2.9 200 East Area

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For the purpose of describing groundwater contamination, the 200 East Area is divided into two parts:

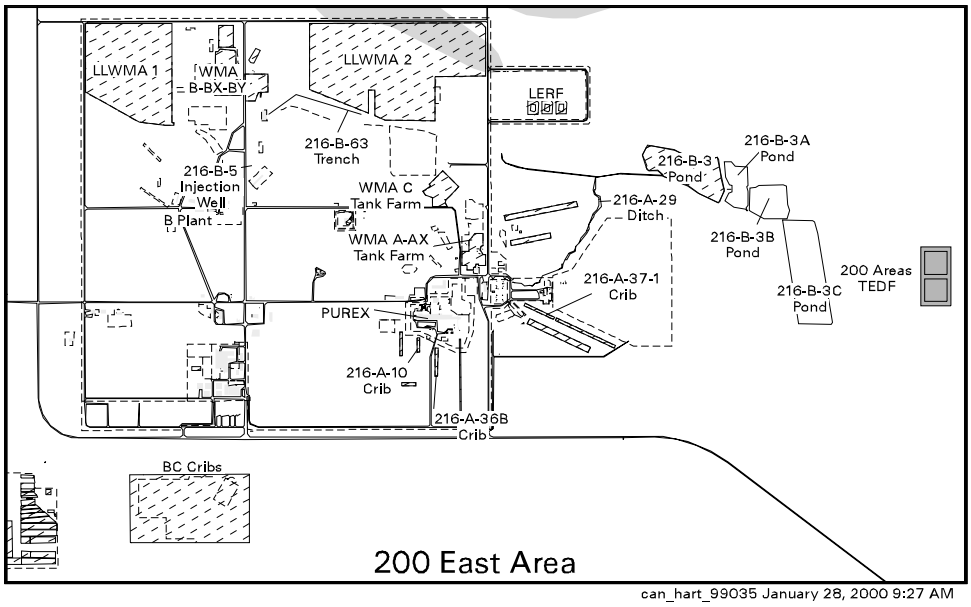
- the B Plant area in the northwestern and northern parts of the 200 East Area
- the Plutonium-Uranium Extraction (PUREX) Plant area in the southeast and eastern parts of the 200 East Area.

The vast majority of the 200 East Area groundwater contamination has its source in these two areas.

The discussion in this section is divided into two parts representing these two areas within the overall 200 East Area. Within each section, the general groundwater flow, major contaminants, and specific *Resource Conservation and Recovery Act of 1976* (RCRA) facility monitoring are discussed. The major groundwater contaminants of the 200 East Area are tritium, iodine-129, technetium-99, uranium, strontium-90, plutonium, and nitrate.

2.9.1 B Plant

This section describes the area associated with facilities surrounding B Plant and extends north to the perimeter fence. B Plant was used to recover plutonium from irradiated fuel using the bismuth phosphate process from 1945-1956. Contamination in the B Plant area is the result of waste disposal to the soil column at a variety of locations. The sources of waste actively monitored for contamination include the 216-B-5 injection well, the Waste Management Area B-BX-BY, 216-B-63 ditch, and Low-Level Burial Grounds Waste Management Areas 1 and 2. Throughout the active life of B Plant, the waste that was disposed to these facilities included effluent from process streams, chemicals, cooling water, and condensate. Due to similarity in the chemical makeup of some of these waste streams, it is difficult to assign specific groundwater contaminants to individual receiving sites. Certainly there are instances where generally high contaminant concentrations can be assigned to waste facilities (e.g., tank farms versus low-level burial grounds). The broadly distributed groundwater plumes throughout the eastern Central Plateau, however, are the result of disposal to



unspecified waste units within the B Plant area and adjacent PUREX complex (Section 2.9.2).

Monitoring Objectives at B Plant

Groundwater monitoring is conducted near B Plant:

- triennially to annually to describe the nature and extent of contamination
- semiannually to monitor trends in variable constituents/wells
- semiannually to detect possible impact of three RCRA waste management areas
- quarterly to assess contamination from one RCRA waste management area.

2.9.1.1 Groundwater Flow

The difference in water-table elevation across the B Plant area and the northwestern part of the 200 East Area is very small, making it difficult to determine groundwater flow direction and rate from water-table maps. Much of what is known about flow direction can be derived from plume maps and multiple trend plots of water levels at wells. In general, groundwater elevations in the unconfined aquifer continue to decline throughout the B Plant area, a result of the subsiding groundwater mound at 216-B-3 pond (see Section 2.9.2.11).

In the past, groundwater flow in the B Plant area was to the northwest, which was responsible for the contaminant plumes such as tritium and technetium-99 that extend northwest toward the gap between Gable Butte and Gable Mountain. Part of the reason groundwater flow was to the northwest was the large volume of wastewater discharged at 216-B-3 pond. However, after discharges at 216-B-3 pond ceased (Section 2.9.2.11), its influence on groundwater flow in the B Plant area decreased. More recently, groundwater flow has changed from a northwestern flow to a western flow (see Section 2.9.1.10 and Table A.2) or southwestern flow (see Section 2.9.1.9).

2.9.1.2 Tritium

Tritium contamination is widespread throughout the northwestern part of the 200 East Area and extends north through the gap between Gable Mountain and Gable Butte and southeast toward the PUREX Plant (see Plate 3). Tritium contamination from B Plant has declined greatly because of natural decay. The peak concentrations are receding to the southeast

Although tritium concentrations in the B Plant area have declined since 1990, two wells in the B Plant vicinity continue to have tritium exceeding the drinking water standard (Plate 3 and Figure 2.9-1). Well 299-E28-2 had a reported concentration of 23,000 pCi/L in April 1999. During April 1998, the reported value was 34,000 pCi/L. The tritium concentration in well 299-E28-24 was 30,700 pCi/L. This well was not sampled for tritium in fiscal year 1998. The last time this well was sampled (in September 1993), the reported tritium value was 57,000 pCi/L.

Another pulse of tritium at levels above the interim drinking water standard can be found between Gable Mountain and Gable Butte (see Plate 3). Monitoring well 699-61-62 indicated a maximum average concentration for fiscal year 1999 of 42,000 pCi/L and 54,000 pCi/L for fiscal year 1998. Like tritium concentrations farther south by B Plant, tritium concentrations between Gable Mountain and Gable Butte have declined with time. Peak concentrations do not appear to be moving. Sources of the tritium have not been defined, but are presumed to be B Plant facilities.

2.9.1.3 Iodine-129

Contamination from iodine-129 is present throughout the B Plant area. Like the tritium plume, the iodine-129 plume extends to the northwest through the Gable Mountain-Gable Butte gap and southeast toward the PUREX Plant (Figure 2.9-2). Twenty-one wells had concentrations of iodine-129 above the drinking water standard (1.0 pCi/L) during fiscal year

1999. Four of the wells have iodine-129 values that are increasing. The remaining 17 wells had concentrations that declined or remained unchanged from fiscal year 1998 reported values. Iodine-129 concentrations range up to 6.5 pCi/L in well 299-E33-42.

Several wells between Gable Mountain and Gable Butte are sampled for iodine-129 to define the northern plume and to track the movement of this plume out of the 200 Areas (see Figure 2.9-2). The most recent results for these wells were below detection limits, but concentrations have been at or above the drinking water standard occasionally in the past (Figure 2.9-3).

2.9.1.4 Technetium-99

A plume of technetium-99 (interim drinking water standard 900 pCi/L) extends from the area of Waste Management Area B-BX-BY to beyond the 200 East Area boundary to the northwest (Figure 2.9-4). The plume has two parts. The larger part of the plume is to the north and possibly represents early releases of technetium-99 from the BY cribs. Detection of technetium-99 at levels lower than the interim drinking water standard (900 pCi/L) north of the Gable Mountain-Gable Butte gap indicates that technetium-99 has moved north, into, and through the gap. The southern portion of the plume lies mostly within the boundary of the 200 East Area. This portion of the plume may be associated with west-southwest groundwater flow and movement of more recent BY cribs contamination. For a more detailed discussion, see Section 2.9.1.9).

Overall, technetium-99 in the B Plant area is increasing in concentration. In the area of Waste Management Area B-BX-BY, 17 wells exceeded the interim drinking water standard for technetium-99 in fiscal year 1999. Fourteen of those wells show a significant increase in concentration. The concentration of technetium-99 ranges to more than 5,000 pCi/L within the BY cribs area.

2.9.1.5 Uranium

Uranium contamination in the B Plant area is limited to three isolated areas (refer to Plate 1 for locations):

- wells monitoring Waste Management Area B-BX-BY
- wells near the 216-B-5 injection well
- wells at the 216-B-62 crib (299-E28-21 and 299-E28-18).

Although the trend is decreasing slightly since 1998, many wells in all three of these areas exceeded the 20-µg/L proposed drinking water standard during fiscal year 1999. Section 2.9.1.9 discusses uranium contamination at Waste Management Area B-BX-BY in more detail.

2.9.1.6 Strontium-90 and Cesium-137

Several wells in the vicinity of B Plant have trends indicating historical concentrations of strontium-90, but the highest levels are near the 216-B-5 injection well. Four wells (299-E28-2, 299-E28-23, 299-E28-24, and 299-E28-25) had concentrations of strontium-90 above the interim drinking water standard (8.0 pCi/L) in fiscal year 1999. Two wells (299-E28-23 and 299-E28-25) are the only ones exceeding the derived concentration guide (1,000 pCi/L). The samples were a mixture of filtered and unfiltered groundwater but the data do not show any significant difference in concentration.

Strontium-90 values that exceed the drinking water standard in the B Plant area range in concentration from 32 to 10,000 pCi/L. The highest concentration (10,000 pCi/L) was reported from well 299-E28-23, which is near the 216-B-5 injection well. Of the four wells exceeding the drinking water standard, well 299-E28-23 is the only well that shows a steady increase in levels of strontium-90 since 1990. Well 299-E28-2 had rising strontium-90 concentrations until early 1999, when it dropped suddenly. Concentrations in wells 299-E28-24 and 299-E28-25 have declined since 1990.

During fiscal year 1999, of the four wells with concentrations of strontium-90 greater than the drinking water standard (8 pCi/L), only one well (299-E28-23) had concentrations of cesium-137 greater than the drinking water standard (200 pCi/L). The concentration of cesium-137 at well 299-E28-23 during December 1998 was 1,840 pCi/L. None of the wells had concentrations exceeding the derived concentration guide (3,000 pCi/L). The trends for cesium-137 for all four of the wells have been relatively stable since 1994.

Cesium-137, strontium-90, and uranium are present in groundwater near the former 216-B-5 injection well. Plutonium is also present, but levels are declining.

2.9.1.7 Plutonium

Plutonium-239 and -240 concentrations continue to be detected in unfiltered groundwater samples taken near the 216-B-5 injection well. The plutonium concentration in well 299-E28-23 was 65.8 pCi/L, the maximum level for the B Plant area, in fiscal year 1999. The concentration has been rising in this well since 1994 but showed no increase in concentration during fiscal year 1999. Wells 299-E28-24 and -25 also had concentrations above background. However, plutonium-239 and -240 concentrations in these wells have declined since 1994. Plutonium-239 and -240 adsorb well onto soil particles and, therefore, do not migrate far from the discharge source (i.e., the 216-B-5 injection well).

2.9.1.8 Nitrate

A nitrate plume originating in the 200 East Area extends beyond the boundary fence line, extending northwest to the Columbia River (Figure 2.9-5). The plume has two parts: (1) a western plume that extends from B Plant to the northwest, which appears to be a portion of a larger plume extending from the PUREX Plant, and (2) an eastern portion of the plume extending from the BY cribs toward the northwest. The two portions of the plume join northwest of the 200 East Area and extend northwest to the Columbia River.

Significant concentrations of nitrate can be found throughout the 200 East Area, but those exceeding the drinking water standard in the vicinity of B Plant extend northwest from the BY cribs and Waste Management Area B-BX-BY. Twenty-six wells reported nitrate results above the drinking water standard in fiscal year 1999, and fourteen increased in concentration. The highest nitrate concentration was found in well 299-E33-16 near the 216-B-8 crib. Groundwater samples from this well had a yearly average of 490 mg/L for fiscal year 1999, nearly double the nitrate concentration since fiscal year 1997. Nitrate groundwater contamination surrounding Waste Management Area B-BX-BY and the BY cribs is discussed further in Section 2.9.1.9.

2.9.1.9 Waste Management Area B-BX-BY Assessment Summary

Waste Management Area B-BX-BY includes underground single-shell tank farms B, BX, and BY located in the eastern part of the 200 East Area. In fiscal year 1991, a system of RCRA-compliant wells was installed around this area to monitor the quality of the groundwater (WHC-SD-EN-AP-012, WHC-SD-EN-AP-012, Rev. 1). In 1996, the waste management area was placed in a groundwater quality assessment program as required (WHC-SD-EN-AP-002), based on specific conductance values that were elevated above the critical mean (365.7 µS/cm) in downgradient well 299-E33-32 (see Figure A.15). The monitoring frequency was increased from semiannually to quarterly.

During 1997, nitrate and technetium-99 concentrations were above the drinking water standards of 45 mg/L and 900 pCi/L, respectively, in well 299-E33-41, between the B and BX Tank Farms. It was concluded that waste from the waste management area had, most likely, entered the groundwater and was detected in this well (PNNL-11826).

Although concentrations of nitrate and technetium-99 were rising in the groundwater along the western side of the waste management area, the source could not be identified. A further determination is being conducted to identify the rate and extent of groundwater contamination at Waste Management Area B-BX-BY.

RCRA Waste Management Area B-BX-BY contains single-shell tanks that may have contaminated groundwater with technetium-99 and nitrate. The hydraulic gradient is very flat, and the direction of groundwater flow is not known with certainty.

Groundwater Flow

The hydraulic gradient is nearly flat across the 200 East Area (Plate 2), making it difficult to determine upgradient versus downgradient locations from water-level measurements at wells. Part of this difficulty is related to surveying errors that create potential errors in water levels. In 1998, the Hanford Groundwater Monitoring Project changed the datum to which water levels are referenced (PNNL-12086, Section 3.3.2.1) to the North American Vertical Datum of 1988 (NAVD88). Previously, it had been the National Geodetic Vertical Datum of 1929 (NGVD29). Converting older survey data to elevations based on a NAVD88 datum can contribute to vertical errors as much as ~1 centimeter. Another source of error is introduced by specific surveys used to calculate vertical elevation. Even greater error than introduced by datum converting is introduced by using survey data from separate surveys. The overall result is that discrepancies between the data (datums) used have resulted in ambiguity in groundwater levels measured at wells.

However, a general flow direction can be estimated from water levels. Figure 2.9-6 shows hydrographs for 11 wells that are used to monitor the water table at Waste Management Area B-BX-BY and nearby Low-Level Waste Management Areas 1 and 2. Most of the water elevations reference a survey commonly referred to as NGVD29-2. This survey was used in preference to multiple surveys based on NAVD88.

In addition, as part of the RCRA assessment work, vertical plumbness was measured in several wells that appeared to complicate the interpretation of local flow. Well 299-E33-39 was surveyed in fiscal year 1999 because data from that well consistently displayed anomalously low water elevations. Based on deviations from vertical, determined with a downhole gyroscope, a 12-centimeter correction was added to the water levels in this well.

The data from selected wells shown in Figure 2.9-6 depict general, local, water-level trend. Spurious and outlying data were removed from the individual well trends to facilitate interwell comparisons. The upgradient water elevations are in wells to the north, indicating a southwest flow direction. Although there are data from a few wells in this area that do not agree with this trend, the majority of wells investigated appear to mirror this general southwestern flow. This direction is consistent with recent interpretations of plume movement and with in situ flowmeter results (BHI-00442).

As can be seen in the hydrographs, it could be misleading to determine the direction of groundwater flow by using water-table elevations at several wells collected over a very small time interval. Consequently, it may not be appropriate to provide a three-point solution. However, based on observations of recent contaminant movement and on wells that consistently appear to be at the same relative elevations, an estimated flow direction lies between 200 and 250 degrees azimuth.

The average linear flow rate is calculated to be 0.9 meter per day (see Table A.2). This equates to 324 meters of effective groundwater movement per year. If discrete, highly permeable, flow channels are considered as the prime avenues of contaminant transport, then a flow rate of 0.9 meter per day may be low.

This relatively high flow velocity has implications that relate to the optimal sampling frequency at which the groundwater is monitored. Because the waste management area is less than 305 meters across, contamination related to leaking tank waste might move through the area in less than 1 year. Given the rapid movement of contaminate events seen in the past at well 299-E33-41 and Waste Management Area S-SX, semiannual or even quarterly sampling may not be sufficient to clearly identify and differentiate tank-related waste from background contamination left from discharges to the surrounding cribs, trenches, and reverse wells (PNNL-11810, PNNL-11826). As part of the RCRA Waste Management Area B-BX-BY assessment, a study is being conducted to determine the best sampling frequency for monitoring this area.

Groundwater Contamination

A discussion of the state of contamination surrounding Waste Management Area B-BX-BY is presented in this section, including historic constituent trends that depict the temporal and spatial distribution of contaminants. Several distinct groups of contaminants are recognized, based on spatial relationships and on identifying ratios of co-contaminants.

Although the primary inorganic constituents in tank waste at Waste Management Area B-BX-BY include aluminum, cesium-137, cyanide, nitrate, strontium-90, sulfate, technetium-99, uranium, and other heavy metals, most tank constituents are not mobile. The main tank constituents known to be mobile and used for tracking tank-related waste are nitrate and associated anions, technetium-99 (as TcO_4^-), and uranium. Groundwater samples are also analyzed for cobalt-60, which can be mobile in the presence of the cyanide anion.

Assessment monitoring at Waste Management Area B-BX-BY suggests there are three distinct plumes.

The following discussion centers on those constituents used to track contamination moving through the waste management area and to identify groups of contamination that, most likely, have different source histories. Rather than discuss each contaminant species separately, it is more constructive to discuss groups of constituents that appear centered on three different wells. The first group is centered on well 299-E33-7, where the primary constituents are cobalt-60, cyanide, nitrate, technetium-99, and tritium. The second group is centered on well 299-E33-16 that has high nitrate, elevated technetium-99, and slightly elevated chromium. The third set of contaminants is located at well 299-E33-44, just east of the BY Tank Farm. This group has elevated nitrate, nitrite technetium-99, and uranium. The nature of contamination observed at each of these locations is described below. The location map is found in Appendix A (Figure A.15).

Well 299-E33-7. The highest recent values of technetium-99 (7,030 pCi/L) are observed in the northern area of the BY cribs at well 299-E33-7. The drinking water standard is 900 pCi/L. Technetium-99, however, has risen in wells farther south in the BY cribs and along the western side of the waste management area (Figure 2.9-7). The elevated nitrate apparently migrated with the technetium-99 and was also found in wells at the northeastern corner of Low-Level Waste Management Area 1 (Figure 2.9-8). Nitrate concentrations in all the wells noted in Figures 2.9-7 and 2.9-8 are above the 45 mg/L maximum contaminant level. The July 1999 concentration of nitrate in well 299-E33-7 was 337 mg/L. Analyses of groundwater from wells at Waste Management Area Low-Level Burial Grounds 1 indicate that technetium-99 is also rising at the northwest corner of the 200 East Area and contamination appears to be moving in a southwestward direction, recently impacting well 299-E33-35 (Figure 2.9-9). High values of tritium (maximum of 10,500 pCi/L at well 299-E33-7) are consistent with the elevated technetium-99.

With the recent data collected for the RCRA assessment, it appears that nitrate and technetium-99 have been rising since the early 1990s. This observation

is consistent with the recent analysis of the groundwater flow direction from the northeast to the southwest. This plume movement implies that the source is the original BY crib plume moving back through the area with the lowering of the water table farther to the east. Nitrate, along with chloride, sulfate, and associated cations, is the apparent cause of the elevated specific conductance value first observed in well 299-E33-32 in 1996.

Cobalt-60 and cyanide are also detected in the groundwater underneath the BY cribs in wells 299-E33-7, -38 and -5. The highest values were found in June 1998 at well 299-E33-7 (66 pCi/L for cobalt-60 and 347 μg/L for cyanide). The drinking water standards for cobalt-60 is 100 pCi/L and for cyanide is 200 μg/L. Cyanide and, possibly, cobalt-60 were also found southeast of the BY cribs in samples from well 299-E33-13. Contamination observed in well 299-E33-13 recently assumed a character similar to that at well 299-E33-7. Cyanide and cobalt-60 were not found in other wells in the area. Consequently, it is not yet clear whether these constituents are moving with the nitrate, technetium-99, and tritium or are entering the groundwater from the vadose zone.

Well 299-E33-16. The main characteristic of contamination detected in the groundwater at this well is an extremely high nitrate concentration, close to 500 mg/L (Figure 2.9-10). Associated with the nitrate is technetium-99 above the drinking water standard, at ~2,000 pCi/L in June 1999 (see Figure 2.9-10). Also, chromium is elevated at 53.5 μg/L but below the 100-μg/L maximum contaminant level. Nitrate, elevated above the maximum contaminant level, was also detected at surrounding wells 299-E33-15, -17, and -20. However, the elevated technetium-99 and chromium are not found in the groundwater at these wells, suggesting that the contamination at well 299-E33-16 is localized.

Well 299-E33-44. This well was constructed in 1998 to sample groundwater between high levels of technetium-99 (12,000 pCi/L in August 1997) and uranium (maximum of 81 μg/L in November 1998) detected at well 299-E33-41 and elevated nitrate, technetium-99, and uranium found in wells 299-E33-13 and -38. The relationship between the technetium-99 and uranium in well 299-E33-41 is shown in Figure 2.9-11. Similar increases in chloride and sulfate correlated with the high frequency technetium-99 pulses. The associated uranium traveled through the local area at a retarded flow rate, with respect to the more mobile anions, but repeated the same high frequency pattern. These events are discussed in detail in PNNL-11826 and PNNL-11793.

Initial groundwater samples from well 299-E33-44, collected in October 1999, revealed that technetium-99 and nitrate are above the drinking water standard (4,480 pCi/L and 95 mg/L, respectively). The highest levels of uranium in the area were found here . The maximum concentration was found in April 1999 (350 μg/L). Unlike the technetium-99 and nitrate observed to the north, the groundwater in this well has neither cyanide nor cobalt-60 in detectable quantities. Also, relatively high levels of nitrite (400 to 600 μg/L) were found in the groundwater samples from this well. A check for coliform proved to be negative. Efforts are currently under way to sample well 299-E33-9 inside the BY Tank Farm to ascertain if this contamination suite is local to well 299-E33-44 or if there is a small plume located under Waste Management Area B-BX-BY.

Contaminant Ratios. One diagnostic tool for identifying different contaminant plumes in the groundwater surrounding Waste Management Area B-BX-BY is the ratio of nitrate to technetium-99. Tank-related sources are expected to have low ratios because of the large concentrations of technetium-99 with respect to nitrate estimates in tank wastes (HNF-SD-WM-TI-740). For example, the ratio of nitrate (in mg/L) to technetium-99 (in pCi/L) for the pulses of contamination shown in Figure 2.9-11 are approximately four. Ratios based on current estimates of tank waste are typically below four. These ratios are low compared to background values, which are in the thousands.

Nitrate to technetium-99 ratios for data collected during the second quarter of 1999 are mapped in Figure 2.9-12. For contamination associated with well 299-E33-7, ratios generally range from 40 to 50. Ratios within this range cover the BY cribs, the western side of the waste management area, and extends to the west at wells 299-E33-26, -34, and -35. With nitrate and technetium-99 increasing in wells 299-E33-28, -32, and -43, the region displaying this signature is expected to increase.

