7.0 200-ZP-1 Operable Unit

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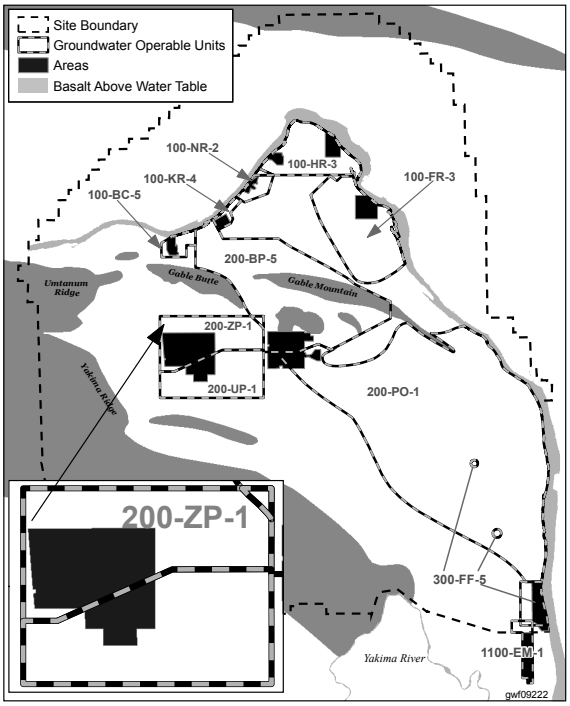
The 200-ZP-1 Operable Unit (OU) activities focus on monitoring and remediation of groundwater contaminant plumes beneath the northern and central portions of the 200 West Area and 600 Area, adjacent to the 200 West Area. The OU lies within the larger 200-ZP-1 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (Figure 1-4 in Chapter 1.0). Figure 7-1 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 from 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 7.1 describes the waste facilities, hydrogeology and groundwater flow characteristics for the 200-ZP-1 OU. Section 7.2 describes groundwater contaminants and compliance monitoring during this reporting cycle. Section 7.3 summarizes the CERCLA groundwater interim remedial system performance for effective capture of carbon tetrachloride and technetium-99 within the OU. Section 7.4 addresses groundwater monitoring of facilities under RCRA, and the SALDS. Conclusions and recommendations are presented in Section 7.5.

Although previous annual groundwater monitoring reports covered a fiscal year (FY) reporting period, this report describes the groundwater monitoring results for the 15-month period from October 1, 2008, through December 31, 2009. As a result of this change, the following date conventions are used in this chapter:

- Fiscal year (FY) 2009: Refers to the fiscal year named (i.e., October 1, 2008, to September 30, 2009).
- Calendar year (CY) 2009: Refers to the calendar year named (i.e., January 1, 2009, to December 31, 2009).
- Reporting period: Refers to the entire 15-month reporting period covered for this report (i.e., October 1, 2008, to December 31, 2009).

7.1 Conceptual Model

This section provides a brief discussion of the conceptual model on which contaminant distribution and migration rate are based. Elements that contribute to the conceptual model include waste site operations, hydrogeologic framework, and groundwater characteristics.

Carbon tetrachloride is the primary contaminant of concern associated with discharges to the 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs and Trenches.

The main contaminant of concern is carbon tetrachloride, with its degradation products trichloroethene and chloroform that are associated with discharges to the 216-Z-1A, 216-Z-9, and 216-Z-18 Trenches.

The contaminant plume extends from these waste sites to the north and northeast, with the highest concentration areas beneath the TX-TY Tank Farms. Additional contaminants of concern within the 200-ZP-1 OU include trichloroethene, technetium-99, chromium, nitrate, tritium, and iodine-129. Once contamination reaches the water table, the migration path follows groundwater flow to the east and northeast. Monitoring activities have focused on the wells that are screened in the upper aquifer. Further examination of contaminant distributions in the aquifer has revealed contaminant migration into deeper regions of the aquifer. In response to observed distributions, deeper wells are considered in the monitoring results, and vertically discrete samples are collected at new wells throughout the saturated interval as the wells are drilled.

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 Ringold Unit 9, the silt and clay of the Ringold lower mud unit (Unit 8), the semiconsolidated sand and gravel of Ringold Unit 5, the fine- to coarse-grained Cold Creek unit, 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 beneath the Ringold lower mud unit (Ringold confined aquifer) and within and between the basalt flows (upper basalt-confined aquifer system and the lower basalt aquifers). The unconfined aquifer is the aquifer directly impacted by waste disposal operations in the central and northern 200 West Area and, therefore, is the only aquifer discussed in this section. The aquifer occupies Ringold Unit 5, and its base is generally the fine-grained Ringold lower mud unit. Depths from land surface to the water table range from 64 to 106 meters, with the largest 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*). The aquifer in the Ringold Formation is absent in the eastern portion where the Hanford formation truncates the Ringold Formation. The elevation of the top of the lower mud unit increases to the northeast; thus, a portion of this unit is interpreted to occur above the water table.

Groundwater in the northern portion of the 200 West Area predominantly flows toward the east-northeast, but it is locally influenced by the 200-ZP-1 pump-and-treat system and effluent discharges to the SALDS (Figure 7-2). The groundwater flow rates, calculated using the Darcy relationship (SGW-38815, *Water-Level Monitoring Plan for Hanford Site Soil and Groundwater Remediation Projects*), typically range from 0.0001 to 0.5 meters per day within the 200-ZP-1 groundwater interest area. The water table continues to decline at a rate of ~0.21 to 0.35 meters per year. The water table in the 200 West Area was influenced by past discharge of wastewater, and the aquifer is still re-equilibrating after termination of these discharges. The flow direction in the northern portion of the groundwater interest area has changed ~35 degrees over the past decade, from a north-northeastern direction to a more eastern direction; however, the changes from year to year are becoming less apparent as the water declines to background 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 has fourteen extraction wells in the vicinity of the 216-Z Cribs and Trenches and west of Waste

Management Area (WMA) TX-TY (Figure 7-1). 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 associated with the injection wells, and a region of drawdown is associated with the extraction wells, causing flow to converge on the extraction zone from all directions. The injection wells, which are due west of Low-Level Waste Management Area 4 (LLWMA-4), have also affected groundwater flow and contaminant concentrations beneath this facility.

7.2 Groundwater Contaminants

This section describes the major contaminants of concern for the 200-ZP-1 OU, which include carbon tetrachloride, trichloroethene, nitrate, total chromium, hexavalent chromium, tritium, iodine-129, and technetium-99. Cribs, trenches, and underground tanks are the principal sources of contamination that migrates to the water table. Contaminant plume extent for all constituents reflects the reported concentration in the upper 15 meters of the aquifer and does not represent deeper contamination. Contaminant contours represent the annual average concentration calculated from all sampling events performed during the reporting period.

Plume areas (square kilometers) above the drinking water standard in the 200-ZP-1 Operable Unit:

Carbon Tetrachloride*, 5 µg/L — 11.475
Chromium, 100 µg/L — 0.05
Iodine-129, 1 pCi/L — 0.735
Nitrate, 45 mg/L — 5.389
Technetium-99, 900 pCi/L — 0.0651
Trichloroethene, 5 µg/L — 0.151
Tritium, 20,000 pCi/L — 0.558
Uranium, 30 µg/L — 0.009

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

7.2.1 Carbon Tetrachloride

Carbon tetrachloride is the principal contaminant of concern for the 200-ZP-1 OU and is found at levels greater than the drinking water standard (DWS) (5 µg/L) in groundwater under most of the 200 West Area (Figure 7-3). The main sources of carbon tetrachloride are three of the 216-Z Cribs and Trenches that received waste from the Plutonium Finishing Plant. Interim remediation of this plume began in 1994. The capture and cleanup requirements to remediate this area are described in the interim Record of Decision (EPA/ROD/R10-95/114, *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit*). The target capture zone for interim remediation was the area with concentrations greater than 2,000 µg/L at the 216-Z Cribs and Trenches.

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, over-fine sediments.

The carbon tetrachloride plume extent is depicted in Figure 7-3. The 2,000 µg/L contour is located along the western edge of WMA TX-TY. Within and adjacent to this area, fourteen extraction wells are staggered on a north-to-south line and operate to remove contaminated groundwater for subsequent treatment at the 200-ZP-1 interim treatment facility (Figure 7-1). After treatment, the remediated water is injected at five wells oriented north to south, west of LLWMA-4. The outermost plume contour at the DWS (5 µg/L) extends beyond the boundaries of the 200 West Area to the north, south, and east. The main plume orientation indicates migration predominantly northeast to east. The overall extent of each concentration contour interval during CY 2009 is similar to that for the previous reporting period in FY 2008. Carbon tetrachloride levels in well 299-W11-10 (eastern boundary of the 200 West Area) showed an increasing trend during FY 2008 that peaked in CY 2009. Two new wells (299-W12-2 [EW-5] and 299-W12-4 [EW-19]) were drilled along the eastern boundary of the 200 West Area during CY 2009 and were sampled at discrete intervals in the saturated zone. Each well yielded samples with carbon tetrachloride levels greater than 1,000 µg/L at depths greater than 15 meters.

During CY 2009, ten wells in the 200-ZP-1 performance monitoring network exceeded 2,000 µg/L; seven of these were extraction wells. Monitoring

well 299-W15-50 had the highest recorded concentration at 3,900 µg/L, followed by monitoring well 299-W11-87 with a concentration of 3,200 µg/L. Performance monitoring well 299-W13-1 is the third of the monitoring wells and has a reported maximum concentration of 2,700 µg/L. Well 699-48-71 (outside of the northeastern corner of the 200 West Area) has shown a continuing increase in carbon tetrachloride, above the DWS in 2002 and currently over 80 µg/L (Figure 7-4). Each of the fourteen extraction wells had lower reported maximum concentrations for CY 2009 than during the previous reporting period in FY 2008.

The standard monitoring approach for the annual groundwater report has been to include only those groundwater wells in the upper 15 meters of the unconfined aquifer when considering carbon tetrachloride concentration distribution for the 200-ZP-1 OU plume map (Figure 7-3). However, higher carbon tetrachloride concentrations have been observed at depths greater than 15 meters at wells downgradient from the source zone. Figure 7-5 provides a map of the carbon tetrachloride plume, derived from concentrations measured in all groundwater wells screened above the basalts within the suprabasalt sediments. The vertical distribution of carbon tetrachloride is developed from 200-ZP-1 groundwater monitoring wells along transects shown in Figure 7-6. The vertical and laterally continuous carbon tetrachloride plume is represented in Figures 7-7 and 7-8. Both plume maps show carbon tetrachloride migrating vertically downward at a greater distance from the source zone. Additionally, the absolute concentration is declining at a greater distance as a result of dispersion and degradation.

Depth-discrete sampling is performed at the 200-ZP-1 OU for all new groundwater extraction wells. By the end of CY 2009, ten new extraction 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 7-5). The westernmost new extraction well drilled was 299-W15-225 (EW-1), which is located in the highest concentration portion of the carbon tetrachloride plume. Vertical profiles of the depth-discrete carbon tetrachloride samples collected for the ten extraction wells are presented in Figure 7-9. The position of each well in Figure 7-5 and the corresponding carbon tetrachloride depth profile demonstrate the same downward trending phenomenon shown in Figures 7-7 and 7-8.

7.2.2 Trichloroethene

Trichloroethene is detected at levels above the DWS (5 µg/L) in the 200-ZP-1 groundwater interest area. The main trichloroethene plume (Figure 7-10) extends north and northeast from the 216-Z Cribs and Trenches, particularly the 216-Z-9 Trench. The three discrete plumes are (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. Concentrations at wells in all three locations show a slight increase during CY 2009 relative to FY 2008. Trichloroethene exceeded the DWS in 22 performance monitoring wells, including nine extraction wells (seven wells adjacent to WMA TX-TY and the two wells east of WMA T). The maximum reported concentration during CY 2009 was 50 µg/L at extraction well 299-W15-45. East of WMA T, a concentration of 14 µg/L was reported at well 299-W11-34P.

The plumes for both WMA TX-TY and WMA T are within the capture zone for their respective pump-and-treat systems. The plume east of WMA T is downgradient and outside of the capture zone for extraction wells on the west side of WMA T.

7.2.3 Nitrate

Nitrate concentrations were above the DWS (45 mg/L, as nitrate) beneath much of the 200-ZP-1 groundwater interest area (Figure 7-11). 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 450 mg/L) are discernible in the 200-ZP-1 OU: (1) a plume located beneath WMA T, and (2) a plume at well 299-W18-16 (near the 216-Z Cribs and Trenches). 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 for 241-T pump-and-treat wells. The central path of the nitrate plume bisects both sets of pump-and-treat wells for the 200-ZP-1 OU. The highest concentration for the reporting period is 2,550 mg/L at well 299-W10-4, which is south of WMA T. The high value reported for well 299-W18-16 is 708 mg/L. The size and concentration contours reported during CY 2009 are similar to those for FY 2008. In general, the nitrate plume remained stable during CY 2009 relative to FY 2008.

In addition to depth-discrete sampling for carbon tetrachloride, nitrate concentrations were measured in vertically discrete locations at new well locations drilled during CY 2009. This sampling is used to assess contaminant migration within the saturated profile. Figure 7-12 shows the vertical profile at near-source well 299-W14-20 (EW-2) in the central region of the plume and at well 299-W12-3 (EW-18) located in the 200 West Area's eastern boundary, downgradient from the previous well. The plot shows (as is also noted with the carbon tetrachloride plume) nitrate at a higher concentration in the well closer to the source area and lower in the profile further along the flow path.

7.2.4 Chromium

Chromium contamination is found at levels above the DWS (100 µg/L) at WMA T and WMA TX-TY (Figure 7-13). 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. Chromium is found beneath the single-shell tank farms at the 200-ZP-1 OU. Concentrations greater than 100 µg/L are found beneath WMA T. At non-CERCLA well 299-W14-13, the maximum concentration during CY 2009 was 744 µg/L but ended the year with a concentration of 394 µg/L. The maximum concentration reported at CERCLA well 299-W10-4 (south of WMA T) was 552 µg/L. The chromium plume direction is oriented toward the northeast and is present in a compact group of wells. A total of nine performance monitoring wells exceeded the DWS for chromium during CY 2009, and eight 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 northern set of wells at WMA T also has chromium concentrations two to three times lower than wells directly south; it is uncertain whether this is a result of capture during pump-and-treat or proximity to the source. The concentration in the extraction wells at the end of CY 2009 was 144 µg/L in well 299-W11-45 and 138 µg/L in well 299-W11-46. In general, the chromium plume remained stable during CY 2009 relative to the values observed in FY 2008.

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

7.2.5 Tritium

Tritium contamination at levels greater than the DWS (20,000 pCi/L) in the 200-ZP-1 groundwater interest area is restricted mainly to a plume extending northeast from waste disposal facilities adjacent to WMA T and WMA TX-TY. These WMAs have multiple tritium sources in the groundwater. In addition, tritium from permitted discharges at the SALDS is found in the groundwater (Figure 7-14) (see Section 7.4.5 for discussion of tritium at the SALDS). The maximum tritium concentration at well 699-48-77A was 77,000 pCi/L, which is more than two times the concentration reported for well 299-W11-34P. Well 299-W11-34P had the highest reported tritium concentration in the 200-ZP-1 OU for a non-SALDS well. The first of these wells is adjacent to the SALDS, and the second well is located northeast of WMA T. Only five performance monitoring wells in the 200-ZP-1 OU exceeded the DWS during the reporting period. Well 699-48-77A had a high peak discharge after a transfer from the K Basins in FY 2008, resulting in a tritium spike of 820,000 pCi/L. Since that event, the tritium concentration in this well has declined to 9,600 pCi/L. Well 699-48-77D (the farthest downgradient well at the SALDS) experienced an end-of-year peak of 180,000 pCi/L in October 2009, which is an increase from 98,000 pCi/L measured in the well during July 2009. This peak event is the lag response after discharge water arrived at well 699-48-77C and until the discharge water reached well 699-48-77D.

In general, the tritium plume at the SALDS remained stable except for the discharge campaign of the previous FY. The 20,000 pCi/L contour from the single-shell tank farms may have receded slightly, although the general lack of monitoring wells at the northern boundary to define the plume extent makes this determination problematic. Some fluctuation occurred in wells, with some wells increasing from last year (299-W11-43) and others decreasing (299-W11-37). This plume also remained stable relative to the previous reporting period.

7.2.6 Iodine-129

Iodine-129 is found in the 200-ZP-1 groundwater interest area beneath WMA TX-TY (Figure 7-15). Determining the extent of iodine-129 contamination is difficult because the detection limit is often near or above the 1.0 pCi/L DWS. Ten performance monitoring wells exceeded the DWS for iodine-129 during the reporting period. The maximum concentration reported was 4.5 pCi/L at well 299-W11-34P, northeast of WMA T. The maximum concentrations reported at the 241-T pump-and-treat wells were 1.94 pCi/L at well 299-W11-46 and 1.86 pCi/L at well 299-W11-45. In general, the iodine-129 plume did not change appreciably from the previous reporting period.

7.2.7 Technetium-99

Technetium-99 maximum concentration has steadily declined in extraction well 299-W11-46, from a high of 113,000 pCi/L in 2007 to 8,600 pCi/L in CY 2009.

Technetium-99 within the 200-ZP-1 groundwater interest area is found at levels significantly above the DWS (900 pCi/L) on the eastern (downgradient) side of WMA T and is centered on two areas in the vicinity of WMA TX-TY (Figure 7-16). The U.S. Environmental Protection Agency (EPA)-mandated DWS of 900 pCi/L is in effect for the plumes.

The purpose of the 241-T pump-and-treat wells is to capture technetium-99 migrating in groundwater beneath the WMA. The maximum technetium-99 concentrations recorded for CY 2009 at the two extraction wells were 8,600 pCi/L at 299-W11-45 and 6,400 pCi/L at 299-W11-46.

The plume centered on WMA T is migrating to the northeast. The maximum concentration for the plume is 9,800 pCi/L at performance monitoring

well 299-W11-40, which was the only well exceeding the DWS within the OU. The plume centered on the northern portion of WMA TX-TY is elongated toward the southeast, with the maximum concentration of 4,000 pCi/L at extraction well 299-W15-765. The southern plume under WMA TX-TY is slightly elongated to the east, with the maximum concentration of 3,400 pCi/L at performance monitoring well 299-W15-41. The technetium-99 concentrations at wells in all three plumes have fluctuated but remained relatively stable during CY 2009 relative to FY 2008.

7.2.8 Other Constituents

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

During CY 2009, the annual average chloroform concentrations in the 200-ZP-1 groundwater interest area remained below the 80 µg/L DWS (defined for total trihalomethane). 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.

Only well 299-W11-37 (northeast of the T Tank Farm) exceeded the current DWS (30 µg/L), with a maximum concentration of 37 µg/L. The uranium concentration in this well has steadily declined over the years and had a reported value of 48 µg/L during FY 2008.

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 2009 maximum fluoride concentration of 4.86 mg/L. This reflects a slight increase in fluoride from 4.56 mg/L in FY 2008. Release of lanthanum fluoride used in the bismuth phosphate process is a possible cause of this contamination.

Antimony concentrations in several wells exceeded the DWS (6 µg/L) in CY 2009; 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 2009 and previous years are believed to be false-positive results.

During CY 2009, filtered arsenic was detected at levels above the 10 µg/L DWS in wells 299-W10-4 and 699-48-77A, located southwest of WMA T and south of the SALDS. Maximum concentrations at these wells were reported at 12.0 µg/L and 10.8 µg/L, respectively. This concentration is slightly higher than the FY 2008 maximum of 10.8 µg/L at well 299-W10-4. 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 2,950 µg/L was at new well 299-W12-1. During the previous year, well 299-W10-4 reported an iron concentration of 1,700 µg/L. Review of samples collected for multiple years at individual wells indicates that the concentration typically fluctuates over a wide range. Iron sampling results are suspect because iron is a naturally occurring component of aquifer sediment and is found in well materials, particularly during drilling. 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 DWS (5 µg/L) in two wells in the 200-ZP-1 groundwater interest area during CY 2009. The maximum concentration reported (5 µg/L) was at well 299-W15-152 (at the eastern boundary of LLWMA-4) and well 299-W15-17 (at the northeastern corner of LLWMA-4). Methylene chloride (dichloromethane) can be a degradation product or impurity in carbon tetrachloride (tetrachloromethane), but it is also a common laboratory contaminant.

Tetrachloroethene is often detected at levels below the DWS (5 µg/L) in the 200-ZP-1 groundwater interest area. The maximum concentration for the reporting period was 4.4 µg/L in well 299-W15-50, south of WMA TX-TY. During FY 2008, the reported maximum tetrachloroethene concentration was 2.1 µg/L in wells 299-W10-4 and 299-W10-24.

7.3 CERCLA Groundwater Activities

The interim remedial action objectives for the 200-ZP-1 Operable Unit (EPA/ROD/R10 95/114) are as follows.

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

The final feasibility study and proposed plan were issued in July 2008 (DOE/RL-2007-28; DOE/RL-2007-33). The final record of decision for the 200-ZP-1 Operable Unit was signed in September 2008 (EPA et. al. 2008).

This section addresses CERCLA groundwater performance monitoring and interim remedial measures at the 200-ZP-1 OU, as outlined in the interim Record of Decision (EPA/ROD/R10-95/114), and as implemented in *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 remedial design/remedial action work plan that was issued during the current reporting period (DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*). Additional tasks performed to support the final Record of Decision (*Declaration of the Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington* [EPA et al. 2008], dated September 2008) include installing nine of twenty extraction wells that will support the groundwater treatment facility and 90% complete balance of design for the new groundwater treatment facility.

Within the 200-ZP-1 OU, interim actions have been implemented to remediate carbon tetrachloride, chloroform, and trichloroethene in the vicinity of the 216-Z liquid waste disposal cribs and trenches. The final remedy for the 200-ZP-1 OU will address carbon tetrachloride as the primary contaminant of concern throughout the vertical extent of the aquifer in accordance with the final Record of Decision (EPA et al. 2008). The *200-UP-1 and 200-ZP-1 Operable Units Pump-and-Treat System Annual Report for Fiscal Year 2008* (DOE/RL-2008-77) provides a detailed status of the interim remediation from previous years. Interim remedial measures are 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 waste stream at an interim treatment facility in the 200 West Area. Treated effluent is then pumped back into the aquifer at the injection wells, which 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 dangerous waste constituents for both CERCLA and AEA programs. Remediation activities at this site include pump-and-treat from wells 299-W11-45 and 299-W11-46. Effluent from these wells is transferred to the Effluent Treatment Facility (ETF), where constituents are removed before discharge to ground at the SALDS.

7.3.1 CERCLA Decision Documents

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 *Code of Federal Regulations* [CFR] 300, Appendix C, "National Oil and Hazardous Substances Pollution Contingency Plan") were completed in FY 2007.

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 Record of Decision, were issued in the 200-ZP-1 pump-and-treat remedial design/remedial action work plan (DOE/RL-2008-78) in March 2009.

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

- The *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2003-55) was prepared in FY 2004 and implemented in FY 2005.
- The *Remedial Investigation Report for 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24) was published in October 2006.
- The *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) were completed in July 2008.
- The final selected remedy for the 200-ZP-1 OU was completed in September 2008 in the final Record of Decision (EPA et al. 2008).
- During the current reporting period, the *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 Record of Decision) was issued.

7.3.2 Pump-and-Treat System for Carbon Tetrachloride

The main 200-ZP-1 OU pump-and-treat system is located near the middle of the 200 West Area (Figure 7-1) and removes carbon tetrachloride as the primary contaminant of concern, with chloroform and trichloroethene as secondary contaminants of concern. The baseline groundwater plume is centered on a high-concentration carbon tetrachloride plume that has its source from discharges to three waste sites located south and east of the Plutonium Finishing Plant. The remedial action objective, as defined in the interim Record of Decision (EPA/ROD/R10-95/114) and carried forward into the final Record of Decision (EPA et al. 2008), states that the pump-and-treat remedy will capture the high-concentration carbon tetrachloride plume in the upper 15 meters of the unconfined aquifer. The pump-and-treat system began

Carbon tetrachloride mass was reduced in the area of highest concentrations through pumping and treating over 462.4 million liters of groundwater from fourteen extraction wells during CY 2009. This resulted in the removal of 544.4 kilograms of carbon tetrachloride.

operation in 1994 and includes fourteen extraction wells and five injection wells as of CY 2009. Groundwater extracted by the well network is processed through the 200-ZP-1 interim treatment system before it is pumped back into the aquifer at the five active injection wells. Currently, the high-concentration plume extends north of the Plutonium Finishing Plant and is centered west of WMA TX-TY. 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 the annual performance report for CY 2009, as required by the 200-ZP-1 interim Record of Decision (EPA/ROD/R10-95/114). The production metrics and operational results of the pump-and-treat activities are included in this discussion. Detailed background information, discussion on the contaminant sources, and operational results from the previous years for the 200-ZP-1 pump-and-treat system are presented in DOE/RL-2008-77 and in earlier annual reports.

7.3.2.1 Changes in 2009

During CY 2009, 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. The following summarizes the 200-ZP-1 pump-and-treat activities and developments for CY 2009:

- An upgrade of the leak-detection system at the interim pump-and-treat facility was performed in November 2008. The upgrade provides additional leak-detection coverage for the influent lines, the 200-ZP-1 treatment facility, and the effluent line.
- A new heater/chiller unit was installed to moderate temperature variations at the plant. This improvement further enhances the operational efficiency of the system.
- Additional extraction wells were installed that will eventually support remediation activities defined in the final Record of Decision (EPA et al. 2008). Well placement was guided by numerical modeling activities that were subsequently published during CY 2009.
- Several documents relevant to carbon tetrachloride pump-and-treat operations were completed, including the following:
  - DOE/RL-2008-56, *200-West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses, Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit* [in review prior to publication]
  - DOE/RL-2008-57, *Sampling and Analysis Plan for the First Set of Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit*
  - DOE/RL-2008-77, *200-UP-1 and 200-ZP-1 Operable Units Pump-and-Treat System Annual Report for Fiscal Year 2008*
  - DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*
  - DOE/RL-2009-38, *Description of Modeling Analysis in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan*
  - PNNL-18100, *Spatial Analysis of Contaminants in 200 West Area Groundwater in Support of the 200-ZP-1 Operable Unit Pre-Construction Remedy Design*

- PNNL-18118, *Revised Geostatistical Analysis of the Inventory of Carbon Tetrachloride in the Unconfined Aquifer in the 200 West Area of the Hanford Site*
- PNNL-18279, *Aquifer Testing Recommendations for Well 299-W15-225: Supporting Phase I of the 200-ZP-1 Groundwater Operable Unit Remedial Design*
- PNNL-18732, *Field Test Report: Preliminary Aquifer Test Characterization Results for Well 299-W15-225: Supporting Phase I of the 200-ZP-1 Groundwater Operable Unit Design*
- SGW-42736, *Geohydrologic Data Package in Support of 200-ZP-1 Modeling*.

