2.9 200-UP-1 Operable Unit

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The scope of this section is the 200-UP-1 groundwater interest area, which includes the 200-UP-1 groundwater operable unit (see Figure 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined the groundwater interest areas informally to facilitate scheduling, data review, and interpretation. Figure 2.9-1 shows facilities and groundwater monitoring wells in this region. Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater and form extensive plumes within the region. Groundwater is monitored (1) to track existing contaminant plumes within the operable unit; (2) to assess the performance of an interim action pump-and-treat system for remediation of technetium-99 and uranium; (3) for the *Resource Conservation and Recovery Act* (RCRA) units at Waste Management Areas U and S-SX, 216-S-10 pond and ditch, and 216-U-12 crib; and (4) for the Environmental Restoration Disposal Facility under a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) record of decision (ROD 1995b). In addition to the above mentioned constituents, high-priority contaminants of concern include strontium-90, trichloroethene, chloroform, chromium, cadmium, and arsenic.

Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater and form extensive plumes within the region.

The sampling and analysis plan for fiscal year (FY) 2004 sampling of the 200-UP-1 Operable Unit is incorporated into the Draft *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76, Rev. 1, Draft A), which was revised during the year to support FY 2005 sampling (DOE/RL-92-76, Rev. 1, Draft B).

Groundwater monitoring in the 200-UP-1 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring

- ***Five monitoring wells are sampled annually or semiannually at the pump-and-treat area.***
- ***Three extraction wells are sampled annually or semiannually at the pump-and-treat area.***
- ***One monitoring well is sampled biennially at the pump-and-treat area.***
- ***Thirty-six wells are sampled annually, semiannually, or biennially for 12 constituents of concern throughout the remainder of the 200-UP-1 Operable Unit (outside of the pump-and-treat area).***
- ***Four wells are sampled semiannually at the Environmental Restoration Disposal Facility.***
- ***In FY 2004, all wells were sampled as scheduled.***

Facility Monitoring

- ***Two wells are sampled quarterly at the 216-U-12 crib.***
- ***Eight wells are sampled quarterly at Waste Management Area U.***
- ***Sixteen wells are sampled quarterly at Waste Management Area S-SX.***
- ***Three wells are sampled semiannually for the 216-S-10 pond and ditch.***
- ***In FY 2004, all wells were sampled as scheduled although the December 2003 sampling for many wells at Waste Management Area S-SX was delayed until early February 2004 due to the weather.***
- ***Sampling is coordinated with other programs to avoid duplication.***

AEA Monitoring

- ***Twelve wells are sampled annually or semiannually for contaminants, radionuclides, and general chemistry not otherwise scheduled under CERCLA and RCRA.***
- ***In FY 2004, all wells were sampled as scheduled.***
- ***Sampling is coordinated with CERCLA and RCRA sampling to avoid duplication.***

This plan integrates CERCLA and *Atomic Energy Act of 1954* (AEA) monitoring, and is a revision of the original integrated plan issued during June 2002 (DOE/RL-2002-10). The objectives of this monitoring are to regionally determine the spatial extent of existing contaminant plumes within the operable unit, assess the performance of an interim remedial action pump-and-treat system, and to identify emerging contamination issues. Appendix A presents the monitoring well network for the 200-UP-1 Operable Unit, including a well list, sampling frequencies, and analyte lists.

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

Chromium — 1.07
Iodine-129 — 4.51
Nitrate — 6.86
Technetium-99 — 0.12
Trichloroethene — 0.07
Tritium — 6.67
Uranium — 0.56

****Carbon tetrachloride included in Section 2.8.***

Groundwater flows primarily to the east within the 200-UP-1 groundwater interest area (see Figure 2.8-2 in Section 2.8). Water levels have been falling in this area since the 1980s, and flow directions have changed from southeast to east during this time. From March 2003 to March 2004, the water-table elevation fell by an average of 0.25 meter in the south 200 West Area. Groundwater flow is not significantly influenced by the pump-and-treat system at the 200-UP-1 Operable Unit. Groundwater pumping rates associated with this system are relatively low, so the hydraulic effect is localized.

Eight new monitoring wells were installed in the operable unit during calendar year 2004. Five wells are located outside the 200 West Area boundary to the east (699-30-66, 699-36-70B, 699-38-70B, 699-38-70C, and 699-40-65), one at the 200-UP-1 pump-and-treat area (299-W19-48), one to the south of the pump-and-treat area (299-W21-2), and one at Waste Management Area U (299-W19-47). Sampling results for these wells are included in the following sections, as appropriate.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under CERCLA, RCRA, and AEA monitoring.

2.9.1 Groundwater Contaminants

The following sections give an overview of the contaminant plumes and contaminants of concern for the 200-UP-1 groundwater interest area. It is a summary of the combined results of CERCLA, RCRA, and AEA monitoring performed in this area. The focus of this section is the top of the unconfined aquifer. Information on the vertical distribution of contaminants in the aquifer is given where available.

2.9.1.1 Technetium-99

Technetium-99 above the drinking water standard occurs in two regions of the 200-UP-1 groundwater interest area: an extensive, three-part plume downgradient from the 216-U-1,2 cribs and two small plumes at Waste Management Area S-SX (Figure 2.9-2). The large plume originated from the 216-U-1,2 cribs, which were active in the 1950s and 1960s. When effluent was disposed at the nearby 216-U-16 crib in the mid-1980s, it migrated north along a caliche layer and mobilized the technetium-99 and uranium in the soil column beneath the 216-U-1,2 cribs, adding to the groundwater plume (DOE/RL-92-76, Rev. 1, Draft B).

Technetium-99 concentrations declined downgradient of the 216-U-1,2 cribs due to the effects of a pump-and-treat system.

During FY 2004, peak concentrations continued to decline in the central part of this plume due to the operation of an interim remedial action pump-and-treat system. All measured concentrations remained below the remedial action goal of 9,000 pCi/L. The maximum concentration measured was 5,900 pCi/L found in well 299-W19-36 (the maximum during FY 2003 was 18,200 pCi/L in well 299-W19-43). Two wells (299-W19-9 and 299-W19-18) located at or just downgradient of the 216-U-1,2 cribs were sampled during FY 2004. Technetium-99 concentrations were found below the drinking water standard (900 pCi/L) in both wells, indicating that the crib and vadose zone beneath it do not represent a significant ongoing source of technetium-99. The trend is stable in well 299-W19-18, but increased during the fiscal year in well 299-W19-9 to 760 pCi/L. Refer to Section 2.9.2 for a more thorough discussion of the pump-and-treat remediation system.

To the east of the 200 West Area, technetium-99 concentrations also declined as the plume attenuated. In one of the new wells (699-38-70C) located ~650 meters east of the 200 West Area boundary, technetium-99 concentrations (ranging from 1,000 to 1,600 pCi/L) above the drinking water standard (900 pCi/L) were found throughout the unconfined aquifer from the water table to the Ringold Formation lower mud unit. The well was completed at a depth of ~30 meters below the water table (2 meters above the lower mud unit), and the measured technetium-99 concentration from the well at this depth was 1,000 pCi/L.

Concentrations of technetium-99 in well 299-W23-19, at Waste Management Area S-SX, reached 188,000 pCi/L in January 2003, the highest value ever measured in Hanford groundwater. Values remained stable at ~42,500 pCi/L during FY 2004.

At Waste Management Area S-SX, a technetium-99 plume originates from the southwest corner of the waste management area and another plume originates from the north part. During FY 2004, the technetium-99 concentration in well 299-W23-19 (located at the southwest corner of this waste management area near the source of the south plume) remained stable at ~42,500 pCi/L (Figure 2.9-3). The technetium-99 concentration at this well had risen to 188,000 pCi/L in January 2003 (above the U.S. Department of Energy [DOE] derived concentration guide of 100,000 pCi/L), then fell to ~74,300 pCi/L by the end of the fiscal year. This plume is migrating to the east-southeast, and the plume front has entered a region of sparse well coverage and cannot be tracked further. The north plume originates from the S Tank Farm and appears to be shifting more to the north as it migrates eastward. The peak concentration measured in this plume during the fiscal year was 4,200 pCi/L in well 299-W22-48. Refer to Section 2.9.3.2 for more information about technetium-99 at this waste management area.

Technetium-99 is found in the downgradient wells at Waste Management Area U. However, concentrations are below the drinking water standard. The maximum concentration measured during FY 2004 was 740 pCi/L in well 299-W19-45. Refer to Section 2.9.3.1 for more information about technetium-99 at this waste management area.

The 216-U-12 crib is a confirmed source of technetium-99 to the groundwater (PNNL-11574). Although the monitoring well coverage downgradient of this crib is sparse, the measured concentrations available (wells 299-W22-79 and 699-36-70A) are below the drinking water standard.

2.9.1.2 Uranium

Within the 200-UP-1 groundwater interest area, uranium primarily occurs in an extensive plume downgradient from the 216-U-1,2 cribs (Figure 2.9-4) and is associated with the technetium-99 plume here. The plume extends a total of ~1.5 kilometers to the east and northeast. The uranium originated from the 216-U-1,2 cribs, which were active in the 1950s and 1960s. Additional mass was added to the plume when effluent disposed of at the nearby 216-U-16 crib in the mid-1980s migrated north along a caliche layer and mobilized the technetium-99 and uranium in the soil column beneath the 216-U-1,2 cribs (DOE/RL-92-76, Rev. 1, Draft B).

Uranium responds more slowly than technetium-99 to the pump-and-treat system. All concentrations were below the remedial action goal (480 µg/L) but remain above the drinking water standard (30 µg/L) in wells within the pump-and-treat area.

An interim remedial action pump-and-treat system continued to operate during FY 2004, and concentrations in this plume generally declined or remained stable. During the fiscal year, all measured uranium concentrations were below the remedial action goal of 480 µg/L for all wells within the area designated for pump-and-treat remediation. The maximum concentration measured in this area during FY 2004 was 440 µg/L in well 299-W19-36 (the maximum during FY 2003 was 1,200 µg/L in well 299-W19-43). Uranium is not as mobile as technetium-99 in groundwater, so uranium concentrations are not falling as rapidly as the technetium-99 concentrations. All measured uranium concentrations within the remediation target area remained above the drinking water standard (30 µg/L).

During FY 2004, uranium was found at 600 µg/L in well 299-W19-18 located 70 meters downgradient of the 216-U-1,2 cribs. The historical peak uranium concentration in this well was 9,650 µg/L in the late 1980s. Uranium concentrations for this well are shown in Figure 2.9-5. Concentrations have changed little over the past 10 years – the trend exhibits what appears to be a tailing effect. Perhaps when uranium from beneath the cribs reached the groundwater, a good portion of it precipitated or sorbed onto sediment grains. This

region may be acting as an ongoing source in the aquifer as the uranium slowly desorbs into the groundwater. Another possibility is the uranium continues to leach from the vadose zone beneath the cribs.

A small uranium plume has previously been depicted beneath the 216-S-13 crib (PNNL-14548). This facility was active in the 1950s and 1960s, resulting in uranium concentrations above the drinking water standard in well 299-W22-21, which monitored the groundwater near the crib. This well was periodically sampled until 1997, but has since gone dry. There are no longer any useable wells in this vicinity. It has been 7 years since a groundwater sample was collected near this crib, so whether or not uranium occurs in groundwater above the drinking water standard is unknown. This issue is expected to be addressed as part of the remedial investigation process.

2.9.1.3 Tritium

The tritium plume emanating from the southeast 200 West Area has nearly stopped spreading in most directions and is contracting in some areas.

Disposal facilities associated with the Reduction Oxidation (REDOX) Plant are the primary sources of tritium in the 200-UP-1 groundwater interest area. The REDOX Plant operated from 1952 until 1967, although effluent releases continued to occur after this time. A large tritium plume emanates from the south part of the 200 West Area to the east and northeast (extending ~5 kilometers). Two high concentration areas occur within this plume – a large one extending to the east and northeast from the 200 West Area and a smaller one extending ~550 meters to the east-southeast from the vicinity of the 216-S-25 crib (Figure 2.9-6).

Most wells east of the 200 West Area are scheduled for biennial sampling; they were last sampled during FY 2003 and are not due to be sampled again until FY 2005. Measured concentrations in the central part of the plume range from ~200,000 to 600,000 pCi/L. Although tritium concentrations are increasing in some wells within this central part, concentrations are declining in most wells. The overall picture is of a plume that has nearly stopped spreading in most directions and is contracting in some areas as radiological decay dominates over advective transport. Well 699-38-65, located ~1.6 kilometers east of the 200 West Area boundary, was sampled during FY 2004, and the tritium concentration here has declined to below the drinking water standard (Figure 2.9-7). This decline may be caused by a relatively high concentration portion of the plume migrating away from this well, coupled with radiological decay. Major cation and anion concentrations (including nitrate) are relatively stable in this well, thus making it unlikely that a nearby source of water is entering the aquifer and diluting the plume. (The drinking water standard for tritium is 20,000 pCi/L.)

Measured tritium concentrations near the 216-S-25 crib were generally stable or declining during FY 2004. The concentration adjacent to the crib (at well 299-W23-9) declined from 288,000 pCi/L in January 2003 to 102,000 pCi/L in August 2004, indicating that the strength of the tritium source is declining (the nitrate concentration has also declined). This part of the plume is migrating to the east-southeast, passing beneath Waste Management Area S-SX. The front of this high concentration area has now entered an area of sparse well coverage and will not be able to be tracked further (the next downgradient well is ~600 meters away).

A portion of the iodine-129 plume is migrating to the east out of the 200 West Area.

Information on the vertical distribution of tritium in the aquifer is sparse. Three of the eight wells (299-W19-48, 699-30-66, and 699-36-70B) installed within the operable unit during calendar year 2004 were sampled for tritium at different depths during drilling. The results indicate that tritium mainly occurs in the upper part of the aquifer near the water table. However, none of these wells were completed in a high concentration portion of the plume.

2.9.1.4 Iodine-129

Iodine-129 plumes in the 200-UP-1 groundwater interest area originate from both U Plant and REDOX Plant disposal facilities (Figure 2.9-8). One plume emanates from the vicinity

of the 216-U-1,2 cribs, while another originates from the south part of the 200 West Area. At the current level of monitoring detail, these plumes merge downgradient and become indistinguishable. This combined plume (as denoted by the 1-pCi/L contour level) extends to the east and northeast a total distance of ~3.5 kilometers.

As stated in PNNL-14548, a high concentration portion of the iodine-129 plume is believed to be migrating to the east out of the 200 West Area into the surrounding 600 Area. Measured concentrations in the central part of this plume range from 5 to 35 pCi/L. Iodine-129 concentrations were generally stable or had decreased slightly compared to FY 2003. The concentration has been falling rapidly in well 699-38-65, the same well in which tritium concentrations have also been declining (see Section 2.9.1.3). Iodine-129 is essentially no longer detectable in this well. (The drinking water standard for iodine-129 is 1 pCi/L.)

2.9.1.5 Strontium-90

During FY 2004, 30 analyses for strontium-90 were performed on samples collected from 14 wells within the groundwater interest area. Strontium-90 was found above detection limits in only one well: 299-W22-10, located downgradient of the 216-S-1,2 cribs. The result was 35 pCi/L, which is above the 8 pCi/L drinking water standard. Concentrations have been falling here since December 2001, when a peak value of 76 pCi/L was measured. Apparently, a small plume in the aquifer is migrating past this well. These cribs received highly acidic waste from the REDOX Plant between 1952 to 1956. In 1955, the waste is believed to have corroded the casing of a nearby well (299-W22-3), which allowed the effluent to bypass the soil column and flow down the well directly into groundwater (Waste Information Data System).

2.9.1.6 Chlorinated Hydrocarbons

Carbon tetrachloride is widespread in the 200-UP-1 groundwater interest area. The maximum concentration measured during FY 2004 was 650 µg/L in well 299-W19-36, an extraction well for the 200-UP-1 pump-and-treat system. Recent sampling at discrete vertical intervals within the aquifer beneath the 200 West Area (during well installation) demonstrate that carbon tetrachloride concentrations can increase with depth down to the Ringold Formation lower mud unit, at least in some areas. Well 299-W19-36 is screened near the water table, so concentrations higher than 650 µg/L may occur at depth. Carbon tetrachloride originated from disposal facilities associated with the Plutonium Finishing Plant, which is part of the 200-ZP-1 groundwater interest area. (For a more thorough discussion of carbon tetrachloride in the 200 West Area, see Section 2.8.)

Carbon tetrachloride is widespread in the 200-UP-1 groundwater interest area. The plume originated from disposal facilities associated with the Plutonium Finishing Plant in the 200-ZP-1 groundwater interest area.

Chloroform is a degradation product of carbon tetrachloride. A total of 104 chloroform analyses were performed on samples from 42 wells within the 200-UP-1 groundwater interest area, and there were no exceedances of the 100-µg/L drinking water standard. The maximum measured concentration was 22 µg/L in a sample collected 46 meters below the water table (3 meters above the Ringold Formation lower mud unit) during installation of well 699-38-70B.

Trichloroethene is found within the 200-UP-1 groundwater interest area above the drinking water standard (5 µg/L) in two regions – one near and downgradient from the pump-and-treat system and another near the 216-S-20 crib. A total of 104 trichloroethene analyses were performed on samples from 42 wells within the interest area, and the drinking water standard was exceeded in four wells (299-W19-35, 299-W22-20, 699-38-70B, and 699-38-70C). However, concentrations are not significantly above the drinking water standard – the maximum concentration measured was 9 µg/L.

During drilling of two new wells within the operable unit, carbon tetrachloride and trichloroethene concentrations were found to increase with depth in the aquifer.

Two new wells were installed outside the 200 West Area downgradient of the pump-and-treat system during FY 2004 (699-38-70B and 699-38-70C), and trichloroethene was found above the drinking water standard in both wells. Both wells were advanced to the Ringold Formation lower mud unit, and groundwater samples were collected at

various depths within the aquifer during drilling. As is the case for carbon tetrachloride, trichloroethene concentrations generally increased with depth down to the lower mud unit. The peak concentration in well 699-38-70B was 8 µg/L at 37 meters below the water table (12 meters above the lower mud unit). The peak concentration at well 699-38-70C was 9 µg/L at 19 meters below the water table (15 meters above the lower mud unit). These results indicate that the occurrence trichloroethene above the drinking water standard is more widespread than previously recognized.

The peak measured trichloroethene concentration downgradient of the 216-S-20 crib was 6 µg/L in well 299-W22-20, down from 11 µg/L the year before. In FY 2002, trichloroethene exceeded the drinking water standard at well 299-W19-34B (6 µg/L), completed deep in the aquifer at the pump-and-treat site. The concentration here has now fallen to 3 µg/L, which is below the drinking water standard (5 µg/L).

2.9.1.7 Chromium

Chromium is found in four regions of the 200-UP-1 groundwater interest area: at Waste Management Area S-SX, at the 216-S-10 pond and ditch, in the vicinity of the 216-S-20 crib, and in the 600 Area east and southeast of the 200 West Area. During FY 2004, samples from three wells exceeded the drinking water standard (100 µg/L): well 299-W22-20 at the 216-S-20 crib (560 µg/L), and wells 299-W23-19 (320 µg/L) and 299-W22-50 (120 µg/L) at Waste Management Area S-SX. During FY 2003, wells 699-32-62 in the 600 Area and 299-W26-7 at the 216-S-10 pond and ditch had chromium concentrations exceeding the drinking water standard. Neither of these wells were sampled during the fiscal year; well 699-32-62 is scheduled for biennial sampling and well 299-W26-7 went dry during FY 2003. Chromium at Waste Management Area S-SX is discussed in Section 2.9.3.2, and chromium at the 216-S-10 pond and ditch is discussed in Section 2.9.3.3.

