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Pacific Northwest National Laboratory
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RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY

D. G. Horton

March 2007

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Richland, Washington 99352

Summary

Waste Management Area (WMA) TX-TY contains underground, single-shell tanks that were used to store liquid waste that contained chemicals and radionuclides. Most of the liquid has been removed, and the remaining waste is regulated under the *Resource Conservation and Recovery Act* (RCRA) as modified in 40 CFR Part 265, Subpart F and Washington State's Hazardous Waste Management Act (HWMA, RCW 70.105 and its implementing requirements in the Washington State dangerous waste regulations [WAC 173-303-400]). WMA TX-TY was placed in assessment monitoring in 1993 because of elevated *specific conductance*. A groundwater quality assessment plan was written in 1993 (Caggiano and Chou 1993) describing the monitoring activities to be used in deciding whether WMA TX-TY had affected groundwater. That plan was updated in 2001 (Hodges and Chou 2001) for continued RCRA groundwater quality assessment as required by 40 CFR 265.93 (d)(7). This document further updates the assessment plan for WMA TX-TY by including (1) information obtained from ten new wells installed at the WMA after 1999 and (2) information from routine quarterly groundwater monitoring during the last five years. Also, this plan describes activities for continuing the groundwater assessment at WMA TX-TY.

This plan describes the data quality objectives (DQO) process used to guide information gathering to further the assessment at WMA TX-TY. The general approach of the assessment is to (1) determine what effects the newly expanded 200-ZP-1 pump-and-treat operation will have on the monitoring being done at the WMA, (2) improve our understanding of the lateral and vertical distributions of contaminants and their relationship to potential sources within the study boundary, and (3) continue routine quarterly groundwater sampling and analysis to comply with RCRA regulatory requirements.

This assessment plan includes a sampling and analysis plan (Appendix A) consisting of a field sampling plan and a quality assurance project plan. The sampling and analysis plan is used as the principal controlling document to conduct the work identified by the data quality assessment process.

Acronyms

AEA	Atomic Energy Act
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
DOE	U.S. Department of Energy
DQO	data quality objectives
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
groundwater project	Groundwater Performance Assessment Project
HEIS	Hanford Environmental Information System
HWMA	*Hazardous Waste Management Act*
PNNL	Pacific Northwest National Laboratory
PUREX	Plutonium-Uranium Extraction (Plant)
QAPP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act*
REDOX	Reduction-Oxidation (Plant)
RFI/CMS	RCRA facility investigation/corrective measures study
RPD	relative percent difference
RSD	relative standard deviation
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
WMA	waste management area

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1.0 Introduction

Waste Management Area (WMA) TX-TY, containing the TX and TY Tank Farms, is located in the central portion of the 200 West Area (Figure 1.1) and was used for the interim storage of radioactive waste from chemical processing of reactor fuel for plutonium production. The WMA is regulated under the *Resource Conservation and Recovery Act* (RCRA) as modified in 40 CFR Part 265, Subpart F and Washington State's Hazardous Waste Management Act (HWMA, RCW 70.105 and its implementing requirements in the Washington State dangerous waste regulations [WAC 173-303-400]). WMA TX-TY was placed in assessment monitoring in 1993 because of elevated *specific conductance*, a RCRA indicator parameter, in two downgradient wells. A groundwater quality assessment plan was written in 1993 (Caggiano and Chou 1993) describing the monitoring activities to be used in deciding whether WMA TX-TY had affected groundwater. That plan was updated in 2001 (Hodges and Chou 2001) for continued RCRA groundwater quality assessment as required by 40 CFR 265.93 (d)(7). This document further updates the assessment plan for WMA TX-TY by including (1) information obtained from ten new wells installed at the WMA since the previous version of this plan and (2) information from routine, quarterly groundwater monitoring during the last 5 years. Also, this plan describes activities for continuing the groundwater assessment at WMA TX-TY. Information pertinent to the WMA TX-TY groundwater assessment available through April 2006 is considered in this plan.

1.1 Background

Figure 1.2 shows the general layout of WMA TX-TY. A detection level RCRA groundwater monitoring program for WMA TX-TY was initiated in 1989 (Jensen et al. 1989; Caggiano and Goodwin 1991). The WMA was placed into assessment monitoring in 1993 because specific conductance values in downgradient wells 299-W10-17 and 299-W14-12 exceeded the upgradient background value (critical mean) of 667 μS/cm (Caggiano and Chou 1993). In the case of well 299-W14-12, the increased specific conductance was accompanied by elevated technetium-99, iodine-129, tritium, nitrate, calcium, magnesium, sulfate, and chromium. The first assessment report (Hodges 1998) concluded that: (1) elevated technetium-99 and co-contaminants in well 299-W14-12 was consistent with a source within the WMA, and contaminant chemistry was consistent with a small volume source of tank waste; and (2) an upgradient source (the 216-T-25 trench) was possible. Subsequent drilling and sampling of well 299-W15-40, located between the 216-T-25 trench and the WMA, eliminated the 216-T-25 trench as a possible source because high levels of contamination were not found in the well. Accordingly, continuation of the groundwater assessment is required. This plan describes the activities for the continued assessment.

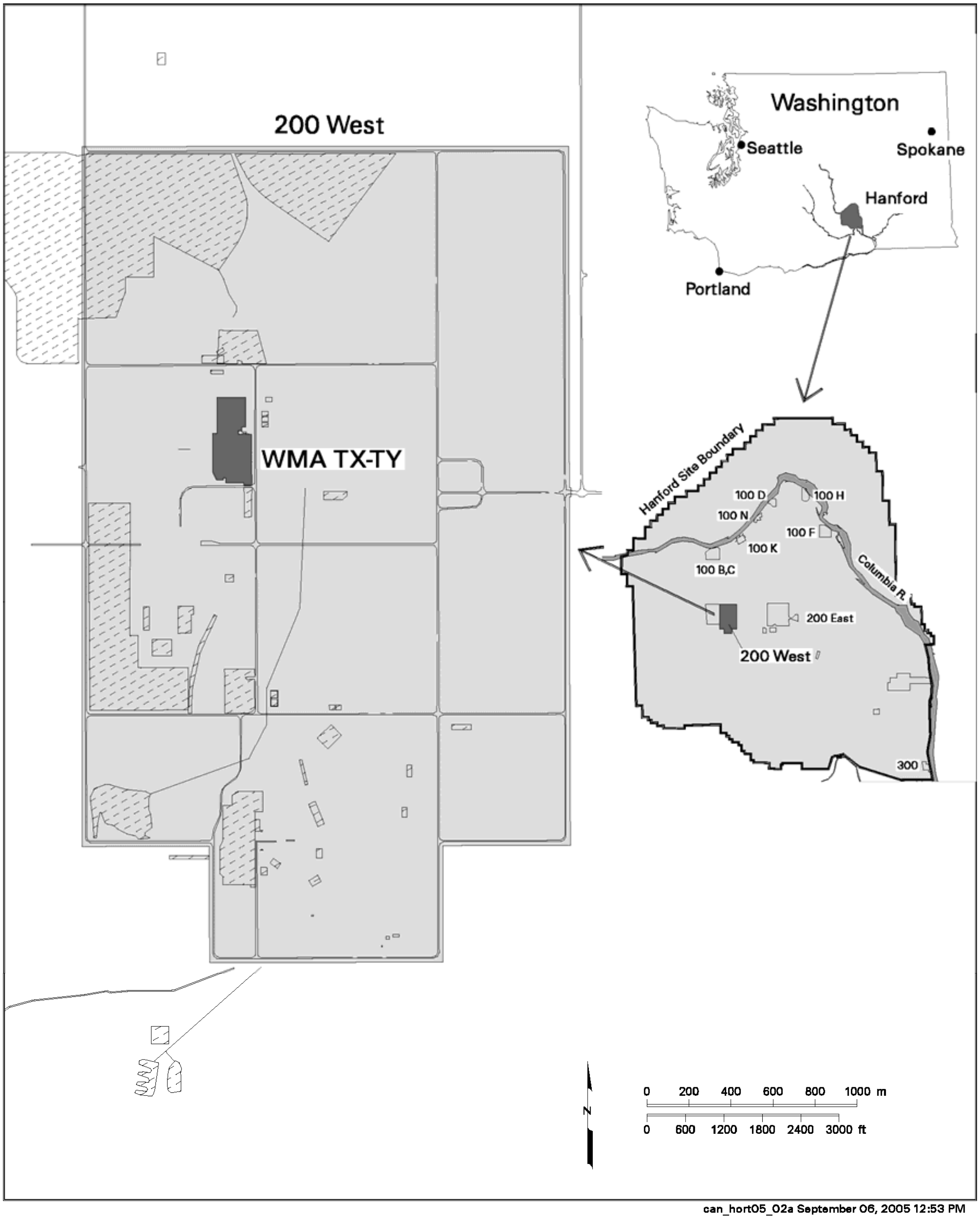

Figure 1.1. Location Map for Waste Management Area TX-TY

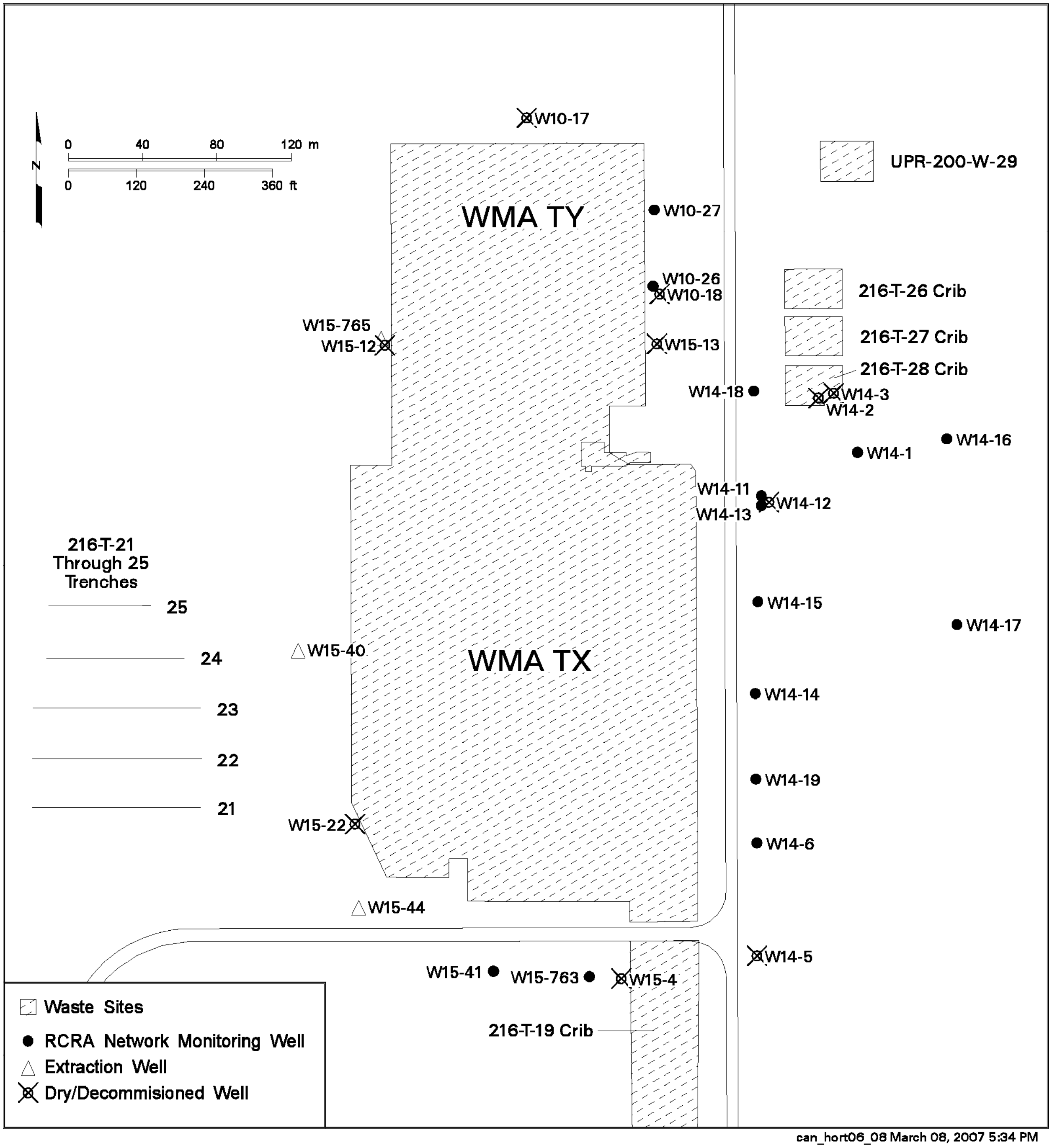

Figure 1.2. General Layout of Waste Management Area TX-TY including Locations of Nearby Past-Practice Facilities and Monitoring Wells

1.2 Objectives

The objectives for the continued assessment of groundwater quality at WMA TX-TY, as required by 40 CFR 265.93(d)(7)(i), are to determine

(i) the rate and extent of migration of the hazardous waste or hazardous waste constituents in the groundwater and

(ii) the concentration of hazardous waste or hazardous waste constituents in the groundwater.

An additional objective of this groundwater quality assessment stems from the expansion of the 200-ZP-1 Operable Unit carbon tetrachloride pump-and-treat system. In July 2005, the 200-ZP-1 pump-and-treat system was expanded by adding four additional extraction wells. All four wells are located upgradient of WMA TX-TY and include the upgradient monitoring wells 299-W15-40, 299-W15-44, and 299-W15-765 (Figure 1.2). These wells are expected to add about 380 liters per minute to the extraction system and are anticipated to affect the existing groundwater monitoring network by reversing the direction of groundwater flow at WMA TX-TY. Thus, an additional objective of this groundwater assessment is to evaluate the effects of the expanded pump-and-treat system on the capability of the existing groundwater monitoring network to detect and track contamination originating from the WMA.

These objectives are related to the remedial investigation of the vadose zone for the RCRA facility investigation/corrective measures study (RFI/CMS) at WMA TX-TY as described in the Hanford Federal Facility Agreement and Consent Order Change Request M-45-98-03 (Tri-Party Agreement, Ecology et al. 1989). In accordance with the agreement between the U.S. Department of Energy (DOE), and the Washington State Department of Ecology (Ecology) concerning this change request, the continuing RCRA groundwater quality assessment and the RFI/CMS work will be conducted under separate but coordinated plans. Data from the RCRA groundwater quality assessment will be used in RFI/CMS planning and will be included either by reference or directly with the vadose zone data from the RFI/CMS efforts.

1.3 Scope

The scope of this plan is to acquire the necessary groundwater data to reach the above objectives and integrate the RCRA groundwater quality assessment with the 200-ZP-1 groundwater operable unit and the single-shell tank RFI/CMS.

Groundwater monitoring objectives of RCRA, *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), and the *Atomic Energy Act* (AEA) often differ slightly and the contaminants monitored are not always the same. For RCRA regulated units, monitoring focuses on non-radioactive dangerous waste constituents. Radionuclides (source, special nuclear, and by-product materials) may be monitored in some RCRA unit wells to support the objectives of monitoring under the AEA and/or CERCLA. Please note that pursuant to RCRA, the source, special nuclear and by-product material component of radioactive mixed waste, are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

1.4 General Approach

The data quality objectives (DQO) process was used to guide information gathering to further the assessment at WMA TX-TY and the DQO results are described in Chapter 3. The resulting, general approach to meet the specific or immediate objectives for the continued assessment (i.e., to determine the concentration, rate of movement and extent of contamination) includes the following major components:

- Evaluate the adequacy of the groundwater monitoring network for determining the rate of movement and extent of contaminants in the aquifer. The recent modifications to the 200-ZP-1 pump-and-treat operation upgradient of WMA TX-TY most likely will adversely affect the monitoring network's ability to adequately monitor contaminants. The pump-and-treat also may restrict the further migration of those contaminants; but may also transfer them to another location if they are not removed by the treatment process.

- Use spatial and temporal mapping of the contaminant plumes to delineate the extent and concentration of contaminants and their relationship to potential sources within the study boundary. In concert with hydrogeologic data, estimate the approximate rate, direction, and extent of contaminant migration both horizontally and vertically within the aquifer.

- Use the results of special isotopic studies to aid the identification of contaminant sources (e.g., differentiation of tank leaks, distinguish cribs versus tanks) affecting groundwater quality.

- Continue routine, quarterly groundwater sampling and analysis to comply with RCRA regulatory requirements.

- Continue annual reporting.

1.5 Plan Organization

A review of existing data including waste characteristics, geology and hydrology, and vadose zone and aquifer contamination is presented in Chapter 2.0. The DQO process for this groundwater assessment is given in Chapter 3.0. An updated conceptual model is given as part of the DQO chapter. References cited are listed in Chapter 4.0. A sampling and analysis plan (including a field sampling plan and a quality assurance plan) for the groundwater quality assessment at WMA TX-TY is included in Appendix A. Appendix B provides pertinent hydrogeologic and monitoring well information.

2.0 Background

2.1 Facility Description and Operational History

WMA TX-TY occupies an area of approximately 74,000 m^2 and contains 24 underground single-shell tanks constructed in 1947 and 1948, for the tanks in the TX Tank Farm, and in 1951 and 1952 for the tanks in the TY Tank Farm. Each of the 24 tanks has a capacity of 2.87 million liters. The 18 tanks in the TX Tank Farm are arranged in three 4-tank and two 3-tank cascades. The six tanks in the TY Tank Farm are arranged in three 2-tank cascades. In addition to the tanks, six diversion boxes and ancillary pumps, valves and pipes are included in the *Hanford Facility Dangerous Waste Part A Permit Application* (DOE 2000a) for single-shell tank farm system TX-TY.

The single-shell tanks are constructed of carbon steel (ASTM A283 Grade C) lining the bottom and sides of a reinforced concrete shell. The concrete dome top is unlined. The tanks are 22.9 meters in diameter and are about 11.4 meters in height. The bottoms of the tanks are about 14 meters below grade with about 2.4 meters of fill over the top. Various ports in the tank tops are available for waste transfer and monitoring. In addition, vadose zone monitoring wells (drywells) are located around the tanks and extend generally to 22 to 45 meters depth to allow monitoring of radionuclide and moisture migration outside the tanks by geophysical methods. All tanks in the TX and TY Tank Farms have been interim stabilized (Hanlon 2004). Interim stabilized means that a tank contains less than 189,250 liters of drainable interstitial liquid and less than 18,925 liters of supernatant. Table 2.1 lists the volume contents of each tank in WMA TX-TY.

The routing of liquid waste from the operations buildings to the tank farms was done with underground lines and diversion boxes. The diversion boxes are concrete boxes that were designed to contain any waste that leaked from the high-level waste transfer line connections. Diversion boxes generally drained to nearby catch tanks where any spilled waste was stored and then pumped to single-shell tanks. It is estimated that each diversion box contains 23 kilograms of lead (DOE 2000b).

Two septic tanks are located within the WMA TX-TY area. The 2607-WT septic tank is west of the 242-T Evaporator and between the TX and TY Tank Farm. The unit is connected to a sanitary tile field, began operating in 1952, and received approximately 20 liters per day (DOE 1991). The septic system probably no longer receives effluent but could have been a source for moisture in the vadose zone in the past. The 2607-WTX septic system, located at the south fence line of the TX Tank Farm, received 740 liters of sanitary wastewater per day beginning in 1950. Although no end date for use of the 2607-WTX septic system was found in the literature, a field investigation done in June 2006 verified that the septic system was inactive (WIDS).

The tanks in TX Tank Farm were constructed in 1947 and 1948 and initially were used to support the bismuth phosphate process. (The bismuth phosphate process operated from 1944 to 1956.) The TY Tank Farm was constructed in 1951 and 1952 and, by 1952, both the TX and TY Tank Farms were used to support the uranium recovery program being conducted in the U Plant, as well as the bismuth phosphate process. (The uranium recovery program lasted from 1954 to 1957.) Some of the tanks in WMA TX-TY also received waste from the Reduction-Oxidation (REDOX) (REDOX operated from 1952 to 1966) and Plutonium-Uranium Extraction (PUREX) Plant operations (PUREX operated from 1956 to 1988).

Table 2.1. Inventory by Tank (Hanlon 2004)

Tank	Tank Integrity	Drainable Liquid Remaining (L)[(a)]	Sludge (L)	Salt Cake (L)
TX Tank Farm				
TX-101	Sound	26,495	280,090	64,345
TX-102	Sound	102,195	7,570	813,775
TX-103	Sound	68,130	0	548,825
TX-104	Sound	41,635	128,690	124,905
TX-105	Assumed Leaker	94,625	30,280	2,149,880
TX-106	Sound	140,045	18,925	1,298,255
TX-107	Assumed Leaker	26,495	0	109,765
TX-108	Sound	30,280	22,710	457,985
TX-109	Sound	22,710	1,373,955	0
TX-110	Assumed Leaker	52,990	140,045	1,627,550
TX-111	Sound	37,850	162,755	1,214,985
TX-112	Sound	98,410	0	2,399,690
TX-113	Assumed Leaker	68,130	352,005	2,062,825
TX-114	Assumed Leaker	64,345	15,140	1,998,480
TX-115	Assumed Leaker	94,625	30,280	2,062,825
TX-116	Assumed Leaker	79,485	249,810	2,017,405
TX-117	Assumed Leaker	37,850	109,765	1,707,035
TX-118	Sound	117,335	0	934,895
TY Tank Farm				
TY-101	Assumed Leaker	7,570	272,520	177,895
TY-102	Sound	49,205	0	261,165
TY-103	Assumed Leaker	87,055	389,855	193,035
TY-104	Assumed Leaker	18,925	162,755	0
TY-105	Assumed Leaker	45,420	874,335	0
TY-106	Assumed Leaker	3,785	60,56o	0

(a) Drainable liquid equals the sum of supernatant and drainable interstitial liquid.

Waste management operations have created a complex intermingling of the tank waste. Nonradioactive chemicals have been added to the tanks and varying amounts of waste- and heat-producing radionuclides have been removed. In addition, natural processes have caused settling, stratification, and segregation of waste components. Waste was also cascaded (allowed to flow by gravity from one tank to another) through a series of tanks; cooling and precipitation of radionuclides and solids occurred in each tank of the cascade. Some of the supernatant from the last tank in a cascade was sent to cribs, via surface pipelines, because of shortage of tank storage capacity. As a result, it is very difficult to estimate the composition of the wastes remaining in the tanks through operational records. A detailed history of tank farm operations is given by Anderson (1990).

Several past-practice liquid disposal facilities are in the vicinity of the WMA TX-TY. In some instances, it is difficult to distinguish single-shell tank waste from crib and trench waste because similar waste was stored in or disposed in both. The 216-T-21 through T-24 specific retention trenches, located west of the TX Tank Farm, were used in 1954 and received a total of 5,000,000 liters of first cycle supernatant waste from the TX-109, TX-110, and TX-111 single-shell tanks. The 216-T-25 trench was active during September 1954 and received 3,000,000 liters of evaporator waste from the 242-T Evaporator. Evaporator waste was also stored in the single-shell tanks.

The 216-T-26, 216-T-27, and 216-T-28 cribs are located east of the TY Tank Farm. The 216-T-26 crib operated between August 1955 and November 1956 and received 12,000,000 liters of first-cycle scavenged tributyl phosphate supernatant wastes routed through the TY-101, TY-103, and TY-104 single-shell tanks. The 216-T-27 crib operated between September and November 1965 and received about 7,190,000 liters of 300 Area laboratory waste and waste from the 221-T Building routed through the T-111 and T-112 single-shell tanks. Wastes were routed to the 216-T-27 crib following breakthrough of contaminants to groundwater under the 216-T-28 crib (DOE 1991). DOE 1991 states that waste routed to the crib consisted of material generated during periods when a sudden increase (four orders of magnitude) in radionuclide activity in the wastes occurred. Each time waste was pumped to the 216-T-27 crib, groundwater samples taken near the 216-T-28 crib increased in radioactivity (DOE 1991).

The 216-T-28 crib was active from February 1960 until February 1966 and it received 42,300,000 liters of waste that included steam condensate decontamination waste, miscellaneous waste from 221-T Building, decontamination waste from the 2706-T Building and 300 Area laboratory waste.

Finally, the 216-T-19 crib and tile field, located south of the TX Tank Farm, operated from 1951 to 1980. The crib and tile field received 455,000,000 liters of effluent from the 242-T Evaporator and T Plant operations.

The wastes disposed to some of the cribs and trenches adjacent to WMA TX-TY were similar to the wastes stored in the single-shell tanks. This similarity of wastes makes it difficult to distinguish waste sources for existing groundwater contamination.

Initial corrective actions have been implemented at WMA TX-TY. Surface water controls were placed adjacent to WMA TX-TY in 2001 to stop run-on of natural precipitation and all water lines leading to the farms were cut and capped at that time.

2.2 Tank Leaks and Unplanned Releases

Thirteen of the tanks at WMA TX-TY have been declared leakers (Hanlon 2004). Information about these leaks is given in Table 2.2. However, little information and no previous leak inventory estimate has been developed for seven of the tanks (TX-105, TX-110, TX-113, TX-114, TX-115, TX-116, and TX-117) (Field and Jones 2005). Contamination associated with these tanks may be from waste pipeline leaks or from nearby tanks that are known to have leaked. Leaks associated with the remaining six tanks are discussed in the following paragraphs.

Tank TX-107 was declared a leaker in 1984. Hanlon (2004) lists a leak volume of 9,460 liters. Tank TX-107 was used as the 242-T Evaporator receiver tank. Spectral gamma logging in drywells around tank TX-107 showed high levels of cobalt-60 and europium-154 contamination in the vadose zone

(Jones et al. 2000). The leak volume for tank TX-107 was increased by Field and Jones (2005) to 30,280 liters based on the size of the vadose zone contaminant plume.

Table 2.2. Tank Leak Volume Estimates

Tank Number	Date Declared Confirmed, or Assumed Leaker	Volume Leaked (L)[a]	Volume Leaked (L)[b]	Interim Stabilized Date
241-TX-105	1977	30,280	No basis for estimate	April 1983
241-TX-107	1984	9,460	30,280	October 1979
241-TX-110	1977	30,280[a]	No basis for estimate	April 1983
241-TX-113	1974	30,280[a]	No basis for estimate	April 1983
241-TX-114	1974	30,280[a]	No basis for estimate	April 1983
241-TX-115	1977	30,280[a]	No basis for estimate	September 1983
241-TX-116	1977	30,280[a]	No basis for estimate	April 1983
241-TX-117	1977	30,280[a]	No basis for estimate	March 1983
241-TY-101	1973	<3,785	3,790	April 1983
241-TY-103	1973	11,360	11,360	February 1983
241-TY-104	1981	5,300	5,300	November 1983
241-TY-105	1960	132,500	132,480	February 1983
241-TY-106	1959	75,700	75,700	November 1978

(a) Data from Hanlon (2004).
(b) Data from Field and Jones (2005).

A 1973 leak of less than 3,785 liters from tank TY-101 is reported in Hanlon (2004) based on observed liquid level decreases in the tank. The existing drywells associated with tank TY-101 provide no indication of a major leak (Jones et al. 2000).

Tank TY-103 was listed in 1973 as having leaked about 11,300 liters. The tank stored tributyl phosphate waste from 1957 through early 1968. From 1968 through 1973, tank TY-103 contained PUREX and B Plant waste (Jones et al. 2000). Spectral gamma logging indicates cesium-137 and cobalt-60 contamination in the vadose zone near the tank. The combination of cesium-137 and cobalt-60 suggests a tributyl phosphate waste source (Jones et al. 2000).

Hanlon (2004) lists tank TY-104 as having leaked 5,300 liters in 1981 based on liquid level decreases in the tank. However, neither the spectral gamma logging data nor the waste transfer records provide a rationale for listing tank TY-104 as a potential leaker (Jones et al. 2000).

Hanlon (2004) lists a leak volume of 132,500 liters and a leak date of 1960 for tank TY-105. The waste transfer records indicate a 132,500 liter leak of tributyl phosphate waste in 1959. Spectral gamma logging indicates cesium-137 and cobalt-60 contamination around the tank that is consistent with tributyl phosphate waste (Jones et al. 2000).

Hanlon (2004) lists a leak volume of 75,700 liters and a leak date of 1959 for tank TY-106. Although the waste transfer records indicate an apparent waste loss in 1959, the gamma contamination profiles around the tank do not support listing tank TY-106 as a leaker (Jones et al. 2000).

In addition to leaks, eleven unplanned releases have been documented in or near the WMA. The following information about those releases is from DOE (1991) and the Waste Information Data System.

- Unplanned release UN-200-W-17 occurred in 1952 south of the TX Tank Farm when a spill occurred during transfer of waste from tank 241-TX-106 to 241-TX-114. Surface contamination resulted over a 91 meter by 183 meter area. Some highly contaminated areas were stabilized with asphalt.

- Unplanned release UN-200-W-76 occurred in August 1977 around the 241-TX-155 diversion box. The release consisted of contaminated rabbit fecal pellets. The pellets and soil were removed and remaining contamination was covered with clean soil.

- Unplanned release UN-200-W-99 occurred in September 1968 along Camden Avenue near the southeast corner of the TX Tank Farm. Airborne contamination of strontium-90 was released from the 241-TY-153 diversion box resulting in 20,000 to 100,000 counts per minute. Road contamination was covered with new tar and the area between Camden Avenue and the TX Tank Farm was covered with gravel and marked with underground contamination signs. Test plots in 1978 showed strontium-90 particulate matter still present.

- Unplanned release UN-200-W-100 occurred in November 1954 from a process line extending from tank TX-105 to tank TX-118. The spill was first cycle waste containing approximately 10 curies of fission products. The contaminated area was covered with 0.3 meter of clean soil.

- Unplanned release UPR-200-W-126 occurred in May 1975 next to the 241-TX-153 diversion box. Spotty contamination became airborne when maintenance was being done on the transfer line from the diversion box. The occurrence report describes personnel contamination but does not refer to any ground contamination.

- Unplanned release UPR-200-W-129 occurred in January 1979 at the pump pit at tank TX-113. Caustic radioactive solution was released through the pit cover while testing a jumper assembly. The area was surveyed and the pump pit hosed down.

- Unplanned release UPR-200-W-149 occurred during 1977 surrounding tank TX-107. This unplanned release is the suspected tank leak from tank TX-107.

- Unplanned release UPR-200-W-150 occurred in 1973 surrounding tank TY-103. Overflow of the 241-TX-155 diversion box resulted in backflow into the tank, depositing 3.3 centimeters of sludge. Drywells around the tank showed no significant increase in gamma activity attributable to the event.

- Unplanned release UPR-200-W-151 occurred in 1974 surrounding tank TY-104. Approximately 5,300 liters of supernatant leaked from the tank. The leak consisted of REDOX ion exchange waste, PUREX organic waste, bismuth phosphate first-cycle waste, tributyl phosphate waste and decontamination waste. Jones et al. (2000), however, state that spectral gamma logging suggests extensive near-surface, waste transfer piping leaks and that neither the gamma logging nor the waste transfer records support listing the tank as a leaker.

- Unplanned release UPR-200-W-152 occurred in 1960 surrounding tank TY-105. An unknown quantity of tributyl phosphate waste was reported to have leaked from the tank.

- Unplanned release UPR-200-W-153 occurred during 1959 surrounding tank TY-106. Routine surveillance of drywells indicated a change in the gamma profile. The waste was listed as an unknown quantity of tributyl phosphate waste. The tank was stabilized with diatomaceous earth.

2.3 Waste Characteristics

Two basic chemical processing operations were the source of most of the hazardous waste transferred to the TX and TY Tank Farms. These were the bismuth phosphate process and the tributyl phosphate process; lesser quantities of waste from the REDOX and PUREX processes were also sent to the tank farms. The bismuth phosphate, REDOX, and PUREX processes were chemical separations programs for recovery of plutonium from irradiated reactor fuels. The tributyl phosphate process recovered uranium metal in waste generated by the bismuth phosphate process. Waste from all these processes was made alkaline for storage in the tanks (Anderson 1990).

Table 2.3 gives a partial listing of specific waste transferred to each tank in WMA TX-TY. Anderson (1990) gives approximate chemical compositions for the major waste types sent to the TX and TY Tank Farm single-shell tanks. Most recently, Higley et al. (2004) give estimates of the chemical and radiological inventories for each waste stream. Jones et al. (2000) have recently given estimates for the composition of the leaked fluids from tanks TX-107, TY-103, TY-105, and TY-106. Table 2.4 gives a partial leak inventory from their data.

2.4 Geology and Hydrogeology

This section updates the description of the geology beneath the single-shell tanks WMA TX-TY with new information from ten wells drilled since the previous version of this plan (Hodges and Chou 2001). This information assists decisions concerning well location and well construction if new wells are added to the monitoring network. The geologic interpretation is also used to evaluate pathways to groundwater through the vadose zone and groundwater flow properties.

Table 2.3. Partial Listing of Tank Contents and Waste Received for the TX and TY Tank Farm Single-Shell Tanks (Agnew et al. 1997)

Tank	Waste Type
241-TX-101	Metal waste from bismuth phosphate, evaporator bottoms, REDOX high-level waste, cladding waste, organic wash waste from PUREX, REDOX ion exchange, tributyl phosphate waste, REDOX ion exchange, first cycle decontamination waste, B Plant low-level waste, Battelle Northwest Laboratory waste, B Plant high-level waste, laboratory waste, cesium recovery ion exchange waste, N Reactor decontamination waste, PUREX low-level waste, and Z Plant waste.
241-TX-102	Metal waste from bismuth phosphate, evaporator bottoms, REDOX high-level waste, cladding waste, organic wash waste from PUREX, and REDOX ion exchange.
241-TX-103	Metal waste from bismuth phosphate, evaporator bottoms, tributyl phosphate waste.
241-TX-104	Metal waste from bismuth phosphate, evaporator bottoms, REDOX high-level waste, organic wash waste from PUREX, REDOX ion exchange, tributyl phosphate waste, and B Plant low-level waste.
241-TX-105	Metal waste from bismuth phosphate, evaporator bottoms, REDOX high-level waste, cladding waste, organic wash waste from PUREX, and REDOX ion exchange.
241-TX-106	Metal waste from bismuth phosphate, REDOX high-level waste, cladding waste, organic wash waste from PUREX, and REDOX ion exchange.
241-TX-107	Metal waste from bismuth phosphate, evaporator bottoms, and REDOX high-level waste.
241-TX-108	Metal waste from bismuth phosphate, evaporator bottoms, tributyl phosphate waste, and decontamination waste.
241-TX-109	Evaporator bottoms, tributyl phosphate waste, and first cycle decontamination waste.
241-TX-110	Evaporator bottoms, tributyl phosphate waste, and first cycle decontamination waste.
241-TX-111	Evaporator bottoms, tributyl phosphate waste, and first cycle decontamination waste.
241-TX-112	Evaporator bottoms and first cycle decontamination waste.
241-TX-113	Evaporator bottoms and first cycle decontamination waste.
241-TX-114	Evaporator bottoms and first cycle decontamination waste.
241-TX-115	Metal waste from bismuth phosphate, REDOX high-level waste, evaporator bottoms, cladding waste, tributyl phosphate waste, and decontamination waste.
241-TX-116	Evaporator bottoms.
241-TX-117	Evaporator bottoms and first cycle decontamination waste.
241-TX-118	Evaporator bottoms, cladding waste, tributyl phosphate waste, first cycle decontamination waste, and Z Plant waste.
241-TY-101	Evaporator bottoms, REDOX high-level waste, tributyl phosphate waste, and first cycle decontamination waste.
241-TY-102	Evaporator bottoms, REDOX high-level waste, organic wash waste from PUREX, REDOX ion exchange, tributyl phosphate waste, first cycle decontamination waste, and B Plant low-level waste.
241-TY-103	Evaporator bottoms, REDOX high-level waste, organic wash waste from PUREX, REDOX ion exchange, tributyl phosphate waste, first cycle decontamination waste, B Plant low-level waste, and decontamination waste.
241-TY-104	REDOX high-level waste, organic wash waste from PUREX, REDOX ion exchange, tributyl phosphate waste, first cycle decontamination waste, B Plant low-level waste, and decontamination waste.
241-TY-105	Tributyl phosphate waste.
241-TY-106	Tributyl phosphate waste.