7.3.2.2 Extraction System Performance

For the 318-day period that the system operated during the 15-month reporting period, the average combined rate for the extraction wells was 730.4 liters per minute. The extraction system produced 462.4 million liters of groundwater in CY 2009, which is a 34.2% increase in comparison to the 304.5 million liters of water treated in FY 2008. The increase in volume of treated groundwater is attributed to the longer reporting period of five quarters as compared with four quarters for the previous reporting period. The total volume of groundwater pumped since startup in 1994 is ~4.45 billion liters (Table 7-1). Since 2004, the amount of carbon tetrachloride removed in relation to the amount of groundwater extracted has decreased. This change likely reflects overall decreases in the concentration of carbon tetrachloride in the aquifer as reported at the influent tank. However, clogging, scale buildup, and lack of maintenance at the extraction wells cannot be eliminated as contributors to this decrease.

Groundwater flow in the vicinity of the 200-ZP-1 pump-and-treat system presents an estimate of the extent of capture developed by the system during CY 2009. During FY 2009, extraction and injection rates at the 200-ZP-1 pump-and-treat system changed as a result of facility shutdowns and aquifer testing activities. Average discharge rates for the fourteen 200-ZP-1 extraction wells by quarter are presented below:

- Period 1 (October through December): 785.5 liters per minute
- Period 2 (January through March): 1,099 liters per minute
- Period 3 (April through June): 149.1 liters per minute
- Period 4 (July through September): 580.7 liters per minute
- Period 5 (October through December): 1,038 liters per minute.

The extraction rates were uniform for the first two quarters, declined during the second two quarters, and recovered in the fifth quarter. Lower discharges for Periods 3 and 4 are attributed to facility shutdowns and aquifer testing activities.

Contaminant concentrations at the treatment system's influent tank T-01 represent a composite of all extraction well water entering the system. Average carbon tetrachloride at influent tank T-01 for CY 2009 was 1,377 µg/L.

7.3.2.3 Capture Zone Analysis

This section describes groundwater flow in the vicinity of the 200-ZP-1 pump-and-treat system and presents an estimate of the extent of capture developed by the remedy during CY 2009. Groundwater levels are measured throughout 200 West Area continuously at some wells using pressure transducers with data

loggers, and on a regular basis at other wells using manual (depth-to-water) measurements. Groundwater elevations indicate that flow is generally west to east throughout the 200 West Area. Locally these rates and directions of flow are affected by pumping at three treatment systems: 200-UP-1, 200-ZP-1, and 241-T.

Water-Level Mapping and Capture Zone Estimation Method

Flow rates and directions are affected by pumping related to remedial activities. As a result, water-level maps and estimates of the extent of capture are prepared using a method that incorporates drawdown (or mounding) in response to extraction (or injection) at wells. This technique is an alternative to using a numerical model for interpreting capture using measured water levels and pumping rates. The technique is detailed in *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance* (SGW-42305). Estimating capture using water-level mapping follows the three-step procedure described below. Derivations for the equations listed, and of additional equations that describe expected changes in water levels near rivers and ponds, are presented in "Kriging Water Levels with a Regional-Linear and Point-Logarithmic Drift" (Tonkin and Larson 2002), "A Simple Approach to Account for Radial Flow and Boundary Conditions When Kriging Hydraulic Head Fields for Confined Aquifers" (Brochu and Marcotte 2003), and SGW-42305.

Step one involves the preparation of water-level maps using universal kriging (*Geostatistics: Modeling Spatial Uncertainty* [Chiles and Delfiner 1999]; "On the Use of a Main Trend for the Kriging Technique in Hydrology" [Volpi and Gambolati 1978]), which enables a trend to be incorporated in the map. The form of the trend is defined by the analyst, and the trend coefficients are estimated automatically through kriging. For example, where planar groundwater flow exists, a linear trend is appropriate, which leads to the following estimate of the water level, H, at any location (x,y) (Equation 7-1):

$$H(x,y) = A + Bx + Cy + \varepsilon(x,y) \qquad \textbf{(Equation 7-1)}$$

where A, B, and C are regression coefficients and $\varepsilon(x,y)$ is the residual from the linear trend. Because the objective is to estimate the extent of capture, the trend must also reflect the expected response of water levels to pumping at the wells, which is accomplished using a term that can be derived from the Thiem equation or the Cooper-Jacob equation. These equations state that under quasi-steady conditions, water-level changes due to pumping are centered on the pumped well and are proportional to the logarithm of the radial distance (r) from the pumped well, the pumping rate (Q), and the aquifer transmissivity. If superposition is used to sum the effects of multiple pumped wells, these pumping effects can be combined with the linear trend to give the following water level estimator:

$$H(x,y) = A + Bx + Cy + D\sum_{1}^{n} Q_i \log_{10}(r_i) + \varepsilon(x,y) \qquad \textbf{(Equation 7-2)}$$

where n is the number of pumped wells; $Q_i \log_{10}(r_i)$ describes the effect of pumping at well i; and D is the regression coefficient corresponding to the pumping effects.

Step 2 uses particle tracking to estimate flow directions and the extent of capture using the mapped water levels. Particle tracking on a single water-level map provides an instantaneous depiction of capture corresponding to the water levels and pumping rates used to prepare that map. Because data loggers provide essentially continuous water-level data with corresponding pumping rates, maps depicting water levels and capture can be produced on any frequency. However, determining a best estimate

of capture on the basis of numerous maps can be difficult. This is accomplished in the third step of the analysis.

In the third analysis step, a capture frequency map is used to depict the capture estimated on the basis of numerous water-level maps. A capture frequency map depicts the frequency with which each released particle terminates at a pumped well, calculated over all water-level maps. A frequency of 1.0 indicates that the particle is captured on every map, a frequency of 0.0 (zero) indicates that a particle is not captured on any map, and intermediate frequencies indicate that the particle is captured on some maps and not on others. Since each individual water-level map is instantaneous, there is no explicit consideration for the time taken for contaminants to be recovered. Thus, a capture frequency map is most appropriately interpreted as an ensemble estimate for the monitoring period. Causes for frequencies below 1.0 include changing pumping rates and occasional violations of the underlying assumptions. Because low capture frequencies can be misleading, only frequencies of 0.5 and higher are depicted in the figures.

When interpreting the results of this analysis, the following should be considered:

- A capture frequency map typically provides a reasonable estimate of remedy-wide capture within the footprint of the measured data, but distinguishing the capture zones of individual wells within a multi-well remedy can be prone to error. Therefore, inferences based on a capture frequency map should focus on area-wide capture and the relative distribution of low and high frequencies.
- Results presented on the basis of water-level mapping assume that vertical flow is negligible compared to horizontal flow, which is usually a reasonable assumption at some distance from pumping wells.

Approximate Flow Patterns and Extents of Capture

Figure 7-17 summarizes pumping rates at the 200-ZP-1 pump-and-treat system and clearly indicates several distinct periods of operation for the system. The system operated reasonably continuously during three periods (identified as “ZP-1 Period 1,” “ZP-1 Period 2,” and “ZP-1 Period 3” in Figure 7-17) and intermittently at other times. Note that the 200-UP-1 and 241-T systems, which each discharge to the ETF, operated reasonably continuously the first three quarters of 2009 and were not operational for the last quarter of 2009.

Figure 7-18 depicts water-level contours throughout the 200 West Area on (a) March 19, 2009, and (b) August 6, 2009, at which times the 200-ZP-1, 241-T, and 200-UP-1 systems were operating. Figure 7-18 illustrates the impact of pumping at 200-ZP-1 and, to a lesser extent, depicts local inflections in the water levels due to pumping at the 200-UP-1 and 241-T systems. Multiple maps analogous to that presented in Figure 7-18, constructed using weekly average water levels (obtained throughout CY 2009 with transducers and corresponding pumping rates), were used to develop an estimate of the extent of capture by the 200-ZP-1 pump-and-treat system.

Figure 7-19 depicts the estimated extent of hydraulic capture developed by the system calculated from the weekly average water-level maps using a capture frequency map. Figure 7-19 was calculated using weekly average water-level maps calculated only during the periods identified as “ZP-1 Period 1,” “ZP-1 Period 2,” and “ZP-1 Period 3” in Figure 7-17. Figure 7-20 depicts the same estimated extent of hydraulic capture presented in Figure 7-19, together with contours depicting the extent of groundwater contaminated by carbon tetrachloride.

Conclusions

At the 200-ZP-1 pump-and-treat system, the majority of extraction (and injection) wells penetrate a small fraction of the total saturated thickness of the unconfined aquifer. The capture frequency map presented on the basis of water-level mapping assumes that vertical flow is negligible compared to horizontal flow, which is usually a reasonable assumption at some distance from pumping wells. Therefore, the most reasonable assumption is that the capture frequency map is valid for the upper portion of the unconfined aquifer that is intercepted by the majority of the extraction wells. In this case, the validity of the capture frequency map diminishes with increasing depth below the bottom of the screened intervals of the majority of extraction wells.

The overlay of the capture frequency map prepared using the water-level mapping technique with contours depicting the extent of carbon tetrachloride (Figure 7-20) suggests that, when operating, the current 200-ZP-1 system is likely effective in containing a majority of the high-concentration carbon tetrachloride plume present in the upper portion of the aquifer within the high capture frequencies. Beyond these areas, and at some depth below the bottom of the screened intervals of the majority of the extraction wells, the 200-ZP-1 system is not effective at containing the carbon tetrachloride. An analysis similar to that presented here, and reaching similar conclusions, was presented in the 200-ZP-1 OU feasibility study (DOE/RL-2007-28) and formed the basis of the 200-ZP-1 system design documented in the final Record of Decision (EPA et al. 2008).

7.3.2.4 Treatment System Performance

The total amount of carbon tetrachloride removed in CY 2009 was 544.4 kilograms (Table 7-1), which is a 15.2% increase in mass removal in comparison to 461.5 kilograms removed in FY 2008. The increase in mass removal is due, in part, to the change to reporting on the basis of CY (which encompasses five quarters) rather than FY (which encompasses four quarters) reported for 2008.

The online availability in CY 2009 was 62.5% compared to 62.3% in FY 2008. The performance measurement was low because of leak-detection alarms, system upgrade activities, and aquifer testing activities during CY 2009. Total availability (which factors out scheduled downtimes and, therefore, emphasizes the impact of unscheduled outages) was 65.4% in FY 2009. This is a decrease from the 95.5% reported in FY 2008 and is a result of leak-detection alarms and aquifer testing. Treatment system availability is shown in Table 7-2. Figure 7-21 depicts monthly online availability, and Figure 7-22 provides a graphical representation of the carbon tetrachloride removal efficiency calculated by influent and effluent concentrations at the process facility.

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 vapor 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.

7.3.2.5 Compliance Monitoring

The carbon tetrachloride and trichloroethene plumes (Figures 7-3 and 7-10, respectively) have been defined by semiannual (or higher frequency) analytical data, including the results from twelve active groundwater monitoring wells and fourteen extraction wells penetrating the upper aquifer in the plume area. The data provide the primary means to determine the effectiveness of the 200-ZP-1

pump-and-treat system, evaluate remedial action objectives, and support delineating the current plume. Chloroform is also monitored as a decay product of carbon tetrachloride. Trend plots for carbon tetrachloride, chloroform, and trichloroethene concentrations at the monitoring and extraction wells during the current and previous three FYs are presented in Figures 7-23, 7-24, and 7-25, respectively.

The CY 2009 contaminant monitoring highlights at the 200-ZP-1 pump-and-treat system 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) remained stable in size, but the average concentrations declined in the wells defining this area since the FY 2008 reporting period. The maximum average concentration of 2,200 µg/L was reported at extraction wells 299-W15-40, 299-W15-44, and 299-W15-765.
  - The area enclosed by the 1,000 µg/L contour for carbon tetrachloride remained stable in size in CY 2009 relative to FY 2008. The 1,000 µg/L contour was extended slightly northeast of WMA T and south of the 216-Z-9 Trench.
  - The chloroform concentrations were reduced to the greatest extent in the main portion of the carbon tetrachloride plume. Monitoring wells with chloroform concentrations greater than 20 µg/L showed a general decline across the monitoring well network in CY 2009 relative to FY 2008 measurements.
  - The CY 2009 trichloroethene plume increased in size and extent, primarily to the north beneath WMA T. The areas of highest concentration continues to occur at extraction wells in the main carbon tetrachloride plume.
- Extraction wells:
  - The CY 2009 carbon tetrachloride concentrations in extraction wells generally showed a decreasing trend in comparison to FY 2008. Average annual concentrations exceeded 2,000 µg/L at three of the fourteen extraction wells. Average annual values ranged from 350 to 2,200 µg/L. The FY 2006 and FY 2007 concentrations showed a decreasing trend, and an increasing trend was shown for FY 2008.
  - None of the quarterly sampling results for extraction wells exceeded 3,000 µg/L for carbon tetrachloride during CY 2009.
  - The CY 2009 average carbon tetrachloride concentration at southernmost extraction well 299-W15-36 was 350 µg/L, which is a decrease of 140 µg/L from the FY 2008 average. The last time this well exceeded the 2,000 µg/L limit was in July 2000.
  - 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 2009 concentration was 1,700 µg/L, with a high value of 1,900 µg/L reported in December 2009.
  - Chloroform levels in extracted groundwater have not exceeded the 80 µg/L DWS at any well since August 1996. Maximum concentrations at the extraction wells in CY 2009 ranged from 2.1 µg/L at well 299-W15-45 to 20 µg/L at well 299-W15-44.
  - The average trichloroethene 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 14 µg/L at well 299-W15-44.

- Monitoring wells:
  - The highest carbon tetrachloride concentrations measured within the performance monitoring well network occurred at wells 299-W11-87 and 299-W15-50, with maximum quarterly concentrations of 3,900 µg/L and 3,200 µg/L, respectively.
  - Chloroform concentrations at all wells monitoring the upper unconfined aquifer continued to be well below the 80 µg/L DWS.
  - The highest trichloroethene average annual value for CY 2009 was measured at monitoring well 299-W11-34P (14.0 µg/L).
- Deep wells:
  - Carbon tetrachloride concentrations above the remedial action objective were measured in deep wells 299-W13-1 and 299-W11-87, located near the eastern boundary of the 200 West Area. These wells are screened deep in the unconfined aquifer, just above the Ringold mud unit and, therefore, are not included on the plume map. The average annual carbon tetrachloride concentrations were 2,400 µg/L for well 299-W11-87 and 2,100 µg/L for well 299-W13-1. Average concentrations for carbon tetrachloride in the other eight deep monitoring wells ranged from 1 to 1,300 µg/L.
  - Chloroform concentrations at each of the ten deep wells that are part of the overall monitoring network were stable or decreasing, with average concentrations ranging from 3 to 28 µg/L.
  - Maximum trichloroethene concentrations measured in the ten deep monitoring wells ranged from 1 to 9.4 µg/L. Average annual concentrations exceeding the 5 µg/L DWS occurred only at wells 299-W13-1 and 299-W14-71.

7.3.2.6 Carbon Tetrachloride Monitoring Results

The purpose of monitoring the carbon tetrachloride contaminant plume within the 200-ZP-1 OU is to track the removal of contamination from groundwater, with the intent of reducing concentration to below 2,000 µg/L, prevent further migration of the plume to downgradient receptors, and reduce the plume footprint. This section addresses those aspects of the carbon tetrachloride plume. Prior to startup of pump-and-treat operations in 1994, the maximum carbon tetrachloride concentration had exceeded 4,000 µg/L south of WMA TX-TY, in the area of the 216-Z Cribs and Trenches. Since pump-and- treat operations began, the high-concentration footprint has been reduced to near the high-concentration area (greater than 2,000 µg/L) in all monitoring wells, with the exception of three extraction wells west of WMA TX-TY. The maximum concentration of 2,200 µg/L was reported during CY 2009 in shallow aquifer wells 299-W15-40, 299-W15-44, and 299-W15-765. During FY 2008, five extraction wells exceeded the remedial action objective, and all extraction wells showed declines in concentration in CY 2009.

The overall footprint of the carbon tetrachloride plume did not change appreciably from FY 2008 to the current reporting period. The 2,000 µg/L and 1,000 µg/L plume contours, which are nearest to the extraction well network, were comparable to the contours generated during FY 2008.

7.3.2.7 Secondary Contaminants

Chloroform levels in extracted groundwater have not exceeded the 80 µg/L DWS at any well since the August 1996 startup of Phase II operations. Maximum concentrations at the extraction wells during CY 2009 ranged from 2 µg/L

(well 299-W15-45) and 19 to 20 µg/L (wells 299-W15-44, 299-W15-40, and 299-W15-765). Average chloroform concentrations at the extraction wells were decreasing or stable compared to FY 2008 annual averages. The source of chloroform is interpreted to be from the degradation of carbon tetrachloride (DOE/RL-2007-22, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid [DNAPL] Source Term Characterization Report Addendum*).

The trichloroethene concentrations exceeded the 5 µg/L DWS at three of the fourteen extraction wells. The CY 2009 average annual trichloroethene concentration was above the DWS at wells 299-W15-40 (7 µg/L), 299-W15-44 (8 µg/L), and 299-W15-765 (6 µg/L). The CY 2009 concentrations generally showed a stable trend at all extraction wells compared to FY 2008 values. The maximum detected concentration was 14 µg/L at well 299-W15-44.

The trichloroethene levels were at or exceeded the DWS of 5 µg/L at 2 of 21 monitoring locations. For CY 2009, the average annual trichloroethene concentration measured in the monitoring wells ranged from 1.0 to 9.5 µg/L. Monitoring wells with concentrations at or above the DWS are located south of WMA T (i.e., wells 299-W15-41 and 299-W15-50). None of the eight wells monitoring the southern portion of the carbon tetrachloride plume had detectable concentrations of trichloroethene in CY 2009. Wells in the high-concentration portion of the carbon tetrachloride plume showed decreasing or stable trichloroethene values when compared to FY 2008.

Chloroform and trichloroethene concentrations have also been monitored in the ten deep wells located east of the pump-and-treat system. Levels of both chloroform and trichloroethene showed generally stable trends in the nine of the ten deep wells in CY 2009. Chloroform levels have been well below the DWS, ranging from 1 to 18 µg/L. Only wells 299-W13-1 (5 µg/L) and 299-W14-71 (7.8 µg/L) had average trichloroethene concentrations exceeding the DWS.

7.3.2.8 Historical Plume Trends

The carbon tetrachloride plume map for CY 2009 is presented in Figure 7-3. The systematic reduction in the size and extent of the plume (as observed over the previous 2 years, and based on the area enclosed by the 2,000 and 1,000 µg/L contours) showed a slight decrease in CY 2009. However, sampling data for the wells located in the region to the south of the current southern extent of 1,000 µg/L contour continued to show a slight increase in concentrations. The current plume configuration indicates that the 200-ZP-1 pump-and-treat activities in CY 2009 were successful in continuing to reduce the distribution of carbon tetrachloride in the upper 15 meters of the unconfined aquifer, as has been observed in previous years.

The area enclosed by the 2,000 µg/L contour representing the central plume core showed a slight reduction in size in CY 2009. This portion of the plume also showed lower average annual concentrations in CY 2009 than in FY 2008 for each of the ten FY 2008 extraction wells. The highest concentration detected in the core of the carbon tetrachloride plume during the reporting period was 2,660 µg/L, which occurred during the first quarter of FY 2009 at extraction well 299-W15-44 at the southwestern corner of WMA TX-TY.

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 2009. The current plume map (Figure 7-3) shows that the northern portion of the carbon tetrachloride plume perimeter is further east and northeast of WMA T relative to where it was noted in FY 2008. A detailed discussion of carbon tetrachloride plume reduction

since inception of the pump-and-treat remedy is provided in Appendix H of DOE/RL-2008-77.

7.3.3 Pump-and-Treat System for Technetium-99

Technetium-99 mass was reduced in the area of highest concentrations through pumping and treating more than 74.0 million liters of groundwater from two extraction wells during CY 2009. This resulted in removal of 33,993 kilograms of nitrate, 22.7 grams of technetium-99, 13.2 grams of uranium, and 95.9 kilograms of carbon tetrachloride.

A pump-and-treat test system began operating in September 2007 as part of a designed interim remediation activity to treat technetium-99 contamination, specifically to the east of and within WMA T. The interim remediation activity was implemented as part of the general remedial guidance for the 200-ZP-1 OU based on the interim Record of Decision (EPA/ROD/R10-95/114) and the data quality objectives process (WMP-28389, *T-Area Technetium-99 Data Quality Objectives Summary Report*). The pump-and-treat test system currently consists of two extraction wells (299-W11-45 and 299-W11-46) that dispose the extracted groundwater via a direct discharge line connection to the 200 Areas Liquid Effluent Retention Facility (LERF), and then to the ETF.

Technetium-99 is most commonly found in the 200 West Area in groundwater downgradient of the tank farms or liquid disposal waste sites associated with tank farm or evaporator processes. Potential sources for technetium-99 include the 216-T-21 through 216-T-25 Cribs; the 216-T-26 through 216-T-28 Cribs; the 242-T evaporator; and the T, TX, and TY Tank Farms. The following subsections address CY 2009 activities in regard to technetium-99 groundwater contamination at the 200-ZP-1 OU.

7.3.3.1 Changes in 2009

The groundwater 241-T pump-and-treat system, adjacent to WMA T, consists of two extraction wells that operated from November 17, 2008, through October 14, 2009. Well 299-W11-46 operated at full capacity for the entire operational period. Well 299-W11-45 experienced pump problems early during system operation that were resolved; the well came online in January 2009 and was then fully operation for the remainder of the reporting period. There were no other disruptions or modifications to the extraction system during CY 2009.

7.3.3.2 Extraction System Performance

Average pumping rates during CY 2009 at wells 299-W11-45 and 299-W11-46 were 37.9 liters per minute and 113.6 liters per minute, respectively. The average discharge rate from both wells is 149 liters per minute. Total volume discharge from wells 299-W11-45 and 299-W11-46 was 15,575,967 liters and 62,129,861 liters, respectively. The volume of water removed during FY 2008 was 44,870,953 liters. The higher total volume, in part, reflects the five quarters of reporting during CY 2009 relative to four quarters for FY 2008.

During CY 2009, extraction rates at the 241-T pump-and-treat system changed as a result of facility shutdowns. Average extraction rates for the two extraction wells (299-W11-45 and 299-W11-46) by quarter are as follows:

- Period 1 (October through December): 66.6 liters per minute
- Period 2 (January through March): 165.0 liters per minute
- Period 3 (April through June): 165.8 liters per minute
- Period 4 (July through September): 169.6 liters per minute
- Period 5 (October through December): 177.9 liters per minute.

Discharge rates are lower during the first quarter due to facility shutdown; however, pumping rates were maintained for the remaining three quarters at a consistent rate. The pumping rate for the fifth quarter reflects operations for the

first 14 days in October, after which the system was shutdown through December for maintenance to the ETF. Target contaminants collected by the extraction system include technetium-99, carbon tetrachloride, nitrate, trichloroethene, and hexavalent chromium.

7.3.3.3 Capture Zone Analysis

This section describes groundwater flow in the vicinity of the 241-T system and presents an estimate of the extent of capture developed by the system during CY 2009. Groundwater levels are measured continuously throughout the 200 West Area at some wells using pressure transducers with data loggers, and on a regular basis at other wells using manual (depth-to-water) measurements. Groundwater elevations indicate that flow is generally west to east throughout the 200 West Area, but these rates and directions of flow are affected by pumping at three treatment systems (200-UP-1, 200-ZP-1, and 241-T).

Approximate Flow Patterns and Extents of Capture

Figure 7-26 summarizes the pumping rates at the 241-T system and clearly illustrates two distinct periods of operation for the system. The 241-T pump-and-treat system, which discharges to the ETF, operated continuously during a single period (identified as "241-T Period 1" in Figure 7-26) comprising the first three quarters of 2009 and was not operational for the last quarter of 2009. The nearby 200-ZP-1 system operated reasonably continuously during three periods and intermittently at other times.

The water-level mapping and capture zone estimate method described previously for the 200-ZP-1 system (Section 7.4.3) was used to develop a capture frequency map to depict the capture estimated on the basis of numerous water-level maps. Figure 7-27 depicts the water-level contours in the vicinity of the 241-T pump-and-treat system on (a) March 19, 2009, and (b) August 6, 2009, at which times the 241-T system (and the nearby 200-ZP-1 and 200-UP-1 systems) were operating. Figure 7-27 illustrates the impact of pumping at the 241-T system. Multiple maps analogous to those presented in Figure 7-27 (constructed using weekly average water levels obtained throughout CY 2009 with transducers and corresponding pumping rates) were used to develop an estimate of the extent of capture developed by the 241-T system.

Figure 7-28 depicts the estimated extent of hydraulic capture by the 241-T system calculated from the weekly average water-level maps using a capture frequency map. Figure 7-28 was calculated using weekly average water-level maps calculated only during the period identified as "241-T Period 1" in Figure 7-26 (i.e., at times when the 241-T system was operating). Figure 7-29 depicts the same estimated extent of hydraulic capture that is presented in Figure 7-28, as well as contours depicting the extent of groundwater contaminated by technetium-99.

Conclusions

The overlay of the capture frequency map with contours depicting the extent of technetium-99 (Figure 7-29) suggests that pumping at the 241-T system is well situated to recover technetium-99 from groundwater and that the current remedy may successfully contain and ultimately recover the majority of the detected technetium-99. However, the 450 pCi/L contour is not fully encompassed by the high capture frequencies, and the absence of monitoring wells to the north of the 241-T extraction wells leads to some uncertainty in the extent of capture (i.e., the margins of the capture zone) in that direction.

7.3.3.4 Treatment System Performance

The effluent from the 241-T extraction wells is pumped to the LERF prior to transfer and removal of contaminants at the ETF. The ETF processed waste during the four quarters of FY 2009 (October 2008 through September 2009) but was offline during the last quarter of CY 2009 (October 2009 through December 2009) for facility maintenance. The percent availability of the 241-T pump-and-treat system for the reporting period is shown in Figure 7-30. Well 299-W11-46 was offline from October 2008 through November 17, 2008. The percentage availability for this well after November 17, 2008, was 96.4%. If the downtime before startup is factored in, the availability was 89.7%. Well 299-W11-45 was offline from October 2008 through January 13, 2009, and after restart had an availability of 95.8%.

