

2.10 200-BP-5 Operable Unit

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This section discusses the data, analyses and interpretations compiled in fiscal year (FY) 2007 for the 200-BP-5 Operable Unit including the groundwater under the northern half of the 200 East Area, the region north to West Lake, around Gable Mountain and through Gable Mountain Gap to the Columbia River (see Figure 1.0-1 in Section 1.0). Groundwater is monitored in the 200-BP-5 Operable Unit to track regional and local contaminant plumes, and to support six *Resource Conservation and Recovery Act* (RCRA) units and several *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) past-practice sites. Figures 2.10-1 and 2.10-2 show the operable unit boundaries and wells within the operable unit.

In parts of the operable unit large volumes of processing waste were discharged to the soil column, both intentionally and unintentionally. These discharges occurred over most of Hanford's operational history, from the mid-1940s through the late 1980s. During this time, water levels rose and declined according to production schedules (Figure 2.10-3). The major sources of influence on regional flow were the B Pond and Gable Mountain Pond (Figure 2.10-4). These major effluent release sources were associated with relatively low contaminated water and used to intentionally control other areas hydraulically where liquid effluent releases were more contaminated. One such area, the B Complex area, in the northwest corner of the 200 East Area had numerous large volume effluent disposal sites and several storage facilities reporting unplanned releases. The waste discharge history combined with a sparse distal well network and a complex hydrogeologic environment has resulted in high levels of uncertainty in development of a defensible conceptual site model. This complexity has led to the development of several conceptual site models over the years, which are being investigated by the 200-BP-5 remedial investigation/feasibility study process.

Groundwater is monitored in the 200-BP-5 Operable Unit to track regional and local contaminant plumes.

Groundwater monitoring in the 200-BP-5 Operable Unit includes the following monitoring activities:

CERCLA and AEA Monitoring (Appendix A)

- *Ninety-five wells are sampled annually to triennially. Two wells were delayed until October 2007.*
- *In FY 2007, three new wells were installed.*

Facility Monitoring (Appendix B)

- *Twenty-six wells are sampled quarterly to annually at Waste Management Area B-BX-BY. One quarterly sample was missed.*
- *Twelve wells are sampled semiannually at the 216-B-63 trench.*
- *Twenty-six wells are sampled semiannually at Low-Level Waste Management Areas 1 and 2.*
- *Two wells are sampled semiannually at the Liquid Effluent Retention Facility.*
- *Nine wells are sampled quarterly at Waste Management Area C.*

The water-level elevation only differs ~4 centimeters across most of the 200 East Area.

Providing additional data to evaluate conceptual models is one focus of the 200-BP-5 Operable Unit remedial investigation.

Three factors combine to form an extremely complex hydraulic environment within part of the operable unit. First, highly permeable sediments form an essentially flat gradient on the water table making flow direction and rate estimates based solely on water elevations questionable. Second, large volume waste discharges associated with Hanford operations changed the natural groundwater gradient and saturated areas not associated with the preexisting or natural unconfined aquifer. Third, variations in aquifer thickness possibly lead to structural controls in thin aquifer areas and unclear delineation of contaminants in thick aquifer areas. As mentioned above, an example of these factors is most evident in the B Complex area (e.g., Waste Management Area B-BX-BY and surrounding cribs and trenches).

The most current water table elevation of the unconfined aquifer is shown in Figure 2.10-5. The relief is not sufficient to warrant constructing contours across the 200 East Area. The map is based on water-level measurements collected in July 2007 for the Hanford Site. The measurements were collected over a short time period for the 200 East Area to reduce barometric effects associated with atmospheric pressure changes. The measured water-level elevation only differs ~4-centimeters across most of the 200 East Area, which is on the order of the total uncertainty associated with determining water-level elevations. Consequently, other methods are used to provide some estimate flow direction and rate.

Early groundwater monitoring wells were generally located near waste effluent sources to determine the effectiveness of cribbing criteria rather than determining the extent of various plumes. The cribbing criterion was devised to limit the migration and concentration of contaminants entering the groundwater. By this method less tank space would be needed for storage and groundwater would not be significantly impacted. However, certain mobile contaminant levels within the groundwater have in the past and recently been reported with significantly elevated concentrations. Due to the lack of distal wells and the addition of new waste sites or unplanned releases near older waste sites and unplanned releases it became increasingly difficult to define source and plume extent. Through the years various conceptual models were developed to explain the distal data with various levels of uncertainty. Providing additional data through various means to evaluate some of these past conceptual models is one focus of the 200-BP-5 Operable Unit remedial investigation. A more

complete picture of the subsurface will facilitate the development of the baseline risk assessment and selection of appropriate remedial alternatives, resulting in a more effective solution. The planned scope of the remedial investigation/feasibility study for the 200-BP-5 Operable Unit is summarized in Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit and the appended Sampling and Analysis Plan (DOE/RL-2007-18).

Before Hanford operations affected the water table, flow in the 200 East Area was thought to be from west to east. Early in the Hanford operation history a buried basalt ridge that extended along the northern boundary of the 200 East Area roughly parallel to Gable Mountain was considered a barrier for northern flow from 200 East Area (Figure 2.10-6). However, as increasing artificial recharge was planned for the PUREX operation, concern for contamination flow north to the gap between Gable Butte and Gable Mountain (Gable Gap) and to the Columbia River was considered (HW-49728). To offset the effects of discharge from PUREX to B Pond, the Gable Mountain Pond

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

Cyanide — 0.07
Iodine-129 — 5.37
Nitrate — 4.73
Strontium-90 — 0.65
Technetium-99 — 1.92
Tritium — 0.47
Uranium — 0.39

was created (Figure 2.10-2). Although this hydraulic balance/dam was devised to immobilize groundwater contamination from moving north, groundwater contaminant data provide evidence of historic flow to the north from the 200 East Area. High nitrate contamination (e.g., 1,300 mg/L) in well 699-50-53A (Figure 2.10-2) located over the basalt anticlinal ridge was first reported in 1960. Also in 1975, tritium contamination was detected in well 699-49-57A with a maximum value of 400,000 pCi/L. These elevated concentrations of nitrate and tritium were associated with crib discharges to the south.

Since the reduction and subsequent halt of liquid effluent discharges to the soil, the water table has slowly declined. While the water table has declined the areal extent of the basalt surface emerging from the unconfined aquifer has increased. Understanding the influence of basalt structure on groundwater flow is important to understanding and predicting contaminant migration north of the 200 East Area. For areas where the aquifer is very thin over the anticlinal high and the groundwater chemistry is apparently unchanging, there may be very little flow. This appears to be the case in wells 699-50-59, 699-55-57 and 699-52-57 (Figure 2.10-2). The present groundwater elevation in the aquifer at wells 699-50-59 and 699-55-57 is ~0.3 meters. Both these wells, where the aquifer is very thin, show unchanging contaminant concentrations over the past few years (Figure 2.10-7). In addition, well 699-52-57 has gone dry. However, well 699-49-57A, located in between these wells, has shown increasing uranium concentrations. Although uranium is increasing in well 699-49-57A, nitrate and technetium-99 values have shown no apparent trend in the past few years. Currently it is unknown if some transmissive aquifer channel associated with a Paleo Flood or ancestral Columbia River path may exist (Figure 2.10-6) or if past contaminant plumes in this area may be moving off the basalt subcrop. Further characterization may be necessary to ascertain the hydraulic conditions in the aquifer surrounding well 699-49-57A.

Better definition of contaminant migration and rate in the 200-BP-5 Operable Unit is one of the primary objectives of the remedial investigation activities. Recent work done in support of the 200-BP-5 Operable Unit remedial investigation/feasibility study use constituent migration over time to evaluate groundwater flow direction and rate in several areas across the operable unit (Sections 2.10.1.1, 2.10.3.1, and 2.10.3.6). Studies like these not only improve the estimate of flow direction and rate, but assist evaluating potential risks from the groundwater contamination and assist in making remedial decisions.

The contaminant of greatest concern in the 200-BP-5 Operable Unit is technetium-99 because it is mobile, has a long half life and has a broad areal extent (DOE/RL-2007-18; WMP-28945; DOE/RL-2001-49, Rev. 1). Although it has a limited spatial distribution, uranium is also recognized as an important contaminant because of the high concentration reported in the groundwater. Groundwater is monitored in this operable unit to define the local extent of contamination associated with specific CERCLA and RCRA treatment, storage, and disposal units. The regional extent and distribution of technetium-99, uranium, nitrate, iodine-129, tritium, and other significant contaminants are also monitored. As mentioned above the monitoring program is being expanded to reduce uncertainty in the extent of certain contaminants for a more defensible baseline risk assessment.

The upper basalt-confined aquifer is also monitored in the 200-BP-5 Operable Unit to evaluate potential migration of contaminants from the overlying unconfined

Understanding the influence of basalt structure on groundwater flow is important to understanding contaminant migration north of the 200 East Area.

Better definition of contaminant migration is one of the primary objectives of remedial investigation activities.

*In general,
groundwater
currently enters the
200 East Area from
the west.*

aquifer (Section 2.14). This is evident in one well, 299-E33-12, which in the past was a conduit for contamination from the unconfined aquifer to the upper confined aquifer (RHO-RE-ST-12P). Also current increases in contamination at wells 699-53-55A and 699-53-55B may indicate potential contamination from the confined aquifer near an erosional window. The basalt north of the anticlinal high was significantly eroded by late Pleistocene flooding. The stratigraphy at two wells, 699-55-60A and 699-53-55A, show that all or most of the Elephant Mountain Basalt was removed allowing communication with the Rattlesnake Ridge interbed. The interbed is generally the uppermost confined aquifer (DOE/RL-2005-76). Due to contaminant concentrations at wells 299-E33-12, 699-53-55A, and 699-53-55B, further investigations in FY 2008 are planned to determine the extent of contamination potentially associated with the confined aquifer.

Section 2.10.1 provides general information regarding contaminant plumes and concentration trends for contaminants of concern. Section 2.10.2 discusses aspects of groundwater monitoring specific to the 200-BP-5 Operable Unit. Specific information regarding contaminant distribution for RCRA units within the 200-BP-5 Operable Unit is presented in Section 2.10.3.

2.10.1 Groundwater Contaminants

This section summarizes the distribution of groundwater contamination in the 200-BP-5 Operable Unit. Specific information is provided for several CERCLA sites (the 216-B-5 reverse well, BY cribs, and Gable Mountain Pond) as well as general information regarding regional contaminant distribution, particularly in the area of the Gable Gap. Results are provided for tritium, nitrate, iodine-129, technetium-99, cyanide, uranium, cobalt-60, cesium-137, strontium-90, plutonium-239/240, sulfate, chloride, and mercury. See Figure 2.10-1 for locations of wells monitored in the 200 East Area and Figure 2.10-2 for locations of wells monitored in the 600 Area for the 200-BP-5 Operable Unit. Contaminant distribution maps presented in this section show annual averages where some wells have four quarters of data, some two quarters and some one value per year.

2.10.1.1 Tritium

Tritium contamination is widespread throughout the 200-BP-5 Operable Unit (Figure 2.10-8) extending from the 200 East Area north over the anticlinal high through the Gable Gap and to the Columbia River. The highest tritium concentrations for the 200-BP-5 Operable Unit occur under the BY cribs where a local plume extends west to the north side of Low-Level Waste Management Area 1 and within the Gable Gap at well 699-60-60.

The maximum tritium concentration in the operable unit in FY 2007 was located in the BY cribs in well 299-E33-4 at 173,000 pCi/L. This peak was a short duration event rising from a low of 53,400 pCi/L in November 2006 to the peak in July 2007 and back to 88,000 pCi/L by late September 2007. A spike was also seen in well 299-E33-7 in June 2007, which dissipated considerably by late August 2007. No other corresponding peaks were identified in the BY cribs. In addition, no corresponding peaks were reported in wells to the southeast or west as of the completion of FY 2007. Unfortunately, the absence of wells to the north, east, and west does not allow a full picture of migration from BY cribs.

Another local high is found in one well, 699-60-60, within the Gable Gap area with a concentration reported at the drinking water standard of 20,000 pCi/L. This is a decrease from 25,700 pCi/L reported last year. This small tritium plume appears to be the trailing remains from a more concentrated plume that migrated through the gap area during the 1990s. Tritium concentrations within the gap continue to decrease. Further south, in well 699-49-57A, where the historic maximum tritium concentration was 400,000 pCi/L in 1975 the value is now 11,500 pCi/L (Figure 2.10-9).

2.10.1.2 Nitrate

For FY 2007, the nitrate distribution is shown in Figures 2.10-10 and 2.10-11 using averaged values. Concentrations exceeding the drinking water standard (45 mg/L) occur in the following areas: southeast of Waste Management Area C, on the southeast corner of the Low-Level Waste Management Area 2, beneath the 216-B-5 reverse well, in the northwest portion of the 200 East Area to well 699-50-59 on the structural basalt high, Gable Mountain Pond, and from the 'basalt window' at well 699-53-55C northwest to well 699-55-57. For wells within and north of the Gable Mountain Gap to the Columbia River, nitrate concentrations were reported at levels less than the drinking water standard. Nitrate occurrences at the C Tank Farm, on the west side of Low-Level Waste Management Area 1 and at Low-Level Waste Management Area 2 are discussed in Sections 2.10.3.4 and 2.10.3.6, respectively.

The maximum nitrate concentration detected in the operable unit was located beneath the BY cribs in well 299-E33-4 at 8,630 mg/L. The duration of this peak was similar to tritium with concentration lows in November 2006 and September 2007. Overall during 2007, the average nitrate concentrations were higher in the northern BY crib wells (299-E33-4 and 299-E33-7) than the southern wells and wells to the southeast of the BY cribs. Note that the depth of the aquifer beneath the BY cribs is thickest in well 299-E33-7. Subsequent increases in nitrate contamination to the southeast of the BY cribs indicates possible migration. This directional increase is consistent with the following contaminants: technetium-99, cyanide, and cobalt-60. Limited depth-discrete studies of nitrate and technetium-99 in this area have indicated the contaminants may be migrating down the basalt contour. This is consistent with the basalt surface in this area. However, the absence of wells monitoring the area north and northwest of the cribs does not allow a full picture of migration from BY cribs (Figure 2.10-11). Based on pattern matching trends and contaminant suites, contamination from the BY cribs is also affecting groundwater along the northern border of Low-Level Waste Management Area 1.

At the 216-B-8 crib, the maximum nitrate value increased from 881 mg/L in FY 2006 to 956 mg/L in FY 2007 in well 299-E33-16 located beneath the 216-B-8 crib. The concentration increase indicates infiltration from the 216-B-8 crib. It should be noted that over the past few years, concentrations have increased beneath certain waste sites significantly, however, when the local area is mapped, the peripheral contours from 2001 through 2007 are comparable and movement appears to be nearly stagnant at least to the east, south, and west. Additional discussion is provided in Section 2.10.3.1.

Historically, nitrate is found extending beyond the northwest corner of the 200 East Area, over the basalt anticlinal high and toward the Columbia River within the Gable Gap (see Figure 2.10-11). Just north of the BY cribs where the basalt anticlinal high is located, values over 1,000 mg/L were reported during the 1960s in wells 699-49-57A and 699-50-53A (Figure 2.10-2). Values decreased through the early 1970s and then spiked up in 1973 and remained high through the 1970s in well

The maximum nitrate concentration detected in the operable unit was located beneath the BY cribs in well 299-E33-4 at 8,630 mg/L.

699-49-57A. However concentrations remained low in Gable Gap. From the late 1980s to the end of 2000, values have continued to increase primarily in well 699-49-57A as water levels have continued to decline. Nitrate also increased in well 699-49-57A some time between 2000 and 2003, remaining relatively unchanged since then (Figure 2.10-7). Levels decreased this last year from 277 mg/L in FY 2006 to 237 mg/L in FY 2007. These results are consistent with the recently installed well, 699-50-59, located ~700 meters northwest of well 699-49-57A, which has reported unchanging chemistry with a decrease in average concentration from 110 to 98 mg/L.

The unchanging chemistry in well 699-50-59 along with the results from well 699-50-56 (44 mg/L), located ~460 meters northeast of well 699-49-57A, appear to constrain the nitrate plume to the west and east, respectively. However, with high levels of contamination reported in well 699-49-57A along with the absence of full geochemistry (anions and cations for Stiff diagrams) and increasing concentrations of uranium there appears to be active transport near this well. Characterization efforts, planned as part of the operable unit remedial investigation/feasibility study, may require additional information to ascertain the hydraulic conditions in the aquifer surrounding well 699-49-57A.

Farther north, nitrate concentrations are found above the drinking water standard (45 mg/L) in well 699-53-55C, increasing from 132 to 135 mg/L this last year. This well is located in the 'basalt window' where the Elephant Mountain Basalt was removed during the Pleistocene floods leaving the unconfined aquifer in communication with the confined Rattlesnake interbed aquifer. The source of the nitrate may be related to past high levels found in the late 1980s in well 699-50-53A, where levels were 1,500 mg/L in the 1960s and 735 mg/L in the late 1980s to early 1990s. The extent of this contaminant plume is not understood at this time; however, concentrations have continued to steadily increase in wells 699-53-55B and 699-53-55C over the past decade. In support of the 200-BP-5 Operable Unit remedial investigation/feasibility study, further work will be planned to study this area to help address the extent of this contamination.

Downgradient of well 699-53-55C, nitrate levels are increasing in well 699-57-59 from 20.8 to 27 mg/L over the last year. This increasing trend appears to be associated with the increasing contaminant levels at well 699-53-55C as does the recently increasing values at well 699-60-60 where levels have increased from 31.4 to 40.3 mg/L over the last year.

Left from past facility discharges, nitrate continued to be detected in wells monitoring Gable Mountain Pond at levels above the drinking water standard of 45 mg/L. In general, trends are either decreasing or remain unchanged. For example, the highest values are found in well 699-53-48A where the nitrate concentrations have been decreasing since 1996, from 177 to 165 mg/L over this last year. In well 699-53-47A, nitrate levels have remained nearly constant with a change from 88 mg/L in FY 2006, to 93 mg/L in FY 2007.

The 216-B-5 injection well is located northeast of 221-B Building and has shown increasing nitrate levels since the mid-1990s. Over the last two years levels have increased from 29.7 mg/L in FY 2005 to 57.1 mg/L this last year. The groundwater at this location continues to be the only location within the 200-BP-5 Operable Unit that has elevated cesium-137 and plutonium-239. See Section 2.10.1.7 for further discussion of this facility.

Characterization efforts may require additional information about the hydraulic conditions in the aquifer north of 200 East Area.

2.10.1.3 Iodine-129

Iodine-129 contamination is present throughout the 200-BP-5 Operable Unit. The distribution of iodine-129 follows a pattern through 200 East Area similar to tritium (Figures 2.10-12 and 2.10-13). Groundwater concentrations exceeding the iodine-129 drinking water standard of 1 pCi/L in the 200-BP-5 Operable Unit are generally limited to the 200-East Area, but do extend north of the 200 East Area as far as well 699-57-59 (1.4 pCi/L), within Gable Gap. Concentrations exceeding the drinking water standard do not extend beyond Gable Gap.

In addition, a region of elevated iodine-129 concentrations is present in the B Complex area with values less than 5 pCi/L during FY 2007.

2.10.1.4 Technetium-99

The distribution of technetium-99 above the drinking water standard (900 pCi/L) includes Waste Management Area C, the B Complex area, the basalt anticlinal ridge north of the 200 East Area, and at the 'basalt window' in well 699-53-55A and extending to well 699-55-57 (Figures 2.10-14 and 2.10-15). North of well 699-55-57 and through the gap, values do not exceed the drinking water standard.

The highest technetium-99 concentrations in FY 2007 were reported under the BY cribs at 73,400 pCi/L in well 299-E33-4. This is a significant increase from FY 2006 when the maximum value was 42,900 pCi/L. The technetium-99 concentration peaked similar to tritium and nitrate with lower concentrations in November 2006 and September 2007. Also similar to nitrate the average technetium-99 concentrations were higher in the northern wells than the southern wells under the BY cribs. The subsequent increases in technetium-99 contamination to the southeast of the BY cribs indicates migration which is consistent with co-contaminants nitrate, cyanide, and cobalt-60. Limited studies of co-contaminants nitrate and technetium-99 have indicated the contaminant suite may be migrating down the basalt contour. This is consistent with the basalt surface in this area, which dips generally to the south. However, the absence of wells monitoring the area north and northwest of the BY cribs does not allow a full picture of migration from BY cribs (Figure 2.10-15). Based on pattern matching of trends and contaminant suites, this contamination is also present in wells along the northern border of Low-Level Waste Management Area 1.

Significant increases in technetium-99 levels were also found in a number of wells south and southeast of the BY cribs during FY 2007. For example, well 299-E33-16 at the 216-B-8 crib peaked at 14,100 pCi/L in November 2006. Levels in well 299-E33-18, near the 216-B-7A/7B cribs averaged 13,750 pCi/L with little variation this last year. On the southern border of Waste Management Area B-BX, in well 299-E33-337 a short duration increase was reported from May 2006 to February 2007 with concentrations from 66.3 pCi/L to 3,230 pCi/L. Subsequent to this peak technetium-99 returned to 167 pCi/L by late August. These separate isolated areas with different groundwater chemistry suggest multiple sources. Further information on contaminant trends in the area is located in Section 2.10.3.1.

Similar to nitrate, historical technetium-99 concentrations were high north of the 200 East Area providing part of the evidence for northern flow direction in the past (Section 2.10). As with nitrate, technetium-99 levels increased in well 699-49-57A sometime between 2000 and 2003 when data were not collected. However, since 2003, the concentration is relatively unchanging with a value of 4,850 pCi/L in

The highest technetium-99 concentrations in FY 2007 were reported under the BY cribs at 73,400 pCi/L.

Limited studies of nitrate and technetium-99 indicated they may be migrating down the basalt contour.

Contamination is increasing in well 699-53-55C, located in an area where the Elephant Mountain Basalt has been eroded.

2003 and 4,480 pCi/L in 2007 (Figure 2.10-7). These results are consistent with the recently installed well 699-50-59, located ~700 meters northwest, which has reported unchanging chemistry (anion and cation balance) with a decrease in technetium-99 concentration from 1,370 to 1,130 pCi/L over the last year. The unchanging chemistry in well 699-50-59 along with the low technetium-99 results from well 699-50-56 (560 pCi/L), located ~460 meters northeast, appear to constrain the technetium-99 plume on the west and east, respectively. However, with high levels of contamination reported in well 699-49-57A along with the absence of full geochemistry and increasing concentrations of uranium there appears to be active transport near this well (Figure 2.10-15). Characterization efforts, planned as part of the operable unit remedial investigation/feasibility study, may require additional information to ascertain the hydraulic conditions in the aquifer surrounding well 699-49-57A.

Another area of increasing contamination is at well 699-53-55C, within the 'basalt window,' an area where the Elephant Mountain Basalt has been eroded, creating a relatively thick aquifer. Technetium-99 concentrations increased from 2,600 to 2,750 pCi/L over the last year. As with nitrate, this contamination appears to be migrating northwest through the other wells sampled in the vicinity of Gable Mountain Gap. The Gable Gap wells (699-57-59, 699-59-58, and 699-60-60) showed slight increases in concentration over the last year (Figure 2.10-14). The concentrations for these gap wells are below the drinking water standard (900 pCi/L). As discussed in WMP-28945, the source of this rising contamination may be a vestige of the contamination observed in the late 1980s in well 699-50-53A. It is worth noting that high contamination (technetium-99 concentrations over 30,000 pCi/L) was observed at well 699-50-53A during the mid-1980s to early 1990s. The extent of this contaminant plume is not understood at this time; however, concentrations have continued to steadily increase in wells 699-53-55B and 699-53-55C over the past decade. In support of the 200-BP-5 remedial investigation/feasibility study, further work is planned to study this area to help address the extent of this contamination.

2.10.1.5 Cyanide and Cobalt-60

Uranium recovery waste was disposed directly to the soil column in seven of the eight BY cribs in the mid-1950s. The waste was transferred from tanks in the BY Tank Farm. Within the operable unit, cyanide is detected in the B Complex area and wells to the northwest and in a few wells at Waste Management Area C. Cyanide concentrations are above the drinking water standard (200 µg/L) under and southeast of the BY cribs and in well 299-E33-34, located in the northeast corner of Low-Level Waste Management Area 1 (Figure 2.10-16). Due to the significant concentrations of this contaminant in the groundwater from wells beneath the BY cribs, this constituent assists in distinguishing contaminant signatures associated with the BY cribs.

The maximum cyanide concentration detected in the operable unit in FY 2007 was located in the BY cribs in well 299-E33-4 at 3,990 µg/L. This value is an increase from the maximum value of 1,470 µg/L, reported last year. The increased value reported in this well is consistent with the increased values for technetium-99, nitrate, and cobalt. Overall during 2007, the average cyanide concentrations were more elevated in the northern wells (299-E33-4 and 299-E33-7)^(a) than the southern wells and wells

(a) Well 299-E33-4 contains too little water (~0.3 meter) to sample by routine methods. It was sampled with a bailer in FY 2007 and sample turbidity ranged from 34 to 73 NTU. Well 299-E33-7 contains more water (~1 meter) and was sampled with a pump in FY 2007 and samples had low turbidity (<5 NTU).

to the southeast of the BY cribs. For example, the average cyanide concentration in well 299-E33-1A was 569 µg/L as compared to 341 µg/L at well 299-E33-13. The subsequent increase in cyanide contamination to the southeast of the BY cribs indicates migration which is also seen with technetium-99, nitrate, and cobalt-60. However, the absence of wells monitoring the area north and northwest of the cribs, does not allow a full picture of migration from BY cribs (Figure 2.10-16). Limited studies of contaminants nitrate and technetium-99 have indicated the contaminant suite may be migrating down the basalt contour. This is consistent with the basalt surface in this area. Additional discussion is provided in Section 2.10.3.1.

Cobalt-60 has a short half-life (5.3 years) making radioactive decay relevant for this constituent. Consequently, concentrations are usually found at less than the drinking water standard (100 pCi/L). Currently the only area where concentrations exceed the drinking water standards were in wells monitoring the BY cribs. The highest cobalt-60 concentration in FY 2007 was in well 299-E33-4 at 599 pCi/L, an increase from 290 pCi/L last year. The next highest values in well 299-E33-7, increased from 49.5 to 93.4 pCi/L during the year. As discussed previously, both wells had corresponding high cyanide, nitrate, technetium-99, and tritium levels.

2.10.1.6 Uranium

Uranium concentrations exceed the drinking water standard (30 µg/L) in wells monitoring the B Complex and to the northwest, wells near the 216-B-62 crib, and wells near the 216-B-5 injection well (Figure 2.10-17).

The highest uranium concentrations in the 200-BP-5 Operable Unit during the last several years have been consistently reported in well 299-E33-9 beneath the BY Tank Farm. Although samples collected and analyzed at well 299-E33-9 had the highest average uranium for the site (786 µg/L) in FY 2007, well 299-E33-41 was reported with the highest peak value at 935 µg/L in August 2007. The average value at well 299-E33-41 for FY 2007 was 554 µg/L. Another location showing consistently high average uranium results this year was well 299-E33-18, near the 216-B-7A and 216-B-7B cribs at 754 µg/L (Figure 2.10-17). Other wells reporting concentrations greater than 10 times the drinking water standard (> 300 µg/L) included 299-E33-16 (beneath 216-B-8 cribs), 299-E33-31 (west of well 299-E33-9), and 299-E33-38 (northwest of well 299-E33-9).

The groundwater contamination in the B Complex area is present in a northwest-southeast pattern that, in recent years, has shown a broadening to the east, west and south as shown in the mapped time series of uranium in Figure 2.10-18.^(b) Although it has been suggested the uranium contamination was moving quickly to the northwest (Christensen et al. 2004), the location of the 100-µg/L contour to the northwest for the past several years is nearly unchanged, indicating nearly stagnant groundwater conditions. This observation is based on contours which include wells 299-E33-26, 299-E33-34 and 299-E33-9, the three locations that define northwest flow in the past. Regardless of the uranium increases in the local area, the uranium does not seem to have significant movement along the edges of the plume.

Conversely, uranium concentrations have been increasing in well 699-49-57A in the last several years with a maximum of 18 µg/L in FY 2007. These increases

The highest uranium concentrations in the operable unit during the last several years have been in well 299-E33-9 beneath the BY Tank Farm.

(b) Figure 2.10-18 shows a slightly different interpretation of the uranium plume than the PNNL-16346 (2006) and Figure 2.10-17 (2007). The alternative interpretation of Figure 2.10-18 shows separate plume centers beneath BY and B Tank Farms. Ongoing studies may clarify which interpretation is more valid.

Uranium concentrations have been increasing in well 699-49-57A, north of 200 East Area, with a maximum of 18 µg/L in FY 2007.

suggest that groundwater in this area is moving (Figure 2.10-17). However, it should be noted that uranium concentrations reported at well 699-49-57A are at the same magnitude as uranium values reported in proximal wells in the 1990s.

Uranium concentrations exceeded the drinking water standard in one well (299-E33-34) at Low-Level Waste Management Area 1. Uranium levels have decreased in this well from a maximum value of 107 µg/L in 2004 to the FY 2007 value of 74.8 µg/L. Concentrations in well 299-E28-27 on the southeast corner of the facility increased from 16.2 to 26.2 µg/L over the last year. Further information on contamination at Low-Level Waste Management Area 1 can be found in Section 2.10.3.3.

216-B-62 Crib. For the last 8 years, uranium has been detected at levels close to the drinking water standard (30 µg/L) in well 299-E28-18, which monitors the 216-B-62 crib. This crib is located northwest of B Plant (Figure 2.10-17). Uranium concentrations were over 200 µg/L in the mid-1980s, but declined to current levels by the late 1980s. The maximum FY 2007 uranium concentration at the 216-B-62 crib was 31 µg/L reported for well 299-E28-18. Well 299-E28-21 also monitors the crib but is located north of well 299-E28-18. Uranium concentrations have been decreasing at this location since the initial high values were observed in the mid-1980s. In FY 2007, the concentration was 10.9 µg/L, a decrease from the FY 2006 value of 13.3 µg/L. The source of uranium for these wells has been linked to the 216-B-62 crib, however, based on waste site soil inventory estimates for the crib, uranium may be from another source.

216-B-5 Injection Well. Uranium contamination is associated with the cesium-137, plutonium, and strontium-90 contamination found at the 216-B-5 injection well. The highest uranium concentration detected in FY 2007 at this site was 37.4 µg/L in well 299-E28-23, located ~1 meter from the injection well (Figures 2.10-17). Uranium concentrations are roughly stable in well 299-E28-23. Uranium values were significantly lower in wells 299-E28-24 (22.1 µg/L) and 299-E28-25 (15.4 µg/L) located farther from the injection well. During FY 2007, a uranium value of 39.5 µg/L was reported for well 299-E28-6, located south of the injection well. Uranium concentrations have been generally stable in well 299-E28-6 since 2002, with a slight decline in FY 2007. It is not known if the source of uranium contamination in this well is the 216-B-5 injection well.

2.10.1.7 Cesium-137, Strontium-90 and Plutonium-239/240

Cesium-137 contamination (>200 pCi/L) in the 200-BP-5 Operable Unit is limited to the 216-B-5 injection well. Cesium-137 has relatively low mobility and is generally found near the source. Well 299-E28-23 near the 216-B-5 injection well has consistently had concentrations of cesium-137 greater than the drinking water standard (200 pCi/L) but less than the U.S. Department of Energy (DOE) derived concentration guide (3,000 pCi/L). In FY 2007, a concentration of 1,120 pCi/L was reported for this well. All other wells sampled at this site had cesium-137 concentrations below the drinking water standard in FY 2007.

During FY 2007, strontium-90 contamination in the 200-BP-5 Operable Unit was reported in the groundwater at the 216-B-5 injection well and at Gable Mountain Pond. Four wells (299-E28-2, 299-E28-23, 299-E28-24, and 299-E28-25) near the 216-B-5 injection well had concentrations of strontium-90 above the drinking water standard (8 pCi/L) in FY 2007. Two of these wells continued to have strontium-90 concentrations greater than the DOE derived concentration guide (1,000 pCi/L). The

highest strontium-90 concentration was reported for well 299-E28-23, with reported values of 4,130 and 3,960 pCi/L in FY 2007. Concentrations have been declining in this well since 2000; however, the concentration in FY 2007 are slightly elevated over the FY 2006 concentrations of 3,390 and 3,290 pCi/L. Strontium-90 also exceeded the DOE derived concentration guide in well 299-E28-25, with a concentration of 1,590 pCi/L reported in FY 2007.

In several wells near Gable Mountain Pond, strontium-90 concentrations rose in the 1990s and have declined since 2000 but remain above the drinking water standard. The plume did not change significantly during FY 2007. Strontium-90 was detected in groundwater at levels above the DOE derived concentration guide in well 699-53-47A in FY 2000, but has been below the guide since FY 2003. The concentration in this well was 614 pCi/L in FY 2007, representing a slight decrease from the FY 2006 concentration of 679 pCi/L. Concentrations at well 699-53-48A decreased from 741 pCi/L in FY 2005 to 397 pCi/L in FY 2006 and to 329 pCi/L in FY 2007. Strontium-90 concentrations in both wells have decreased from their peaks in the late 1990s.

Plutonium-239 and plutonium-240 were detected in past years in the groundwater near the 216-B-5 injection well. Plutonium contamination is relatively immobile and, therefore, is found only near the injection well. The highest reported plutonium concentration in FY 2007 was for well 299-E28-23 that had reported filtered values of 12.0 and 12.7 pCi/L and unfiltered values of 35.4 and 40.4 pCi/L. The unfiltered results were above the DOE derived concentration guide for plutonium (30 pCi/L). The lower concentration in the filtered versus unfiltered samples suggests that a portion of the plutonium is associated with particulates. The concentration of plutonium in well 299-E28-23 has not exhibited a clear change in trend in recent years. Other wells sampled near the 216-B-5 injection well site have also had plutonium levels below the DOE derived concentration guide in recent years.

2.10.1.8 Sulfate and Chloride

Sulfate and chloride concentrations have been increasing over part of the 200-BP-5 Operable Unit since the mid to late 1990s and have recently exceeded the secondary drinking water standards in a few locations. A distribution map of sulfate results for FY 2007 is provided in Figure 2.10-19. Relevant information on chloride concentrations is discussed in section 2.10.3.1.

The secondary drinking water standard of sulfate (250 mg/L) was exceeded in wells 299-E33-4, 299-E33-9, and 299-E33-16. These high values are, most likely associated with the other contaminants since sulfate compounds were used in the Hanford processing streams. However, along the sub-crop in Low-Level Waste Management Area 2 and Liquid Effluent Retention Facility where the aquifer is slowly receding down the basalt gradient, sulfate is increasing to values as high as 671 mg/L in well 299-E27-10 with no associated contaminants other than chloride (185 mg/L) and nitrate (109 mg/L). The increasing regional sulfate trend is affecting upgradient wells at Waste Management Area C (Section 2.10.3.6) and may be affecting the groundwater as far south as Waste Management Area A-AX (Section 2.11.3.3). The reason for the increasing sulfate is not known at this time.