Table 2.4. Partial Inventory Estimates for Tank Leak Fluids from Tanks in Waste Management Area TX-TY (data from Jones et al. 2000; mol/L have been converted to µg/L)

Element or Radionuclide[(a)]	Concentration			
	TX-107	TY-103	TY-105	TY-106
Sodium (µg/L)	2.32E+08	2.11E+08	9.18E+07	8.99E+07
Chromium (µg/L)	4.33E+06	4.00E+06	1.72E+05	1.69E+05
Calcium (µg/L)	1.13E+06	1.13E+06	3.66E+05	3.61E+05
Nitrate (mg/L)	2.49E+05	2.34E+05	1.63E+05	1.61E+05
Nitrite (mg/L)	7.04E+04	6.90E+04	9.80E+03	9.66E+03
Sulfate (mg/L)	1.95E+04	1.82E+04	1.40E+04	1.38E+04
Fluoride (mg/L)	1.54E+03	1.92E+03	0.00E+00	0.00E+00
Uranium (µg/L)	1.83E+06	1.96E+06	3.76E+05	3.69E+05
Tritium (pCi/L)	1.52E-04	1.22E-04	5.16E-06	5.08E-06
Cobalt-60 (pCi/L)	2.39E-05	1.62E-05	1.63E-07	1.61E-07
Strontium-90 (pCi/L)	8.09E-02	5.71E-02	1.16E-02	1.14E-02
Technetium-99 (pCi/L)	1.51E-04	1.13E-04	4.94E-06	4.87E-06
Ruthenium-106 (pCi/L)	4.65E-09	3.01E-09	6.78E-04	6.67E-14
Iodine-129 (pCi/L)	2.91E-07	2.17E-07	9.32E-09	9.17E-09
Cesium-137 (pCi/L)	2.23E-01	2.38E-01	1.30E-02	1.28E-02

(a) Radionuclides are decayed to January 1, 1994.

The regional geologic setting of the Pasco Basin and the Hanford Site has been described previously by Delaney et al. (1991) and Reidel et al. (2002). Tallman et al. (1979) and Lindsey et al. (1994) and, most recently, Williams et al. (2002) have described the geology of the 200 West Area. The reader is referred to those references for descriptions of the regional geology.

The geology specific to WMA TX-TY was first described by Price and Fecht (1976a, b) and then by Caggiano and Goodwin (1991). More recently the WMA TX-TY geology was summarized by Lindsey and Reynolds (1998) and by Wood et al. (2001). Reidel et al. (2006) updated previous work to include observations from several new wells at the WMA. Their geologic description is comparable to recent, regional studies (Williams et al. 2002; Wood et al. 2001) and ensures coherence within the larger framework of stratigraphic interpretations of the Hanford Site. Any small differences that exist between the geologic description given in Reidel et al. (2006) and descriptions in previous reports result primarily from differences in survey elevations used to interpret lithologic contacts. These are small differences and do not represent any significant change or discrepancy. The geologic description given below is summarized from Reidel et al. (2006).

Figure 2.1 shows the locations of all wells in the vicinity of WMA TX-TY that were used for geologic interpretation. The quality of data obtained from these wells varies and is a function of when

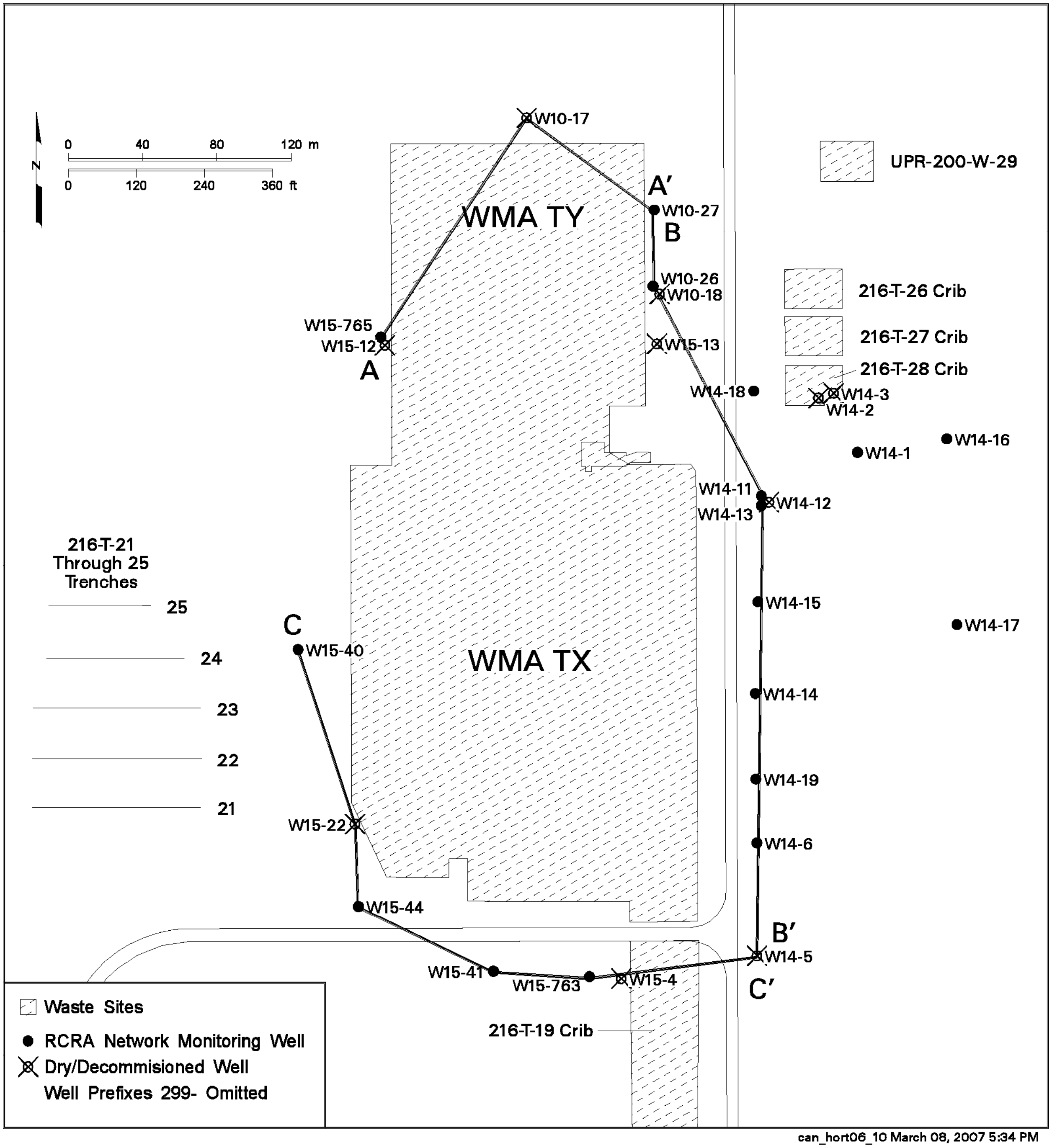

Figure 2.1. The Locations of Wells and Cross-Sections at Waste Management Area TX-TY

they were drilled, drilling methods, and their purpose. Pertinent information about the wells is given in Appendix B. In general, data from RCRA standard boreholes are of higher quality than data from the older (pre-1988) boreholes.

Lithologic logs were interpreted from the well-site geologist's (or driller's) logs. Geophysical logs, particle size distributions, and laboratory moisture data were then compared with the lithologic logs. In some cases, geophysical logs (e.g., gross gamma-ray) allowed refinement of the data by permitting more precise placement of geologic contacts than when lithologic logs alone were used. This was particularly true for wells where only older, driller's logs and no geologist's logs were available.

2.4.1 Stratigraphy and Lithology at Waste Management Area TX-TY

The vadose zone beneath WMA TX-TY is between about 66 and 70 meters thick and consists of the Hanford formation, the Cold Creek unit, the Taylor Flats member of the Ringold Formation, and the upper part of unit E of the Wooded Island member of the Ringold Formation. The water table is at about 136.3 meters elevation and the unconfined aquifer beneath WMA TX-TY is estimated to be between about 50 to 58 meters thick based on March 2005 water levels and the elevation of the Ringold Formation lower mud unit in wells local to WMA TX-TY.

The geology beneath WMA TX-TY consists of basalt basement overlain by nine sedimentary sequences distinguished mainly by texture (particle size), mineralogy, responses to natural gamma logs, and stratigraphic position. These sequences are (from top to bottom):

- Holocene eolian sediments and/or backfill material
- Hanford formation gravel-dominated sequence
- Hanford formation sand-dominated sequence
- Cold Creek unit silts and sands
- Cold Creek unit calcic paleosols
- Ringold Formation, member of Taylor Flats (not present in all boreholes)
- Ringold Formation, member of Wooded Island unit E
- Ringold Formation, member of Wooded Island lower mud
- Ringold Formation, member of Wooded Island unit A

Figure 2.2 shows a generalized stratigraphic column for the WMA TX-TY area. The site specific stratigraphic information used to construct geologic cross-sections, thickness maps and structure contour maps at WMA TX-TY is given in Appendix B. The cross-sections are shown in Figures 2.3 through 2.5. (See Figure 2.1 for locations of cross-sections).

The dense interior of the Elephant Mountain Member of the Saddle Mountains Basalt is the base of the suprabasalt aquifers in the area. The Elephant Mountain Member was not encountered in any boreholes in the WMA TX-TY area. Based on driller's logs from nearby deep well 299-W11-26, located about 270 meters northeast of the TY Tank Farm, the elevation of the top of the Elephant Mountain Member is at about 60 meters above sea level. The Elephant Mountain Member dips gently to the southwest into the Cold Creek syncline.

The Ringold Formation, member of Wooded Island unit A overlies the Elephant Mountain Member beneath WMA TX-TY. Unit A is described on borehole logs of cuttings and samples from wells near the WMA TX-TY area as pebble to cobble gravel with up to 15% sand and very little silt. Some interstratified sand horizons exist within the gravel and there are some highly cemented zones. Unit A was completely penetrated in only one borehole in the area of WMA TX-TY (well 299-W11-26) where it was found to be 23 meters thick.

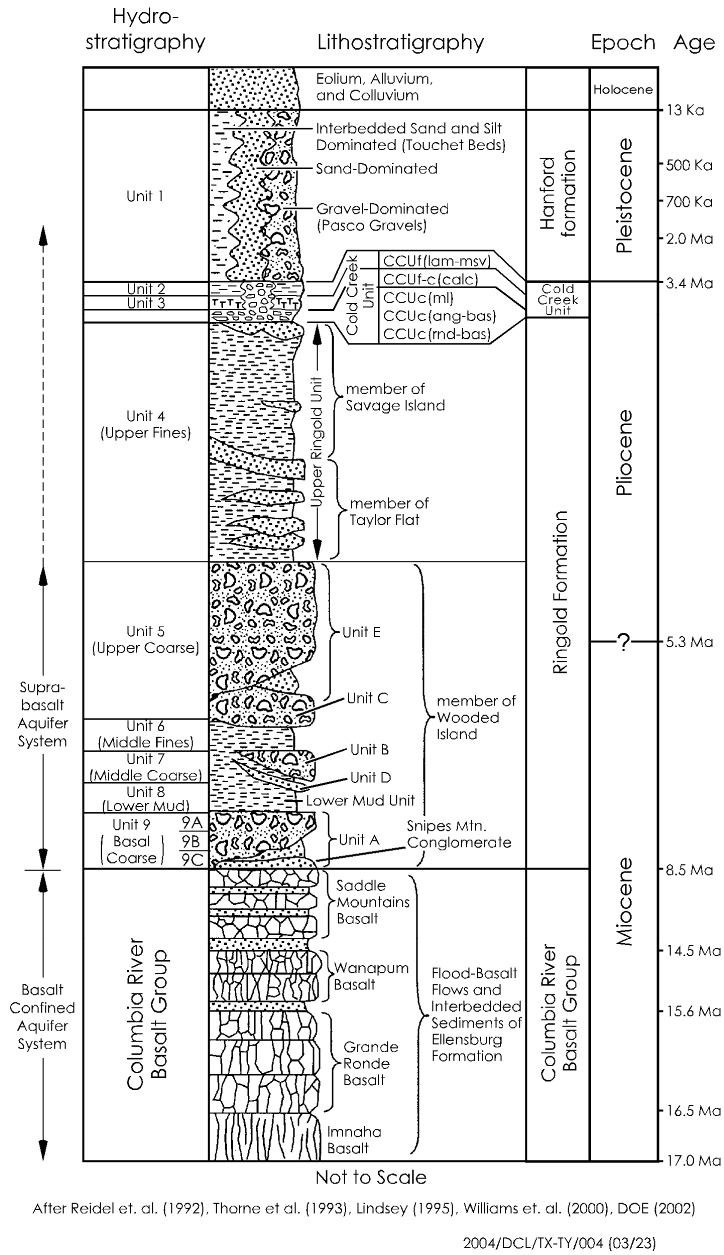

Figure 2.2. Generalized Stratigraphic Column for the Hanford Site (modified from Lindsey 1996). The column is not to scale. The member of Savage Island, the member of Wooded Island units C, B, and D, and the Snipes Mountain Conglomerate are not present at Waste Management Area TX-TY.

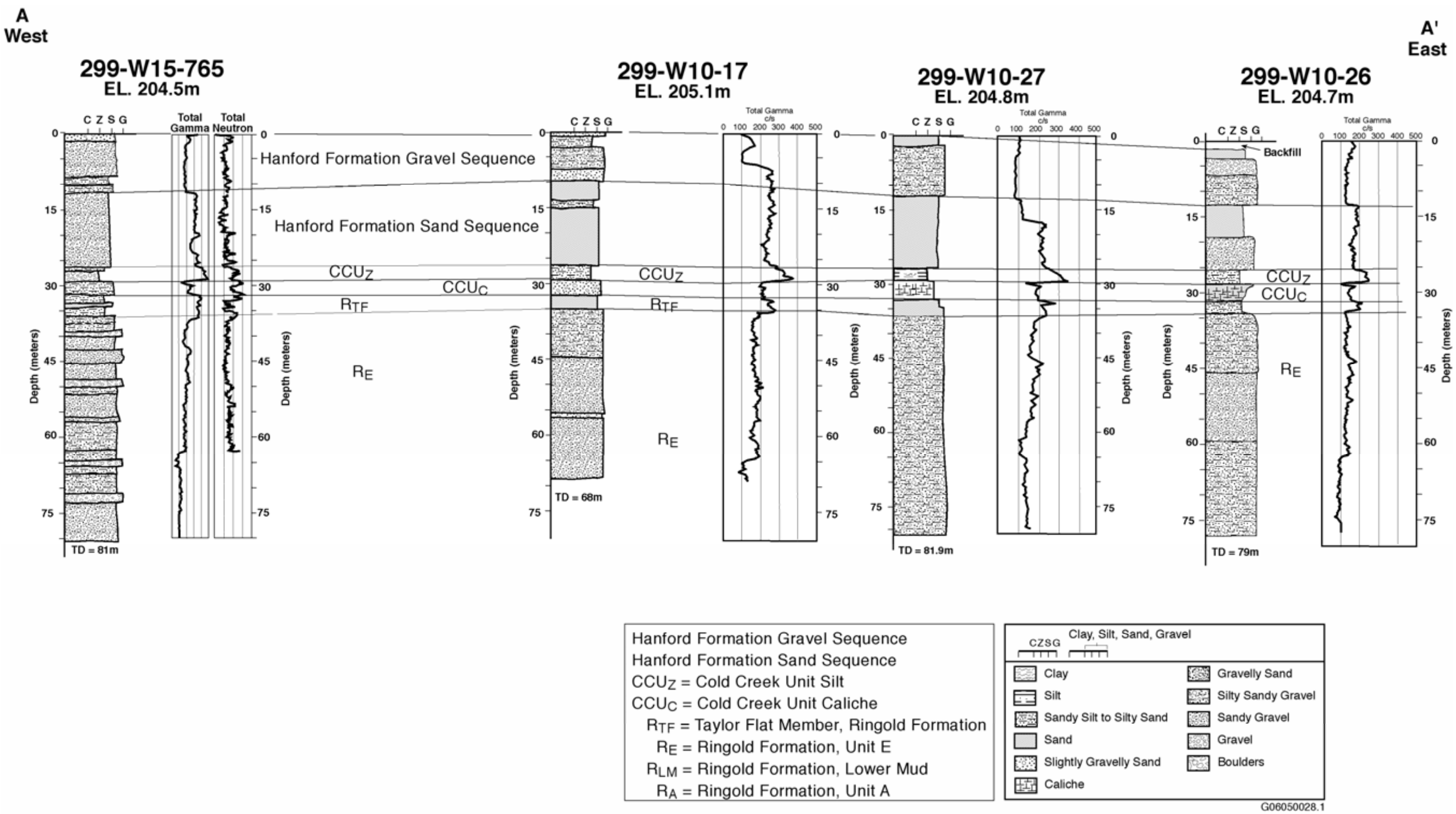

Figure 2.3. Cross-Section of the Geology North of Waste Management Area TX-TY (see Figure 2.1 for location of cross-section)

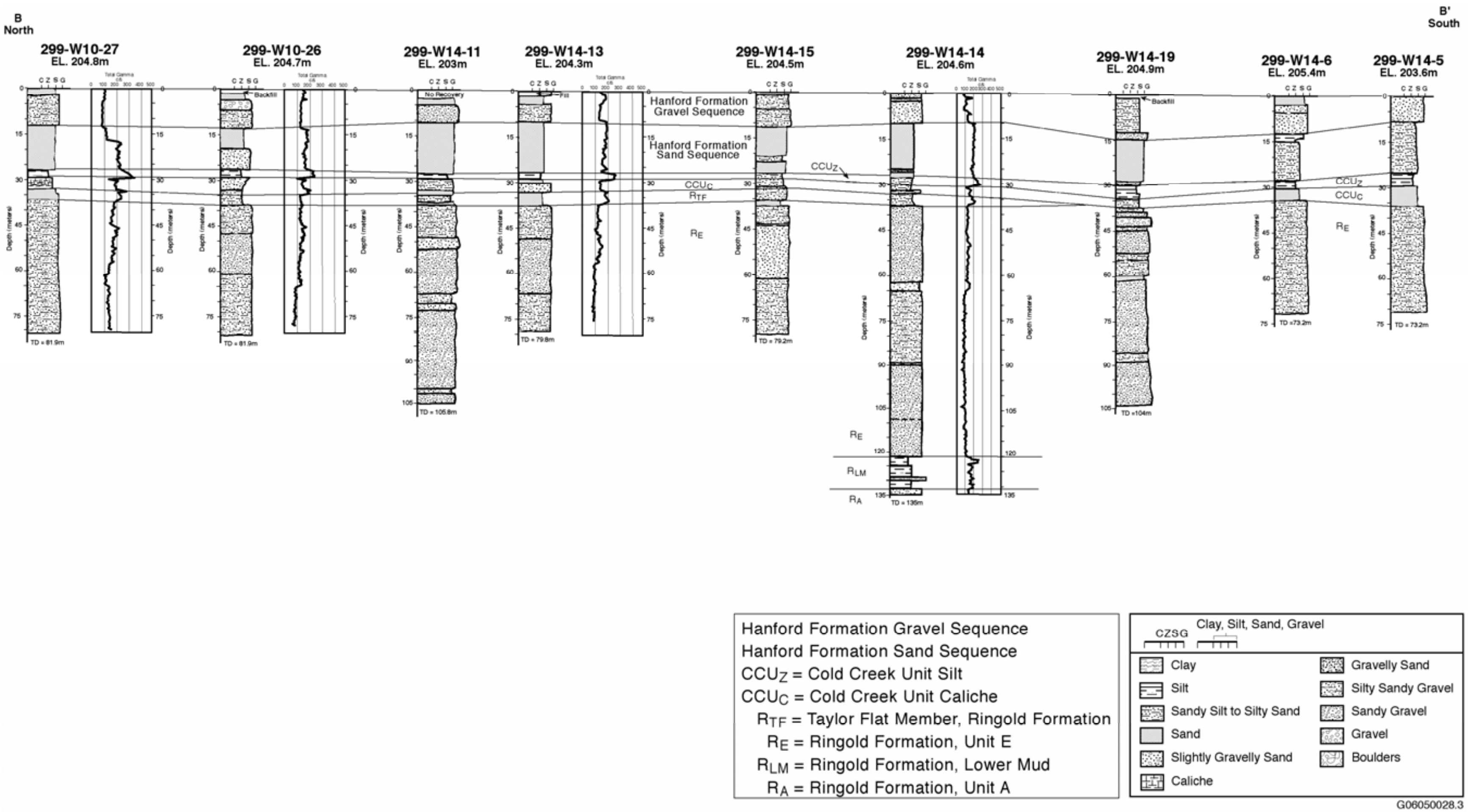

Figure 2.4. Cross-Section of the Geology East (downgradient) of Waste Management Area TX-TY (see Figure 2.1 for location of cross-section)

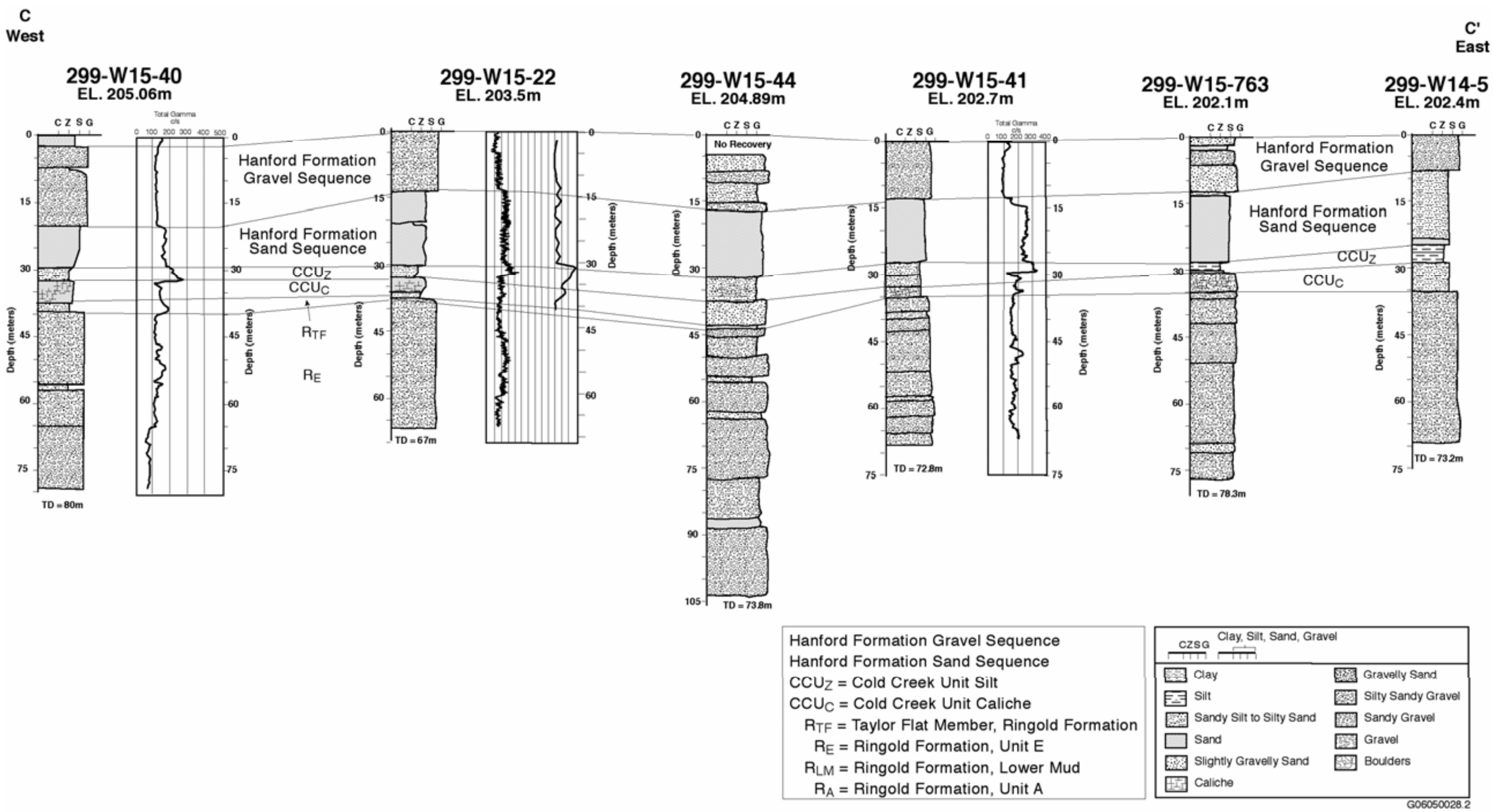

Figure 2.5. Cross-Section of the Geology South of Waste Management Area TX-TY (see Figure 2.1 for location of cross-section)

The Ringold Formation, member of Wooded Island lower mud unit (R_{LM}) overlies unit A. The lower contact of the lower mud unit is usually sharp and easy to distinguish from drill cuttings and natural gamma logs. The lower mud unit is described as laminated to massive clay, silt, and sandy silt. Sediments in the lower mud unit are consolidated and generally contain no calcium carbonate. The lower mud unit was completely penetrated in two wells near WMA TX-TY; well 299-W14-14 where it was found to be 11 meters thick and well 299-W11-26 where it was found to be 5.2 meters thick.

The lower mud unit is equivalent to hydrogeologic unit 8 of (Williams et al. 2002). They describe hydrogeologic unit 8 as separating the suprabasalt aquifer into an upper unconfined aquifer in the sediments above the lower mud unit and a lower, confined aquifer in the Ringold Formation unit A. Groundwater in the unconfined aquifer and the confined Ringold Formation unit A aquifer does not flow vertically through hydrogeologic unit 8 (Williams et al. 2002).

Where the lower mud unit is not present, the suprabasalt aquifer is a single system. The data available from the WMA TX-TY area suggests that the lower mud unit is continuous beneath the entire WMA.

Overlying the lower mud unit is the Ringold Formation, member of Wooded Island unit E (R_E). The contact between the two is easily distinguished on natural gamma logs by a considerable drop in gamma activity in going from the lower mud unit upward into unit E. Unit E is described on borehole logs of cuttings and samples from wells near the WMA TX-TY area as a pebble to cobble gravel with a fine- to coarse-grained sand matrix. Gravel content is usually greater than 60 to 70%. Occasionally, what are interpreted as large boulders are encountered during drilling. The sediments are variably consolidated, usually poorly sorted and show variable amounts of calcium carbonate. Iron oxide staining is common. “Slow drilling,” “hard drilling,” and “switched to hard tool” are common comments on the geologists’ logs when drilling in unit E sediments.

Unit E was fully penetrated by two wells in the WMA TX-TY area: well 299-W14-14 where it was found to be 85 meters thick and well 299-W11-26 where it was 83 meters thick. Many wells in the WMA TX-TY area penetrate the top of unit E. Unit E is fairly flat beneath WMA TX-TY although there may be a slight dip toward the west or southwest (Figure 2.6 D).

Unit E is overlain by bedded sandy silt, sand, and silty sand of the Ringold Formation, member of Taylor Flats (R_{TF}). These sediments are unconsolidated to consolidated and poorly to well sorted. Local pebbly areas occur. In places, calcium carbonate occurs as stingers and nodules whereas in other places no calcium carbonate exists. The lower boundary of the member of Taylor Flats is easily recognized by the difference in texture between this fine-grained member and the underlying unit E gravels.

The member of Taylor Flats is up to 5 meters thick beneath WMA TX-TY, but is not present in most wells toward the southern end of the WMA (Figure 2.7 C). Based on the elevations at the top of the member of Taylor Flat, the member has a general, gentle dip toward the southwest (Figure 2.6 C).

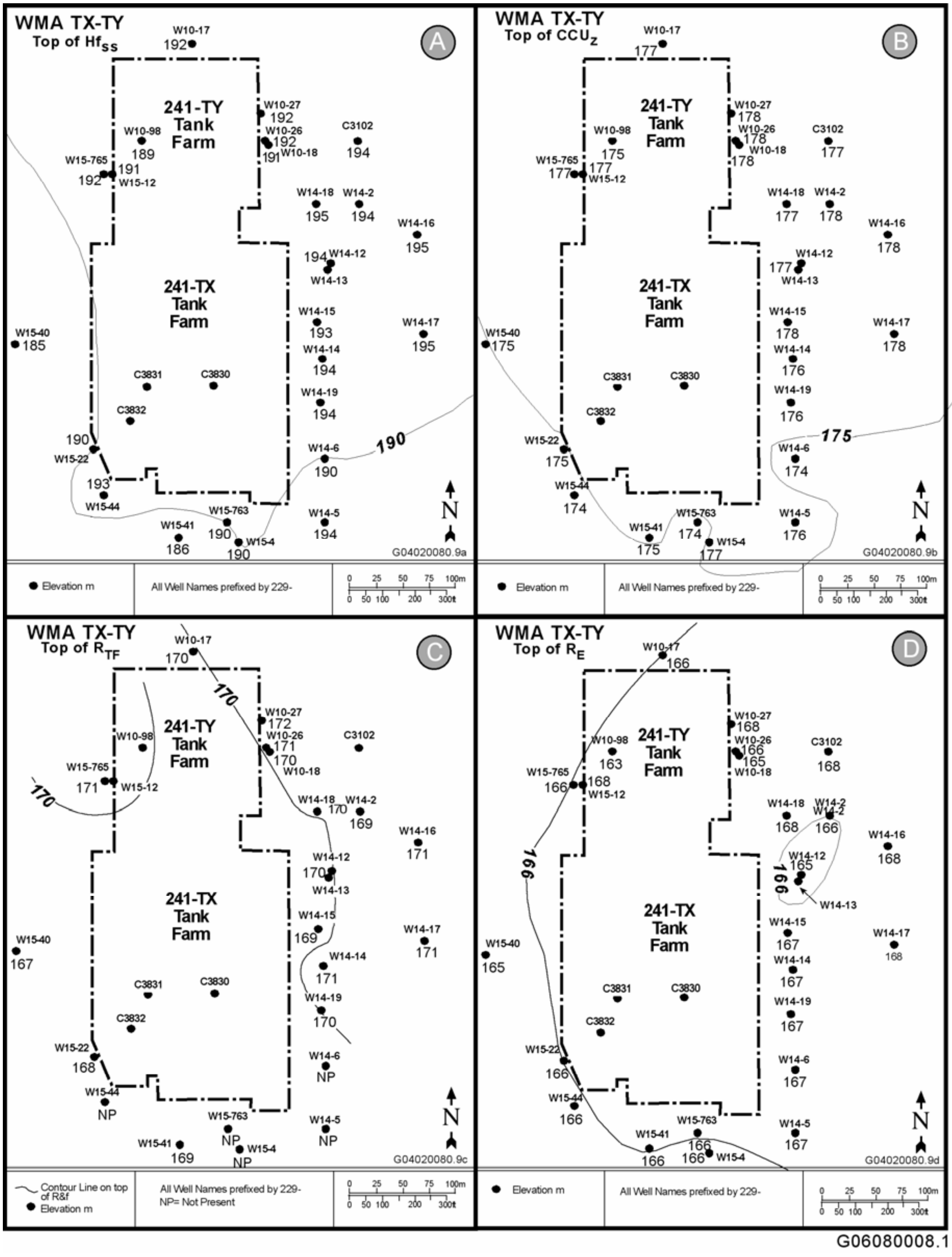

Figure 2.6. Structure Contour Maps for Selected Units under Waste Management Area TX-TY (from Reidel et al. 2006). NP = Not present.

The Cold Creek unit calcic paleosol sequence (CCU_C) formerly known as the Plio-Pleistocene caliche) overlies the member of Taylor Flats. The contact between the two is marked by a substantial increase in calcium carbonate in the paleosol sequence and a substantial decrease in the natural gamma log going from the underlying sands and silts into the paleosol sequence. The Cold Creek paleosol sequence consists of calcium carbonate-cemented silt, silty sand, and sandy silt with some gravel in places. In most wells the amount of calcium carbonate is fairly continuous throughout the unit, but in others there are caliche-rich and caliche-poor zones. In places, the sediment becomes so cemented with calcium carbonate that the driller has to change from drive barrel to hard tool in order to continue drilling.

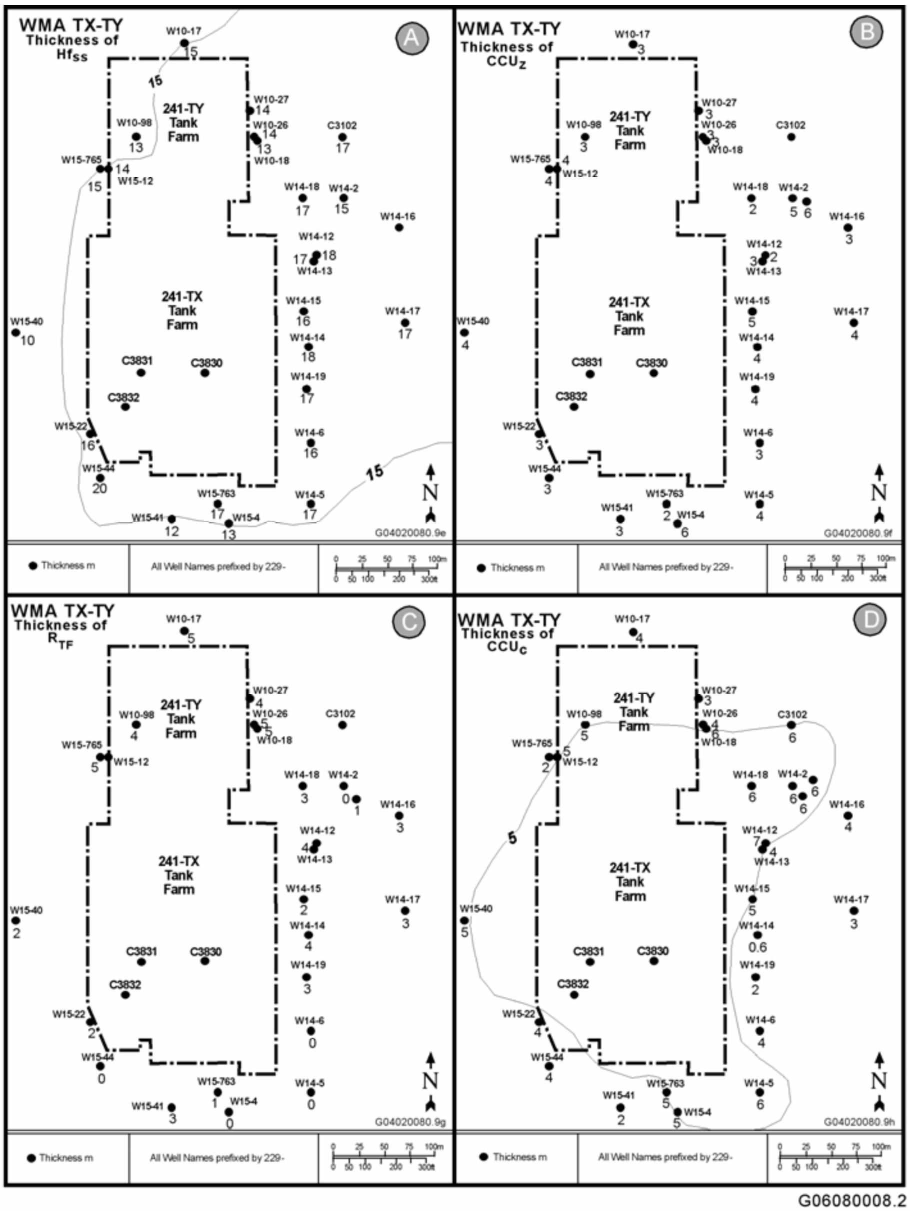

Figure 2.7. Thickness Maps for Selected Units under Waste Management Area TX-TY (from Reidel et al. 2006)

The Cold Creek unit calcic paleosol sequence occurs in all wells at WMA TX-TY. The sequence ranges in thickness from 0.6 to 7.6 meters with an average thickness of about 4.25 meters under the WMA.

Cold Creek unit fluvial and/or eolian sediments (CCU_Z) overlie the calcic paleosol sequence at WMA TX-TY. These sediments are slightly to well consolidated, moderately to well sorted silt and sandy silt. They may contain calcium carbonate but lack the extensive cementation found in the underlying calcic paleosols. The Cold Creek fluvial and/or eolian sequence is between 2 and 5 meters in thickness and averages about 3 meters thick at WMA TX-TY (Figure 2.7 B). The surface of the unit dips very gently to the southwest (Figure 2.6 B).

The driller's log for well 299-W10-2, located about 170 meters north of TY Tank Farm, noted perched water from 26 to 31 meters depth. This closely corresponds to the top and bottom of the Cold Creek fluvial and eolian sequence in the well. Perched water has not been found associated with the Cold Creek unit beneath the WMA TX-TY. (Perched water also was noted associated with a silt lens in the overlying Hanford formation sand-dominated sequence in well 299-W15-7, located about 150 meters south of the TX Tank Farm.)