The nitrate, technetium-99, uranium, and carbon tetrachloride mass removed from the extraction wells is based on reported quarterly concentration and groundwater volume pumped. During CY 2009, the total mass removed was as follows: nitrate at 33,993 kilograms, technetium-99 at 22.7 grams (0.38 Ci), uranium at 13.2 grams, and carbon tetrachloride at 95.9 kilograms.

Removal efficiency refers to the mass of each contaminant that is processed through the ETF relative to the mass of contaminant remaining when discharged as effluent to the SALDS. For the contaminants nitrate, technetium-99, and uranium, the removal efficiencies are reported as 100% for all four quarters of FY 2009. For carbon tetrachloride, removal efficiencies were 100% for all months, except for the last week in May and the first 2 weeks in June when removal efficiency was 99.8%. Due to facility maintenance, the ETF was not operational during the last quarter of CY 2009 and, consequently, the extraction well network was also in standby mode at that time.

7.3.3.5 Compliance Monitoring

Three distinct technetium-99 plumes are discernable in the 200-ZP-1 OU. All of the technetium-99 plumes originate from the T Tank Farm, TX-TY Tank Farm, or associated cribs. To address the high technetium-99 concentrations in WMA T, monitoring wells 299-W11-45 and 299-W11-46 were converted to extraction wells in September 2007 as part of a pump-and-treat test. The wells were connected to a cross-site pipeline that transfers contaminated water to the ETF in the 200 East Area for treatment. Prior to startup of groundwater extraction, the fourth quarter FY 2007 technetium-99 concentrations at wells 299-W11-45 and 299-W11-46 were 19,100 pCi/L and 113,000 pCi/L, respectively. Concentrations have steadily decreased at both wells since system startup in 2007. The maximum concentrations of technetium-99 reported in wells 299-W11-45 and 299-W11-46 for CY 2009 were 6,400 pCi/L and 8,600 pCi/L, respectively.

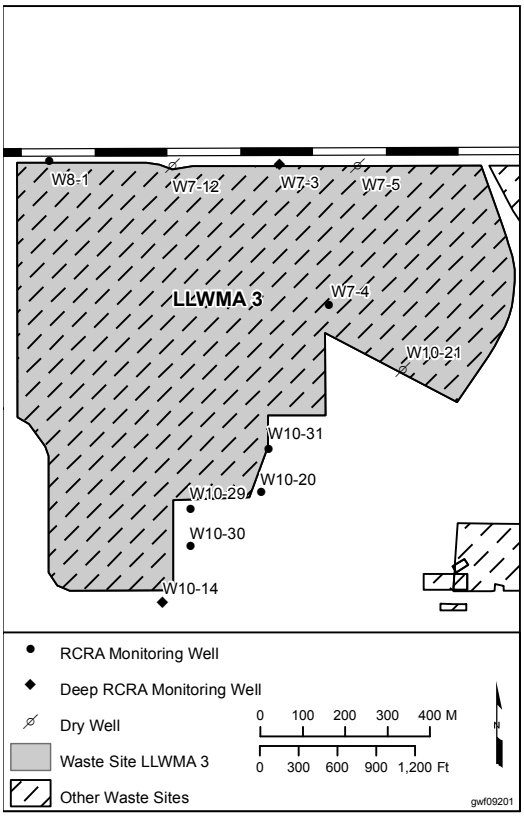
The two extraction wells that comprise the 241-T pump-and-treat system are designed to capture the technetium-99 plume beneath the T Tank Farm (Figure 7-16). The pump-and-treat wells are located in close proximity to the high-concentration core of the plume. All wells downgradient from the T Tank Farm have shown a decline in technetium-99 concentration since pumping began in 2007. The highest concentrations appear in the two extraction wells (299-W11-45 and 299-W11-46). These wells have also exhibited the largest absolute decline in contaminant levels, as shown in Figure 7-31. Monitoring well 299-W11-47, which is directly east of the T Tank Farm, has retained a relatively constant concentration profile since before startup of pump-and-treat operations through CY 2009. The maximum concentration recorded in this well was 442 pCi/L in 2006, and the highest concentration reported

in CY 2009 was 420 pCi/L. Technetium-99 concentrations in well 299-W11-34P (northeast of the T Tank Farm) also remain fairly high at 400 pCi/L, which is a decrease from the FY 2008 concentration of 460 pCi/L. Deep monitoring well 299-W10-33, located at the southern edge of the T Tank Farm, does not show appreciable levels of technetium-99 in the groundwater. This well was drilled in 2007 and is sampled at vertically discrete intervals in the saturated zone. Records indicate that technetium-99 is present at concentrations of 458 pCi/L in the shallow water table and has been non-detected at depths greater than 15 meters since well completion.

7.4 Facility Monitoring

This section describes the results of monitoring at individual units such as treatment, storage, and disposal units or tank farms. Some of these units are monitored under RCRA requirements for dangerous waste constituents and under AEA for source, special nuclear, and byproduct materials. Data from facility-specific monitoring are also integrated into CERCLA groundwater investigations. Dangerous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. Pursuant to RCRA, the source, special nuclear, and byproduct material components of radioactive mixed waste are not regulated under RCRA but are instead regulated by the U.S. Department of Energy (DOE), acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information purposes only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

The 200-ZP-1 OU contains four RCRA sites with groundwater monitoring requirements: LLWMA-3, LLWMA-4, WMA T, and WMA TX-TY. This section summarizes the results of statistical comparisons, assessment studies, and other developments for this reporting period. Groundwater data are available in the Hanford Environmental Information System database and in the data files accompanying this report. Additional information (including well and constituent lists, maps, flow rates, and statistical tables) is included in Appendix C.



7.4.1 Low-Level Waste Management Area 3

D. A. Gamon

Groundwater at LLWMA-3, in the north-central portion corner of the 200 West Area (Figure 7-1), 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.

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 *Washington Administrative Code* [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). The AEA monitoring requirements were derived from *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds* (DOE/RL-2000-72). All of the wells were successfully sampled during the reporting period. Appendix C, Table C-23 includes a list of wells, constituents monitored, and the indicator parameter comparison values. The following subsections provide the annual evaluation requirements for the monitoring network, groundwater results, and compliance status.

7.4.1.1 Network Evaluation

New wells have been postponed until the effects of the proposed expansion of the pump-and-treat activities in the 200 West Area have been evaluated.

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 six wells. Samples are analyzed for the indicator parameters, anions, and metals semiannually, and for mercury, lead, phenols, and volatile organic compounds 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 two wells along the northern boundary and four wells along the southeastern boundary. Wells 299-W7-3 and 299-W10-14 are screened at the bottom of the unconfined aquifer; the other network wells are screened at the water table. The two northern boundary wells are now more cross-gradient to groundwater flow direction due to changing flow direction in this area. The only previously existing upgradient well on the western side of the WMA, well 299-W9-1, went dry in 2000. The LLWMA-3 has had no upgradient monitoring wells since that time. No new wells are expected at LLWMA-3 until the effects of the enhanced 200-ZP-1 OU pump-and-treat system are known.

The water table continued to decline beneath LLWMA-3 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 groundwater flow direction in this portion of 200 West Area is northeast across LLWMA-3 based on the March 2009 water-level data (Figure 7-2).

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 C, Table C-1). A current groundwater map that includes LLWMA-3 is shown in Figure 7-2.

Appendix C, Figure C-12 shows the location of wells in the LLWMA-3 monitoring network. All wells were sampled as scheduled during the reporting period.

7.4.1.2 Groundwater Contaminants

Groundwater at LLWMA-3 is monitored under RCRA and AEA 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). Performance assessment monitoring of radionuclides at LLWMA-3 is designed to complement RCRA detection monitoring and is aimed specifically at monitoring radionuclides that are not regulated under RCRA. The current goal of performance assessment monitoring at LLWMA-3 is to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information to interpret changes. Under the current monitoring plan

(DOE/RL-2000-72), technetium-99, iodine-129, tritium, and uranium are monitored specifically for performance assessment.

- Technetium-99 concentrations were all less than 20 pCi/L during the reporting period. The only detected concentration was 12 pCi/L in well 299-W10-31. Historically, the technetium-99 concentration in this well has been at undetectably low levels. Section 7.2.7 discusses the technetium-99 distribution in the 200-ZP-1 OU.
- Uranium concentrations at LLWMA-3 were less than 2 µg/L (maximum of 1.33 µg/L in well 299-W7-3) during the reporting period. These values are well below the DWS of 30 µg/L.
- Iodine-129 was detected above the DWS in one well during the reporting period (3.16 pCi/L in well 299-W10-30). Iodine-129 had not previously been detected in any wells currently in use at LLWMA-3.
- Tritium was detected in only one well, 299-W8-1, at a low level (820 pCi/L) in June 2009. This well borders the northwestern edge of LLWMA-3 and is cross-gradient from the groundwater flow direction at the LLWMA. The following September 2009 sample result was at non-detectable levels, as was previously the trend for this well.
- Carbon tetrachloride and associated trichloroethene 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 concentration was 120 µg/L in well 299-W10-31. Carbon tetrachloride concentrations in well 299-W10-31 show a decreasing trend since the well was drilled in FY 2006.
- The nitrate distribution at LLWMA-3 is consistent with regional plumes (Section 7.2.3). The maximum concentration during the reporting period (42.8 mg/L) was in well 299-W10-31.

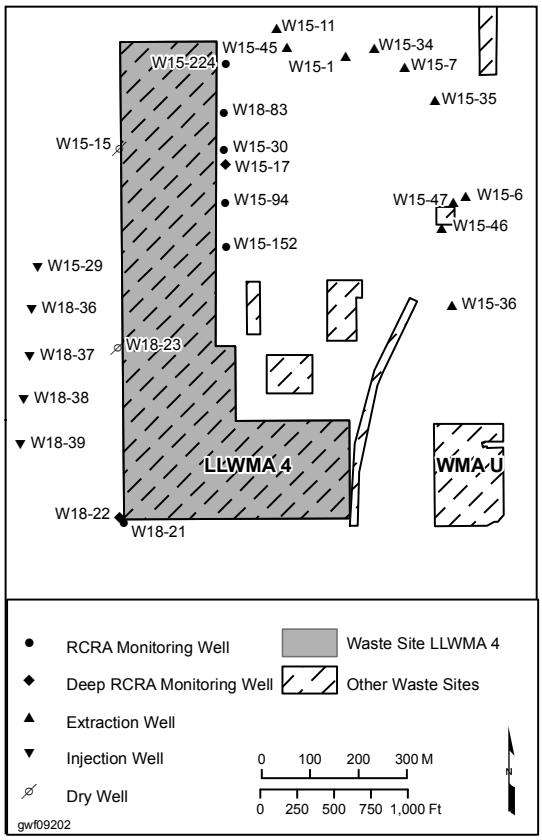
7.4.1.3 Compliance Status

Interim status indicator evaluation groundwater monitoring at LLWMA-3 will continue in FY 2010. Statistical evaluations at LLWMA-3 will remain suspended until new upgradient wells are constructed.

7.4.2 Low-Level Management Area 4

D. A. Gamon

The LLWMA-4 is located in the 200 West Area, just west of the Plutonium Finishing Plant and the U Tank Farm (Figure 7-1). 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, as modified in 40 CFR 265 and *Revised Code of Washington* (RCW) 70.105, "Hazardous Waste



Management," and its implementing requirements in Washington State's dangerous waste regulations (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 indicator and site-specific parameters (PNNL-14859). The AEA monitoring requirements were derived from DOE/RL-2000-72. All of the wells were successfully sampled during the reporting period. Appendix C, Table C-24 includes a list of wells, constituents monitored, and the indicator parameter comparison values. The following subsections provide annual evaluation requirements for the monitoring network, groundwater results, and compliance status.

7.4.2.1 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 east.

The monitoring network at LLWMA-4 consists of two upgradient wells and six downgradient wells. Upgradient wells 299-W15-15 and 299-W18-23 went dry in 2008. The upgradient well pair 299-W18-21 (screened at the water table) and 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. These wells were upgradient wells 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 the wells, which is no longer upgradient of the facility in relation to the existing downgradient wells located northeast of this well pair. 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 are screened across or at the top of the water table. The LLWMA-4 is sampled semiannually and analyzed for the indicator parameters, anions, and metals. Mercury, lead, phenols, and volatile organic compounds are 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.

The water table continued to decline beneath the LLWMA-4 monitoring wells 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. 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.

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 C, Table C-1). A current groundwater map that includes LLWMA-4 is shown in Figure 7-2.

Appendix C, Figure C-13 provides the location of wells in the LLWMA-4 monitoring network. All wells were sampled as scheduled during the reporting period.

7.4.2.2 Groundwater Contaminants

Groundwater at LLWMA-4 is monitored under RCRA and AEA 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). Performance assessment monitoring of radionuclides at LLWMA-4 is designed to complement RCRA detection monitoring and is aimed specifically

at monitoring radionuclides that are not regulated under RCRA. The current goal of performance assessment monitoring at LLWMA-4 is to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, tritium, and uranium are monitored specifically for performance assessment.

As in previous years, downgradient wells continued to exceed the statistical comparison value for total organic halides in all samples during the reporting period. Well 299-W15-30 is a replacement for well 299-W15-16, which has gone dry. The DOE previously reported the exceedance of the statistical comparison value in well 299-W15-16 (now dry) to the EPA and Washington State Department of Ecology (Ecology) in August 1999. The exceedances have also been iterated in annual groundwater reports. The elevated total organic halide concentrations are consistent with observed levels of carbon tetrachloride from Plutonium Finishing Plant operations (Section 7.2.1).

During the early part of the reporting period, technetium-99 concentrations increased in upgradient well 299-W18-21 (maximum concentration of 260 pCi/L) and increased slightly in downgradient well 299-W15-152 (maximum concentration of 300 pCi/L). In the latter part of the reporting period, the concentration of technetium-99 decreased in upgradient well 299-W18-21 (minimum concentration of 54 pCi/L). Several other downgradient wells (299-W15-30, 299-W15-83, and 299-W15-94) had slight increases in technetium-99 concentrations during the year. These increases and decreases in concentrations (fluctuations) may be the result of injection and extraction well operations in proximity to WMA TX-TY.

The highest annual average uranium concentration during the reporting period was 22.6 µg/L in upgradient well 299-W18-21, which is below the DWS of 30 µg/L. This reporting period, the uranium value is consistent with the FY 2008 concentration of 22 µg/L in this well. Uranium concentrations in the other monitoring wells ranged from ~1 µg/L to 2.2 µg/L. These concentrations are consistent with regional concentrations.

Iodine-129 was not detected in LLWMA-4 wells during the reporting period, as was the case in FY 2008.

The highest tritium concentrations ranged from 1,400 to 1,600 pCi/L in downgradient wells during the reporting period. The tritium concentration continued an overall decreasing trend in upgradient well 299-W18-21: from ~6,000 pCi/L in 1998 and 1,500 pCi/L in FY 2008, to 410 pCi/L for the reporting period. The tritium concentration remained steady or non-detect in all other current monitoring wells during the reporting period. Tritium concentrations are consistent with regional concentrations.

Nitrate continued to exceed the DWS at all monitoring wells, except deep downgradient well 299-W15-17 (27 mg/L), deep upgradient well 299-W18-22 (19 mg/L), and water table upgradient well 299-W18-21 (37.8 mg/L). During the reporting period, concentrations ranged from 19 to 129 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.

Carbon tetrachloride concentrations display downward or stable trends in all wells in the network for which historical data are available. During the reporting period,

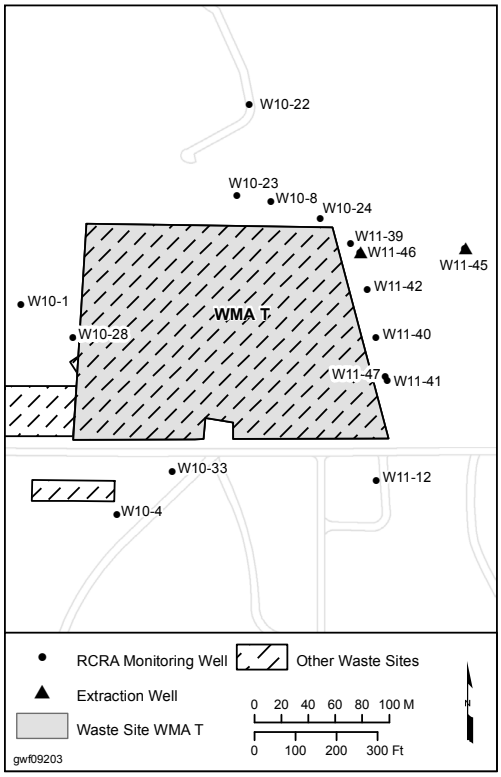
the maximum carbon tetrachloride concentration in well 299-W15-94 declined from 310 µg/L in FY 2008 to 170 µg/L. Known sources of carbon tetrachloride include the 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib (DOE/RL-2006-20). Chloroform and trichloroethene concentrations remained below the DWS in all LLWMA-4 wells. None of the wells had trichloroethene concentrations above detection limits.

7.4.2.3 Compliance Status

Total organic carbon exceeded the statistical comparison value (critical mean) in well 299-W15-224 in August 2008 (FY 2008). Requests for data review were submitted, and new samples submitted for reanalysis. The resampling event took place in December 2008, and the results received in January 2009 indicated that no organic compounds were identified that would account for the elevated total organic carbon.

In January 2009, the Soil and Groundwater Remediation Project prepared a groundwater quality assessment plan to evaluate the elevated total organic carbon (SGW-40211, *First Determination RCRA Groundwater Quality Assessment Plan for the Low-Level Burial Grounds Low-Level Waste Management Area 4)*, which proposed sampling of wells 299-W15-224, 299-W15-30, and 299-W15-83 for additional analytes. The samples were analyzed for 40 CFR 264, Appendix IX ("Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; Ground-Water Monitoring List") volatile organic and semivolatile organic compounds, total organic halides, chemical oxygen demand, oil and grease, phenols, pesticides, herbicides, polychlorinated biphenyls, dioxans, dissolved oxygen, total petroleum hydrocarbons (diesel, gasoline, and kerosene), and coliform bacteria.

In July 2009, the results of the first determination did not find dangerous waste/dangerous waste constituents in the groundwater at LLWMA-4, and monitoring returned to indicator evaluation monitoring, as reported in *Groundwater Quality Assessment Plan for Low-Level Waste Management Area 4* (SGW-41903). Interim status indicator evaluation groundwater monitoring at LLWMA-4 will continue in FY 2010.



7.4.3 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 (Figure 7-1) and was used for interim storage of radioactive waste from chemical processing of reactor fuel for plutonium production. The WMA is regulated under RCRA, as modified in 40 CFR 265, Subpart F ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; Preparation, Evaluation, and Response; Ground-Water Monitoring") and RCW 70.105, and its implementing requirements in Washington State's dangerous waste regulations (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. 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.

7.4.3.1 Network Evaluation

Appendix C, Table C-34 lists the constituents to be analyzed for RCRA monitoring. The wells are sampled quarterly, semiannually, or annually each year.

Appendix C, Table C-34 also indicates the purpose of each well and whether the wells meet WAC requirements. The network currently consists of two upgradient, two assessment, one far-field, and nine downgradient monitoring wells. 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, and the direction of groundwater flow is not expect to change greatly in the near future.

However, the 200-ZP-1 pump-and-treat system is in the process of being expanded in the 200 West Area. The change to this system is expected to impact groundwater flow direction and velocity at WMA T, but the magnitude and direction of the changes will not be known until after the system becomes operational late in 2011. 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.

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 C, Table C-1). A current groundwater map that includes WMA T is shown in Figure 7-2. All wells were sampled as scheduled during the reporting period.

7.4.3.2 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 7.4.3, 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, *Interim-Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Areas T and TX-TY*). Elevated specific conductance in the well, principally a result of 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 started a rapid increase in late 1995 and exceeded the critical mean in early 1996. In the case of 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 trichloroethene. The source for the carbon tetrachloride and trichloroethene contamination was liquid disposal associated with processes at the Plutonium Finishing Plant and not

The primary dangerous waste constituents found beneath WMA T in 2009 are chromium, carbon tetrachloride, and trichloroethene. The source for the carbon tetrachloride and trichloroethene was liquid disposal associated with processes at the Plutonium Finishing Plant and not WMA T.

WMA T (Sections 7.2.1 and 7.2.2). 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 well 299-W10-4 (552 µg/L), located at the southwestern corner of the WMA. The highest chromium concentration found in wells screened within the aquifer in WMA T was 216 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 138 µg/L. The highest chromium concentration in adjacent downgradient well 299-W11-39 (screened at the water table) was 54.9 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. This well's highest annual concentration for the reporting period was 152 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 fluoride plume was present north and east of WMA T during the reporting period. The highest fluoride concentration exceeding the 4.0 mg/L primary DWS during the reporting period was in well 299-W10-8 (4.86 mg/L).

A local nitrate plume is located within the regional nitrate plume beneath WMA T (Figure 7-11). The plume retained the same general configuration as in FY 2008. During the reporting period, the highest annual nitrate concentrations were in upgradient wells 299-W10-28 (1,440 mg/L) and 299-W10-4 (3,070 mg/L). The nitrate concentrations above the DWS in downgradient wells were between 73 and 770 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.

A technetium-99 plume is centered along the eastern (downgradient) side of WMA T (Figure 7-16). The maximum technetium-99 concentrations in the upper portion of the aquifer are in downgradient wells 299-W11-40 (9,800 pCi/L) and 299-W11-42 (9,000 pCi/L). These wells are currently located in the center of the plume. The remainder of the monitoring wells showed decreasing concentration trends or remained stable. The largest annual decrease was noted in well 299-W11-40, which decreased from 6,800 to 700 pCi/L throughout the year and follows the trends of wells in this area.

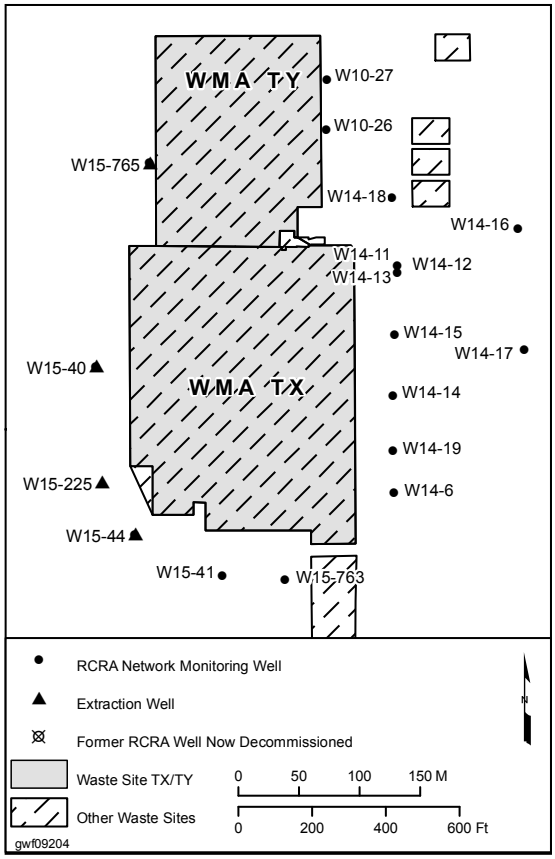
Figure 7-32 shows the technetium-99 concentration in downgradient wells that are screened at the water table and at depth below the water table. The technetium-99 concentration indicates a decreasing trend in all wells screened deeper in the aquifer during the reporting period, which is likely due to nearby pump-and-treat operations.

7.4.3.3 Compliance Status

Assessment status groundwater monitoring at WMA T will continue in CY 2010.

7.4.4 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 (Figure 7-1) and was used for interim storage of radioactive waste from chemical processing of reactor fuel for plutonium production. The WMA is regulated in accordance with WAC 173-303 and the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). This plan implements the requirements of WAC 173-303-400, incorporating by reference 40 CFR 265, Subpart F, documenting the assessment-level groundwater monitoring program for WMA TX-TY.

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 is 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 hazardous waste or hazardous waste constituents in the groundwater and the concentration of those hazardous waste or hazardous waste constituents in the groundwater.

During CY 2009, special sampling of an older carbon-steel well 299-W15-3 was performed in May 2009. Analytical results showed the highest technetium-99 concentration (40,000 pCi/L) that has been found at WMA TX-TY.

7.4.4.1 Network Evaluation

The network currently consists of two upgradient, two mid-field, and twelve downgradient monitoring wells. Some of the wells in the monitoring network are also sampled for the 200-ZP-1 OU. Sampling for WMA TX-TY and 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 is expected to be dry in 2010.

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 late in 2011.

7.4.4.2 Groundwater Contaminants

As stated in Section 7.4.4, 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. In the case of 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 include carbon tetrachloride and trichloroethene. The carbon tetrachloride and trichloroethene are attributed to other waste sites associated with Plutonium Finishing Plant operations (Sections 7.2.1 and 7.2.2). Nitrate and fluoride are also found in the groundwater beneath the WMA. Chromium is the dangerous constituent monitored under the RCRA assessment program.

During the reporting period, a special sampling of well 299-W15-3 was performed in May 2009 at the request of the project scientist. The well is located inside the TY Tank Farm and adjacent to tank TY-106. The well was drilled in 1952, is constructed of carbon steel, and perforated from 61 to 72 meters below ground surface. The well was last sampled in 1991. The results show that the groundwater from well 299-W15-3 has extremely high concentrations of most major and minor cations and anions, as well as some contaminants. Summing the major cations and anions yields a salinity of 4.67% (compared to 0.83% in the next most contaminated well, 299-W14-13).

Of particular note is 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 nitrate found at well 299-W14-11 (3,600 mg/L) during drilling. The nitrate concentration in 1991 at well 299-W15-3 was 117 mg/L. Also noted were the very low tritium (5,100 pCi/L) and iodine-129 (0.42 pCi/L) concentrations and the 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, thus making comparison of the 2009 values not possible.

During the reporting period, nitrate concentrations exceeded the DWS (45 mg/L) in all wells in the monitoring network. Figure 7-11 shows a plume map for nitrate in the area. Overall, the nitrate concentrations remain stable in most wells at WMA TX-TY.

The highest nitrate concentration at the WMA during the reporting period was 677 mg/L in downgradient well 299-W10-27. The nitrate concentration in other downgradient wells was between 41.4 mg/L (299-W14-14) and 391 mg/L (299-W14-13). Much of the nitrate contamination is attributed to Plutonium Finishing Plant 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 7.2.3 provides information on nitrate in the north-central 200 West Area.