During the time of northward movement, prior to the early 1990s, the highest concentrations of nitrate and technetium-99 were found in well 699-50-53A, located north-northeast of the study area. The nitrate to technetium-99 ratio from this well during the early 1990s was 42, for a technetium-99 value of 17,000 pCi/L and 716 mg/L of nitrate. This ratio is very similar to that of the contamination currently moving through the northern part of this waste management area.

The nitrate to technetium-99 ratio at well 299-E33-16 is above 200 because of high nitrate levels with low technetium-99 values (less than half that observed at wells 299-E33-7 or -44). As can be seen in Figure 2.9-12, none of the surrounding wells have a similar ratio. Wells immediately to the north, east, and south have high nitrate values but do not have technetium-99 above the drinking water standard, resulting in much higher ratios. The contamination detected in this well appears to have a limited spatial extent. It may be that at least part of the aquifer at this site is locally isolated by structure on the basalt. The relief on the top of the basalt can be as much as 4.3 meters, which is similar to the aquifer thickness at this well. If the basalt surface is locally depressed, then the contamination found in the groundwater may be residual from liquid waste discharged to the 216-B-8 crib.

Finally, the ratios at wells 299-E33-44 and -41 (~25) are noticeably lower than those wells in the surrounding area. The nitrate and technetium-99 levels at well 299-E33-41 are significantly low, both currently below the drinking water standard. If a groundwater sample can be collected from well 299-E33-9, located west of well 299-E33-44 but within the tank farm boundaries, further conclusions may be possible concerning the source of this groundwater contamination at well 299-E33-44.

Correlation with Possible Sources

The contamination discharged to the ground at the BY cribs appears to be migrating from the north in a southwesterly direction, impacting the groundwater under the BY cribs and the northwestern part of Waste Management Area B-BX-BY. This plume, consisting of nitrate, technetium-99, and tritium, is monitored as it moves through the BY and BX tank farms into the northeastern corner of Low-Level Waste Management Area 1. It is unclear whether the cobalt-60 and cyanide associated with the original plume are moving through the area. Although these contaminants are detected in the groundwater under the BY cribs, as of May 1999 they have not been detected farther to the west or south, except in well 299-E33-26.

The elevated chromium, nitrate, and technetium-99 that are detected in the groundwater at well 299-E33-16 appear to be local. This region of the groundwater has only recently been monitored, when assessment level monitoring began. Consequently, it is not known how long the nitrate and technetium-99 have been above the drinking water standard. If the local aquifer is hydraulically isolated from the BY crib plume, it may be difficult to determine trends or changes in the groundwater chemistry at well 299-E33-16.

The origins of the contamination at well 299-E33-44 are, as yet, not understood. The lower nitrate to technetium-99 ratio and the high uranium values may indicate the contamination is from tank waste. It may be possible to determine the source of the contamination after groundwater samples from well 299-E33-9 are analyzed.

2.9.1.10 216-B-63 Trench RCRA Parameters

Groundwater monitoring continues to provide evidence that no dangerous non-radioactive constituents

from the site have entered groundwater from this trench (see Appendix A). RCRA interim status indicator parameters are pH, specific conductance, total organic carbon, and total organic halides (40 CFR 265.92[b][3]). Included in the analysis list for this trench are a gamma scan, alkalinity, gross beta, and turbidity. Analytical results have revealed no contamination that could be attributed to this facility. Groundwater analysis continued to indicate an increase in concentrations of calcium, magnesium, sodium, and sulfate in several wells. However, the concentration of these constituents did not exceed maximum contaminant levels. The reason(s) for these increases are unknown, but they probably indicate the addition of relatively clean wastewater to the groundwater system possibly from 216-B-3 pond. The rate of change in concentration, however, has slowed and may indicate that groundwater chemistry is stabilizing beneath the facility.

RCRA monitoring at the 216-B-63 crib indicates the site has not contaminated groundwater.

2.9.1.11 200 East Low-Level Burial Grounds

The two low-level burial grounds in east area, Low-Level Waste Management Area 1 and Low-Level Waste Management Area 2, are monitored under interim status detection monitoring.

Low-Level Waste Management Area 1

The groundwater monitoring network for Low-Level Waste Management Area 1 continues to meet all RCRA requirements. Sampling is done semiannually at 16 monitoring wells for the constituents listed in Table A.39. Water levels are continuing to decline in the 200 East Area, but none of the monitoring wells in Low-Level Waste Management Area 1 are expected to go dry within the next 10 years. Based on contaminant plume movement in previous years, groundwater flow direction was interpreted to be toward the northwest with flow rates less than 0.5 meter per day (Table A.2). However, in recent years, the direction of groundwater flow in the northwestern part of the 200 East Area is changing from a northwestern flow to a more southern or southwestern flow. See Section 2.9.1.9 for a detailed discussion of groundwater flow direction and flow rates at Waste Management Area B-BX-BY.

The upgradient/downgradient comparison value for specific conductance was consistently exceeded in well 299-E33-34 in fiscal year 1999. Nitrate at levels well above the 45 mg/L maximum contaminant level was the major contributor to this exceedance (see Figure 2.9-5). Nitrate levels in nearby wells 299-E32-10 and 299-E33-28 also exceeded the maximum contaminant level. The source of the nitrate contamination is assumed to be from the cribs to the east of Low-Level Waste Management Area 1. Elevated nitrate is also present in wells on the southern and western sides of this area. Values exceeded the maximum contaminant level in wells 299-E28-26, 299-E32-2, 299-E32-3, and 299-E32-6. These high levels were associated with the nitrate plume originating from southeast of Low-Level Waste Management Area 1 (see Section 2.9.1.8).

Low-Level Waste Management Area 2

Contamination indicator parameters were sampled semiannually (see Table A.41) in compliance with RCRA interim status regulations at this facility. Groundwater flows to the west at 0.06 to 0.8 meter per day (see Table A.2). The groundwater monitoring network continues to provide adequate coverage. However, if the decline in water levels in the area continues at the current rate additional wells are expected to go dry in ~3 years. Additional wells may be required in some instances, but many of the monitoring wells

Low-level waste management areas 1 and 2 are monitored as RCRA sites. Data from fiscal year 1999 indicated they have not contaminated groundwater.

in this network are at or near the top of basalt. Alternative methods to monitor this waste management area may be necessary to determine contaminant releases.

There is no evidence of groundwater contamination from Low-Level Waste Management Area 2. The upgradient/downgradient comparison value for specific conductance is consistently exceeded in upgradient well 299-E34-7. The major causes of increased conductivity are sulfate, nitrate, and calcium. Nitrate exceeded the 45 mg/L maximum contaminant level in this well. There are no apparent sources of sulfate or nitrate in Low-Level Waste Management Area 2 near well 299-E34-7. The source of these constituents is unknown.

The quadruplicate averages for total organic carbon at well 299-E27-10 and for total organic halogen at well 299-E34-3 exceeded the established upgradient/downgradient comparison values in the January 1999 sampling events. Both of these exceedances were attributed to suspicious values reported by the laboratory. The values for both constituents returned to normal ranges in samples collected in April 1999.

2.9.2 PUREX Plant

Numerous disposal facilities received waste from PUREX Plant operations. In particular, numerous cribs to the south and east of the PUREX building impacted groundwater quality over a large area of the site. The most extensive and significant contaminants are iodine-129, nitrate, and tritium. Three cribs (216-A-10, 216-A-36B, and 216-A-37-1) are at least partially responsible for the significant contamination and were monitored in accordance with RCRA in fiscal year 1999. Monitoring results indicate that the impact to groundwater originates from other facilities as well. These other facilities are located generally northeast and east of the plant, that are being addressed under the CERCLA/RCRA past-practice process. The 216-A-29 ditch, B Pond, and high-level waste tanks in waste management areas A-AX and C also are monitored in accordance with RCRA. However, to date there is no evidence to indicate that these sites have contaminated groundwater.

Monitoring Objectives at PUREX Plant

Groundwater monitoring is conducted near PUREX Plant:

- triennially to annually to describe the nature and extent of contamination
- semiannually to monitor trends in variable constituents/wells
- semiannually to detect possible impact of five RCRA waste management areas
- quarterly to assess contamination from one RCRA waste management area
- quarterly or semiannually to detect possible impact of the Treated Effluent Disposal Facility.

2.9.2.1 Groundwater Flow

In the 200 East Area, groundwater flows primarily in two general directions: to the northwest through Gable Gap (located between Gable Mountain and Gable Butte) and to the southeast and east toward the Columbia River (see Plate 2). These flow directions are based on contaminant-plume maps and water-elevation data. However, the location of the divide between flow to the northwest and flow to the southeast is not discernible because the water table in the 200 East Area is nearly flat, which is primarily the result of a zone of high transmissivity in this region.

Groundwater flow rate and direction beneath the individual waste facilities vary and are discussed in the following sections on RCRA monitoring.

2.9.2.2 Tritium

The highest tritium concentrations in the 200 East Area continued to be found in wells near cribs that received effluent from the PUREX Plant (see Plate 3). Activities of more than 2 million pCi/L (the derived concentration guide) were detected only in well

299-E17-9 next to the 216-A-36B crib (Figure 2.9-13). The maximum concentration detected in this well in fiscal year 1999 was 3.87 million pCi/L in October 1998, which was also the maximum tritium concentration detected in any well on the Hanford Site during fiscal year 1999. Tritium concentrations that exceeded the 20,000-pCi/L interim drinking water standard continued to be found in many wells affected by cribs near the PUREX Plant.

Prior to fiscal year 1998, tritium levels measured in well 699-37-47A, near the southeastern corner of the 200 East Area and completed in 1996, remained below 20,000 pCi/L. The April 1998, October 1998, and April 1999 levels were 35,000, 36,000, and 31,000 pCi/L, respectively. The rise in tritium in this well is probably due to the reduction in wastewater volume discharged in the vicinity of 216-B-3 pond. Well 699-37-47A is very near the mixing area of groundwater from the northwest that has higher tritium concentration and groundwater from the 216-B-3 pond area that has lower tritium levels. As the influence of wastewater volumes in the 216-B-3 pond area continues to shrink, the mixing area for groundwater from the two sources (near well 699-37-47A) becomes more dominated by groundwater from the northwest that has higher tritium concentrations.

The movement of the widespread tritium plume (see Plate 3), extending from the southeastern portion of the 200 East Area to the Columbia River, was consistent with patterns noted in fiscal year 1998 (see Section 5.10.3.2 of PNNL-12086). Separate tritium pulses associated with the two periods of PUREX Plant operations contributed to the plume. The first pulse, which resulted from discharges from 1956 to 1972, can be detected near the Columbia River (e.g., well 699-40-1, Figure 2.9-14). Elevated tritium concentrations measured immediately downgradient from the 200 East Area represent the second pulse associated with the restart of operations between 1983 and 1988. The area immediately downgradient of the cribs, where concentrations are greater than 200,000 pCi/L, is naturally attenuating as a result of radioactive decay and dispersion combined with the decreasing source that resulted from the termination of operations. Figure 2.9-15 clearly shows the arrival of the plume in early 1987 at well 699-24-33, near the Central Landfill, long after the passage of the plume from the earlier operation. The tritium concentrations in this well during the passage of the first pulse were at least three times the maximum concentrations in the second pulse. Thus, the second pulse is expected to have a significantly lower impact than the first pulse downgradient toward the Columbia River. The overall decline in concentrations throughout this plume indicates that the greatest impact expected at the Columbia River have already occurred.

Waste facilities associated with the PUREX Plant contaminated groundwater with tritium, iodine-129, and nitrate. The tritium plume has reached the Columbia River at levels above the drinking water standard, but concentrations are generally declining.

The zone of lower tritium concentrations near Energy Northwest (see Plate 3) may be due to discharges (over 75 liters per minute) of drinking water filter backwash water, various wash-water systems, and storm runoff that dilute the plume. Another possibility is that the zone of lower tritium concentration corresponds to a zone of lower hydraulic conductivity in the unconfined aquifer. At that site, the water table is within the upper portion of the Ringold Formation that locally may have a greater degree of cementation.

2.9.2.3 Iodine-129

The highest iodine-129 (interim drinking water standard of 1.0 pCi/L) concentrations observed in the 200 East Area in fiscal year 1999 were near the PUREX Plant cribs (see Figures 2.1-5 and 2.9-2). The maximum concentration of iodine-129 detected in fiscal year 1999 was 12.5 pCi/L in well 299-E17-14 during October 1998. This well monitors the 216-A-36B crib. Concentrations of iodine-129 in groundwater near

the PUREX cribs are generally declining slowly or are stable, as shown for well 299-E17-9 (Figure 2.9-16). The iodine-129 plume extends southeast into the 600 Area and appears to coincide with the tritium and nitrate plumes (see Plate 3 and Figure 2.1-4). Iodine-129 is measured in wells at the Old Hanford Townsite, the area of the 200 Areas plume with the highest tritium concentrations near the Columbia River. These wells show no clear increasing or decreasing trends in iodine-129, and have never been detected above the drinking water standard (see Figure 2.9-3). Recent results have been below detection limits (note that open symbols in Figure 2.9-3 indicate the result was less than analytical error and thus was undetected).

2.9.2.4 Nitrate

High nitrate concentrations continued to be found near liquid waste disposal facilities that received effluent from PUREX Plant operations. The maximum nitrate concentration detected near the PUREX Plant in fiscal year 1999 was 191 mg/L in well 299-E17-9, which is adjacent to the 216-A-36B crib. The extent of the nitrate plume that emanates from the 200 East Area (see Figures 2.1-4) is nearly identical to that of the tritium plume. However, the area with nitrate greater than 45 mg/L (the maximum contaminant level) is considerably more restricted than the area with tritium above the interim drinking water standard (20,000 pCi/L). Nitrate at levels above the maximum contaminant level north of the 400 Area, within the area impacted by PUREX operations, is attributable to 400 Area disposal (discussed in Section 2.10.2).

2.9.2.5 Strontium-90

A single well (299-E17-14) near cribs south of the PUREX Plant had a concentration above the interim drinking water standard (8.0 pCi/L) for strontium-90 (a beta emitter) in fiscal year 1999. The maximum strontium-90 concentration detected in fiscal year 1999 was 17.2 pCi/L from well 299-E17-14 next to the 216-A-36B crib during April 1999. The impact is very localized because of the lower mobility of strontium-90 compared to iodine-129, nitrate, and tritium. This result is consistent, in part, with a gross beta (interim drinking water standard of 50 pCi/L) concentration of 68.6 pCi/L in the same well. Strontium-90 was detected at four other wells near the 216-A-10 and 216-A-36B cribs during fiscal year 1999. The concentrations have been stable since 1994.

The 68.6 pCi/L result for gross beta at well 299-E17-14 during fiscal year 1999 is more than can be accounted for from the 17.2 pCi/L result for strontium-90 in the same well. The higher result for gross beta is probably due to technetium-99 (also a beta-emitter). The last technetium-99 result from well 299-E17-14 was 209 pCi/L (fiscal year 1994). Technetium-99 is no longer routinely sampled at well 299-E17-14 because previous results were significantly less than the drinking water standard (900 pCi/L), and the gross beta analysis could be used as a screening tool for technetium-99 and other beta-emitters.

2.9.2.6 Manganese

Manganese concentrations decreased in fiscal year 1999 in two wells (299-E25-17 and 299-E25-19) south of the 216-A-37-1 crib after a fiscal year 1998 peak. The concentration increased in early fiscal year 1998 to levels not reached since 1993 and continued to rise throughout the remainder of the year (Figure 2.9-17). The concentration continued to increase to a maximum of 64 μg/L (at well 299-E25-19) in October 1998 and then began to decrease. After January 1999, the concentration of manganese remained below the secondary maximum contaminant level (50 μg/L) in both wells. The source of the increased levels of manganese is unknown but presumed to be the 216-A-37-1 crib.

2.9.2.7 PUREX Cribs RCRA Parameters

The PUREX cribs (216-A-10, 216-A-36B, and 216-A-37-1 cribs) are monitored in interim status to assess groundwater quality (see Appendix A). Groundwater flow for the two western cribs (216-A-10 and 216-A-36B) is toward the southeast at ~0.003 to 0.48 meter per day. For the eastern crib (216-A-37-1), groundwater flow is southwest at ~0.018 to 0.18 meter per day. The PUREX cribs are located in a region

where several groundwater plumes contain constituents that exceed drinking water standards. The similarities in effluent constituents disposed to these cribs, as well as to the 216-A-45 crib, make determining the contribution of the PUREX cribs very difficult. However, during fiscal year 1999, the following constituents exceeded drinking water standards in at least one well in the near-field well network:

- gross beta (one well only, 299-E17-14)
- iodine-129
- nitrate
- manganese (secondary maximum contaminant level)
- strontium-90 (one well only, 299-E17-14)
- tritium.

Three of the cribs associated with the PUREX Plant are monitored together as a RCRA waste management area. They contributed to the contaminant plume that extends toward the southeast.

The far-field monitoring well network of the PUREX cribs is integrated with the well network for the 200-PO-1 Operable Unit and the site surveillance well network downgradient of the 200 East Area. These well networks monitor an approximate area of the Hanford Site covered by the tritium plume (above 2,000 pCi/L) from the 200 East Area. Besides the tritium plume, this area also contains the iodine-129 and nitrate plumes. The data from RCRA monitoring of the PUREX cribs are integrated into the assessment of the overall extent of contamination for these constituents (Sections 2.9.2.2 through 2.9.2.6).

2.9.2.8 Waste Management Area A-AX RCRA Parameters

This section provides information on the current nature of the unconfined uppermost aquifer in the immediate region of Waste Management Area A-AX. Aquifer properties were determined from the stratigraphic interpretations, current water elevations, previous aquifer tests, and regional groundwater table provided in PNNL-12086.

Groundwater Flow

The water table is extremely flat across the 200 East Area. In areas with flat water tables, the choice of surveys may affect the relative position of the water elevation in a well with respect to other network wells. A switch in the relative water elevations of wells used to determine direction would change the interpretation of the flow direction.

When the groundwater project switched from using the NGVD29 vertical control datum to the NAVD88 datum, the hydrographs gave a more realistic estimate of flow direction. In one of the five wells used to monitor the water table, a comparison between hydrographs referenced to NGVD29 versus NAVD88 indicate a survey error on the same scale as the water level difference across the Waste Management Area A-AX site. This well was eliminated from interpretation of flow direction because it is not known which survey may be in error.

RCRA Waste Management Area A-AX contains single-shell tanks. Monitoring data from fiscal year 1999 did not indicate any impact to groundwater. Because of changes in flow direction, the well network may need revising.

Although well 299-E24-19 is used to monitor the groundwater quality, water-table elevations for this well appear abnormally low on a hydrograph. This well may be slightly out of plumb, explaining the abnormal trough in the water-table surface there. The hydrograph for the four remaining wells is shown in Figure 2.9-18 (for well locations, see Figure A.14). As can be seen, the flow direction appears to be toward the east. However, given the uncertainties in water

elevations, it is probably not possible to use water elevations alone to determine local flow at this site.

The original groundwater monitoring network, which is still in use today, was designed for a narrowly focused southwestern groundwater flow direction. The consequences of having a potentially eastern flow in the RCRA compliance network is under investigation. The monitoring plan for this site is being revised. Recommendations are made to resolve the discrepancy between the flow directions based on water levels and that based on plume movement. If the flow is found to be other than to the southwest, a new well network will be designed. Depending on which hydraulic conductivity value is used, the effective flow rate at Waste Management Area A-AX is estimated to be between 0.52 to 0.66 meter per day (see Table A.2 for specific values used in these calculations). This equates to 189 to 245 meters of groundwater movement per year.

Groundwater Chemistry

This section provides information on the results of RCRA groundwater monitoring at Waste Management Area A-AX for fiscal year 1999. Information on recently occurring and past contaminant issues is provided. Routine, interim detection groundwater sampling began at Waste Management Area A-AX in fiscal year 1992. Indicator parameters have not been exceeded at this site during this time. Specific conductance values generally range from 220 to 300 µS/cm, reflecting changes in chloride, nitrate, and sulfate concentrations. Calcium and sodium are the principal balancing cations. Figure 2.9-19 shows trend plots for nitrate, sulfate, and technetium-99, comparing contaminant levels between the five RCRA groundwater monitoring wells. The specific conductance changes that occurred at Waste Management Area A-AX are dominated by sulfate. For most of the wells, sulfate values range from 23 to 30 mg/L, which is close to the Hanford Site background values reported in WHC-EP-0595 (~14 to 60 mg/L). Nitrate values range from ~4 to 8 mg/L, which falls within the ranges of background values of 3 to 12 mg/L for the Hanford Site (WHC-EP-0595). The maximum contaminant levels for nitrate and sulfate are 45 and 250 mg/L, respectively.

Sulfate concentrations above background values were identified in two wells, 299-E25-40 and 299-E25-41, where values reach ~70 mg/L. Speculation on the source of the elevated sulfate is probably not useful until the flow direction can be determined with more confidence.

Nitrate concentrations in well 299-E24-20 are ~38 mg/L, which is above the maximum background value of 12 mg/L (Figure 2.9-20). This well is located south of the 244-AR vault. Nitrate values rose from 6 mg/L in February 1996 to 38 mg/L in February 1998. Although there is no elevated technetium-99 associated with this increase in nitrate, there is a distinct correlation with tritium. Values rose from 4,180 pCi/L of tritium in February 1996 to ~7,200 pCi/L in February 1998. Most tritium values at the waste management area range from 2,800 to 4,000 pCi/L. The drinking water standards for tritium and nitrate are 20,000 pCi/L and 45 mg/L, respectively. Without more complete knowledge of the local groundwater flow direction, it is not possible to speculate on the source of this isolated, elevated nitrate.

Chromium, nickel, and manganese are detected in well 299-E24-19 (Figure 2.9-21). Chromium has sporadically exceeded the 100 µg/L maximum contaminant level since fiscal year 1991. Values range from 140 µg/L in early fiscal year 1994 to 2,820 µg/L in October 1998. The concentration dropped to 707 µg/L in December 1998. Nickel and manganese also exceeded the 100 µg/L and 50 µg/L drinking water standards, respectively. In October 1998, the maximum concentrations of 883 µg/L for nickel and 141 µg/L for manganese were detected. Historically, iron only slightly correlates with chromium except for the recent October 1998 maximum.

Nitrate concentrations in well 299-E24-19 also increased in October 1998 from 3,320 to 7,171 µg/L. This is the first occurrence in this well of any nonmetal constituents correlating with changes in chromium. Because there are no other correlations with other constituents at this well except the metals, nickel and manganese, and no other local occurrences

of chromium have been documented in other wells, the elevated metals are, most likely, due to corrosion of the screen. Further sampling is required to address the significance of the slightly elevated nitrate.

Technetium-99 declined to low levels (36 pCi/L in December 1998) in well 299-E25-46 after an increase to 374 pCi/L in August 1977 (Figure 2.9-22). The increase in technetium-99 concentrations correlates with a rise in nitrate values during the same time period. Until issues relating to the direction of groundwater flow are resolved, no further speculation on contaminant source is useful.

The drinking water standard of 1 pCi/L is exceeded for iodine-129 in all monitoring wells at Waste Management Area A-AX. This area sits within a large, regional, iodine-129 plume that extends to the southeast. The source is apparently associated with the PUREX cribs (PNNL-12086).

2.9.2.9 Waste Management Area C RCRA Parameters

This section provides information on the current nature of the unconfined, uppermost aquifer in the immediate region of Waste Management Area C. Aquifer properties were determined from the stratigraphic and lithologic interpretations, current water elevations, previous aquifer test results, and from the regional groundwater map provided in PNNL-12086.

RCRA Waste Management Area C contains single-shell tanks. Monitoring data from fiscal year 1999 did not indicate any impact to groundwater.