A Hanford formation sand-dominated sequence overlies the Cold Creek fluvial sediments beneath WMA TX-TY. The sequence is equivalent to the sandy sequence of Lindsey et al. (1992) and to Qfs of Reidel and Fecht (1994).

The Hanford formation sand-dominated sequence is described on borehole logs of cuttings in the WMA TX-TY area as variably bedded silty sand, sand, and slightly gravelly to gravelly sand. The sediments are poorly to well sorted and unconsolidated. Fine-grained, silt-rich lenses are common and range from about 5 to 10 centimeters up to about 30 centimeters in thickness. Based on observations of outcrop and intact core, the sand-dominated sequence is interpreted to have been deposited during the waning stages of glacial flooding.

The Hanford formation sand sequence ranges from about 10 to 20 meters and averages about 16 meters in thickness beneath the WMA (Figure 2.7 A). The sandy beds are "salt and pepper" sands ranging from about 30% basaltic and 70% felsic sand to 70% basaltic and 30% felsic sand. The sequence is not cemented but does contain zones bearing calcium carbonate occurring as small concretions and as coatings on grains.

Thin silt lenses cap some individual beds within the Hanford formation sand-dominated sequence. These lenses are generally 15 centimeters or less in thickness but range up to about 30 centimeters thick. Generally, the silt lenses cannot be correlated among boreholes.

The base of the Hanford formation sand-dominated sequence is recognized by a change from the finer-grained silty sand to coarser grained deposits and is reflected by a decrease in natural gamma activity when logging upward from the sediments of the Cold Creek unit into the Hanford formation. The top of the sand-dominated sequence is more difficult to distinguish and is usually chosen at the top of the shallowest sand bed that is greater than 3 meters thick, beneath gravel-dominated deposits. In some wells, this corresponds to a decrease in natural gamma activity when going from the sand-dominated sequence upward into the gravel-dominated sequence. The Hanford formation sand-dominated sequence tends to be thicker beneath the eastern part of the WMA (Figure 2.7 A) and dips slightly toward the west or southwest (Figure 2.6 A).

A Hanford formation gravel-dominated sequence overlies the sand-dominated sequence. The gravel-dominated sequence is described on borehole logs of cuttings as consisting of silty sandy gravel and sandy gravel with some interbedded sand and silty sand. This sequence is equivalent to the Hanford formation upper gravel sequence of Lindsey et al. (1992) and Qfg of Reidel and Fecht (1994). Caggiano and Goodwin (1991), in the original groundwater monitoring plan for single-shell tanks, did not differentiate this sequence and the underlying Hanford formation sand-dominated sequence. The upper gravel-dominated sequence was deposited by high-energy, glacial flood waters.

The Hanford formation gravel-dominated sequence ranges from 6 to 18 meters thick in the WMA TX-TY area and averages about 10 meters thick. Much or the entire unit was removed from most, if not all, of the tank farm during construction and replaced as backfill after construction was complete. The base of the gravel-dominated sequence was chosen at the top of the first sand or silty sand sequence that is at least 3 meters thick. This contact may be somewhat arbitrary, particularly in boreholes with only a driller's log and no natural gamma log.

Holocene deposits overly the Hanford formation at WMA TX-TY. These deposits are limited to wind blown silt and sand. Eolian sheet sands occur sporadically at the surface and generally are less than about 3 meters thick. Eolian sediments were removed during tank farm construction. Backfill material occurs to about 15 meters depth in the tank farm. The backfill is poorly sorted, gravelly sand to sandy gravel (Price and Fecht 1976a, b) from the gravel-dominated sequence of the Hanford formation.

Price and Fecht (1976a, b) state that clastic dikes were detected in the TX and TY Tank Farms during construction although they could not be mapped. Recently, clastic dikes have been recognized in core samples from RCRA monitoring well 299-W10-27, from characterization borehole C3102 at the 216-T-26 crib, and from borehole C3831 drilled adjacent to tank TX-107 (Serne et al. 2004).

2.4.2 Aquifer Properties

This section provides information on the properties of the unconfined aquifer in the immediate region of WMA TX-TY. Aquifer properties were determined from stratigraphic interpretations, current water level elevations, and aquifer testing. Most of the information given in this section is summarized from Serne et al. (2004) and Reidel et al. (2006).

Currently, the water table at WMA TX-TY is about 136 meters above sea level. The suprabasalt aquifer system beneath WMA TX-TY is estimated to be about 76 meters thick based on the depth to top of basalt in well 299-W11-26, located about 270 meters northeast of the WMA. The suprabasalt aquifer system consists of the confined or semi-confined aquifer in the Ringold Formation unit A, which is about 21 meters thick and lies between the top of basalt and the bottom of the lower mud unit, and the unconfined aquifer, which is about 50 to 58 meters thick and lies above the lower mud unit. (The lower mud unit is a confining or semi-confining unit.) All wells in the WMA TX-TY monitoring network are screened in the unconfined aquifer, hydrogeologic unit 5 (Williams et al. 2002) (the Ringold Formation unit E).

Water levels in the unconfined aquifer were raised by as much as 20 meters (above the pre-Hanford Site natural water table of about 125 meters above sea level; Kipp and Mudd 1974) beneath WMA TX-TY because of artificial recharge from liquid waste disposal operations active between the mid 1940s and 1995. The largest volumes of discharge were to the 216-T pond system and the 216-U-10 pond system.

Figure 2.8 shows the groundwater elevations in several wells adjacent to WMA TX-TY since the early 1950s. The figure shows that the increase in water-table elevation was most rapid in the early 1950s (and late 1940s) and was somewhat stable between the late 1960s and the late 1980s. Water levels began to decline in the late 1980s beneath WMA TX-TY when wastewater discharges in the 200 West Area were reduced. The decline in water levels may have implications for the groundwater monitoring network at the WMA TX-TY as will be discussed later.

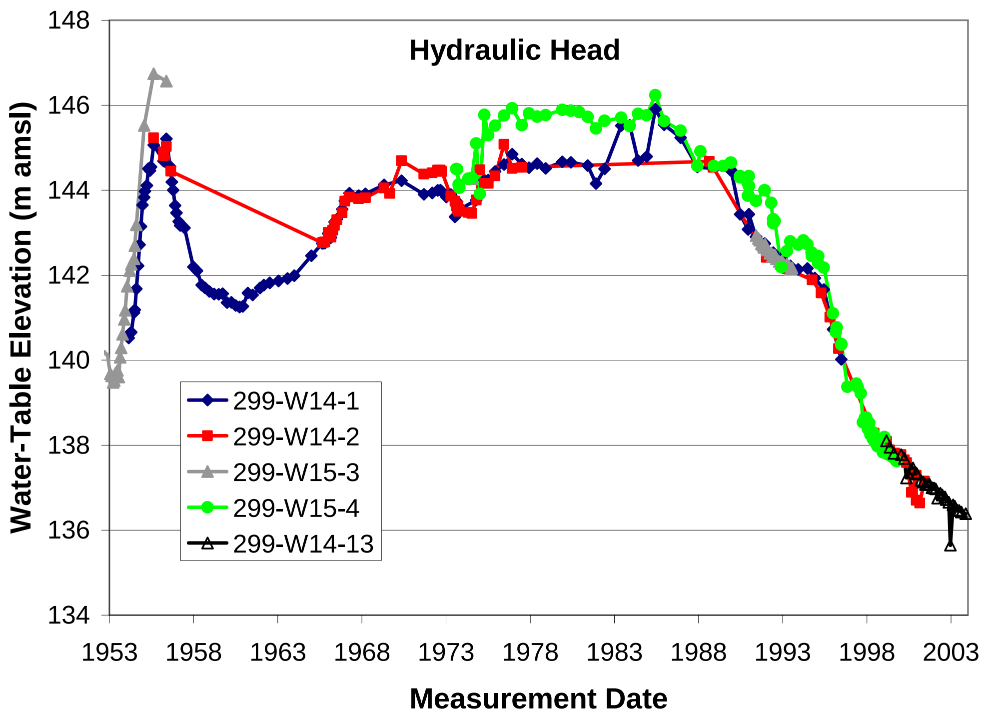

Figure 2.8. Hydrographs of Selected Wells Adjacent to Waste Management Area TX-TY

Accompanying the changes in water level were changes in groundwater flow direction. Histograms (in rose diagram format) showing groundwater flow directions beneath the northern part of 200 West Area during different time periods are shown in Figure 2.9. The rose diagrams plot the solutions to numerous three-point analyses using water level information from various well triplets in the north central part of 200 West Area. The petals of the rose diagrams point in the direction of groundwater flow and the length of the petals represent the percentage of measurements showing that groundwater flowed in the indicated direction. It should be noted that the changes in groundwater flow directions did not occur abruptly but most likely took place over a period of months.

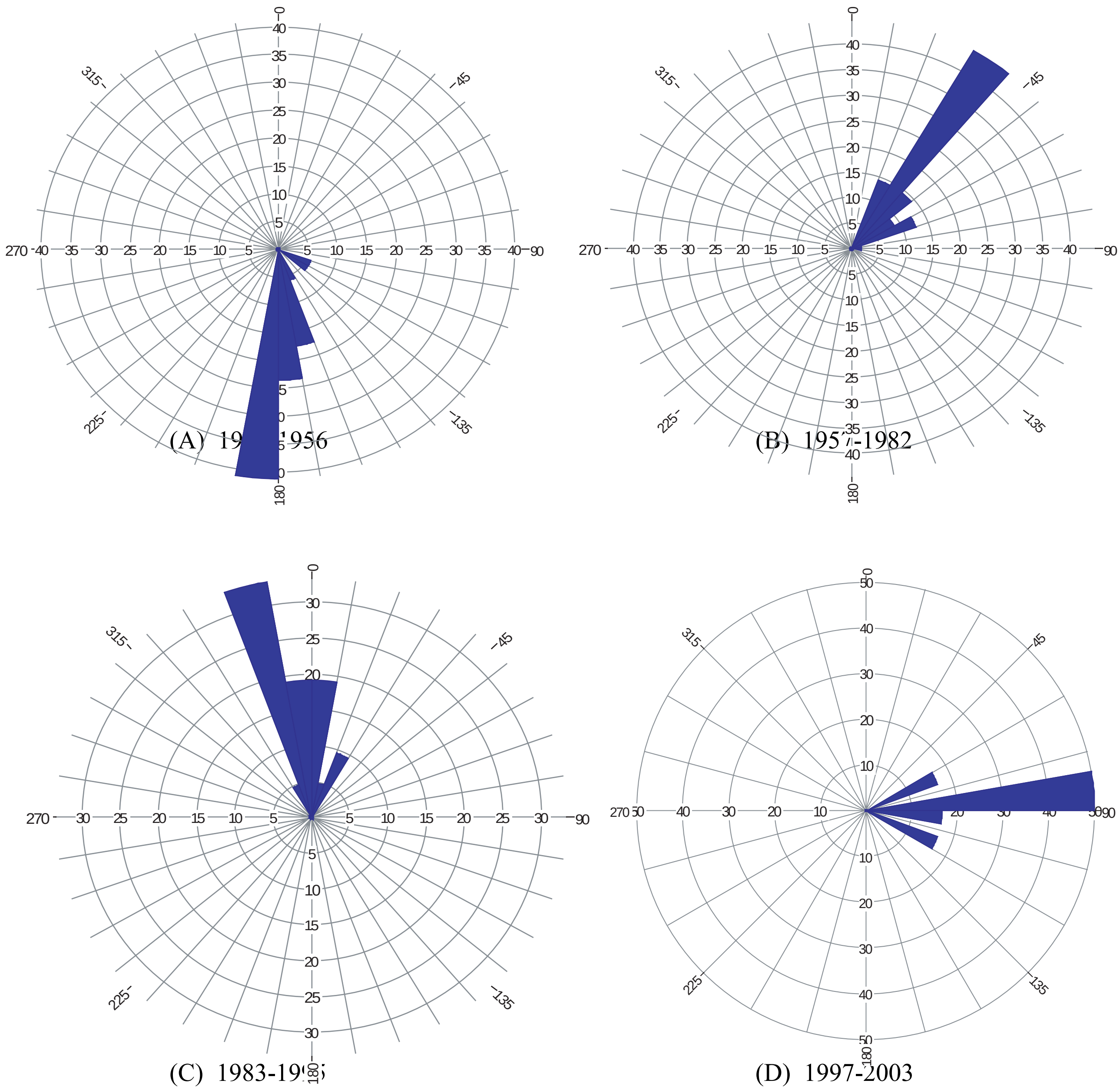

Figure 2.9. Groundwater Flow Directions in the North Part of 200 West Area. (A) 1954 to 1956, 1 well triplet, 17 measurements; (B) 1957 to 1982, 2 well triplets, 56 measurements; (C) 1983 to 1995, 4 well triplets, 21 measurements; (D) 1997 to 2003, 3 well triplets, 6 measurements (from Reidel et al. 2006).

Pre-Hanford Site (circa 1942) groundwater flow direction was toward the east (Kipp and Mudd 1974). The rose diagram in Figure 2.9A shows that groundwater flow had changed toward the south in the area by the early 1950s. This shift resulted from disposal of large volumes of liquid to the 216-T pond system, located north of the T Tank Farm. In 1956, groundwater flow direction changed again and started flowing towards the northeast due to the increasing influence of the groundwater mound under 216-U pond and a decreasing influence of the mound under 216-T pond (Figure 2.9B). Discharges to 216-T pond ended in 1976 but continued at 216-U pond until 1984. As discharges to the 216-U pond declined in the early 1980s, groundwater flow shifted to a more northward direction as the groundwater mound began to decrease and discharges to the 216-U-14 ditch continued. The slight westward component to the groundwater flow direction between early 1980s and mid 1990s (Figure 2.9C) may be a result of the discharges to the 216-U-14 ditch, located southwest of WMA TX-TY, influencing water levels in some of the wells used in the analysis. All non-permitted discharges to the ground ceased and the influence of the 216-U pond mound on the groundwater beneath the TX and TY Tank Farms diminished in 1995. Consequently, the flow direction changed again in about 1996 and began to return toward an eastward direction (Figure 2.9D).

These large shifts in groundwater flow direction have large implications for contaminant distribution in the uppermost aquifer beneath WMA TX-TY. In the late 1940s and early 1950s, any contamination in the aquifer would have moved toward the south. Then, in the late 1950s and until the mid-1990s any contamination present would have moved northward. Today, groundwater contamination beneath WMA TX-TY and surrounding area is generally migrating east.

Phase I of the 200-ZP-1 pump-and-treat operation began in 1994 with one extraction well. The operation was expanded to three extraction wells in 1996 (Phase II) and then to six extraction wells in August 1997 (Phase III). The first distinct effects of the pump-and-treat operation on groundwater flow direction beneath WMA TX-TY were observed on the June 1998 water table map (Hartman 1999). Since that time groundwater flow beneath the southern part of the WMA has been toward the south or south southwest toward the extraction wells.

In July 2005, four extraction wells were added to the 200-ZP-1 Operable Unit, carbon tetrachloride pump-and-treat system. All four of these wells are immediately upgradient (west) of WMA TX-TY. It is expected that these new extraction wells soon will alter the direction of groundwater flow and the direction of groundwater flow will change toward the west. Increasing concentrations of contaminants, seen in one of these wells (299-W15-765) beginning in November 2005, is probably a direct result of drawing contaminants from beneath the tank farms to the wells.

A March 2005 water table map for WMA TX-TY is shown in Figure 2.10. The influences of the early phases of the 200-ZP-1 pump-and-treat are clearly seen south of the WMA. The most recent extraction wells to the pump-and-treat system were not yet added in March 2005 when the map was made.

Borehole tracer dilution and tracer pumpback tests were conducted in five new RCRA monitoring wells at the TX and TY Tank Farms between fiscal years 1999 and 2002. These tests provided some information about flow rate and aquifer heterogeneity. The tests allowed direct observation of the effect of lateral groundwater flow through the well screens and, thus, provided an indication of the variability of flow through the screened intervals. Details of the test methods, computations, and results are included in Spane et al. (2001a, 2001b, 2002, and 2003).

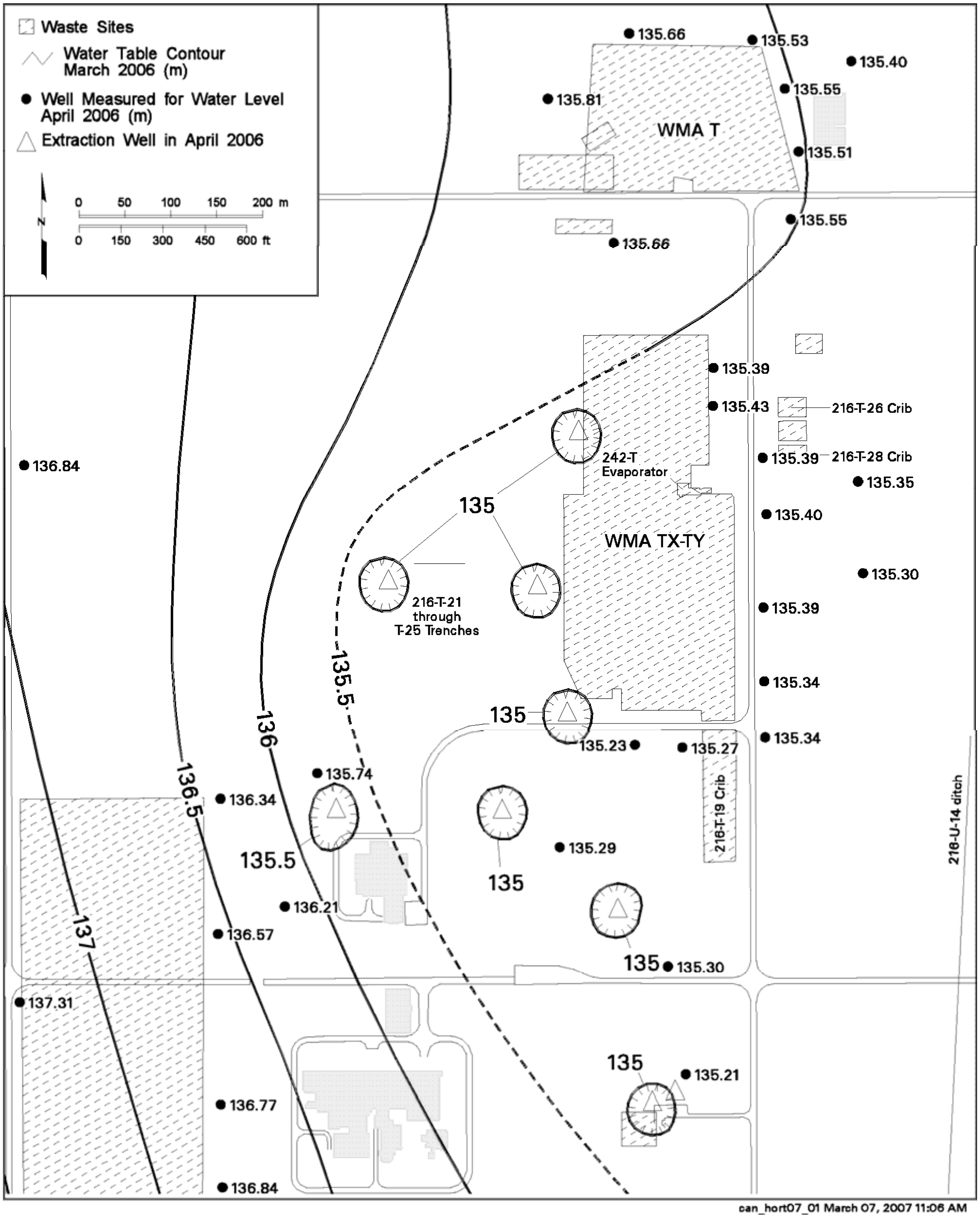

Figure 2.10. March 2005 Water-Table Map for the Waste Management Area TX-TY

A significant feature of the tracer dilution test results is evidence for downward, vertical hydraulic gradients within the upper portion of the aquifer in wells 299-W10-26, 299-W14-13, and 299-W14-14. Vertical flow within two of these wells was first indicated by electromagnetic flow meter surveys (Waldrop and Pearson 2000). Vertical flow was subsequently corroborated by tracer-dilution studies and later verified in two wells by vertical tracer tests specifically designed to detect vertical flow within a borehole (Spane et al. 2001a). Data from all three types of tests are shown in Table 2.5.

The existence of vertical flow in a well does not necessarily reflect actual groundwater flow conditions within the surrounding aquifer, but its presence implies a vertical flow gradient in the well bore and has implications pertaining to how representative are the groundwater samples collected from the wells. Also, the vertical gradient in some wells along the downgradient edge of WMA TX-TY may have an impact on contaminant distribution in the aquifer.

Table 2.5. In-Well, Downward Vertical, Flow-Velocity Summary for Wells 299-W10-26, 299-W14-13, and 299-W14-14 at Waste Management Area TX-TY (Spane et al. 2001a, 2003; Waldrop and Pearson 2000).

Test Well	Tracer-Dilution Profile		Vertical Tracer Test[a]		Electromagnetic Flow-Meter Survey	
	Range (m/min)	Average (m/min)	Range (m/min)	Average (m/min)	Range (m/min)	Average (m/min)
Waste Management Area TX-TY						
299-W10-26	0.002 – 0.004 ↓	0.003 ↓	0.004 – 0.008 ↓	0.005 ↓	0.003 – 0.006 ↓	0.004 ↓
299-W14-13	0.008 – 0.015 ↓	0.011 ↓	0.013 – 0.014 ↓	0.012 ↓	0.012 – 0.013 ↓	0.012 ↓
299-W14-14	0.0054 – 0.0058 ↓	0.0056 ↓	ND	ND	ND	ND

(a) In-well, vertical, flow-velocity range calculated using tracer peak arrival method for selected sensor depth, while the average was determined using the center-of-mass technique.
(b) ↓ Directional symbol indicating vertical flow direction.
ND = Not determined.

A second feature of the hydrologic test data is the suggestion of higher or lower permeability at certain depths within the screened interval of some wells relative to other depths. For example, tracer tests indicate that the highest permeability in the screened interval of well 299-W14-15 is within approximately the upper 1 meter below the water table (calculated well screen velocity of 0.170 meter/day). Beneath this zone is a low permeability zone (calculated well screen flow velocity of 0.077 meter/day) and velocity below the low permeability zone is intermediate (0.096 to 0.120 meter/day). Similar tests show lower permeability in the upper part of the well screen in well 299-W15-41 with higher permeabilities at depth. Thus, apparent differences in permeability do not appear to correlate over appreciable distances from well to well.

For the WMA TX-TY groundwater assessment, additional hydraulic property data were obtained from slug tests and drawdown tests conducted in new wells drilled since 1999. Effective porosities were determined from tracer drift and tracer pumpback tests. Hydraulic properties are discussed in detail by Spane et al. (2001a, 2001b, 2002, 2003) and are presented in Tables 2.6 and 2.7.

Table 2.6. Results from Tracer-Dilution and Tracer-Pumpback Tests in Wells at Waste Management Area TX-TY (Spane et al. 2001a, 2001b, 2002)

Well	Effective Porosity[a]	Horizontal Groundwater[a] Flow Velocity in the Aquifer (m/d)	Average In-Well Horizontal Flow Velocity[b] (m/d)
299-W10-26[c]	0.010	0.124	0.086
299-W14-13[d]	0.009	0.191	ND
299-W14-14[c]	0.020	0.122	0.041
299-W14-15	0.002	1.1	0.119
299-W15-41	0.068	0.374	0.311

(a) Data from tracer pump back tests.
(b) Data from tracer dilution tests.
(c) Slight downward vertical flow, data uncertain.
(d) Strong downward vertical flow, data highly uncertain.

Table 2.7. Hydraulic Properties from Slug and Constant Rate Pumping Tests and Calculated Horizontal Flow Velocities at New Wells at Waste Management Area TX-TY

Well	Hydraulic[a,b] Conductivity (m/d)	Hydraulic[a,c] Conductivity (m/d)	Transmissivity[a,c] (m^2/d)	Specific[a,c] Yield	Calculated Flow Velocity (m/d)
299-W10-26	1.39 – 1.95	1.49	82	0.14	0.014[d]
299-W10-27	0.05 – 0.07	ND	ND	ND	0.0007[e]
299-W14-13	1.66 – 2.43	2.45	135	0.12	0.020[d]
299-W14-14	2.31 – 3.22	2.21	121	0.12	0.027[d]
299-W14-15	3.52 – 4.92	4.09	225	0.01	2.46[f]
299-W14-16	3.90 – 5.08	ND	ND	ND	0.051[e]
299-W14-17	3.71 – 4.89	ND	ND	ND	0.489[e]
299-W14-18	0.39 – 0.54	ND	ND	ND	0.005[e]
299-W15-40	0.88 – 1.22	ND	ND	ND	0.012[e]
299-W15-41	14.2 – 19.9	19.6	1130	0.12	0.29[f]
299-W15-763	0.71 – 0.93	ND	ND	ND	0.009[e]

(a) Data from Spane et al. 2001a, 2001b, 2002, and 2003.
(b) Slug test data.
(c) Constant rate pumping test data.
(d) Estimated using maximum hydraulic conductivity value, a gradient of 0.001, and specific yield from this table. Specific yield was used because downward flow in the well resulted in uncertain effective porosity.
(e) Estimated using maximum hydraulic conductivity value, a gradient of 0.001 and effective porosity values of 0.1.
(f) Estimated using maximum hydraulic conductivity value, a gradient of 0.001, and effective porosity value from Table 2.6.
ND = Not determined.

The horizontal groundwater flow velocities determined from tracer pump back tests (Table 2.6) are greater than the calculated velocities (Table 2.7) for wells which have downward vertical flow in the well bore and the vertical flow in these wells probably resulted in overestimation of the measured flow velocity. Both the measured and calculated velocities are about the same for wells which have no vertical flow.

Overall, there are four orders of magnitude difference in the flow velocities in Table 2.7. The flow velocity in well 299-W10-27 is substantially less than the velocities calculated for some of the other wells. The well had low water production and excessive drawdown during well development and extremely long recovery times during slug testing both of which are indicative of low permeability. Well 299-W10-26 is nearest to well 299-W10-27 and the hydraulic conductivity at well 299-W10-26 is typical of other wells in the area. Thus, the low permeability zone at well 299-W10-27 appears to be a local feature of the aquifer formation.

Taken as a whole, the geologist's logs, geophysical logs, development pumping data, and the hydrologic testing data all indicate heterogeneity in the aquifer properties within the screened intervals of several individual wells and among wells at WMA TX-TY. No widespread trends have been identified.

The hydrographs in Figure 2.11 show that water levels have declined by about 3.2 meters since the beginning of 1998 beneath the WMA TX-TY. Between 1998 and 2004 the average rate of water table decline has been between about 0.3 to 0.4 meter/year in all monitoring wells at WMA TX-TY, although the decline in wells at the southern end of the WMA is overprinted by artificial changes in water levels brought on by the 200-ZP-1 pump-and-treat system. The rapid decrease in water levels has resulted in monitoring wells going dry more quickly than previously predicted and has necessitated the drilling of fifteen new monitoring wells since 1999. Given an estimated pre-Manhattan project water table elevation of 125 meters above mean sea level (Kipp and Mudd 1974), the only monitoring wells currently in the WMA TX-TY groundwater monitoring network that are expected to go dry are wells 299-W14-6 and 299-W15-41, although water levels will decrease to near the bottom of the open interval in several of the wells (Table 2.8).

2.5 Contamination at Waste Management Area TX-TY

This section summarizes the current and historical groundwater contamination at WMA TX-TY. Vadose zone contamination is also discussed in this section because residual vadose zone contamination is a potential source for future groundwater contamination.

As stated in Section 1.3, groundwater monitoring objectives of RCRA, CERCLA, and the AEA often differ slightly and the contaminants monitored are not always the same. For RCRA regulated units, monitoring focuses on non-radioactive dangerous waste constituents. Radionuclides (source, special nuclear and by-product material) may be monitored in some RCRA unit wells to support objectives of monitoring under the AEA and/or CERCLA. Please note that pursuant to RCRA, the source, special nuclear and by-product material component of radioactive mixed wastes, are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

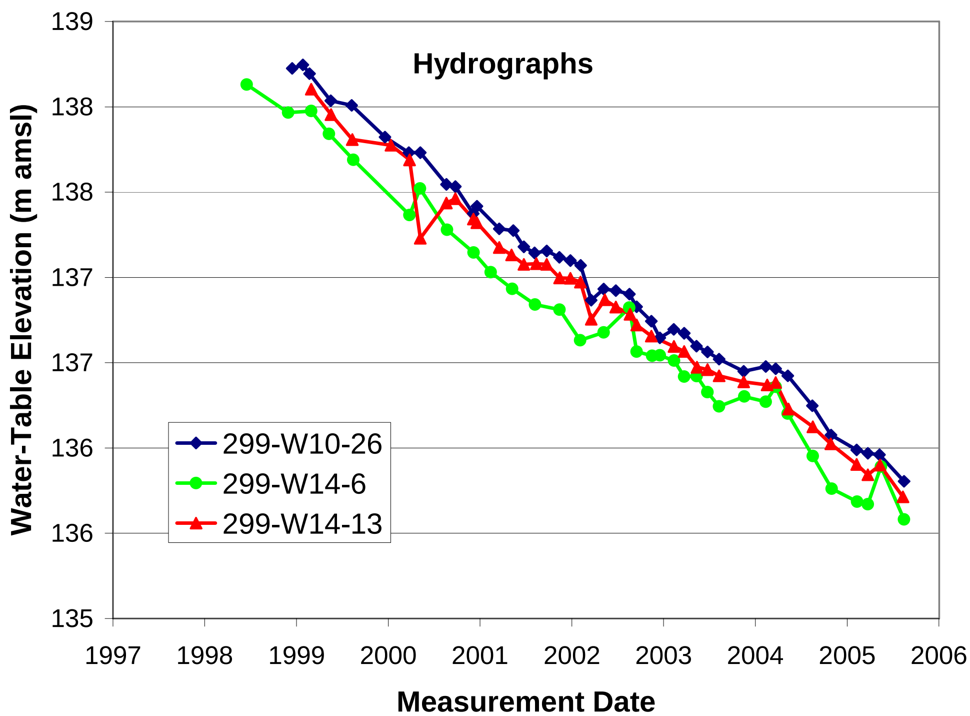

Figure 2.11. Hydrographs for Three Wells at Waste Management Area TX-TY

Table 2.8. Calculated Life Expectancy for Wells in the Waste Management Area TX-TY Monitoring Network

Well Name	Elevation at Bottom of Screened Interval (m amsl)	Water Table Elevation, May 2005 (m amsl)	Water Above Bottom of Screen, May 2005 (m)	Year Well is Expected to be Dry[(a)]
299-W10-26	127.82	135.960	9.14	NA
299-W10-27	126.88	135.681	8.80	NA
299-W14-6	134.53	135.891	1.36	2009
299-W14-11	121.57	135.839	14.27	NA
299-W14-13	127.63	135.899	8.27	NA
299-W14-14	127.82	135.548	7.73	NA
299-W14-15	126.99	135.691	8.70	NA
299-W14-16	126.78	135.767	8.99	NA
299-W14-17	126.77	135.710	8.94	NA
299-W14-18	127.13	135.859	8.73	NA
299-W14-19	126.02	135.581	9.56	NA
299-W15-40	127.93	136.157	8.23	NA
299-W15-41	132.40	135.744	3.34	2016
299-W15-44	127.59	135.735	8.14	NA
299-W15-763	126.95	135.820	8.87	NA
299-W15-765	126.79	136.138	9.35	NA

(a) Assume 0.3 meter/year decline in water table and 125 meters pre-Hanford elevation.
NA = Not applicable. Well is not expected to go dry based on 0.3 meter/year water table decline and 125 meters pre-Hanford water-table elevation.

2.5.1 Groundwater Contamination

Most of the information presented in this section is from Horton et al. (2002), Hartman et al. (2000, 2001, 2002, 2003, 2004, 2005), and Serne et al. (2004).

Chromium, carbon tetrachloride, and trichloroethene are the only dangerous waste constituents found in the groundwater beneath WMA TX-TY. Carbon tetrachloride and trichloroethene are monitored as part of the 200-ZP-1 Operable Unit. Nitrate is also found in groundwater beneath the facility. In addition to the dangerous waste constituents, the non-RCRA-regulated constituents technetium-99, iodine-129, and tritium are found in groundwater at the WMA.

Carbon tetrachloride is present in the unconfined aquifer beneath most of the 200 West Area (Figure 2.12). (Note that all plume maps in this document represent conditions in the upper approximately 9 to 10 meters of the unconfined aquifer.) The highest average carbon tetrachloride concentrations at the top of the aquifer near WMA TX-TY in fiscal year 2005 were along the western edge of the WMA where concentrations were equal to or greater than 2,400 μg/L in wells 299-W15-44, 299-W15-40, and 299-W15-765. The carbon tetrachloride is believed to be from pre-1973 waste from the Plutonium Finishing Plant and not from WMA TX-TY.

The major sources for trichloroethene are disposal sites associated with the Plutonium Finishing Plant. As with carbon tetrachloride, the maximum trichloroethene concentrations found near WMA TX-TY, in 2005, were along the western and upgradient edge. The highest fiscal year 2005 average concentrations at the top of the aquifer were in well 299-W15-40 (12 μg/L), 299-W15-44 (14 μg/L), and well 299-W15-765 (11 μg/L) (Figure 2.13). The waste management area is not considered a source for trichloroethene.

A regional tritium plume lies beneath WMA TX-TY and much of the north half of the 200 West Area (Figure 2.14). There is also a small, local area of very high tritium concentration east of the WMA TX-TY; the highest average tritium concentration in 2005 was 1,500,000 pCi/L in well 299-W14-13 in this area. The source for the tritium may be the TY Tank Farm because Corbin et al. (2005) estimate that only tanks TX-107, TY-103, TY-105, and TY-106 had concentrations of tritium greater than 1 million pCi/L. Alternatively, the 216-T-19 crib and tile field may be the tritium source because they received waste with tritium concentrations greater than 1 million pCi/L in the 1960s and early 1970s. However, no other wells between the 216-T-19 tile field and well 299-W14-13 have tritium above the drinking water standard.

Figures 2.15 and 2.16 show the tritium distribution with depth in the upper part of the unconfined aquifer as determined by sampling and analysis during drilling of new wells. The graphs in Figure 2.15 show that the tritium concentration generally increases with depth in the tested wells located east and south of the TX Tank Farm. Two of the wells show a decrease in concentration between 20 and 30 meters below the water table. Well 299-W14-14 also shows a decrease but at a deeper level and at the level of the Ringold Formation lower mud unit. (The top of the lower mud is at 56 meters below the water table in well 299-W14-14.) Below the lower mud unit, the tritium concentration begins to increase again. The available data suggest that the tritium concentration in the area of WMA TX-TY has a maximum at some depth below the water table, but the depth of the maximum is different in different wells. The situation is complicated by variable permeability in the aquifer, vertical in-well hydraulic gradients, and by perturbations resulting from the 200-ZP-1 pump-and-treat operation.