In CY 2009, chromium was detected above the 100 µg/L DWS in some wells within WMA TX-TY. The highest chromium concentration was 744 µg/L in downgradient well 299-W14-13, which was a slight increase from FY 2008 concentrations. 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 217 µg/L. These results are nearly identical to the FY 2008 concentrations, 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 concentration of chromium during the reporting period was 88.1 µg/L. Historically, chromium concentrations decrease rapidly in monitoring wells south of this well, and this trend continued during CY 2009.

Nitrate, technetium-99, and iodine-129 accompanied chromium, and all four contaminants showed the same trend through FY 2008 as shown in the first part of the reporting period (Figure 7-33). This might have indicated that all four contaminants shared a common source and that part of the plume passed through the well during a short period of time between the end of FY 2007 and beginning of FY 2008 (Figure 7-33).

A small tritium plume exists along the east-central portion of WMA TX-TY (Figure 7-14). The tritium concentration exceeded the 20,000 pCi/L DWS in three wells in the area. The highest reporting period tritium concentration was 1.6 million pCi/L in well 299-W14-13. The highest tritium concentration in adjacent well 299-W14-11 (screened from 11.6 to 14.6 meters below the water table) was 400,000 pCi/L during the reporting period. The tritium concentrations in these two wells indicate that the highest concentrations are found near the water table in this area. The source for the high tritium in the area could be WMA TX-TY, the 242-T evaporator, the 216-T-19 Crib and Tile Field (which received evaporator condensate from the 242-T evaporator), the 216-T-26 through 216-T-28 Cribs, or a combination of these potential sources.

Iodine-129 exceeded the 1 pCi/L DWS in three wells during the reporting period (Figure 7-15). The highest iodine-129 concentration measured at the WMA during the reporting period was 34.5 pCi/L in the January 2009 sample from well 299-W14-13. The average iodine-129 concentration was 26 pCi/L during the reporting period. The average iodine-129 concentration in adjacent and deeper screened well 299-W14-11 was 11 pCi/L. Well 299-W14-17, which is east of well 299-W14-15, had increasing detectable levels of iodine-129 this year. This increase in concentration indicates part of the plume may be moving eastward in this area.

During the reporting period, technetium-99 exceeded the DWS of 900 pCi/L in downgradient network monitoring wells 299-W14-11 and 299-W14-13 and one mid-field, non-network well (299-W15-3, as noted above). The highest technetium-99 concentration in network monitoring well 299-W14-13 was 6,400 pCi/L. The highest concentration in deeper well 299-W14-11 was 3,900 pCi/L. The data from these two wells indicate that the highest technetium-99 concentrations are near the water table in this area (similar to chromium, nitrate, and iodine-129). The technetium-99 concentration also increased in well 299-W14-17 in October 2009 from the previous concentration of 540 to 900 pCi/L, indicating the plume may be moving eastward in this area.

Technetium-99 is also above the DWS in wells south and west of WMA TX-TY, where it is likely drawn to the wells from groundwater beneath the TX and TY Tank

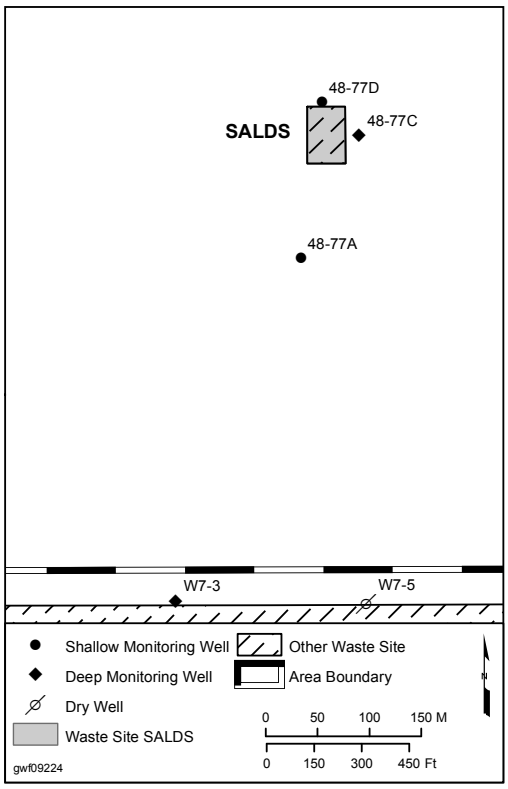
Farms by the 200-ZP-1 pump-and-treat system extraction wells. Wells 299-W15-44 and 299-W15-765 began operation as extraction wells for the 200-ZP-1 OU in July 2005 and, shortly thereafter, technetium-99 concentrations began to increase in the wells.

As in FY 2008, the nuclear activation product, nickel-63, was found in wells 299-W14-11 and 299-W14-13 during the reporting period. The highest concentrations were 145 pCi/L in well 299-W14-11 and 422 pCi/L in well 299-W14-13. One-twenty-fifth of the derived concentration guideline (equivalent to 4 mrem) for nickel-63 is 12,000 pCi/L, which is far larger than the detected concentrations at the WMA.

7.4.4.3 Compliance Status

Assessment status groundwater monitoring at WMA TX-TY will continue in FY 2010.

7.4.5 State-Approved Land Disposal Site



The ETF processes contaminated aqueous waste from various Hanford Site facilities. The treated wastewater contains tritium, which cannot be removed by the ETF, and it is discharged to the 200 Areas 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 FY 2009, 90.4 million liters of water were discharged to the SALDS compared to 75.15 million liters in FY 2008.

A state waste discharge permit (WAC 173-216, "State Waste Discharge Permit Program") requires groundwater monitoring at this site. 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).

For all of the wells, the hydraulic head has declined an average of 0.38 meters per year. This average rate of decline includes increasing water levels at the three proximal wells at 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.

Numerical flow and transport modeling of the SALDS was performed during FY 2009, as required by the State of Washington to comply with State Waste Discharge Permit ST 4500.

7.4.5.1 Network Evaluation

Groundwater monitoring for tritium was conducted in twelve wells around the facility (Appendix C, Figure C-20). The 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 C, Table C-43).

Wells immediately surrounding the facility were sampled four times during CY 2009. 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 ETF. 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.

7.4.5.2 Groundwater Contaminants

The primary contaminant of concern at the SALDS is tritium. Additional constituents sampled include the 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 SGW-42604, Appendix A.

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

During 2009, the maximum tritium activities decreased by an order of magnitude at well 699-48-77A (77,000 pCi/L) but remained unchanged from values reported in FY 2008 in the other two proximal wells: 699-48-77C (64,000 pCi/L) and 699-48-77D (110,000 pCi/L). The decline in tritium concentration at well 699-48-77A (shown in Figure 7-34) shows a return to normal operations after high-concentration discharges associated with ETF treatment of K Basin wastewater in FY 2008. Concentrations of all chemical constituents with permit limits were within the permit limits 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. Concentrations of lead, copper, and mercury were present at 0.32 µg/L, 2.2 µg/L, and less than detection, respectively. Concentrations of major anions and cations continued at below the background levels observed prior to operation of the facility. The low concentrations are due, in part, to mixing with clean water discharged to the SALDS.

7.4.5.3 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 2009 confirmed that the SALDS was in compliance with the terms described in the state waste discharge permit.

7.5 Conclusions and Recommendations

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

7.5.1 Conclusions

The 200-ZP-1 OU is located on the Central Plateau of the Hanford Site, in the northern half of the 200 West Area separations area. Waste discharge associated with processing of nuclear material was released to the ground at specific waste disposal and storage facilities, resulting in groundwater contamination. The primary constituents of concern in the 200-ZP-1 OU are carbon tetrachloride and technetium-99. Remedial action at this OU has focused on pump-and-treat operations to capture and contain the high-concentration regions of these plumes. Two distinct pump-and-treat systems are currently in operation. The pump-and-treat network that addresses carbon tetrachloride contamination has been active since 1995 and currently consists of fourteen extraction wells and five injection wells. The primary source of carbon tetrachloride is from cribs and trenches south of WMA TX-TY, with the main plume located along the western edge of the WMA. The pump-and-treat

network that addresses technetium-99 contamination has been in service since 2007 and consists of two extractions wells located east of WMA T.

Monitoring and performance assessment of the pump-and-treat network for the 200-ZP-1 OU are subject to regulation in accordance with RCRA and CERCLA. The final remedy for treatment of the carbon tetrachloride plume, as agreed to by the Tri-Parties (i.e., DOE, EPA, and Ecology), is documented in the final Record of Decision for the 200-ZP-1 OU (EPA et al. 2008).

The 200-ZP-1 interim pump-and-treat system continues to remove carbon tetrachloride from the highest concentration area west of WMA TX-TY. Fewer wells exceeded the high concentration limit of 2,000 µg/L during CY 2009 than observed in FY 2008. However, the maximum extent of the carbon tetrachloride plume (to the 5 µg/L DWS) expanded slightly to the boundary of the 200 West Area, though the concentrations continue to decline as the source is contained and the carbon tetrachloride is subject to dispersion and decay. Remediation of carbon tetrachloride influent at the treatment facility continues to perform at near 100% removal efficiency. Effluent concentration from the treatment facility to the reinjection wells is consistently below the 5 µg/L DWS.

Observation of technetium-99 concentration in wells near the high-concentration core, east of WMA T, shows declines in all wells during CY 2009 relative to FY 2008. Technetium-99 concentration remains constant at downgradient well 299-W11-7, northeast of the pumping wells that are beyond the pump-and-treat capture zone. Other wells located downgradient from the source zone also show a general decline in technetium-99 compared to previous FYs. Technetium-99 plumes adjacent to WMA TX-TY are subject to capture by the 200-ZP-1 interim pump-and-treat system. Most monitoring wells show stable to decreasing trends for technetium-99 during CY 2009 relative to FY 2008.

Measurable progress was made in FY 2008 toward meeting the specific RAOs. 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 original 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 operating within the 2,000 µg/L portion of the plume. Carbon tetrachloride north of the high-concentration area is migrating 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. These issues are addressed under the final Record of Decision for the 200-ZP-1 OU (EPA et al. 2008). An expanded pump-and-treat system will be installed and operational by 2011.

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

  During CY 2009, 544.4 kilograms of carbon tetrachloride were removed from 462.4 million liters of groundwater. Since the startup of the pump-and-treat operations, ~11,977 kilograms of carbon tetrachloride have been removed from over 4.4 billion liters of groundwater. The volume of water treated in CY 2009 was ~34.2% more than FY 2008, which is the result of the longer reporting period. 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 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 Groundwater 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 also issued to support the final remedy. Data collected over the last 12 years of pump-and-treat system operation were used to develop the final Record of Decision (EPA et al. 2008).

7.5.2 Recommendations

The recommendations for the 200-ZP-1 OU include the following:

- 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 the optimum design and operation of the remediation facility.
- Collect additional depth-discrete groundwater samples during installation of new final extraction/injection wells to assist in defining the vertical distribution of carbon tetrachloride, the appropriate length of well screens, and the 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 if there is any degradation in well efficiency. If well performance is found to have declined due to scale buildup on the screen and in the filter pack, well rehabilitation should be planned.

Table 7-1. Volume Extracted and Processed Since Startup at the 200-ZP-1 Interim Pump-and-Treat System.

Total processed groundwater:	
Total groundwater processed in FY 2009 (liters)	340,615,682
Total groundwater processed in first quarter FY 2010 (liters)	121,813,691
Total groundwater processed since startup (March 1994) to end of FY 2009 (billions of liters)	4.33
Total groundwater processed since startup (March 1994) to end of first quarter FY 2010 (billions of liters)	4.45
Carbon tetrachloride mass removed:	
Total mass of carbon tetrachloride removed in FY 2009 (kilograms)	373.96
Total mass of carbon tetrachloride removed in first quarter FY 2010 (kilograms)	170.42
Total mass of carbon tetrachloride removed since startup (March 1994) (kilograms)	11,790.56
Total mass of carbon tetrachloride removed since startup (March 1994) to end of first quarter FY 2010 (kilograms)	11,960.98
Summary of FY 2009 operational parameters:	
Removal efficiency % by mass, average for year - [(influent - effluent) / (influent)] x 100	99.6%

Notes:
FY = fiscal year

Table 7-2. Treatment System Availability at the 200-ZP-1 Interim Pump-and-Treat System.

FY 2009 availability:	
Total possible hours run in a year	8,760.0
Scheduled outages (e.g., connecting new wells, maintenance, etc.) (hours)	393.2
Unscheduled outages (primarily shutdowns due to leak detection alarms shutdowns) (hours)	2,892.5
Total time online (hours)	5,474.3
Online availability ([{total hours - total outages hours} / total hours] x 100)	62.5%
Total availability ({total hours - total outage hours} / {total hours - scheduled outage hours} x 100)	65.4%
First quarter FY 2010 availability:	
Total possible hours run in first quarter	2,208.0
Scheduled outages (e.g., connecting new wells, maintenance, etc.) (hours)	8.1
Unscheduled outages (primarily shutdowns due to leak detection alarms shutdowns) (hours)	32.2
Total time online (hours)	2,167.7
On-line availability ([{total hours - total outages hours} / total hours] x 100)	98.2%
Total availability ({total hours - total outage hours} / {total hours - scheduled outage hours} x 100)	98.5%

Notes:
FY = fiscal year

Figure 7-1. Facilities and Groundwater Monitoring Wells in the 200-ZP-1 Operable Unit.

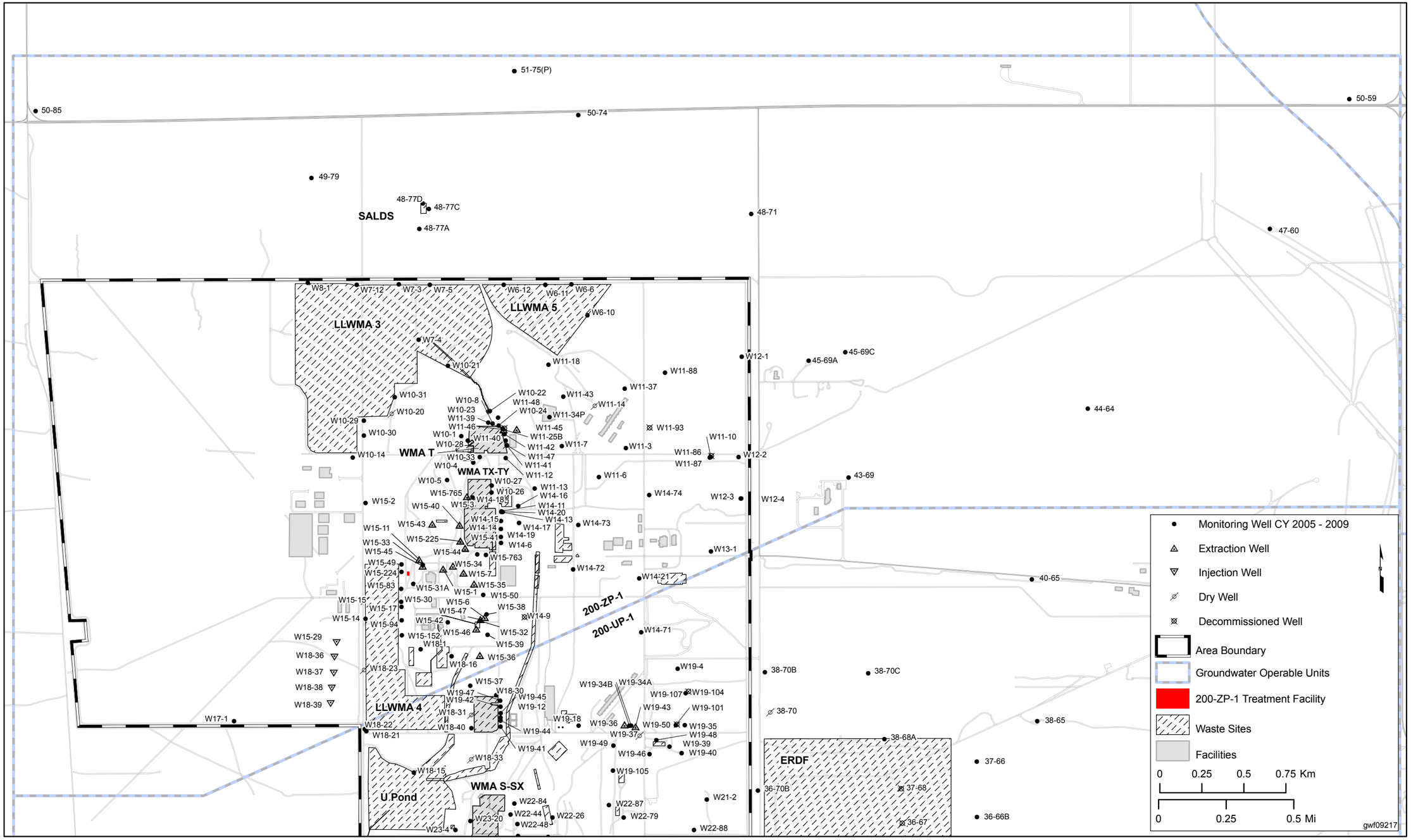


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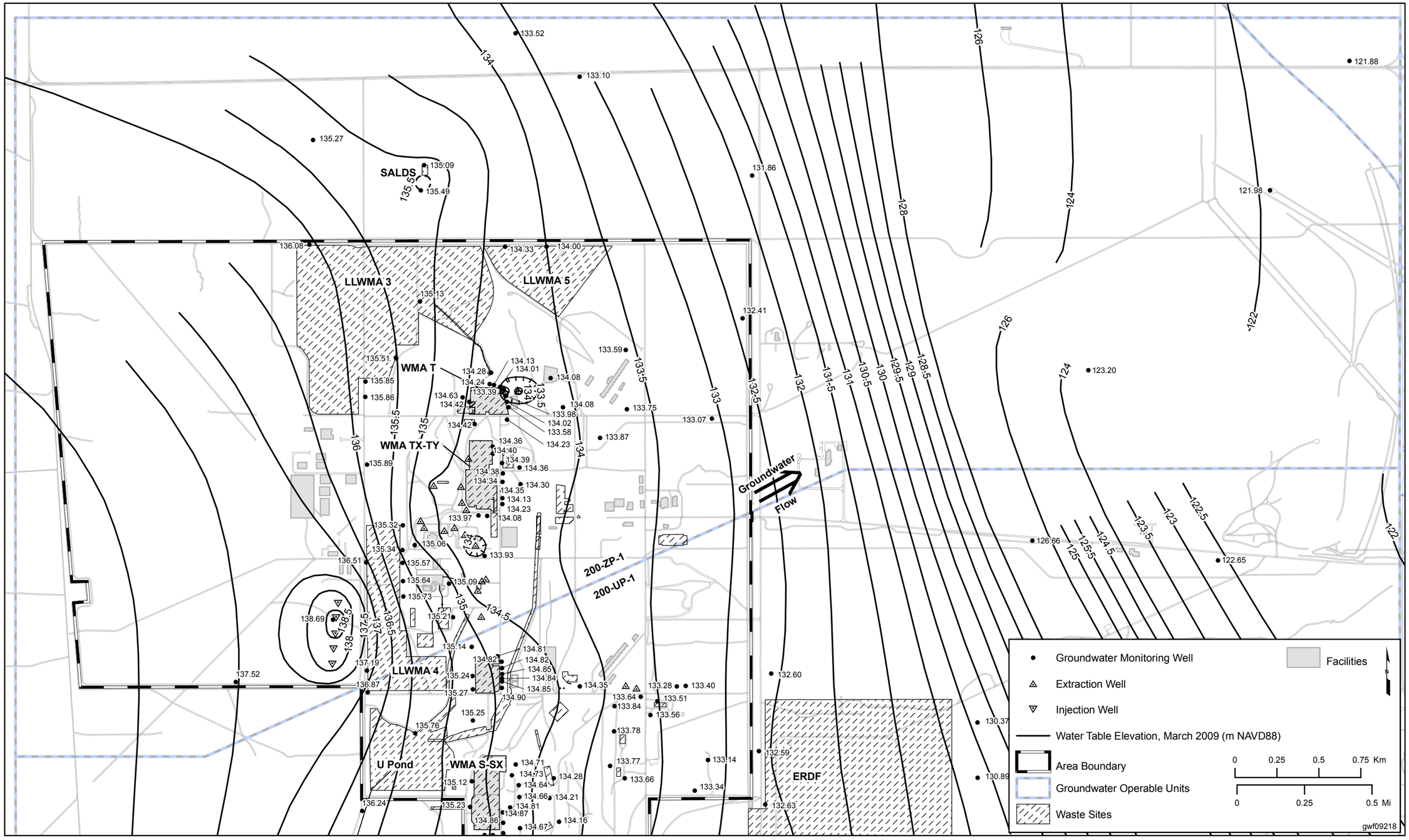
Figure 7-2. 200 West Area Water Table Map, Calendar Year 2009.



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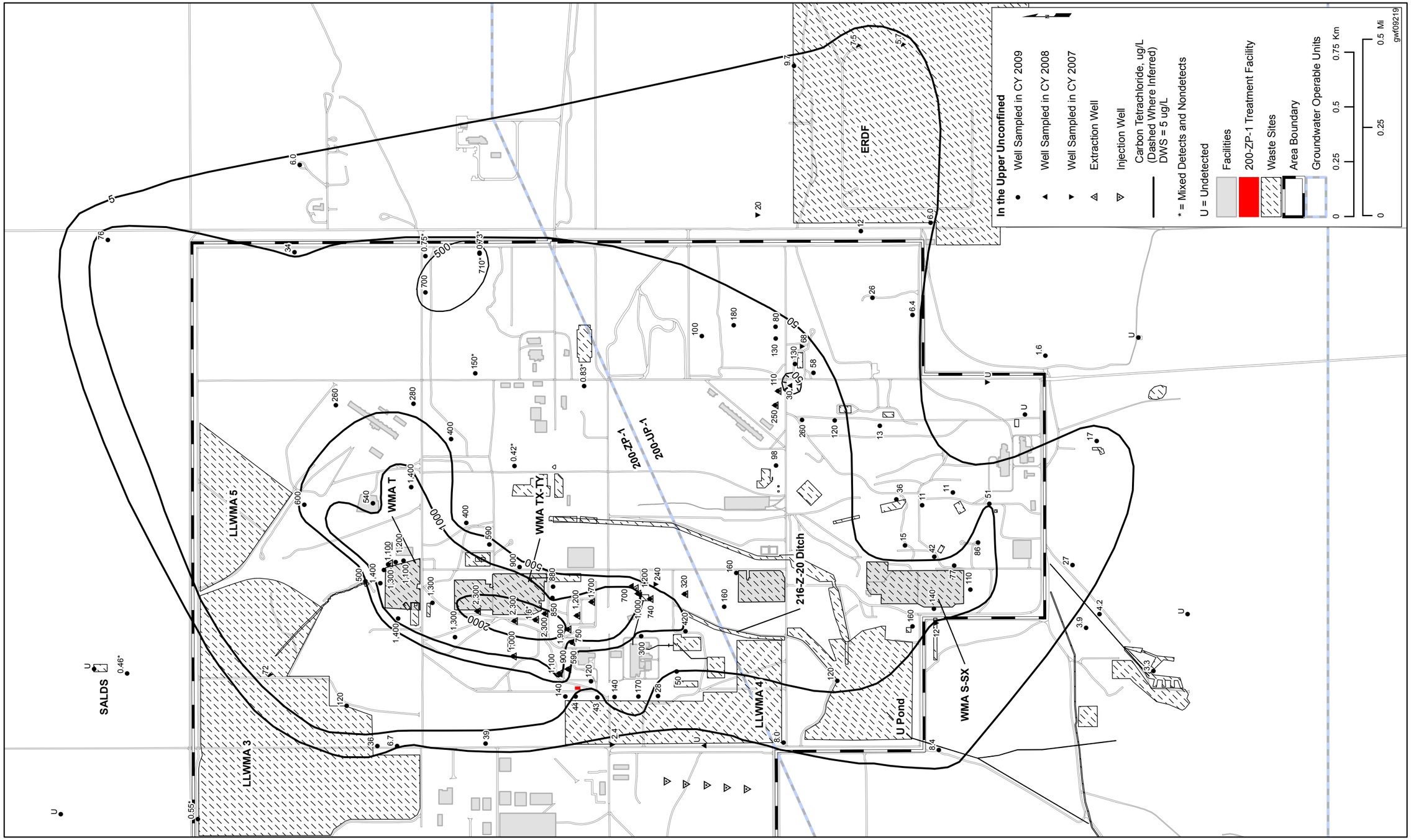

Figure 7-3. Average Carbon Tetrachloride Concentration in the 200 West Area, Upper Portion of Unconfined Aquifer.

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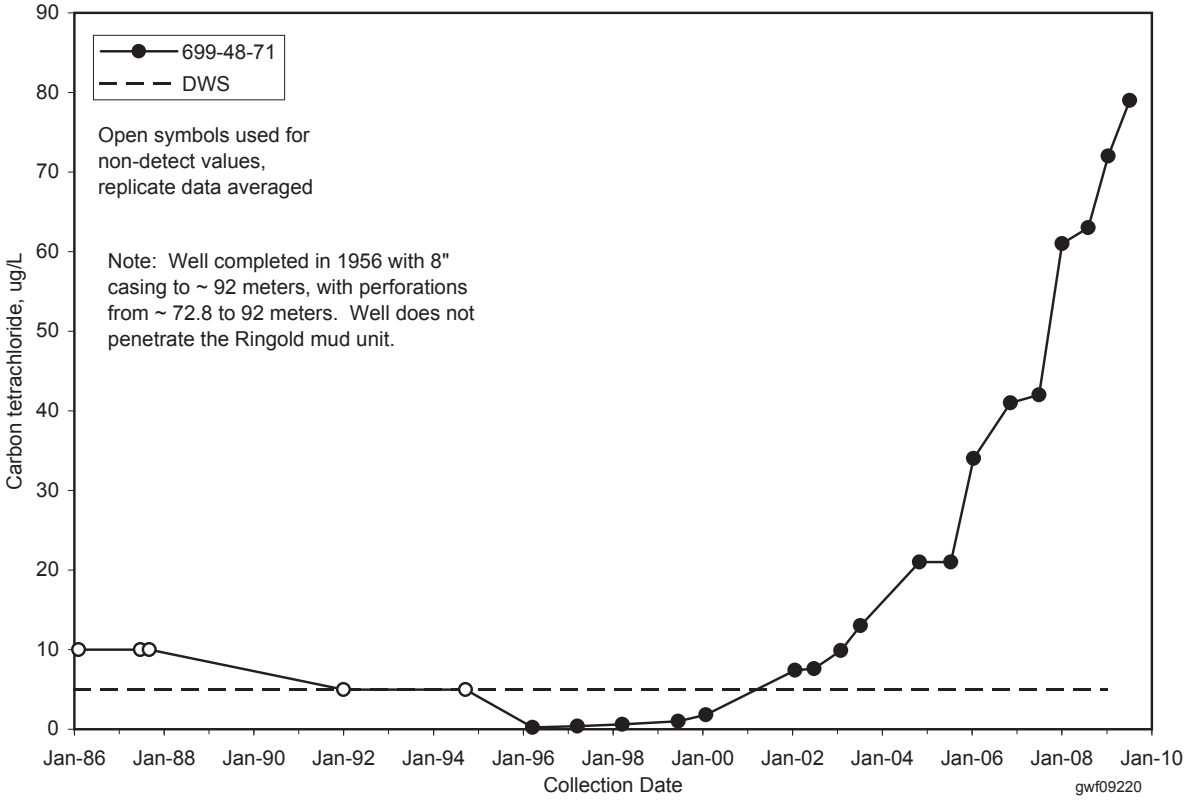
Figure 7-4. Carbon Tetrachloride Concentration in Well 699-48-71, Northeast of the 200 West Area.



