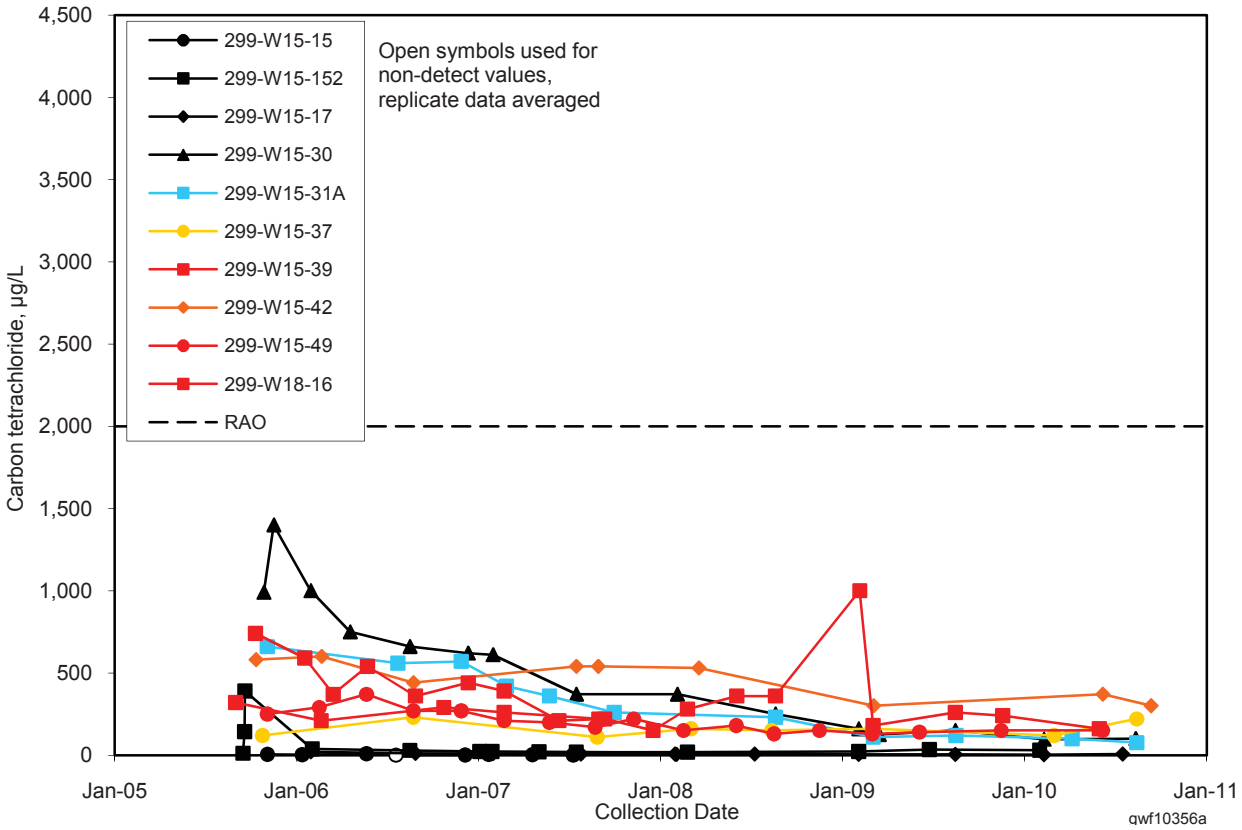
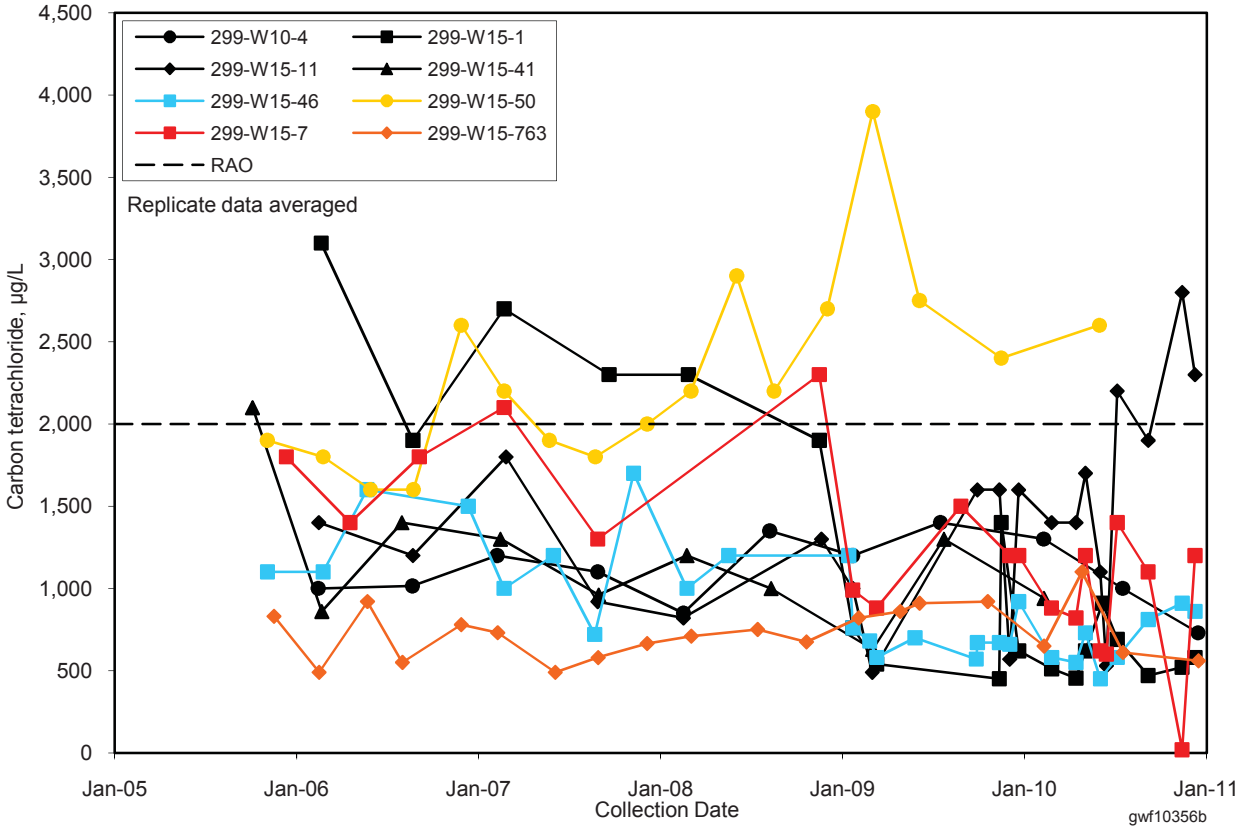