2.10.1.9 Mercury

Low levels of mercury (drinking water standard, 2 µg/L) have appeared sporadically in a few wells monitoring the low-level burial grounds and the BY cribs. In most wells in this area, samples have been analyzed for mercury routinely as far back as

In several wells near Gable Mountain Pond, strontium-90 concentrations have declined since 2000 but remain above the drinking water standard.

the late 1980s. All but a few results during this period have historically been below detection limits (minimum detection limits range from 0.05 to 0.2 µg/L). Recently, however, mercury results in a few wells have been above detection limits with the most conspicuous of these occurring in well 299-E33-7, located in the northern portion of the BY cribs in November 2006 at a concentration of 4.3 µg/L. A review of soil analyses for mercury beneath the BY cribs showed the concentrations were at or below Hanford Site background levels. Well 299-E33-34, at the northeast corner of Low-Level Waste Management Area 1, previously produced several sequential low-level (maximum 0.19 µg/L) detections, but was below detection (<0.09 µg/L) in FY 2007. Although mercury is not commonly detected in Hanford groundwater samples several wells during the Groundwater Background Study (DOE/RL-96-61) reported elevated concentrations of mercury.

2.10.2 Operable Unit Activities

CERCLA monitoring requirements in the 200-BP-5 Operable Unit have been defined in the sampling and analysis plan (DOE/RL-2001-49, Rev. 1). The sampling and analysis plan was revised in late FY 2004 to integrate *Atomic Energy Act* (AEA) monitoring and make slight modifications in the 200-BP-5 monitoring network. A second revision will be completed in early FY 2008 to incorporate the new wells being installed as part of the 200-BP-5 remedial investigation. CERCLA monitoring includes sampling of the regional plumes, and sites discussed in the above sections which include: B Complex waste sites, B Plant waste sites, Semi works waste sites and both the Gable Mountain and B Pond. However, due to the location of B Pond, the 200-PO-1 Operable Unit also monitors this area. Results of monitoring are discussed in Section 2.10.1.

An interim or final record of decision has not been established yet for the 200-BP-5 Operable Unit. This report is the only formal report presently being prepared on a regular basis for the unit.

A characterization program was designed to support decisions during the remedial investigation/feasibility study process (WMP-28945), including consolidation on a preferred conceptual model. During FY 2007, the following activities were completed for the 200-BP-5 Operable Unit CERCLA remedial investigation/feasibility study:

- Release of *Data Quality Objective Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process* (WMP-28945) in February, 2007.
- Release of *Draft A Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit and the appended Sampling and Analysis Plan* (DOE/RL-2007-18) in March 2007.
- Installation and initial monitoring of three groundwater monitoring wells. Two wells, 699-50-56 and 699-48-50B, are located north of the 200 East boundary and monitor the unconfined aquifer. One well, 299-E33-50, is located north of the 216-B-8 Crib and monitors the confined aquifer.
- Design for 12 investigation wells of which 10 wells are planned for installation in FY 2008.
- Characterization activities associated with sediment and groundwater sample

collection, aquifer testing, borehole geophysical logging, elemental isotope studies, contaminant ratio analyses, and Stiff diagram investigations.

- Conducted surface resistivity surveys analyzed with inversion theory. Results were mapped and considered during placement of further characterization work.
- Development of local and regional conceptual models to provide a defensible and useful understanding of geology/hydrogeology, the natural and Hanford-induced hydraulic character and chemical evolution of the groundwater systems, including groundwater flow directions and rate.
- Planning and preparation for extensive hydraulic characterization with pumping tests and in situ tracer investigations to better characterize hydraulic properties plus depth-discrete groundwater sampling/analyses in select wells to map the vertical extent of contamination.
- Preliminary design work for possible future remedial activities was initiated.

Three new wells (299-E33-50, 699-48-50B, and 699-50-56) were added to the 200-BP-5 monitoring network in FY 2007. These wells will serve as groundwater monitoring wells for the 200-BP-5 Operable Unit and will support the 200-BP-5 Operable Unit remedial investigation/feasibility study. Well 299-E33-50 was completed in the Rattlesnake Ridge interbed confined aquifer and is located in the north-central portion of the 200 East Area of the Hanford Site just north of the 216-B-8 crib. Wells 699-48-50B and 699-50-56 were completed in the suprabasalt unconfined aquifer and are located in the 600 Area, directly north of the 200 East Area and south of the Gable Gap.

The 200-BP-5 monitoring network and analytes are listed in Appendix A. In FY 2007, sampling was planned for 91 wells. Of these, 89 wells were successfully sampled during FY 2007. Sampling of the remaining two wells was delayed until October 2007.

2.10.3 Facility Monitoring

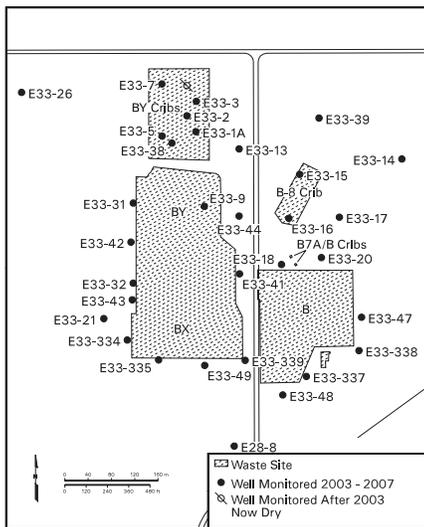
This section describes results of monitoring at individual units such as treatment, storage, and disposal units or tank farms. Some of these facilities are monitored under the requirements of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 1.2, pursuant to RCRA, the source, special nuclear, and by-product material components of radioactive mixed waste are not regulated under RCRA and 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 Operable Unit contains six RCRA sites with groundwater monitoring requirements: Waste Management Area B-BX-BY, 216-B-63 trench, Low-Level Waste Management Areas 1 and 2, Liquid Effluent Retention Facility, and Waste Management Area C. This section summarizes results of statistical

comparisons, assessment studies, and other developments for FY 2007. Groundwater data are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

2.10.3.1 Waste Management Area B-BX-BY

Located in the northwest part of the 200 East Area, this waste management area consists of the B, BX and BY Tank Farms along with its ancillary equipment. The three farms, jointly, consist of 36 underground tanks ranging from 2- to 2.9-million-liter capacity and four 208,000-liter tanks constructed between 1945 and 1949. Seventeen of the larger tanks are known or suspected to have leaked in the past along with three of the smaller tanks. A well location map and table of wells along with analytes sampled for the waste management area this fiscal year are included in Appendix B.



Waste Management Area B-BX-BY is currently in a RCRA groundwater quality assessment program (PNNL-13022, Rev. 1). A first determination investigation showed contamination from past unplanned releases to the soil column associated with the farms, most likely, compromised groundwater quality (PNNL-11826, 1998). Consequently, the site continues in RCRA assessment with quarterly monitoring to assess the extent and rate of contaminant migration associated with the waste management area. Sampling is also conducted to monitor for new occurrences of groundwater contamination that may be associated with the farms or ancillary equipment. In addition to monitoring dangerous waste constituents for RCRA assessment, the site is monitored for CERCLA and AEA purposes under the 200-BP-5 Groundwater Operable Unit program.

In the past, the RCRA groundwater assessment work for the current fiscal year has been included in this report in lieu of a separate report. Although the same reporting will be done this year to capture FY 2007 RCRA groundwater assessment work, this may not be the case in outlying years. When significant results have been generated during the fiscal year, a data package to capture relevant data, analyses and interpretations may be prepared from which a summary will be included in this document. Consequently, the following detailed discussion should not set a precedent for future report contents.

The primary dangerous waste constituents found beneath Waste Management Area B-BX-BY in FY 2007 are nitrate, sulfate, chloride and cyanide along with the non-RCRA regulated constituents technetium-99, uranium, tritium and cobalt-60. In the past, elevated nitrite levels were also observed. These constituents are contributed to multiple facilities, including Waste Management Area B-BX-BY and the surrounding cribs. Also elevated values of iron and manganese are found in one location north of the site. Because the high concentrations of iron and manganese are found only under the BY cribs, past releases at these facilities are the most likely source.

Based on multiple methods of determining groundwater flow direction, the apparent direction at Waste Management Area B-BX-BY is to the south (PNNL-16346; Narbutovskih et al. 2002.) Work done in support of the 200-BP-5 Operable Unit remedial investigation along with in situ flow rate measurements and time series mapping of major plumes provides evidence of slow contaminant migration to the

south at this waste management area. Locally, the aquifer was formed by past Hanford operations associated with large volume releases (i.e., B Pond and the PUREX cribs). Presently, it is slowly receding in the direction of the dipping basalt surface as water levels decline, with current aquifer thicknesses ranging from 0.3 meter in the north to less than 5.5 meters south of the waste management area. The water has receded completely at one location under the 216-B-49 crib where the basalt is above the aquifer. Another location at the BY cribs has ~0.3 meter of aquifer left. Thus, the location of the edge of aquifer and the basalt surface above the aquifer is close to the north side of the BY cribs.

The rate of decline in the water table has decreased over the years since B Pond ceased operations. For example, the water table decreased by nearly 0.3 meter from 1998 to 1999, by 0.12 to 0.18 meter from 2001 to 2002, then 0.09 meter in 2005 to 0.06 meter in 2006. From 2006 to 2007, there was no decrease in the elevation of the water table at this site. In the artificially induced part of the aquifer, this decreasing rate of decline may reflect the slow flow rate as shown by in situ investigations. Least squares regression fits to hydrographs indicate most monitoring wells, screened across the entire aquifer, will remain useful for over 15 years provided the rate of decline does not increase.

The waste management area is surrounded with past-practice facilities where waste that is the same or similar to stored material in the tanks was intentionally discharged to the soil column. To distinguish non-tank groundwater contamination from tank-related contamination, the monitoring network includes 24 near-field and 5 far-field wells. Most wells are monitored quarterly to allow pattern matching of contaminate trends although a few wells are sampled semi-annually (see Appendix B for details).

Assessment studies have identified several distinct suites of contaminants depending on location within the B Complex area. (PNNL-13116; PNNL-14187; PNNL-14548, PNNL-15070; PNNL-16346). A brief description of these contaminants suites is provided in the following paragraphs.

- **Nitrate, Chloride, Sulfate, Technetium-99, and Uranium.** These contaminants are located under the BY Tank Farm. In the past, elevated nitrite has also been found with this contaminant suite. Migration of contamination through the vadose zone may, at least partly, source this groundwater contamination. Further assessment of the source is ongoing although its proximity to the BY Tank Farm suggests a possible tank-related source.
- **Tritium and Nitrate.** This contaminant suite was found on the southwest corner and along the south border of the waste management area. With the recent migration of technetium-99, uranium and nitrate from upgradient under the waste management area, this suite does not appear today as a distinct group. Movement of elevated tritium with low levels of nitrate from a perched water zone located ~4.5 meters above the water table under the BX Tank Farm, most likely, caused this local plume. In the 1960s and 1970s, large volumes of tritium were generated and moved through the tank farm waste transfer lines from the in-tank solidification process making this a possible tritium source for the perched water. For more information see PNNL-15070.
- **Technetium-99, Nitrate, Uranium, Sulfate, Tritium, Cobalt-60, and Cyanide.** This contaminant suite, found under and around the BY cribs, comprises

This discussion for Waste Management Area B-BX-BY constitutes the annual RCRA groundwater assessment documentation of analyses and interpretations completed during FY 2007.

the highest levels of contamination in the groundwater at the B complex of facilities, except for uranium. Elevated iron and manganese are also in the groundwater above the drinking water standards (300 µg/L and 50 µg/L, respectively) under the BY cribs. This suite is, most likely, associated with waste released in the past to the BY cribs and for tritium, also the 216-B-57 crib. Evidence is presented that shows this contaminant suite is slowly impacting wells to the south during FY 2007.

- ***Nitrate, Technetium-99 and Uranium.*** Located under the 216-B-8 crib, this local area had the highest nitrate concentrations during the late 1990s. Although elevated nitrite was observed in 2005, analysis of recent sharp increases in all three main contaminants suggest the source is associated with past discharges to the 216-B-8 crib.

Although there is wide-spread contamination in the 200 East Area, there are local plumes of nitrate, technetium-99, uranium, chloride and tritium in the immediate region of the waste management area and surrounding disposal facilities. Time series mapping, trend plots, Stiff diagrams, nitrate to technetium-99 ratio, uranium isotopes and spectral gamma logs are used to investigate possible sources, identify wells with similar sources and delineate flow migration pathways. The following discussion pertains to the waste management area and the surrounding facilities.

Nitrate. A series of nitrate maps, shown in Figure 2.10-20, tracks the development of this contaminant plume across the waste management area from 1995 to the present in 3-year intervals. In 1995, elevated nitrate was found in a northwest to southeast pattern extending from the northeast corner of Low-Level Waste Management Area 1, through the BY cribs to northern part of the 216-B-8 tile field. From 1995 to 1998, within the B complex area, this northwest-southeast extending contaminant migrated to the southwest and south as shown by the change in location of the 30 mg/L (dark blue), 40 mg/L (green) and 50 mg/L (yellow) contours. By 2001, the plume migrated sufficiently to move the 100-mg/L contour (orange) to the southwest. During the time from 1995 to 2001, the water table dropped nearly one meter, indicating the groundwater, and consequently the contamination, was moving.

From 2001 to 2007, the plume expansion to the southwest has slowed with some southern movement of the 40- and 50-mg/L contour (green and yellow) on the west side of the BX Tank Farm. During this time period, the water dropped considerably less, approximately 0.4 meter. This drop equates to a 0.13 meter decline for a 3-year interval. The decrease in plume expansion appears to reflect a reduction in flow rate over the last several years. Also, the 50-mg/L contour (yellow) in 2001 through the BX Tank Farm marks the approximate location where the natural part of the aquifer begins, i.e., in pre-Hanford time there was no aquifer north of this location. South of this location, the plume tends to expand to the southeast, toward the 216-B-63 trench. This movement can be seen by comparing the location of the 30 mg/L (dark blue), 40 mg/L (green) and 50 mg/L (yellow) contours north of the B Tank farm in 2004 to southeast of the farm in 2007. Note also that throughout the time from 1995 to 2004, contours have moved to the southeast through Low-Level Waste Management Area 1 and south of the tank farms as shown by the southeast movement of the 10 mg/L (violet) and 30 mg/L (light blue) contours. This same movement is seen in regional nitrate contaminant maps found in annual groundwater reports (PNNL-11793; PNNL-13788; PNNL-15070; PNNL-16346). The pre-Hanford flow direction in this natural part of the aquifer was considered to be southeast, parallel to the natural edge of the unconfined aquifer against the basalt subcrop (RHO-ST-42).

The migration direction, based on these data, agree with results of tritium mapping and in situ methods (PNNL-13022, Rev. 0).

Superimposed on this slowly migrating background plume are developing contaminant centers, historically located under the BY cribs and at the 216-B-8 crib. For example, in the map for FY 2001, a value of 651 mg/L at the 216-B-8 crib and 624 mg/L at the BY cribs mark two local areas where nitrate is higher than at surrounding wells. Data on the 2004 map show significantly higher values under the BY cribs with a maximum of 1,070 mg/L (red). By 2007, the area with values over 1000 mg/L has increased noticeably to the south and southeast. During the same period, under the 216-B-8 crib, nitrate concentrations have increased from 558 mg/L to 956 mg/L, expanding to the southeast with a value of 673 mg/L (orange). Further discussion of these locally increasing nitrate trends along with the co-contaminants of uranium, technetium-99 and in some locales, cyanide, is found later in this section.

Technetium-99. Coincident with the nitrate plume is developing technetium-99 contamination. Time series mapping, covering the years from 2002 to 2007, is shown in Figure 2.10-21. As seen in the nitrate mapping, local centers of technetium-99 are developing within the larger slowly migrating plume under the BY cribs, at the 216-B-8 crib and near the 216-7A/7B cribs. For example, one feature displaying southern movement of the technetium-99 plume is the very slow migration of the 50-pCi/L (purple) contour from 2002 to 2004. Even the 200-pCi/L and 1,000-pCi/L contours do not show the movement on the west side of the waste management area like the nitrate data in Figure 2.10-21. However, from 2002 to 2005, there is a distinct southern movement of the 200 pCi/L contour reflecting rising contaminant level migrating over the southern border of the BX and B Tank Farms. It is important to note that there are no facilities or high levels of groundwater contamination southeast of the B Tank Farm that could source these increasing trends. Thus, the flow direction is generally from the north to the south.

Another distinct feature displaying southern movement is seen from 2004 to present day. The 10,000-pCi/L (yellow) contour demonstrated steady expansion from under the BY cribs to the south and southeast. As shown by the time-series mapping, migration is from north to south with the highest technetium-99 values found under the BY cribs. Further information on possible facility sources can be obtained by identifying the impact of water drivers with chloride concentrations and co-contaminants with trend plots.

Chloride. When water is released at the surface in arid environments, either intentionally, unintentionally, or from natural precipitation, the percolating moisture leaches chloride from buried soil horizons, bringing elevated chloride to the groundwater. By mapping the changes in groundwater chloride data, areas where water drivers are bringing contamination residing in the vadose zone to the groundwater may be identified (Scanlon 1991).

A comparison of changing chloride over time is presented in Figure 2.10-22 for the years 2001 and 2007. In 2001, the highest chloride value occurred under the BY Tank Farm suggesting a point of entry for contamination in this vicinity. Until recently, this was also the location of the highest historic uranium contamination. The center of the 20 mg/L contour is near the northwest corner of the BY Tank farm, the southwest corner of the BY cribs and the east side of the Hanford barrier over the 216-B-57 crib. This area is a local topographic low area.

*Time series mapping
of contaminants
indicates migration
to the south at
Waste Management
Area B-BX-BY.*

Over the past 10 to 15 years, there is evidence that this locale was impacted by significant surface water from a variety of sources. For example, a distinct erosional feature developed during the 1990s to present day forming a channel ~1.2 meters deep between the B-57 Hanford Barrier and the northwest corner of the BY Tank Farm. A picture of this feature taken after heavy precipitation is shown in Figure 2.10-23. This location is only one of many where ponding after heavy precipitation was observed. This last year, the erosional feature was filled so water can no longer drain from the northwest corner (or south of the B-57 Barrier) to the BY cribs through this channel.

In addition, on the north side of the barrier, a water line valve was left open for extended time periods to irrigate deciduous trees planted during the mid-1990s in support of testing the Hanford Barrier. Between the water from channeling of natural precipitation, from long-term leaking or open water line valves, and from continuous, multiple-year use of the irrigation sprinkler system at the B-57 Barrier, the local chloride high may mark one approximate entry point for significant contaminant infiltration in this area.

By 2007, a discrete chloride high still exists under the BY Tank Farm as shown by the 50-mg/L and 60-mg/L contours. With the highly contaminated soils and known perching horizons in this vicinity (PNNL-13022, Rev. 1) combined with a slow flow rate, an influx of waterborne contamination from the vadose zone may explain the increasing contamination observed over the last 12 to 14 years in this local region.

Although higher chloride values are seen under the BY cribs, the most notable change within Waste Management Area B-BX-BY is the expansion of chloride to the south and southeast as seen by the migration of the 15-mg/L and 20-mg/L contours. This incursion of elevated chloride to the south and southeast is similar to movement of contours observed in both nitrate and technetium-99 indicating flow to the south.

Uranium. Within this slowly migrating background contamination are areas where nitrate, technetium-99, uranium and, in some places, cyanide concentrations may be migrating from the vadose zone into the groundwater. Over the last few years, these co-contaminants formed sharply rising trends in six wells in various parts of the B Complex area. At some of these sites, there does not appear to be much dispersion of the contamination before it encounters a nearby well suggesting the contaminants are entering the groundwater near the well bore. Co-varying trends between nitrate, uranium, technetium-99 and, in some places, cyanide show these constituents are co-contaminants traveling together in the groundwater. Thus, these contaminants may have a common source in the vadose zone.

The historic center of uranium contamination is under the BY Tank Farm in well 299-E33-9. However, during the last several years, this center has expanded to the south where sharp increases in uranium along with nitrate and technetium-99 are observed. The current maximum uranium concentration is southeast of the BY Tank Farm in well 299-E33-41 at 935 µg/L (Figure 2.10-24). Technetium-99 and nitrate concentrations increased with the uranium to maximum values for this locale of 5,850 pCi/L and 132 mg/L respectively. This is the closest groundwater monitoring well to the pocket of contaminated soil associated with a past leak from the 241-BX Tank Farm. At well 299-E33-18, near the 216-7A/7B cribs and just north of the 200 series tanks at the B Tank Farm, a local maximum uranium value of 844 µg/L was observed along with corresponding increases in technetium-99 to 15,000 pCi/L and

nitrate to 536 mg/L. The uranium at this well has associated technetium-99 and nitrate concentrations at three to four times greater than closer to well 299-E33-41.

Although at low levels, uranium continues to increase along the southwest and south sides of the waste management area as shown in Figure 2.10-25. With the natural uranium background at 2.5 µg/L (WHC-EP-0595), these data clearly indicate, along with the increasing nitrate and technetium-99 (Figures 2.10-20 and 2.10-21) that uranium is migrating to the south from the high values seen in the north.

Under the 216-B-8 crib at well 299-E33-16, sharply increasing and co-varying trends resulted in new local maximum contaminant values during FY 2007 with technetium-99 at 14,100 pCi/L, uranium at 386 µg/L and nitrate at 956 mg/L (Figure 2.10-26). The steeply increasing but short duration trends suggests the contamination is being driven to the water table close to the well. At the northwest corner of the BY Tank Farm, in well 299-E33-31, new maximum values of technetium-99, uranium and nitrate were also observed at 5,460 pCi/L, 398 µg/L and 427 mg/L, respectively. Low levels of cyanide have also been reported for the last year. This well is downgradient from the BY cribs, the only known locale of elevated cyanide in the groundwater.

The groundwater at two other areas displayed rapidly increasing changes in uranium and cyanide the last year. Located southeast of the BY cribs, contaminant levels in well 299-E33-13 have reached new maximum levels with 211 µg/L for uranium, 596 µg/L for cyanide, 10,900 pCi/L for technetium-99, and 1,020 mg/L for nitrate (Figure 2.10-27). It is important to note the strong corresponding trends between cyanide and uranium, indicating a common source for the cyanide and uranium. The elevated cyanide concentration indicates contamination observed at this well, including the uranium, is migrating from under the BY cribs similar to the time series mapping of nitrate and technetium-99 (Figures 2.10-20 and 2.10-21).

Also southeast of the BY cribs in well 299-E33-15, uranium, cyanide, technetium-99, and nitrate also sharply increased (Figures 2.10-27). For example, technetium-99 rose from 611 to 3,310 pCi/L while uranium increased from just over the background level (2.5 µg/L) at 4 µg/L to 25 µg/L and cyanide rose from 5.7 to 71 µg/L over the last fiscal year. These correlations between key contaminants associated with the scavenged waste discharged to soils at the BY cribs in the early 1950s and uranium strongly suggest migration of uranium from under the BY cribs to the south.

Under the BY cribs, the highest uranium concentration in FY 2007 was 372 µg/L in well 299-E33-38, up from 338 µg/L in FY 2006. However, other wells in the cribs have also shown increasing uranium along with cyanide, technetium-99 and nitrate. For example, uranium increased in well 299-E33-1A from about 29 to 134 µg/L while cyanide increased from about 13 to 645 µg/L and technetium-99 increased from 1,730 to 17,700 pCi/L over the last few years (Figure 2.10-28). The strong correlation between cyanide and uranium strongly suggests a common source in the soils under the BY cribs.

The only place where the trend in uranium has not continued to track with the other contaminants found in the groundwater is east of the BY Tank Farm in well 299-E33-44. Prior to 2003, the technetium-99, nitrate and uranium tracked together, indicating a common source for these co-contaminants. The maximum uranium value observed at this well was 567 µg/L in 2001. However, beginning in 2003, the uranium concentration began to decrease while the technetium-99 and nitrate levels

Comparisons of uranium concentrations to cyanide, technetium-99, and nitrate values indicate not only several common sources but a local flow from under the BY cribs to the south and southeast.

rose (Figure 2.10-29). This divergence of trends indicates a different contaminant plume has moved into this area, with higher nitrate and technetium-99 but lower uranium. The only location in the groundwater where higher values of nitrate and technetium-99 but lower concentrations of uranium were found during this time was upgradient under the BY cribs. Cyanide has also been increasing at this location over the past several years suggesting movement from the BY cribs to well 299-E33-44. However, use of trends plots are only one way to examine relationships between different groundwater constituents. Several other graphical means are used to further delineate locations with common sources and migration pathways.

Stiff Diagrams. As seen by the complexity in contaminant suites across the waste management area and surrounding facilities, not only are there large differences in contaminant concentrations across the site, the associated chemistry varies. To obtain a better understanding of the differences in groundwater contaminant chemistry and to trace the migration of similar groundwater signatures over the waste management area, two methods are employed to provide further insight to source chemistry and migration routes. Stiff diagrams, developed to depict water chemistry (Stiff 1951), are simple pictorial representations of the relative ionic analytical values. This method develops a graphical signature through time, based on multiple parameters affecting the groundwater at a specific location. A comparison of patterns both spatially and through time is used to identify regions of similar source and to trace migration patterns across the waste management area.

A relatively small number of inorganic solutes are generally present in concentrations greater than 5 mg/L (Kebow 2001). The cations are calcium, magnesium, potassium and sodium while the anions are chloride, bicarbonate and sulfate. Although usually considered a trace constituent in natural environments, it was necessary to include the nitrate values to allow the electrical charge to balance and to study contamination. The data from these eight ions were used to calculate Stiff graphs. In natural aquifer systems, different water types produce different shapes, providing a visual fingerprint of water chemistry. For this application, different contaminant sources produced distinct shapes providing characteristic visual signatures. Once a shape for a specific contaminant source area was established, a comparison of patterns allowed wells with similar trends to be identified.

***Chemistry in wells
close to cribs is
characteristically
high in nitrate.***

The Stiff diagrams shown in Figure 2.10-30, cover the area from under the BY cribs to the southern border of the waste management area. Stiff diagrams in agreement are shown in the same colors to facilitate the following discussion. These correlations indicate the groundwater chemistry in these wells have similar sources. Note that chemistry in wells close to cribs is characteristically high in nitrate, replacing both bicarbonate and sulfate as the dominant anion. Also as contaminant levels rise, sodium is becoming more evident in crib-associated wells, especially in well 299-E33-16, under the 216-B-8 crib where sodium is replacing calcium as the dominant cation forming a unique sodium nitrate signature.

Beginning in the north, correlations are made between data from wells 299-E33-38 and 299-E33-1A, both located in the BY cribs and three wells to the south and southeast (wells 299-E33-13, 299-E33-15, and 299-E33-44). For example, data in well 299-E33-13 collected in 2005 and 2006 correlate with upgradient well 299-E33-1A for the years 2005 and 2007. Stiff diagrams at well 299-E33-38 from 1999 through early 2006 match data from later dates in well 299-E33-15 from 2001 to late 2006, indicating movement from the BY cribs to the southeast. These results

agree with comparisons of trend plots presented previously. Finally data from well 299-E33-38 in 1998 and 2004 match Stiff diagrams for well 299-E33-44 for later dates (1999 and 2005). Likewise, data from April 2006 at well 299-E33-1A agrees with the 2007 Stiff diagram in well 299-E33-44. When plotted on a Piper diagram, which is a set of tertiary plots relating major groundwater chemistry components, results from well 299-E33-44 fit closely to data from well 299-E33-1A, providing further support of a common source (Hem 1959). These results, also, agree with the southeast contaminant migration from the BY cribs as shown on the time series mapping of nitrate and technetium-99 and with the trend plots of uranium, cyanide, technetium-99 and nitrate (Figures 2.10-20, 2.10-21, 2.10-27, and 2.10-28).

The groundwater chemistry forms a distinctly different Stiff pattern under the BY Tank Farm in well 299-E33-9, marked by low alkalinity (bicarbonate) with both high sulfate and nitrate balancing the even higher calcium and elevated sodium. Historically, this area marked the center of uranium contamination. This unique Stiff signature does not occur anywhere in the immediate B Complex region. The only agreement found to date is from the data collected in the late 1980s in well 699-50-53A. Located to the north on the anticlinal basalt high, the groundwater at this well showed elevated nitrate, technetium-99, cyanide and cobalt-60 in the mid- to late 1980s, believed to be sourced from the BY cribs. Well 699-50-53A is drilled into the basalt and showed evidence of fracture communication when water levels rose in the basalt during the 1950s. Well 299-E33-9 is located in a basalt low. Further data north of the BY cribs is being collected in FY 2008 to better evaluate possible connections and migration pathways.

The Stiff diagram at well 299-E33-31, located west of well 299-E33-9 has begun to take on some similar characteristics to well 299-E33-9. This location has the next highest value of elevated chloride after well 299-E33-9, suggesting a common water driver for the two locales. Along with the increasing calcium and decreasing alkalinity, some aspects of the shape are similar to that at well 299-E33-9. However the nitrate is already higher at well 299-E33-31 than at 299-E33-9, while the sulfate is lower. With low levels of cyanide beginning to occur in well 299-E33-31, this area may be experiencing some contamination locally from the vadose zone and some contamination regionally from the BY cribs. The changing shape of the Stiff diagram over time may provide more information in the future.

In the past, it was suggested the contamination in the groundwater and in the vadose zone on a perching horizon at wells, 299-E33-41 and 299-E33-18, is sourced from the pocket of contaminated soil associated with the 1951 metals waste leak from tank BX-102. A comparison of Stiff diagrams from 1998 to the present shows the pattern of major groundwater chemistry is different in the two locations. For example, in 1998, groundwater at well 299-E33-18, located north of the B Tank Farm, not only had higher total dissolved solids than in well 299-E33-41, as shown by the size of the Stiff diagram but was already displaying increasing nitrate, sodium, and calcium. By 2007, these differences are more pronounced even though both wells are increasing in groundwater contamination. It is important to note that well 299-E33-41 has less total dissolved solids and indeed, less contamination than well 299-E33-18, even though this well is significantly closer to the tank BX-102 contaminated soil.

This difference in groundwater chemistry is supported by recent results in mapping the increasing uranium found in the perching zone at both wells. Spectral gamma results from 2006 and 2007 in wells 299-E33-18 and 299-E33-41 clearly show higher levels of uranium in the perching zone farther from the tank BX-102 release in well

Groundwater in well 299-R33-9, under the BY Tank Farm, has a unique Stiff diagram.

299-E33-18 than in the closer well 299-E33-41 (Figure 2.10-31). Also along with the increasing uranium, technetium-99 and nitrate seen in well 299-E33-18 this last year, a large increase in uranium was observed from 2006 to 2007 in the perching zone at well 299-E33-18 while very little increase in uranium levels were observed close to the tank BX-102 release in well 299-E33-41. Furthermore, a cross plot of uranium isotopes from the spectral gamma logging, displays two distinctly different trends for the two wells, suggesting there may be different sources of uranium in the area. The distinctly different Stiff signatures would agree with the possibility of more than one contaminant source operating at these locales.

Two other comparisons can be made with the Stiff diagrams. First the developing pattern of chemistry at well 299-E33-44 does not agree with that found at well 299-E33-41, even prior to the decrease in uranium at well 299-E33-44. Considering both locations are experiencing high levels of contamination, this difference would suggest different contaminant sources for each locale. Second, well 299-E33-337 is located on the southern border of the B Tank Farm. In the last few years, technetium-99, uranium, and nitrate impacted the groundwater at this recently installed well. Although the data only goes back to 2005 for this well, there does not appear to be a match to current or earlier data from well 299-E33-41, which is upgradient from this location. Although the contamination impacting the groundwater at this well is migrating from the north, it does not, at this time, appear to be the same source as seen in well 299-E33-41. In conclusion, Stiff diagrams provide a different but complementary way to study groundwater chemistry both between well locations and through time. Results presented here show that some wells south of the BY cribs are experiencing contaminant migration to the south while other wells continue to show the influence of, most likely, nearby facilities.

Results from nitrate to technetium-99 ratio plots, time-series contaminant mapping and Stiff diagrams indicate slow contaminant migration to the south.

Nitrate to Technetium-99 Ratios. Additional evidence that can increase our understanding of groundwater contamination is found by studying log-log ratio plots of nitrate and technetium-99. These ratios, like the graphical Stiff diagrams have been helpful to chemically fingerprint and identify different contaminant sources moving through the groundwater. When a pure waste source with a fixed nitrate to technetium-99 ratio enters the aquifer close to a well such that the contamination does not have the opportunity to mix with the ambient groundwater chemistry, the ratio will remain constant over time as the concentration of the nitrate and technetium-99 increases forming a horizontal line on a log-log plot. If the groundwater is already contaminated with another chemistry when the new vadose zone source enters the aquifer and there is enough travel distance in the groundwater to allow mixing, a diagonal two-part mixing curve will be formed over time on a log-log plot.

In the top panel of Figure 2.10-32, nitrate to technetium-99 ratios for well 299-E33-41 are compared to those of well 299-E33-18. When compared to the bottom panel of Figure 2.10-32, it is seen that technetium-99 in well 299-E33-41 increased from 410 to 5,850 pCi/L with similar large increases in nitrate during the last three years. This is shown in the linear trend on the nitrate to technetium-99 ratio plot, marked from 2005 through 2007 (Figure 2.10-32). Although data from both wells display linear two-part mixing curves, the trends are different, indicating different contaminant sources are impacting the groundwater at these two locations. Note that data from the BX-102 characterization borehole, 299-E33-45, does not fall on either linear trend. With this comparison, there are now three very different

lines of evidence, i.e., Stiff diagrams, spectral gamma logging results and nitrate to technetium-99 ratios, that the groundwater contamination at well 299-E33-18 is from a different source than at well 299-E33-41.

When well 299-E33-41, located close to the BX-102 release with high levels of uranium in the soil, is compared to well 299-E33-9, the location of the high uranium in the groundwater, there is no apparent correlation between the two data sets (Figure 2.10-32). Although the recent increasing contamination at 299-E33-41 displays a two-part mixing curve, there is no clear trend forming under the BY Tank Farm after a peak in contamination moved through in 2001. The groundwater in this area may be experiencing a change in source contamination that has not increased in concentration enough to form a linear trend. Regardless, there is not a correlation at this time between the two locations.

A correlation can be seen when recent contamination from 2003 to 2007 at well 299-E33-44 is compared to data from upgradient well 299-E33-38 (Figure 2.10-33). The nitrate to technetium-99 ratio at well 299-E33-38 forms a strong linear horizontal trend, indicating the contamination at this location is single-sourced (i.e., the ratio remains relatively constant over time). From the time technetium-99 and nitrate began increasing and the uranium began to decrease in well 299-E33-44, data from this well moved to a horizontal trend similar to that seen under the BY cribs. This correlation is further evidence that contamination from under the BY cribs has migrated to the groundwater at well 299-E33-44.

In the past, the groundwater at well 299-E33-44 had high levels of uranium. Since 2005, contaminant levels at well 299-E33-41 have increased. A comparison of nitrate to technetium-99 ratios between the two locations is shown in Figure 2.10-33. Not only is there no correlation for the current contaminant events at the two locations, even when uranium was high at well 299-E33-44 from 1998 to the peak in 2001, there is no connection. As with the data from well 299-E33-18, neither locale appears to have the same contaminant source.