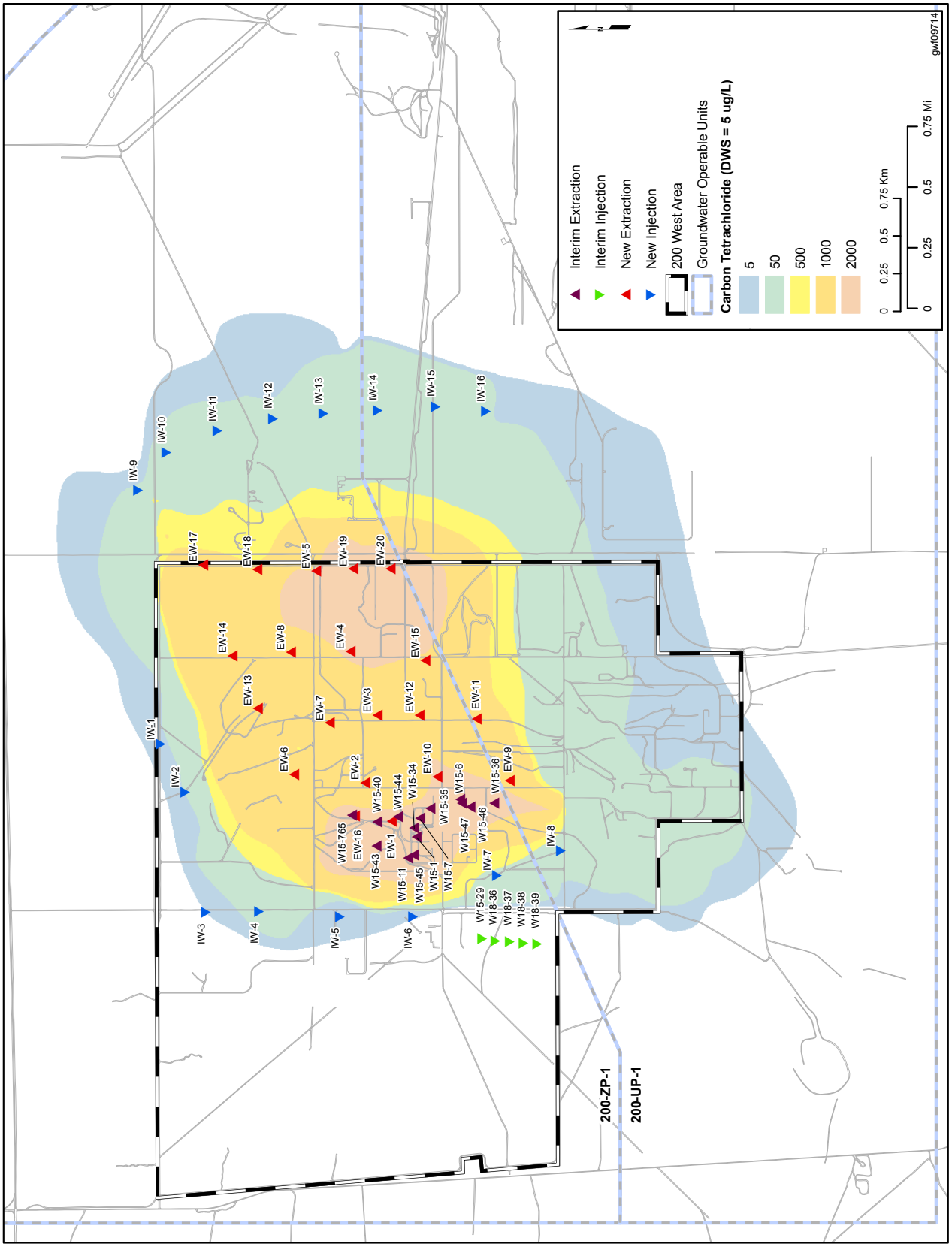


Figure 7-5. Average Carbon Tetrachloride Concentration in 200 West Area Within All of the Suprabasalt Sediments and New Treatment System Extraction and Injection Wells.

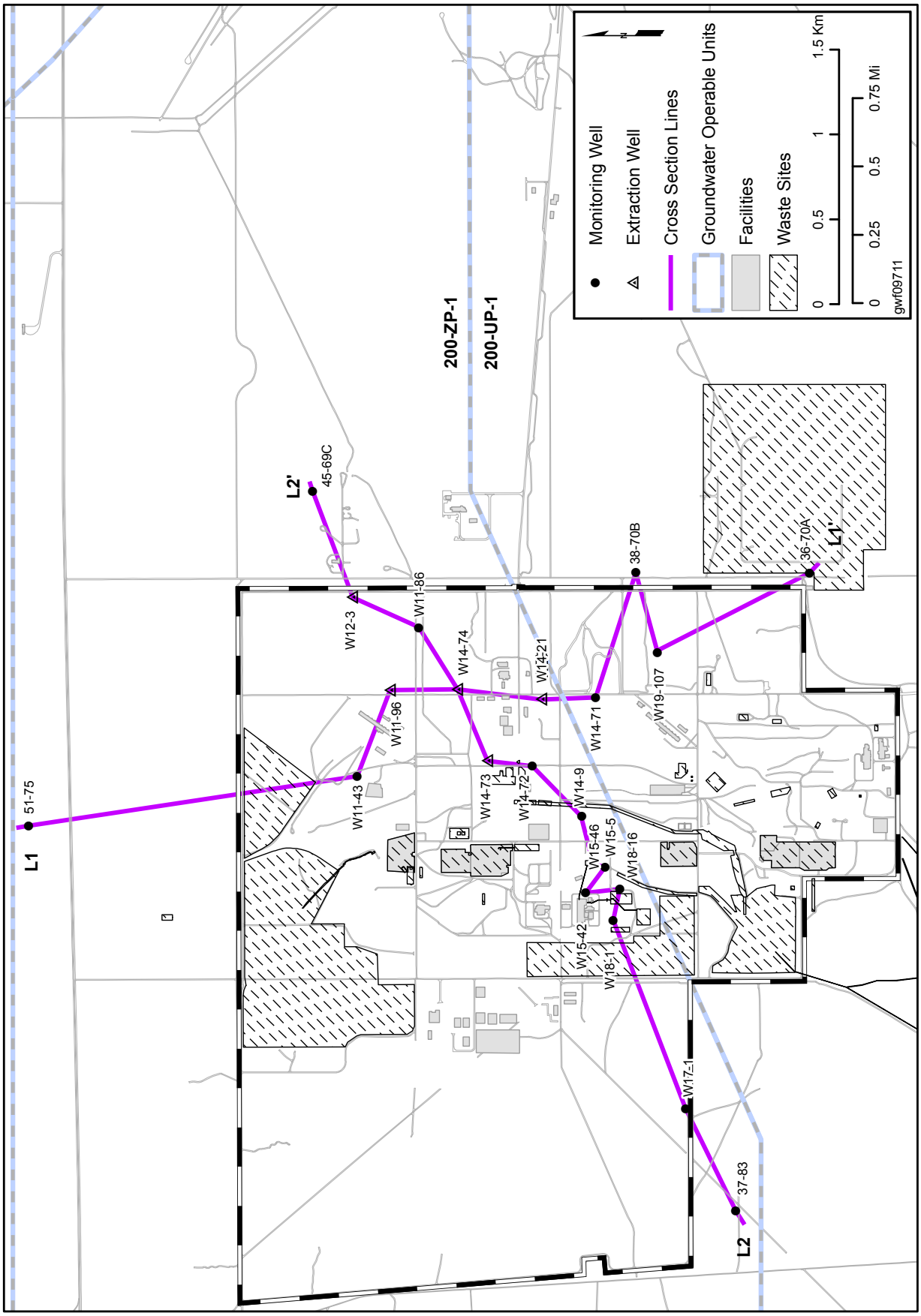


Figure 7-6. 200-ZP-1 Carbon Tetrachloride Transect Lines for Vertical Profile Slices L1-L1' and L2 L2'.

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Figure 7-7. 200-ZP-1 Groundwater Operable Unit Carbon Tetrachloride Plume Cross Section L1 L1'.

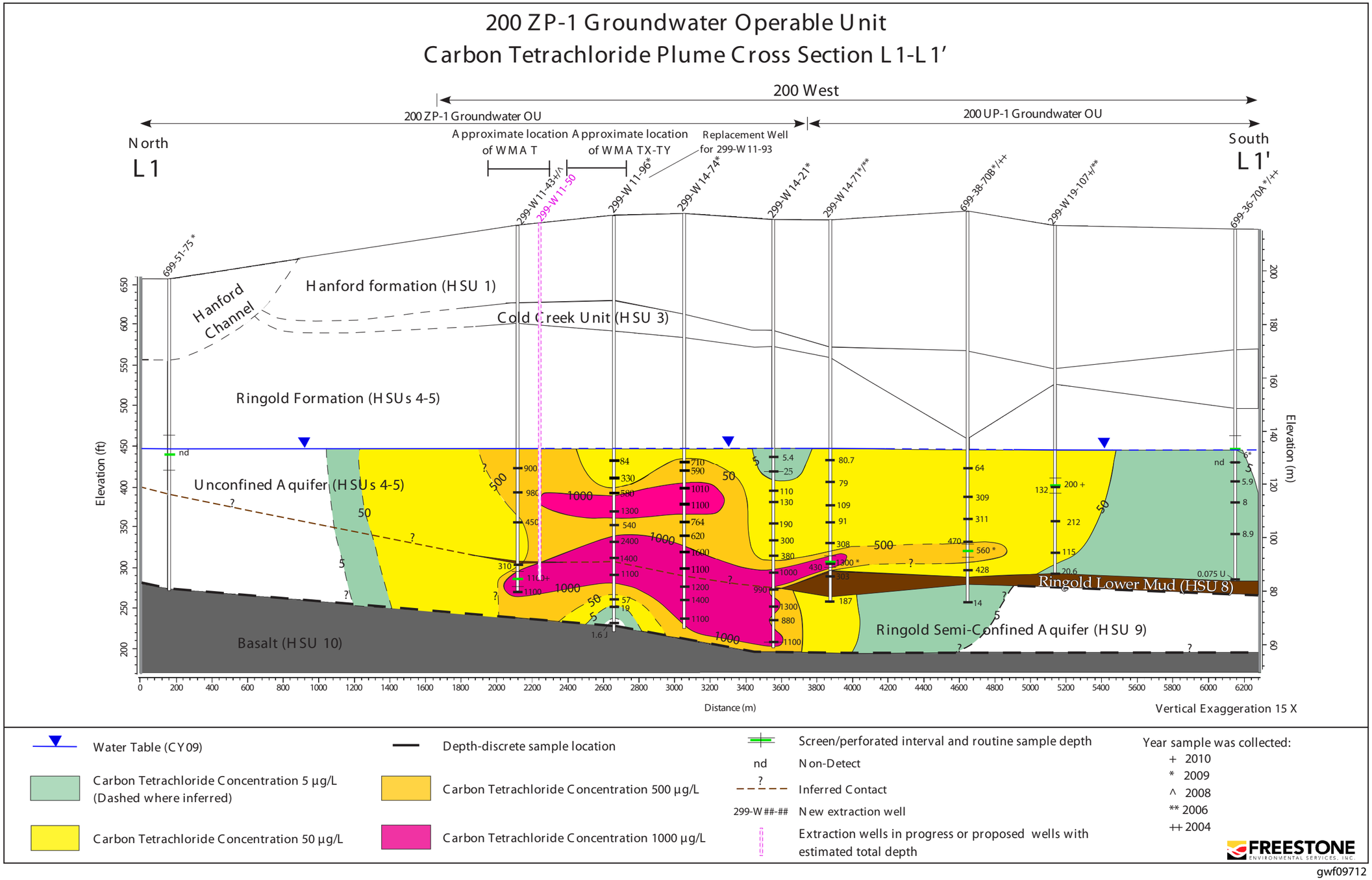

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Figure 7-8. 200-ZP-1 Groundwater Operable Unit Carbon Tetrachloride Plume Cross Section L2 L2'.

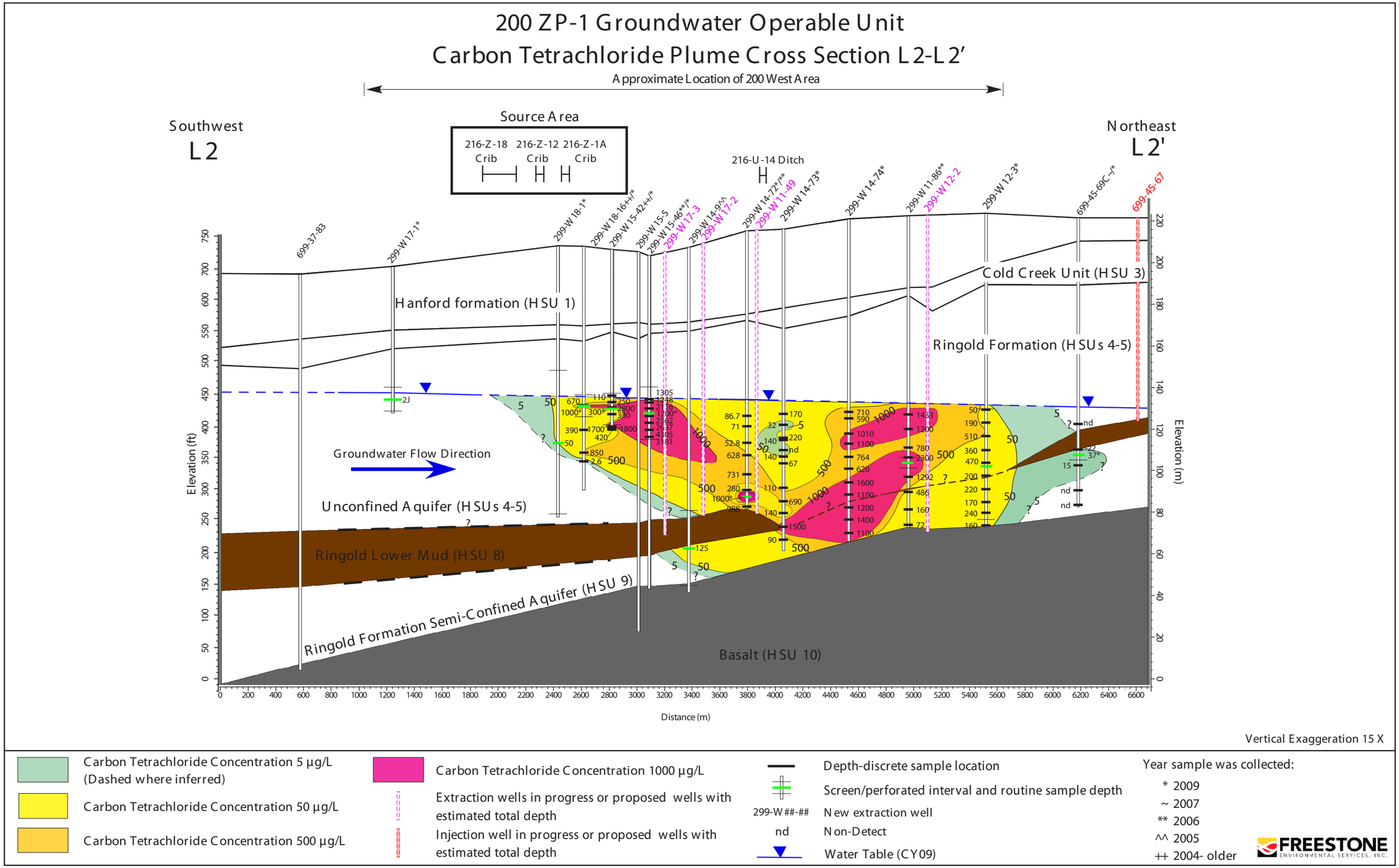

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Figure 7-9. Carbon Tetrachloride Concentrations with Depth in Northern 200 West Area, Upper Portion of Unconfined Aquifer.

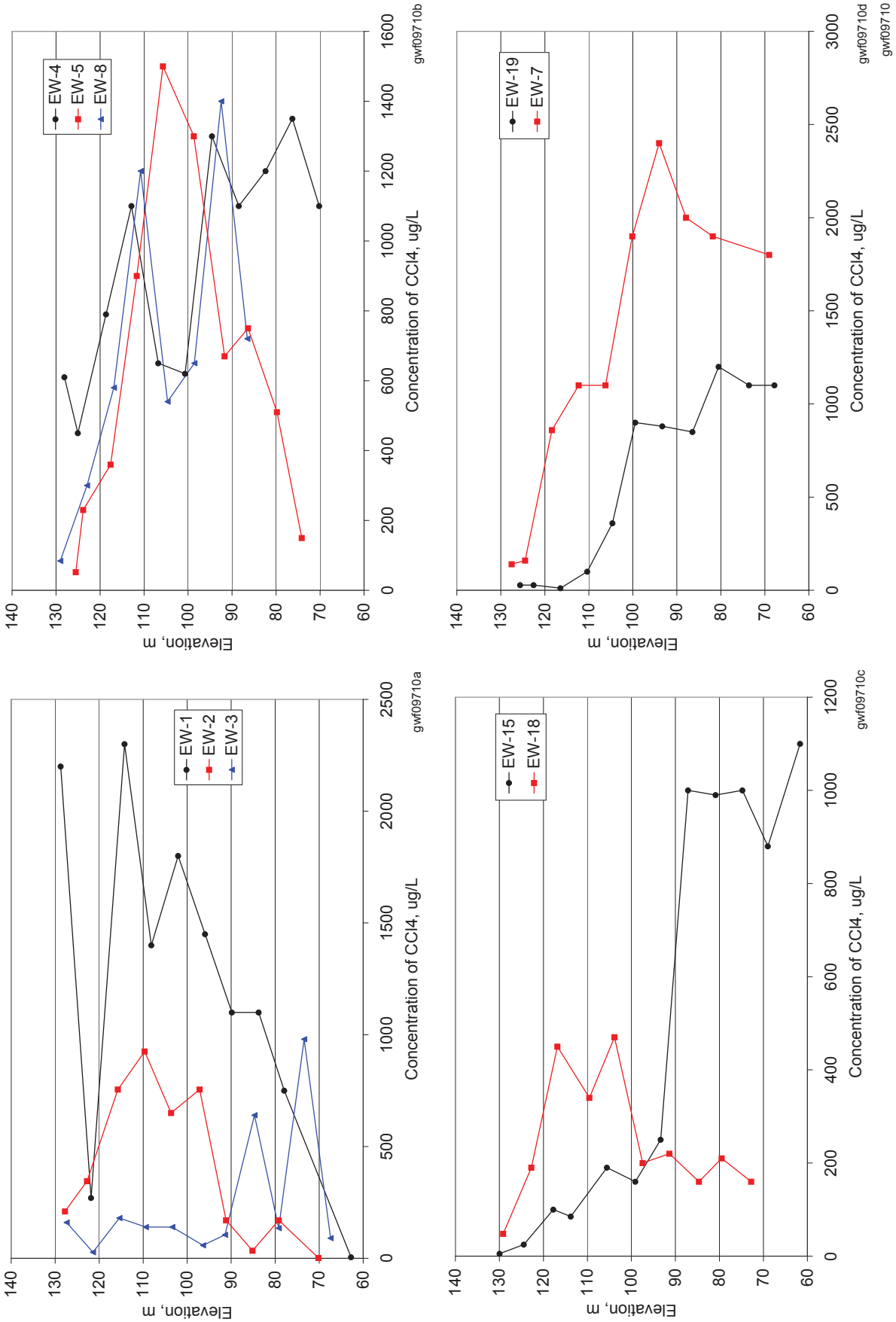


Figure 7-10. Average Trichloroethene Concentration in Central and Northern 200 West Area, Upper Portion of Unconfined Aquifer.

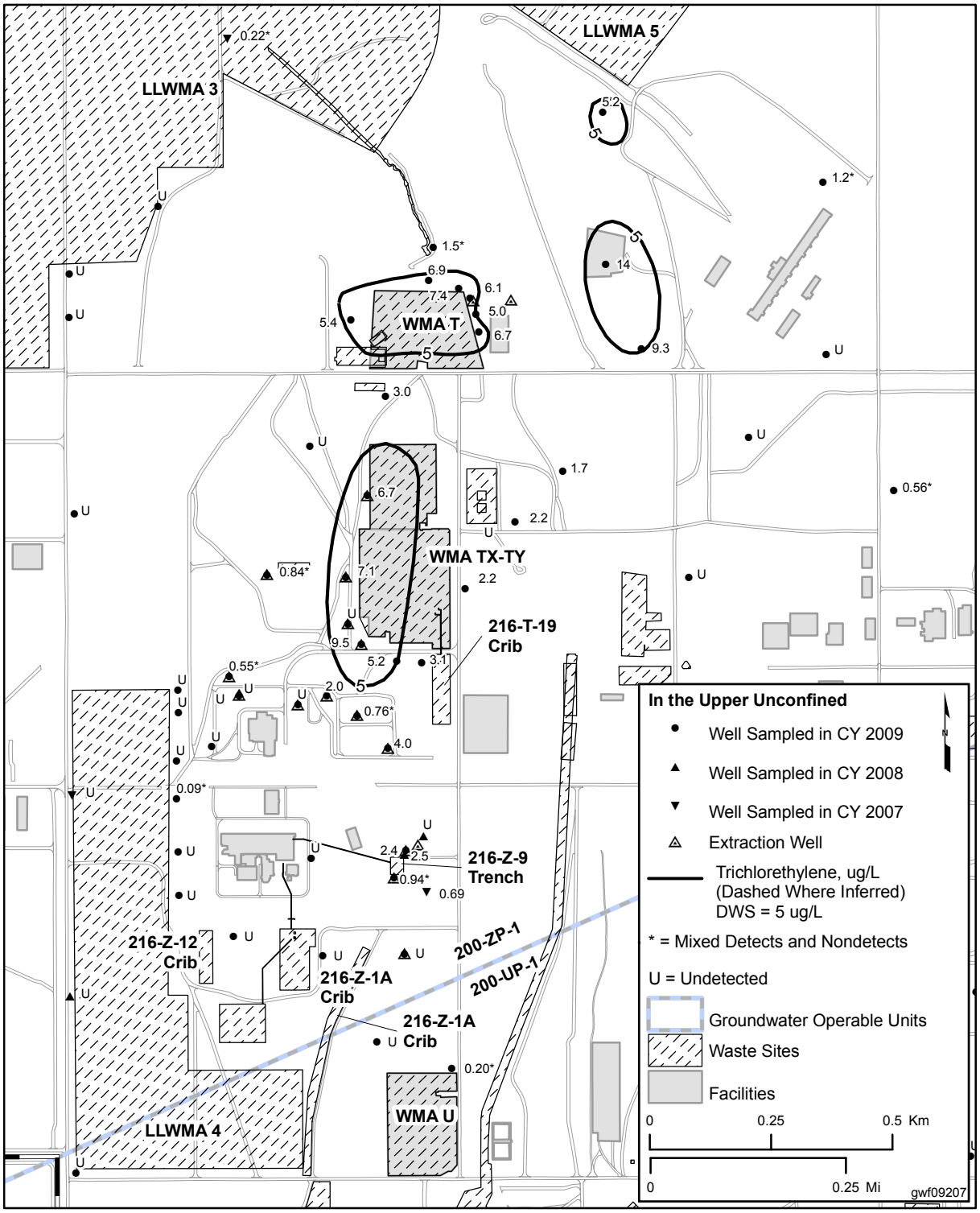


Figure 7-11. Average Nitrate Concentration in Central and Northern 200 West Area, Upper Portion of the Unconfined Aquifer.

