2.8 200 West Area

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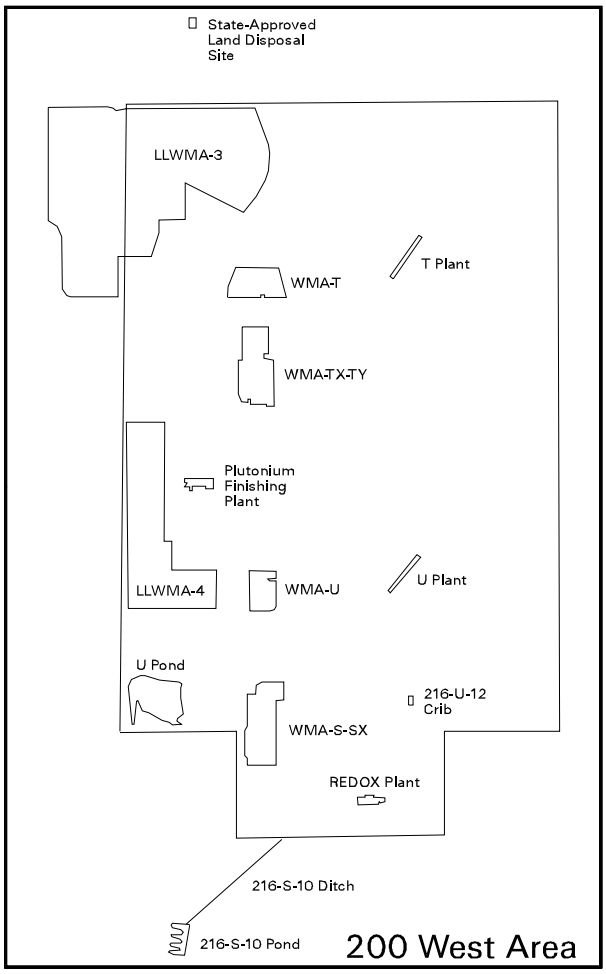
Contamination in 200 West Area can be divided into five major regions:

- Plutonium Finishing Plant
- T Plant
- U Plant
- REDOX Plant
- State-Approved Land Disposal Site.

The discussion in this section is divided into groundwater flow, the major radioactive and non-radioactive hazardous contaminants, and specific *Resource Conservation and Recovery Act of 1976* (RCRA) facility monitoring. Where appropriate, groundwater remediation is also discussed. The major contaminant plumes found in 200 West Area are carbon tetrachloride, iodine-129, nitrate, technetium, trichloroethylene, tritium, and uranium. Chromium is also found in small, scattered areas.



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2.8.1 Plutonium Finishing Plant

The Plutonium Finishing Plant operated from 1949 through 1987 for the final stages of plutonium purification. The Plutonium Finishing Plant was not a significant contributor to the iodine-129 or tritium plumes. Migration of plutonium contamination from the vadose zone is of concern because large quantities of plutonium, in the presence of organic complexing agents, were disposed to ground in the area. The formation of plutonium bearing colloids that could enhance mobility is also a concern. No further investigation of the mobility of plutonium was undertaken in fiscal year 1999. Carbon tetrachloride and other volatile organic compounds form the major plumes discussed in this section. Relatively widespread nitrate contamination is also present.

The only facilities near the Plutonium Finishing Plant with RCRA monitoring requirements are the burial grounds in Low-Level Waste Management Area 4. These are not believed to contribute to groundwater contamination. Remediation of volatile organic compounds in groundwater and the vadose zone is being undertaken in this area using a pump-and-treat system. Large masses of carbon tetrachloride continue to be removed from the vadose zone, reducing this source of groundwater contamination. The groundwater pump-and-treat system removes smaller amounts of carbon tetrachloride as groundwater is withdrawn

Monitoring Objectives Near Plutonium Finishing Plant

Groundwater monitoring is conducted near the Plutonium Finishing Plant:

- triennially to annually to describe the nature and extent of contamination
- semiannually to detect the possible impact of one RCRA waste management area
- semiannually to monitor trends in variable constituents/wells
- various time intervals to evaluate the performance of a pump-and-treat system for carbon tetrachloride.

and re-injected. As a result, significant changes in groundwater flow and contaminant distribution are occurring.

2.8.1.1 Groundwater Flow

Groundwater near the Plutonium Finishing Plant flows generally from west to east (see Plate 2). Flow is heavily influenced by the ongoing 200-ZP-1 Operable Unit pump-and-treat activities. Six extraction wells to the north, east and south of the Plutonium Finishing Plant and five injection wells to the west of Low-Level Waste Management Area 4 have created an area of flow converging on the extraction zone. These conditions are expected to continue until the end of the pump-and-treat program, at which time the flow direction will become generally eastward.

Details of groundwater flow beneath the pump-and-treat system and Low-Level Waste Management Area 4 are discussed below.

2.8.1.2 Carbon Tetrachloride

Carbon tetrachloride contamination is present in the unconfined aquifer system beneath most of the 200 West Area and has migrated past the 200 West Area boundary (Figure 2.8-1), covering an area of over 11 square kilometers. The contamination is believed to be from pre-1973 waste associated with the Plutonium Finishing Plant. The maximum carbon tetrachloride concentration detected in the 200 West Area in fiscal year 1999 was in extraction well 299-W15-32, where the annual average concentration was 6,600 µg/L. Data from extraction wells are taken from project-specific data files and, thus, are not included on the diskette provided with this report. The allowable maximum contaminant level for carbon tetrachloride in drinking water is 5 µg/L.

The major identified sources of carbon tetrachloride are the 216-Z-9 trench, the 216-Z-1A tile field, and the 216-Z-18 crib. The 216-Z-12 crib, the 216-Z-19 ditch, and the 216-T-19 tile field may also have contributed. These sources are shown in Figure A.12. Vadose zone carbon tetrachloride sources are discussed in Section 3.2.2.1.

A large plume of carbon tetrachloride under the 200 West Area originates mainly from waste sites associated with the Plutonium Finishing Plant. The area of the plume increased slightly during the past year.

In the central part of the plume, the area within the 4,000 µg/L contour has increased during the period of pump-and-treat operations. Concentrations of carbon tetrachloride are increasing in the northernmost extraction wells 299-W15-33, 299-W15-34, and 299-W15-35 and nearby monitoring wells such as well 299-W15-1 (Figure 2.8-2). Concentrations in the southern extraction wells 299-W15-32 and 299-W15-36 and nearby monitoring wells are declining slowly. BHI-01311, Rev. 0 discusses in more detail the continued existence of high concentrations in the area of pump-and-treat remediation, which supports the presence of a continuing source of carbon tetrachloride, such as non-aqueous phase liquid below the water table or continued recharge from the vadose zone. Concentrations are declining around the active injection wells as shown in Figure 2.8-1.

The part of the plume greater than 1,000 μg/L extends to the north and northeast reaching the vicinity of Low-Level Waste Management Area 3 burial ground and T Plant. Well 299-W10-20, for example, has persistent concentrations of carbon tetrachloride near or above 1,000 μg/L, even though it is not located near any known sources. Other wells in the vicinity also have high carbon tetrachloride values, with the exception of well 299-W10-19, where the concentrations have declined sharply since 1997 (Figure 2.8-3). The reason for this localized decline is unknown but suggests variability that may be related to contaminant or water source distribution. It is possible that past discharges to the 200 West power plant pond and the 216-W laundry waste crib, located in the east-central part of the 200 West Area, resulted in the nearly due north and northeastward transport of the carbon tetrachloride. As suggested by BHI-01311, Rev. 0 further investigation of possible sources and historical flow directions in the northwestern 200 West Area is warranted.

Carbon tetrachloride concentrations greater than 1,000 μg/L also are found near T Plant northeast of the known carbon tetrachloride sources near the Plutonium Finishing Plant. High concentrations persist in well 299-W11-14 but have declined in upgradient well 299-W11-7, suggesting a pulse of contamination is moving downgradient (Figure 2.8-4). Concentrations in well 299-W12-1, located in the northeastern corner of the 200 West Area, have increased since 1997 to a maximum of 8 μg/L (Figure 2.8-5). The carbon tetrachloride plume has been divided into two lobes on its northern boundary, likely because of the discharge of relatively clean water to the 216-T-4-2 ditch. Concentrations of a number of contaminants are increasing in that vicinity since that discharge ceased in 1995 (Section 2.8.2).

Carbon tetrachloride concentrations have been increasing markedly in the vicinity of Waste Management Area S-SX. For example, concentrations in well 299-W23-15, located directly south of the SX Tank Farm, rose from less than 5 μg/L in fiscal year 1995 to 120 μg/L in fiscal year 1999 (see Figure 2.8-5). The previously low concentrations in this area could have been caused by the discharge of carbon tetrachloride-free water to portions of the 216-U-14 ditch, north of the tank farms, until 1995. This discharge may have affected groundwater flow, so that carbon tetrachloride spread to the east and west of the tank farms.

Information on the distribution of carbon tetrachloride in the eastern half of the 200 West Area is very sparse. The original well network had large gaps in this area and several key wells have gone dry. Whether or not a low concentration area exists in the east-central part of the 200 West Area is uncertain. This low concentration area may have resulted from past discharges to the 200 West power plant pond and the 216-W laundry waste crib as is suggested by two 1990 samples from well 299-W14-10 where carbon tetrachloride was below the detection limit.

Carbon tetrachloride contamination extends a considerable distance southeast of the Plutonium Finishing Plant to the eastern edge of the Environmental Restoration Disposal Facility. Concentrations in fiscal year 1999 were slightly below the maximum contaminant level but were greater than the maximum contaminant level in fiscal year 1998 (see Figure 2.8-5).

Carbon tetrachloride contamination has been observed to depths greater than 60 meters in the aquifer. In places, contamination at depth extends greater distances laterally than at the water table, as reported previously (PNNL-12086). Little information is available on the distribution of carbon tetrachloride at depth. Available data consist of a few well nests and depth discrete samples collected from older wells with large open intervals. One disadvantage of the depth discrete samples is the potential for vertical mixing within the well or along the annulus. A discussion of depth distribution of carbon tetrachloride is presented in the fiscal year 1998 annual groundwater report (PNNL-12086). A detailed summary of the available data on the depth distribution of carbon tetrachloride has recently been published in BHI-01311, Rev. 0. Two figures from that report showing the carbon tetrachloride distribution in two deeper zones of the

unconfined aquifer are reproduced here and compared to carbon tetrachloride contours at the top of the aquifer (Figure 2.8-6 and Figure 2.8-7).

2.8.1.3 Chloroform and Trichloroethylene

Two sources of chloroform in Hanford Site groundwater are from chlorination of organic matter during purification of potable water and then its subsequent disposal to ground, or by biodegradation of carbon tetrachloride. Biodegradation is believed to be the major source of chloroform in the 200 West Area. The maximum contaminant level for chloroform is 100 μg/L (total trihalomethanes), which is 20 times higher than that for carbon tetrachloride. The distribution of chloroform is shown in Figure 2.8-8. Values for chloroform are all below the maximum contaminant level.

The distribution of trichloroethylene near the Plutonium Finishing Plant is shown in Figure 2.8-9. Disposal near T Plant may have also contributed to this plume. The plume is fairly extensive but concentrations are only slightly above the 5 μg/L maximum contaminant level.

2.8.1.4 Plutonium and Americium

The single well, 299-W15-8, near the 216-Z-9 crib, where plutonium and americium have been detected in groundwater, has not been monitored since 1991 when the well went dry. No replacement well has been funded. The fiscal year 1998 annual report (PNNL-12086) presents the latest information on plutonium and americium in groundwater and the vadose zone in this vicinity. Report WHC-SD-EN-TI-248 discusses how complexants may mobilize transuranics in the vadose zone.

2.8.1.5 Nitrate

The 216-Z-9 trench received an estimated 1.3 million kilograms of chemicals containing nitrate during its operation from 1955 to 1962. Other liquid waste disposal facilities associated with the Plutonium Finishing Plant received smaller but significant amounts of nitrate. There is, thus, a nitrate plume originating in this area, but additional sources of nitrate from disposal facilities near T Plant also contribute to the contamination. The extent of nitrate in the western and northern 200 West Area is shown in Figure 2.8-10. The highest nitrate concentrations are associated with facilities near T Plant and are discussed in Section 2.8.2.6.

Nitrate concentrations are increasing in wells downgradient from the injection wells for the 200-ZP-1 pump-and-treat system. This increase appears to be from nitrate in the injected water that was not treated for nitrate removal. Thus, nitrate concentrations in wells 299-W18-23 and 299-W18-26 are now greater than the maximum contaminant level (Figure 2.8-11). This nitrate results in an increase in specific conductance of water from wells that are now upgradient of Low-Level Waste Management Area 4, decreasing the usefulness of specific conductance for RCRA detection monitoring.

2.8.1.6 Low-Level Waste Management Area 4 RCRA Parameters

The standard detection monitoring system, using upgradient versus downgradient comparisons of indicator parameter concentrations, is of limited use at Low-Level Waste Management Area 4. Water from the 200-ZP-1 pump-and-treat project has been reinjected into groundwater wells located immediately west of Low-Level Waste Management Area 4, changing the groundwater chemistry baseline. Background levels for the contamination indicator parameters were re-established in the second quarter of 1999. There does not appear to be any contaminant release from Low-Level Waste Management Area 4. Wells and analytes monitored are listed in Appendix A.

RCRA monitoring at Low-Level Waste Management Area 4 indicates no groundwater contamination from this facility. Monitoring this area is challenging because of extraction and injection of groundwater from a nearby remediation system.

At the inception of RCRA monitoring at Low-Level Waste Management Area 4 in 1988, groundwater flow was primarily from east to west. However, as the effects of past liquid disposal practices began to dissipate, groundwater flow beneath this facility began to return to the west to east conditions that pre-dated the Hanford Site. The groundwater flow conditions are also being influenced by the ongoing 200-ZP-1 pump-and-treat program, which has extractions wells to the east and injection wells to the west of Low-Level Waste Management Area 4. Groundwater flow is expected to remain in the easterly direction after the pump-and-treat activities are completed.

Carbon tetrachloride, nitrate, and trichloroethylene are the major contaminants in monitoring wells surrounding Low-Level Waste Management Area 4. These constituents are not related to the disposal of waste in this facility. They are attributed to contaminant plumes originating to the east of Low-Level Waste Management Area 4 that have spread over the 200 West Area.

All of the wells in the monitoring network contain carbon tetrachloride above the 5 μg/L maximum contaminant level. In contrast, only monitoring well 299-W15-16 exceeded the 5 μg/L maximum contaminant level for trichloroethylene in April 1999, with a value of 6 μg/L. Subsequent results were below the maximum contaminant level.

Nitrate exceeded the 45 mg/L maximum contaminant level in wells 299-W15-15, 299-W15-16, 299-W15-18, 299-W18-21, 299-W18-23, 299-W18-24, and 299-W18-26. With the exception of 299-W18-21, this contamination is related to the recognized nitrate plume in the 200 West Area. The elevated nitrate levels in well 299-W18-21 appear to be isolated from the main body of this nitrate plume. However, this may simply indicate a preferential flow path in this direction.

2.8.1.7 Groundwater Remediation at 200-ZP-1 Operable Unit

The pump-and-treat system for the 200-ZP-1 Operable Unit is successfully containing and capturing the high concentration portion of the carbon tetrachloride plume. Contamination in the groundwater was reduced in the area of highest concentrations through mass removal, and additional information was collected through hydraulic monitoring, contaminant monitoring, and treatment system operation.

Groundwater is pumped and treated in the 200 West Area to prevent carbon tetrachloride contamination from spreading. In fiscal year 1999, 1,290 kilograms of carbon tetrachloride were removed.

Interim Remedial Action Objectives

The pump-and-treat system for the 200-ZP-1 Operable Unit, located north of the Plutonium Finishing Plant, was implemented as an interim action. The interim action objectives (ROD 1995) are the following:

- prevent further movement of contaminants from the highest concentration area of the plume (i.e., containing carbon tetrachloride inside the 2,000 to 3,000 μg/L contour)
- reduce contamination in the area of highest carbon tetrachloride concentrations
- provide information that will lead to development of a final remedy that will be protective of human health and the environment.

The following information is summarized from DOE/RL-99-79. The 200-ZP-1 Operable Unit facilities and Phase III extraction, injection, and monitoring well locations are shown in Figure A.12.

History of Operations

The pump-and-treat operations were implemented in a three-phase approach. Phase I operations, which have been terminated, consisted of a pilot-scale treatability test that ran from August 29, 1994 to July 19, 1996. During that period, contaminated groundwater was removed from a single extraction well, treated

using granular activated carbon, and returned to the aquifer through an injection well. For more detailed information about operations during the treatability test, refer to DOE/RL-95-30.

Phase II operations commenced August 5, 1996 and ended on August 8, 1997 for transition to Phase III operations. The well configuration during Phase II operations consisted of three extraction wells, all completed in the top 15 meters of the aquifer. The groundwater was treated using an air stripper followed by granular activated carbon of the air stream and returned to the aquifer through a single injection well.

From August 8 to 28, 1997, well-field piping and treatment equipment were upgraded for Phase III operations, which were initiated on August 29, 1997. The well configuration was expanded to six extraction wells, in the top 15 meters of the aquifer, and five injection wells. The Phase III treatment system uses air stripping combined with vapor-phase, granular activated carbon technology to remove the volatile organic compounds from the contaminated groundwater.

Contaminant Removal

Carbon tetrachloride contamination in the groundwater was reduced in the area of highest concentrations through mass removal. Approximately 339.9 million liters of contaminated groundwater were treated in fiscal year 1999 at an average flow rate of 707 liters per minute. Production rates for the six extraction wells ranged from 27 to 310 liters per minute. The average influent concentration for the six extraction wells was 3,788 μg/L, ranging from 3,300 to 4,400 μg/L.

Treatment of the contaminated water resulted in the removal of 1,290 kilograms of carbon tetrachloride in fiscal year 1999. Since initiation of pump-and-treat operations in August 1994, ~954.8 million liters of water have been treated, resulting in removal of 3,386 kilograms of carbon tetrachloride. Table 2.8-1 shows the volumes of treated water and the mass of carbon tetrachloride removed by quarter since inception of operations.

The most significant system shutdowns in fiscal year 1999 occurred when sporadic, elevated carbon tetrachloride concentrations (exceeding the 5 μg/L maximum contaminant level) were detected in the water exiting the treatment system. Normally, carbon tetrachloride concentrations are at or below the 2 μg/L detection limit after treatment and before injection. The reason for the increased concentrations was identified as an algae buildup in the air-stripper packing material, which interferes with the air-stripping efficiency. While concentrations of carbon tetrachloride in the effluent tank exceeded the maximum contaminant level of 5 μg/L during those exceptions, concentrations measured at the injection wells were never above the detection limit. It appears that carbon tetrachloride volatilizes from the return water while the water is transported through the pipeline to the injection wells.

To deal with the algae problem, chlorine was injected into the influent tank to reduce the algae content. Since concentrated chlorine (~3,000 mg/L) was injected into the system on May 27, 1999, the carbon tetrachloride concentrations in the effluent tank have been below the maximum contaminant level of 5 μg/L. The system is scheduled for cleaning and replacement of the packing in early fiscal year 2000, which will increase air-stripping efficiency.

The environmental restoration contractor sampled for coliform contamination at extraction well 299-W15-35, located nearest to the Z Plant septic field, and in the treatment influent tank on August 4, 1999. The effluent from the Z Plant septic system was suspected to have been impacting the groundwater in the area of the 200-ZP-1 Operable Unit. Coliform was not detected in these samples.

Technetium-99 was measured in special samples collected in fiscal year 1999. The technetium-99 results ranged from a minimum of 20 pCi/L measured at extraction well 299-W15-37 to 286 pCi/L measured at extraction well 299-W15-32. None of the results exceeded the drinking water standard of 900 pCi/L.

Overall Effectiveness

Carbon tetrachloride concentrations increased at all three of the northern extraction wells, but were stable or decreased slightly in the three southern wells (Figure 2.8-12 and Figure 2.8-13). The greatest average fiscal year 1999 concentrations were measured at the two northernmost extraction wells (299-W15-33 [6,218 μg/L] and 299-W15-34 [4,700 μg/L]) and the lowest average concentrations were observed at the southernmost well (299-W15-37 [358 μg/L]). Table 2.8-2 compares average carbon tetrachloride concentrations at the extraction wells for fiscal year 1997, fiscal year 1998, and fiscal year 1999, the mean flow rate for each extraction well, and the relative concentration changes.

There were no significant changes in chloroform and trichloroethylene concentrations in the extraction wells for fiscal year 1999 when compared to fiscal year 1998 concentrations. Chloroform concentrations ranged from 17 to 38 μg/L, while trichloroethylene concentrations ranged from 5 to 16 μg/L.

As discussed above, the influent tank concentrations of carbon tetrachloride increased to an average of 3,788 μg/L. The hydraulic gradient created by the extraction wells is moving significant quantities of dissolved organic mass from the high concentration area of the plume to the extraction wells. Figure 2.8-14 shows the detail of the fiscal year 1999 carbon tetrachloride plume map in the area of the remediation system, and Figure 2.8-15 shows the June 1996 baseline plume map.

Several conclusions can be drawn from changes in the carbon tetrachloride plume maps (refer to DOE/RL-99-79 for additional details and discussion).

- The plume center (greater than 3,000 μg/L) is moving primarily in a northerly and easterly direction toward the four northernmost extraction wells.
- The concentrations of carbon tetrachloride east of the pumping wells may be decreasing indicated by a decrease in concentrations in monitoring well 299-W14-9, from ~100 μg/L in mid-1997 to ~20 μg/L at the end of fiscal year 1999.
- The area of the 4,000 μg/L contour has apparently increased in size, noted by comparing the fiscal year 1999 plume map with the June 1996 baseline plume map. Spreading of the 4,000 μg/L contour is attributed to the effects of pumping.
- Concentrations of carbon tetrachloride south and east of injection well 299-W15-29 are decreasing, as demonstrated by the indentation in the 1,000 μg/L contour on Figure 2.8-14. This implies that injection of the treated water is displacing the plume to the east.

Water-Level Impact and Capture-Zone Analysis

General groundwater flow in the vicinity of the extraction wells is still east-northeast in this area (Figure 2.8-16). Water levels are estimated to be declining in this area at a rate of about 0.47 meter per year (DOE/RL-99-79).

The entire high concentration area of the plume (greater than 2,000 μg/L) was contained hydraulically in fiscal year 1999 (DOE/RL-99-79). Based on numerical modeling results, the radius of influence of the pumping wells across the high concentration area extends over 124 meters from extraction well 299-W15-33 (Figure 2.8-17).

2.8.2 T Plant

T Plant operated from 1944 through 1953 to separate plutonium contaminated fuel using the bismuth phosphate process. It was subsequently converted to an equipment decontamination facility. Chlorinated hydrocarbons (carbon tetrachloride and trichloroethylene), iodine-129, nitrate, and tritium form the most extensive contaminant plumes in the vicinity of T Plant. The majority of the chlorinated hydrocarbon contamination appears to originate in the vicinity of the Plutonium Finishing Plant, though there may be a contribution from T Plant facilities. Nitrate contamination appears to originate from both T Plant and Plutonium Finishing Plant facilities. Technetium-99 contamination at levels above drinking water standards is not as extensive but high levels are found near Waste

Monitoring Objectives Near T Plant

Groundwater monitoring is conducted near T Plant:

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

Management Area T and Waste Management Area TX-TY. In addition, minor uranium, chromium, and fluoride contamination is found near T Plant.

Waste Management Areas T and TX-TY are monitored as RCRA treatment, storage and disposal facilities. They were both monitored according to interim status assessment requirements in fiscal year 1999. The status of the assessment monitoring is discussed in Sections 2.8.2.11 and 2.8.2.12. Low-Level Waste Management Area 3 was monitored under RCRA interim status detection requirements and is discussed in Section 2.8.2.13.

2.8.2.1 Groundwater Flow

Groundwater flow in the northern portion of the 200 West Area is predominantly to the east-northeast, with the flow direction more to the east in the area immediately around and to the east of T Plant (see Plate 2). In the past, the flow direction in this part of the 200 West Area was strongly influenced by liquid waste disposal practices at other facilities in 200 West Area. As little as 5 years ago, the flow direction was mainly north-northeast. As the influence of past liquid disposal practices continues to decline, groundwater flow is expected to approach pre-Hanford conditions and become primarily eastward. Pump-and-treat operations at the 200-ZP-1 Operable Unit are impacting flow directions in the southern part of this area.

Sections 2.8.2.11, 2.8.2.12, and 2.8.2.13 on RCRA monitoring contain additional discussion of groundwater flow.

2.8.2.2 Tritium

A tritium plume lies beneath much of the northern half of the 200 West Area and extends to the northeast (see Plate 3). The plume geometry suggests the major tritium source is near the TY Tank Farm, the 242-T evaporator, and associated disposal cribs. Tritium concentrations remain extremely high in the area immediately east of the TY Tank Farm. In June 1998, tritium concentration suddenly increased to 3.21 million pCi/L in well 299-W14-2, adjacent to the 216-T-28 crib. In fiscal year 1999, concentrations in this well dropped, but concentrations increased in nearby wells 299-W14-12 and its replacement well 299-W14-13 (Figure 2.8-18). The August sample from well 299-W14-13 contained the maximum concentration detected in fiscal year 1999, 2 million pCi/L, which is equal to the derived concentration guide. The hydraulic gradient in this vicinity is very flat due to the interaction of the regional gradient and the influence of the 200-ZP-1 Operable Unit pump-and-treat system. Condensate from the 242-T evaporator is a likely source of this contamination; however, the cause for the sudden increase is unknown.

Waste sites associated with T Plant have contaminated groundwater with high concentrations of tritium. The contaminant is associated with iodine-129 and technetium-99.

In an area north of Waste Management Area T, tritium is consistently found at levels much lower than the surroundings, which may be related to past discharge of relatively clean water to the 216-T-4-2 ditch (WHC-EP-0815). Discharge of water to the 216-T-4-2 ditch ceased in 1995, followed by an increase in tritium concentrations in nearby wells.

2.8.2.3 Iodine-129

The extent of iodine-129 above the interim drinking water standard near T Plant (Figure 2.8-19) coincides generally with the technetium-99 and tritium (see Plate 3) plumes. The interpretation of iodine-129 results is somewhat complicated by analytical difficulties at the primary laboratory that affected numerous higher concentration values. The analytical issues are being addressed in discussions with the laboratory. High concentrations of iodine-129 were measured in well 299-W14-2 with a maximum concentration of 47.4 pCi/L for data that are not associated with analytical problems (annual average from this well was 32 pCi/L). Concentrations from this well appeared to decline during the course of the year.

2.8.2.4 Technetium-99

A technetium-99 plume is present in the T Plant area (Figure 2.8-20), but the concentrations are less than the drinking water standard in most of the area. The two areas with technetium-99 greater than the drinking water standard are near the northeastern corner of Waste Management Area T and in the Waste Management Area TX-TY. The RCRA assessment concluded that Waste Management Area T and TX-TY were probably the sources of at least some of this technetium-99 (PNNL-11809). Further details on the technetium-99 contamination are discussed with the tank farm assessment summaries in Sections 2.8.2.11 and 2.8.2.12.

2.8.2.5 Uranium and Gross Alpha

Few analyses for uranium were performed in the vicinity of T Plant in fiscal year 1999 because most wells showed insignificant levels in previous monitoring. Wells monitored near the single-shell tank farms for RCRA compliance are sampled for gross alpha measurements, which would show an increase if uranium contamination appeared. Because uranium is typically the source of most elevated gross alpha measurements seen at the Hanford Site, it is discussed in this section. Uranium was detected above the proposed maximum contaminant level in only one well in the T Plant area. Well 299-W11-14 contained 49.7 μg/L of uranium in the single sample taken in fiscal year 1999. The value continues the slow decline seen for the past several years. This well is located immediately northwest of T Plant, and the source of the uranium has not been determined.

Elevated levels of gross alpha concentration were noted in well 299-W11-27, north of the T Tank Farm prior to its going dry. Although a gross alpha concentration of 90 pCi/L was detected in 299-W11-27 in March, it was not detected in the replacement well 299-W10-24 in March or in samples collected later. Thus, the elevated gross alpha levels in 299-W11-27 are suspected to be related to high turbidity and particulate matter in the samples. High turbidity is often encountered in wells that are nearly dry because the water must be collected near the bottom of the well, and the well often cannot be purged sufficiently to remove the particulate matter. In these cases, the concentrations of contaminants such as uranium, which may be found within or sorbed to particulates, are not representative of aquifer conditions.

2.8.2.6 Nitrate

Nitrate continued to be present in groundwater at concentrations in excess of the 45 mg/L maximum contaminant level beneath much of the northern part of 200 West Area (see Figure 2.8-10). The maximum concentration in this vicinity in fiscal year 1999 was 823 mg/L in well 299-W10-4. Concentrations of nitrate in this well have been rising since 1997. The nitrate contamination is more widespread than the iodine-129, technetium-99, or tritium plumes discussed previously. It is probable that there are multiple sources of nitrate in this area, including disposal facilities near the Plutonium Finishing Plant.

2.8.2.7 Chromium

Chromium at levels above the 100 μg/L maximum contaminant level in filtered samples is restricted to the immediate vicinity of Waste Management Area T and TX-TY (Figure 2.8-21). The maximum average annual concentration detected in fiscal year 1999 was

294 μg/L in well 299-W14-13, east of Waste Management Area TX-TY, where concentrations have been generally increasing.

A small chromium plume has been identified in the vicinity of T Tank Farm. The source for this persistent plume has not been identified. Chromium is of interest because it has been identified in tank waste and may help form a signature of mobile tank waste components. A recent increase in chromium to levels above the maximum contaminant level near Waste Management Area TX-TY is discussed in more detail in Section 2.8.2.12.

2.8.2.8 Fluoride

Fluoride was detected above the 4-mg/L maximum contaminant level near the T Plant waste disposal facilities. The fluoride contamination was found in a number of wells in the vicinity of Waste Management Area T, with annual average measurements in wells 299-W10-4 (4.6 mg/L) and 299-W10-12 (4.1 mg/L) greater than the maximum contaminant level. Fluoride may be associated with tank waste.

2.8.2.9 Chlorinated Hydrocarbons

Although the bulk of the carbon tetrachloride plume in the 200 West Area is known to have originated from liquid waste disposal facilities in the vicinity of the Plutonium Finishing Plant, a second source may exist in the vicinity of T Plant. According to WHC-SD-EN-TI-248, the source could be carbon tetrachloride that was dissolved in the 242-T evaporator overhead and discharged from 1973 to 1976 to the 216-T-19 crib. The carbon tetrachloride distribution in the 200 West Area is shown in Figure 2.8-1. Carbon tetrachloride concentrations in the vicinity of T Plant are highly variable. Of particular interest are relatively low carbon tetrachloride concentrations (less than 500 μg/L but still above the 5-μg/L maximum contaminant level) in the vicinity of the southeastern corner of Waste Management Area TX-TY. This area is within the hydraulic influence of the 200-ZP-1 Operable Unit pump-and-treat system discussed previously. Although data are sparse, there appears to be a generally low carbon tetrachloride concentration area in the east-central part of the 200 West Area.

Trichloroethylene is also found at levels above the maximum contaminant level in the vicinity of T Plant but at levels considerably lower than carbon tetrachloride. The area of trichloroethylene greater than the maximum contaminant level extends from the Plutonium Finishing Plant northeast through the T Plant vicinity (see Figure 2.8-9).

2.8.2.10 Iron, Manganese, and Nitrite

Wells 299-W11-24 and 299-W11-28, located to the east of Waste Management Area T, have had reported high values of iron and manganese in filtered samples. Iron jumped suddenly to a maximum of 9,500 μg/L in well 299-W11-24 in fiscal year 1999 but increased slowly to a fiscal year 1999 maximum of 394 μg/L in well 299-W11-28. Manganese in well 299-W11-24 reached a fiscal year 1999 maximum level of 1,380 μg/L, while the fiscal year maximum value for well 299-W11-28 was 209 μg/L. The manganese trends closely follow those of iron. Elevated nitrite has also been detected at levels (expressed as μg/L NO_2^-) up to 1,862 μg/L in well 299-W11-24 and 295 μg/L in well 299-W11-28 for fiscal year 1999 but does not follow the same trend as the iron and manganese. The high nitrite, iron, and manganese are indicative of reducing conditions; however, the cause of the reducing conditions is unknown.

2.8.2.11 Waste Management Area T RCRA Assessment Summary

Waste Management Area T, located in the north-central portion of the 200 Area, consists of the T Tank Farm and ancillary equipment (e.g., diversion boxes). Constructed between 1943 and 1944, the tank farm contains twelve 2-million-liter tanks and four 208,000-liter tanks. The tanks began receiving waste in 1944, initially receiving principally waste from the bismuth phosphate process. During early operations, tank waste was cascaded through sets of three tanks and overflow from the third tank was discharged to the ground in

cribs and tile fields to the west of the waste management area. Seven of the tanks in the waste management area are known or suspected to have leaked.

This site continued to be monitored under an assessment program in fiscal year 1999. The well and analyte lists for this unit are given in Appendix A.

Groundwater Flow

Groundwater flow directions at Waste Management Area T have been highly variable over the life of the facility because of changing effluent discharge patterns within the 200 West Area. The flow direction when the RCRA monitoring network was established was toward the northeast. The present flow direction is generally toward the east as indicated by the large scale water-table map (see Plate 2). However, locally flow directions may diverge from the regional pattern because variable cementation within the Ringold aquifer may result in preferred groundwater flow paths. The pre-Hanford flow direction in the vicinity of Waste Management Area T is believed to have been from west to east, and it was expected that groundwater flow in this area would eventually move to that direction. However, the change has happened fairly rapidly over the past several years and may have been accelerated by operation of the 200-ZP-1 Operable Unit pump-and-treat system less than 1 kilometer to the south.