The final comparison is made between well 299-E33-41, near the BX-102 Tank release and data from well 299-E33-337 (Figure 2.10-34). Technetium-99 levels recently exceeded 3000 pCi/L on the south side of the waste management area at this locale. The data shown for well 299-E33-41 are from the peak technetium-99 concentrations of 12,000 pCi/L, observed in 1997. In general, nitrate to technetium-99 ratios of 10 or less indicate a tank-associated source for contamination. As can be seen for data from well 299-E33-38, crib-related sources usually have significantly higher nitrate to technetium-99 ratios. The 1997 technetium-99 peak in well 299-E33-41 had a ratio of 4 indicating a tank-associated source (PNNL-11826). The data from well 299-E33-337 forms a strong linear two-part mixing trends with the low ratio of 13 for the highest technetium value of 3230 pCi/L. Although the trends are not exactly the same, the nitrate to technetium-99 ratio trend in well 299-E33-337 suggests a tank-associated source for this location. Note that the ratio from boring 299-E33-45 does correlate with data from either well.

By studying the groundwater data with multiple methods and incorporating results from vadose zone investigations, a picture of subsurface conditions at Waste Management Area B-BX-BY shows a slowly moving Hanford-induced aquifer receding to the south down the basalt gradient to the natural deeper aquifer. This direction is shown in time series mapping of mobile constituents such as nitrate,

technetium-99, tritium, and by the increasing uranium, technetium-99, and nitrate migrating south over the southern waste management area border.

There are multiple contaminated pockets of soil associated with numerous intentional and unintentional releases to the ground that are contributing to the contaminant plumes under and near these sites. Based on time series mapping, the region around the BY cribs is clearly the major source for contaminants although the soils at the 216-B-8 crib also contribute. Based on the last two years of groundwater monitoring, there appears to be more than one place the uranium is entering the groundwater. Elevated chloride, historically high uranium with relatively low nitrate and technetium-99 and a unique Stiff pattern suggest a point of entry under the BY Tank Farm. Recent spectral gamma logs along with sharp increases in uranium and technetium-99 in groundwater contamination suggest one or more points of entry near the 216-7A/7B cribs, just north of the B Tank Farm. The correlation of sharply increasing cyanide with uranium under the BY cribs suggest another point of entry may be located in the north. In addition, a spike in uranium, nitrate and technetium-99 under the 216-B-8 crib this last year, along with nitrate to technetium ratios and Stiff diagrams, suggests this locale as another point of entry. These locations are supported by recent surface geophysical exploration results that show conductive signatures nearby.

The 200-BP-5 Operable Unit remedial investigation has developed an aggressive drilling and sampling program to further characterize and address uncertainties in contaminant sources with at least twelve new borings (Section 2.10.2). Once the results of this extensive investigation are analyzed, a more complete understanding of the subsurface will be obtained to guide risk analyses and contaminant remediation decisions.

2.10.3.2 216-B-63 Trench

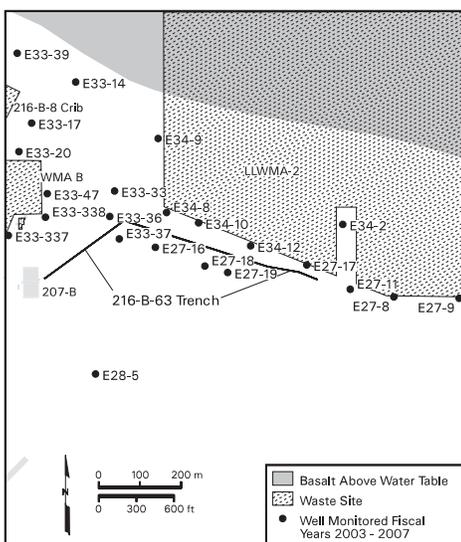
Interim-status RCRA detection monitoring at the 216-B-63 trench requires that the 12 network wells be sampled semiannually for the four contamination/indicator parameters (total organic carbon, total organic halides, specific conductance, and pH), temperature, and turbidity (Appendix B).

Groundwater quality parameters including alkalinity, metals, anions and phenols are also monitored on an annual schedule.

No specific evidence for hazardous waste originating from the 216-B-63 trench has been detected in groundwater at the facility. None of the four contamination indicators exceeded critical means in any of the 216-B-63 wells during FY 2007. Specific conductance continued to rise in nearly all wells in the 216-B-63 network (Figure 2.10-35) during FY 2007, with exception of wells 299-E27-11 and 299-E27-19, which remain relatively unchanged. This rise can be attributed to increasing concentrations of nitrate, sulfate, and chloride. These anions may have reached a peak in the western extremity of the network, while in other wells concentrations are still climbing (Figure 2.10-36). Wells near the center of the facility, along an east-west line (e.g., 299-E34-12, 299-E27-11), display less obvious trends in these constituents.

Groundwater flow direction and rate beneath the 216-B-63 trench remained indeterminate during FY 2007. The hydraulic gradient is too low to define a dominant flow direction or rate with any degree of confidence. As such, the designation of “upgradient” and “downgradient”

Groundwater chemistry results indicate that multiple vadose zone sources contribute to groundwater contamination that is migrating to the south.



wells, as well as the identification of specific sources of the anions, is problematic. The pattern of increase and decline of anions, such as sulfate, in some wells suggests these constituents are possibly moving from northwest to southeast at the western end of the facility.

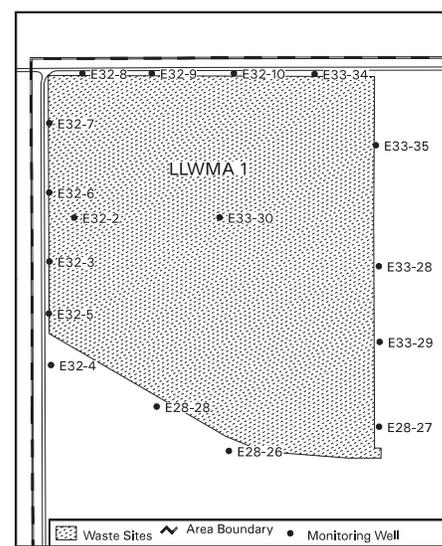
2.10.3.3 Low-Level Waste Management Area 1

Groundwater at Low-Level Waste Management Area 1 continued to be monitored under RCRA and AEA. During FY 2007, all 17 wells in the network were sampled semiannually for RCRA contamination indicator and site-specific parameters as dictated by the sampling and analysis plan (PNNL-14859; DOE/RL-2000-72). Appendix B includes a well location map, a list of wells, and the constituents monitored.

The groundwater gradient in this part of the 200 East Area is almost flat, making the determination of groundwater flow direction difficult (Figure 2.10-5). No meaningful flow rate could be calculated, given the variability and low gradient. Trend surface analysis conducted in FY 2007 was used to define a flow direction to the north. However, considerable uncertainty remained in FY 2007 in the determination of a dominant flow direction. In addition, the temporal and spatial variability in flow are not thoroughly understood. Trend surface analysis of hydraulic heads conducted in 2006 indicated a dominant northward flow direction beneath Low-Level Waste Management Area 1. However, tracking of contaminant plumes between wells indicates north, southeast, and southwest directions. Encroachment of some specific contaminants (e.g., cyanide and technetium-99) into the north and east portions of the facility (e.g., well 299-E33-34) are consistent with origins at BY cribs and/or Waste Management Area B-BX-BY, thus suggesting a west-to-southwestward movement. For these reasons, no attempt will be made to update the interim status designation of upgradient and downgradient wells until a stable flow direction is reestablished. A precision survey of wells began in early FY 2008 to further refine the trend surface analysis and hopefully provide more conclusive information about the gradient in the area around Low-Level Waste Management Area 1.

Specific conductance continued to exceed the statistical upgradient/downgradient comparison value (critical mean) in northern wells 299-E33-34 and 299-E32-10, with the highest replicate average of 1,452 $\mu\text{S}/\text{cm}$ occurring in June of 2007 in well 299-E33-34. Although generally increasing since 1998, the rates of increase in specific conductance in these two wells has been sporadic (Figure 2.10-37). Rising trends in specific conductance were occurring in FY 2007 in three northern (299-E32-8, 299-E32-9, and 299-E32-10) and two southern wells 299-E33-29 and 299-E28-27 (Figure 2.10-38). In these wells, elevated specific conductance is related to a regional nitrate plume (Figure 2.10-11), and to less well-defined but widespread occurrences of sulfate, chloride, and cations. These are discussed further in the following paragraphs. Well 299-E32-5 exceeded the critical mean of 808 $\mu\text{S}/\text{cm}$ in December 2006 (858 $\mu\text{S}/\text{cm}$), but re-sampling in March 2007 produced an average result of only 570 $\mu\text{S}/\text{cm}$. This well is located near a storm water infiltration site and recently experienced a sudden but intermittent rise in major ions. The appearance and concentrations of these constituents are consistent with occurrences at other sites where clean water infiltration through the vadose zone caused leaching of natural salts (e.g., PNNL-13121). The pH and specific conductance results for all other

A precision survey of wells may improve the analysis of groundwater flow beneath Low-Level Waste Management Area 1.



***Rising concentrations
of anions and cations
continue to occur
in several wells in
Low-Level Waste
Management Area 1.***

wells were below the critical mean in FY 2007. Statistical comparison values to be used for indicator parameters in FY 2008 are listed in Appendix B.

Elevated and rising concentrations of anions and cations continue to occur in several wells in Low-Level Waste Management Area 1. Upward trends in sulfate, chloride, nitrate, calcium and magnesium are mostly restricted to the upgradient wells along the southeast border and downgradient wells along the northern border of the facility. Nitrate shows recent or ongoing upward trends in 10 wells, distributed around the periphery of the facility. In most cases, the upward trend for all of these constituents began in the early to late 1990s. Nitrate was above drinking water standards in every well in the network in FY 2007 except in two southern wells, 299-E33-28 and 299-E33-29. The highest nitrate concentration was found in well 299-E33-34 (544 mg/L) in December 2006. The ultimate source(s) of these ions is unknown, but they are probably associated with BY cribs, Waste Management Area B-BX-BY, and/or other nearby, historical disposal sites in the 200 East Area.

Several wells that produced detectable total organic carbon results in FY 2006 were below detection for FY 2007. Wells 299-E28-28 and 299-E32-10 produced replicate averages above comparison values for total organic halides and total organic carbon, respectively, in December 2006 and January 2007 samples, but subsequent samples from these two wells were below detection for both constituents. The elevated results appear to be related to laboratory error. No other wells had average concentrations for total organic halides or total organic carbon that were above the critical mean values (see Appendix B). Averages for pH were all within the critical range during FY 2007.

All wells in the network were sampled once for mercury during FY 2007, but only well 299-E33-30 produced a result (0.10 µg/L) above detection. Well 299-E33-34, located in the northeast corner of Low-Level Waste Management Area 1 had previously produced several sequential low-level (maximum 0.19 µg/L) detections of mercury, but was below detection (<0.09 µg/L) in FY 2007. The drinking water standard is 2 µg/L. Mercury is not commonly detected in Hanford groundwater samples and is not considered highly mobile under conditions typical of Hanford Site aquifers. For further discussion, see Section 2.10.9.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 1, under AEA authority, is designed to complement the RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. Performance assessment monitoring at Low-Level Waste Management Area 1 is performed per DOE/RL-2000-72 to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information from upgradient wells to interpret the changes. Iodine-129, technetium-99, tritium, and uranium are monitored semiannually specifically for performance assessment.

Contaminant characteristics at Low-Level Waste Management Area 1 include the following:

- Technetium-99 concentrations continued to be above detection in all wells in the network during FY 2007, and is particularly elevated in wells 299-E33-34, 299-E32-10, and 299-E33-35 near the northeast corner of Low-Level Waste Management Area 1. The highest concentrations in FY 2007 remained in well 299-E33-34 (8,970 pCi/L in June 2007) but all three of these wells produced

average results lower than in FY 2006 (Figure 2.10-39). The maximum technetium-99 concentration was 11,000 pCi/L in the June 2006 sample. The contamination levels are consistent with regional distributions that appear to have originated in the vicinity of the BY cribs (Figure 2.10-15). Northern wells 299-E32-5 and 299-E32-9 and southern wells 299-E33-28 and 299-E28-27 also show generally increasing technetium-99 concentrations in recent years that continued in FY 2007. However, levels remained relatively low, with the highest result at 144 pCi/L in well 299-E33-28.

- Uranium concentrations decreased significantly in well 299-E33-34 in the northeast corner of the waste management area, producing an average uranium concentration of 72 µg/L and a maximum of 75 µg/L in the June 2007 sample. This contamination is associated with a relatively recent plume with possible origins in the vicinity of Waste Management Area B-BX-BY. Northern wells 299-E32-8, 299-E32-9 and southern wells 299-E33-28 and 299-E28-27 have all shown upward trends during the past several years. Well 299-E28-27 in particular, produced a relatively significant rise, from an average of 15 µg/L in FY 2006 to 23 µg/L in FY 2007. All wells except 299-E33-34 remain below drinking water standards for uranium (30 µg/L). Wells on the west and southwest perimeter display downward trends in uranium concentrations from already low values.
- Tritium contamination is also believed to be from regional contamination, not related to the burial grounds. Tritium concentrations were less than the drinking water standard in FY 2007 in all wells in the network, and are declining in most wells. The exceptions to this are wells 299-E33-34 and 299-E33-35 in the northeast corner of the facility, which appears to be associated with increases beneath and west of the BY cribs. Well 299-E33-34 produced a historical maximum (17,500 pCi/L) in June 2007, and well 299-E33-35 produced an historical high average of 9,800 pCi/L.
- Iodine-129 was above detection in three southern wells and five northern wells, with the maximum (4.20 pCi/L) occurring in well 299-E32-9. The activities and distribution of iodine-129 in this area has shown significant change over several years and is consistent with the regional distribution and believed to be from liquid waste facilities during active operations.
- Nitrate contamination at Low-Level Waste Management Area 1 displayed upward trends in four southern wells and four northern wells during FY 2007. The highest concentrations are in the northeast corner of the facility, approximately coincident with the highest technetium-99. Thus, the northeast nitrate plume has a likely source in the BY cribs, and possibly other nearby waste sites. Nitrate is still highest in well 299-E33-34, with an average concentration of 540 mg/L. This value is down from a spike of 713 mg/L that occurred in FY 2006.
- Low levels of chromium were detected in filtered samples in 10 wells during FY 2007. The highest value (22 µg/L) was detected in well 299-E33-34, which is the locus of several other contaminant maxima at Low-Level Waste Management Area 1.
- Cyanide (drinking water standard = 200 µg/L) was above detection in 12 wells in the Low-Level Waste Management Area 1 network during FY 2007. The highest concentration, and the only value above drinking water standard, was 357 µg/L

*Uranium
concentrations
decreased in well
299-E33-34 in
FY 2007.*

in well 299-E33-34. In general, concentrations were highest in the northern and western wells. Upward trends in cyanide are present in wells 299-E32-3, 299-E32-9, and 299-E32-10. The contaminant source appears to be associated with the BY cribs.

2.10.3.4 Low-Level Waste Management Area 2

Groundwater at Low-Level Waste Management Area 2 is monitored under RCRA (PNNL-14859) and AEA (DOE/RL-2000-72). During FY 2007, the well network was sampled semiannually for RCRA indicator and site-specific parameters. Sampling was successful at nine wells for both sampling rounds. Appendix B includes a well location map, a list of wells, and the constituents monitored.

The groundwater gradient in this part of the 200 East Area is virtually flat, making the determination of groundwater flow direction difficult. Basalt occurs above the water table beneath the northern half of Low-Level Waste Management Area 2. No attempt will be made to update upgradient well designations used in the statistical tests until a stable flow direction is evident. The basalt surface above the water table in the north part of Low-Level Waste Management Area 2 constrains possible flow directions for the unconfined aquifer. However, it is possible that the flow is influenced by continued drainage of the unsaturated sediment and recharge moving laterally on the basalt surface to the saturated aquifer sediment. Given the broad uncertainties in flow direction and low gradient in this area, flow rates and directions based on hydraulic head are not estimated. Flow to the southwest was indicated in FY 2006 by the movement of the nitrate plume from well 299-E34-7

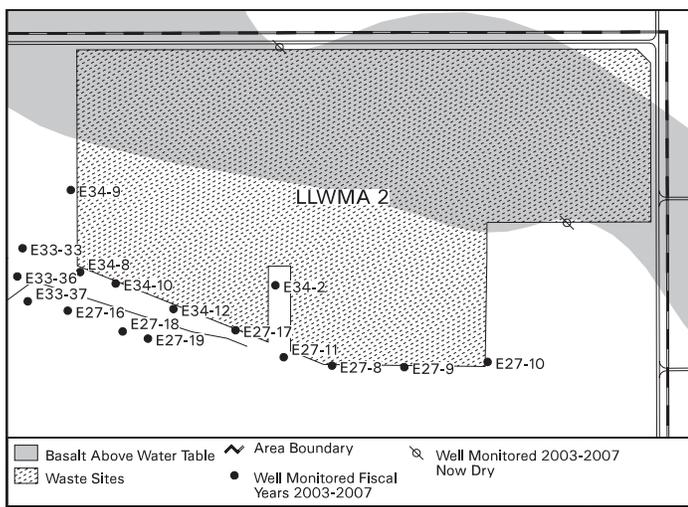
(no sample, dry) to well 299-E27-10 and a possible south-southwesterly flow component is seen in wells in the southeast portion of the network (discussed further in the following paragraphs).

No critical mean values for the four indicator parameters, i.e., specific conductance, pH, total organic carbon, and total organic halide, were exceeded in the FY 2007 samples from Low-Level Waste Management Area 2. Appendix B lists the initial statistical comparison values to be used in FY 2008 based on data for the upgradient well 299-E27-10.

Specific conductance along the south side of the area has exhibited a generally increasing trend in wells 299-E27-10, 299-E27-9, and 299-E27-8 for the past several years. Incursion of sulfate, chloride, nitrate, and major cations that are widespread in the

200 East Area are the apparent cause of the increase in specific conductance. As exemplified by sulfate in Figure 2.10-40, wells farther east appear to lead the increase. The timing of arrival of inflections in sulfate concentrations identifiable in all three wells appears to support a component of flow to the south-southwest.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 2, under AEA authority, is designed to complement the RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level Waste Management Area 2 is to gather data to assess



changes in concentrations at downgradient wells using statistical tests and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, and uranium are monitored specifically for performance assessment.

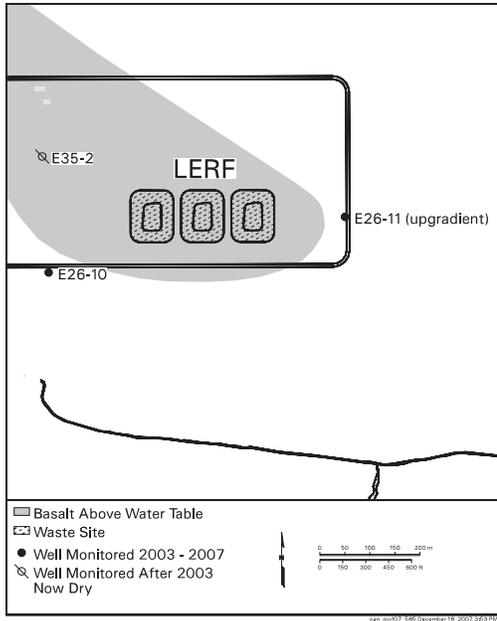
Contaminant characteristics at Low-Level Waste Management Area 2 include the following:

- Technetium-99 concentration continued to increase in well 299-E27-10 and at a slower rate in well 299-E27-9, south of Waste Management Area 2. Activities reached 100 pCi/L in well 299-E27-10 for FY 2007. This contamination is believed to be from past disposal of liquid waste in the 200 East Area and unrelated to Low-Level Waste Management Area 2. Well 299-E27-9 produced the only other detection of technetium-99 (maximum =15.20 pCi/L) during FY 2007.
- Tritium contamination was found at levels less than the drinking water standard in all wells in the network. The trends for tritium in the wells with detectable tritium were all downward, with the highest activity during FY 2007 at 616 pCi/L in well 299-E27-9. The tritium activities were consistent with regional distributions.
- Iodine-129 was detected in only two wells in Low-Level Waste Management Area 2; wells 299-E27-9 and 299-E27-8 produced results of 2.45 and 1.77 pCi/L, respectively, during FY 2007. Iodine-129 activities appear to be generally decreasing during past several years in wells with results above detection. These levels are consistent with the regional iodine-129 distribution (e.g., from Waste Management Area B-BX-BY and nearby liquid waste disposal sites) and do not appear to be related to a burial ground source.
- Uranium concentrations in Low-Level Waste Management Area 2 samples remain <5 µg/L and do not indicate a burial ground source.
- Nitrate contamination at levels above the drinking water standard was restricted to well 299-E27-10 on the south side of Low-Level Waste Management 2. Concentrations increased to 61 mg/L in this well during FY 2007.
- Major ions are increasing in wells mostly in the northwestern and eastern portions of the network, but with wells 299-E34-12, 299-E27-17, and 299-E27-11 notably exempt from this increase for most constituents.

Major ions are increasing in wells in the northwestern and eastern portions of the network.

2.10.3.5 Liquid Effluent Retention Facility

The Liquid Effluent Retention Facility operates under final status permit conditions stipulated as agreed to by Ecology and DOE. The current groundwater monitoring network is hydrogeologically inadequate to monitor the unit. Two of the three groundwater wells installed to monitor the compliance side of the unit are dry and the water table has dropped below the top of basalt beneath the facility. Therefore, statistical evaluation of the indicator parameters (specific conductance, pH, total organic carbon, and total organic halide) is not conducted. Ecology and DOE have negotiated a process to modify the RCRA permit that includes an evaluation plan to characterize Liquid Effluent Retention Facility hydrostratigraphy. Most specifically, two new wells are planned that will explore the possibility of a continuation of the uppermost aquifer into basalt flow-top and weathered zone. Until a monitoring approach is decided upon, it has been agreed that interim status detection monitoring requirements would be retained.



Specific conductance, nitrate, chloride and sulfate continued to rise in both remaining wells (299-E26-10 and 299-E26-11) during 2007. Specific conductance was highest in well 299-E26-10 at $867\mu\text{S}/\text{cm}$ (Figure 2.10-41). All of the anions are below drinking water standards in both wells. A regional rise of anions and cations is evident in wells located in the central and eastern portions of 200 East Area. Downgradient wells installed for the Liquid Effluent Retention Facility before it began receiving waste recorded the early indications of the regional rise in specific conductance. The rise of specific conductance and anions in upgradient well 299-E26-11 began much more recently, in 2005.

The current plan assumes that groundwater continues to move in a southwest direction, one of the flow directions outlined in previous reports (PNNL-14804). Because of the isolated situation of downgradient well 299-E36-10, and drops in the water table below the facility, no reasonable estimate of flow rate is possible for the immediate vicinity of the Liquid Effluent Retention Facility. Appendix B provides a general flow direction and rate based on regional estimates for the eastern portions of the 200 East area

(see Section 2.0).

2.10.3.6 Waste Management Area C

Waste Management Area C is located in the east central portion of the 200 East Area and consists of the C Tank Farm, the 244-CR vault and ancillary equipment such as waste transfer lines and seven diversion boxes. The tank farm contains twelve single-shell 100 series (2-million-liter) and four single-shell 200 series (208,000-liter) tanks constructed in 1943 and 1944. Three of the larger tanks and all four smaller tanks are confirmed or assumed leakers.

Required under 40 CFR 265.93(b) as referenced by WAC 173-303-400, groundwater is monitored under a RCRA interim status indicator program to detect if dangerous waste constituents associated with the facility have compromised groundwater quality. The current groundwater monitoring plan is PNNL-13024 as modified by PNNL-13024-ICN-4. Although semi-annual sampling is required, wells are sampled quarterly with a limited constituent list at the request of Ecology and in support of waste retrieval operations during sluicing events. These extra sampling events are not part of the required RCRA groundwater monitoring. Based on the required semi-annual sampling, indicator parameter critical means were not exceeded this fiscal year.

In addition to monitoring dangerous waste constituents for RCRA, the site is monitored for radionuclides under AEA and CERCLA (WMP-28945). For the 200-BP-5 Operable Unit remedial investigation/feasibility study, a new groundwater monitoring well is currently being installed southwest of the site to determine the extent of groundwater contamination and provide information for risk analyses. A well location map, a list of the nine RCRA network wells, the critical means values used for upgradient/downgradient comparisons in FY 2008 and the site specific constituents are available in Appendix B.

No discernible changes in flow direction were seen during FY 2007. Ranging from southwest to south-southwest, the flow direction was determined by in situ

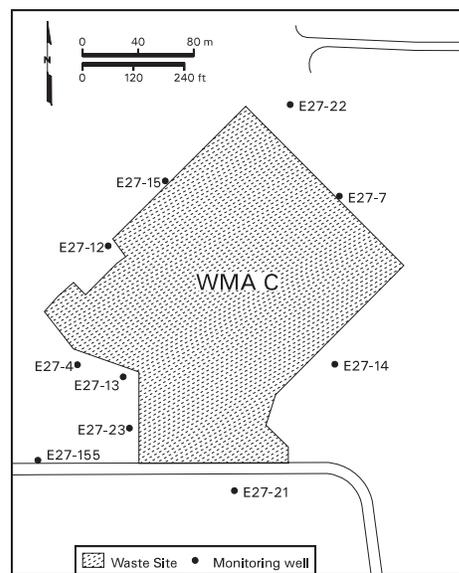
A regional rise of anions and cations is evident in wells located in the central and eastern portions of 200 East Area.

flow measurements, contaminant migration, contaminant ratios and water elevations (PNNL-13788, RPP-23738). Based on work done in support of the 200-BP-5 Operable Unit remedial investigation/feasibility study, it was shown that sulfate is migrating from the northeast near the basalt subcrop and continues to affect the groundwater at this site. A time series of the 80-mg/L contour (Figure 2.10-42) illustrates the sulfate movement into and across the C Tank Farm. The flow rate, estimated from this contaminant's travel time, is 0.09 meter/day. The rate of water table decline continued to decrease from 10 and 7 centimeters per year reported in FY 2005 and FY 2006, respectively to 5 centimeters in FY 2007. Based on a least squares regression fit to the water table, older wells in the network may not require replacement for over 15 years provided the rate of decline does not increase.

The primary contaminants in the groundwater are sulfate, nitrate and the non-RCRA regulated constituent, technetium-99. Also there are elevated chloride concentrations and low levels of cyanide at some wells. With rising sulfate concentrations northeast of the farm, upgradient specific conductance values are high, ranging from 741 to 645 $\mu\text{S}/\text{cm}$. This sulfate control on the specific conductance is illustrated in Figure 2.10-43, which compares specific conductance to sulfate and nitrate concentrations in upgradient well 299-E27-7. Although sulfate concentrations to the northeast near the receding aquifer boundary have been over 650 mg/L, there does appear to be a local contaminant component of sulfate in some locations. For example, the drinking water standard for sulfate (250 mg/L) was recently exceeded southeast of the site in well 299-E27-14. This well is nearly cross gradient of the farm but down gradient of a waste transfer line. In addition at this well, technetium-99 is elevated at 1,850 pCi/L (drinking water standard 900 pCi/L). Also this locale is the only place where the nitrate concentration is above the drinking water standard (45 mg/L) at 64.2 mg/L in June 2007. Thus, cross gradient to downgradient of the site, sulfate concentrations may have a contaminant source.

Over most of the site, nitrate is elevated above the background value of 12.4 mg/L (WHC-EP-0595); however, as stated previously, the concentration is above the drinking water standard in only one location, well 299-E27-14 (Figure 2.10-44). A comparison between mapped nitrate concentrations for June 2005 and June 2007 (Figure 2.10-45) shows only a small increase in nitrate over the last two years. Although there was some increase in the nitrate concentration at upgradient in well 299-E27-7, larger increases were downgradient in wells 299-E27-14 and 299-E27-21. Overall, however, nitrate contamination remains at low levels.

Currently, technetium-99 concentrations range from 56 pCi/L in upgradient well 299-E27-7 to 6,280 pCi/L in downgradient well 299-E27-23 (Figure 2.10-46). Currently, technetium-99 is increasing in only one well, 299-E27-23. Installed in 2003, this well is downgradient of the 244-CR Vault and unplanned release 200-E-81, associated with the 241-CR-151 diversion box. Although the initial technetium-99 level (8,370 pCi/L) was high in well 299-E27-4 in 2004, concentrations continue to decline, currently at 2,510 pCi/L. This well is close to the 241-C-151 diversion box, the site of a past pipeline break in 1969, resulting in the loss of approximately 9,800 liters of PUREX Plant waste. Recent characterization work by the Tank Farm Vadose Zone Project has shown mobile contaminants in the vadose zone to a



Primary groundwater contaminants at Waste Management Area C are sulfate, nitrate, and technetium-99.

depth of at least 24 meters, suggesting contamination may have migrated to greater depths. Of note is the increasing technetium-99 level in well 299-E27-12, located north of the 241-C-153 diversion box. Concentrations rose from 70.7 to 206 pCi/L from June 2006 to March 2007. Other downgradient wells have either decreased or remained nearly the same as during FY 2007. A comparison of the 900-pCi/L contour over the last 5 years (Figure 2.10-47) provides a spatial view of the changing technetium-99 pattern.

A better understanding of contamination that may be related to the tank farm is gained from comparing nitrate and technetium-99 trends. Nitrate to technetium-99 ratios plotted on a log-log plot against increasing technetium-99 (Figure 2.10-48) shows distinct mixing trends for the three downgradient wells on the southwest side of the site. Trend lines are shown indicating the direction of increasing time with changing technetium-99 concentrations. For example, the ratios for well 299-E27-13 display a linear trend from 1999 to 2003 during the time technetium-99 was increasing at this locale (see Figure 2.10-46 for comparison).

Several observations are made from these data. First, data from wells 299-E27-13 (1999 to 2003) and 299-E27-23 (2005 to 2007) form distinct linear trends. Although not as clear, from 2004 to 2005, a third trend may exist for well 299-E27-4. The technetium-99 concentration was already elevated when this well was installed in FY 2003 so the peak value, which would be nearest to the source value was not obtained. Second, each trend appears distinctly different from the others. Third the ratio for peak technetium-99 concentrations for each well is low, with a value of 2.64 for well 299-E27-4, 4.36 for well 299-E27-23 and 4.21 for well 299-E27-13. These low ratio values suggest tank-associated sources for each of these contaminant events (PNNL-14187, PNNL-14548). Because these nitrate to technetium-99 ratios form three distinct mixing curves, there may be three different sources for groundwater contamination on the southwest side of the site.

Further information is gained by comparing data between upgradient and downgradient locations. In Figure 2.10-48, a comparison of the nitrate to technetium-99 mixing curve for well 299-E27-23 is made to the peak technetium-99 value seen in upgradient well 299-E27-7 from 1998 through 2003. During this time, the technetium-99 concentration rose from 81 pCi/L to 2,760 pCi/L in 2002 then fell to 39.2 pCi/L by late 2003 (Figure 2.10-46). The ratio at peak technetium-99 contamination was 9.9 also suggesting a tank-related source. The mixing curve defined by this sharp pulse of technetium-99 matches closely that observed at downgradient well 299-E27-23, suggesting a common contaminant source for the groundwater at the two wells.

Another way to study groundwater chemistry is by comparing total ionic groundwater chemistry through Stiff diagrams. The milli-equivalent concentrations for total cations balanced against total anions are represented graphically on a scale of anions versus cations. Figure 2.10-49 shows results from a recent investigation. A comparison is made for groundwater data collected in September or October 2006, except for well 299-E27-15, which had data sets out of electrical balance. Data from earlier in the year was used for this well. The signature at the upgradient wells, 299-E27-22 and 299-E27-7, is clearly dominated by calcium and sulfate moving in from upgradient. Data for a few earlier years are shown for upgradient well 299-E27-7 to show the original calcium bicarbonate signature, lower in total dissolved solids. This bicarbonate pattern is characteristic of artificially recharged groundwater which

was prevalent throughout the region during times of large water releases at PUREX. Note the similar signatures seen at downgradient wells 299-E27-4 and 299-E27-23, which may not be as affected by the migration of calcium sulfate from upgradient. Downgradient well 299-E27-14, which has the highest calcium and sulfate levels has an even more pronounced calcium sulfate signature. However, chloride is greater in the upgradient wells than in well 299-E27-14, suggesting the slightly elevated chloride may be associated with the upgradient sulfate signature. In general, with the upgradient dominating influence from calcium sulfate, no distinct features are discerned to help differentiate tank farm sources from non-tank farm source. This situation may change as plume signatures develop over time.

Although seen sporadically at several locations, cyanide has been consistently elevated at upgradient well 299-E27-7 since 2004. However, this year, concentrations fell from 36.8 µg/L in June 2006 to 3.8 µg/L in June 2007 (drinking water standard 200 µg/L). In well 299-E27-14, concentrations, although still low, have ranged from 5.3 to 14.9 µg/L. The C Tank Farm is the only known local source for cyanide (HNF-SD-WM-TI-740). Consequently, like the low nitrate to technetium-99 ratios, the presence of cyanide in the groundwater suggests a tank-related source for some contamination observed in the groundwater. Further characterization work, planned by the 200-BP-5 Operable Unit remedial investigation/feasibility study and the Tank Farm Vadose Program, may provide additional information and data to assist in delineation the specific contaminant sources at this waste management area.