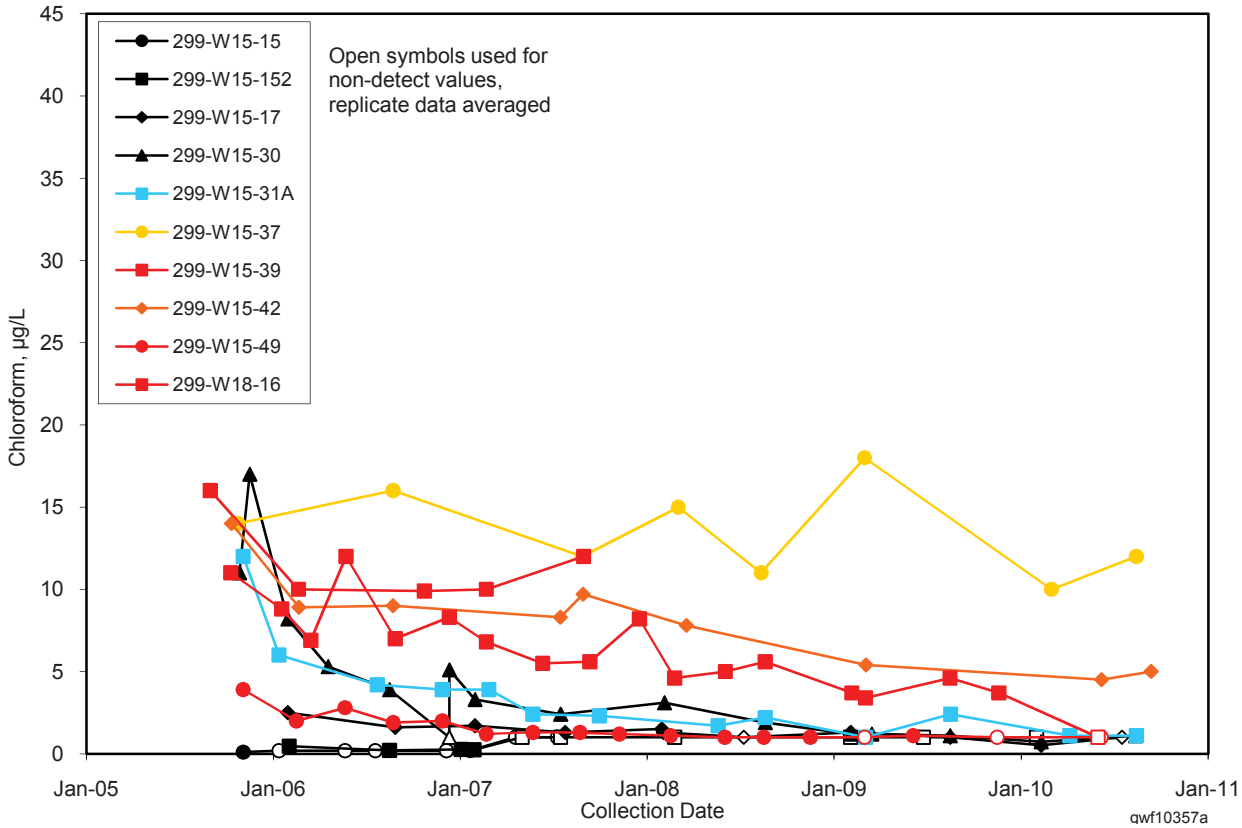
Figure 12-16. Carbon Tetrachloride Trend Plots for Monitoring Wells