RCRA Waste Management Area T contains single-shell tank farms that may have contaminated groundwater with technetium-99 and nitrate. Two new wells were drilled in 1999, but more wells are needed to replace those that are going dry.

Groundwater Contamination

Technetium-99 concentrations began increasing in downgradient well 299-W11-27 in late 1995 and early 1996, soon after effluent discharges to ground stopped in the 200 West Area (Figure 2.8-22). The concentration of technetium-99 peaked at 21,700 pCi/L in February 1997. Technetium-99 subsequently decreased to a low of 6,000 pCi/L when the last sample was taken in March 1999 as water levels dropped in the well. Technetium-99 in replacement well 299-W10-24, drilled immediately adjacent 299-W11-27, has ranged between 1,960 and 3,660 pCi/L with little apparent trend. This may be because of the longer interval open below the water table in the replacement well or residual effects of well drilling and development. The sampling pump in 299-W10-24 is set at a depth of ~4.6 meters below the water table.

Technetium-99 concentrations in well 299-W11-23 started to increase in November 1997, reaching a high of 8,540 pCi/L in November 1998. Technetium-99 subsequently dropped to 2,755 pCi/L in March 1999 before springing back to 7,110 pCi/L in August 1999. The detection in 299-W11-23 is apparently a result of the change in groundwater flow direction from northeast to east. Apparently, the plume, stretching northeast from 299-W11-27, is moving eastward across 299-W11-23. The location and concentrations of the plume inside the waste management area that initially impacted 299-W11-27 are unknown at this time.

Nitrate concentration trends in well 299-W11-27 and its replacement 299-W10-24 are shown in Figure 2.8-23. The recent increase in nitrate concentration in well 299-W11-27 is strongly correlated with the technetium-99 trend (compare to Figure 2.8-22), but this correlation does not carry through to the replacement well 299-W10-24. The concentration of nitrate in well 299-W10-24 is much higher than that in 299-W11-27 whereas the technetium-99 is lower. This suggests that the pulse in nitrate and technetium-99 in well 299-W11-27 is a feature of the very top of the aquifer. However, the highest nitrate concentrations are somewhat deeper, with a different source. Given the widespread nature of the nitrate plume, much of the nitrate appears to be from liquid waste disposal facilities, but the nitrate/technetium-99 association may represent shallow release from T Tank Farm operations.

Chromium concentrations in well 299-W11-27 exhibited a peak in fiscal year 1996, earlier than the peak in technetium-99. The chromium in replacement well 299-W10-24 is higher than currently found in well 299-W11-27, indicating the chromium may not be associated with the technetium-99 source since the technetium-99 was higher in well 299-W11-27.

Monitoring Network

The original RCRA monitoring network for Waste Management Area T, completed in 1992, consisted of one upgradient and three downgradient wells. Three of these wells have subsequently gone dry, as a result of the falling water table in the area, and the fourth will be dry soon. In addition, a change in groundwater flow direction has resulted in gaps in the downgradient coverage. Existing, pre-RCRA wells were used to the extent possible to meet the needs resulting from a declining water table and changing groundwater flow directions; however, new wells are needed to meet both the needs of downgradient monitoring and for tracking the known contaminant plume.

Two new RCRA compliant monitoring wells were drilled in fiscal year 1999 to replace existing groundwater monitoring wells and to fill gaps in the downgradient network resulting from changes in groundwater flow directions (PNNL-12125). Well 299-W10-23 was drilled as a replacement for well 299-W10-15 and 299-W10-24 was drilled as a replacement for well 299-W11-27; both were completed with 10.7-meter screened intervals to allow for future declines in water-table elevation. In addition, 299-W10-24 was drilled to a depth below the Ringold lower mud unit before being backfilled and completed as a monitoring well at the top of the aquifer.

Well 299-W10-24 was drilled to an initial depth of 131.8 meters, ending below the lower mud, a confining unit within the lower Ringold Formation but above the top of the basalt. During drilling discrete level groundwater samples were taken at depths of 87.5, 99.1, 116.7, 122.5, and 131.4 meters. The discrete sampling detected significant levels of carbon tetrachloride, nitrate, technetium-99, and tritium throughout the thickness of the aquifer (Table 2.8-3), including beneath the lower mud, which is generally considered to be a confining layer and the bottom of the unconfined aquifer. Technetium-99 generally decreases downward through the aquifer; however, carbon tetrachloride reaches a maximum concentration of 1,600 µg/L at a depth of 99.1 meters, and nitrate and tritium peak at a depth of 87.5 meters.

2.8.2.12 Waste Management Area TX-TY RCRA Assessment Summary

Waste Management Area TX-TY continued to be monitored under an assessment program in fiscal year 1999. The well and analyte lists for this area are given in Appendix A.

Groundwater Flow

Groundwater flow directions at Waste Management Area TX-TY have been highly variable over the life of the facility because of changing effluent discharge patterns within the 200 West Area. The flow direction when the RCRA monitoring network was established was toward the northeast. The pre-Hanford flow direction in the vicinity of Waste Management Area TX-TY is believed to have been from west to east, and it was expected that groundwater flow in this area would eventually move to that direction. However, groundwater flow directions have changed fairly rapidly over the past several years as a result of the 200-ZP-1 Operable Unit pump-and-treat operation located immediately to the south of the waste management area. The current flow direction is generally toward the east in the northern part of the waste management area, toward the southeast in the central part

RCRA Waste Management Area TX-TY contains single-shell tank farms that may have contaminated groundwater with technetium-99 and nitrate. Four new wells were drilled in 1999 to replace those that have gone dry.

of the waste management area, and toward the south in the southern part of the waste management area (see Plate 2). However, locally flow directions may diverge from the regional pattern because variable cementation within the Ringold aquifer may result in preferred groundwater flow paths.

Groundwater Contamination

Contaminant levels (chromium, cobalt-60, iodine-129, nitrate, technetium-99, and tritium) were elevated in well 299-W14-12 when first sampled in 1992 and remained high for several years. Technetium-99 had a high value of 13,300 pCi/L in November 1992 (Figure 2.8-24). Contaminant concentrations dropped sharply, along with falling water levels in 1995 to 1996 and remained at relatively low levels during 1997 to 1998. In late 1998 contaminant levels began to increase and continued that trend until the last sampling of the well in January 1999. Concentrations in replacement well 299-W14-13 appear lower but also exhibit an upward trend reaching a maximum of 5,130 pCi/L in August 1999 (see Figure 2.8-24).

High chromium concentrations were also found several years ago in well 299-W14-12, east of Waste Management Area TX-TY. Concentrations have been lower for several years (Figure 2.8-25). Well 299-W14-12 has gone dry and replacement well 299-W14-13 exhibits increasingly higher concentrations of filtered chromium, ranging from 180 to 433 μg/L in fiscal year 1999.

The groundwater flow direction in the vicinity of 299-W14-12 was toward the northeast when monitoring was initiated. Flow is currently toward the southeast. Thus, it seems likely that 299-W14-13 intersects a plume that is distinct from the plume first sampled by 299-W14-12. The location and extent of the earlier plume is uncertain because of the lack of monitoring wells to the east of the line of compliance at Waste Management Area TX-TY.

Technetium-99 levels have increased in well 299-W15-4 since the initiation of the 200-ZP-1 Operable Unit pump-and-treat operations (see Section 2.8.1) south of the waste management area (Figure 2.8-26). Concentrations exceeded the drinking water standard of 900 pCi/L in July 1999, though the most recent sample in October 1999 was below the drinking water standard. Well 299-W15-4, originally constructed to monitor the 216-T-19 crib, is directly south of the waste management area in a direct flow path between the waste management area and the nearest extraction well. It is possible that the waste management area is the source of the technetium-99 observed in 299-W15-4. This small increase is important for evaluating the impact of the pump-and-treat remediation on contaminants in the T Plant area and for potential future impact of increasing technetium-99 on the operation of the pump-and-treat system. Technetium-99 in well 299-W15-22, located in the southwestern corner of Waste Management Area TX-TY was increasing in fiscal year 1998 to an average activity of 3,100 pCi/L. However, this well could not be sampled because of declining water levels and has not yet been replaced. This suggests that the remediation may have a larger impact on the plume geometry than can be detected by the current monitoring network. Technetium-99 reached a concentration of 286 pCi/L in northern extraction well 299-W15-32 in fiscal year 1999 (see Section 2.8.1.7).

Monitoring Network

The original RCRA monitoring network for Waste Management Area TX-TY, completed in 1992, consisted of one upgradient and three downgradient wells. Three of these wells have subsequently gone dry, as a result of the falling water table in the area, and the fourth will be dry soon. In addition, a change in groundwater flow direction has resulted in gaps in the downgradient coverage. Existing, pre-RCRA wells were used to the extent possible to meet the needs resulting from a declining water table and changing groundwater flow directions; however, new wells are needed to meet both the needs of downgradient monitoring and for tracking of the known contaminant plume.

Four new RCRA compliant monitoring wells were drilled in fiscal year 1999 to replace existing groundwater monitoring wells. The new wells fill gaps in the downgradient network resulting from changes in groundwater flow directions. Well 299-W10-26 was drilled as a replacement for downgradient monitoring well 299-W10-18 and 299-W14-13 was drilled as a replacement for downgradient monitoring well 299-W14-12. Well 299-W14-14 was drilled along the southeastern boundary of the waste management area to provide monitoring coverage resulting from changes in groundwater flow direction. Well 299-W15-40 was drilled both as a replacement for upgradient monitoring well 299-W15-22 and to monitor the 241-T-25 trench, which was considered a potential source for contaminants detected in well 299-W14-12. All four wells were completed with 10.7-meter screened intervals to allow for future declines in water-table elevation. In addition, 299-W14-14 was drilled to a depth of 135 meters before being completed as a top-of-the-water-table monitoring well.

Well 299-W14-14 was drilled to an initial depth of 135 meters, ending below the lower mud, a confining unit within the lower Ringold Formation, but above the top of the basalt. During drilling, discrete level groundwater samples were taken at depths of 14.5, 30.1, 39.8, 56.9, and 68.5 meters below the water table. The discrete sampling detected significant levels of carbon tetrachloride, nitrate, technetium-99, and tritium, throughout the thickness of the aquifer (Table 2.8-4), including beneath the lower mud, which is generally considered to be a confining layer, and the bottom of the unconfined aquifer. Technetium-99 generally decreases downward through the aquifer; however, it does seem to peak at a depth of 14.5 meters. Carbon tetrachloride reaches a maximum concentration of 920 μg/L at a depth of 39.8 meters.

2.8.2.13 Low-Level Waste Management Area 3 RCRA Parameters

This site continued to be monitored under a detection program in fiscal year 1999. Concentrations of the indicator parameters, pH, specific conductance, total organic carbon, and total organic halogen, in downgradient wells did not exceed levels in upgradient wells during this reporting period. There are no indications that Low-Level Waste Management Area 3 has contributed to groundwater contamination. Wells and analytes monitored at this site are listed in Appendix A.

RCRA monitoring at Low-Level Waste Management Area 3 indicates no groundwater contamination from this facility.

The maximum contaminant level for carbon tetrachloride and nitrate are consistently exceeded at Low-Level Waste Management Area 3. These constituents are not related to the disposal of waste in this facility. They are attributed to contaminant plumes originating to the south of Low-Level Waste Management Area 3. Trichloroethylene continues to exceed the 5 μg/L maximum contaminant level in well 299-W10-21.

Groundwater flow beneath Low-Level Waste Management Area 3 is generally to the northeast trending more to the east-northeast under the 218-W-3AE burial ground. The flow direction in this area has been influenced by past liquid disposal practices in other portions of the 200 West Area. As these influences continue to decline, the flow direction is expected to return to the pre-Hanford conditions, with groundwater flowing from west to east.

2.8.3 U Plant

U Plant was built for plutonium recovery using the bismuth phosphate process but was never used for that purpose. It was used for recovery of uranium from bismuth phosphate process waste from 1952 until approximately 1962.

A groundwater contaminant plume, containing iodine-129, nitrate, technetium-99, and uranium, originates from U Plant disposal facilities and extends beyond the 200 West Area fence line to the east. The

216-U-1 and 216-U-2 cribs are the major sources of the plume. Waste from these cribs is believed to have been remobilized by disposal to the 216-U-16 crib (WHC-EP-0133). Additional sources of contaminants include the 216-U-17, 216-U-8, and 216-U-12 cribs.

Monitoring Objectives Near U Plant

Groundwater monitoring is conducted near U Plant:

- triennially to annually to describe the nature and extent of contamination
- quarterly to detect the possible impact of one RCRA waste management area
- quarterly to monitor trends in contaminants from one RCRA site
- various time intervals to evaluate the performance of a pump-and-treat system for technetium-99 and uranium.

Interim action groundwater pump-and-treat remediation is taking place in the vicinity of U Plant. Because of the effects of remediation and past injection of treated water into the aquifer, the plume maps in this report are somewhat generalized in the area of system influence. This section discusses the contamination from the facilities in the vicinity of U Plant and includes the contamination being remediated in accordance with CERCLA and the specific reporting requirements for RCRA monitoring at the 216-U-12 crib and Waste Management Area U single-shell tank farm.

2.8.3.1 Groundwater Flow

Groundwater flow in the vicinity of U Plant in the 200 West Area is primarily to the east (see Plate 2). Water levels in this portion of the 200 West Area are higher than the pre-Hanford conditions, but the flow direction has been relatively unchanged over the last 10 or more years. This is because the facilities which were the main contributors to the elevated water levels are to the west of U Plant.

Details of groundwater flow at RCRA sites are discussed in Sections 2.8.3.6 and 2.8.3.7. Details of the effects of groundwater remediation are discussed in Section 2.8.3.8.

2.8.3.2 Uranium

The highest concentrations of uranium in Hanford Site groundwater in fiscal year 1999 were detected near U Plant in wells downgradient from the 216-U-1 and 216-U-2 cribs and adjacent to the 216-U-17 crib (Figure 2.8-27). Uranium concentrations in wells near the 216-U-1 and 216-U-2 cribs showed a large pulse of uranium in 1986. Trends in uranium concentrations in well 299-W19-3, immediately downgradient from the cribs, are shown in Figure 2.8-28. The uranium levels in this well decreased considerably since the maximum measured in 1986 but have increased again in recent years. Levels in fiscal year 1999 reached 1,990 μg/L. Technetium-99 concentrations, however, have not shown the recent increase. This suggests that the cribs are not currently providing an ongoing source of technetium-99 from the vadose zone. The uranium behavior is different than technetium-99 because of its stronger sorption to the sediment and a greater proportion of the uranium remains at or near the source area.

Groundwater beneath U Plant waste facilities had the highest concentrations of uranium on the Hanford Site in fiscal year 1999. Levels increased in some wells this year, but have declined from their peak in 1986.

The maximum annual average uranium concentration detected near U Plant in fiscal year 1999 was 2,600 μg/L in well 299-W19-20, located near the pump-and-treat extraction well (see Figure 2.8-27). The uranium concentrations for several wells in the U Plant vicinity represent dose values greater than the derived concentration guide dose level. Assuming natural isotopic abundance, a uranium concentration

of 790 µg/L represents the 100-mrem/yr dose equivalent for ingestion of drinking water.

The uranium distribution in the vicinity of the 216-U-17 crib has been affected by pump-and-treat remediation (discussed in Section 2.8.3.8). The remediation system impacted the direction of groundwater flow, both through the pumping and the past injection of treated groundwater upgradient of the pumping well. Because injection ceased in March 1997, its effect on the uranium distribution is decreasing. As expected, uranium concentrations decreased downgradient of the injection well and increased near the pumping well as the plume is drawn toward the pumping well. In fiscal year 1999, however, high concentrations of uranium were detected near the former injection well. This suggests that uranium contamination is moving into the area from upgradient but may also be rebounding from termination of the injection.

2.8.3.3 Technetium-99

Technetium-99 typically followed uranium throughout much of the fuel cycle. Thus, a sizable technetium-99 plume is associated with the 216-U-1, 216-U-2, and 216-U-17 cribs in essentially the same location as the uranium plume. The distribution of technetium-99 in this vicinity is complex, in part because of the operation of the pump-and-treat remediation system that reinjected treated water until March 1997. The maximum annual average technetium-99 concentration associated with this plume in fiscal year 1999 was 25,300 pCi/L, found in well 299-W19-29. This well is located downgradient of the former injection well, and for several years prior to fiscal year 1999, the technetium-99 reflected the low concentrations in the injected water (Figure 2.8-29). The technetium-99 levels are currently higher than they were prior to the start of the remediation. However, technetium-99 concentrations in most wells in the central part of the plume have declined during the period of pump-and-treat operations. Technetium-99 concentrations also declined in downgradient well 699-38-70 (Figure 2.8-30).

Technetium-99 remains slightly elevated in wells downgradient of Waste Management Area U, as compared to upgradient wells. However, levels are below the drinking water standard. The concentrations in most downgradient wells declined to values between 200 and 300 pCi/L. In new well 299-W19-41, however, concentrations of technetium-99 increased from 323 to 638 pCi/L during the course of the year.

The distribution of technetium-99 is similar to uranium in the U Plant area. Nitrate is also present, but is more widespread.

2.8.3.4 Nitrate

Near U Plant, nitrate contamination at levels greater than the maximum contaminant level is considerably more widespread than technetium-99 or uranium (Figure 2.8-31). This reflects the multiple sources of nitrate in the area. In particular, the 216-U-12 crib contributed to nitrate at levels slightly above the maximum contaminant level.

Nitrate concentrations in the vicinity of the 216-U-17 crib are among the highest on the Hanford Site but are not typically monitored because nitrate is not a performance indicator for the pump-and-treat system. In fiscal year 1998, a concentration of 1,700 mg/L nitrate was detected in well 299-W19-26. This well was not sampled for nitrate in fiscal year 1999. The nitrate source is believed to be past disposal to the 216-U-1 and 216-U-2 cribs, the same as the technetium-99 and uranium source.

2.8.3.5 Iodine-129

Iodine-129 was found above the interim drinking water standard in the immediate vicinity of the 216-U-1 and 216-U-2 cribs (Figure 2.8-32). Several of the wells that previously contained iodine-129 at levels above the drinking water standard were not sampled in fiscal year 1999. Downgradient, the iodine-129 plumes from U Plant operations merge with, and

become indistinguishable from, the REDOX Plant plume (see Section 2.8.4.2).

2.8.3.6 216-U-12 Crib RCRA Assessment Summary

RCRA groundwater monitoring continued in an assessment program in fiscal year 1999. The results and findings of the assessment monitoring program are presented in PNNL-11574. The elevated levels of specific conductance in the downgradient wells are attributed to calcium and nitrate. Technetium-99 has been detected in downgradient monitoring wells since monitoring began, indicating that the crib was the source. These findings indicated that the crib contributed to groundwater contamination and must remain in interim status assessment monitoring. The objective of the assessment monitoring is to evaluate the flux of constituents into the groundwater beneath the crib and monitor the known constituents until a corrective action is defined or final status monitoring plan is implemented for the crib.

The 216-U-12 crib is a RCRA site that may have contaminated groundwater with nitrate. New wells are needed to replace those that are going dry.

Declining water levels in the 200 West Area reduced the monitoring network from the original five wells to just three wells (one upgradient and two downgradient). This included one new well that was installed in September 1998. While the wells are sampled quarterly for the constituents of interest (see Table A.17) only two downgradient wells remain active, 299-W22-79 and 699-36-70A (see Figure A.8 and Plate 1). Washington State Department of Ecology (Ecology) and U.S. Department of Energy (DOE) agreed in the form of a Tri-Party Agreement interim milestone M-24-00J that new wells would not be added during calendar year 1999. However, two replacement wells, one upgradient and one downgradient, may be installed in calendar year 2000.

New well 299-W22-79 was sampled for the first time in the first quarter of fiscal year 1999. The well is located approximately halfway between downgradient wells 299-W22-41 and 299-W22-42, both of which went dry and were last sampled in March 1999. Well 299-W22-79 was installed to replace 299-W22-42. Well 299-W22-40 was removed from the network in the first quarter of 1999 after it went dry. Well 299-W22-40 will not be replaced because it was not located directly downgradient of the crib, and no contaminants were detected in the well.

Based on regional groundwater elevations, the groundwater flow direction continues east-southeast to easterly. New wells will be located appropriately to maximize the downgradient coverage of the 216-U-12 crib.

Groundwater flow rates have not changed significantly since last year and are presented in Table A.2.

Site-specific parameters selected for the interim status quality assessment monitoring include gross alpha, gross beta, iodine-129, nitrate, technetium-99, and tritium (see Table A.17). The crib is the source of elevated nitrate and technetium-99 that were detected in downgradient wells 299-W22-41, 299-W22-42, 299-W22-79, and 699-36-70A.

The nitrate and technetium-99 plumes are a series of smaller plumes with sources from several cribs (216-U-1, 216-U-2, 216-U-8, and 216-U-12) in the U Plant area. Iodine-129 and tritium were detected repeatedly in several 216-U-12 crib downgradient monitoring wells, but the sources appear to be the REDOX Plant effluent disposal cribs that are upgradient of the 216-U-12 crib. These plumes are discussed further in Section 2.8.4.

Nitrate continued to be detected at levels greater than the 45 mg/L maximum contaminant level in all the downgradient wells. However, the concentration trend in the nitrate has been downward (Figure 2.8-33). Technetium-99 followed a trend similar to nitrate. Technetium-99 activities ranged from 21.2 to 103 pCi/L in downgradient wells, well below the 900 pCi/L

drinking water standard (Figure 2.8-34). Technetium-99 concentration trends are declining in wells near the crib and increasing farther downgradient in well 699-36-70A. This suggests that the plume is moving downgradient farther east, away from the crib.

During fiscal year 1999, the center of the tritium plume appears to have moved farther east, away from the crib. Tritium concentrations remained above the 20,000-pCi/L interim drinking water standard in downgradient wells 299-W22-42, 299-W22-79, and 699-36-70A during fiscal year 1999. The most recent concentrations are 21,600 and 83,300 pCi/L reported in wells 299-W22-79 and 699-36-70A, respectively.

Iodine-129 is elevated above the 1 pCi/L drinking water standard in wells 299-W22-42, 299-W22-79, and 699-36-70A. Iodine-129 in these wells is 7.64, 2.58, and 15.2 pCi/L, respectively. The iodine-129 source is upgradient of the 216-U-12 crib.

2.8.3.7 Waste Management Area U RCRA Parameters

This waste management area has remained in detection level monitoring since RCRA interim status monitoring began in 1989. Total organic halides exceeded the critical mean value but have an upgradient source. Recalculation of the critical mean for specific conductance (Appendix A) lowered the value from 533 µS/cm to 273 µS/cm. The August 1999 specific conductance for downgradient well 299-W19-41 exceeded this new critical mean. DOE notified Ecology of this exceedance and an assessment plan is being prepared.

Groundwater flow directions at Waste Management Area U have been highly variable over the life of the facility because of changing effluent discharge patterns within the 200 West Area. The flow direction, when the RCRA monitoring network was established, was toward the northeast. Prior to establishment of the Hanford Site, groundwater in the vicinity of Waste Management Area U is believed to have flowed from west to east, and it was expected that groundwater flow in this area would eventually move to that direction. However, groundwater flow directions have been altered over the past several years as a result of the 200-ZP-1 Operable Unit pump-and-treat operation located immediately to the north of the waste management area. The present flow direction is generally toward the east in most of the waste management area but has a northeasterly component in the northern part of the waste management area (see Plate 2). This northeasterly component is a result extraction well 299-W15-37. The waste management area is outside of the capture zone of this well, but near enough to experience deflection of groundwater flow trajectories. Locally flow directions may diverge from the regional pattern because variable cementation within the Ringold aquifer may result in preferred groundwater flow paths.

Waste Management Area U contains single-shell tanks and is a RCRA site. Specific conductance exceeded its critical mean value in one well in August 1999.

Total organic halides have exceeded the comparison value in a number of samples at Waste Management Area U because of the carbon tetrachloride plume originating at cribs associated with the Plutonium Finishing Plant. Large effluent discharges to the 216-U-14 ditch in the early 1990s, coupled with changes in groundwater flow patterns caused by the 200-ZP-1 pump-and-treat operation, have resulted in concentrations in downgradient wells exceeding the comparison value calculated from the upgradient well. Carbon tetrachloride is not a significant tank component, and the total organic halides exceedances are not related to the waste management area.

Technetium-99 is consistently present in downgradient wells at levels less that the drinking water standard of 900 pCi/L. A number of instances where gross beta values exceed the maximum contaminant level are a result of technetium-99.

The original RCRA groundwater monitoring network established at Waste Management Area U consisted of two upgradient and three downgradient wells (see Table A.13). One pre-RCRA well (299-W19-12) is used for indication only to fill a gap between RCRA wells 299-W19-41 and 299-W19-42. Three of the RCRA wells were constructed with 4.6-meter screened intervals and two with 10.7-meter screened intervals. Two of the three wells with the shorter screened intervals have gone dry and the third will not be able to be used within a year. The two that have gone dry have been replaced with new wells.

Well 299-W19-41 was constructed to replace downgradient well 299-W19-32 and well 299-W19-42 was constructed to replace downgradient well 299-W19-31. Both wells were constructed with 10.7-meter screened intervals to allow for future declines in water-table elevation.

Well 299-W18-25 will be dry in the near future, leaving one upgradient well for the waste management area. There are no plans to replace 299-W18-25. Time will tell whether one upgradient well is sufficient to capture the variability of upgradient groundwater. Well 299-W19-12 is an older, non-RCRA compliant well that consistently yields anomalous, high pH values, probably as a result of construction materials.

2.8.3.8 Groundwater Remediation at 200-UP-1 Operable Unit

The goal of the 200-UP-1 pump-and-treat system is to reduce contamination in the highest concentration area of the plumes, reduce human health risks through mass removal, hydraulically contain the contaminant plume, and provide information to support a final remedy decision. The most notable success in fiscal year 1999 was the reduction of technetium-99 to below the 9,000-pCi/L remediation goal in all but two wells. Uranium concentrations remained above the 480-μg/L remediation goal in almost all wells, even after treatment of 425.6 million liters and 5 years of operation.

Groundwater in the U Plant area is pumped and treated to prevent contamination from spreading. The highest concentration portions of the technetium-99 and uranium plumes have shrunk since 1995.

Interim Remedial Action Objectives

The pump-and-treat system for this operable unit is located on the northern side of the 216-U-17 crib (see Figure A.11). The interim action objectives (ROD 1997) are the following:

- reduce contamination in the areas of highest concentration of technetium-99 and uranium to below 10 times (480 mg/L) the cleanup level under the *Model Toxics Control Act* (WAC-173-340) for uranium, and 10 times (9,000 pCi/L) the drinking water standard for technetium-99
- reduce potential adverse human health risks through reduction of contaminant mass
- prevent further movement of these contaminants from the highest concentration area
- provide information that will lead to the development and implementation of a final remedy that will be protective of human health and the environment.

For more detailed information about operations during fiscal year 1999, refer to DOE/RL-99-79.

History of Operations

A separate pump-and-treat remediation system operated in 1985 near the 216-U-1 and 216-U-2 cribs to reduce elevated uranium concentrations. For a discussion of this operation, refer to WHC-EP-0133.

The current system was constructed to contain the highest concentration portion of the technetium-99 and uranium plume. Early operations consisted of a treatability test conducted from March 1994 to September 1995. Phase I pump-and-treat operations

began September 1995 and consisted of one extraction well and one injection well. This system operated until February 7, 1997. Groundwater was treated onsite using an ion-exchange medium, with treated water injected upgradient from the extraction well.

On February 25, 1997, an interim action record of decision was issued (ROD 1997) that initiated Phase II for the 200-UP-1 Operable Unit pump-and-treat operations. The selected remedy consisted of pumping the highest concentration zone of the technetium-99 and uranium groundwater plumes, using the same extraction well and transporting the contaminated groundwater to the Effluent Treatment Facility in the 200 East Area. Since March 1997, contaminated groundwater was pumped from the extraction well, transported in an 11-kilometer pipeline to the Effluent Treatment Facility in the 200 East Area for treatment, and sent to the State-Approved Land Disposal Site north of the 200 West Area for disposal. Secondary contaminants (carbon tetrachloride and nitrate) are also present and are being removed.

Contaminant Removal

Approximately 93.5 million liters of contaminated groundwater were treated at the Effluent Treatment Facility in fiscal year 1999. The average extraction flow rate was 182 liters per minute.

Table 2.8-5 details the volumes of treated water and the carbon tetrachloride, nitrate, technetium-99, and uranium removed by quarter since inception of operations (March 1994). Table 2.8-6 shows the contaminant trends.

Carbon tetrachloride concentrations decrease while groundwater is transported along the 11-kilometer pipeline between extraction wells in the 200 West Area and the Effluent Treatment Facility in the 200 East Area because of outgassing and loss of volatiles. Given the volume of pumped groundwater in fiscal year 1999 (93.5 million liters), the estimated amount of mass lost to the atmosphere was 9.3 kilograms. This loss is in addition to the mass removed during treatment.

Overall Effectiveness

As of July 1999, the high concentration portions of the technetium-99 and uranium plumes were hydraulically contained. However, they were not remediated to the levels required by the interim action objectives (ROD 1997). Significant progress was made in reducing the size and concentrations of the technetium-99 plume. Less progress has been made in remediating the uranium plume because of its tendency to sorb to the soil.

The following conclusions were drawn from these plume maps and from information contained in DOE/RL-99-79.

Technetium-99

- The extent of the plume with high concentrations of technetium-99 was reduced in comparison to the original baseline area (Figures 2.8-35 and 2.8-36). Note that the July 1999 900 pCi/L plume covers about the same area as the June 1995 plume of 9,000 pCi/L.
- Technetium-99 concentrations are below the 9,000-pCi/L remediation criterion, with the exception of only two monitoring wells (299-W19-26 and 299-W19-29) (see Figure 2.8-35).
- A localized technetium-99 "hot-spot," originating upgradient of the targeted plume area, appears to be moving downgradient from well 299-W19-28 through wells 299-W19-29 and 299-W19-36.
- Technetium-99 concentrations increased significantly in well 299-W19-36 from 1,470 pCi/L in 1998 to 8,230 pCi/L in 1999. It is likely that technetium-99 will exceed the remediation action objective of 9,000 pCi/L during the next scheduled sampling. This well is the former injection well that was shut down in early 1997.

Uranium

- The extent of the plume with high concentrations of uranium (more than 480 μg/L) appears to be slightly smaller than the June 1995 baseline plume (Figures 2.8-37 and 2.8-38).

- Continued low uranium concentrations (~200 mg/L) in the monitoring well directly downgradient of the extraction well (299-W19-40) indicate that the high concentration portions of the plumes are contained, thereby preventing downgradient migration.
- Uranium concentrations in four monitoring wells and the extraction well have remained above the 480-µg/L remediation objective. The much slower response to remediation compared to technetium is due to uranium's tendency to sorb to soil, making it more difficult to extract.
- Uranium concentrations increased in wells 299-W19-29 and 299-W19-36. The increase in concentrations is attributed to recovery associated with termination of injection well operations. Prior to shutdown of the injection well, contaminants were diluted from injection of treated water.

Water-Level Impact and Capture-Zone Analysis

Water levels declined ~0.56 meter in fiscal year 1999, as the overall 200 West Area water table decreased. Two of the monitoring wells in the 200-UP-1 Operable Unit (299-W19-24 and 299-W19-28) went dry during fiscal year 1999 because of declining water levels. In addition, wells 299-W19-23, 299-W19-26, and 299-W19-38 were switched to a bailer-sampling method because groundwater returns could not be sustained using pumps. It is expected that similar modifications will be made to other monitoring wells in fiscal year 2000, as water levels continue to decline.

Groundwater modeling indicates that the targeted plume is captured under the current well configuration (Figure 2.8-39). It is estimated that one pore volume has been extracted from the original high concentration portion of the plume based on the original baseline plume map (DOE/RL-99-79) (Figure 2.8-40).

2.8.4 REDOX Plant

The REDOX Plant was used for separating plutonium from irradiated fuel from 1951 through 1967. Groundwater plumes, originating in the vicinity of the REDOX Plant and its associated waste storage and disposal facilities, include chromium, iodine-129, nitrate, technetium-99, trichloroethylene, tritium, and uranium, at levels above the maximum contaminant levels/drinking water standards. Strontium-90 was not detected at levels above the interim drinking water standard in this area in fiscal year 1999. Two facilities in this vicinity, Waste Management Area S-SX and 216-S-10 pond and ditch, have RCRA monitoring requirements. Other facilities appear to have produced the major part of the groundwater contamination, although high concentrations of technetium-99 and other contaminants are attributed to leaking tanks or associated piping in Waste Management Area S-SX.

Monitoring Objectives Near REDOX Plant

Groundwater monitoring is conducted near the REDOX Plant:

- triennially to annually to describe the nature and extent of contamination
- semiannually to detect the possible impact of one RCRA waste management area
- quarterly to assess contamination from one RCRA waste management area.

2.8.4.1 Groundwater Flow

The groundwater flow in the southern portion of the 200 West Area is principally to the east, with a slight southeastern component (see Plate 2). The southeastern trend is more apparent in the area of the decommissioned U Pond. Flow directions in this area have shifted more to the east as the impact of past liquid disposal activities have declined. This shift to the east will continue as these influences continue to abate.

Flow beneath RCRA sites is discussed in Sections 2.8.4.8 and 2.8.4.9.

2.8.4.2 Tritium

A tritium plume extends eastward from the vicinity of the REDOX Plant in the southern part of the 200 West Area (see Plate 3). The eastern part of the plume curves to the north, but the tritium concentrations in the northern part of this plume are declining, as illustrated by the tritium trend plot for well 699-38-65 (Figure 2.8-41).

The tritium plume from the 200 West Area extends to US Ecology's low-level radioactive waste disposal facility. The maximum tritium concentration (4,565 to 4,907 pCi/L) detected in groundwater at that facility in fiscal year 1998 was in well 699-35-59 (US Ecology well no. 13). Tritium concentrations in that well, located on the western (upgradient) side of the facility, continued to increase over the past several years. These data were provided by US Ecology and are not included on the diskette included with this report or shown in Plate 3.