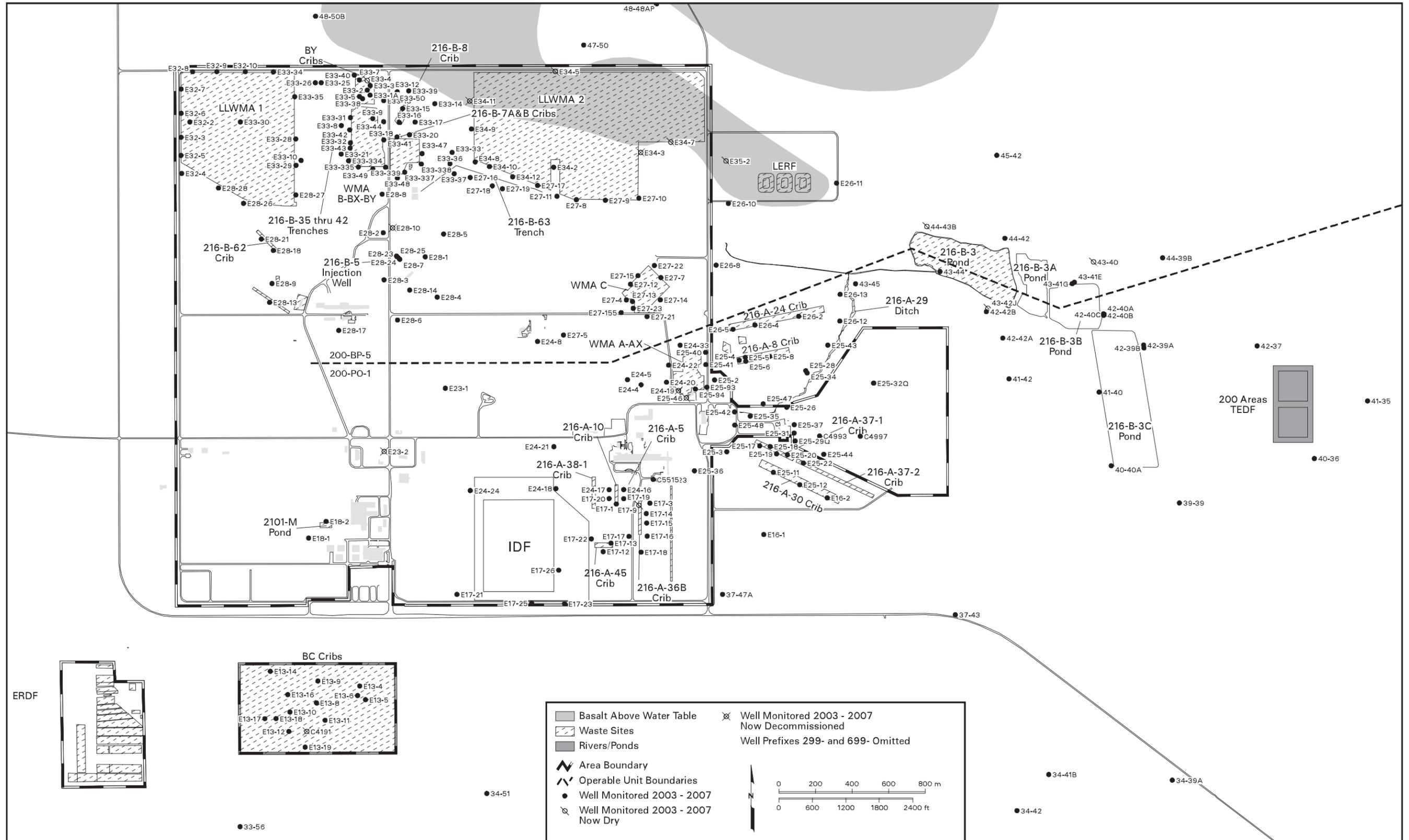


Figure 2.10-1. 200-BP-5 Operable Unit Groundwater Monitoring Wells in the 200 East Area

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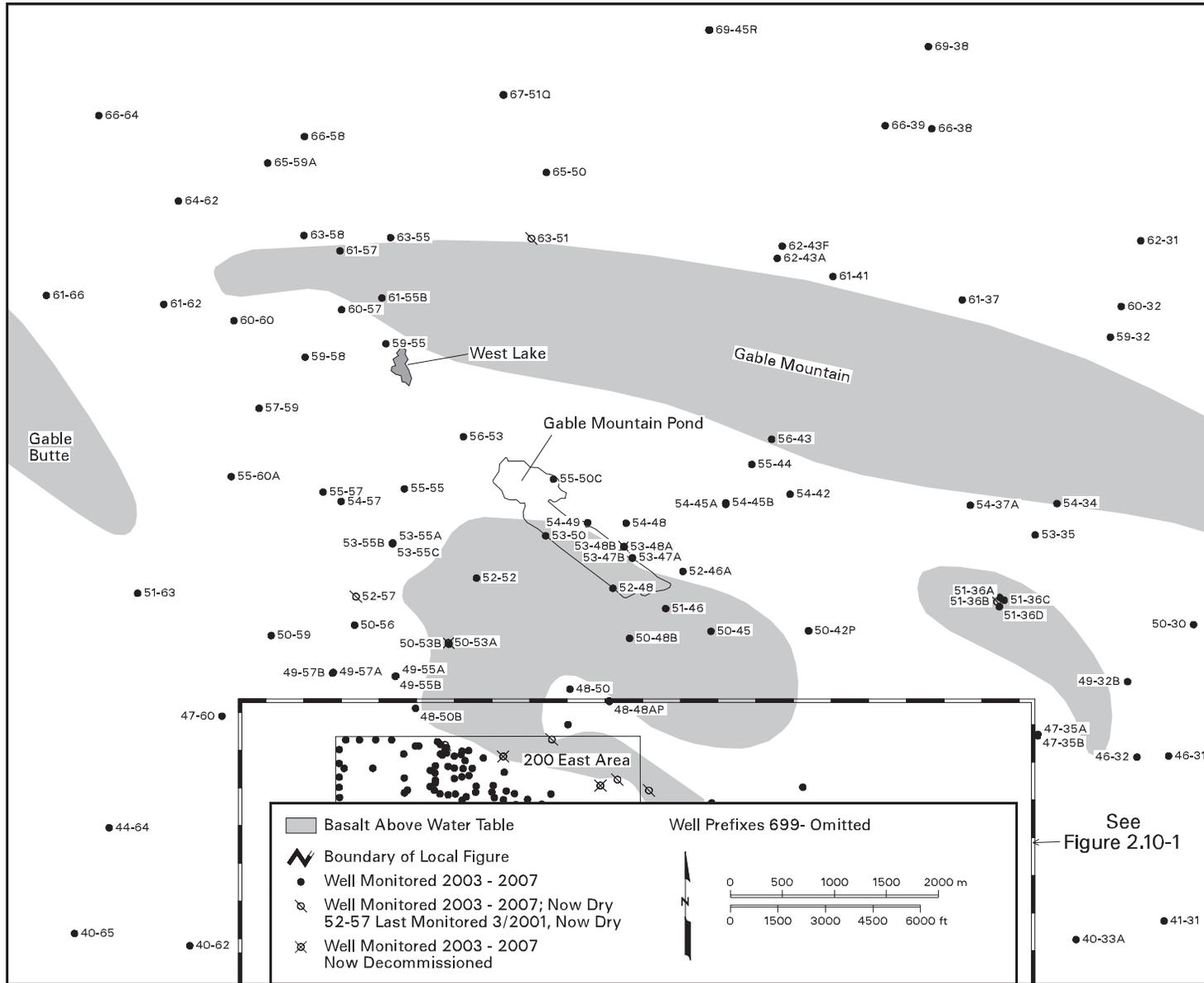


Figure 2.10-2. 200-BP-5 Operable Unit Groundwater Monitoring Wells Located in the 600 Area

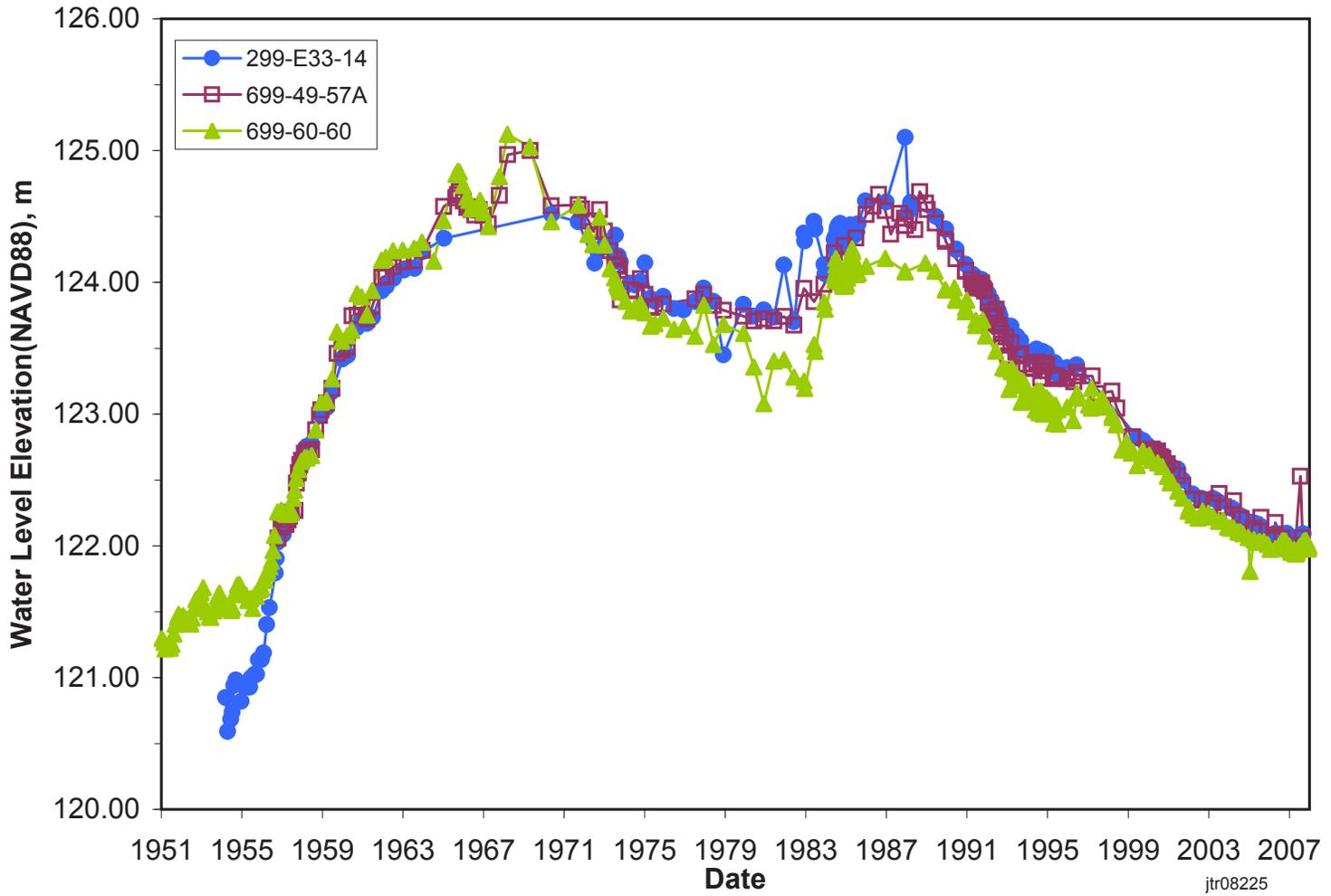


Figure 2.10-3. Water Elevations for Wells Monitoring the 200-BP-5 Operable Unit

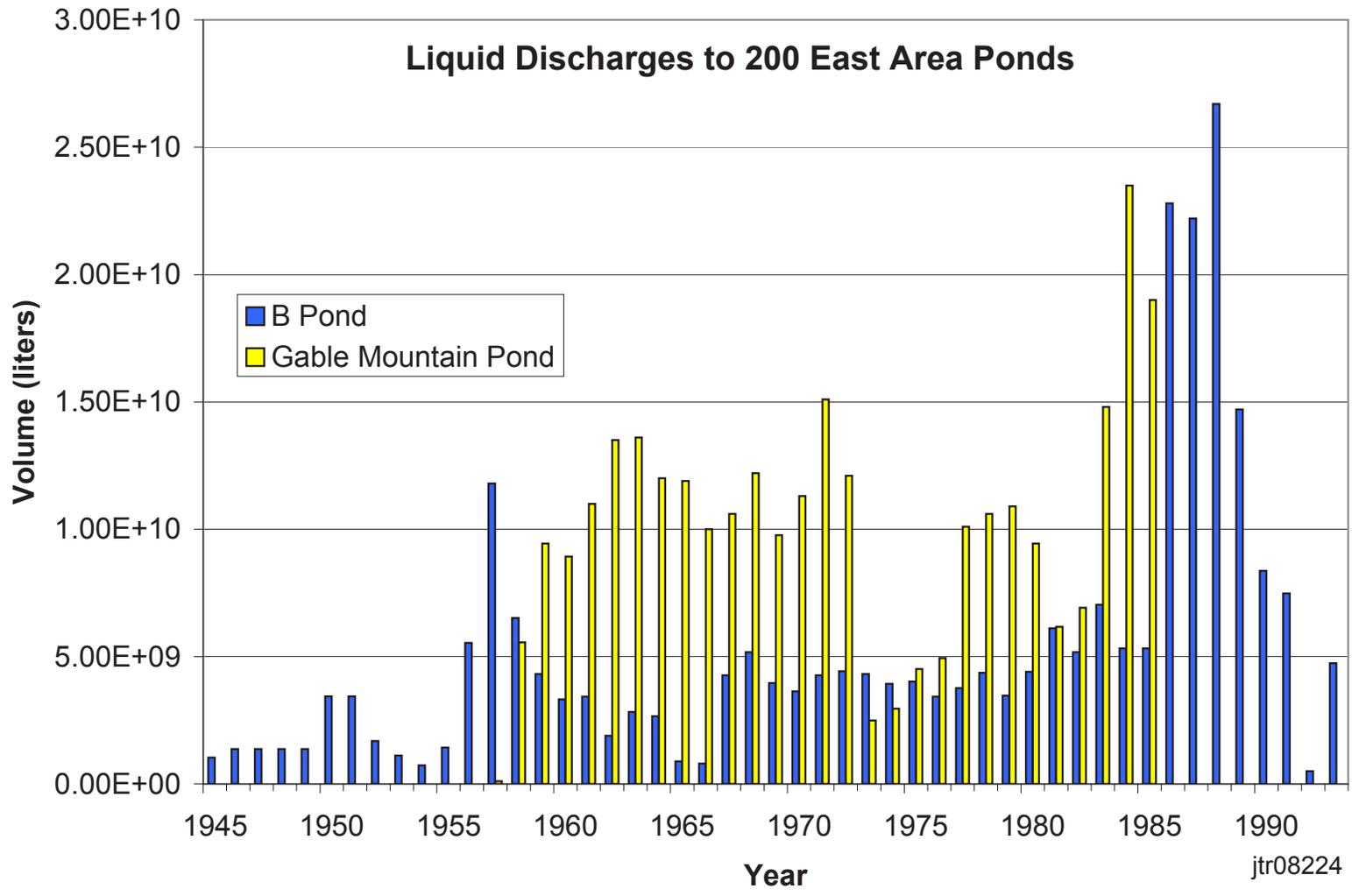


Figure 2.10-4. Liquid Discharges to 200 East Area Ponds

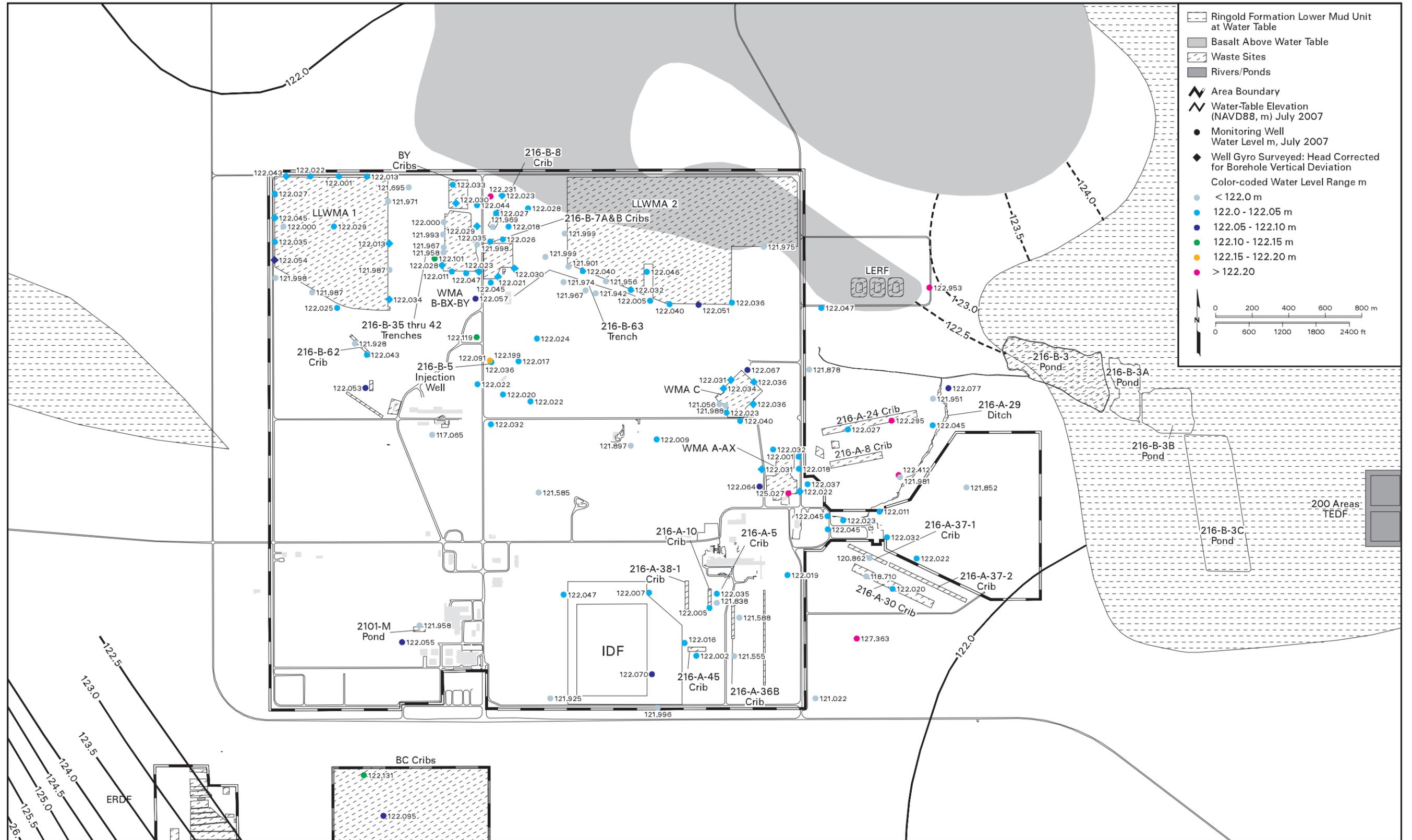


Figure 2.10-5. 200 East Area Water-Table Map, July 2007

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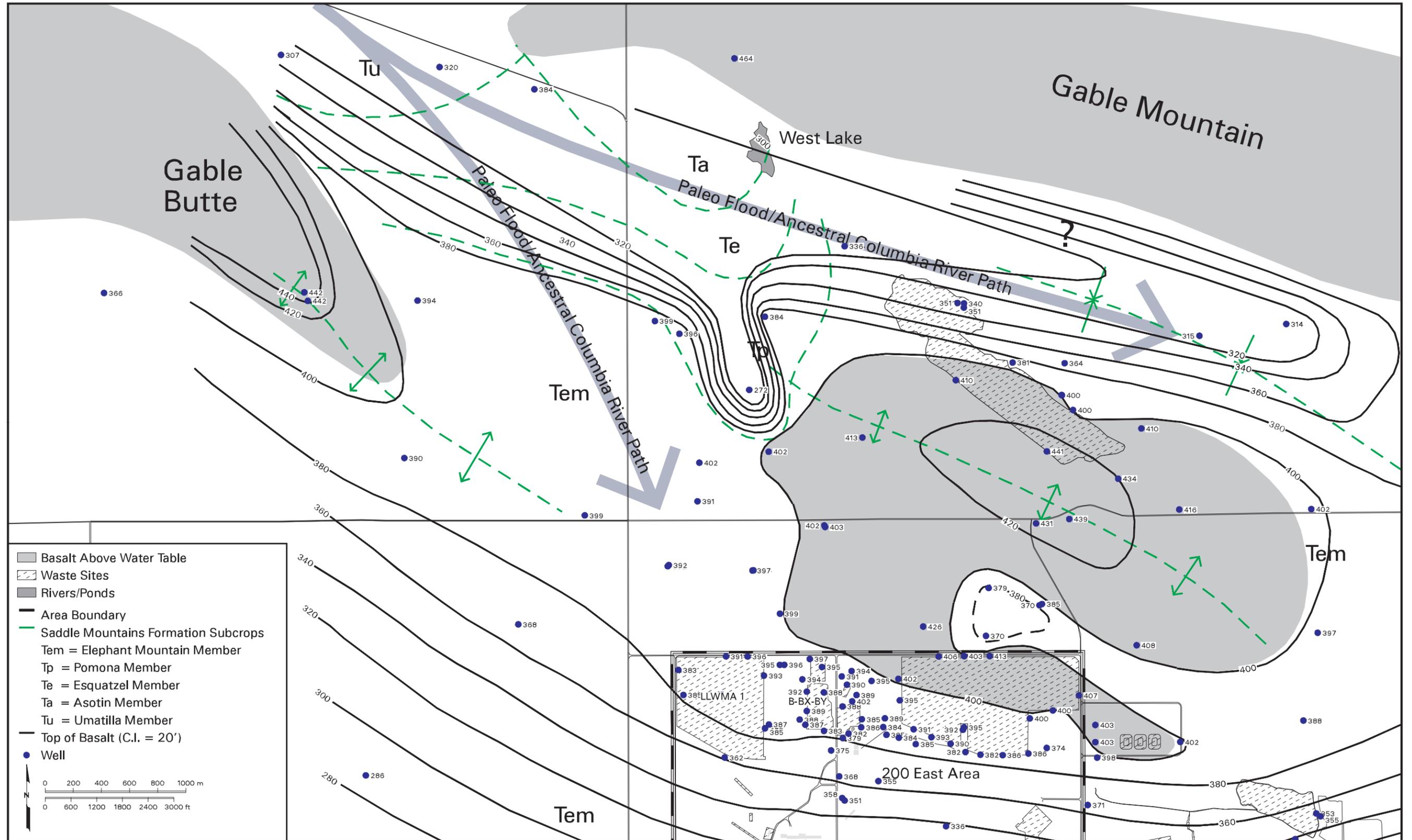


Figure 2.10-6. Basalt Contours and Anticlinal Ridges in Gable Gap Area (after PNNL-12261)

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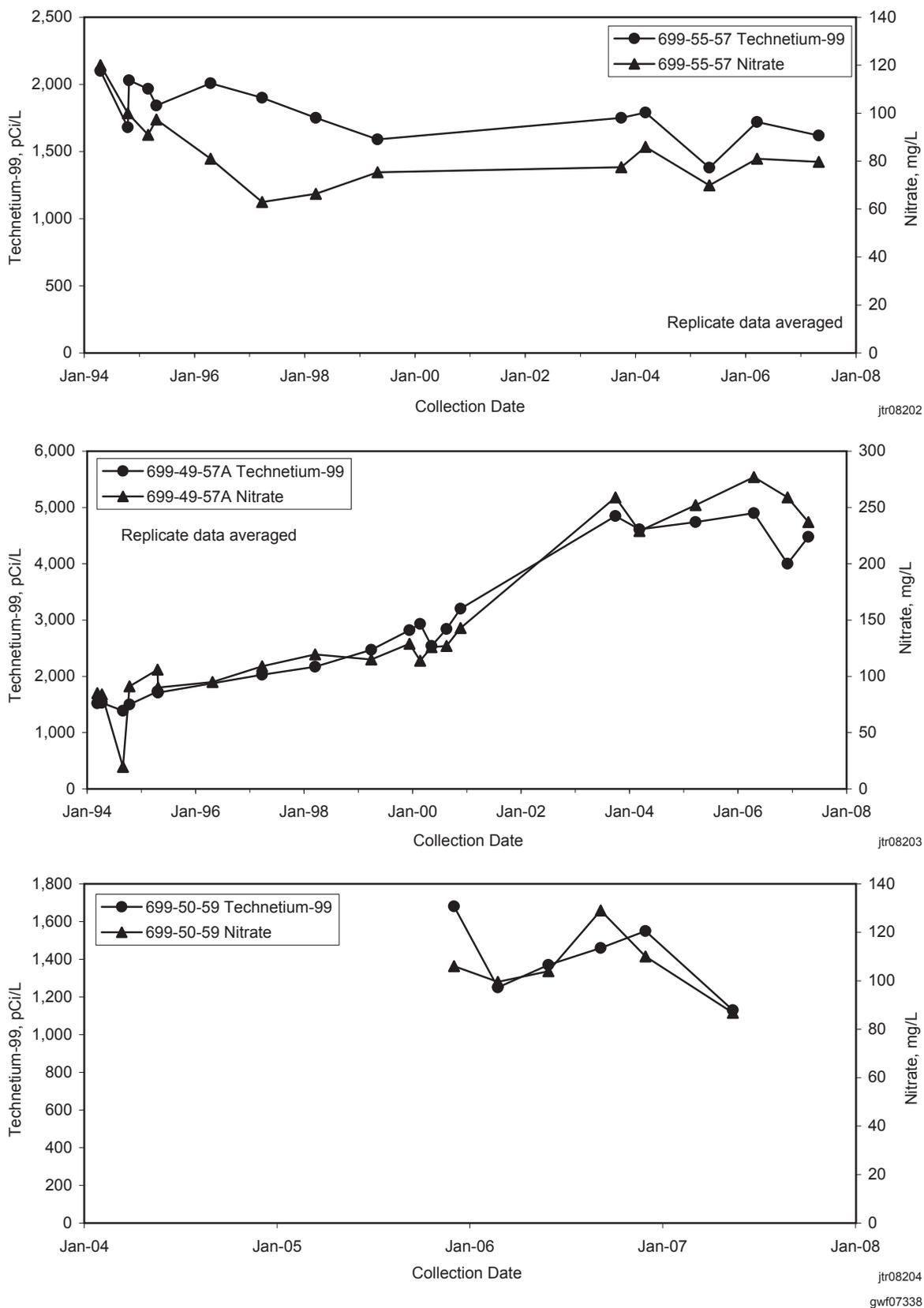


Figure 2.10-7. Technetium-99 and Nitrate Concentrations South of the Gap between Gable Butte and Gable Mountain and North of 200 East Area

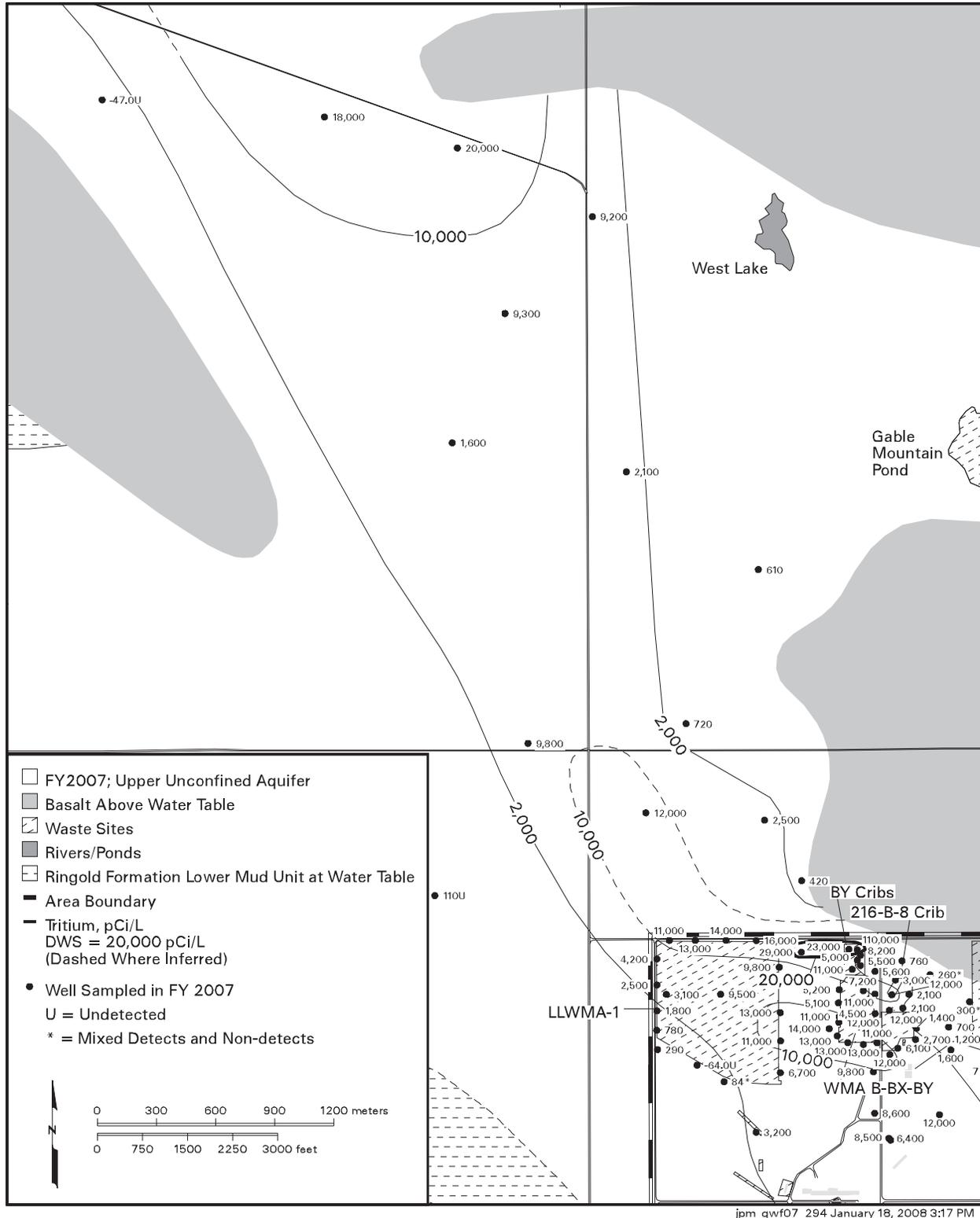


Figure 2.10-8. Average Tritium Concentrations in 200-BP-5 Operable Unit, Upper Part of Unconfined Aquifer

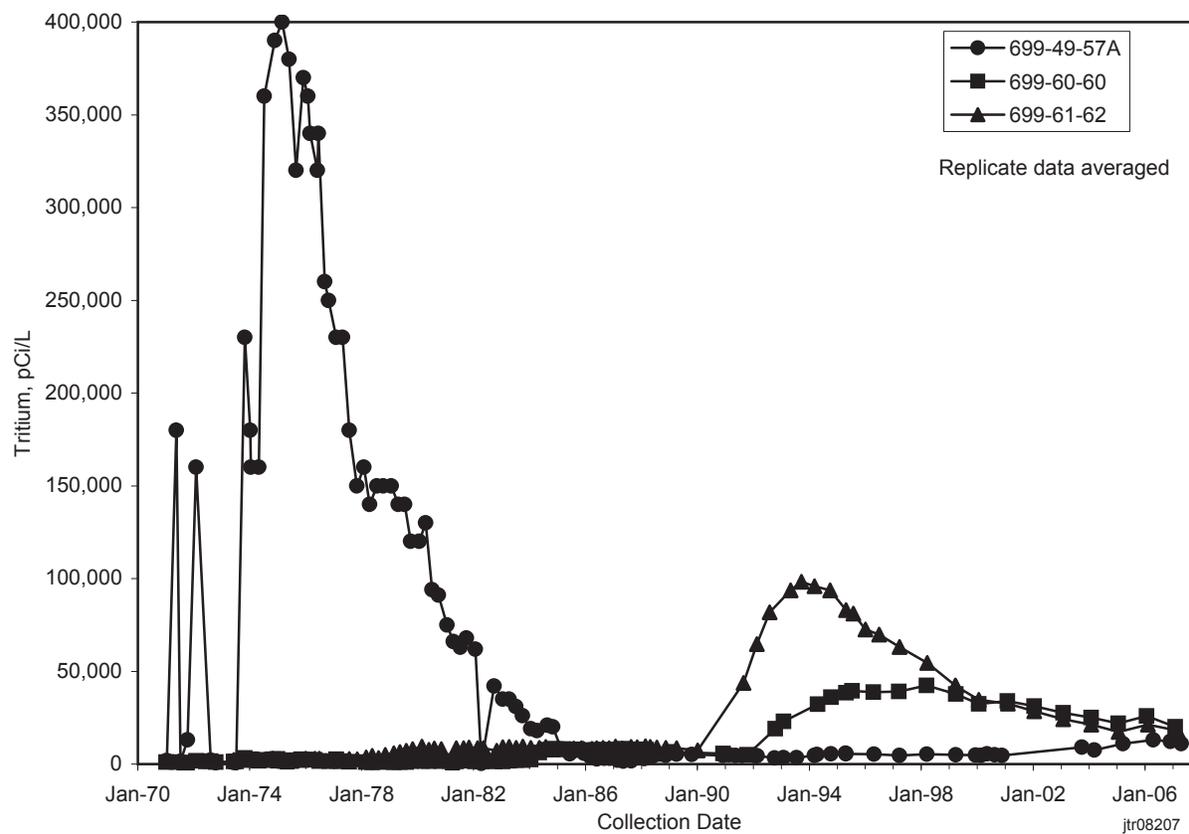


Figure 2.10-9. Historic Maximum Tritium Values During the Mid-1970s in Wells 699-49-57A, 699-60-60, and 699-61-62