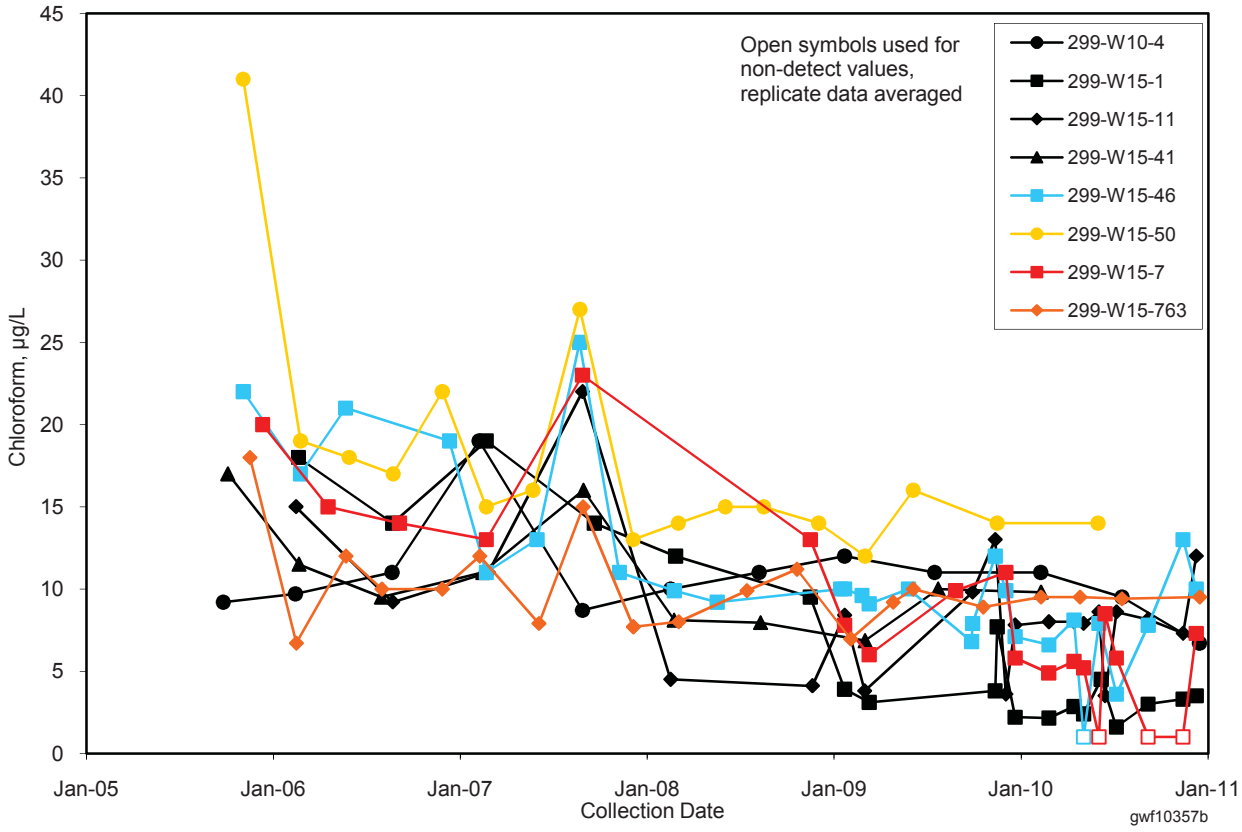




gwf10356

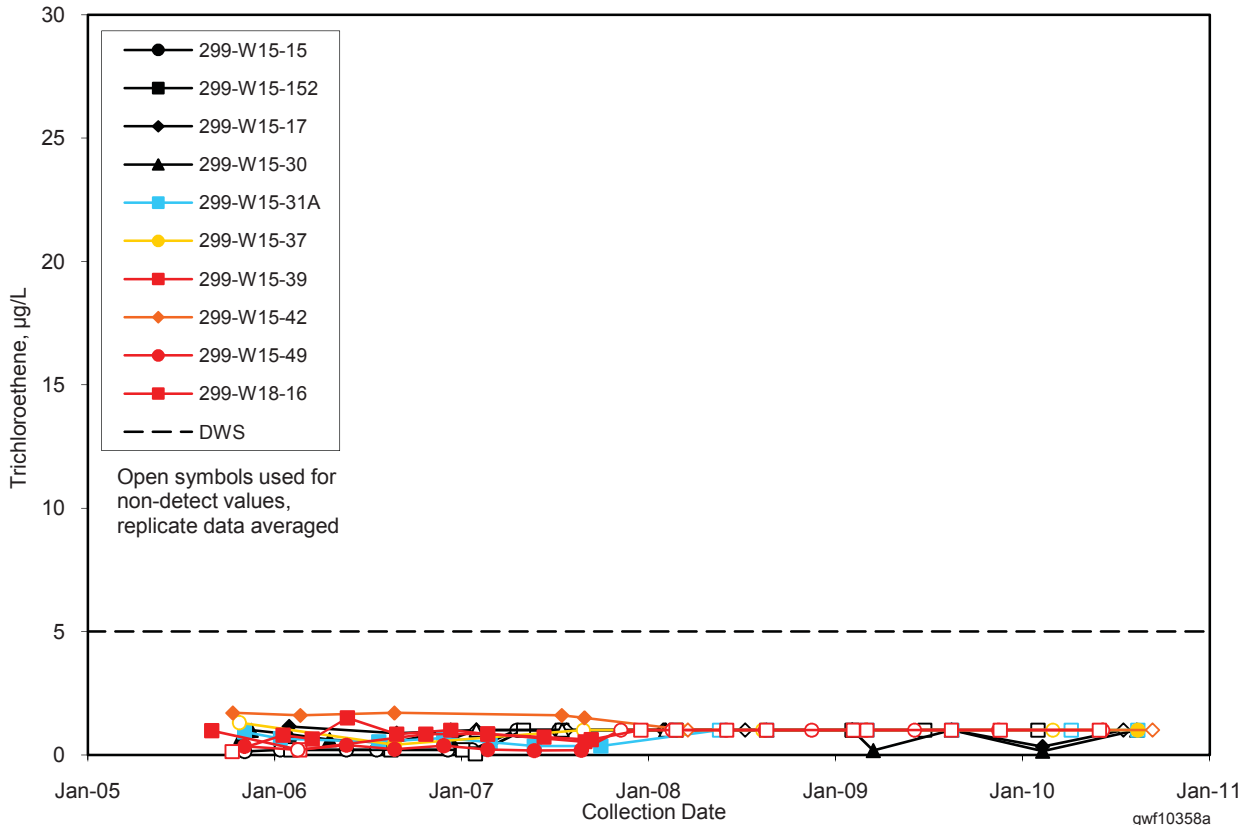
Figure 12-17. Chloroform Trend Plots for Monitoring Wells