Chromium is frequently detected in filtered samples east and southeast of the 200 West Area. The concentration in well 699-32-62 was 174 µg/L in FY 2003. The chromium concentrations have declined slowly since chromium was first analyzed at this well in 1992. The sources and extent of this contamination are uncertain. The location of this plume is consistent with disposal to the REDOX Plant ponds/ditches south and southwest of the 200 West Area. Chromium is detected in several other wells in this area, but its extent to the south of well 699-32-62 is poorly defined.

2.9.1.8 Nitrate

Nitrate plumes in the 200-UP-1 groundwater interest area originated from both U Plant and REDOX Plant disposal facilities and are widespread throughout the area. The multiple sources of nitrate from U Plant include the 216-U-1,2; 216-U-8; and 216-U-12 cribs. The nitrate plumes from these and other sources merge downgradient into a single large plume, which extends to the east and northeast a total distance of ~4 kilometers (Figure 2.9-9). Nitrate sources from the REDOX Plant disposal facilities may also have contributed to this plume. Only a few wells within this plume (outside of the 200 West Area) were sampled during the fiscal year – most are scheduled for biennial sampling and were sampled during FY 2003. This plume continues to migrate slowly to the east, as evidenced by an increasing nitrate trend in well 699-40-62 at the eastern edge of this plume.

Multiple sources of nitrate created a large plume, which is moving to the east.

The nitrate distribution depicted in Figure 2.9-9 represents nitrate concentrations at the water table, since most of the wells are screened across the water table. However, two of the new wells (699-38-70B and 699-38-70C) installed within the groundwater interest area during FY 2004 were screened near the bottom of the aquifer, just above the Ringold Formation lower mud unit. Both wells are located outside the 200 West Area downgradient from the pump-and-treat system. In well 699-38-70B, nitrate concentrations at the bottom of the aquifer were measured at 16 mg/L. In well 699-38-70C, however, the measured nitrate concentration was 190 mg/L. This result indicates that high nitrate concentrations occur deep in the unconfined aquifer in some places. Neither of these wells were sampled for

nitrate at the water table during drilling; therefore, a direct comparison of shallow versus deep concentrations cannot be made. Three of the new wells were sampled for nitrate during drilling. At wells 299-W19-48 and 699-36-70B, elevated nitrate occurs only near the water table, while in well 699-30-66, nitrate occurs throughout the aquifer thickness (down to the lower mud unit) at approximately half the drinking water standard (45 mg/L).

In Figure 2.9-9, a nitrate plume is depicted extending from west and southwest of Low-Level Waste Management Area 4 to Waste Management Area U. In well 299-W18-21, an upgradient well for Low-Level Waste Management Area 4, nitrate concentrations have been rising since 1993. In the two upgradient wells (299-W18-31 and 299-W18-40) for the U Tank Farm, nitrate concentrations have been rising significantly since ~2001 and exceeded 20 mg/L during FY 2004. Nitrate in all three of these wells is interpreted to be a single plume, which implies an advective travel time of ~8 years from well 299-W18-21 to the U Tank Farm. This travel time is within the range expected based on the reported groundwater flow velocities for Low-Level Waste Management Area 1 and the U Tank Farm. The source of this plume is not certain, but since 299-W18-21 is an upgradient well at Low-Level Waste Management Area 4, the plume is depicted in Figure 2.9-9 as emanating from somewhere west and southwest of Low-Level Waste Management Area 4. The only known waste site in this area is the 216-U-11 trench, which received overflow water from the 216-U-10 pond during the 1940s and 1950s. However, it has not been confirmed that this trench is the source of the nitrate.

The groundwater flow direction has changed over the years in the area west and southwest from Low-Level Waste Management Area 1. While U Pond and the 216-U-14 ditch were active, a groundwater mound resulted in westward flow in this area. Since discharges to ground ceased in the mid-1990s, the groundwater flow has resumed its pre-Hanford flow direction toward the east. This perhaps explains why nitrate began to rise in well 299-W18-21 in the mid-1990s. It is also theoretically possible that a nitrate plume migrated toward the west under past flow conditions and is now returning to the 200 West Area under eastward flow. If this were the case, however, it is expected that the plume would have dispersed considerably causing more wells to be impacted than is currently being observed.

Waste Management Area U is also a source of nitrate to groundwater (see Section 2.9.3.1). Nitrate concentrations in several of the downgradient wells remained above the drinking water standard during the fiscal year. The peak measured nitrate concentration at the U Tank Farm during FY 2004 was 65 mg/L in well 299-W19-41.

Nitrate occurs in two small plumes associated with REDOX Plant disposal facilities: one near the 216-S-20 crib and another near the 216-S-25 crib. In well 299-W22-20, downgradient of the 216-S-20 crib, the average nitrate concentration for FY 2004 was 100 mg/L, up from 92 mg/L the year before. From 1952 through 1972, this crib received waste from laboratory hoods and decontamination sinks in the 222-S Building, along with laboratory waste from the 300 Area.

There is a nitrate plume associated with the tritium plume emanating from the vicinity of the 216-S-25 crib. In well 299-W23-9, at the downgradient end of this crib, nitrate concentrations increased from FY 2000 through 2003, suggesting an additional release of nitrate to the aquifer from the soil column beneath the crib. This release may be diminishing, because the FY 2004 concentration was 240 mg/L, down from 480 mg/L the year before (the tritium concentration has also declined).

Nitrate also appears to be associated with the technetium-99 plume in this vicinity from Waste Management Area S-SX (see Section 2.9.3.2). The peak nitrate concentration in this area occurred in well 299-W23-19 at the southwest corner of Waste Management Area S-SX. The September 2004 sample yielded a concentration of 360 mg/L, which is significantly lower than last year's peak concentration of 1,680 mg/L.

2.9.1.9 Other Constituents

During FY 2003, 1,4-dioxane was detected at 160 µg/L in a sample collected from well 299-W22-20, which is located downgradient from the 216-S-20 crib. This well was sampled twice during FY 2004, and 1,4-dioxane was not detected in either sample. The well is filling in with silt, making the use of sampling pumps problematic. The first sample was collected during March using a Kabis sampler without purging the well; 1,4-dioxane was not detected in that sample, but since the well was not purged, it was suspected that a representative sample was not obtained. Another sample was collected in September with the Kabis sampler, immediately after purging three borehole volumes with a dart bailer. No 1,4-dioxane was detected in that sample. Therefore, 1,4-dioxane is no longer present in the aquifer near this well. Perhaps a small pulse of 1,4-dioxane entered the aquifer from the vadose zone and has now moved downgradient of well 299-W22-20. During FY 2004, 60 analyses for 1,4-dioxane were performed on samples from 35 wells within the entire groundwater interest area, and there were no detections of this constituent.

In FY 2003, 1,4-dioxane was detected in a single well near the 216-S-20 crib but was not detected during FY 2004.

Arsenic and cadmium are both listed as contaminants of concern for the 200-UP-1 Operable Unit. During FY 2004, there were no detections for either constituent above a drinking water standard. The arsenic drinking water standard is 10 µg/L, and the cadmium drinking water standard is 5 µg/L.

The contaminants of concern for the 200-UP-1 Operable Unit have been classified into an initial list of high priority constituents that resulted from a data quality objective process to support integrated CERCLA/AEA monitoring, as well as additional contaminants of concern that resulted from a data quality objective process to support the remedial investigation/feasibility study (DOE/RL-92-76, Rev. 1, Draft B). Most of the groundwater sampling conducted within the operable unit is for the high priority constituents. To determine if the additional constituents occur in groundwater within the operable unit, seven wells were sampled for the additional constituents during FY 2004. The seven wells selected are 299-W19-43 and 299-W19-46 within the pump-and-treat area; 699-38-70 downgradient of the pump-and-treat area; and 299-W22-83, 299-W23-4, 299-W23-10, and 299-W23-21 in the vicinity of the 216-S-25 crib and S-SX Tank Farm. These additional constituents of concern are documented in the remedial investigation/feasibility study work plan (DOE/RL-92-76, Rev. 1, Draft B) and include an extended list of volatile organic compounds, metals, anions, ammonium ion, ammonia, cyanide, sulfide, cresols, phenols, total petroleum hydrocarbons (kerosene range), beta emitters (carbon-14 and selenium-79), alpha emitters (neptunium-237 and protactinium-231), and gamma emitters (cesium-137 and cobalt-60).

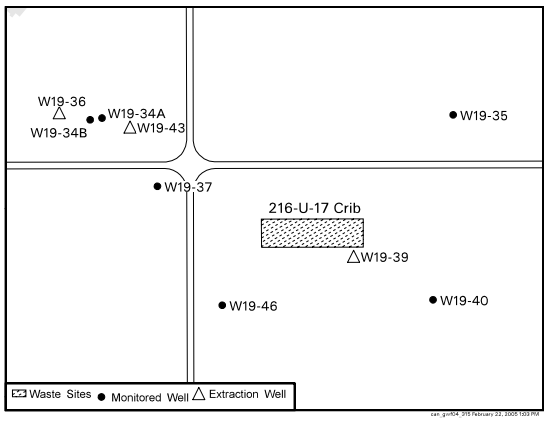
In 7 wells supporting the remedial investigation/ feasibility study, there were no detections above a drinking water standard for 35 additional constituents of concern.

Other than those constituents that are ubiquitous in groundwater (i.e., magnesium, manganese, and vanadium), there were no confirmed detections of an additional contaminant of concern in the groundwater. Only two of the additional contaminants of concern (other than those widely occurring) were found at levels above twice their detection limit: selenium-79 in well 299-W22-83 (at 20.3 pCi/L with a minimum detectable activity of 8.16 pCi/L) and tetrachloroethene in well 299-W23-21 (at 1.3 µg/L with a detection limit of 0.17 µg/L). The selenium-79 result in well 299-W22-83 should be viewed as tentative until it is confirmed with another sample result (scheduled for FY 2005), since the reported value is only 2.5 times the minimum detectable activity. The tetrachloroethene result may be a false positive, because this constituent was not detected in three other samples collected from this well during FY 2004. The drinking water standard for tetrachloroethene is 5 µg/L. Selenium-79 does not have an established drinking water standard, but a concentration of 630 pCi/L equates to a radiological dose of 4 millirem per year for a drinking water exposure scenario, which is a radiological dose limit established by DOE. Sulfide (1,600 µg/L) and cyanide (25 µg/L) were detected in well 699-38-70 but were not detected in a concurrent duplicate sample. Sulfide was detected in two other wells (at 1,200 µg/L in both wells 299-W22-83 and 299-W23-10) at less than twice the detection limit (700 µg/L), but could be false positives given the results at well 699-38-70. Other constituents were found very

near their detection limits and were qualified by the analytical laboratory as being estimates and are assumed to be false positives. Magnesium, manganese, and vanadium are metals widely found in groundwater, and their reported values were consistent with levels typically found within the groundwater interest area.

2.9.2 Interim Groundwater Remediation for Technetium-99 and Uranium

The pump-and-treat system at the 200-UP-1 Operable Unit operates as an interim action to contain the high concentration portions of the technetium-99 and uranium plumes emanating from the 216-U-1,2 cribs and to reduce the concentrations in these plumes (ROD 1997). The remedial action goal for the interim action is 9,000 pCi/L for technetium-99 and 480 µg/L for uranium. These concentrations are 10 times the technetium-99 drinking water standard and 10 times the uranium cleanup level under the *Model Toxics Control Act* (WAC 173-340) at the time the record of decision was issued. After removal from the three extraction wells, groundwater is transported via pipeline from the 200 West Area ~11 kilometers to the Effluent Treatment Facility in the 200 East Area. The treated groundwater is disposed at the Treated Effluent Disposal Facility and the State-Approved Land Disposal Site. The sampling and analysis plan for FY 2004 sampling is incorporated into the Draft *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76, Rev. 1, Draft A). Appendix A presents the monitoring well network, including a well list, sampling frequencies, and analyte lists. All wells were sampled as scheduled.



2.9.2.1 Progress During FY 2004

During the fiscal year, ~93.8 million liters of contaminated water from the 200-UP-1 Operable Unit were treated at the Effluent Treatment Facility. Over 801 million liters have been treated since startup of remediation activities in FY 1994. During FY 2004, 23.5 kilograms of uranium and 12 grams (0.2 curie) of technetium-99 were removed from the aquifer. In addition, 5.4 kilograms of carbon tetrachloride and 5,207 kilograms of nitrate (secondary contaminants of concern) were removed. These values along with the amount of mass removed since startup of operations are given in Table 2.9-1.

The average extraction system pumping rate for the entire year was 177.9 liters per minute, which is below the remedial design of 189.3 liters per minute. In January 2004, a third extraction well, 299-W19-36, was brought on line in addition to wells 299-W19-39 and 299-W19-43. With this additional extraction well and more consistent operations, the average pumping rate has increased to 192.2 liters per minute. Even so, overall extraction well production rates continue to decrease because of the regionally declining water table.

Another effect of the regionally declining groundwater level is a reduced ability to monitor and track plume changes, because several monitoring wells in the baseline plume area have gone dry. To improve plume tracking, new well 299-W19-48 was drilled upgradient of well 299-W19-39 at the end of

The remedial action objectives for the 200-UP-1 Operable Unit (ROD 1997) are:

- ***Reduce contamination in the areas with the highest concentration to below 480 µg/L for uranium and 9,000 pCi/L for technetium-99.***
- ***Reduce potential adverse human health risks through reduction of contaminant mass.***
- ***Prevent further movement of these contaminants from the highest contamination area.***
- ***Provide information that will lead to the development and implementation of a final remedy that will protect human health and the environment.***

EPA specified enhancements needed to the system in their 5-year review (EPA 2001).

calendar year 2004. For more detailed information about operations during FY 2004, refer to the pump-and-treat annual report (DOE/RL-2004-72.)

During FY 2004, concentrations of technetium-99 and uranium were below their remedial action goals, and the high concentration portions of the plumes were hydraulically contained.

2.9.2.2 Influence on Aquifer Conditions

Throughout the entire FY 2004, measured technetium-99 and uranium concentrations were below their respective remedial action goals at all four wells in the baseline plume area (i.e., that portion of the plume originally designed to be contained by the treatment system). In addition, the high concentration portions of the technetium-99 and uranium plumes were hydraulically contained. Figures 2.9-10 and 2.9-11 show measured technetium-99 and uranium concentrations for several wells in the pump-and-treat area. Figures 2.9-12 and 2.9-13 show the technetium-99 and uranium plumes at the pump-and-treat area, based on average concentrations for the fiscal year. Maps depicting the baseline technetium-99 and uranium plumes in 1995 and the current plumes in 2004 are presented in the report summary.

Technetium-99 and uranium concentrations in compliance wells 299-W19-40 and 299-W19-35, and in monitoring well 299-W19-37 midway between the extraction wells, also remained below the remedial action goal. Uranium concentrations at all wells within the pump-and-treat area remain above the revised drinking water standard of 30 µg/L, however.

During FY 2004, the water-level declined 0.4 meter, which is similar to the 0.38-meter decline observed in FY 2003. The water-level decline is responsible for reduced pumping rates at the three extraction wells and for causing a number of wells in the monitoring network to go dry. New monitoring well 299-W19-48 was installed the end of calendar year 2004 between monitoring well 299-W19-37 and extraction well 299-W19-39. This area has posted some of the highest historical concentrations of technetium-99 and uranium. The purpose of this new well is to characterize the extent of contamination with depth and ascertain the effectiveness of the pump-and-treat system in meeting the remedial action goals.

Since contaminant concentrations have been below the remedial action goals for the entire FY 2004, a rebound test is planned for calendar year 2005. The purpose of this study is to determine whether or not contaminant concentrations will remain below the remedial action goals with the pumping wells turned off. The current plan is to shut off all three extraction wells in January 2005 and initiate a monthly sampling and analysis program for monitoring changes in contaminant concentrations. After a 1-year monitoring period, the path forward for the pump-and-treat system will be decided.

A rebound test is planned for calendar year 2005 to determine whether or not contaminant concentrations will remain below the remedial action goals with the pumping wells turned off.

2.9.2.3 Geochemical Evaluation of Uranium Mobilization

Beginning in FY 2001, MSE Technology Applications, Inc. was funded by the U.S. Department of Energy (DOE) Headquarters to develop a conceptual model of uranium movement in the 200-UP-1 Operable Unit. This work was completed at the end of FY 2004. The primary task associated with this project was a geochemical modeling effort, with the goal of producing an acceptable correlation between predicted and observed concentrations of uranium in the groundwater. The scope of the project for the 200-UP-1 Operable Unit included the following tasks:

- Sample the soil and pore water for analysis of chemical and physical properties to develop a geochemical model describing uranium partitioning between the soil and the groundwater for the site.
- Use the geochemical model to investigate the partitioning relationships that may exist for potential contaminant transport paths at the site.
- Simulate uranium transport for potential transport paths at the site, including its source.
- Update the conceptual model of uranium transport at the site with the model, providing the best fit of the simulated results with observed data.

The computer model used was PHREEQCI (Parkhurst and Appelo 1999), which is a public domain equilibrium geochemical modeling program developed and supported by the U.S. Geological Survey. The modeling efforts focused on the processes (aqueous speciation, surface complexation, and precipitation) that may have controlled uranium mobility beneath the 216-U-1,2 cribs. The key modeling elements included simulating one-dimensional advective transport of the waste to the aquifer, mixing of contaminated water from the unsaturated zone with the aquifer water, and advective transport of atmospheric water through the contaminated sediments. Several scenarios were considered for the potential pathways of the crib waste to the aquifer. The scenarios were also modeled using a range of parameter values (e.g., unsaturated soil column volume, water saturation ratio, waste pore volumes, and mixing ratios). Each model predicted uranium concentrations at the water-table interface and in the aquifer that could be compared to measured, historical concentrations or used to predict future concentrations.

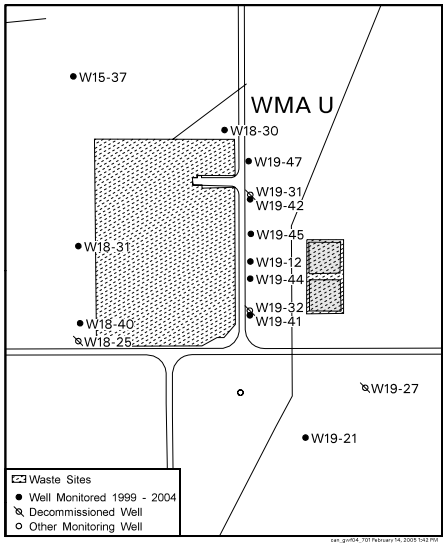
A geochemical model of uranium migration beneath the 216-U-1,2 cribs indicates that uranium sorbs to sediment grains instead of precipitating to form a solid phase.

The conceptual model for uranium movement to the groundwater, as summarized in BHI-01311, is that contamination from the 216-U-1,2 cribs was initially retained above the Cold Creek unit and later mobilized by high-volume acidic discharges from the 216-U-16 crib. The uranium contamination reached the groundwater through a break in the continuity of the Cold Creek unit underlying the cribs, such as an erosional feature that is infilled with coarser materials, a permeable clastic dike, or an old borehole that was not adequately sealed. The results of the current modeling effort are consistent with this conceptual model and agree well with historical data of uranium contamination in groundwater. This modeling effort concluded that the uranium in the vadose zone likely sorbed on the sediment and did not precipitate to form a solid phase uranium source (e.g., sodium autunite precipitate).