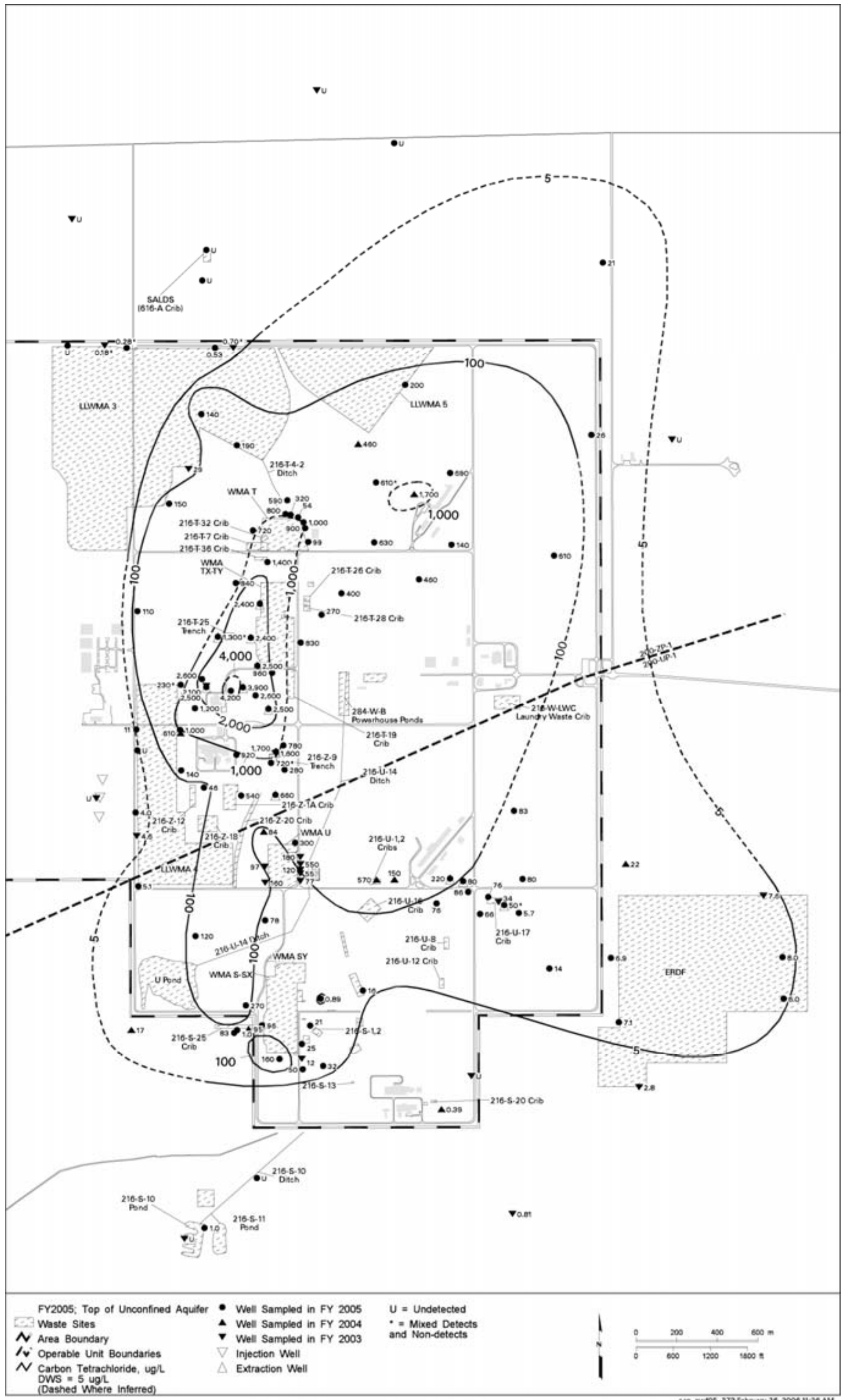

Figure 2.12. Average Fiscal Year 2005 Concentration of Carbon Tetrachloride in the 200 West Area, Top of the Unconfined Aquifer (from Hartman et al. 2006)

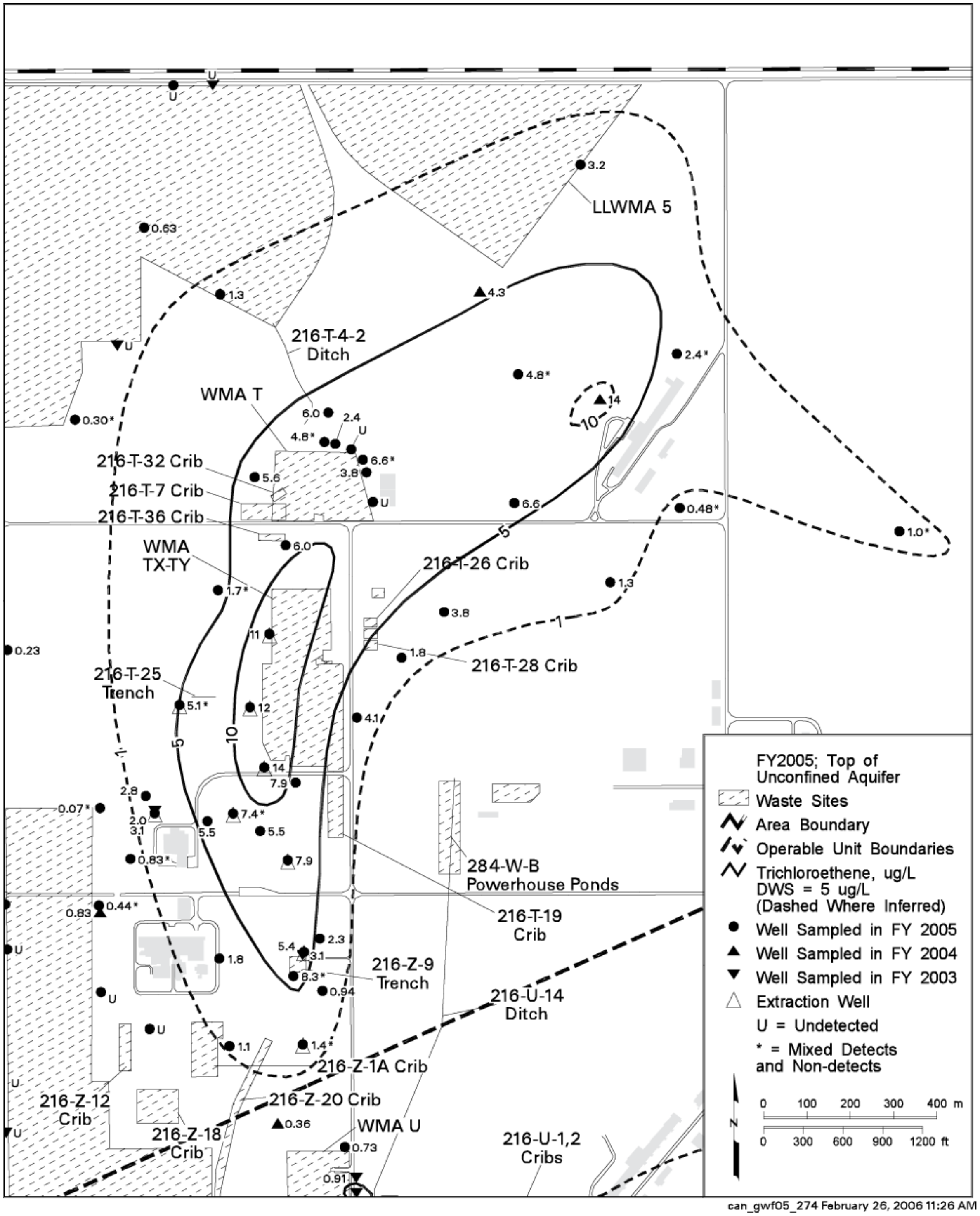

Figure 2.13. Average Fiscal Year 2005 Concentrations of Trichloroethene in the North Part of the 200 West Area, Top of the Unconfined Aquifer (from Hartman et al. 2006)

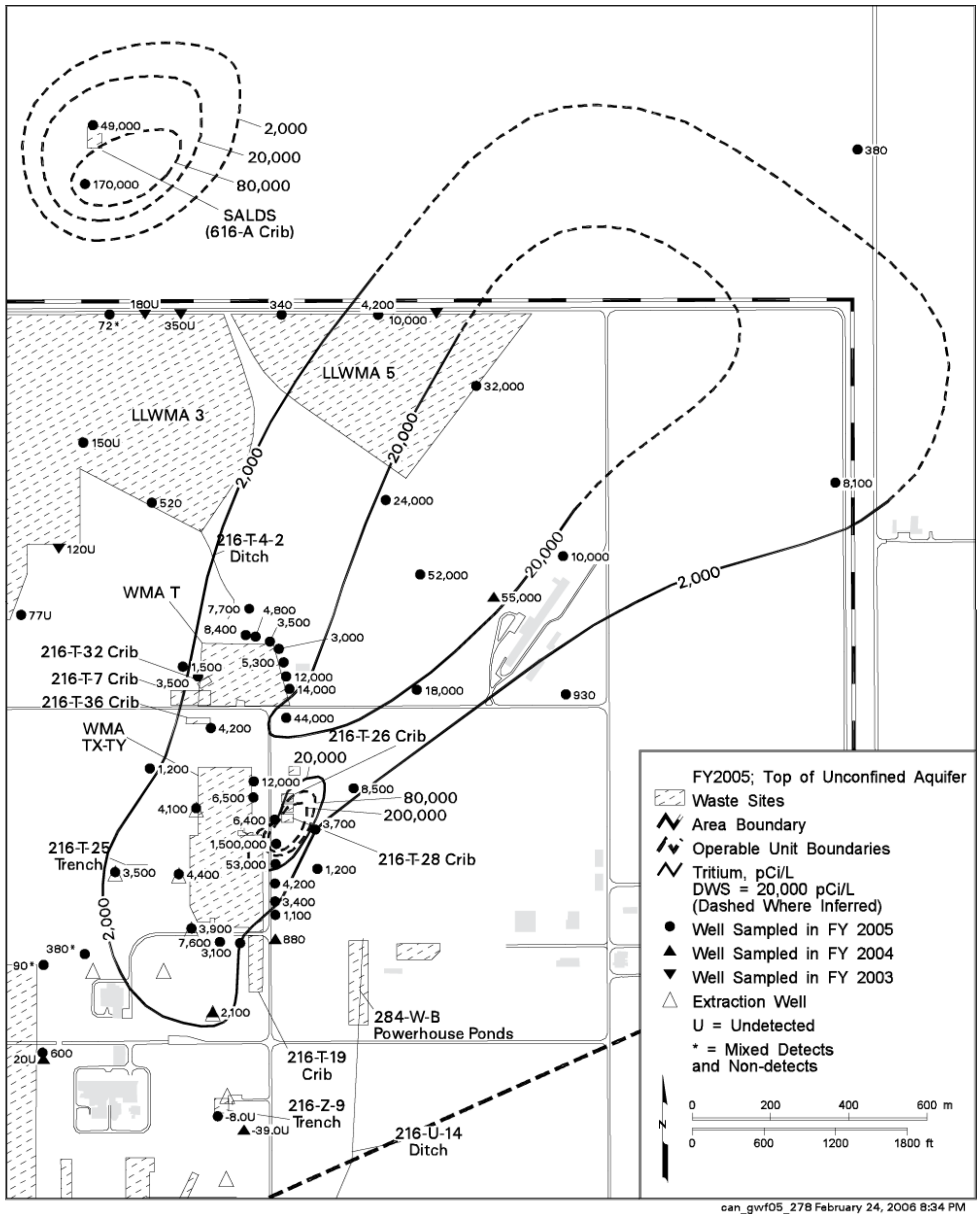

Figure 2.14. Average Fiscal Year 2005 Tritium Concentrations in the North Part of 200 West Area, Top of the Unconfined Aquifer (from Hartman et al. 2006)

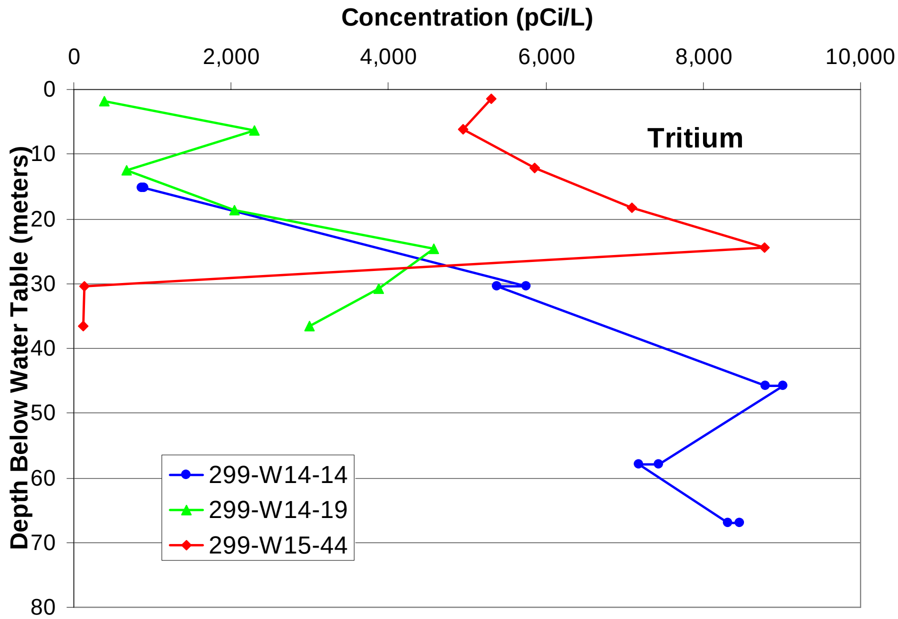

Figure 2.15. Tritium Distribution with Depth in the Upper Part of the Unconfined Aquifer Beneath Waste Management Area TX-TY

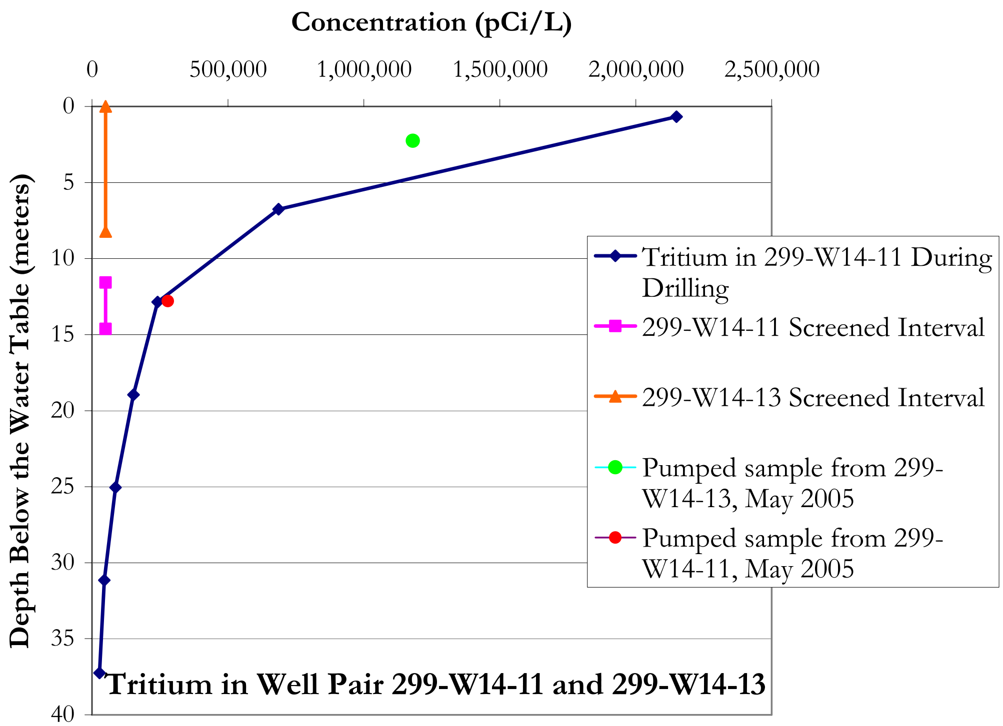

Figure 2.16. Tritium Concentration versus Depth in Well 299-W14-11 at Waste Management Area TX-TY

Figure 2.16 shows the tritium distribution with depth in well 299-W14-11, located in the local high tritium concentration plume east of WMA TX-TY. The tritium concentrations in this well are much higher than the concentrations in other wells at WMA TX-TY. The tritium concentration in well 299-W14-11 decreases with depth, unlike the distribution shown in Figure 2.15. However, the concentration in the deepest sample is 27,400 pCi/L, which is much greater than any concentration in the other wells. The extremely high tritium concentration very near the water table suggests a local source for the tritium, and these high concentrations probably mask any concentration changes associated with the regional plume. Also shown on Figure 2.16 is the tritium concentration of the latest pumped sample from well 299-W14-13, located about 5 meters from well 299-W14-11. That value is from the screened, top 8 meters of the aquifer and is about 1,180,000 pCi/L, which is a reasonable mean of the concentrations in the upper 8 meters of well 299-W14-11. These data contradict the earlier interpretation using data from well pair 299-W14-13 and 299-W14-12 that tritium was evenly distributed throughout the aquifer (Horton 2002).

A regional plume underlies WMA TX-TY and much of the north part of the 200 West Area (Figure 2.17). All monitoring wells in the WMA TX-TY monitoring network have nitrate concentrations in excess of the 45 mg/L maximum contaminant level. As with tritium, there is a local nitrate high in wells 299-W14-13 and 299-W14-11, located east of the WMA. The highest nitrate concentration in this area during 2005 was 553 mg/L in well 299-W14-13. There is also an area of relatively low nitrate concentration, relative to the regional plume, north of well 299-W14-13 (Figure 2.17) that has existed since at least the mid-1990s. The cause for the low nitrate in the area is not known.

The nitrate concentration versus depth below the water table in several wells at WMA TX-TY is shown in Figures 2.18 and 2.19 and in Table 2.9. The two wells shown in Figure 2.18 are about 3 meters apart and located in the local nitrate plume east of WMA TX-TY. Both wells show extremely high nitrate concentrations very close to the water table and the nitrate concentration drops off rapidly with depth. The nitrate concentration in well 299-W14-13 appears to drop off much more rapidly than in well 299-W14-11. The situation is complicated, however, because of a downward, in-well hydraulic gradient in well 299-W14-13 (see Section 2.4.2), because of differences in the sample collection methods (samples from well 299-W14-11 were collected during drilling by air lift and pump; samples from well 299-W14-13 were collected by in-situ dialysis in the completed well screen), and because the samples were collected at different times (samples were collected from well 299-W14-13 during September 2002; samples were collected from well 299-W14-11 during April and May 2005). However, the very high concentrations at shallow levels in the aquifer, and the limited aerial distribution of the high nitrate concentrations east of WMA TX-TY, suggest a nearby source for the contamination.

Figure 2.19 and Table 2.9 show nitrate concentration versus depth for wells at WMA TX-TY that are not located in the local plume east of the WMA. The two wells in Figure 2.19 show a decrease in nitrate concentration through the upper part of the aquifer, similar to the decreases seen in the high concentration plume east of the WMA, although the absolute concentrations are much less than those in the high concentration plume. (Well 299-W15-44 is strongly influenced by the 200-ZP-1 pump-and-treat operation so that the pump-and-treat system may have influenced the vertical nitrate distribution in that well.) However, both wells show an increase in nitrate concentration with depth starting at about 12 to 20 meters below the water table. Several of the wells in Table 2.9 show similar increases in nitrate concentration with depth in the aquifer, although no samples deeper than 15 meters are available for most of the wells. (The nitrate data for the 12.6 meter sample from well 299-W14-18 is questionable because concentrations for most cations and anions in the sample are unreasonably low.)

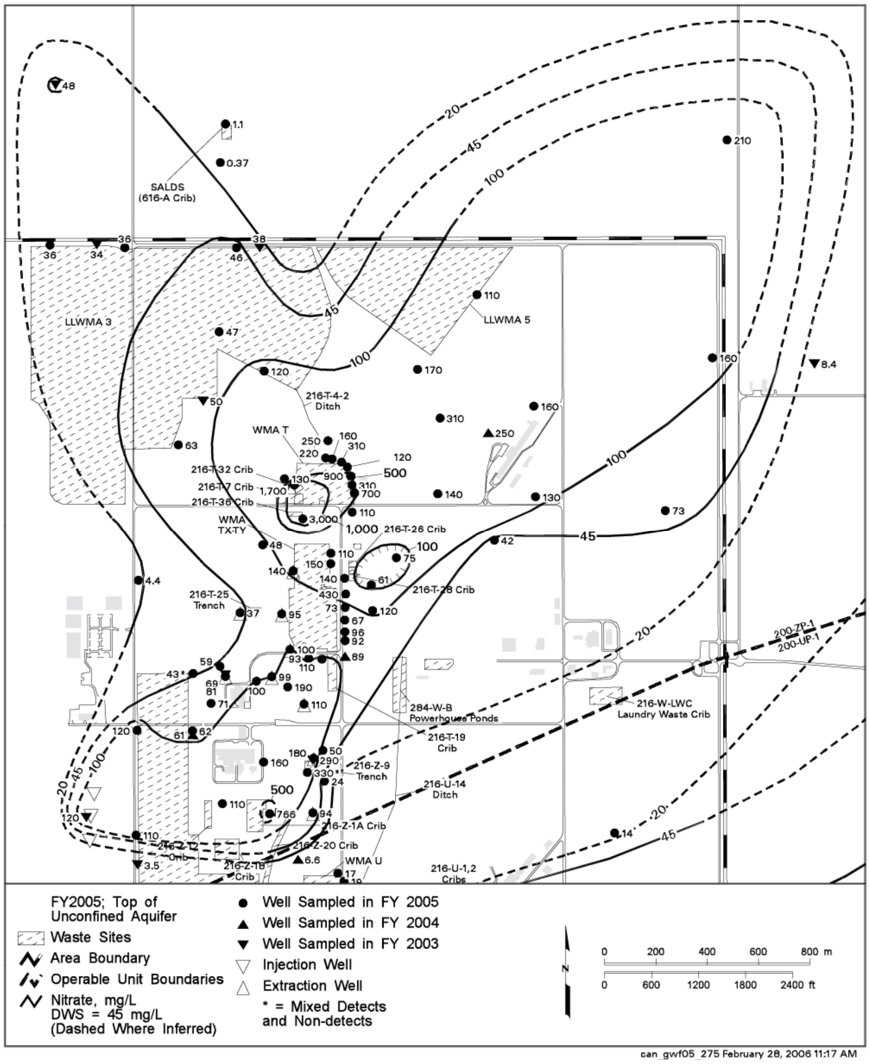

Figure 2.17. Average Concentrations of Nitrate in the North Part of 200 West Area, Top of the Unconfined Aquifer (from Hartman et al. 2006)

The nitrate concentration profiles from wells at WMA TX-TY are interpreted to show two plumes. The shallow, high concentration plume, east of the WMA (Figure 2.18), is interpreted to be a small, localized plume from a nearby source because the plume has not traveled sufficiently to disperse the high concentrations to any appreciable depth and because the high concentrations are not found in wells adjacent to those shown in Figure 2.18. The deeper plume, illustrated by the increasing nitrate concentrations below 15 to 20 meters, is interpreted to represent a more regional plume perhaps associated with the carbon tetrachloride plume found beneath most of the 200 West Area.

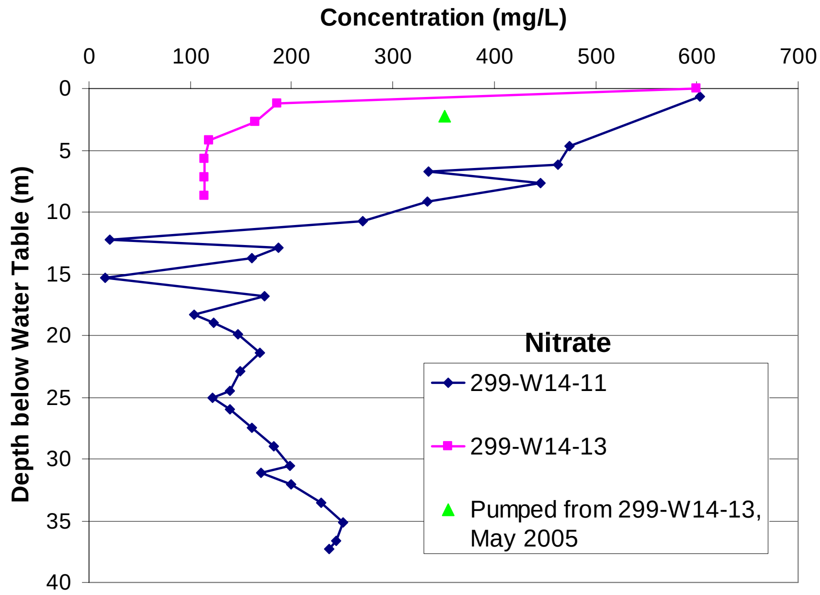

Figure 2.18. Nitrate Concentration in Well Pair 299-W14-11 and 299-W14-13

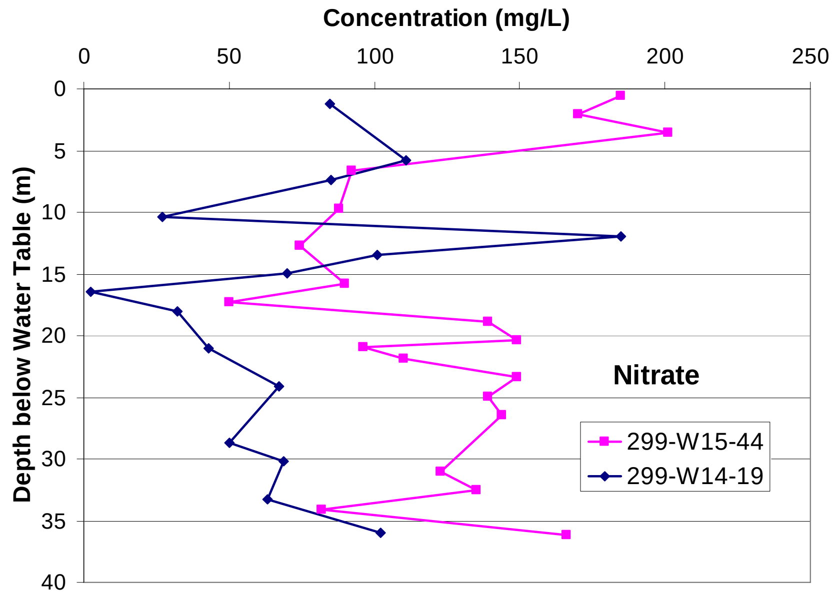

Figure 2.19. Nitrate Concentration versus Depth Below the Water Table in Well 299-W14-19 and 299-W15-44 at Waste Management Area TX-TY (data from Horton 2003)

Table 2.9. Nitrate Concentration in Groundwater Collected during Drilling of New RCRA Wells at Waste Management Area TX-TY (data from Horton and Hodges 1999, 2001 and Horton 2002)

Depth Below the Water Table (m)	Nitrate Concentration (mg/L)	Depth Below the Water Table (m)	Nitrate Concentration (mg/L)
299-W14-15[(a)]		**299-W14-16[(a)]**	
3.4	64	3.1	30
5.1	94	6.1	46
9.6	111	9.1	80
299-W15-765[(b)]		13.1	149
5.5	24.3	**299-W14-14[(b)]**	
13.8	174.1	4.3[(c)]	62.9
299-W14-18[(b)]		14.5	226
At the water table	56.8	30	41.4
12.6	3.3	39.8	32.5
		56.9	42.8
		68.5	40.2

(a) Field analysis.
(b) Laboratory analysis.
(c) Sample from screened interval after well completion.

A plume map for technetium-99 in the groundwater in the area of WMA TX-TY is shown in Figure 2.20. The figure shows a local, high concentration plume located east of WMA TX-TY, coincident with the local, high tritium and nitrate plumes. The first indication of high technetium-99 in the groundwater in the area was the first sample from well 299-W14-12, collected in April 1992 (Figure 2.21). The concentration in the well at that time was 8,240 pCi/L. The technetium-99 concentration subsequently reached ~13,300 pCi/L in 1993 at which time the concentration began to decrease until January 1997. At that time, technetium-99 concentration began to increase and reached 6,200 pCi/L in January 1999 when the well went dry (Serne et al. 2004). The increasing technetium-99 trend was continued in the replacement well 299-W14-13 (although offset to lower concentrations) until early 2000 when technetium-99 concentrations climbed to ~8,000 pCi/L. In early 2000, technetium-99 began to decrease and dropped to ~3,300 pCi/L in early 2001. This was followed by a second increase in technetium-99 concentration (up to 9,080 pCi/L) in well 299-W14-13 which lasted until August 2004. Since that time, the technetium-99 concentration in well 299-W14-13 has decreased to 7,590 pCi/L.

The technetium-99 concentrations in wells 299-W14-12 and 299-W14-13 have been used to presume a technetium-99 concentration gradient in the upper part of the aquifer (Horton 2002; Serne et al. 2004). The concentration of technetium-99 in the last sample from well 299-W14-12 was ~6,000 pCi/L. This represents the concentration of technetium-99 in the top part of the aquifer in January 1999 when the well went dry. The sample from replacement well 299-W14-13 (located about 3 meters away), taken about the same time, contained ~1,500 pCi/L technetium-99. That sample represented a mean technetium-99 concentration from the upper, screened 10 meters of the aquifer. The conclusion was that technetium-99 existed at the top of the aquifer at about 6,000 pCi/L and the concentration decreased deeper in the aquifer (Horton 2002; Serne et al. 2004). The 2,500 pCi/L technetium-99 value from well 299-W14-13 is a mixture of relatively high concentration technetium-99 near the water table with more dilute groundwater from deeper in the aquifer.

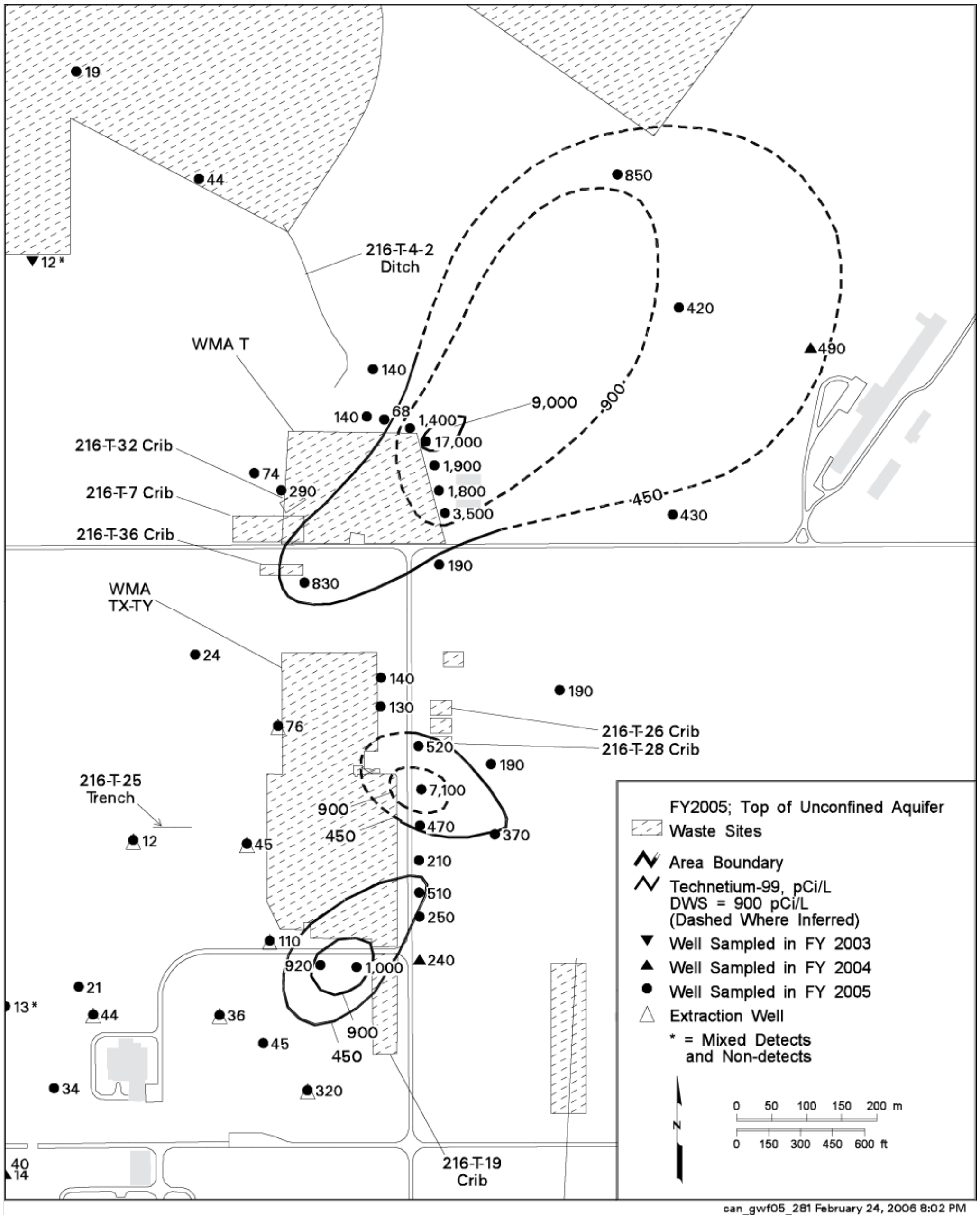

Figure 2.20. Average Fiscal Year 2005 Concentrations of Technetium-99 in the Area of Waste Management Area TX-TY, Top of the Unconfined Aquifer (from Hartman et al. 2006)

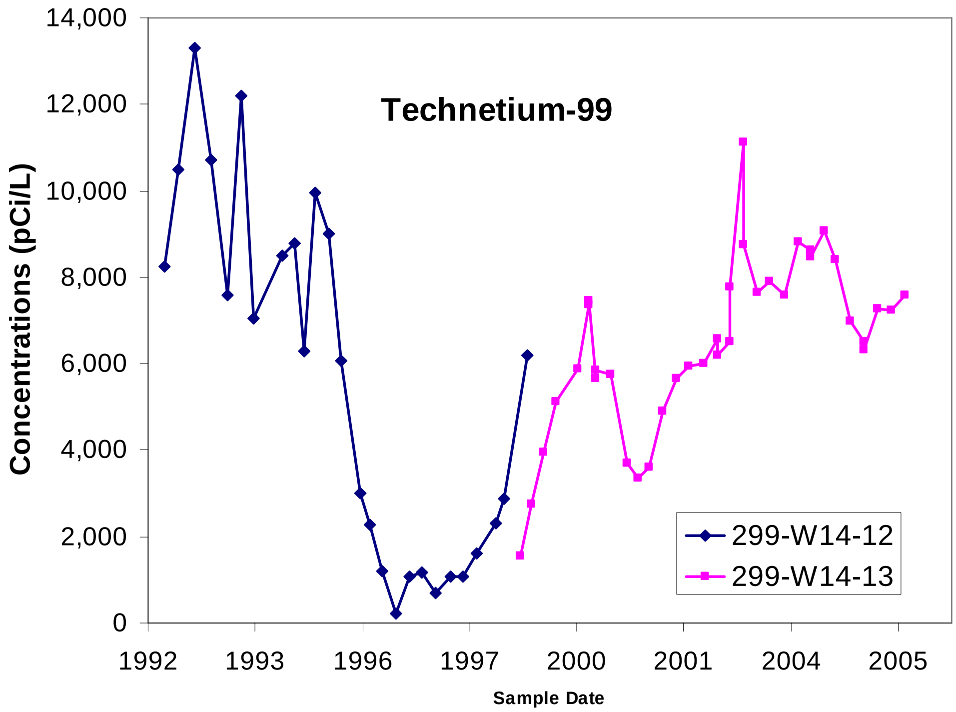

Figure 2.21. Technetium-99 Concentration versus Time in Selected Wells East of Waste Management Area TX-TY

Analytical results from sampling during drilling of well 299-W14-11 in early 2005 and depth discrete, multi-level dialysis sampling in well 299-W14-13 in 2002 supported a significant technetium-99 gradient in the upper part of the unconfined aquifer in the area east of WMA TX-TY. Figure 2.22 shows the technetium-99 concentration versus depth in the two wells. Although there is substantial difference in the absolute values of the concentrations, both wells show the same trend with depth. The technetium-99 concentration increases rapidly from near the water table to a maximum concentration between 1 and 5 meters below the water table, and thereafter decreases with depth. No sample was taken between the water table and 5 meters below the water table in well 299-W14-11 so it is not known that the maximum technetium-99 actually corresponds to 5 meters depth in the aquifer at that well. The reason for the offset in absolute values of the concentrations between the two wells, located about 3 meters apart, is not known. However, and as mentioned above in the nitrate discussion, the situation is complicated by differences in the sample collection methods, the long time period over which data were collected (approximately 3 years between the dialysis sampling 299-W14-13 and drilling 299-W14-11), and a downward hydraulic gradient in well 299-W14-13. Nevertheless, the available data indicate a substantial concentration gradient in the upper part of the aquifer with the highest concentrations near the water table. Note that technetium-99 exceeds the drinking water standard of 900 pCi/L in well 299-W14-11 to a depth of 27 meters below the water table.

The localized extent of the high technetium-99 concentration at wells 299-W14-11 and 299-W14-13 and the fact that the highest concentrations are near the water table suggest that the technetium-99 contamination east of WMA TX-TY is from a source local to the wells. Given the current direction of groundwater flow, the most likely source for the technetium-99 is the TY Tank Farm. However, the 216-T-26 through 216-T-28 cribs also are potential sources. Fecht et al. (1977) state that gross gamma logs obtained prior to 1977 showed contamination at the 216-T-28 crib extended from near the surface to the water table and that breakthrough to groundwater could have occurred at the site. They also state that waste from the crib was noted in well 299-W14-1, located 38 meters south of the crib so that considerable lateral spreading had occurred in the vadose zone beneath the TY cribs. Therefore, it is possible that some of the contamination encountered at wells 299-W14-11 and 299-W14-13 may have originated from the TY cribs.