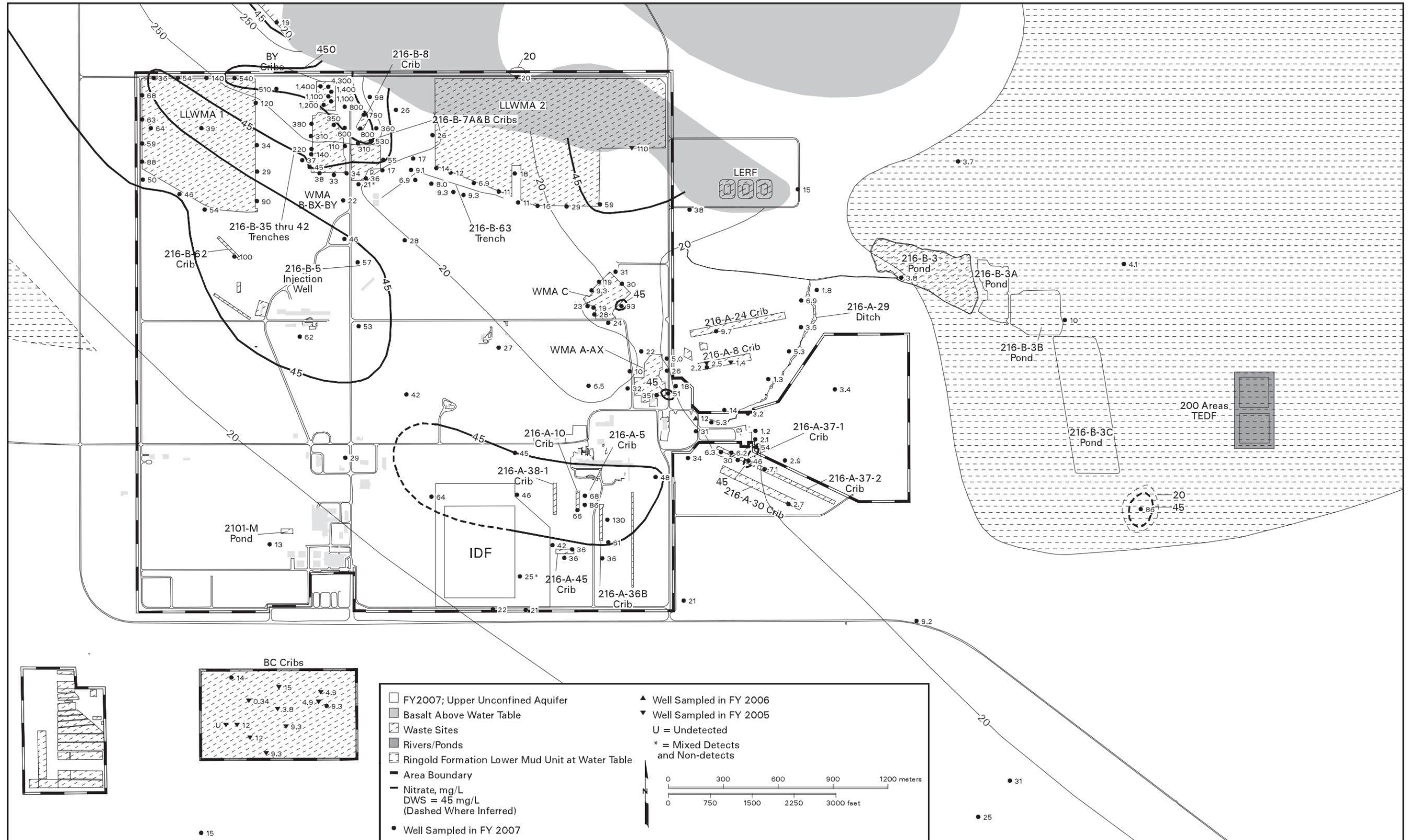
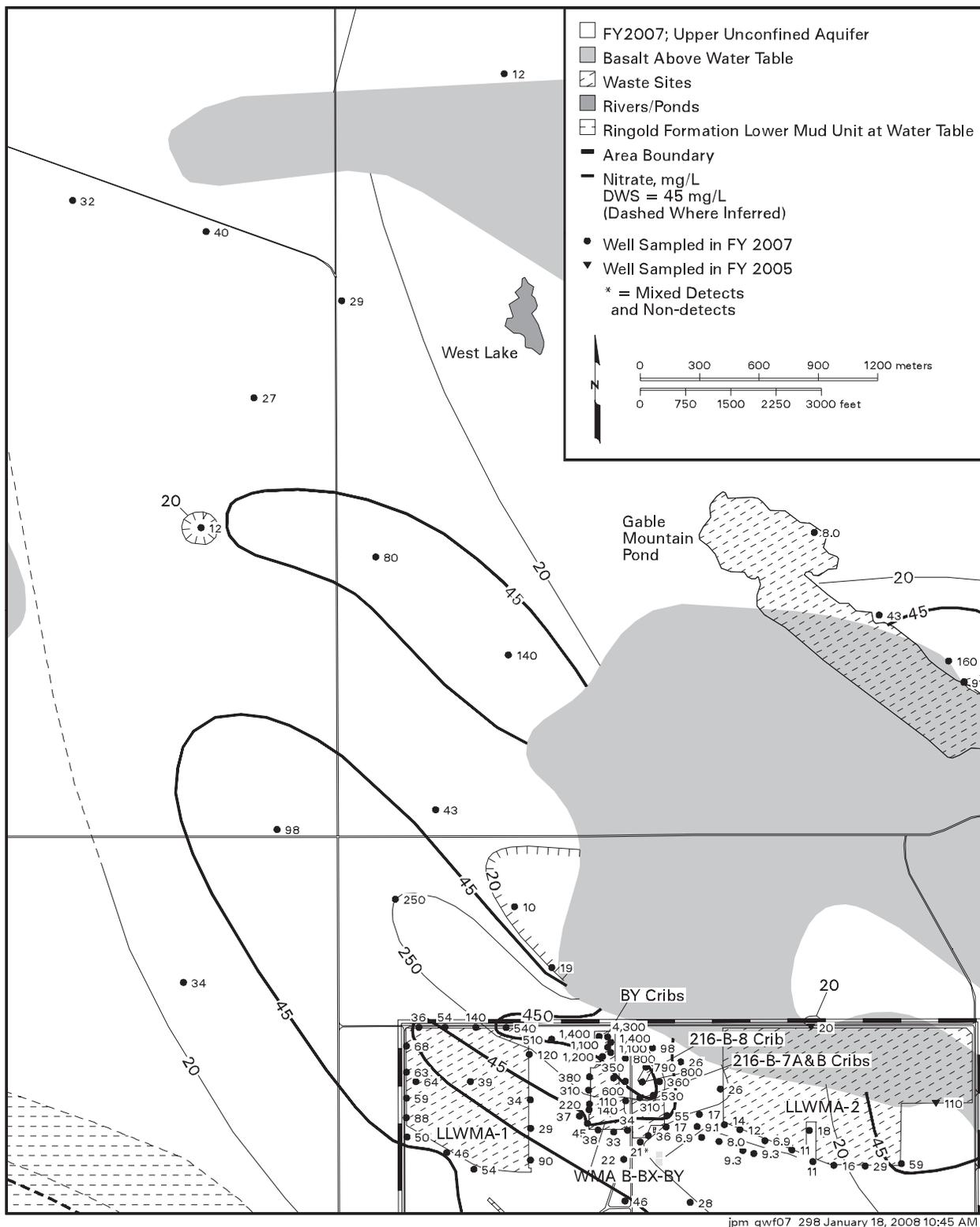


Figure 2.10-10. Average Nitrate Concentrations in 200 East Area, Upper Part of Unconfined Aquifer

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Figure 2.10-11. Average Nitrate Concentrations in 200-BP-5 Operable Unit, Upper Part of Unconfined Aquifer

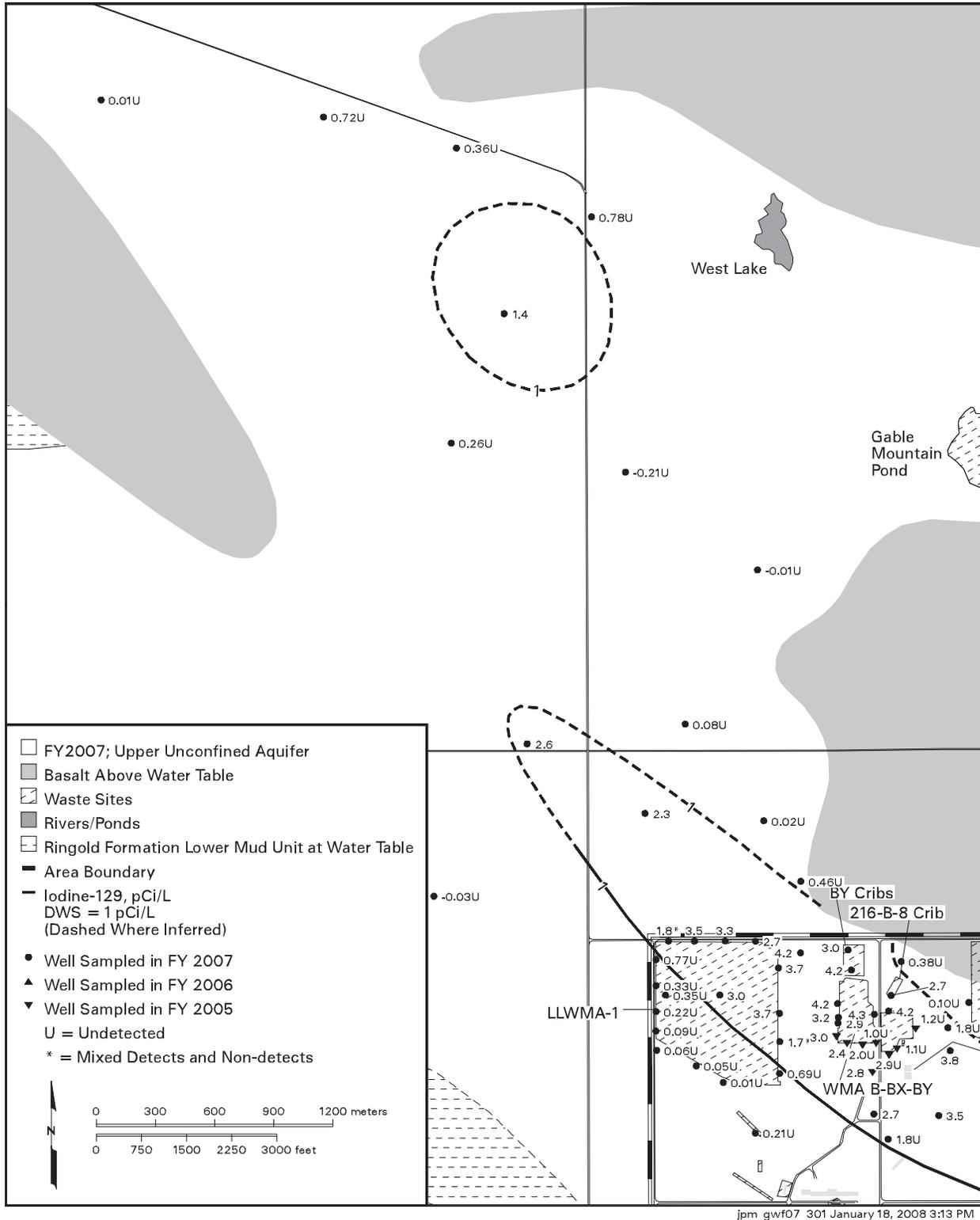


Figure 2.10-12. Average Iodine-129 Concentrations in 200-BP-5 Operable Unit, Upper Part of Unconfined Auifer

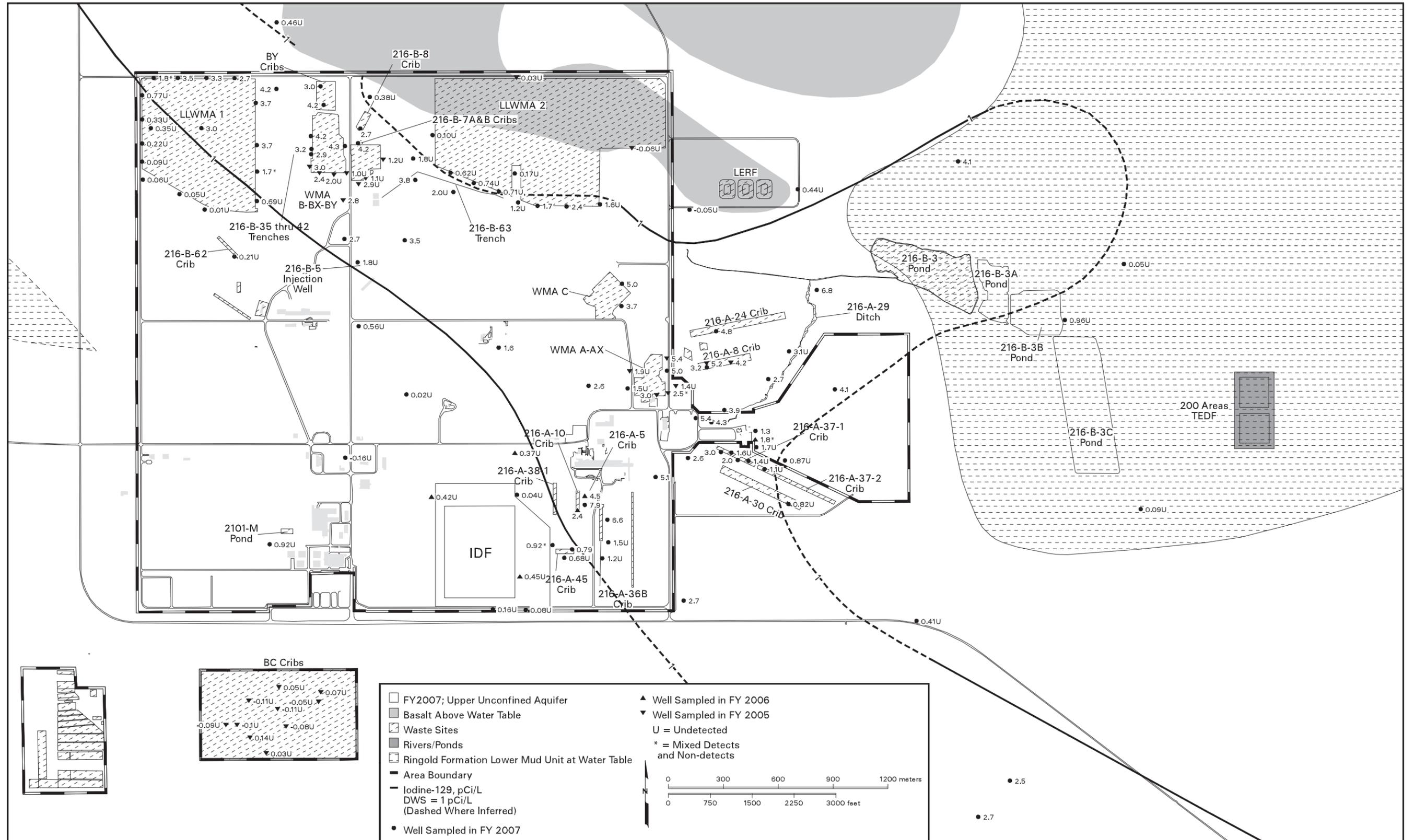


Figure 2.10-13. Average Iodine-129 Concentrations in 200 East Area, Upper Part of Unconfined Aquifer

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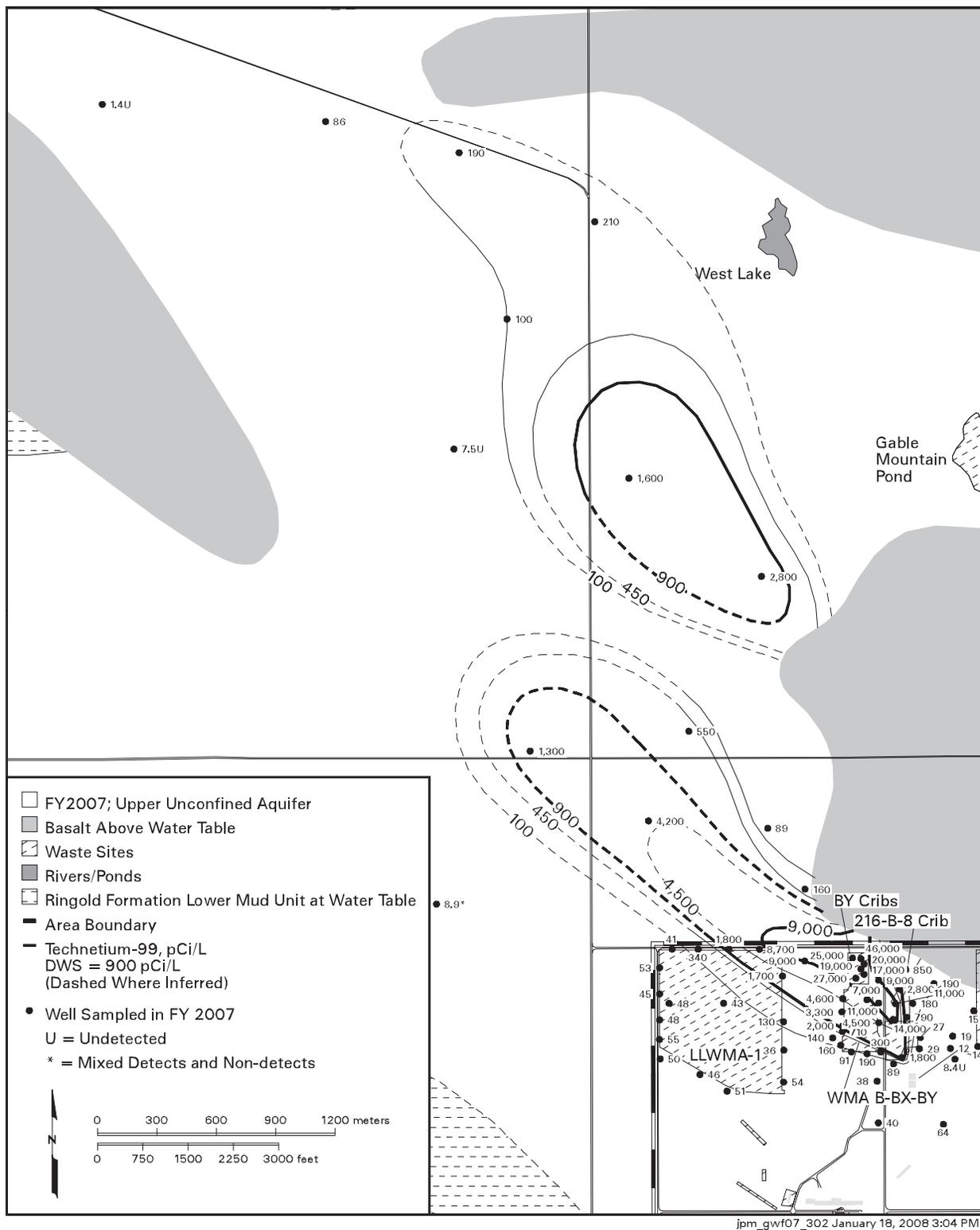


Figure 2.10-14. Average Technetium-99 Concentrations in 200-BP-5 Operable Unit, Upper Part of Unconfined Aquifer

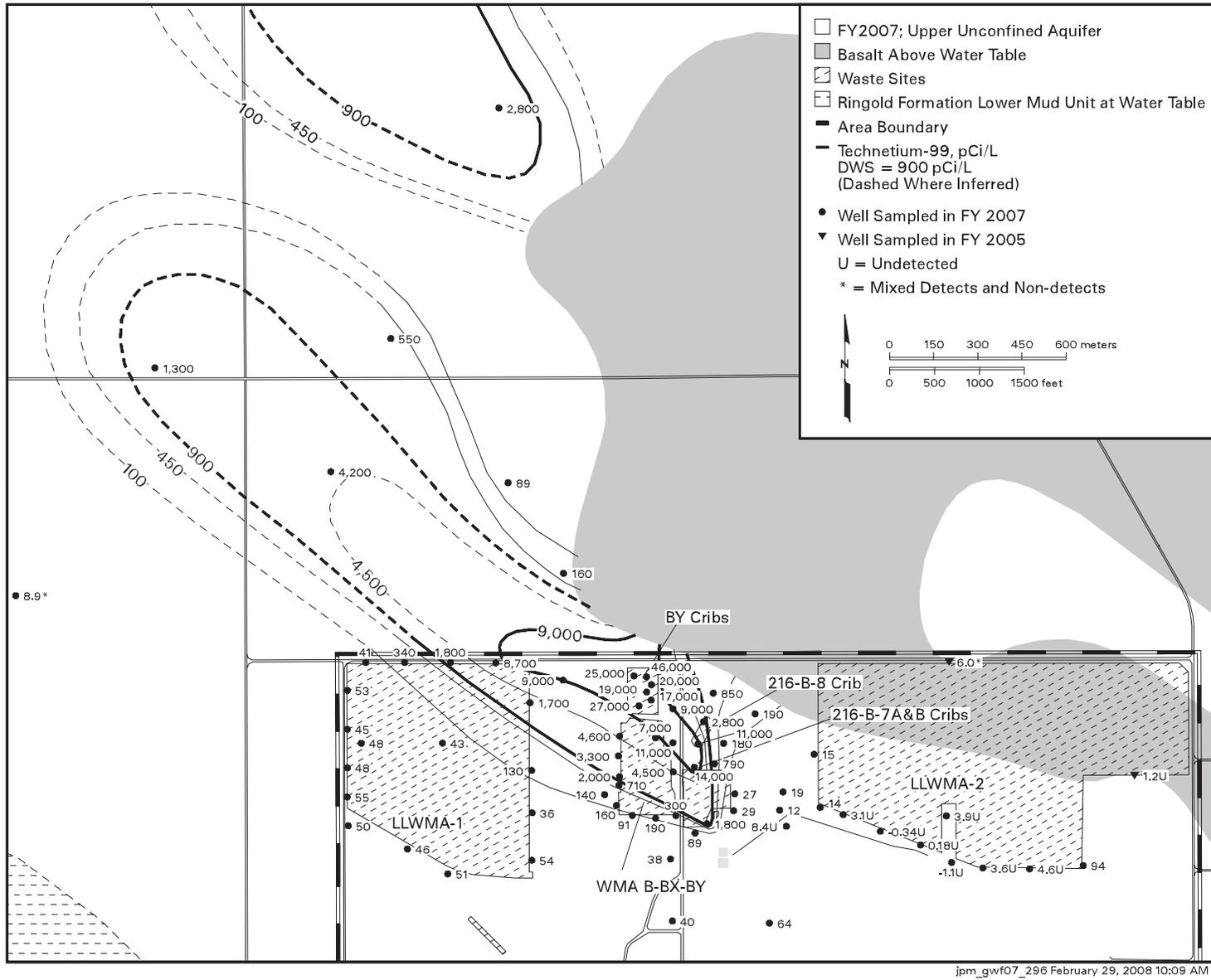
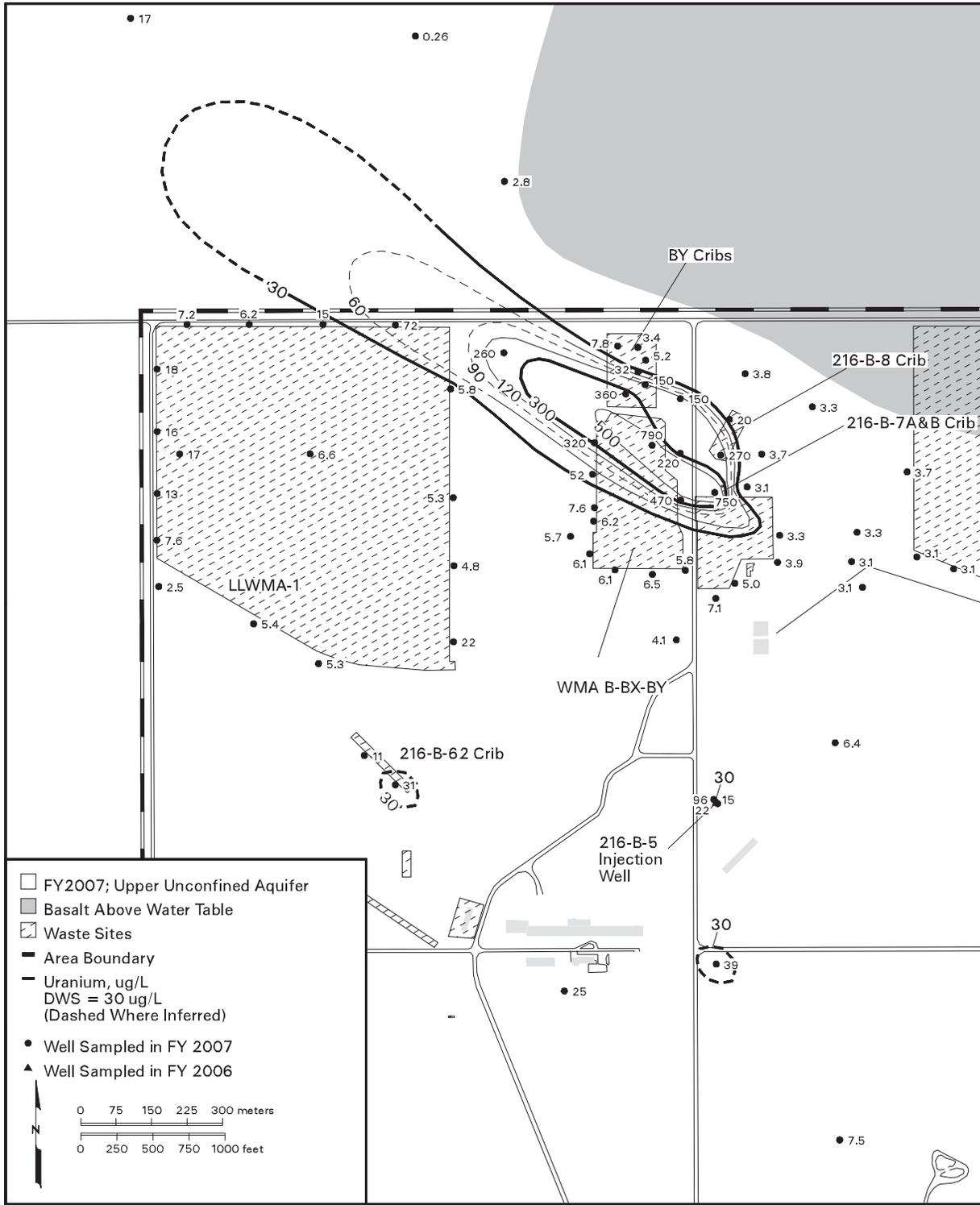


Figure 2.10-15. Average Technetium-99 Concentrations in B Complex Area and Low-Level Waste Management Area 1, Upper Part of Unconfined Aquifer



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Figure 2.10-17. Uranium Concentrations in Northwest 200 East Area, Upper Part of Unconfined Aquifer

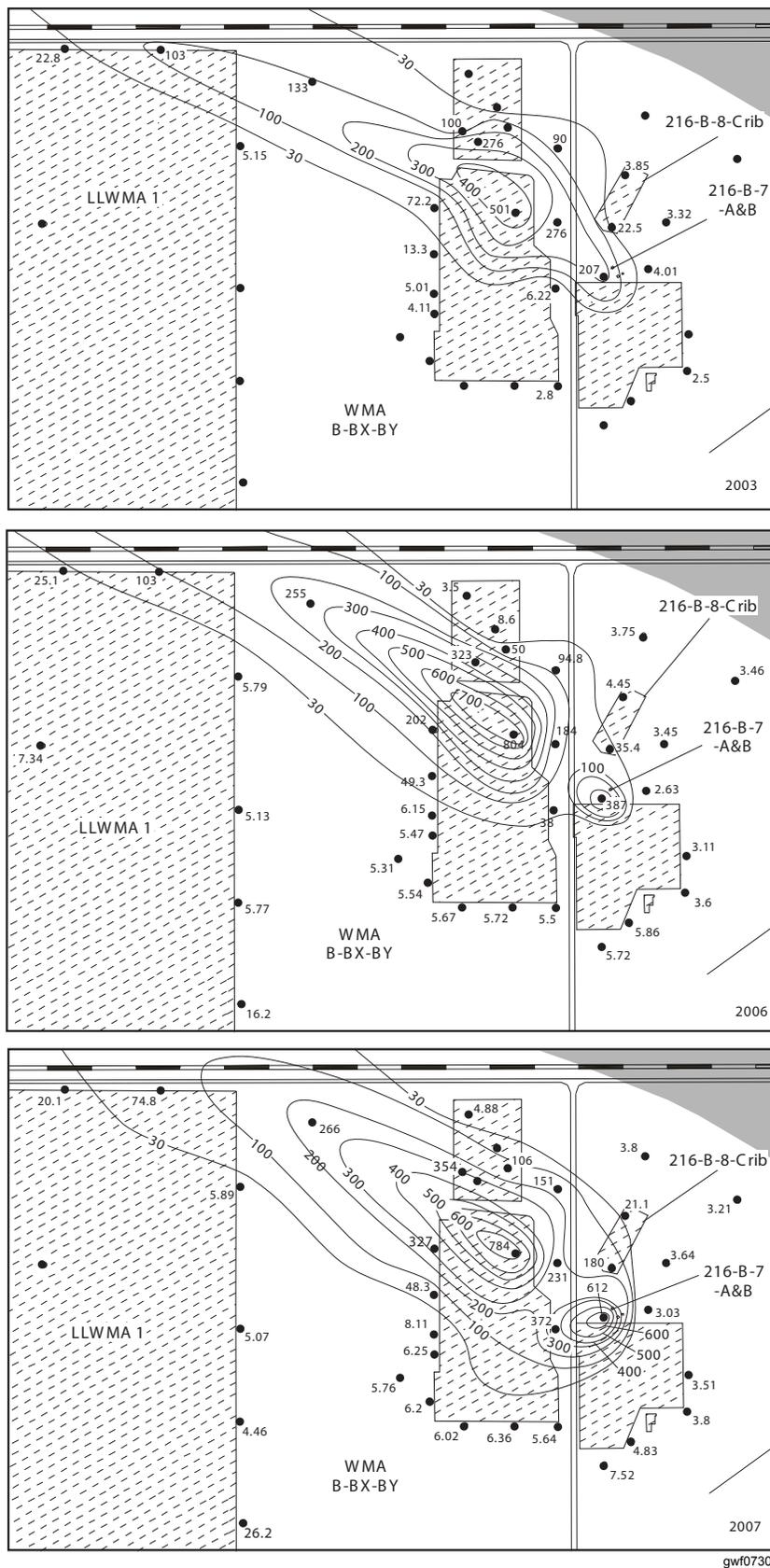


Figure 2.10-18. Time Series Maps of Uranium from 2003 to 2007

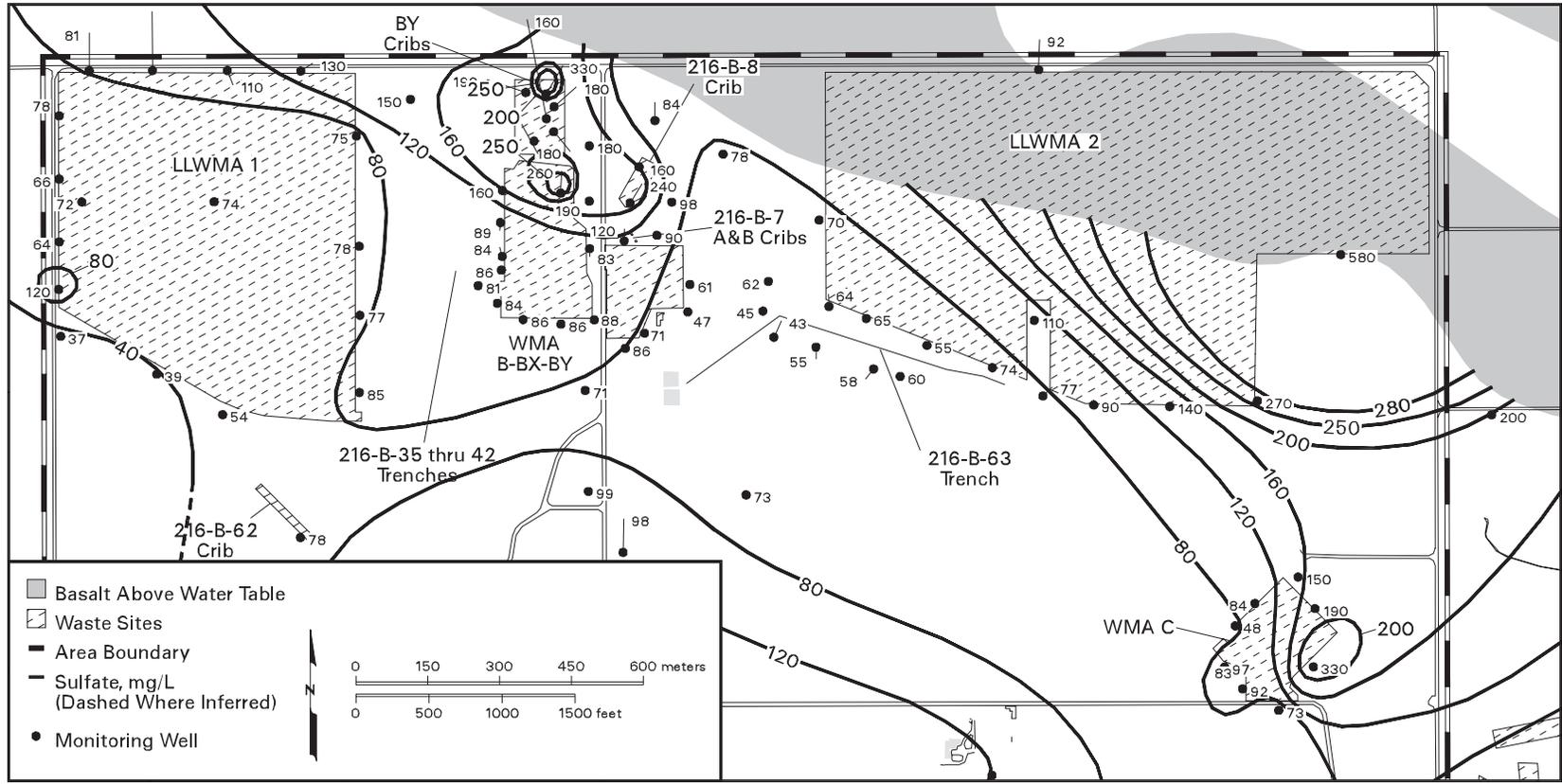


Figure 2.10-19. Average Sulfate Concentrations Along the Basalt Sub-crop in 200-BP-5 Operable Unit, Upper Part of Unconfined Aquifer