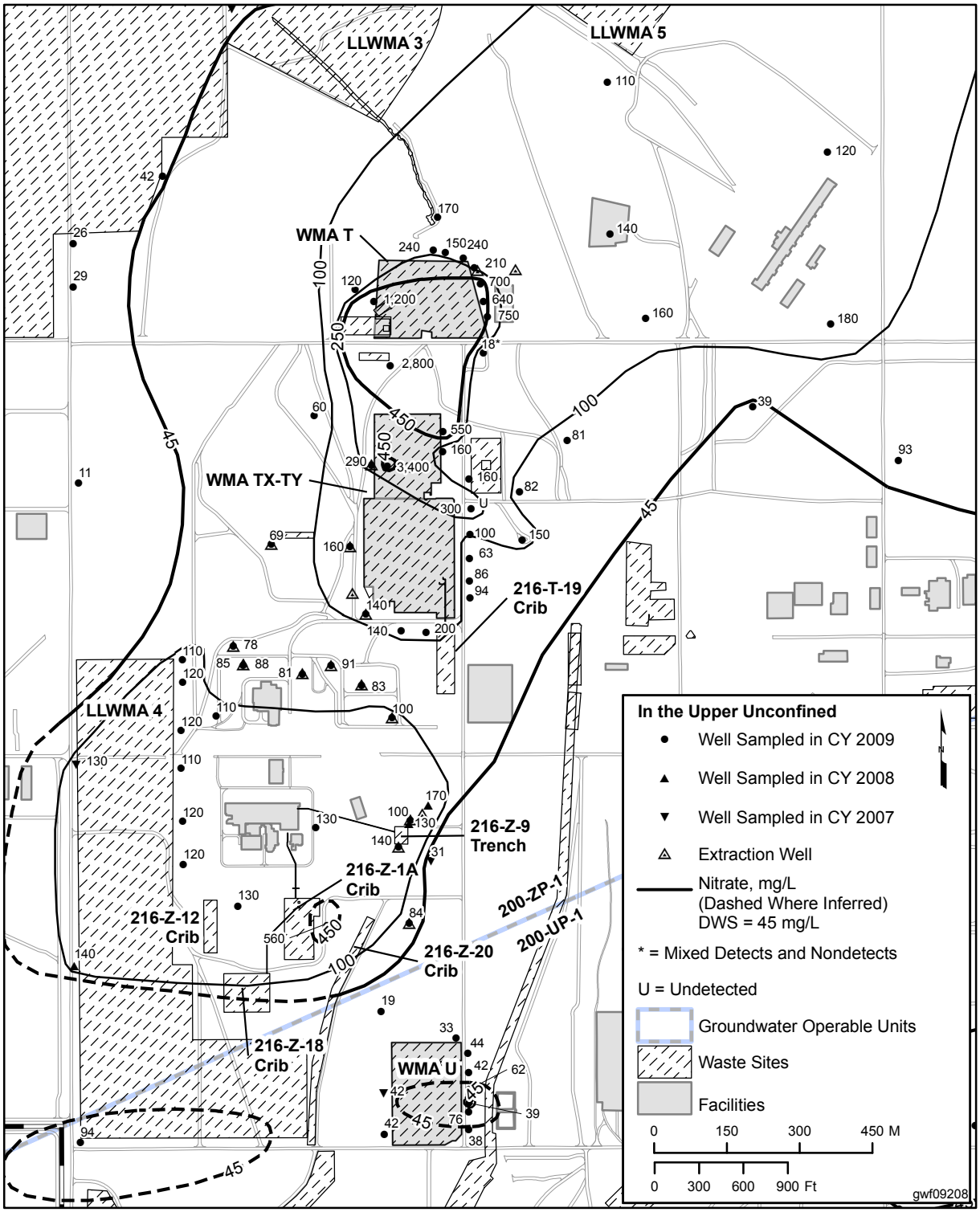


Figure 7-12. Depth Discrete Nitrate Concentration at Near-Source Well 299-W14-20 (EW 2) and Downgradient Well 299-W12-3 (EW-18).

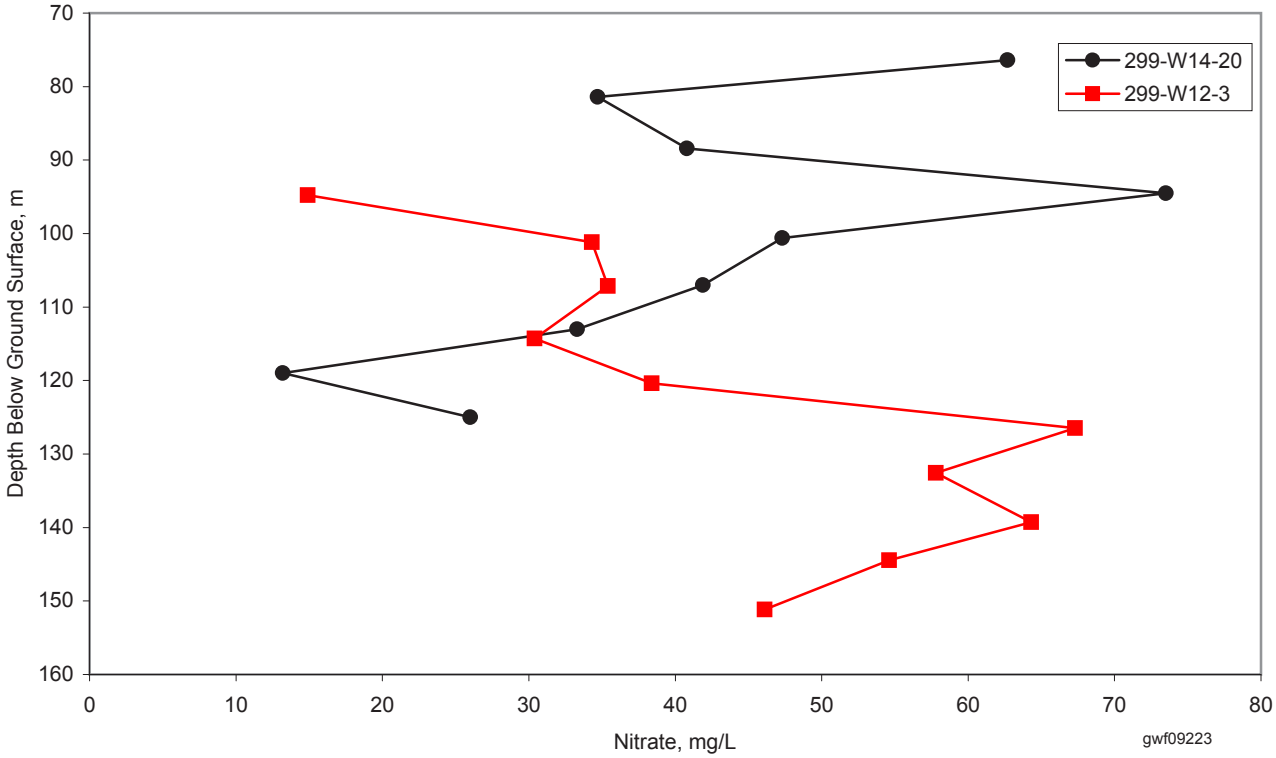


Figure 7-13. Average Filtered Chromium Concentration Near Waste Management Areas T and TX-TY, Upper Portion of Aquifer.

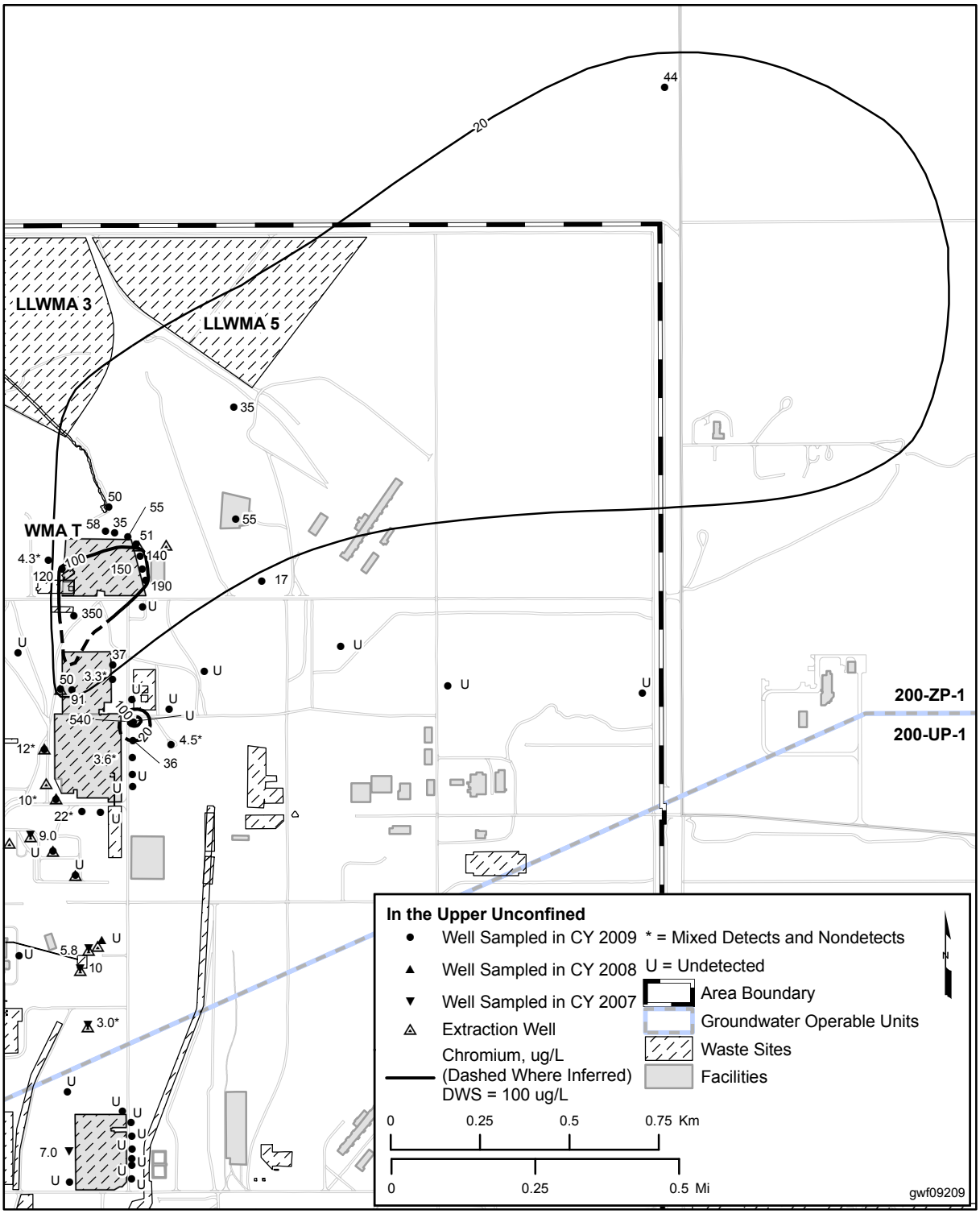


Figure 7-14. Average Tritium Concentration in Central and Northern 200 West Area, Upper Portion of Unconfined Aquifer.

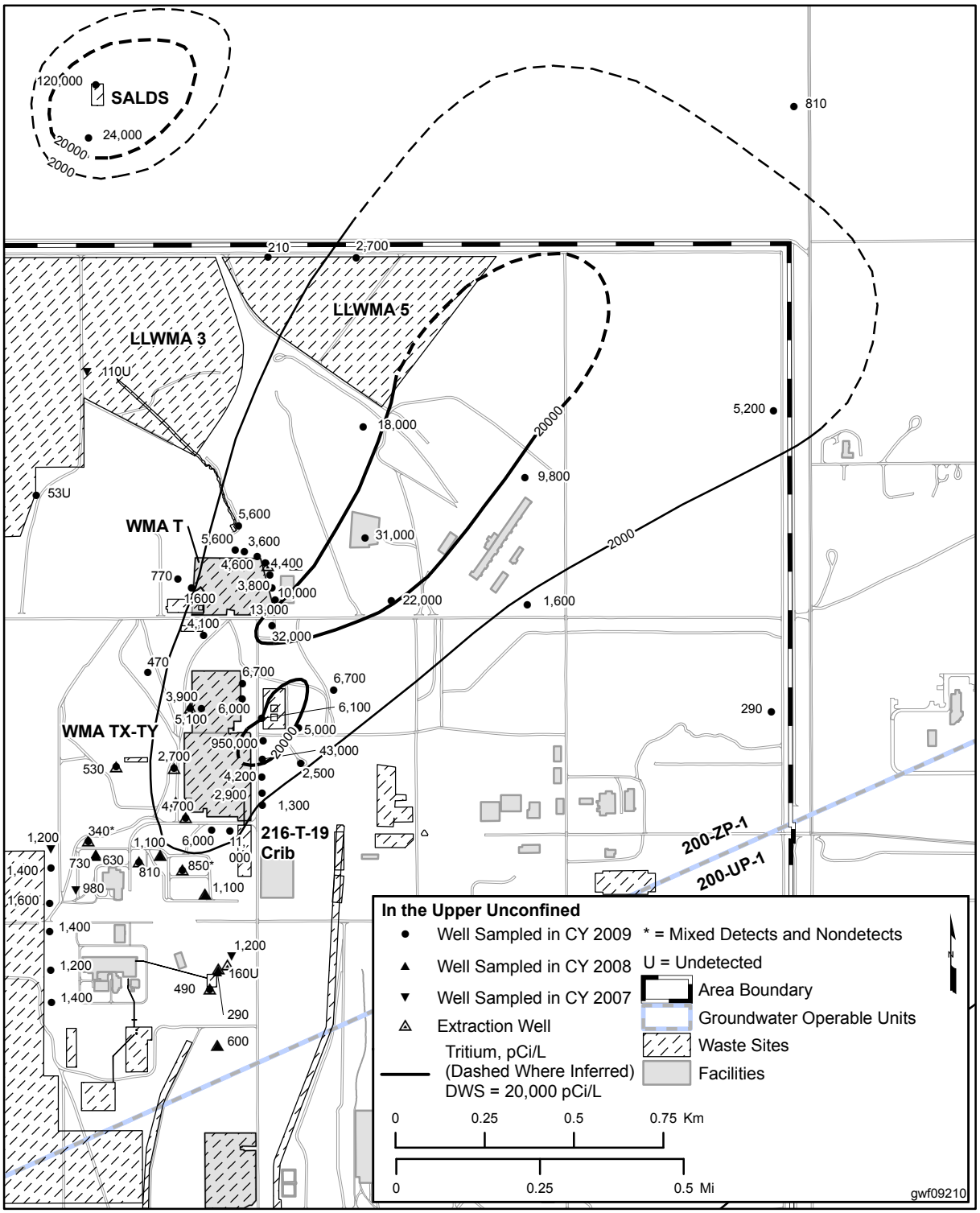


Figure 7-15. Average Iodine Concentration in Central and Northern 200 West Area, Upper Portion of Unconfined Aquifer.

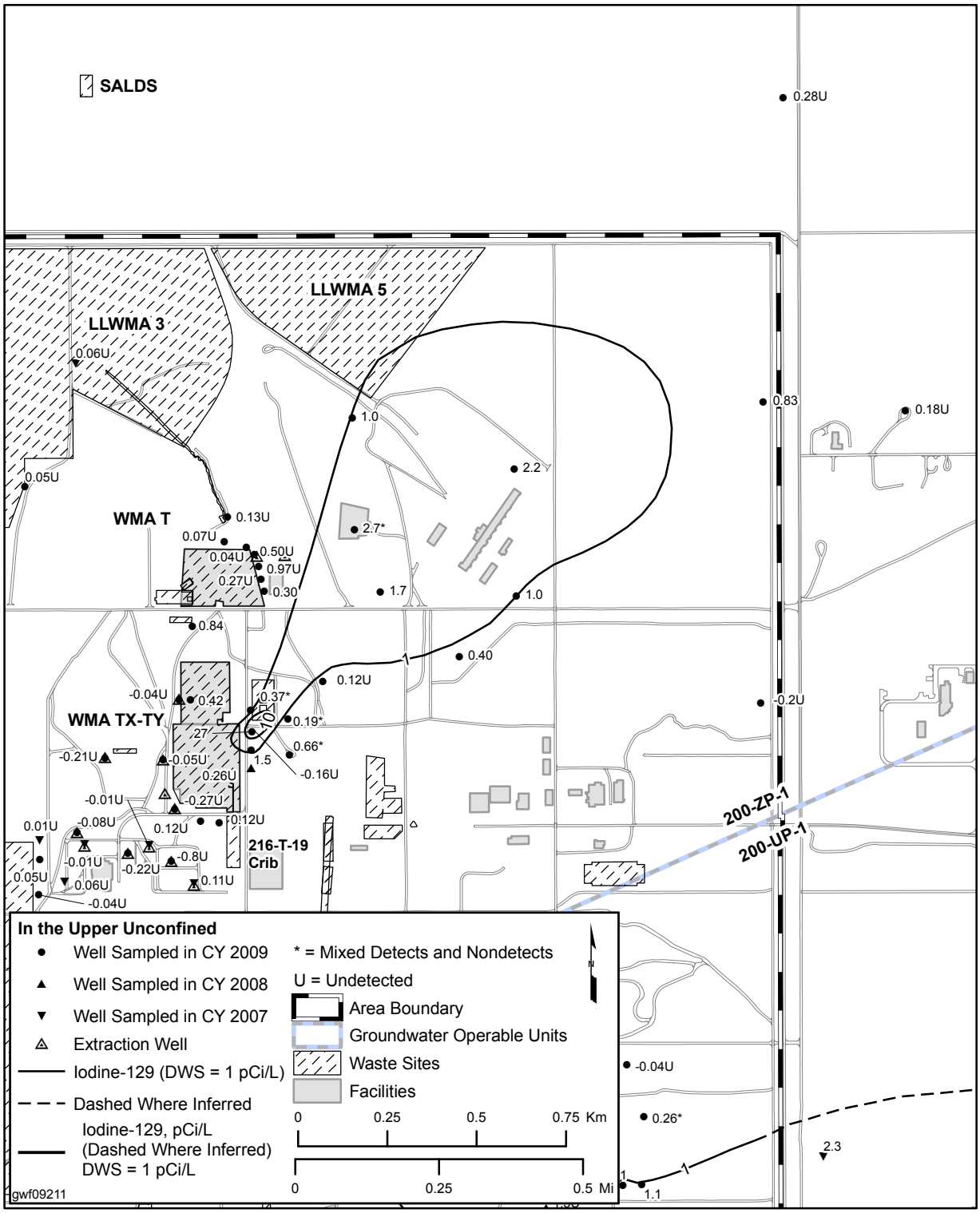


Figure 7-16. Average Technetium-99 Concentration in Central and Northern 200 West Area, Upper Portion of Unconfined Aquifer.

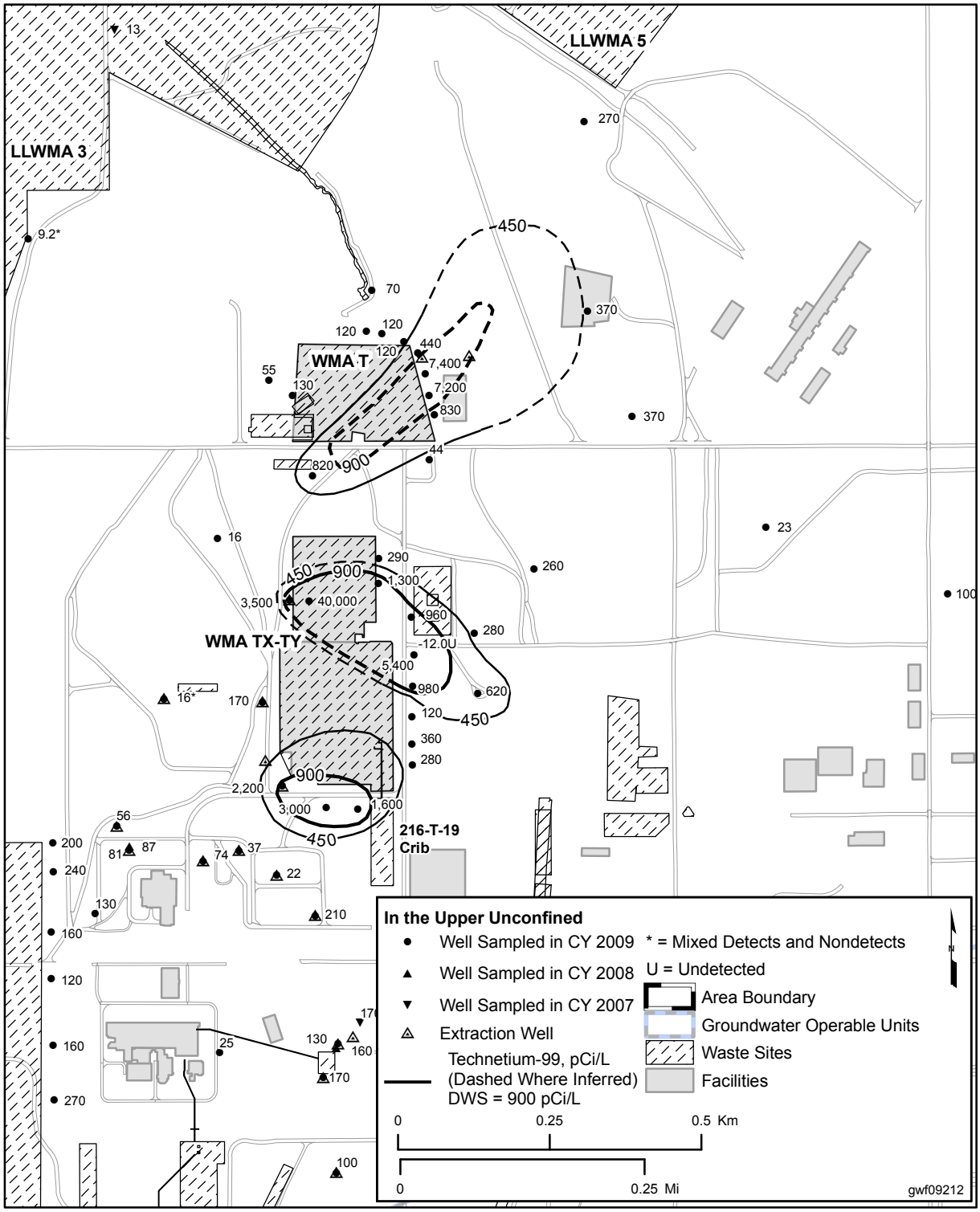
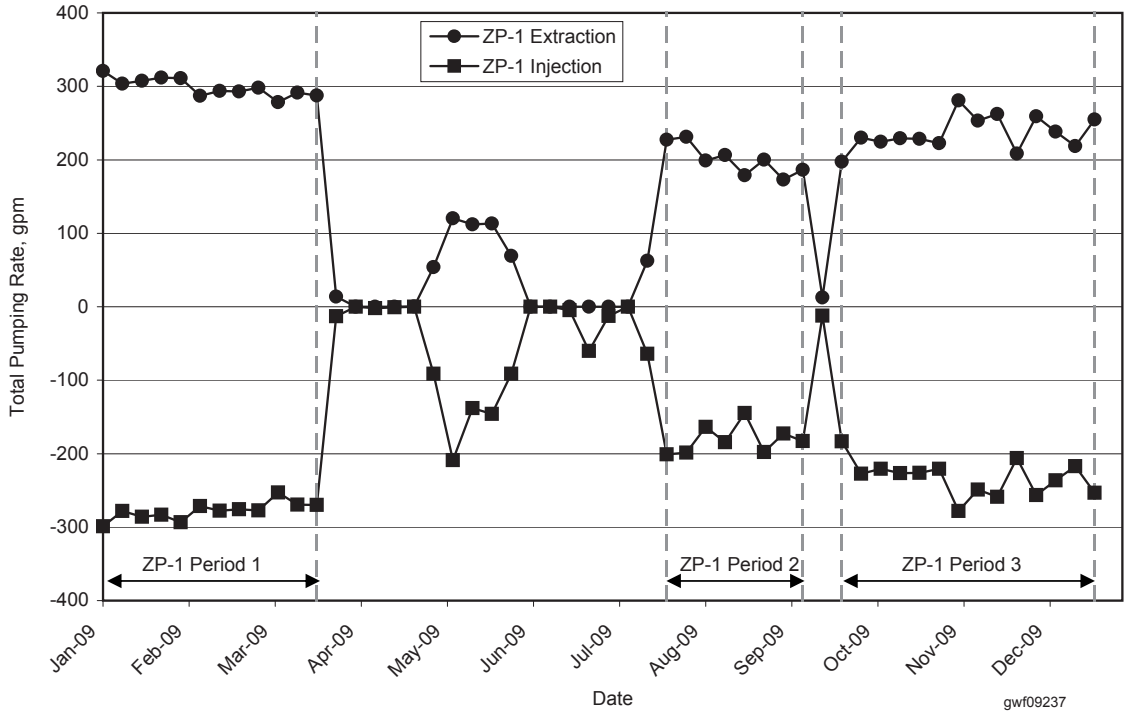


Figure 7-17. Pumping Rates and Periods for 200-ZP-1 Remedy.



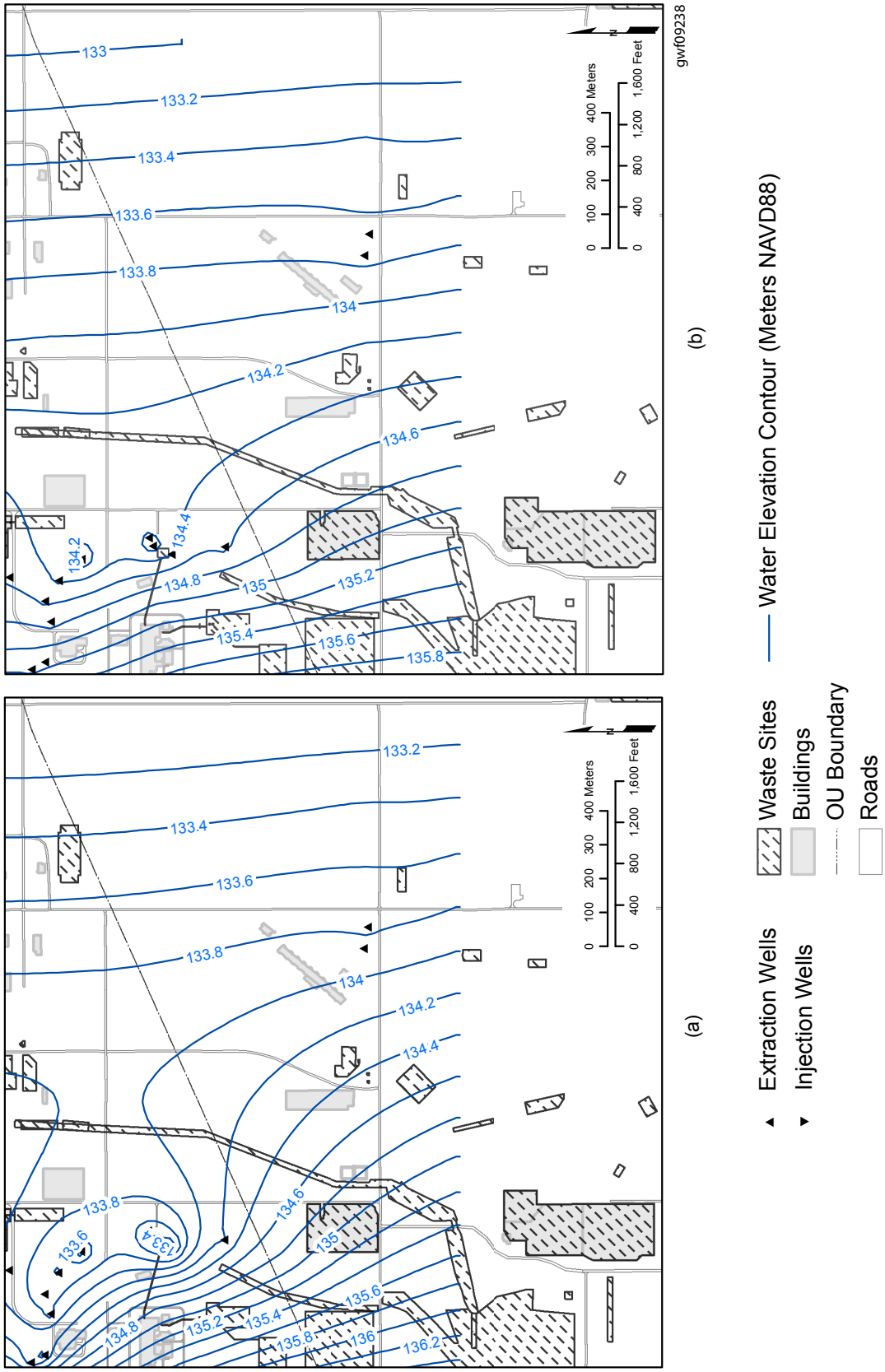


Figure 7-18. Example Groundwater Elevation Contours in the 200-ZP-1/200-UP-1 Area, (a) March 19, 2009, and (b) August 6, 2009.