Groundwater Flow

The water table is extremely flat across the 200 East Area. In areas with flat water tables, the choice of surveys may actually affect the relative position of the water elevation in a well with respect to other network wells. A switch in the relative water elevations of wells could affect the interpretation of the flow direction.

Figure 2.9-23 shows hydrographs for four of the five RCRA network wells that are used to monitor the water table at Waste Management Area C. The data from well 299-E27-15 is historically inconsistent with data from the other wells in the Waste Management Area C network and is, most likely, deviated from vertical. A gyroscopic survey may alleviate the problems with water-level data from the well.

The data from the other four wells are plotted on Figure 2.9-23. Well 299-E27-7 is historically the upgradient well and 299-E27-13 is the downgradient well. Well 299-E27-12 appears to be slightly elevated with respect to well 299-E27-13. Thus, the direction of groundwater flow at Waste Management Area C appears to be toward the southwest. The flow is consistent with the regional water-table map (see Plate 2).

The original groundwater monitoring network, which is still in use today, was designed for a localized western flow direction (WHC-SD-EN-AP-012, Rev. 1). A new groundwater monitoring plan is being prepared that will propose an approach to better determine flow direction.

Depending on which hydraulic conductivity value is used, the effective flow rate at Waste Management Area C is estimated to be between 0.7 to 1.4 meter per day (see Table A.2 for specific values used in these calculations). This equates to 267 to 534 meters of groundwater movement per year.

Currently in RCRA network wells, the open intervals within the aquifer range from 3.2 to 2.4 meters. In well 299-E27-7, the open interval is 14.3 meters. The rate of water-table decline has increased from 9.1 centimeters per year in June 1997 to ~30.5 centimeters per year in March 1999. If this current rate continues, well 299-E27-13, one of the downgradient wells with less than 3 meters of water, may become unusable in 6 or 7 years.

Groundwater Contamination

Critical mean values of the indicator parameters (pH, conductivity, total organic carbon, and total

organic halides) were not exceeded during fiscal year 1999. As sluicing operations were conducted at tank C-106, this site was temporarily placed on monthly monitoring to assist in detecting effects of waste retrieval operations on groundwater quality.

All wells showed concentrations of iodine-129 above the 1-pCi/L interim drinking water standard. The single-shell tank resides within the regional iodine-129 plume that extends throughout this area. Although tritium continues to be elevated in upgradient well 299-E27-7 at 2,520 pCi/L in February 1999, values across the waste management area remain well below the 20,000-pCi/L drinking water standards.

Nitrate rose in well 299-E27-14 from 11 mg/L in July 1998 to 30 mg/L in October 1998. (Figure 2.9-24). If the flow direction to the south-southwest is correct, then well 299-E27-14 may be downgradient from Waste Management Area C. Consequently, this rise in nitrate may be associated with tank farm concentrations. Both the specific conductance and nitrate, however, are below the critical mean set for this RCRA site, and the drinking water standard for nitrate of 45 mg/L. As can be seen in Figure 2.9-24, both upgradient and downgradient wells experienced a slight but steady increase in nitrate levels. A comparison is made between chloride, nitrate, and sodium for well 299-E27-14 in Figure 2.9-25. Both chloride and sodium can be seen to track with the nitrate. However, neither the sulfate nor the calcium show similar trends.

Along with an increase of nitrate at well 299-E27-14 is a corresponding increase in technetium-99 shown in Figure 2.9-26. Technetium-99 contamination rose from 184 pCi/L in February 1998 to 672 pCi/L in September 1998. The July 1999 value was 460 pCi/L. Although elevated with respect to the surrounding area, values are still below the drinking water standard of 900 pCi/L. Similar to the increases in nitrate, the technetium-99 levels are steadily increasing in all the surrounding wells. The September 1999 value for well 299-E27-15 is 98 pCi/L. Figure 2.9-27 shows the direct correlation between nitrate and technetium-99 in well 299-E27-14. As can be seen, the nitrate and technetium-99 concentrations are highly correlated.

With the uncertainty in the current direction of groundwater flow, it is not possible to determine the source of increasing contamination observed at Waste Management Area C. However, it is important to note that, unlike the other single-shell tanks in the 200 East Area, Waste Management Area C is not surrounded with past-practice liquid effluent disposal facilities. Consequently, with no nearby sources and no known local plumes that might be moving through the area, it becomes even more important that the flow direction be determined by a direct, in situ method. Because waste retrieval operations have ceased, the area will be monitored every other month during fiscal year 2000 and will be returned to semiannual monitoring beginning in fiscal year 2001.

2.9.2.10 216-A-29 Ditch RCRA Parameters

The direction of groundwater flow beneath the ditch is west-southwest, based on nitrate and tritium plume maps (see Figures 2.1-4, 2.9-5, and Plate 3) and on water-level elevations in the monitoring wells. The tritium plume map (see Plate 3) shows that the flow direction swings to the southeast as groundwater flows to the southeastern corner of the 200 East Area. The calculated gradient is ~0.0005 for the entire length of the ditch and yielded a flow rate of ~0.03 to ~0.09 meter per day (see Table A.2).

RCRA monitoring at the 216-A-29 ditch in fiscal year 1999 indicated the site has not contaminated groundwater.

The water table beneath the ditch has steadily declined since discharges to the B Pond system were terminated. Figure 2.9-28 shows the water levels are continuing to decline in wells monitoring the head and discharge ends of the ditch. The change in water-table elevation resulted in a flattened water table at both the head and discharge ends of the ditch.

Indicator parameters were not exceeded during fiscal year 1999. Water-level measurements were taken during routine sampling throughout the year. Although

groundwater levels continue to decline regionally, there is sufficient water in network wells for groundwater monitoring purposes.

In the past, sulfate was elevated at 216-A-29 ditch network wells, but reduced dramatically as sulfate bearing wastewater was reduced from 216-A-29 ditch effluent. In the last few years, two wells (299-E25-35 and 299-E25-48) (Figure 2.9-29) have shown a slight increase in sulfate concentration but they remain less than 70 mg/L. Background is ~10 mg/L.

2.9.2.11 216-B-3 Pond Parameters

The 216-B-3 pond system consisted of a main pond, three expansion ponds (3A, 3B, and 3C), and portions of several ditches leading to the main pond (see Figure A.17). In 1994, the main pond and adjoining ditches were decommissioned and filled, and three expansion ponds were clean closed under RCRA regulations. Currently, only the main pond and an adjoining segment of the 216-B-3-3 ditch are subject to RCRA groundwater monitoring requirements.

The B Pond system was placed into assessment monitoring status in 1990 because of elevated total organic carbon and total organic halides in two wells (699-43-41E and 699-43-41F). Since 1990, these two indicators have been below limits of quantitation. The only contaminants consistently detected in groundwater that could be attributed to B Pond operations were nitrate (maximum 22.5 mg/L) and tritium (maximum 232,000 pCi/L. In January 1998, a detection-level program was restored.

Groundwater monitoring is based on two types of potential contamination:

- contamination potentially entrained in the groundwater that has moved away from the point of infiltration
- potential contamination entering groundwater from the vadose zone.

The configuration of the monitoring well network is based on these assumed modes of contaminant occurrence and on monitoring discrete depths within the aquifer. During fiscal year 1999, the monitoring well network was revised to accommodate changes in groundwater flow direction and additional insights on the potential for contaminant transport. One new well was installed to increase coverage at the southwestern edge of the facility. The monitoring well network for fiscal year 1999 is given in Table A.31; the location of the new well is shown in Figure A.17. As indicated in Figure A.17, the well network was more extensive in the past when the expansion ponds were part of the regulated unit and before constraints on groundwater flow were recognized as discussed below (PNNL-12261, PNNL-11986).

The 216-B-3 pond is a RCRA site that formerly created a large recharge mound, affecting groundwater flow in a broad area. This mound has recently dissipated. Groundwater monitoring in fiscal year 1999 showed no evidence of contamination.

Groundwater Flow

Groundwater flow around B Pond has historically been described as radial, away from the center of a groundwater mound that formed beneath the facility (see Plate 2). In recent years, this mound has become less defined, primarily because of the discontinuation of discharges. The direction of groundwater flow near B Pond altered in response to the changes in hydraulic head. Also, recent hydrogeologic investigations (PNNL-12261) have indicated that actual flow to the south and southeast of B Pond is very limited because of the relatively impermeable character of the sediment in these areas (see Section 2.9.3). In fiscal year 1999, a range of groundwater flow velocity was estimated at 0.01 to 19.2 meters per day (see Table A.2) was detected. The higher end of this range (and hydraulic conductivity range) would apply to the limited portion of the permeable Hanford formation that hosts the uppermost aquifer. As head drops, and the water table declines into the less permeable Ringold Formation, the higher groundwater flow estimates may decrease.

Water levels in B Pond wells have dropped since the mid-1980s, as discharges to the facility decreased and then ended in 1994 (the clean closed 3C expansion pond continued to receive reduced amounts of clean water until August 1997). Figure 2.9-30 is a hydrograph of four wells in the B Pond monitoring network that illustrates the nature of water-level drop in most B Pond wells. During a period from 1996 to 1997, several wells in the network experienced a precipitous drop in water levels that has slackened somewhat since about late 1997. Calculations of rates of water-level decline during fiscal year 1999 indicate that rates of decline have slowed in most wells in the current network. Based on these calculations, the estimated service lives of the wells range from 2.4 and 5.2 years in wells 299-E26-11 and 699-43-45, respectively, to >100 years in well 699-40-39. Most of the remaining wells have expected lives of 20 to 40 years. Wells such as 699-43-45 (see Figure 2.9-30) have shown a more steady decline over time, perhaps because they are completed in less permeable portions of the aquifer or farther from the effluent source, thus dampening the hydraulic response to changes in discharges.

The monitoring network for B Pond was revised in fiscal year 1999 to reflect recent changes in flow patterns.

Groundwater Quality

The B Pond site-specific contaminants and contamination indicator parameters are given in Table A.31. The site-specific contaminants, radionuclide indicators gross alpha and gross beta, are monitored. These are monitored because of the known or potential radionuclides sent to B Pond in the past. Specific conductance, though also a general indicator parameter of contamination, is given special site-specific importance because of the anionic components of the known waste discharged to B Pond.

Groundwater samples from the B Pond network were collected semiannually during fiscal year 1999, mostly in January and June. No critical means of contamination indicator parameters were exceeded during fiscal year 1999.

Well 699-42-39B produced the highest gross alpha and gross beta results during fiscal year 1999, 3.78 and 13.1 pCi/L, respectively. Most gross alpha results are less than 4.0 pCi/L, and most gross beta results are less than 10 pCi/L. No trends are apparent in any of the downgradient B Pond wells for these indicators, but gross beta shows a slight upward trend in upgradient well 299-E32-4. The highest result thus far in this well is 15.4 pCi/L in December 1998.

Historically, concentrations of some metals have exceeded primary or secondary drinking water standards, but are mostly thought to be a result of well construction or natural groundwater conditions. These metals included chromium, iron, and manganese. Although unfiltered samples of these metals exceeded the drinking water standards, this was in particulate form and an artifact of the sampling process. The elevated levels were not found in filtered samples.

Tritium concentrations in groundwater at the B Pond remain above the drinking water standard, but continue to decrease. Nitrate was present historically in concentrations above site-wide background estimates, but below drinking water standards. These constituents are tracked in selected B Pond wells for surveillance monitoring and are sampled on a triennial basis. Well 699-41-40 (not in the current B Pond network) has historically produced the highest tritium results in the B Pond area, with a maximum of 232,000 pCi/L in 1988, and a March 1998 result of ~100,000 pCi/L. Well 699-42-39B produced a tritium result of ~60,000 pCi/L in the most recent (April 1998) analysis for this radionuclide. Trends for tritium concentrations in all B Pond wells continue generally downward. Nitrate is sampled annually, according to the recent revision of the network and constituent list, and is scheduled for sampling as of this writing. Historical results for nitrate, as recent as 1997, indicate a continuing decline in nitrate concentrations at B Pond.

The groundwater monitoring plan and network will likely be revised in fiscal year 2000, primarily because of the dynamic hydrologic circumstances at the facility and new information on hydrostratigraphy in the immediate vicinity of the B Pond (PNNL-12261).

2.9.2.12 Liquid Effluent Retention Facility

The Liquid Effluent Retention Facility is monitored in a final status detection evaluation program and is included in the Hanford Site RCRA Permit. Until the final status monitoring plan is approved by the regulators, the site will continue to operate under the existing interim status groundwater monitoring plan (WHC-SD-EN-AP-024). The RCRA indicator parameters are pH, specific conductance, total organic carbon, and total organic halides (40 CFR 265.92[b][3]). Included in the analysis list for this facility are alkalinity, gamma scan, gross beta, and turbidity (see Table A.37). No indicator parameters (and other parameters) were exceeded in fiscal year 1999.

RCRA monitoring at the Liquid Effluent Retention Facility shows no evidence of groundwater contamination from the site. The aquifer beneath the site is very thin, and alternative approaches to monitoring are being investigated.

The direction of groundwater flow beneath the facility is generally to the southwest, based on the regional water-table contours (see Plate 2). However, using only water-level data from wells monitoring the facility, the local flow direction is generally to the west. The gradient is 0.002 to 0.005 and reflects the effects of the B Pond groundwater mound to the east. The flow rate is estimated to range from 0.04 to 6.0 meters per day (see Table A.2).

Groundwater monitoring shows no evidence that dangerous, non-radioactive constituents from the Liquid Effluent Retention Facility entered the groundwater. The critical mean for specific conductance was exceeded in January 1999 and triggered a confirmation sampling in February. The wells affected by the exceedance included 299-E26-9 and 299-E26-10. Results of an assessment indicated that a return to natural background conditions was the source of the elevated specific conductance. A regional dilution of groundwater had occurred due to long-term discharges to the 216-B-3 Pond. The effect of this dilution has only recently abated and several regional wells east of the 200 East Area fence line have shown increasing specific conductance. Specific conductance background levels for the facility were re-calculated based on recent data.

The current network is composed of three wells, one of which is upgradient. The network was temporarily out of compliance when, in June 1999, well 299-E26-9 was declared dry. The well still has ~0.5 meter of water in the casing, but retrieving a representative sample is not possible. The Washington State Department of Ecology (Ecology) was notified on July 1, 1999, of the loss of a downgradient well. After negotiations between DOE and Ecology, the state of Washington issued a variance letter on September 22, 1999, giving DOE time (18 months) to design and implement a new monitoring network. The eighteen month timeframe discussed in the September letter may be preempted by the loss of another downgradient well. Well 299-E35-2 has less than 1 meter of water. In less than 1 year, it may not be possible to sample the groundwater from this well.

2.9.2.13 200 Areas Treated Effluent Disposal Facility

The 200 Areas Treated Effluent Disposal Facility is a non-RCRA waste disposal site built to provide an infiltration bed for treated liquid effluent from the generating facilities in the 200 Areas. The facility is located ~600 meters east of the 216-B-3C expansion pond (see Figure A.17). In operation since June 1995, the facility allows infiltration of steam condensate and other clean water to the soil column. The facility is regulated by State Waste Discharge Permit ST-4502 (WAC 173-216). Groundwater sampling and analysis in the three monitoring wells at the facility are also governed by ST-4502. The constituent list and frequency

of sampling are specified in the permit and are provided in Table A.43. Currently, all three Treated Effluent Disposal Facility wells are sampled quarterly and semiannually.

Groundwater monitoring at the Treated Effluent Disposal Facility began ~2.5 years prior to the construction of the infiltration basins. The three monitoring wells (699-40-36, 699-41-35, and upgradient well 699-42-37) were completed in 1992 and were sampled as an unofficial portion of the B Pond groundwater monitoring network until April 1995. At that time, sampling and analysis of wells at the Treated Effluent Disposal Facility was conducted according to provisions of the state waste discharge permit.

Infiltration from the Treated Effluent Disposal Facility flows along the top of a clay-rich layer of sediment and does not reach the uppermost aquifer beneath the site.

Groundwater in the uppermost aquifer beneath the Treated Effluent Disposal Facility occurs under confined conditions within Ringold unit A gravels. The Ringold lower mud unit forms an effective aquitard between the vadose zone (Hanford formation) and the uppermost aquifer. Thus, effluent discharged to the Treated Effluent Disposal Facility does not reach the uppermost aquifer in the area but is diverted laterally by the lower mud unit. This condition was recognized during construction of the wells at the facility. Consultation with regulators determined that these wells would be monitored to confirm that effluent was not taking a direct route to groundwater. Ongoing collection and analysis of hydrologic and hydrogeochemical data corroborate this assumption (PNNL-11986).

The potentiometric surface in the vicinity of the Treated Effluent Disposal Facility (Figure 2.9-31) is influenced by the decaying effects of a hydraulic mound created by the nearby B Pond. The hydrographs of Figure 2.9-32 illustrate the decline in hydraulic head in Treated Effluent Disposal Facility wells as a result of the subsiding mound. Although the rate of decline in the hydraulic head increased in recent years, linear calculations between fiscal years 1998 and 1999 indicate that the wells still have from ~55 years (699-42-37) to ~100 years (699-40-36 and 699-41-35) of service life before going dry.

The average linear groundwater flow rate is 0.004 meter per day (see Table A.2). Contouring of head values in the vicinity of the facility (see Figure 2.9-31) indicate that flow direction is south-southwest.

Recent work on the hydrostratigraphy and groundwater geochemistry in the vicinity of the Treated Effluent Disposal Facility indicates that groundwater flow in the uppermost aquifer is extremely slow and displays a unique geochemical composition and greater age compared with other portions of the uppermost aquifer on the Hanford Site (PNNL-11986; PNNL-12261). This uppermost aquifer is probably the Ringold Formation confined aquifer (see Section 2.9.3). Low-level tritium analyses have indicated a maximum concentration of 8.69 pCi/L of tritium in the three wells monitoring this facility. This level of tritium is anomalously low compared with both the expected values in the uppermost aquifer and Columbia River. These studies also indicate that the lower mud unit effectively blocks any infiltration of effluent to the uppermost aquifer in the vicinity of the facility. No permit enforcement limits in groundwater were exceeded in the facility's wells during fiscal year 1999.

Future groundwater monitoring at the Treated Effluent Disposal Facility will need to incorporate the constraints of the unique hydrogeologic circumstances beneath the facility. Currently, the state waste discharge permit (WAC 173-216) and groundwater monitoring plan for the facility are being revised to account for new knowledge of the hydrogeologic and hydrogeochemical setting of the facility. The new permit is scheduled to take effect in April 2000.

2.9.2.14 Water Quality at Shoreline Monitoring Locations

Seven aquifer sampling tubes are located near the Old Hanford Townsite. The sampling tubes are polyethylene tubes that were installed in the aquifer at locations near the low water shoreline. One of the seeps was sampled in fall 1998. The sample had concentrations of 2,800 pCi/L tritium, 3.9 pCi/L gross beta concentration, and no detectable gross alpha. The sample was not analyzed for iodine-129. The specific conductance of the sample was 262 µS/cm, a value that may indicate a mixture of groundwater and river water from bank storage.

A seep in the riverbank near the Old Hanford Townsite also was sampled in fall 1998. The seep is located ~1 mile downstream of the aquifer sampling tube. The seep sample had concentrations of 120,000 pCi/L tritium and 36 mg/L nitrate. These values are about the same as concentrations in groundwater in the vicinity. Gross alpha and gross beta concentrations were 3.22 and 23.3 pCi/L, respectively. The concentration of iodine-129 was 0.22 pCi/L, and the concentration of technetium-99 was 105 pCi/L. Specific conductance measured 394 µS/cm. This relatively high value indicates the sample was primarily groundwater, not river water draining back from bank storage.

2.9.3 Confined Aquifer in the Lower Ringold Formation

PNNL-10886 subdivided the Ringold Formation into 6 hydrogeologic units (units 4 through 9). The Ringold Formation confined aquifer consists of the lowermost hydrogeologic unit (unit 9), which consists of fluvial sand and gravel overlying the upper basalt flow. It is confined by hydrogeologic unit 8, also referred to as the lower mud sequence, which is the thickest and most laterally continuous mud unit beneath the Hanford Site. The base of the aquifer is the dense interior of the upper basalt flow. Previous studies have often included portions of the Ringold confined aquifer when describing and mapping the unconfined aquifer. Interpretations prior to 1999 do not differentiate these aquifers and do not attempt to separate the groundwater results (i.e., plume mapping and potentiometer surfaces) for the separate aquifers.

The Ringold confined aquifer is known to be in communication with the unconfined aquifer in the 200 East Area, where they are adjacent to the unconformity created by erosion and subsequent deposition of the Hanford formation (PNNL-12261).

Currently, there is not a specific monitoring network designed to monitor conditions within the Ringold confined aquifer. Most of the wells that monitor the Ringold confined aquifer are located east and south of 200 East Area. Therefore, this section focuses on that region.

2.9.3.1 Groundwater Flow

The groundwater project has constructed a preliminary potentiometric surface for a portion of the confined aquifer in the Ringold Formation (Figure 2.9-33). This map is incomplete and subject to uncertainty because only a few wells are monitored within this aquifer.

Groundwater in the Ringold Formation confined aquifer flows generally west to east in the vicinity of the 200 West Area and west to east along the southern boundary of the aquifer. These flow patterns indicate that recharge occurs west of the 200 West Area (Cold Creek Valley) as well as from the Dry Creek Valley. In the central portion of the aquifer, groundwater flow is to the northeast. In addition, a groundwater mound is present northeast of B Pond as a remnant of past wastewater discharges to this facility. This mound causes groundwater to flow southwest beneath B Pond. A stagnation point is believed to exist to the south of B Pond, where the groundwater flow divides between flowing toward the 200 East Area and flowing toward the east. Therefore, groundwater flow converges on the 200 East Area where the confining mud unit (unit 8) is absent and flow discharges to the unconfined aquifer.

There appears to be an upward gradient between the confined and unconfined aquifers near the 200 East Area in a region where the confining unit (unit 8) is absent (Figure 2.9-34). Well 299-E25-28 is completed within hydrogeologic unit 9 of the Ringold Formation (below the water table), and well 299-E25-34 is completed across the water table within the overlying Hanford formation (unit 1). This figure shows that hydraulic heads are apparently higher in well 299-E25-28. This supports the concept of groundwater discharging from the confined aquifer in the vicinity of the 200 East Area may recharge the overlying unconfined aquifer.

A confined aquifer in the lower Ringold Formation contains a "mound" in water levels. Tritium contamination has been detected in this aquifer near its juncture with the unconfined aquifer.

The contours on Figure 2.9-33 are similar to the potentiometric surface for the upper basalt-confined aquifer (Section 2.14). Hydraulic head and flow patterns in the central portion of the Hanford Site are very similar in both aquifers. Hydraulic heads differ in the western portion of the aquifers (~3 to 4 meters of head difference in the northern part of the 200 West Area) where a downward hydraulic gradient exists. Hydraulic heads are also expected to diverge to the east and an upward hydraulic gradient is expected in the vicinity of the Columbia River.

2.9.3.2 Contaminant Distribution

Most of the available chemical data from the Ringold confined aquifer are from wells on the 200 Areas plateau. This is believed to be the only area where contamination can migrate from the unconfined aquifer into the confined aquifer.

The primary factors contributing to the observed groundwater chemistry are the hydrostratigraphy and groundwater flow patterns. The ion chemistry and tritium concentrations corroborate the interpretation of groundwater flow described in Section 2.9.3.1. Because groundwater flow in the unconfined aquifer is isolated from flow in the Ringold confined aquifer (except within the erosional unconformity), the groundwater chemistry must be evaluated for each aquifer independently.

