4.0 200-BP-5 Operable Unit

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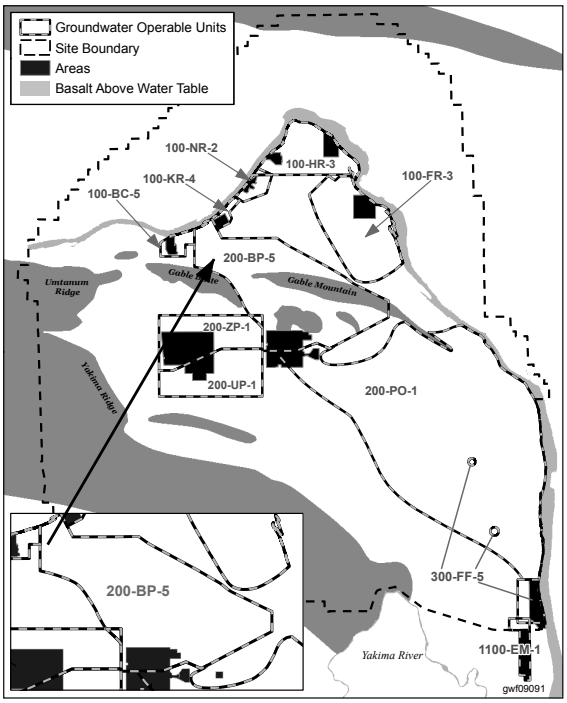
The chapter covers the period from October 1, 2008, through December 31, 2009. This report covers a 15-month period as the result of moving from a fiscal year (FY) reporting period (October 1 to September 31) to a calendar year (CY) reporting period (January 1 to December 31). Because of this change, the following date conventions are used throughout this report:

- FY 2009: Refers to the fiscal year named (i.e., October 1, 2008, to September 30, 2009).
- 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).



This chapter describes the groundwater flow and contaminant distributions in the 200-BP-5 Operable Unit (OU), which includes portions of the 200 East Area and adjacent 600 Area. The boundaries of the 200-BP-5 OU encompass an approximate area of 84.5 square kilometers. Figures 4-1 and 4-2 identify waste site, waste management units, and wells in the 200 East Area and 600 Area, respectively, within the 200-BP-5 OU. Note that these figures are also provided to identify well locations in subsequent figures and text discussions in this chapter.

The groundwater in the 200-BP-5 OU is monitored to track local and regional contaminant plumes.

The groundwater in the 200-BP-5 OU is monitored to track local and regional contaminant plumes associated with past-practice sites in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and the *Atomic Energy Act of 1954* (AEA). The main CERCLA sites monitored in the 200-BP-5 OU include the following:

- B Pond and Gable Mountain Pond
- BY Cribs and other proximal waste sites
- 216-B-5 injection well
- B Plant waste sites (including the 216-B-9, 216-B-12, and 216-B-62 Cribs).

In addition, the 200-BP-5 OU monitoring network is supplemented by several wells associated with sites that are monitored in accordance with the *Resource Conservation and Recovery Act of 1976* (RCRA). The RCRA sites in the 200-BP-5 OU include the following:

- Single-shell tank farms at Waste Management Area (WMA) B-BX-BY and WMA C
- Low-Level Waste Management Areas (LLWMAs) 1 and 2
- Liquid Effluent Retention Facility (LERF)
- 216-B-63 Trench
- 216-B-3 Pond.

Note that the 216-B-3 Pond is partially in the 200-BP-5 OU and partially in the 200-PO-1 OU. Discussion on the 216-B-3 Pond site is provided with the 200-PO-1 OU

in Chapter 5.0. Wells monitoring the 216-B-3 Pond within the 200-BP-5 OU were reviewed and discussed for each contaminant identified in Section 4.2, if applicable.

Ten contaminants of concern were initially defined in the *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit* (DOE/RL-2001-49) and are the main constituents discussed in Section 4.2. One of the constituents, cobalt-60, has decreased below the drinking water standard (DWS) due to decreased infiltration, radiological decay, and natural attenuation. Technetium-99 and uranium are the contaminants of concern recognized as increasing the most, and groundwater is monitored to define the regional extent of these contaminants, as well as the other contaminants defined in the sampling and analysis plan (DOE/RL-2001-49). Several RCRA wells that supplement the 200-BP-5 OU monitoring network near treatment, storage, and disposal (TSD) units were also used to interpret local changes in contaminant distribution. Section 4.4 discusses WMA monitoring results associated with the RCRA sites.

The groundwater contaminant concentrations in the 200-BP-5 OU did not show a significant difference by comparison to last year's concentrations.

The groundwater concentrations for the contaminants of concern at the 200-BP-5 OU did not show a significant difference by comparison to last year's concentrations (FY 2008) in this OU. However, some incremental degradation of water quality near selected sites was observed.

A brief conceptual model for the 200-BP-5 OU is provided in Section 4.1. Although no active groundwater remediation is ongoing in the 200-BP-5 OU, several remedial investigation activities have been completed toward the development of a Record of Decision. The CERCLA activities completed during this monitoring period are discussed in Section 4.3, and Section 4.5 provides a brief discussion of the conclusions and recommendations for the 200-BP-5 OU monitoring network.

4.1 Conceptual Model

This section provides a brief discussion of the conceptual model for contaminant distribution based on waste sites, hydrogeologic data, and current and historical groundwater data. Specific waste site data are not provided; however, inventory and historical vadose zone investigation data have been considered for those sites overlying elevated groundwater contaminant concentrations. The main discussion is based on the groundwater contaminant distribution within the 200-BP-5 OU.

The extent of groundwater contamination for contaminants of concern for the current reporting period has not shown significant differences from last year in this OU, although some local contaminant increases were observed near certain waste sites, as described in Section 4.2. Several CERCLA sites are monitored locally as sources of groundwater contamination. Groundwater results from previous monitoring and the current reporting period provide the basis for the extent of contaminants from these sites, which is discussed further in Sections 4.2 and 4.4. Sites exhibiting contaminants of concern exceeding DWSs include B Pond, Gable Mountain Pond, the BY Cribs and other proximal waste sites in this area, the 216-B-5 injection well, the 216-B-62 Cribs, WMA B-BX-BY, WMA C, and possibly the 216-B-2-series ditches.

A southerly flow reversal extending from FY 2008 continued over most of the more contaminated areas within the 200-BP-5 OU for approximately half of the reporting period

One reason that the regional extent of contaminant distribution did not change during this reporting period is because the groundwater flow direction over at least part of the OU experienced a groundwater flow reversal for approximately half of the reporting period. A southerly flow direction was statistically defined in the summer of 2008 at LLWMA-1, and a statistically significant northerly flow direction was

not observed until July 2009. The spatial extent of the flow reversal is uncertain. The cause of the initial flow reversal is attributed to high Columbia River stages in the spring of 2008 (see Section 2.2). The flow change effects are uncertain in the southeastern portion of the OU because the monitoring network is sparse and the water elevation shows little to no variation. Due to the uncertainty of groundwater flow direction in the southeastern portion of the OU within the 200 East Area, a low-level water elevation survey was initiated this year. The methods used to reduce uncertainty in these measurements include higher resolution well elevation surveys and gyroscopic surveys to determine borehole deviation from vertical.

Contributing to the flow reversal of 2008 is the diminishing influence of now inactive waste effluent ponds (B Pond and Gable Mountain Pond) on the regional groundwater flow and the associated declining water table elevation (Figure 4-3). Discharges to Gable Mountain Pond and B Pond were terminated in 1987 and 1994, respectively. The surface expressions of these ponds quickly went dry after termination of liquid releases; however, the influence on the regional groundwater from continued infiltration waned slowly. Prior to termination the groundwater within the unconfined aquifer was greatly influenced by these ponds. Over the past 5 years nitrate groundwater results beneath the dry Gable Mountain Pond have shown no significant change in concentration. The stable results suggest that no net change has occurred in the nitrate contaminant plume in this area. In addition, strontium-90 concentrations continue to decrease (e.g., ranging from 18% to 75%) beneath the southern portion of the dry pond, while non-detect values beneath the northern portion continue to be observed, indicating diminished infiltration, decay, and limited migration. Only minor changes of nitrate, sulfate, technetium-99, and cyanide have been reported from wells downgradient of identified sources west of the dry B Pond. For example, although the reported gradient at LLWMA-2 (just west of B Pond) has suggested substantial groundwater flow, 0.4 to 5.1 meters per day, to the west along the southern boundary over the past 20 years, significant nitrate and sulfate increases in upgradient well 299-E27-10 have not been noted in well 299-E34-12 (~1,100 meters to the west). Likewise, the gradient at WMA C (southwest of B Pond) has been reported as southwest for over a decade, with flow rates of 0.7 to 4.8 meters per day; however, cyanide, which has consistently been detected in wells 299-E27-7 and 299-E27-14 for the past decade, has not been detected consistently in wells southwest of these two wells. An assessment associated with the exceedance of the critical mean at WMA C will include installing two new wells, which may help with the low-level water elevation survey in this area and determine the extent of cyanide and groundwater flow direction in this area. These examples of limited contaminant migration downgradient of the former discharge pond indicate the diminishing influence these ponds have over the hydraulic region today. Thus, changes associated with the Columbia River and possibly other permitted discharge locations which in the past did not appear to affect the regional groundwater flow in 200 East Area are now apparently capable of changing the groundwater flow direction for a limited time.

The upper basalt-confined aquifer is also monitored in the 200-BP-5 OU based on the potential for contaminant migration from the overlying unconfined aquifer. However, because of the declining unconfined water table elevation, most confined aquifer wells indicate an upward flow regime. It is also apparent, based on historic information and some of the new 200-BP-5 OU remedial investigation wells, that past contaminant migration into the confined aquifer was limited. The main source of contamination was in well 299-E33-12 (near WMA B-BX-BY), associated with

Flow rates are not provided for the 200-BP-5 OU because of the flow direction reversal.

poor well construction during early Hanford operations. The well seal was remedied in the late 1970s and appears to have sealed the pathway. Additional information on this site is provided in *Data Quality Objectives Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process* (WMP-28945, Rev. 1, Section 1.4.4). The only other area where contamination is increasing within or adjacent the Rattlesnake interbed sediments, generally located beneath the Elephant Mountain Basalt confining formation, is near a cluster of three wells 699-53-55A, B, and C west of Gable Mountain Pond. The well cluster is located in an area previously defined as a basalt window, an area where the upper confining Elephant Mountain Basalt has been eroded by past fluvial events. The wells are screened across the bottom, middle, and top of the unconfined aquifer in this area, respectively. Vertical contaminant migration appears to be occurring at well 699-53-55A due to the following:

- Elevated nitrate and technetium-99 are, and have been, present in the upper portion of the unconfined aquifer.
- Nitrate and technetium-99 concentrations have increased over the past decade at depth as evidenced by the results from well 699-53-55B, which are nearly equal in concentration to the upper aquifer concentrations.
- Upgradient wells within the Rattlesnake interbed, where the Elephant Mountain Basalt had not been eroded, have not found technetium-99 and much less nitrate.
- The missing Elephant Mountain Basalt does not provide a barrier for downward migration.

Thus, it appears the increasing nitrate and technetium-99 are migrating vertically downward; however, it is uncertain why vertically downward contaminant migration may be occurring at this location, as the current water elevations indicate an upward gradient. A depth-discrete sampling investigation is planned in FY 2010 to better understand the vertical distribution of nitrate and technetium-99 contamination. Additional information is provided in Sections 4.2.1.3 and 4.2.3.2 for wells 699-53-55A, B, and C and the current nitrate and technetium-99 concentrations. Also, a cross-section conceptual model of contaminant transport is shown in Figure 1-10 of WMP-28945. Note that the paleochannel location discussed in WMP-28945 has been recently changed based findings associated with two new wells recently installed for the remedial investigation. The new paleochannel conceptual model is briefly described in Sections 4.2.1.3 and 4.2.3.2.

Plume areas (square kilometers) above the drinking water standard in the 200-BP-5 Operable Unit:

Cyanide, 200 µg/L — 0.325

Iodine-129, 1 pCi/L — 6.6

(*includes plume area that overlaps into the ZP1 and BP5 area of overlap)

Nitrate, 45 mg/L — 4.82

(*includes plume area that overlaps into the ZP1 and BP5 area of overlap)

Strontium-90, 8 pCi/L — 0.437

Technetium-99, 900 pCi/L — 1.96

Tritium, 20,000 pCi/L — 0.144

Uranium, 30 µg/L — 0.407

4.2 Groundwater Contaminants

This section summarizes the distribution of groundwater contamination in the 200-BP-5 OU, as required by the sampling and analysis plan (DOE/RL-2001-49). Constituents of concern defined in DOE/RL-2001-49 include nitrate, iodine-129, technetium-99, uranium, strontium-90, cyanide, cobalt-60, cesium-137, plutonium-239/240, and tritium. Cobalt-60 and mercury have been included in previous reports, but their groundwater values did not exceed the DWSs this year; therefore, these constituents are not discussed. Note that cobalt-60 and mercury are still monitored in accordance with the previously mentioned sampling plan. Sulfate, although not identified in DOE/RL-2001-49 as a constituent of concern, is discussed because it exceeded the secondary DWS. The main discussion for each constituent provides the areal extent of concentrations/activity exceeding

the DWSs, flow direction, and planned activities in these areas for FY 2010. Flow rates are not provided for this OU because of the flow direction reversal that was statistically confirmed by the low-level groundwater study at LLWMA-1.

Flow rates are not provided for the 200-BP-5 OU because of the flow direction reversal.

At the beginning of FY 2009 (October 2008), groundwater flow in LLWMA-1 was to the south, remnant of the high Columbia River stage in the spring of 2008 (DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*). Statistical confirmation of a return to a northwesterly flow direction was first noted in July 2009; thus, for more than half of the reporting period, southern or no apparent flow existed in this area. The reversal was also observed in the contaminant concentration fluctuations reported quarterly and semiannually in wells north and south of LLWMA-1 and WMA B-BX-BY. More specifically, most of the mobile constituents showed an increase in the southern wells in the first portion of the reporting period and then decreased in the latter part of the reporting period, when the flow was statistically determined to have returned to a northwest flow direction. As a result of the flow reversal, the net change between the 2008 and the 2009 plume demarcations is not significantly different.

Contaminant distribution maps presented in this section show annual averages: some wells provide four quarters of data, some wells provide two quarters of data, and other wells provide one value per year. The 200-BP-5 OU well network is divided into 200 East Area wells (Figure 4-1) and the 600 Area wells (Figure 4-2). Additional wells other than those defined in DOE/RL-2001-49 included the twelve remedial investigation wells associated with the *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit* (DOE/RL-2007-18) and wells associated with RCRA TSD sites.

Elevated constituents of interest in the 200-BP-5 OU occur near the following waste sites and are discussed in the subsections that follow:

- B Complex (e.g., the WMA B-BX-BY and surrounding waste sites)
- 216-B-62 Crib and north along the west side of LLWMA-1
- Wells 699-53-55A, B, and C (located near Gable Mountain Gap and Gable Mountain Pond)
- Gable Gap, Gable Mountain Pond, and B Pond
- B Plant
- 216-B-5 injection well
- WMA C
- LLWMA-2.

The constituent discussions that follow appear in order by the size of the groundwater plume, following the order listed above. The number of wells monitored for each constituent in the OU is provided for comparison to the required number of wells for monitoring in accordance with DOE/RL-2001-49 and DOE/RL-2007-18.

4.2.1 Nitrate

Nitrate analyses were performed on groundwater samples at least once from 117 wells across the 200-BP-5 OU. Only sixty wells are currently required by DOE/RL-2001-49 and DOE/RL-2007-18. The other analyses are associated with RCRA TSD units.

The average annual distribution of nitrate above the DWS (45 mg/L) is shown in Figure 4-4. Figures 4-1 and 4-2 need to be used to identify specific well names, because providing well names to the plume figure detracts from the legibility of

the figure. Wells in the eight areas listed above that had nitrate concentrations above the DWS during this monitoring period are discussed below. Although nitrate is found in wells at these locations, some of the locations may be monitoring a plume migrating from a distal source.

4.2.1.1 Wells at the B Complex and Extending Northwest Beyond the 200 East Area and Beyond Well 699-49-57A

The highest nitrate concentrations in the 200-BP-5 OU continue to be reported from the wells associated with the BY Cribs. Well 299-E33-7 had a concentration of 1,700 mg/L (December 2009), which was the highest concentration from this well in 50 years and also the highest concentration reported in the OU for the reporting period (October 2008 through December 2009).

As discussed in previous annual reports, the nitrate plume extends to the northwest, beyond the 200 East Area. The estimated 45 mg/L (DWS) northern contour is between wells 699-49-57A and 699-55-60A (Figure 4-4).

A groundwater flow reversal occurred over this area from July 2008 until July 2009 based on statistical gradient analyses associated with a low-level water table study (see Section 2.2). Consequently, a 7.5% decrease in nitrate concentration was reported at well 699-49-57A in April 2009 (223 mg/L) in comparison to the preceding June 2008 sampling event (241 mg/L).

Near WMA B-BX-BY, nitrate appeared to migrate to the south during the flow reversal period.

Near WMA B-BX-BY, nitrate appeared to migrate to the south during this reversal period. For example, well 299-E33-42 (located along the western boundary of WMA BX and along the southern portion of the nitrate plume) increased 30% from the spring of 2008 (421 mg/L) to early 2009 (549 mg/L) before decreasing 46% by the end of July 2009 (297 mg/L) after the groundwater flow regime was confirmed to have returned to a northwesterly flow direction. Similar increases and decreases were reported in most wells along the southern boundary of WMA B-BX. Overall, there was little net change in the plume configuration from the previous monitoring period.

One southern location where increasing nitrate concentrations persisted, even after the northwesterly groundwater gradient was re-established, was at well 299-E33-339. The increased concentrations may be associated with vadose zone contributions from a nearby source. An alternative explanation for the elevated concentration increase is possible density flow along a preferential path in the aquifer from elevated nitrate concentration areas to the north (e.g., wells 299-E33-343 and 299-E33-345). The density plume conceptual model has been discussed in this area by several authors over the years of groundwater monitoring starting in the 1950s. The most recent discussion was provided in *Potential for Groundwater Contamination from High Density Wastes Disposed at the BY Cribs, 200-BP-1 CERCLA Operable Unit* (WHC-SD-EN-TA-003), and a summary of this discussion is provided in Appendix D, Table D-1 of WMP-28945. The density conceptual model assumes that released waste liquids retain their density while traveling through the vadose zone, sink through the aquifer, travel along the dip of the basalt to the south in this area. Some of the waste sites released liquid wastes were reported with original densities as high as 1.4 (e.g., BY Cribs). A depth-discrete groundwater sampling investigation is planned for FY 2010 and should provide a better understanding of the possibility of density flow for certain constituents.

4.2.1.2 216-B-62 Crib and North Along Western Side of Low-Level Waste Management Area 1

For the past 10 years, nitrate has been detected at levels exceeding the 45 mg/L

DWS in well 299-E28-18, which monitors the 216-B-62 Crib (Figure 4-4). The 216-B-62 Crib is located northwest of B Plant. The nitrate concentration for this reporting period in well 299-E28-18 was 190 mg/L versus 126 mg/L for FY 2008.

Nitrate concentrations south of well 299-E28-18 (in well 299-E28-13) have been lower than concentrations at well 299-E28-18 during the previous 10 years. The concentration this reporting period for well 299-E28-13 was 65.5 mg/L, which is slightly higher than FY 2008 but is consistent with concentrations during the previous 10 years. Well 299-E28-13 was first considered to be upgradient of well 299-E28-18 in 1993, based on an assessment for LLWMA-1 (WHC-SD-EN-EV-025, *Results of Groundwater Quality Assessment Program at Low-Level Waste Management Area 1 of the Low-Level Burial Grounds*); the well continues to be considered as upgradient.

Another potential source of nitrate in this area is the 216-B-12 Crib. This site is located to the southeast of the 216-B-62 Crib and downgradient of well 299-E28-13. However, results are not available for the 216-B-12 Crib area for the past 16 years. An investigation/monitoring replacement well is planned to be drilled in FY 2010 near this crib, which may provide clarification of the nitrate source.

Well 299-E28-21 (located northwest of well 299-E28-18) also monitors the 216-B-62 Crib. Nitrate concentrations have been lower at well 299-E28-21 than at well 299-E28-18 over approximately the past two decades, and nitrate concentrations were much lower in June 2008 (72.6 mg/L).

4.2.1.3 Wells 699-53-55A, B, and C Near Gable Mountain/Gable Butte Gap

The cluster of three wells 699-53-55A, B, and C are located in an area previously defined as a basalt window, west of Gable Mountain Pond (Figure 4-4). The wells are screened across the bottom, middle, and top of the unconfined aquifer in this area, respectively. Well 699-53-55A is screened at the base of the aquifer, which is more than 42.7 meters beneath the water table and extends into the Pomona Basalt. Well 699-53-55B is screened ~15.3 to 21.3 meters below the water table, and well 699-53-55C is screened across the upper portion of the aquifer. As discussed in Section 4.1, a cross-section of these wells with a conceptual model of contaminant transport is provided in Figure 1-10 of WMP-28945. Note the change in the contaminant transport discussed in Section 4.1 versus that provided in Figure 1-10 of WMP-28945.

Nitrate concentrations were slightly lower in wells near Gable Mountain Gap for the first time in more than a decade.

Nitrate concentrations were reported slightly lower at wells 699-53-55B and C than last year (141 and 143 mg/L versus 153 and 144 mg/L, respectively) which was the first time in more than a decade a decreasing result was report for both wells. Note that a small decrease was reported once, in 2005, during the past decade for well 699-53-55C. The sample results were from April 2009, near the end of the groundwater gradient reversal (see Section 2.2). Although concentrations decreased in wells 699-53-55B and C, there was a slight increase in well 699-53-55A. Wells further to the northwest (e.g., 699-55-57, 699-57-59, and 699-59-58) did not report significant changes; thus, the plume configuration appears to be unchanged from FY 2008.

Recent basalt-contouring revisions in this area appear to provide a reasonable model for previous increases in nitrate concentration in these wells. The new top-of-basalt contour map defines a paleochannel just east of dry well 699-50-53A, extending northwest toward well 699-53-55C. Groundwater results for well 699-50-53A in the early 1990s indicated a concentrated nitrate plume (i.e., up to 730 mg/L). However, well 699-50-53A went dry in the mid-1990s, and no wells are available between wells 699-50-53A and 699-53-55C to define the extent or maximum

nitrate concentration potentially sourcing the nitrate at wells 699-53-55B and C. An additional well along the conceptualized eroded basalt channel would help to define the extent of nitrate and determine the basalt elevation contours.

4.2.1.4 Wells Monitoring Gable Mountain Pond

The nitrate plume concentrations at Gable Mountain Pond showed change during the reporting period.

The highest nitrate concentration reported near Gable Mountain Pond was from well 699-53-48A (173 mg/L), located beneath the southeastern portion of the inactive dry pond, which has been dry since the late 1980s. The nitrate concentration in this well has not changed significantly over the previous 2 years; however, the concentration decreased significantly during the prior 10 years. Further to the northwest in well 699-54-49, nitrate concentrations are lower and have remained about the same over the previous 5 years. For this reporting period, the nitrate concentration in well 699-54-49 was 46.9 mg/L. Further still to the northwest in well 699-55-50C (located near the northwest end of Gable Mountain Pond), the nitrate concentration was reported at 7.39 mg/L for this reporting period. This concentration is consistent with the concentrations reported over the previous 5 years. Based on these results, the plume configuration in this area did not change. It should be noted that well 699-54-45A (located east of Gable Mountain Pond) continues to be reported below detectable concentrations for nitrate and constrains the eastern boundary of the plume.

4.2.1.5 Wells Monitoring B Plant

Elevated nitrate was detected in one well, 299-E28-17, south of B Plant. The concentration of 66.8 mg/L was slightly higher than in FY 2008. Due to the limited number of wells in this area, it is not certain if this well is associated with migration from a distal source, proximal source, or a combination of these. Two investigation/monitoring wells are planned for installation in FY 2010 in this area and may provide an understanding of the nitrate extent in this area.

4.2.1.6 216-B-5 Injection Well and 216-B-9 Crib

Only one well, 299-E28-25, was sampled near the 216-B-5 injection well for nitrate during the reporting period. The concentration of 57.5 mg/L is consistent with the results from the previous 2 years and much less than the FY 2006 results. Further north, well 299-E28-2 reported results similar to those of previous years. Due to the lack of results to the northwest and southeast of well 299-E28-25, it is difficult to determine the exact extent of nitrate near the 216-B-5 injection well and whether the elevated concentrations in well 299-E28-25 is associated with migration from a distal source, proximal source, or a combination of these. However, due to the consistent concentrations in this well, the nitrate plume configuration was not changed in this area from last year.