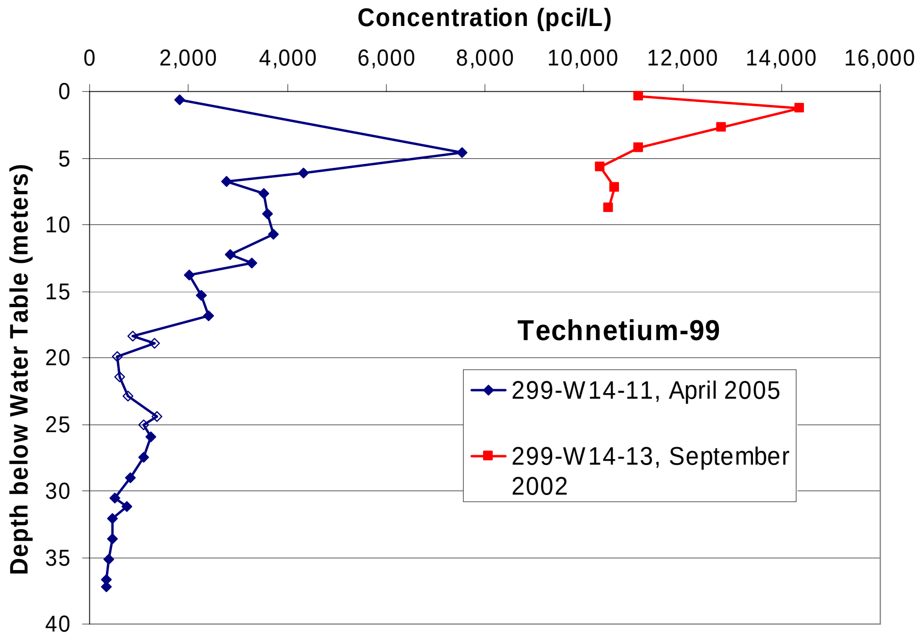

Figure 2.22. Technetium-99 Concentration versus Depth in Two Wells East of Waste Management Area TX-TY. Open diamonds are less than the instrument quantitation limit.

Figure 2.23 shows technetium-99 versus time for wells located near the southwest edge of WMA TX-TY, in the area greatest perturbed by the 200-ZP-1 pump-and-treat system. Phase 1 of the 200-ZP-1 pump-and-treat operation began in 1994 with one extraction well. The operation was expanded to three wells (Phase 2) in 1996 and, finally, to six extraction wells (Phase 3) in August 1997. Phase 4 occurred in July 2005 with the addition of four extraction wells. The first effect of the pump-and-treat operation on groundwater flow direction beneath WMA TX-TY was observed on the June 1998 water-table map (Hartman 1999), which showed perturbations in the water-table contours at the south part of the WMA. Well 299-W15-22, located at the southwest corner of the WMA and originally drilled as an upgradient well, was the closest to the 200-ZP-1 pump-and-treat extraction wells before it went dry in 1998. Technetium-99 began to increase in this well in May 1997, exceeded the maximum contaminant level in August 1997, and reached a high of 3,680 pCi/L in May 1998.

Well 299-W15-4 is an older pre-RCRA well originally drilled to monitor the 216-T-19 crib at the southeast corner of the WMA. Prior to May 1998, the well was sampled only on an annual basis; however, available data indicate that technetium-99 started to increase in this well in mid-1997 and reached a peak concentration of 980 pCi/L in July 1999. Well 299-W15-763 was completed as a replacement well for 299-W15-4 in 2001. The first routine sample from this well indicated a technetium-99 concentration of 57 pCi/L. The most recent sample taken from this well contained

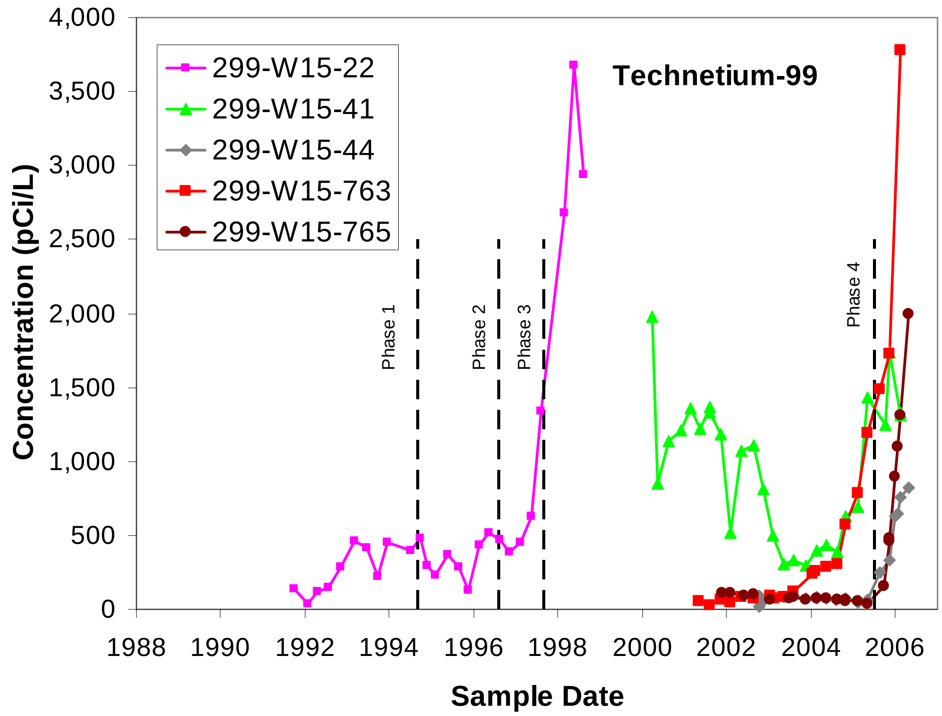

Figure 2.23. Technetium-99 versus Time in Wells Disturbed by the 200-ZP-1 Pump-and-Treat Operation at Waste Management Area TX-TY. "Phase" refers to the number of extraction wells in operation (see text).

1,190 pCi/L technetium-99 (Figure 2.23). Finally, well 299-W15-41 was completed in January 2000 and was first sampled in March 2000. The initial sampling yielded a technetium-99 concentration of 1,980 pCi/L. Concentrations of technetium-99 subsequently decreased to about 300 pCi/L before increasing again to 1,430 pCi/L in May 2005.

Given the southerly groundwater flow direction imposed on the southern portion of the WMA by the pump-and-treat operation, one explanation for the increasing technetium-99 south of the WMA is that groundwater contaminated with technetium-99 is being drawn from beneath the WMA into the pump-and-treat system. Alternatively, technetium-99 may be originating from the 216-T-19 crib and tile field (DOE 2002).

Upgradient wells 299-W15-40 and 299-W15-765 and downgradient well 299-W15-44 were among the wells added to the 200-ZP-1 pump-and-treat system in July 2005. Since that time the technetium-99 concentration has increased in wells 299-W15-44 and 299-W15-765 (Figure 2.23). The increase is probably due to extracting technetium-99 from beneath the WMA.

A local chromium plume is centered east of WMA TX-TY at well 299-W14-13. The plume has existed at least since April 1992 when well 299-W14-12 was first sampled (Figure 2.24). The highest concentration recorded in the plume was 768 µg/L in February 2005. There is some discrepancy among the data concerning the depth distribution of chromium in the aquifer at this location. The chromium concentrations in well pair 299-W14-12 and 299-W14-13 suggested that the chromium concentration is relatively low near the water table and increases with depth when well 299-W14-13 was drilled in 1998

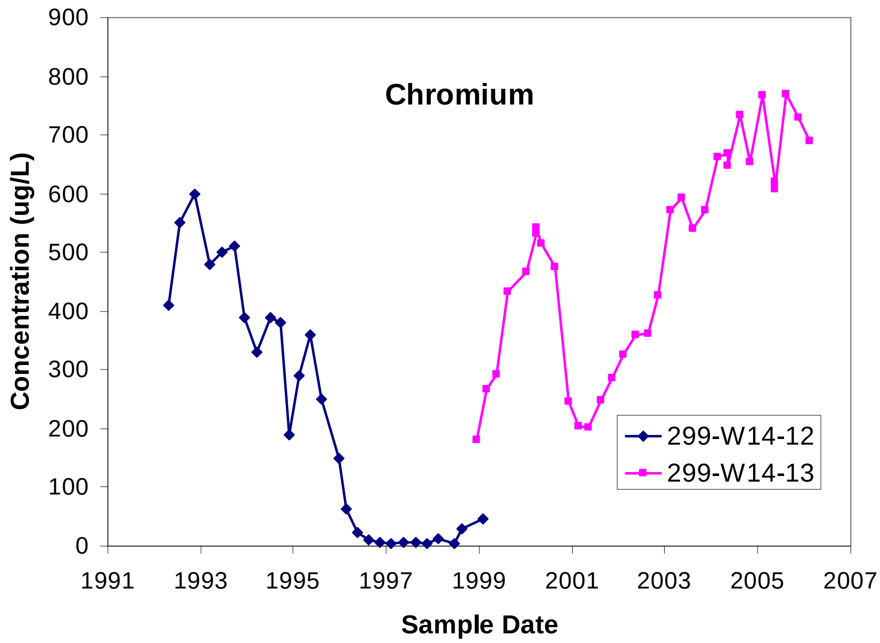

Figure 2.24. Chromium in Well Pair 299-W14-12 and 299-W14-13 East of Waste Management Area TX-TY

(Horton 2002). In 2002, depth discrete samples were obtained by dialysis from the screened interval of well 299-W14-13 which suggested that the chromium concentration may be slightly higher at the water table than at depth (Serne et al. 2004). Figure 2.25 shows that the concentrations of chromium and technetium-99 in well 299-W14-13 track each other through time and the ratio of the two is fairly constant. This indicates a single source for the two contaminants and supports a downward decrease in chromium concentration similar to the downward decrease in technetium-99 concentration shown in Figure 2.22.

A small, localized iodine-129 plume exists coincident with the technetium-99 and chromium plumes in well 299-W14-13, east of WMA TX-TY (Figure 2.26). The plume was first noted in April 1992 when well 299-W14-12 was first sampled for iodine-129 (Figure 2.27). The largest iodine-129 concentration in the well was 64 pCi/L in September 1993, and the last measured concentration (above detection limit) was 22 pCi/L in August 1998 when the well went dry. Iodine-129 continues to be detected in well 299-W14-13 (about 3 meters from well 299-W14-12) where the most recent concentration is 24.5 pCi/L in February 2006.

Samples were collected for iodine-129 analyses during drilling of well 299-W14-11 in early 2005. Figure 2.28 shows the depth distribution of iodine-129 in the well. The maximum iodine-129 concentration was 72 pCi/L near the water table and the concentration decreased with depth in the aquifer. The concentration of iodine-129 in the most recent (February 2006) pumped sample from well 299-W14-13 is a reasonable average of the concentrations seen in interval of well 299-W14-11 corresponding to the screened interval of well 299-W14-13. The most recent (February 2006) iodine-129 concentration in well 299-W14-11 was below detection limit. The source for the iodine-129 is not known for certain. The

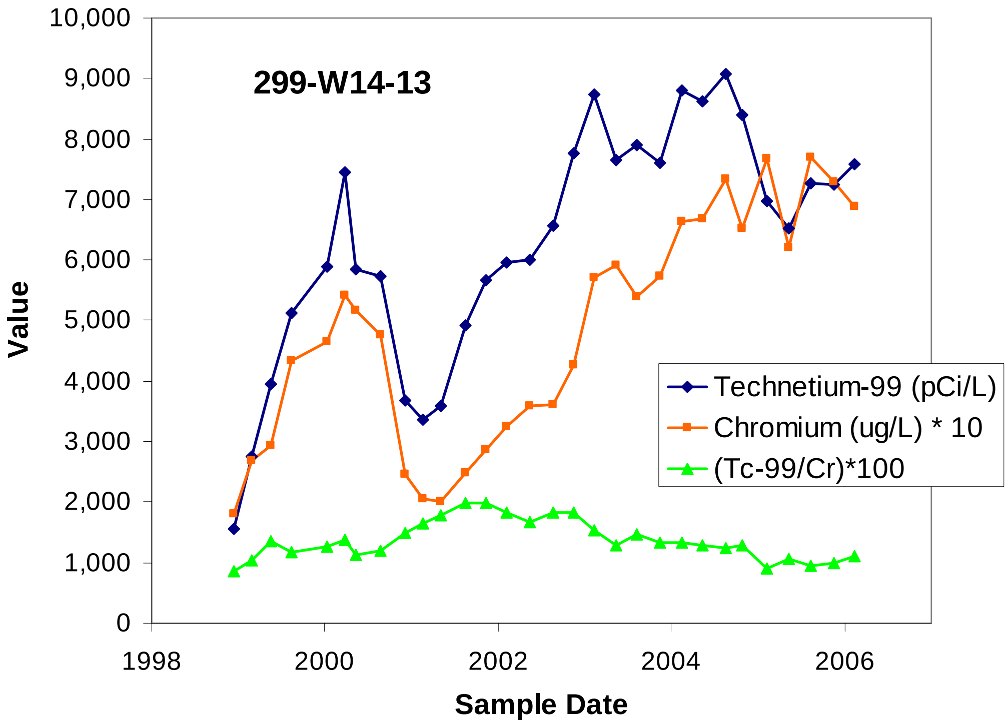

Figure 2.25. Technetium-99 and Chromium (*10) Concentrations, and Tc-99/Cr (*100) Ratios for Samples from Well 299-W14-13

shallow occurrence of iodine-129 in the aquifer is consistent with a nearby source. The estimated iodine-129 concentrations in the waste disposed to the 216-T-28 crib and in the leaks from tanks TX-103, TY-103, TY-105, and TY-106 (Corbin et al. 2005) are all large enough to account for the iodine-129 in the aquifer at well 299-W14-13.

2.5.1.1 Early Contamination at Waste Management Area TX-TY

Groundwater contamination was first noted in the area of WMA TX-TY in the early 1950s. The earliest contamination was in groundwater wells 299-W14-1, 299-W14-2, and 299-W14-3 and was probably the result waste disposal to the TY cribs. The concentrations of nitrate in wells 299-W14-1 and 299-W14-2 were 2,300 and 840 mg/L respectively when the wells were first sampled in October 1957 (Figure 2.29). A year earlier, a series of eleven uranium analyses between November 1955 and January 1956 showed concentrations between about 16 and 22 μg/L uranium in well 299-W14-2.

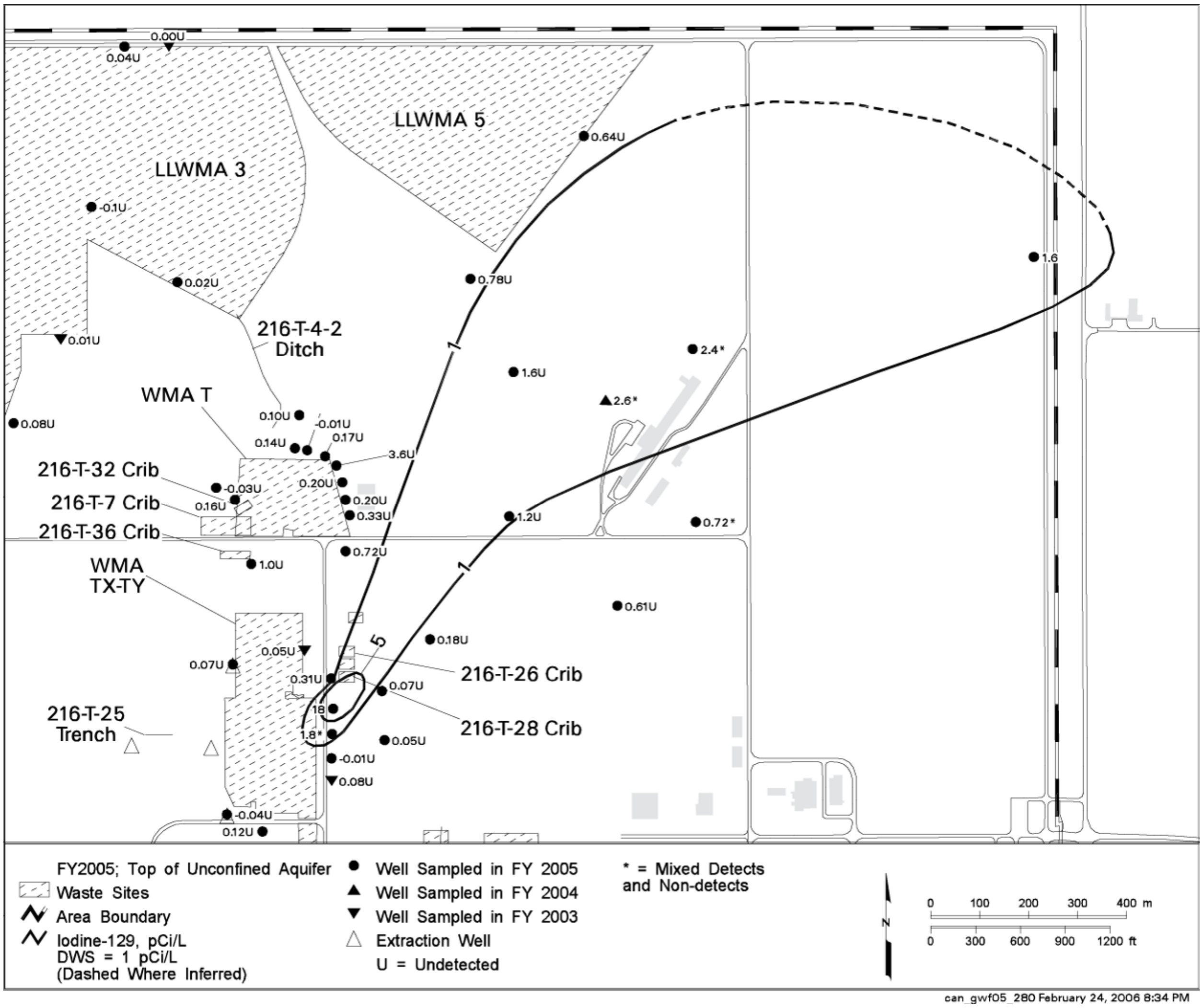

Figure 2.26. Average Fiscal Year 2005 Concentrations of Iodine-129 the Area of Waste Management Area TX-TY, Top of the Unconfined Aquifer (from Hartman et al. 2006)

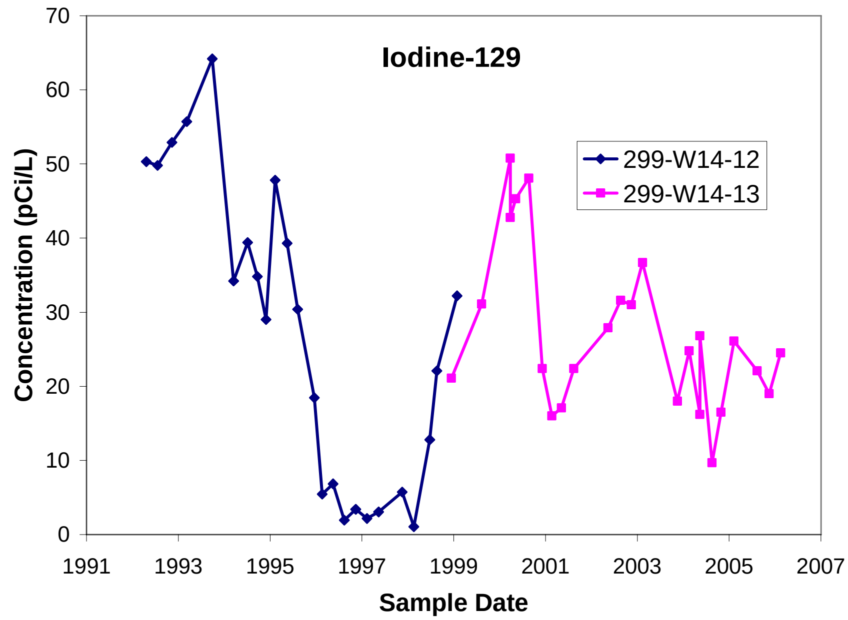

Figure 2.27. Iodine-129 Concentration in Wells 299-W14-12 and 299-W14-13, East of Waste Management Area TX-TY

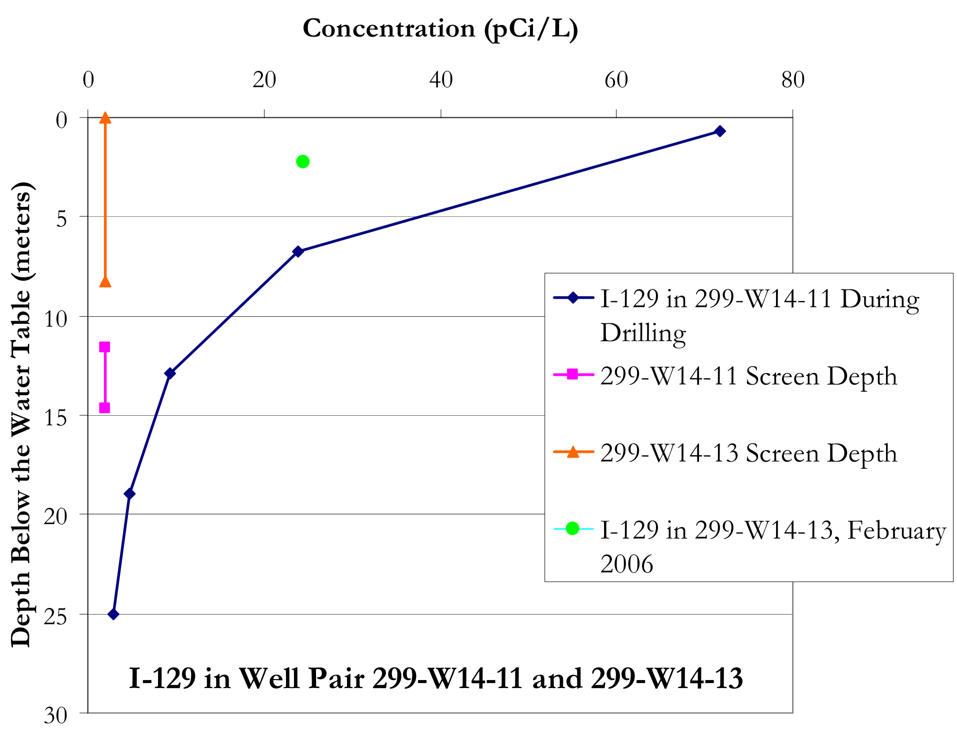

Figure 2.28. Iodine-129 Concentration versus Depth in Well 299-W14-11

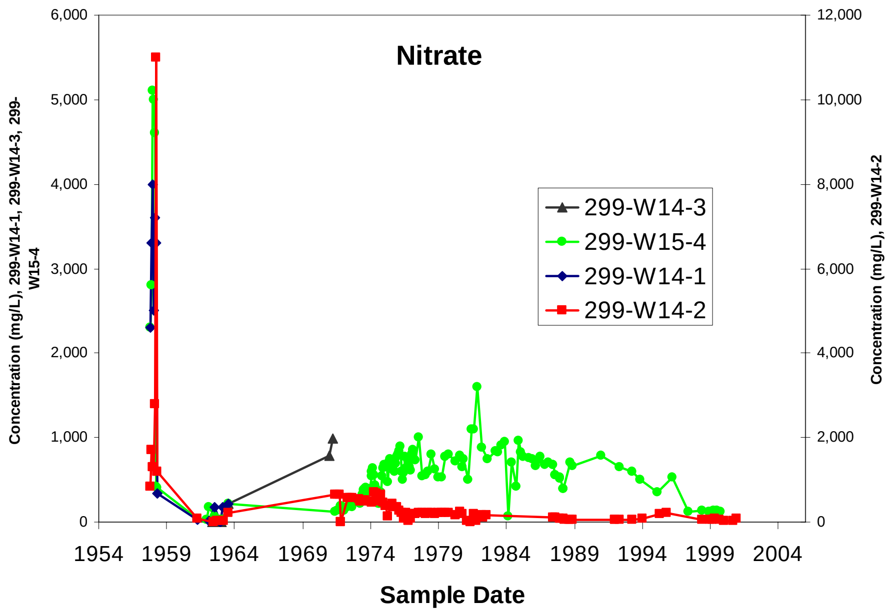

Figure 2.29. Early Nitrate Concentrations in Selected Wells Near Waste Management Area TX-TY

The earliest analyses of gross beta in wells 299-W14-1 and 299-W14-2, located at the 216-T-28 crib, were from 1959 and 1955 respectively and showed between 1,000 and 10,000 pCi/L beta activity. Gross beta analyses then were stopped in these wells and did not begin again until 1966 when gross beta was extremely high in both wells. The highest gross beta in the area was between 12,000,000 and 18,000,000 pCi/L from August 1965 to July 1966 in wells 299-W14-2 and 299-W14-3 (Figure 2.30).

Cobalt-60 currently is not detected in any of the monitoring wells at WMA TX-TY. However, cobalt-60 was detected in well 299-W14-12 until mid-1996 when the well went dry (Figure 2.31). The last concentration measured in the well was 16.4 pCi/L. Higher levels of cobalt-60 had been found in two other wells throughout the 1970s (Figure 2.31). Concentrations as high as 74 pCi/L were found in well 299-W14-2, located at the 216-T-28 crib, in early 1971. These concentrations decreased to less than 5 pCi/L in the early 1980s and cobalt-60 was undetectable from the mid-1980s to the life of the well in 1990. (Cobalt-60 has a half-life of 5.3 years which accounts for much of the decrease.)

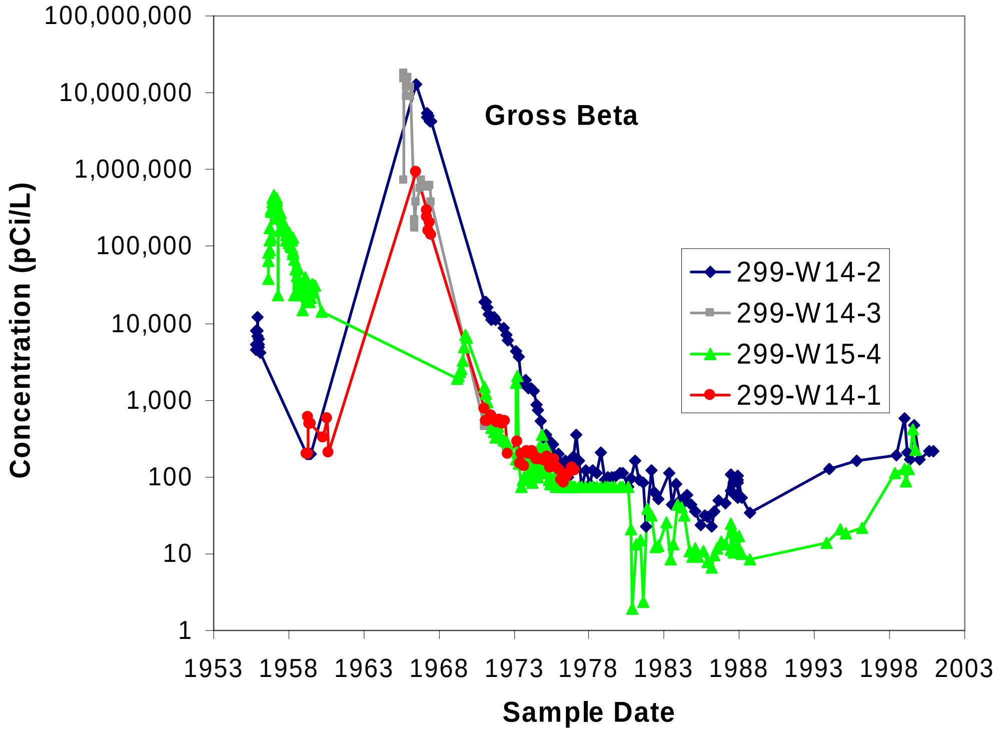

Figure 2.30. Gross Beta Concentrations in Selected Wells Near Waste Management Area TX-TY. Wells 299-W14-1, 299-W14-2, and 299-W14-3 are east of WMA TX-TY at the 216-T-28 crib; well 299-W15-4 is south of WMA TX-TY at the 216-T-19 crib and tile field.

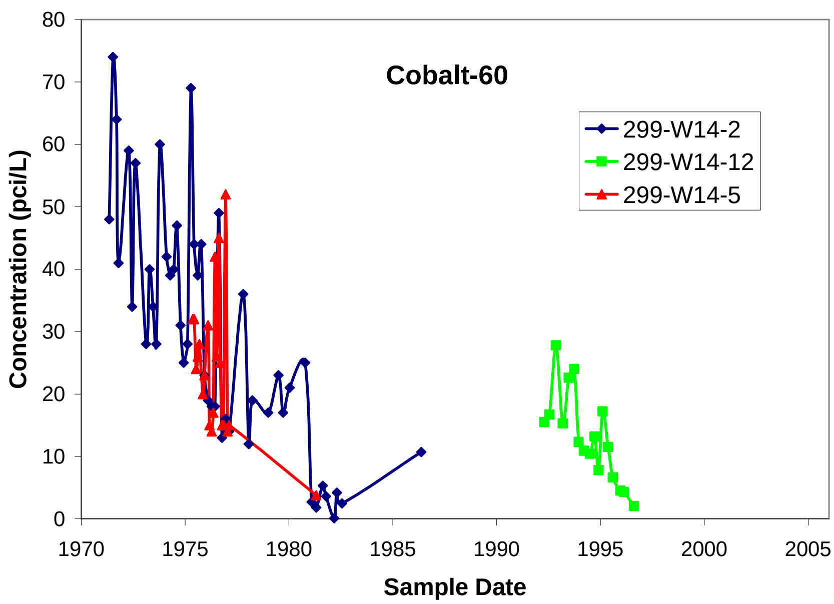

Figure 2.31. Cobalt-60 Concentration in Selected Wells East of Waste Management Area TX-TY

Two other wells in the area showed contamination in the groundwater in the mid 1950s. Well 299-W15-3 is located about 10 meters southwest of tank 241-TY-106. The well was first sampled in October 1956 and the sample contained 11,000 pCi/L gross beta and, between November 1956 and December 1957, eight groundwater samples from the well contained 8 to 20 μg/L uranium. Groundwater from the well was first analyzed for nitrate in November 1957, at which time the concentration was 1,100 mg/L.

Well 299-W15-4 is located just south of the TX Tank Farm and adjacent to the 216-T-19 crib and tile field. In late 1956 through early 1958, extremely high levels of cobalt-60, gross beta (Figure 2.30), and nitrate (Figure 2.29) were found in groundwater samples from the well. Cobalt-60 concentrations were between 2,000 and 3,400 pCi/L, gross beta was up to 460,000 pCi/L, and nitrate was up to 5,100 mg/L at that time.

The most likely source for the early contamination east of WMA TX-TY is the 216-T-26 through 216-T-28 cribs. As mentioned earlier, Fecht et al. (1977) noted that gross gamma logs from wells near the 216-T-28 crib showed radioactivity from near the ground surface to the water table and that contaminant breakthrough to the groundwater could have occurred at that site. The most likely source for the early contamination in well 299-W15-4 is the adjacent 216-T-19 crib and tile field. The first effluent was discharged to the tile field in September 1951. The tile field had been in use for five years before the first groundwater samples were collected from well 299-W15-4. The first samples showed very high cobalt-60, nitrate, and gross beta contamination. That contamination decreased fairly abruptly in late 1957 to mid 1958 soon after groundwater changed flow direction from southerly to northeasterly. The flow direction after early 1957 would have moved contamination from the tile field away from the well.

Well 299-W15-3 is located about 10 meters southwest of tank TY-106. Tank TY-106 was reported to have leaked 75,700 L of liquid waste in 1957 (Field and Jones 2005). Elevated gross beta and uranium were found in the first sample collected from the well in November 1956, prior to the reported leak. Therefore, it is unlikely that tank TY-106 was the source of the late 1956 groundwater contamination. However, there is no other known then upgradient (northern) source for the contamination found in the well in the mid 1950s.

2.5.2 Vadose Zone Contamination

Contaminants that reach the water table must pass through the vadose zone. Spectral gamma logging in boreholes drilled around the single-shell tanks in WMA TX-TY was conducted in 1996 and 1997 to delineate the location of gamma emitting radionuclides in the vadose zone (DOE 2000 b, c). Whereas most of the radioactive contaminants detectable by gamma logging are considered fairly immobile in the Hanford Site sediments, their identification provides a minimum indication of how deep the more mobile constituents may have migrated.

Figure 2.32 contains selected figures from the addendum (DOE 2000b) to the TX Tank Farm spectral gamma logging report. These figures show the general distribution of gamma contamination around the tanks. The actual gamma logs are included in the logging report (DOE 2000b).

Figure 2.32 shows a general representation of detected contamination at progressively deeper levels beneath the ground surface ranging from 1.8 to 28 meters deep. Contaminant distribution at the 1.8 meters depth illustrates the extent of contamination at and near the surface and just above the top of the single-shell tanks (Figure 2.32A). The interpretation is that the europium-154, adjacent to tank TX-117, is the result of a pipeline leak (DOE 2000a). The highest near-surface cesium-137 concentration is in the northern part of the tank farm between tanks TX-117 and TX-118. The maximum depth of the cesium-137 originating from near surface sources is about 4 meters (DOE 2000b).

Figure 2.32B shows the distribution of gamma emitting contamination at 14.6 meters depth which corresponds to the approximate base of the tanks. Several contaminant plumes exist at this depth. The highest cesium-137 concentration measured in the TX Tank Farm vadose zone was measured adjacent to tank TX-114 at this depth (62,700 pCi/g) (DOE 2000b). The maximum lateral extent of uranium-235/-238, adjacent to tank TX-105 is shown on Figure 2.32C. The maximum lateral extent of cobalt-60 was found 2.1 meters deeper at 20.7 meters depth.

The deepest level illustrated in Figure 2.32 is 28 meters below the ground surface (Figure 2.32D). The cobalt-60 plume that was associated with tank TX-107 at 18.6 meters depth, has moved away from the tank toward the southwest at 28 meters depth.

The contaminant distribution at various depths in the vadose zone at the TY Tank Farm is shown in Figure 2.33. Figure 2.33A shows the distribution of near-surface contamination at 0.6 meter depth. The maximum cesium-137 concentration is adjacent to tank TY-104. The maximum vertical extent of cesium-137 contamination originating from a surface source is about 6.1 meters deep (DOE 2000c).