Tritium has been detected in the Ringold confined aquifer near the 200 East Area. Figure 2.9-35 illustrates major ion chemistry using Stiff diagrams (Stiff 1951) and also includes tritium concentrations. The figure illustrates that groundwater chemistry correlates with groundwater flow paths in the unconfined aquifer and in the Ringold confined aquifer (unit 9).

The major ion chemistry of groundwater in the Ringold confined aquifer, adjacent to the aquifer juncture, is of the calcium-bicarbonate type and has elevated tritium activities similar to groundwater in the unconfined aquifer (see Figure 2.9-35). South and east of B Pond toward the May Junction Fault, groundwater in the Ringold confined aquifer has lower tritium concentrations and is of the sodium-bicarbonate type. Tritium concentrations and other chemical data indicate that groundwater in the Ringold confined aquifer near the fault has not been displaced or diluted by wastewater associated with 200 East Area operations.

Tritium was present in discharges to B Pond, which is located directly above the erosional juncture that allows communication between the unconfined and confined aquifers. During active disposal, groundwater mounding increased the driving head and forced groundwater and any associated contamination into the confined aquifer. The groundwater moved laterally within the confined aquifer and the potentiometric head increased to equilibrium with the overlying recharge mound. Disposal to B Pond ceased in 1994, and since that time, water levels and tritium concentrations in the unconfined aquifer have decreased significantly. This reduced head has created an upward gradient between the confined and unconfined aquifers. Horizontal flow is toward the southwest so the high concentrations of tritium in the confined aquifer are expected to move toward the unconfined aquifer.

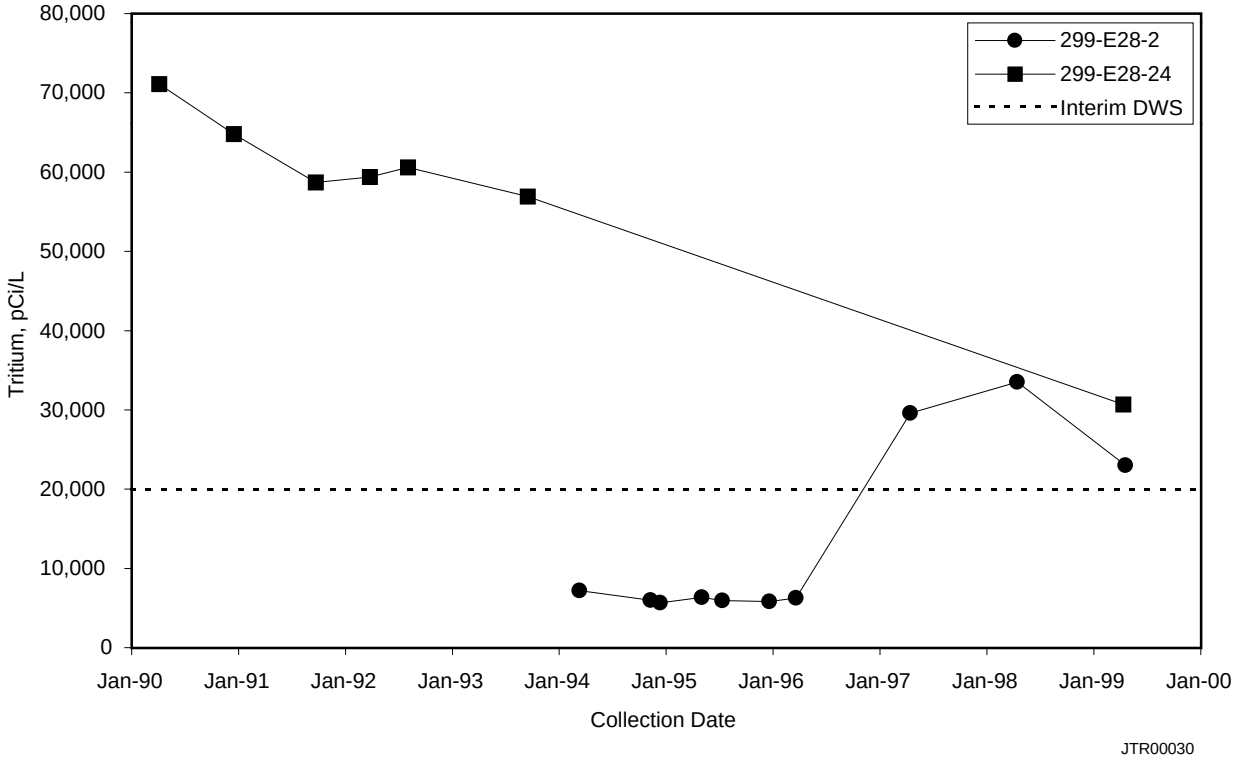


Figure 2.9-1. Tritium in B Plant Area

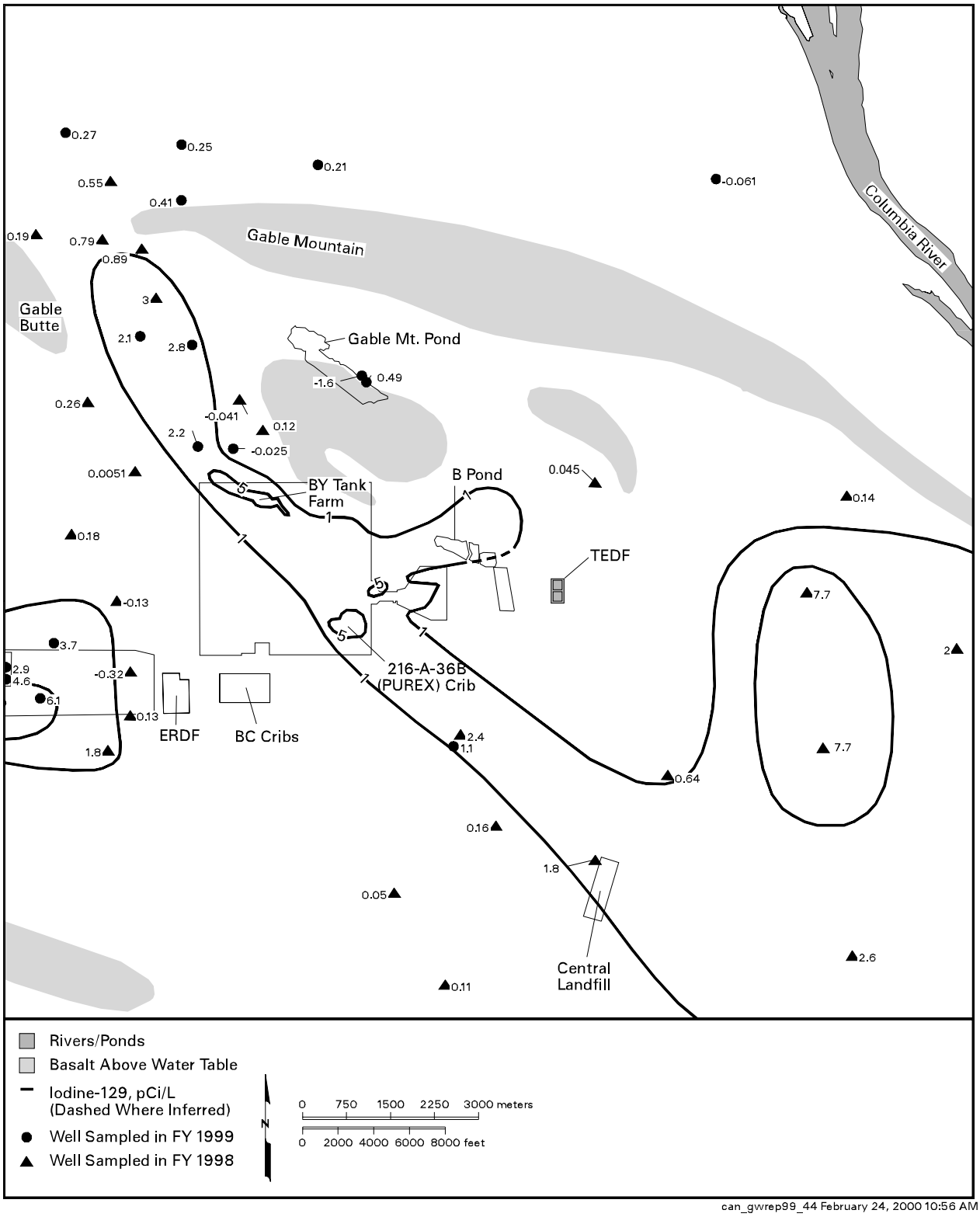


Figure 2.9-2. Average Iodine-129 Concentrations in 200 East Area, Extending Northwest Toward Gable Gap, Top of Unconfined Aquifer

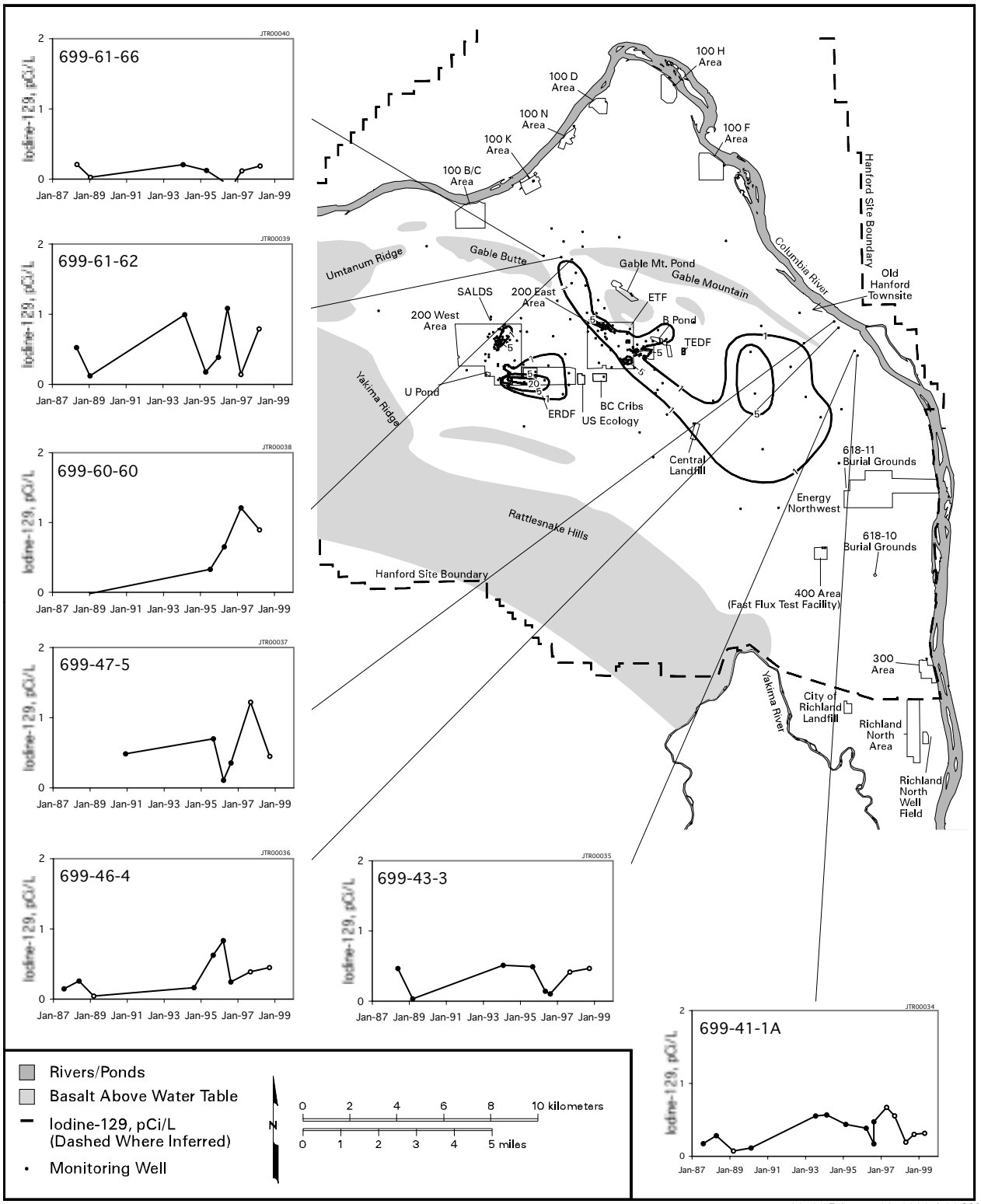


Figure 2.9-3. Iodine-129 in the Gable Gap and Old Hanford Townsite Areas

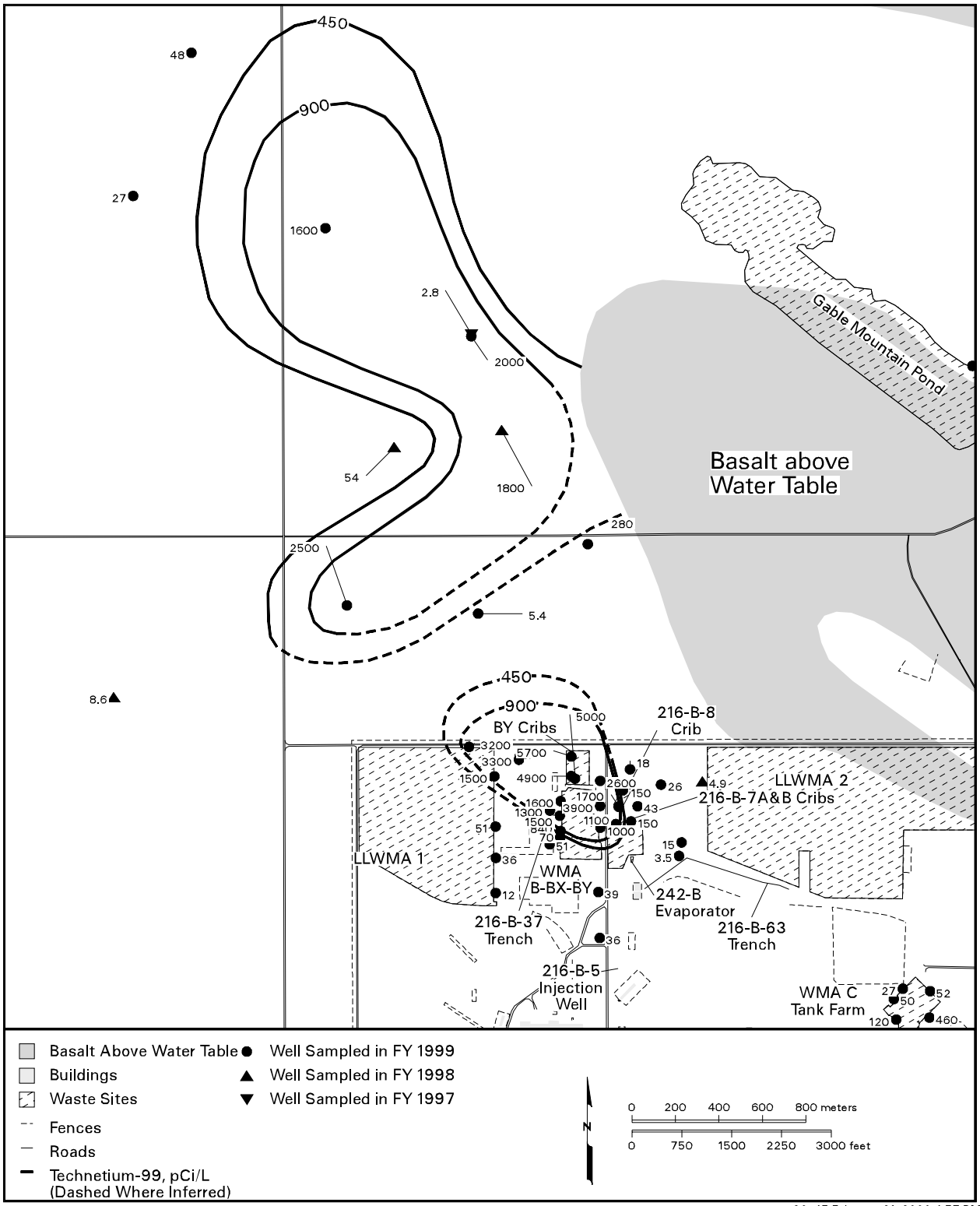


Figure 2.9-4. Average Technetium-99 Concentrations, Northern 200 East Area, Top of Unconfined Aquifer

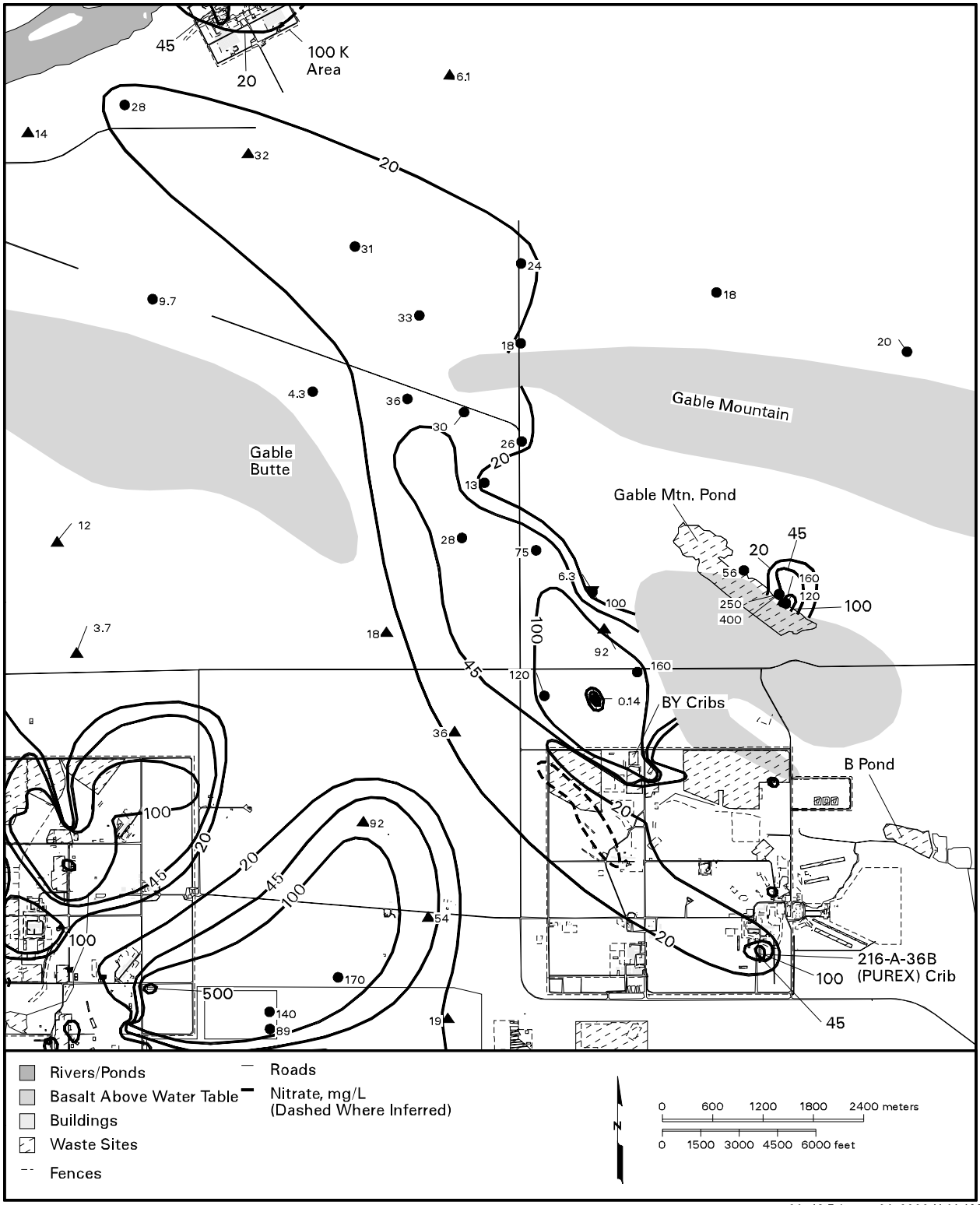


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Figure 2.9-5. Average Nitrate Concentrations in 200 East Area, Top of Unconfined Aquifer

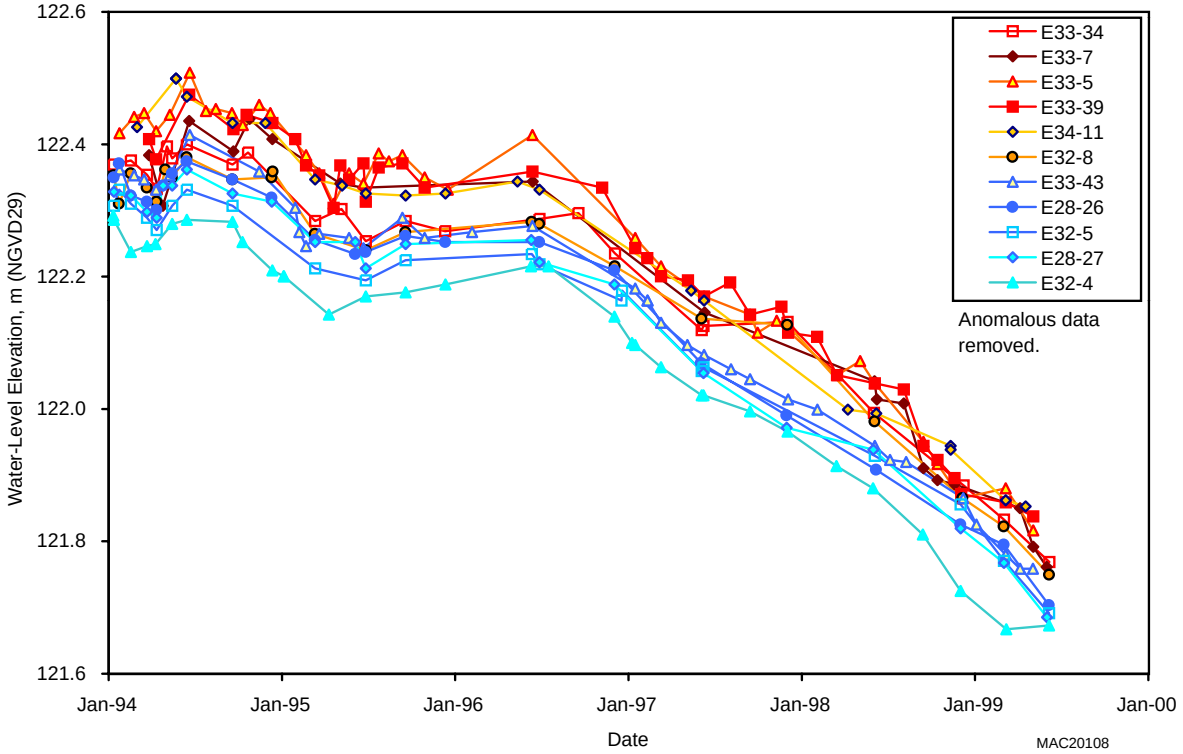


Figure 2.9-6. Hydrographs of Wells Located North, East, West and Southwest of Waste Management Area B-BX-BY