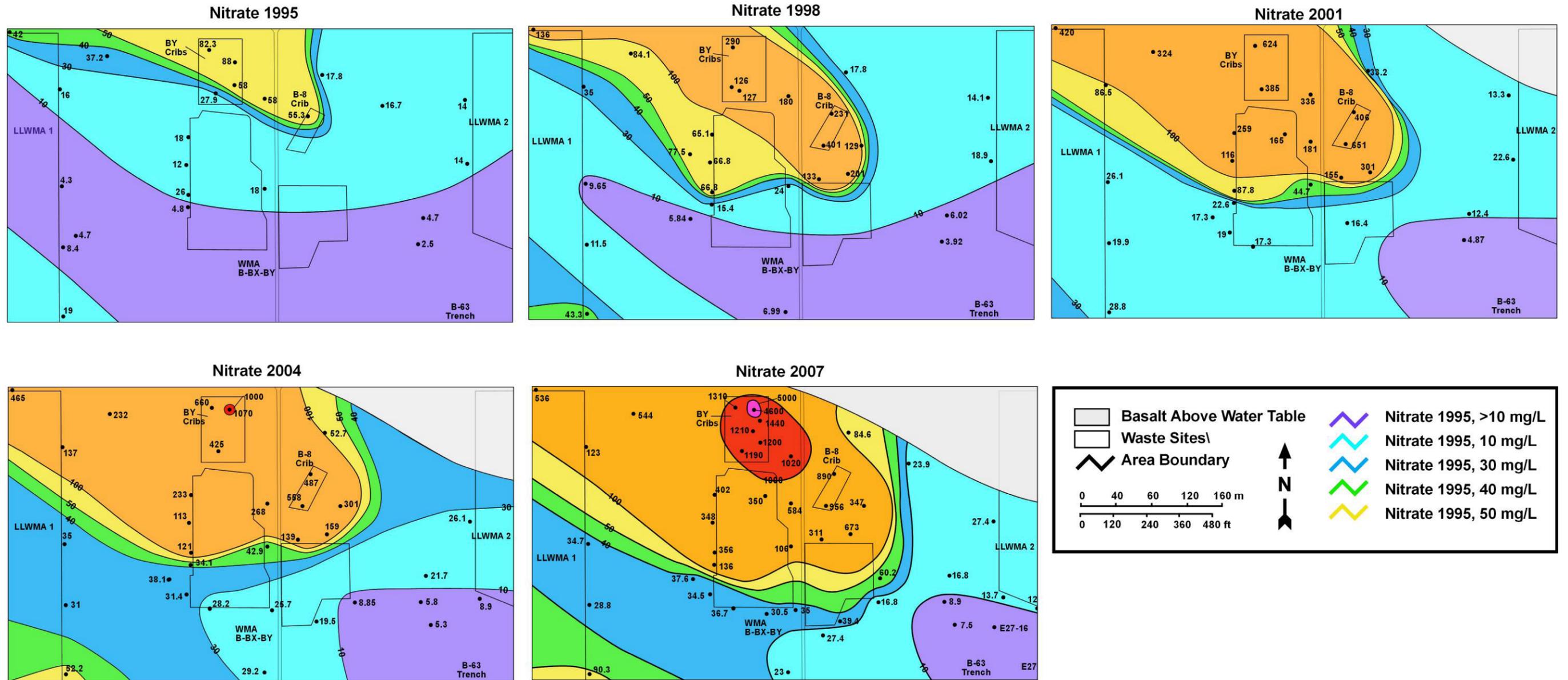


Figure 2.10-20. Time Series of Nitrate Plume Migration, 1995 to 2007

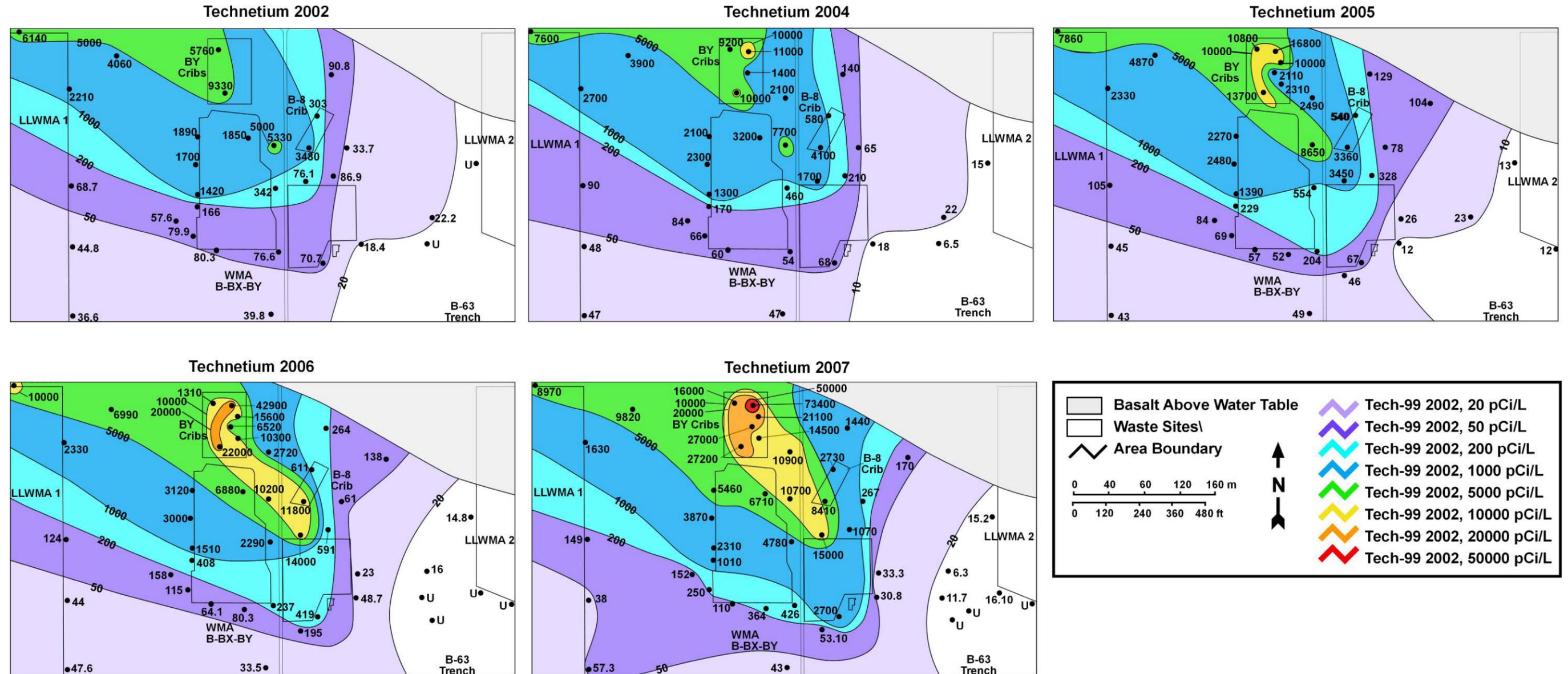
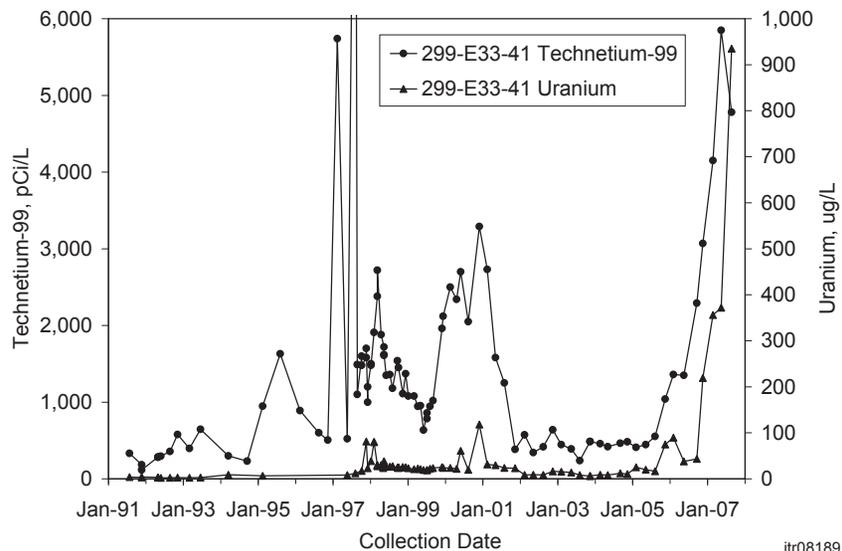


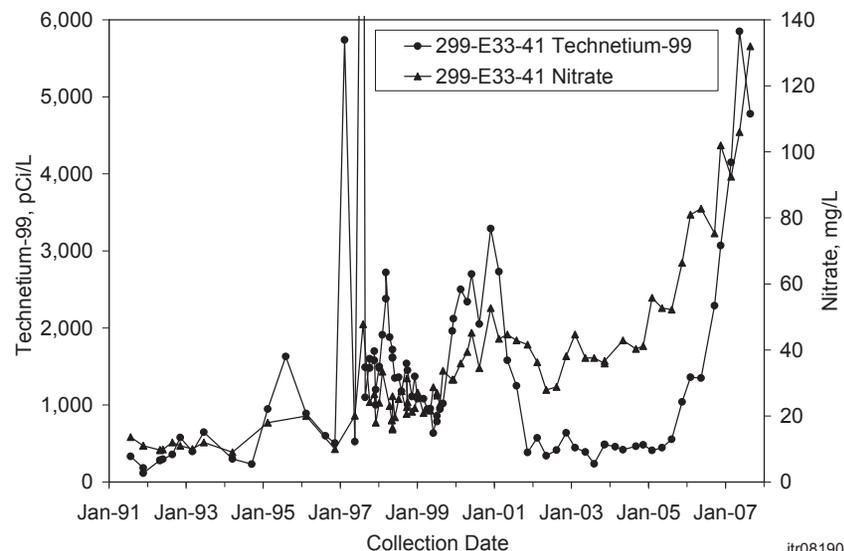
Figure 2.10-21. Time Series of Technetium-99 Plume Migration, 2002 to 2007



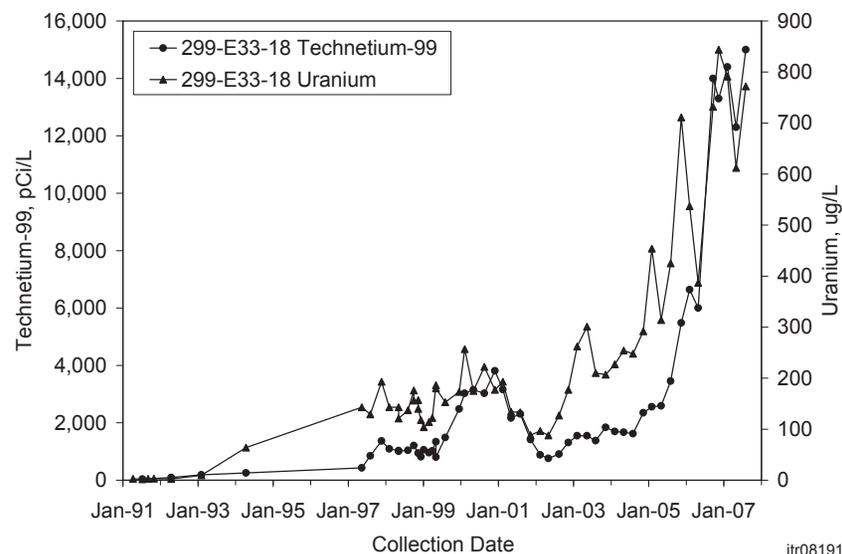
Figure 2.10-23. Photograph of Erosion at BY Cribs Facing Southwest Between the BY Tank and the B-57 Barrier, June 2004



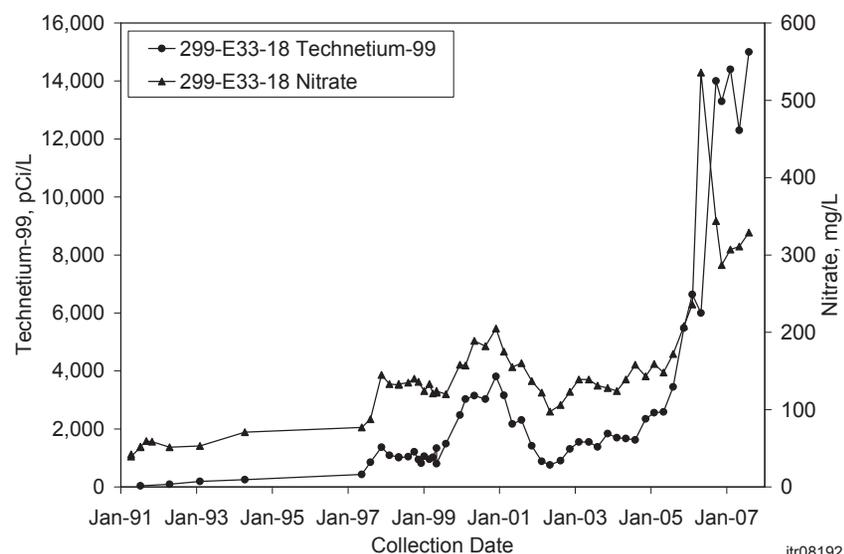
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Figure 2.10-24. Technetium-99, Uranium, and Nitrate Concentrations for Wells 299-E33-18 and 299-E33-41

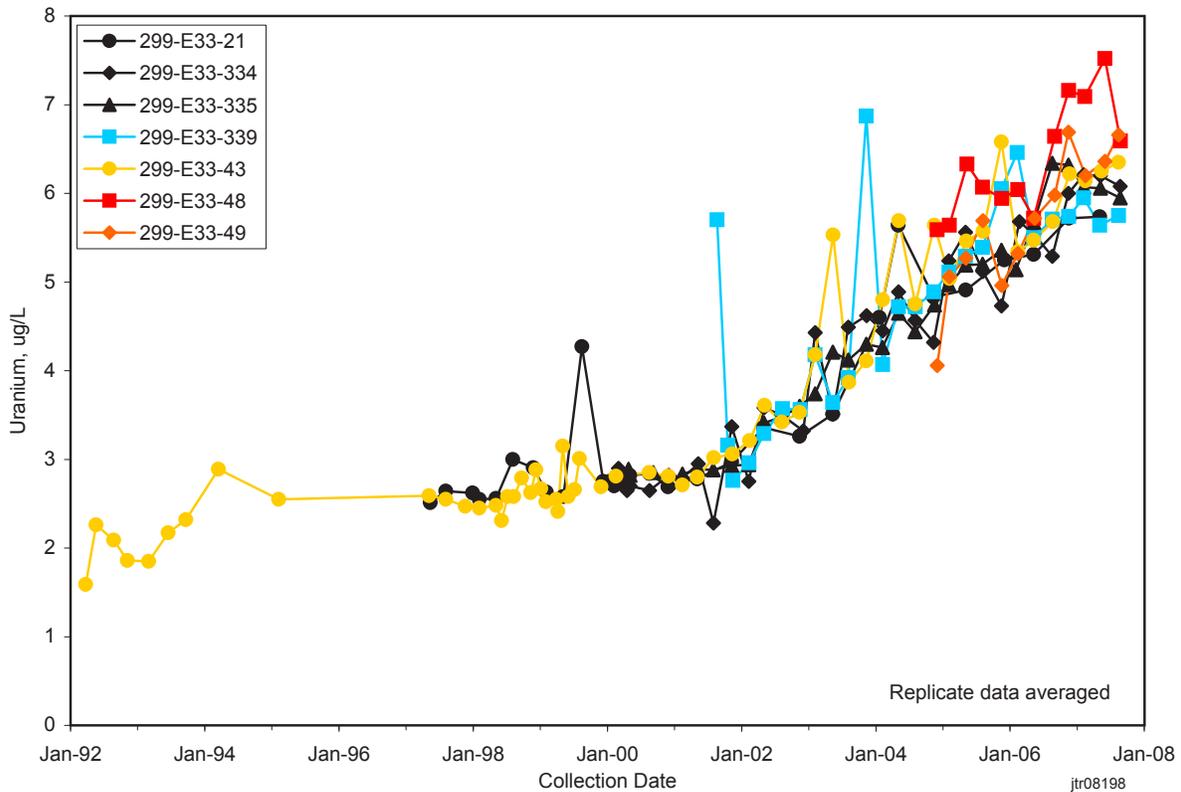
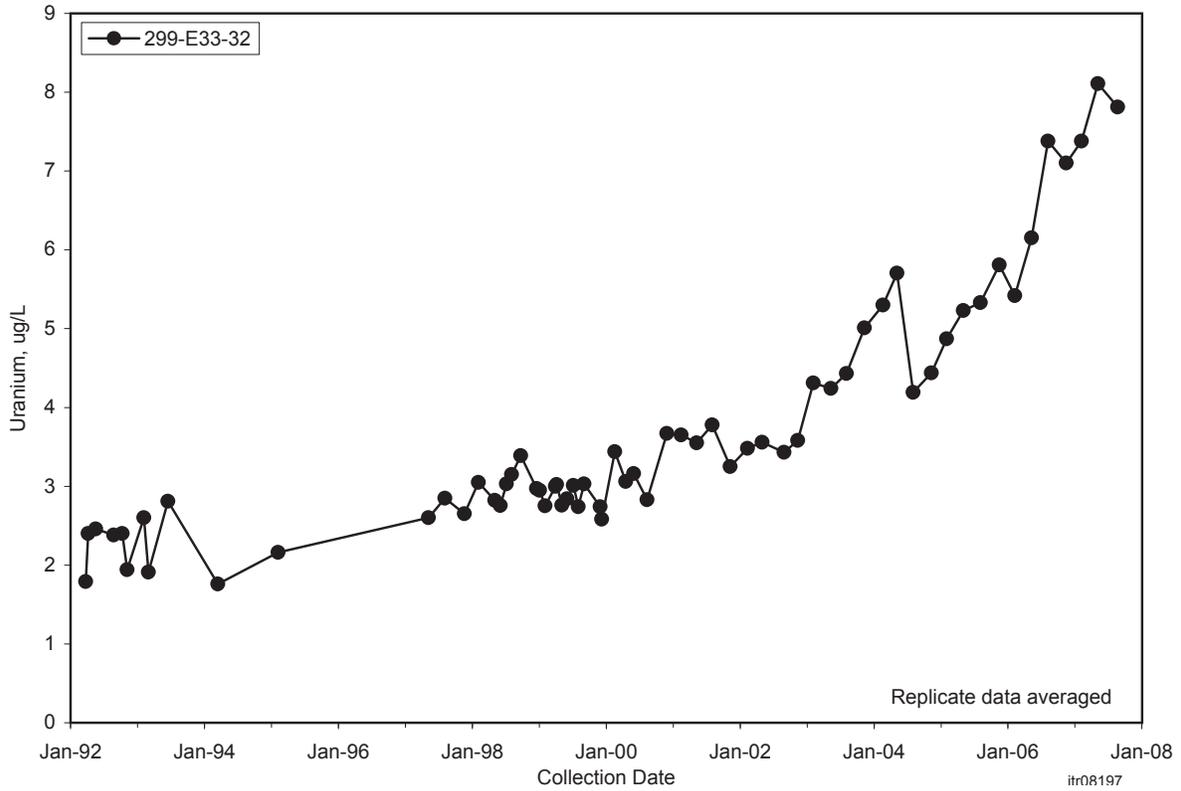
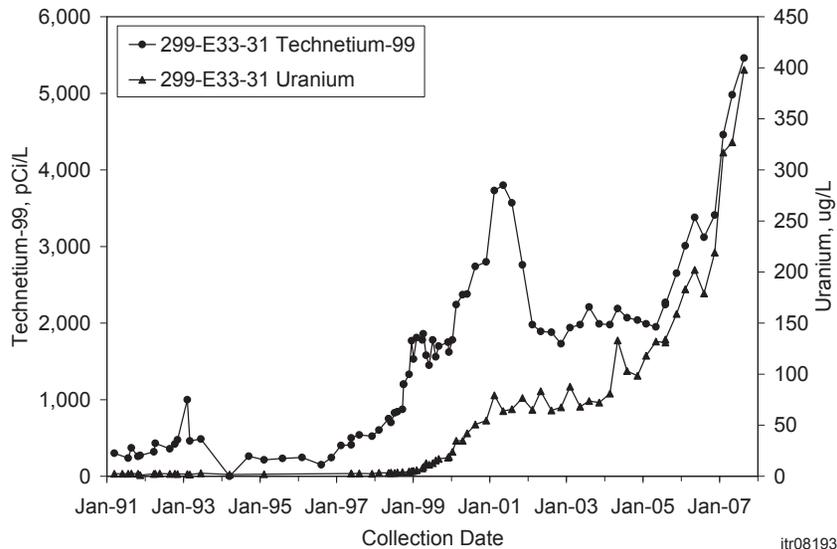
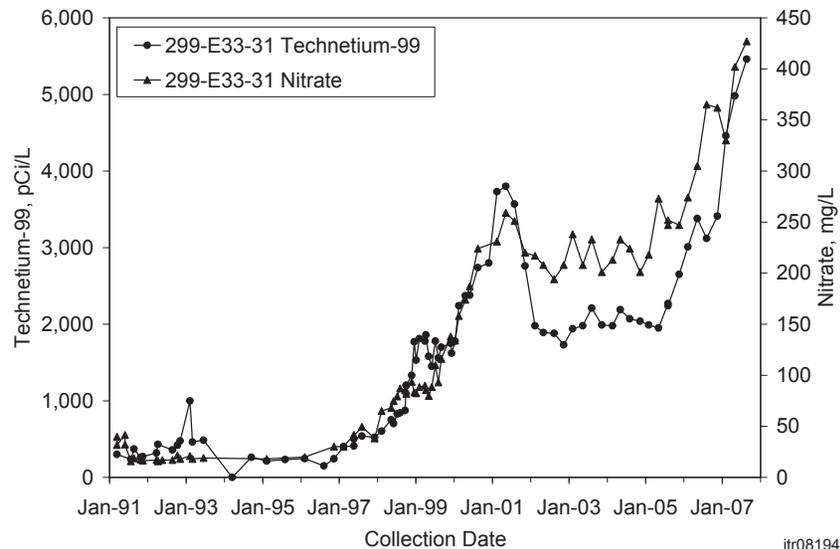


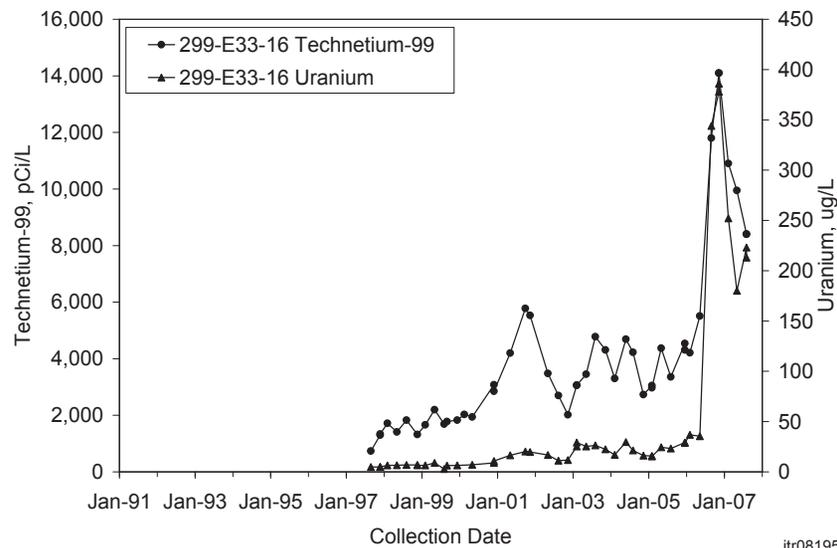
Figure 2.10-25. Uranium Concentrations on South Side of Waste Management Area B-BX-BY



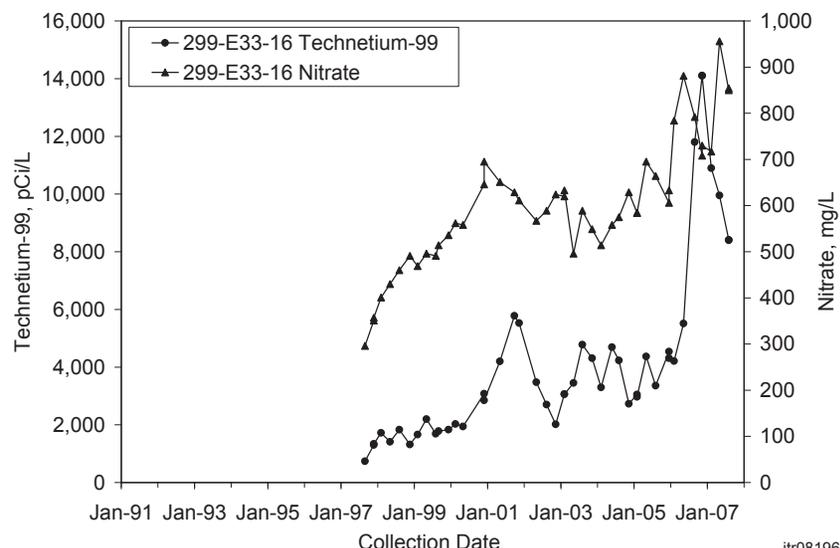
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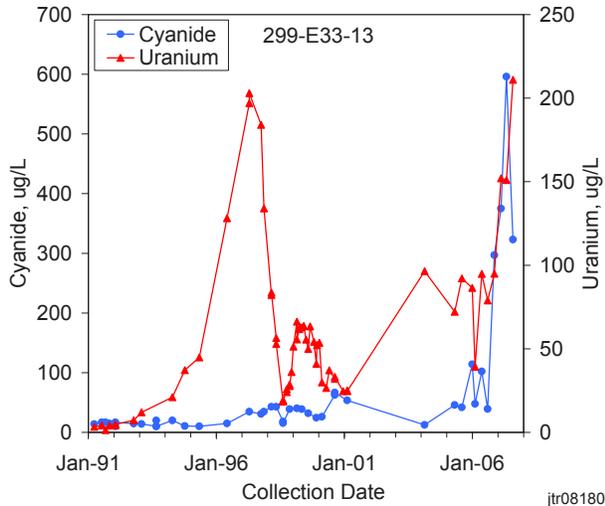


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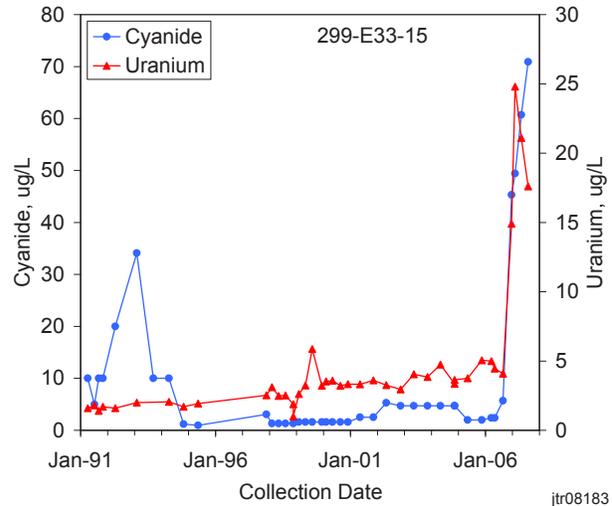


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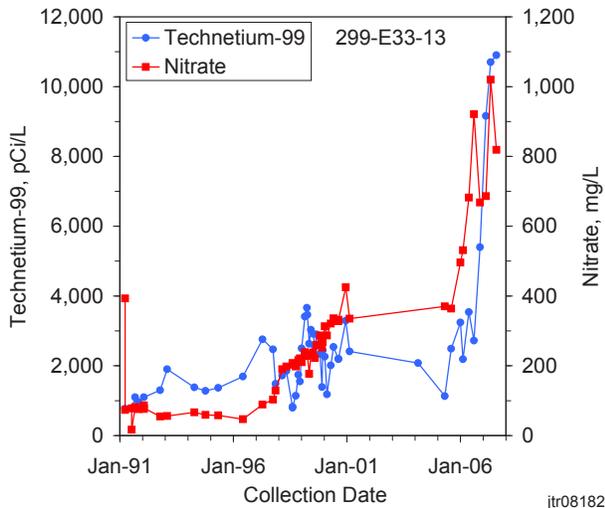
Figure 2.10-26. Technetium-99, Uranium, and Nitrate Concentrations for Wells 299-E33-31 and 299-E33-16



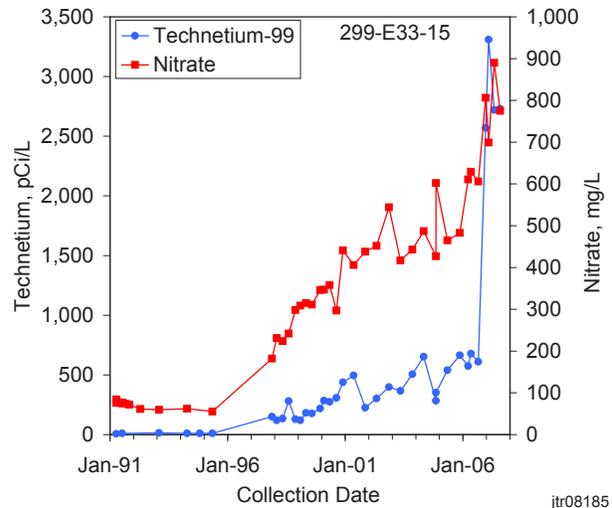
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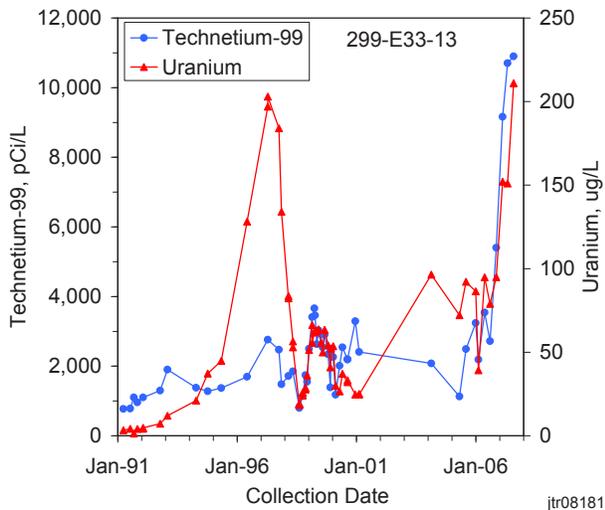
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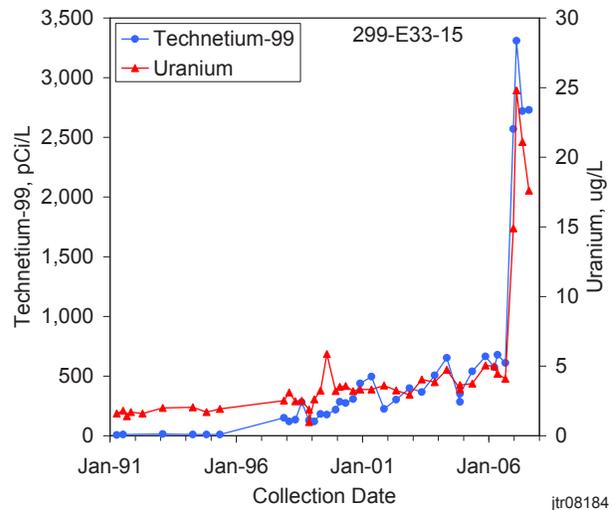
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jtr08185



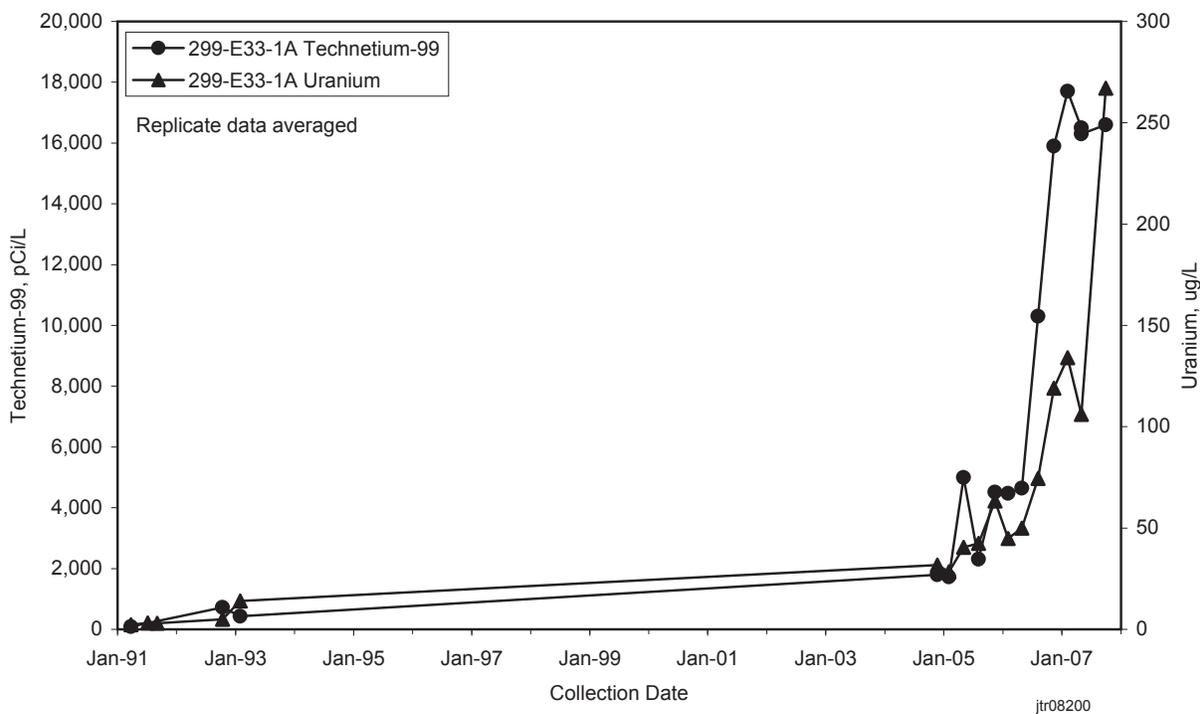
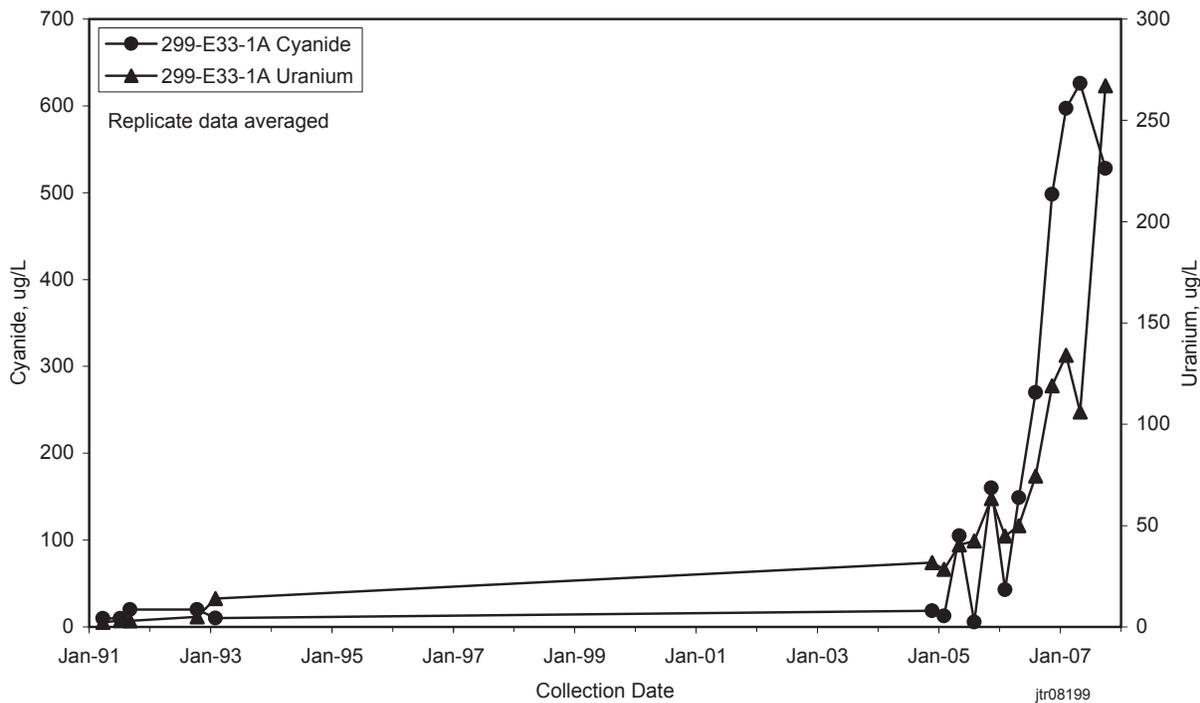
jtr08181



jtr08184

gw07328

Figure 2.10-27. Cyanide, Uranium, Technetium-99, and Nitrate Concentrations for Well 299-E33-13 and 299-E33-15



gwf07327

Figure 2.10-28. Uranium, Cyanide, and Technetium-99 Concentrations Beneath the BY Cribs in Well 299-E33-1A