2.9.3 Facility Monitoring

This section describes results of monitoring individual facilities such as treatment, storage, and disposal units or tank farms. Some of these facilities are monitored under the requirements of RCRA for hazardous waste constituents and the AEA for source, special nuclear and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 2.1 pursuant to RCRA, the source, special nuclear, and by-product material component of radioactive mixed waste are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority.

Detailed groundwater monitoring is conducted at five facilities within the groundwater interest area. Four of these sites are monitored in accordance with RCRA regulations. Assessment monitoring is conducted at Waste Management Areas U and S-SX and the 216-U-12 crib; detection monitoring is conducted at the 216-S-10 pond and ditch. Groundwater monitoring at the Environmental Restoration Disposal Facility is conducted in accordance with a CERCLA record of decision (ROD 1995b). Groundwater data for these facilities are available on the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report.



2.9.3.1 Single-Shell Tank Waste Management Area U

The objective of RCRA monitoring at this waste management area is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer [40 CFR 265.93(d) as referenced by WAC 173-303-400]. Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for Waste Management Area U.

Waste Management Area U was placed into assessment status in 2000 when specific conductance in groundwater monitoring wells downgradient of the waste management area exceeded upgradient levels (PNNL-13185). An assessment of that finding determined that the waste management area had affected groundwater quality with elevated concentrations of nitrate and possibly chromium in wells downgradient of the waste management area (PNNL-13282). The contaminant concentrations did not exceed their respective drinking water standards, and the area affected appeared to be limited to the southeast corner of the waste management area. A groundwater quality assessment plan (PNNL-13612) was prepared in 2001. The plan was modified in 2003 (PNNL-13612-ICN-1) to include monitoring of new wells 299-W18-40, 299-W19-44, and 299-W19-45 and to modify the analyte list. The plan as modified serves as the current plan by which groundwater quality is assessed at Waste Management Area U.

Monitoring shows that Waste Management Area U contaminated groundwater with nitrate, technetium-99, and chromium.

The monitoring network includes eight wells sampled quarterly – two upgradient and six downgradient of the waste management area. All eight wells were sampled each quarter during FY 2004. As part of the Tri-Party Agreement (Ecology et al. 1989) M-24 milestone process for installation of new wells, it was decided to construct one additional well in 2004 on the northeast side of the waste management area, due east of the 244-UR vault. This well was completed in September 2004; it will be sampled for the first time in November 2004 and then quarterly thereafter with the other wells in the network. With the completion of this well, all monitoring points identified for the waste management area are being monitored. The monitoring network is adequate to assess the impact of the waste management area on groundwater quality beneath the site.

Groundwater flow conditions at Waste Management Area U have varied greatly over the past several decades because of changing wastewater disposal in areas surrounding the waste management area, but groundwater flow has been generally to the east since 1996. During FY 2004, the direction and velocity of groundwater flow have remained the same as in the previous year. The rate at which the water table is dropping has also remained constant at ~0.3 meter per year in all of the monitoring wells during FY 2004. Therefore, the hydraulic gradient has not changed. The average linear velocity calculated based on a hydraulic conductivity of 6.12 meters per day, a specific yield of 0.17 determined in well 299-W19-42 (PNNL-13378), and a gradient of 0.0021 is ~0.08 meter per day (see Appendix B). This rate is consistent with the regional groundwater flow interpretation.

Groundwater chemistry beneath Waste Management Area U in FY 2004 has remained similar to that presented in past years for wells downgradient of the waste management area. The waste management area has been identified as the source for a small contaminant plume that is limited to the downgradient (east) side of the site (PNNL-13282). Plume constituents of interest include chromium, nitrate, and technetium-99. In the past, the plume has been delineated by the extent of elevated specific conductance because the plume contains soluble salts comprised of the anions nitrate, chloride, and sulfate that are accompanied by the cations calcium, magnesium, and sodium. Technetium-99, a tank waste constituent, has also been detected on the downgradient side of Waste Management Area U; its distribution has been closely related to that of nitrate.

The highest concentration of chromium was once (1997) approximately half the drinking water standard; however, in August 2004, chromium was only detected in one well, where it was reported at <4 µg/L. Chromium no longer appears to be an issue at Waste Management Area U.

During FY 2004, nitrate concentrations continued to increase in all monitoring wells at Waste Management Area U, including the two upgradient wells. Nitrate concentrations increased above the drinking water standard (45 mg/L) in downgradient wells 299-W19-12 and 299-W19-44. Along with downgradient well 299-W19-41, these are the only wells with nitrate concentrations above the drinking water standard at the waste management area. The highest downgradient nitrate concentrations (~63 mg/L) are nearly three times

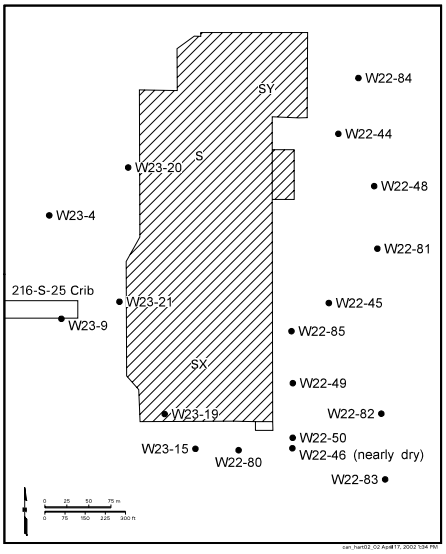
the concentrations found in upgradient wells. These observations and the nitrate plume map (Figure 2.9-9) indicate that a regional upgradient nitrate plume is encroaching into groundwater beneath the waste management area and mixing with the nitrate plume emanating from the waste management area.

Nitrate and technetium-99, while thought to be related in the past, now appear to have different trends on the downgradient (east) side of the waste management area (Figures 2.9-14 and 2.9-15). These constituents are both very mobile in groundwater and would be expected to travel together if they were from the same source. Nitrate concentrations decrease regularly from a high of 63.3 mg/L in well 299-W19-41 (south end of the line of wells) to a low of 15.1 mg/L in well 299-W18-30 (north end of the line of wells). Technetium-99 concentrations differ from this pattern where the low concentrations are on the north and south ends of the line of downgradient wells and increasing to a maximum of 745 pCi/L (below the drinking water standard of 900 pCi/L) in well 299-W19-45 located in the middle of the line of wells. An interesting observation is that technetium-99 concentrations in the three wells north of well 299-W19-12 are all increasing, and those from well 299-W19-12 and south are all decreasing. The technetium-99 concentration in well 299-W19-45, where the highest concentration is now found, jumped by nearly a factor of 3 in August 2004. These observations indicate that nitrate and technetium-99 are from different sources and some of the differences may be related to the intrusion of an upgradient nitrate plume into the waste management area.

Carbon tetrachloride is found in groundwater beneath Waste Management Area U at concentrations above its drinking water standard of 5 µg/L. Well 299-W18-30 is the only well analyzed for carbon tetrachloride and it contained levels of 130 µg/L in August 2004. The regional carbon tetrachloride distribution (see Figure 2.8-3 in Section 2.8) indicates that the source of carbon tetrachloride found in the Waste Management Area U vicinity is from liquid waste disposal sites at the Plutonium Finishing Plant located northwest of the waste management area.

2.9.3.2 Single-Shell Tank Waste Management Area S-SX

The objective of RCRA monitoring at this waste management area is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer. Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for Waste Management Area S-SX. During 2004, waste retrieval operations were conducted on tank S-112 in the S Tank Farm. Vadose zone monitoring during these activities are described in Section 3.2.



Waste Management Area S-SX was placed into assessment status [40 CFR 265.93(d) as referenced by WAC 173-303-400] in 1996 at the direction of Washington State Department of Ecology (Ecology) because of elevated specific conductance and technetium-99 (not regulated by RCRA) in downgradient monitoring wells. A groundwater quality assessment plan (WHC-SD-EN-AP-191) was prepared in 1996 and the planned assessment work conducted in 1996 and 1997. An assessment of the waste management area determined (first determination) that multiple sources within the waste management area had affected groundwater quality with elevated concentrations of nitrate, technetium-99, and chromium in wells downgradient of the waste management area (PNNL-11810). A second groundwater quality assessment plan (PNNL-12114) was prepared in 1999 to further evaluate the contamination found. Since that time, two groundwater quality assessment reports have been published (PNNL-13441; PNNL-13801) covering the time period from November 1997 through December 2001, and the assessment plan was revised twice (PNNL-12114-ICN-1; PNNL-12114-ICN-2) to account

for new wells added to the monitoring network and revisions to the sampling and analysis schedule. The plan as modified serves as the current plan by which groundwater quality is assessed at Waste Management Area S-SX.

The monitoring network consists of 16 wells: 2 upgradient and 13 downgradient of the waste management area, and 1 well located within the area. The wells are sampled quarterly. All 16 wells were sampled each quarter during FY 2004, although the sampling of 5 of the wells was delayed from December 2003 to early February 2004 because of cold weather in December and January. As part of the Tri-Party Agreement M-24 milestone process for installation of new wells, it was decided to construct one additional well in 2004 southeast of the waste management area, due south of well 299-W22-46, to better define the south boundary of a contaminant plume in this area. The need and specifications for this well are described in CP-15329. This well will be installed in 2005. Over the past several years, the leading fronts of contaminant plumes emanating from the waste management area have migrated beyond the farthest downgradient monitoring wells in the network. Additional, further downgradient wells have been identified to monitor these areas. These wells are also identified in CP-15329, but have yet to be included in the Tri-Party Agreement M-24 milestone process.

Sources within Waste Management Area S-SX have contaminated groundwater with nitrate, chromium, and technetium-99. The south portion of the plumes expanded in FY 2004.

Groundwater Flow. During FY 2004, the direction and velocity of groundwater flow remained the same as in the previous year, in spite of the falling water table. The rate at which the water table is dropping remained the same as last year, which is estimated at ~0.3 meter per year. This decline was the same in all wells across the waste management area; therefore, the hydraulic gradient has remained stable. Estimates of groundwater flow velocity, using travel times for tritium and technetium-99 between monitoring wells in the vicinity of Waste Management Area S-SX, suggest groundwater flow rates of 25 to 50 meters per year, or 0.07 to 0.14 meter per day. Calculated average linear velocities (using Darcy's method) based on hydraulic conductivity and tracer test data, also suggest similar flow rates (0.009 to 0.36 meter per day; see Appendix B). The groundwater flow direction inferred from water-table elevation contours suggests an east-southeast flow direction over the larger area around the waste management area (see Figure 2.8-2 in Section 2.8). This direction of flow is consistent with the shape of the contaminant plume on the south side of the waste management area and the direction in which it is expanding.

Groundwater Contamination. Groundwater beneath this waste management area is contaminated with nitrate, hexavalent chromium, and technetium-99 attributed to two general source areas within the waste management area. One source area is in the S Tank Farm and the other is located to the south in the SX Tank Farm. The nitrate, chromium, and technetium-99 plumes are depicted in Figures 2.9-16, 2.9-17, and 2.9-18, which show average concentrations for the fiscal year. Carbon tetrachloride (see Figure 2.8-3 in Section 2.8) is also present in groundwater beneath the waste management area, but its source is upgradient of the waste management area (PNNL-13441). Tritium is also present beneath the waste management area as seen in Figure 2.9-6, but its source is the 216-S-25 crib located just west (upgradient) of the SX Tank Farm (PNNL-13441).

The north plume, with a source in the S Tank Farm, has migrated eastward mainly through well 299-W22-48. During FY 2004, constituent concentrations in this plume (chromium, nitrate, and technetium-99) increased significantly in well 299-W22-44. This well is located north of well 299-W22-48, where concentrations of the same constituents decreased during FY 2004 and are now about the same as in well 299-W22-44. The bulk of the contaminant plume is now in the area surrounding wells 299-W22-44 and 299-W22-48, which is more northward than in previous years. The plume is bounded by wells 299-W22-84 on the north and 299-W22-81 on the south, because chromium, nitrate, and technetium-99 concentrations are significantly less than the two wells in the middle of the plume.

The contaminant plumes located in the south portion of the waste management area comprise nitrate, chromium, and technetium-99 just as in the S Tank Farm plume to the

north. In addition, tritium and carbon tetrachloride plumes are present beneath the waste management area, but their sources are the 216-S-25 crib and the Plutonium Finishing Plant cribs, respectively (PNNL-13441). The nitrate plume originated in the tank farm as well as in the 216-S-25 crib, as suggested by its distribution in Figure 2.9-16. The downgradient migrating nitrate front, as indicated by the 45-mg/L isopleth, was beyond the farthest downgradient monitoring well 299-W22-83 for the entire year. Nitrate concentrations in this well increased from 45.2 mg/L at the end of FY 2003 to a maximum of 70.2 mg/L in June 2004. The same pattern was observed for the chromium (Figure 2.9-17) and technetium-99 (Figure 2.9-18) distributions at the distal end of the plume, but major differences were observed in the plume near the source area as represented by well 299-W23-19.

In the vicinity of the SX Tank Farm plume source area, chromium concentrations increased during FY 2004 by approximately five-fold from 58 µg/L to 320 µg/L in well 299-W23-19, well above the drinking water standard of 100 µg/L (Figure 2.9-19). This indicates that a new pulse of chromium contaminated water has reached groundwater. Figure 2.9-17 shows that this pulse of chromium is distinct from an earlier pulse that is now located in the middle of the plume area. The middle of the plume is represented by well 299-W22-50, where chromium concentrations have reached a peak and have been decreasing throughout 2004 (Figure 2.9-20). This earlier chromium pulse has continued to migrate downgradient where the peak has yet to reach well 299-W22-83, but chromium concentrations in this well are increasing and approaching the drinking water standard (Figure 2.9-21).

Technetium-99 trends differed greatly from chromium trends in the SX Tank Farm plume source area (i.e., well 299-W23-19) as seen in Figure 2.9-19. During FY 2004, when chromium concentrations increased five-fold, technetium-99 concentrations remained stable at ~45,000 pCi/L after decreasing four-fold in 2003 from 188,000 pCi/L. These opposite trends indicate that chromium and technetium-99 may have different sources within the tank farm. The surprising aspect of these observations is that they occurred during the time in which well 299-W23-19 was purged for a minimum of 3,785 liters of water after each quarterly sampling event. The large volume purge was started in March 2003 and continued through 2004. Because of the rapid decrease in technetium-99 concentrations through the rest of 2003, it could be interpreted that the purging had a beneficial influence on the technetium-99 concentrations. However, because technetium-99 concentrations suddenly stabilized throughout 2004 and chromium concentrations rose rapidly even while the practice of purging continued, the effect of purging on contaminant concentrations may not be as significant as indicated by the 2003 technetium-99 trends. At the middle (Figure 2.9-20) and distal end (Figure 2.9-21) of the SX Tank Farm plume, trends for nitrate, chromium, and technetium are similar, indicating either a single source or that the constituents arrived at the water from different sources within the waste management area but at the same time in the past.

In 2003, DOE and Ecology agreed to the practice of extended purging during sampling at well 299-W23-19 to remove technetium-99 from the groundwater. This practice continued during FY 2004.

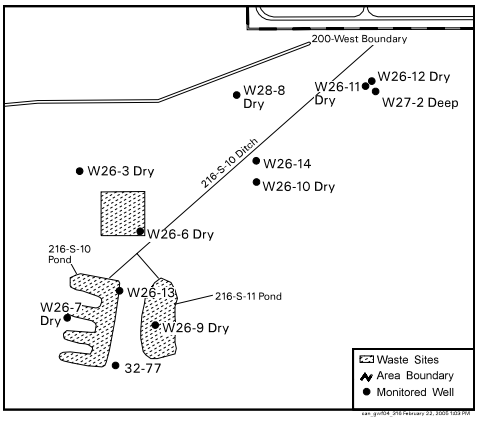
In figures depicting nitrate, chromium, and technetium-99 distributions, a low concentration island has been drawn in each plume at wells 299-W22-80 and 299-W23-15 to reflect preliminary information that may indicate the constituent concentrations in samples collected from these wells are artificially low. The evidence includes (1) aquifer tests that indicate a natural upward flow exists in the screened section of well 299-W22-80 and (2) preliminary time series sampling during extensive pumping that indicates water near well 299-W22-80 (which is sampled using standard well purging protocol) is much less contaminated than water in the surrounding area. Therefore, clean water near the bottom of well 299-W22-80 may be migrating up through the well and diluting the plume in the upper part of the aquifer. A similar process is assumed to be occurring at well 299-W23-15 due to its proximity to well 299-W22-80 and similarly low concentrations. The contaminant plumes are also interpreted as occurring farther to the south than previously depicted (e.g., PNNL-14548). This interpretation is based on preliminary information collected during

FY 2005 at a new well installed ~50 meters south of well 299-W22-46, which became available prior to completion. These observations will be more fully investigated in the future.

Specific Conductance Measurements in Well 299-W23-19. Well 299-W23-19 was re-configured in February and March 2003 and instrumented with a permanent sampling pump and four specific conductance probes located at regularly spaced vertical positions in the well screen. Also, at the request of Ecology, the practice of purging at least 3,785 liters of water from the well after each quarterly sampling event was started in March 2003. Details for the installation are presented in the annual report for 2003 (PNNL-14548). This work was done to test the possibility that fluctuations in sample groundwater chemistry reflected actual variations in the plume. Specific conductance is a measure of the quantity of the major dissolved constituents such as calcium, magnesium, chloride, and nitrate in the water. Because these constituents are major components of the contaminant plume, specific conductance is an easily measured indicator of the plume location and spatial and temporal variations in the plume. Specific conductance measurements collected in 2004 are presented in Figure 2.9-22. The same data collected for the June 2004 sampling and purging event are presented in Figure 2.9-23.

Figure 2.9-22 shows, as reported in 2003, that sampling greatly perturbs the water chemistry in the well. Figure 2.9-23 presents an expanded view of the data during the June 15, 2004, sampling and purging event. Figure 2.9-23 shows the magnitude of the difference in groundwater composition between static and dynamic conditions in the well. Prior to 0800 hours, measurements were made under static conditions. When the pump was turned on, specific conductance increased in the upper three probes, but dropped in probe #4, the deepest probe located ~1 meter below the pump intake and ~0.7 meter above the bottom of the well. Because the pump intake is set between probes #3 and #4, water pumped to the ground surface would have a composition that is a blend of water passing these two probes. Figure 2.9-23 shows that during the extended purging, when the pumping rate is increased four-fold, the water level drops below the uppermost probe #1 (shown in blue) causing the probe to report conductance values of zero. When pumping is stopped, the well recovers and probe #1 is rewetted. The general responses are the same as reported in 2003 and indicate that static measurements (no active pumping) can vary depending on where the measurements are made in the well, and that the contamination resides in the upper portion of the aquifer, largely above probe #3.