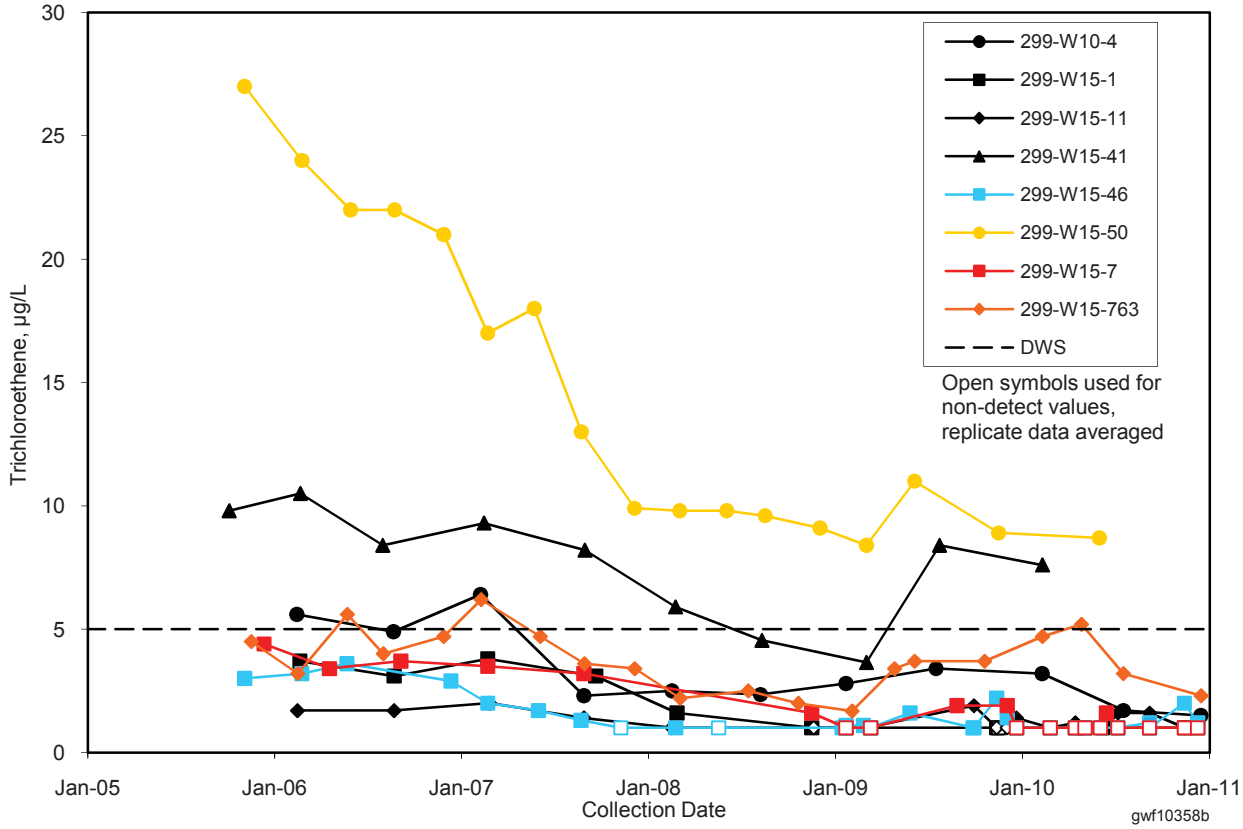




gwf10357

Figure 12-18. Trichloroethylene Trend Plots for Monitoring Wells





gwf10358

Figure 12-19. Carbon Tetrachloride Trend Plots for Extraction Wells