Movement of this tritium plume is expected to be slow because of the low-permeability sediment in the area and the dissipation of the groundwater mound beneath the 200 West Area since the reduction of effluent discharge.

Tritium was found above the interim drinking water standard upgradient of the REDOX Plant near the 216-S-25 crib and Waste Management Area S-SX. The source of tritium in wells in this area is attributed to the past-practice disposal sites (e.g., 216-S-4, 216-S-21, 216-S-25). Tritium concentrations in well 299-W23-9, located near the 216-S-25 crib, have risen in recent years but have not reached the levels seen in the late 1980s. The tritium pulse seen since 1995 in well 299-W22-46 may be the downgradient expression of the discharge from the 216-S-25 crib (Figure 2.8-42).

2.8.4.3 Iodine-129

An iodine-129 plume from the 200 West Area extends into the 600 Area to the east and coincides with the tritium plume originating near the REDOX Plant (see Figure 2.8-32). This iodine-129 plume and the iodine-129 contamination originating farther north near U Plant appear to coalesce downgradient and become indistinguishable at the current level of monitoring detail. The maximum iodine-129 concentration detected in this plume in fiscal year 1999 was 38 pCi/L in well 699-35-70. However, well 299-W22-9, which previously has had the maximum iodine-129 concentrations, could not be sampled due to declining water levels.

2.8.4.4 Technetium-99

Technetium-99 was above the drinking water standard in two small plumes located near Waste Management Area S-SX (Figure 2.8-43). In addition, groundwater samples from a borehole drilled in early fiscal year 2000 just inside the southwestern corner of Waste Management Area SX, showed technetium-99 concentrations of 48,000 pCi/L, currently the highest on the Hanford Site. This borehole was subsequently completed as a groundwater monitoring well (well 299-W23-19). Evidence from recent years suggests that multiple sources of technetium-99 in the Waste Management Area S-SX tank farm are contributing to groundwater contamination (PNNL-11810). It should be noted that past data suggest that the 216-S-13 crib may have contributed to the technetium-99 detected further downgradient of Waste Management Area S-SX. Well 299-W22-21, located next to the 216-S-13 crib, could no longer be sampled in fiscal year 1999. Therefore, there is a scarcity of wells to track the migration of technetium-99 downgradient of Waste Management Area-S-SX. Technetium-99 in the vicinity of Waste Management Area S-SX is discussed in Section 2.8.4.8.

2.8.4.5 Nitrate

Nitrate was detected in fiscal year 1999 above the maximum contaminant level in two small plumes in the vicinity of the REDOX Plant. The first plume is located near the 216-S-20 crib, which received laboratory waste from the 222-S Building (see Figure 2.8-31). Lower concentrations of nitrate are also associated with the tritium and iodine-129 plumes extending to the east of the REDOX Plant.

Nitrate was detected above the maximum contaminant level in well 299-W23-9 near the 216-S-25 crib and extends past Waste Management Area S-SX (see Figure 2.8-31). It also appears that a low concentration of nitrate is associated with the technetium-99 plumes in this vicinity.

2.8.4.6 Chromium

Chromium continues to be detected at levels above the maximum contaminant level in well 299-W26-7, the upgradient well for the 216-S-10 pond and ditch (Figure 2.8-44). Chromium concentrations in this well have decreased to 175 µg/L in fiscal year 1999 from 576 µg/L in fiscal year 1998. The source of the chromium contamination has not been determined, but it is possibly related to the 216-S-10 pond or to earlier disposal to upgradient facilities (termed the "REDOX swamp" in some early reports).

There may be a relationship between the chromium observed in well 299-W26-7 and chromium detected farther downgradient, south of the 200 East Area (discussed in Section 2.11.5).

2.8.4.7 Trichloroethylene

A small trichloroethylene plume, with concentrations just above the maximum contaminant level, has been found in past years to the east of the REDOX Plant. Trichloroethylene was not detected at levels above the maximum contaminant level in this vicinity in fiscal year 1999. The 216-S-20 crib is a likely source of the trichloroethylene plume.

2.8.4.8 Waste Management Area S-SX RCRA Assessment Summary

Waste Management Area S-SX continued to be monitored under a RCRA assessment program in fiscal year 1999. A new groundwater quality assessment plan for continued investigations at this waste management area was prepared during the year (PNNL-12114) to cover ongoing groundwater characterization efforts being conducted concurrently with the RCRA facility investigation corrective measures study (HNF-5085, Rev. 0). Results of the continued groundwater assessment findings are scheduled for release as a topical report in September 2000. The wells and analytes for this area are listed in Appendix A.

RCRA Waste Management Area S-SX contains single-shell tanks that may have contaminated groundwater with technetium-99. Four new wells were drilled in fiscal year 1999 to help characterize the contaminant plume.

Groundwater Flow

Flow rate estimates, using travel times for tritium between upgradient and downgradient 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 (PNNL-12114). Contours of water-table elevation suggest a general southeasterly flow direction (see Plate 2). Calculated Darcy flow rates (see Table A.2) from 0.0023 to 0.43 meter per day bracket the travel time-based estimates above. The water table is gradually declining at the rate of ~0.6 meter per year, which may result in a future shift to a more easterly flow direction and decreased flow rates as the gradient declines.

Assuming the contaminant-based flow rate estimates noted above are the most representative, the average arrival time from an imaginary north-south centerline through the waste management area to the nearest downgradient RCRA monitoring wells is ~3 to 6 years at 25 meters per year or 1.5 to 3 years at 50 meters per year. At 50 meters per year, it would take over 20 years for a contaminant plume to migrate from within Waste Management Area S-SX to the nearest downgradient 200 West Area fence line location and much longer to reach the Columbia River.

Groundwater Contamination

The general distributions of contaminant plumes in the vicinity of Waste Management Area S-SX are

discussed earlier in this section. Contaminants have tended to migrate to the east-southeast as also suggested by the water-table contours for this area (see Plate 2). In addition to estimates of the extent of groundwater contamination based on the somewhat limited number of near-field monitoring wells in the area, additional information concerning both areal and vertical extent of contamination is emerging from the new wells installed in late 1999.

The constituents of interest for this waste management area have been identified previously based on process knowledge and results of in-tank sampling and analysis. The radioactive constituents with greatest concentrations in the tanks are cesium-137 and strontium-90. The more mobile components of the waste that have been identified in groundwater beneath this waste management area include technetium-99 as pertechnetate, chromate, nitrate, and tritium. While upgradient sources exist because of past-practice discharges to adjacent cribs, tank farm waste input can be distinguished from upgradient sources by isotopic and chemical ratios (PNNL-12114; HNF-4936, Rev. 0). For example, upgradient ratios of technetium-99 to nitrate are very low compared to occurrences in downgradient wells (~0.01 versus ~0.1 to 0.2, respectively).

The occurrence of nitrate, chromium, and technetium-99 in groundwater at the SX Tank Farm is consistent with the high percentage of these mobile constituents in the water extracts from contaminated soil samples near tanks SX-108 and -109 (see Tables 3.2-2 and 3.2-3). While a direct link between the above tank source and groundwater cannot be made at this time, the high percentage of water extractable nitrate, technetium-99, and chromium suggests there is potential for transport of this type of waste through the vadose zone to groundwater. In contrast, cesium-137 is not detected in groundwater. This is consistent with a very low percentage of this radionuclide in the water leach fraction (Table 3.2-3) of contaminated sediment from borehole 41-09-39.

Technetium-99, Nitrate, Chromium, and Tritium. Concentration trends for three primary mobile constituents of concern (chromium, nitrate and technetium-99) have undergone changes during the past year (Figure 2.8-45). Technetium-99 levels in well 299-W22-46, southeast of the SX Tank Farm, declined slightly, with a fiscal year 1999 average of 3,600 pCi/L (Figure 2.8-46). Chromium has declined more rapidly than technetium-99 in well 299-W22-46 and no longer appears to be co-variant with nitrate and technetium-99. This pattern may be a result of overlapping plumes from two different sources that converge in the vicinity of well 299-W22-46. The technetium-99/nitrate ratios for samples from the new wells as discussed above also suggest multiple sources. Another notable change is the rising concentrations of chromium, nitrate, and technetium-99 in downgradient well 299-W22-45 at the SX Tank Farm (see Figure 2.8-45). Based on the location of this well, and inferred flow directions, this new groundwater occurrence represents a different vadose zone source, possibly originating in the northeastern area of the SX Tank Farm. The well is located downgradient from diversion boxes and valve pits that have been sources of surface spills in the past. Single-shell tanks are less likely sources in this area than the ancillary waste systems because of flow direction considerations (see Figure A.5). Technetium-99 concentrations in new well 299-W23-19, located on the southeastern side of tank SX-115, were up to 48,000 pCi/L in screening samples.

Cesium-137 and Strontium-90. Except for non-RCRA well 299-W23-7, located inside and along the eastern side of SX Tank Farm, cesium-137 and strontium-90 were not detected in the monitoring well network for Waste Management Area S-SX during fiscal year 1999. Evaluation of historical and recent groundwater data (HNF-4936, Rev. 0) showed that results for these two constituents of interest were at or below the routine detection limits (~10 pCi/L for cesium-137 and ~1 pCi/L for strontium-90) and were within the 95% confidence limits for field trip blank results. Also, a special study reduced the cesium-137 detection limit. For example, samples from the two wells with the highest technetium-99 concentrations (299-W23-19, the SX-115 well, and new well 299-W22-50) were less than 0.02 to 0.047 pCi/L, respectively).

A maximum cesium-137 concentration of 49 pCi/L in non-RCRA well 299-W23-7 has been previously reported and discussed (PNNL-12114). However, this occurrence is primarily particulate and is thought to be an artifact of past well installation and maintenance methods (HNF-4936, Rev. 0). Older gamma logs for this well indicate the presence of surface soil contamination at the wellhead. Thus, contaminated soil may have fallen into the well during construction or during subsequent maintenance activities. Also, water can no longer be pumped from this well. It is now on the priority list for decommissioning because it could provide a conduit for downward migration of contaminants.

Gross Alpha. Elevated gross alpha (120 pCi/L) was detected during the year in the same well (299-W23-7) that has exhibited elevated cesium-137 prior to the well going dry. Previous investigation of elevated gross alpha in this well (PNNL-12114) included an analysis of uranium and selected alpha emitters that were reported as non-detections (americium-241, plutonium-238 and 239). Uranium accounted for most, if not all, the alpha emitters present. As with the cesium-137 in this well, the source is likely a result of contamination during well maintenance or other tank farm activities in the past. Additional characterization will be performed during decommissioning of this well. A more complete isotopic analysis of the alpha emitters (e.g., all the uranium isotopes as well as transuranics) may be useful in understanding the origin of the contamination.

Anomalous Metal Occurrences. High concentrations of chromium and iron occurred during the year in well 299-W23-15, located immediately south of the southwestern corner of the SX Tank Farm. This well has previously (1992-1994) exhibited moderately elevated chromium and iron. During fiscal year 1999, iron concentrations (filtered) peaked at over 900 μg/L on May 13, 1999, and total chromium of 42 μg/L was measured on August 9, 1999. Sample splits for the August 9, 1999 sampling were analyzed by the standard method (inductively coupled plasma emission spectroscopy metals analysis using both filtered and unfiltered samples) and by a hexavalent specific method (unfiltered sample). Results are shown in Table 2.8-7.

Table 2.8-7 indicates that most of the iron was particulate in the August 9, 1999, sample. This suggests the previous high iron concentration of over 900 μg/L for a filtered sample involved filter failure (i.e., a submicron colloidal phase of iron passed through the 0.45-micron membrane filter).

The elevated aluminum for the unfiltered samples, but not for the filtered samples (see Table 2.8-7), suggests the presence of an aluminosilicate mineral phase. For example, the routine practice of acidification of unfiltered samples for metals analysis results in partial dissolution and release of aluminum and silicon from clay minerals such as bentonite or related mineral phases. Table 2.8-7 also indicates that a large fraction (over 60%) of the total chromium was present as hexavalent chromium. In this case, a particulate or submicron colloidal phase cannot explain the elevated chromium result because the hexavalent chromium method is specific for dissolved chromate. Further investigation is needed to understand this anomalous occurrence.

Monitoring Network

Four new wells were drilled in calendar year 1999 to assess both areal and vertical distribution of contaminants near the waste management area. One well was drilled for the RCRA facility investigation remedial measures study (HNF-5085, Rev. 0) as a vadose characterization borehole near tank SX-115. This well was then deepened and completed as a groundwater monitoring well (299-W23-19). The other three wells were installed downgradient from S and SX tank farms in accordance with the RCRA groundwater assessment plan for Waste Management Area S-SX (PNNL-12114). Groundwater samples were collected from selected depths during drilling. Depths sampled included the very top of the aquifer (0 to 0.5 meter) and at 6 meters in all three RCRA compliant wells. In addition, samples were collected from 12, 30, 60, 90 (top of Ringold mud) and 120 meters (below the lower

mud unit) in new well 299-W22-50, installed at the southeastern corner of SX Tank Farm. Groundwater samples from the latter well were collected for both tank waste constituents and volatile organic compounds.

Special sampling in fiscal year 1999 indicated contaminant concentrations are highest at the very top of the aquifer.

New well 299-W23-19 (located on the southwestern side of tank SX-115) was initially completed with a temporary 1.5-meter screen at the top of the aquifer. After discovery of high concentrations of technetium-99 (up to 48,000 pCi/L), the well was completed with a longer permanent well screen. This will allow further characterization of the nature of the groundwater contamination at this location. Initial measurements at the water table in this well resulted in concentrations of technetium-99 and nitrate (31,000 pCi/L) that were ~25% higher than concentrations obtained when the well was pumped at ~1 meter below the static water level. The observation of higher concentrations near the water table is consistent with a well located very near the source where contaminants initially enter the aquifer from the vadose zone. Thus sampling from wells located very near vadose zone contamination must allow for the potential occurrence of higher concentrations at or near the water table where the vadose zone contaminants are transported down to groundwater under unsaturated flow conditions.

Installation of one new downgradient well (299-W22-48) improved spatial coverage at the S Tank Farm. Only very low nitrate (~20 mg/L) and technetium-99 (less than 50 pCi/L) concentrations were detected at this location. In addition, there were no differences in concentrations between the top of the aquifer and at 6 meters below the water table. Previously observed occurrences of elevated nitrate and technetium-99 in an older upgradient well (299-W23-1), located near tank S-107, indicated that contamination from within S Tank Farm reached groundwater upgradient of new well 299-W22-48 sometime in the past. For example, a technetium-99 transient increase in well 299-W23-1 occurred in 1985 and again in 1997.

New well 299-W22-48 was also cored to near the water table. The core samples will be used to clarify contaminant sorption mechanisms and moisture movement through the vadose zone in the vicinity of single-shell tank farms. The information acquired will also help to better define the stratigraphy in the S Tank Farm portion of this waste management area. One important finding during the coring was the discovery of a section of clastic dike at 52 meters below ground surface. Clastic dikes have been suggested as one type of preferential pathway for transport of moisture and contaminants to groundwater beneath Waste Management Area S-SX.

New well 299-W23-49, located midway and downgradient of SX Tank Farm, was installed as a replacement for well 299-W22-39 that is going dry. Samples of the very top of the aquifer, at 6 meters, and development water pumped from the 4.6 meters of screened interval, all indicated low nitrate (10 mg/L) and very low technetium-99 (less than 50 pCi/L). Thus, there was no indication of a very shallow plume of contaminants at the top of the aquifer or more deeply distributed contamination (below 6 meters). A field screening method for technetium-99 (and cesium-137) was successfully demonstrated for the first time at the Hanford Site. During this RCRA drilling, the screening method was used to determine if there was an indication of increasing tank waste contamination with depth. The drilling plans included a provision to extend the borehole another 15 meters if there was an indication of increasing concentrations with depth.

New well 299-W22-50 is located at the far southeastern corner of the SX Tank Farm and ~15 meters north of well 299-W22-46. This well is a multipurpose well intended to

- replace the existing well when it goes dry in 2 to 3 years

- conduct a two-well test to reduce the uncertainty in hydraulic conductivity
- evaluate depth distribution of contaminants.

The vadose zone portion was also cored to improve understanding of the fine structure stratigraphy in this area and to obtain sample media for laboratory tests (sorption tests, moisture content, porosity, hydraulic conductivity). Field screening results for samples collected during drilling indicated elevated nitrate (52 mg/L) and technetium-99 (~12,000 pCi/L) at the top of the aquifer that declined rapidly with depth. The concentrations of technetium-99 and nitrate were four to five times lower at 6 meters below the static water level in the well than at the top (0 to 0.5 meter). The technetium-99-to-nitrate ratio (200 pCi/mg) based on field screening measurements suggests this newly discovered groundwater contamination is from a different tank farm source than the source responsible for groundwater contamination observed at either the new well near tank SX-115 or at nearby well 299-W22-46. For example, the technetium-99/nitrate ratios for the latter are both ~100 pCi/mg. The ratio for the new occurrence at 299-W22-50 appears to more closely match the water leachate results (210 pCi/mg) for contaminated soil beneath tank SX-108. The RCRA well observations suggest there are at least two different tank farm source areas or types that account for groundwater contamination downgradient from the southern end of this waste management area.

2.8.4.9 216-S-10 Pond and Ditch RCRA Parameters

The inactive 216-S-10 pond and ditch was monitored semiannually under RCRA interim status indicator evaluation (see Tables A.1 and A.15). None of the indicator parameter concentrations in downgradient monitoring wells exceeded critical mean values during fiscal year 1999 (see Table A.3). However, a site-specific constituent, chromium, continued to exceed the 100 μg/L maximum contaminant level in upgradient well 299-W26-7 (175 μg/L in the December 1998 and 216 in June 1999) (see Figure 2.8-44). Because the upgradient well is located immediately adjacent to the 216-S-10 pond (see Figure A.7), the elevated chromium could be from an upgradient source or from the pond. A new monitoring plan will be prepared to reclassify this well as a downgradient well and replace it with a new upgradient well in calendar year 2000. Further description of the chromium plume is presented in Section 2.8.4.6.

RCRA monitoring at the 216-S-10 pond and ditch provides no evidence of groundwater contamination from this facility. Declining water levels have left this site without adequate well coverage.

The water table continued to decline in the 200 West Area during fiscal year 1999. This continuing decline reduced the 216-S-10 monitoring network from one upgradient and three downgradient wells to just one upgradient well (299-W26-7) and one downgradient well (299-W26-12). Downgradient wells 299-W26-9 and 299-W26-10 went dry during the first half of the year. RCRA interim status monitoring requirements specify that a minimum of one upgradient and three downgradient monitoring wells are needed to monitor the site. As a result, two additional wells are needed to bring the monitoring network back into compliance with RCRA regulations. If well 299-W26-7 is designated as a downgradient well, one upgradient and one downgradient well needs to be constructed. Ecology recommended that only one of the wells be drilled, the replacement for 299-W26-10, and approved this direction in the form of Tri-Party Agreement milestone M-24-00K.[a] New well 299-W26-13 was installed in December 1999 at a location directly downgradient of the 216-S-10 pond. Two new wells have been proposed to DOE and Ecology to be installed in

(a) Letter from Dib Goswami, Washington State Department of Ecology, to M. J. Furman, U.S. Department of Energy, Richland, Washington, dated April 12, 1999, "Site-Wide Resource Conservation and Recovery Act Well Installation for Milestone M-24-00."

calendar year 2000 as part of a revised groundwater monitoring network. Background values for the facility have been recalculated based on just one upgradient well (299-W26-7). Based on regional groundwater elevations, the groundwater flow direction continues east-southeast to easterly. New wells will be located appropriately to maximize the downgradient coverage of the 216-S-10 pond and ditch.

Groundwater flow rates have not changed significantly since last year and are presented in Table A.2.

Sample results that exceeded drinking water standards and maximum contaminant levels this year are presented in Table A.3. Besides chromium, only carbon tetrachloride and nickel exceeded maximum contaminant levels. Carbon tetrachloride has been detected above or near the drinking water standard across the area. This is due primarily to the spreading of the regional plume across 200 West (see Section 2.8.1.2). The 216-S-10 pond is not the source of this constituent.

2.8.5 State-Approved Land Disposal Site

The State-Approved Land Disposal Site (also known as the 616-A crib) is located ~500 meters north of the northern boundary of 200 West Area (see Plate 1). The site receives, clean, treated water that occasionally contains high levels of tritium (up to ~10 million pCi/L) from the 200 Areas Effluent Treatment Facility. Operation of the site began in December 1995. By the end of September 1999, ~304 curies of tritium and over 270 million liters of effluent had been discharged. However, recent discharges have not contained appreciable tritium; only ~10 curies of tritium have been sent to the site since February 1998.

The State-Approved Land Disposal Site is used to dispose treated water that occasionally contains tritium. Tritium is detected in the wells closest to the site at levels above the drinking water standard.

A new state waste discharge permit is being planned for the facility, to take effect in mid-2000. The groundwater analytical constituent list will be adjusted to reflect effluent character and improved understanding of the groundwater system near the facility. Wells and analytes for this facility are listed in Appendix A.

2.8.5.1 Groundwater Flow

Effluent discharges have created a limited groundwater mound in the immediate vicinity of the State-Approved Land Disposal Site. This is reflected in the hydrograph of well 699-48-77A in Figure 2.8-47. The local mounding effect is superimposed on the general decline of groundwater levels in the 200 West Area and vicinity, as reflected in the hydrographs of wells 699-48-77D and C, and in well 699-48-77A prior to April 1997. This general decline is a response to the discontinuation of effluent disposal activities in the 200 West Area in the late 1980s.

The hydraulic gradient beneath the site in March 1999 was calculated to range from 0.04 between proximal wells 699-48-77A and D near the facility to ~0.0018 between the facility and the 200 West Area. Average linear groundwater flow velocity is estimated to be between 0.03 and 5.8 meters per day (see Table A.2). The higher velocity would occur near the infiltration area of the site and would move generally outward ("radially") from the slight groundwater mound at that location. The lower flow rate would apply to areas removed from the vicinity of the mound.

2.8.5.2 Extent of Contamination

Tritium is monitored in 21 wells near the facility on a semiannual to annual basis, and additional constituents are measured in three nearby wells (699-48-77A, C, and D) and one background well, 299-W8-1, on a quarterly schedule (see Figure A.13). Water levels are measured annually at the time of sample collection in these wells and monthly in the three nearby wells.

During fiscal year 1999, groundwater monitoring wells immediately surrounding the State-Approved Land Disposal Site continued to show the effects of

effluent containing high levels of tritium that were discharged to the facility over the last few years. Concentrations of tritium in groundwater are generally less than in fiscal year 1998, reflecting the reduced concentrations in the effluent over the past ~2 years (PNNL-13058). The highest tritium level observed in groundwater at the State-Approved Land Disposal Site during fiscal year 1999 (730,000 pCi/L) was measured in a sample from well 699-48-77D in October 1998. Figure 2.8-48 illustrates the trends in tritium concentrations in the wells since monitoring began at the facility. Wells 699-48-77A, C, and D are the only wells affected thus far by tritium from disposal to the area.

Monitoring for additional constituents in groundwater also occurs quarterly in the three nearby wells. Approximately 6 months following the startup of operation, analyses began to reveal elevated levels of tritium and other constituents and indicators in well 699-48-77A, the nearby well farthest from the State-Approved Land Disposal Site (see Figure 2.8-48). Further research indicated that the clean water discharged to the site was dissolving soluble components of the soil in the vadose zone, such as gypsum, resulting in elevated concentrations of sulfate, chloride, calcium, and sodium, and abrupt rises in conductivity and total dissolved solids (PNNL-11633; PNNL-11665). Figure 2.8-49 illustrates the trend for sulfate in the nearby wells and the background well. This event also revealed that the focus of infiltration of effluent was displaced to the south (nearer well 699-48-77A), most likely by the same geologic feature (a caliche horizon) that is responsible for the elevated dissolved solids. The rise of sulfate in well 699-48-77D occurred without a corresponding rise in tritium, thus indicating that this well was affected by dissolved soil salts from a test discharge released several months prior to operation. Tritium-bearing effluent did not affect well 699-48-77D until ~1.5 years after well 699-48-77A detected tritium. This apparent paradox is the result of the limited volume of the test discharge, the location of the infiltration point of effluent, and ambient groundwater flow.

Predictions of hydraulic head by a groundwater numerical model prepared in 1997 (PNNL-11665) compare favorably with current conditions. The same model apparently slightly overestimates the extent of the tritium plume in groundwater near the facility. The probable reason for the overestimation is that the quantity of tritium disposed to the facility thus far is ~50% of the projected quantity through 1999, as assumed by the model.

Table 2.8-1. Volume of Groundwater Treated and Mass of Carbon Tetrachloride Removed Since Startup of Operations at 200-ZP-1

Reporting Period	Liters Treated	Mass of Carbon Tetrachloride Removed (kg)
August 1994 - July 1996	26,676,000	75.85
August 1996 - September 1996	33,232,327	60.96
October 1996 - December 1996	44,583,715	143.54
January 1997 - March 1997	69,869,604	237.2
April 1997 - June 1997	41,877,094	140.8
July 1997 - September 1997	62,469,305	228.8
October 1997 - December 1997	81,629,000	245.7
January 1998 - March 1998	72,791,000	279.5
April 1998 - June 1998	90,842,900	348.9
July 1998 - September 1998	90,899,200	338.1
October 1998 - December 1998	83,552,570	315.57
January 1999 - March 1999	77,079,156	310.2
April 1999 - June 1999	90,657,196	337.8
July 1999 - September 1999	88,657,486	323.7
Total	954,816,553	3,386.5

Table 2.8-2. Average Carbon Tetrachloride Concentrations for Each of the Extraction Wells and the Influent Tank at 200-ZP-1 During Fiscal Year 1999

Well Name[a]	FY 1999 Min. Value (µg/L)	FY 1999 Max. Value (µg/L)	FY 1997 Mean Concentration (µg/L)	FY 1998 Mean Concentration (µg/L)	FY 1999 Mean Concentration (µg/L)	FY 1999 Mean Flow Rate[b] (L/min)	Overall Change
299-W15-33	5,300	7,100	5,058	6,000	6,218	57.0	Higher
299-W15-34	3,800	5,700	2,900	3,770	4,700	82.8	Higher
299-W15-35	3,100	4,400	3,351	3,660	3,858	310.0	Higher
299-W15-32	4,300	5,900	7,120	6,560	5,023	27.0	Lower
299-W15-36	1,300	2,100	2,820	2,040	1,697	94.6	Lower
299-W15-37	210	720	280	235	358	57.8	Higher
Influent Tank	3,300	4,400	3,270	3,530	3,788	--	Higher

(a) Wells listed from north to south.
(b) Some discrepancies in discharge rate at the different measurement locations were observed. These are still being resolved. Flow rates may actually be higher by ~10% to 20%.

Table 2.8-3. Results from Discrete Level Groundwater Sampling During Drilling of Well 299-W10-24[a]

Depth Below Surface (m)	Depth Below Water Table (m)	Carbon Tetrachloride (μg/L)	Technetium-99 (pCi/L)	Tritium (pCi/L)	Nitrate (mg/L)
70.9[b]	0.3	Not analyzed	13,000	7,380	120
75.2[c]	4.6	Not analyzed	2,090	20,600	456
87.5	16.9	490	358	29,600	531
99.1	30.8	1,600	374	26,700	443
116.7	46.3	760	212	19,500	349
122.5	52.2	360	126	12,700	301
131.4[d]	61.0	220	96	9,220	282

(a) Sampled October 9 through October 16, 1998.
(b) Sampled with Kabis Sampler in well 299-W11-27 on August 13, 1998.
(c) Sampled in well 299-W10-24 after completion on December 15, 1998.
(d) Collected below Ringold lower mud unit.

Table 2.8-4. Results of Discrete Level Sampling During Drilling of Well 299-W14-14[a]

Depth Below Surface (m)	Depth Below Water Table (m)	Carbon Tetrachloride (μg/L)	Technetium-99 (pCi/L)	Tritium (pCi/L)	Nitrate (mg/L)
70.5[b]	4.3	140	110	4,230	120
80.8	14.5	180	556	893	226
96.3	30.1	380	81	5,380	41
106.1	39.8	920	32	9,010	33
122.5	56.9	380	29	7,180	43
134.7[c]	68.5	590	33	8,460	40

(a) Samples taken October 24 through November 9, 1998.
(b) Sample taken from screened interval after well completion on December 10, 1998.
(c) Collected below Ringold lower mud unit.

Table 2.8-5. Quantity of Treated Groundwater and Contaminant Mass Removed Since Initiation of 200-UP-1 Pump-and-Treat Operations

Reporting Period	Liters Treated	Mass Technetium-99 Removed (g)	Mass Total Uranium Removed (g)	Mass Carbon Tetrachloride Removed (g)	Mass Nitrate Removed (kg)
March 1994 - November 1994[a]	3,898,550	3.41	4,422	Not reported	NA
December 1994 - August 1995	11,391,491	7.79	9,831	992	NA
September 1995 - November 1995	17,198,571	3.95	3,895	630	NA
December 1995 - March 1996	31,311,340	9.05	9,105	1,609	NA
April 1996 - June 1996	22,459,108	5.40	6,845	1,569	NA
July 1996 - September 1996	22,370,327	4.01	5,134	2,790	NA
October 1996 - December 1996	20,300,000	3.33	5,607	2,980	NA
January 1997 - February 1997[b]	2,667,600	0.83	963	73	NA
February - March 30, 1997	Shut down	NA	NA	NA	NA
March 31 - September 30, 1997	32,414,481	5.6	11,000	888	2,260
October 1 - December 31, 1997	20,390,054	3.31	6,300	572	1,530
January 1 - March 31, 1998	19,791,765	2.08	4,900	460	1,070
April 1 - June 30, 1998	33,538,750	3.58	8,680	907	2,150
July 1 - September 30, 1998	26,346,466	1.57	3,750	296	900
October 1 - December 31, 1998	22,174,396	1.49	4,910	341	979
January 1 - March 31, 1999	23,720,542	1.89	4,450	601	1,050
April 1 - June 30, 1999	24,369,400	2.29	5,400	600	1,400
July 1 - September 30, 1999	23,206,922	2.14	5,940	460	1,430
Total[c]	357,180,798	61.74	101,132	15,768	12,770

(a) Data from the treatability test as reported in DOE/RL 95-02, Rev. 0.
(b) Estimated values based on 189 liters per minute flow, running 24 hours per day, at 97.5% efficiency.
(c) Fiscal year 1998 total was reported incorrectly as 338,413,037 liters and should have been reported as 264,078,503 liters.
NA = Not applicable.

Table 2.8-6. Summary of Contaminant Trends in the Extraction Well at 200-UP-1

Contaminant	FY 1997	Average FY 1998	Average FY 1999
Technetium-99	>3,000 pCi/L	2,050 pCi/L	1,400 pCi/L
Uranium	275 µg/L	265 µg/L	210 µg/L
Carbon tetrachloride	18 µg/L	24 µg/L	18 µg/L
Nitrate	75 mg/L	63 mg/L	48 mg/L

Table 2.8-7. Comparison of Filtered and Unfiltered Metal Results on August 9, 1999 for Well 299-W23-15

Method	Chromium (µg/L)	Iron (µg/L)	Aluminum (µg/L)
Filtered (ICP)	16	25	27 U
		131	46
Unfiltered (ICP)	41	1,700	727
	42	1,500	627
Unfiltered (hexavalent-chromium)	25	NA	NA
	25	NA	NA

ICP = Inductively coupled plasma emission spectroscopy.
U = Result is a non-detection; the value shown is the vendor assigned method detection limit.
NA = Not applicable.