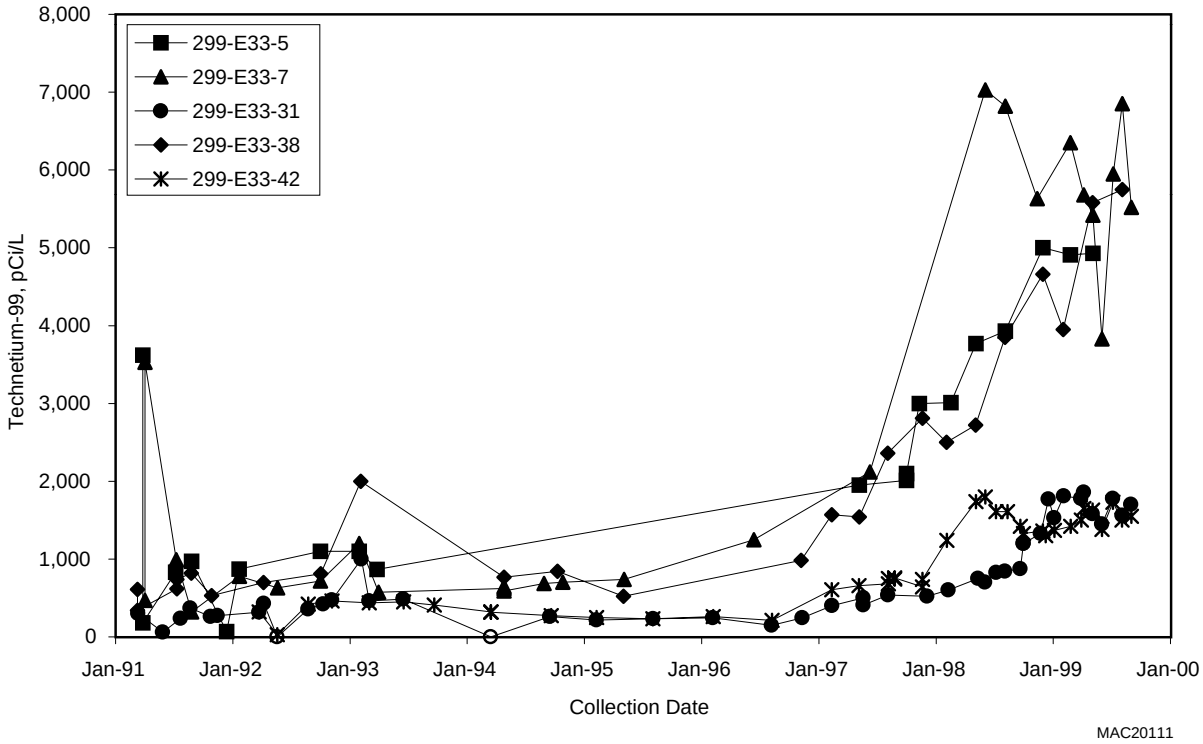


Figure 2.9-7. Technetium-99 in Wells at Waste Management Area B-BX-BY

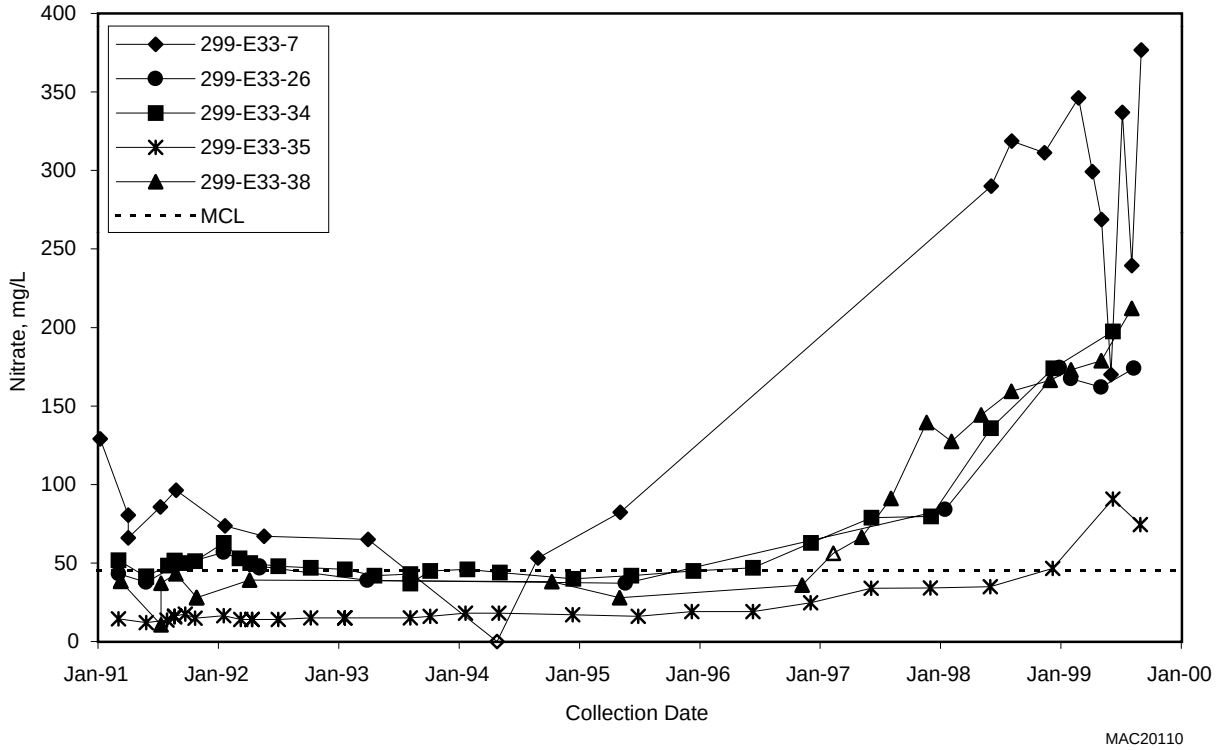


Figure 2.9-8. Nitrate in Wells at Waste Management Area B-BX-BY

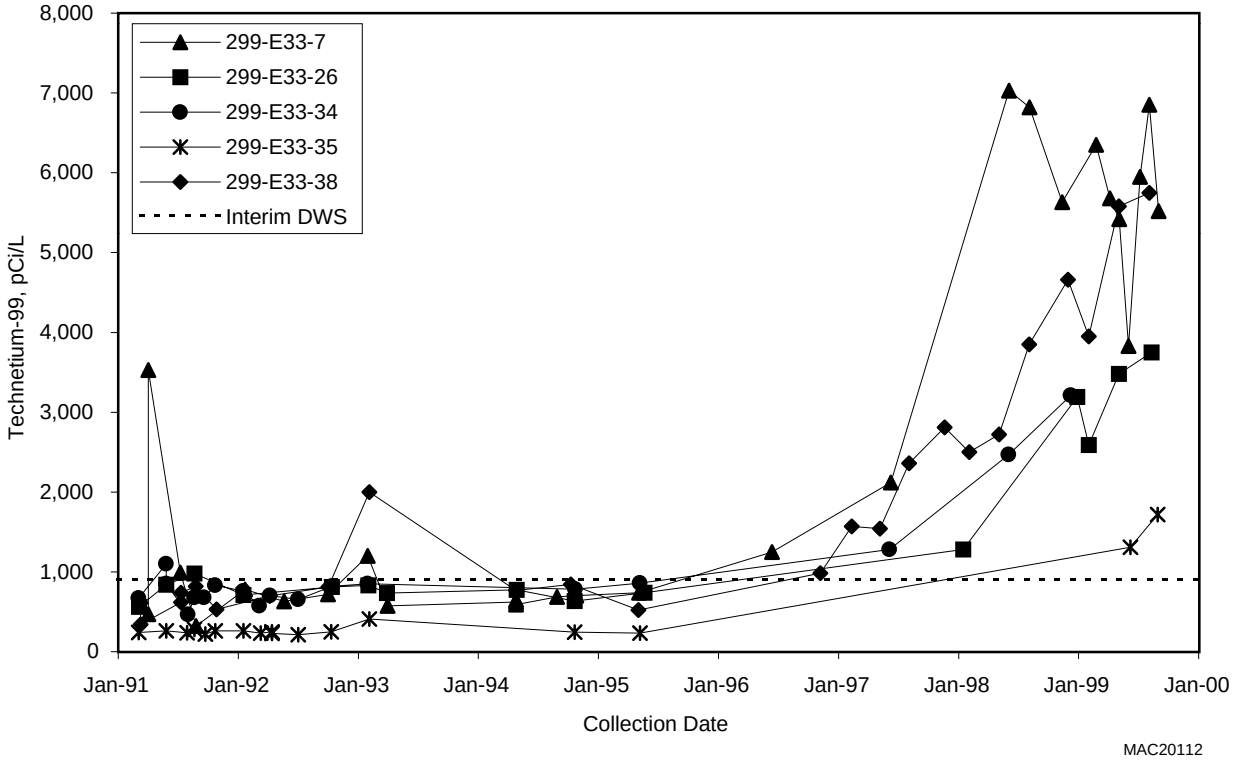


Figure 2.9-9. Technetium-99 at Waste Management Area B-BX-BY

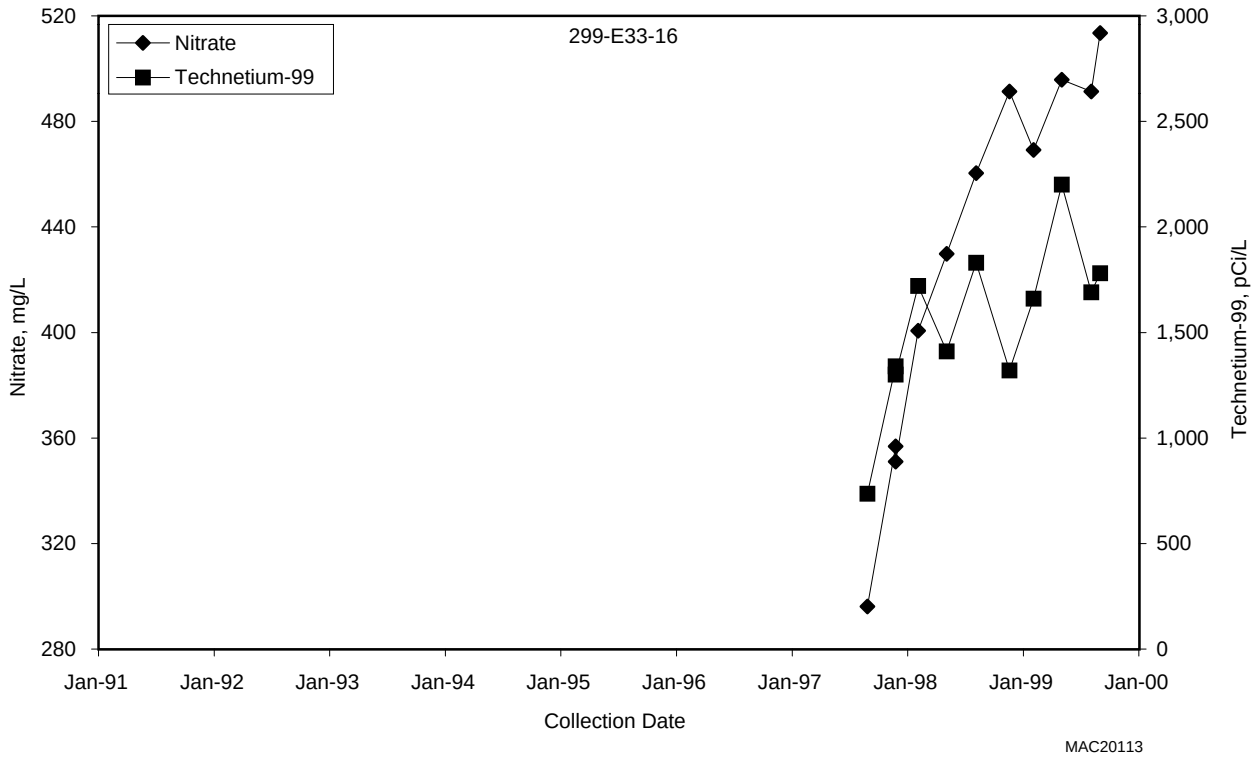


Figure 2.9-10. Nitrate and Technetium-99 in Well 299-E33-16 at Waste Management Area B-BX-BY

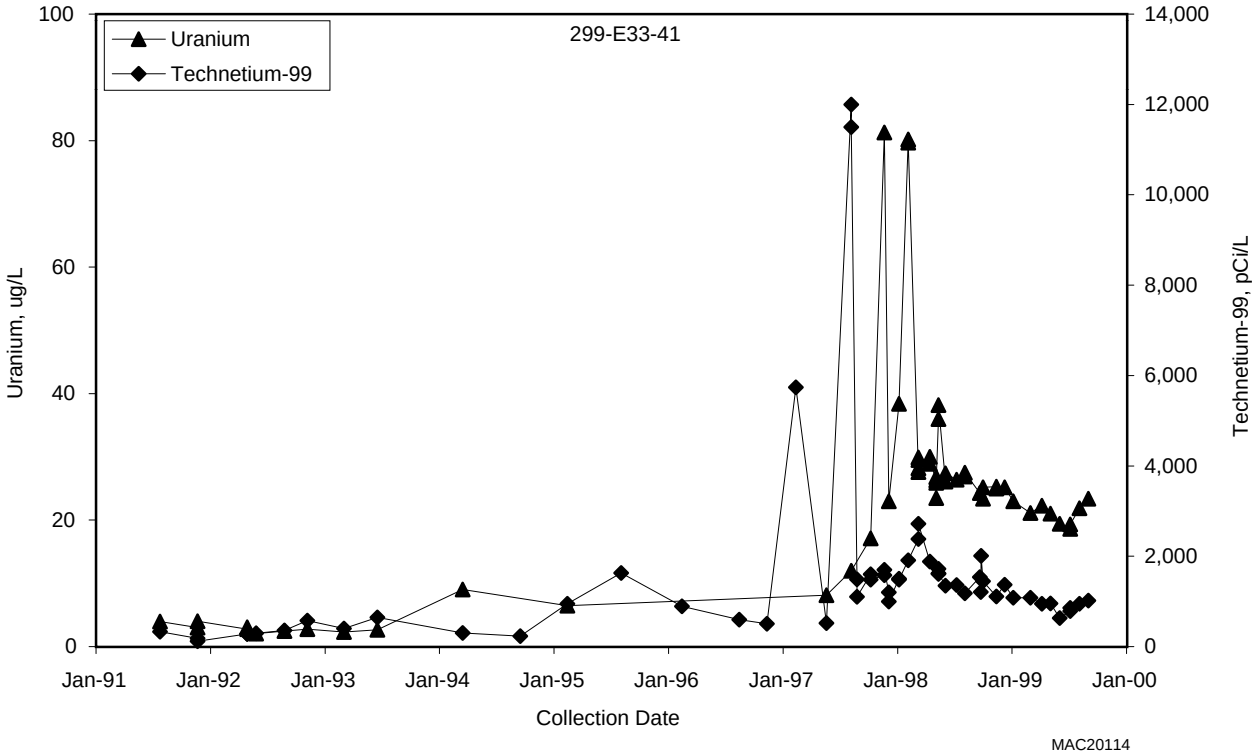


Figure 2.9-11. Technetium-99 and Uranium in Well 299-E33-41 at Waste Management Area B-BX-BY

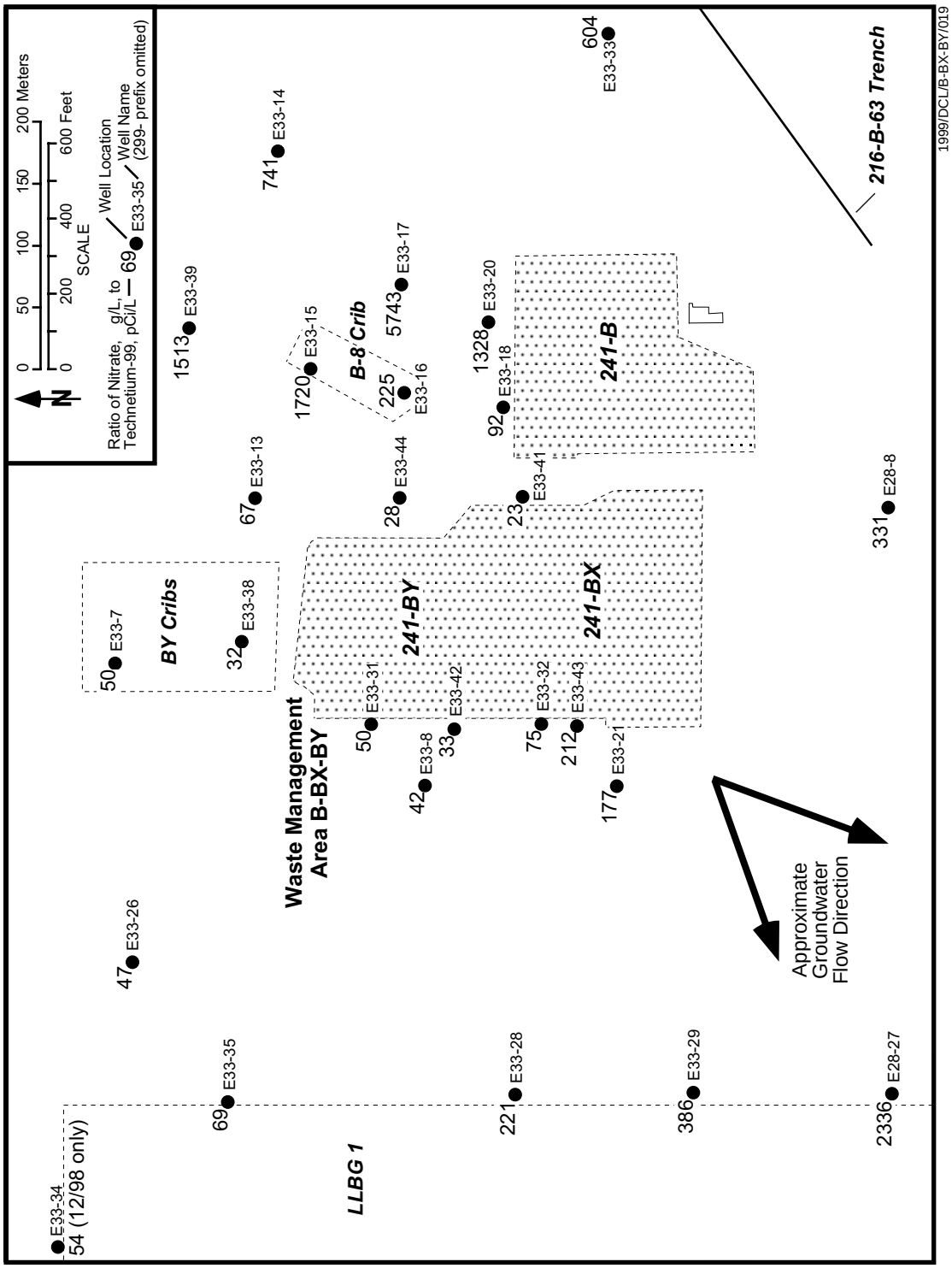


Figure 2.9-12. Ratio of Nitrate to Technetium-99, April through June 1999

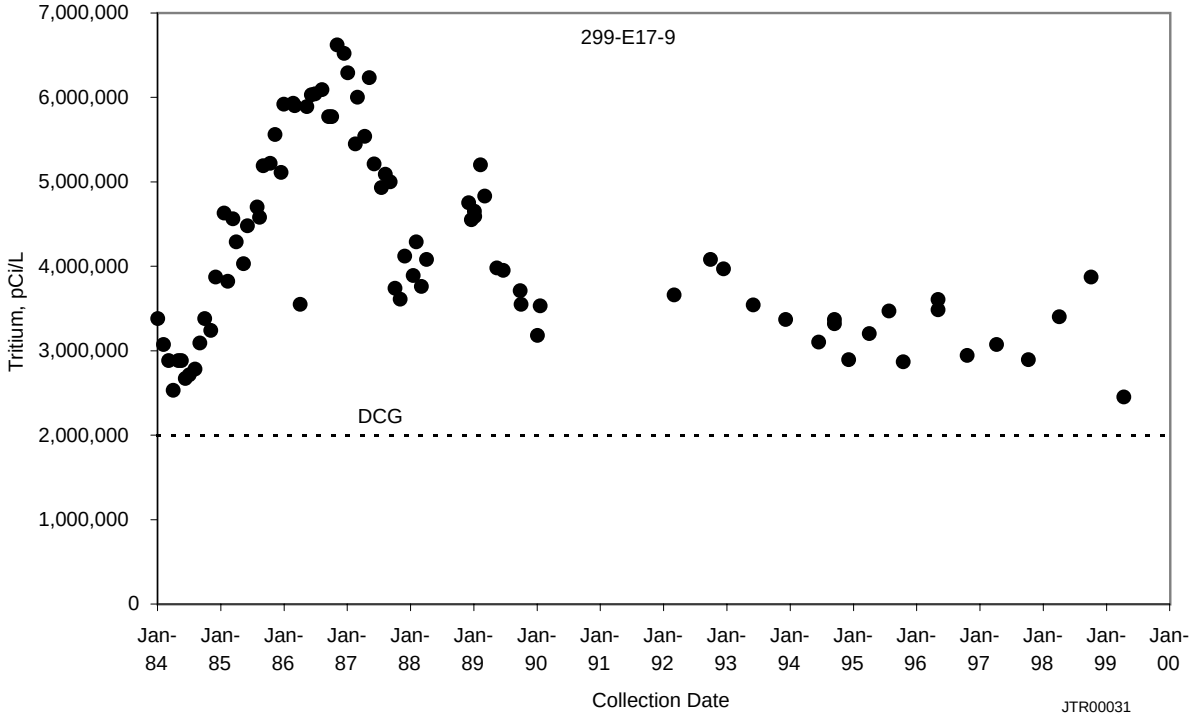


Figure 2.9-13. Tritium in Well 299-E17-9 at 216-A-36B Crib

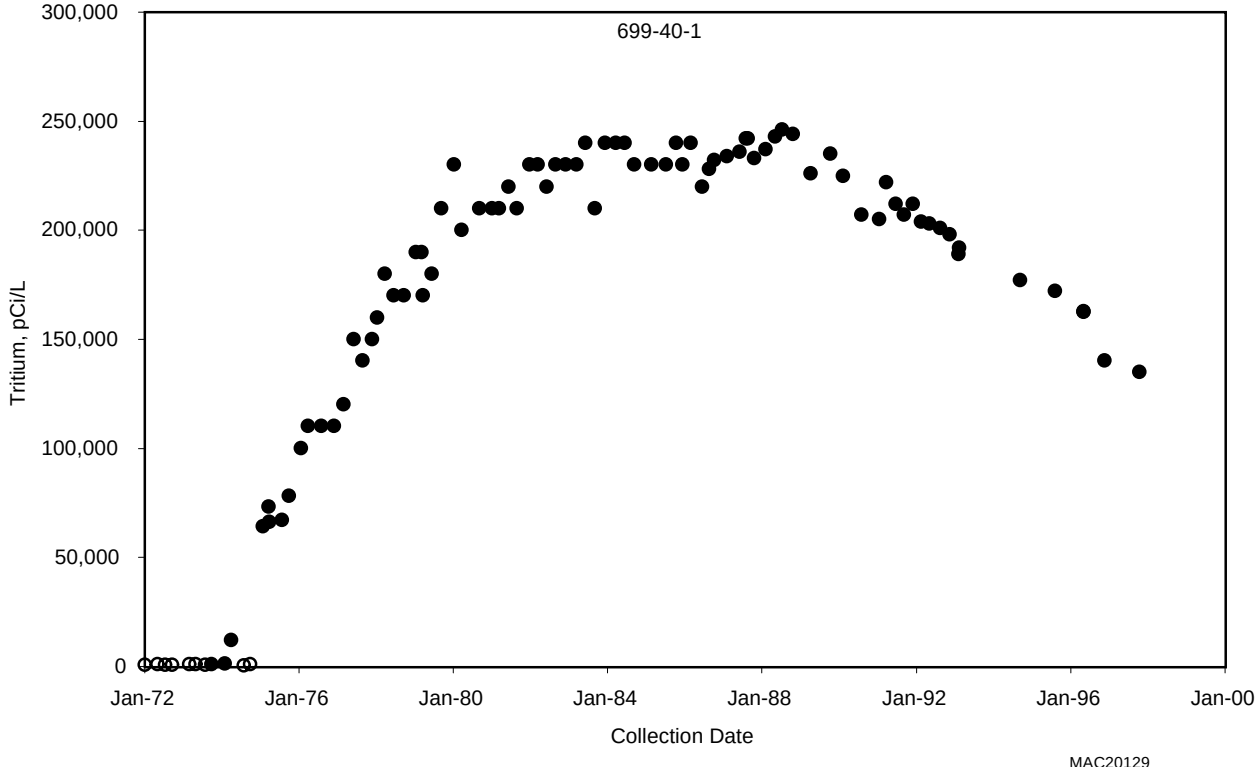


Figure 2.9-14. Tritium in Well 699-40-1 at the 600 Area Near the Old Hanford Townsite