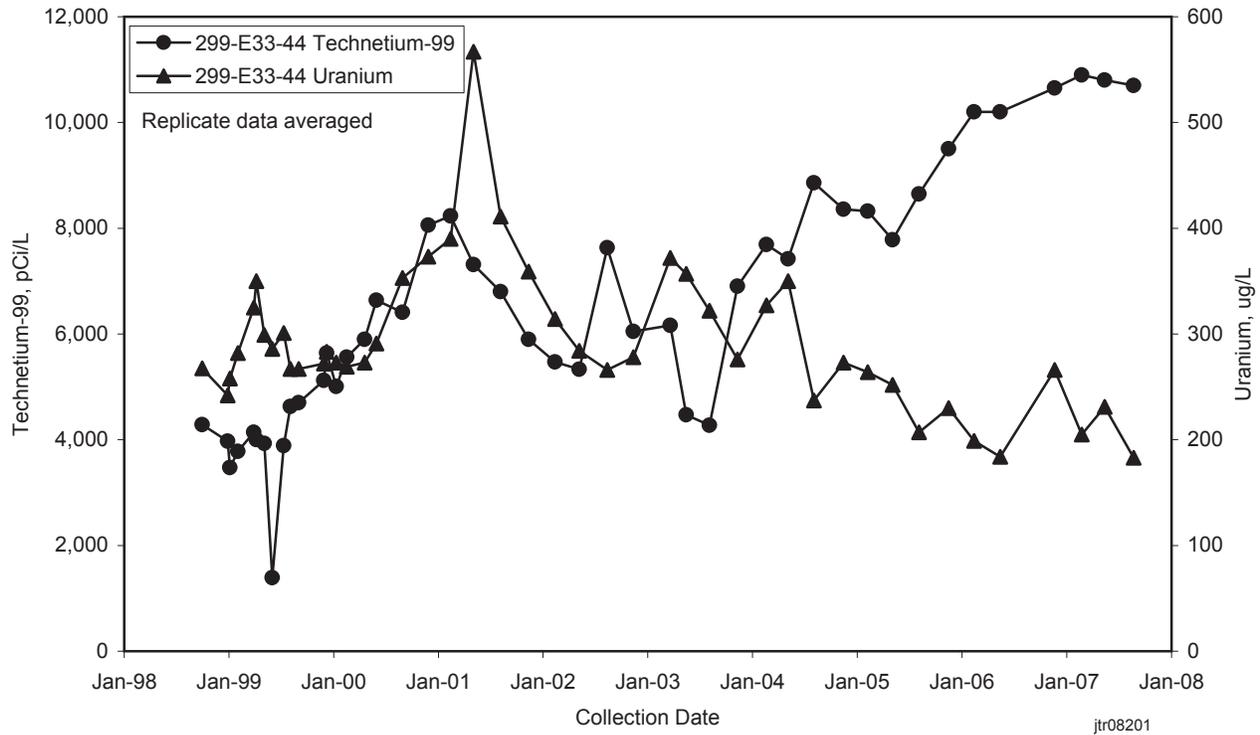
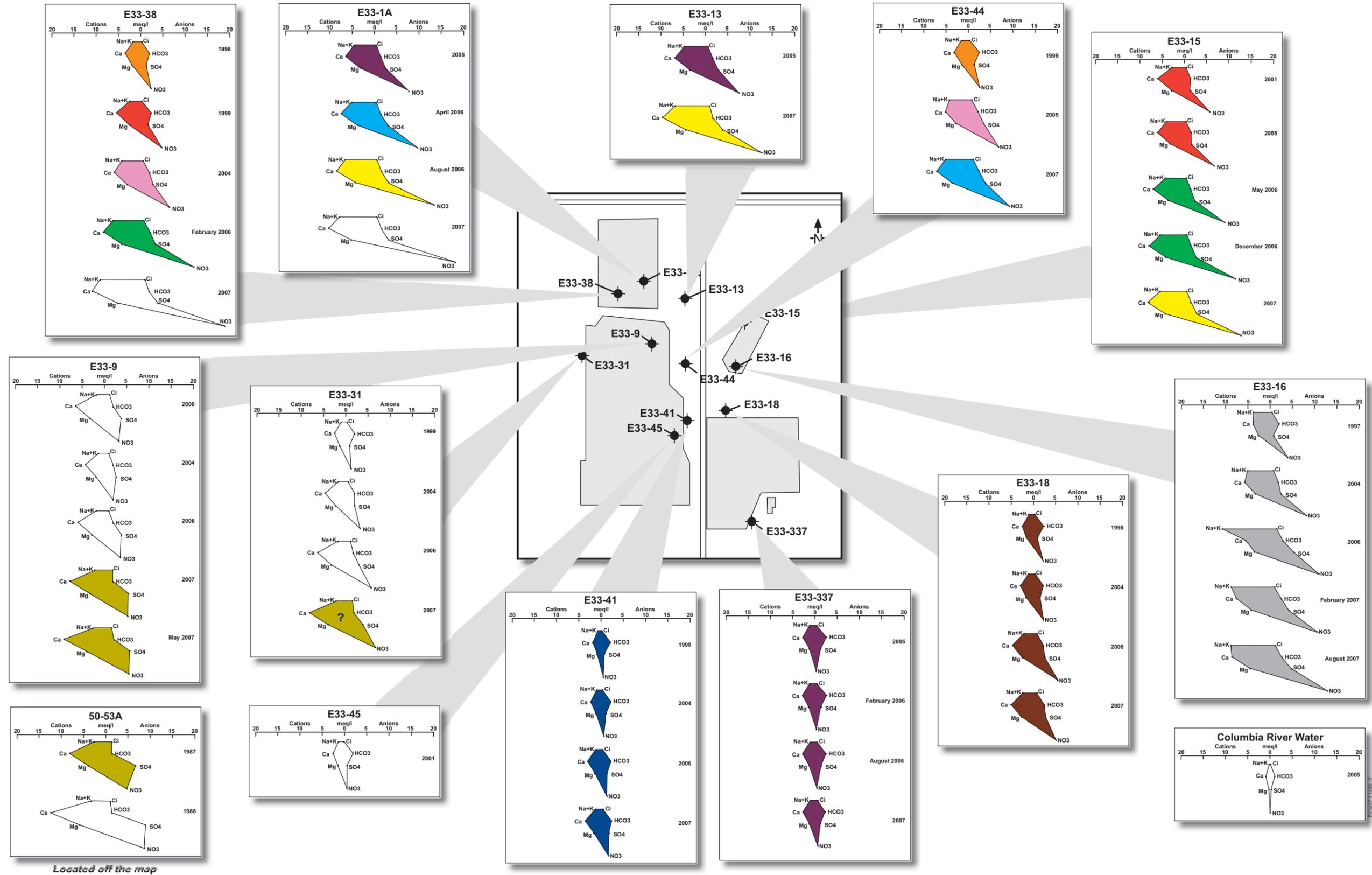


Figure 2.10-29. Increasing Technetium-99 and Decreasing Uranium Concentrations at Well 299-E33-44



Located off the map

Figure 2.10-30. Stiff Diagrams for Wells at Waste Management Area B-BX-BY and Surrounding Facilities (Matching colors are Stiff Diagrams with common contaminant signatures.)

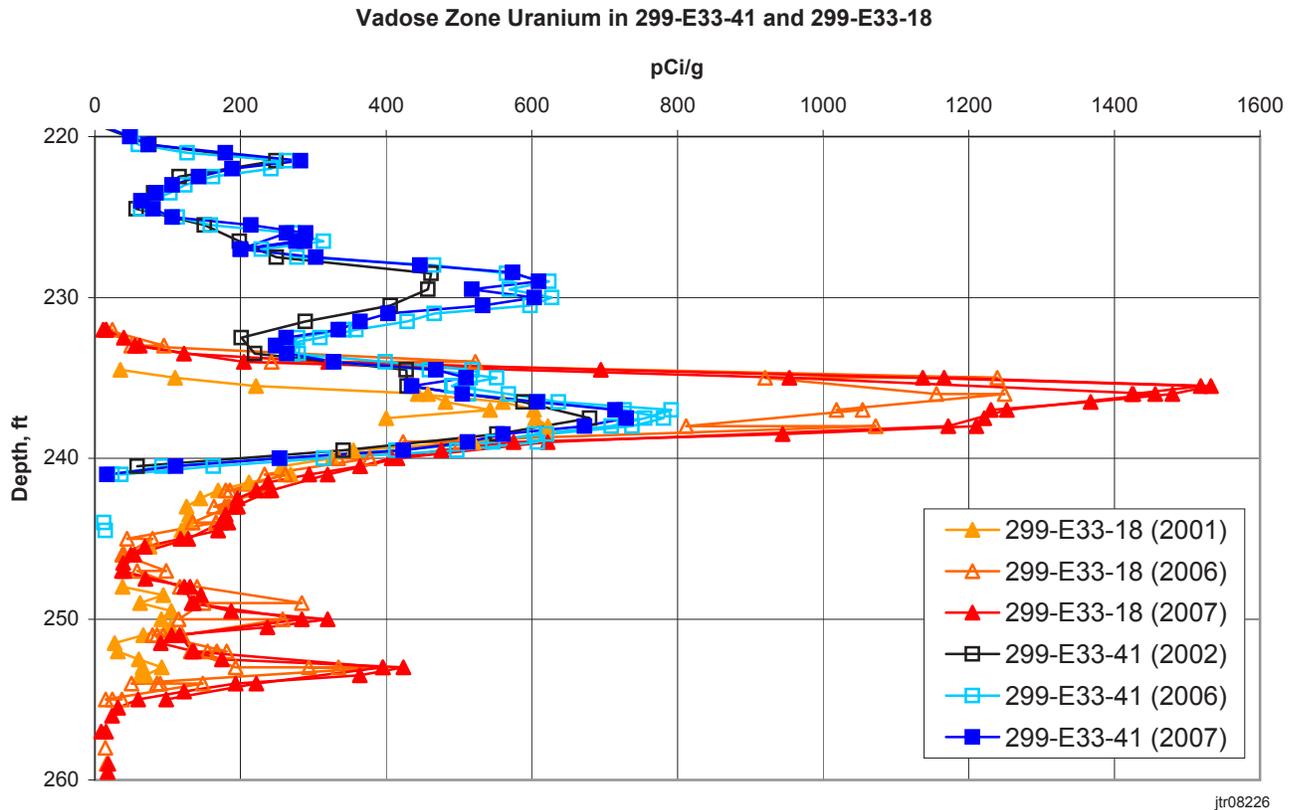


Figure 2.10-31. Spectral Gamma Results for Well 299-E33-18 and 299-E33-41, FY 2007

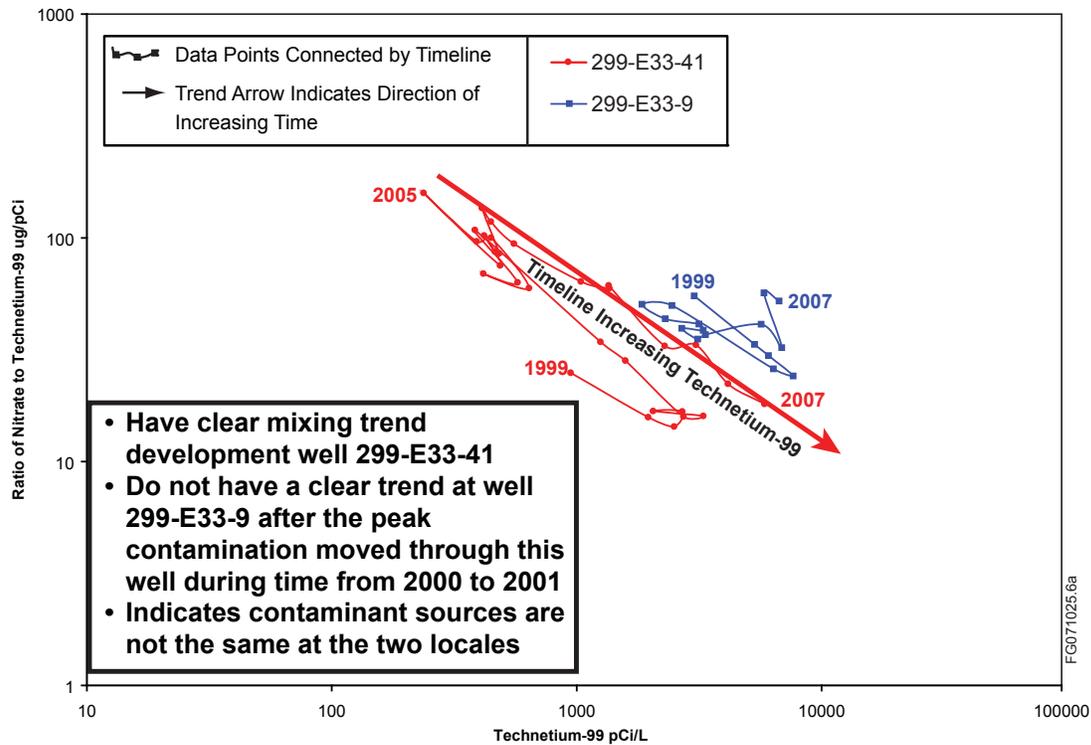
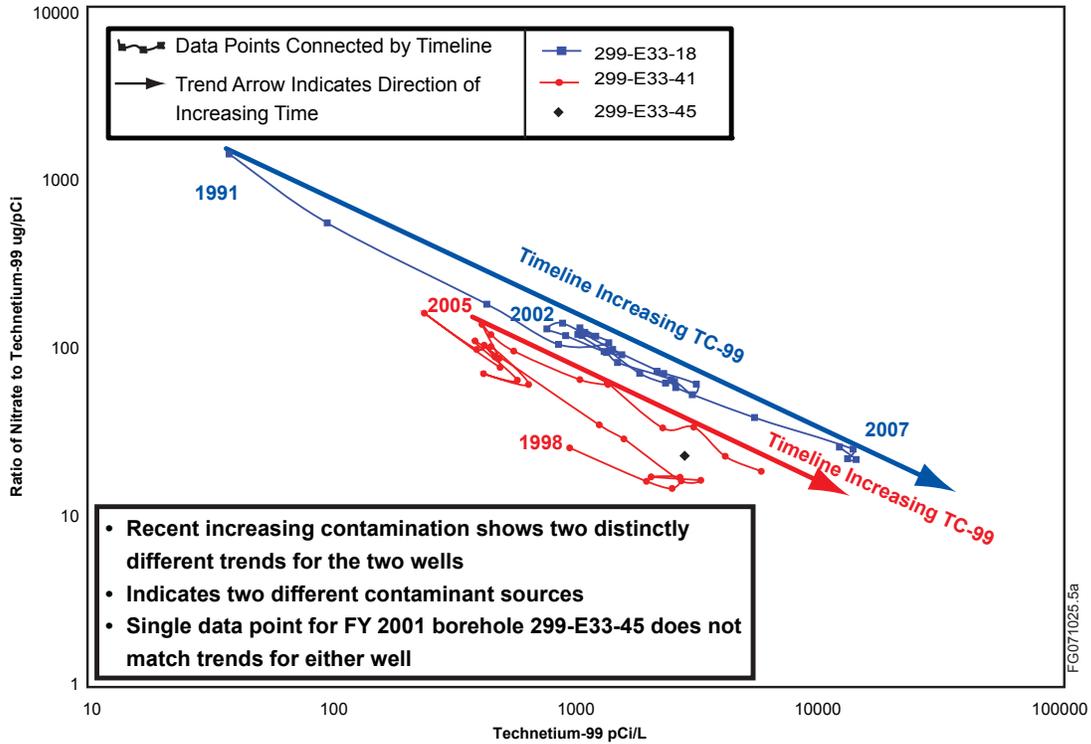


Figure 2.10-32. Nitrate to Technetium-99 Ratios Comparing Well 299-E33-18 to 299-E33-41 and Well 299-E33-41 to 299-E33-9

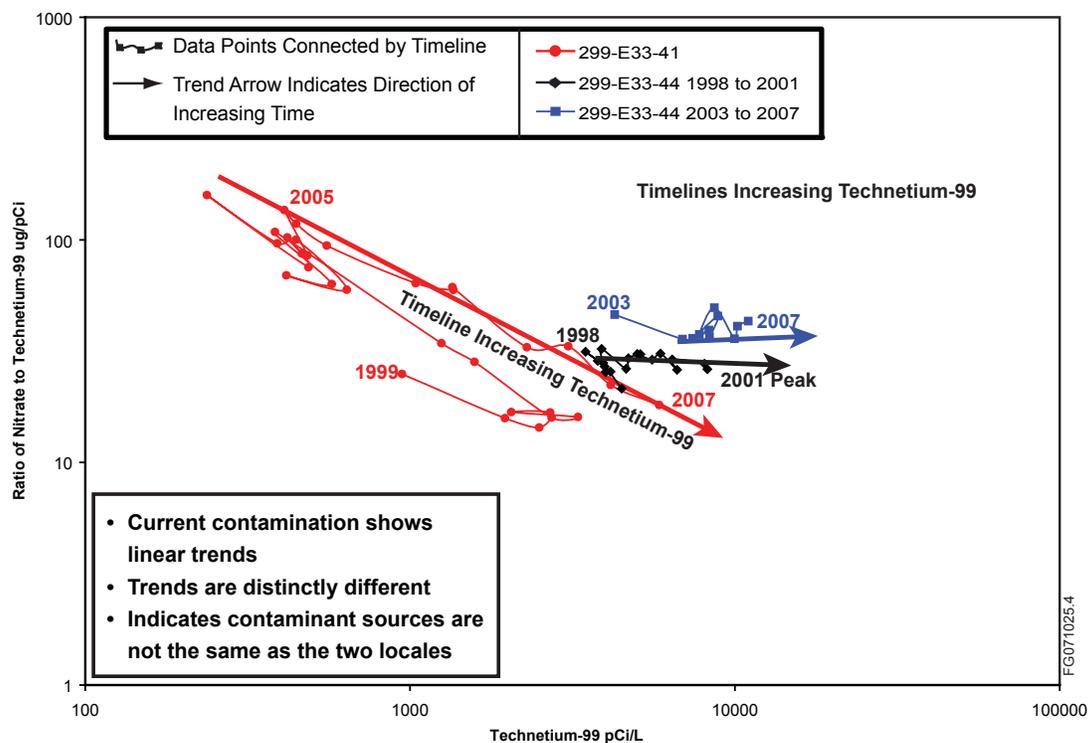
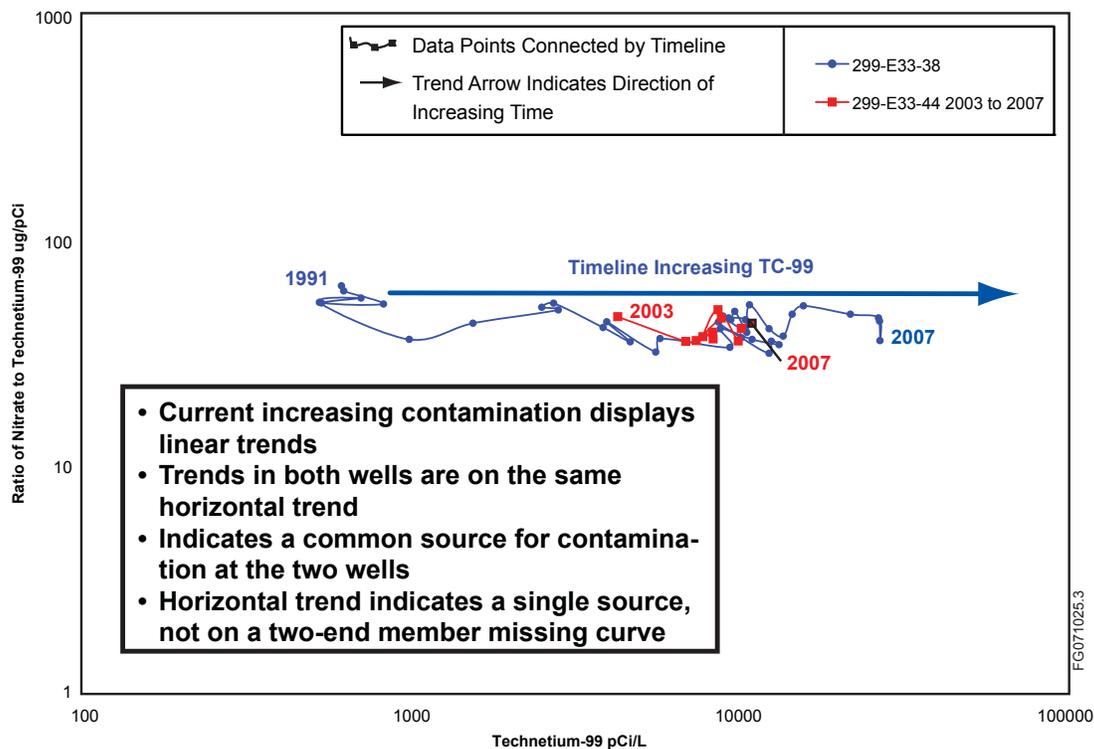


Figure 2.10-33. Nitrate to Technetium-99 Ratios Comparing Well 299-E33-38 to 299-E33-44 and Well 299-E33-41 to 299-E33-44

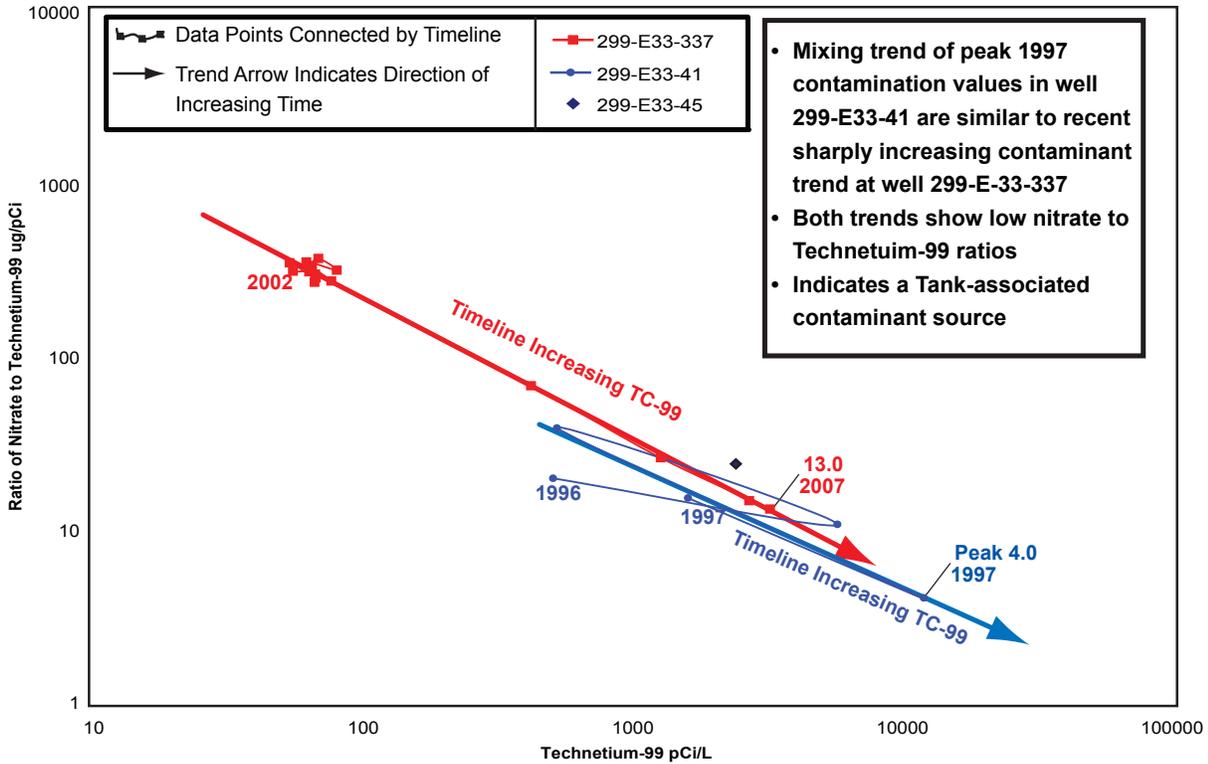


Figure 2.10-34. Nitrate to Technetium-99 Ratios Comparing Well 299-E33-337 to 299-E33-41 and Borehole 299-E33-45

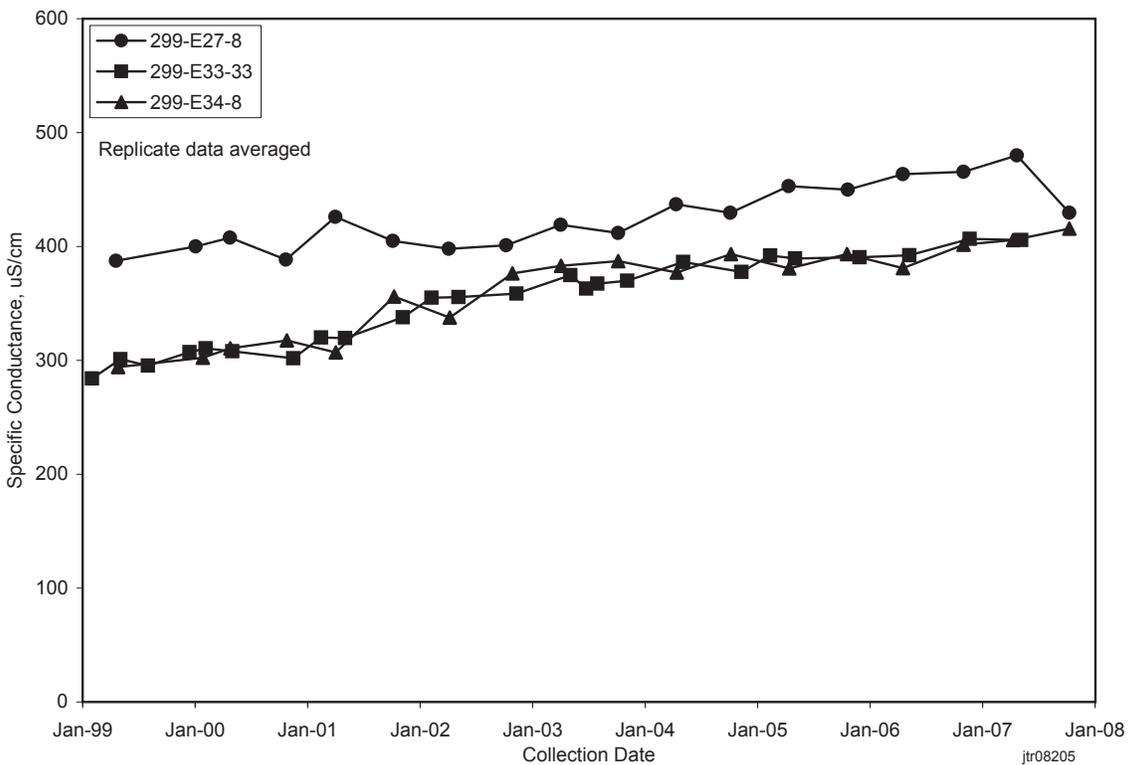


Figure 2.10-35. Specific Conductance Trends at the 216-B-63 Trench

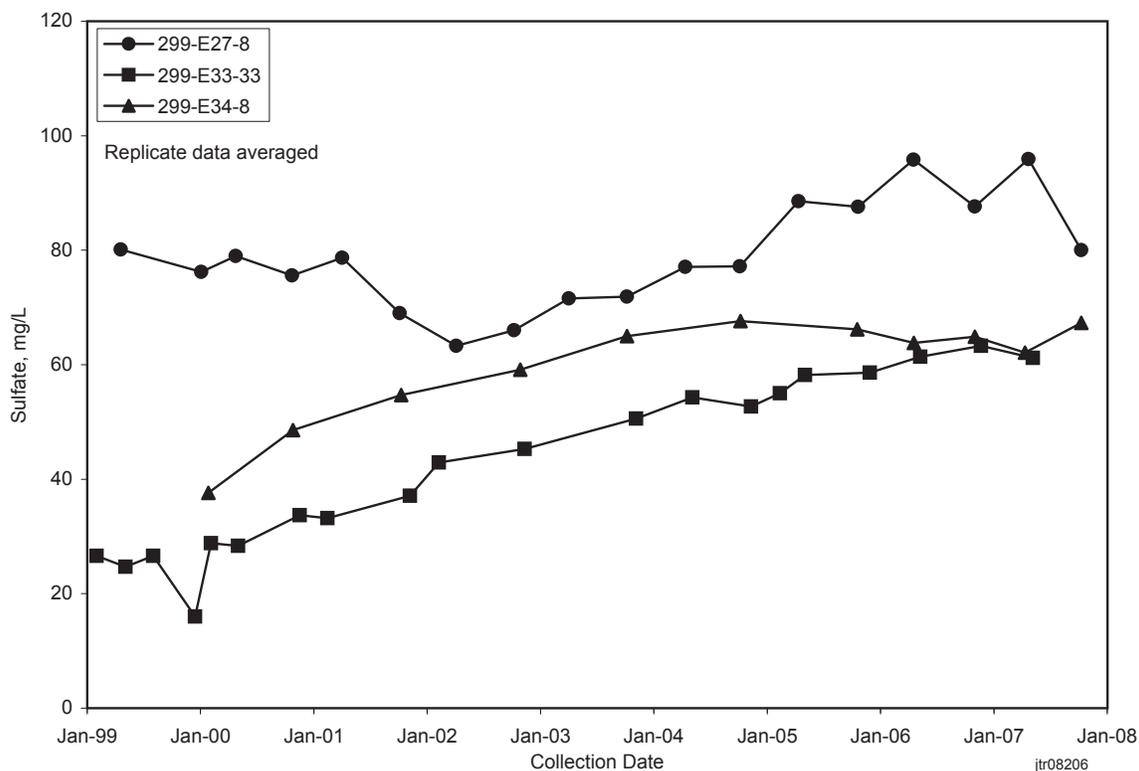


Figure 2.10-36. Sulfate Concentrations in Wells 299-E27-8, 299-E33-33 and 299-E34-8 at the 216-B-63 Trench

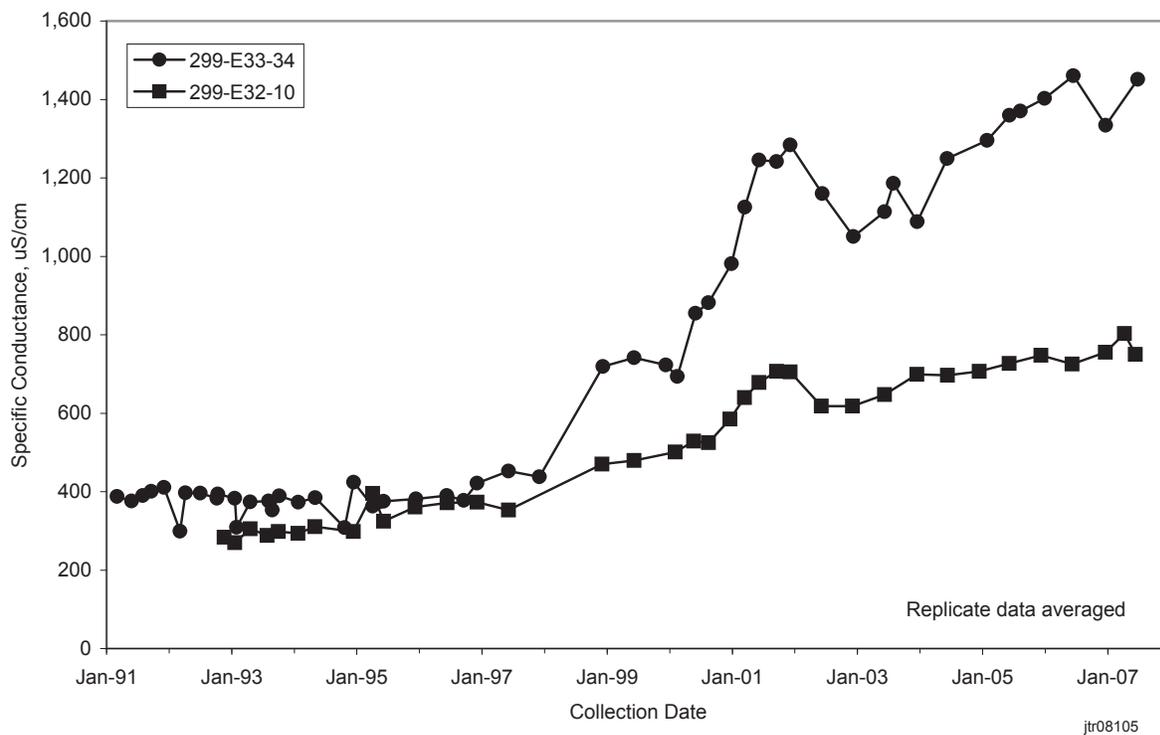


Figure 2.10-37. Specific Conductance in Wells 299-E33-34 and 299-E32-10 at Low-Level Waste Management Area 1

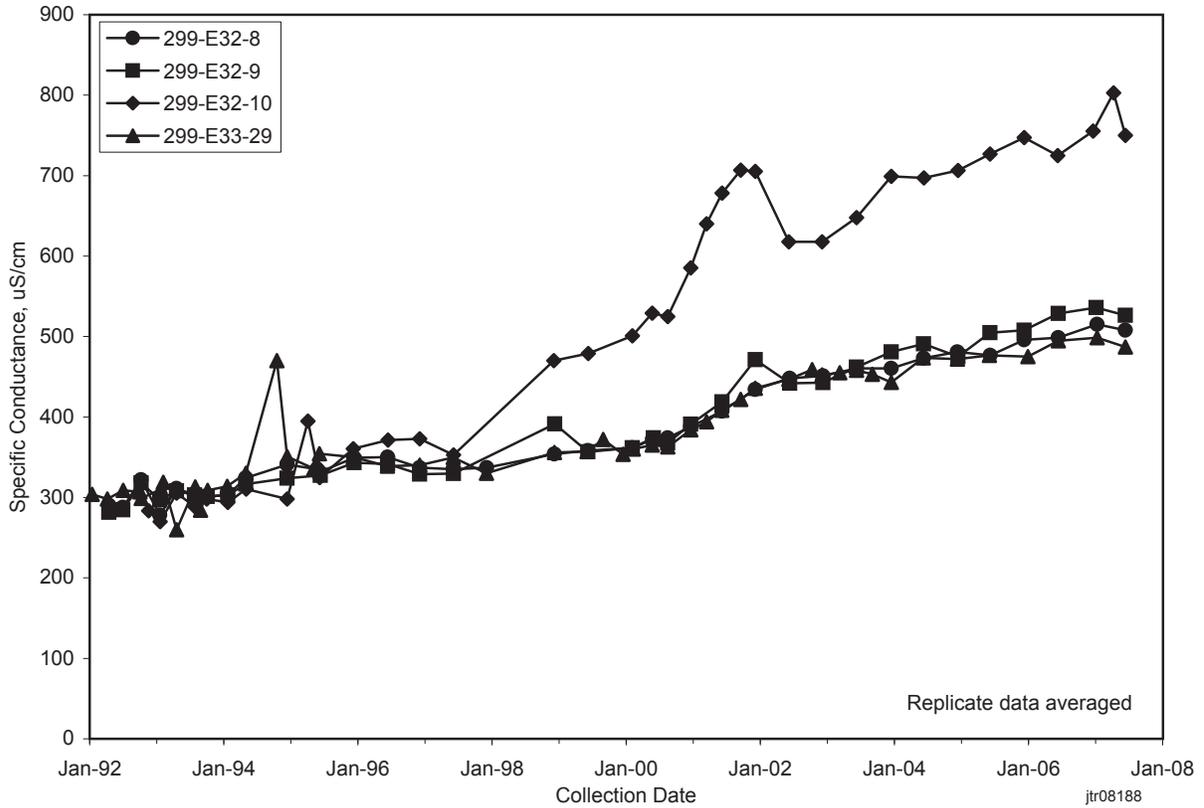


Figure 2.10-38. Specific Conductance at Low-Level Waste Management Area 1

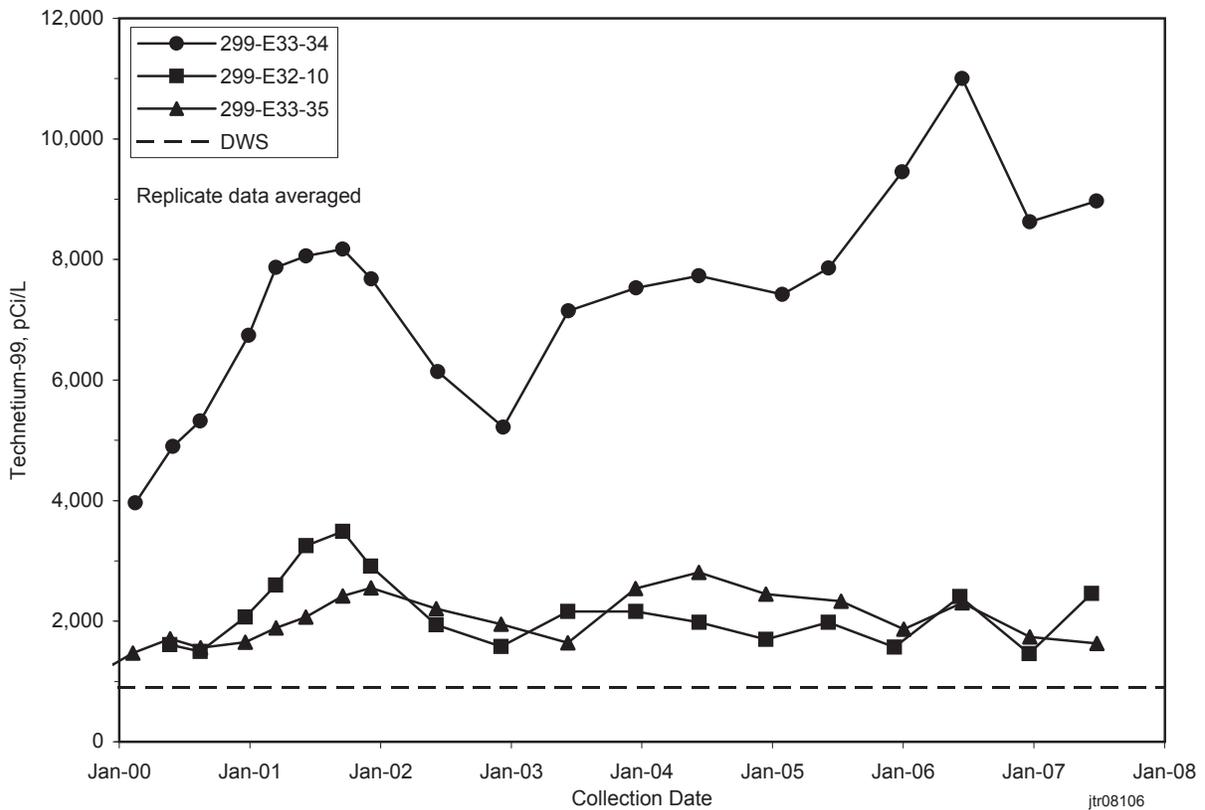


Figure 2.10-39. Technetium-99 Concentrations in Wells 299-E33-34, 299-E32-10, and 299-E33-35 at Low-Level Waste Management Area 1