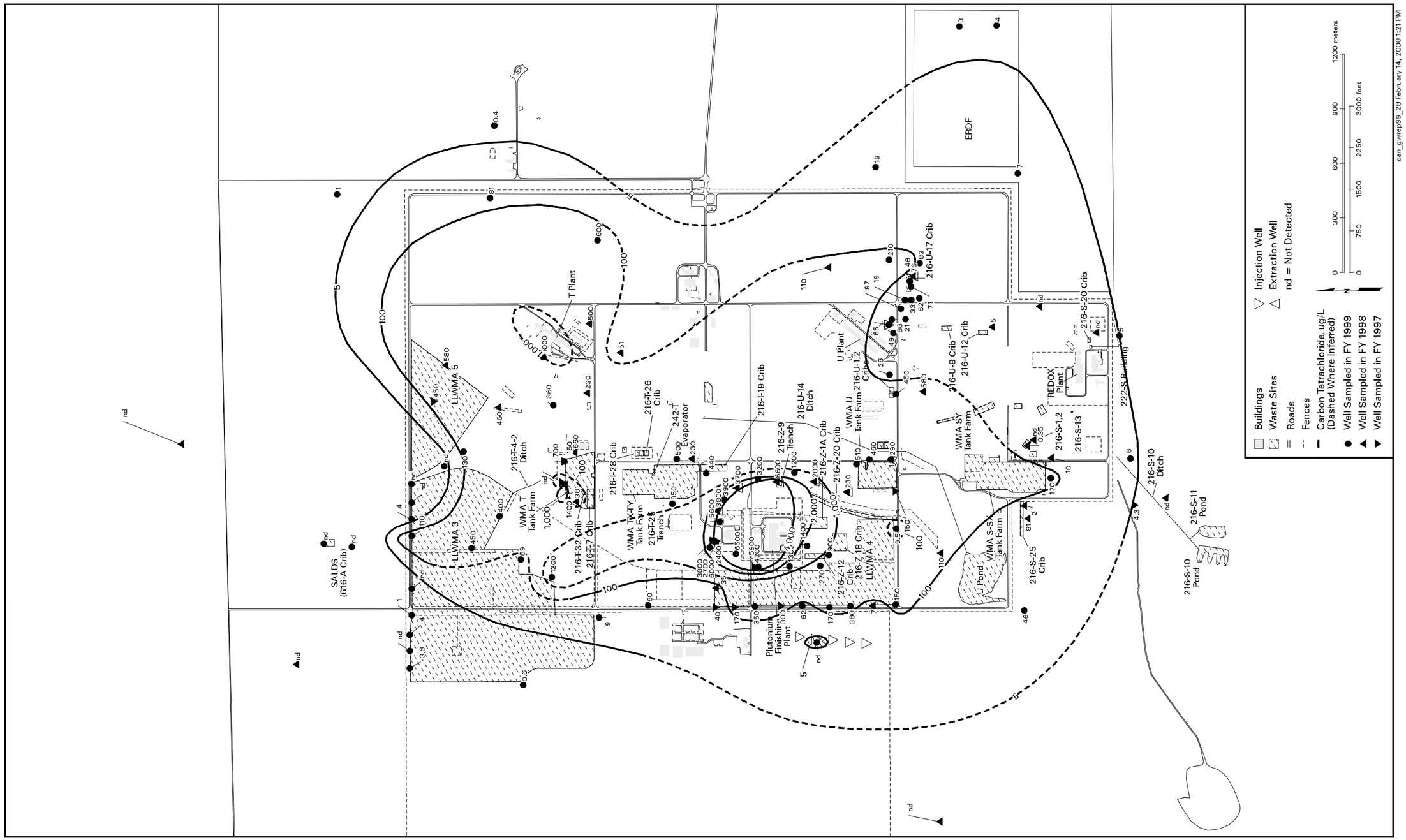

Figure 2.8-1. Average Carbon Tetrachloride Concentrations in 200 West Area, Top of Unconfined Aquifer

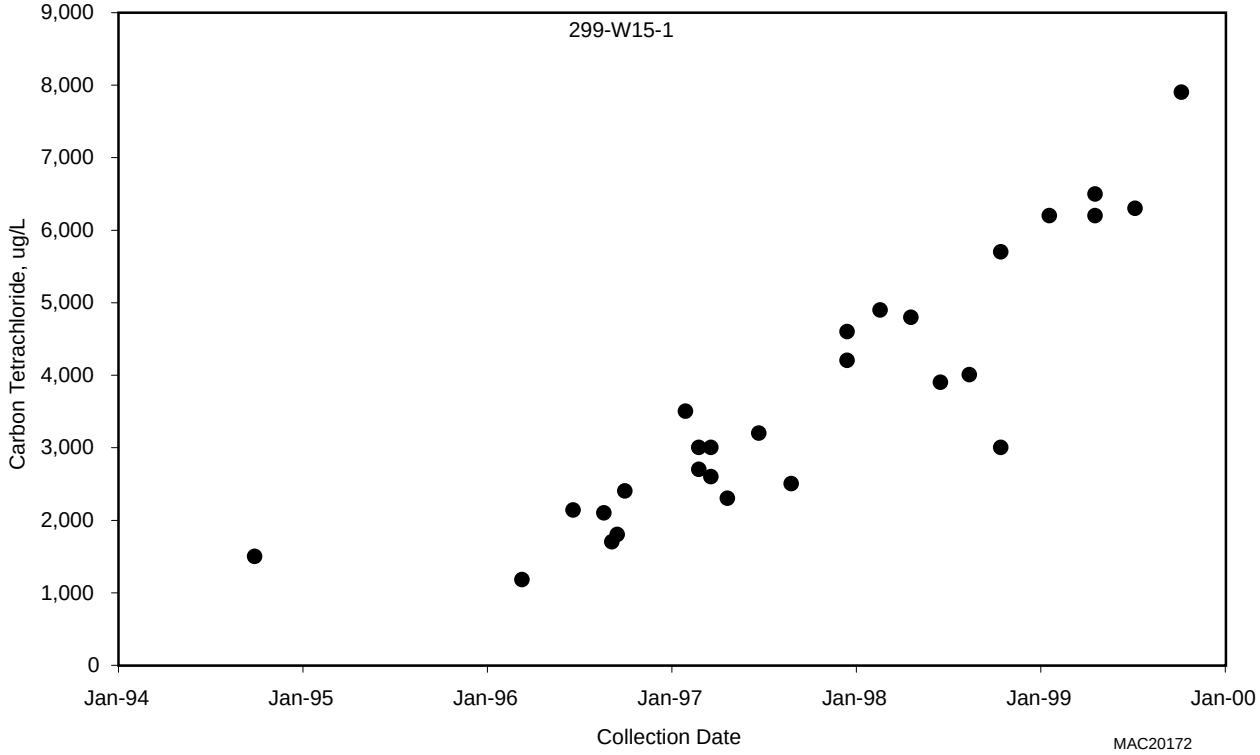

Figure 2.8-2. Carbon Tetrachloride in Well 299-W15-1 Near Northern Extraction Wells

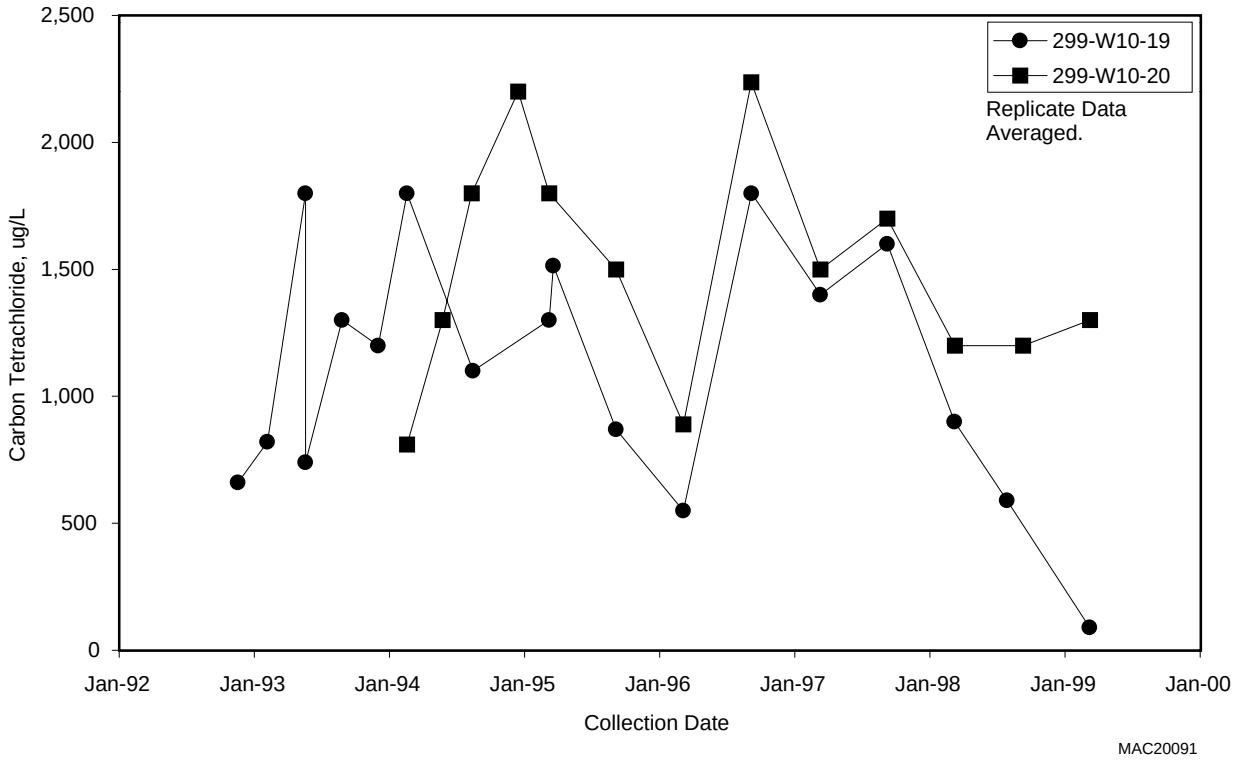

Figure 2.8-3. Carbon Tetrachloride in Wells 299-W10-19 and 299-W10-20, Northwestern 200 West Area

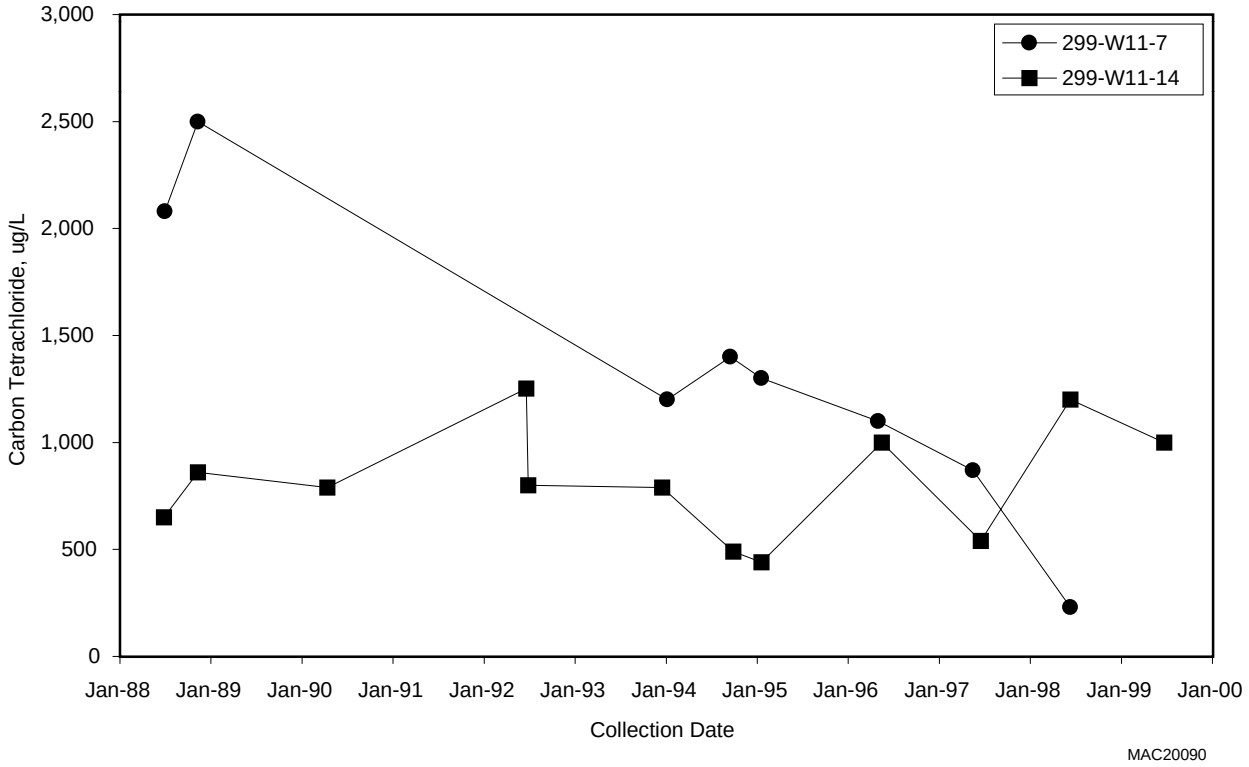

Figure 2.8-4. Carbon Tetrachloride in Wells 299-W11-14 and 299-W11-7, Northwestern 200 West Area

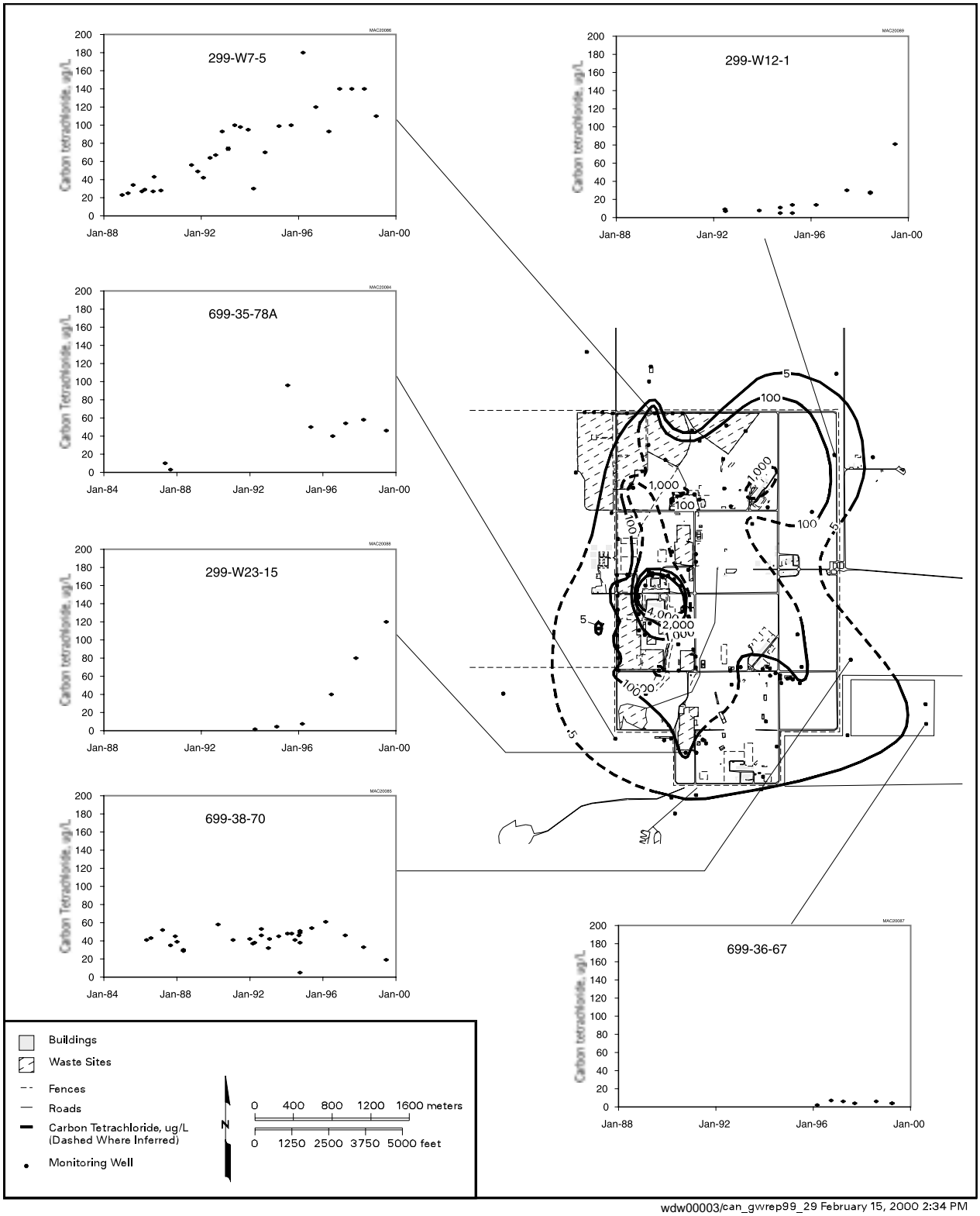

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Figure 2.8-5. Carbon Tetrachloride Concentrations in Wells Monitoring 200 West Area, Top of Unconfined Aquifer

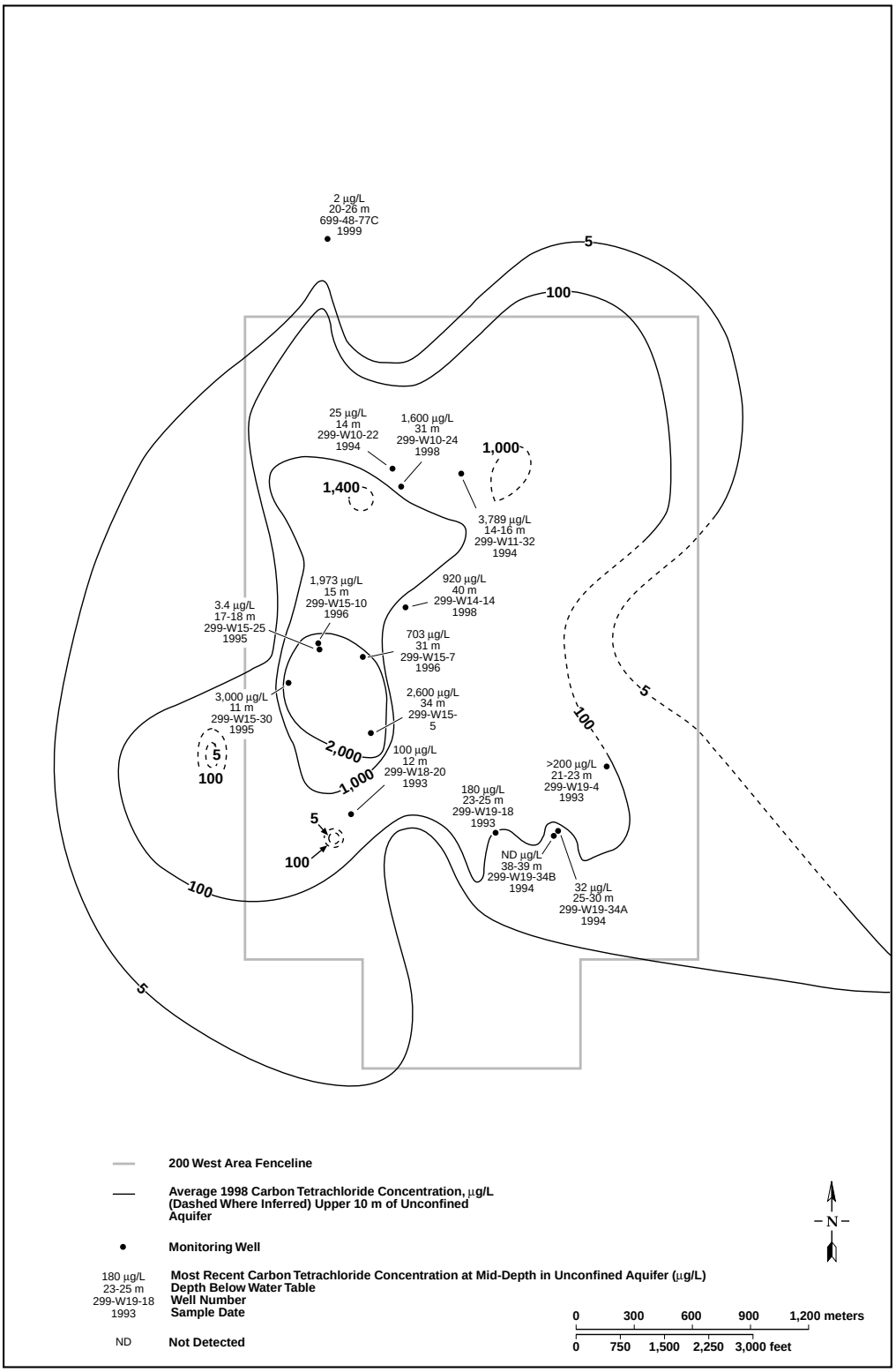

Figure 2.8-6. Carbon Tetrachloride Concentrations in the Middle Unconfined Aquifer, 200 West Area, Compared to Concentration Contours at the Top of the Unconfined Aquifer (DOE/RL-99-79)

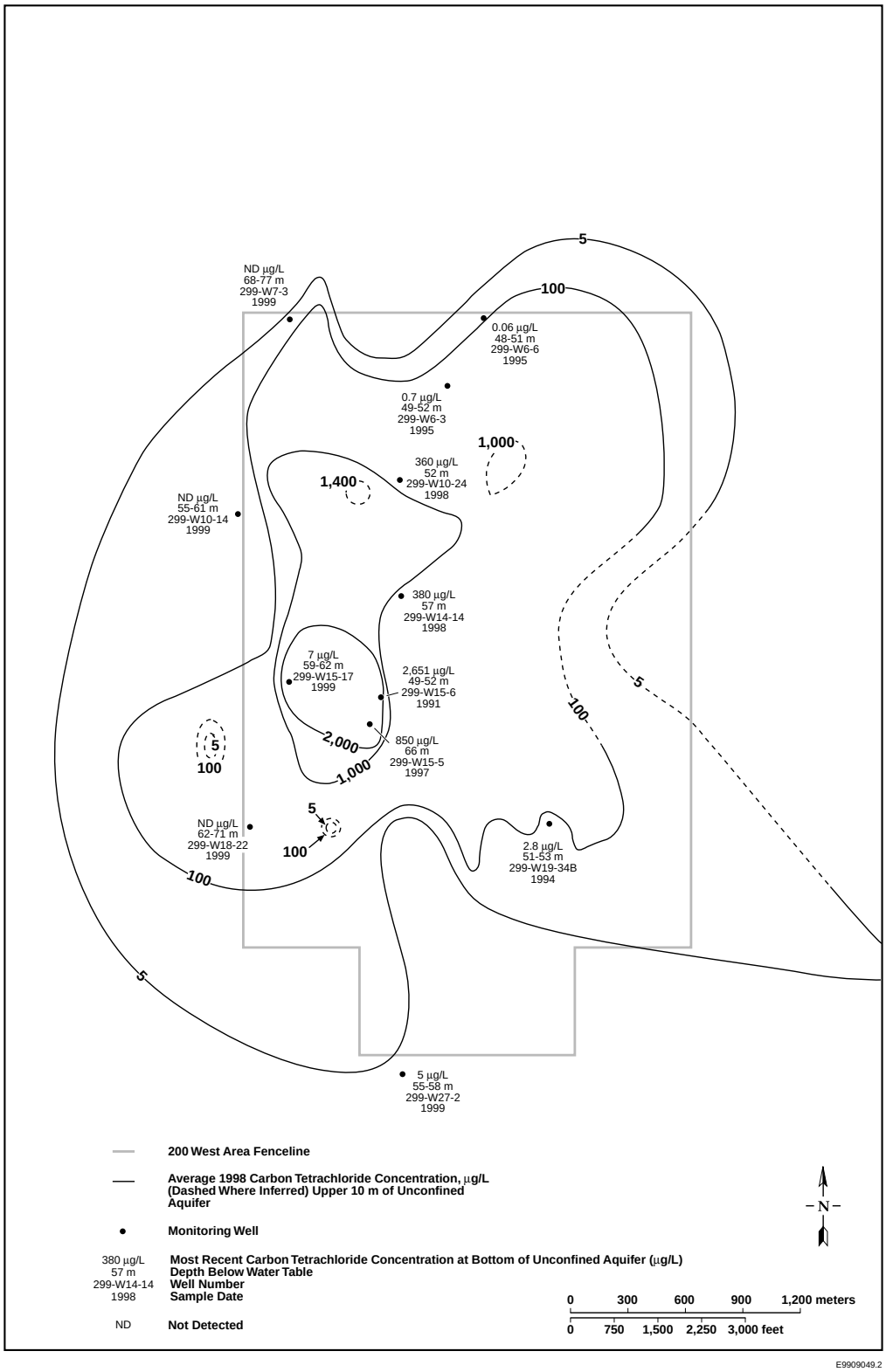

Figure 2.8-7. Carbon Tetrachloride Concentrations in the Lower Unconfined Aquifer, 200 West Area, Compared to Concentration Contours at the Top of the Unconfined Aquifer (DOE/RL-99-79)

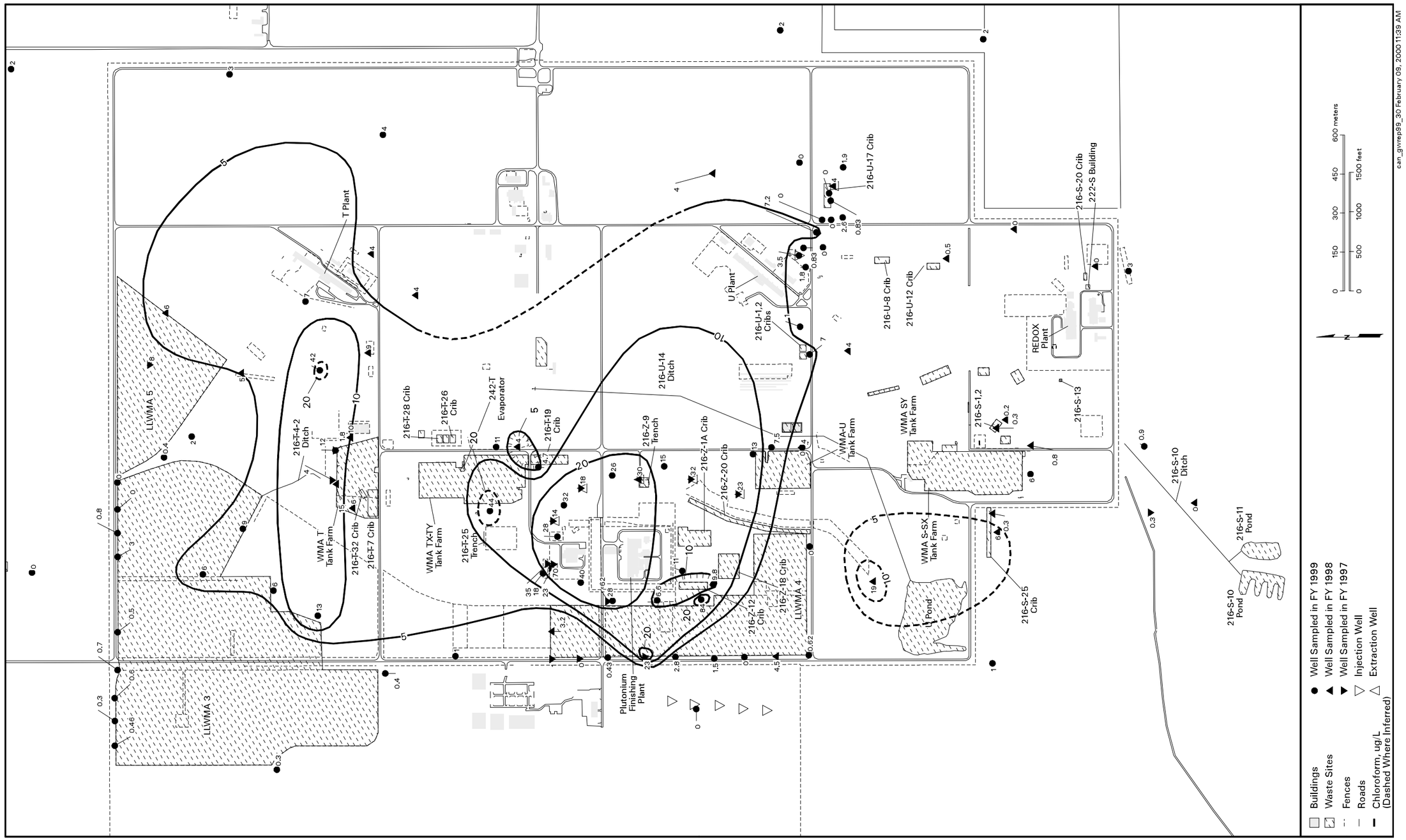

Figure 2.8-8. Average Chloroform Concentrations in 200 West Area, Top of Unconfined Aquifer

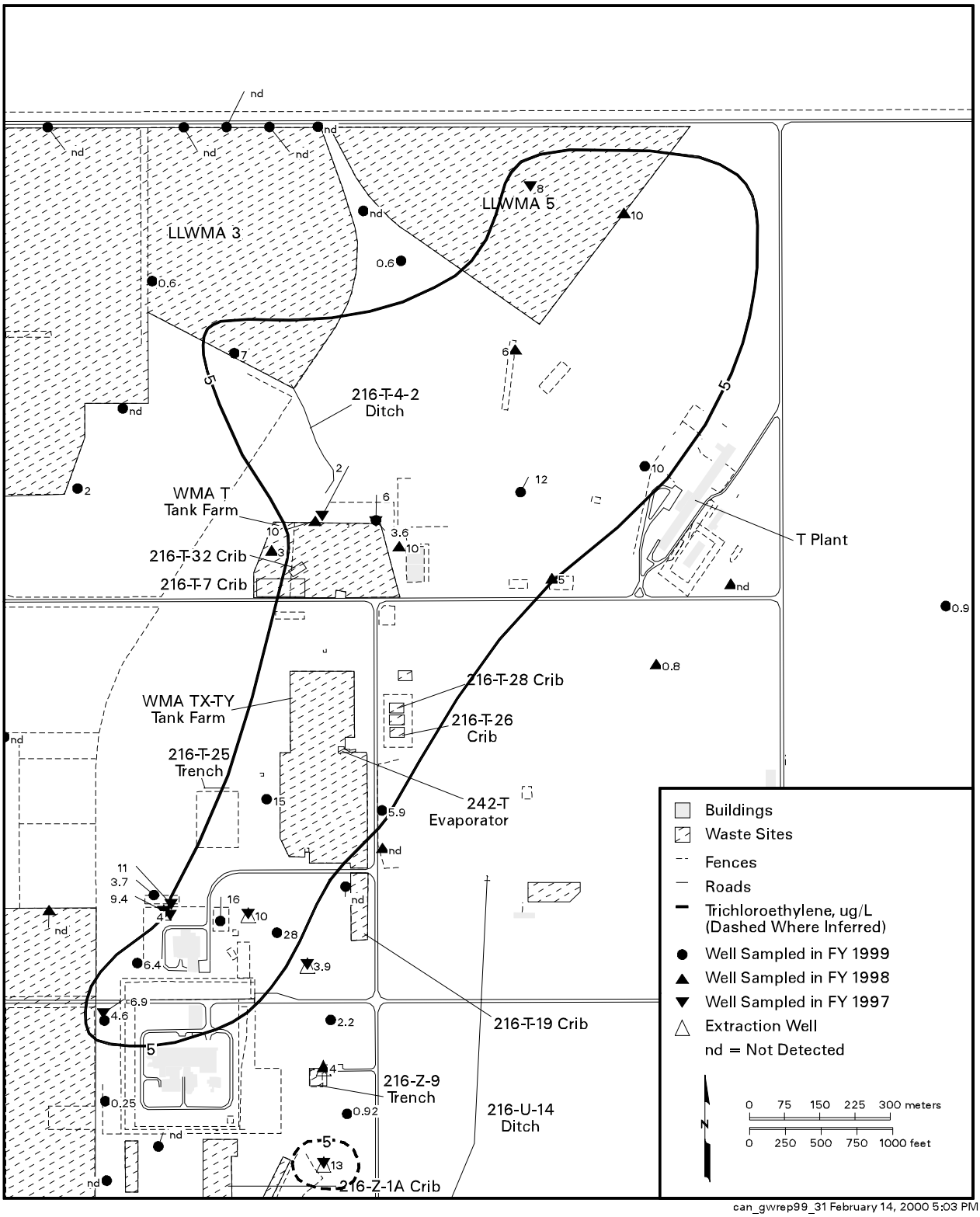

Figure 2.8-9. Average Trichloroethylene Concentrations in 200 West Area, Top of Unconfined Aquifer

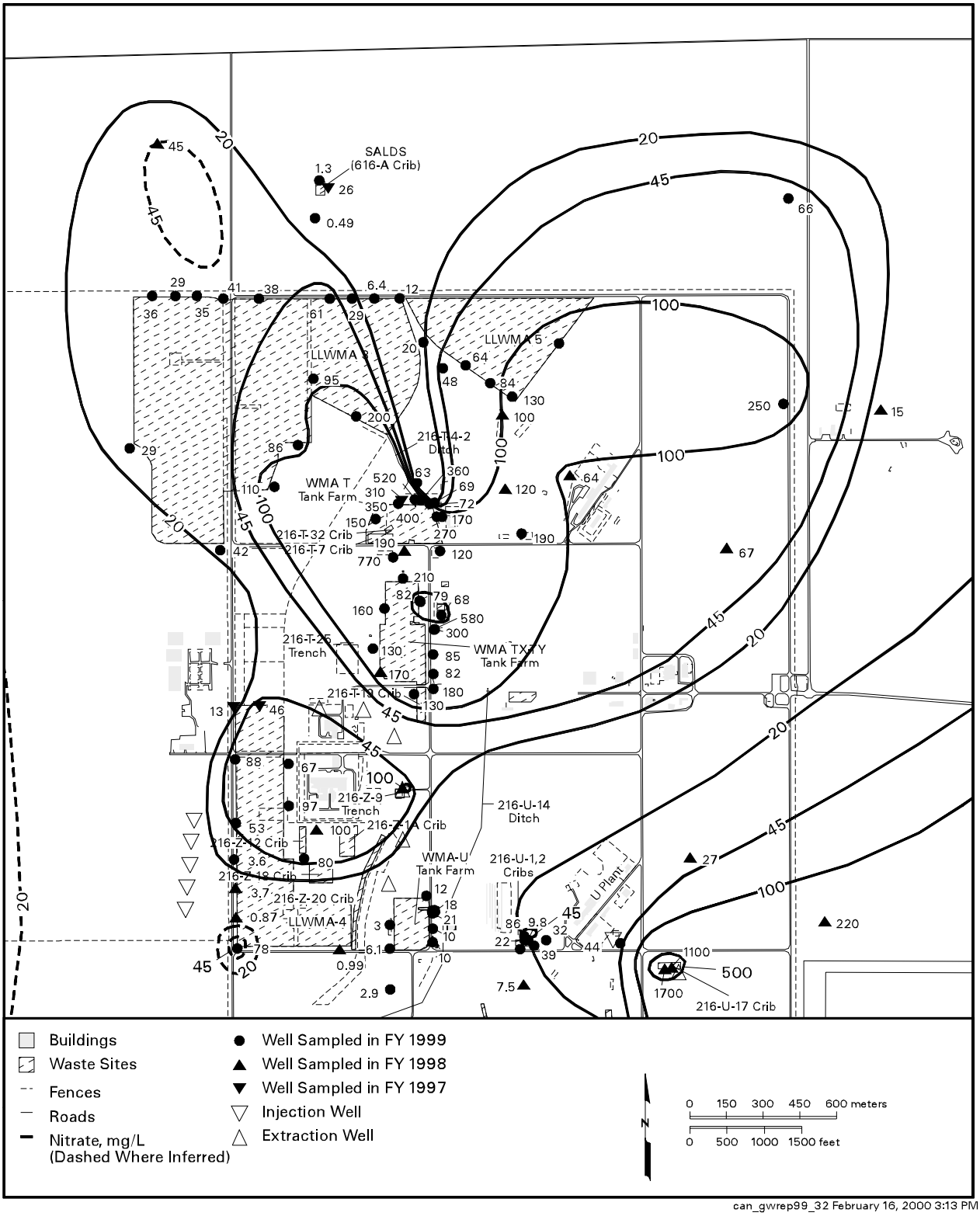

Figure 2.8-10. Average Nitrate Concentrations in the Western and Northern 200 West Area, Top of Unconfined Aquifer