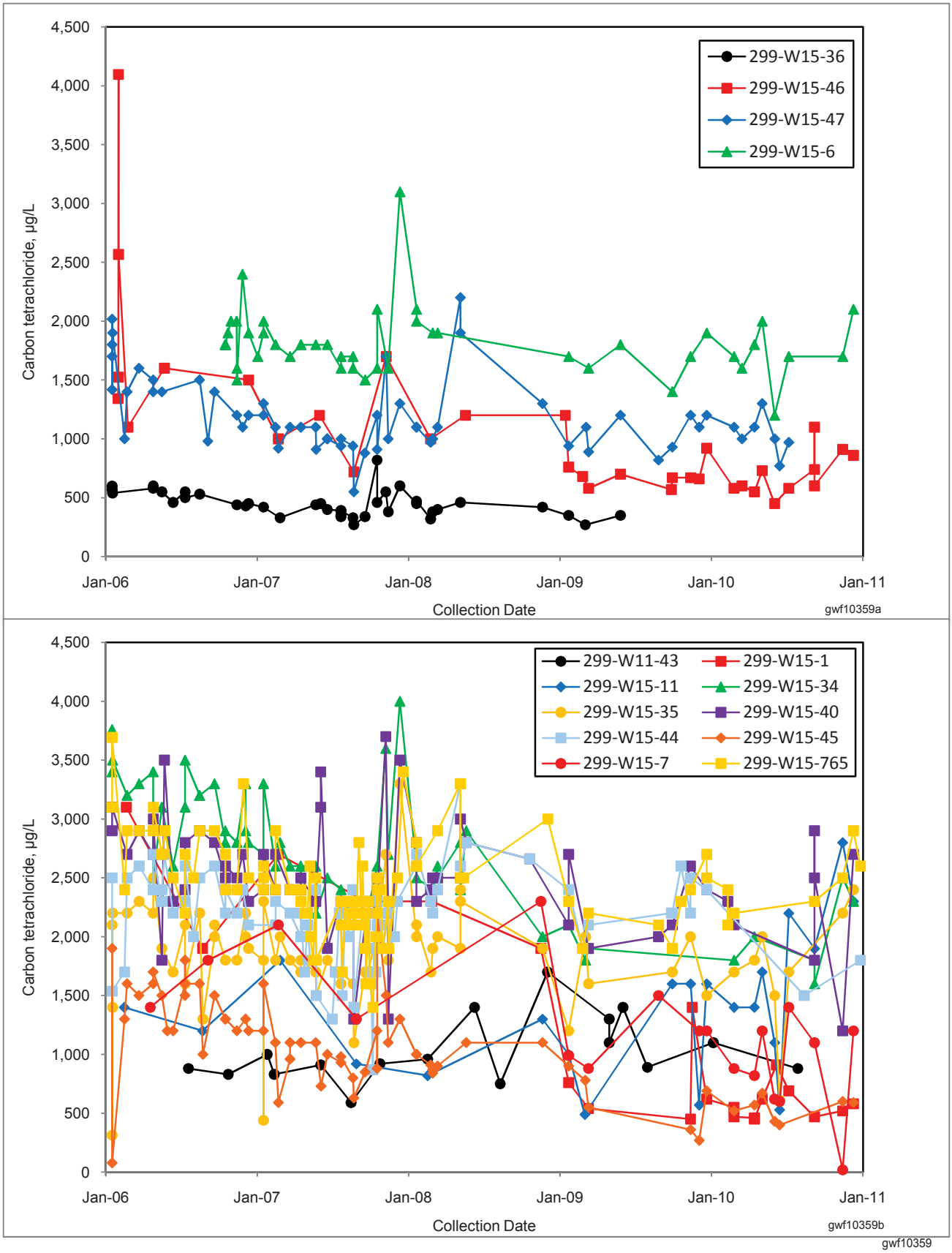


Figure 12-20. Technetium-99 Trend Plots for Monitoring Wells

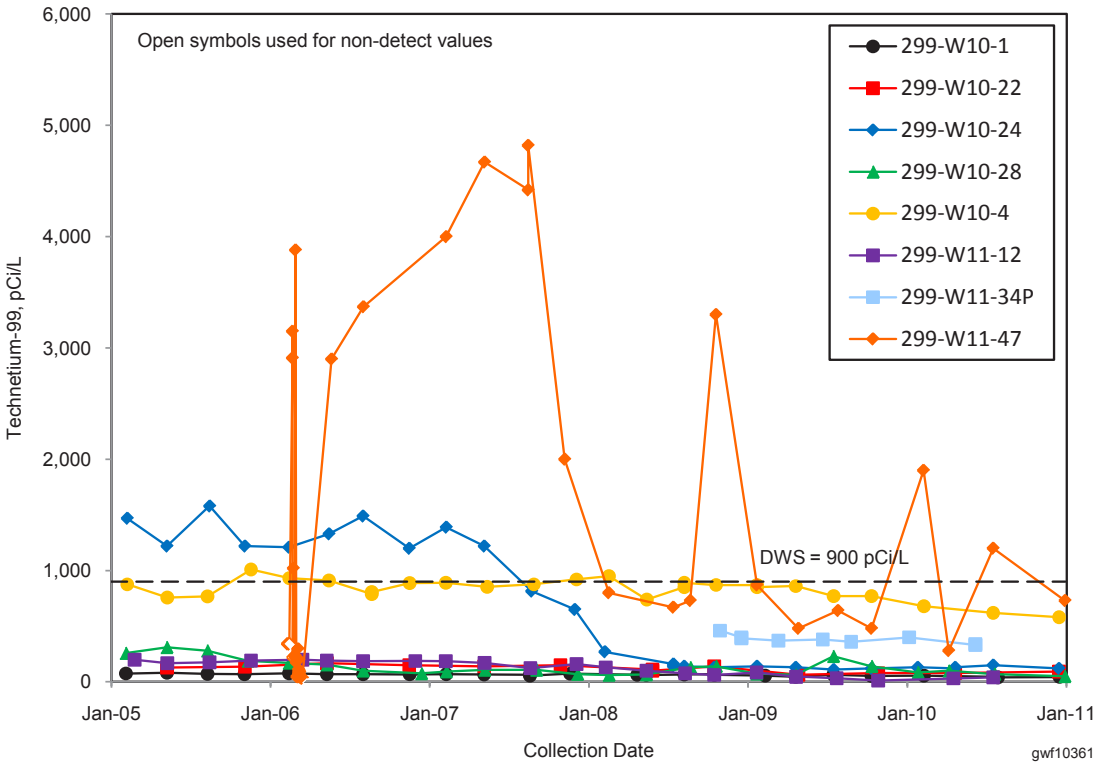
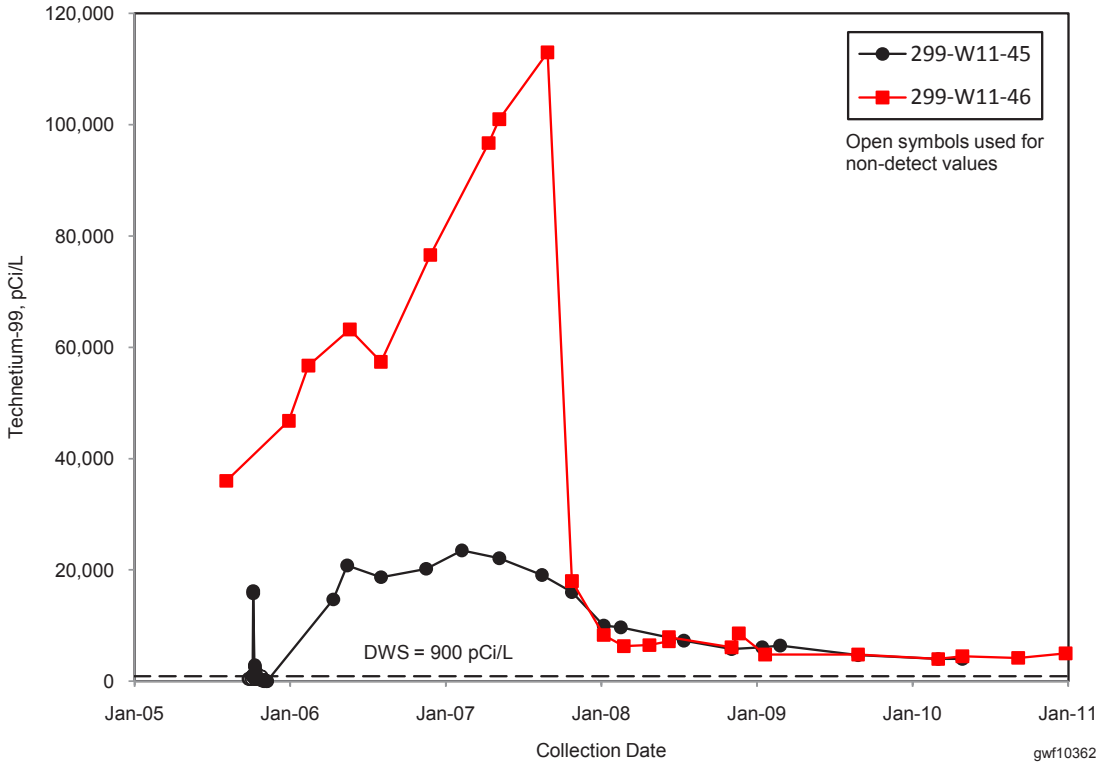