Groundwater Treatment. To remove technetium-99 from the groundwater, the practice of extended purging during sampling at well 299-W23-19 was continued during FY 2004. This practice was agreed to by DOE and Ecology and was begun in 2003. After samples are collected from this well each quarter, purging of the well is continued at a higher flow rate until a minimum of 3,785 liters of water is removed from the aquifer. This water is transferred to the Effluent Treatment Facility for treatment and disposal. Table 2.9-2 presents the date, amount of water collected, and a calculation of the mass and activity of technetium-99 removed from the aquifer. A total of ~0.0007 curie (~0.043 gram) of technetium-99 was recovered during FY 2004. Since the start of this treatment in 2003, a total of ~0.002 curie (~0.110 gram) of technetium-99 has been recovered.



2.9.3.3 216-S-10 Pond and Ditch

The 216-S-10 pond and ditch was active from 1951 through 1991, and received effluent primarily from the REDOX Plant chemical sewer. The site is monitored semiannually under RCRA interim status indicator evaluation [WAC 173-303-400 and by reference 40 CFR 265.93(b)] to detect any effect on groundwater that may occur from past facility operations. Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for the 216-S-10 pond and ditch.

RCRA groundwater monitoring has been conducted in accordance with interim status requirements since 1991. The 216-S-10 facility has not received liquid waste since October 1991 and is scheduled to be closed under a Part B Permit after 2006 in accordance with the Tri-Party Agreement (Ecology et al. 1989) permit modification schedule, and in accordance with a future CERCLA record of decision. Results of the CERCLA 200-CS-1 Chemical Sewer Group Operable Unit remedial investigation conducted during FY 2003 at the 216-S-10 pond and ditch are detailed in Section 3.1.

All but three of the monitoring wells for the 216-S-10 pond and ditch have gone dry.

The water table beneath the 216-S-10 pond and ditch continued to decline in FY 2004. The current RCRA monitoring network consists of two downgradient wells (the others having gone dry): well 299-W26-13 located near the pond and new well 299-W26-14 located just east of the central portion of the ditch. Upgradient well 299-W26-7 went dry in 2003. The network also includes one deep downgradient well, 299-W27-2, which is screened at the bottom of the uppermost unconfined aquifer. RCRA requirements for interim status monitoring specify that a minimum of one upgradient and three downgradient monitoring wells are needed to monitor the site. The groundwater monitoring plan, updated in 2002 (PNNL-14070), proposed to deepen or replace two existing dry wells to bring the facility back into compliance with RCRA and Washington Administrative Code (WAC) requirements. All new RCRA wells installed at Hanford are negotiated annually by Ecology, DOE, and EPA and approved under the Tri-Party Agreement (Ecology et al. 1989) Milestone M-24-00.

During 2004, the only exceedance of a drinking water standard occurred in the deep well 299-W27-2 for carbon tetrachloride, which is believed to have come from an upgradient source. Nickel is also elevated in this well, but its source is unknown. The long, gradual increase in nickel concentrations, followed by a stable elevated trend in FY 2004, suggests this occurrence is not an analytical or sampling artifact but may be due to corrosion of stainless steel well materials. Similar increases in nickel have occasionally been noted in other wells as they go dry (e.g., well 299-W7-1).

Elevated chromium concentrations at well 299-W26-7 (now dry) have varied above the 100-µg/L drinking water standard during the past 10-year life of the well. This may have been caused by short-term releases migrating through the vadose zone from past effluent releases in the pond. For example, historical records document a 1983 release to the 216-S-10 facility of a high-salt waste (simulated tank waste) containing hexavalent chromium. Although well 299-W26-7 was designated as an upgradient well, it is located very close to one lobe of the pond system and could easily have been affected by drainage spreading laterally in the vadose zone (see Appendix B). A REDOX Plant disposal pond, which is located immediately upgradient of the 216-S-10 pond and ditch, has not been ruled out as a potential source of chromium contamination.

There were no exceedances of an indicator parameter during FY 2004, so the 216-S-10 pond and ditch remains in detection monitoring.

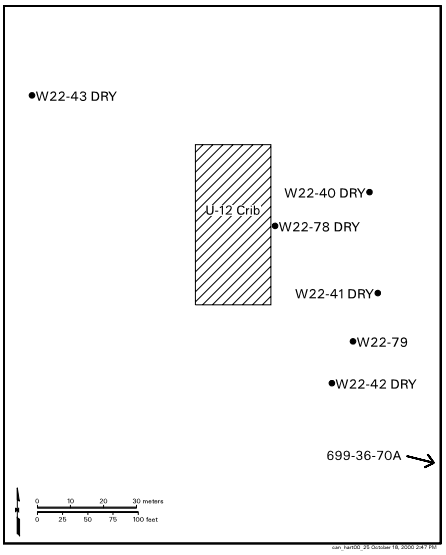
Nitrate concentrations were covariate with chromium concentrations in dry wells 299-W26-7, 299-W26-9, 299-W26-10, and 299-W26-12. The upgradient well 299-W26-7 had the highest nitrate concentrations. This and other data presented in PNNL-14070 suggests that the 216-S-10 pond could be the source of this nitrate and chromium increase. Although chromium and nitrate were elevated in the dry upgradient well 299-W26-7, significant concentrations of these constituents have not been detected in the downgradient wells. Chromium concentrations in new well 299-W26-13 (located nearby and just downgradient of well 299-W26-7) are only slightly elevated above the chromium concentrations in the other two downgradient wells, which are near background.

Because the only upgradient well, 299-W26-7, went dry in year 2003, the comparison of RCRA indicator parameters (specific conductance, pH, total organic carbon, and total organic halides) between upgradient and downgradient wells was conducted using the most recent collected background values of contaminant indicator parameters from well 299-W26-7 before it went dry (see Appendix B). When data from a new upgradient well become available, new background values will be calculated and used for the required upgradient/downgradient comparisons. Based on statistical evaluations of contamination

indicator parameters conducted during FY 2004, there are no statistically significant differences (i.e., constituents in the downgradient wells are not elevated compared to the upgradient well). Therefore, this site remains in detection monitoring.

Based on regional groundwater elevations, the groundwater flow direction continues toward the east-southeast. The average linear velocity has not changed significantly since last year and ranges from 0.007 to 0.3 meter per day.

2.9.3.4 216-U-12 Crib



The 216-U-12 crib is located ~600 meters south of U Plant in the southeast portion of the 200 West Area. The crib is an unlined, gravel-bottom, percolation crib 3 meters by 30 meters, and 4.6 meters deep. The crib received process effluent from U Plant, including corrosive liquid condensate from the 224-U Building, and operated from 1960 through 1972 and from 1981 until it was permanently retired in February 1988. A yearly average of over 1.02 x 10^7 L/yr of effluent was disposed to the crib from 1960 through 1972 (RHO-CD-673). Total volume disposed to the 216-U-12 crib exceeded 1.33 x 10^8 L from 1960 through 1972.

The objective of RCRA monitoring at the 216-U-12 crib is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer. Groundwater monitoring under the AEA tracks radionuclides at this crib and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for the 216-U-12 crib.

In FY 2004, the 216-U-12 crib was regulated under a RCRA interim-status assessment program [WAC 173-303-400 and by reference 40 CFR 265.93(d)]. Monitoring was conducted under a groundwater assessment sampling and analysis plan issued during 2003 (PNNL-14301). The number of network monitoring wells in FY 2004 remained the same as FY 2003. Declining water levels in the 200 West Area have reduced the 216-U-12 crib monitoring network from the original four wells to just two downgradient wells (299-W22-79 and 699-36-70A), which is fewer than the minimum number of wells required by RCRA. Ecology, EPA, and DOE annually negotiate the location and priority of installation for future Hanford Site groundwater monitoring wells under Tri-Party Milestone M-24-00. The 216-U-12 crib network is sampled quarterly for the constituents of interest (see Appendix B).

The current objectives of interim status assessment monitoring for the 216-U-12 crib include the following:

- Continue groundwater monitoring to assess the migration of potential dangerous waste constituents out of the vadose zone into the groundwater.
- Monitor under interim status assessment until a final status monitoring plan is implemented following closure of the facility.

The 216-U-12 crib contributed to nitrate and technetium-99 contamination.

These objectives support the delineation of the existing known plumes, which through RCRA/CERCLA integration, is being managed under the CERCLA 200-UP-1 monitoring program. The existing plumes co-mingle with plumes from other U Plant and REDOX Plant source areas, making it difficult to distinguish the specific plumes emanating from the 216-U-12 crib.

Future closure of the 216-U-12 crib will be coordinated with and conducted under CERCLA per the U Plant waste sites focused feasibility study (DOE/RL-2003-23) and proposed plan (DOE/RL-2003-24). The 216-U-12 crib will be closed under RCRA final status requirements (WAC 173-303-645) based on a modified program as allowed by the Tri-Party Agreement action plan, Section 5.5. A revised and updated groundwater monitoring plan for the 216-U-12 crib, containing the proposed final status approach [as required under WAC 173-303-645(11)], is being reviewed by the regulatory agencies. This plan is intended

to serve as a transition to a monitoring approach that embraces both the RCRA treatment, storage, and disposal unit (i.e., 216-U-12 crib) and the 200-UW-1 U Plant area waste sites operable unit. RCRA closure requirements for the 216-U-12 crib will be fulfilled by the CERCLA/RCRA integration process for the 200-UW-1 and 200-UP-1 Operable Units. RCRA interim status groundwater monitoring objectives, as stated above, will remain the same until closure of the crib and then shift to the regulatory approved final status closure/post-closure plan. The 200-UP-1 Operable Unit is responsible for contaminants within the groundwater beneath the 200-UW-1 Operable Unit.

All but two monitoring wells at the 216-U-12 crib have gone dry.

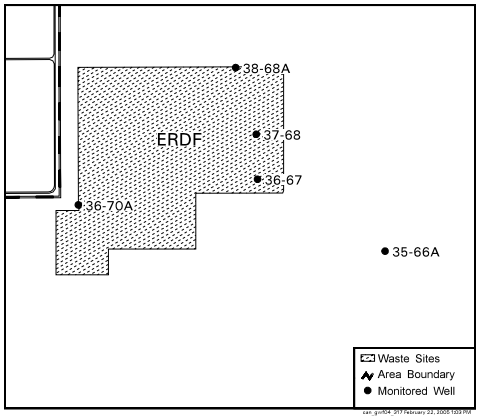
The 216-U-12 crib was placed into assessment status due to elevated specific conductance downgradient of the facility. Elevated calcium and nitrate are the major contributors to the specific conductance. Technetium-99 is also defined as a co-contaminant that is migrating with nitrate in the groundwater. These constituents are being evaluated through quarterly groundwater monitoring. The regional nitrate and technetium-99 plumes are actually a co-mingled series of smaller plumes with sources from several cribs (216-U-1,2; 216-U-8; and 216-U-12) in the U Plant area.

The key indicator parameter, specific conductance, remained relatively unchanged during 2004 in both network wells 299-W22-79 and 699-36-70A. During 2004, nitrate continued to decline below the drinking water standard (45 mg/L) in well 299-W22-79 and remained relatively unchanged above the standard in far field well 699-36-70A. The co-contaminant, technetium-99 (which is not regulated under RCRA), remains elevated slightly above background in both network wells (highest value reported for FY 2004 was 64 pCi/L in well 699-36-70A). All other constituents remained on trend at or near background throughout the year.

There are not enough network wells at the 216-U-12 crib to determine groundwater flow direction; however, based on the surrounding regional groundwater elevations, the direction of groundwater flow beneath the 216-U-12 crib continues relatively unchanged toward the east-southeast to east (see Figure 2.8-2 in Section 2.8). The pre-Hanford flow direction in the vicinity of the 216-U-12 crib is believed to have been from west to east, and it is expected that groundwater flow will eventually return to a more eastward direction. Average linear groundwater flow velocities remain relatively the same as last year and range from 0.01 to 0.003 meter per day (see Appendix B).

2.9.3.5 Environmental Restoration Disposal Facility

The Environmental Restoration Disposal Facility is a low-level, mixed waste facility where waste from surface remedial actions on the Hanford Site is disposed. The site is designed to meet RCRA standards, although it is not permitted as a RCRA facility. Groundwater monitoring is conducted in accordance with a CERCLA record of decision (ROD 1995b). One upgradient well (699-36-70A) and three downgradient wells (699-37-68, 699-36-67, and 699-35-66A) are sampled semiannually, typically in the second and fourth quarters of the fiscal year. All four wells were sampled as planned during FY 2004, although some wells were sampled later than others due to maintenance issues. For a discussion of leachate monitoring at this facility, see Section 3.2. Appendix B contains additional information regarding the Environmental Restoration Disposal Facility. See BHI-01738 for calendar year 2003 groundwater and leachate monitoring results. Calendar year 2004 results will be described in an upcoming report. See BHI-00873 for the sampling and analysis plan.



Results of groundwater monitoring at the Environmental Restoration Disposal Facility continued to indicate that the facility has not adversely impacted groundwater quality. Several constituents are present in the groundwater at or above drinking water standards (tritium, iodine-129, nitrate, and carbon tetrachloride), but these constituents are elevated in both the upgradient and downgradient wells. Figures 2.9-6, 2.9-8, and 2.9-9, and Figure 2.8-3 in

Section 2.8 indicate that these plumes originate in the 200 West Area and have migrated into the vicinity of the Environmental Restoration Disposal Facility.

Results of groundwater monitoring at the Environmental Restoration Disposal Facility continued to indicate that the facility has not adversely impacted groundwater quality.

Both filtered and unfiltered samples are collected for metals (except for uranium samples, which are unfiltered). Overall, the FY 2004 sampling results appear more stable than the previous fiscal year, likely due (at least in part) to lower and more stable turbidity observed in the samples. High turbidity (suspended solids) is a common source for variability in water sample analytical results.

It was previously noted (PNNL-14548) that values for gross beta in well 699-35-66A, and gross beta, unfiltered total chromium, and unfiltered zinc in well 699-37-68, were higher than normal. These metals results were associated with higher than normal turbidity in the samples (filtered chromium and zinc were on trend). Samples collected during FY 2004 in this well had lower turbidity values; the gross beta values stabilized, and the unfiltered total chromium and unfiltered zinc values decreased. None of these constituents, when filtered, have exceeded a drinking water standard, but future results will continue to be evaluated. Potential new out of trend values (high) were noted for the following: gross alpha, technetium-99, and unfiltered zinc in well 699-35-66A; and technetium-99 in well 699-37-68. Values for all these constituents remained well below drinking water standards. The technetium-99 increases are not large relative to previous years (maximum measured value in FY 2004 was 68 pCi/L); however, both wells show a nominal tripling of the technetium-99 concentrations over the last 6 years. It is possible that this increase is due to plumes from the 200 West Area migrating into the vicinity of the Environmental Restoration Disposal Facility.

Table 2.9-1. Summary of Contaminant Mass Removed from the Aquifer during Pump-and-Treat Operations at the 200-UP-1 Operable Unit, FY 2004 and Totals Since Startup of Operations

Contaminant	Fiscal Year 2004	Since Startup (March 1994)
Uranium	23.5 kg	203 kg
Technetium-99	12 g (0.2 Ci)	114.1 g (1.94 Ci)
Carbon tetrachloride	5.4 kg	31.2 kg
Nitrate	5,207 kg	32,550 kg

Table 2.9-2. Quantity of Treated Groundwater and Technetium-99 Mass Removed from the Aquifer during Extended Purging at Well 299-W23-19, FY 2004

Sample Date	Volume of Water Treated Liters (gal)	Technetium-99 Concentration (pCi/L)	Activity of Technetium-99 Removed (Ci)	Mass of Technetium-99 Removed (g)
December 16, 2003	3,944 (1,042)	43,000	0.00017	0.010
March 22, 2004	4,845 (1,280)	42,200	0.00020	0.012
June 15, 2004	3,989 (1,054)	41,800	0.00017	0.010
September 29, 2004	4,111 (1,086)	46,100	0.00019	0.011
Totals	16,889 (4,462)	NA	0.00073	0.043

NA = Not applicable.

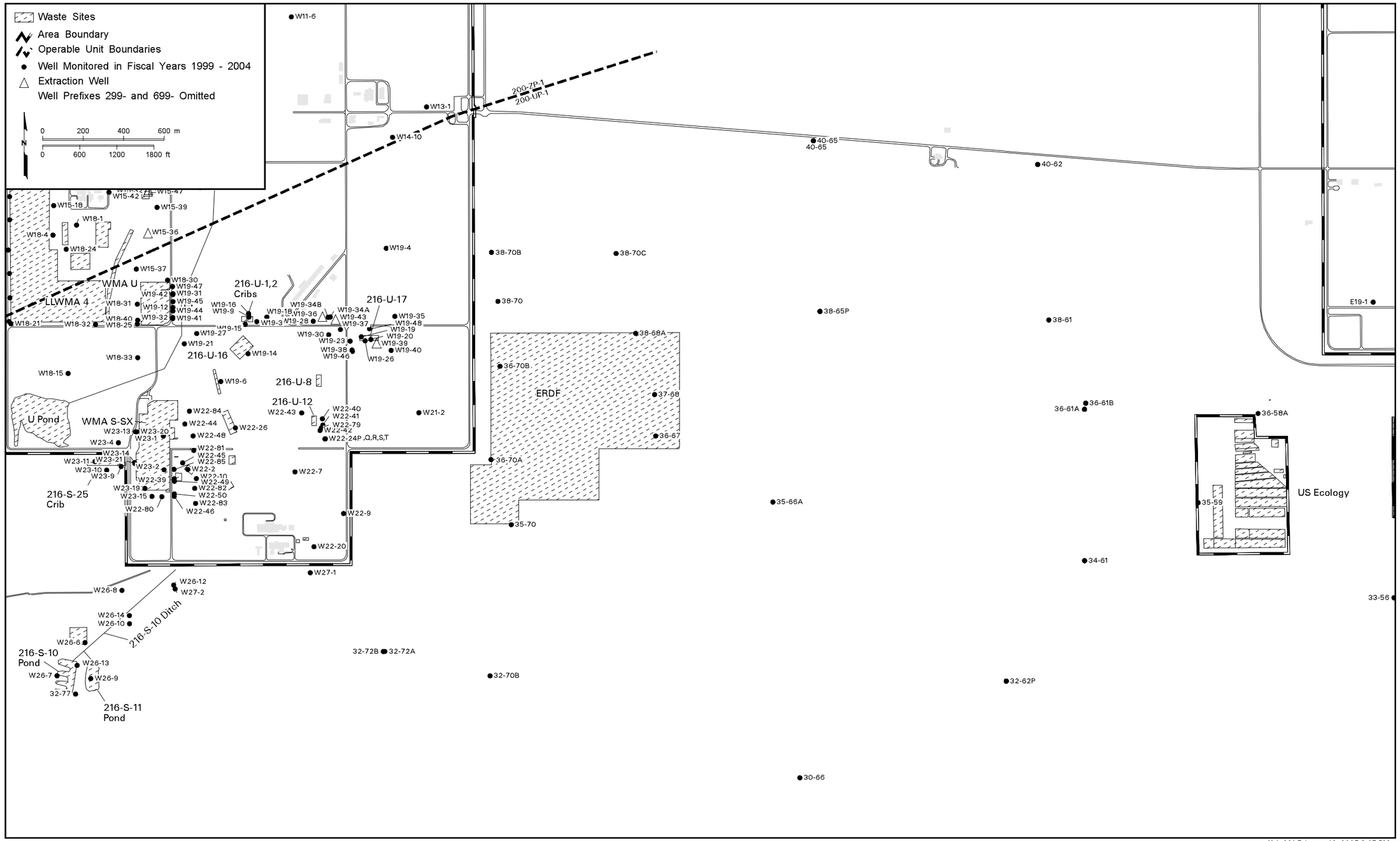


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Figure 2.9-1. Facilities and Groundwater Monitoring Wells in the 200-UP-1 Groundwater Interest Area