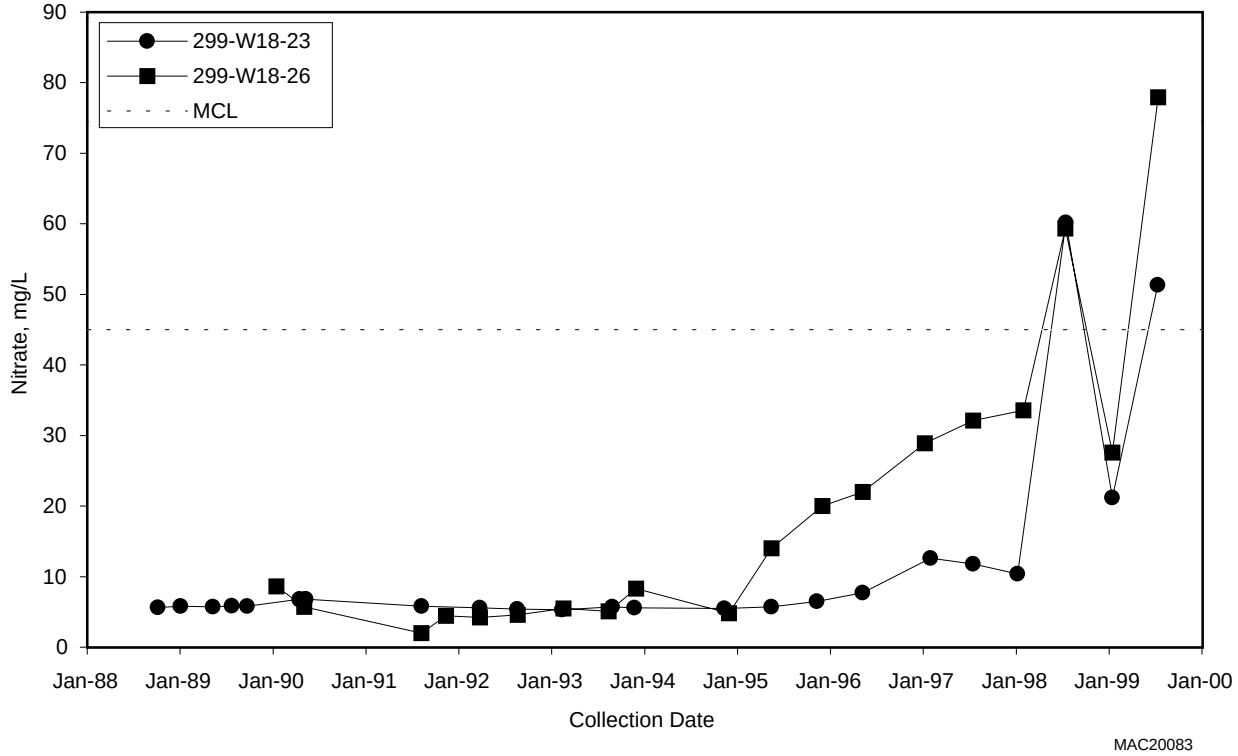

Figure 2.8-11. Nitrate in Wells 299-W18-23 and 299-W18-26, Western 200 West Area

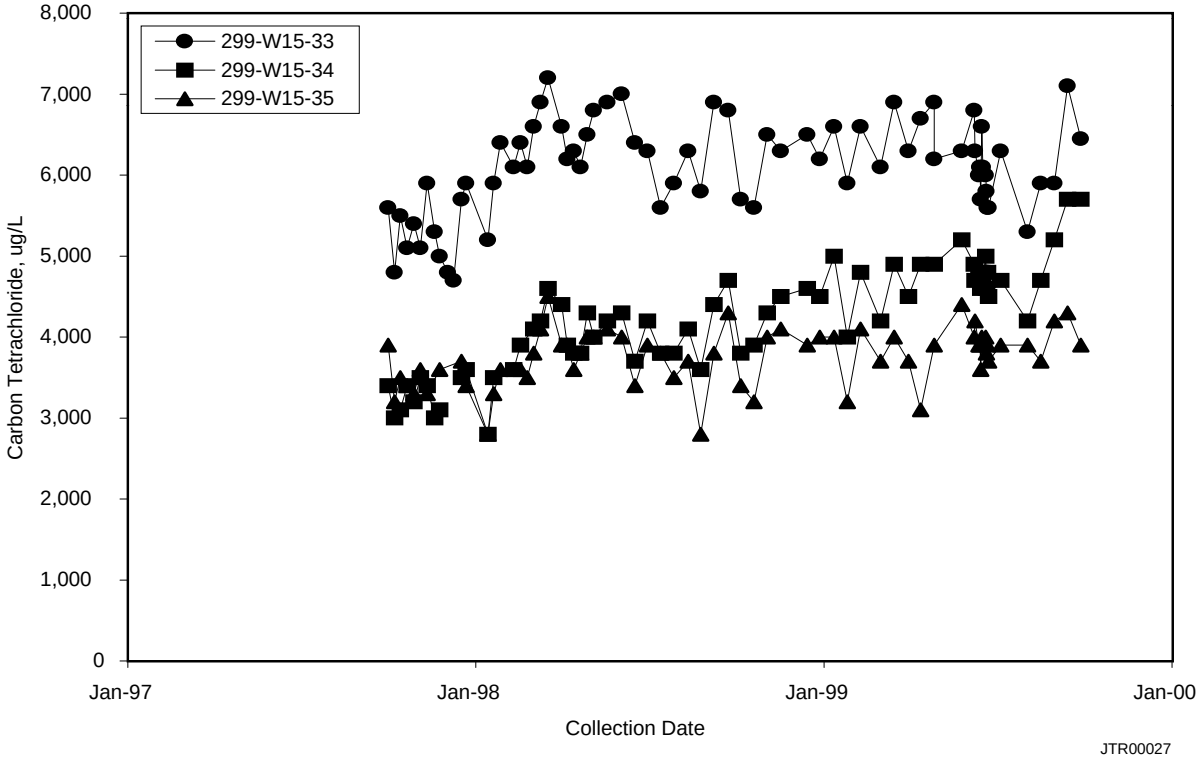

Figure 2.8-12. Carbon Tetrachloride in Northern Extraction Wells for 200-ZP-1 Pump-and-Treat System

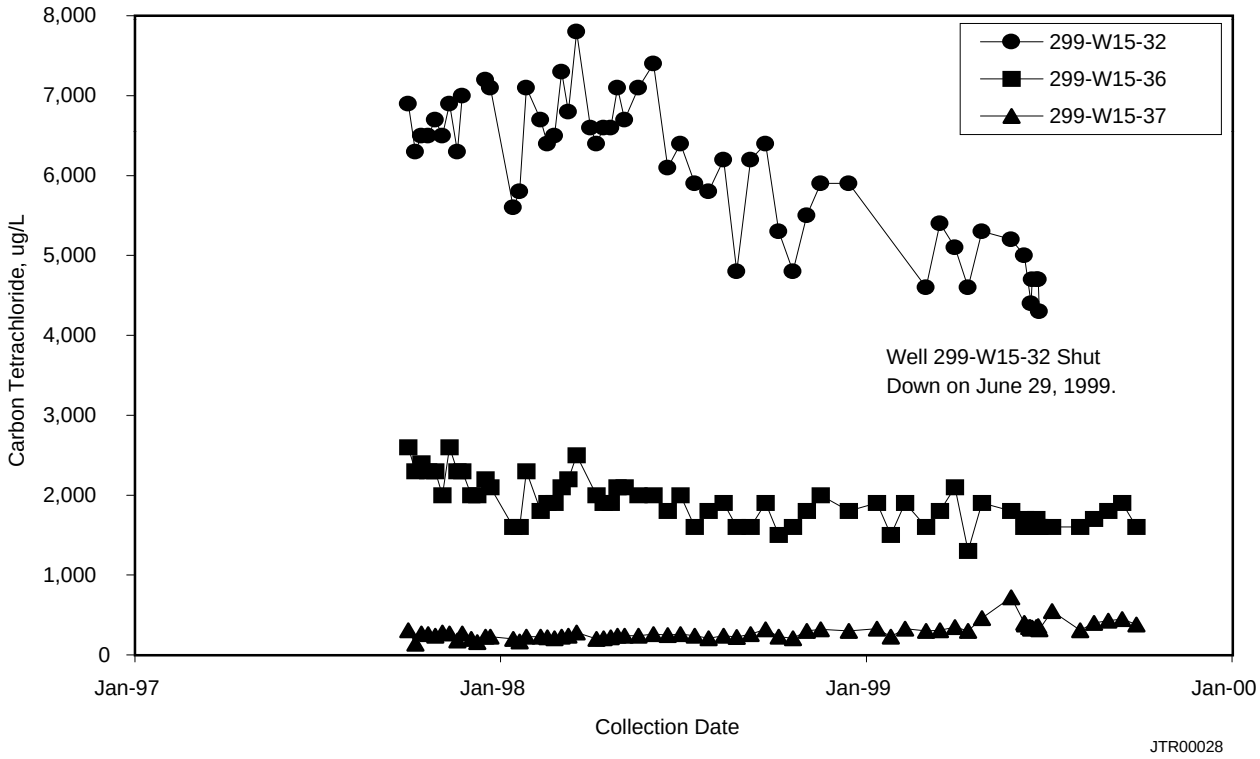

Figure 2.8-13. Carbon Tetrachloride in Southern Extraction Wells for 200-ZP-1 Pump-and-Treat System

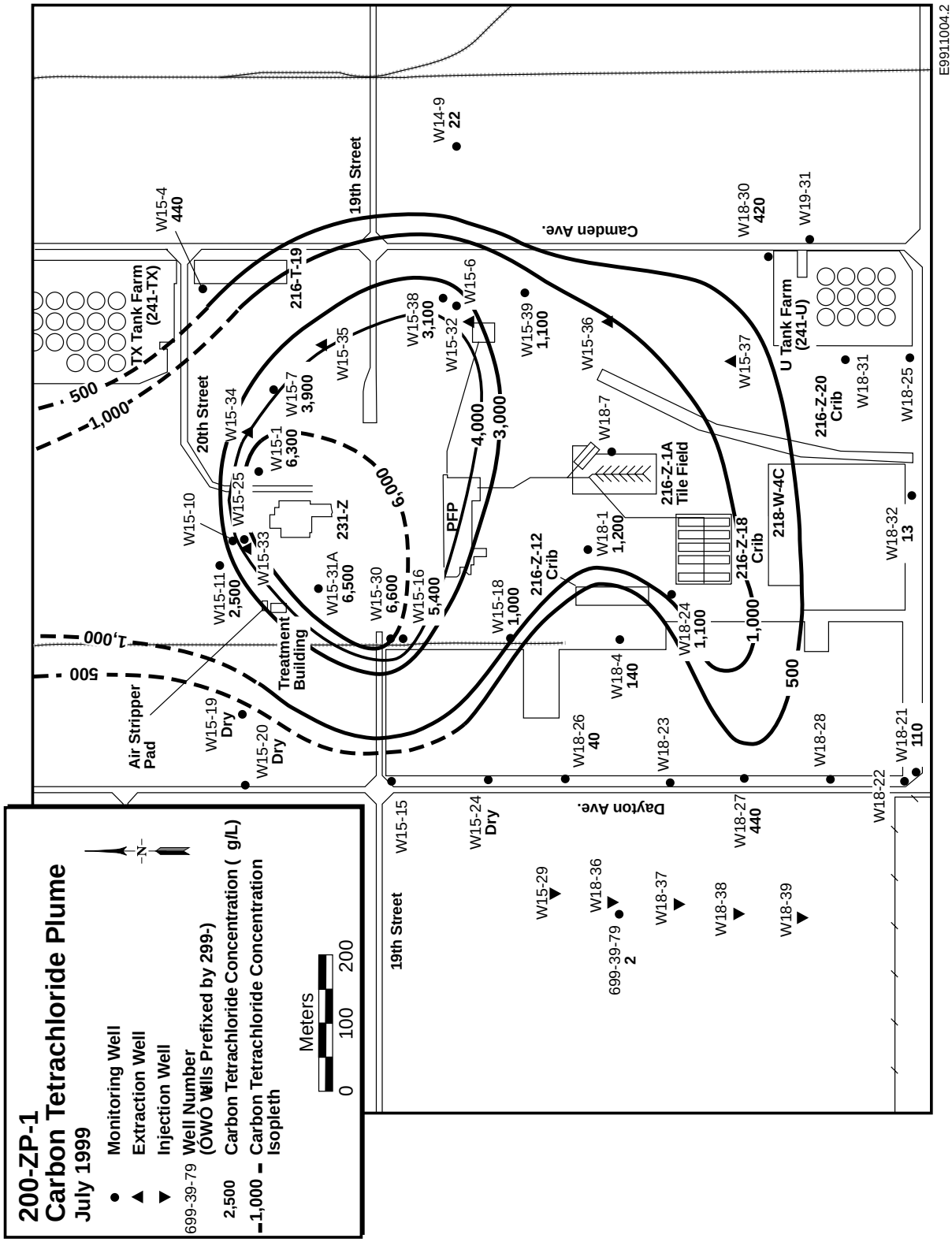

Figure 2.8-14. 200-ZP-1 Carbon Tetrachloride Remediation Area Plume, July 1999 (DOE/RL-99-79)

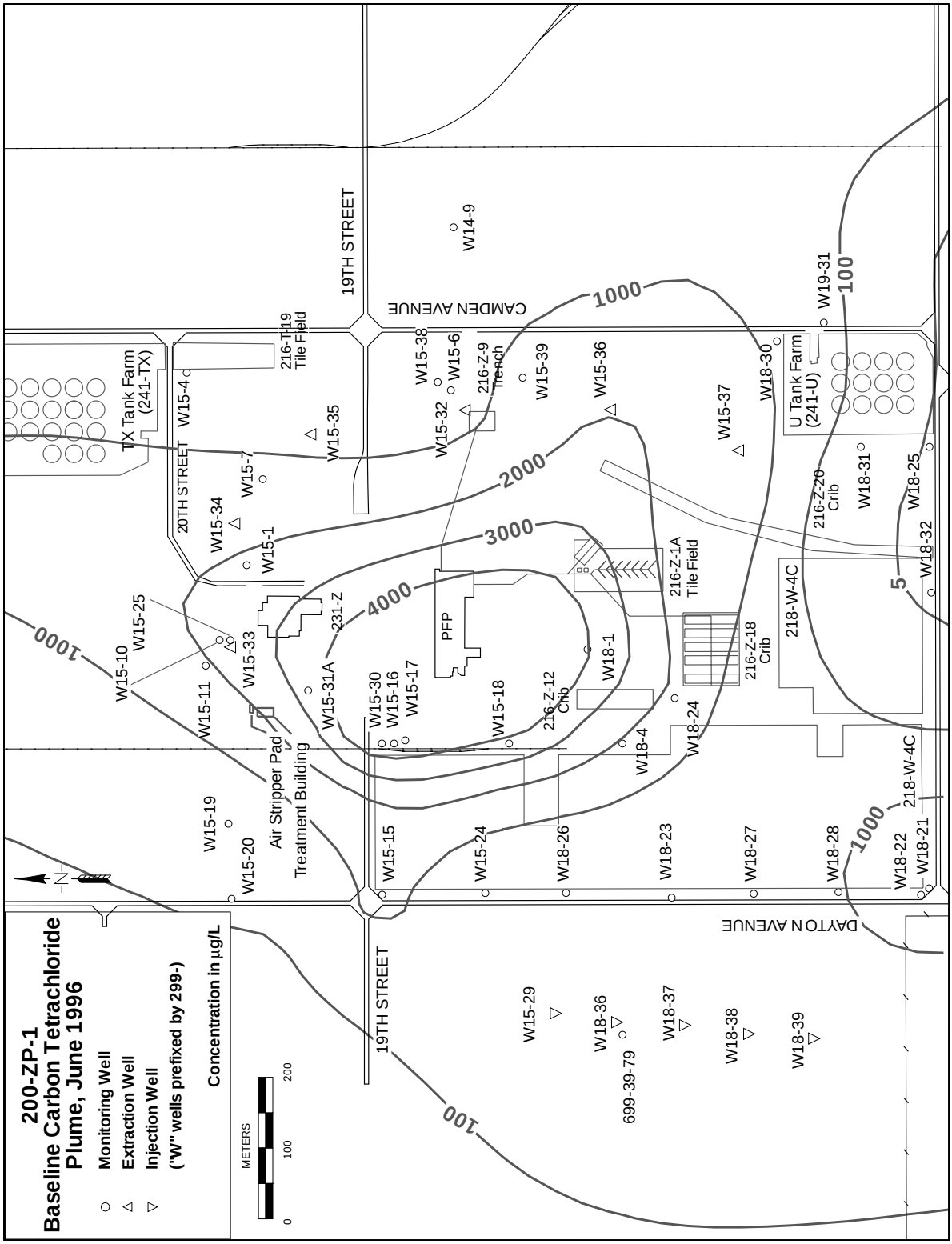

Figure 2.8-15. 200-ZP-1 Carbon Tetrachloride Baseline Plume for the Remediation Area, June 1996 (DOE/RL-99-79)

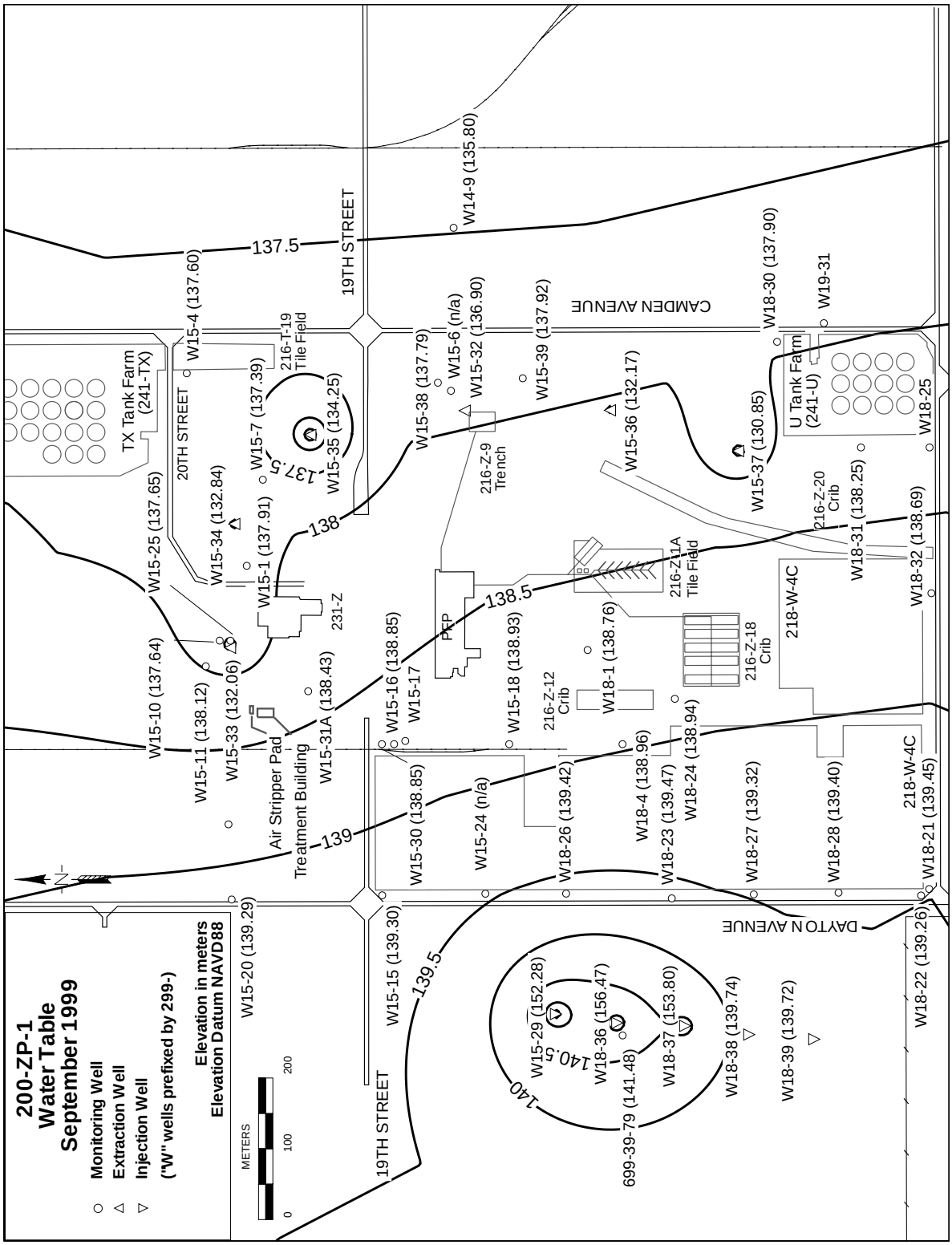

Figure 2.8-16. Water Table for September 1999, Vicinity of the 200-ZP-1 Remediation (DOE/RL-99-79)

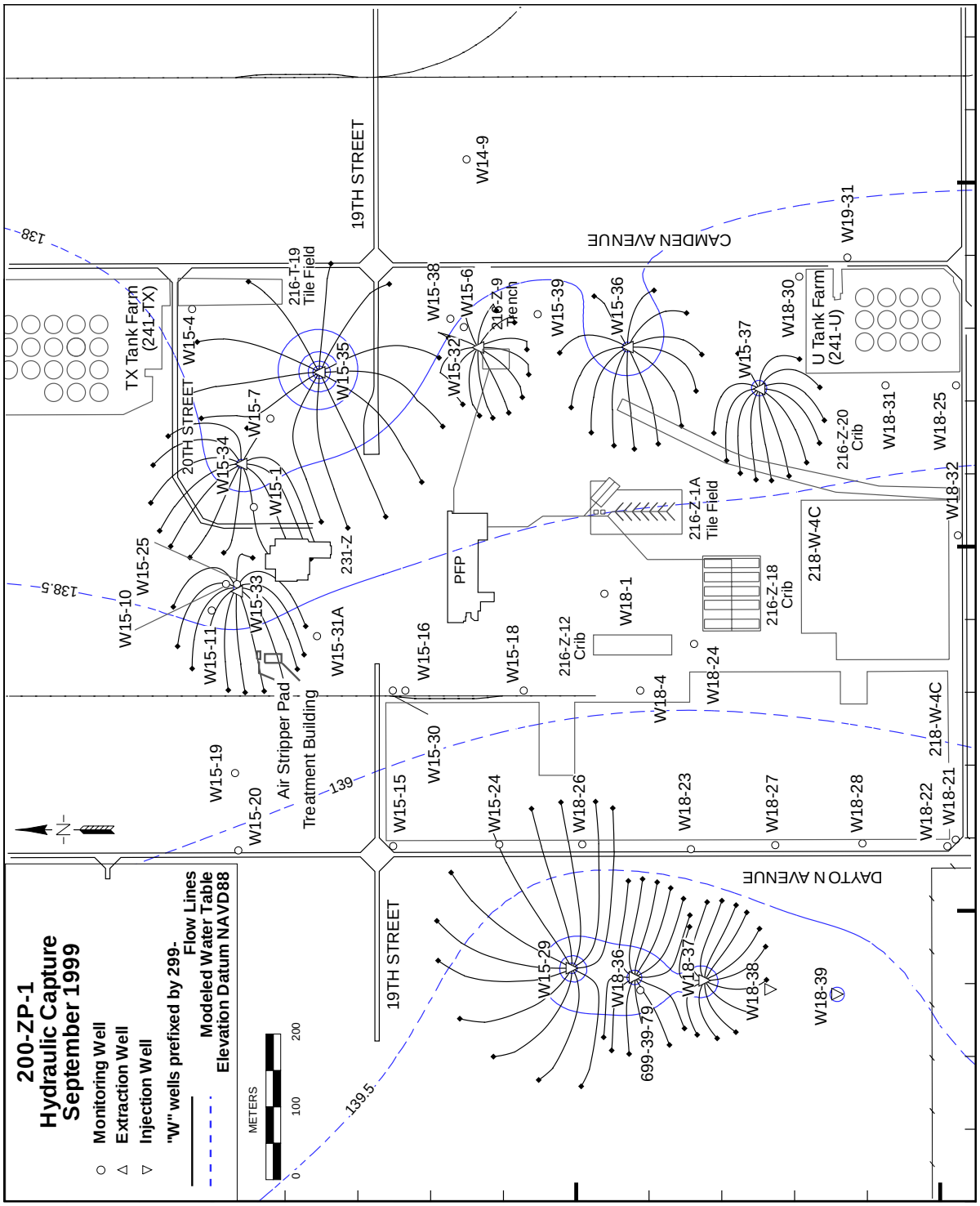

Figure 2.8-17. 200-ZP-1 Pump-and-Treat System Estimated Area of Hydraulic Capture as of September 1999 (DOE/RL-99-79)

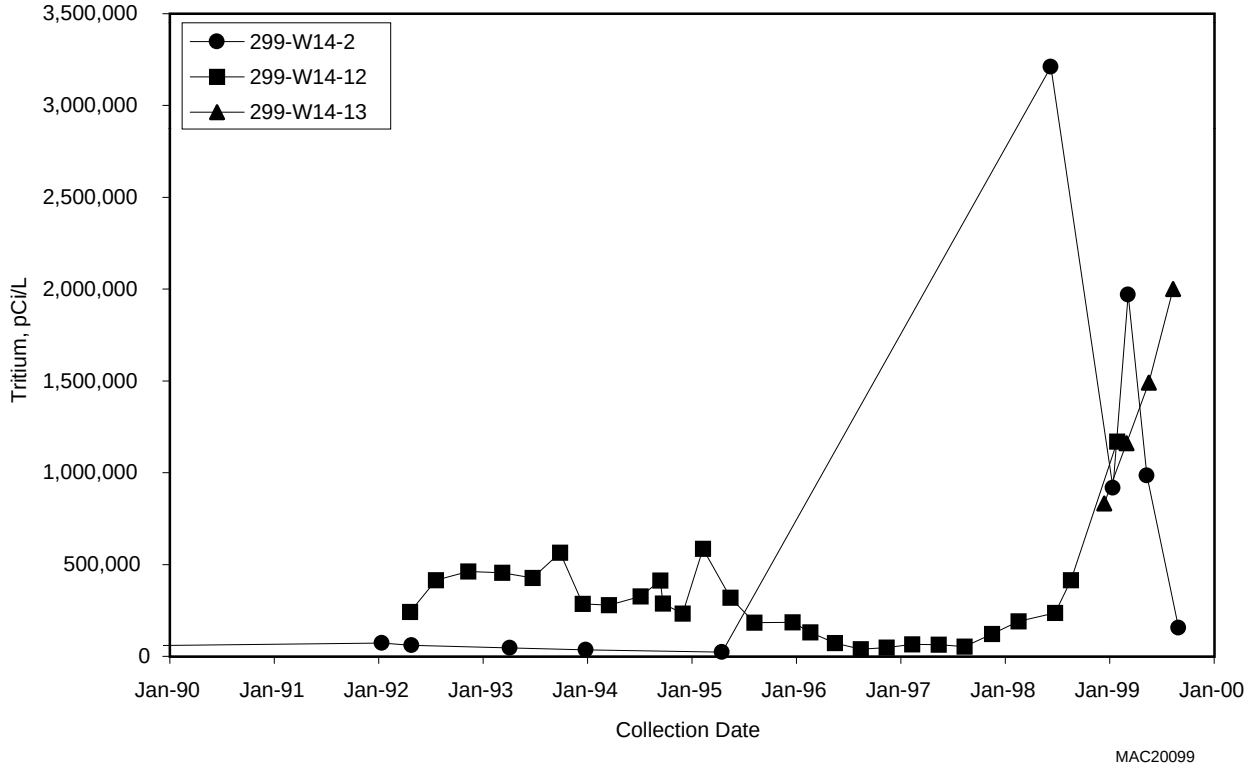

Figure 2.8-18. Tritium in Wells 299-W14-2, 299-W14-12, and 299-W14-13, East of TY Tank Farm

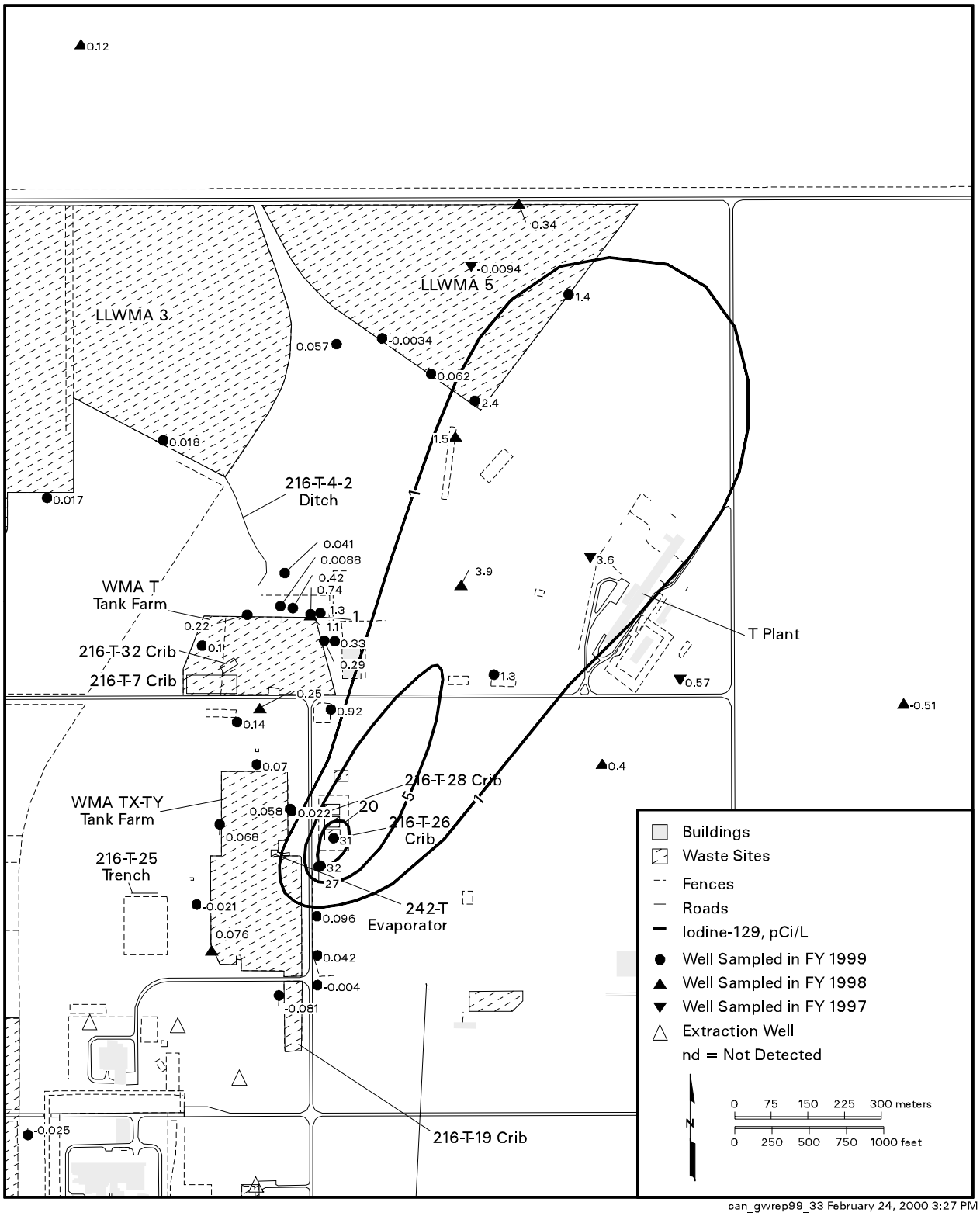

Figure 2.8-19. Average Iodine-129 Concentrations in Northern 200 West Area, Top of Unconfined Aquifer