Figure 12-21. Technetium-99 Trend Plots for Extraction Wells



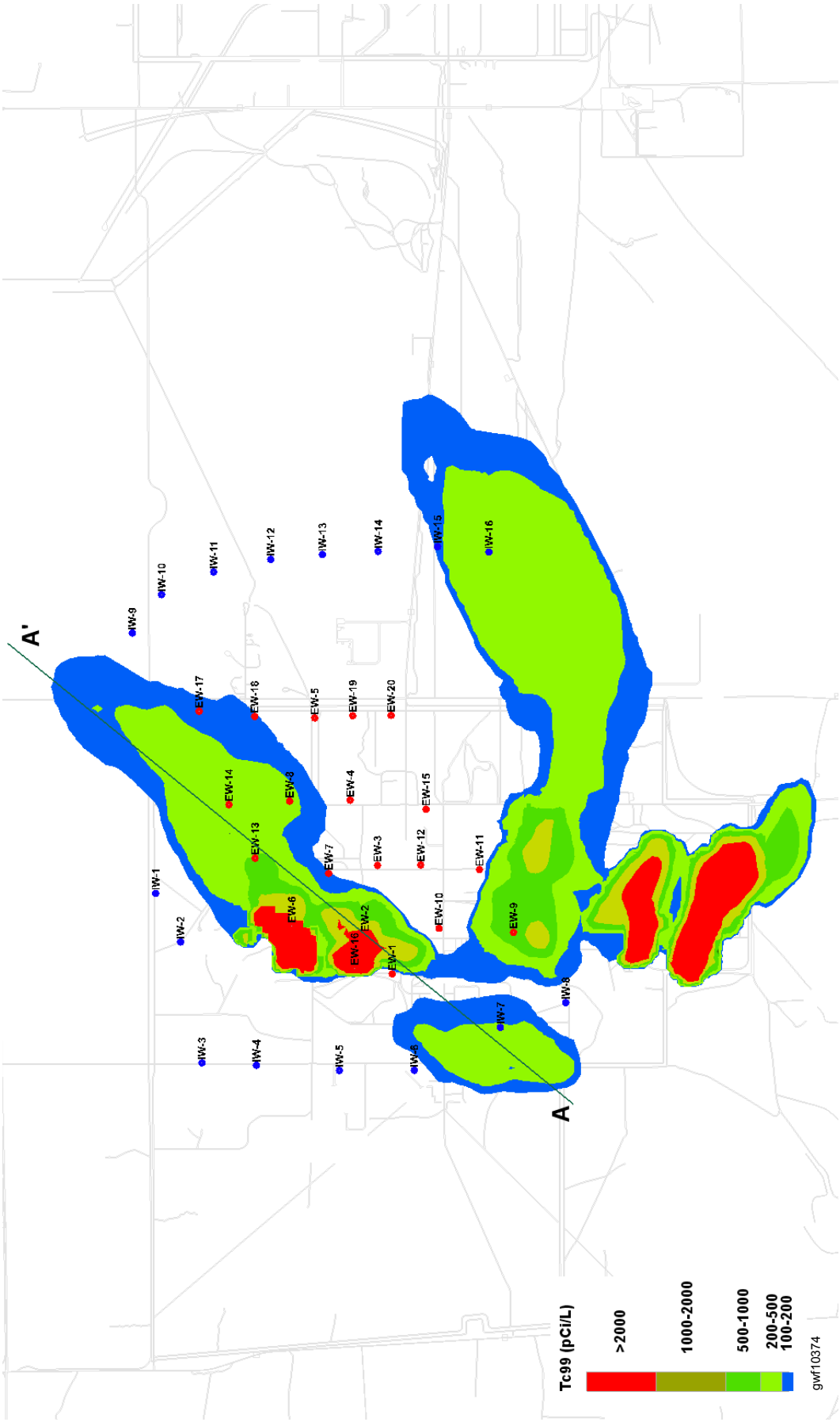


Figure 12-22. 200-ZP-1 Groundwater Operable Unit Technetium-99 Concentration Plan View at 127 m Elevation Above Mean Sea Level and Cross-Section A-A'