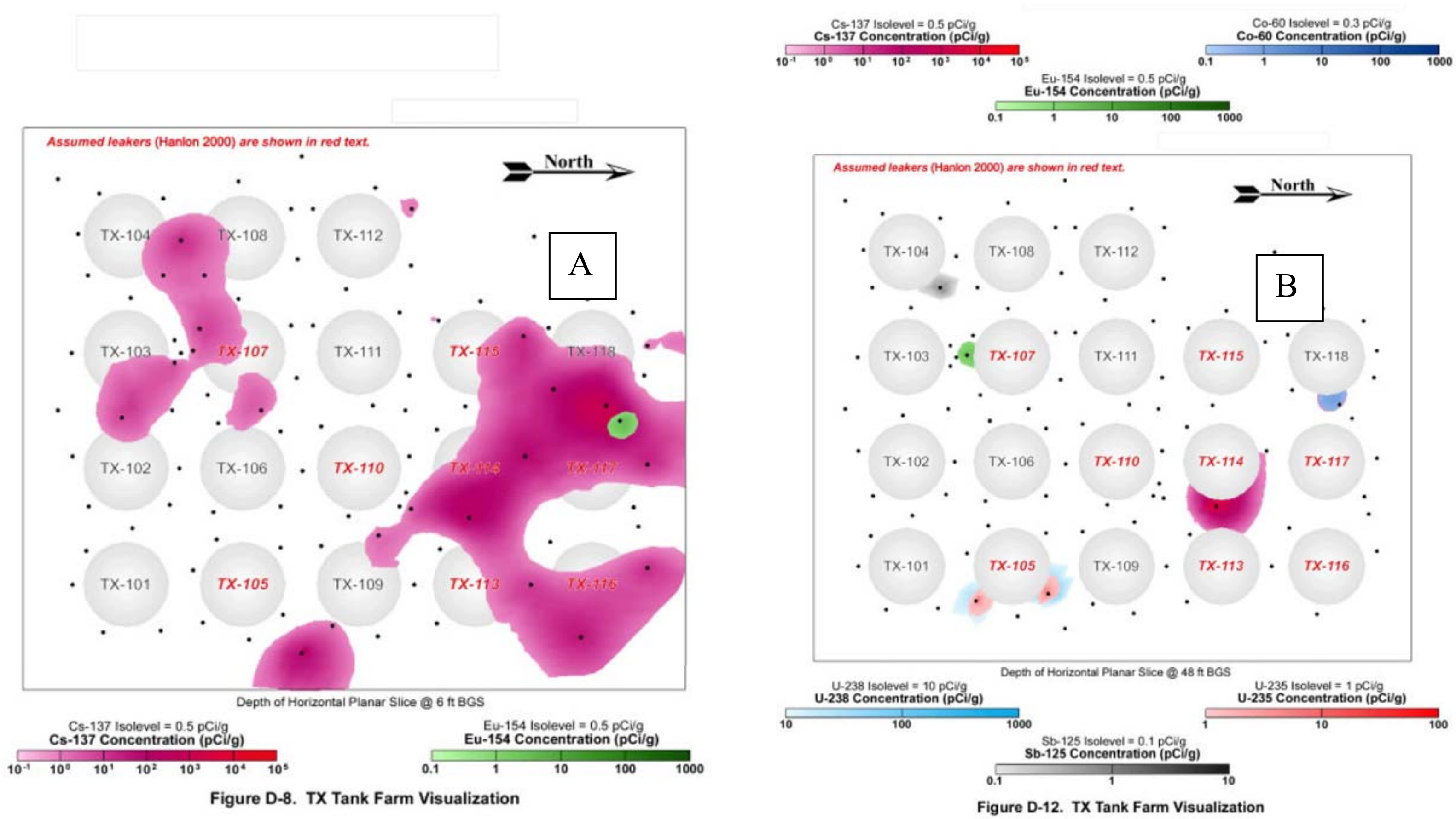

Figure 2.32. Vadose Zone Contamination in the TX Tank Farm (from DOE 2000b). Note depths are given in feet below ground surface. Multiply by 0.3048 to change feet to meters.

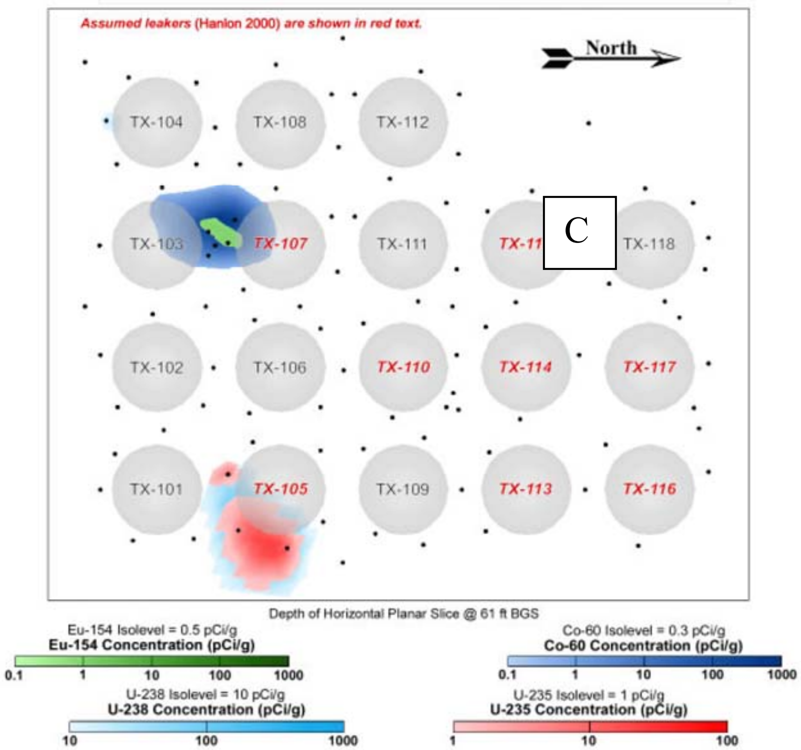

Figure D-14. TX Tank Farm Visualization

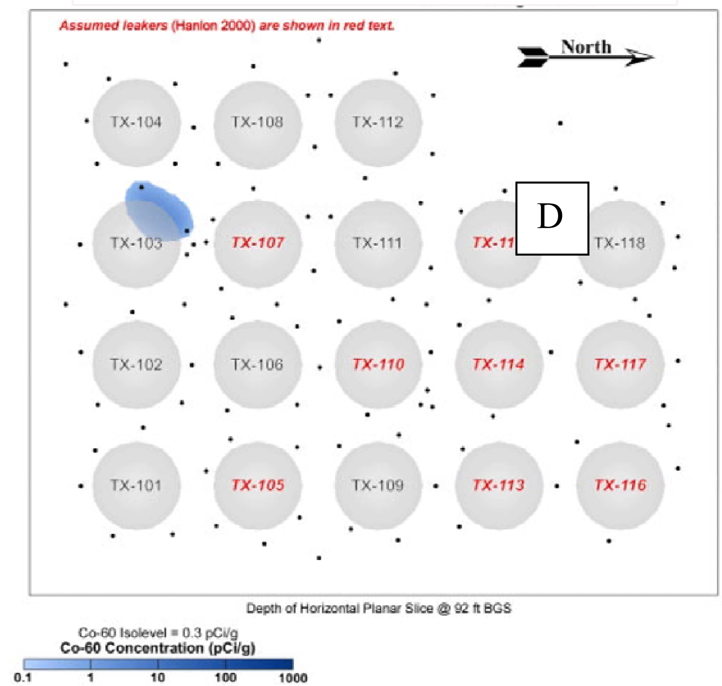

Figure D-17. TX Tank Farm Visualization

Figure 2.32. (contd)

The contaminant distribution at 14.3 meters depth, which is slightly above the base of the tanks, is shown in Figure 2.33B. The maximum cesium-137 concentration measured in the vadose zone at the TY Tank Farm was measured at this depth, adjacent to tank TY-103 (about 10^7 pCi/g). The maximum vertical extent of the cesium-137 contamination, associated with tanks TY-103 and TY-105 was about 22.9 meters below ground surface (DOE 2000c).

The contaminant distribution at 29.6 meters depth, within the Cold Creek silt unit, is shown in Figure 2.33C. Because most boreholes in the TY Tank Farm extend to only 30.5 meters depth, the contaminant distribution in Figure 2.33C is the deepest for which data are available beneath the entire tank farm. Only one borehole penetrates to 44.2 meters depth. Cobalt-60 contamination was detected at that depth between tanks TY-105 and TY-106 (Figure 2.33D). This is the deepest well in the tank farm so that the maximum vertical extend of the cobalt-60 contamination is not known.

Several drywells and groundwater wells at the 216-T-19 crib and tile field and the 216-T-26 through T-28 cribs were periodically monitored in the past. Fecht et al. (1977) state that in 1959, three years after the disposal to the 216-T-19 crib was temporarily terminated, radioactive contaminants were detected in well 299-W15-4 from 8.2 meters below the ground surface to the water table. Thus, groundwater contamination due to discharges to the 216-T-19 crib and tile field is probable.

Fecht et al. (1977) also noted that wells monitoring the 216-T-28 crib showed radioactivity from near the ground surface to the water table and that, during disposal to the crib, the radiation intensity increased through the entire sediment column. Radioactivity adjacent to the 299-W14-1 well, located 38 meters southeast of the crib, showed that substantial lateral spreading of contamination had occurred in the vadose zone at that area.

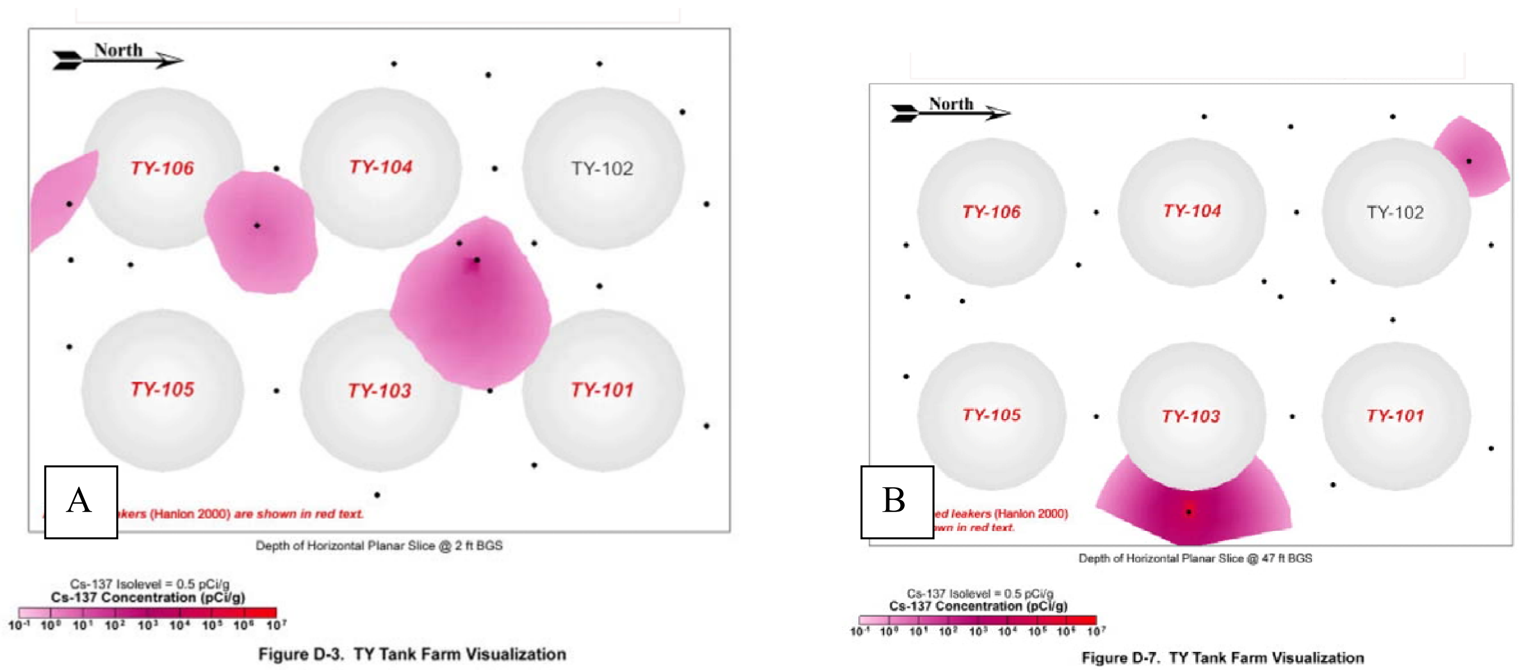

Figure 2.33. Vadose Zone Contamination in the TY Tank Farm (from DOE 2000c). Multiply by 0.3048 to convert feet to meters

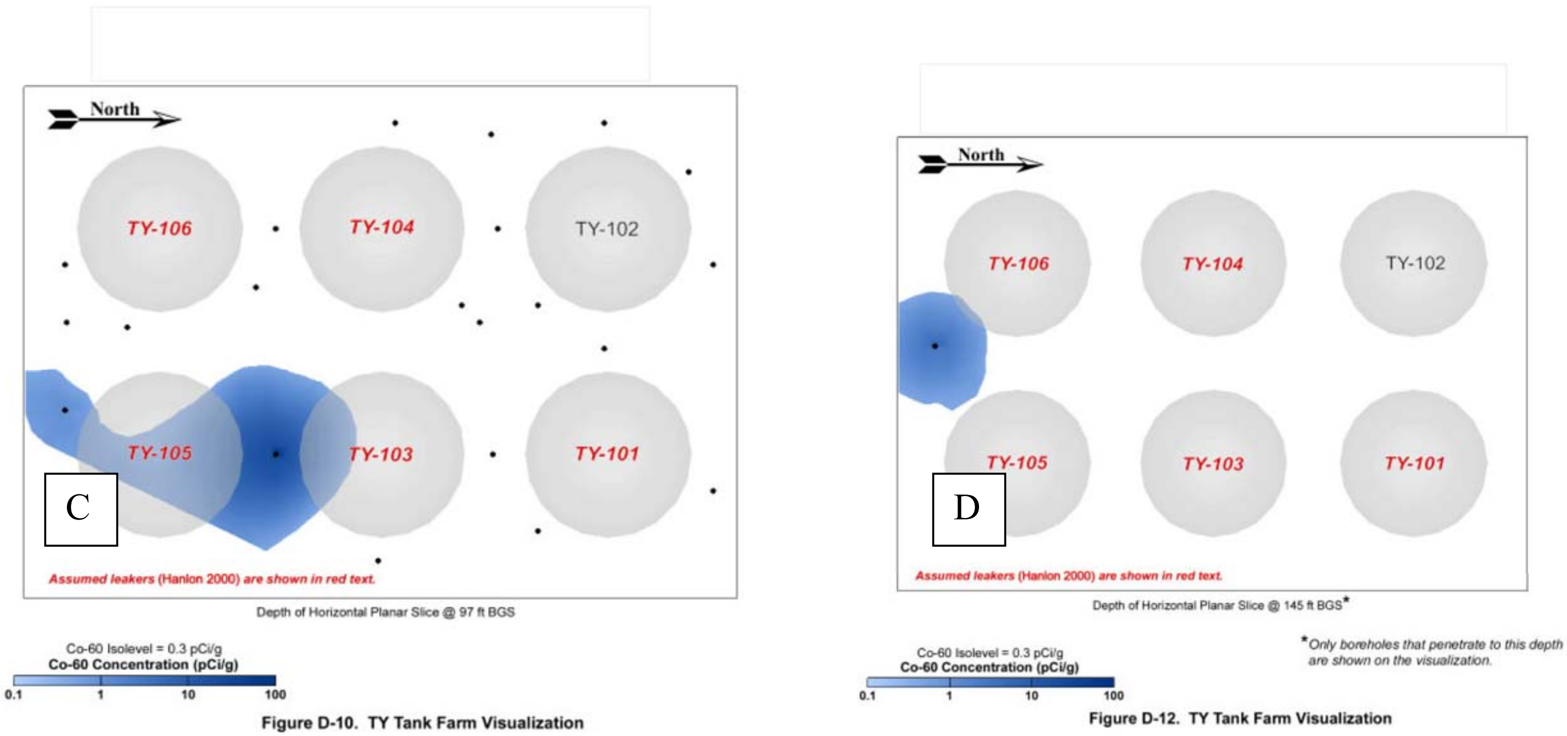

Figure 2.33. (contd)

3.0 Data Quality Objectives

This chapter applies the relevant components of the general DQO process as an aid in designing a cost-effective data collection plan to support decision making for the RFI/CMS and for the groundwater assessment at WMA TX-TY. The process was originally designed by the U.S. Environmental Protection Agency (EPA) to expedite cleanup activities at RCRA corrective action or superfund sites (EPA 2000). Thus, not all of the steps apply to a groundwater quality assessment. The important or essential aspects of the DQO process are that key decisions are identified in the form of questions or statements and that data acquired are appropriate to make the necessary decisions.

The process for developing DQOs involves the following seven primary steps:

1. State the problem (Section 3.1).
2. Identify the decision and expected action (Section 3.2).
3. Identify decision inputs (Section 3.3).
4. Define the study boundaries (Section 3.4).
5. Develop decision rules (Section 3.5).
6. Specify limits on decision errors (not applicable to groundwater monitoring plans).
7. Optimize the sampling design (Section 3.6).

3.1 Statement of the Problem

The problem addressed by this DQO is the uncertainty in the conceptual model pertaining to determination of (1) contaminant source, (2) groundwater flow rate and flow direction, (3) lateral and vertical contaminant distributions, (4) driving forces to move contaminants to groundwater, and (5) contaminant pathways to groundwater.

The uncertainties in the conceptual model of WMA TX-TY are discussed in this section.

3.1.1 Scoping Process

The scoping process gathers the information that will be used to develop the conceptual model of WMA TX-TY. Such information includes the following items:

- History of operations at WMA TX-TY.
- Waste characteristics.
- Characterization of existing vadose zone and groundwater contamination.
- Site geology and hydrology.

This information was discussed in Chapter 2.0 as background information to refine the conceptual model and define problem statements and key issues.

3.1.2 Regulatory Drivers

WMA TX-TY is regulated under RCRA interim-status regulations (40 CFR 265, Subpart F) and Washington's HWMA (RCW 70.105). Implementing requirements are provided in Washington's

Dangerous Waste Regulations (WAC 173-303). The site was originally placed in groundwater assessment monitoring status (40 CFR 265.93 [d]) in 1993 because specific conductance values in downgradient wells 299-W10-17 and 299-W14-12 exceeded the upgradient background value of 667 μS/cm (Caggiano and Chou 1993).

The elevated specific conductance in well 299-W10-17 was principally due to sodium and nitrate in a regional contaminant plume. The high specific conductance in well 299-W14-12 was accompanied by elevated technetium-99, iodine-129, tritium, nitrate, calcium, magnesium, sulfate, and chromium (Hodges and Chou 2001). In the first assessment report, Hodges (1998) concluded that: (1) elevated technetium-99 and co-contaminants in well 299-W14-12 were consistent with a source within the WMA TX-TY and that contaminant chemistry was consistent with a small volume tank waste source; and (2) an upgradient source (216-T-25 trench) was possible. The subsequent construction and sampling of well 299-W15-40 showed that no contamination exists in the groundwater between the 216-T-25 trench and the WMA; therefore, the trench has been eliminated as a possible source for the contamination in well 299-W14-12.

As a result of the first assessment report (Hodges 1998), a revised assessment plan was written (Hodges and Chou 2001) to guide the investigation into the rate and extent of aquifer contamination beneath the WMA. This document updates the revised assessment plan (Hodges and Chou 2001).

This DQO considers both RCRA regulated dangerous waste constituents and certain non-dangerous waste constituents to satisfy the integration of the RCRA groundwater quality assessment with the 200-ZP-1 Operable Unit and the vadose zone RFI/CMS. This provides comprehensive interpretations of groundwater contamination.

Groundwater monitoring objectives of RCRA, CERCLA, and the AEA often differ slightly and the contaminants monitored are not always the same. For RCRA regulated units, monitoring focuses on non-radioactive dangerous waste constituents. Radionuclides (source, special nuclear and by-product material) may be monitored in some RCRA unit wells to support objectives of monitoring under the AEA and/or CERCLA. Please note that pursuant to RCRA, the source, special nuclear, and by-product material component of radioactive mixed waste, are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

3.1.3 Conceptual Model for Waste Management Area TX-TY

This section describes the current conceptual model for WMA TX-TY. This model will be modified as new data become available and new understanding is developed. The current conceptual model for WMA TX-TY illustrates the complexity and the spatial and temporal relationships of five important parameters: contaminant sources, driving forces, migration pathways to groundwater, changes in groundwater flow direction and flow rate, and the current contaminant distributions in the aquifer. The model described in this section is a synthesis of the information given in Chapter 2.0.

3.1.3.1 Contaminant Sources

Several potential sources for groundwater contamination exist at the WMA TX-TY area:

- Tank leaks.
- Liquid wastes disposed to past-practice facilities located east, south, and west of WMA TX-TY.
- Unplanned releases including leaking pipelines.
- Regional contamination from far-field sources (e.g., Plutonium Finishing Plant).

Each of these potential sources is discussed in Chapter 2.0. Currently, it is not possible to distinguish sources within WMA TX-TY from sources outside the WMA in instances where tank waste was purposely discharged to nearby, past-practice facilities.

There are regional sources for most of the tritium, carbon tetrachloride, and nitrate found in the groundwater beneath WMA TX-TY with the exception of a probable local source for the extremely high tritium and nitrate near well 299-W14-13. Results discussed in Chapter 2.0 indicate that both tank waste from the WMA and waste from past-practice cribs, trenches, and tile fields, located east and south of WMA TX-TY, have impacted groundwater in the vicinity of the WMA.

All tanks in WMA TX-TY have been interim stabilized, which means each tank contains less than 189,000 liters of drainable liquid and less than 18,900 liters of supernate (Hanlon 2004). Consequently there is little risk that large, new leaks will occur from the tanks. However, a total of 1,203,630 liters and 211,960 liters of drainable liquid remain in all tanks in the TX and TY Tank Farms respectively and 3 tanks in the TX Tank Farm still containing greater than 100,000 liters of drainable liquid; so, the possibility of future impacts to groundwater remains.

Spectral gamma ray logging in WMA TX-TY has shown that there are substantial amounts of cesium-137 and cobalt-60 with lesser amounts of europium-152, -154, antimony-125, and uranium-235, -238 in the vadose zone (DOE 2000b, c). Although these constituents are relatively immobile in the vadose zone environment (except cobalt-60 and possibly uranium), their presence indicates that more mobile (and non-gamma ray emitting) contaminants such as nitrate, chromium, and technetium-99 are probably also present. Therefore, most future tank waste contamination in the groundwater is expected to result from either remobilization of residual vadose zone plumes or leaks associated with liquid waste transfers and single-shell tank remediation.

All non-permitted, liquid discharges were terminated at the Hanford Site in 1995. Therefore, no flushing of contaminants to groundwater will result from future intentional discharges. However, residual vadose zone pore water and associated contaminants remain in the vadose zone beneath past-practice disposal facilities and WMA TX-TY. This residual contamination is expected to slowly bleed into the aquifer for the foreseeable future under the influence of natural infiltration.

Non-tank sources have contributed to groundwater contamination in the past. The earliest evidence of groundwater contamination is high levels of gross beta, nitrate, and uranium in wells located at the 216-T-28 crib, east of WMA TX-TY, in the mid to late 1950s. The earliest groundwater contamination pre-dates any reported tank leak from the TX-TY Tank Farms (Hanlon 2004).

3.1.3.2 Driving Forces

In general, there are two ways to transport contaminants to groundwater. The first is associated with very large leaks when the amount of liquid is sufficient to reach groundwater through gravitational forces and capillary action. The second is associated with smaller volumes of water (or other liquid) available to remobilize residual waste in vadose zone plumes. Since most tanks in WMA TX-TY no longer contain large amounts of liquid waste and since large volume disposal to cribs and tile fields no longer takes place, it is unlikely that a sufficient source of liquid large enough to reach groundwater unassisted will exist at WMA TX-TY.

The second mechanism is to move existing vadose zone contamination to groundwater. This involves an external source of water and is the most likely possibility at WMA TX-TY. The most likely external sources are broken water lines and natural precipitation. Broken water lines can produce large volumes of water; however, all known water lines in the area have been pressure tested and all unnecessary water lines have been turned off and capped. It is possible but unlikely that a previous and unidentified water line will leak and substantially mobilize existing vadose zone contamination to groundwater in the area.

Remobilization of vadose zone waste also can occur as a result of heavy rainfall and sudden snowmelt. Johnson and Chou (1998) discuss the extent that rapid snowmelt from recent years has contributed to increased infiltration at WMA S-SX. A rapid snow melt in February 1979 caused extensive flooding in the T Tank Farm (Hodges 1998). The detrimental effects of natural recharge can be enhanced by gravel surfaces, lack of vegetation, and the presence of surface depressions that collect and pond runoff and snow melt. Recently, berms have been constructed around the TX and TY Tank Farms to eliminate run-on from adjacent areas so extensive flooding such as that of February 1979 at the T Tank Farm should not occur in the future.

The surface of the TX and TY Tank Farms is covered with gravel and kept free of vegetation. Recently, Gee and Ward (2002) used a water balance model based on surface sediment texture and the past 20-year climate record to predict the amount of annual drainage in selected tank farms. Drainage estimates from the model suggest an annual drainage of 28 to 56 millimeters/year for the U Tank Farm and the S Tank Farm in 200 West Area. No analysis was specifically made for the TX or TY Tank Farm but surface conditions are similar.

3.1.3.3 Migration Pathways

The water table at WMA TX-TY is approximately 67 to 71 meters below the surface. Because the vadose zone is so thick, much of the migration pathway from a near-surface source to a groundwater monitoring well will be in the unsaturated zone. Liquid migration through the unsaturated zone is highly dependent on heterogeneities and anisotropy in the sediment. The sediments making up the vadose zone beneath WMA TX-TY consist of moderate to high-energy Hanford formation flood deposits with a large variability in grain size and grain sorting; the Cold Creek unit with variable caliche development; and the Ringold Formation member of Taylor Flats and member of Wooded Island unit E with variable grain size, grain sorting, cementation, and compaction. These variabilities occur at scales of centimeters to meters. Consequently, it is not realistic to define specific migration pathways through the vadose zone beneath WMA TX-TY.

The sediment layer with the most influence on moisture migration through the vadose zone is the Cold Creek unit. The relatively low permeability of the Cold Creek unit has two important effects on migration of moisture. First, the fine-grained nature of the Cold Creek silt unit requires that it essentially become saturated before moisture breakthrough to underlying units. This tends to lengthen the time required for moisture to reach the water table and results in lateral spreading of moisture and contamination. Second, the cemented Cold Creek caliche unit tends to pond water locally in several places beneath the 200 West Area. This also lengthens the time required for moisture to reach the water table and results in lateral migration.

Clastic dikes are sub-vertical, sedimentary features that crosscut existing near- horizontal bedding. Recent work by Ward et al. (2004) shows that at low water fluxes the fine-textured region of clastic dikes dominate flow, at intermediate fluxes both the coarse sand host matrix and the fine-textured regions contribute to flow, and at high input fluxes the coarse-textured host sediments dominate flow.

Clastic dikes exist in the subsurface at several areas of the Hanford Site and have been documented at TX-TY Tank Farm (Price and Fecht 1976; Fecht et al. 1999). Clastic dikes also have been noted at the other tank farms in 200 West Area and in drill cores from wells in the area (C3102 at the 216-T-26 crib, 288-W22-48 at the WMA S-SX, 299-W23-16 at the 216-U-14 ditch, and 299-W10-22 at the 216-T-4-2 ditch). Several clastic dikes are known to extend at least 20 meters into the subsurface; the maximum vertical extent known for a clastic dike is about 45 meters.

Another feature that can act as a preferential, vertical pathway is the annular space of wells and boreholes with no, or poorly constructed, annular seals. There is documentation indicating that only 6 of the 95 drywells in the TX Tank Farm and none of the drywells in the TY Tank Farm (Chamness and Merz 1993), used for secondary leak detection, have been retrofitted with annular seals to prohibit downward migration of fluids between the casing and the vadose zone sediments. Most drywells were drilled between 15.2 to 45.7 meters deep and the water table beneath WMA TX-TY is about 68 to 70 meters below ground surface. Thus, there is about 22 to 55 meters of vadose zone between the bottom of the drywells and the water table.

All WAC 173-160 compliant monitoring wells at WMA TX-TY have annular seals. However, the as-built diagram for groundwater monitoring well 299-W14-6, part of the current monitoring network and located on the east side of the TX Tank Farm, does not show a well seal. Also, well 299-W14-5, which is now dry and located adjacent to WMA TX-TY, has no documentation concerning an annular seal. These wells are potential preferential pathways for any contaminants that encountered the wells in the past or may encounter the wells in the future. Other older wells in the area have been decommissioned.

Field studies at the Hanford Site suggest that relatively narrow, vertical zones of moisture can flow through unsaturated sediment. Gee and Ward (2001) describe infiltration tests with different ionic strength fluids and how the fluid properties influence formation of moisture "fingers." Once such vertical pathways are established by an initial infiltration event, subsequent infiltration events will prefer the same pathways.

Further evidence to support this type of flow behavior comes from direct observation of infiltration tests performed at the 105A mock tank site, 200 East Area (Narbutovskih et al. 1996). Electrical resistivity tomography was used at that site to track leaked saline water, as fingered flow, from the surface to a depth of about 21 meters. Furthermore, analysis of the infiltration rate, time to reach depth, and total volume of leaked fluid indicated that a low-volume, point leak might reach groundwater in that area within a few months (Hartman and Dresel 1997). Of note, however, is the more heterogeneous stratigraphy in 200 West Area (specifically the existence of the Cold Creek unit) which would tend to increase the travel time through the vadose zone to groundwater.

3.1.3.4 Changing Groundwater Flow Direction

Historical changes in groundwater flow direction were discussed in Section 2. Using the general flow directions from Figure 2.9 and the water-table gradients in Reidel et al. (2006) and assuming an average hydraulic conductivity of 2.5 meters/day (within the broad range given in Table 2.7) and an effective porosity of 0.2, groundwater could have traveled and carried contaminants from WMA TX-TY or other nearby sources approximately (1) 34 meters toward the south between 1954 and 1957, (2) 170 meters northeast between 1957 and 1982, (3) 110 meters north or northwest between 1983 and 1995, and (4) 49 meters toward the east between 1997 and 2006. (The earliest reported tank leak at WMA TX-TY is tank TY-106 in 1959.) Although these distances are estimates, they show that changes in the groundwater flow direction could have contributed to relatively widespread contaminant distribution.

3.1.3.5 Contaminant Distribution

Section 2.5.1 showed that the concentrations of several constituents decrease with increasing depth in the unconfined aquifer in the area east of the 242-T Evaporator. Most concentration gradients (tritium, nitrate, technetium, iodine-129) decrease quite rapidly in the upper couple of meters of the aquifer. Vertically, this part of the aquifer is bracketed by only two samples such that the detailed description of contaminant distribution near the water table is not known. Section 2.5.1 also provided information about the known lateral extent of contamination at WMA TX-TY, particularly at wells 299-W14-11 and 299-W14-13 where the highest concentrations of contaminants are found. The lateral extent of contamination downgradient of this area is not well known, although it does not extend as far as wells 299-W14-16 and 299-W14-17.

3.1.4 State the Problem

The problems addressed by this DQO are the uncertainties in the conceptual model which are summarized in Table 3.1.

Table 3.1. Summary of Problem Statement

	Problem Statement	Source of the Problem
1	The source or sources for contamination at WMA TX-TY are not well known.	Multiple potential sources include tank leaks, spills, transfer pipelines, adjacent cribs and trenches, and the 242-T Evaporator.
2	Groundwater flow rate and direction at WMA TX-TY have changed through time and are currently being altered by the 200-ZP-1 pump-and-treat system.	Groundwater flow rate and direction are required by 40 CFR 265.93(d)(4)(i) and WAC 173-303-400.
3	The mechanism(s) driving contamination to groundwater at WMA TX-TY are not well defined.	Potential driving forces include natural infiltration, past intentional disposal to ground, and past water line leaks. Elimination of driving forces mitigates further contamination of groundwater from vadose zone sources.
4	The general lateral and vertical extents of contamination in groundwater at WMA TX-TY at the large and intermediate scale (10s to ~100 meters) is bounded. The lateral and vertical distributions of contamination in groundwater at WMA TX-TY at smaller scales (<10 meters) are known for the high contamination area east of the WMA.	The extent of contamination is required by 40 CFR 265.93(d)(4)(i) and WAC 173-303-400.
5	The concentrations of dangerous waste contaminants in groundwater at WMA TX-TY are well defined in the upper 10 meters of the aquifer at monitoring well locations but the concentrations change with time. The concentrations of dangerous waste contaminants in groundwater at WMA TX-TY will probably change due to the effects of the 200-ZP-1 pump-and-treat operation.	The concentrations of dangerous waste constituents is required by 40 CFR 265.93(d)(4)(i) and WAC 173-303-400.
6	The pathway(s) for contaminant migration to groundwater at WMA TX-TY are not well defined.	The natural pathways to groundwater are through a heterogeneous and anisotropic unsaturated zone. Man-made pathways include poorly constructed wells and boreholes. Eliminating or inhibiting migrations pathways mitigates further contamination of groundwater from vadose zone sources.

3.2 Identify Decisions

The decision statements identified below are regulatory driven as stated in 40 CFR 265.93(d)(4)(i) and (ii) [and by reference WAC 173-303-400] and as indicated in the Technical Enforcement Guidance Document (EPA 1986). The primary information needed for the ongoing groundwater quality assessment at WMA TX-TY is the information to make the following decisions:

1. Determine if the well network is consistent with the rate and direction of groundwater flow and, therefore, requires no action or if the well network is inconsistent with the rate and direction of groundwater flow and, therefore, requires modification. (Addresses problem statements 2 and 4.)

2. Determine whether changes in concentration of dangerous waste constituents in the groundwater originating from the regulated unit are well defined by the existing sampling frequency, in which case no change in sampling schedule is required, or whether changes in concentrations are not well defined, requiring an increase in sampling frequency. (Addresses problem statement 5.)

Additional information is needed to support decisions concerning facility and groundwater remediation activities at WMA TX-TY. This information is the data needed to address the following decision statements:

3. Determine whether the source or sources of groundwater contamination beneath WMA TX-TY are adequately identified, requiring no change in the assessment well network, or if the source or sources of groundwater contamination are not adequately identified, requiring modification of the well network. (Addresses problem statement 1.)

4. Determine whether identified driving forces account for migration of contamination through the vadose zone to groundwater, requiring no action, or whether driving forces for contaminant migration are not well understood, requiring modification to the assessment well network or additional studies. (Addresses problem statement 3.)

5. Determine whether the pathways that allowed contamination to traverse the vadose zone and enter groundwater at WMA TX-TY are adequately known, requiring no action, or whether the pathways for contaminant migration are not well identified, requiring modification to the assessment well network or additional studies. (Addresses problem statement 6.)

The information needed to make these decisions is discussed in Section 3.3.

3.3 Decision Inputs

This section describes the information needs for addressing the general decisions and site-specific questions identified above. A summary of the information needs is given in Table 3.2. More detailed discussion of the information needs is given in the sections following Table 3.2.

3.3.1 Groundwater Flow Rate and Direction

The rate and direction of groundwater flow is fundamental to assessing the rate of migration and extent of groundwater contamination from the assumed source. Estimating contaminant arrival times at some point of potential exposure (or point of compliance) depend on knowing the rate and direction of groundwater flow.

3.3.1.1 Data Needs and Approach

The flow rate and flow direction where tank waste constituents have been observed in groundwater need to be determined.

This fundamental information must be acquired by investigative techniques based on field measurements.

Table 3.2. Required Information and Sources

Decision Statement[(a)]	Variable	Required Information	Source
1	Groundwater flow rate	Calculated groundwater flow rate	Hydraulic conductivity, effective porosity, and water-table gradient
		Hydraulic conductivity, effective porosity, and water-table gradient	Some hydraulic properties data exist from aquifer testing. Water-table gradient determined from water-level measurements.
1	Groundwater flow direction	Water-table elevations	Quarterly and annual water-level measurements
1	Lateral extent of contamination	Groundwater flow rate and flow direction	See above
		Groundwater chemical composition	Concentrations are determined from quarterly, semi-annual, and annual (depending on constituent) groundwater sampling and analysis
1	Vertical extent of contamination	Groundwater chemical composition	Depth-discrete groundwater data are available at the local, high contamination area east of the WMA. Additional data are needed if high contamination is found in other areas.
2	Contaminant concentrations	Concentration of contaminants in groundwater	Concentrations are determined from (1) quarterly, semi-annual, and annual (depending on constituent) groundwater sampling and analysis and (2) analysis of depth-discrete groundwater samples.
3, 4, 5	Contaminant source(s), driving forces, and migration pathways	Lateral and vertical contaminant distribution	See above.
		Contaminant concentrations	See above.
		Isotopic signatures	Analyses of groundwater samples for Ru-101, -102, and 104; Sr-87/Sr-86; N-15, and O-18 in nitrate; uranium isotopes; and stable chromium isotopes. Preliminary data are available. Additional data needed from groundwater and source term fluids.
		Possible new wells	Any new wells needed to differentiate contaminant sources require prioritization through the well drilling data quality objectives.
(a) From Section 3.2.			

Flow Rate. Flow rate is a fundamental parameter for predicting plume movement and distribution. The configuration of wells in the monitoring network at WMA TX-TY is not conducive to measurement of flow rate using multi-well methods such as tracer tests. Instead, the more classic method to estimate flow rate, using the Darcy equation, will be done. This approach is based on hydraulic conductivity of the aquifer in combination with the water-table gradient and effective porosity. The effective porosity and hydraulic conductivity have been estimated from the results of aquifer tests (slug tests, tracer tests, and pumping tests) in several wells at WMA TX-TY. The water-table gradient is determined from water-level measurements. Water-level measurements are collected quarterly at WMA TX-TY. Groundwater flow rates at WMA TX-TY currently are influenced by the 200-ZP-1 carbon tetrachloride extraction wells.