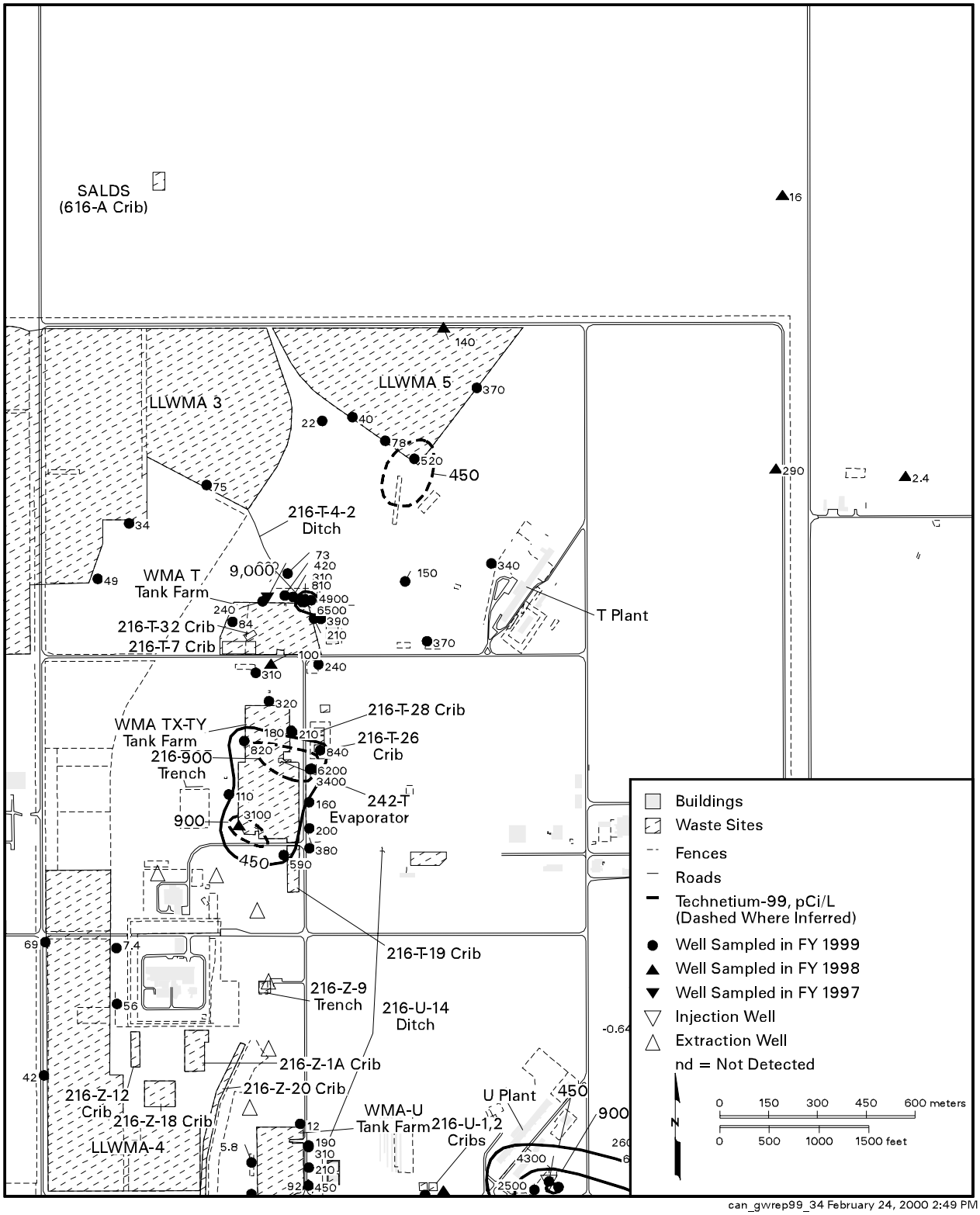

Figure 2.8-20. Average Technetium-99 Concentrations in Northern 200 West Area, Top of Unconfined Aquifer

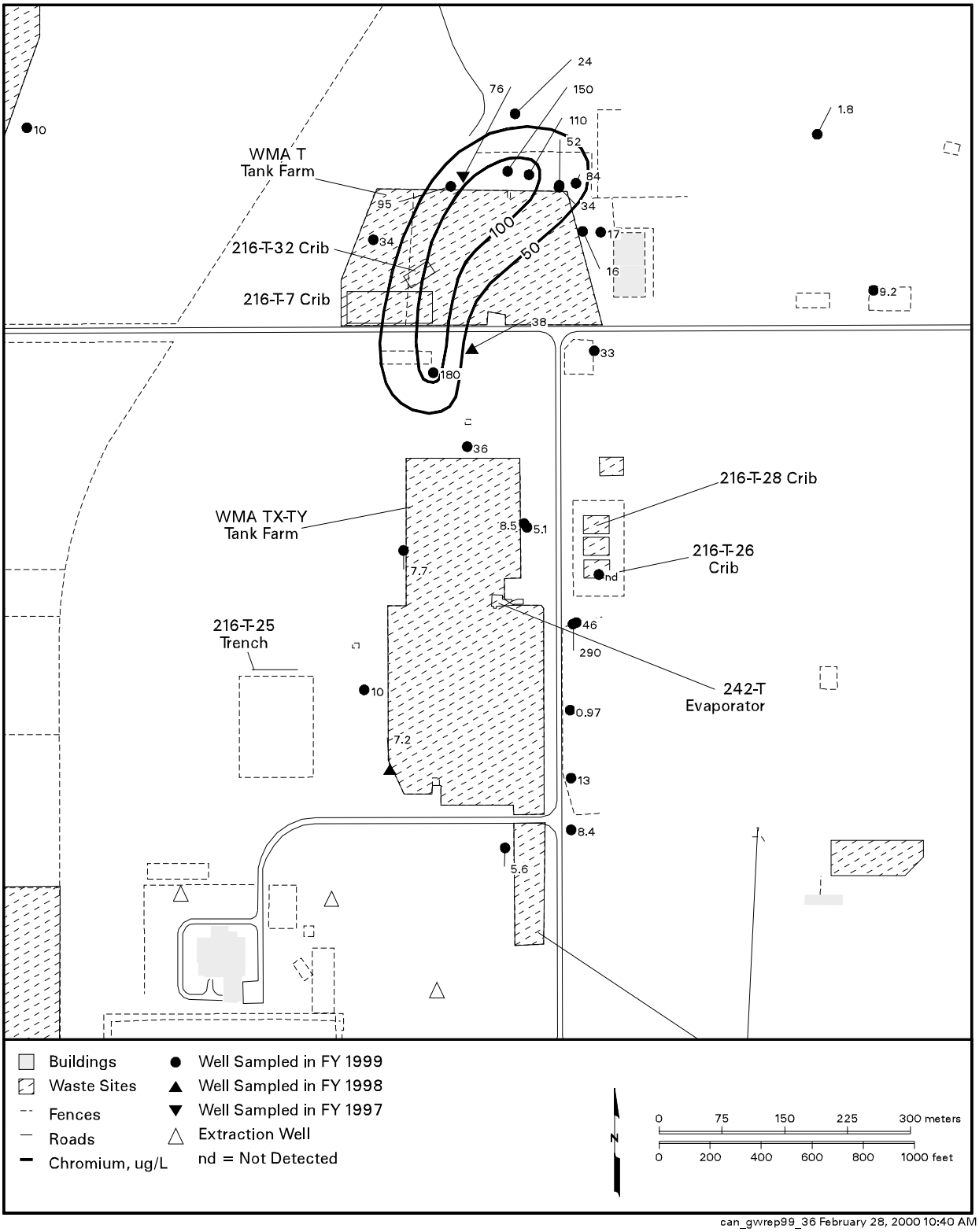

Figure 2.8-21. Average Filtered Chromium Concentrations Near Waste Management Areas T and TX-TY, Top of Unconfined Aquifer

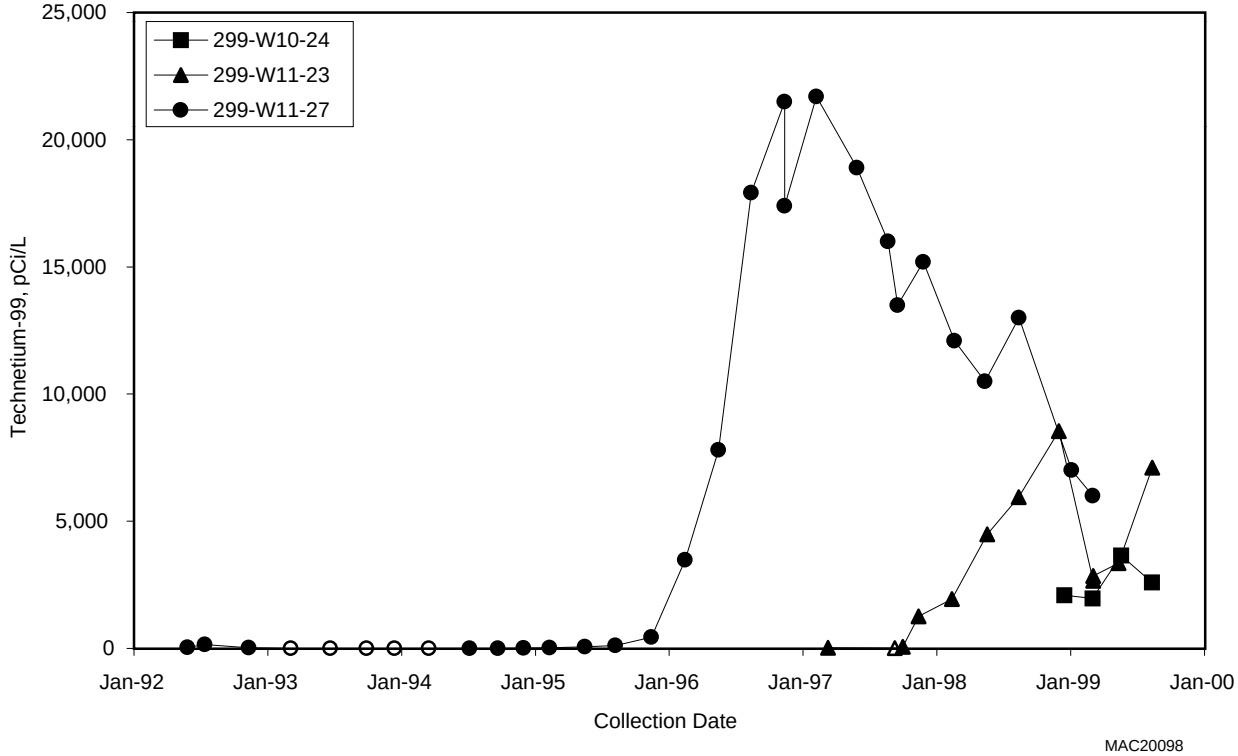

Figure 2.8-22. Technetium-99 in Wells 299-W11-27, 299-W11-23, and 299-W10-24, North of T Tank Farm

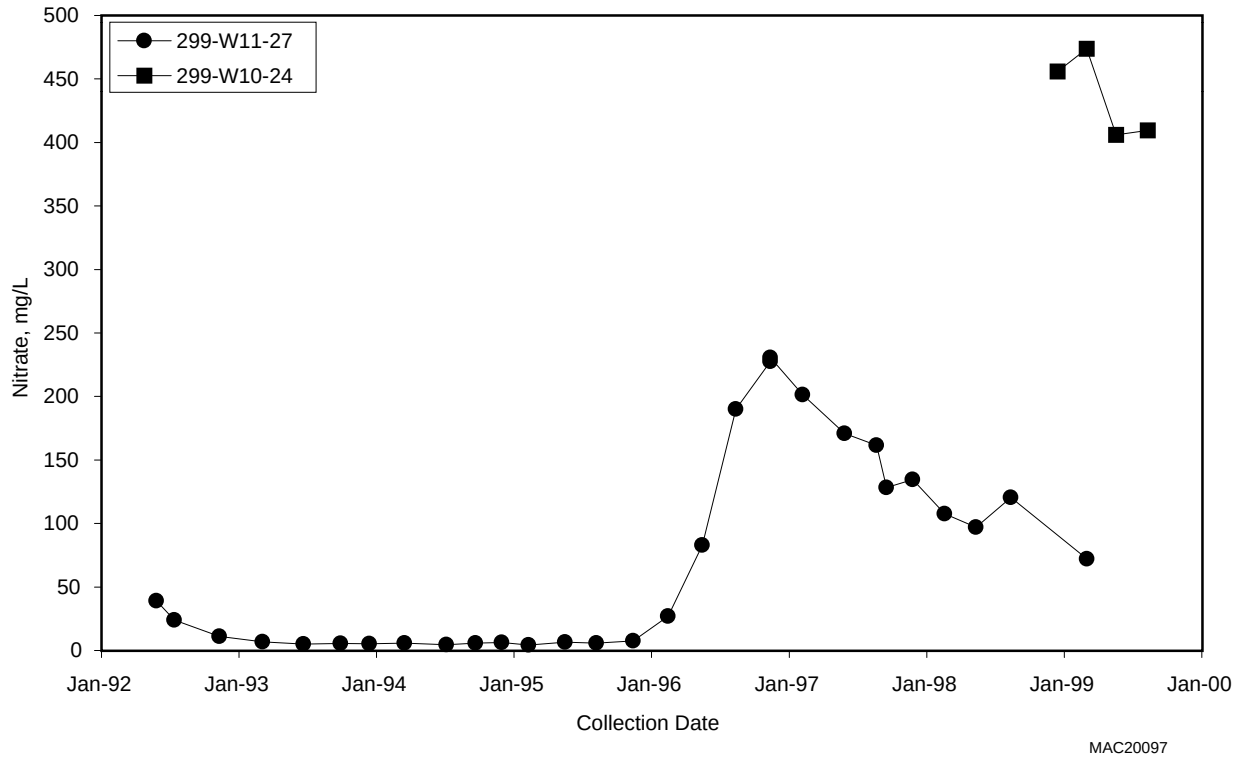

Figure 2.8-23. Nitrate in Wells 299-W11-27 and 299-W10-24, North of T Tank Farm

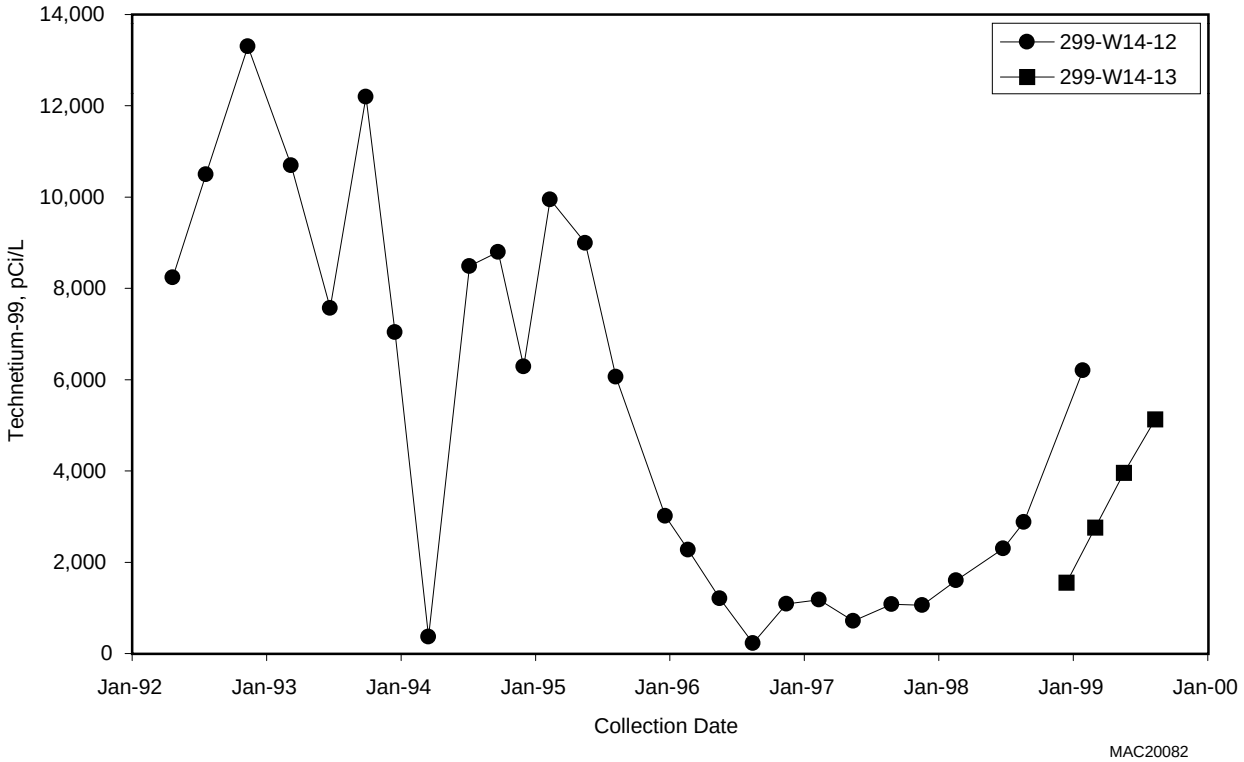

Figure 2.8-24. Technetium-99 in Wells 299-W14-12 and 299-W14-13, East of TX-TY Tank Farms

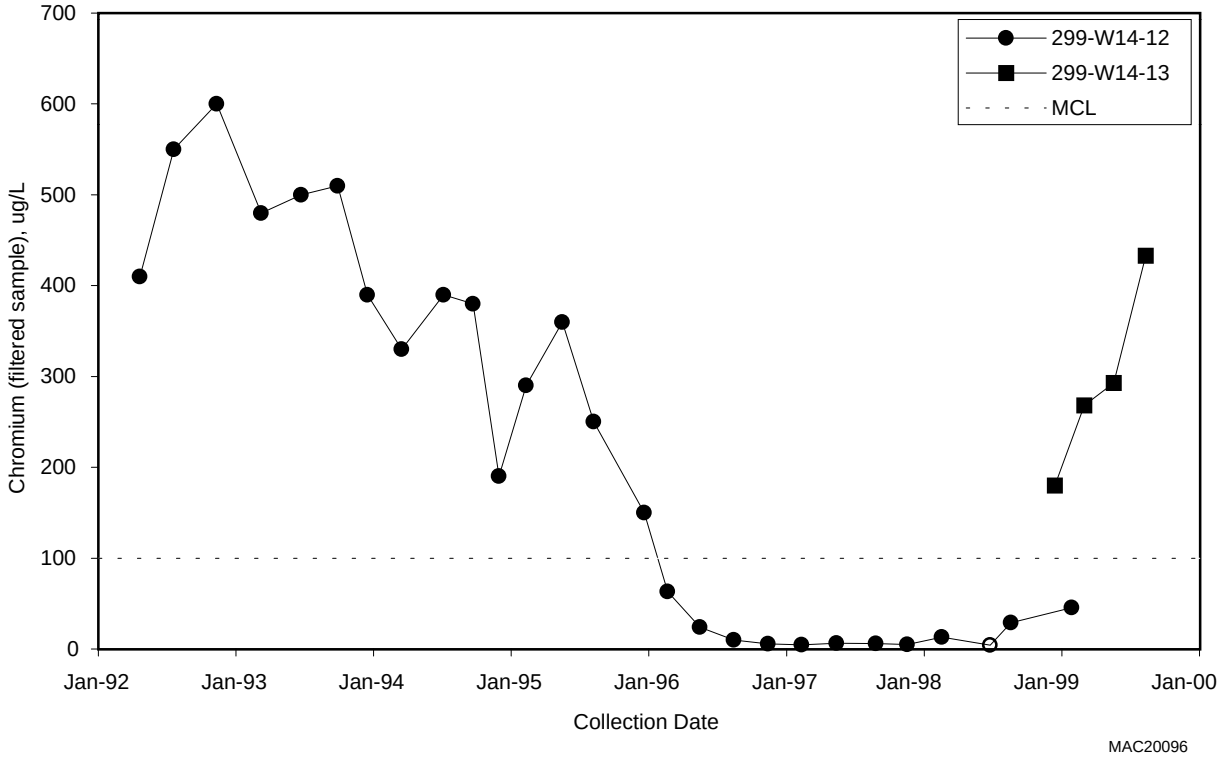

Figure 2.8-25. Chromium in Wells 299-W14-12 and 299-W14-13, East of TX-TY Tank Farms

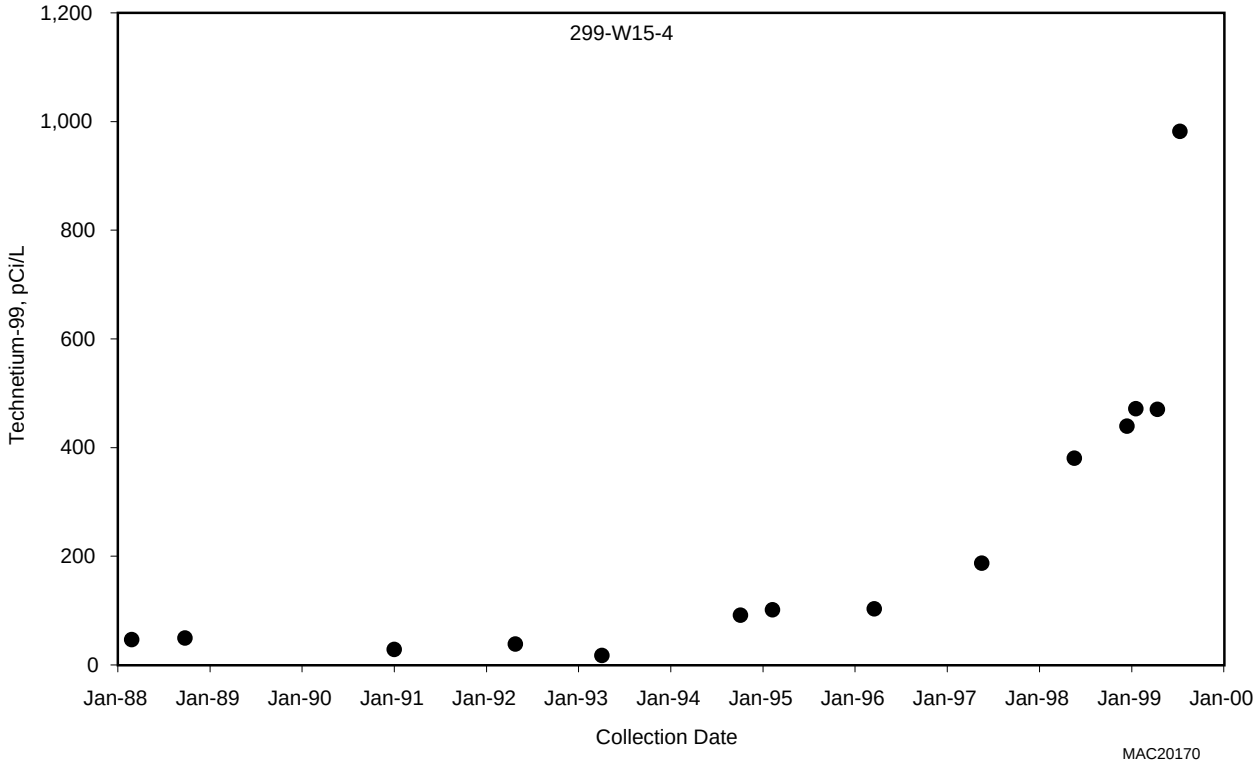

Figure 2.8-26. Technetium-99 in Well 299-W15-4, South of TX-TY Tank Farms

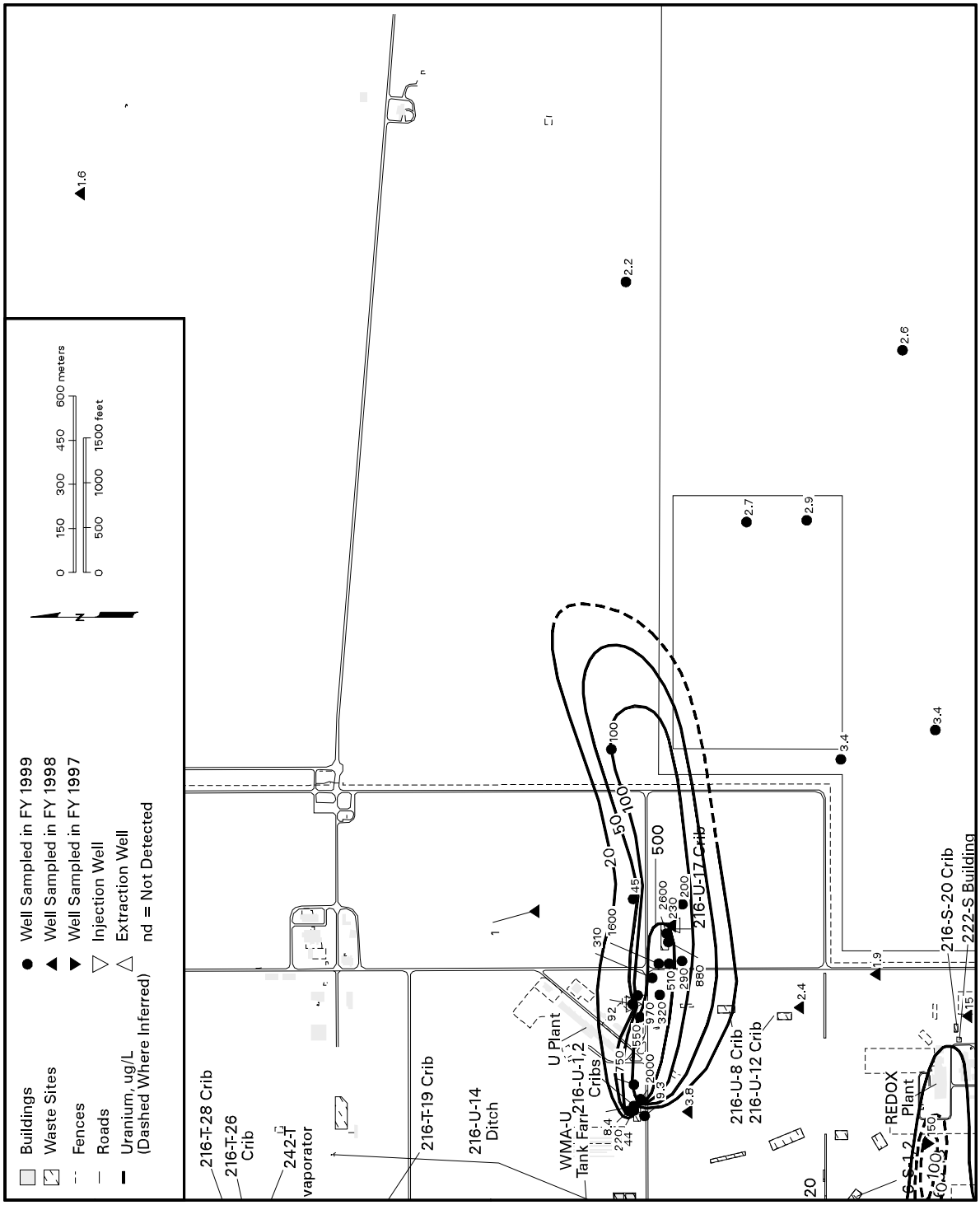

Figure 2.8-27. Average Uranium Concentrations in Eastern 200 West Area, Top of Unconfined Aquifer

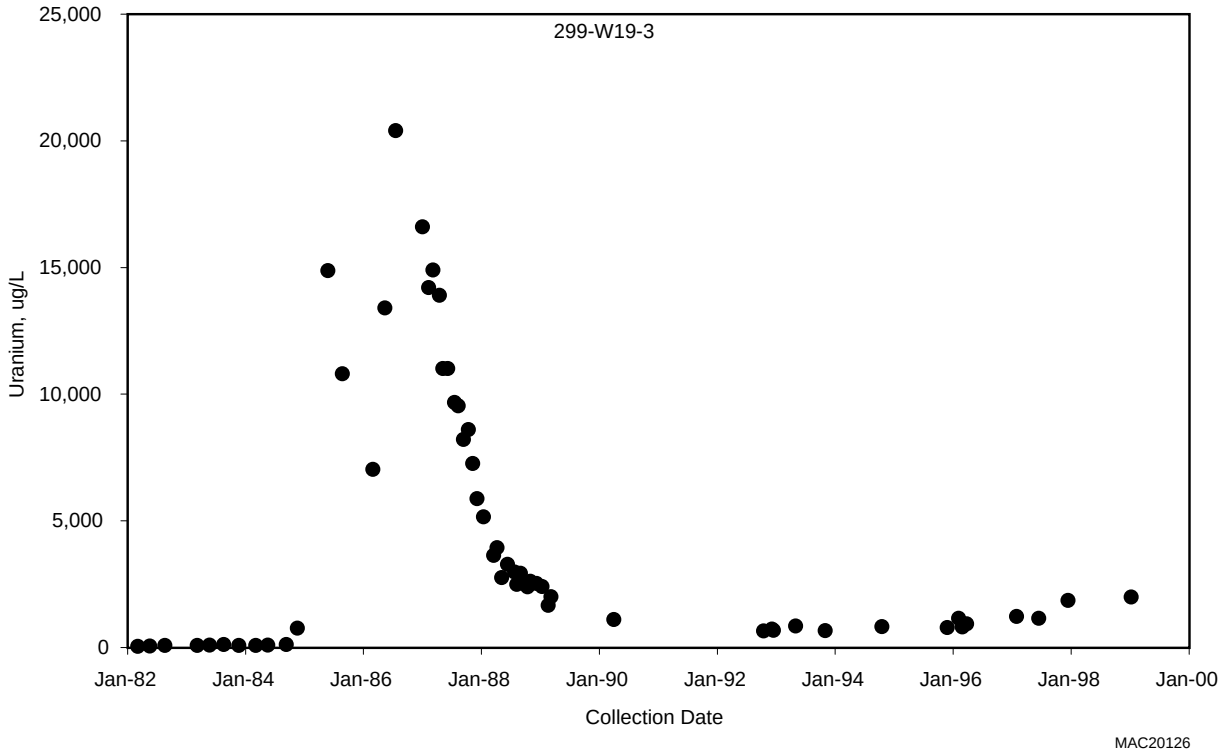

Figure 2.8-28. Uranium in Well 299-W19-3 Near the 216-U-1 and 216-U-2 Cribs

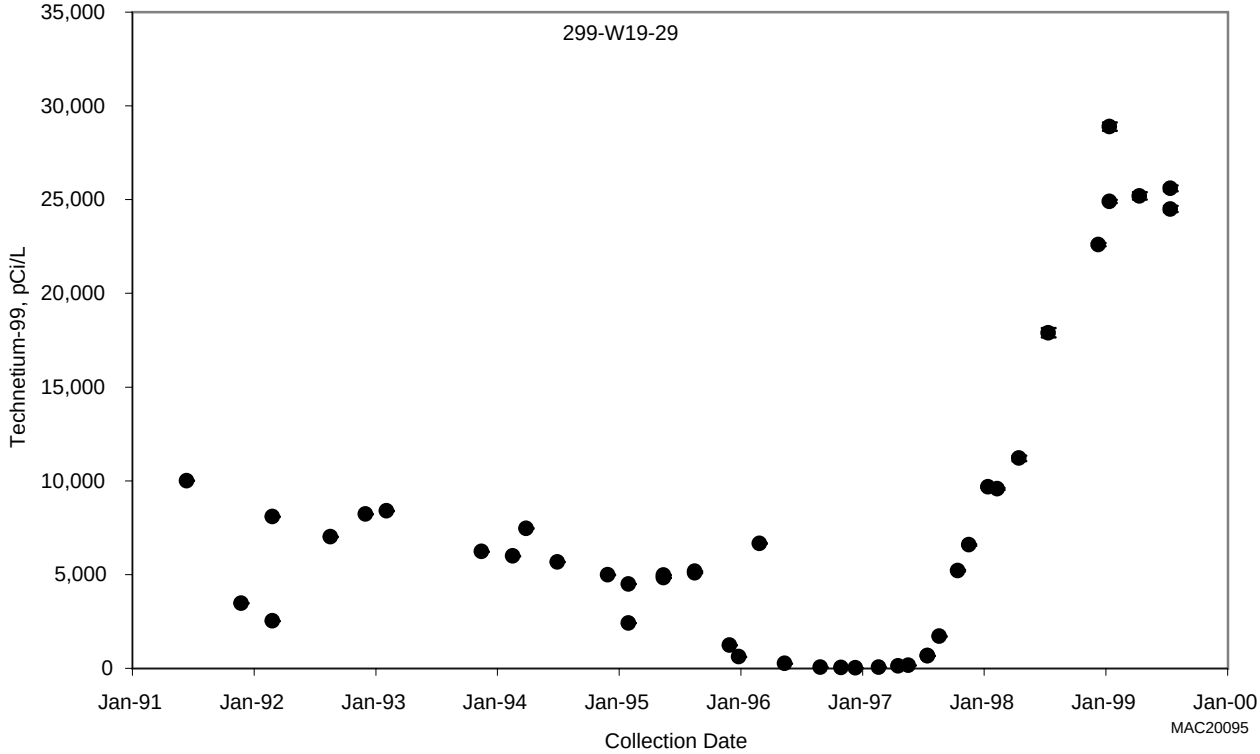

Figure 2.8-29. Technetium-99 in Well 299-W19-29 Near U Plant

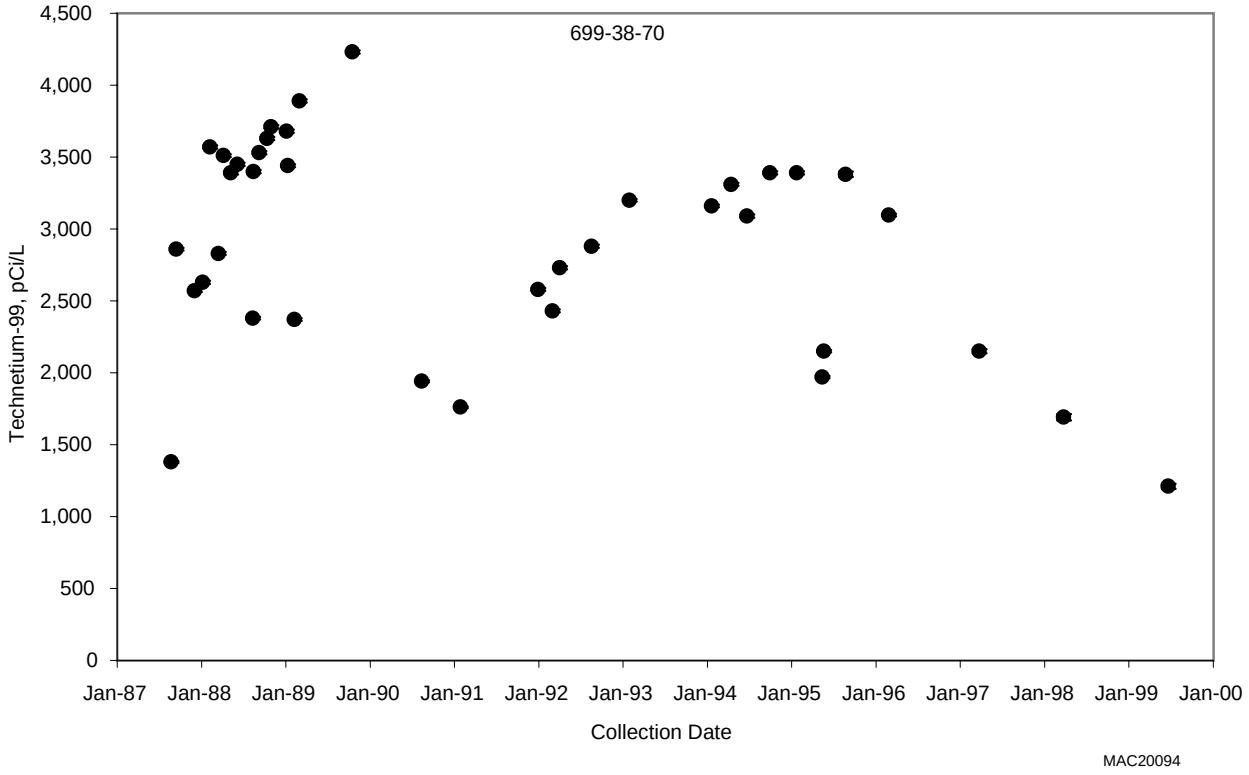

Figure 2.8-30. Technetium-99 in Well 699-38-70, East of U Plant

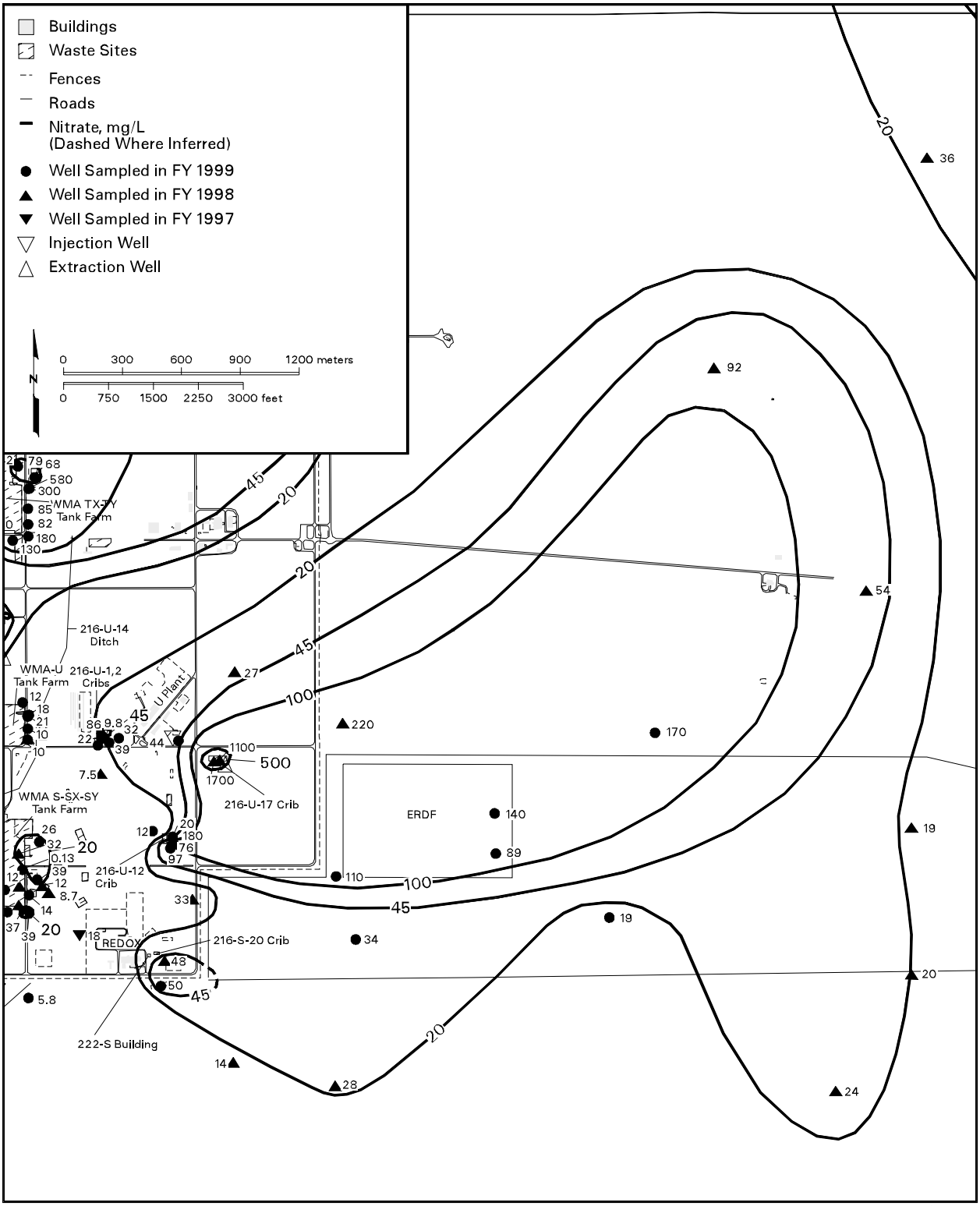

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Figure 2.8-31. Average Nitrate Concentrations in Southern and Eastern 200 West Area, Top of Unconfined Aquifer