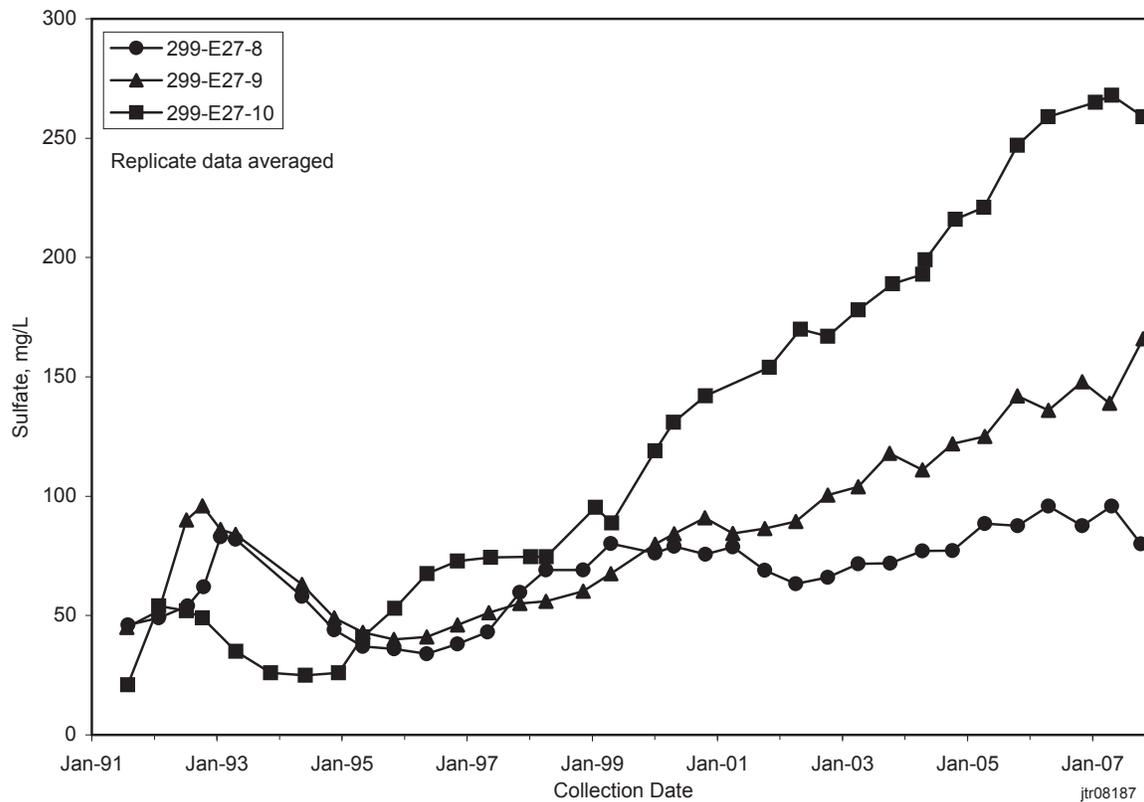


Figure 2.10-40. Sulfate Concentrations in the Southeastern Wells of Low-Level Waste Management Area 2

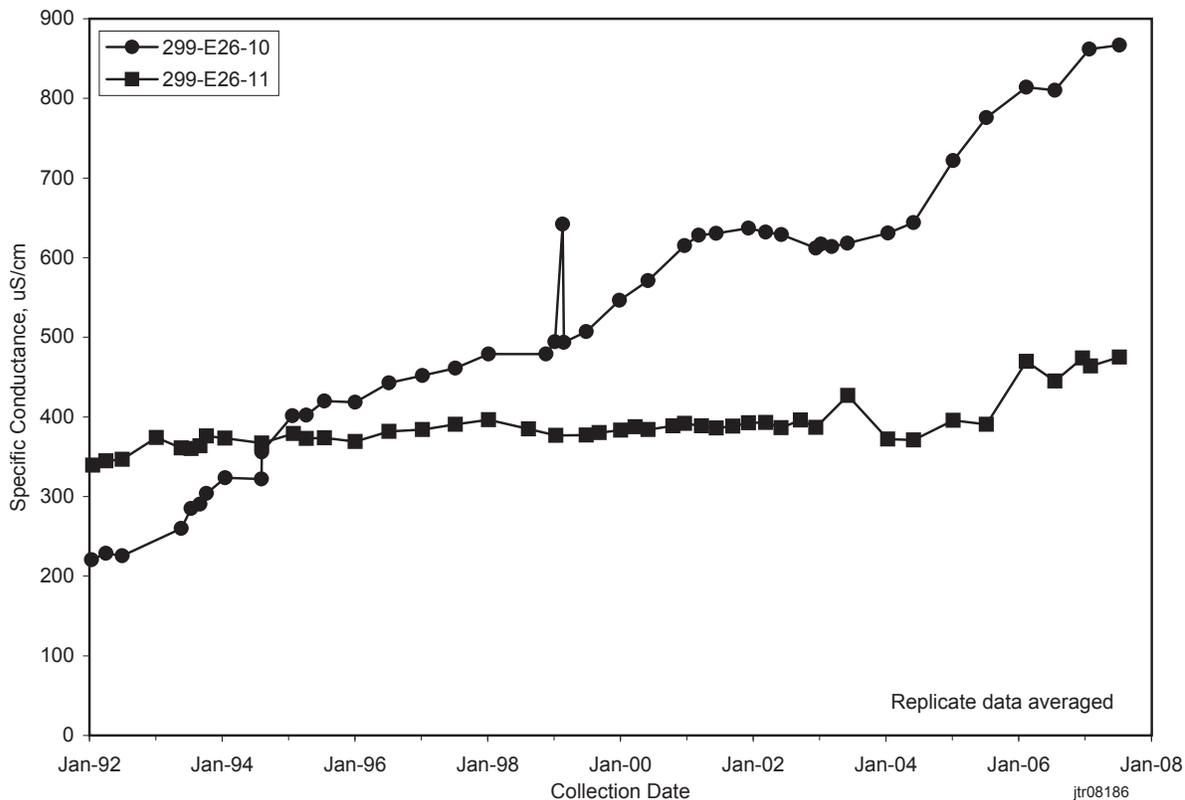


Figure 2.10-41. Specific Conductance in Wells 299-E26-10 and 299-E26-11 at Liquid Effluent Retention Facility

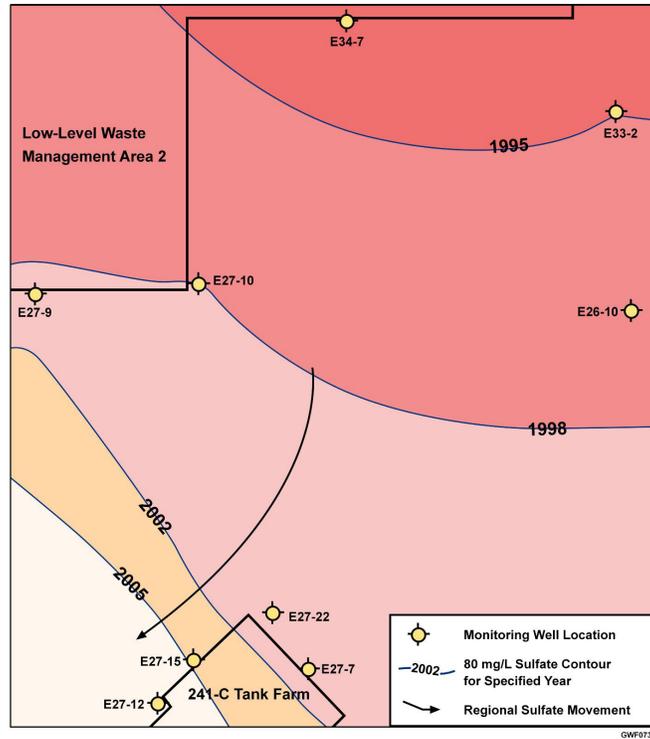


Figure 2.10-42. Migration of Sulfate Contamination Providing Flow Rate and Direction

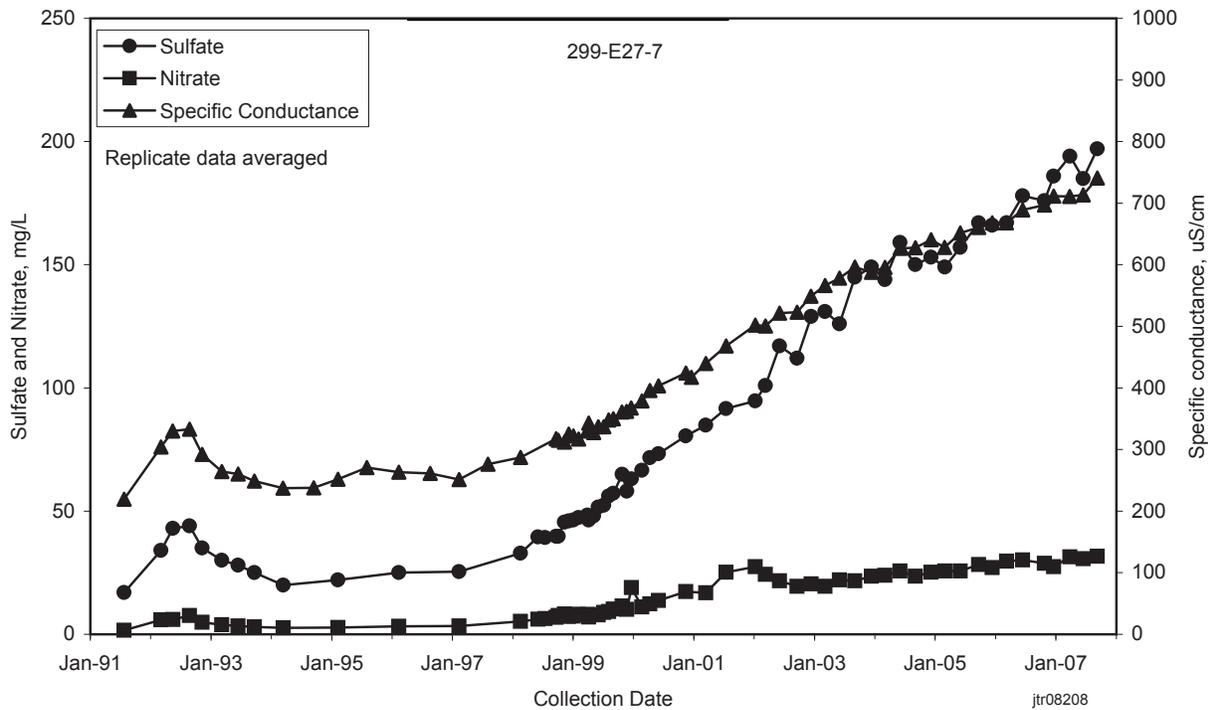


Figure 2.10-43. Sulfate, Nitrate, and Specific Conductance in Well 299-E27-7, Waste Management Area C

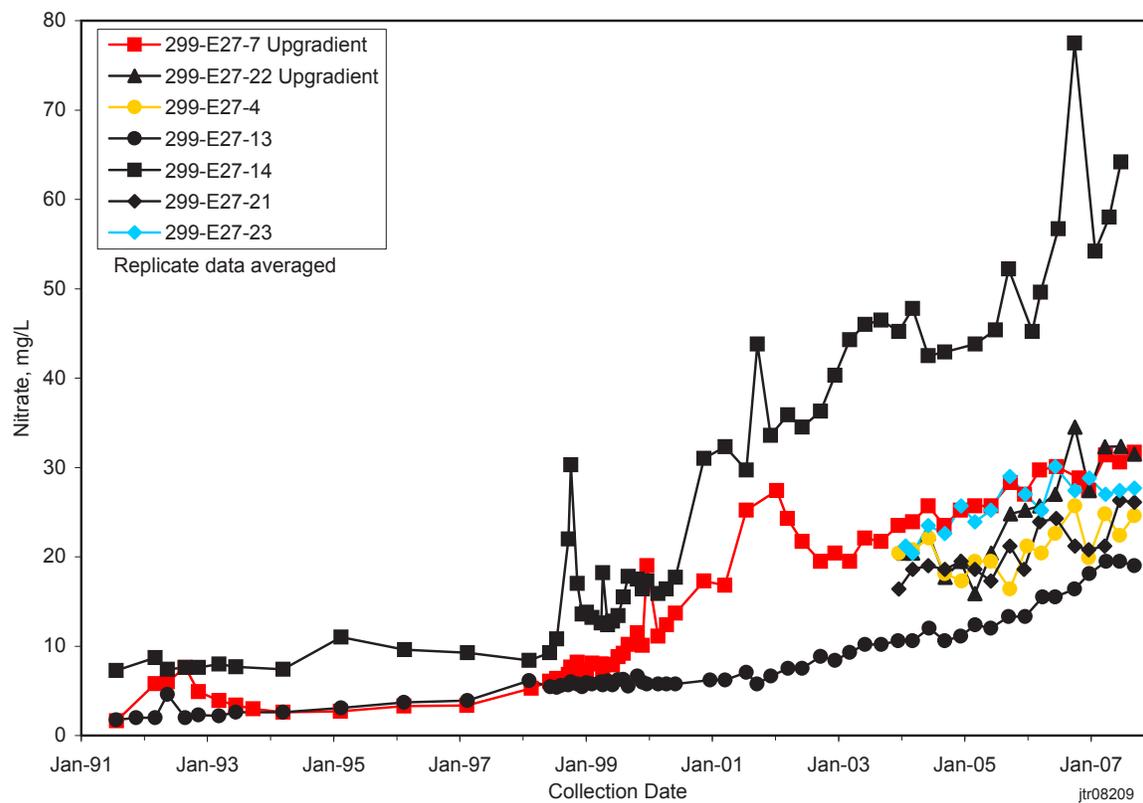


Figure 2.10-44. Nitrate Concentrations in Wells Monitoring Waste Management Area C

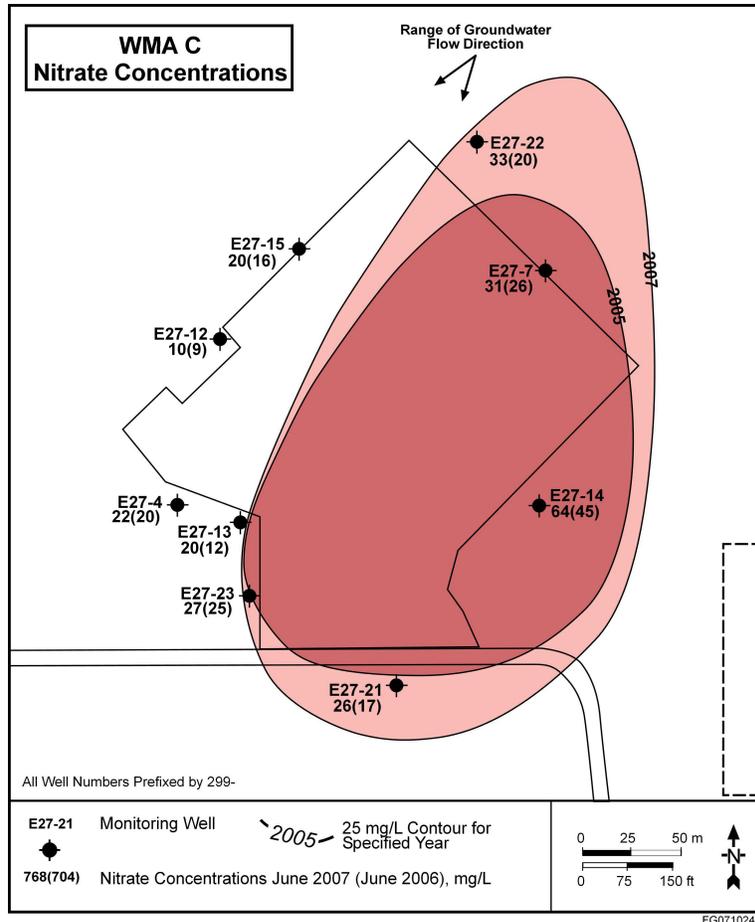


Figure 2.10-45. Nitrate Plume Migration at Waste Management Area C, June 2005 and June 2007

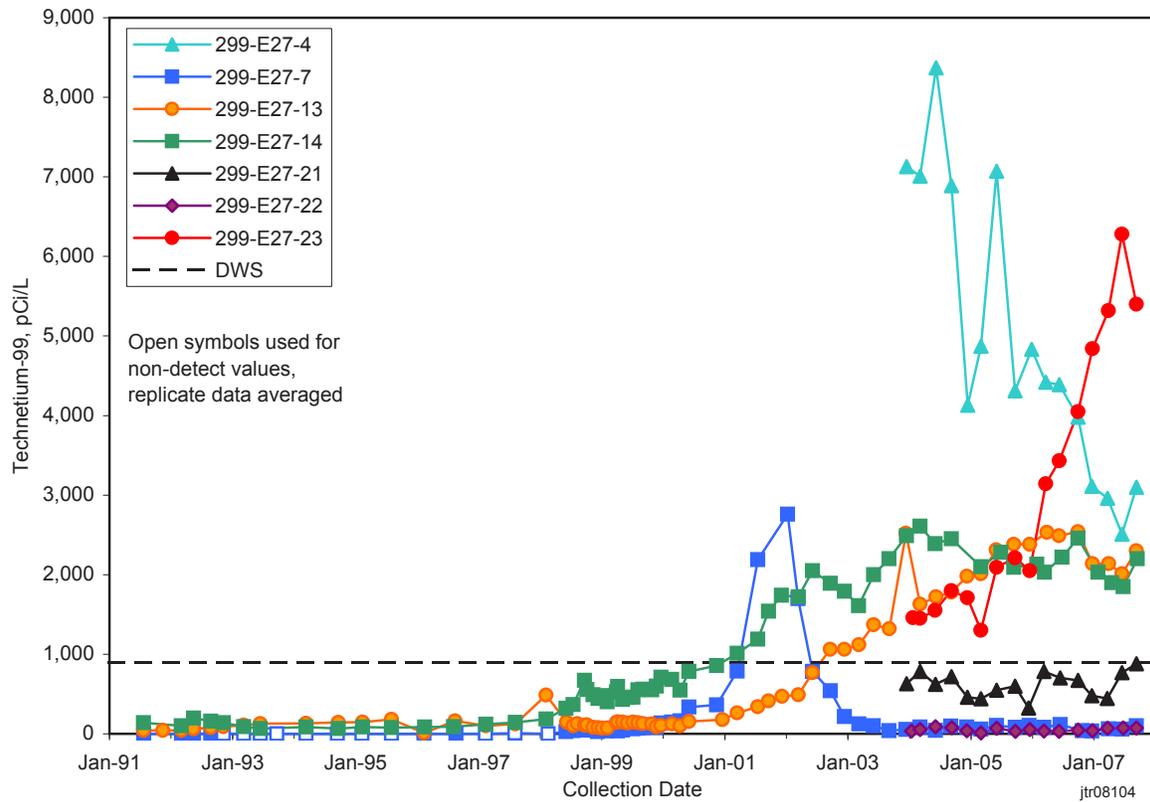


Figure 2.10-46. Technetium-99 Concentrations in Wells at Waste Management Area C

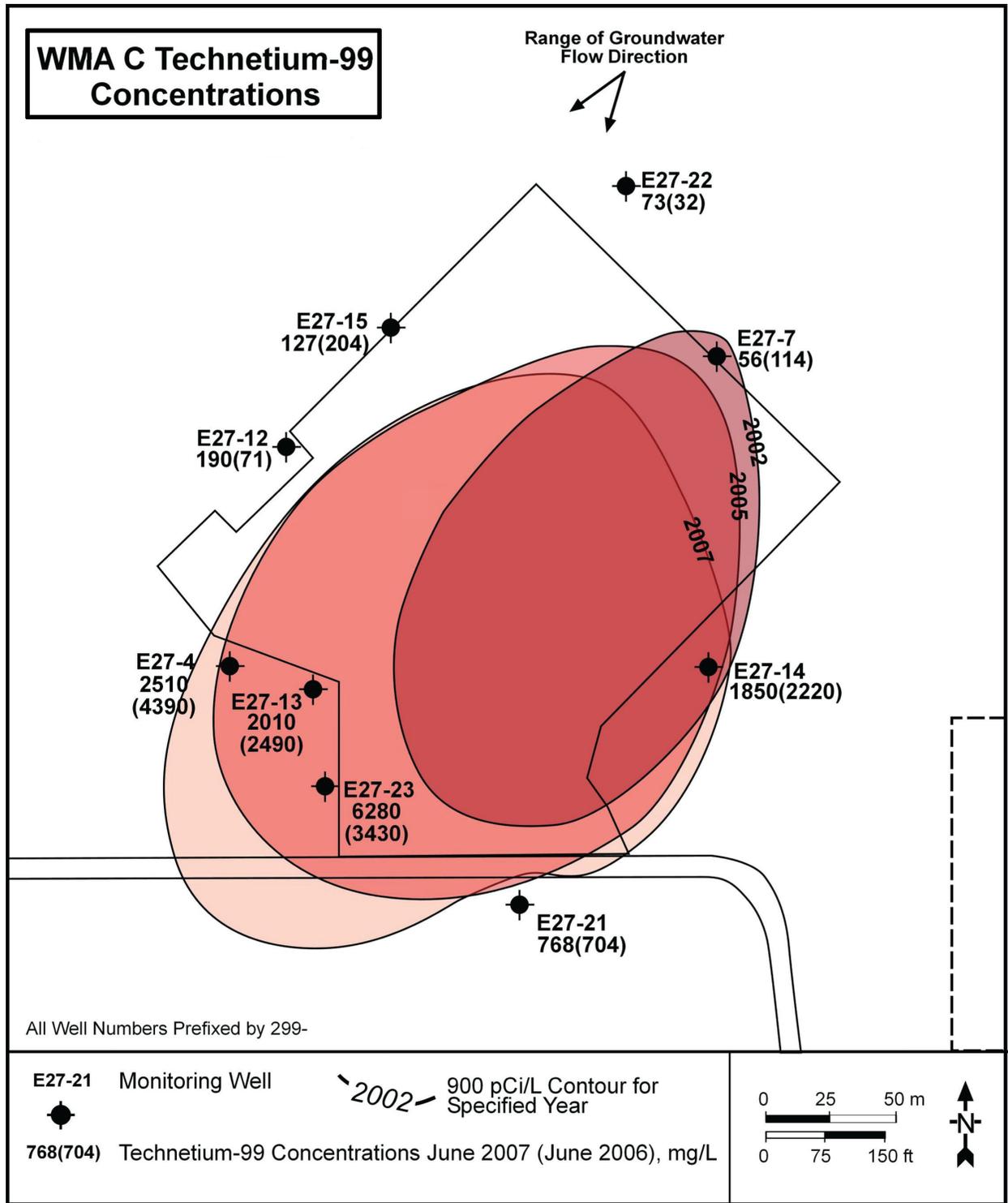


Figure 2.10-47. Technetium-99 Plume Migration at Waste Management Area C, June 2002, June 2005 and June 2007

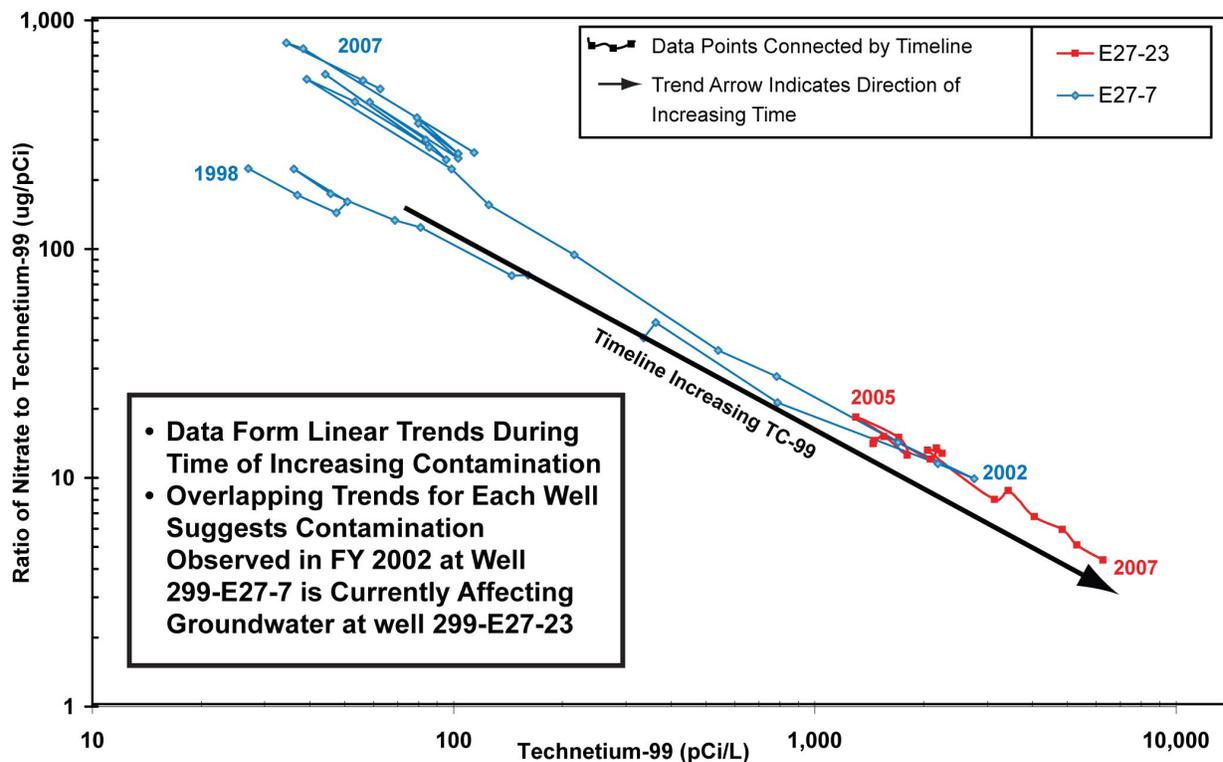
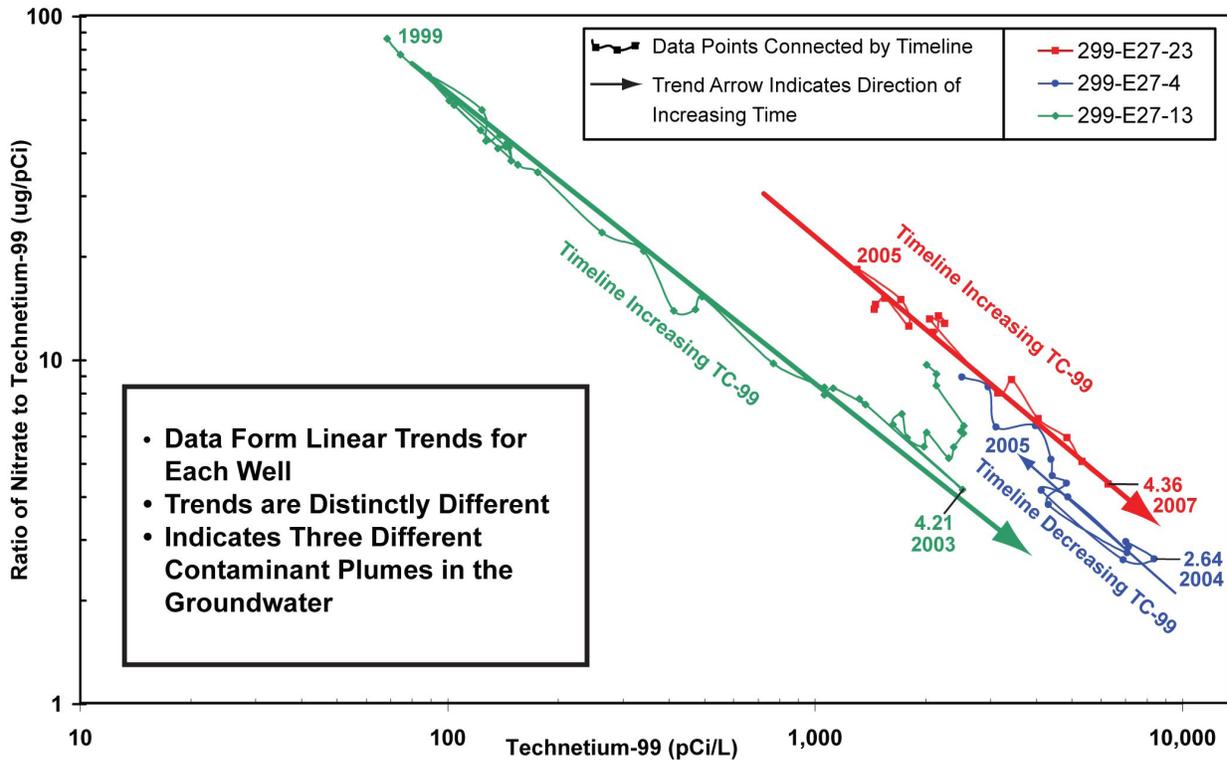
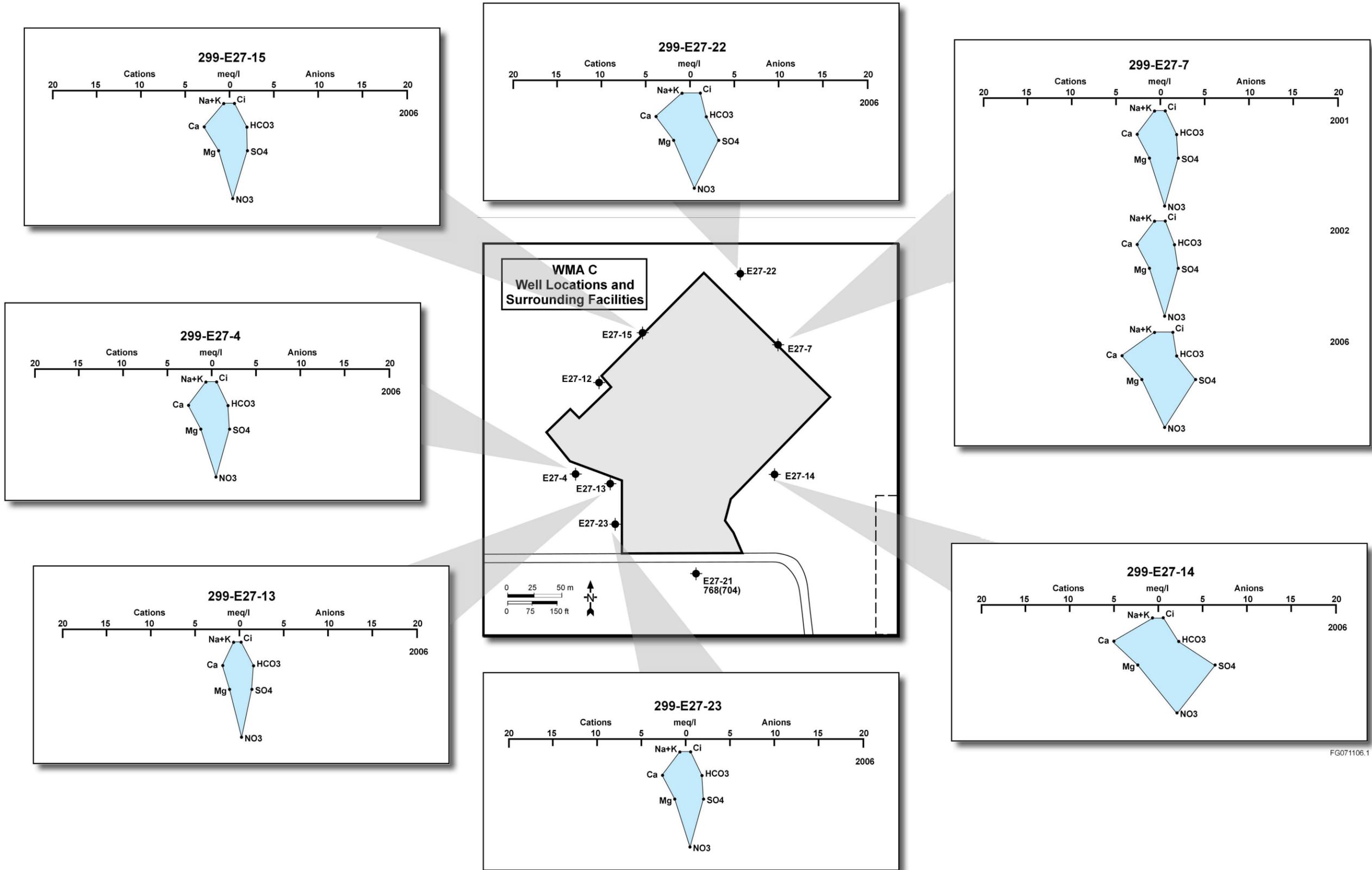


Figure 2.10-48. Ratios of Nitrate to Technetium-99 at Waste Management Area C



FG071106.1

Figure 2.10-49. Stiff Diagrams Mapped to Show Total Ion Chemistry in the Groundwater at Waste Management Area C