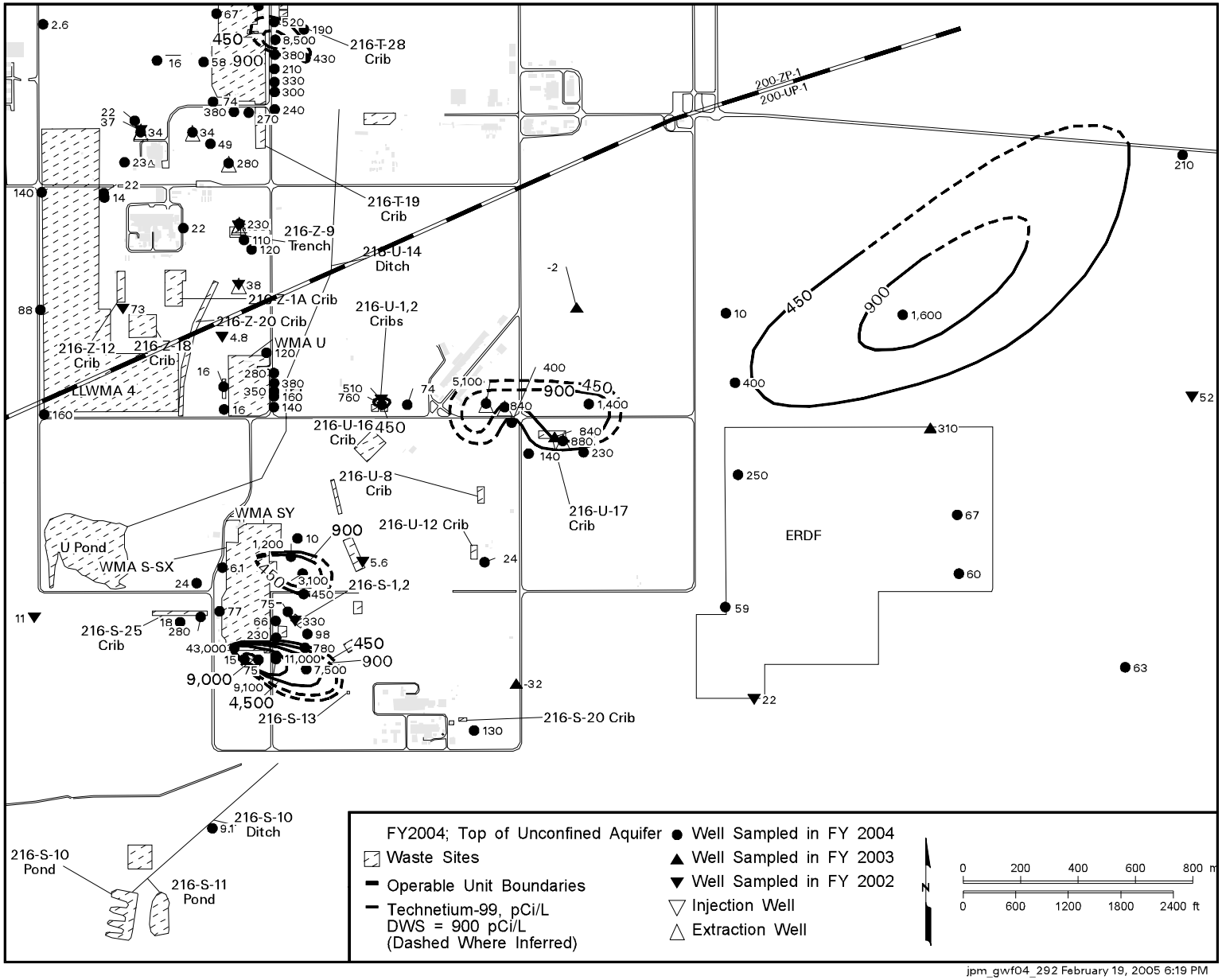

Figure 2.9-2. Average Technetium-99 Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

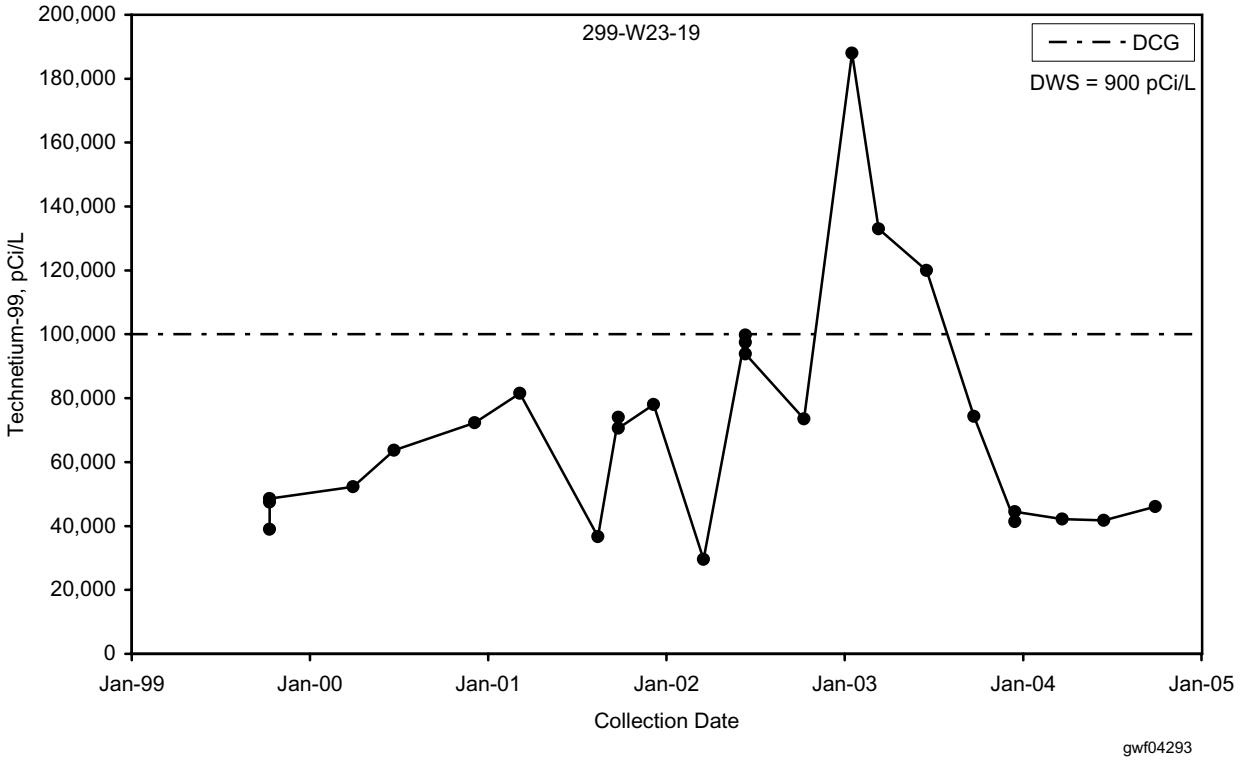

Figure 2.9-3. Technetium-99 Concentrations at Waste Management Area S-SX

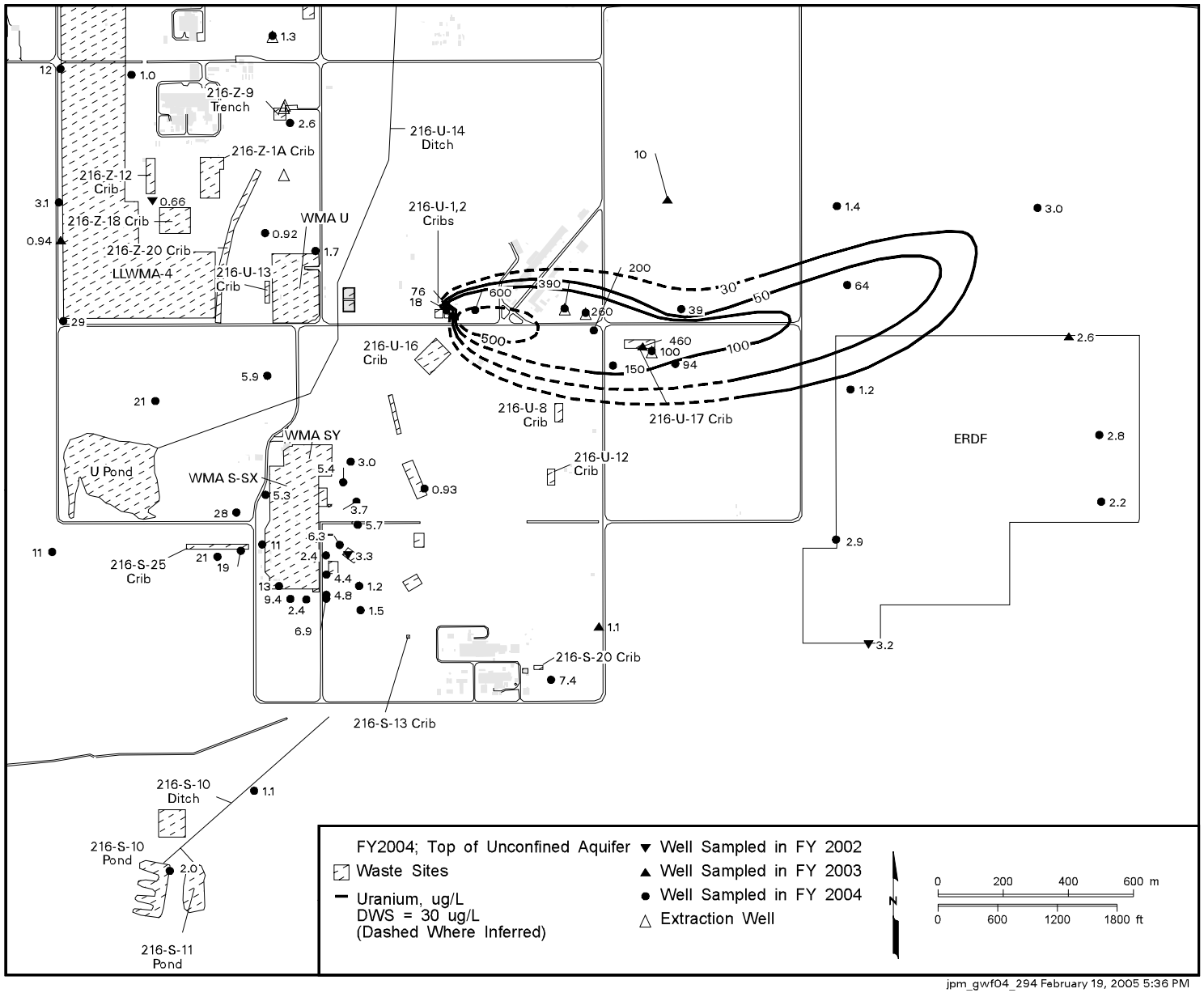

Figure 2.9-4. Average Uranium Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

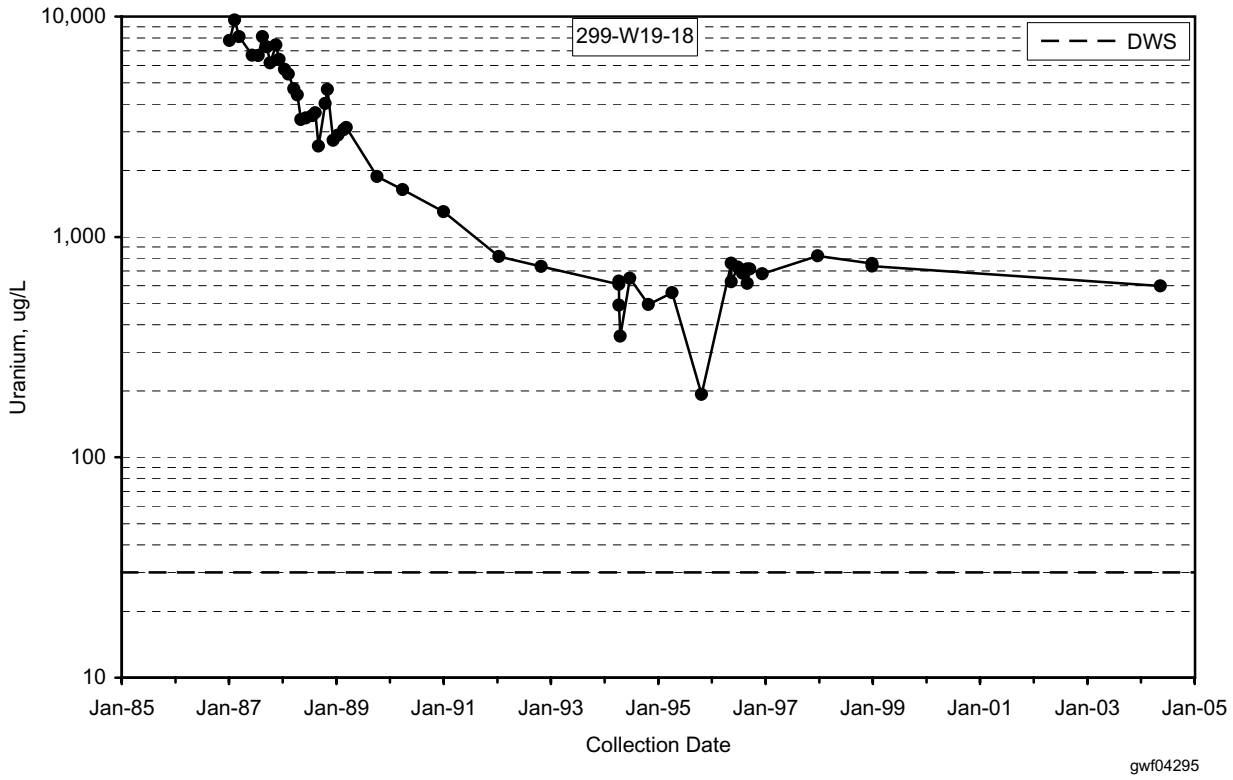

Figure 2.9-5. Uranium Concentrations Near the 216-U-1,2 Cribs

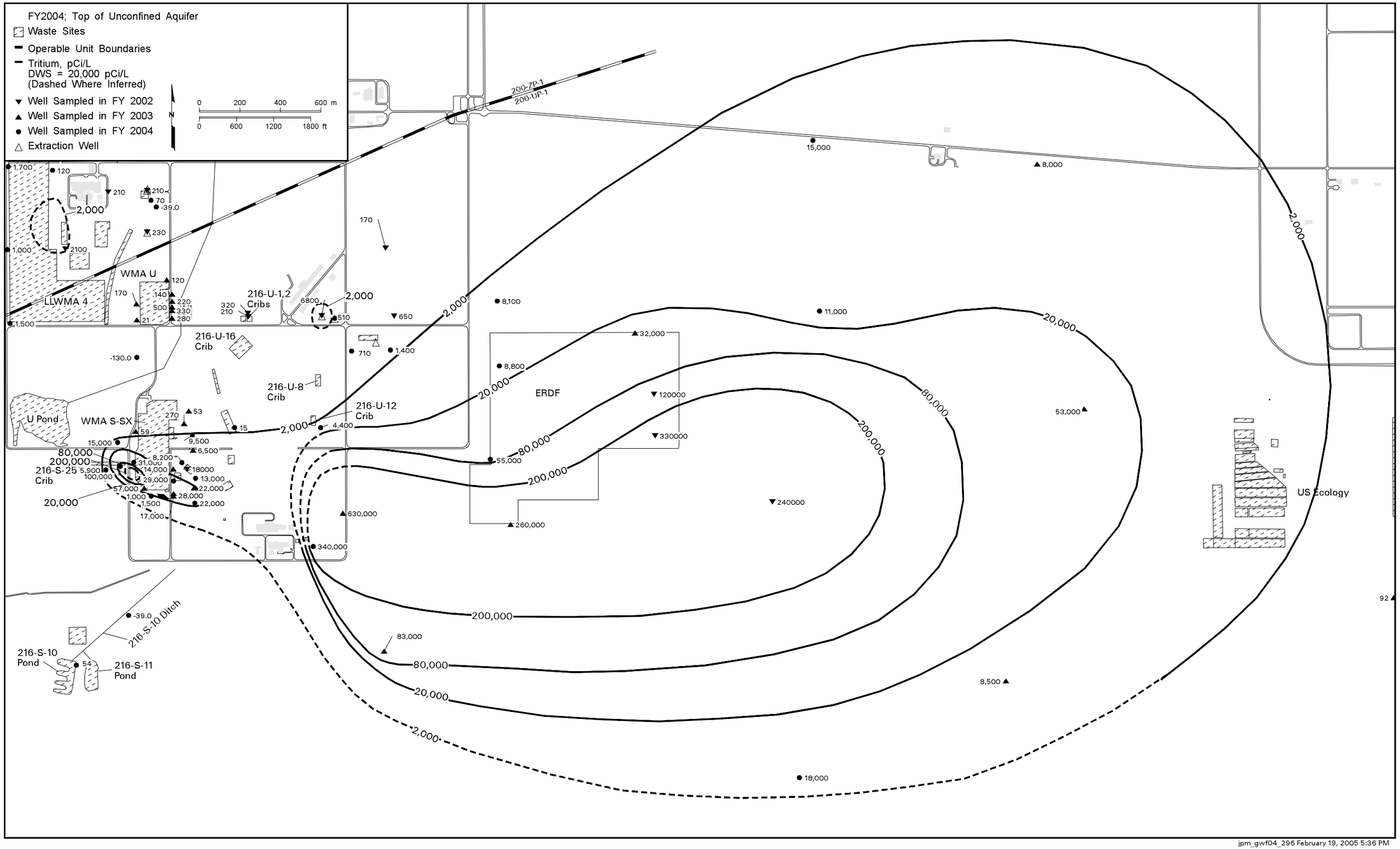

Figure 2.9-6. Average Tritium Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