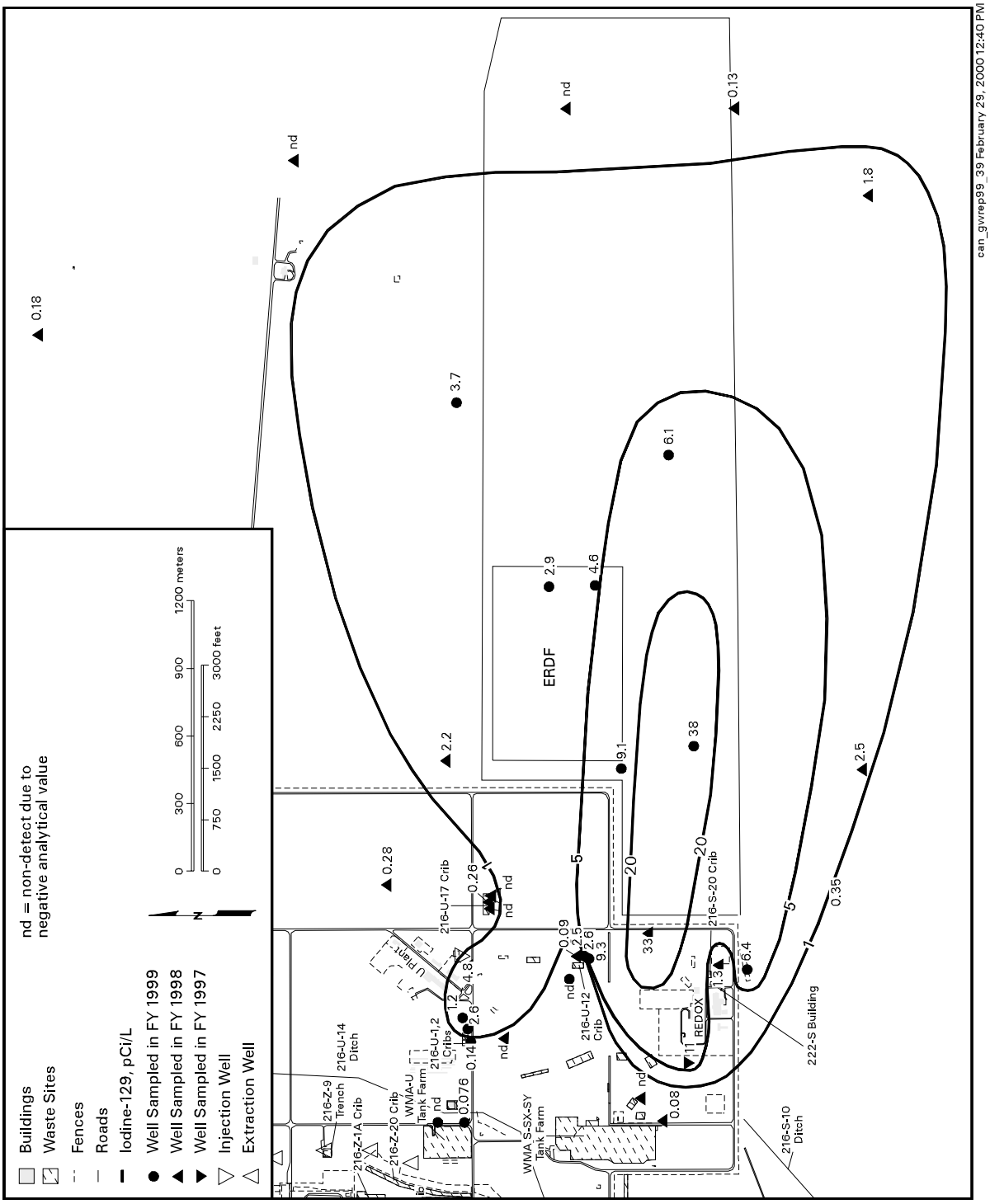

Figure 2.8-32. Average Iodine-129 Concentrations in Southern and Eastern 200 West Area, Top of Unconfined Aquifer

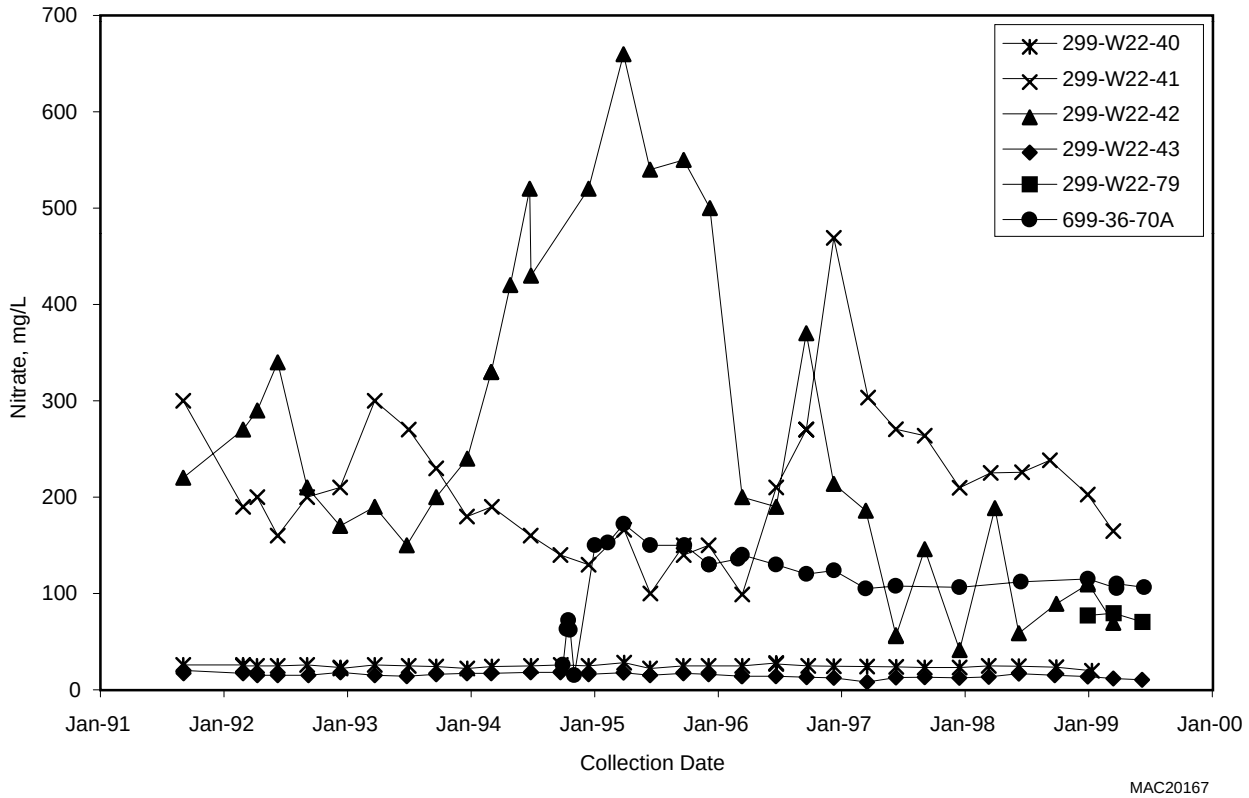

Figure 2.8-33. Nitrate in Wells Near the 216-U-12 Crib

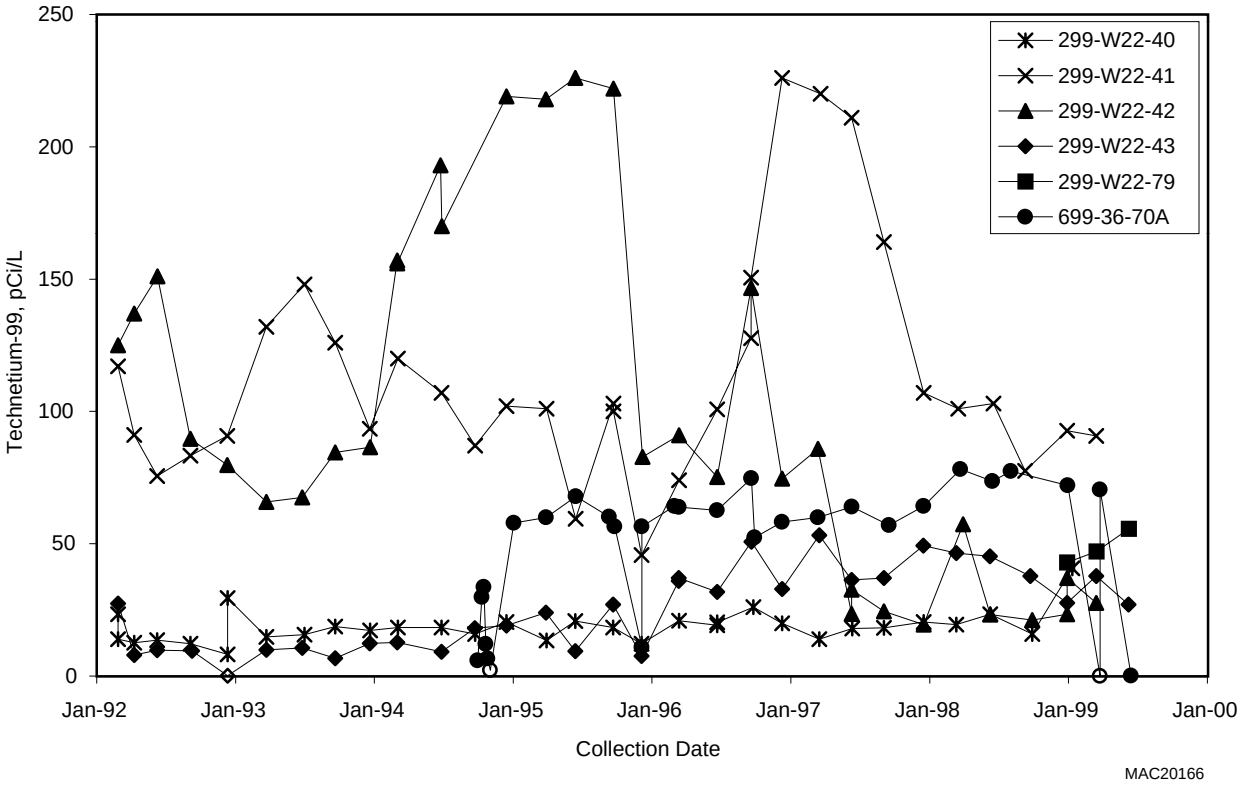

Figure 2.8-34. Technetium-99 in Wells Near the 216-U-12 Crib

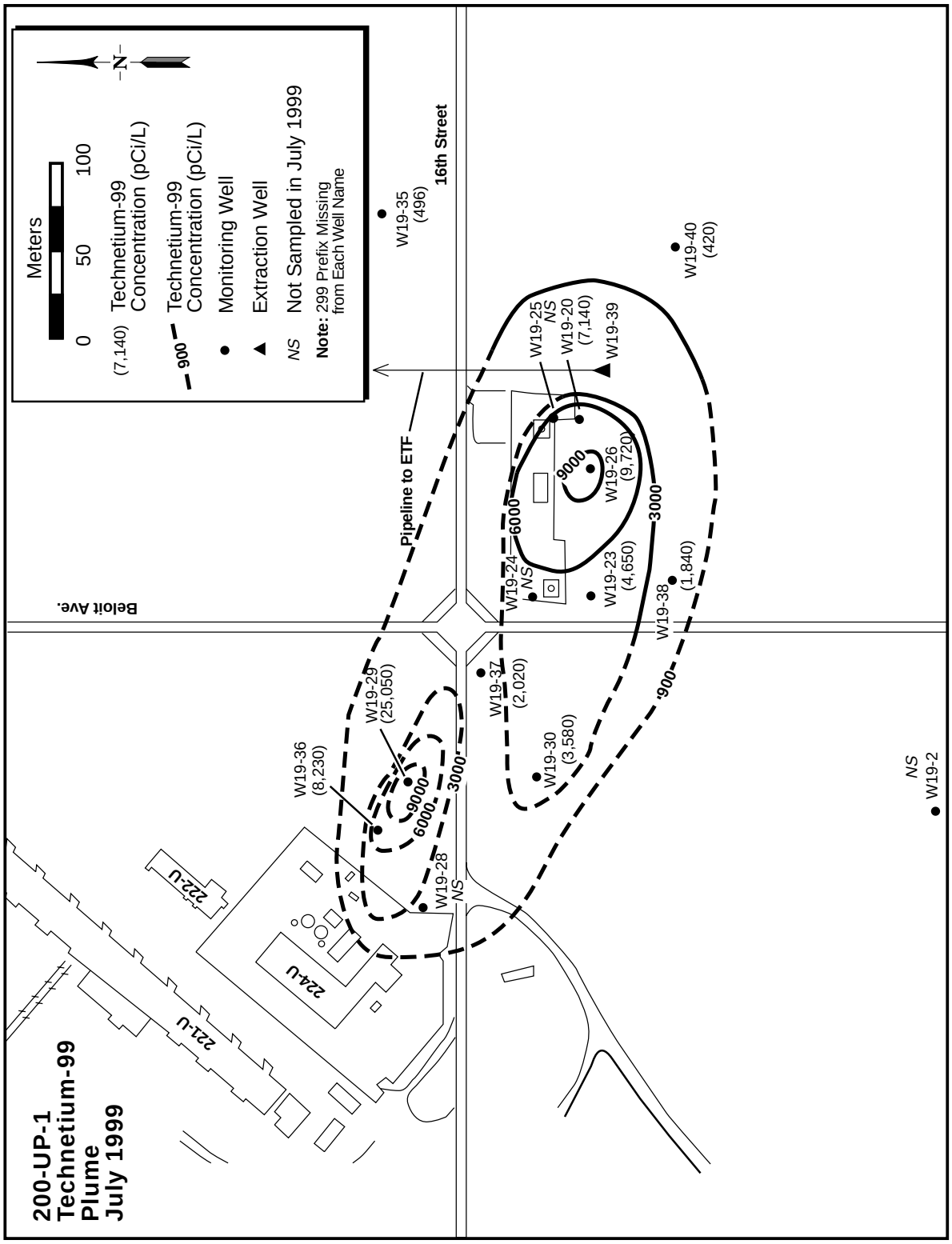

Figure 2.8-35. 200-UP-1 Technetium-99 Plume, July 1999 (DOE/RL-99-79)

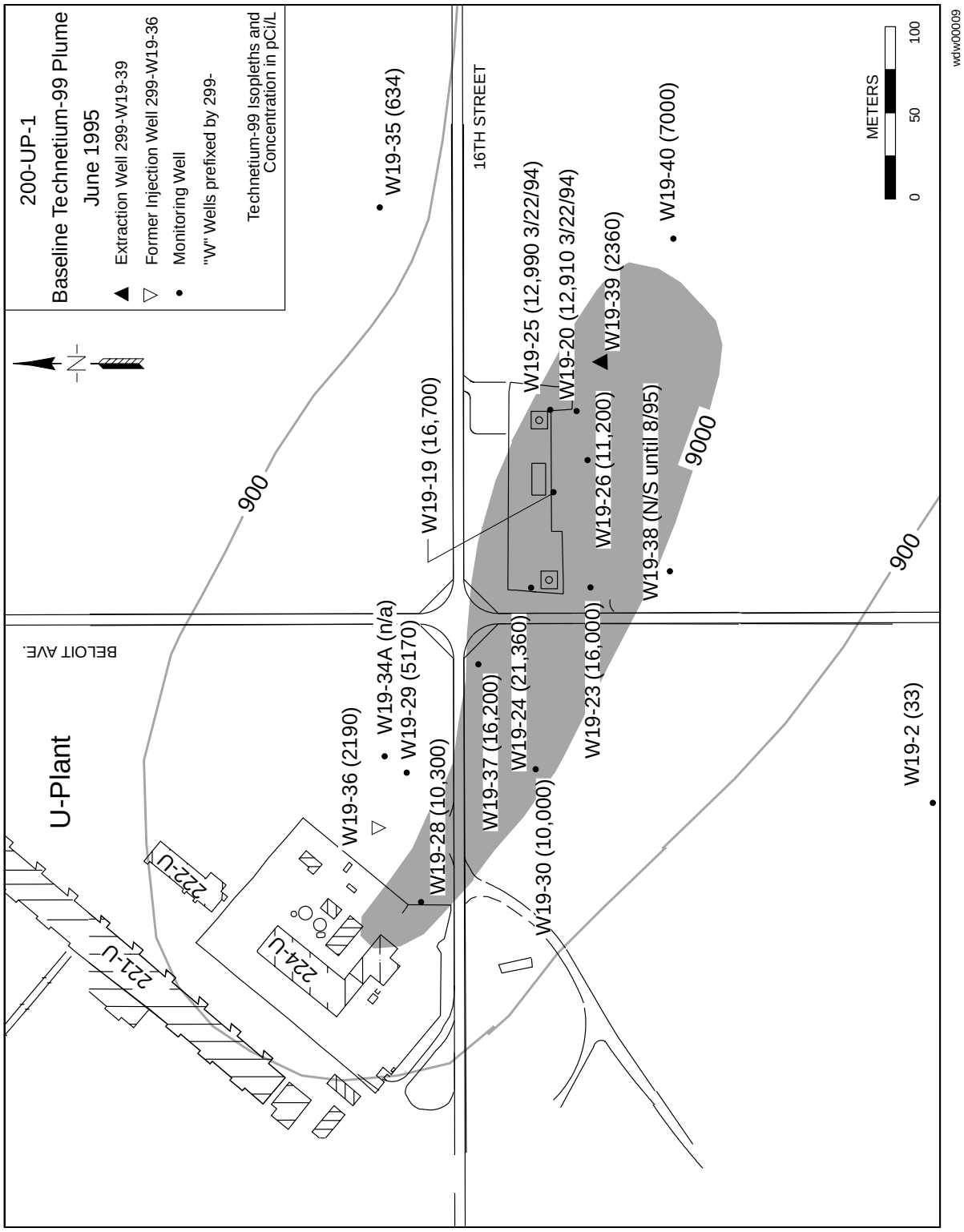

Figure 2.8-36. 200-UP-1 Technetium-99 Baseline Plume, June 1995 (DOE/RL-99-79)

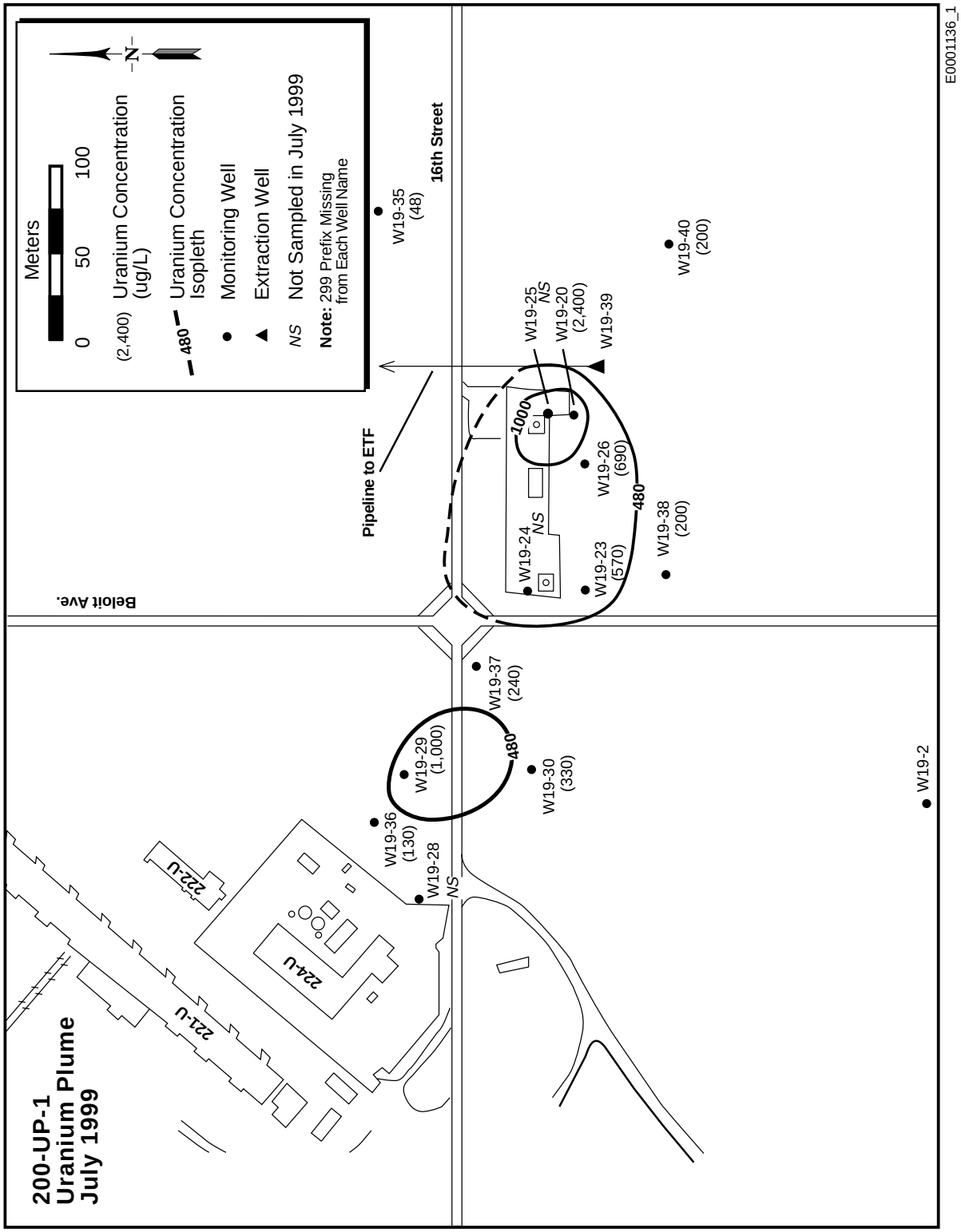

Figure 2.8-37. 200-UP-1 Uranium Plume, July 1999 (DOE/RL-99-79)

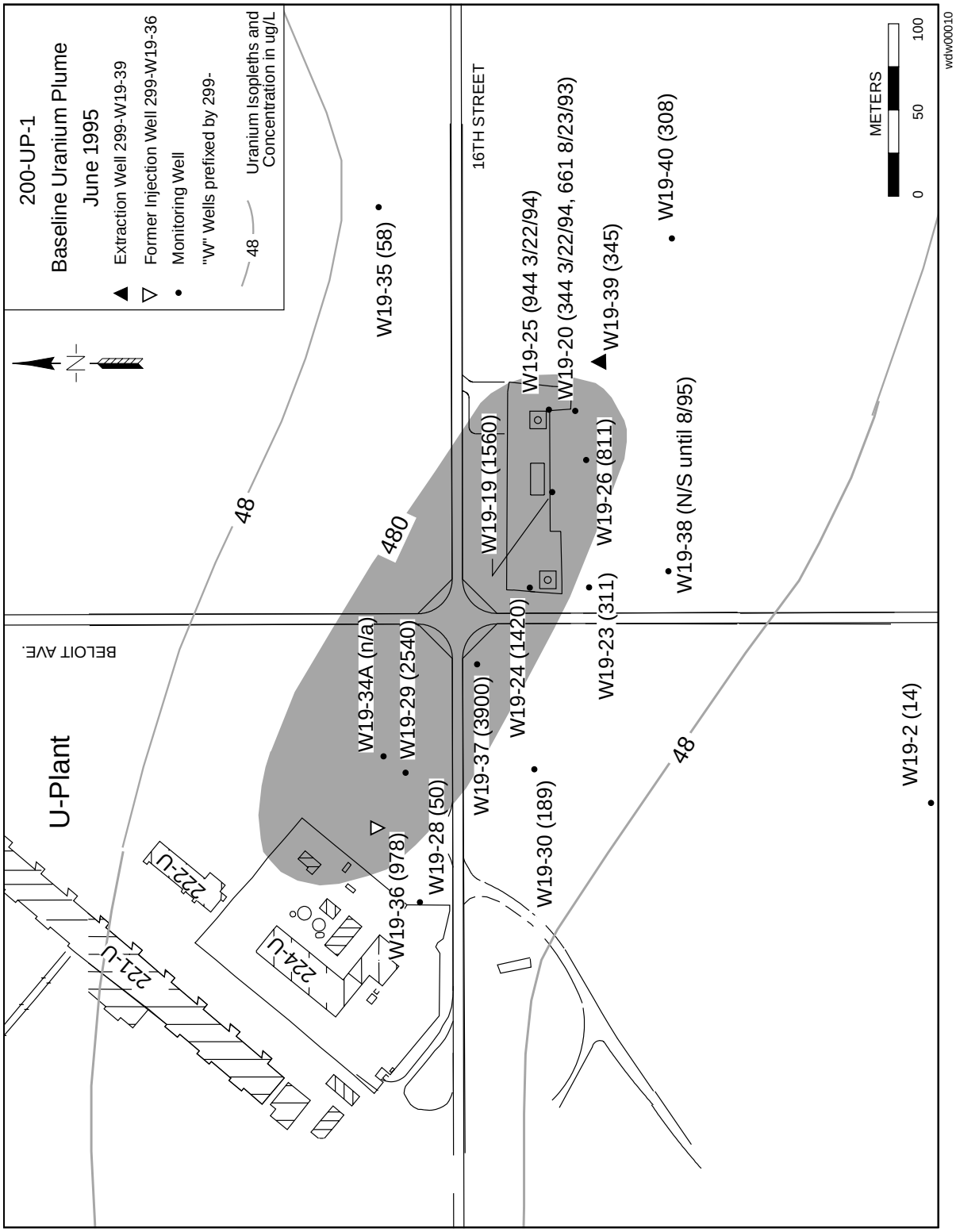

Figure 2.8-38. 200-UP-1 Uranium Baseline Plume, June 1995 (DOE/RL-99-79)

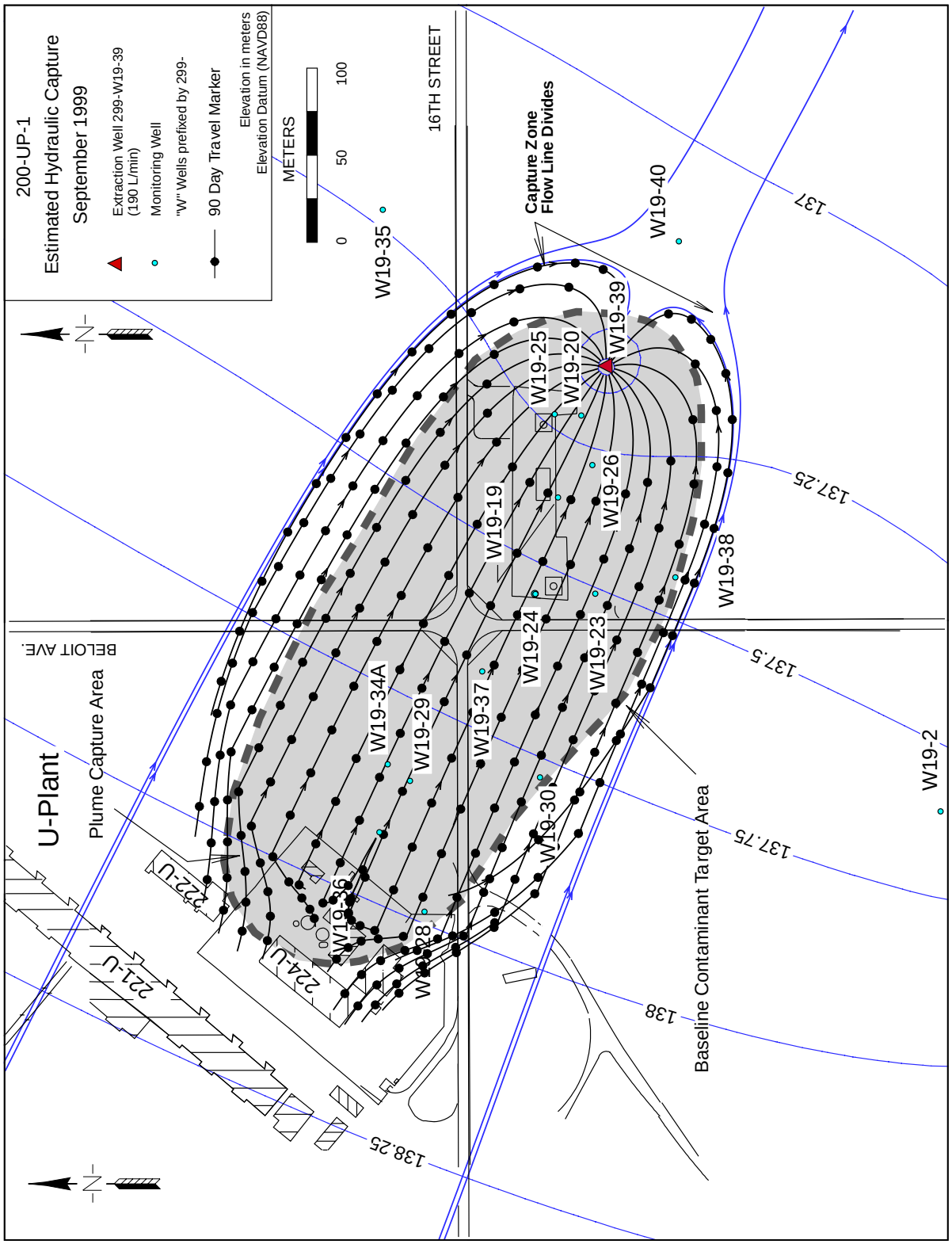

Figure 2.8-39. 200-UP-1 Pump-and-Treat System Estimated Area of Hydraulic Capture as of September 1999 (DOE/RL-99-79)