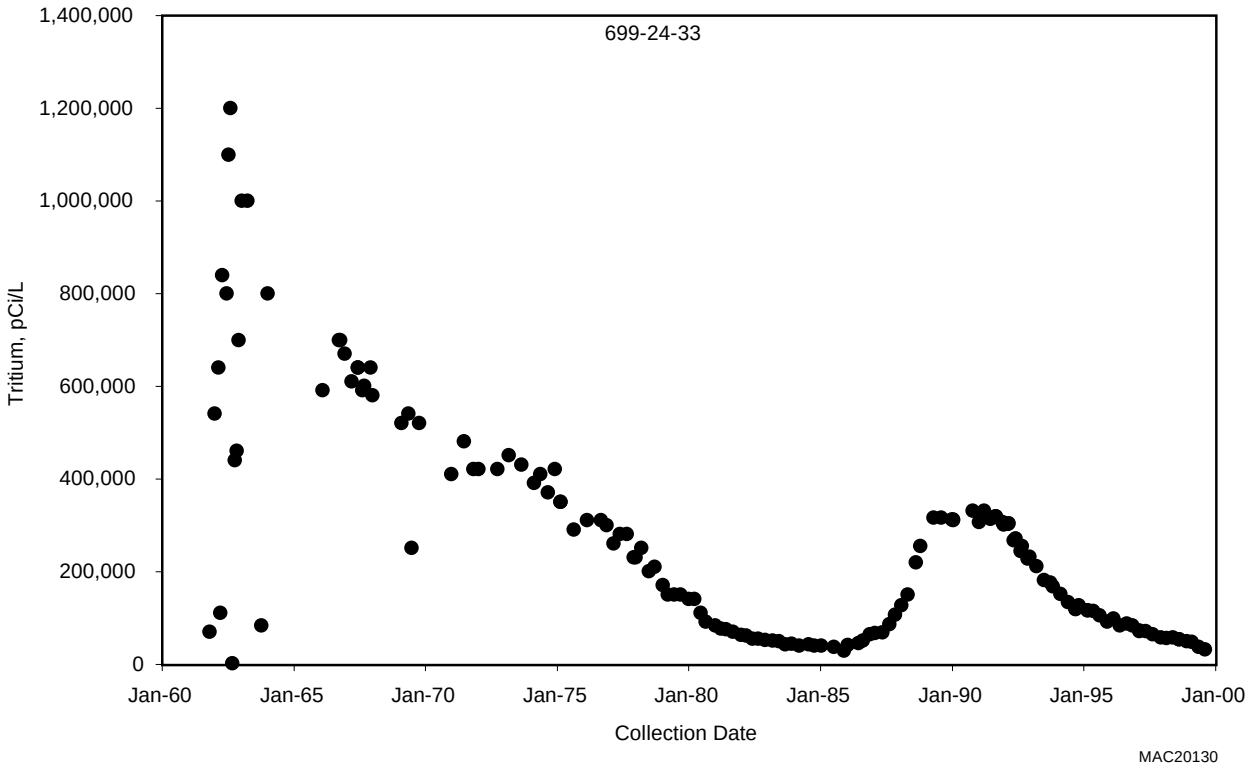


Figure 2.9-15. Tritium in Well 699-24-33 Near the Central Landfill

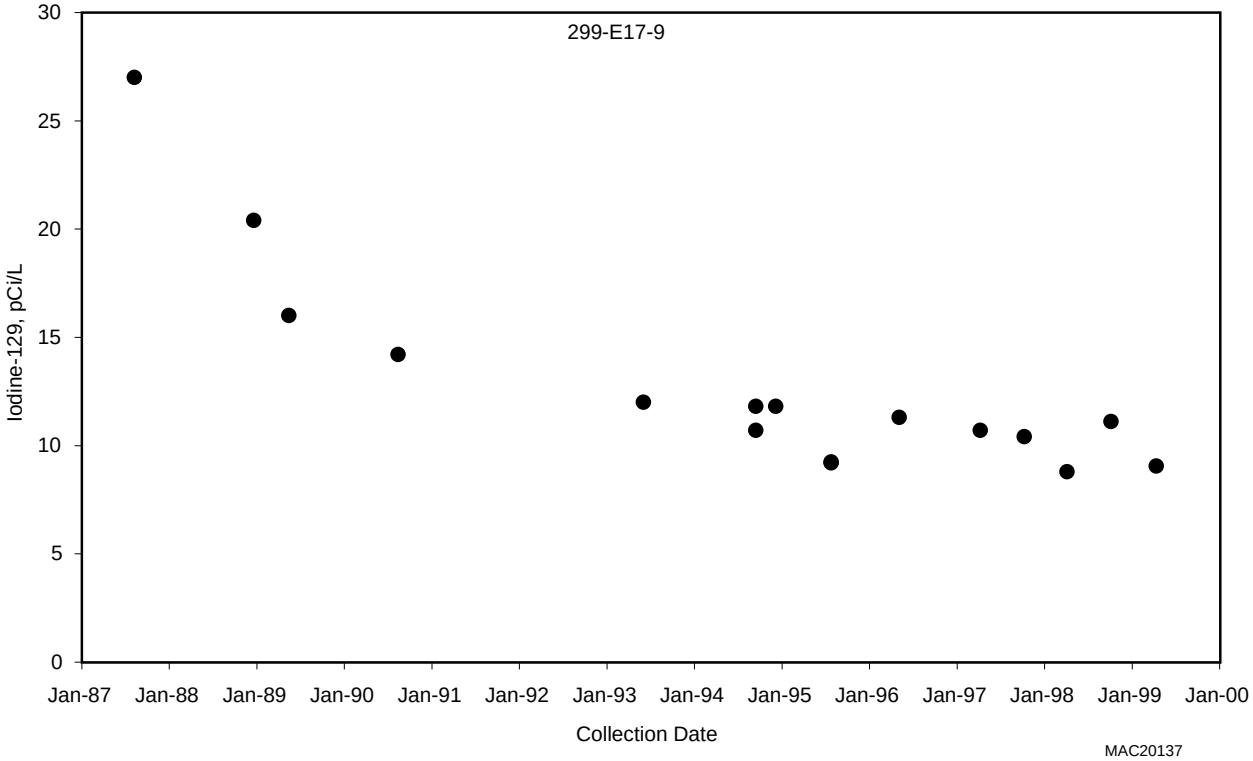


Figure 2.9-16. Iodine-129 in Well 299-E17-9 at 216-A-36B Crib

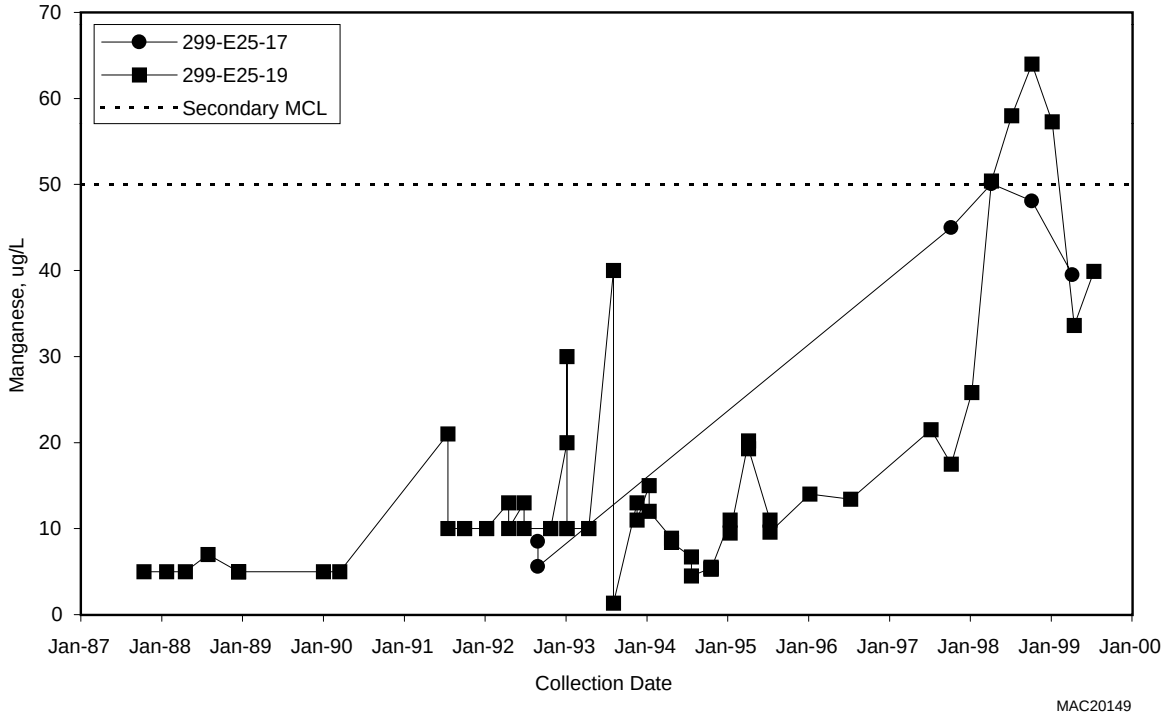


Figure 2.9-17. Manganese at 216-A-37-1 Crib

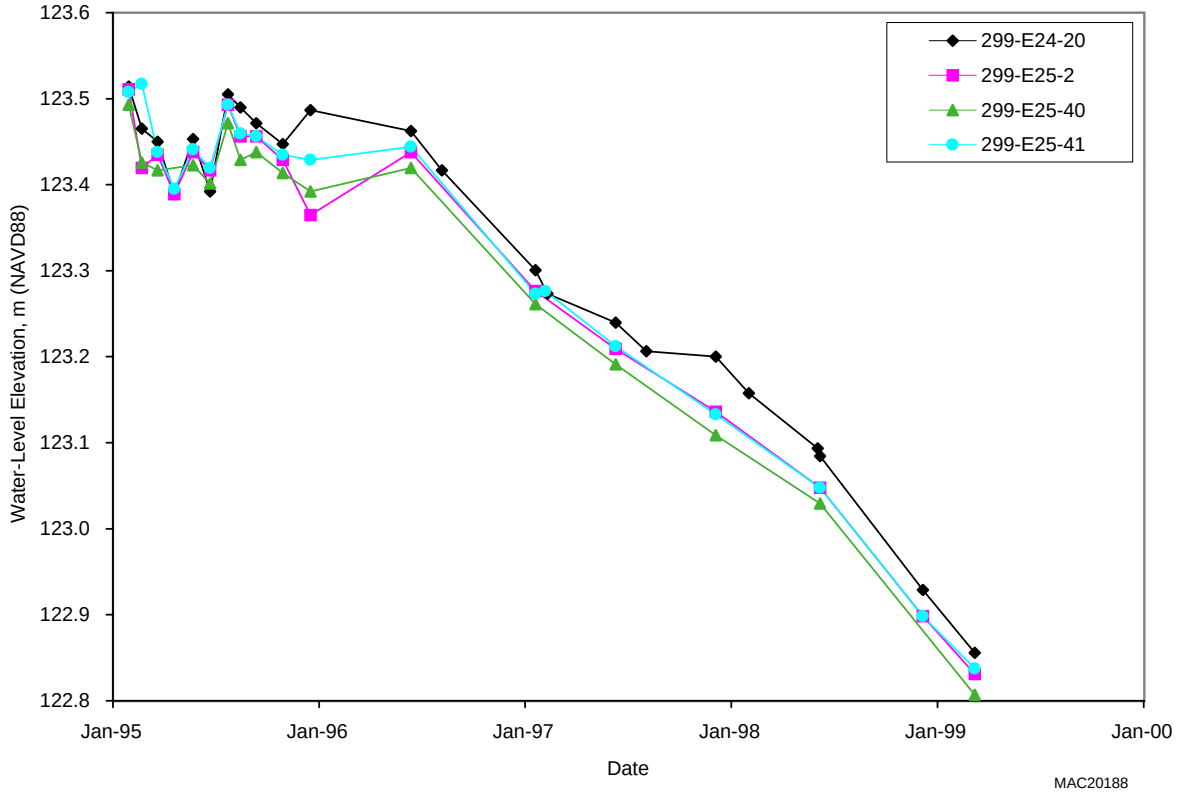


Figure 2.9-18. Hydrographs of Wells at Waste Management Area A-AX Using NAVD88

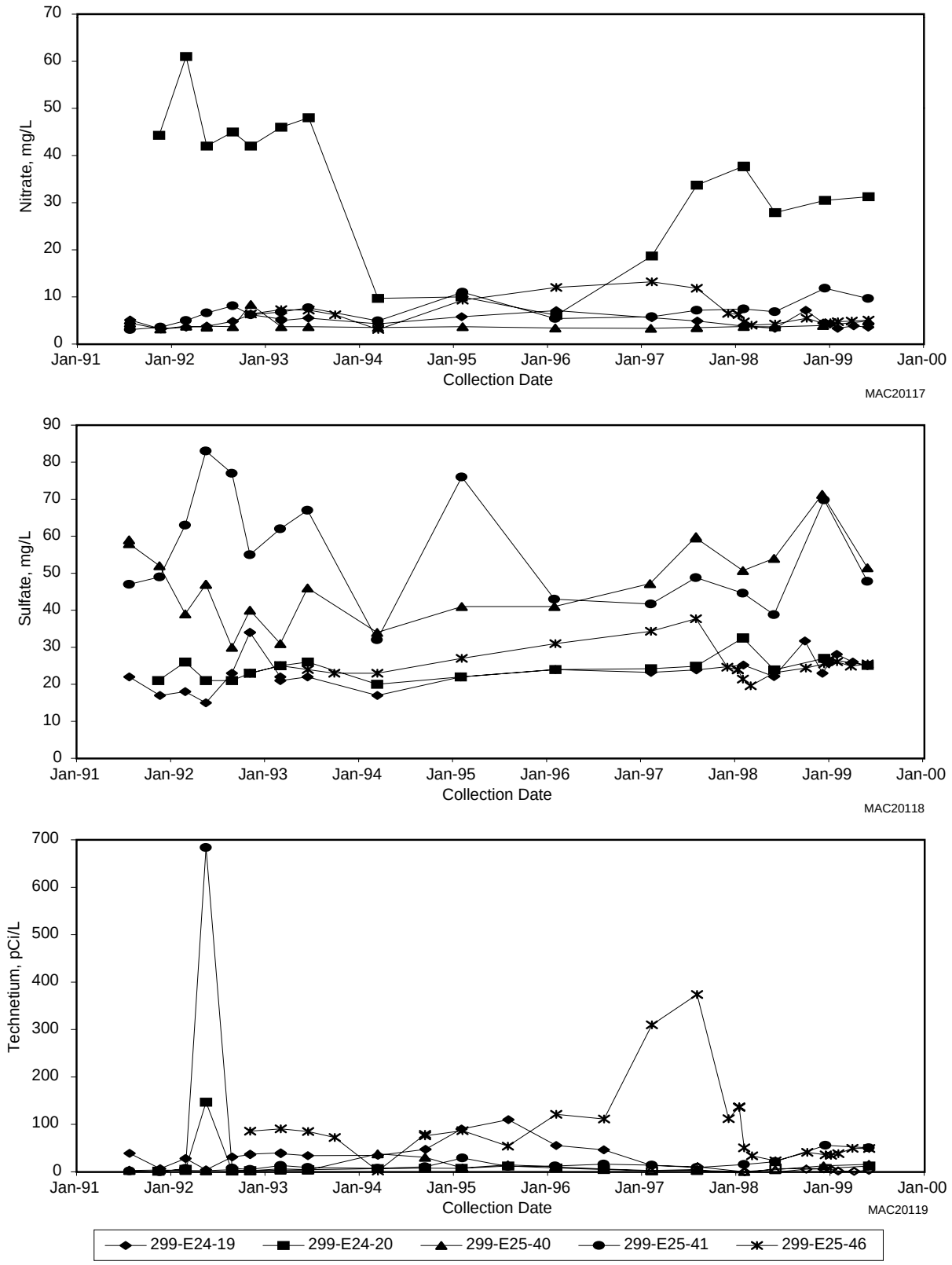


Figure 2.9-19. Nitrate, Sulfate, and Technetium-99 in Wells at Waste Management Area A-AX

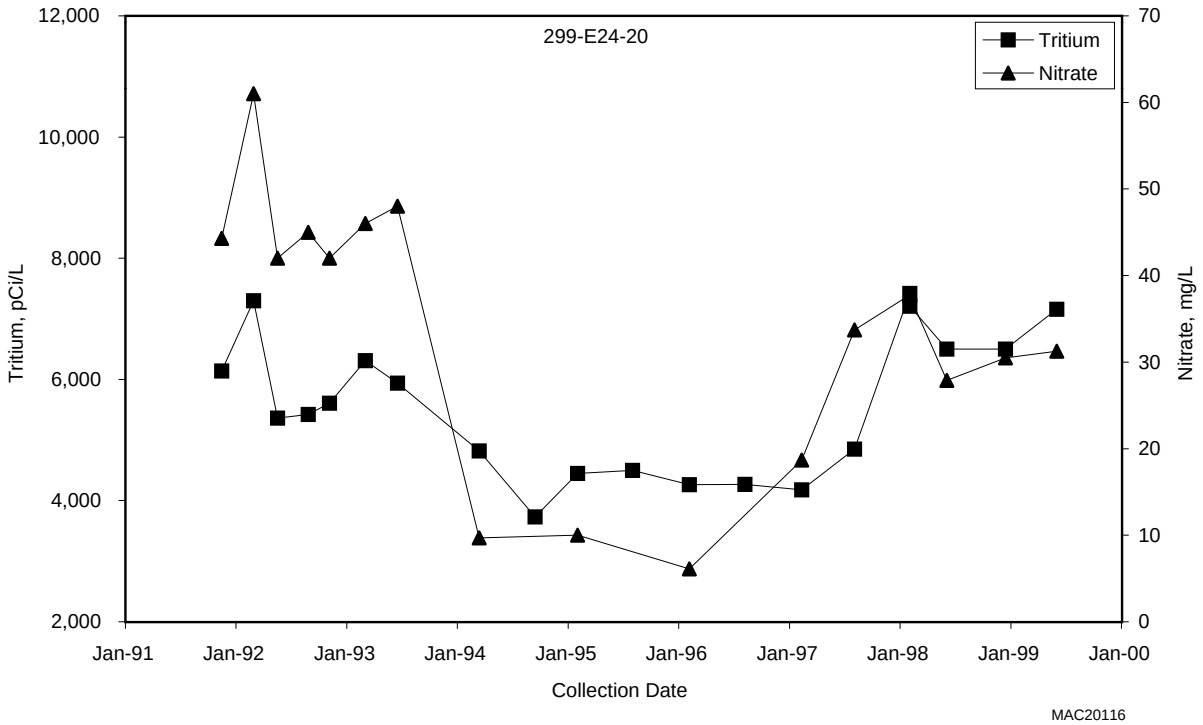


Figure 2.9-20. Tritium and Nitrate in Well 299-E24-20 at Waste Management Area A-AX

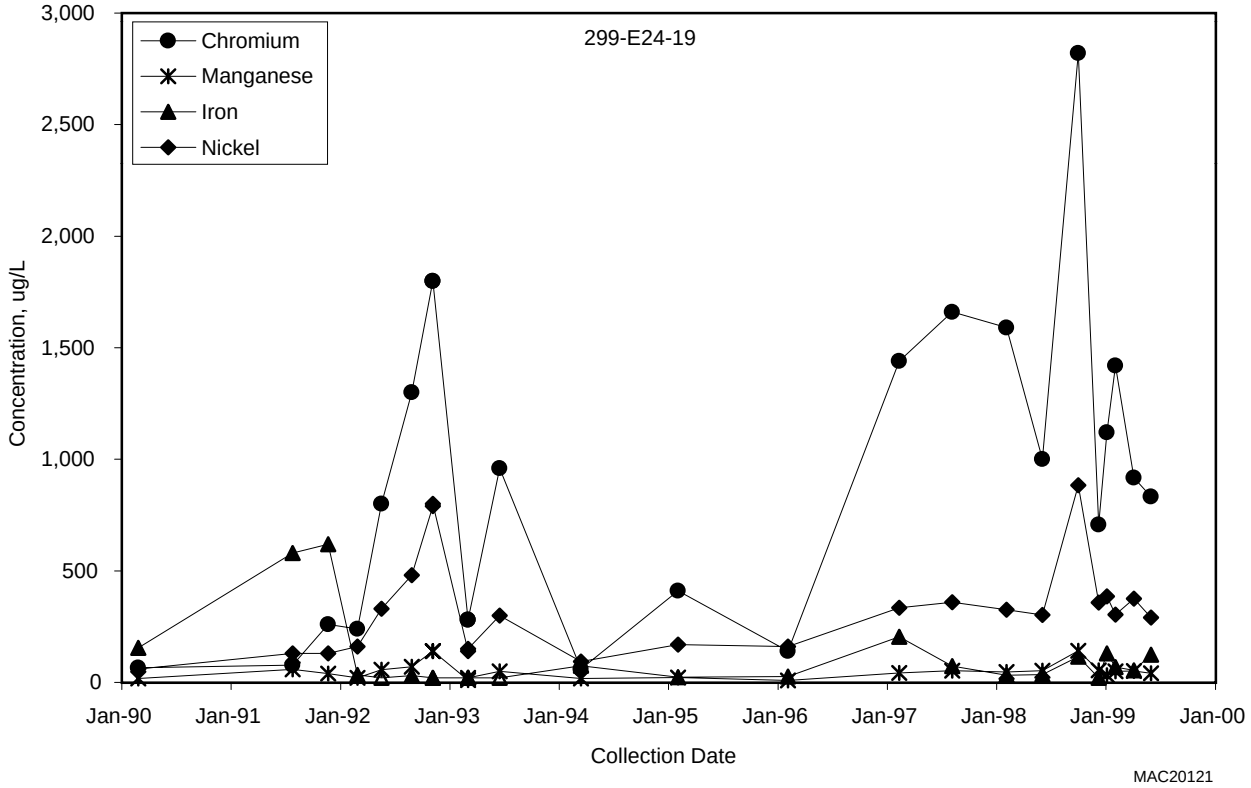


Figure 2.9-21. Chromium, Iron, Manganese, and Nickel in Well 299-E24-19 at Waste Management Area A-AX