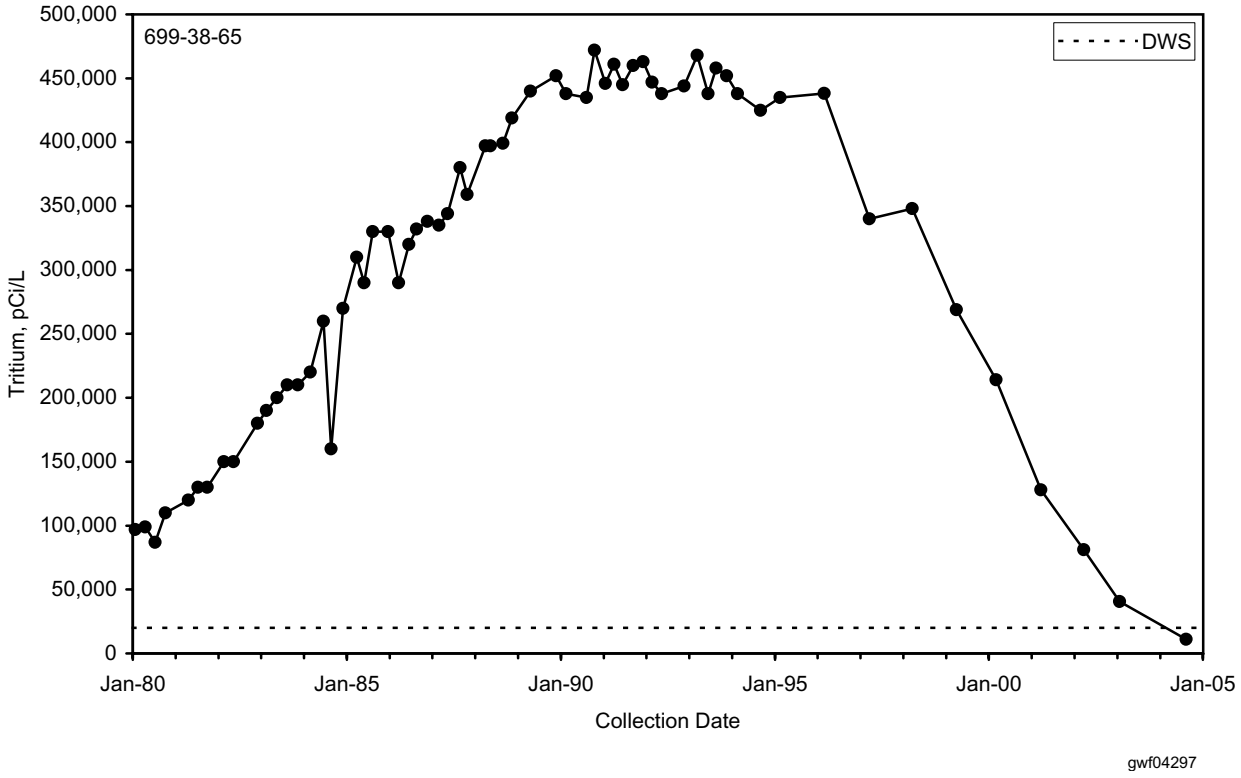

Figure 2.9-7. Tritium Concentrations East of the 200 West Area

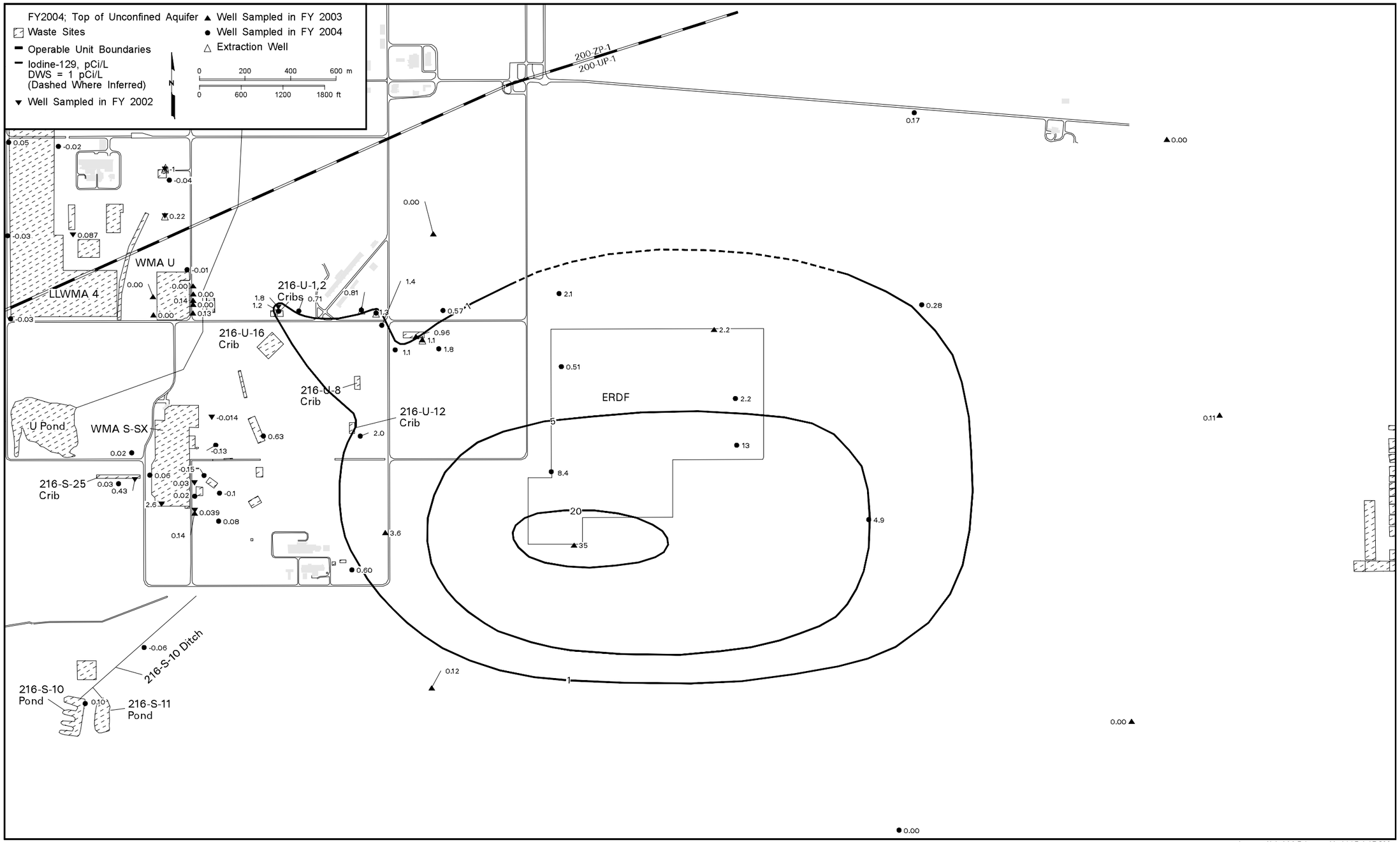

Figure 2.9-8. Average Iodine-129 Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

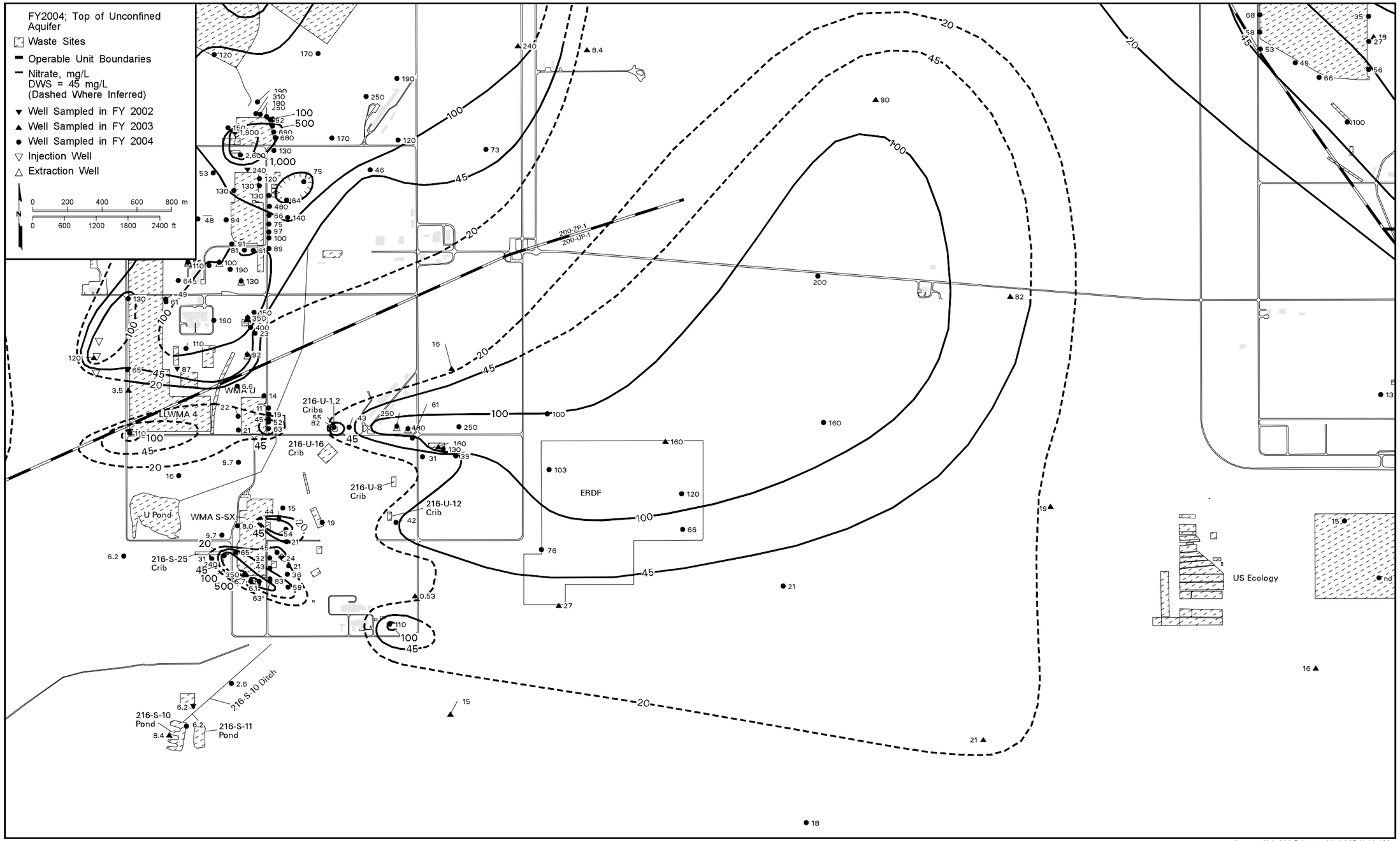

Figure 2.9-9. Average Nitrate Concentrations in the 200-UP-1 Groundwater Interest Area, Top of Unconfined Aquifer

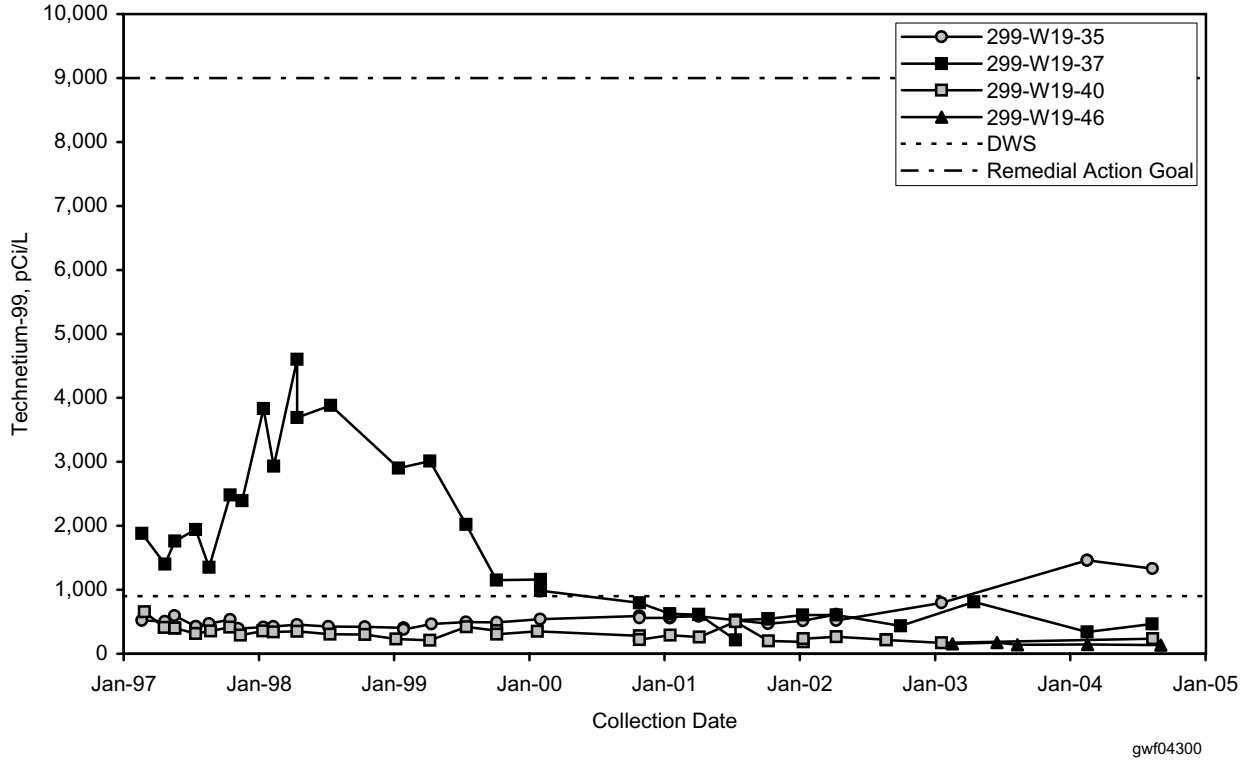

Figure 2.9-10. Technetium-99 Concentrations in Monitoring Wells at the 200-UP-1 Pump-and-Treat Area

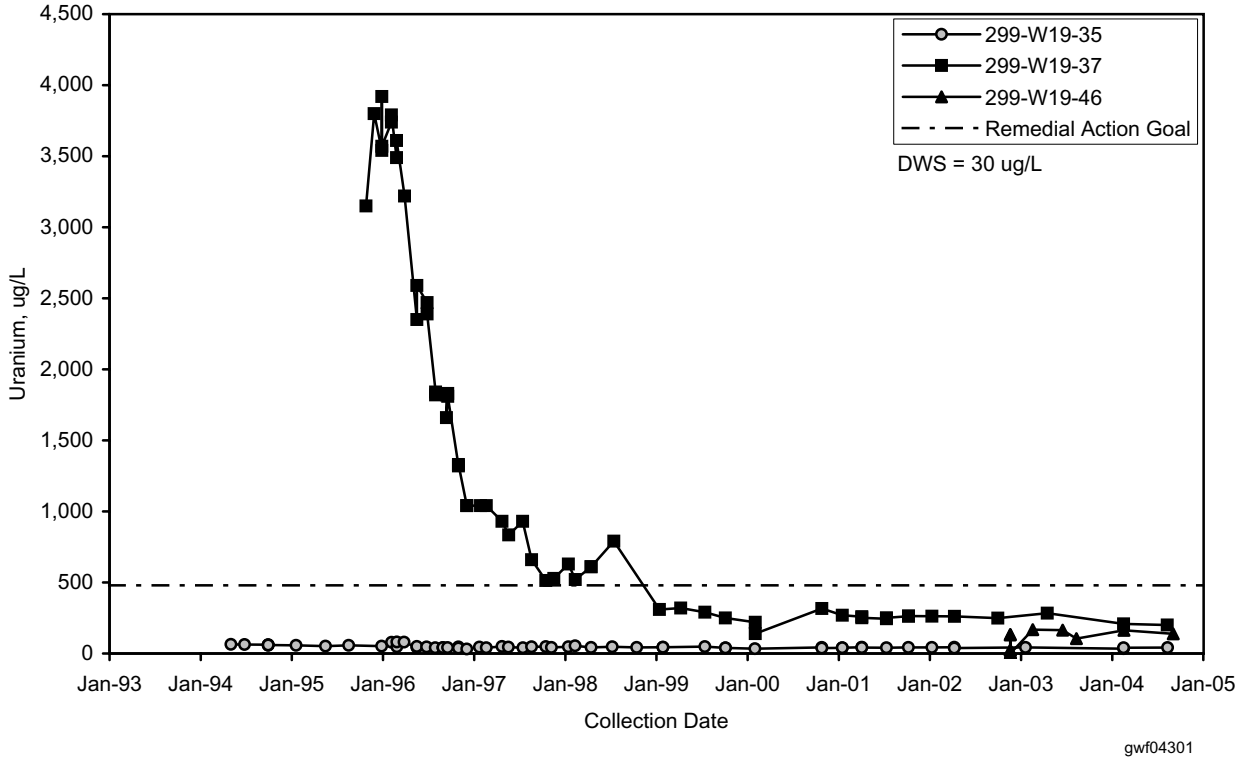

Figure 2.9-11. Uranium Concentrations in Monitoring Wells at the 200-UP-1 Pump-and-Treat Area

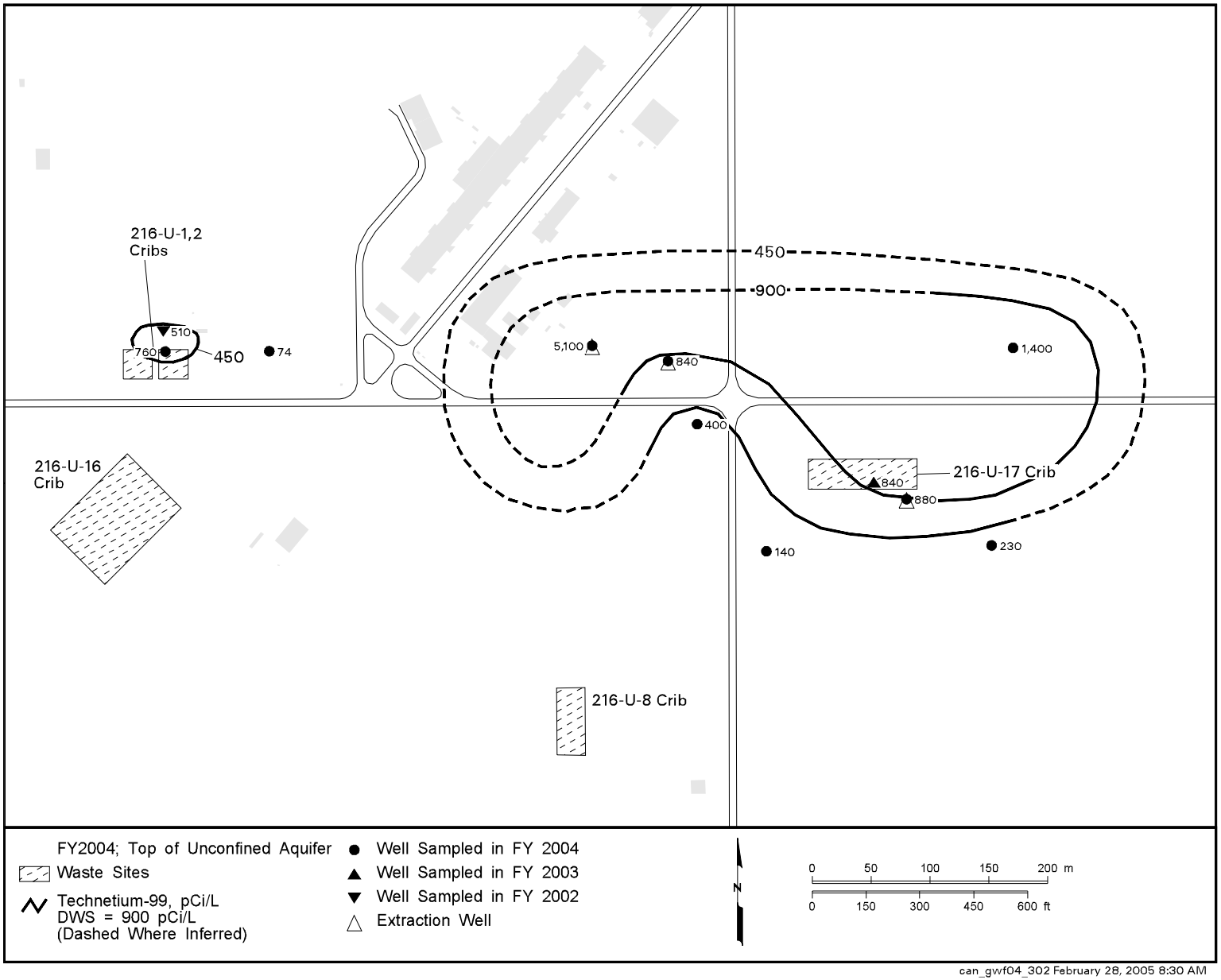

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Figure 2.9-12. Average Technetium-99 Concentrations in the 200-UP-1 Pump-and-Treat Area, Top of Unconfined Aquifer