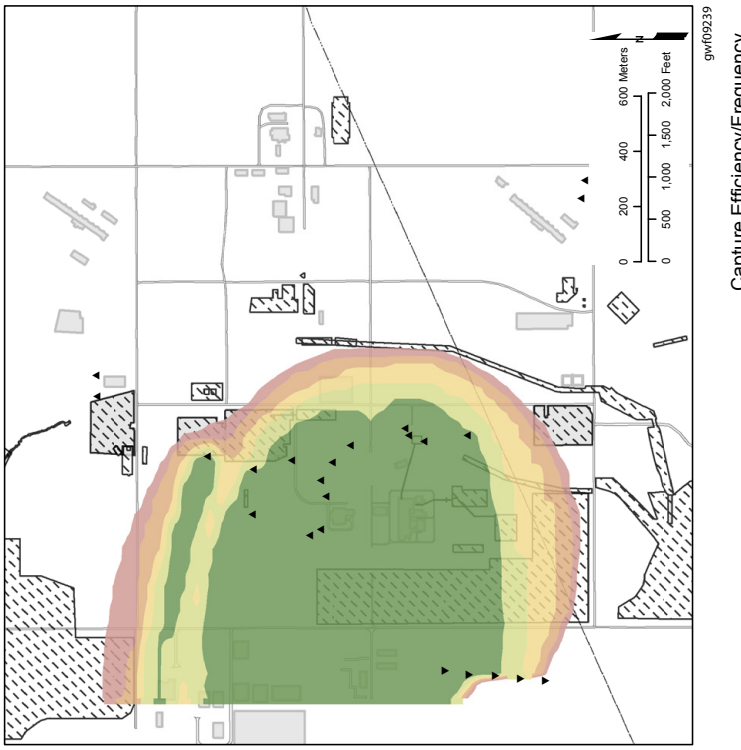


Figure 7-19. 200-ZP-1 Approximate Extent of Capture During ZP-1 Periods 1, 2 and 3 Combined.

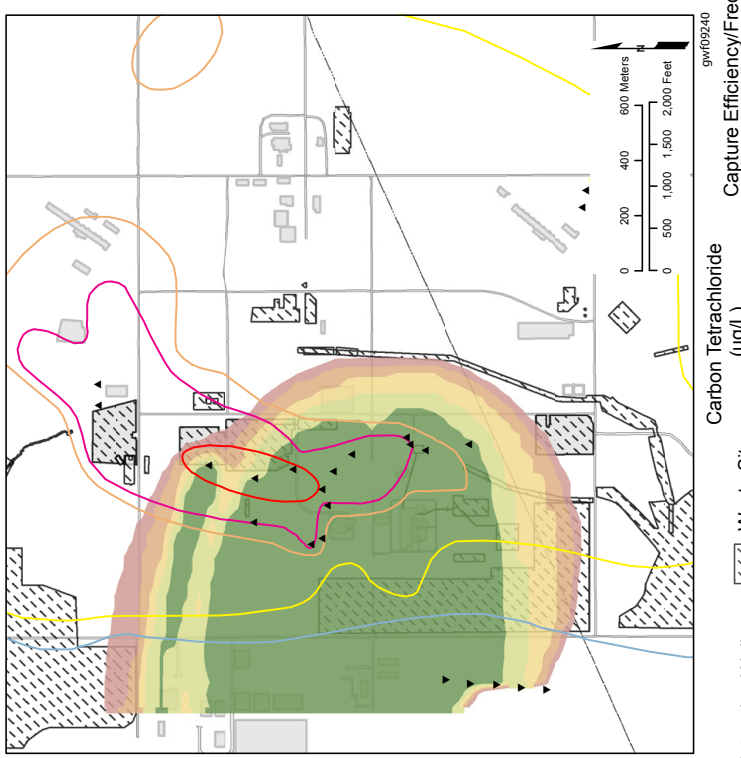


Figure 7-20. 200-ZP-1 Approximate Extent of Capture During ZP-1 Periods 1, 2 and 3 Combined, Overlaid with the Contoured Extent of Carbon Tetrachloride in 2009.

Figure 7-21. 200-ZP-1 Operable Unit Pump-and-Treat System Availability for the Reporting Period.

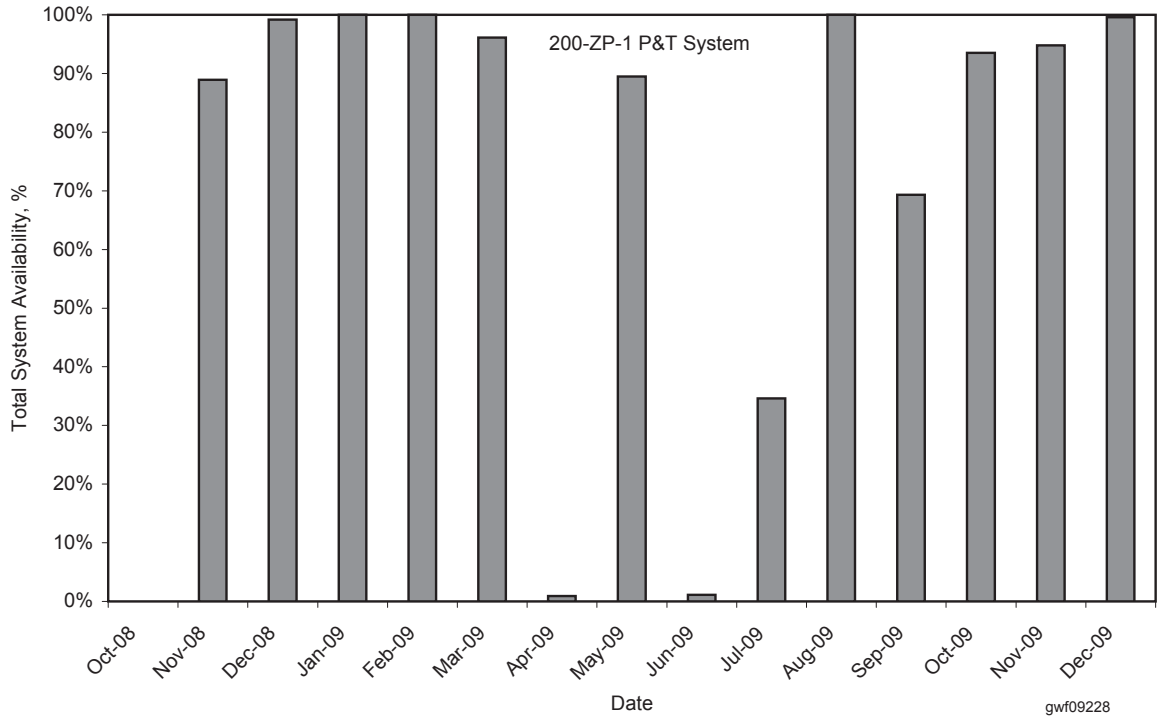


Figure 7-22. 200-ZP-1 Operable Unit Carbon Tetrachloride Concentration at Influent Tank T 01 and Effluent Tank T 02 for the Reporting Period.

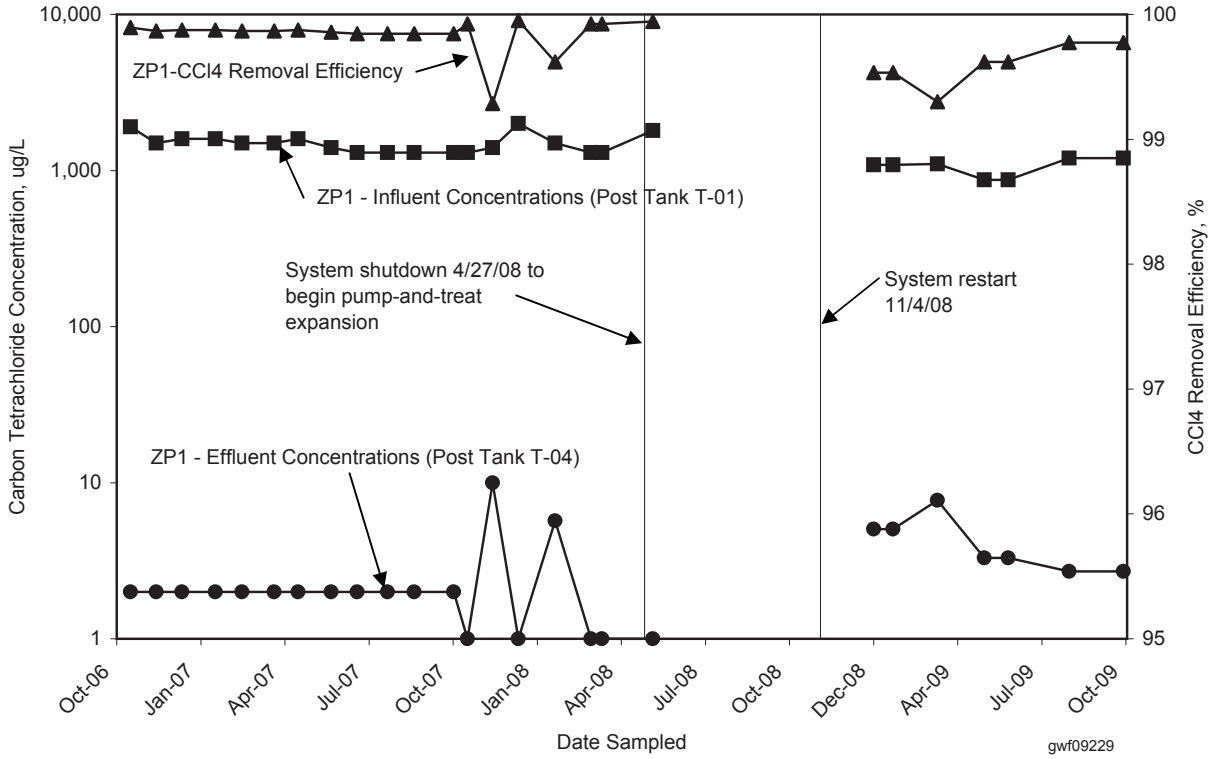


Figure 7-23. Monitoring Wells, Carbon Tetrachloride Trend Plots.

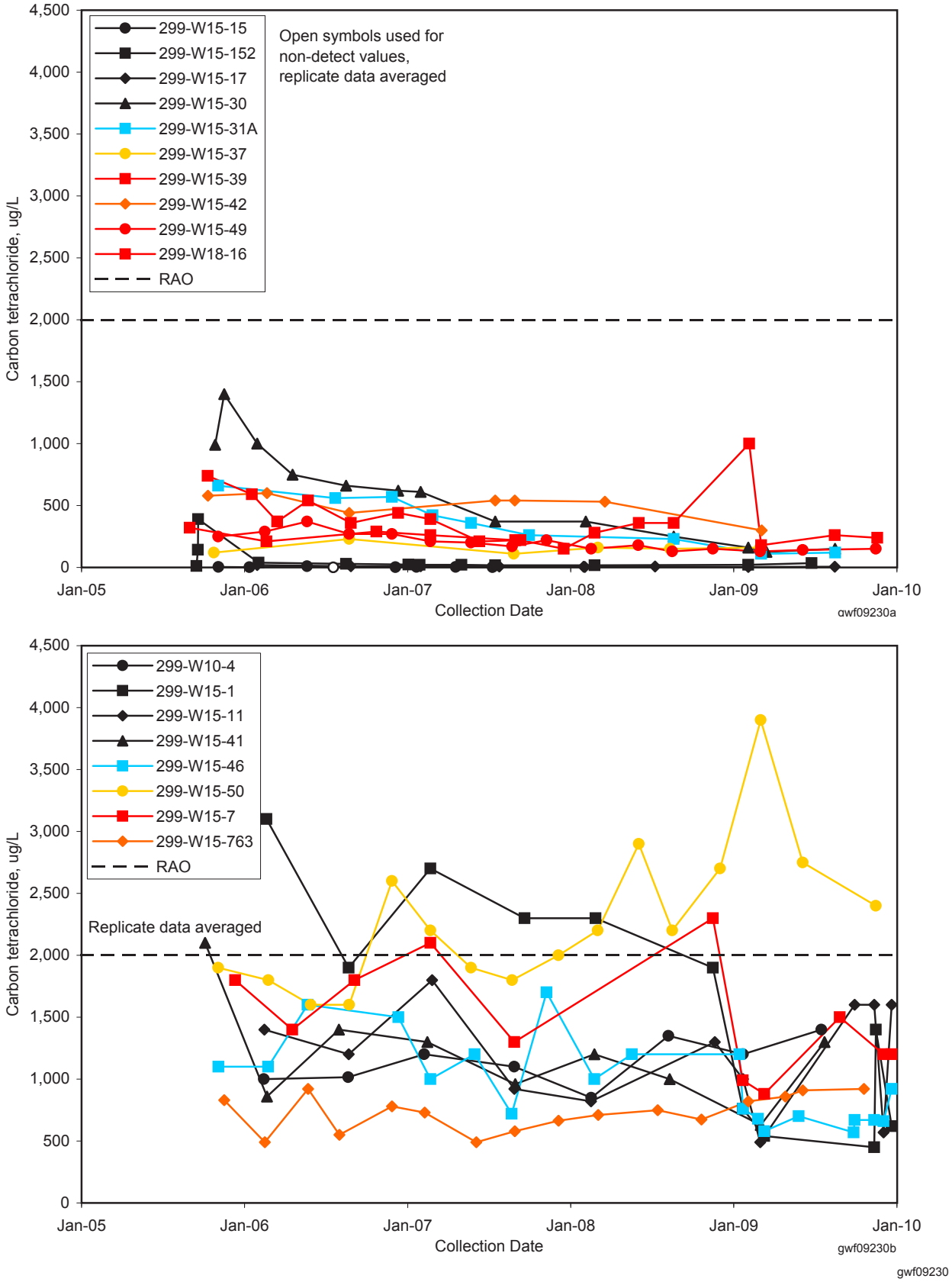
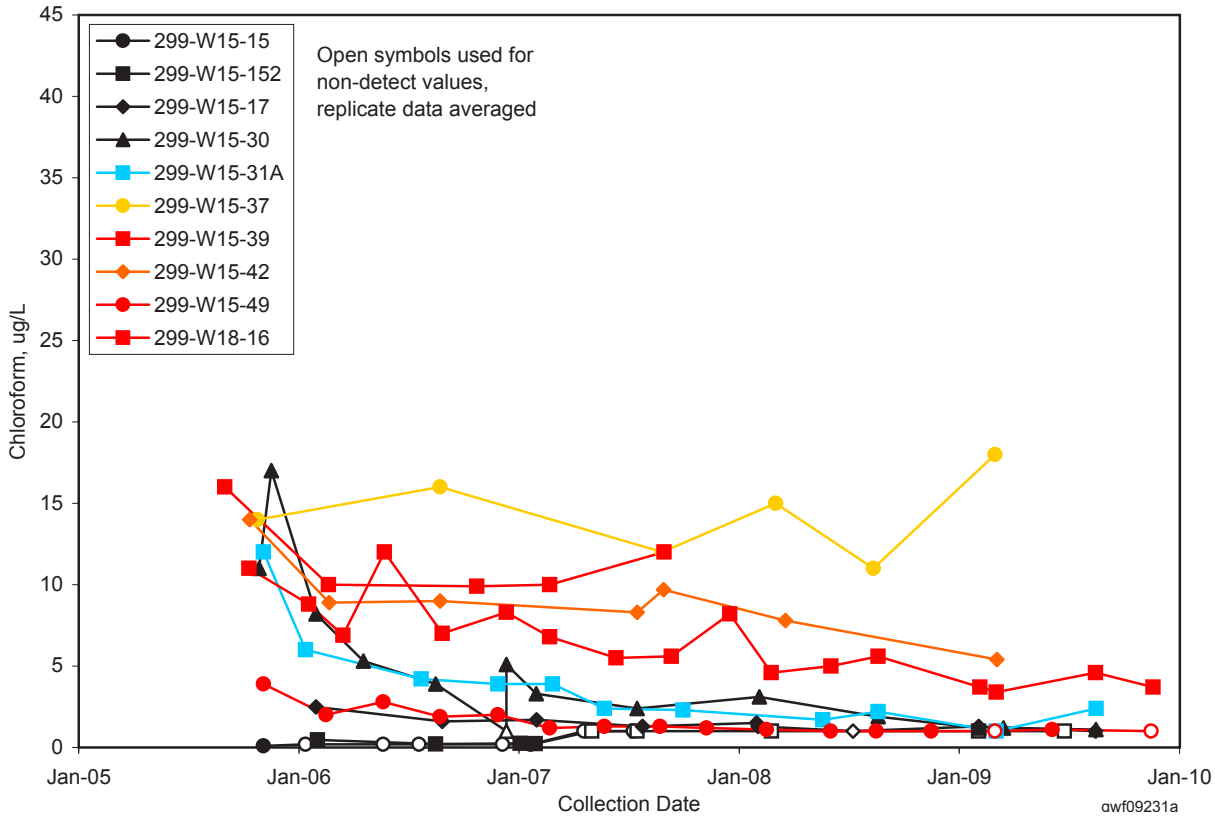


Figure 7-24. Monitoring Wells, Chloroform Trend Plots.



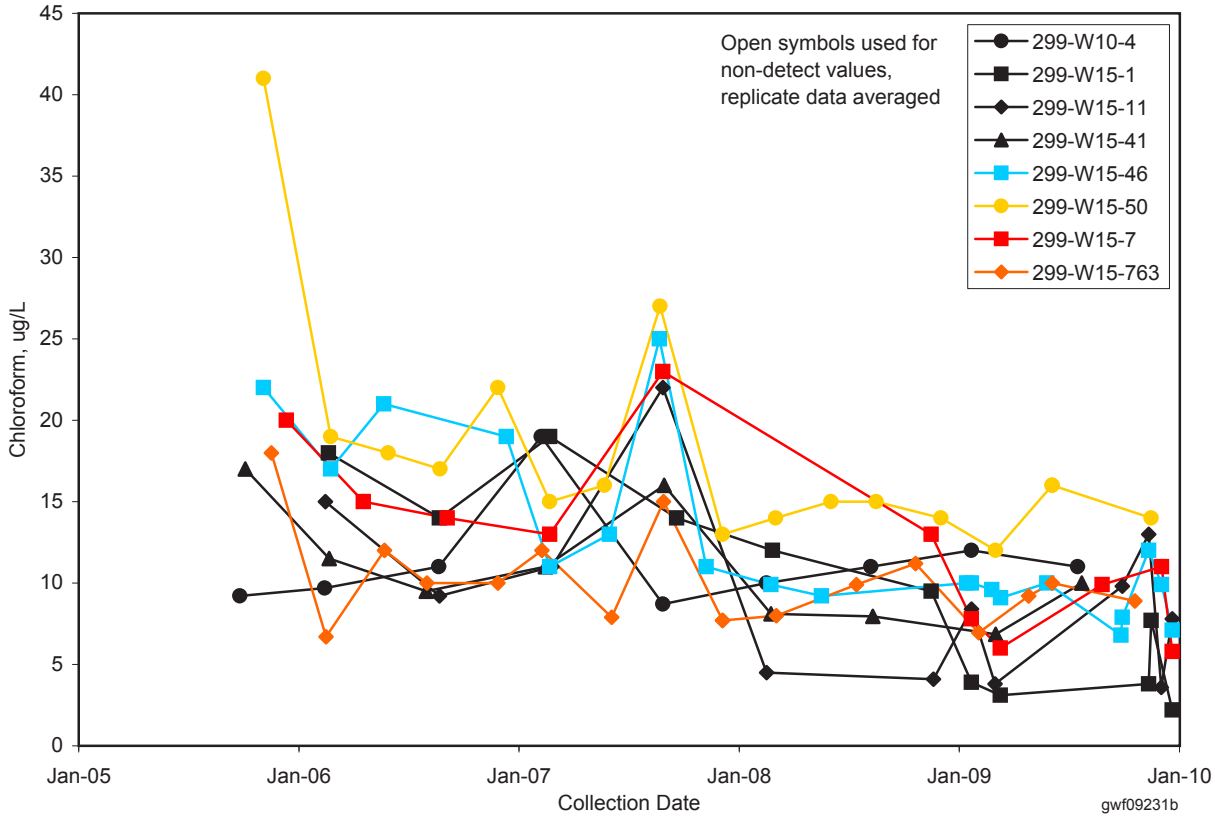


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Figure 7-25. Monitoring Wells, Trichloroethene Trend Plots.

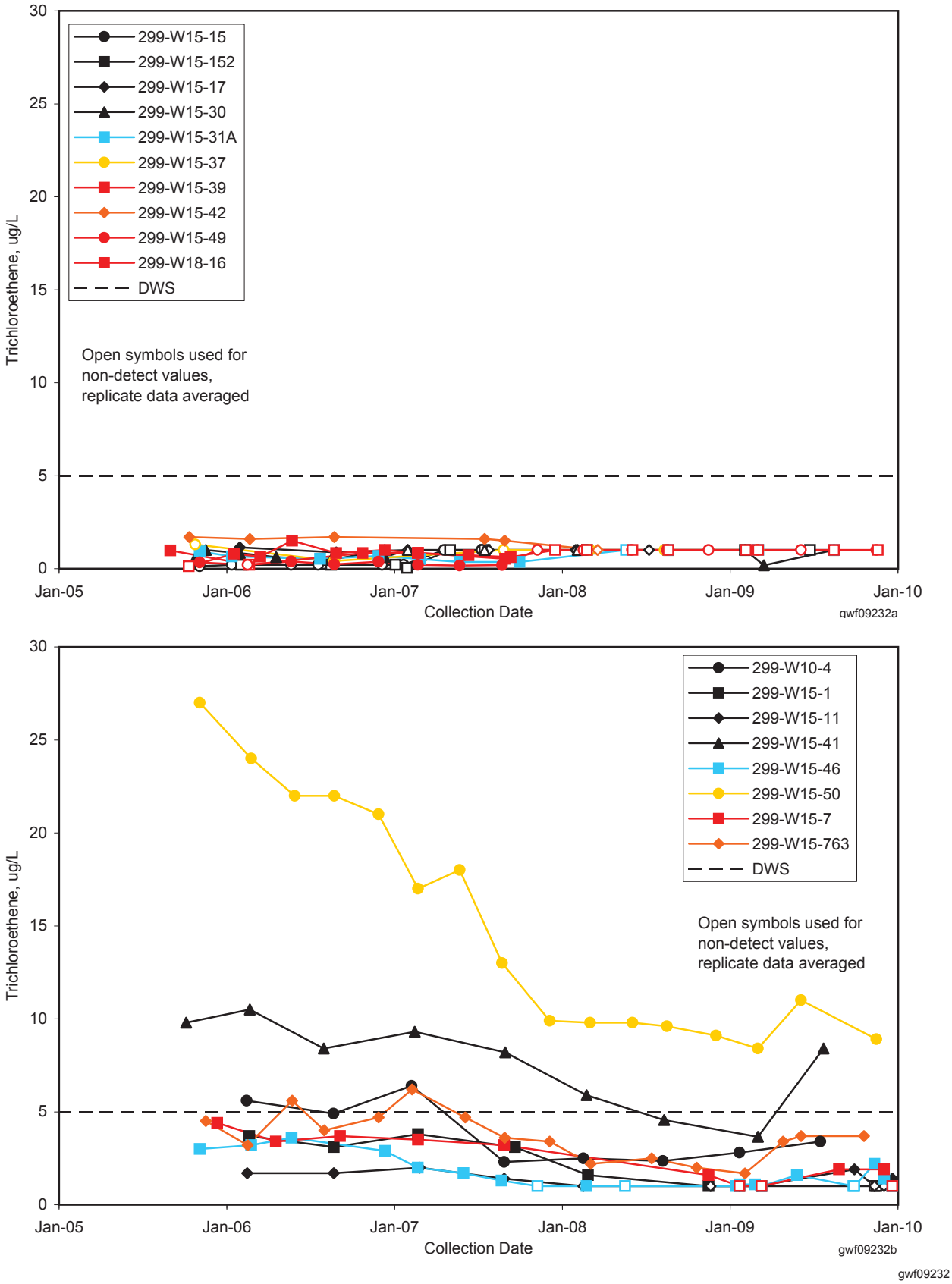
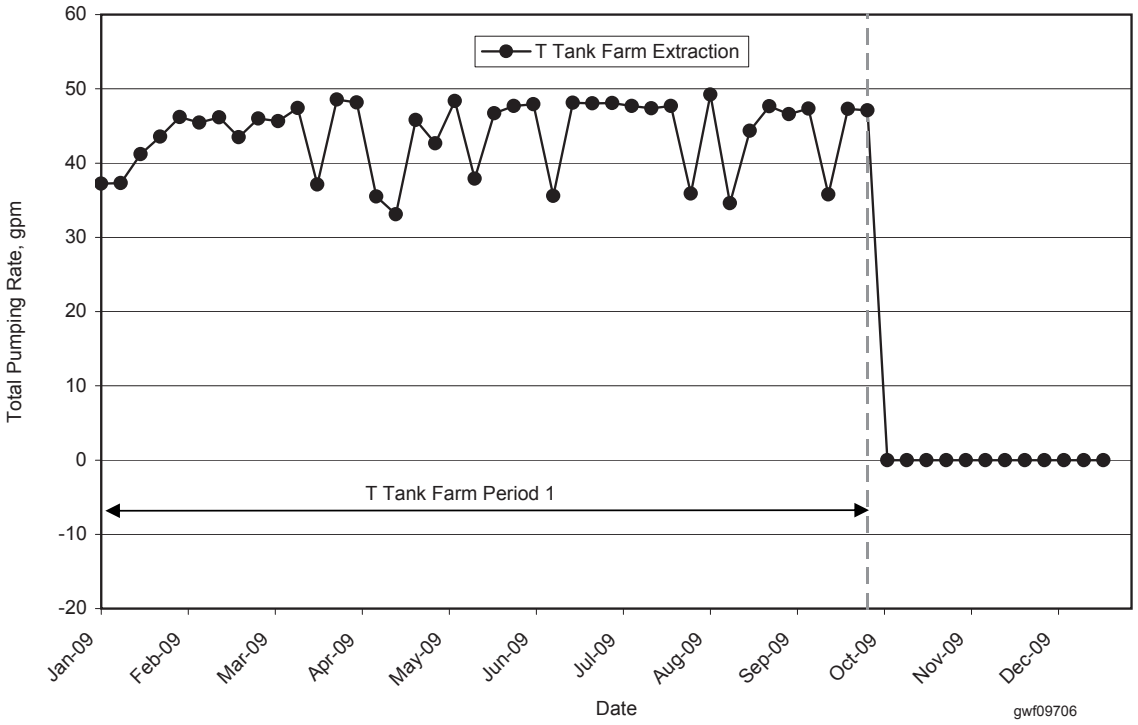


Figure 7-26. Pumping Rates and Periods for the Waste Management Area 241-T Remedy.