4.2.1.7 Wells at Waste Management Area C

The elevated nitrate in the WMA C monitoring network indicates a source at the WMA.

Two wells at WMA C reported concentrations exceeding the DWS: one well (299-E27-155) is located southwest of the tank farm, and one well (299-E27-14) is located along the southeast side of the tank farm. The highest quarterly nitrate concentration was reported from well 299-E27-14 at ~115 mg/L. Figure 4-4 shows the average annual distribution of nitrate in this area.

The elevated nitrate in well 299-E27-14 indicates a WMA C source because the nitrate concentration in this well is more than twice the average concentrations in the documented upgradient wells 299-E27-7 or 299-E27-22. The high levels of nitrate in well 299-E27-14 contributed to an exceedance of the critical mean for specific conductivity in June/July 2009 and the subsequent planned assessment monitoring

action for FY 2010. One subsequent action includes the addition of two new wells: one well northwest of WMA C, and one well south of well 299-E27-14. The well south of 299-E27-14 will help to delineate the nitrate extent in this area.

The elevated nitrate concentration in well 299-E27-155 is much higher than any past or present concentrations reported in wells immediately to the northeast (e.g., 299-E27-4, 299-E27-13, or 299-E27-23). It is uncertain why these wells (considered to be upgradient of well 299-E27-155) do not have higher concentrations because these wells appear to be between the likely source (WMA C) and well 299-E27-155. One possible explanation is a density model, which may have created a predominant downward contaminant flow in this area. Note that well 299-E27-155 is screened along the bottom portion of the aquifer, while the wells to the northeast are screened across the upper portion of the aquifer. Four wells in this area are planned for sampling at multiple depths in FY 2010 to determine if density effects should be considered. Additional discussion of this area is provided in Section 4.4.4.

4.2.1.8 Wells at Low-Level Waste Management Area 2

Elevated nitrate was detected in one well, 299-E27-10, near LLWMA-2. The highest nitrate concentration this reporting period (52.2 mg/L) was lower than that reported during the previous 4 years for this well. Further discussion of this area is provided in Section 4.4.2.

4.2.2 Iodine-129

Iodine-129 analyses were performed on groundwater samples at least once from 77 wells across the 200-BP-5 OU. Only 33 wells are currently required by DOE/RL-2001-49 and DOE/RL-2007-18. Additional analyses are associated with AEA requirements.

The distribution of iodine-129 above the 1 pCi/L DWS is shown in Figure 4-5. Figures 4-1 and 4-2 need to be used to identify specific well names, because providing well names to the plume figure detracts from the legibility of the figure. Five primary areas are discussed below in regard to iodine-129 activities that were above the DWS during this monitoring period for the 200-BP-5 OU:

- Wells at the B Complex and extending northwest beyond the 200 East Area and beyond well 699-49-57A
- Wells monitoring the 216-B-5 injection well and 216-B-9 Crib
- Wells monitoring WMA C
- Wells monitoring LLWMA-2 and west of LERF
- Wells monitoring B Pond.

Although iodine-129 is present at wells in these locations, some of the locations may only be monitoring a migrating plume from a distal source.

4.2.2.1 Wells at the B Complex and Extending Northwest Beyond the 200 East Area and Beyond Well 699-49-57A

The highest iodine-129 concentrations in the 200-BP-5 OU were from new remedial investigation/monitoring well 299-E33-345, along the northern boundary of B Tank Farm.

The highest iodine-129 activity in the 200-BP-5 OU was from new investigation/monitoring well 299-E33-345 (6.74 pCi/L in April 2009), which is located along the northern boundary of B Tank Farm and west of the 216-B-7A and B Cribs. It is difficult to discern what source(s) may be contributing to this plume for the following reasons: (1) iodine-129 is not monitored in the southern WMA B-BX-BY wells, (2) most wells are only monitored annually for iodine-129, and (3) the 4 pCi/L isopleth includes much of this area. However, it is apparent that the B or BX Tank Farms,

or the cribs north of B Tank Farm, has/have contributed to the iodine-129 plume based on the iodine-129 activities reported in vadose zone well 299-E33-344 located in a 4.6-meter-thick perched aquifer (~3.05 meters above the unconfined aquifer).

The iodine-129 groundwater plume from this area has migrated to the northwest and extends beneath the BY Tank Farm and cribs, through the northern portion of LLWMA-1, to well 699-49-57A north of the 200 East Area. The 1 pCi/L (DWS) leading contour is between wells 699-49-57A and 699-55-60A (Figure 4-5). A groundwater flow reversal occurred over this area (Section 4.2.1), which may have contributed to the slight decrease in iodine-129 reported at well 699-49-57A in April 2009 (3.23 pCi/L) in comparison to a concentration of 3.34 pCi/L reported in June 2009.

4.2.2.2 Wells Monitoring 216-B-5 Injection Well and 216-B-9 Crib

The highest activity (3.02 pCi/L) during this reporting period was ~1 meter from the 216-B-5 injection well. Due to the limited number of wells outside of the wells adjacent to the 216-B-5 injection well, it is uncertain if the iodine-129 reported in wells monitoring the 216-B-5 injection well is from this source or more distal source.

Although elevated iodine-129 (2.5 pCi/L) was reported in well 299-E28-2 (located ~170 meters to the northwest), it is also uncertain whether the elevated activity is associated with the 216-B-5 injection well, the 216-B-9 Crib, or a more distal source. The uncertainty associated with the 216-B-9 Crib is because the 216-B-9 Crib was not included in the *Hanford Soil Inventory Model, Rev. 1* (RPP-26744). The next nearest well to the northwest is well 299-E28-27, which reported mixed results for the same sampling period: one detect value and two non-detect values. Based on limited well spacing and infrequent well sampling, it cannot be determined if the 216-B-5 injection well is a continuous source of iodine-129. However, the wells near the 216-B-5 injection well do provide valuable information for defining the western edge of the 1 pCi/L isopleths.

4.2.2.3 Wells Monitoring Waste Management Area C

All of the wells at WMA C that were sampled for iodine-129 had reported activities exceeding the DWSs. The highest activity was in upgradient well 299-E27-7 (5.56 pCi/L), which is located on the northeast side of the tank farm. The groundwater iodine-129 activity beneath WMA C may be associated with contributions from tank farm leaks that have migrated laterally along a dip in the vadose zone before entering the groundwater near this well. An alternative explanation is that the source of the iodine-129 is completely from the former unlined ditches that feed B Pond (e.g., 216-B-2-1 and 216-B-2-2) and/or the inactive B Pond. Comparable inventories of iodine-129 were reported for B Pond as those determined for several of the WMA C tank releases (RPP-6744). Because a well is not located between well 299-E27-7 and the ditches or upgradient pond to the northeast, it is not possible to determine if WMA C sources contributed to the iodine-129 activity in the groundwater at this time.

An assessment well associated with WMA C is planned to be installed in FY 2010 to the northeast of the tank farm. This well may provide sufficient data to determine if iodine-129 associated with WMA C has contributed to the groundwater contamination.

4.2.2.4 Wells Monitoring Low-Level Waste Management Area 2

Elevated iodine-129 activities have been detected in the wells along the southeastern portion of LLWMA-2. The highest semiannual activity (2.6 pCi/L) was from well 299-E27-9 during the reporting period. The most probable source

for the iodine-129 is the past releases associated with the inactive 216-B-2-1 and 216-B-2-2 Ditches. The driving force for these releases to groundwater may have been the volume of liquid associated with these releases, as well as a subsequent liquid release associated with the 216-B-2-3 Ditch (located to the south of the inactive 216-B-2-1 and 216-B-2-2 Ditches) during the mid-1980s. The extent of the 216-B-2-3 Ditch release was determined after water began entering an empty burial trench at LLWMA-2 in 1986 (DOE/RL-2009-76). The empty burial trench was north of the inactive 216-B-2-1 and 216-B-2-2 Ditches. An alternative source may be associated with B Pond; however, well 299-E26-10 at the LERF has not shown any detectable iodine-129 activity, although it is closer to B Pond than the wells monitoring LLWMA-2.

4.2.2.5 Wells Monitoring B Pond Wells

Eight wells are located near the B Pond in the 200-BP-5 OU. Two of these wells located in the 200-BP-5 OU were reported with detectable iodine-129 activities during the reporting period. The highest activity was from well 699-45-42 (3.16 pCi/L), which is consistent with values reported since sampling for iodine-129 began at this well in 1988. The highest value reported from this well was 4.34 pCi/L in June 1997. The other well, 299-E26-8 (further to the southwest) is located in the Rattlesnake Ridge interbed confined aquifer and does not provide an indication of the western extent in the unconfined aquifer. An assessment well associated with WMA C is planned to be installed in FY 2010 to the west of B Pond and to northeast of the C Tank Farm. This well should provide sufficient data to determine the contributions of iodine-129 associated with B Pond or the ditches that feed B Pond.

4.2.3 Technetium-99

Technetium-99 analyses were performed on groundwater samples at least once from 103 wells across the 200-BP-5 OU. Only 56 wells are currently required by DOE/RL-2001-49 and DOE/RL-2007-18. The other analyses are associated with AEA requirements.

The distribution of technetium-99 above the 900 pCi/L DWS was limited to three isolated regions during FY 2009 in the 200-BP-5 OU (Figure 4-6):

- Wells at the B Complex and extending northwest beyond the 200 East Area and beyond well 699-49-57A
- Wells 699-53-55A, B, and C near the Gable Gap
- Wells at WMA C.

Figures 4-1 and 4-2 need to be used to identify specific well names, because providing well names in the plume figure detracts from the legibility of the figure.

4.2.3.1 Wells at the B Complex and Extending Northwest Beyond the 200 East Area and Beyond Well 699-49-57A

The highest technetium-99 activity in the 200-BP-5 OU continued to be reported in wells monitoring the BY Cribs. Each BY Crib well sampled had a peak activity in early 2009, and the peak activities were the highest ever reported for each of the wells. The highest activity (39,000 pCi/L) was from well 299-E33-38. Subsequent sample results significantly decreased. The decreases have ranged from 6,000 to 11,000 pCi/L.

As discussed in previous annual reports, the technetium-99 plume extends to the northwest beyond the 200 East Area. The 900 pCi/L (DWS) leading contour is found between wells 699-49-57A and 699-55-60A (Figure 4-6). A groundwater flow reversal

occurred over this area (Section 2.2), which may have contributed to a 16% decrease in technetium-99 activity at well 699-49-57A in April 2009 (4,100 pCi/L) as compared to June 2008 (4,900 pCi/L).

Near WMA B-BX-BY, technetium-99 appeared to migrate to the south during this reversal period. For example, well 299-E33-42 (located along the western boundary of WMA BX and in the southern portion of the plume) increased 57% from the spring of 2008 (4,400 pCi/L) to the spring of 2009 (6,900 pCi/L). After the groundwater flow direction was statistically determined to return to a northwest flow direction, the subsequent July 2009 technetium-99 activity decreased 18% (5,700 pCi/L). Similar increases and decreases were reported in most wells along the southerly WMA B-BX-BY boundary.

Minor contributions from other vadose zone sources (e.g., 216-B-7A and B Cribs and 241-BX-102 tank release) may have caused increased activity in wells near these sources. For example, well 299-E33-339 (located along the southeastern boundary of the BX Tank Farm) reported an eight-fold increase from February 2008 (804 pCi/L) to May 2009 (6,560 pCi/L). Another explanation for the activity increase in this well is possible density flow along a preferential path in the aquifer. For further discussion regarding the density conceptual model, see Section 4.2.1.1. A depth-discrete groundwater sampling investigation is planned for FY 2010 and should provide an understanding of the possibility of a density flow for certain constituents.

4.2.3.2 Wells 699-53-55A, B, and C Near Gable Gap

Wells 699-53-55A, B, and C are located in an area previously defined as a basalt window, west of the dry Gable Mountain Pond (Figure 4-6). The wells are screened across the bottom, middle, and top of the unconfined aquifer in this area. Well 699-53-55A is screened at the base of the aquifer, which is more than 42.7 meters beneath the water table, and extends into the Pomona Basalt. Well 699-53-55B is screened ~15.3 to 21.3 meters below the water table, and wells 699-53-55C is screened across the upper portion of the aquifer.

Technetium-99 activities were reported as slightly lower during this reporting period at wells 699-53-55B and C than last year (2,500 and 2,800 pCi/L versus 2,550 and 3,000 pCi/L, respectively), which was the first time in more than a decade that a decreasing result was reported for both wells. Note that a small decrease was reported twice (in 2005 and 2007) during the past decade for well 699-53-55B. The sample results were from April 2009, near the end of the groundwater gradient reversal period (see Section 2.2). Although activities decreased in 699-53-55B and C, a slight increase was noted in well 699-53-55A, increasing from 106 pCi/L to 110 pCi/L in 2009. The wells further to the northwest did not report significant changes; thus, the plume configuration appears to be unchanged from FY 2008.

Technetium-99 activity was lower near Gable Mountain Gap for the first time in more than a decade.

Recent basalt-contouring revisions in this area appear to provide a reasonable model for the technetium-99 activity reported in these wells. The new top-of-basalt contour map defines a paleochannel to the east of well 699-50-53A that extends northwest toward well 699-53-55C. Groundwater results reported for well 699-50-53A in the early 1990s indicated a high-activity technetium-99 plume (i.e., up to 30,000 pCi/L). However, well 699-50-53A went dry in the mid-1990s, and no well is located between wells 699-50-53A and 699-53-55C to define the extent or maximum technetium-99 activity potentially sourcing well 699-53-55C. An additional well along the conceptualized eroded basalt channel would help to define the extent of technetium-99 and refine the basalt elevation contours.

4.2.3.3 Wells at Waste Management Area C

Six wells at WMA C were reported with activities exceeding the technetium-99 DWS. Four of the wells (299-E27-4, 299-E27-13, 299-E27-23, and 299-E27-155) are located along the western-southwestern side of the tank farm, and two of the wells (299-E27-14 and 299-E27-21) are located along the south-southeast side of the tank farm. Higher technetium-99 activities were reported in the western-southwestern wells compared to the south-southeast wells, with the highest activity during the reporting period in well 299-E27-23 (13,000 pCi/L). Figure 4-6 shows the estimated distribution of technetium-99 in this area.

A previous groundwater annual report (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*) provided a comparison between well 299-E27-23 and upgradient well 299-E27-7 using nitrate to technetium-99 plots. Although the time-series trend plots for these two wells are comparable, the other western/southwest wells 299-E27-4 and 299-E27-13 did not appear to have comparable trend plots; thus, the data suggest multiple sources.

Another observation from previous groundwater annual reports for WMA C is the significant differences in the reported groundwater flow rate. The rate has been reported from undetermined to 4.8 meters per day over the last 10 years based on the gradient derived from wells adjacent to WMA C. As a result, a regional low-gradient water-level study was initiated in this area in 2009 to resolve the gradient and flow direction; however, the lack of wells southwest of WMA C may make deriving a statistically significant gradient beneath WMA C difficult. The addition of three wells in this area during FY 2010 may provide the necessary data for more certainty of the gradient in this area. The wells to be installed include two WMA C wells (299-E27-24 and 299-E27-25) located south and northeast of the WMA and a 200-BP-5 OU remedial investigation well (299-E24-25) at the former Hot Semiworks site located west of WMA C.

4.2.4 Uranium

Uranium analyses were performed at least once from 97 wells across the 200-BP-5 OU. Only 47 wells are currently required by DOE/RL-2001-49 and DOE/RL-2007-18. The other analyses are associated with AEA requirements.

Uranium contamination in the 200-BP-5 OU was limited to four isolated regions during FY 2009 (Figure 4-7):

- Wells at the B Complex and northwest beyond the 200 East Area
- Wells near the 216-B-62 Crib and north along the western side of LLWMA-1
- Wells near the 216-B-5 injection well
- Wells monitoring B Plant.

Figures 4-1 and 4-2 need to be used to identify specific well names, because providing well names on the plume figure detracts from the legibility of the figure.

4.2.4.1 Wells at the B Complex and Northwest Beyond the 200 East Area

Prior to installation of well 299-E33-343 (along the northwest corner of B Tank Farm), the highest uranium groundwater concentration in the 200-BP-5 OU during the last several years was from well 299-E33-9 in the BY Tank Farm. Remedial investigation/monitoring well 299-E33-343 provided evidence in the vadose zone and groundwater identifying the main source of the uranium groundwater plume in this area. Vadose zone porewater uranium isotopic signature analyses from well 299-E33-343 were effectively the same as the previous investigation analyses for

the 241-BX-102 tank release (PNNL-19277, *Conceptual Models for Migration of Key Groundwater Risk Contaminants Through the Vadose Zone and into the Upper Unconfined Aquifer Below the B-Complex*). In addition, the groundwater results were much higher (5,550 µg/L in June 2009) than any other well in the area, which is indicative of the close proximity to the uranium point of entry into the groundwater.

The 200-BP-5 remedial investigation/ monitoring well data near BX Tank Farm provided sufficient evidence to link releases from tank 241-BX-102 to uranium groundwater contamination.

The groundwater contamination near well 299-E33-343 has migrated predominantly to the northwest over the past two decades based on uranium isotopic comparisons, vadose zone investigations, uranium plume migration, and the low-level water elevation study in this area. The majority of the uranium appears to have migrated west of well 299-E33-44, near well 299-E33-9 and between wells 299-E33-31 and 299-E33-38 (Figure 4-8). Some uranium also appears to have migrated northward, east of well 299-E33-44 and then northwest beneath the southern portion of the BY Cribs. Minor contributions from the 216-B-7A and B and 216-B-8 Cribs may be comingled; however, the infiltration pathway has not been confirmed for these potential sources. The northern extent of the 30 µg/L uranium contour is between wells 299-E33-34 and 699-49-57A (Figure 4-7).

A recent reversal of the groundwater flow direction (discussed in Section 2.2) may explain the recent peak concentration (679 µg/L) observed in well 299-E33-339 (located along the southern portion of the BX Tank Farm). Other explanations for the elevated concentration in this well include (1) a component of southern vadose zone migration from 241-BX-102 unplanned liquid release, or (2) density flow through the aquifer from well 299-E33-343, or (3) a combination of these explanations. A depth-discrete groundwater sampling investigation is planned in FY 2010 and should provide further understanding of the density flow conceptual model.

4.2.4.2 Wells Near 216-B-62 Crib and North Along the Western Side of Low-Level Waste Management Area 1

Over the past 10 years, uranium has been detected at levels near the 30 µg/L DWS in well 299-E28-18, which monitors the 216-B-62 Crib located northwest of B Plant (Figure 4-7). Uranium concentrations were over 200 µg/L in the mid-1980s but have since declined to levels similar to those reported during this monitoring period (43.7 µg/L) by the late 1980s.

Well 299-E28-21 also monitors the 216-B-62 Crib but is located north of well 299-E28-18. Uranium concentrations have been decreasing at this well since the initial high values were observed in the mid-1980s. For FY 2009, the uranium concentration was 10.9 µg/L.

The source of uranium for these wells (299-E28-18 and 299-E28-21) was initially linked to the 216-B-62 Crib; however, based on RPP-26744 for waste sites in this area, the only waste site with significant uranium inventory is the 216-B-12 Crib. Additional supporting evidence for the 216-B-12 Crib as the source of elevated uranium in the groundwater is the elevated uranium detected in the deep vadose zone to the southeast of this crib. Geophysical logging in well 299-E28-16 before it was decommissioned in 2004 reported elevated uranium between 47 and 50 meters below ground surface; this, combined with the determined northern groundwater flow direction (WHC-SD-EN-EV-025) in 1993, makes the 216-B-12 Crib a likely source. An investigation/monitoring well is planned to be drilled in FY 2010 near the 216-B-12 Crib, and the results should provide further understanding of the potential uranium source and uranium groundwater extent in this area.

The current uranium plume extent is defined only around well 299-E28-18, as it is the only well with uranium values exceeding the DWS. It should be noted that no proximal wells near the 216-B-12 Crib have been sampled since the mid-1990s.

4.2.4.3 Well Near the 216-B-5 Injection Well

The 216-B-5 injection well is located northeast of B Plant (Figure 4-7). A small uranium plume has been reported since groundwater monitoring began at the injection well approximately three decades ago. The highest uranium concentration (26.4 µg/L) for this monitoring period was at well 299-E28-23, located ~1 meter from the injection well. Uranium concentrations have been decreasing at this well over the previous 2 years, with the concentration currently below the DWS. Lower uranium values are found in proximal wells 299-E28-25 and 299-E28-24 (to the northwest and southeast of well 299-E28-23, respectively).

4.2.4.4 Wells Monitoring B Plant

Elevated uranium concentrations were detected in two wells near B Plant: 299-E28-6 (average 39 µg/L) and 299-E28-17 (26.4 µg/L). The well distribution in this area is sparse, so the origin of the uranium in these wells is not known. One well is located near the 216-B-10A and B Cribs. However, inventory results for these cribs indicate less than 5 kilograms of uranium (RPP-26744); therefore, they are not considered a source of groundwater contamination. The other well, 299-E28-6, is located to the east of B Plant, which is not near any waste site.

The only waste site source with significant uranium concentrations in the B Plant area is the 216-B-12 Crib; however, flow from this potential source has been considered to the north in the past. Two investigation/monitoring wells are planned to be drilled in FY 2010, and the results should provide additional understanding of the uranium extent in this area.

4.2.5 Strontium-90

Strontium-90 analyses were performed at least once from 39 wells across the 200-BP-5 OU. However, six Gable Gap wells and one triennial Gable Mountain Pond well were not sampled from the 35 required wells in accordance with DOE/RL-2001-49 and DOE/RL-2007-18. The Gable Gap wells not sampled have historically been reported with mainly non-detect values: 699-57-59, 699-59-58, 699-60-60, 699-61-62, 699-61-66, and 699-64-62. These wells were deleted from the schedule in 2008 in anticipation of a revision to the 200-BP-5 OU groundwater sampling and analysis plan and were not added back into the schedule when the plan was not released. All required wells are scheduled for sampling in FY 2010. Well 699-54-48 near Gable Mountain Pond was delayed due to inaccessibility and later required maintenance; the well was not sampled before the end of the reporting period.

Eleven of the wells sampled were reported with strontium-90 levels above detection. Nine of the wells reported strontium-90 concentrations above the 8 pCi/L DWS. Five of the wells with strontium-90 levels above the DWS are located near the 216-B-5 injection well, and the other four wells are located near Gable Mountain Pond (Figure 4-9).

The highest strontium-90 activity (4,900 pCi/L) for this reporting period was ~1 meter from the 216-B-5 injection well, which is also the only well above the U.S. Department of Energy (DOE)-derived concentration guide of 1,000 pCi/L. Distal strontium-90 activities indicate a predominant history of northwest groundwater flow from the 216-B-5 injection well. This is demonstrated by the 1,900 pCi/L activity from

well 299-E28-25 (~7 meters to the northwest) versus the significantly lower activity of 240 pCi/L in well 299-E28-24 (~5 meters to the southeast). The predominant northwest transport of strontium-90 is further seen by the 140 pCi/L concentration in well 299-E28-2 (~170 meters to the northwest). The next closest well to the northwest is well 299-E28-27, which has continued to report non-detect values.

The highest strontium-90 activity reported near Gable Mountain Pond was in well 699-53-47A, located beneath the southeastern portion of the pond, at 522 pCi/L. The concentration from this well has steadily decreased over the last 12 years from 1,320 pCi/L. To the north from well 699-54-49, concentrations have appeared stable over the previous 5 years at 170 pCi/L. Well 699-55-50C, located near the northwest end of Gable Mountain Pond, was again reported with a non-detect strontium-90 activity. The continued non-detect values in this well indicate limited movement to the northwest toward Gable Gap.

4.2.6 Cyanide

Cyanide analyses were performed at least once from 88 wells across the 200-BP-5 OU. Only 34 wells are currently required by DOE/RL-2001-49 and DOE/RL-2007-18. The other analyses are associated with RCRA TSD units.

The distribution of cyanide above the 200 µg/L DWS occurs in the area beneath the BY Cribs and extends to the northwest beyond the 200 East Area boundary (Figure 4-10). It should be noted that elevated cyanide concentrations were also reported in well 699-53-55C at 195 µg/L (west of Gable Mountain Pond).