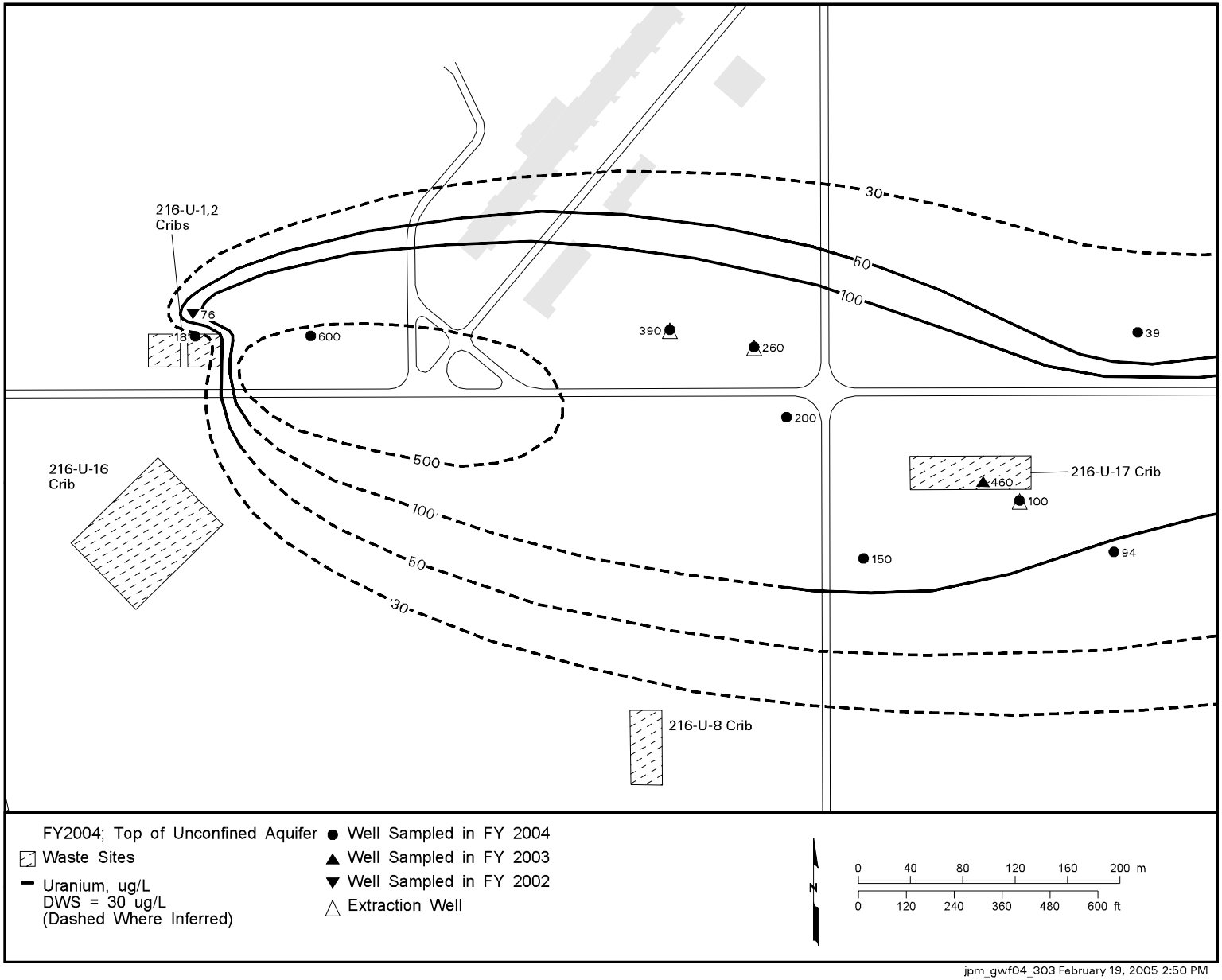

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Figure 2.9-13. Average Uranium Concentrations in the 200-UP-1 Pump-and-Treat Area, Top of Unconfined Aquifer

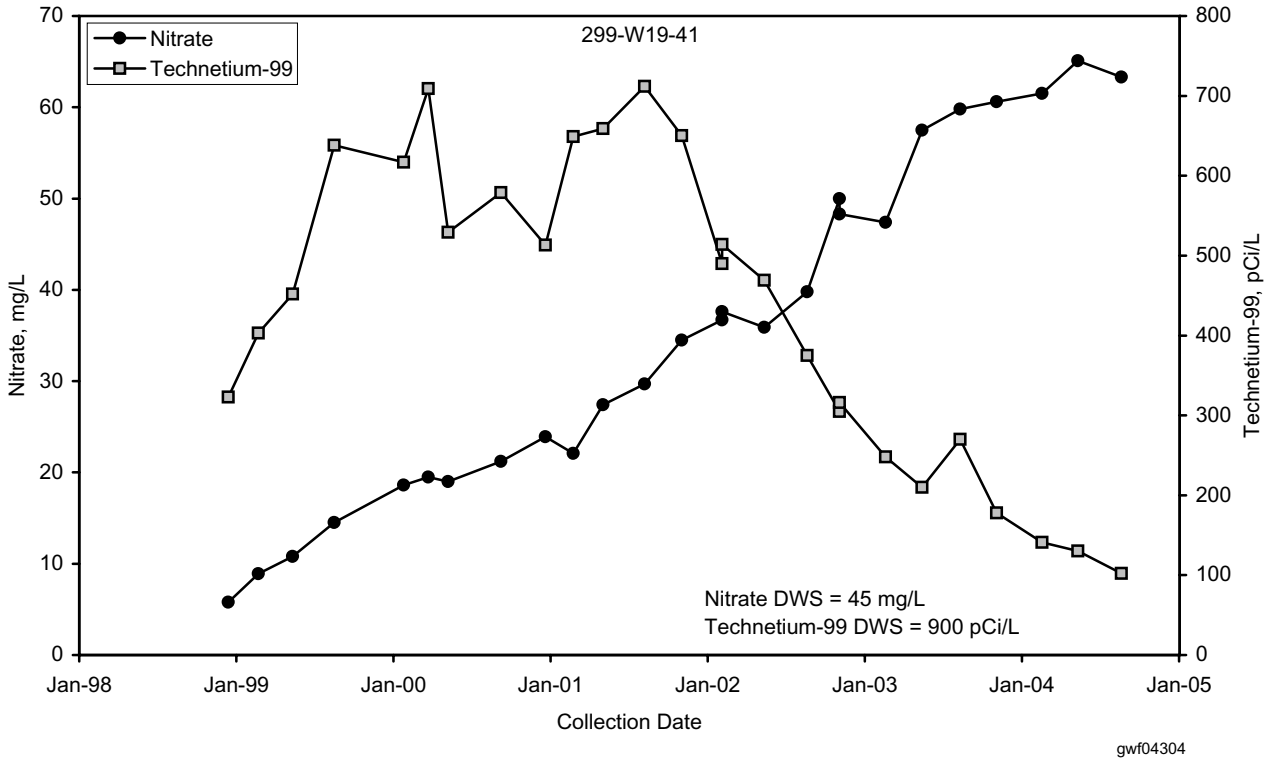

Figure 2.9-14. Trends for Nitrate and Technetium-99 Concentrations in Well 299-W19-41 at Waste Management Area U

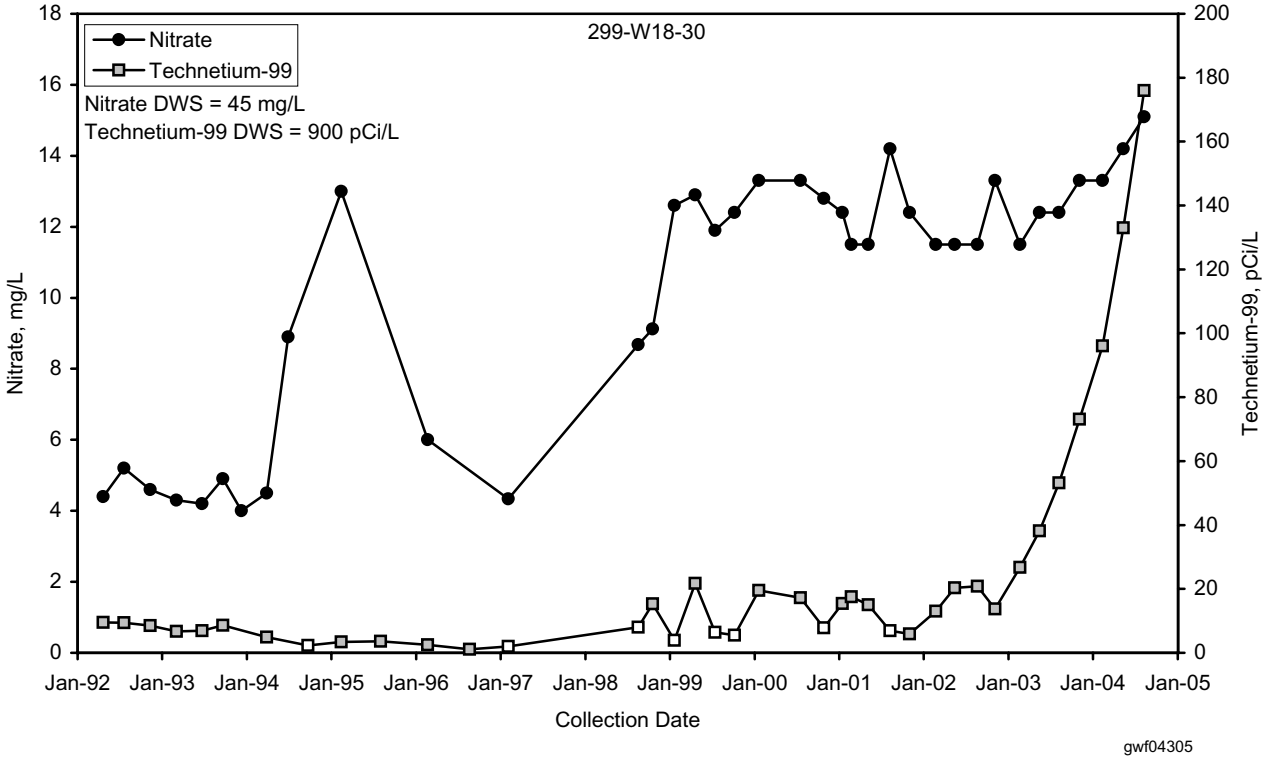

Figure 2.9-15. Increasing Trends for Nitrate and Technetium-99 Concentrations in Well 299-W18-30 at Waste Management Area U

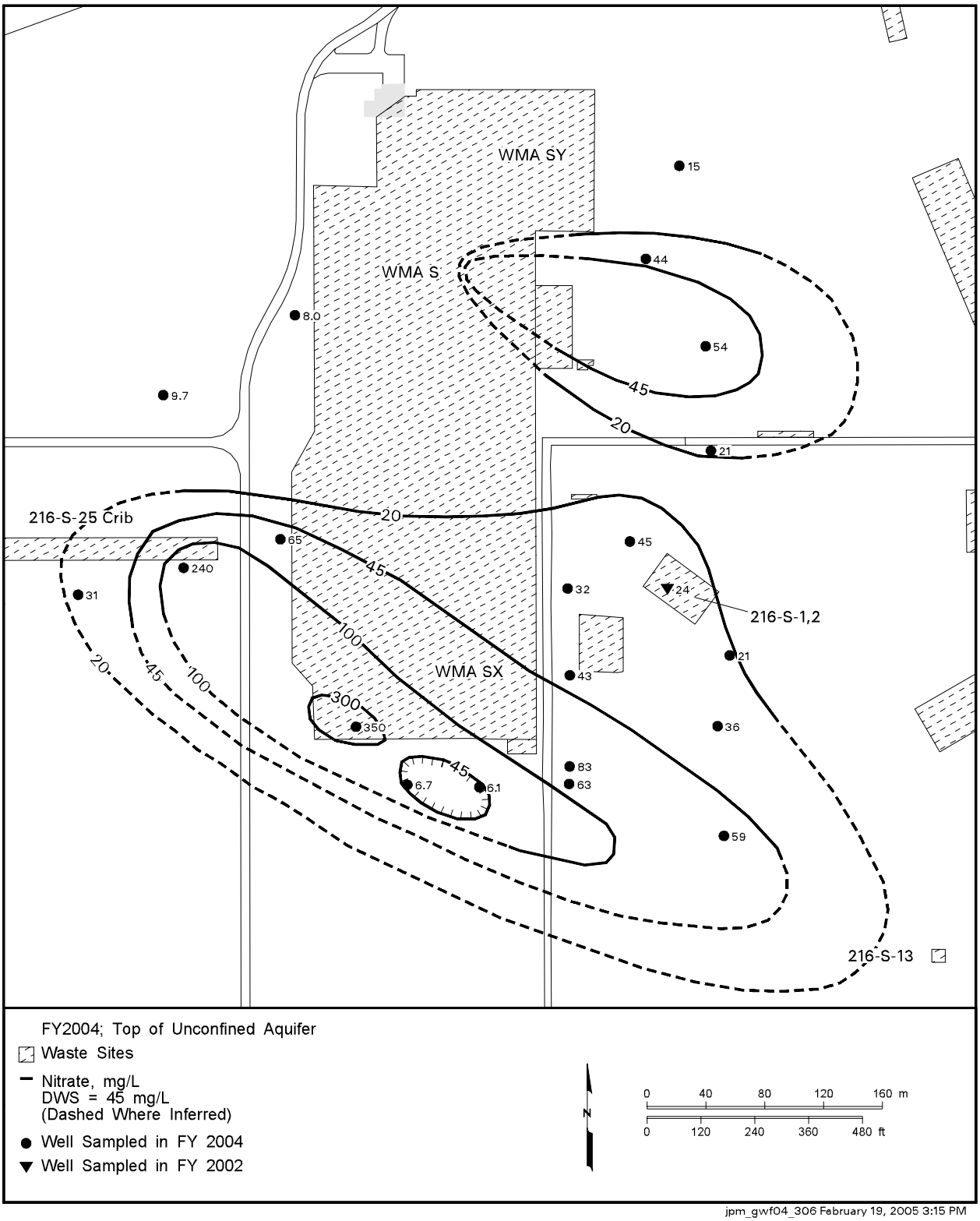

Figure 2.9-16. Average Nitrate Concentrations at Waste Management Area S-SX, Top of Unconfined Aquifer

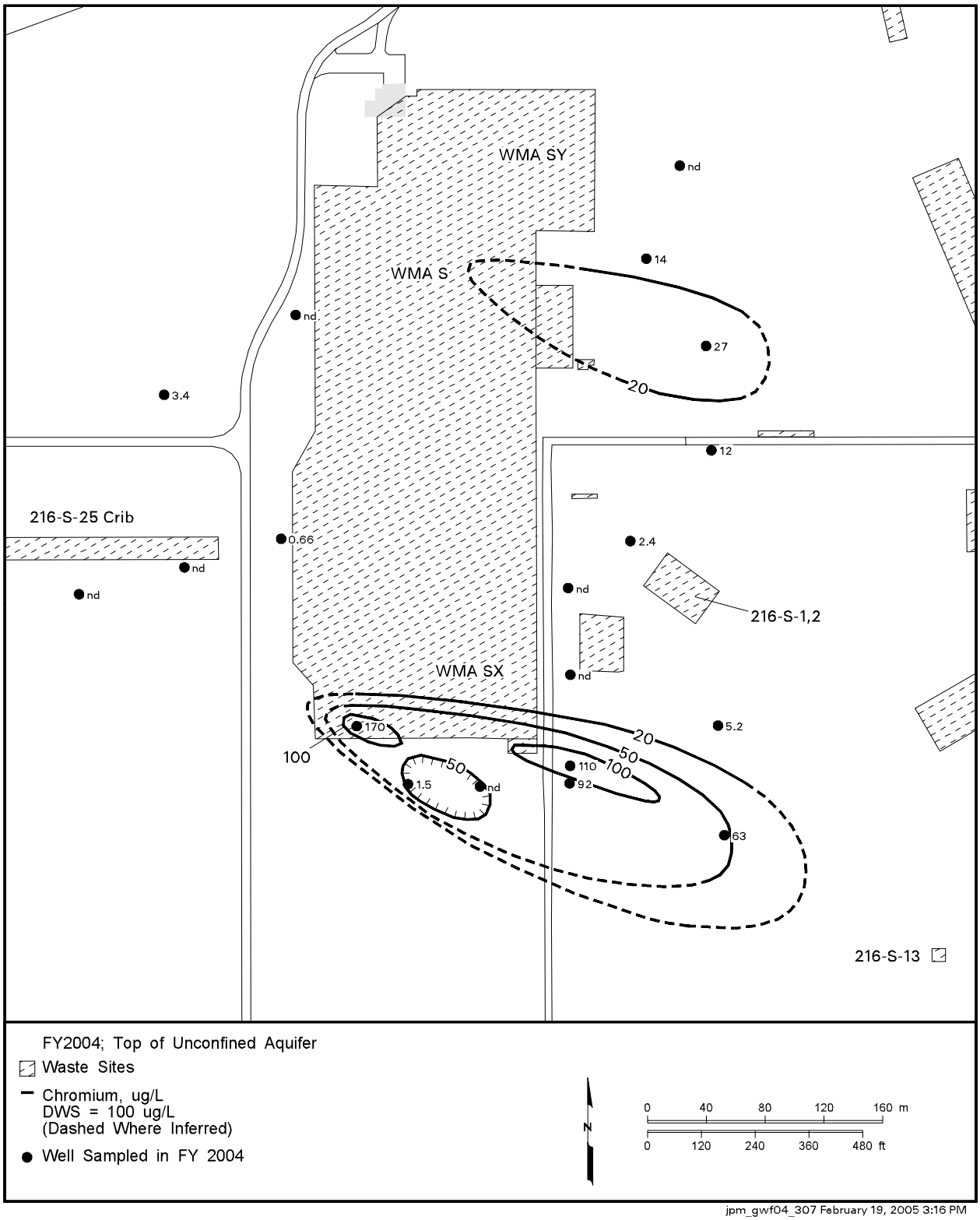

Figure 2.9-17. Average Chromium Concentrations at Waste Management Area S-SX, Top of Unconfined Aquifer