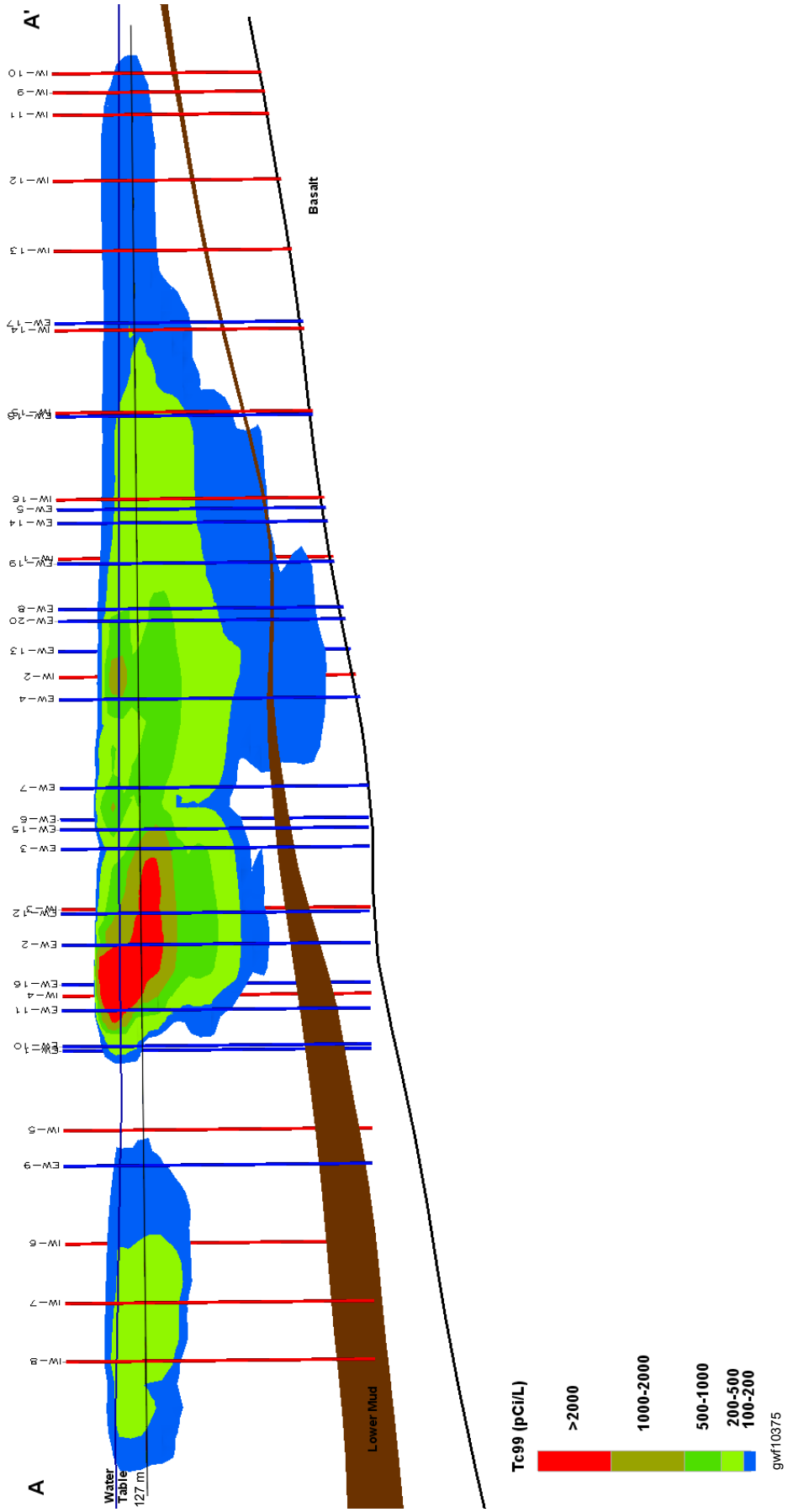


Figure 12-23. 200-ZP-1 Groundwater Operable Unit Technetium-99 Plume Cross-Section A-A'

Figure 12-24. Concentration of Selected Contaminants in Wells 299-W14-3 and 299-W14-5, Waste Management Area TX-TY