The maximum cyanide concentration in the 200-BP-5 OU this reporting period was located beneath the BY Cribs in well 299-E33-7 (1,730 µg/L), which is the highest concentration reported in this well. Although the concentration was the highest, it was reported early in 2009 and subsequent results have since declined.

As discussed in previous annual reports, the cyanide plume extends to the northwest beyond the 200 East Area boundary. The 200 µg /L (DWS) cyanide contour is between wells 299-E33-34 and 699-49-57A, as noted in Figure 4-10. Cyanide is also present to the south and east of the BY Cribs. The inventory south and east of the BY Cribs is thought to be associated with the groundwater reversal and possible density contaminant flow through the aquifer along the dip of the basalt. The aquifer is thin in this area, and the basalt surface slopes to the south and east from the BY Cribs. A depth-discrete groundwater sampling investigation is planned for FY 2010 and should provide further understanding of the density flow conceptual model.

4.2.7 Cesium-137

Cesium-137 analyses were performed at least once from eighty wells across the 200-BP-5 OU. Only 35 wells are currently required by DOE/RL-2001-49 and DOE/RL-2007-18. The other analyses are associated with AEA requirements or are provided with other required gamma (e.g., cobalt-60) analyses at other 200-BP-5 OU wells.

The 216-B-5 injection monitoring wells were the only wells with detects for cesium-137 in the 200-BP-5 OU.

Only three wells (near the 216-B-5 injection well) had detectable cesium-137 within the 200-BP-5 OU, with activities ranging from 36 to 2,430 pCi/L. Well 299-E28-23, located ~1 meter from the 216-B-5 injection well, had the highest activity at 2,430 pCi/L (see Figure 4-1 for the well location). Although the reported activity is above the 200 pCi/L DWS it is less than the DOE-derived concentration guide of 3,000 pCi/L. The current activity is ~65% of the average activities in the 1980s.

Cesium-137 has relatively low mobility in the subsurface and does not migrate

significant distances, as can be observed by the much lower activity (78.6 pCi/L) from well 299-E28-24, which is located ~5 meters to the southeast of the 216-B-5 injection well. Even lower activity (36 pCi/L) is found ~7 meters to the northwest in well 299-E28-25. Based on historical comparisons, this plume appears to be decaying without much movement, as modeled and concluded in the *200-BP-5 Operable Unit Treatability Test Report* (DOE/RL-95-59).

4.2.8 Plutonium-239/240

Plutonium-239/240 analyses were performed at least once from 24 wells across the 200-BP-5 OU. However, samples from six Gable Gap wells were not collected from the thirty required wells in accordance with DOE/RL-2001-49 and DOE/RL-2007-18. The wells that were not sampled have historically been reported with non-detect values: 699-57-59, 699-59-58, 699-60-60, 699-61-62, 699-61-66, and 699-64-62. These wells were deleted from the sampling schedule in 2008 in anticipation of a revised 200-BP-5 OU sampling and analysis plan, and they were not added back to the 2009 schedule when the plan was not released. However, the wells were added back into the sampling schedule for FY 2010.

Only the three wells near the 216-B-5 injection well have continuously detected plutonium-239/240 over the years. The activities during this reporting period ranged between 0.64 and 42 pCi/L. Well 299-E28-23, located ~1 meter from the 216-B-5 injection well, had the highest concentration (42 pCi/L). Plutonium-239/240 is nearly immobile in the subsurface, as reflected by the stable low results in wells 299-E28-24 and 299-E28-25 (located ~5 to 7 meters from the 216-B-5 injection well).

4.2.9 Tritium

Tritium analyses were performed at least once from 110 wells across the 200-BP-5 OU. Only 45 wells are currently required by DOE/RL-2001-49 and DOE/RL-2007-18. The other analyses are associated with AEA requirements or are shared wells with other OUs.

Tritium above the DWS of 20,000 pCi/L is limited to three wells.

Tritium above the 20,000 pCi/L DWS is limited to three wells (Figure 4-11). Figure 4-1 needs to be used to identify specific well names, because providing well names on the plume figure detracts from the legibility of the figure. One well, 299-E33-7, is located beneath the northwestern portion of the BY Cribs. This well had the highest quarterly tritium activity (91,000 pCi/L), which was not unexpected due to the tritium inventory received by the overlying 216-B-50 Crib and previous groundwater results from this well. The average annual value in Figure 4-11 is 48,000 pCi/L. The significant fluctuations reported throughout the year indicate infiltration and groundwater movement.

The elevated tritium levels in well 299-E33-7 continue to correlate in the other two wells (299-E33-26 and 299-E33-34) with elevated tritium in this area. Although these wells correlate with well 299-E33-7, they may be representative of a tritium source from the 216-B-57 Trench, which is the only other source that received significant tritium inventory in this area. Based on the uranium plume migration, these wells are downgradient of the 216-B-57 Crib; however, the high activities during the reporting period in these wells were significantly less than well 299-E33-7 (27,000 and 26,000 pCi/L, respectively). In addition, the activity trends in these wells are both similar but differ from the trend in well 299-E33-7. The northern extent of the 20,000 pCi/L contour is between wells 299-E33-34 and 699-49-57A.

Overall, the plume extent above the DWS is shrinking. Activities from the wells in the northern portion of the 200-BP-5 OU near the Columbia River have decreased below the DWS, as well as the activities in the Gable Gap region.

4.2.10 Sulfate

Sulfate analyses, like nitrate, were performed at least once from 117 wells across the 200-BP-5 OU. The distribution of sulfate above the DWS (250 mg/L) is generally limited to a few locations within the 200-BP-5 OU, as provided below:

- BY Crib wells
- Wells 299-E33-9 and 299-E33-31 within and along the northwest boundary of the BY Tank Farm
- Well 299-E27-14 at WMA C
- Well 299-E27-10 at LLWMA-2.

Since the concentrations are so localized, they are not represented on a map.

4.2.10.1 BY Crib Wells

High sulfate concentrations beneath the BY Cribs are not unexpected based on the large inventories of sulfate that were added in the initial phase of the bismuth phosphate process. The waste generated (referred to as metal waste) was eventually sent to the BY Cribs after further separation of various fission and metal products. Thus, considering previous vadose zone and groundwater sample results, the current groundwater results are consistent with the other contaminants of concern associated with the BY Cribs (e.g., cyanide, nitrate, and technetium-99).

4.2.10.2 Wells 299-E33-9 and 299-E33-31 Within and Along the Northwest Boundary of Waste Management Area BY

The concentrations reported in the wells 299-E33-9 and 299-E33-31 appear to be sourced from the BY Cribs. The high sulfate concentrations in these wells were reported during a prolonged groundwater gradient reversal to the south, which was determined by a low-level groundwater elevation study. Further evidence of a northern source is provided by the decreased concentrations reported in these wells after the groundwater flow direction was re-established to the northwest.

4.2.10.3 Well 299-E27-14 at Waste Management Area C

High sulfate concentrations at WMA C were associated with initiation of assessment monitoring at the WMA this year.

The sulfate concentration reported in well 299-E27-14 (along the southeast side of WMA C) appears to be associated with a WMA C release. During June/July 2009, the RCRA indicator parameter (specific conductance) was exceeded in well 299-E27-14, primarily due to high sulfate and nitrate concentrations. The sulfate concentrations were higher in this well than any other well in the northeastern portion of the 200 East Area. A probable co-contaminant, cyanide, also reported in this well, appears to be from WMA C, as no other upgradient sources exist. A groundwater quality assessment plan was prepared and is being implemented to determine the extent of contaminants impacting the groundwater at WMA C. The assessment includes the installation of one well to the south of well 299-E27-14, which is expected to provide critical information on the extent of contaminants to the south. Further discussion of primary contaminants exceeding the DWS at WMA C is provided in Section 4.4.4.2. A regional map of the sulfate concentrations is referenced in Section 4.4.4.2, which shows how sulfate appears to be distributed throughout the region.

4.2.10.4 Well 299-E27-10 at Low-Level Waste Management Area 2

The sulfate concentration in well 299-E27-10 has continued to increase since the late 1990s. The highest concentration this reporting period was 294 mg/L, which was reported in the fall of 2009. The sulfate concentration in this well may be associated with releases from the 216-B-2-1 and 216-B-2-2 Ditches. High concentrations of

sulfate were reported beneath the 216-B-2-2 Ditch during the 200-CW-3 OU remedial investigation (DOE/RL-2000-35, *200-CW-1 Operable Unit Remedial Investigation Report*). The *Borehole Summary Report for the 216-B-2-2 Ditch* (BHI-01177) reported four zones of elevated moisture at depth. In addition, the subsurface lithology has been described as having silt-rich interbeds capable of generating perched water conditions (WHC-SD-EN-TI-290, *Geologic Setting of the Low-Level Burial Grounds*). These interbeds appear to dip to the northeast. A possible contributor for the driving force to groundwater associated with the 216-B-2-1 and 216-B-2-2 releases may have been a subsequent release associated with the 216-B-2-3 Ditch, which was determined after water began entering an empty burial trench at LLWMA-2 in 1986. By May 1997, significant sulfate increases were reported in well 299-E34-7. An increasing trend began in 1999 in well 299-E27-10, located to the southwest of well 299-E34-7 (Figure 4-12). Whether the sulfate migrated through the aquifer towards well 299-E27-10 or infiltrated into the aquifer from the vadose zone is unknown. However, both wells are north of the 216-B-2-1 and 216-B-2-2 Ditches, the prevailing dip direction of the vadose zone sediments.

Although the gradient at LLWMA-2 has suggested flow to the west along the southern boundary for nearly two decades, the sulfate increases observed in well 299-E27-10 have not been noted in well 299-E34-12, which is ~1,100 meters to the west. However, sulfate concentrations began increasing in well 299-E27-10, which is southwest of well 299-E34-7, only 2 years after being observed in well 299-E34-7. This indicates either groundwater flow to the southwest with flow up to 0.5 meters per day or a slower westward groundwater flow of less than 0.27 meters per day. The flow to the west and flow rate will continue to be uncertain until significant sulfate increases are seen in well 299-E34-12. The rationale for using well 299-E34-12 rather than some relatively closer well (e.g., 299-E27-8 or 299-E27-9) is that the releases were directly above these wells and, thus, the increases found in these wells may be from a different vadose zone pathway or transverse dispersion during groundwater flow to the south.

4.3 CERCLA Groundwater Activities

The CERCLA monitoring requirements for the 200-BP-5 OU are defined in the sampling and analysis plan (DOE/RL-2001-49), which was revised in late FY 2004 to integrate AEA monitoring and make minor modifications in the monitoring network. The CERCLA monitoring data are used to define the groundwater contaminant plume extent and movement and includes sampling of significant waste source plumes originating from the 216-B-5 injection well site, BY Cribs, and Gable Mountain Pond. A remedial investigation is being conducted to identify the appropriate remedial actions to address the contaminant plumes in the 200-BP-5 OU. The remedial investigation activities are defined in DOE/RL-2007-18. The work plan incorporated minor changes (DOE/RL-2007-18, Rev. 1) in FY 2009 at the request of the U.S. Environment Protection Agency. The following discussion includes the activities completed and the results, as required by DOE/RL-2007-18 and DOE/RL-2001-49.

Analyses for the eight remedial investigation wells were completed and compiled during the reporting period. Chemical analyses for four of the remedial investigation wells were published in FY 2009, which included the alpha numeric wells “B,” “C,” and “N,” as identified in DOE/RL-2007-18. Note that two wells were installed for the “B” well: well 299-E33-345 in the unconfined aquifer, and well 299-E33-344

in a 4.6-meter-thick perched aquifer (~3.05 meters above the unconfined aquifer). The results are provided in the following documents:

- PNNL-SA-18578, *Analytical Data Report for Water Samples Collected from Operable Unit BP-5 B Well*
- PNNL-SA-62124, *Analytical Data Report for Sediment Samples Collected from BP-5 Operable Unit C Well*
- PNNL-SA-62141, *Analytical Data Report for Grab Samples Collected from BP-5 Operable Unit N Well*
- PNNL-SA-62656, *Analytical Data Report for Grab Samples Collected from Operable Unit BP-5 B Well*.

The other well results completed were for 299-E33-205 (well "C") and 699-52-55 (well "N").

Two borehole summary reports were completed in FY 2009 that describe the drilling and construction activities for the eight monitoring wells ("A" through "E," "G," "H," and "N") that were completed in FY 2008:

- SGW-39496, *Borehole Summary Report for the Installation of One Groundwater Monitoring Well at the 200-BP-5 Operable Unit*
- SGW-39626, *Borehole Summary Report for the Installation of Seven Groundwater Monitoring Wells at the 200-BP-5 Operable Unit, CY 2008*.

These investigations provided valuable information for the conceptual transport model and development of the baseline risk assessment. The investigations may also yield information useful to future refinement of the flow and transport modeling to support a composite site analysis. Details of the results of activities described in this section will be published in the remedial investigation/feasibility study reports.

The CERCLA groundwater monitoring in FY 2009 included sampling at the existing network monitoring wells in the 200-BP-5 OU in accordance with DOE/RL-2001-49. Triennial sampling is performed for wells that have shown stable trends for several years, which generally includes wells that are distal to the source areas with few identified contaminants and low levels of contamination or that are supplemented by RCRA sampling requirements. Quarterly to semiannual sampling is completed for new wells and existing wells in areas where contaminant concentrations are changing, as identified in the 200-BP-5 data quality objectives summary report (WMP-28945).

The information derived from this routine sampling, in addition to samples from the new remedial investigation wells, has provided evidence for the source of the uranium plume and the flow direction. In addition, the data generated from beneath the BY Cribs have provided clarity regarding the contaminant suite associated with the BY Cribs. New remedial investigation wells 299-E33-50 and 299-E33-340 have provided information on the extent of contamination within the basalt-confined aquifer. The three new remedial investigation wells north of the 200 East Area have clarified transport pathways across the buried basalt anticline ridge.

Overall contaminant concentration/activity increases were associated mainly with WMA B-BX-BY, WMA C, the BY Cribs, and possibly other past-practice liquid effluent waste sites near WMA B-BX-BY. Although new peak concentrations were reported in some of these areas, the extent of contaminant migration is minimal due to either the low hydraulic gradient, the flow reversal observed throughout the northwest portion of the 200 East Area, or the low mobility of the contaminant.

In FY 2009, all but three wells were successfully sampled (i.e., well 699-52-55 did not sustain flow, well 699-54-45B is dry, and well 699-54-48 was delayed due to inaccessibility and later required maintenance). In addition, plutonium-239/240 and strontium-90 analyses were not completed at the guard wells (wells located between Gable Butte and Gable Mountain) due to sample optimization; however, analyses of these constituents are planned for the guard wells in FY 2010. Previous plutonium-239/240 and strontium-90 analytical results for these wells were all reported as undetected.

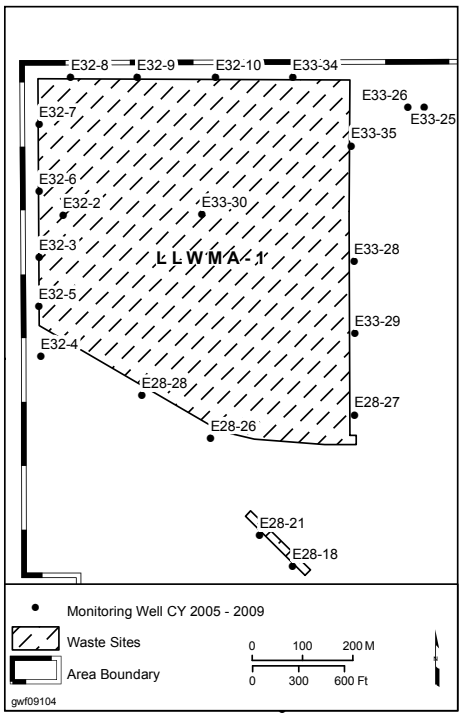
4.4 Facility Monitoring

This section describes results of monitoring at individual units such as TSD units or tank farms. These units are monitored under RCRA requirements for dangerous waste constituents and under AEA for source, special nuclear, and byproduct materials. Data from unit-specific monitoring are also integrated into the CERCLA groundwater investigations. Dangerous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each unit. As previously discussed, pursuant to RCRA, the source, special nuclear, and byproduct material components of radioactive mixed waste are not regulated under RCRA but are regulated by 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 only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

The 200-BP-5 OU contains six RCRA sites with groundwater monitoring requirements: LLWMA-1 and LLWMA-2, WMA B-BX-BY, WMA C, LERF, and 216-B-63 Trench. The following discussion 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.

4.4.1 Low-Level Waste Management Area 1

G. S. Thomas



Groundwater monitoring at LLWMA-1, located in the northwestern corner of the 200 East Area, continued under RCRA and AEA requirements. In accordance with 40 *Code of Federal Regulations* (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 the *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds* (DOE/RL-2000-72). All of the wells were successfully sampled during this reporting period, with the exception of the December 2008 sampling for well 299-E28-27. Appendix C, Tables C-19 and C-20 include lists of the wells and constituents

monitored, and indicator parameter comparison values, respectively. The following subsections discuss the annual evaluation requirements for the monitoring network, groundwater results, and compliance status.

4.4.1.1 Network Evaluation

The interim status monitoring requirements of 40 CFR 265, Subpart F ("Ground-Water Monitoring") and WAC 173-303-400 require upgradient and downgradient monitoring wells that ensure immediate detection of any statistically significant change in concentrations (e.g., above the derived critical mean for the four indicator parameters) of dangerous waste or dangerous waste constituents at the limit of the WMA within the uppermost aquifer. This subsection discusses whether the network remains adequate to monitor LLWMA-1 in accordance with these requirements.

The LLWMA-1 groundwater monitoring network consists of seventeen wells. The groundwater gradient in this portion of the 200 East Area is low, making the determination of groundwater flow direction difficult. Recent precision measurements incorporating careful land surveying, gyroscopic surveying, and project-dedicated tape measurements support a dominant historical northwest groundwater flow direction, which is consistent with previous annual reports. Thus, the six eastern and southeastern wells previously defined as upgradient wells remain as the defined upgradient wells (see Appendix C, Table C-20).

A gradient reversal at LLWMA-1 with subsequent erratic gradient measurements associated with high spring stages of the Columbia River was observed from July 2008 until July 2009.

Despite the dominant historical northwest flow direction at LLWMA-1, a gradient reversal of flow to the south, with subsequent erratic gradient measurements caused by the spring high stages of the Columbia River was observed from July 2008 until April 2009, when northwestern flow direction began to be re-established (see Section 2.2). Note that statistically significant values for a northwest flow direction were not established until July 2009. Given the variable gradient during the first half of the reporting period, no gradient or flow rate is provided for this reporting period. In order to provide a more comprehensive understanding of possible future changes with relation to springtime Columbia River levels, monthly water-level measurements will continue to be collected. The monthly time interval is considered appropriate to monitor the gradient response time to the Columbia River's elevation changes and to investigate if other discharge events at the Hanford Site might affect the groundwater gradient in this area.

Another related LLWMA-1 monitoring network action during this reporting period was the issuance of the *Groundwater Monitoring Needs Assessment for Low-Level Burial Grounds Waste Management Areas* (SGW-40037). This report recommended closing the unused north portion of the burial ground and adding two new downgradient wells along the new, north side of the burial ground between wells 299-E32-2 and 299-E33-30. One well is planned to be completed in FY 2010 and the second well in FY 2011.

4.4.1.2 Groundwater Contaminants

During the reporting period, the indicator parameter measurements for pH, total organic carbon, and total organic halides were consistent with previous results and did not exceed the statistically derived background comparison values (e.g., critical mean). The pH levels for all of the wells ranged from 7.82 to 8.18, which is within the lower and upper bound of the critical mean (7.54 to 8.35, respectively). The highest total organic carbon level of 600 µg/L was reported in well 299-E33-34 during sampling in June 2009, which was significantly below the critical mean of 1,116 µg/L. The highest total organic halide concentration was reported just above

the detection level in well 299-E32-7. The annual groundwater phenol results were all reported as non-detects for December 2008 sampling.

The indicator parameter of specific conductance was reported below the critical mean of 847 µS/cm for all wells, except 299-E32-10 and 299-E33-34. The highest respective levels reported for these two wells (966 and 2,000 µS/cm, respectively) during the reporting period were influenced primarily by the significant nitrate plume migrating from the BY Cribs. The nitrate concentrations in these two wells in comparison with other anion and cation groundwater quality parameters ranged from 57% to 68% of the total milliequivalents per liter. The nitrate concentrations in other WMA monitoring wells are generally less than 35% of the total milliequivalents per liter, indicating a difference in groundwater quality in this portion of the monitoring network compared to the remainder of the network.

Nitrate and cyanide are the only groundwater quality parameters exceeding DWSs beneath LLWMA-1, with nitrate concentrations exceeding the DWS in nearly every well. As reported in previous annual reports, the sources of nitrate are east and south of LLWMA-1. The largest nitrate increase was from well 299-E33-34, where the concentration was reported at 846 mg/L in June 2009. This value is the highest nitrate concentration ever reported in this well and for the monitoring network. Well 299-E33-34 also had the only cyanide concentration (473 µg/L) reported above the DWS. Wells 299-E32-9 and 299-E32-10, located along the northern boundary, also reported increased nitrate and cyanide concentrations. The increased concentrations are consistent with the contaminant trends noted in wells to the east of LLWMA-1. In general, the higher nitrate concentrations in the remaining LLWMA-1 monitoring wells (excluding wells 299-E32-9, 299-E32-10, and 299-E33-34) are found in monitoring wells at the southeastern boundary. This is indicative of the sources to the south and the historical northern groundwater flow direction, as has been reported in previous annual reports.

Performance assessment monitoring of radionuclides at LLWMA-1, in accordance with AEA authority, is designed to complement RCRA detection monitoring and is aimed specifically at monitoring radionuclides not regulated under RCRA. The current monitoring plan (DOE/RL-2000-72, Rev. 1) includes technetium-99, iodine-129, tritium, and uranium specifically for performance assessment.

Technetium-99 increases in the LLWMA-1 northeast monitoring wells is attributed to plume migration from the BY Cribs.

Technetium-99 activities have not changed significantly in wells monitoring LLWMA-1, except in the northeastern portion of the WMA. The increased technetium-99 groundwater concentration in these northeast wells (299-E32-9, 299-E32-10, and 299-E33-34) is the result of the technetium-99 plume migrating from the BY Cribs. Some of the technetium-99 detected in well 299-E33-28 may also be associated with sources in the WMA B-BX-BY, the 216-B-7A and B Cribs, or both.

Elevated iodine-129 activities are also found predominantly in the eastern and northern LLWMA-1 monitoring wells. As indicated in Section 4.2.2, the source of the iodine-129 appears to be locally from the east and regionally from the southeast. Overall concentrations are ~20% lower than the peak activities reported in well 299-E33-34 more than a decade ago.

Uranium concentrations at LLWMA-1 continue to exceed the 30 µg/L DWS only in well 299-E33-34. The concentrations reported for this reporting period were slightly less than those of the previous annual report. The concentration trend in this well appears to have stabilized or is possibly decreasing. Although the uranium concentration has decreased in well 299-E33-34, migration of the plume into wells to the west is apparent, with the concentrations trends increasing in

wells 299-E32-9 and 299-E32-8. Increasing uranium concentrations are also reported in well 299-E28-27, near the southeastern corner of LLWMA-1. The source of this increase is unknown; however, higher concentrations are reported in well 299-E28-18 to the south and 299-E33-42 to the northwest.

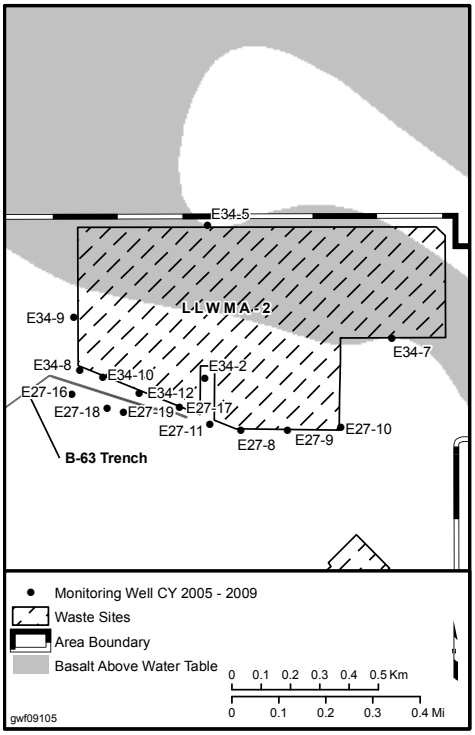
Tritium was reported above the DWS in only one LLWMA-1 monitoring well, 299-E33-34. The activity is the result of migration from wells to the southeast (Section 4.2.9).