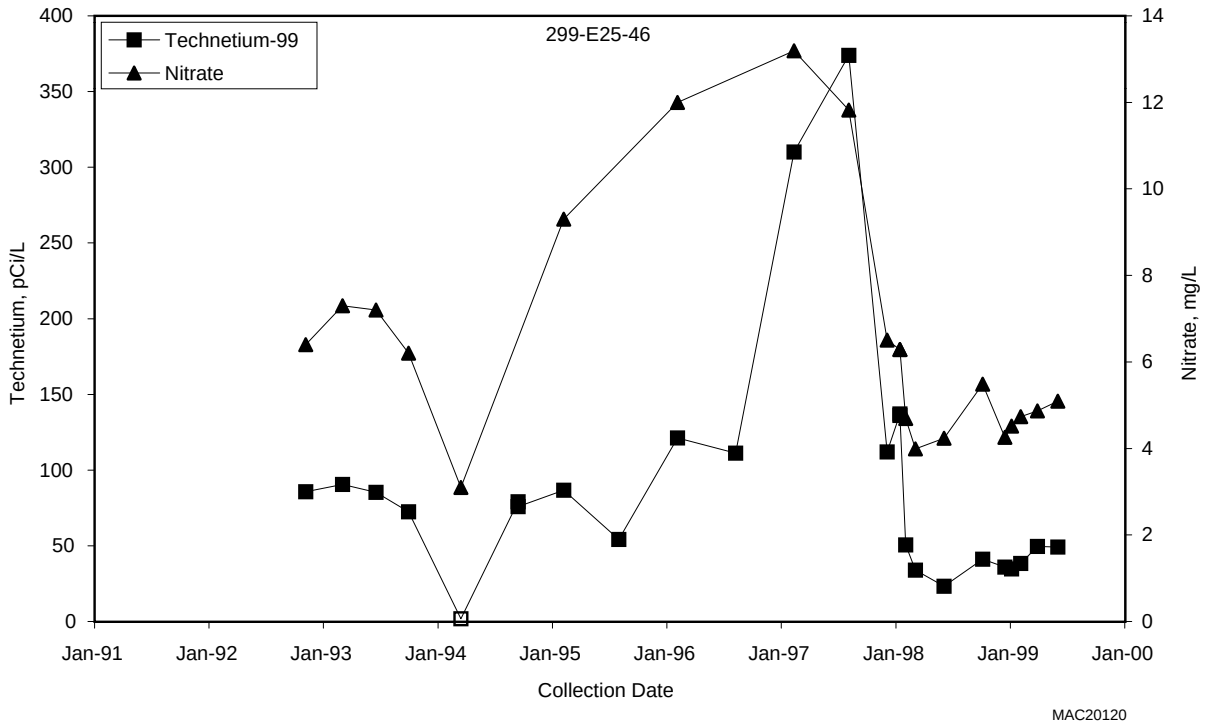


Figure 2.9-22. Technetium-99 and Nitrate in Well 299-E25-46 at Waste Management Area A-AX

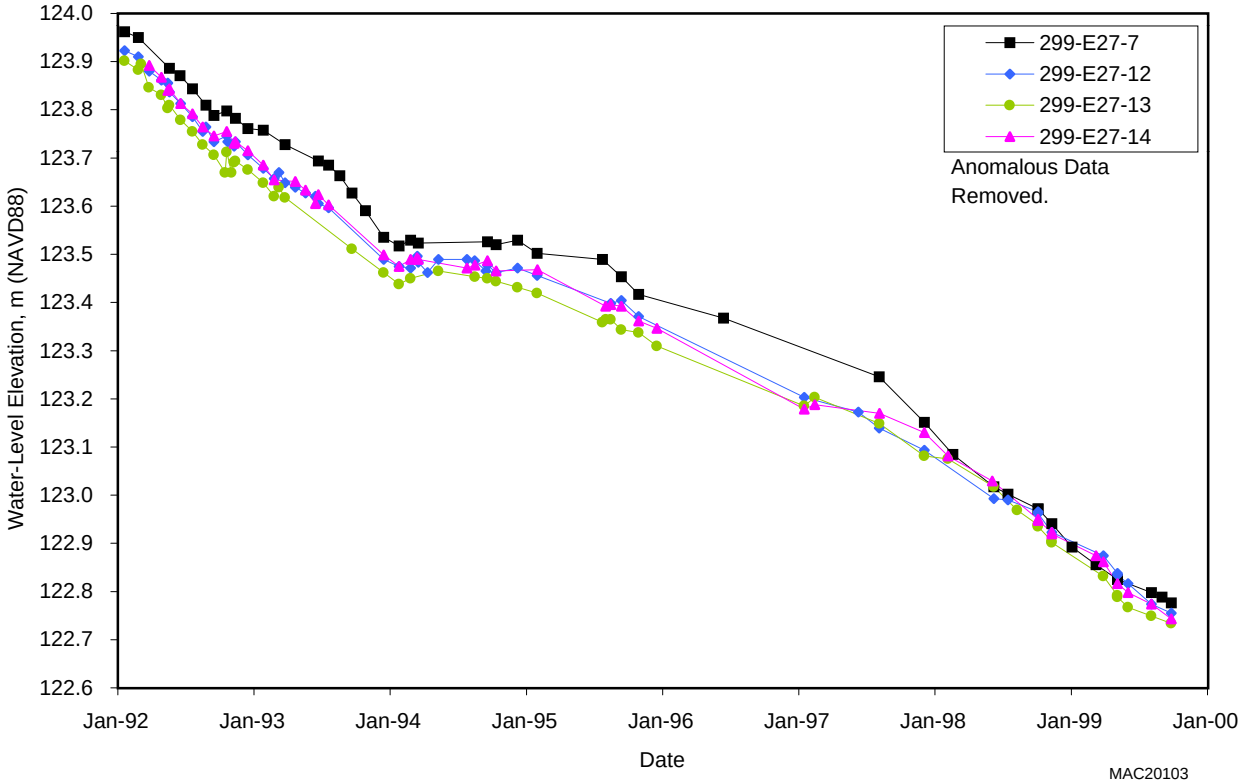


Figure 2.9-23. Hydrographs of Wells at Waste Management Area C

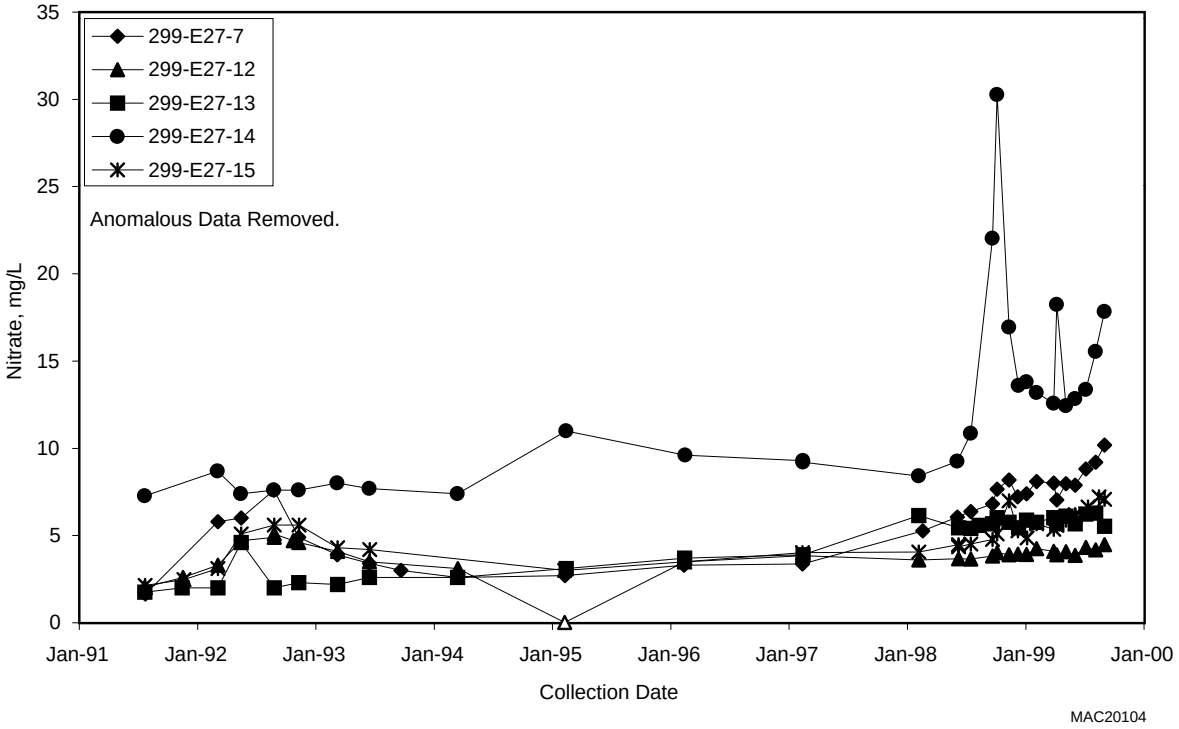


Figure 2.9-24. Nitrate at Waste Management Area C

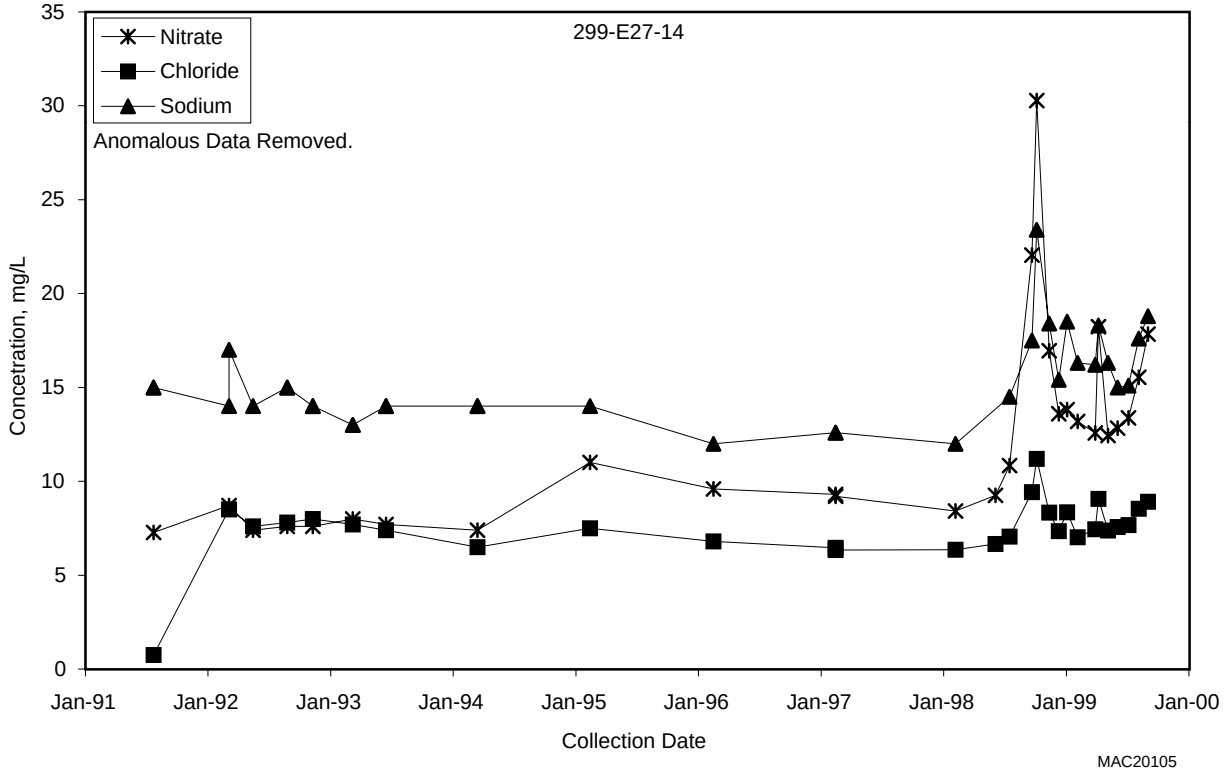
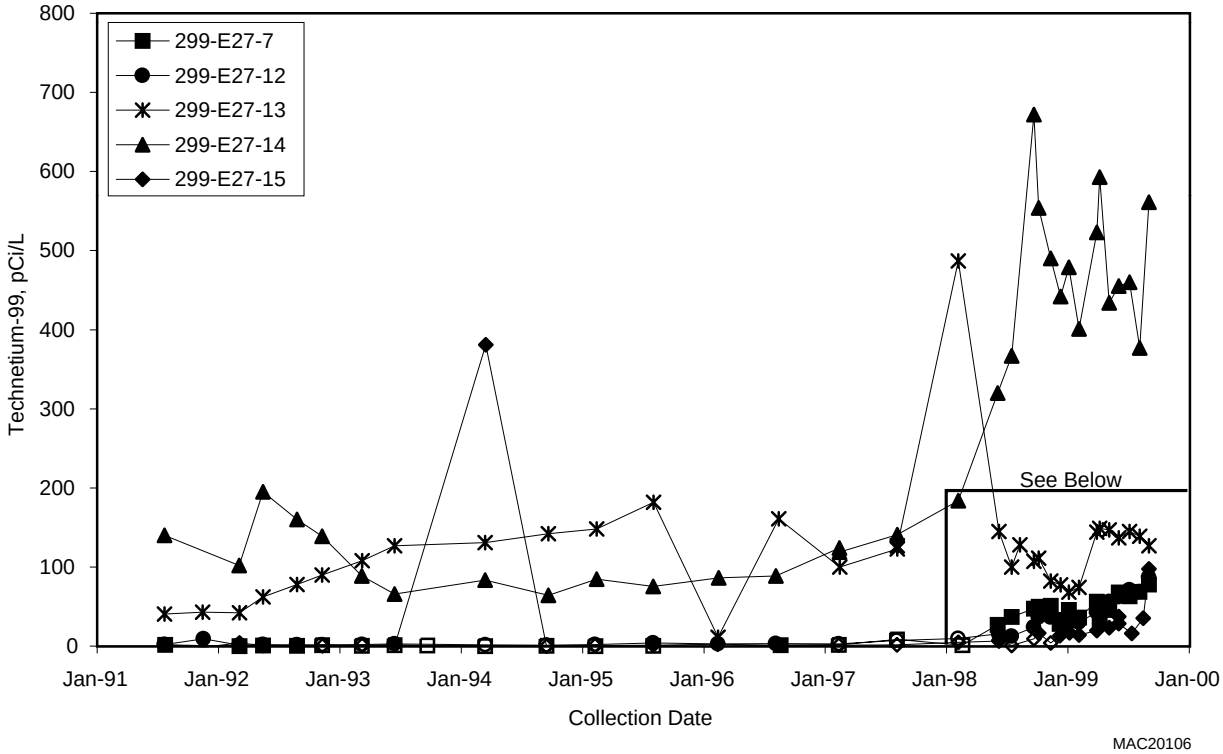


Figure 2.9-25. Nitrate, Chloride, and Sodium in Well 299-E27-14 at Waste Management Area C



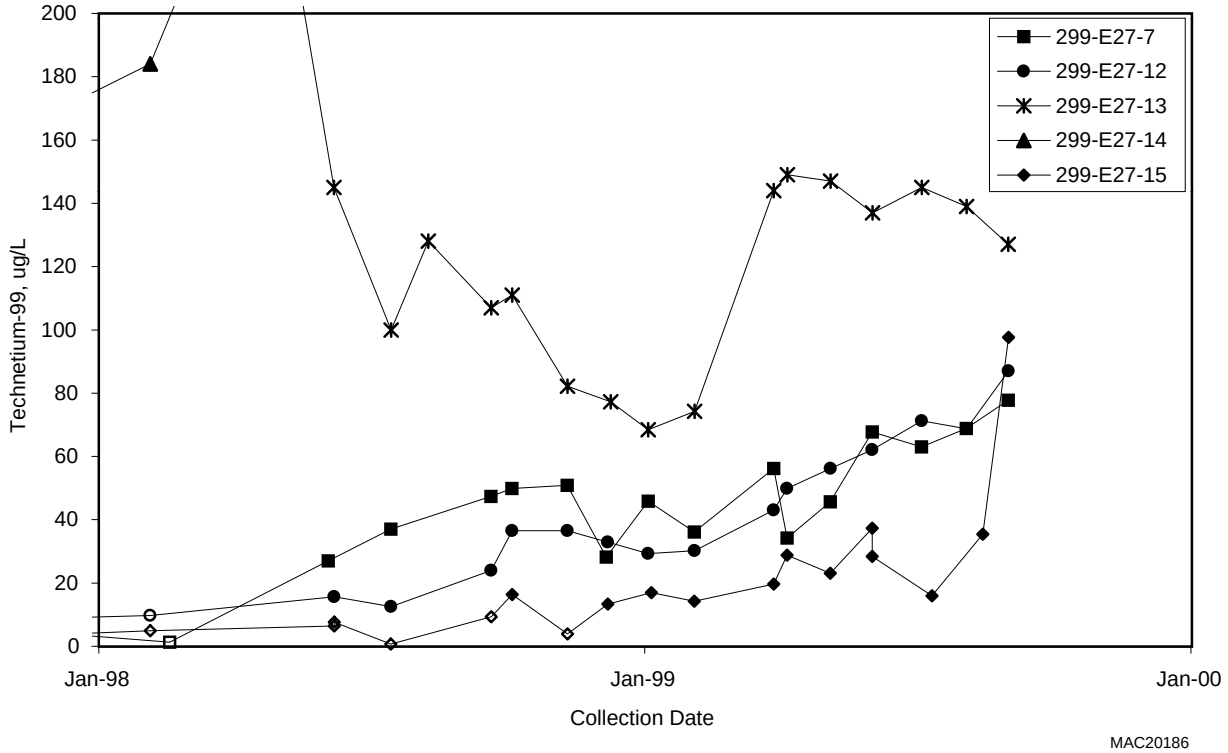


Figure 2.9-26. Technetium-99 at Waste Management Area C

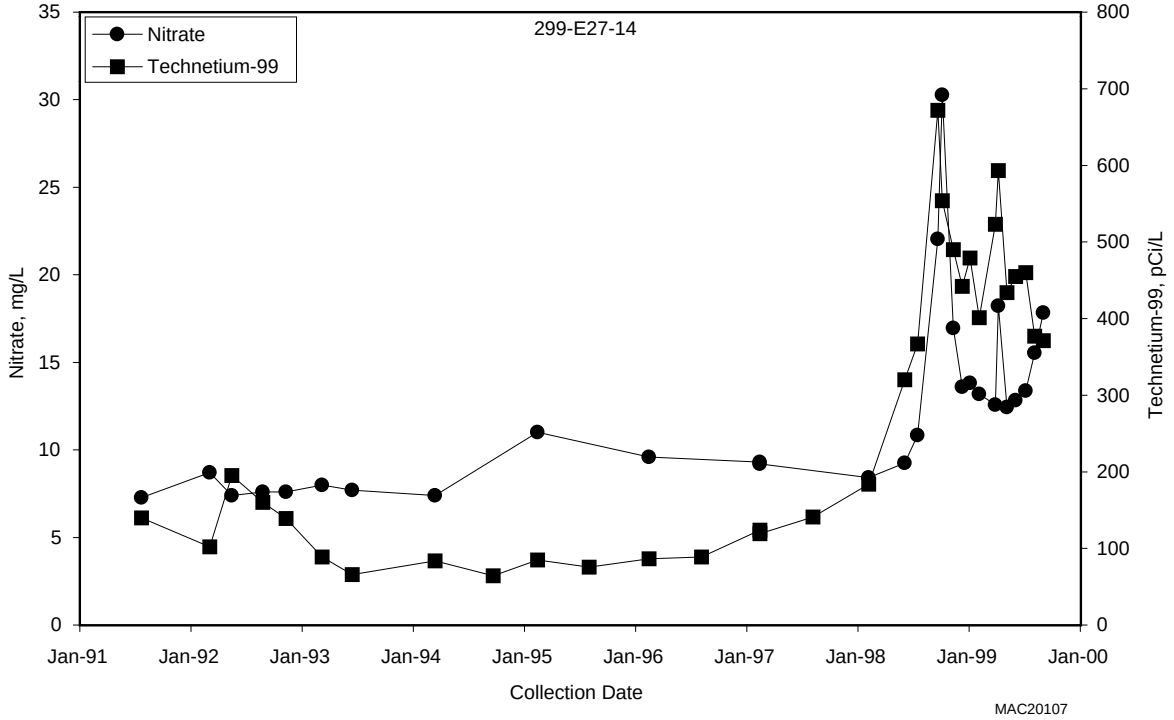


Figure 2.9-27. Nitrate and Technetium-99 in Well 299-E27-14 at Waste Management Area C