Flow Direction. Groundwater flow direction will be inferred from water-table elevations in available wells. This approach depends on accurate depth-to-water measurements. Water-level measurements are collected quarterly during sampling events and annually (usually March) for constructing the annual Hanford Site water-table map. Barometric corrections will be made to the measured data if needed. Reliable casing elevations will be obtained or assessed based on available information. Also, recent measurements of borehole straightness with a down-hole gyroscope have shown that both new and older monitoring wells can deviate significantly from vertical. These deviations affect the depth-to-water measurements and the resulting water-table map from which flow directions are inferred.

Currently, the 200-ZP-1 pump-and-treat operation artificially alters the direction of groundwater flow beneath most of WMA TX-TY. No special studies and no special efforts other than water-level measurements will be done while the pump-and-treat system is operating near WMA TX-TY. The quarterly and annual water-level measurements will be used to construct water-table maps and will be used as input for a series of three point problems to infer flow directions.

The current estimate of flow direction is shown in Figure 2.10.

3.3.1.2 Data Uses

The flow rate and flow direction are necessary input to the understanding the extent of contamination at WMA TX-TY. The uses of this input are described in Section 3.3.2.

3.3.2 Extent of Contamination

The spatial and vertical distribution of contaminants in the aquifer is required by 40 CFR 265.93(d)(4)(i) and provides indications of the nature of the vadose zone source, the driving forces and likely transport processes through the vadose zone and groundwater, input to risk assessments, and information supporting corrective measures and remediation.

3.3.2.1 Lateral Extent of Contamination

The lateral extent of contamination in the vicinity of WMA TX-TY will be estimated using the results from routine, quarterly samples to construct plume maps.

Data Needs and Approach

The lateral extent of contamination in the aquifer needs to be determined.

This fundamental information must be acquired by investigative techniques based on field measurements and analytical laboratory data obtained from monitoring wells. These data need to be integrated with historical groundwater compositions and historical groundwater flow characteristics.

Groundwater Flow Rate and Flow Direction. The groundwater flow rate and flow direction are input obtained from the decision inputs described in Section 3.3.1.

Groundwater Chemical Composition. Analyses of routinely collected groundwater samples are necessary to know the concentrations of contaminants and to estimate the lateral extent of contamination. The samples are collected from all wells in the monitoring network quarterly, semi-annually, or annually (depending on constituent). Samples are collected by pump after purging a minimum of three well volumes and after stabilization of pH, specific conductance, temperature, and turbidity. Sample collection, storage, and transportation are done by subcontractors to the Hanford Groundwater Performance Assessment Project according to specifications in a statement of work to the subcontractor. Sample analyses are routinely done by subcontracted laboratories. Analytical procedures are based on EPA-approved methods or, in the case of radionuclides, on laboratory-specific procedures based on best laboratory practice. The analytical data are used to construct contaminant plume maps. The extent to which a plume map reflects the actual plume depends heavily on the distribution of monitoring wells.

Placement of Monitoring Wells. The current groundwater monitoring network at WMA TX-TY consists of 16 wells (Figure 3.1), 15 of which were installed since early 1998. Nominally the monitoring network consists of two upgradient wells and 14 downgradient wells. However, continued use of the 200-ZP-1 pump-and-treat system probably will result in a reversal in groundwater flow beneath the WMA in the future.

Monitoring wells must be strategically located to delineate contaminant plumes coming from the regulated unit.

In 2003, a DQO study was done with the Hanford Groundwater Performance Assessment Project, DOE, and the regulatory agencies that determined the location of one new well at WMA TX-TY (Byrnes and Williams 2003). That well, well 299-W14-11, was intended to complete the groundwater detection and assessment network for the tank farm and was drilled in fiscal year 2005. However, the two upgradient wells for the WMA were modified to serve as extraction wells for the 200-ZP-1 pump-and-treat operation in July 2005. Prior to the recent addition of extraction wells to the pump and treat system, the number and spacing of wells on the downgradient side of the WMA was considered adequate for detection of contamination along the downgradient side of WMA TX-TY after completion of well 299-W14-11 (Byrnes and Williams 2003). If the pump-and-treat system operates for a sufficient period of time and extracts sufficient quantities of water, some or all of the original downgradient wells will become upgradient wells and there may be insufficient downgradient wells.

The addition of wells 299-W15-44, 299-W15-40, and 299-W15-765 as extraction wells was designed to capture carbon tetrachloride along the entire west side of WMA TX-TY. Thus, as long as the temporary flow direction is toward the west (toward the extraction wells), any contamination coming from the WMA to the west should be detected at these wells.

It is not recommended adding wells to the WMA TX-TY monitoring network until the wells along the western side of the WMA are no longer used as extraction wells and the network is subsequently shown to be inadequate.

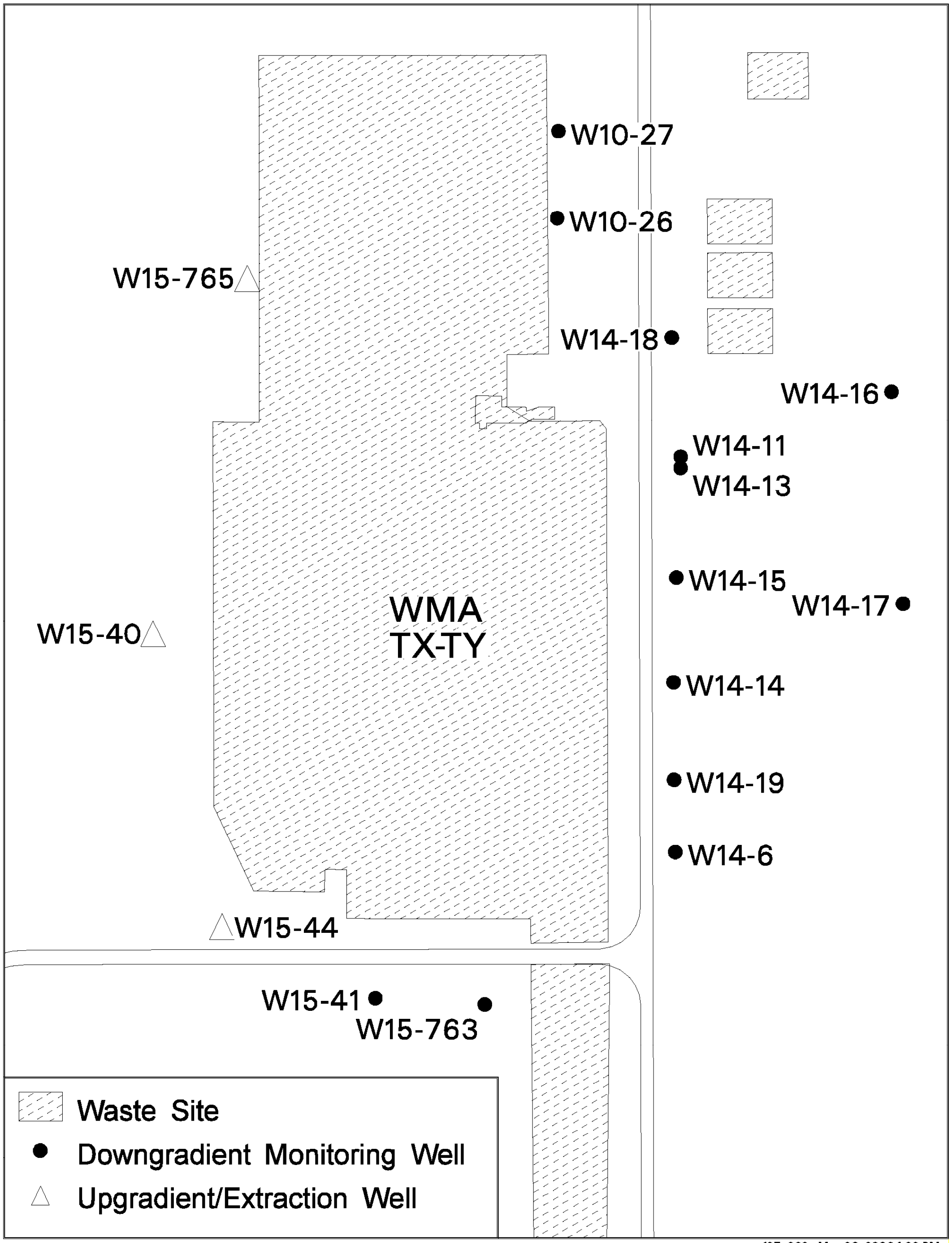

Figure 3.1. Current Groundwater Monitoring Network for Waste Management Area TX-TY

Data Uses

The analytical results from groundwater sampling and analysis are used to construct contaminant plume maps illustrating contaminant distributions. These maps are produced quarterly and published annually for chromium, nitrate, uranium, carbon tetrachloride, trichloroethene, fluoride (annual only), sulfate (annual only), iodine-129, technetium-99, strontium-90, and tritium. The quarterly and annual maps typically show contaminant concentrations at the top of the unconfined aquifer. Plume maps for additional analytes can be made if necessary. Plume maps are also an aid in identification of source areas in cases where distinct plumes emanate from specific facilities.

The extent of contaminant plumes can be modeled using the simple, two-dimensional analytical transport model of Domenico and Robbins (1985). The model assumes that a solute is released along a continuous line source in a uniform aquifer, and predicts the concentrations that would be observed at points downstream of the source. Inputs to the model include the width of the source, the longitudinal and transverse dispersion coefficients, time, hydraulic conductivity, groundwater gradient, effective porosity, and retardation factors.

3.3.2.2 Contaminant Depth Distribution

The vertical extent of contamination at WMA TX-TY has been determined from sample and analysis of groundwater at a few, specific wells.

Data Needs and Approach

The vertical extent of contamination in the aquifer needs to be determined.

This fundamental information must be acquired by investigative techniques based on field measurements and analytical laboratory data described below.

Groundwater Chemical Composition. Samples to describe lateral contaminant distribution are collected by purging a well and then pumping the samples after the well has been completed. Samples collected for vertical contaminant distribution are collected at specific depth intervals in the aquifer, typically during drilling. Wells drilled deep into the aquifer can be screened at depth during well completion. Sampling of wells screened at depth can help define the vertical extent of contamination.

Depth-discrete groundwater samples were collected from new well 299-W14-11, drilled as part of the WMA TX-TY groundwater assessment in 2005. Samples were collected every 1.5-vertical-meter interval throughout the drilled part of the aquifer. The results from these samples, along with previously collected depth-discrete data from adjacent well 299-W14-13, have defined the vertical distribution of technetium-99, nitrate, tritium, and chromium in the area of the well pair.

Currently, contamination potentially from the WMA is restricted to the area local to wells 299-W14-13 and 299-W14-11 (excluding the contamination being drawn toward the 200-ZP-1 extraction wells). If the local contaminant plume spreads, additional vertical profile data are required to determine the vertical distribution of contamination in the newly affected area.

Data Uses

The available analytical data has been used to make concentration versus depth profiles for each tested well. The depth distribution of contaminants may help infer the size of the plumes and distance to contaminant sources from the wells and provide inputs to remedial decisions. For example, a large utility line leak that mobilizes contaminants by localized saturated flow may result in a deeper contaminant distribution in the aquifer than mobilization by slowly migrating moisture from natural infiltration. Also, a deeper contaminant distribution is expected from vertical dispersion from distal sources, whereas a shallow contaminant plume is expected from proximal sources.

The depth distribution of contaminants is basic information needed by the regulatory agencies and DOE to make decisions concerning remedial actions and risk assessments.

3.3.3 Contaminant Concentrations

The concentrations of contaminants in the uppermost aquifer need to be determined.

3.3.3.1 Data Needs and Approach

The results of groundwater sampling and analysis are the data needed to determine the concentrations of contaminants in the aquifer. These are the same data needs described above for determining the lateral and vertical extent of contamination.

3.3.3.2 Data Uses

Contaminant concentrations are evaluated and used to generate plume maps, trend plots, and cross-sections. Contaminant concentrations are reported in RCRA quarterly and annual reports.

3.3.4 Contaminant Sources, Driving Forces, and Migration Pathways

3.3.4.1 Data Needs and Approach

Lateral and Vertical Contaminant Distribution. This information is supplied from the decision inputs described above for determining the lateral and vertical contaminant distributions (Section 3.3.2).

Contaminant Concentrations. This information is supplied from the decision input described above for determining the contaminant concentrations (Section 3.3.3).

Isotopic Signatures. The isotopic signature work is planned in the scope of work funded by the Hanford Site Groundwater Protection Program's Science and Technology Project and not the scope of this groundwater assessment. However, this assessment will use information provided by the Science and Technology Project to the fullest extent possible.

A proposal was submitted to Science and Technology Project to use isotopic signatures of various waste streams in the vicinity of WMAs T and TX-TY and isotopic measurements of groundwater from WMAs T and TX-TY monitoring wells as tools to distinguish the source or sources of groundwater contamination at WMA TX-TY and elsewhere. The special isotopic work is a joint project between Lawrence Berkeley National Laboratory and PNNL. The isotopic systems proposed include

- Ruthenium-101, -102, and -104.
- Strontium-87 and strontium-86.
- $\delta^{15}N$ and $\delta^{18}O$ in nitrate.
- Uranium isotopes.
- Stable chromium isotopes.

All of these isotopic systems, except stable chromium, have been used previously at the Hanford Site. Although the chromium isotopic system may show little difference in the isotopic compositions of chromium from different Hanford Site sources, this proposition will be tested. It is speculative at the moment, but the chromium isotopes may reflect the sources of hexavalent chromium groundwater contamination.

New Monitoring Wells. Evaluation of information gathered during this assessment concerning source(s) of contamination, may lead to a conclusion that one or more new upgradient and/or downgradient wells are needed. Any new proposed wells will be submitted to the DQO process for prioritizing drilling and construction of new wells.

3.3.4.2 Data Uses

Results from these special isotopic studies may help determine the source or sources for the groundwater contamination at WMAs T and TX-TY. Examples of the uses of the isotopic systems are given in the following paragraph. These types of information may be applicable to the groundwater assessment at WMA TX-TY.

A ruthenium fission isotope investigation in the WMA B-BX-BY area found that the technetium-99:ruthenium-101 ratio was higher than expected from the fission yield and that there were two geographically distinguishable technetium-99:ruthenium-101 populations, suggesting possible separate technetium-99 sources in the area (Dresel et al. 2002). The ruthenium isotopic ratios also suggest that there are two sources for fission products in the area: material processed at B Plant and material processed at PUREX Plant. Strontium isotopic ratios have been found to vary in Hanford Site groundwater due to a combination of exchange with sediments and quantity of infiltration. Areas with very high strontium-87 or strontium-86 are believed to reflect disposal of large volumes of process water (Maher et al. 2003). The stable nitrogen and oxygen isotopes in nitrate have been used at the Hanford Site to help distinguish high-level tank waste from low-level process waste and nitric acid (Singleton et al. 2005). Uranium isotopic ratios have been used at the Hanford Site to provide constraints on the source of uranium groundwater contamination in the WMA B-BX-BY area (Christenson et al. 2004).

3.4 Define the Boundaries of the Study

This section defines the boundaries for groundwater quality assessment monitoring at WMA TX-TY. Spatial and temporal boundaries are described as well as well as boundaries on the monitoring network and the analytes to be monitored. This step in the DQO process defines the set of circumstances covered by the questions being addressed.

3.4.1 Spatial Boundaries

The spatial boundaries for groundwater quality assessment monitoring at WMA TX-TY are boundaries defining the WMA, the area upgradient of the WMA between the WMA and upgradient monitoring wells, and the boundaries of downgradient contaminant plumes emanating from the WMA. The uppermost aquifer within this geographical area is the unit of most concern. The uppermost aquifer extends down to the Ringold Formation lower mud unit. The vadose zone within the above described area is also of concern because contaminants in the vadose zone are a source for groundwater contamination.

3.4.2 Temporal Boundaries

The first assessment report (Hodges 1998) found that the tank waste constituent technetium-99 had impacted groundwater. This implies that associated RCRA constituents chromium and nitrate have impacted groundwater in proportion to their concentrations relative to technetium-99 in tank waste. Under 40 CFR 265.93 (d)(7)(i), groundwater quality assessment monitoring must continue until final closure of WMA TX-TY. The expected closure date for all single-shell tanks is 2024.

3.4.3 The Monitoring Network

The current groundwater monitoring network at WMA TX-TY is based on a recent interpretation of subsurface conditions. The initial groundwater monitoring network was designed based on a combination of professional judgment and modeling (Caggiano and Goodwin 1991; MEMO, Wilson et al. 1992). This provided an initial basis for the spacing and locations of wells. Subsequent wells were added to the network based on the same combination of judgment and modeling (Hodges and Chou 2001).

All but one (299-W14-6) of the original eleven detection wells at WMA TX-TY are dry as a result of the declining water table. These wells have been replaced with 15 WAC 173-160 compliant monitoring wells. The current groundwater monitoring network at WMA TX-TY consists of the 16 wells shown on Figure 3.1. As-built diagrams for the current WMA TX-TY assessment network wells are presented in Appendix B. One of these wells is an older well constructed before WAC 173-160 was implemented. Well 299-W14-6 has been used as a downgradient well since flow directions shifted from a northward direction toward the east. It is an older well, with a 9-meter perforated interval.

Two of the wells, 299-W14-16 and 299-W14-17, are mid-field wells located about 100 meters northeast and southeast respectively of well 299-W14-13. The latter well marks the location of the small technetium-99, iodine-129, tritium, nitrate, and chromium plume found east (downgradient) of the WMA. Wells 299-W14-16 and 299-W14-17 are used to monitor the downgradient extent of the high contamination in well 299-W14-13.

Currently, no new wells are planned at WMA TX-TY. Also, no new wells are recommended until the perturbing effects of the 200-ZP-1 pump-and-treat operation have abated. If, at some point, new wells are recommended at WMA TX-TY, the recommendation will be submitted to the well drilling DQO for consideration along with the rest of the Hanford Site's well drilling needs.

3.4.3.1 Constituents to be Monitored

The constituents to be monitored at WMA TX-TY include (1) RCRA-regulated, dangerous-waste constituents of concern, (2) non-RCRA non-dangerous-waste constituents of interest, and (3) supporting groundwater quality constituents. The constituents of concern are those constituents monitored for RCRA and discussed in the following paragraph. The constituents of interest are those constituents monitored under CERCLA and AEA to support tank farm retrieval and remediation and are discussed in subsequent paragraphs. In addition, the supporting groundwater quality constituents are also discussed. All constituents to be monitored are listed in Table 3.3.

Table 3.3. Constituents of Concern, Constituents of Interest, and Supporting Groundwater Quality Constituents to be Monitored at Waste Management Area TX-TY

Constituents of Concern	
Chromium	Nitrate
Constituents of Interest	
Technetium-99	Iodine-129
Tritium	Gross alpha
Gross beta	Gamma scan
Supporting Groundwater Quality Constituents	
Major metals	Major anions
pH	Alkalinity
Specific Conductance	Turbidity
Temperature	Dissolved oxygen
Oxidation-reduction potential	

Constituents of Concern. **Chromium** and **nitrate** are included as constituents of concern for RCRA monitoring at WMA TX-TY. The constituents of concern are those dangerous waste constituents regulated by RCRA that exist in the waste stored in WMA TX-TY and that are found in groundwater downgradient of WMA TX-TY. The specific constituents that have been documented in groundwater include chromium, nitrate, and carbon tetrachloride. Carbon tetrachloride is monitored under CERCLA and is not included as a WMA TX-TY groundwater assessment constituent of concern.

Constituents of Interest. The constituents of interest are non-RCRA regulated, non-dangerous waste constituents. The constituents of interest are compiled from existing contaminants in groundwater downgradient of WMA TX-TY that are not covered in the above paragraph and certain screening parameters for potential radionuclide contaminants.

The constituents of interest that are identified in the groundwater beneath WMA TX-TY are **technetium-99, tritium**, and **iodine-129.** The screening parameters **gross alpha** and **gross beta** are also included in the constituents of interest. These analyses are used to indicate the possible presence of common radionuclide contaminants in the groundwater including strontium-90, and various isotopes of uranium and plutonium. If a screening parameter indicates an increase in alpha or beta activity that cannot be explained by an increase in a specific radionuclide that is already included as a constituent of interest, then additional radionuclide-specific analyses will be initiated. The screening parameters are less expensive than most radionuclide-specific analyses and their use greatly decreases the cost of monitoring. Finally, the isotopes measured by **gamma scan** are included as constituents of interest because they include cesium-137, cobalt-60, and other isotopes known to exist in the vadose zone that could potentially reach groundwater.

Supporting Groundwater Quality Constituents. Table 3.3 gives the supporting groundwater quality constituents. The supporting groundwater quality constituents are used to evaluate the chemical and physical quality of the sample. Basic hydrochemical information is obtained from the supporting groundwater quality constituents to allow quality control checks (e.g., cation/anion charge balance, specific conductance versus the sum of major constituents). Changes in pH and alkalinity also would be expected if tank waste or reaction products reached groundwater. Some groundwater quality constituents can also help evaluate the size of liquid leaks and leak sources.

3.4.4 Practical Constraints

Although not strictly boundaries, practical constraints place limits on planned activities that get accomplished. The most obvious practical constraint is cost. Every effort is made to ensure the collection of the right types of data to support the decisions while keeping the cost of this assessment at a minimum. However, unforeseen changes in budgets may preclude some of the scope proposed for this groundwater assessment.

3.5 Decision Rules

Decision rules address the major or key questions and issues previously discussed. In accordance with the DQO process, "if-then" statements are formulated that lead to actions based on the data or information. However, not all issues or questions identified are amenable to this approach. Table 3.4 summarizes the decision rules and the following sections provide more detail.

3.5.1 Groundwater Flow Rate and Direction

The groundwater flow rate and flow direction are fundamental inputs to evaluating the lateral (and to some extent the vertical) distribution of contamination. The flow rate and flow direction are also valuable input to determine contamination sources. Therefore, the flow rate and flow direction where contaminates are encountered in the groundwater need to be known. However, a decision rule regarding flow rate and flow direction is not feasible because estimations of groundwater flow rate and flow direction are dependent on estimations of hydraulic conductivity and effective porosity, the accuracy of water-level measurements, and heterogeneities in the hydrogeologic system. The best possible recourse is to continue collecting hydrologic data as they become available to refine existing estimates of groundwater conditions.

3.5.2 Extent of Contamination

The extent of groundwater contamination from WMA TX-TY is required by 40 CFR 265.93(d)(4)(i). In addition, the extent of contamination is helpful to determine the source of contamination. Thus, it is important to know the spatial and vertical distribution of contaminants in the unconfined aquifer at WMA TX-TY. A decision rule regarding the lateral extent of contamination is:

> *If a given contaminant plume is enclosed laterally and downgradient by WMA TX-TY network wells or additional operable unit wells with concentrations of one-half or less of the drinking water standard for the given contaminant, then the lateral extent of the given contaminant plume is well understood.*

Table 3.4. Summary of Decision Rules

Decision Statement[a]	Decision Rule
What is the rate and extent of migration of dangerous waste or dangerous waste constituents in the groundwater?	A decision rule for flow rate is not appropriate because flow rate and direction are dependent on estimates of hydrologic properties from a heterogeneous and anisotropic system.
	If a given contaminant plume is enclosed laterally and downgradient by WMA TX-TY network wells or additional operable unit wells with concentrations of one-half or less of the drinking water standard for the given contaminant, then the lateral extent of the given contaminant plume is well understood.
	If sampling within a single well shows that, at some depth, the concentration for a given contaminant is at the local back-ground level, and that concentrations above that depth passed through a maximum value, then the vertical extent of contami-nation for the given contaminant in the area is well known.
What are the concentrations of dangerous waste constituents in the groundwater originating from the regulated unit?	*If contaminant concentrations are stable or on an established trend line, then no frequency change will be made to the sampling schedule.*
	If a screening constituent shows an increase that can not be accounted for by other monitored constituents, then additional groundwater evaluation will be done.
	If results of the additional evaluation indicate that additional constituents of concern or constituents of interest have adversely impacted groundwater quality and are attributed to WMA TX-TY, then that (those) constituent(s) will be added to the list of constituents of concern or to the list of constituents of interest as appropriate.
What is the location or source of groundwater contamination at WMA TX-TY?	*If more data are needed in a specific area to distinguish among two or more potential sources of contamination, then the location for appropriately placed new wells will be submitted for consideration in the next update of the well drilling DQO.*
What are the driving forces that account for the temporal and spatial occurrences of contaminants in the groundwater at WMA TX-TY.	A decision rule for this decision statement is not appropriate because determination of migration pathways results from a synthesis of historical data, data gathered during this assess-ment, and data gathered as part of other Hanford Site projects.
What are the pathways that allowed contamination to traverse the vadose zone and enter groundwater at WMA TX-TY?	A decision rule for this decision statement is not appropriate because determination of driving mechanisms results from a synthesis of historical data, data gathered during this assess-ment, and data gathered as part of other Hanford Site projects.

(a) From Section 3.2.
(b) DQO = data quality objective.
(c) WMA = waste management area.

For cases where the lateral extent of a given contaminant plume is not known, additional wells may be necessary to define the extent of the plume. The installation of new wells is prioritized by the DQO process at the Hanford Site. Therefore, the addition of new wells to the WMA TX-TY monitoring network will be prioritized along with other Hanford Site's needs.

An additional decision rule regarding the vertical extent of contamination is:

If sampling within a single well shows that, at some depth, the concentration for a given contaminant is at the local background level, and that concentrations above that depth *passed through a maximum value, then the vertical extent of contamination for the given contaminant in the area is well known.*

For cases where the concentration for the given contaminant remains high at the total depth of the well, the vertical extent of contamination in the area is not well known. Decisions can be made to prioritize a new, deeper well at that location.

A complicating factor is the continued, overall decline in the regional water table. The absolute elevation at which the contamination ceases to be a problem may change as the water table declines. The water table is expected to decline an additional 5 miters based on current water levels and estimated post-Hanford water levels (Bergeron and Wurstner 2000).

3.5.3 Sampling and Analysis Considerations

3.5.3.1 Sampling Frequency

A quarterly sampling frequency is required by 40 CFR 265.93(d)(7)(i) and by reference WAC 173-303-400(3) for RCRA-regulated constituents at WMA TX-TY. There are no requirements for sampling frequency associated with non-dangerous waste constituents at a WMA under groundwater quality assessment. The sampling frequency for each constituent sampled under this groundwater quality assessment plan is given in the Sampling and Analysis Plan (Appendix A).

A decision rule covering sampling frequency is as follows:

If contaminant concentrations are stable or on an established trend line, then no frequency change will be made to the sampling schedule.

All groundwater data are reviewed quarterly and the sampling schedule is reviewed annually. The sampling schedule will be changed if it is thought necessary by the project scientist.

3.5.3.2 Analyzed Constituents

The constituents of concern were defined in Section 3.4.3.1 as those dangerous waste constituents regulated by RCRA, and that exist in the waters stored in WMA TX-TY, and are found in the groundwater downgradient of WMA TX-TY: specifically chromium and nitrate. The definition of constituents of concern allows for the list of those constituents to be changed (if additional dangerous wastes are found in the groundwater in the future). Decision rules addressing a change in the list of constituents of concern are as follows:

If a screening constituent shows an increase that can not be accounted for by other monitored constituents, then additional groundwater evaluation will be done.

This additional evaluation may include more frequent sampling, or the analysis of specific constituents previously covered by a screening constituent (e.g., strontium-90 as indicated by gross beta), or analysis of other heretofore unconsidered constituent.

If results of the additional evaluation indicate that additional constituents of concern or constituents of interest have adversely impacted groundwater quality and are attributed to

WMA TX-TY, then that (those) constituent(s) will be added to the list of constituents of concern or to the list of constituents of interest as appropriate.

3.5.4 Contaminant Source(s), Migration Pathways, and Driving Mechanisms

Determinations of contaminant source(s), migration pathways, and driving mechanisms results from syntheses of historical data, data gathered during this assessment, and data gathered as part of other programs such as the River Protection Project Tank Farm Vadose Zone Project and the 200-ZP-1 Operable Unit. One likely outcome from these determinations is that more information is needed from a specific area to differentiate between two or more contaminant sources. The major access way for gathering additional information is through additional boreholes or wells. A decision rule addressing this is as follows:

If more data are needed in a specific area to distinguish among two or more potential sources of contamination, then the location for appropriately placed new wells will be submitted for consideration in the next update of the well drilling DQO.

The well drilling DQO process will be used to prioritize the needed wells with wells required by other Hanford Site projects.

Other means of gathering information concerning contaminant sources and possibly migration pathways and driving mechanisms are (1) analysis of constituents not previously analyzed, (2) use of contaminant ratios not previously used, and (3) analysis by contaminant suites.

3.6 Optimize the Sampling Design

The groundwater quality assessment program for WMA TX-TY outlined in this DQO section is judged to be the current most resource-effective data collection design for gathering data to satisfy the DQOs. The resulting data collection design is given in the Sampling and Analysis Plan in Appendix A. However, priority and on-going activities frequently change at the Hanford Site and these changes could lead to further design optimization. Also, additional groundwater quality assessment information may lead to further design optimization. This assessment plan will be reviewed annually to determine whether the activities for the groundwater assessment remain the most resource-effective data generating activities.

An additional cost savings is realized by coordination of sampling activities among RCRA, CERCLA, and AEA monitoring. The sampling schedules for the three monitoring programs are integrated to minimize well trips and duplicate analyses.

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Appendix A

Sampling and Analysis Plan

Appendix A

Sampling and Analysis Plan

This appendix consists of a field sampling plan (FSP) and a quality assurance project plan (QAPP). The FSP specifies the data collection design and the QAPP includes the procedures and project management controls intended to ensure the data collected and associated measurement errors are appropriate to meet the quantitative and qualitative data quality objectives (DQO). Together these two plans form the Sampling and Analysis Plan. The Sampling and Analysis Plan is used as the principal controlling document for conducting the work identified in Section 3.

A.1 Field Sampling Plan

This section contains the data collection design and activities for the continued groundwater quality assessment of Waste Management Area (WMA) TX-TY. A description of each task is provided. Additional discussion and background information associated with the tasks are provided in the main body of the plan.

A.1.1 Task Description

The tasks described are a subpart of the Groundwater Performance Assessment Project (groundwater project) managed for the U.S. Department of Energy (DOE) by Pacific Northwest National Laboratory (PNNL). Project management and organizational interfaces and procedures are described in Section A.2.

A.1.1.1 Determine Groundwater Flow Direction

Water Level Measurements. The depth to water will be measured quarterly in all wells at the time of sampling. These measurements are an indicator of conditions in the well at the time of sampling. However, because these measurements are generally taken over a time period of a few days, they are subject to differential barometric effects due to diurnal and storm-related changes in atmospheric pressure. Therefore, depth-to-water measurements taken at the time of sampling and used to construct water table maps will be corrected for changes in atmospheric pressure if substantial pressure changes occurred over the time period of data collection.

Additionally, depth to water is measured annually in March to construct the annual Hanford Site water-table map. At WMA TX-TY, these March measurements are generally taken in all wells within a few hours time. Thus, the March measurements are not as susceptible to barometric effects as are the quarterly measurements.

A.1.1.2 Well Drilling and Testing

Currently, no new wells are planned for WMA TX-TY. If site conditions change such that new wells are deemed necessary, new wells will be recommended to the well drilling DQO to be prioritized with other Hanford Site well requirements. If new wells will be constructed as a result of the DQO prioritization, appropriate sampling and analysis activities during drilling, geophysical logging activities, and aquifer testing will be described and documented in a separate sampling and analysis plan for drilling new wells.

A.1.1.3 Quarterly Groundwater Sampling and Analysis

Sampling in the WMA TX-TY well network identified for this assessment is an ongoing activity. A quarterly frequency is required by 40 CFR 265.93(d)(7)(i) by reference of WAC 173-303-400(3) for *Resource Conservation and Recovery Act (*RCRA)-regulated constituents. This frequency also is adopted for some constituents of interest and groundwater quality indicators. Other constituents of interest are sampled semi-annually or annually. These frequencies are judged to be adequate for assessing the rate and extent of contaminant migration in the groundwater, and contaminant concentrations for the WMA TX-TY based on the time response of previous contaminant occurrences in monitoring wells and a relatively slow groundwater flow rate in the north central part of 200 West Area.

The selection of the constituents to be monitored was discussed in Section 3.4 of the main body of this assessment plan. The wells to be monitored and the monitoring schedule are shown in Table A.1.

A.1.1.4 Special Isotopic Studies

Special isotopic investigations are planned under the scope of the Science and Technology Project and in conjunction with Lawrence Berkeley National Laboratory to try and distinguish the source or sources for contamination downgradient of WMA TX-TY. The WMA TX-TY groundwater assessment will take full advantage of any results from the special isotope studies as is appropriate for the assessment. The isotopic systems to be investigated include:

- Ruthenium-101, -102, and -104.
- Strontium-87 and strontium-86.
- $\delta^{15}N$ and $\delta^{18}O$ in nitrate.
- Uranium isotopes.
- Stable chromium isotopes.

Several sample sets will be used for these studies. Depth-discrete samples of pumped groundwater from the new well 299-W14-11 were collected for isotopic analyses when the well was drilled. Supplementing these samples are aliquots of groundwater samples collected during routine, quarterly sampling events between 1999 and 2003. Additional samples can be collected if needed.

A.1.1.7 Project Planning and Direction

This task involves ensuring that tasks are on schedule, that resources and personnel will be available when they are needed, and developing workarounds when schedule conflicts occur. Preparation of the assessment plan (this document), preparation of further assessment work plans that may be necessary to implement individual tasks, and any subsequent revisions of the assessment plan are also included in this task. Attending meetings with stakeholders and the integration project team leads to ensure coordination with other related projects is part of this task.

Table A.1. Sampling Schedule for Groundwater Monitoring at Waste Management Area TX-TY

			RCRA Constituents of Concern			Constituents of Interest and Supporting Groundwater Quality Constituents															
Well Name	Purpose(h)	WAC Compliant	Water Level[f]	Chromium (total, filtered)	Nitrate (anions)	Technetium-99	Tritium	Gamma Scan(a)	Gross Beta(b)	Gross Alpha(c)	Metals, filtered (d)	Anions(e)	Alkalinity	pH(f)	Specific Conductance(f)	Turbidity(f)	Temperature(f)	Dissolved Oxygen(f)	Redox(f)	Iodine-1129	Sr-90
299-W10-26	Downgradient	Y	Q	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	—[g]	—
299-W10-27	Downgradient	Y	Q	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	—	—
299-W14-6	Downgradient	N	Q	Q	Q	Q	Q	—	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	—	—
299-W14-11	Downgradient	Y	Q	Q	Q	Q	Q	SA	SA	SA	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	A
299-W14-13	Downgradient	Y	Q	Q	Q	Q	Q	SA	SA	SA	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	A
299-W14-14	Downgradient	Y	Q	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	—	—
299-W14-15	Downgradient	Y	Q	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	—
299-W14-16	Mid-field[h]	Y	Q	Q	Q	Q	Q	—	—	—	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	—
299-W14-17	Mid-field	Y	Q	Q	Q	Q	Q	—	—	—	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	—
299-W14-18	Downgradient	Y	Q	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	—
299-W14-19	Downgradient	Y	Q	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	—	—
299-W15-40	Upgradient	Y	Q[i]	Q	Q	Q	Q	—	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	—	—
299-W15-41	Downgradient	Y	Q	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	SA	—
299-W15-44	Downgradient	Y	Q[i]	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	SA	—
299-W15-763	Downgradient	Y	Q	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	—	—
299-W15-765	Upgradient	Y	Q[i]	Q	Q	Q	Q	A	A	A	Q	Q	Q	Q	Q	Q	Q	Q	Q	SA	—

Footnotes

(a)	Gamma Scan - Analytes include but are not limited to cobalt-60, cesium-137, europium-152, -154.
(b)	Gross Beta - Indicator paramenter for strontium-90 and other beta emiters
(c)	Gross Alpha - Indicator paramenter for uranium isotopes and other alpha emitters
(d)	Metals - Analytes include but are not limited to alumium, bismuth, chromium, manganese, sodium, magnesium, potassium, and calcium
(e)	Anions - Analytes include but are not limited to nitrite, nitrate, chloride, sulfate, and fluoride
(f)	Field Measurement
(g)	Dash indicates analysis is not performed for the indicated well.
(h)	Mid-field wells are wells located downgradient of the downgradient wells and used to determine lateral extent of contamination.
(i)	Water levels are not taken in extraction wells.