4.4.1.3 Compliance Status

The interim status monitoring requirements of 40 CFR 265, Subpart F and WAC 173-303-400 require a groundwater quality assessment program if downgradient indicator parameters exceed the upgradient derived indicator parameter critical mean. The exceedance of specific conductance in well 299-E33-34 was initially reported by DOE to the Washington State Department of Ecology (Ecology) in 1999. Continued observations indicate that contaminant migration from the BY Cribs is the primary cause of increased specific conductance, as discussed in Section 4.4.1.2 and in previous annual reports. Thus, the elevated specific conductance in wells 299-E32-10 and 299-E33-34 is not cause for change of the interim status indicator evaluation groundwater monitoring conducted at LLWMA-1.

4.4.2 Low-Level Waste Management Area 2

G. S. Thomas



Groundwater at LLWMA-2 in the northeastern corner of the 200 East Area continued to be 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 RCRA 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 this reporting period. Appendix C, Table C-21 and C-22, include lists of the wells and constituents monitored, and indicator parameter comparison values, respectively. The following subsections provide annual evaluation requirements for the monitoring network, groundwater results, and compliance status.

4.4.2.1 Network Evaluation

The interim status monitoring requirements of 40 CFR 265, Subpart F and WAC 173-303-400 require upgradient and downgradient monitoring wells that ensure immediate detection of any statistically significant change in concentrations (e.g., above the derived critical mean for the four indicator parameters) of dangerous waste or dangerous waste constituents at the limit of the WMA within the uppermost aquifer. This subsection discusses if the network remains adequate to monitor LLWMA-2 in accordance with these requirements.

The LLWMA-2 groundwater monitoring network consists of nine wells. Over the past 5 years, the local groundwater flow direction has been reported to the west based on small differences along the southern boundary of LLWMA-2; however, over this same time period, other well groupings portray different groundwater flow directions. According to the *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project, Hanford Site* (SGW-38815), small measurement errors can have a large effect on determining flow direction and velocity where the

horizontal gradient is less than 0.001, as is the case for LLWMA-2. Therefore, the annual reports during this timeframe have added observations of mobile anion movement to depict flow direction. The nitrate- and sulfate-derived groundwater flow over the past 5 years has been reported as southwest. Given the variable gradient, based on well selection, no gradient or flow rate is provided for this reporting period. Resolution of this issue is being addressed by a regional, low-gradient, water-level study. This study was initiated in early 2009. The goal is to reduce measurement error associated with water-level measurements and to obtain statistical confidence for reporting groundwater flow direction.

Another related LLWMA-2 monitoring network action during this reporting period was the issuance of SGW-40037, which recommended the addition of two new upgradient wells along the eastern side of the burial ground (Figure 4-13). These wells are planned to be completed in FY 2011 and will define the statistical comparison values for the groundwater indicator parameters. One well, 299-E34-16, is planned east of Trench 94 and will replace dry well 299-E35-1. The other well, 299-E33-15, will be located south of Trench 94, near dry well 299-E34-3. Since the vertical extent of groundwater is limited or non-existent in these areas, the well construction plan will use a potential flow-top hydrogeologic unit. A flow-top hydrogeologic unit was encountered at the LERF where vesicular basalt was apparently interconnected creating a permeable unconfined aquifer. Two downgradient wells are also planned, with one well (299-E34-13) scheduled to be installed in early CY 2010. The hydraulic results of this year's well will be used to provide a go/no go determination for the other downgradient well (299-E34-14) and upgradient well 299-E34-15.

4.4.2.2 Groundwater Contaminants

During the reporting period, the indicator parameter measurements for pH, total organic halides, and specific conductance were consistent with previous results and did not exceed the statistically derived background comparison values (e.g., critical mean). The pH levels for all of the wells ranged from 7.39 to 8.22, which is within the lower and upper bound of the critical mean (6.85 to 8.56, respectively). The highest total organic halide concentration reported was slightly above detection at 7.39 µg/L in April 2009 at well 299-E27-10. The annual groundwater phenol results were all reported as non-detects for the annual October sample collection event.

One well, 299-E34-2, was reported with total organic carbon concentrations above the critical mean during the reporting period. The average concentration (3,847.5 µg/L) exceeded the critical mean value of 3,036 µg/L. This was the first time that total organic carbon was reported above the critical mean in this well. The reported values were not consistent with previous results, and validation samples were collected in January 2010 to determine if a possible reporting error or laboratory contamination issue had occurred. The results of the validation samples were non-detects; thus, the elevated concentrations are flagged as suspect in the Hanford Environmental Information System database and are attributed to a possible reporting error or laboratory contamination issue.

The indicator parameter of specific conductance was reported below the critical mean of 1,278 µS/cm for all LLWMA-2 monitoring wells. The highest specific conductance level was reported in April 2009 for well 299-E27-10 (1,038 µS/cm). The increasing specific conductivity trend in well 299-E27-10 began shortly after increases began at dry well 299-E34-7 (Figure 4-14). Previous annual reports documented the reason for the increased specific conductivity at well 299-E34-7 as the result of increased sulfate, chloride, nitrate, and calcium concentrations. The cause for the

increased constituent concentrations has not been determined to date; however, the basalt chemistry that was initially thought to be the source was eliminated because the ion chemistry in the uppermost basalt confined aquifer was significantly different (PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*). PNNL-14187 also considered leaching or infiltration from the vadose zone as an alternative source affecting the groundwater quality at well 299-E34-7.

Sulfate and nitrate are the only groundwater quality parameters that exceeded DWSs during the reporting period at LLWMA-2, with both exceedances occurring at well 299-E27-10. The highest concentrations this reporting period were 294 and 52.2 mg/L, respectively. Chloride and calcium were also elevated in this well, at nearly 4 and 2.5 times background (77.7 and 140 mg/L), respectively.

Performance assessment monitoring of radionuclides at LLWMA-2, in accordance with AEA authority, is designed to complement RCRA detection monitoring and is aimed specifically at monitoring radionuclides that are not regulated under RCRA. The current monitoring plan (DOE/RL-2000-72) includes technetium-99, iodine-129, tritium, and uranium.

The technetium-99 activity is decreasing in well 299-E27-10, with the lowest activity reported at 52 pCi/L in October 2009. Other wells in the monitoring network have lower technetium-99 activities and only periodically report detected results. Iodine-129 activity is more prominent in the eastern wells, but it appears to be slowly decreasing over the past two decades, with activities currently below 3 pCi/L in all LLWMA-2 wells. Tritium activity has also decreased over the past two decades, with activities currently below 600 pCi/L. Uranium concentrations in LLWMA-2 samples were less than 5 µg/L, which is consistent with background concentrations.

4.4.2.3 Compliance Status

The interim status monitoring requirements of 40 CFR 265, Subpart F and WAC 173-303-400 require a groundwater quality assessment program if downgradient indicator parameters exceed the upgradient derived indicator parameter critical mean. The exceedance of specific conductance in well 299-E34-7 was initially reported in FY 1998 (PNNL-12086, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*). Since FY 2005, when well 299-E34-7 went dry, verified critical mean exceedance have not been reported; therefore, there is no cause for change in the interim status indicator evaluation monitoring program conducted at LLWMA-2.

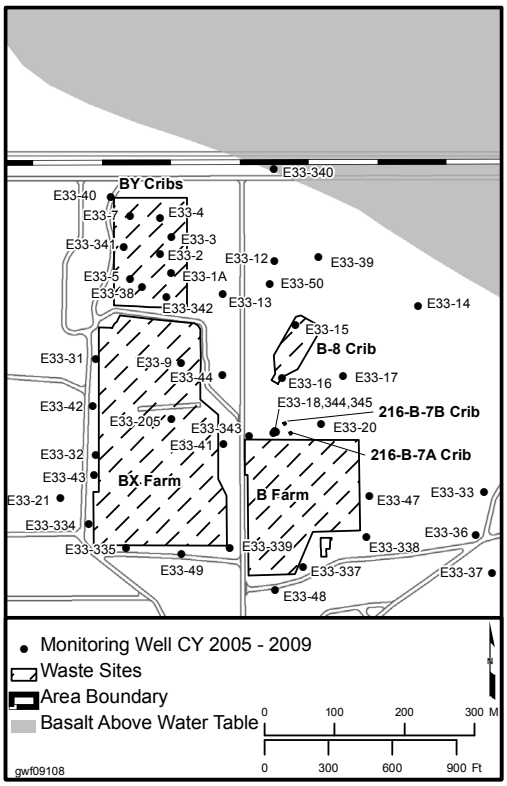
4.4.3 Waste Management Area B-BX-BY

C. J. Martin

Located in the northwestern portion of the 200 East Area, this single-shell tank WMA consists of the B, BX, and BY Tank Farms; ancillary waste transfer lines; and diversion boxes. The three tank farms consist of a total of 36 underground tanks, ranging in capacity between 2 and 2.9 million liters, as well as four 208,000-liter tanks constructed between 1945 and 1949.

Groundwater monitoring is conducted at this WMA in accordance with WAC 173-303-400 (and by reference, 40 CFR 265, Subpart F) and the AEA. The WMA B-BX-BY is currently in a RCRA groundwater quality assessment program and is monitored quarterly, as detailed in the RCRA assessment plan (PNNL-13022, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site*). In addition to monitoring dangerous

waste/dangerous waste constituents for RCRA assessment, the site is monitored for CERCLA and AEA purposes under the 200-BP-5 Groundwater OU program.



4.4.3.1 Network Evaluation

The RCRA groundwater monitoring requirements include an annual evaluation of the network to determine if it remains adequate to monitor the WMA. The network must include upgradient and downgradient wells in the uppermost aquifer. The current network consists of 26 wells. The gradient beneath WMA B-BX-BY is virtually flat (i.e., gradient is near zero), so the network includes wells on all sides of the WMA.

Wells specified in the assessment plan (PNNL-13022) near the WMAs and in nearby past-practice liquid disposal sites are sampled to differentiate tank-related contamination from that associated with the surrounding waste sites. Many of the wells are co-sampled for the 200-BP-5 OU under CERCLA guidance, although CERCLA sampling is generally performed at a lower frequency. Sampling is coordinated to avoid redundancy.

Well 299-E33-9, located in the BY Tank Farm, is a key well for monitoring the downgradient uranium contaminant changes in this area. This well was scheduled for quarterly sampling, but due to limited access to the tank farm and scheduling difficulties, sampling has been reduced to semiannually. These issues prevented only one of the scheduled sampling events during CY 2009.

Determining the hydraulic gradient and flow direction using only the current heads in the network wells is impractical because the water elevation measurement difference over the entire network is only ~0.06 meters. This is within the potential measurement error due to non-verticality of the well. To improve the accuracy of water-level measurements in the northwest 200 East Area, a network of fourteen wells was established at the nearby LLWMA-1, which included two wells from WMA B-BX-BY (299-E33-38 and 299-E33-339). Casing elevations were resurveyed and borehole deviation surveys were performed to correct for non-verticality of the wells. Resulting trend-surface analyses indicated a long-term average flow direction to the northwest, but temporary flow reversals can occur due to high Columbia River stage (see Section 2.2). Presumably, these conclusions also apply to WMA B-BX-BY.

In general, groundwater flows into the 200 East Area from the west. As this flow of water approaches the basalt and mud units occurring above the water table, the flow divides, with some water migrating to the north through Gable Gap and some water moving southeast toward the central portion of the Hanford Site. The WMA B-BX-BY lies within the region of divergent flow to the northwest within the 200-BP-5 OU. The specific location of the groundwater flow divide is currently believed to lie to the southeast of WMA B-BX-BY, toward the middle of the 200 East Area. As discussed above for LLWMA-1, a reversal of flow occurred from the summer of 2008 through the summer of 2009. This reversal may be partly responsible for the rapid increases in contaminants in certain wells along the southern boundary of the WMA. Additional information on the flow in this region is presented in Chapter 2.0.

4.4.3.2 Groundwater Contaminants

In FY 1996, the groundwater monitoring program for WMA B-BX-BY shifted from indicator parameter evaluation to groundwater assessment because specific conductance in a downgradient monitoring well exceeded the critical mean value.

Results from the ensuing investigation indicated that waste products from the WMA had entered and affected groundwater quality (PNNL-11826, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas B-BX-BY at the Hanford Site*). Subsequent annual assessment reports have been included in Hanford Site annual groundwater reports (e.g., DOE/RL-2008-66).

The groundwater in WMA B-BX-BY monitoring wells is sampled and analyzed for the parameters listed in Appendix C, Table C-30). In accordance with WAC 173-303-400 and 40 CFR 265.93, selected WMA B-BX-BY network wells are monitored quarterly for RCRA constituents of concern and associated field/supporting parameters. Some of the wells listed in Appendix C, Table C-30) are sampled at other frequencies for selected constituents to provide additional information on contaminant movement and to differentiate tank-related contamination from contamination associated with the surrounding waste sites. Water-level measurements are taken before each sampling event. During CY 2009, most groundwater samples were collected as scheduled. Because of scheduling issues, well 299-E33-9 was not sampled in February 2009 as scheduled. Sampling at wells 299-E33-31, 299-E33-337, and 299-E33-338 also did not occur during the second quarter of CY 2009.

Additional parameters (i.e., alkalinity, dissolved oxygen, temperature, and turbidity) are measured as indicators of groundwater quality and general aquifer/well environmental conditions. Other anions sampled include chloride and sulfate to detect potential contamination from surrounding waste sites, as well as to provide input for charge-balance calculations.

The primary dangerous waste constituent found beneath WMA B-BX-BY is cyanide. However, based on leak inventories, the likely source is the BY Cribs (RPP-26744). Certain non-RCRA-regulated constituents (e.g., nitrate, sulfate, and radionuclides) are also found within the boundaries of the WMA (DOE/RL-2008-66). In the past, elevated nitrite levels were also observed. These constituents are attributed to multiple sites, including WMA B-BX-BY and the surrounding cribs.

WMA B-BX-BY appears to be a significant source of AEA-regulated contamination in the 200-BP-5 OU.

Several contaminant plumes coincide with WMA B-BX-BY, and the source of some of these plumes is likely from within the WMA. Nitrate, technetium-99, and uranium are observed together under and both northwest and southeast of the BY Tank Farm. The proximity of these contaminants to the BY Tank Farm suggests a possible tank-related source. Technetium-99, nitrate, uranium, sulfate, tritium, cobalt-60, and cyanide occur together near the BY Cribs and, with the exception of uranium, are at high concentrations. Elevated concentrations of iron and manganese are present in the groundwater above DWSs (300 and 50 µg/L, respectively) under the BY Tank Farm. Near the 216-B-8 Crib, nitrate, nitrite, technetium-99, and uranium contamination coincide. In general, many of these contaminants occur together in tank and crib waste, and their coincidence in groundwater monitoring is expected.

Cyanide. Cyanide concentrations from scavenged waste disposed to the BY Cribs continued to increase in groundwater under the BY Cribs, with concentrations ranging up to 1,730 µg/L in well 299-E33-7. The cyanide plume extends a couple of kilometers to the northwest. Much lower cyanide concentrations north of the 216-B-8 Crib (in wells 299-E33-15 and 299-E33-39) also show continued increases, with a maximum of 257 µg/L in well 299-E33-15 during the reporting period. It is important to note that the 216-8 Crib did not receive scavenged waste.

Cyanide concentrations beneath the BY Tank Farm continued to increase in wells 299-E33-9, 299-E33-31, and 299-E33-44, with a maximum concentration of 79.7 µg/L in well 299-E33-44. The concentrations reported in the wells 299-E33-9,

299-E33-31, and 299-E33-44 appear to be sourced from the BY Cribs. In general, the elevated concentrations in these wells were reported during a prolonged groundwater gradient reversal to the south, which was determined by a low-level groundwater elevation study. A contributing explanation for the elevated cyanide concentrations in these wells may be associated with a density flow along the basalt, which dips to the south in this area. A depth-discrete groundwater sampling investigation is planned in FY 2010 and should provide further understanding of the density flow conceptual model.

Only sporadic detection of cyanide has occurred in wells monitoring the B and BX Tank Farms. The maximum concentration measured at the B Tank Farm was 5.4 µg/L in well 299-E33-48, while the maximum concentration measured at the BX Tank Farm was 7 µg/L in well 299-E33-21.

Chromium. Chromium concentrations in wells around the BY Tank Farm and north of the B Tank Farm continue to show a slow increase. The 216-B-8 Crib has the highest overall chromium average at 41.97 µg/L. The 216-B-8 Crib is the likely source based on the inventory added to this waste site versus the other sites. The chromium received at this site was associated with the sodium dichromate used (HW-10475, *Hanford Technical Manual*). In addition, this site received hydrochloric and citric acid (HW-17088, *Underground Disposal of Liquid Wastes at the Hanford Works*). The acid is thought to have enhanced the mobility of the chromium allowing it to migrate deeper into the vadose zone and eventually into the aquifer.

The maximum concentration this reporting period was 68.4 µg/L in well 299-E33-18, located between the B Tank Farm and 216-B-8 Crib. The highest tank farm average is 19.36 µg/L at the BY Tank Farm. All concentrations are well below the chromium DWS of 100 µg/L.

Nitrate. Nitrate is prevalent in WMA B-BX-BY as part of process wastes discharged to both tanks and cribs. Generally, nitrate extends along a northwestern-southeastern trend from the northern portion of the 216-B-8 Crib through the BY Cribs and the northeastern corner of LLWMA-1, and it extends to the north-northwest away from the WMA. DOE/RL-2008-01 provides an extensive history of the nitrate plume. Significant changes were not observed in CY 2009. Nitrate concentrations continued to increase beneath WMA B-BX-BY, the BY Cribs, and the 216-B-8 Crib. The maximum concentration for CY 2009 was beneath the BY Cribs at well 299-E33-7 (1,690 mg/L). The maximum concentration below WMA B-BX-BY was in well 299-E33-20 (624 mg/L), north of the B Tank Farm and south of the 216-B-8 Crib.

Nitrite. Historically, nitrite has been detected in only a few wells in the WMA monitoring network. Nitrite was detected in all of the newly installed wells throughout most of CY 2009, although concentrations decreased to below detection in all but two wells. Well 299-E33-345 (north of the BX Tank Farm) had the highest nitrate concentration (5,720 µg/L) in December 2008. The DWS for nitrite is 3,300 µg/L. The concentration in this well declined rapidly, decreasing to 457 µg/L in April 2009 and falling to below the detection limit by the end of 2009.

Well 299-E33-344, which was recently installed in a perched zone at WMA B-BX-BY, is co-located with well 299-E33-345 and has shown measurable nitrite concentration, with at a maximum of 3,170 µg/L early in the reporting period. This well has maintained nitrite levels greater than 2,500 µg/L throughout this reporting period. Because of the higher concentration in this well, it is possible that the nitrite at well 299-E33-345 is from percolation of the perched water.

Sulfate. Similar to nitrate, sulfate levels continue to increase in wells around WMA B-BX-BY and in the larger 200 East Area. The highest concentrations in wells monitored for WMA B-BX-BY were greater than 200 mg/L in wells in the northern portion of the BY Tank Farm network.

Two wells exceeded the 250 mg/L secondary DWS for sulfate. Well 299-E33-31 (in the northwestern corner of BY Tank Farm) had a maximum concentration of 309 mg/L in late 2008, which decreased to 267 mg/L in 2009. New well 299-E33-342 (northeast of the BY Tank Farm and southeast of the BY Cribs) had a maximum concentration of 287 mg/L but also decreased to 260 mg/L. In comparison, most of the wells around the BY Cribs have sulfate concentrations near or above the DWS, with a network average concentration of 248 mg/L. Further discussion is provided in Section 4.2.10.1 and 4.2.10.2.

Performance assessment monitoring of radionuclides at WMA B-BX-BY, under AEA authority, is designed to complement the RCRA assessment monitoring and is aimed specifically at monitoring radionuclide materials not regulated under RCRA. The current monitoring plan (PNNL-13022) includes technetium-99 and uranium specifically for performance assessment.

Technetium-99. Technetium-99 occurs in wells throughout the WMA B-BX-BY network and is above the DWS of 900 pCi/L in all of the wells associated with the BY Tank Farm, B Cribs, 216-B-8 Crib, and 216-B-7A/7B Cribs. Only two other wells that are not part of the networks for the specific areas listed were above the DWS. Well 299-E33-49 (south of the BX Tank Farm) and well 299-E33-339 (between the BX and B Tank Farms) had maximum concentrations of 1,330 and 6,560 pCi/L, respectively.

The overall technetium-99 concentration trends continued to increase in CY 2009. The maximum concentration was 39,000 pCi/L, detected in well 299-E33-38 in the southwestern corner of the BY Cribs. The highest value within the WMA B-BX-BY network was 26,000 pCi/L in well 299-E33-18, which is located north of the B Tank Farm, between the tank farm and the 216-B-8 Crib. Similarly, high concentrations are also found in new wells 299-E33-343 and 299-E33-345, which are located slightly west of well 299-E33-18.

Technetium-99 contamination is attributed to discharges to the BY Cribs and the 216-B-7 and 216-B-8 Cribs. Mapping the extent of technetium-99 migration indicates some southward movement of this contaminant across the southern border of the BX and B Tank Farms, as indicated by detection in wells 299-E33-49 and 299-E33-339. No other suspected source of technetium-99 is present in this area to contribute to groundwater contamination.

Uranium. The likely source of the observed uranium contamination in WMA B-BX-BY is the 1951 overfill event of tank 241-BX-102. The highest average uranium value in CY 2009 was northwest of the B Tank Farm in newly installed well 299-E33-343 (4,850 µg/L). The next highest concentration was 1,120 µg/L in well 299-E33-41.

The center of uranium contamination was historically believed to be under the BY Tank Farm, based on well 299-E33-39 regularly having the maximum concentration. However, since early 2008, rapid increases in uranium concentration in BX Tank Farm wells to the northeast (76% in well 299-E33-41) and southeast (99% in well 299-E33-339 and 78% in well 299-E33-49) seem to support the tank 241-BX-102 release as the source. Similar rapid increases from 51% to 71%, but at much lower concentrations (maximum concentration in CY 2009 of 269 µg/L),

are also seen in wells 299-E33-32, 299-E33-42, and 299-E33-43, which are northwest of tank 241-BX-102.

The historic shape of uranium plume has suggested groundwater flow to the northwest (Figure 4-7). This interpretation is consistent with recent detailed water-level interpretation in the vicinity of LLWMA-1. However, recent increases (and at greater concentrations) in wells to the northeast and southeast are indications that uranium is moving in those directions.

Depth-discrete sampling will be performed during 2010 to evaluate the possibility of density flow down-dip along the basalt bedrock surface as a mode of contaminant transport.

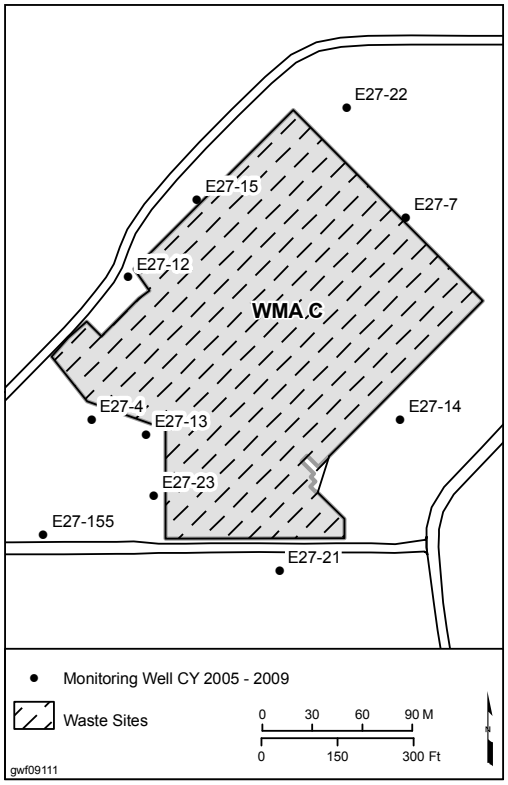
4.4.3.3 Compliance Status

Because WMA B-BX-BY is in groundwater assessment, no comparison between upgradient and downgradient wells is needed. The current network is being re-evaluated as part of updating the current groundwater assessment monitoring plan. The revised plan is scheduled for release in 2010. Until the revised monitoring plan is issued, the current network (which includes five new wells) will remain adequate for monitoring the extent and concentration of contaminants throughout 2010.