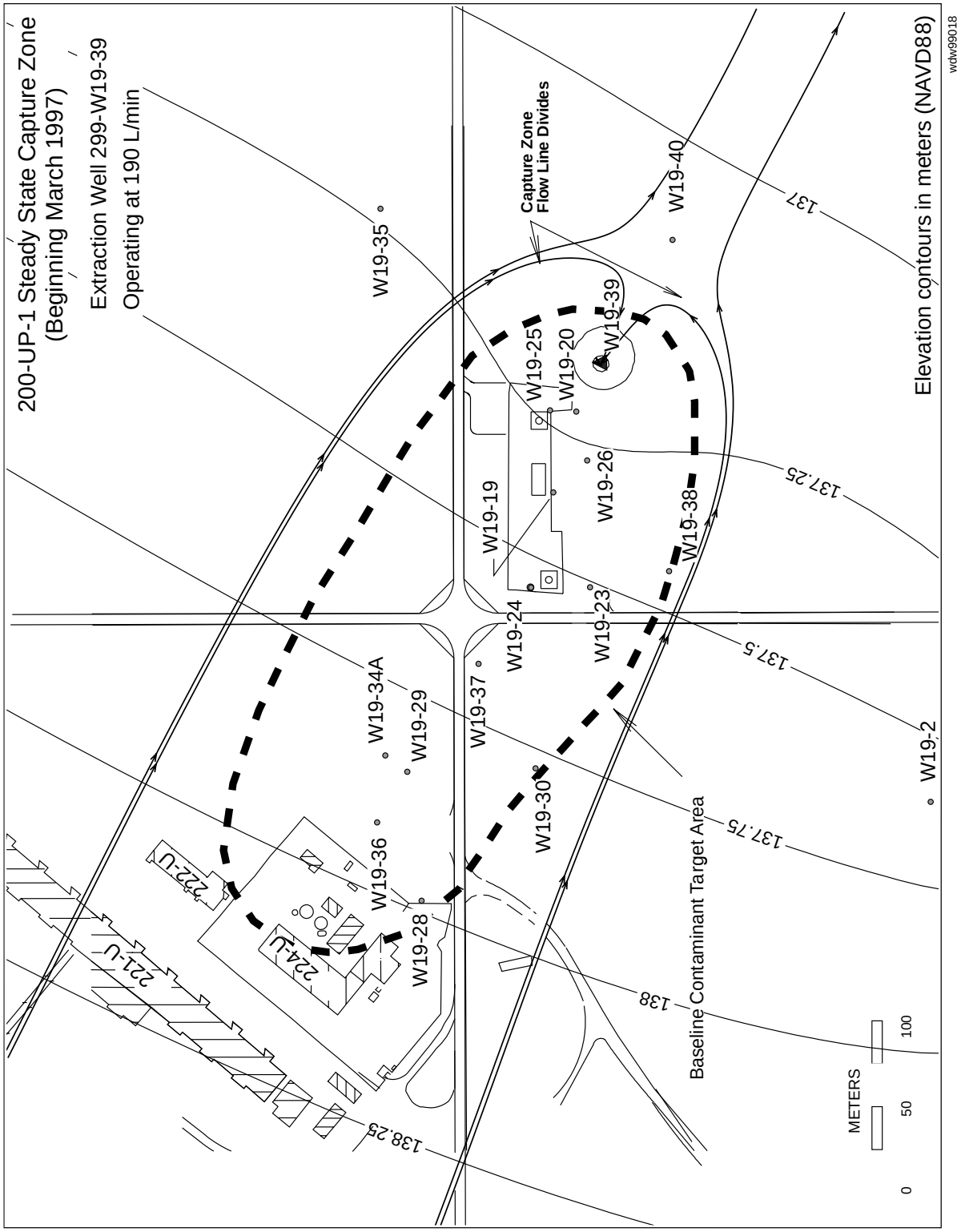

Figure 2.8-40. 200-UP-1 Pump-and-Treat System Steady State Hydraulic Capture Zone Beginning March 1997 (adapted from DOE/RL-99-79)

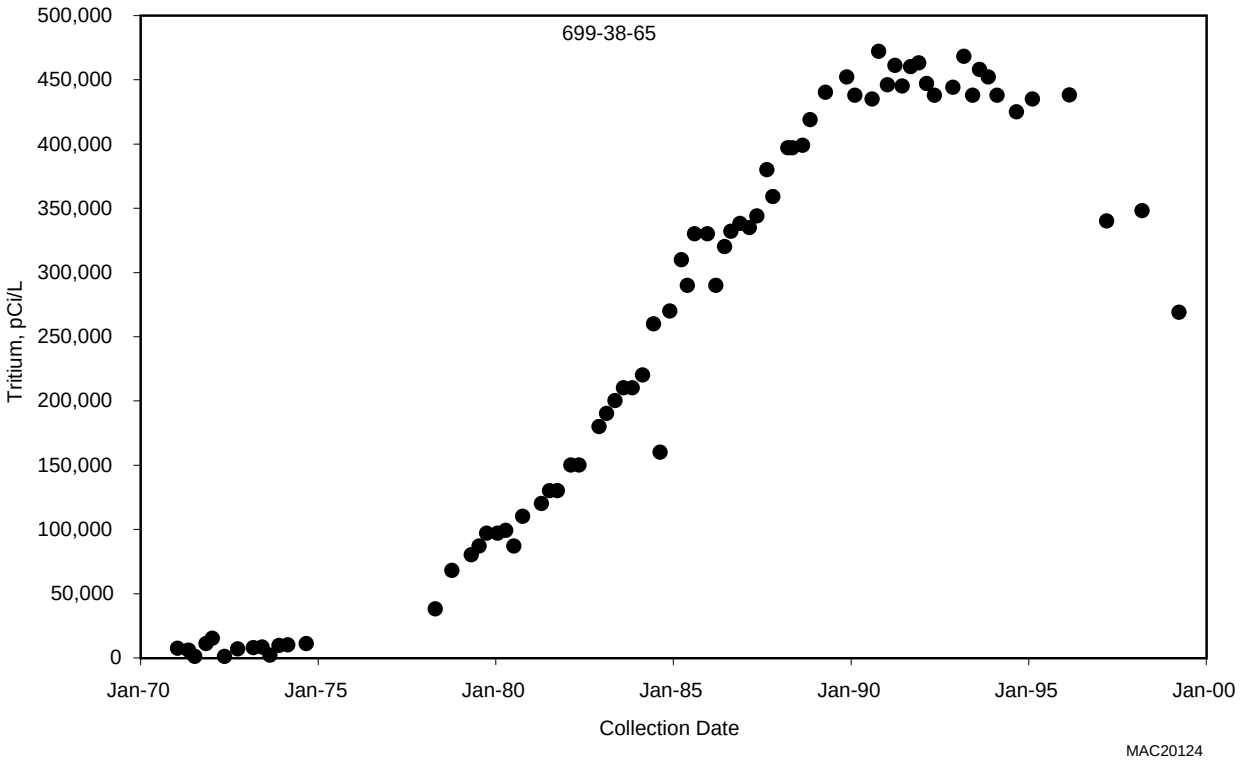

Figure 2.8-41. Tritium in Well 699-38-65, East of 200 West Area REDOX Plant

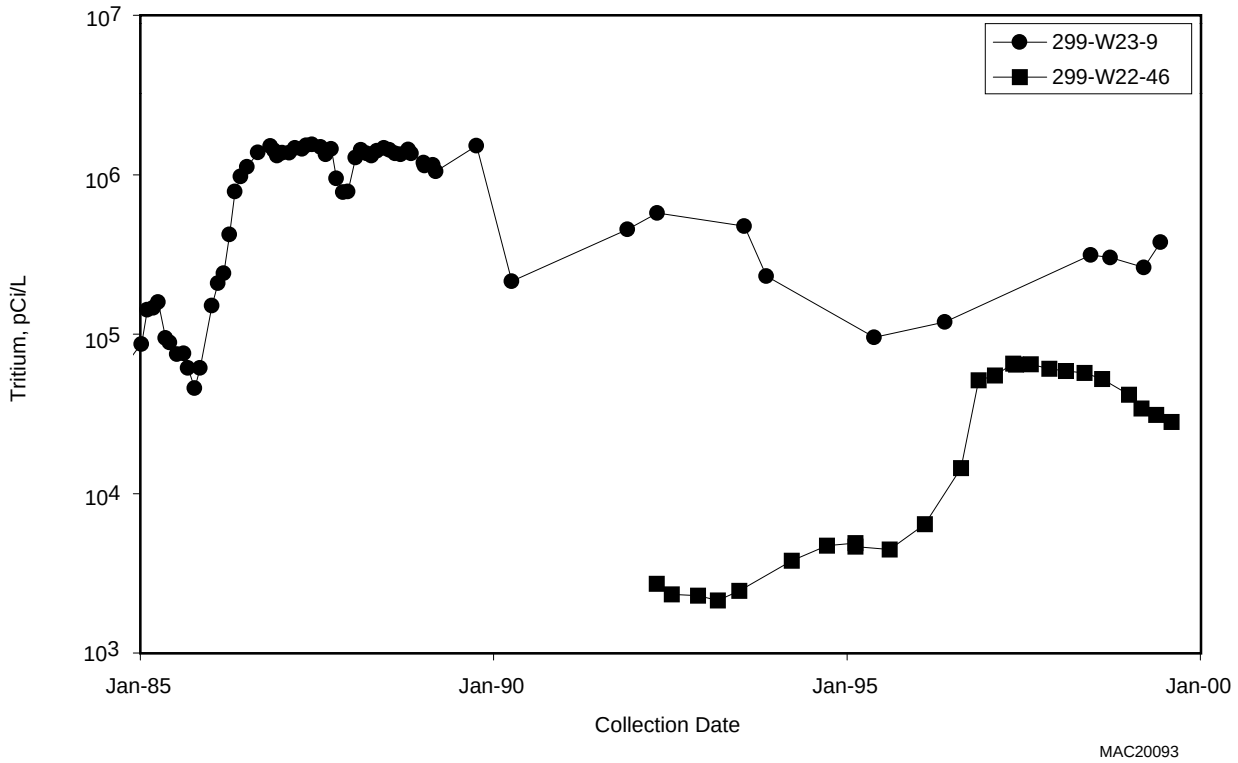

Figure 2.8-42. Tritium in Wells 299-W23-9 and 299-W22-46 Near the 216-S-25 Crib and S-SX Tank Farms

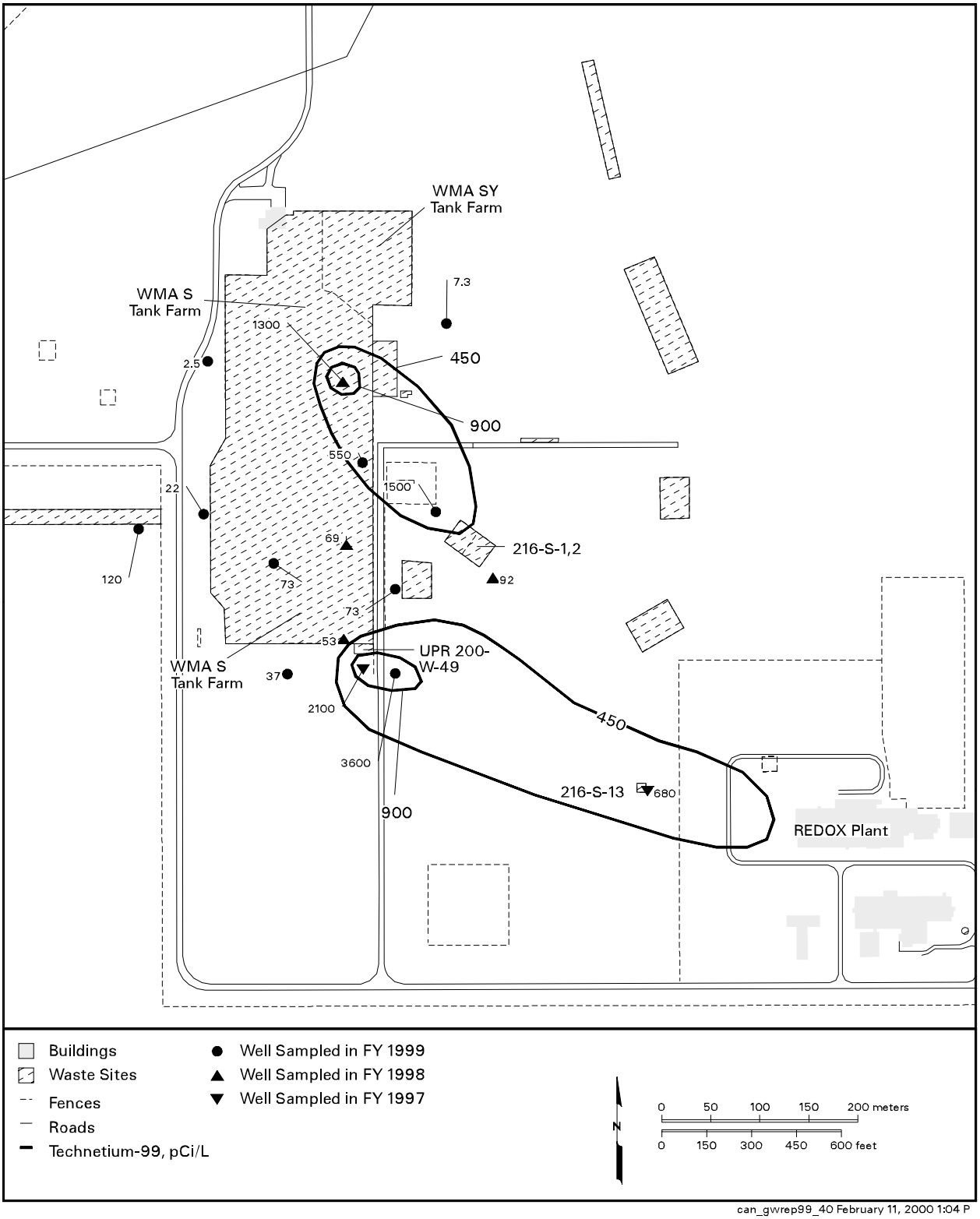

Figure 2.8-43. Average Technetium-99 Concentrations Near S-SX Tank Farms, Top of Unconfined Aquifer

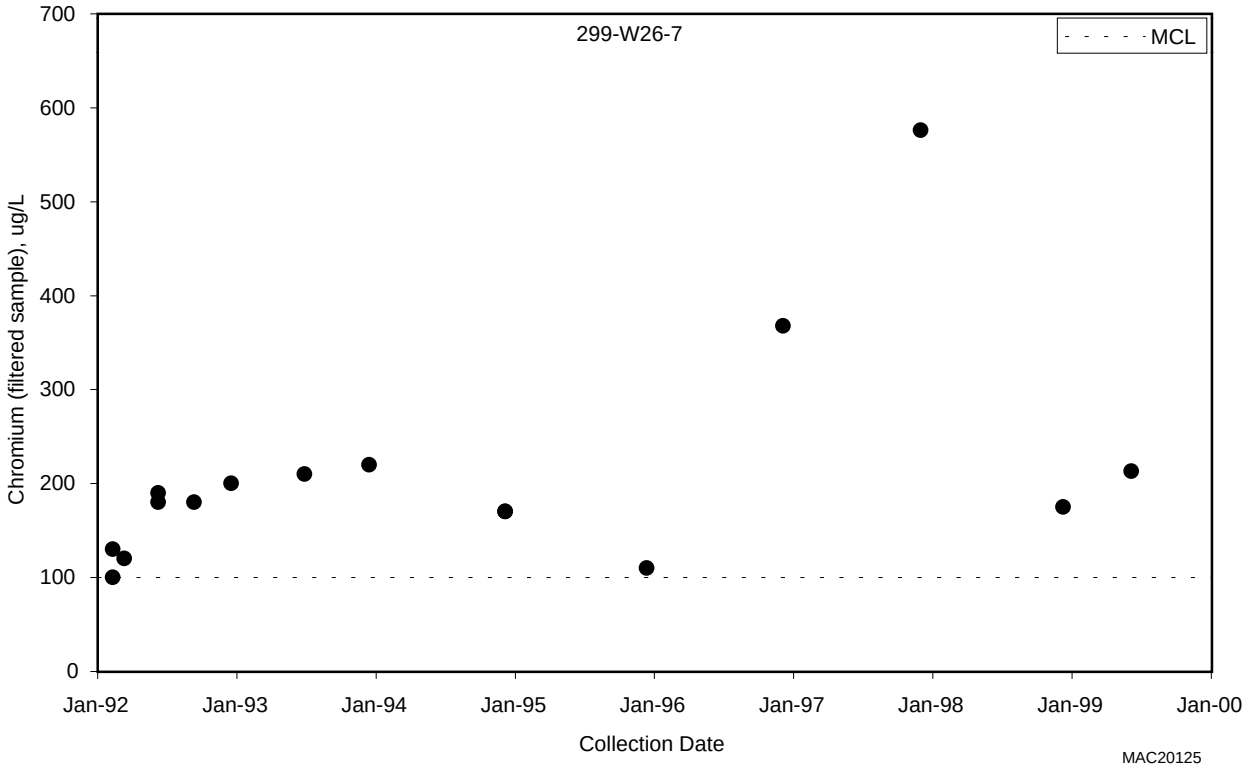

Figure 2.8-44. Chromium in Well 299-W26-7, Monitoring 216-S-10 Pond and Ditch

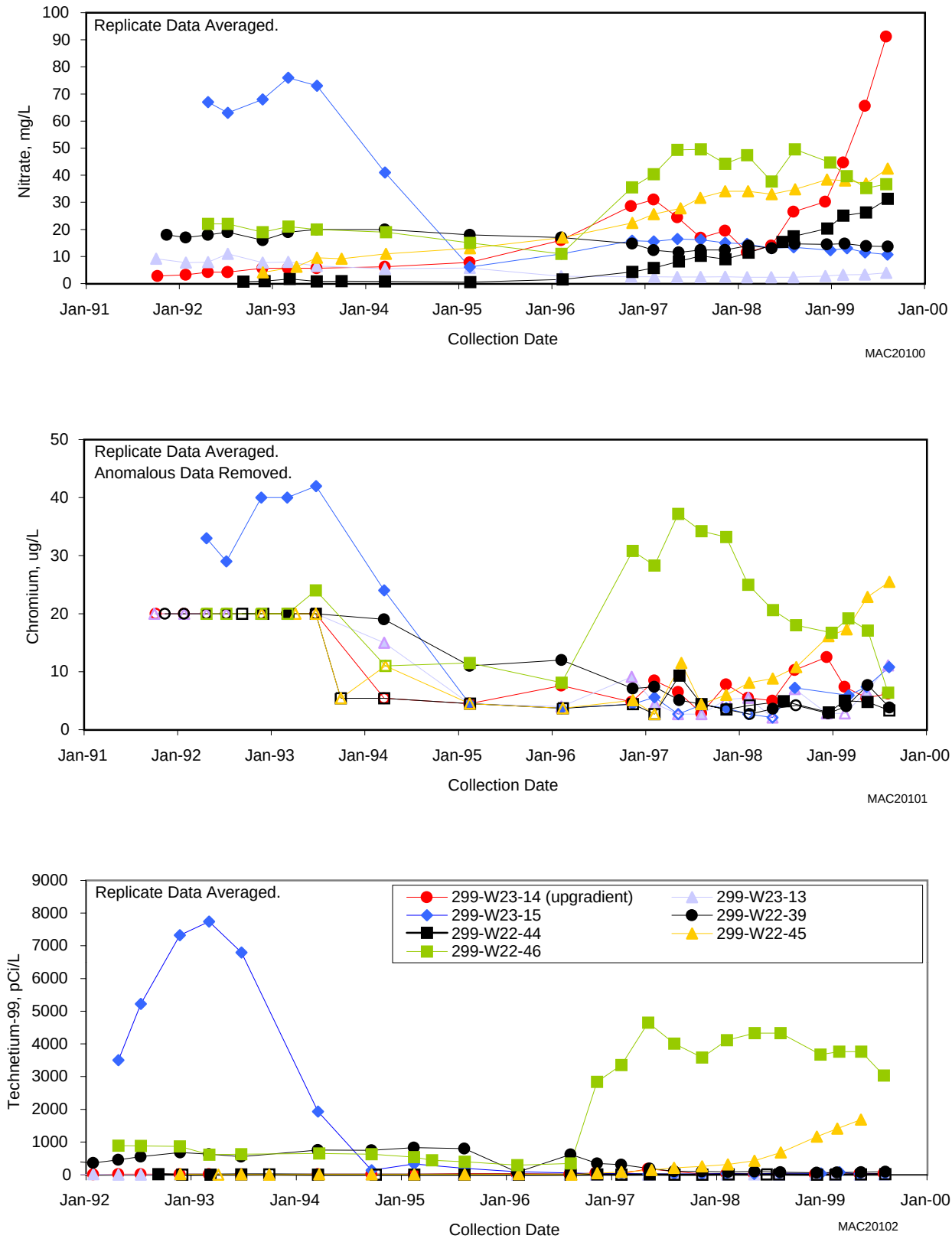

Figure 2.8-45. Technetium-99, Chromium, and Nitrate in Wells at Waste Management Area S-SX

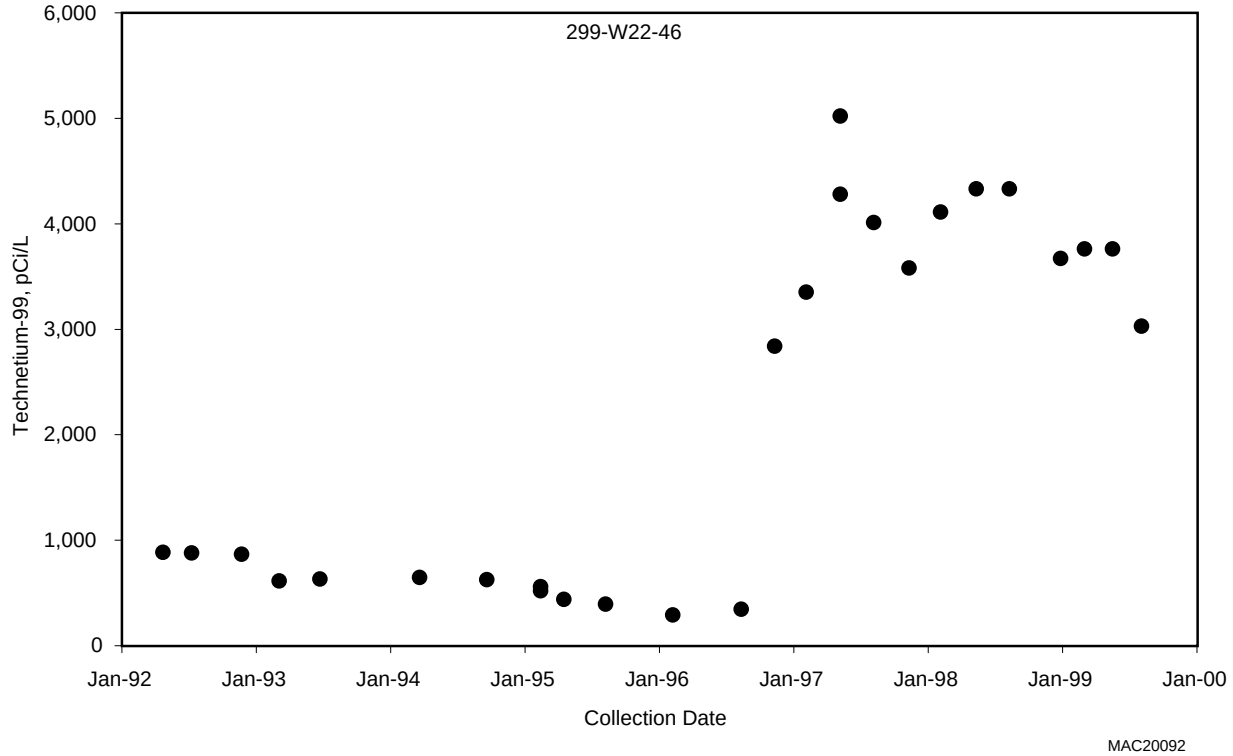

Figure 2.8-46. Technetium-99 in Well 299-W22-46, Southeast of Waste Management Area SX

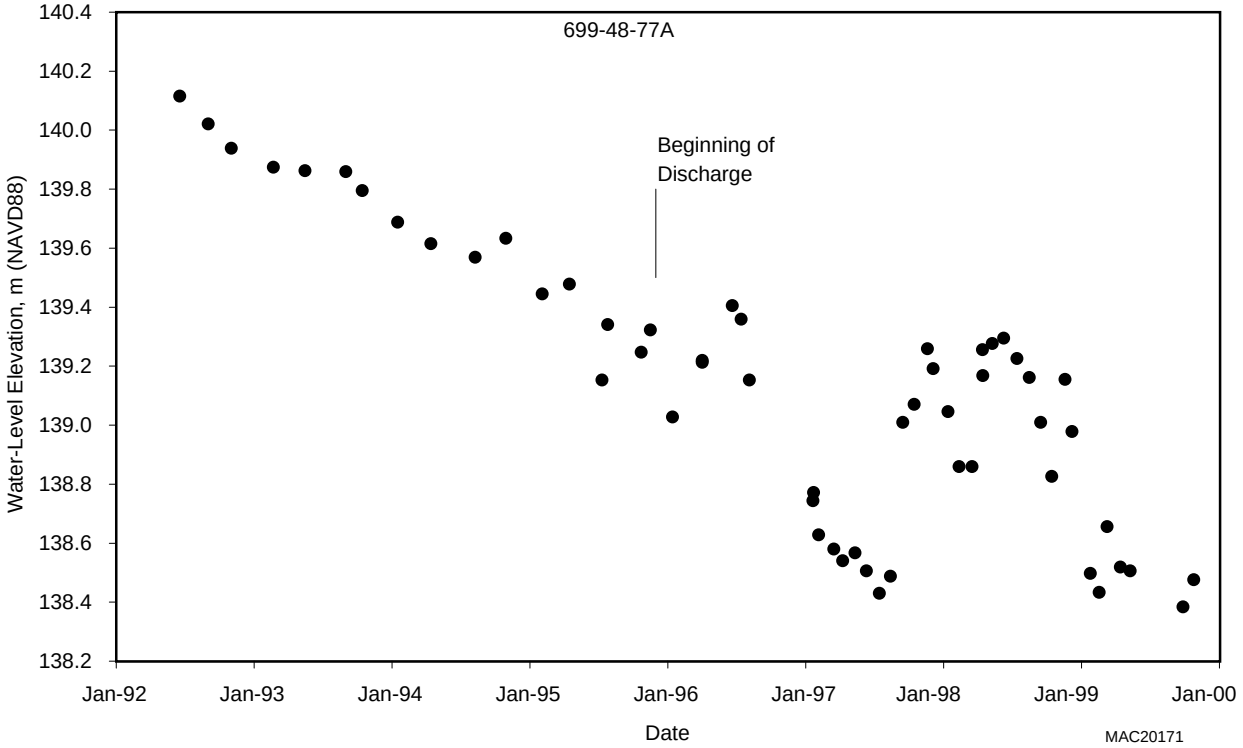

Figure 2.8-47. Water Levels for Well 699-48-77A

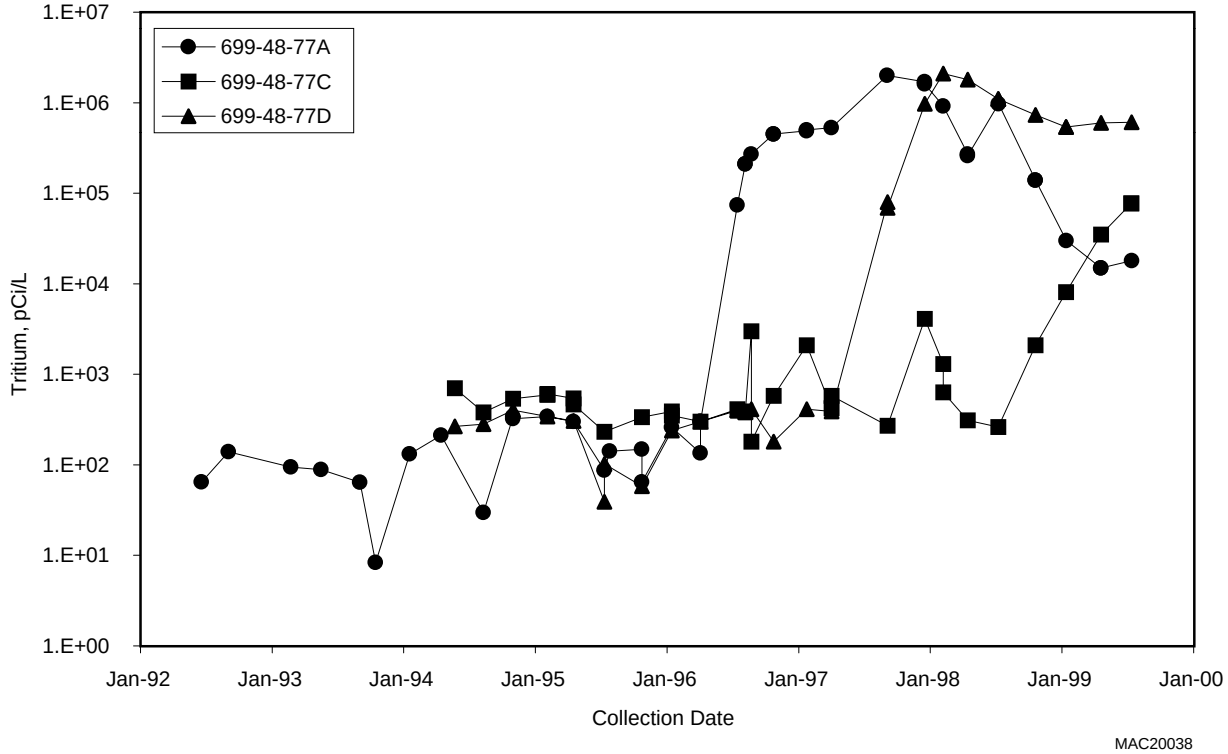

Figure 2.8-48. Tritium in Wells Monitoring the State-Approved Land Disposal Site

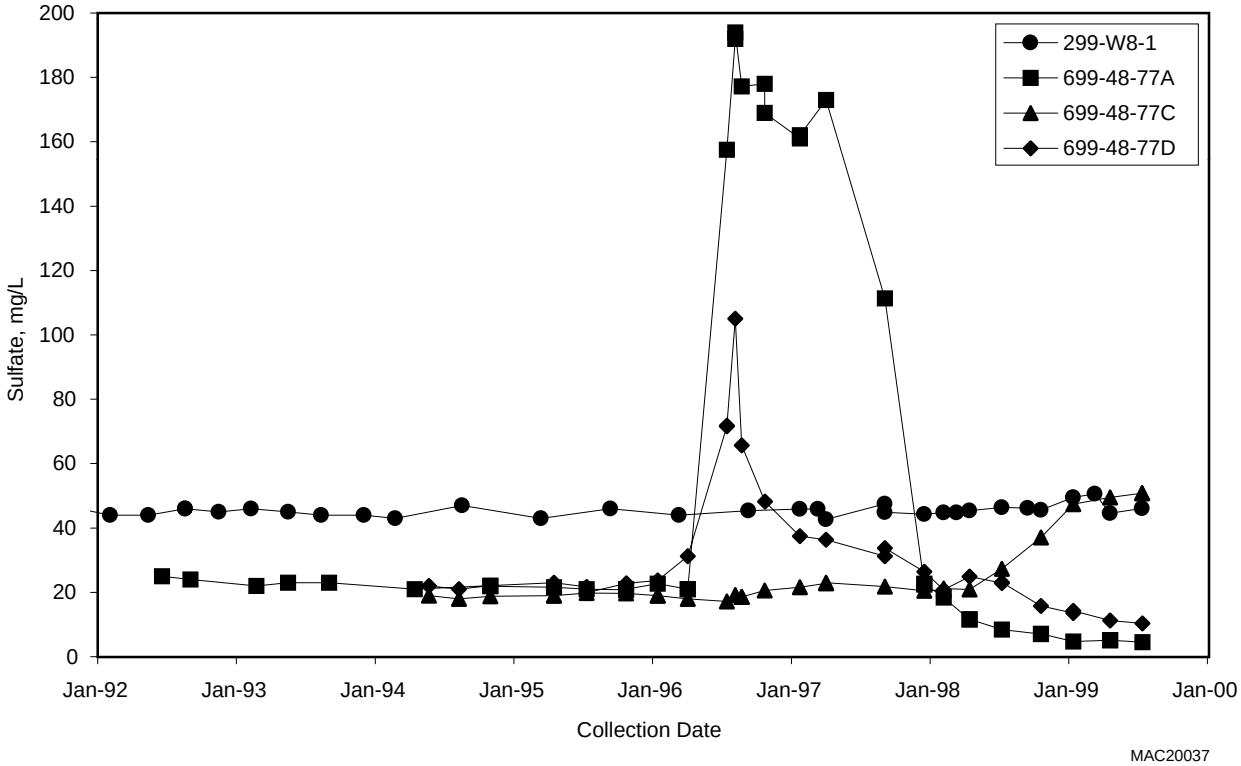

Figure 2.8-49. Sulfate in Wells Monitoring the State-Approved Land Disposal Site