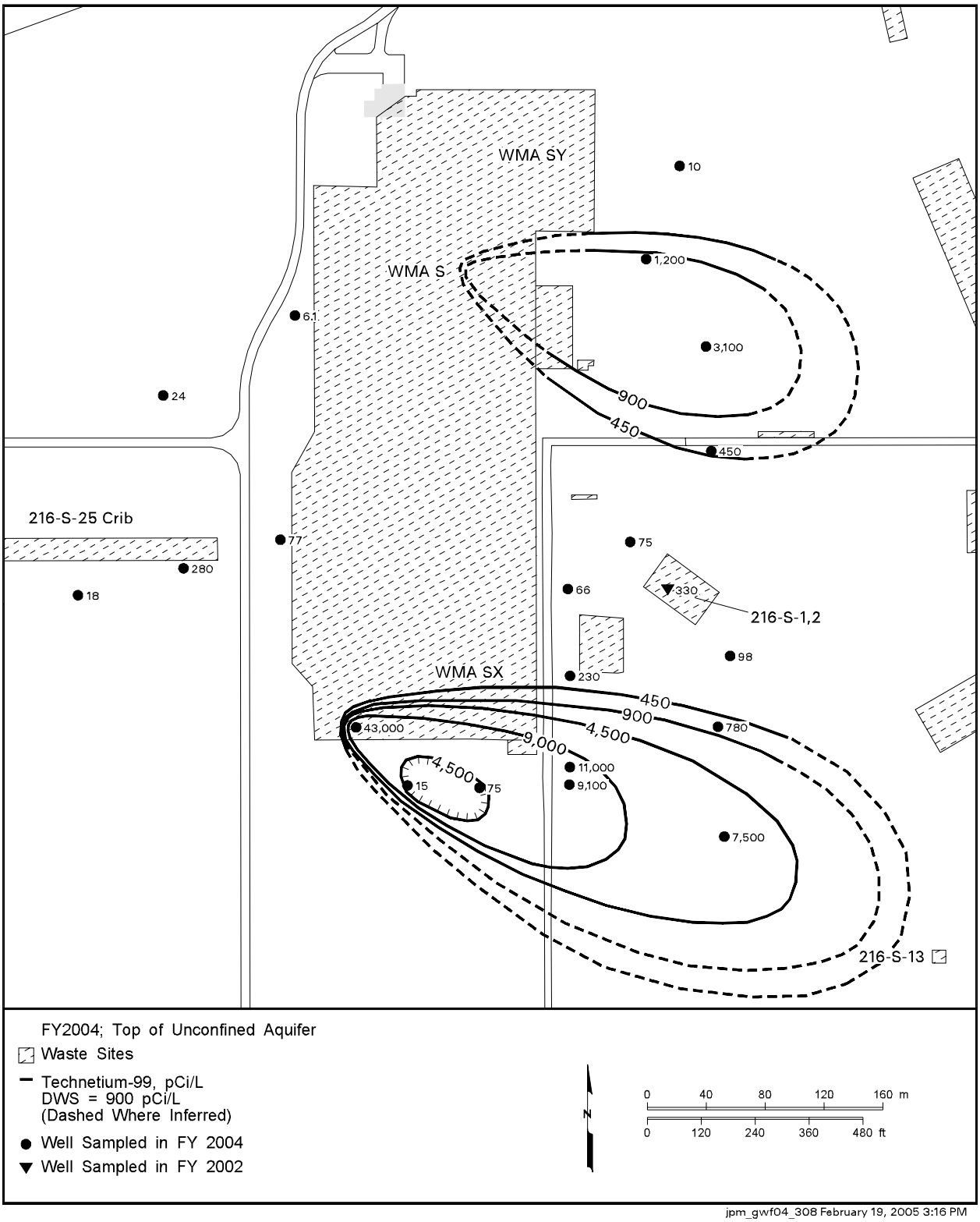

Figure 2.9-18. Average Technetium-99 Concentrations at Waste Management Area S-SX, Top of Unconfined Aquifer

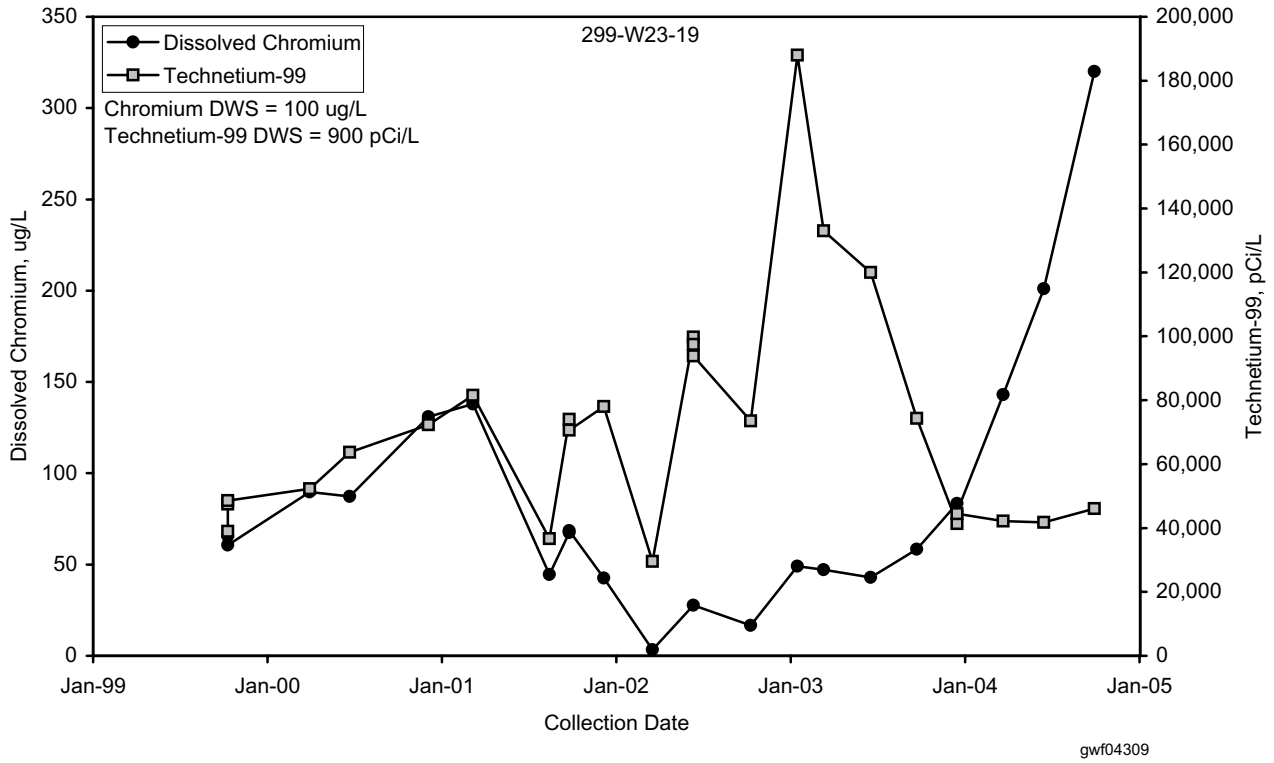

Figure 2.9-19. Chromium and Technetium-99 Concentrations in Well 299-W23-19 Near a Source Area Within the South Portion of Waste Management Area S-SX

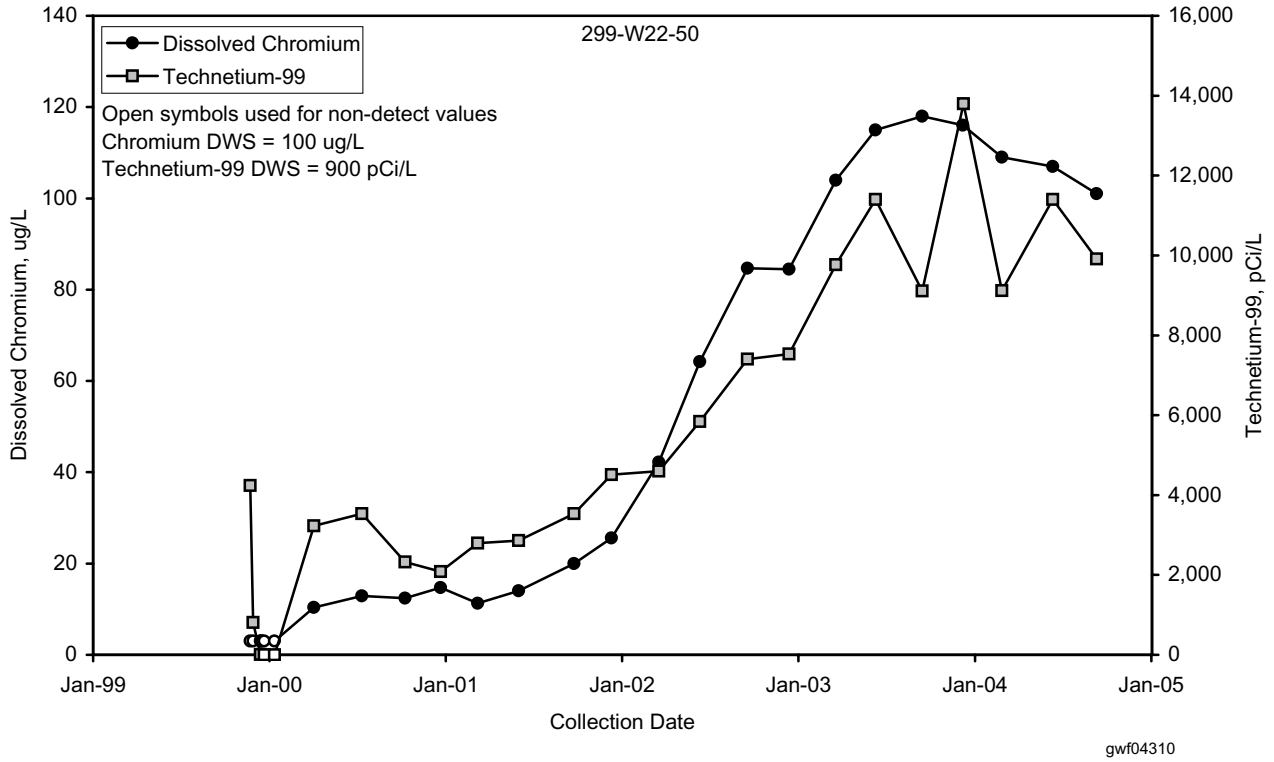

Figure 2.9-20. Chromium and Technetium-99 Concentrations in Well 299-W22-50 Near the Middle of a Plume Emanating from the South Portion of Waste Management Area S-SX

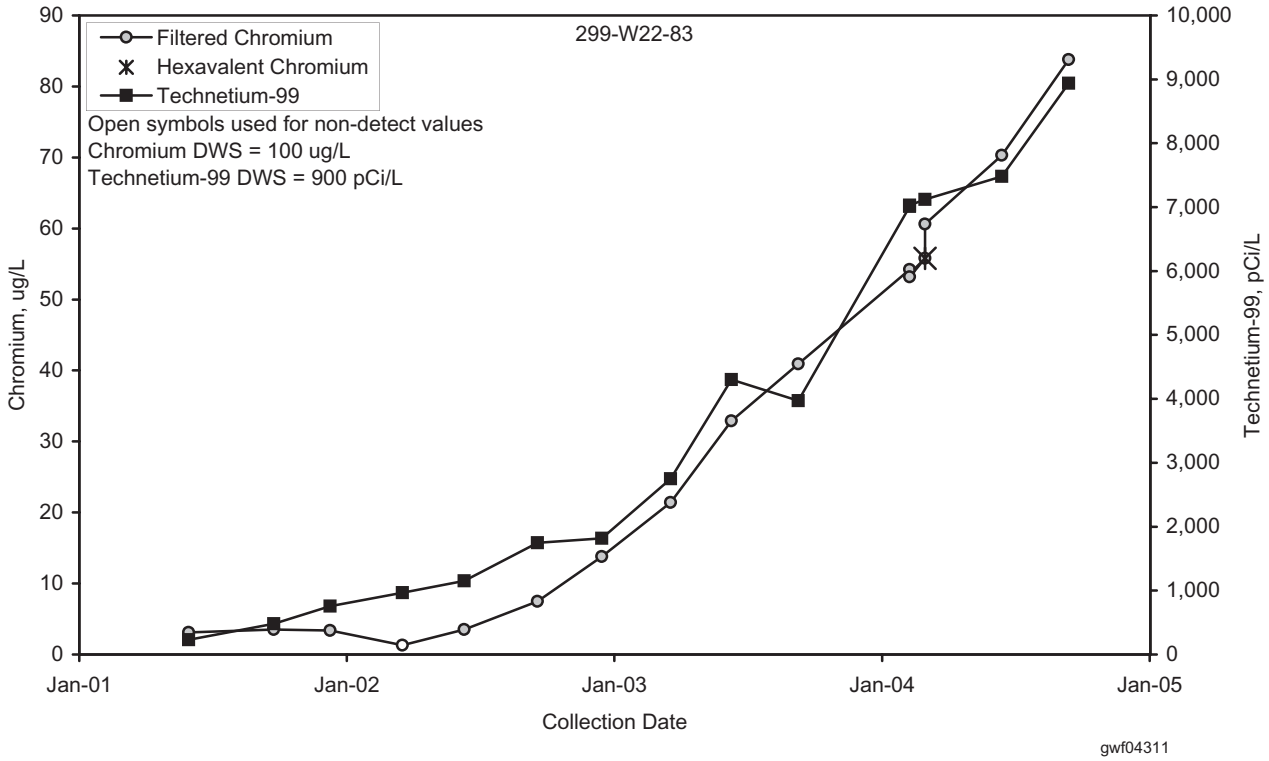

Figure 2.9-21. Chromium and Technetium-99 Concentrations in Well 299-W22-83 Near the Distal End of a Plume Emanating from the South Portion of Waste Management Area S-SX

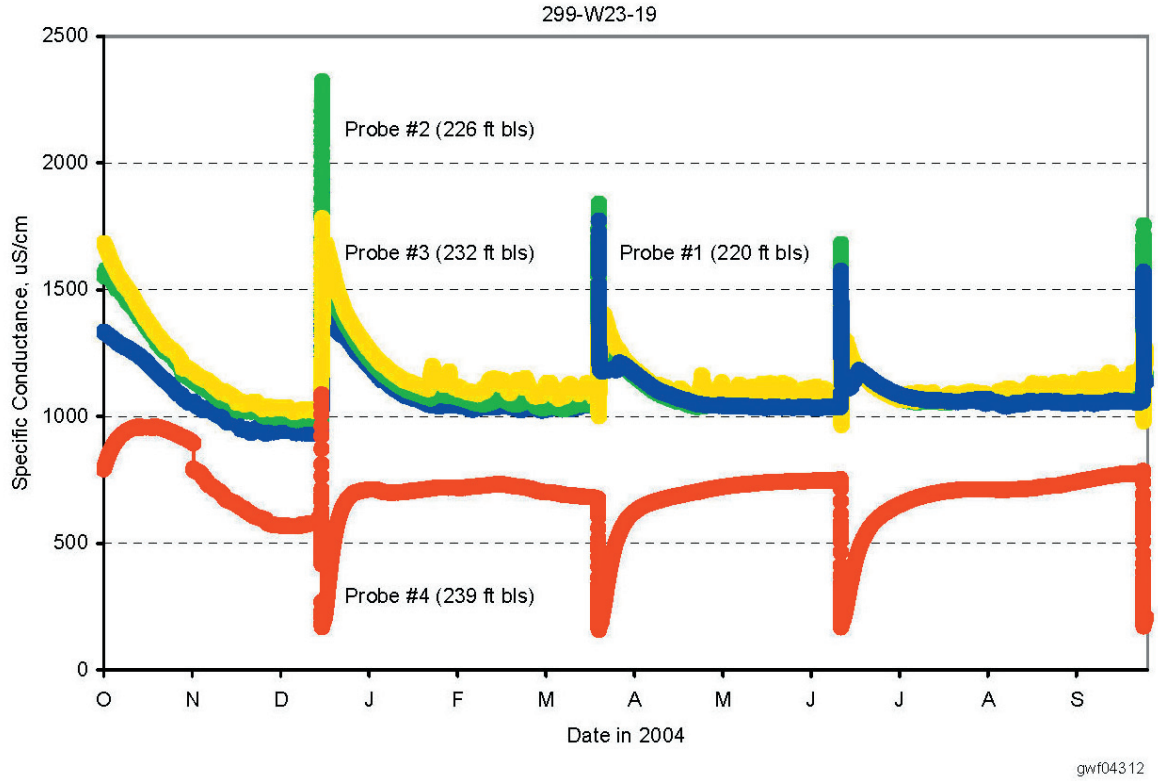

Figure 2.9-22. FY 2004 Wellbore-Fluid Specific Conductance Measurements Collected in Well 299-W23-19 at Waste Management Area S-SX (Data from probe #4 are shown for information purposes but are considered unreliable.)

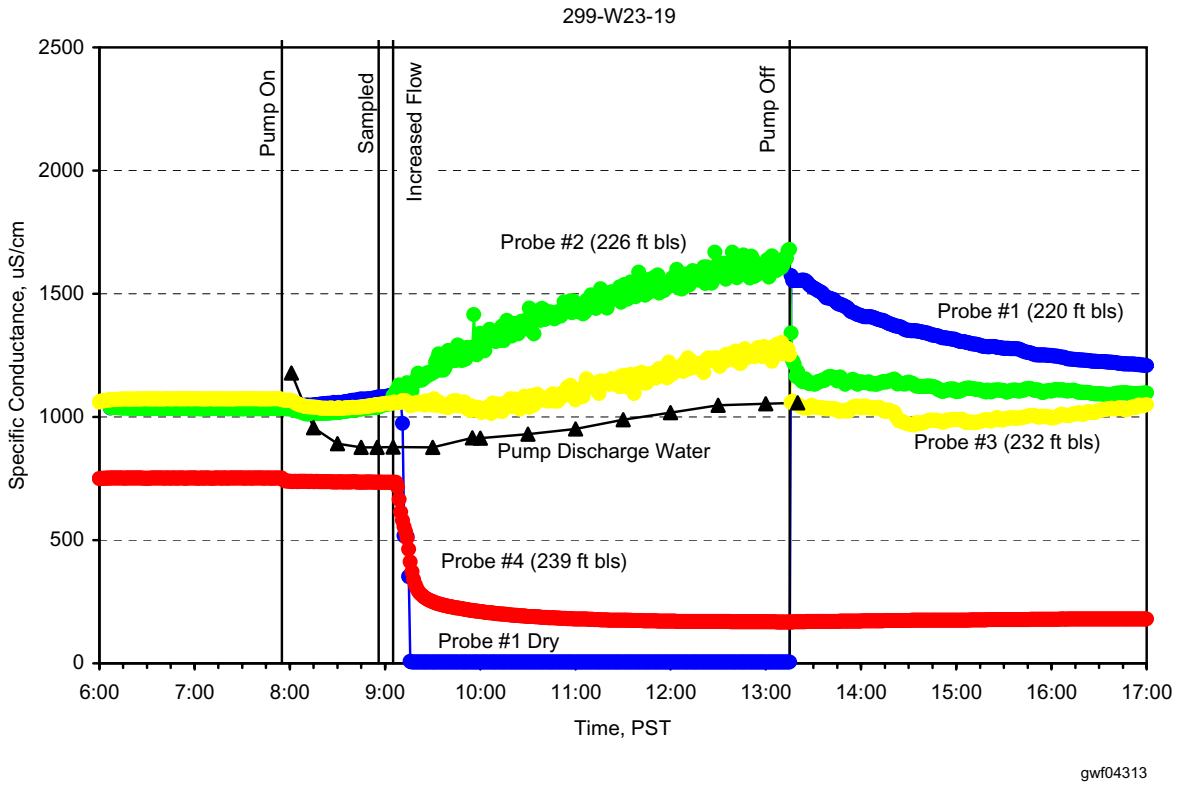

Figure 2.9-23. Wellbore-Fluid Specific Conductance Measurements Collected during Sampling on June 15, 2004, in Well 299-W23-19 (Data from probe #4 are shown for information purposes but are considered unreliable.)