A value for average linear velocity cannot be determined because the hydraulic gradient beneath the WMA is indeterminate.

4.4.4 Waste Management Area C

G. S. Thomas



Groundwater monitoring at single-shell tank WMA C in the central west portion of 200 East Area began the reporting period in interim status detection monitoring in accordance with RCRA and AEA requirements. In accordance with 40 CFR 265.93(b) (as referenced by WAC 173-303-400), the well network was sampled for RCRA indicator and site-specific parameters (PNNL-13024, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, Interim Change Notice 5). However, in July 2009, the indicator parameter of specific conductance was verified to have exceeded the critical mean. As a result, assessment monitoring requirements were initiated in December 2009 (DOE/RL-2009-77, *Interim Status Groundwater Quality Assessment Plan for the Single Shell Tank Waste Management Area C*). The AEA monitoring requirements are derived from DOE/RL-2001-49.

All of the wells were successfully sampled during this reporting period. Appendix C, Tables C-31 and C-32, include lists of the wells and constituents monitored for both the pre- and post-assessment monitoring, respectively. The following subsections provide the annual evaluation requirements for the monitoring network, groundwater results, and compliance status.

4.4.4.1 Network Evaluation

The WMA C began the reporting period under the interim status monitoring requirements of 40 CFR 265, Subpart F and WAC 173-303-400, which require upgradient and downgradient monitoring wells that ensure immediate detection of any statistically significant change in concentrations (e.g., above the derived critical mean for the four indicator parameters) of dangerous waste or dangerous waste constituents

at the limit of the WMA within the uppermost aquifer. However, because of a verified exceedance of the specific conductivity critical mean at well 299-E27-14, the extent of contamination is now required to be determined based on the requirements of 40 CFR 265.93(d)(4)(i). This subsection discusses the network and changes associated with the new requirements for monitoring at WMA C.

The existing groundwater monitoring network at WMA C consists of nine wells. The groundwater gradient in this portion of the 200 East Area is low, making the determination of groundwater flow direction difficult. *Hanford Site Groundwater Monitoring for Fiscal Year 2006* (PNNL-16346) reported that the gradient is too low to calculate a reliable flow rate; therefore, other methods have been used to determine the groundwater flow direction in the past. Previous methods have included hydrograph comparisons, in situ flow measurements with a colloidal borescope, and plume tracking. Plume tracking included developing time-series sulfate isopleths and log-plot comparisons for nitrate and technetium-99. Based on various observations over the past 8 years, the local groundwater flow direction has been reported as southwest to south-southwest. It should be noted that the borescope results were highly variable, and only two wells in one of the several horizons observed provided a southwest flow direction (as noted in PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*). Therefore, the borescope results do not provide a statistically significant indication of flow direction, and caution should be used with the interpreted results. In addition, several potential sources of nitrate and technetium-99 releases within WMA C are under further investigation; using the data to determine a flow direction may be premature due to potential comingling from other various sources. Finally, more regional sulfate contouring indicates a more southern flow direction (Figure 4-15) than the southwest flow direction portrayed in DOE/RL-2008-01. As a result, an additional well is being installed to investigate the potential for a local southerly flow direction (as discussed below). Because of the uncertainty in the flow direction, no gradient or flow rate is provided for this reporting period.

WMA C was placed in assessment monitoring because of exceedance of the critical mean for specific conductance

A recent assessment plan for WMA C (DOE/RL-2009-77) discusses two new wells planned to assess groundwater both northwest and south of well 299-E27-14, where the indicator parameter for specific conductance was verified in July 2009 as exceeding the critical mean (Figure 4-16). The logic for the southern well is that cyanide, known to be associated with in-tank scavenging of cesium-137, has been detected consistently in wells 299-E27-7 and 299-E27-14, which are in a north-south alignment. It was concluded that since cyanide is seldom reported in wells to the southwest and no proximal wells are present south of well 299-E27-14, additional information was needed to determine the extent of the cyanide in this potential direction. The distance of this southern well was based on the travel time for comparable cyanide increases between the two wells. The second planned well location was chosen as a more representative upgradient location based on a southwest flow direction that would be unaffected by releases from WMA C. If these additions are not adequate to provide the extent of dangerous waste or dangerous waste constituents, additional wells will then be considered.

4.4.4.2 Groundwater Contaminants

As mentioned in the previous section, the indicator parameter of specific conductance exceeded the critical mean of 991 µS/cm in well 299-E27-14 during the reporting period. Verification of this result initiated an assessment of the historic and current monitoring data. Evaluation of the data found the dangerous waste constituent cyanide present in groundwater beneath the C Tank Farm. The source

of the cyanide appears to be WMA C, as no other upgradient sources are associated with cyanide (RPP-26744). Historically, cyanide has been detected most prominently in upgradient well 299-E27-7; however, cyanide results during the first two quarters of the reporting period indicated non-detect values, but the June 2009 sample results reported a concentration of 40.7 µg/L. This is the fourth peak above 35 µg/L during a 5-year period. Well 299-E27-14, which is the only other well with frequent cyanide concentrations in the WMA C monitoring network, maintained its average concentration between 10 and 16 µg/L. As discussed in previous reports, usually in regard to technetium-99, the erratic nature for concentration fluctuations of cyanide in well 299-E27-7 indicates short travel time and/or short travel distance from the point of entry, as compared to well 299-E27-14, which appears to have a more stable concentration level (Figure 4-17). Well 299-E27-23, which is located southwest of well 299-E27-7, is also shown in Figure 4-17 to illustrate the inconsistent cyanide results to the southwest. Equally inconsistent results are reported in well 299-E27-21, located to the south-southwest.

During the reporting period, the indicator parameter measurements for pH, total organic carbon, and total organic halides were consistent with previous results and did not exceed the statistically derived background comparison values (e.g., critical mean). The pH levels for all the wells ranged from 7.82 to 8.52, which are within the lower and upper bound of the critical mean (7.13 to 9.03, respectively). The highest total organic carbon level reported was 1,138 µg/L in well 299-E27-23 during June 2009, which is below the critical mean of 3,080 µg/L. The highest total organic halide concentration reported was in well 299-E27-13, at a level just above detection. The annual groundwater phenol results were all reported as non-detects for December 2008 sampling.

As previously mentioned, the indicator parameter of specific conductance exceeded the critical mean of 991 µS/cm in well 299-E27-14. The highest reported concentration was 1,075 µS/cm during September 2009 sampling. As reported in previous annual reports, sulfate is a major component of the specific conductance increase. Although a regional sulfate plume from the north is apparent (PNNL-14187) and comparable sulfate trend plots for LLWMA-2 well 299-E27-10 (located north of WMA C) and WMA C monitoring well 299-E27-14 are observable, the sulfate concentrations at well 299-E27-14 are much higher than at WMA C upgradient well 299-E27-7. This indicates contributions from WMA C, near well 299-E27-14 (Figure 4-18). An alternative reason for the high sulfate concentrations at well 299-E27-14 compared to well 299-E27-7 is that well 299-E27-7 may not be representative of groundwater migrating into well 299-E27-14. Therefore, an additional well is being installed to the northeast as part of the assessment monitoring plan (DOE/RL-2009-77).

The primary constituents above DWSs that continue to be observed at WMA C are the non-RCRA-regulated constituents sulfate, nitrate, technetium-99, and iodine-129. Elevated chloride concentrations (i.e., greater than two times background) are also present in wells 299-E27-7 and 299-E27-14.

The primary constituents above DWSs that continue to be observed at WMA C are the non-RCRA-regulated constituents sulfate, nitrate, technetium-99, and iodine-129.

As described in Section 4.2.1, two wells at WMA C were reported with nitrate concentrations exceeding the DWS of 45 mg/L. Well 299-E27-155 is located southwest of the tank farm, while well 299-E27-14 is located along the southeast side of the tank farm. The highest nitrate concentration was reported in well 299-E27-14 at ~115 mg/L. The elevated nitrate in well 299-E27-14 indicates a WMA C source because the nitrate concentration in this well is more than twice the average concentration in the documented upgradient wells (299-E27-7 and 299-E27-22).

The high levels of nitrate in well 299-E27-14 contributed to the exceedance of the specific conductivity critical mean in the summer of 2009.

Well 299-E27-155 has much higher nitrate concentrations than in any of the wells immediately to the northeast (e.g., 299-E27-4, 299-E27-13, or 299-E27-23). It is uncertain why these wells, considered to be upgradient of well 299-E27-155, do not have higher concentrations since these wells appear to be located between the source and well 299-E27-155. One possible explanation is a density flow model, which may have created a predominant downward contaminant flow in this area. Four wells in this area are planned for depth-discrete sampling in FY 2010 to determine if density flow should be considered.

The high sulfate concentrations reported in well 299-E27-14 also contributed to the exceedance of the specific conductivity critical mean at WMA C. The average concentration for the reporting period in this well were ~40% higher (300.7 mg/L) than at upgradient well 299-E27-7 (214.8 mg/L), which indicates contributions from WMA C.

Performance assessment monitoring of radionuclides at WMA C, under AEA authority, is designed to complement RCRA detection monitoring and is aimed specifically at monitoring radionuclides that are not regulated under RCRA. The current monitoring plan (DOE/RL-2001-49) includes technetium-99 and tritium for performance assessment. Gamma constituents, iodine-129, and uranium are also monitored. Technetium-99 and iodine-129 were the only performance assessment constituents reported above their respective DWSs. The gamma constituents were all non-detects, and uranium was at background concentrations. Tritium values continue to decrease in the area based on the activities reported in wells 299-E27-7 and 299-E27-14.

Six wells at WMA C were reported with technetium-99 activities exceeding the DWS of 900 pCi/L. Four of the wells (299-E27-4, 299-E27-13, 299-E27-23, and 299-E27-155) are located along the western-southwestern side of the tank farm, and two of the wells (299-E27-14 and 299-E27-21) are located along the south-southeast side of the tank farm. Higher technetium-99 activities were reported in the western-southwestern wells as opposed to the south-southeast wells, with the highest activity this reporting period in well 299-E27-23 at 13,000 pCi/L.

All of the wells at WMA C sampled for iodine-129 reported activities exceeding the DWS of 1 pCi/L. The highest activity was 5.56 pCi/L in upgradient well 299-E27-7, located on the northeast side of the tank farm. The iodine-129 activity may be associated with leaks from the tank farm that have migrated laterally along a dip in the vadose zone before entering the groundwater near this well. Another explanation is that the iodine-129 may be from the ditches that feed B Pond and/or the inactive B Pond itself. Comparable inventories of iodine-129 were reported for B Pond, as determined for several of the WMA C tank releases (RPP-26744). Because there is no well located between well 299-E27-7 and the upgradient ditches or B Pond to the northeast, it is not possible at this time to differentiate if WMA C sources contributed to the iodine-129 activity in the groundwater.

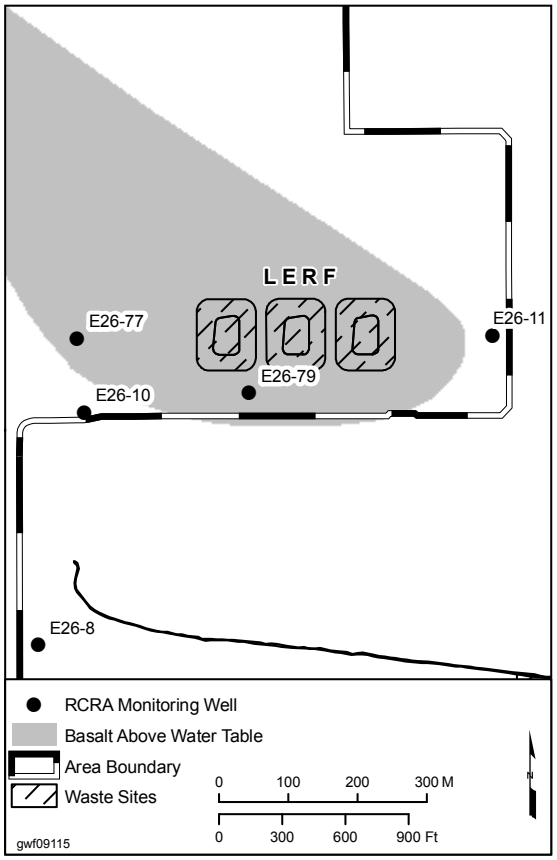
4.4.4.3 Compliance Status

Groundwater at single-shell tank WMA C began the reporting period under interim status indicator evaluation monitoring under RCRA requirements. In accordance with 40 CFR 265.93(b) (as referenced by WAC 173-303-400), the well network was sampled for RCRA indicator and site-specific parameters (PNNL-13024, Interim Change Notice 5). In July 2009, the indicator parameter specific conductance

was verified to have exceeded the critical mean and a draft assessment monitoring plan (DOE/RL-2009-77) was completed and submitted to Ecology. Evaluation of historic and current monitoring data has also indicated the presence of cyanide, a dangerous waste constituent, in groundwater likely associated with WMA C. As a result, assessment monitoring requirements were initiated in December 2009. The AEA monitoring requirements are still derived from DOE/RL-2001-49.

4.4.5 Liquid Effluent Retention Facility

J. L. Smoot and D. C. Weekes



Located on the eastern boundary of the 200 East Area, the LERF consists of three surface impoundment basins. Construction of the complex was completed in 1991. The basins are arranged side by side, with 18.2-meter separation between each basin. The dimensions of each basin (cell) are 100.5 meters by 82.2 meters, with a maximum fluid depth of 6.7 meters.

The primary liner for each basin is a 60-mil, high-density polyethylene geomembrane laid directly over a manufactured geotextile/bentonite layer. The secondary liner is also a 60-mil high-density polyethylene geomembrane laid directly on 0.9 meters of a soil/bentonite mixture. The liners are separated by a synthetic drainage geonet laid on the sides of the basins, with 0.3 meters of drainage gravel at the bottom. The sides slope to a sump, which is pumped when the liquid level reaches ~8 centimeters from the top of the sump and shuts off when the liquid level drops to 18 centimeters below the top of the sump.

The latest stratigraphy interpretation beneath the LERF was constructed from the four original and two additional boreholes drilled for the groundwater monitoring network. Correlations were also made with data from nearby sites. The thickness of the sediments near the LERF basins is ~61 meters. Three principal stratigraphic units present near the LERF are the Hanford formation, the Ringold Formation, and the Elephant Mountain Member of the Saddle Mountains Basalt. The vadose zone beneath the LERF is in the Hanford formation and portions of the Elephant Mountain Member basalt above the water table, as well as potentially some of the Ringold Formation or a paleosol resulting from the weathering of the Elephant Mountain Member flow top near well 299-E26-11. There are no perched water table conditions observed near the LERF basins. The uppermost aquifer directly beneath the LERF consists of thin aquifer(s) in the Hanford formation and Elephant Mountain Member flow top. The aquifer in the Hanford formation is unconfined; however, recent analysis of water-level data for barometric pressure responses indicates that the aquifer near well 299-E26-11 is semiconfined. Well 299-E26-11 is still considered capable of yielding representative samples from the same hydrostratigraphic unit as the other three wells associated with the LERF groundwater monitoring program.

Groundwater at LERF continued to be monitored under final RCRA status permit conditions. The LERF is a regulated unit under the *Revised Code of Washington* (RCW) 70.105 (“Hazardous Waste Management”) and is subject to groundwater monitoring requirements pursuant to WAC 173-303-645 (“Releases from Regulated Units”) and 40 CFR 264, Subpart F. The well network was sampled semiannually for RCRA indicator and site-specific parameters (PNNL-14859). The AEA monitoring requirements were derived from DOE/RL-2000-72.

4.4.5.1 Network Evaluation

The current groundwater monitoring network consists of one upgradient well (299-E26-11) and three downgradient wells (299-E26-10, 299-E26-77, and 299-E26-79), which are sampled semiannually. The initial groundwater monitoring network was installed at the LERF in 1990 before final construction of the complex. In FY 2007, two additional monitoring wells (299-E26-77 and 299-E26-79) were installed to replace two original network wells that went dry. Well 299-E26-77 is west of the basins (near dry well 299-E26-9), and well 299-E26-79 is south of the western edge of Basin 43. The other two monitoring wells include well 299-E26-10 (located in the southwestern corner of the unit) and upgradient well 299-E26-11 (located at the eastern end of the unit). All monitoring wells are compliant with WAC 173-160 ("Minimum Standards for Construction and Maintenance of Wells").

Work began in FY 2008 to better understand the groundwater flow direction beneath the LERF. New vertical elevation surveys and gyroscopic surveys were performed at three wells (299-E26-10, 299-E26-77, and 299-E26-79) in FY 2009 because of the flatness of the water table. Trend surface analyses were applied to the measurements to determine gradient magnitudes and flow directions on two data sets. One data set included all four wells, and another data set was for three wells exclusive of well 299-E26-11 (well 299-E26-11 is set in the semiconfined aquifer and skews the trend data). For the four well network, the average groundwater flow direction was determined to be south-southwest at 214 degrees, and the average gradient magnitude was 2.2×10^{-3} m/m. For the three wells (exclusive of well 299-E26-11), the average groundwater flow direction was determined to also be south-southwest at 194 degrees and the average gradient magnitude was 1.3×10^{-4} m/m, with a calculated groundwater flow at ~0.02 meters per day (see Appendix C, Table C-1).

4.4.5.2 Groundwater Contaminants

Analysis of samples collected during the reporting period indicate that all constituents in the permit were either undetected or below DWSs. Specific conductance and sulfate results slightly increased in well 299-E26-10. Nitrate has also been increasing in this well and in wells south and east of the LERF. The regional increase of anions and cations is evident in wells located in the central and eastern portions of the 200 East Area. Downgradient wells installed before the LERF began receiving waste recorded the early indications of the regional increase in specific conductance.

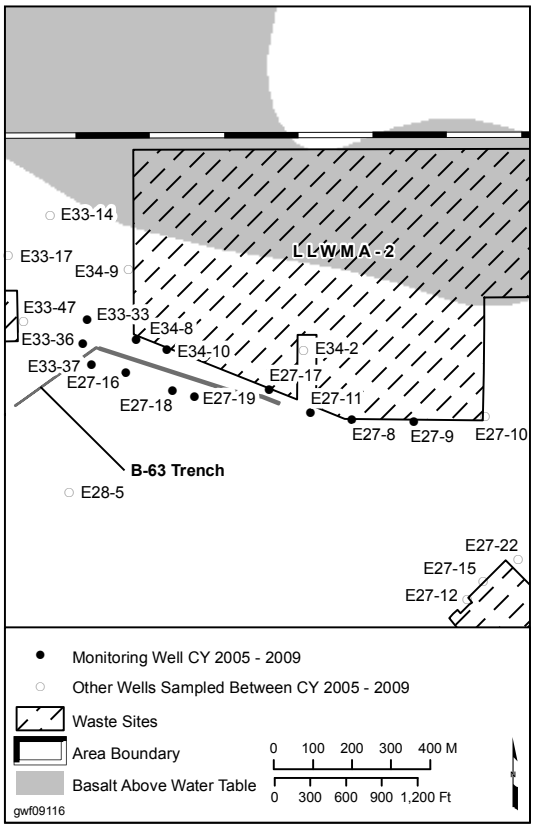
The constituents currently monitored are alkalinity, gross alpha, ammonium, anions, gross beta, metals, phenols, and volatile organics. Nitrate, total organic halogen, total organic carbon, tritium, and gross alpha- and gross beta-emitting isotopes are constituents of concern.

4.4.5.3 Compliance Status

The uppermost aquifer beneath the LERF is being evaluated as part of a groundwater evaluation plan. This plan will be part of a revision of the LERF operating permit that will form the basis for future groundwater monitoring at the unit. The results of the drilling of the new wells suggest that the fractured basalt flow top makes up the basal portion of the unconfined aquifer.

4.4.6 216-B-63 Trench

C. J. Martin



Located southwest of LLWMA-2, the 216-B-63 Trench is one of three non-operational TSD units in the 200-CS-1 Chemical Sewer OU that is currently undergoing closure negotiations. The 216-B-63 Trench is a regulated unit because it received non-radioactive dangerous waste regulated by 40 CFR 261 ("Identification and Listing of Hazardous Waste") after November 19, 1980. The 216-B-63 Trench is regulated as a surface impoundment, as defined in WAC 173-303-040 ("Dangerous Waste Regulations; Definitions").

The groundwater beneath the 216-B-63 Trench is monitored in accordance with WAC 173-303-400 and 40 CFR 265.93(b) to detect dangerous waste/dangerous waste constituent impact to groundwater. The twelve wells in the groundwater monitoring network are sampled semiannually for contamination indicator parameters (i.e., pH, specific conductance, total organic carbon, and total organic halides) and annually for groundwater quality parameters (i.e., alkalinity, metals, phenols, and anions) and site-specific constituents (PNNL-14112, *Groundwater Monitoring Plan for the 216-B-63 Trench on the Hanford Site*). Appendix C, Table C-12, lists the network wells and the groundwater constituents monitored.

The 216-B-63 Trench was an open, unlined, manmade excavation, ~427 meters in length. The trench boundary is located at the southwestern perimeter of LLWMA-2 (218-E-12B Burial Ground) in the 200 East Area. During its operational period, the trench was ~1.2 meter wide, with an average depth of 3 meters, and it had an earthen shielding berm and a side slope of ~10:6. Operations at the 216-B-63 Trench began on March 22, 1970, receiving cooling water from both B Plant and in-tank solidification unit #2. From May 1970 until February 1992, the trench also received B Plant chemical sewer effluent. Approximately 970,000 liters per day of total flow reached the trench. The regulated discharges constituted a minor portion of this flow (less than 1,900 liters per day).The 216-B-63 Trench was removed from service in 1992. Interim stabilization measures were completed at the trench in November 1994, and the site was permanently isolated by filling the weir box at the head end of the ditch with concrete on December 12, 1994.

From 1945 to 1995, groundwater flow direction and hydraulic gradients near the 216-B-63 Trench were highly influenced by hydraulic mounding associated with discharges to the 216-B-3 Pond. Decommissioning of the ponds resulted in a dramatic decline in groundwater elevations throughout the 200 East Area, which has in turn lead to a region of essentially flat groundwater gradients across the 200 East Area. This lack of appreciable gradient results in high uncertainty in the groundwater flow rate and direction. As discussed for LLWMA-2 (Section 4.4.2.1), determining a gradient and flow direction for the reporting period at the 216-B-63 Trench is also indeterminate.

4.4.6.1 Network Evaluation

The interim status monitoring requirements of 40 CFR 265, Subpart F and WAC 173-303-400 require upgradient and downgradient monitoring wells that ensure immediate detection of any statistically significant change in concentrations

(e.g., above the derived critical mean for the four indicator parameters) of dangerous waste or dangerous waste constituents at the limit of the TSD unit within the uppermost aquifer. These requirements also include an annual evaluation of the network to determine if it remains adequate to monitor the unit. The current network consists of twelve wells. This subsection discusses if the network remains adequate to monitor the 216-B-63 Trench in accordance with these requirements.

The present network was adequate for the detection of potential releases from the 216-B-63 Trench throughout CY 2009.

Based on the current configuration of the monitoring network, the wells remain adequate to detect potential releases from the 216-B-63 Trench, regardless of the groundwater flow direction. Since the wells essentially surround the unit and are all sampled on the same frequency for the same constituents, when a flow direction is determined, the wells to be used for the specified upgradient/downgradient comparisons can be selected. Critical means for use during 2010 (Appendix C, Table C-13) were determined using upgradient wells based on historical flow directions.

4.4.6.2 Groundwater Contaminants

As required in accordance with WAC 173-303-400 and RCRA (40 CFR 295.93[b]) in regard to interim status facility indicator parameter monitoring, the required indicator parameters (i.e., pH, specific conductance, total organic carbon, and total organic halides) are statistically compared between upgradient and downgradient wells using the most recent data. Statistical comparison values for three of the indicator parameters (i.e., specific conductance, total organic carbon, and total organic halides) were not exceeded at the 216-B-63 Trench. All samples showed an unusual drop in pH values for the October 2008 sampling event. As a result of this network-wide decline, the pH measurement at upgradient well 299-E34-9 was outside of the lower critical mean bound. The pH values returned to normal levels during April 2009 sampling (Figure 4-19). Groundwater samples were collected and analyzed as scheduled in CY 2009 at all twelve wells monitoring the 216-B-63 Trench.