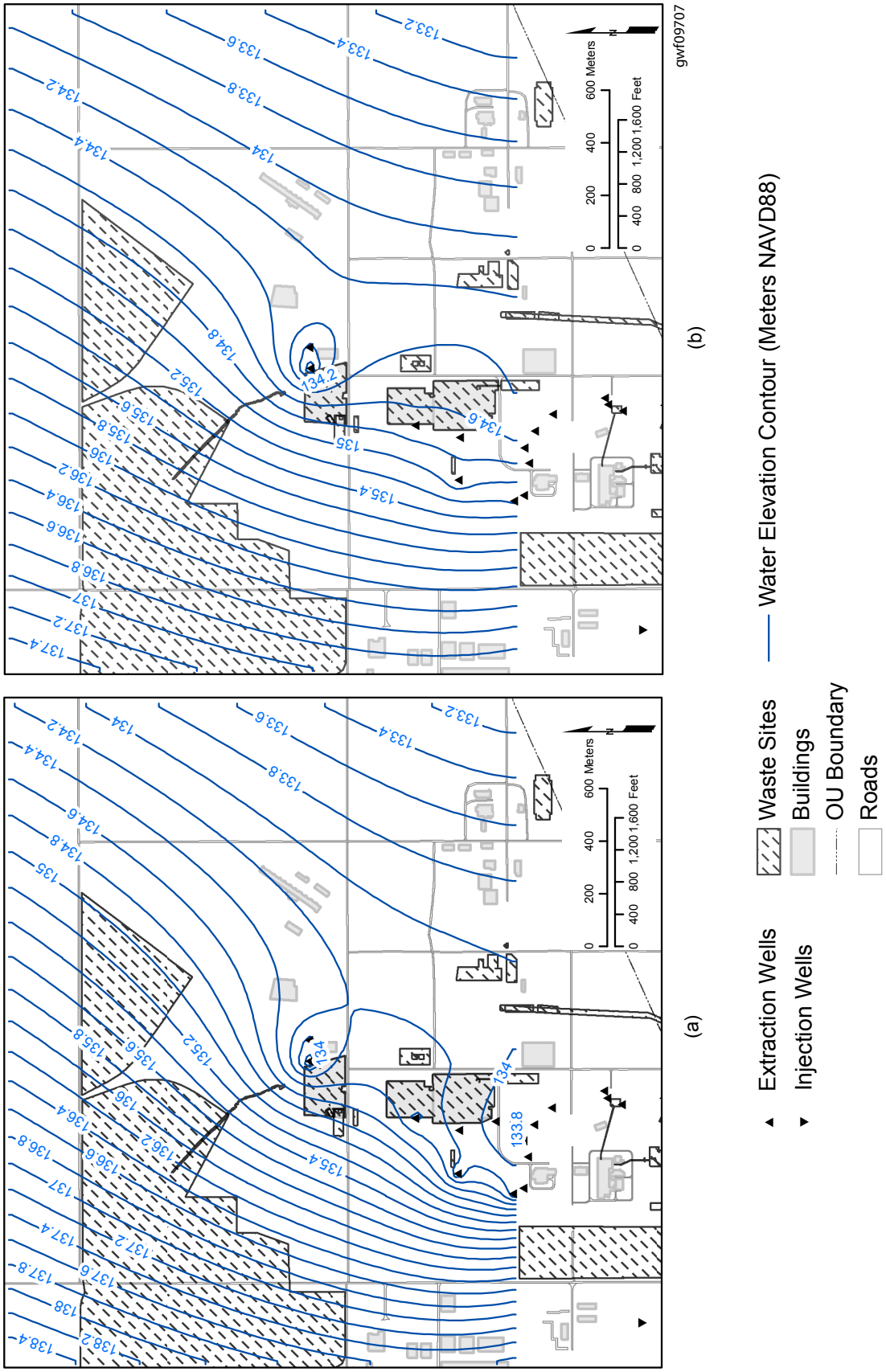


Figure 7-27. Example Groundwater Elevation Contours Throughout the 200-ZP-1 Area, (a) March 19, 2009, and (b) August 6, 2009.

Figure 7-29. Waste Management Area T Approximate Extent of Capture During 241-T Period 1, Overlaid with Contoured Extent of Technetium-99 in 2009.

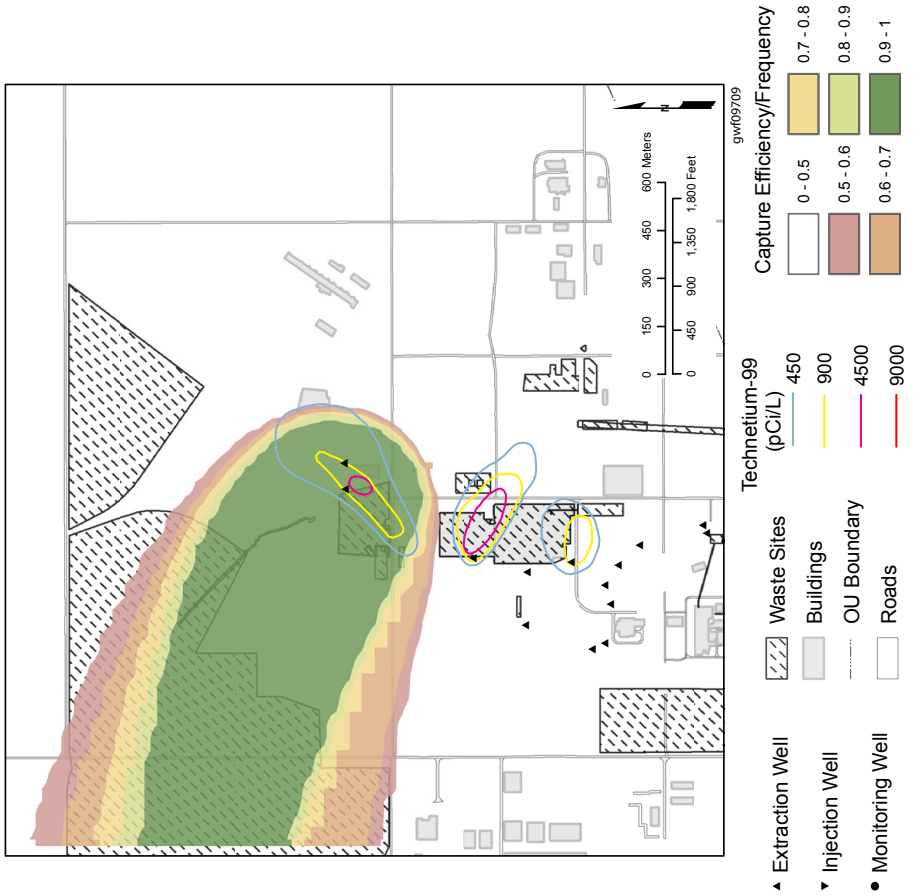


Figure 7-28. Waste Management Area T Approximate Extent of Capture During 241-T Period 1.

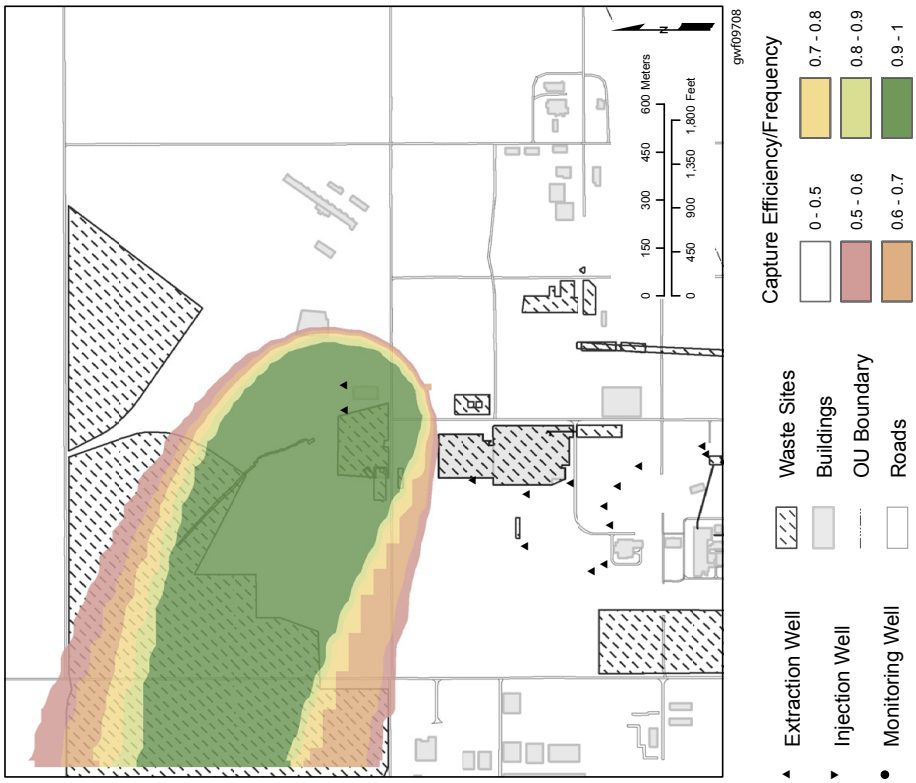


Figure 7-30. 241-T Extraction Well Online Operational Percentages and Hours of Operation.

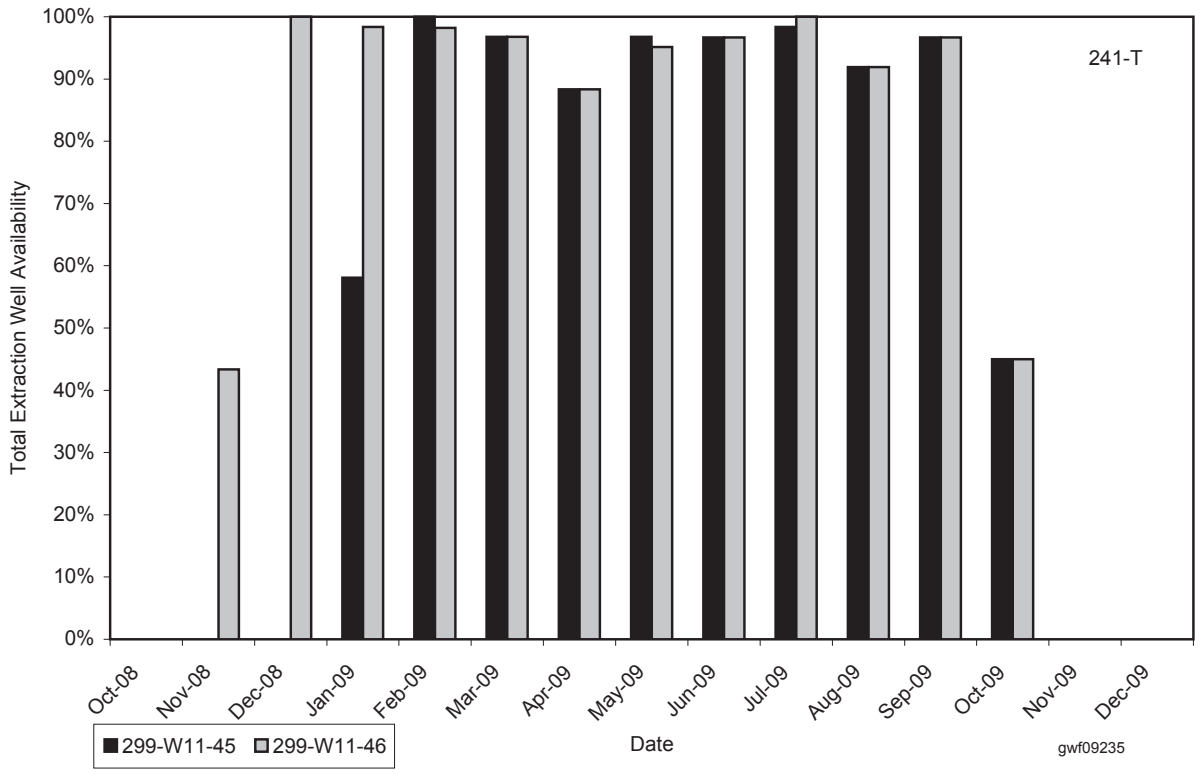


Figure 7-31. Technetium-99 Concentration in Selected Wells Downgradient of Waste Management Area T, Screened at Depth in the Aquifer.

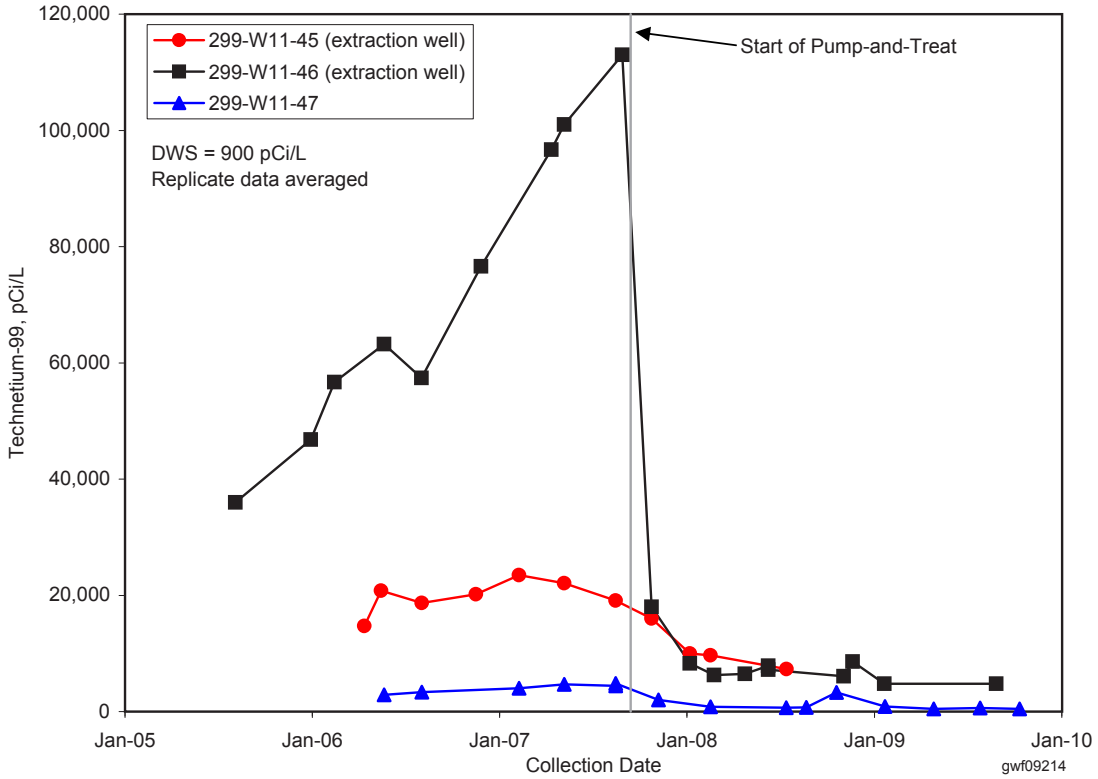


Figure 7-32. Technetium -99 Concentration in Select Water Table Wells Downgradient of Waste Management Area T.

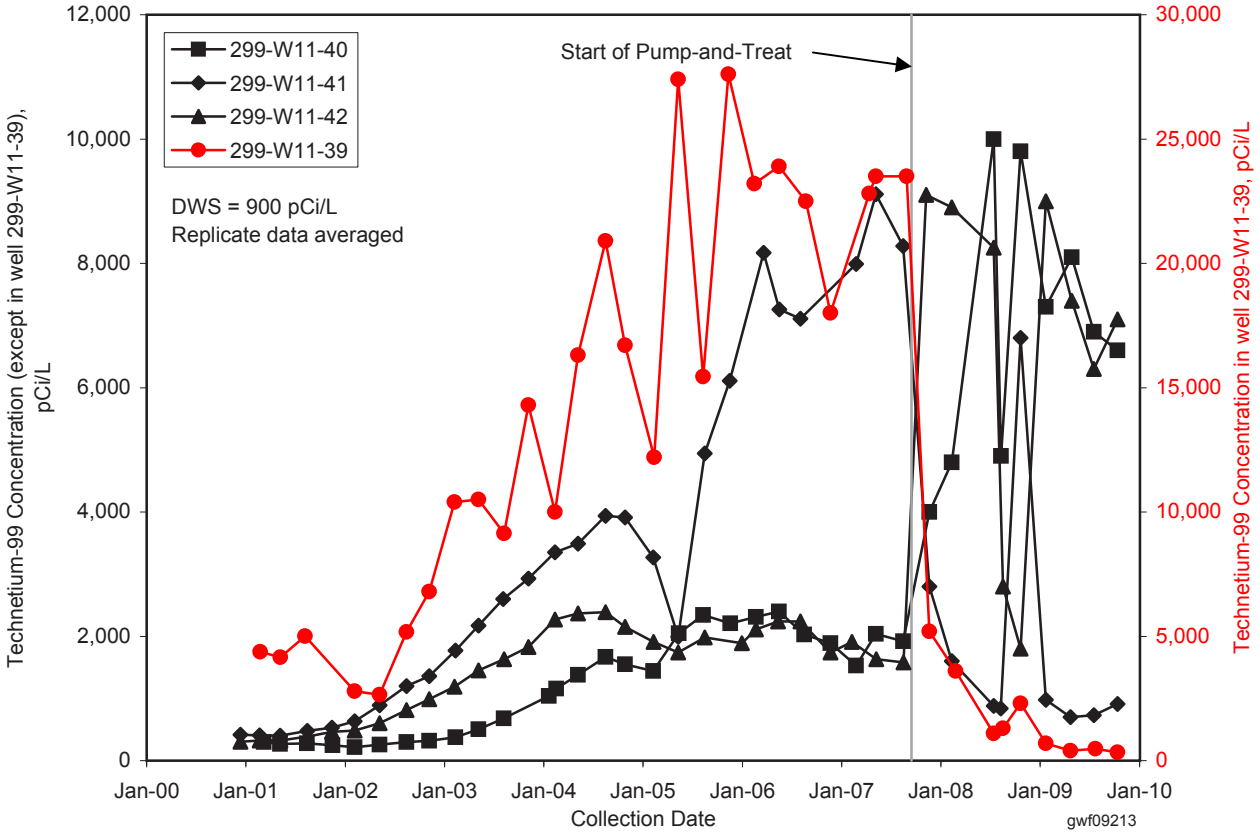


Figure 7-33. Concentration of Selected Contaminants in Well 299-W14-13 and 299-W14-5, Waste Management Area TX-TY.

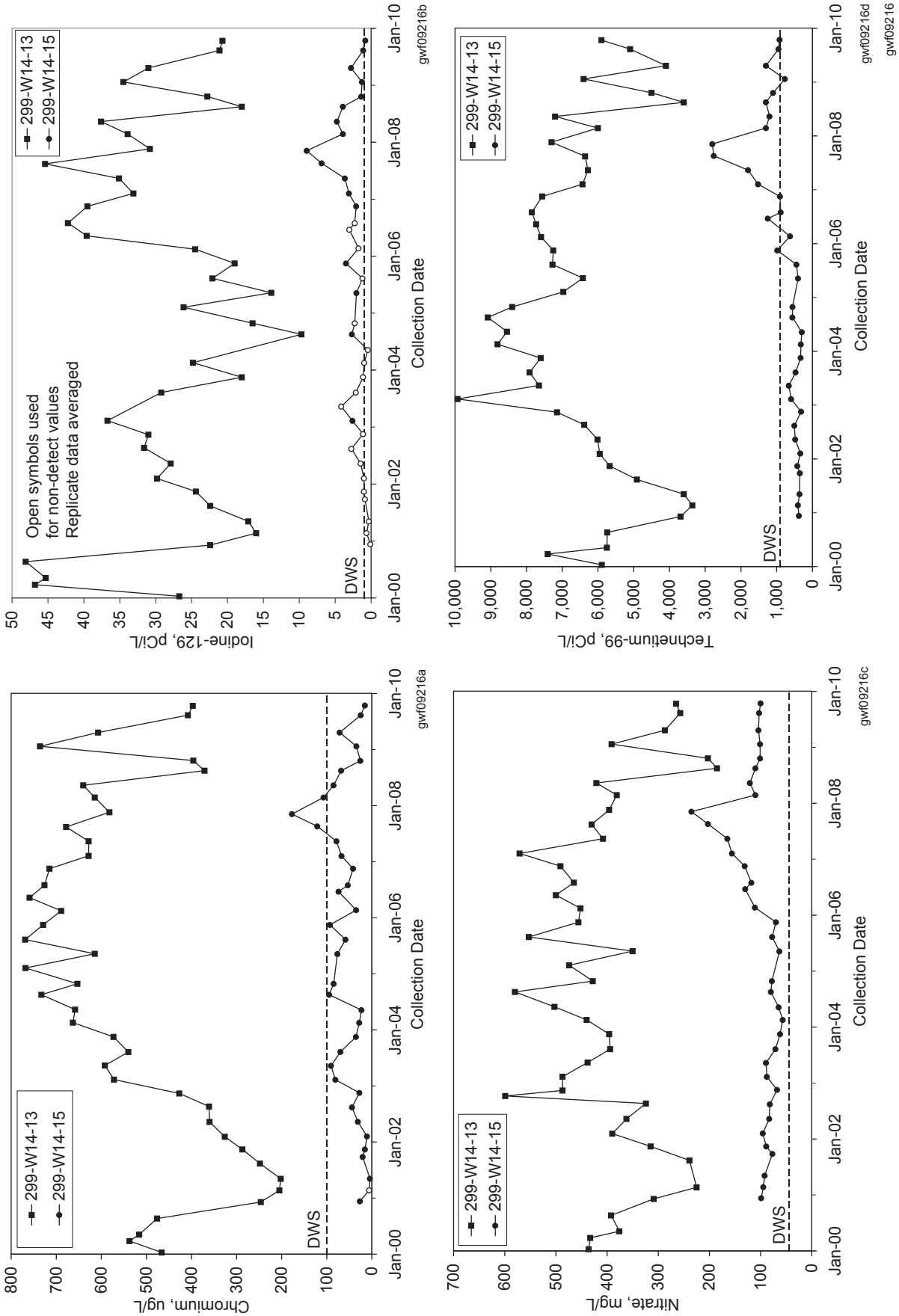
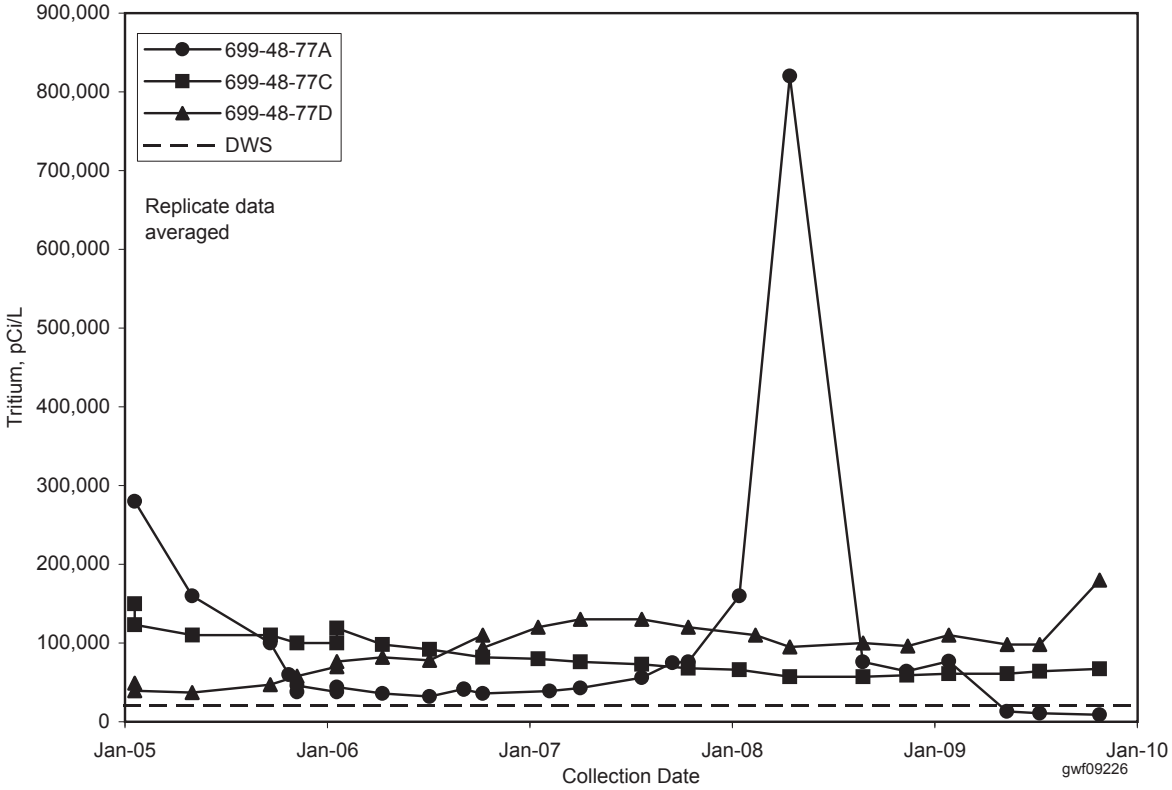



Figure 7-34. Tritium Concentrations in Wells Monitoring the State-Approved Land Disposal Site.