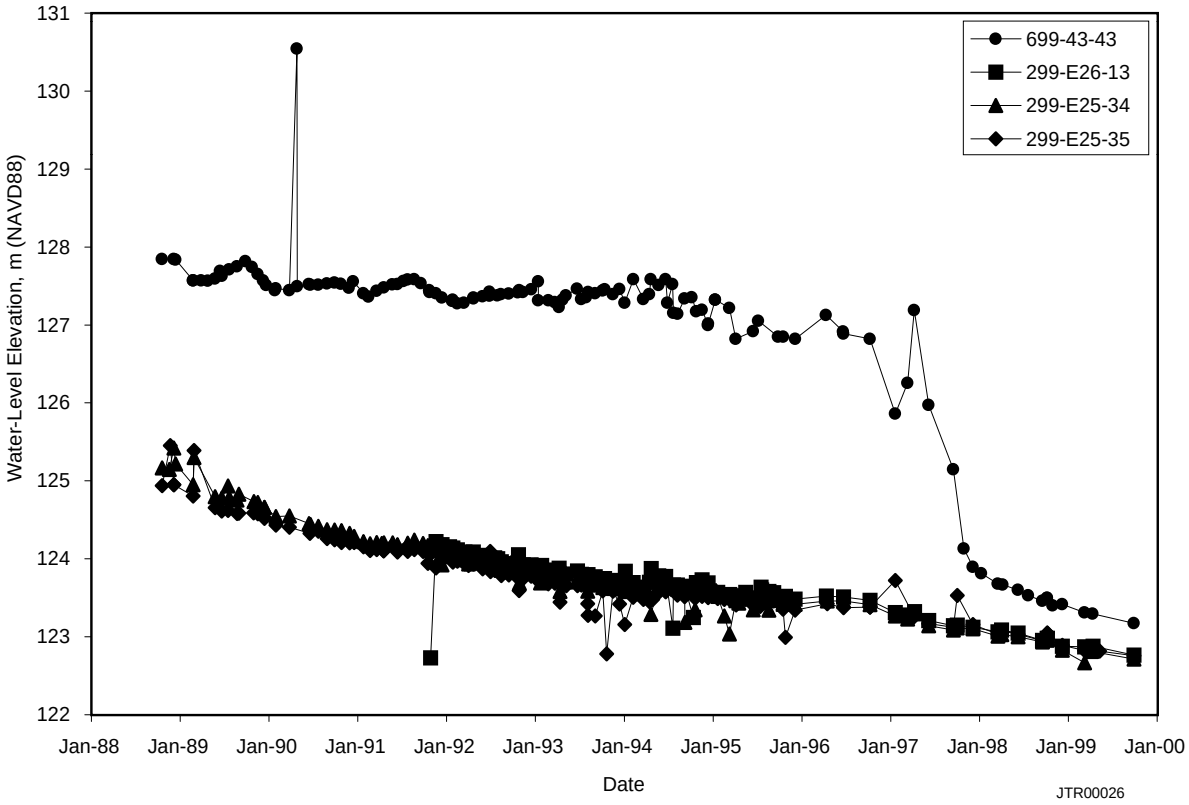


Figure 2.9-28. Hydrographs of Wells at 216-A-29 Ditch

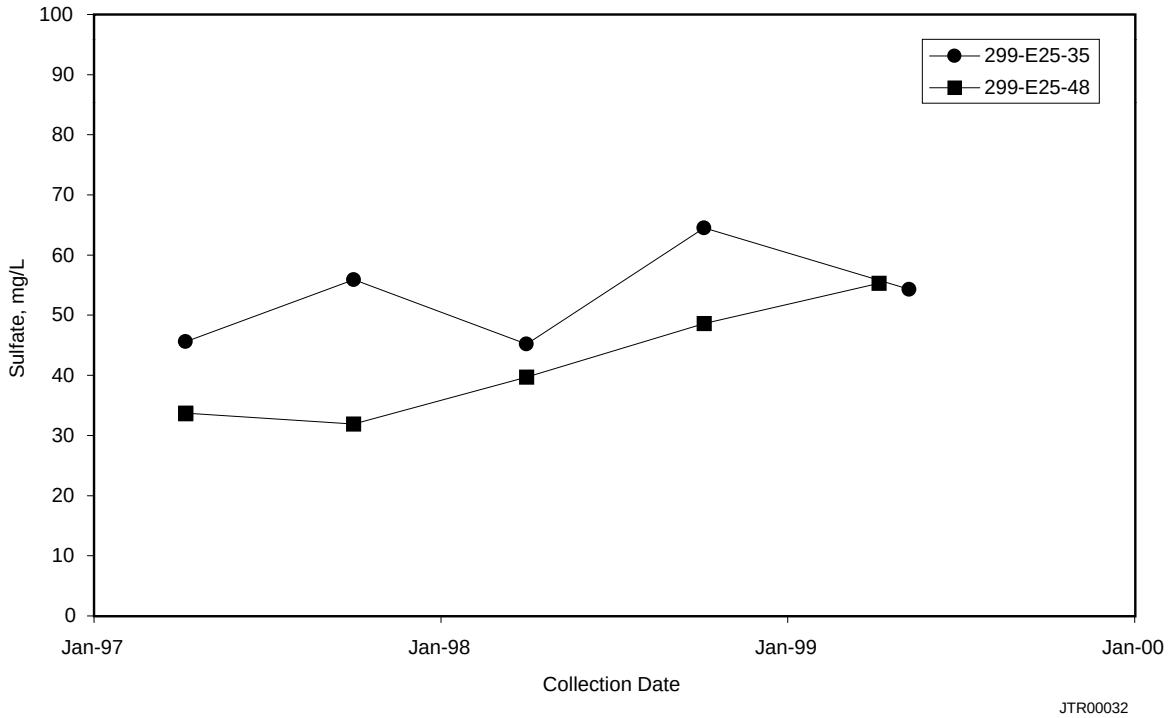


Figure 2.9-29. Sulfate in Wells Monitoring 216-A-29 Ditch

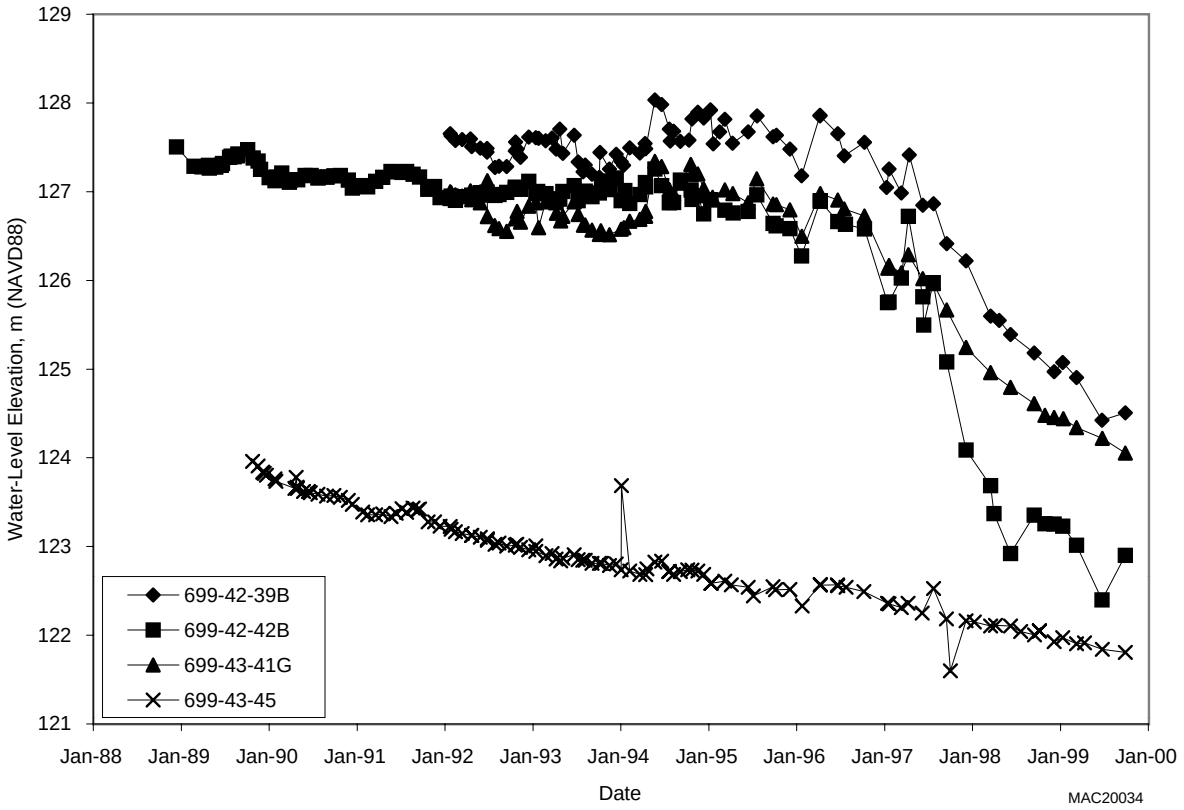


Figure 2.9-30. Hydrographs of Wells at 216-B-3 Pond

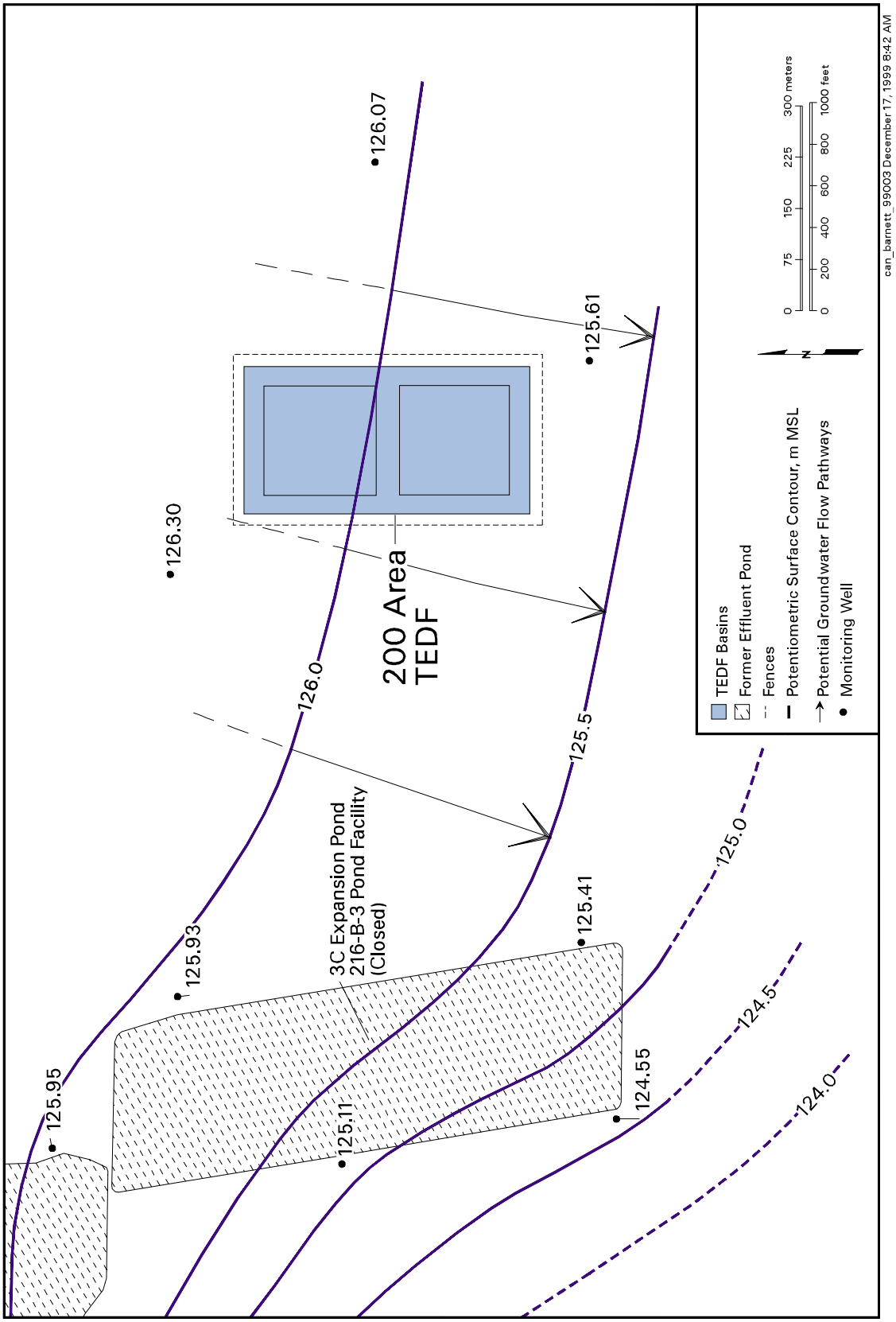


Figure 2.9-31. Potentiometric Surface Map of Unit 7 for the Vicinity of the Treated Effluent Disposal Facility

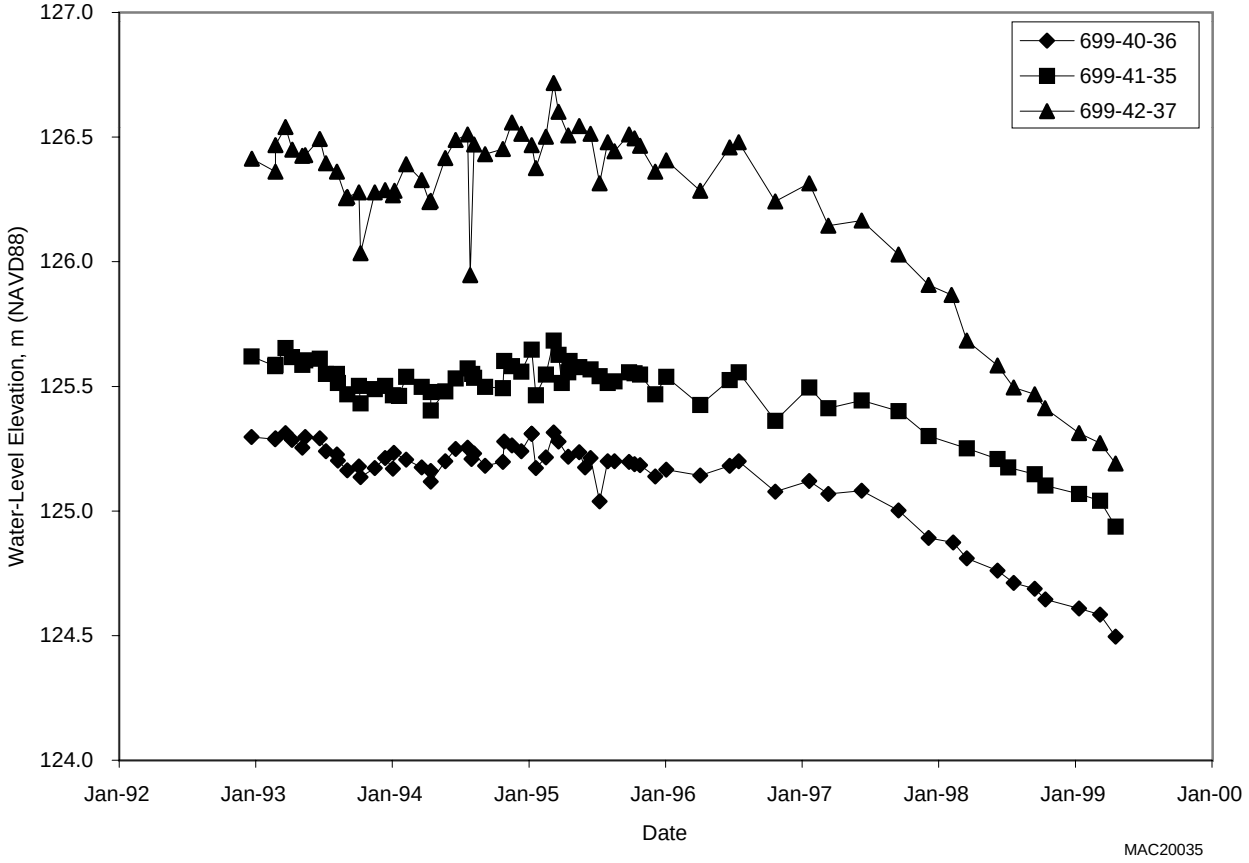


Figure 2.9-32. Hydrographs of Wells at the Treated Effluent Disposal Facility

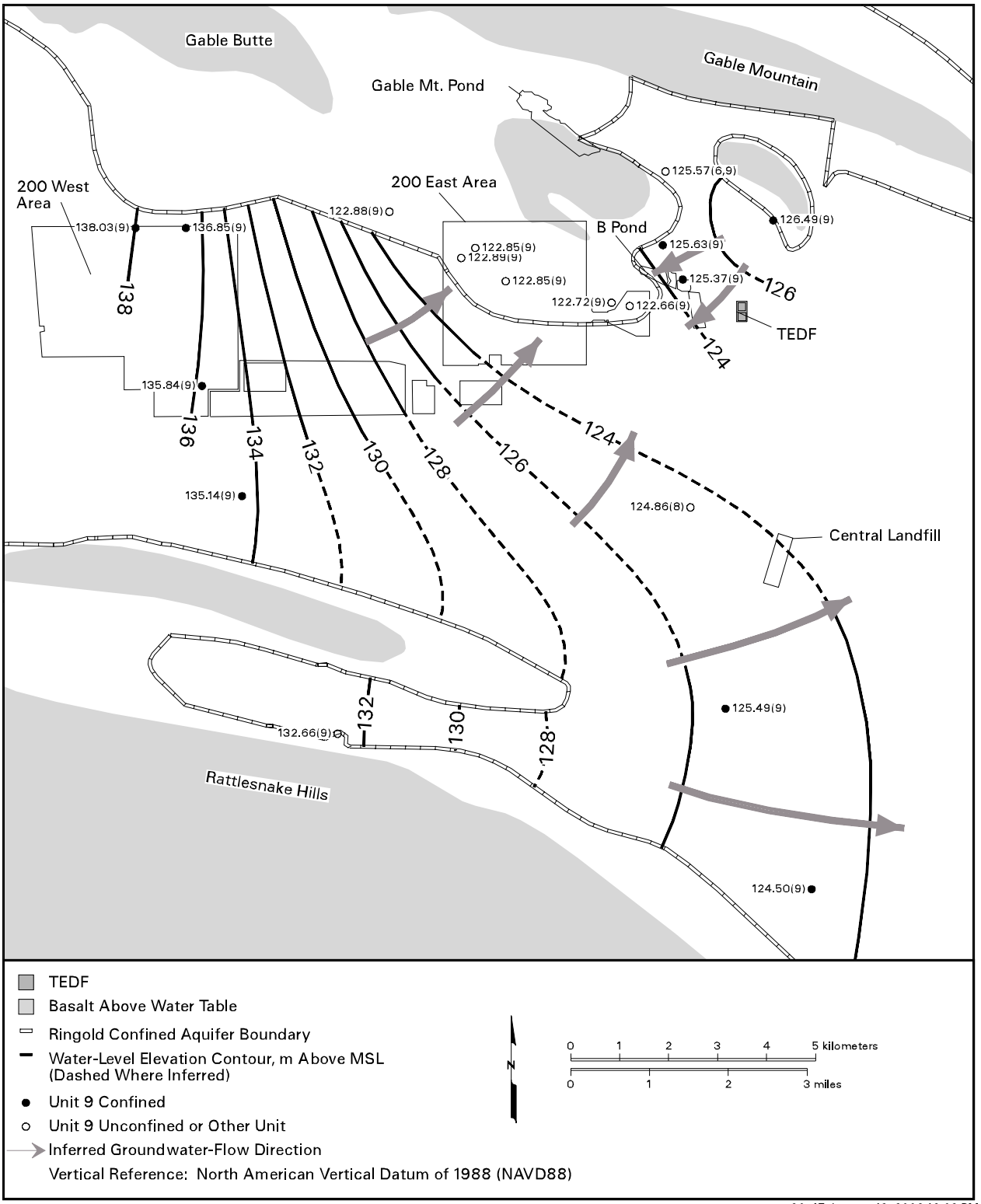


Figure 2.9-33. Potentiometric Surface Map of Ringold Formation Confined Aquifer (Unit 9), Central Hanford Site, March 1999

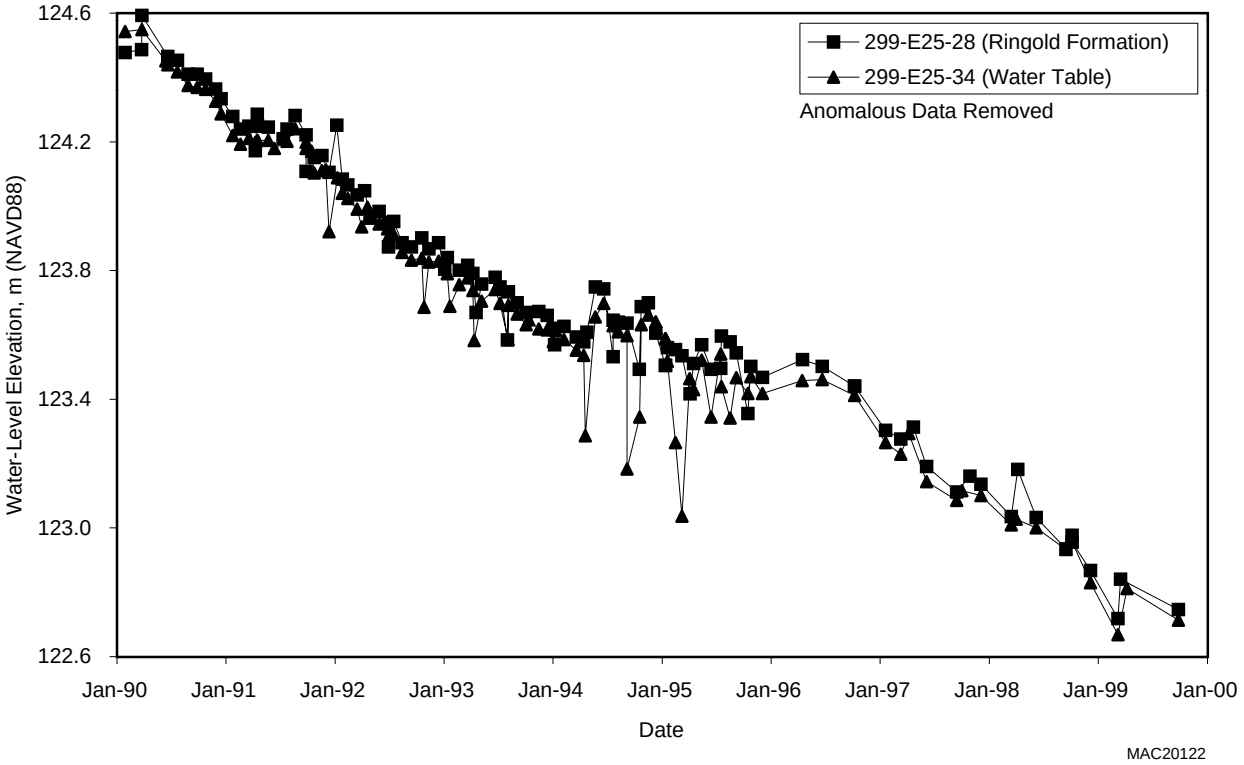


Figure 2.9-34. Water Levels in Wells 299-E25-28 (Ringold Formation Confined Aquifer) and 299-E25-34 (Unconfined Aquifer)

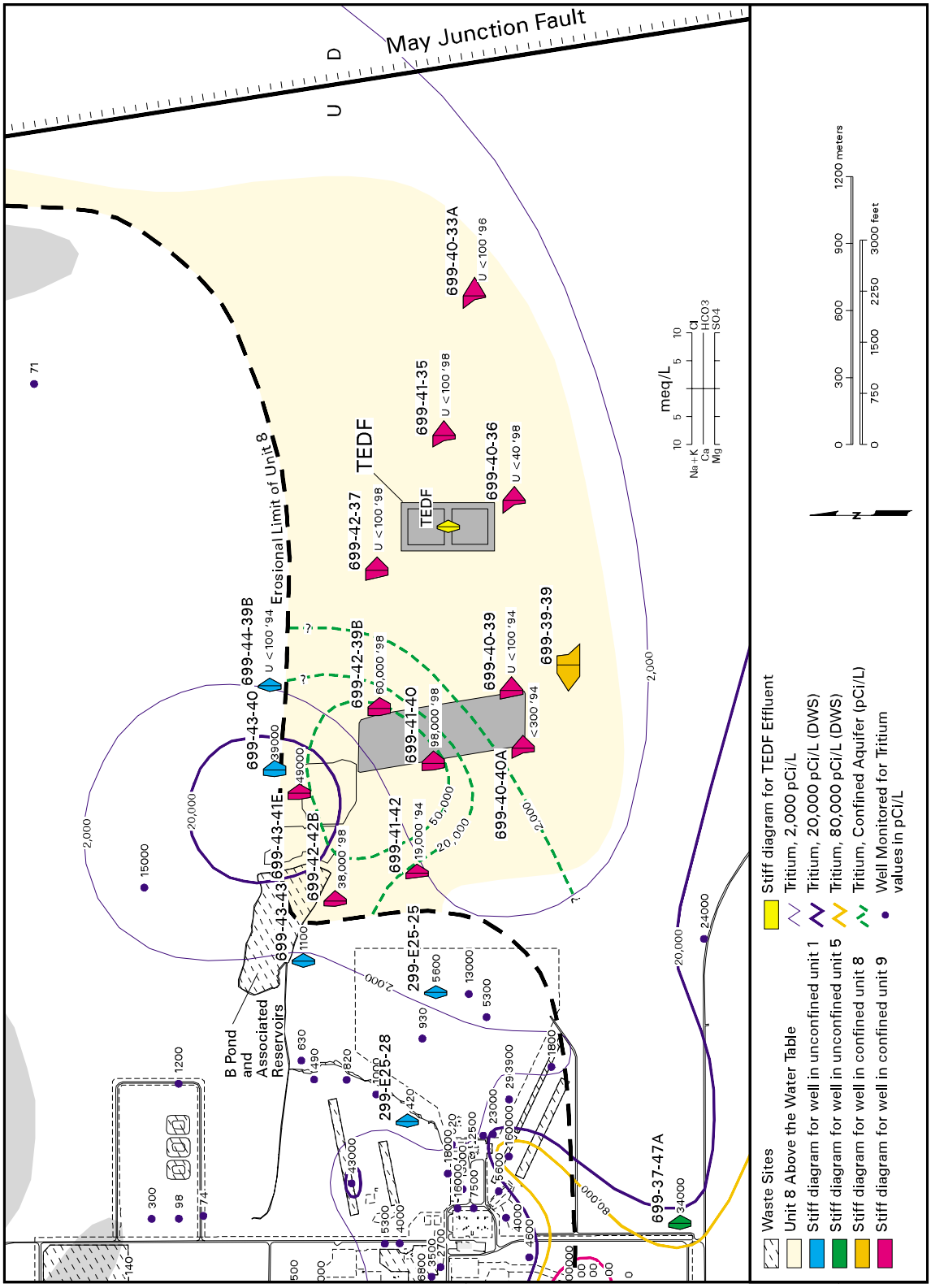


Figure 2.9-35. Major Ion Chemistry and Tritium Concentrations for Confined and Unconfined Groundwater Near 216-B-3 Pond and the Treated Effluent Disposal Facility