The groundwater beneath the 216-B-63 Trench is monitored for detection of dangerous waste/dangerous waste constituent impact to groundwater. The twelve wells in the groundwater monitoring network are sampled semiannually for contamination indicator parameters (i.e., pH, specific conductance, temperature, total organic carbon, and total organic halides). Required groundwater quality parameters (i.e., alkalinity, metals, phenols, and anions) are monitored annually (PNNL-14112). Additional parameters (i.e., dissolved oxygen, temperature, and turbidity) are measured as indicators of sample quality and general aquifer/well environmental conditions. Appendix C contains a list of wells in the monitoring network, their locations, and the groundwater constituents monitored. Water-level measurements are taken before each sampling event.

Specific conductance is the only required parameter showing a trend. Specific conductance continues to increase, which is consistent with corresponding increases in major cations (e.g., calcium, magnesium, potassium, and sodium) and anions (e.g., chloride and sulfate). Well 299-E27-9, which is the furthest away from the actual trench, shows the most rapid increase. The increases associated with well 299-E27-9 are discussed in Section 4.4.2.

Anomalously low specific conductance results were obtained for wells 299-E33-37, 299-E33-36, 299-E34-8, and 299-E34-10; however, values returned to normal during April 2009 sampling. The decline coincides with the drop in pH (as discussed above); none of the chemical constituents provide an indication why conductivity and pH may have decreased. Because both are values collected using field instruments,

the possibility exists for instrument error to have occurred. The data are flagged as suspect in the Hanford Environmental Information System database.

During the reporting period, no detected constituents were above their respective DWSs. No evidence of dangerous waste/dangerous waste constituents impacting groundwater was detected at the 216-B-63 Trench during CY 2009.

4.4.6.3 Compliance Status

A low gradient evaluation study is currently being conducted for LLWMA-2, which will incorporate some of the 216-B-63 Trench wells. This study will help to reduce uncertainty in the flow direction.

Based on the configuration of the monitoring network, the wells remain adequate to detect potential releases from the 216-B-63 Trench, regardless of groundwater flow direction. Since the wells essentially surround the unit and are all sampled on the same frequency for the same constituents, when flow direction is determined, the wells to be used for the specified upgradient/downgradient comparisons can be selected.

To date, no dangerous waste subject to WAC 173-303 from the 216-B-63 Trench has contaminated groundwater; therefore, the site will continue in an interim status indicator evaluation monitoring program for the upcoming year. During CY 2009, all groundwater samples were collected and analyzed as scheduled.

No dangerous waste subject to WAC 173-303 has been found to date from the 216-B-63 Trench; therefore, the site will remain under detection monitoring for indicator parameters.

The current monitoring plan (including the well network, constituents of concern, sampling and -analysis procedure, and a conceptual model, as detailed in PNNL-14112) is undergoing revision and is scheduled to be completed in 2010.

4.5 Conclusions and Recommendations

The conclusions and recommendations for the 200-BP-5 OU are presented in the following sections.

4.5.1 Conclusions

During monitoring of the local and regional contaminant plumes in the 200-BP-5 OU during the past year, much of the OU experienced a groundwater gradient reversal. The gradient at the beginning of the reporting period was to the south because of high Columbia River stages in the spring of 2008 (DOE/RL-2008-66). The gradient reversal to the north was not confirmed until July 2009. Although the groundwater gradient reversal in the northern portion of the 200 East Area was confirmed, areas southeast of this location (along the southern portion of the 200-BP-5 OU) were flat with an undetermined local gradient direction. Because of this occurrence, flow direction and flow rates for most of the OU were not provided during the reporting period.

No significant changes in distribution of the ten contaminant plumes within the 200-BP-5 OU were observed during the monitoring period. Although the contaminant distribution has not shown significant change from last year, some incremental degradation of water quality was observed locally near selected sites. One example is the significant increases in sulfate and nitrate along the southern side of WMA C during the reporting period. These increases lead to initiation of a groundwater assessment monitoring action at WMA C, and initial assessment samples were collected in December 2009. Another action associated with the assessment plan (DOE/RL-2009-77) is the installation of two additional wells. One well will be installed south of well 299-E27-14 where a significant increase of specific conductance was confirmed, indicating that WMA C maybe affecting

groundwater quality. Another well will also be installed to the northeast to determine if possible WMA C contaminants such as cyanide may be from some upgradient source.

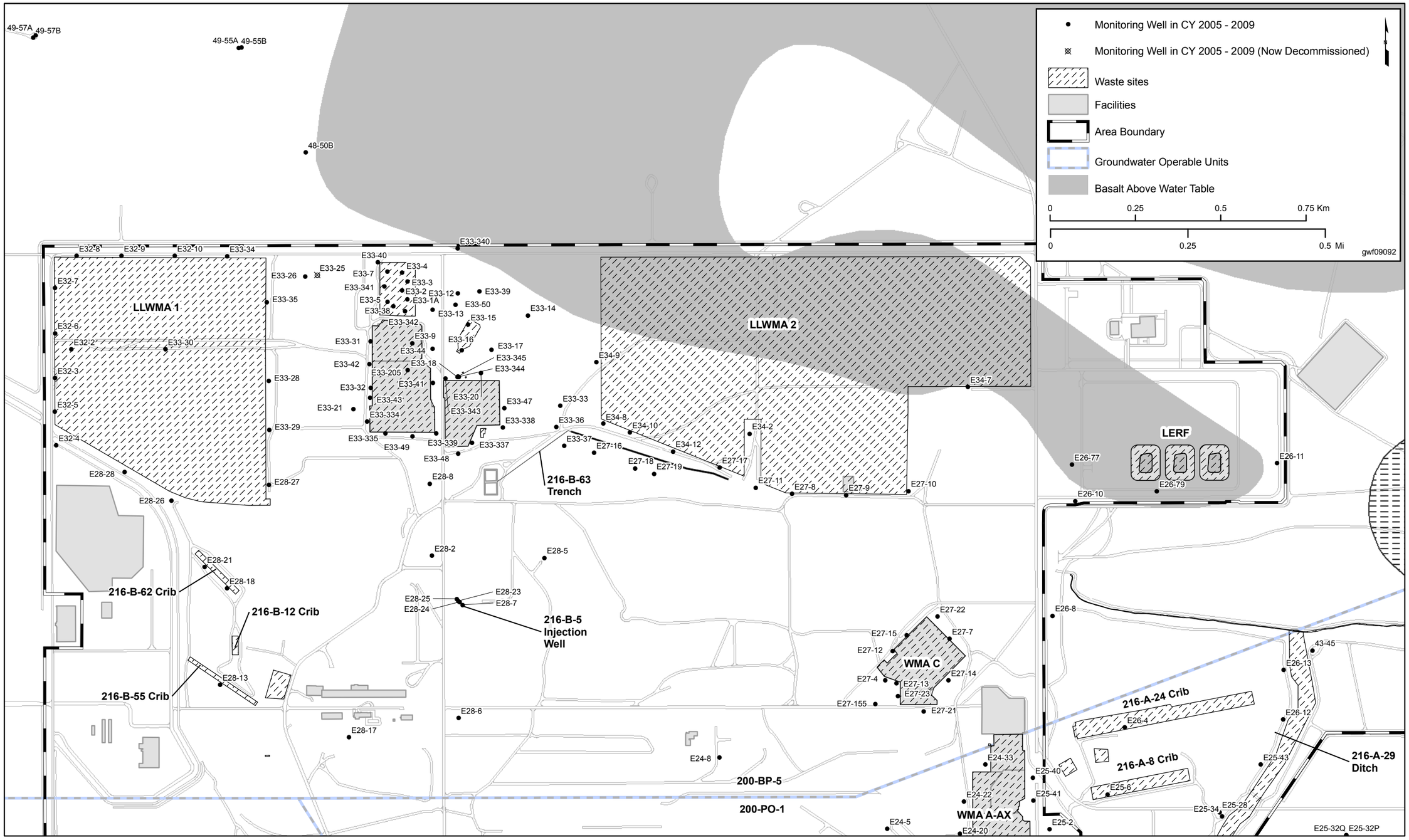
Nitrate was observed with historic high concentrations in well 299-E33-7, beneath the northern portion of the BY Cribs. The high concentration of 1,690 mg/L is the highest concentration reported in 50 years. Other associated contaminants (e.g., cyanide, sulfate, technetium-99, and tritium) that were reported suggest contaminant contributions from the vadose zone are continuing to infiltrate into the groundwater from the source. A data quality objectives process was initiated in October 2009 to begin planning for a treatability test for evaluating the practicality of performing groundwater extraction to remediate contaminant plumes in this area.

Finally, cesium-137, strontium-90, and tritium plumes have seen marked decreases in concentration due to decay over the past few years. Cesium-137 near the 216-B-5 injection well is ~65% of the average concentration observed in the 1980s. The strontium-90 concentration beneath the Gable Mountain Pond, as reported in well 699-53-47A, has steadily decreased over the past 12 years, from 1,320 pCi/L to 522 pCi/L. The tritium concentration near the Columbia River and the Gable Gap area has also decreased below the DWS.

4.5.2 Recommendations

Only one recommendation is made for the 200-BP-5 OU for this reporting period. A monitoring well southeast of well 699-53-55C and north of dry well 699-50-53A is proposed (Section 4.2.3.2) to better define the extent of the technetium-99 plume in this area. The technetium-99 concentrations in well 699-53-55C have been increasing over the past decade. Recent top-of-basalt contouring revisions in this area appear to provide a reasonable model for the increasing technetium-99 concentrations reported in well 699-53-55C. The new top-of-basalt contour map defines a paleochannel to the east of well 699-50-53A that extends northwest toward well 699-53-55C. Groundwater results reported for well 699-50-53A in the early 1990s indicated a concentrated technetium-99 plume (i.e., up to 30,000pCi/L). However, well 699-50-53A went dry in the mid-1990s, leaving a gap between wells 699-50-53A and 699-53-55C. To define the extent or maximum technetium-99 concentration potentially sourcing well 699-53-55C, a replacement well is recommended. An additional well along the conceptualized eroded basalt channel would help to define the extent of technetium-99 and refine the basalt elevation contours.

Figure 4-1. Facilities and Groundwater Monitoring Wells Located in the 200 East Area



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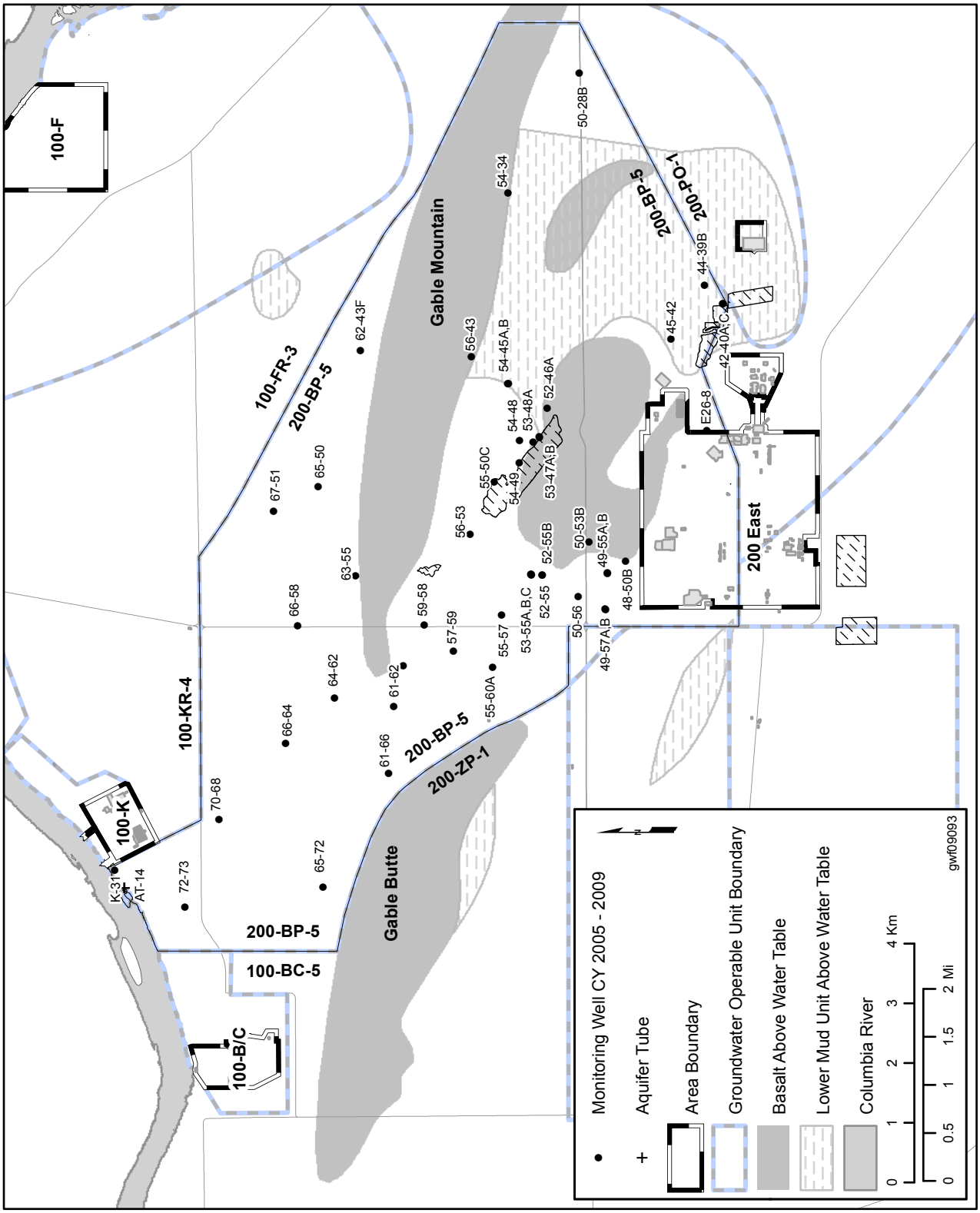

Figure 4-2. Facilities and Groundwater Monitoring Wells Located in the 600 Area Associated with the 200-BP-5 Operable Unit.

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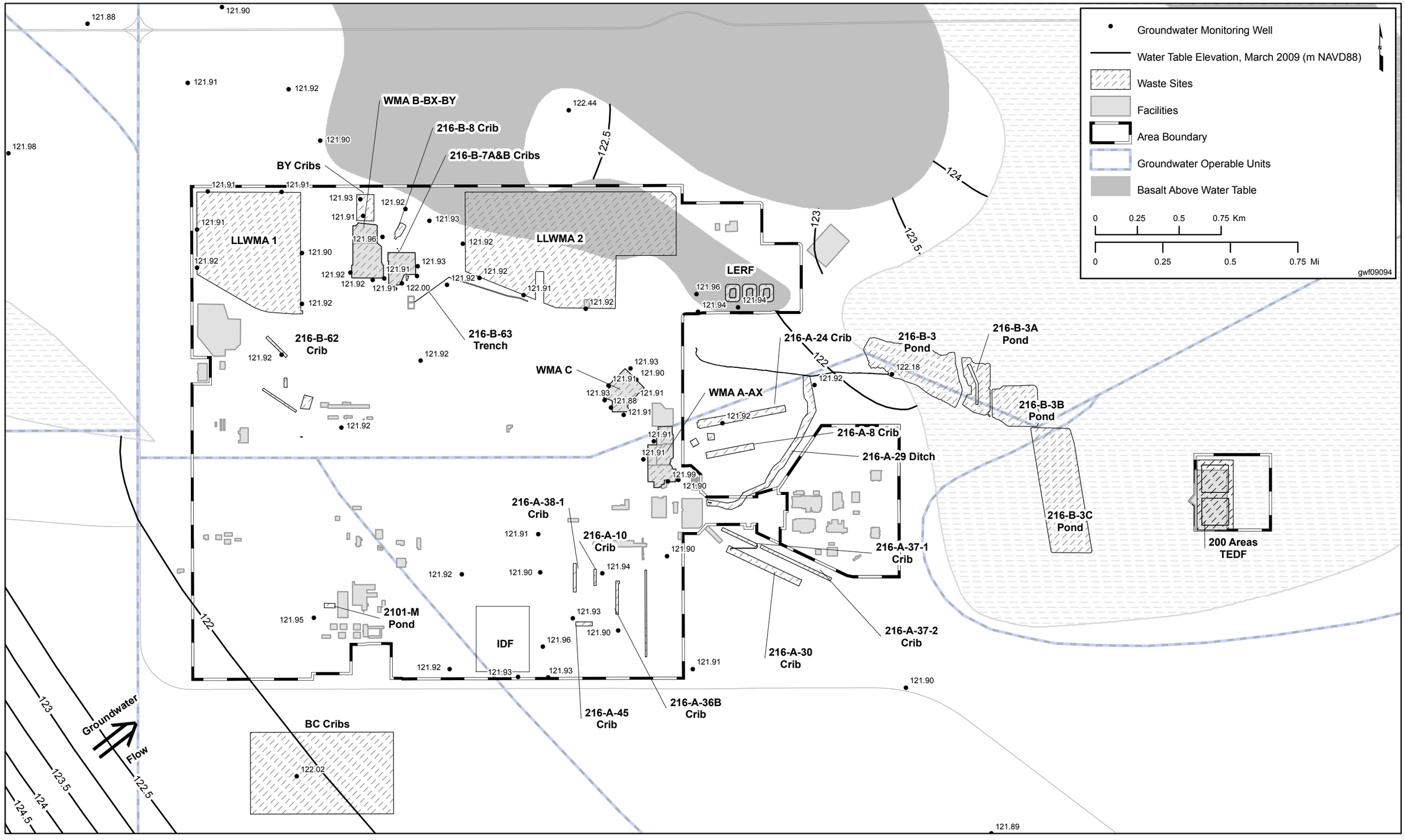
Figure 4-3. 200 East Area Water Table Map, July 2009.



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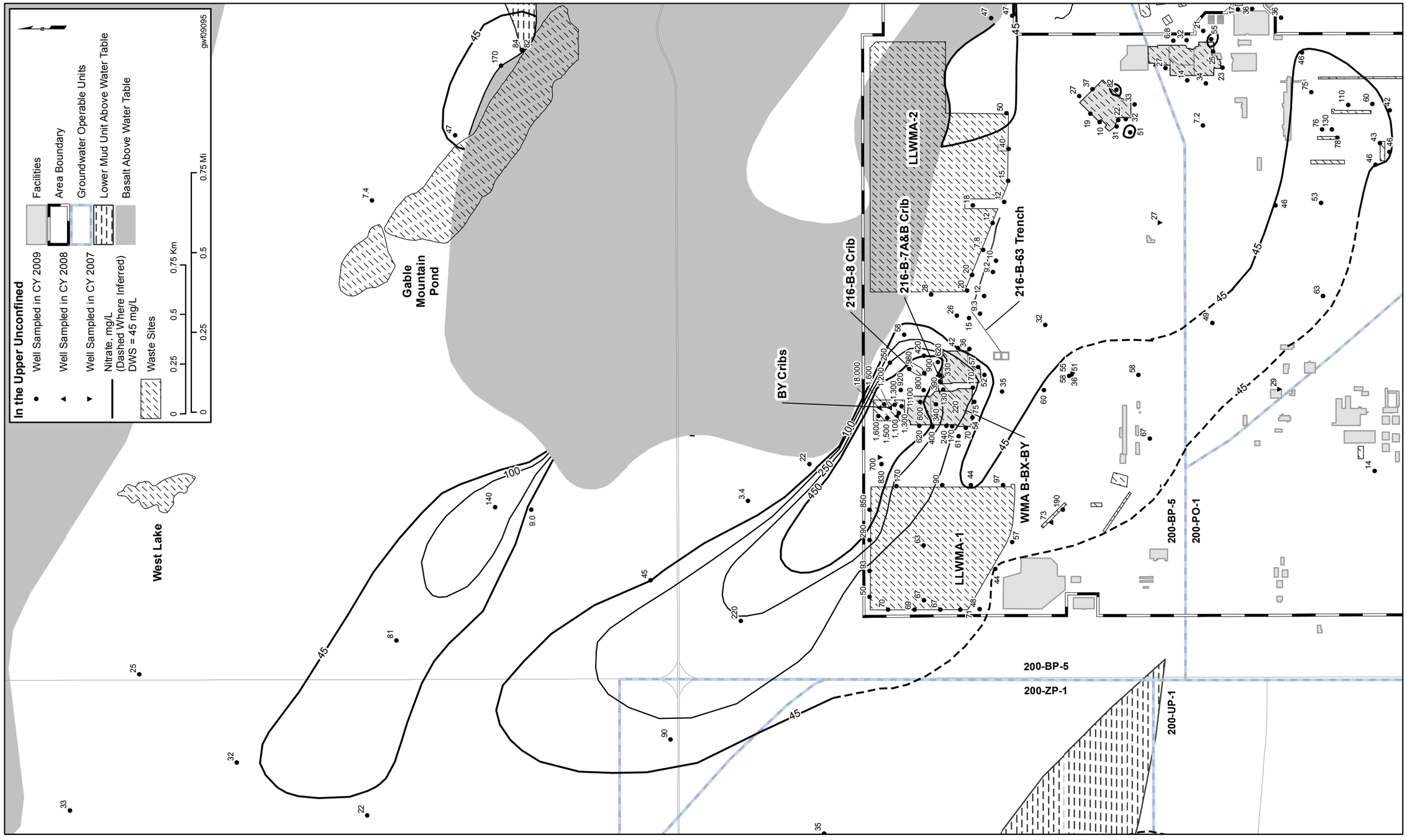

Figure 4-4. Average Groundwater Nitrate Concentrations in the 200 East Area and the 600 Area Within the 200-BP-5 Operable Unit, Fiscal Year 2009.

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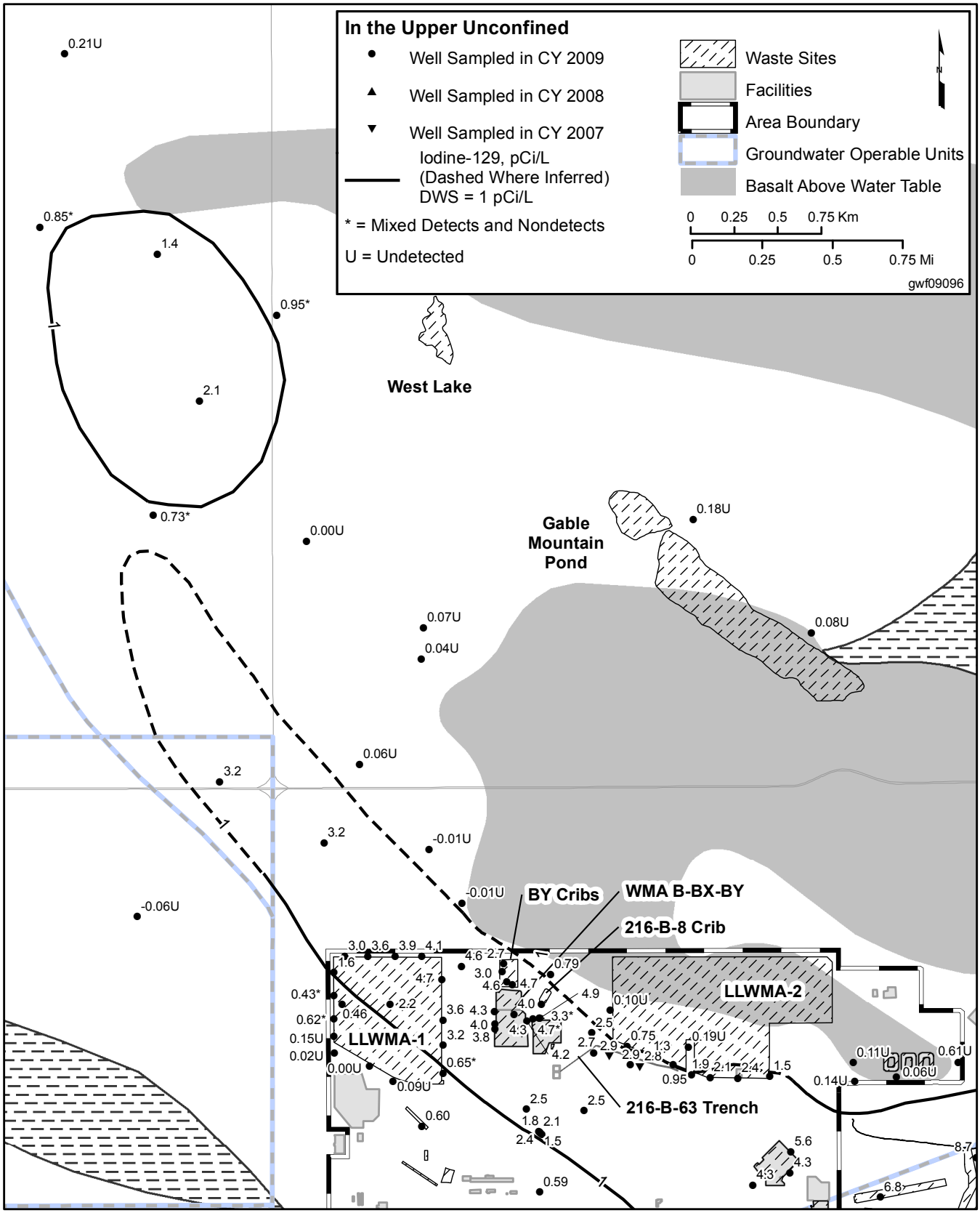
Figure 4-5. Average Groundwater Iodine-129 Concentrations in the 200 East Area and the 600 Area Within the 200-BP-5 Operable Unit, Fiscal Year 2009.