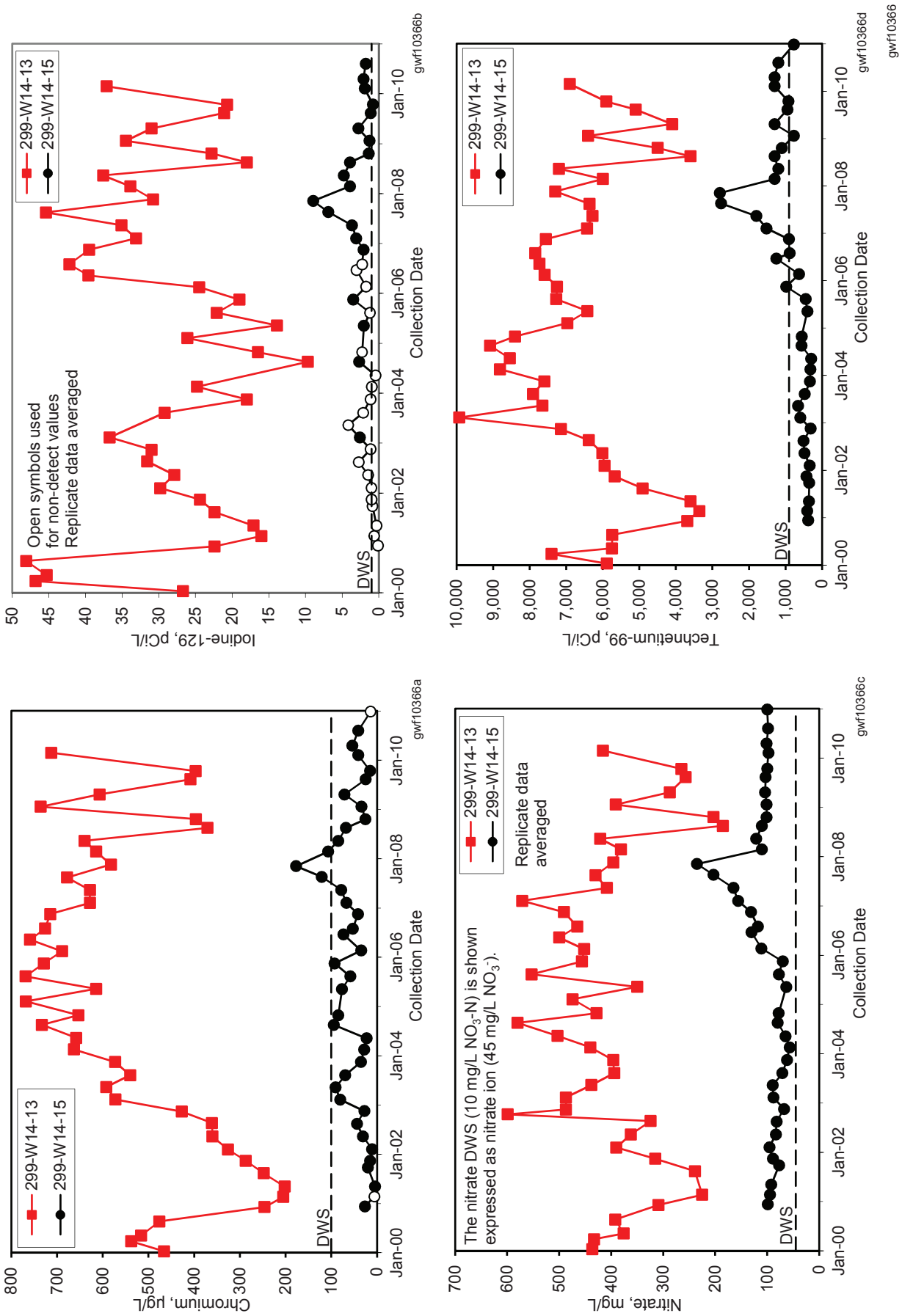
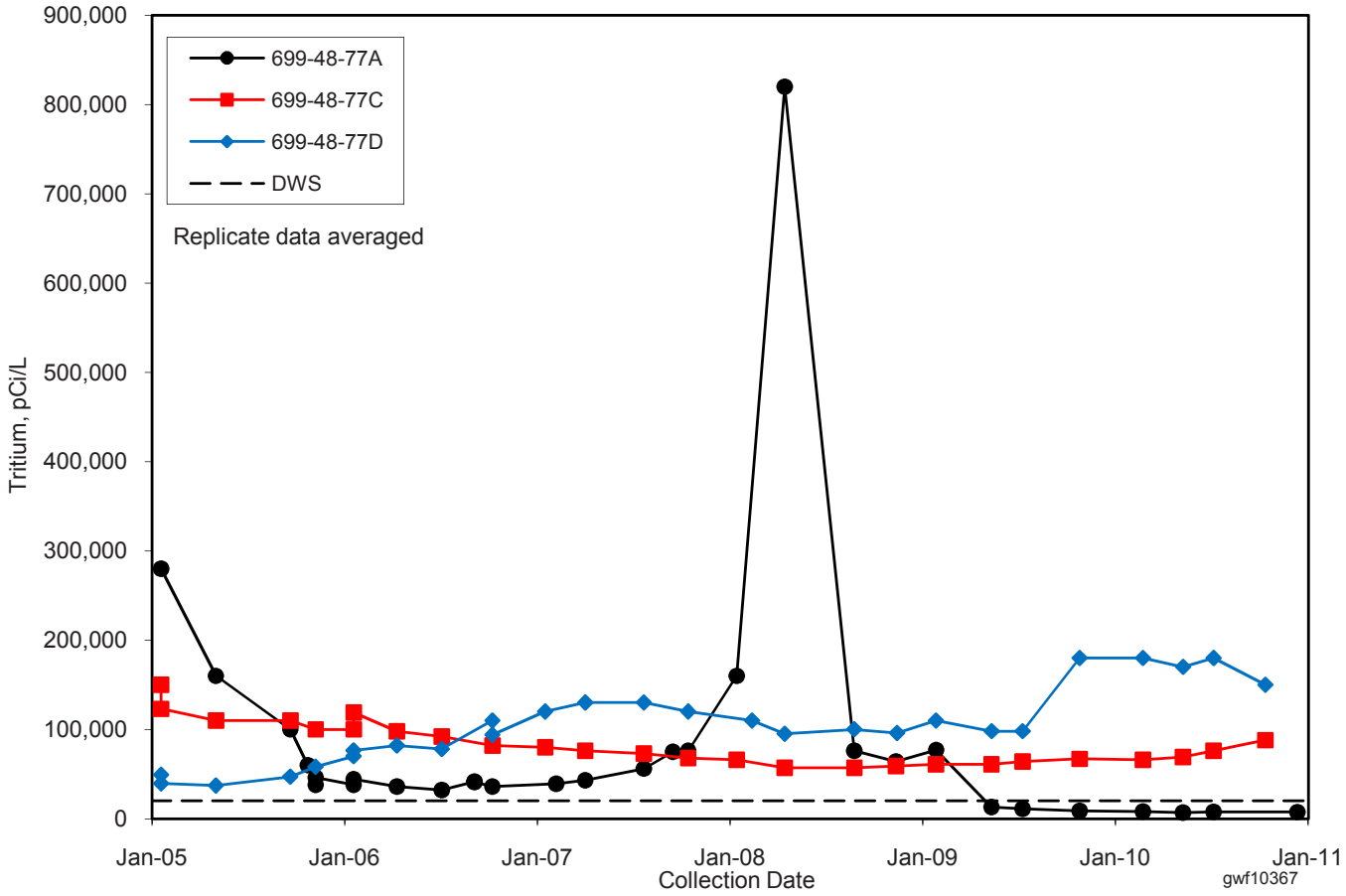



Figure 12-25. Tritium Concentrations in Wells Monitoring the State-Approved Land Disposal Site