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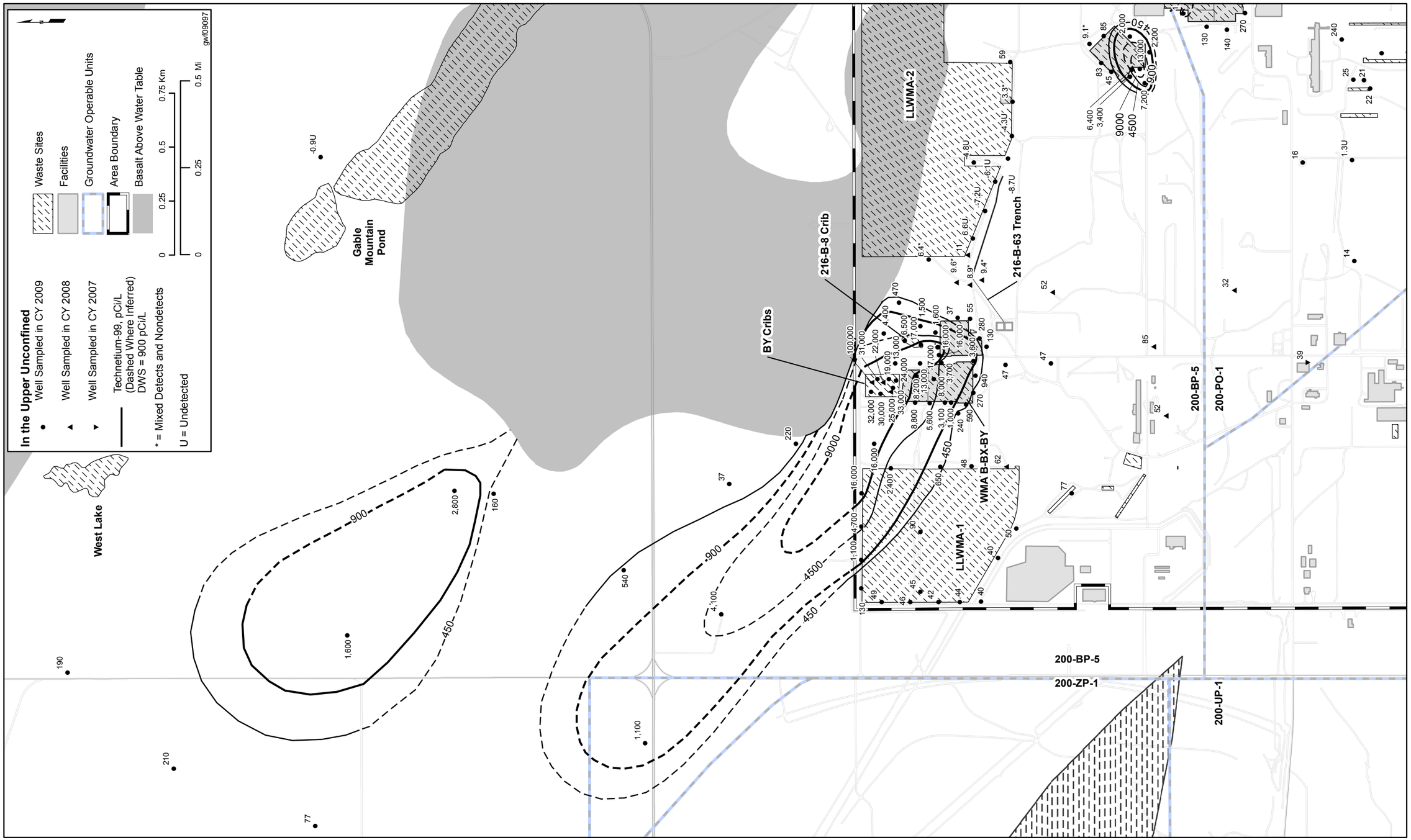

Figure 4-6. Average Groundwater Technetium-99 Concentrations in the 200 East Area and the 600 Area Within the 200-BP-5 Operable Unit, Fiscal Year 2009.

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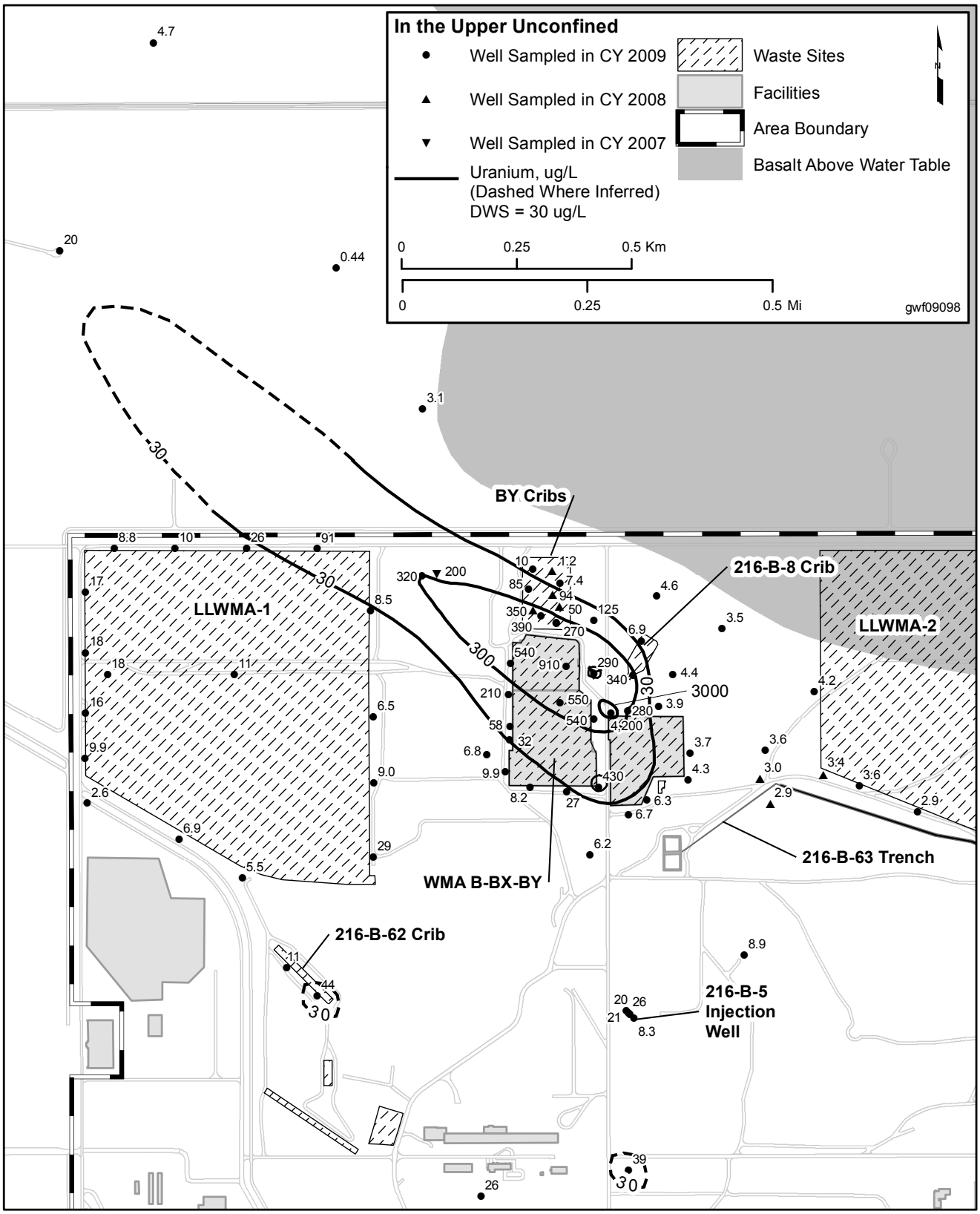
Figure 4-7. Average Groundwater Uranium Concentrations in the 200 East Area and the 600 Area Within the 200-BP-5 Operable Unit, Fiscal Year 2009.



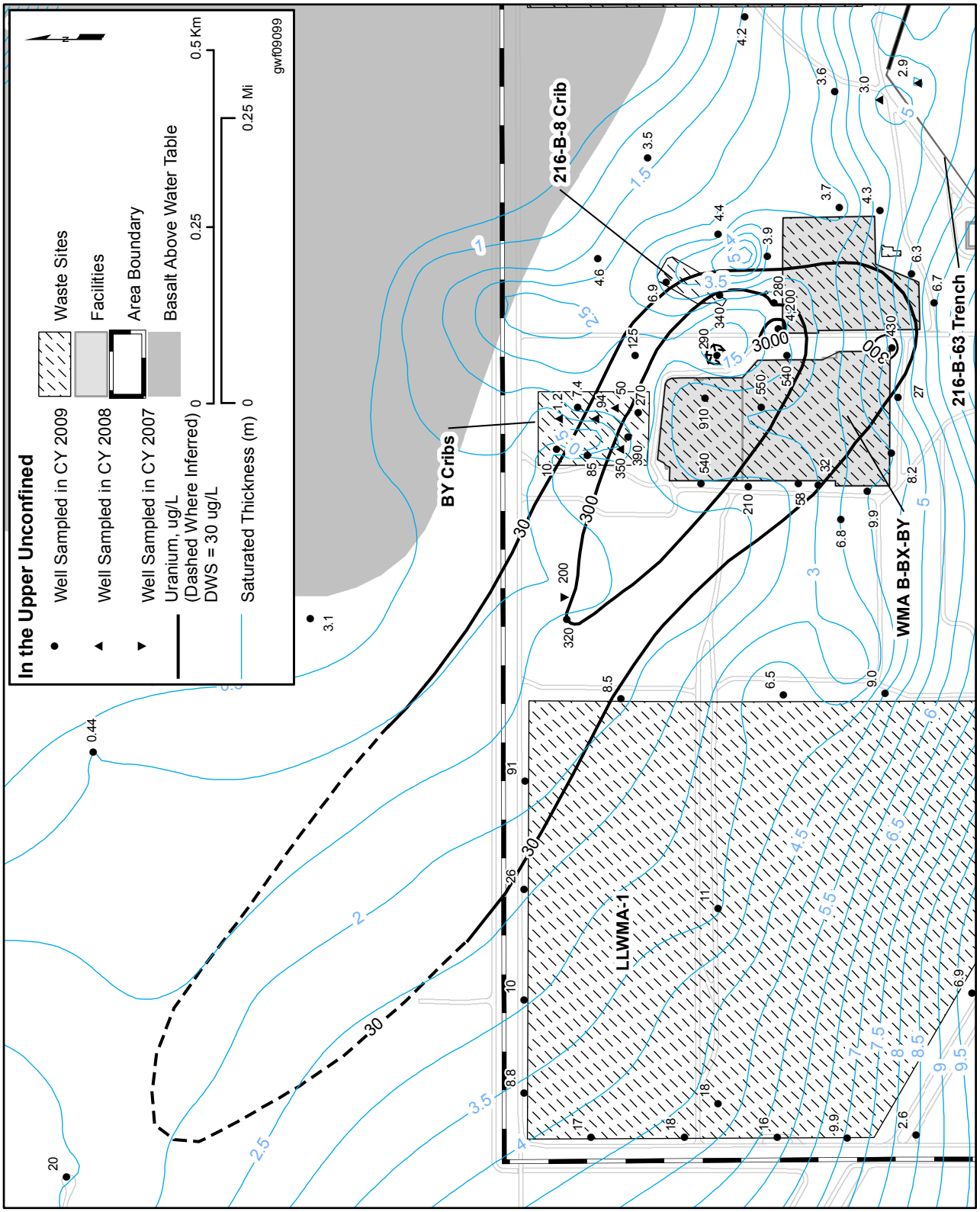
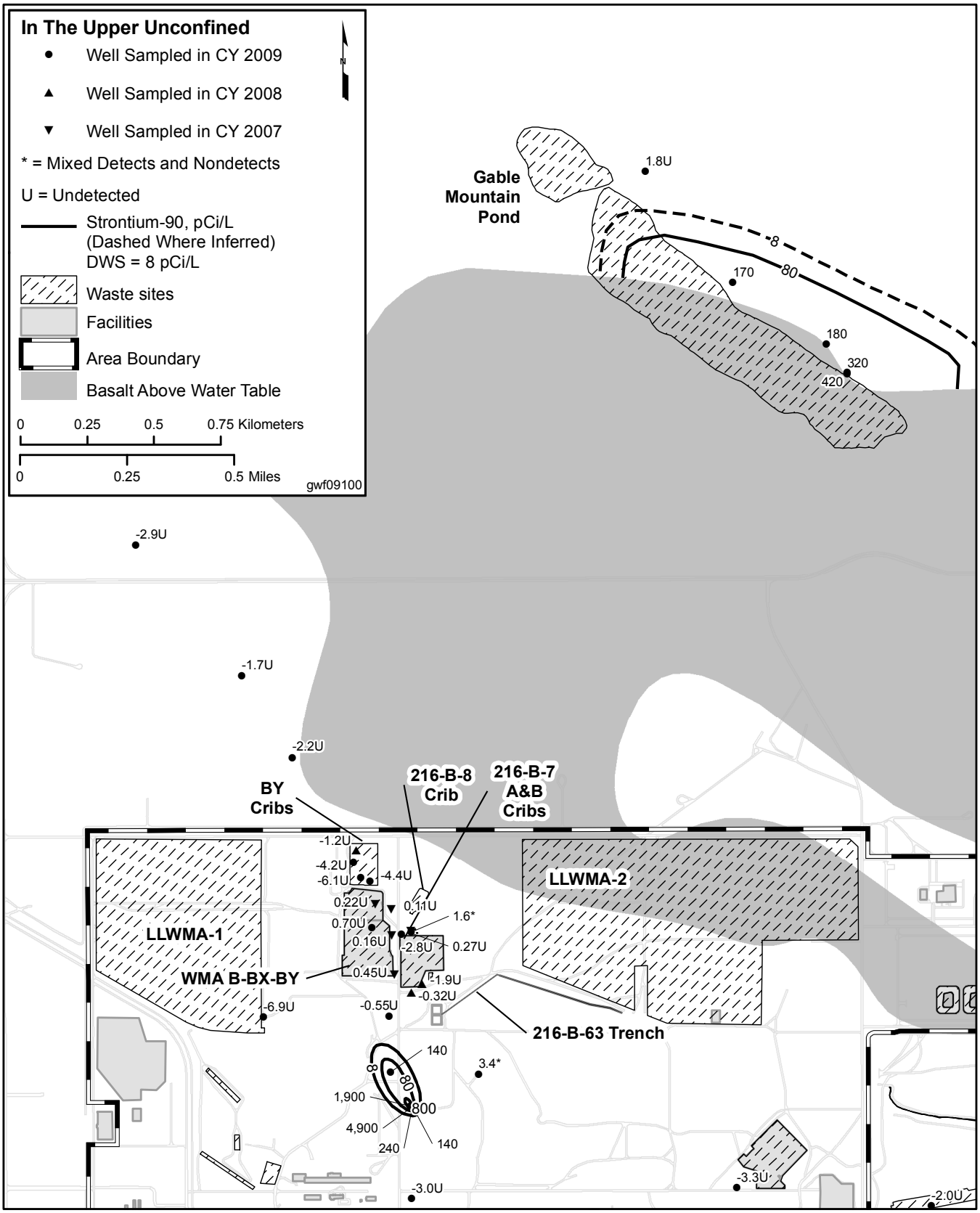


Figure 4-8. Average Groundwater Uranium Concentrations Near Waste Management Area B-BX-BY, Fiscal Year 2009.

Figure 4-9. Average Groundwater Strontium-90 Concentrations in the 200 East Area and the 600 Area Within the 200-BP-5 Operable Unit, Fiscal Year 2009.



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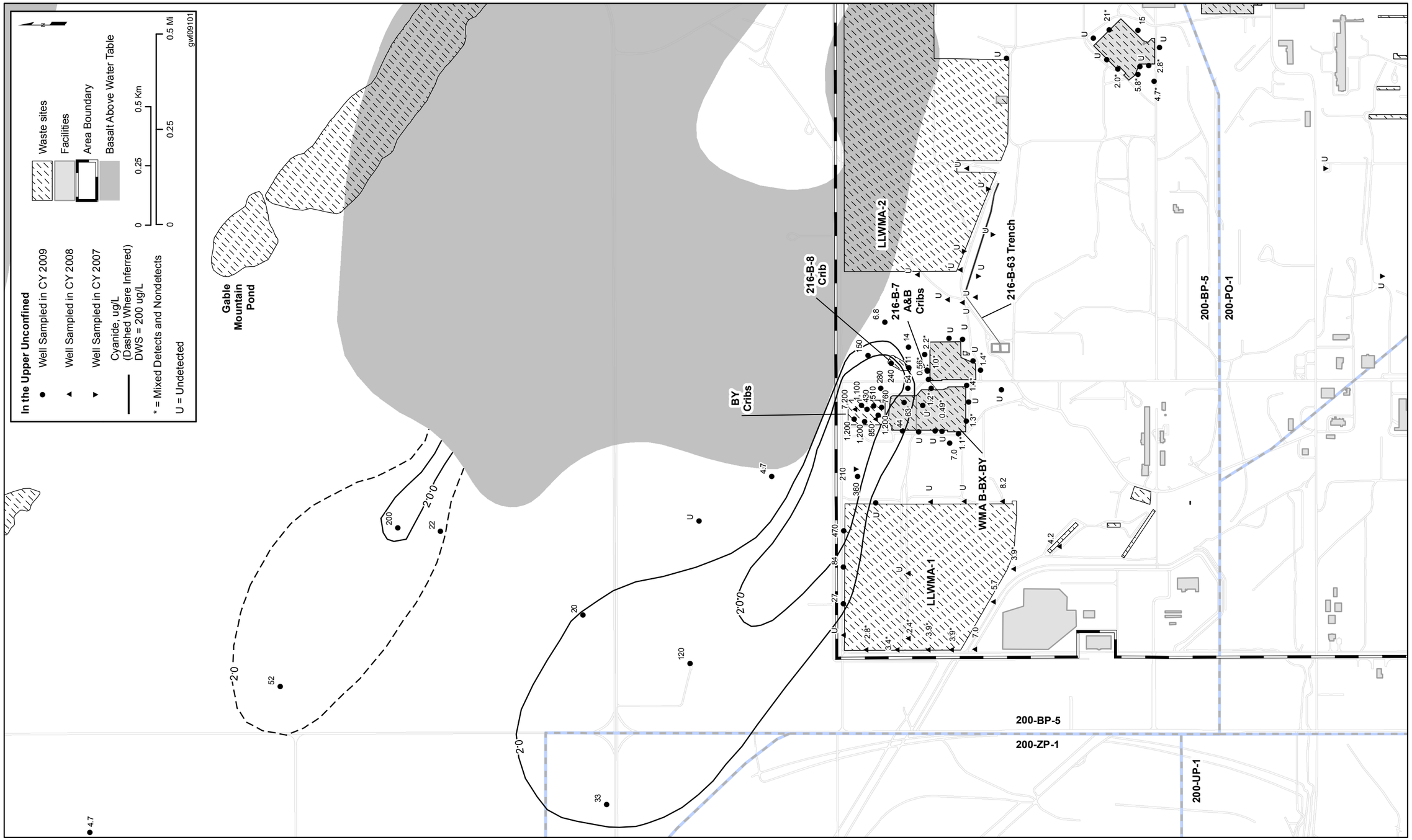

Figure 4-10. Average Groundwater Cyanide Concentrations in the 200 East Area and the 600 Area Within the 200-BP-5 Operable Unit, Fiscal Year 2009.

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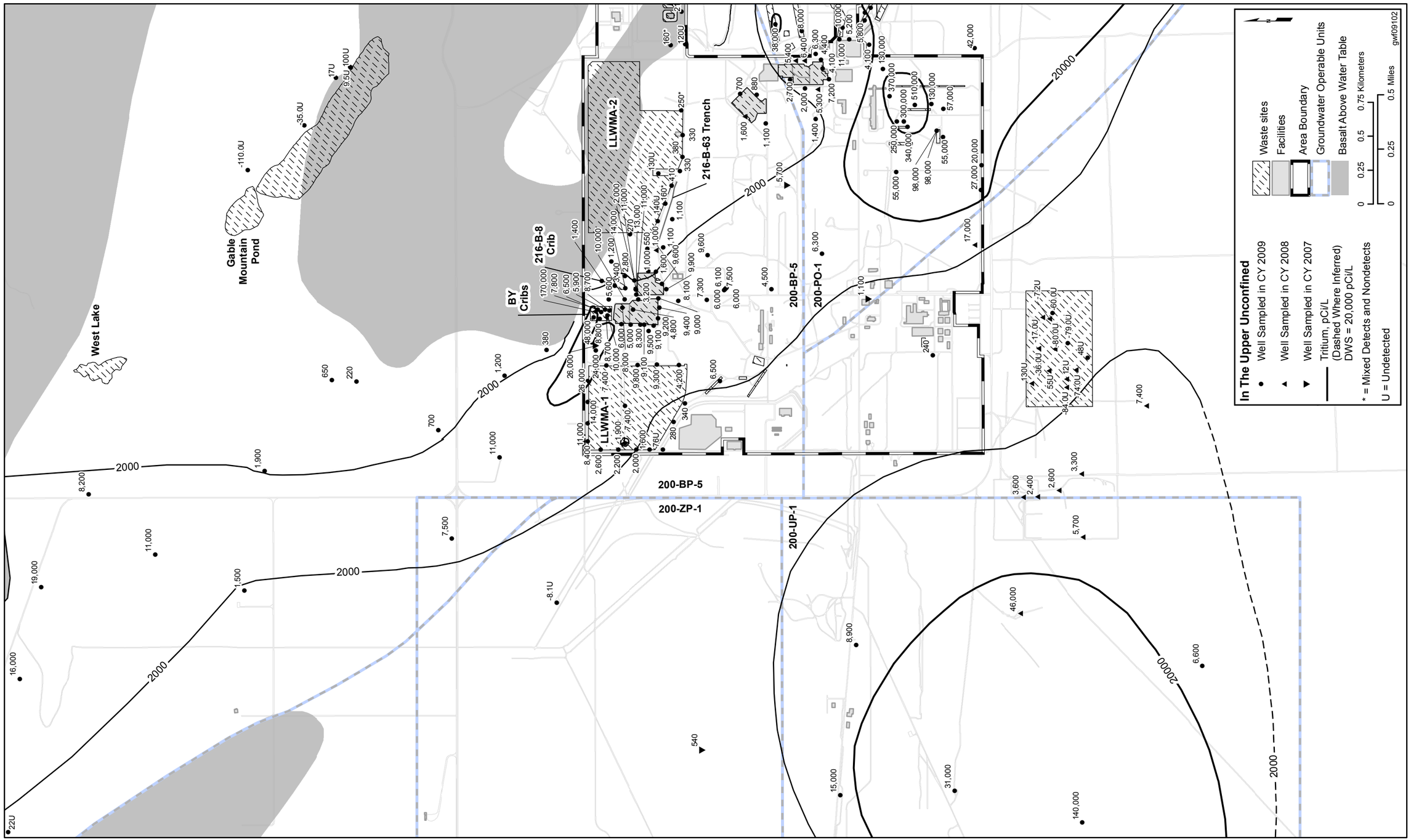

Figure 4-11. Average Groundwater Tritium Concentrations in the 200 East Area and the 600 Area Within the 200-BP-5 Operable Unit, Fiscal Year 2009.

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Figure 4-12. Low-Level Waste Management Area 2 Historical Groundwater Trend Plots for Sulfate.

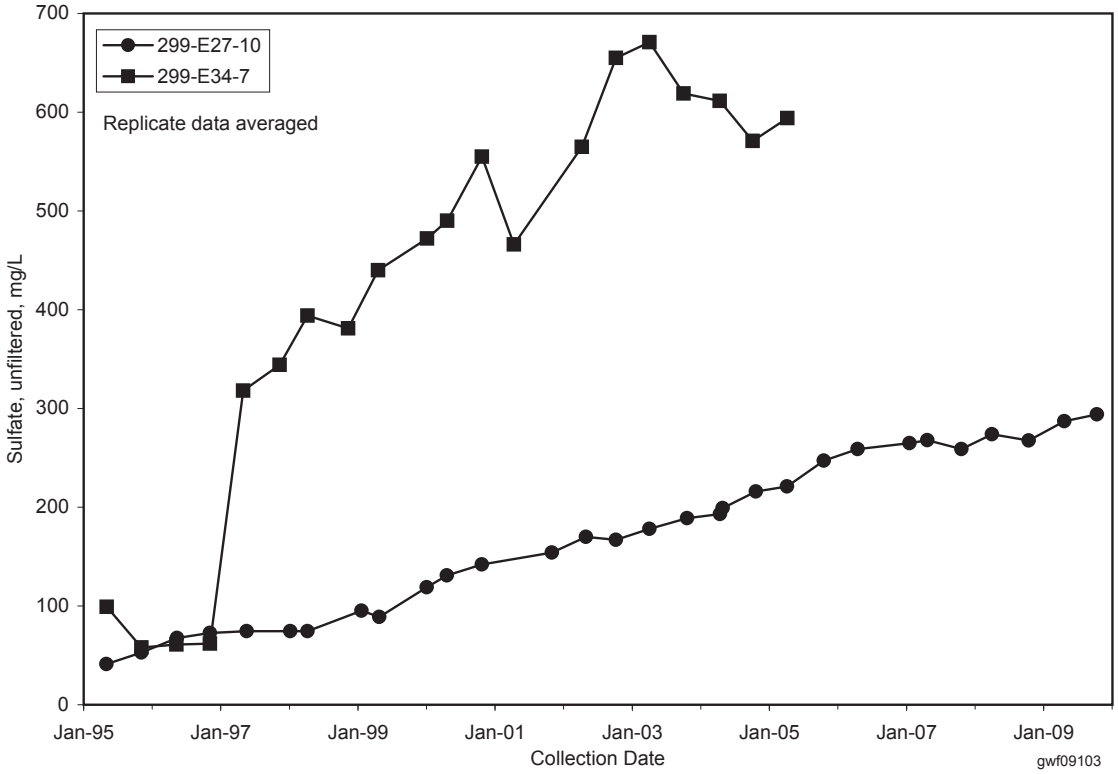
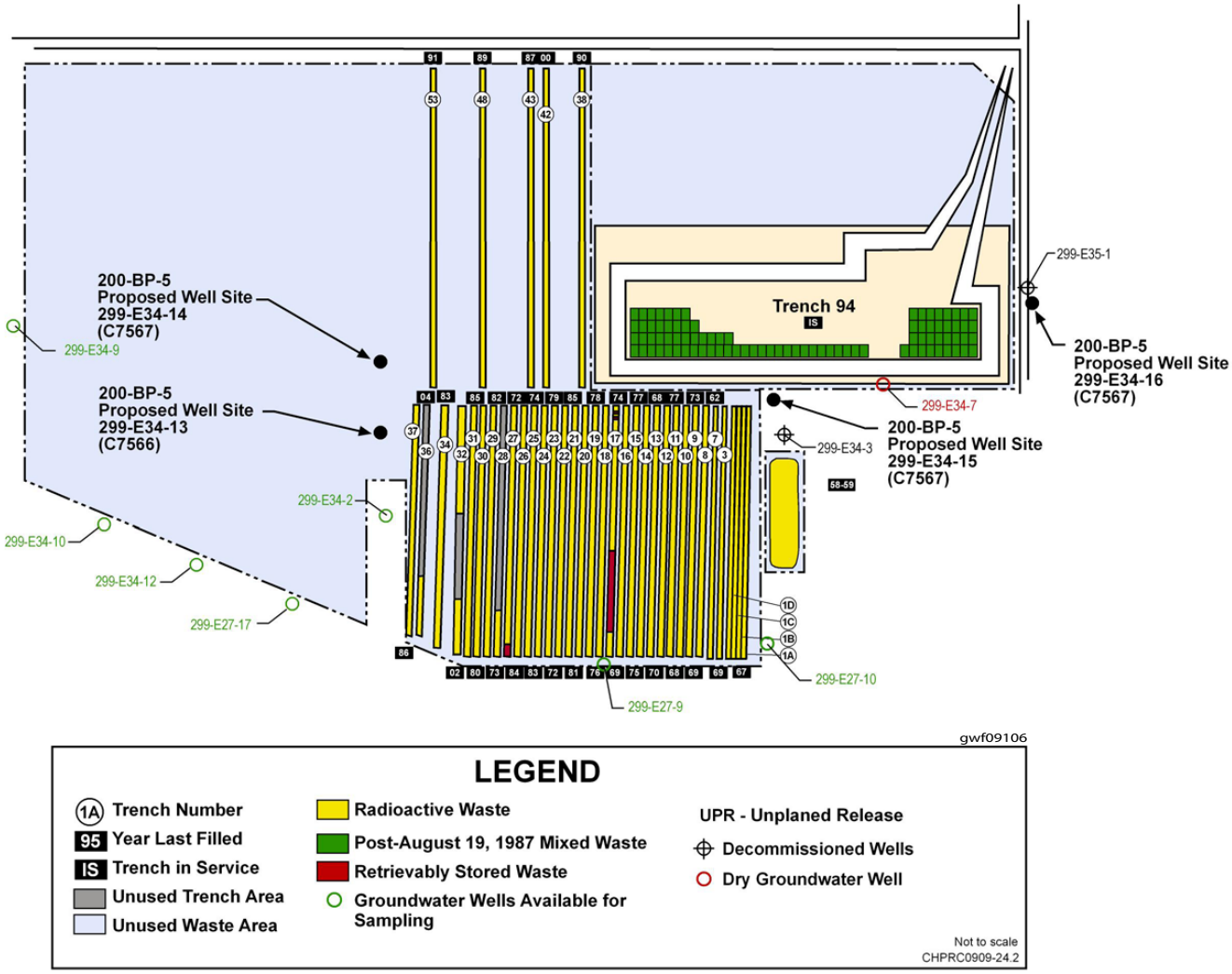


Figure 4-13. Low-Level Waste Management Area 2 New Groundwater Wells Planned for Fiscal Years 2010 and 2011.



Years of Operation (218-E-8): 1958-59
Years of Operation (218-E-12B): 1967 - Present

Figure 4-14. Low-Level Waste Management Area 2 Historical Groundwater Trend Plots of Specific Conductivity at Wells 299E27-10 and 299-E34-7.

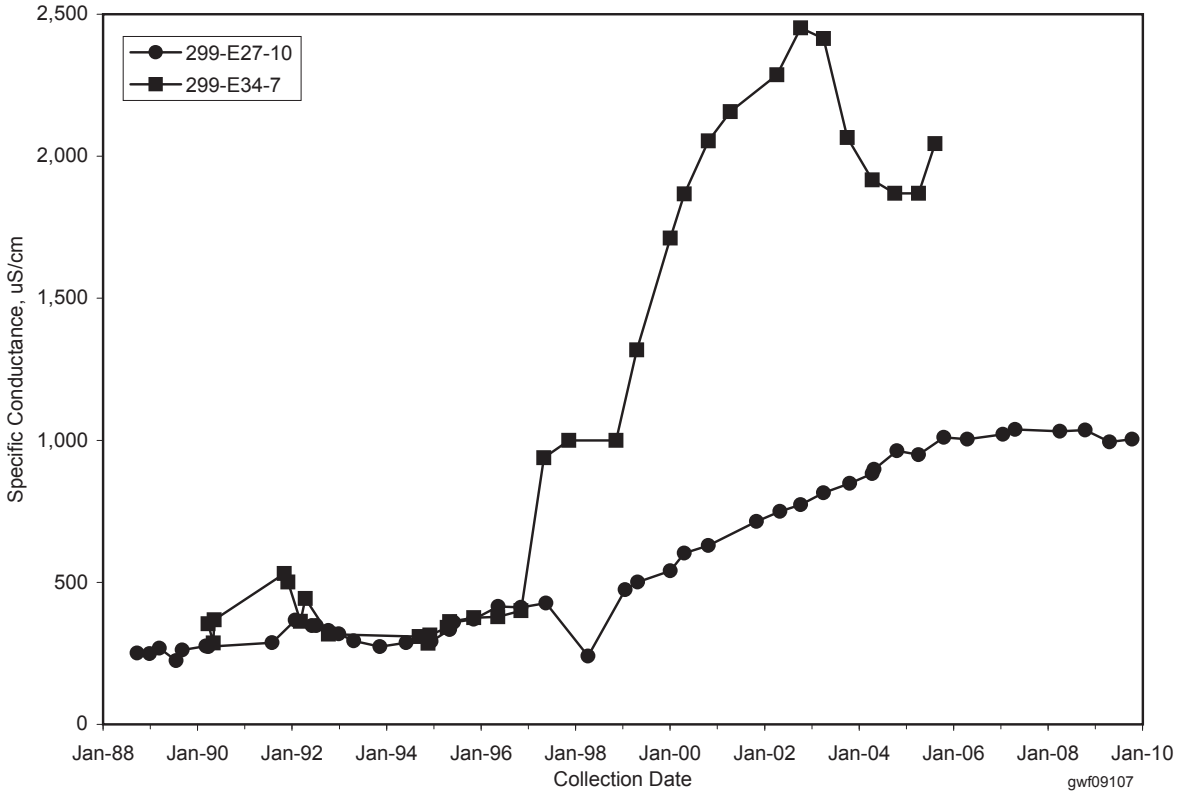


Figure 4-15. Groundwater Sulfate Concentrations and Associated Contour Map in the Northeastern Portion of the 200 East Area.

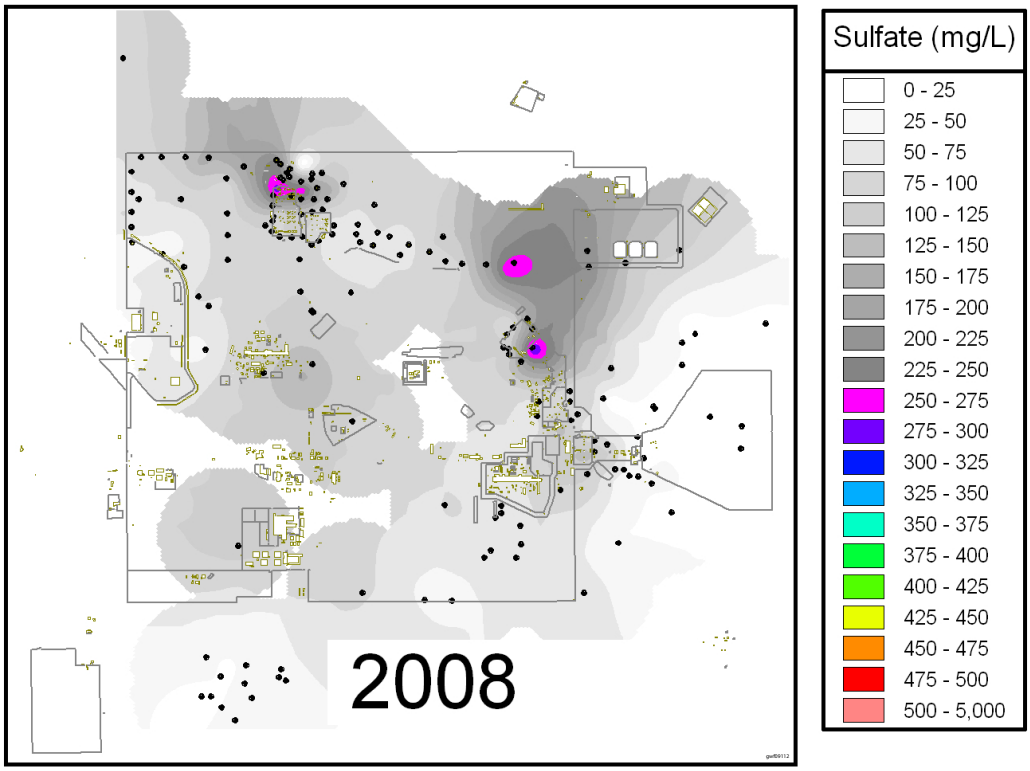


Figure 4-16. Waste Management Area C New Groundwater Wells Planned for Fiscal Year 2010.

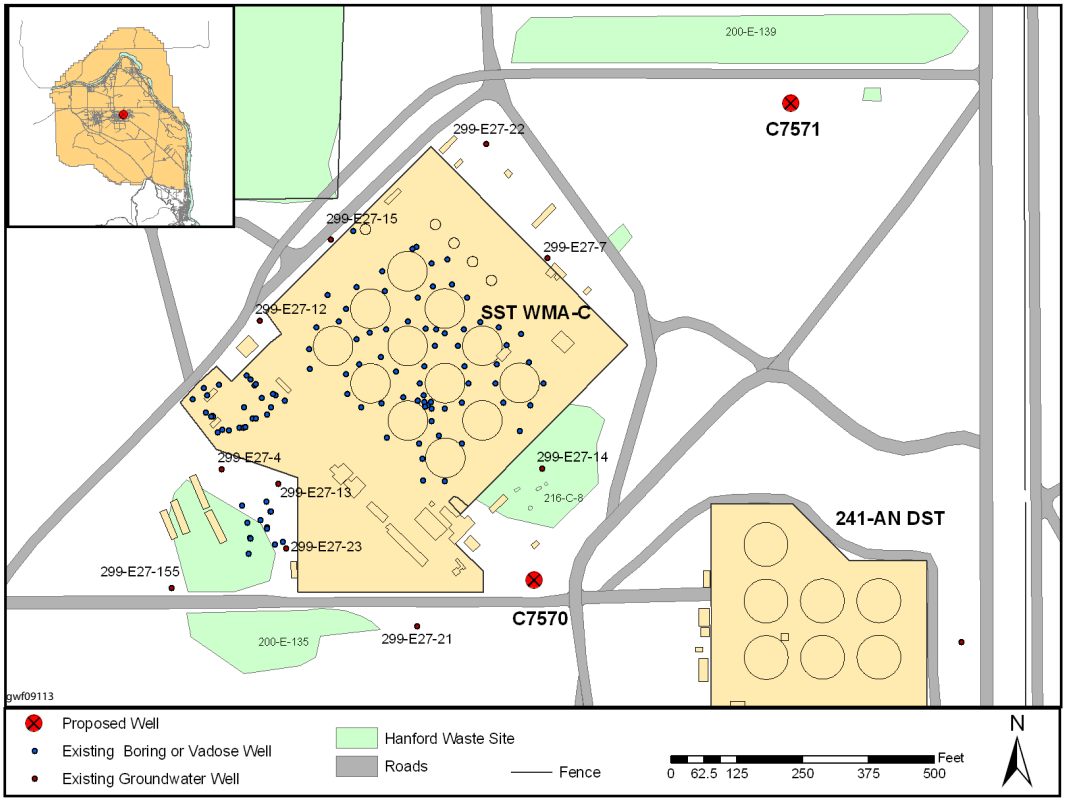


Figure 4-17. Historical Groundwater Cyanide Trend Plots for Waste Management Area C Wells 299-E27-7, 299-E27-14, and 299-E27-23.

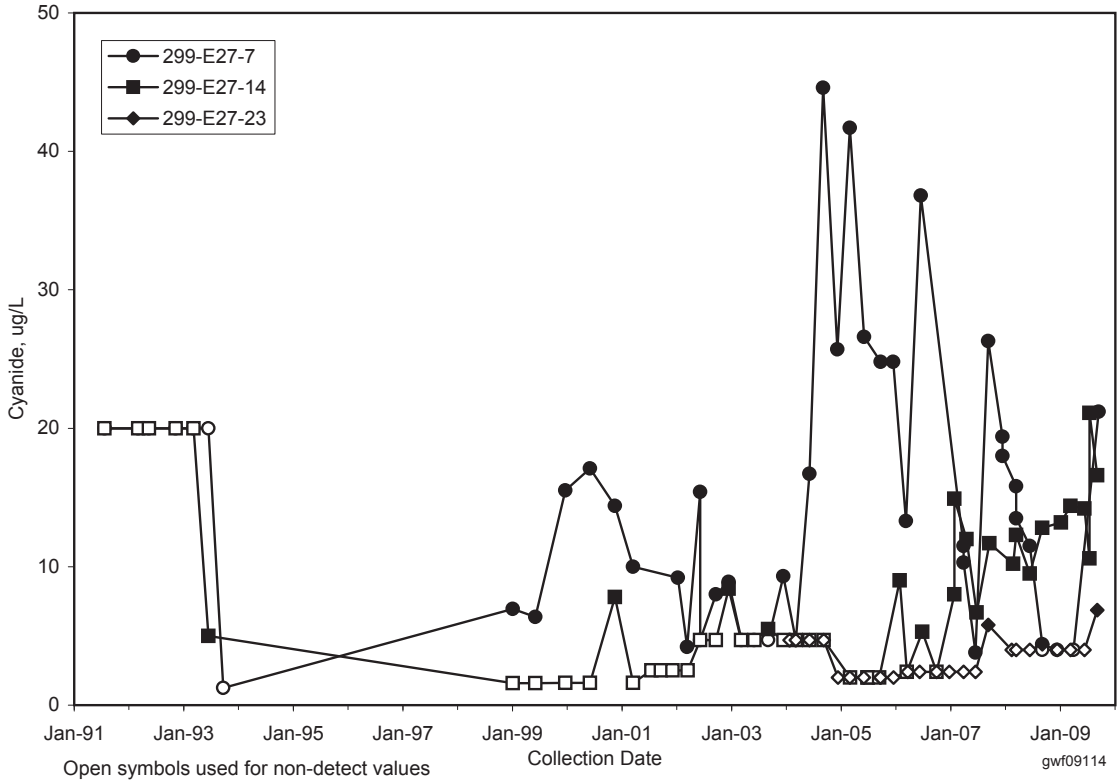


Figure 4-18. Sulfate Trend Plot Comparison for Wells 299-E27-7, 299-E27-10, and 299 E27 14.

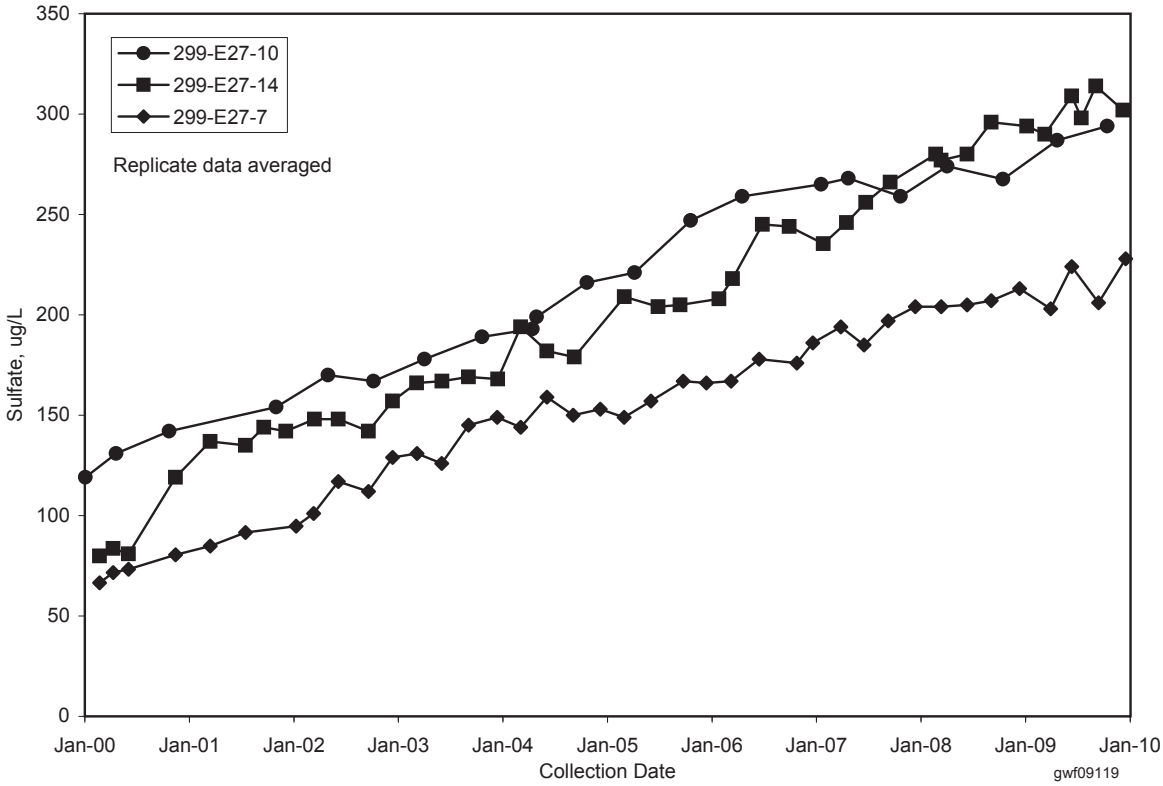
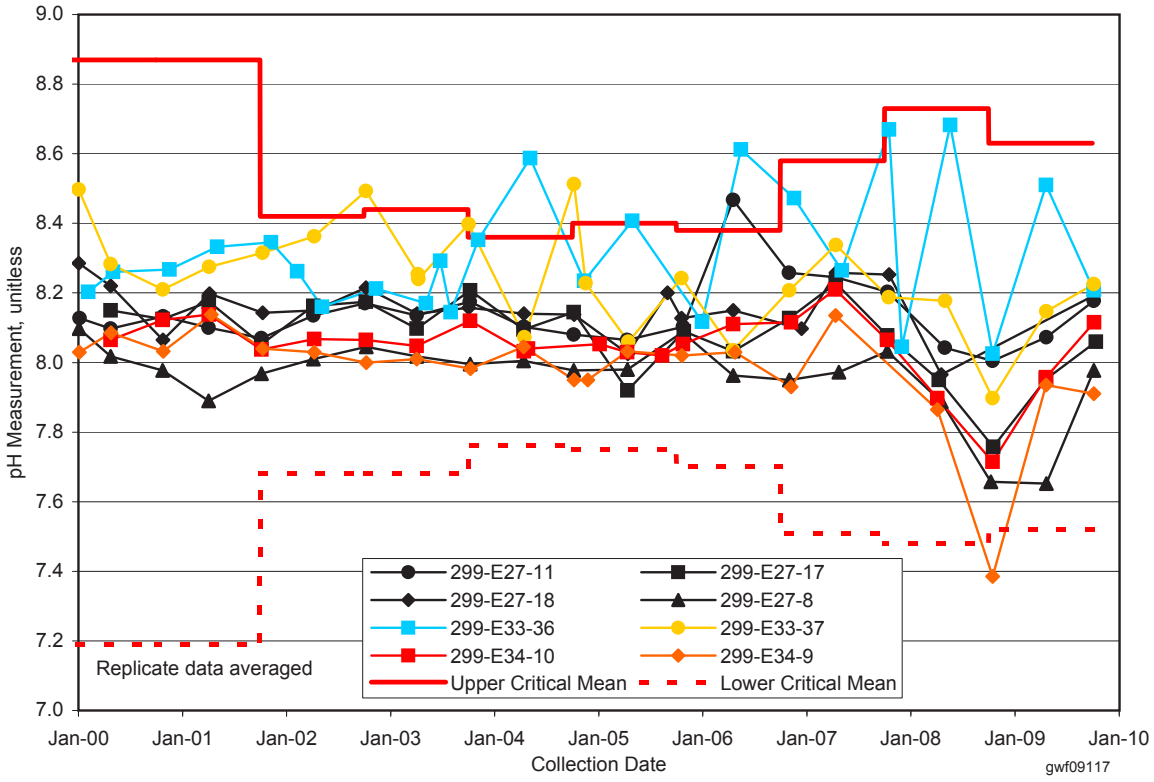



Figure 4-19. Historical Groundwater pH Trend Plots at the 216-B-63 Trench.