Codes

Q =	Quarterly
SA =	Semi-annual
A =	Annual

A.2 Quality Assurance Plan

The groundwater quality assessment investigation at WMA TX-TY is an integral part of the RCRA groundwater-monitoring program of the groundwater project. The scope of the consolidated project includes groundwater monitoring and the hydrogeologic services necessary to install, design, and monitor well networks for groundwater quality and contaminant movement on the Hanford Site. The project is administered by PNNL for the Richland Operations Office of DOE, Environmental Restoration (ER) Branch.

The groundwater project was established in 1996 when scope and personnel for the RCRA groundwater and related operational monitoring activities were transferred from Westinghouse Hanford Company to PNNL. The groundwater project quality assurance plan and current subcontractor procedures/manuals cover much of the work activities required for conducting the WMA TX-TY groundwater quality assessment.

Project description, project organization and designated responsibilities, and project management interfaces between DOE and subcontractor organizations are described in the groundwater project quality assurance plan.

A.2.1 Groundwater Sampling and Analysis Protocol

Samples will be collected for this assessment during routine quarterly sampling. The sampling and analysis methods and procedures and associated quality control for routine quarterly groundwater sampling and analysis are described in EPA (1986).

A.2.1.1 Water-Level Monitoring

Field personnel measure depth to water before sampling or at other times as specified by the groundwater project (e.g., annual water-level measurements). The tapes used to make depth measurements are calibrated semi-annually. Field personnel obtain two consecutive measurements that agree within 6 millimeters and record them along with date, time, measuring tape number, and other pertinent information. Depth to water is subtracted from the elevation of a reference point (usually top of casing) to obtain water-level elevation. Water-level elevations are used to construct water-table maps. Groundwater flow direction beneath WMA TX-TY is determined from water-level measurements.

A.2.1.2 Routine Sampling and Analysis Protocol

Groundwater monitoring for WMA TX-TY is part of the groundwater project and follows project quality assurance protocols. Groundwater monitoring for WMA TX-TY will follow the requirements of the most recent revision of the project quality assurance protocols; this monitoring plan need not be revised to cite future revisions of those protocols.

Project staff schedule sampling and initiate paperwork and oversee sample collection, shipping, and analysis. Quality requirements for any work subcontracted are specified in statements of work or contracts.

The statement of work for sampling activities specifies that those activities will be conducted in accordance with a quality assurance project plan that meets the requirements defined in *Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5) (EPA 2001, as revised). Additional requirements are specified in the statement of work.

Groundwater project staff conduct laboratory audits and field surveillances to assess the quality of subcontracted work and initiate corrective action if needed.

Scheduling Groundwater Sampling

The groundwater project schedules well sampling. Many Hanford Site wells are sampled for multiple objectives and requirements; e.g., RCRA, *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), and *Atomic Energy Act* (AEA). Scheduling activities help manage the overlap, eliminate redundant sampling, and meet the needs of each sampling objective. Scheduling activities include the following:

- Each fiscal year, project scientists provide well lists, constituent lists, and sampling frequency. Each month, project scientists review the sampling schedule for the following month. Changes are requested via change request forms and approved by the sampling and analysis task lead and monitoring project manager.

- Project staff track sampling and analysis through an electronic schedule database stored on a server at PNNL. Quality control samples also are managed through this database. A scheduling program generates unique sample numbers, and a special user interface generates sample authorization forms, field services reports, groundwater sample reports, chain-of-custody forms, and sample container labels.

- Sampling and analysis staff verify that well name, sample numbers, bottle sizes, preservatives, etc. are indicated properly on the paperwork, which is transmitted to the sample collector. Staff verify that the paperwork was generated correctly.

- At each month's end, project staff use the schedule database to determine if any wells were not sampled as scheduled. If the wells or sampling pumps require maintenance, sampling is rescheduled following repair. If a well can no longer be sampled it is cancelled, and the reason is recorded in the database.

Chain of Custody

The sample collector uses chain-of-custody forms to document the integrity of groundwater samples from the time of collection through data reporting. The forms are generated during scheduling and managed by the sample collector. Samplers enter required information on the forms, including the following:

- Sampler's name(s).
- Method of shipment and destination.
- Collection date and time.
- Sample identification numbers.

- Analysis methods.
- Preservation methods.

When samples are transferred from one custodian to another (e.g., from sampler to shipper or shipper to analytical laboratory), the receiving custodian inspects the form and samples and notes any deficiencies. Each transfer of custody is documented by the printed names and signatures of the custodian relinquishing the samples and the custodian receiving the samples, and the time and date of transfer are recorded.

Sample Collection

All of the wells in the WMA TX-TY network are equipped with dedicated sampling pumps. Field personnel measure water levels in each well prior to sampling, then purge stagnant water from the well. Groundwater samples generally are collected after three casing volumes of water have been purged from the well and after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized.

For routine groundwater samples, preservatives are added to the collection bottles, if necessary, before their use in the field. Samples for metals analyses are filtered in the field with 0.45 micrometer, in-line, disposable filters. After sampling, pH, temperature and specific conductance are measured again. Sample bottles are sealed with evidence tape and placed in a cooler with ice for shipping.

Analytical Protocols

Instruments for field measurements (e.g., pH, specific conductance, temperature, and turbidity) are calibrated using standard solutions prior to use and are operated according to manufacturer's instructions. Each instrument is assigned a unique number that is tracked on field documentation and calibrated and controlled.

Laboratory analytical methods are specified in contracts with the laboratories, and are standard methods from *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846; EPA 1986, as revised) or *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020, EPA 1983, as revised).

A.2.2 Borehole Drilling and Testing and Well Completion

Fluor Hanford, Inc. manages borehole drilling and well installation under their safety and related job control procedures. Data needs and objectives for new wells transmitted by letter report to Fluor Hanford, Inc. to include in the detailed specifications for the drilling contracts. No new wells for WMA TX-TY currently are planned. If further assessment of the WMA indicate that new wells are needed, requirements for sediment and groundwater sampling during drilling, analyses of groundwater samples, geophysical logging, hydrologic testing, and well construction will be specified in a separate drilling sampling and analysis plan.

Any requirements for sampling during drilling are specified in separate sampling and analysis plans that are specific to each new well. Chain of custody is required for groundwater samples collected during drilling.

A.2.3 Quality Assurance

The groundwater project's quality assurance program meets *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5, EPA 2001 as revised). The quality assurance program also is based on the quality assurance requirements of DOE Order 414.1C, Quality Assurance, and 10 CFR 830, Subpart A, "General Provisions/Quality Assurance Requirements," as delineated in PNNL's Standards-Based Management System. A quality control plan is included in the groundwater project quality assurance plan. Quality control sampling requirements for subcontracted work are discussed in the statement of work with the subcontractor. The subcontractor's quality assurance protocols also will meet *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5, EPA 2001, as revised).

The groundwater project's quality control program is designed to assess and enhance the reliability and validity of groundwater data. This is accomplished through evaluating the results of quality control samples, conducting audits, and validating groundwater data. This section describes the quality control program for the entire groundwater project, which includes WMA TX-TY. The quality control practices of the groundwater project are based on EPA guidance cited in the Tri-Party Agreement Action Plan, Section 6.5 (Ecology et al. 1989). Accuracy, precision, and detection are the primary parameters used to assess data quality (Mitchell et al. 1985). Data for these parameters are obtained from two categories of quality control samples: those that provide checks on field and laboratory activities (field quality control) and those that monitor laboratory performance (laboratory quality control). Table A.2 summarizes the types of samples in each category and the sample frequencies and characteristics evaluated.

A.2.3.1 Quality Control Criteria

Method detection limits for WMA TX-TY groundwater monitoring shall be consistent with those determined for the groundwater project, as discussed in the project quality assurance plan. Reporting limits for radionuclides are defined in the laboratory contract. Reporting limits as low as one third the derived 4-mrem-dose requirement are preferred, but not always achievable. Limits for precision and accuracy for chemical analyses are based on criteria stipulated in the methods (e.g., EPA/SW-846, EPA 600 series). Method detection limits as low as one third the EPA drinking water standards are preferred, but not always achievable.

Quality control data are evaluated based on established acceptance criteria for each quality control sample type. For field and method blanks, the acceptance limit is generally two times the instrument detection limit (for metals), or method detection limit (for other chemical parameters). However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and phthalate esters, the limit is five times the method detection limit. Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks are flagged with a "Q" in the database to indicate a potential contamination problem.

Table A.2. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field Quality Control		
Full Trip Blank	Contamination from containers or transportation	1 per 20 well trips
Field Transfer Blank	Airborne contamination from the sampling site	1 each day volatile organic compound samples are collected
Equipment Blank	Contamination from nondedicated sampling equipment	1 per 10 well trips or as needed[(a)]
Duplicate Samples	Reproducibility	1 per 20 well trips
Laboratory Quality Control		
Method Blank	Laboratory contamination	1 per batch
Lab Duplicates	Laboratory reproducibility	Method/contract specific[(b)]
Matrix Spike	Matrix effects and laboratory accuracy	Method/contract specific[(b)]
Matrix Spike Duplicate	Laboratory reproducibility and accuracy	Method/contract specific[(b)]
Surrogates	Recovery/yield	Method/contract specific[(b)]
Laboratory Control Sample	Accuracy	1 per batch

(a) When a new type of non-dedicated sampling equipment is used, an equipment blank should be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the equipment's decontamination procedure.
(b) If called for by the analytical method, duplicates, matrix spikes, and matrix spike duplicates are typically analyzed at a frequency of 1 per 20 samples. Surrogates are routinely included in every sample for most gas chromatographic methods.

Field duplicates must agree within 20%, as measured by the relative percent difference (RPD), to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results are also flagged with a "Q" in the database.

The acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are generally derived from historical data at the laboratories in accordance with *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846; EPA 1986, as revised). Acceptance criteria applicable to constituents analyzed for WMA TX-TY monitoring are listed in Table A.3.

Table A.4 lists the acceptable recovery limits for the double-blind standards. These samples are prepared by spiking background well water (currently wells 699-19-88 and 699-49-100C) with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper limit of concentration determined in groundwater on the Hanford Site. Investigations of double-blind standards that are outside of acceptance limits may include (1) reviewing raw data from the laboratory, (2) communicating the problem to the laboratory, (3) requesting reanalysis of the samples,

Table A.3. Field and Laboratory QC Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity - EPA 600 Series, 310.1	MB[b]	<MDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	±20% RPD[c]	Data reviewed[d]
	MS[e]	75-125% recovery[c]	Flagged with "N"
	EB, FTB	<2X MDL	Flagged with "Q"
	Field Duplicate	±20% RPD[f]	Flagged with "Q"
Anions			
Anions by ICP - EPA 600 Series, 300.0	MB	<MDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	±20% RPD[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	EB, FTB	<2X MDL	Flagged with "Q"
	Field Duplicate	±20% RPD[f]	Flagged with "Q"
Metals			
ICP Metals (including chromium) - SW-846, 6010	MB	<CRDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	MSD	±20% RPD[c]	Data reviewed[d]
	EB, FTB	<2X MDL	Flagged with "Q"
	Field Duplicate	±20% RPD[f]	Flagged with "Q"
Radiological Parameters			
Gamma Scan	MB	<2X MDA	Flagged with "B"
Gross Alpha - SW-846, 9310	LCS	70-130% recovery	Data reviewed[c]
Gross Beta - SW-846, 9310	DUP	±20% RPD	Data reviewed[c]
Iodine-129	MS[g]	60-40% recovery	Flagged with "N"
Technetium-99	EB, FTB	<2X MDA	Flagged with "Q"
Strontium-90	Field Duplicate	±20% RPD	Flagged with "Q"
Tritium - SW-846, 906.0			

(a) EPA/SW-846; EPA 1986, as revised.
(b) Does not apply to pH.
(c) Laboratory-determined, statistically derived control limits may also be used. Such limits are reported with the data.
(d) After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory. recheck or flagging the data as suspect (Y flag) or rejected (R flag).
(e) Applies to total organic carbon and total organic halides only.
(f) Applies only in cases where one or both results are greater than 5X the detection limit.
(g) Applies only to technetium-99 and total uranium analyses.

Data Flags:

B, C = Possible laboratory contamination (analyte was detected in the associated method blank).
N = Result may be biased (associated matrix spike result was outside the acceptance limits).
Q = Problem with associated field QC sample (blank and/or duplicate results were out of limits).
CRDL = Contract-required detection limit .
DUP = Laboratory matrix duplicate.
EB = Equipment blank.
FTB = Full trip blank.
MS = Matrix spike.
ICP = Inductively coupled plasma.
LCS = Laboratory control sample.
MB = Method blank.
MDA = Minimum detectable activity.
MDL = Method detection limit.
MSD = Matrix spike duplicate.
RPD = Relative percent difference.
.

(4) scheduling additional quality control blinds or other quality control samples such as blanks or splits, and (5) obtaining/evaluating laboratory quality control data. Depending on the results of the investigation, corrective action may include flagging data in the database, requiring the laboratory to fix a problem, or identifying an alternative laboratory until the issue has been resolved.

Holding time is the elapsed time period between sample collection and analysis. Exceeding recommended holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA 1986, as revised) or *Methods for Chemical Analysis of Water and Wastes* (EPA 1983, as revised). These holding times are specified in laboratory contracts. Data associated with exceeded holding times are flagged with an "H" in the Hanford Environmental Information System (HEIS) database. Flagged data generally are suitable for use in plume maps and trend plots, but may not be suitable for decision-making.

Additional quality control measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned water pollution and water supply performance evaluation studies. The groundwater project periodically audits the analytical laboratories to identify and solve quality problems, or to prevent such problems. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report.

Table A.4. Recovery Limits for Double Blind Standards

Constituent	Frequency	Recovery Limits (%)	Precision Limits (RSD) (%)
Specific conductance	Quarterly	75–125	25
Fluoride	Quarterly	75–125	25
Nitrate	Quarterly	75–125	25
Chromium	Annually	80–120	20
Gross alpha[a]	Quarterly	70–130	20
Gross beta[b]	Quarterly	70–130	20
Tritium	Annually	70–130	20
Cobalt-60	Annually	70-130	20
Strontium-90	Semiannually	70–130	20
Technetium-99	Quarterly	70–130	20
Iodine-120	Semiannually	70–130	20
Uranium	Quarterly	70–130	20

(a) Gross alpha standards will be spiked with plutonium-239.
(b) Gross beta standards will be spiked with strontium-90.
RSD = Relative standard deviation.

A.2.3.2 Groundwater Data Validation Process

The groundwater project's data validation process provides requirements and guidance for validation of groundwater data that are routinely collected as part of the groundwater project. Validation is a systematic process of reviewing data against a set of criteria to determine whether the data are acceptable for their intended use. This process applies to groundwater data that have been verified (see Section A.2.4.1) and loaded into HEIS. The outcome of the activities described below is an electronic data set with suspect or erroneous data corrected or flagged. Groundwater project staff document the validation process quarterly. Documentation is stored in the project file.

Responsibilities for data validation are divided among project staff. Each monitored facility or geographic region is assigned to a project scientist, who is familiar with the hydrogeologic conditions of that site. The data validation process includes the following elements.

- **Generation of data reports** – Twice each month, data management staff provide tables of newly loaded data to project scientists for evaluation (biweekly reports). Also, after laboratory results from a reporting quarter have been loaded into HEIS, staff produce tables of water-level data and analytical data for wells sampled within that quarter (quarterly reports). The quarterly data reports include any data flags added during the quality control evaluation or as a result of prior data review.

- **Project scientist evaluation** – As soon as practical after receiving biweekly reports, project scientists review the data to identify changes in groundwater quality or potential data errors. Evaluation techniques include comparing key constituents to historical trends or spatial patterns. Other data checks may include comparison of general parameters to their specific counterparts (e.g., conductivity to ions) and calculation of charge balances. Project scientists request data reviews if appropriate (see Section A.2.4.2). If necessary, the laboratory may be asked to check calculations or reanalyze the sample, or the well may be resampled. After receiving quarterly reports, project scientists review sampling summary tables to determine whether network wells were sampled and analyzed as scheduled. If not, they work with other project staff to resolve the problem. Project scientists also review quarterly reports of analytical and water-level data using the same techniques as for biweekly reports. Unlike the biweekly reports, the quarterly reports usually include a full data set (i.e., all the data from the wells sampled during the previous quarter have been received and loaded into HEIS).

- Staff report results of quality control evaluations informally to project staff, DOE, and Washington State Department of Ecology (Ecology) each quarter. Results for each fiscal year are described in the annual groundwater monitoring report.

A.2.4 Data Management and Reporting

This section describes how groundwater data are stored, retrieved, and interpreted.

A.2.4.1 Loading and Verifying Data

The contract laboratories report analytical results electronically and in hard copy. The electronic results are loaded into HEIS. Hard copy data reports and field records are maintained as part of the Hanford Facility operating record, unit specific file for the monitored facility. Project staff perform an array of computer checks on the electronic file for formatting, allowed values, data flagging (qualifiers), and completeness. Verification of the hard copy results includes checks for (1) completeness, (2) notes on condition of samples upon receipt by the laboratory, (3) notes on problems that arose during the analysis of the samples, and (4) correct reporting of results. If data are incomplete or deficient, staff work with the laboratory to get the problems corrected. Notes on condition of samples or problems during analysis may be used to support data reviews (see Section A.2.4.2).

Field data such as specific conductance, pH, temperature, turbidity, and depth-to-water measurements are recorded on field records. Data management staff enter these into HEIS manually through data-entry screens, verify each value against the hard copy, and initial each value on the hard copy.

A.2.4.2 Data Review

The groundwater project conducts special reviews of groundwater analytical data or field measurements when results are in question. Groundwater project staff document the process on a review form, and results are used to flag the data appropriately in HEIS. Various staff may initiate a review form: e.g., project scientists, data management staff, and quality control staff. The data review process includes the following steps:

- The initiator fills out required information on the review form, such as sample number, constituent, and reason for the request (e.g., "result is two orders of magnitude greater than historical results and disagrees with duplicate"). The initiator recommends an action, such as a data re-check, sample re-analysis, well re-sampling, or simply flagging the data as suspect in HEIS.

- The data review coordinator determines that the review form does not duplicate a previously submitted review form, then assigns a unique review form number and records it on the form. A temporary flag is assigned to the data in HEIS indicating the data are undergoing review ("F" flag).

- If laboratory action is required, the data review coordinator records the laboratory's response on the review form. Other documentation also may be relevant, such as chain-of-custody forms, field records, calibration logs, or chemist's sheets.

- A project scientist assigned to examine a review form determines and records the appropriate response and action on the review form including changes to be made to the data flags in HEIS. Actions may include updating HEIS with corrected data or result of re-analysis, flagging existing data (e.g., "R" for reject, "Y" for suspect, "G" for good), and/or adding comments. Data management staff updates the temporary "F" flag to the final flag in HEIS.

- The data review coordinator signs the review form to indicate its closure.

- If a review form is filed on data that are not "owned" by the groundwater project, the data review coordinator forwards a copy of the partially filled review form to the appropriate contact for their action. The review is then closed.

A.2.4.3 Interpretation

After data are validated and verified, the acceptable data are used to interpret groundwater conditions at the site. Interpretive techniques include the following.

Hydrographs

Hydrographs will be made using historical (and current) water-level information. Hydrographs show water levels versus time for specified wells. Hydrographs are used to determine decreases, increases, seasonal, or manmade fluctuations in groundwater levels.

Water-Table Maps

Water-table maps will be made using the water-level measurements obtained as described above. Care must be exercised in using water table maps (and hydrographs) for interpretation purposes because there are several potential problems with using historic water level data. In addition to unknown barometric effects, other potential sources of error in resulting water table maps and calculated water table gradients include (1) the straightness of the wells; (2) for some time periods, a relatively flat water table coupled with measurement errors; (3) the communication between the aquifer and the screened or perforated part of the well; (4) changes in lithology; and (5) periodic and local influence from nearby liquid disposal facilities.

Trend Plots

Trend plots will be made using current and historic groundwater compositions. Trend plots graph concentrations of constituents versus time to determine increases, decreases, and fluctuations; they may be used in tandem with hydrographs and/or water-table maps to determine if concentrations relate to changes in water level or in groundwater flow directions.

Plume Maps

Plume maps will be prepared for chromium and nitrate and for selected constituents of interest such as technetium-99. These maps will be made using results of current groundwater sampling and analysis. The maps will describe the current understanding of contaminant distribution. Changes in plume distribution over time aid in determining movement of plumes and direction of flow. Plume maps are prepared by the groundwater project and published annually. Plume maps generally reflect the geographic distribution of contamination in the uppermost part of the aquifer where most wells are screened.

Graphical Methods

Graphical methods are used to display differences and similarities among water quality analyses. Graphical methods area also useful to help identify mixing of waters with different chemical compositions (Hem 1992). Traditional graphical methods include spider diagrams, Stiff diagrams, ion-concentration bar diagrams, and Piper diagrams. These methods will be used as appropriate to interpret groundwater chemical analyses.

Contaminant Ratios

Ratios of contaminant concentrations may be calculated and used to help distinguish different groundwater plumes and to help distinguish between different sources for the contamination if possible. Contaminant ratios are only useful where chemically different waste streams were disposed to two or more different potential source facilities.

Three Point Analyses

Water-table elevations may be used to calculate groundwater flow direction using the three-point analysis (three point problem) method. The method is commonly used by geologists to determine the strike and dip of a plane from the elevations of three points. For this application, the groundwater flow direction is equivalent to the dip of the water table determined by measured water-table elevations in three wells. Several triplets of wells are generally used as available.

Transport Modeling

A simple transport models may be used to predict the distribution of hypothetical contaminants released within the WMA. The monitoring analysis package (Golder 1991) includes the Plume Generation Model (PLUME), the Monitoring Efficiency Model (MEMO), and the Contamination Probability Model (COPRO). This task may use the PLUME model in conjunction with professional judgment estimates to assess the extent of contamination at WMA TX-TY.

PLUME uses an analytical contaminant transport function to generate dilution contour plots of a contaminant plume emanating from a line source of specified length. The model has been used since 1992 to generate the plumes used by the MEMO model. PLUME is based on the two-dimensional analytical transport model presented in Domenico and Robbins (1985) and modified in Domenico (1987). This model assumes that solute is released along a continuous line source in a uniform aquifer, and predicts the concentrations that would be observed at points downstream of the source. The important user input parameters include the following:

- Advection time.
- Source history.
- Width of line source.
- Longitudinal and transverse dispersivities.
- Diffusion coefficient.
- First order decay constant.
- Average contaminant velocity.

Because some of these parameters are not well known, the model may be run repeatedly as necessary to simulate a variety of conditions.

The model can also be run “backwards.” That is, the contaminant configuration today can be used with estimated historical conditions as input to the model, and the model can be run for different periods of time representing the time periods when groundwater flow was to the south, north, and east. These results may help verify potential source area for contamination.

A.2.4.4 Reporting

Regular annual progress reports are required for RCRA sites that are in assessment. As required by 40 CFR 265.94(b)(2) [by reference of WAC 173-303-400(3)], the results of the groundwater quality assessment program must be submitted to the regulator (Ecology) no later than March 1 following each calendar year. Also, as part of the groundwater project, it is anticipated that quarterly status reports will be submitted to DOE and Ecology. Borehole completion packages must also be prepared for each new monitoring well installed to document compliance with WAC 173-160.

A.4 References

10 CFR 830, Subpart A, "General Provisions/Quality Assurance Requirements." *Code of Federal Regulations.*

40 CFR 265, Code of Federal Regulations, Title 40, Part 265. "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." *Code of Federal Regulations.*

Atomic Energy Act, as amended, Ch. 1073, 68 Stat. 919,42 USA 2011 et seq.

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Appendix B

Supporting Information

Appendix B

Supporting Information

This section contains supporting geologic and groundwater monitoring information. This appendix includes the following information:

- Data about wells used to interpret the geology and hydrology.
- Geologic data used to interpret the geology and hydrology.
- As-built diagrams for wells in the WMA TX-TY monitoring network.

Table B.1. Wells and Data Sources Used in This Report

Well Name	Sample Method[a]	Easting (m)	Northing (m)	Surface Elevation (m)	Vertical Datum	Total Depth (m)	Completion Date	Data Sources
299-W10-17	DB 0-42; HT 42-68	566775	136491	204.60	NGVD29	67.9	1990	Geologist's log; CaCO3, soil moisture, gamma log
299-W10-18	DB 0-34; HT 34-68	566847	136396	204.70	NGVD29	67.8	1990	Geologist's log; CaCO3, soil moisture, gamma log
299-W10-26[b]	**AR 0-80**	**566843**	**136401**	**204.63**	**NAVD88**	**79.8**	**1998**	**Geologist's log, gamma log**
299-W10-27	**DB 0-15; SS 15-40; HT 40-82**	**566844**	**136442**	**204.90**	**NAVD88**	**81.9**	**2001**	**Geologist's log, gamma log, neutron log**
299-W14-2	HT 0-68	566945	136340	203.12	As built	68.0	1955	Driller's log; gamma log
299-W14-5	DB 0-26; HT 26-73	566900	136007	202.36	As built	73.2	1974	Driller's log
299-W14-6	**HT 0-9 and 32-73; DB 9-32**	**566900**	**136101**	**202.66**	**As built**	**73.2**	**1974**	**Driller's log**
299-W14-11	**Becker 0-106**	**566902**	**136287**	**203.00**	**GPS**	**106.1**	**2005**	**Geologist's log; gamma log**
299-W14-12	DB 0-31; HT 31-68	566906	136284	203.33	NGVD29	67.8	1991	Geologist's log, gamma log; CaCO3; soil moisture
299-W14-13	**AR 0-80**	**566902**	**136282**	**204.35**	**NAVD88**	**79.9**	**1998**	**Geologist's log; gamma log**
299-W14-14	**CT 0-6 AR 6-135**	**566898**	**136181**	**204.62**	**NAVD88**	**135.0**	**1998**	**Geologist's log; gamma log; neutron log**
299-W14-15	**CT 0-7; AR 7-79**	**566900**	**136231**	**204.58**	**NAVD88**	**79.3**	**2000**	**Geologist's log**
299-W14-16	**AR 0-81**	**567001**	**136318**	**205.37**	**NAVD88**	**80.8**	**2000**	**Geologist's log; gamma log; neutron log**
299-W14-17	**DB 0-6; AR 6-81**	**567007**	**136218**	**205.08**	**NAVD88**	**80.9**	**1000**	**Geologist's log, gamma log; neutron log**
299-W14-18	**DB 0-80**	**566897**	**136344**	**204.26**	**NAVD88**	**79.7**	**2000**	**Geologist's log; gamma log; neutron log**

Table B.1. (contd)

Well Name	Sample Method[a]	Easting (m)	Northing (m)	Surface Elevation (m)	Vertical Datum	Total Depth (m)	Completion Date	Data Sources
299-W14-19	**Becker 0-105**	**566899**	**136135**	**204.90**	**NAVD88**	**104.9**	**2002**	**Geologist's log, gamma log**
299-W15-4	HT 0-66	566820	136019	201.14	As built	66.1	1956	Driller's log; gamma log
299-W15-12	HT 0-69	566699	136369	203.42	As built	68.6	1973	Driller's log
299-W15-22	DB 0-42, HT 42-68	566683	136111	203.52	As built	67.6	1991	Geologist's log; gamma log; CaCO3; soil moisture
299-W15-40	**AR 0-80**	**566653**	**136205**	**205.06**	**NAVD88**	**79.8**	**1998**	**Geologist's log; gamma log**
299-W15-41	**AR 0-73**	**566757**	**136031**	**202.79**	**NAVD88**	**72.9**	**1999**	**Geologist's log; gamma log**
299-W15-44	**Becker 0-104**	**566685**	**136066**	**204.17**	**NAVD88**	**104.2**	**2002**	**Geologist's log; gamma log**
290-W15-763	**Becker 0-78**	**566809**	**136029**	**202.18**	**NAVD88**	**78.5**	**2001**	**Geologist's log**
299-W15-765	**DB 0-47; HT 47-81**	**566697**	**136373**	**204.51**	**NAVD88**	**81.4**	**2001**	**Geologist's log; gamma log; neutron log**

(a) Sample methods: CT = cable tool, DB = drive barrel, HT = hard tool, AR = air rotary, Becket = dual wall percussion.
(b) Bold indicates wells in the RCRA groundwater monitoring network.

Table B.2. Geologic Data for Waste Management Area TX-TY[a]

Well Name	Elevation (meters above mean sea level)							
	Elevation at Bottom[a]	Top of the Hanford formation Gravel Sequence	Top of the Hanford formation Sand Sequence	Top of the Cold Creek Fluvial Sequence	Top of the Cold Creek Caliche	Top of the Ringold Formation member of Taylor Flats	Top of the Ringold Formation Unit E	Top of the Ringold Formation Lower Mud Unit
299-W10-17	136.7	201	194	177	174	170	167	
299-W10-18	136.9	203	192	178	175	170	165	
299-W10-26	**125.769**	**204**	**192**	**178**	**175**	**171**	**169**	
299-W10-27	**122.999**	**202**	**192**	**178**	**175**	**171**	**168**	
299-W14-2	135.12	199	192	177	175	NP[b]	167	
299-W14-5	129.156	202	194	176	172	NP	166	
299-W14-6	**129.461**	**200**	**190**	**174**	**171**	**NP**	**167**	
299-W14-11	**96.927**	**198**	**192**	**175**	**173**	**168**	**165**	
299-W14-12	203258.2	202	193	175	172	NP	165	
299-W14-13	**124.4862**	**201**	**194**	**177**	**174**	**171**	**166**	
299-W14-14	**69.5913**	**203**	**195**	**176**	**173**	**171**	**167**	**82**
299-W14-15	**125.334**	**204**	**193**	**178**	**173**	**169**	**167**	
299-W14-16	**124.598**	**203**	**196**	**179**	**175**	**173**	**167**	
299-W14-17	**124.159**	**202**	**195**	**178**	**174**	**173**	**168**	
299-W14-18	**124.563**	**200**	**194**	**177**	**175**	**171**	**168**	
299-W14-19	**99.959**	**202**	**194**	**177**	**175**	**167**	**166**	
299-W15-4	135.038	201	187	173	169	NP	164	
299-W15-12	134.823	203	190	176	172	NP	167	
299-W15-22	135.918	204	189	172	170	167	165	
299-W15-40	**125.2801**	**203**	**185**	**175**	**172**	**167**	**165**	
299-W15-41	**129.938**	**201**	**186**	**174**	**171**	**169**	**166**	
299-W15-44	**99.928**	**204**	**194**	**174**	**171**	**NP**	**166**	
290-W15-763	**123.655**	**200**	**190**	**174**	**171**	**NP**	**167**	
299-W15-765	**123.125**	**204**	**192**	**176**	**173**	**171**	**166**	

(a) Elevation at total drilled depth.
(b) NP = not present.
Bold indicates wells in the groundwater monitoring network.

WELL CONSTRUCTION AND COMPLETION SUMMARY

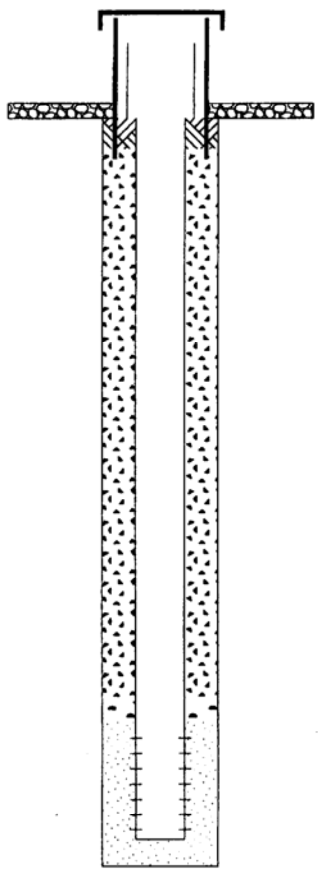
Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W10-26 B8548 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Reverse Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Willie Franklin	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Start Card #:	Not Available
Date Started:	20Aug98	Date Completed:	25Aug98	Elevation Ground Surface:	Brass Marker

Depth to Water: 216.8 ft 25Aug98
(Ground surface)

Elevation of Reference Point: m
Height of Reference Point Above Ground Surface:
Depth of Surface Seal: 10.5 ft.
Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY — Geologist's Log & Geophysical Logs

0 - 4 ft : Backfill
4 - 9 ft : Sand
9 - 22 ft : Gravel
22 - 42.5 ft : Sandy gravel
42.5 - 64 ft : Sand
64 - 89 ft : Gravelly sand
89 - 102 ft : Silty sand - calcareous (97-100: Caliche)
102 - 108 ft : Sand (108-110: caliche)
108 - 114 ft : Silty sand
114 - 116 ft : Sand
116 - 124 ft : Silty sand
124 - 127 ft : Sand
127 - 159 ft : Silty sandy gravel (152-156: large cobbles)
159 - 161 ft : Gravelly sand
161 - 205 ft : Sandy gravel
205 - 262 ft : Silty sandy gravel



Fill	Casing	Screen
0 - 10.5 ft : 9.125-inch hole Cement Seal		
10.5 - 204.5 ft : 9.125-inch hole Bentonite Chips		
204.5 - 211 ft : 9.125-inch hole Bentonite Pellets	217.04 - 0 ft : 4 inch 4" SS Sch. 5 Csg.	217.04 - 252.13 ft : 4 inch 4" Wire Wrap SS .010 Slot Screen
211 - 217.04 ft : 9.125-inch hole 20-40 Silica Sand		
217.04 - 252.13 ft : 9.125-inch hole 20-40 Silica Sand	252.13 - 252.45 ft : 4 inch 4" SS End Cap	
252.13 - 262 ft : 9.125-inch hole 20-40 Silica Sand		

262 ft : Borehole drilled depth

0 - 262 ft : 9.125-in. 8-5/8" Temp. carbon steel csg.

Drawing By: TGB
Reference: Hanford Wells
Revision: 0
Revision Date: 21Sep98
Print Date: 28Dec98

Report Form: WELLS Project File: WELLS.GPJ

BECHTEL

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W10-26

WELL DESIGNATION	:	299-W10-26
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	262.0 ft
MEASURED DEPTH (GS)	:	
AVAILABLE LOGS	:	Data not available
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	Data not available
CURRENT USER	:	RCRA & Operations
PUMP TYPE	:	Data not available
MAINTENANCE	:	Data not available
COMMENTS	:	8-5/8" TUBEX Sys. 4-1/2" Reverse Cir. Drl. Pipe with interchange
TV SCAN COMMENTS	:	

Drawing By: TGB
Reference: Hanford Wells
Revision: 0
Revision Date: 21Sep98
Print Date: 28Dec98

Report Form: WELLS Project File: WELLS.GPJ

0532883

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	**Cable Tool**	Sample Method:	**Grab/Split Spoon**	WELL NUMBER:	**299-W10-27 C3125** TEMPORARY WELL NO: **Not Allowed**
Drilling Fluid Used:	**none**	Additives Used:	**water**	Coordinates: N	**Not documented**
Driller's Name:	**M. Wraspir**	WA State Lic Nr:	**1909**	Coordinates: E	**Not documented**
Drilling Company:	**RSI**	Company Location:	**Woodland, Ca.**	Start Card #:	**Not Available**
Date Started:	**22Jan01**	Date Completed:	**23Mar01**	Elevation Ground Surface:	

Depth to Water: **220.63 ft ft 23Mar01**
(Ground surface)

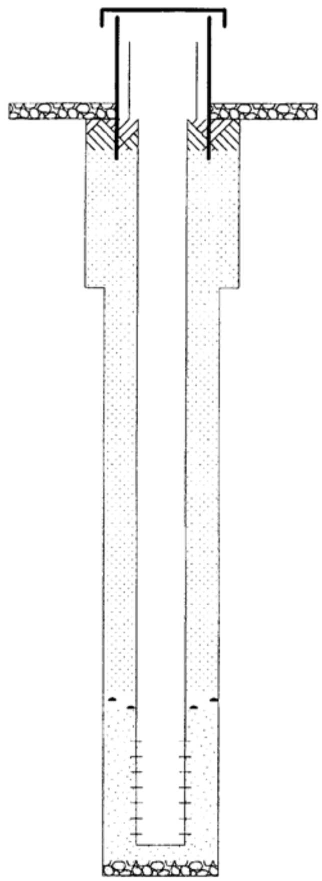
GENERALIZED STRATIGRAPHY **Geologist's Log**

Elevation of Reference Point: **m**

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.9 ft**

Type of Surface Seal: **4x4 Concrete Pad**



0 - 1 ft : Construction gravel
1 - 4.5 ft : Silty SAND (mS)
4.5 - 8.5 ft : SAND (S)
8.5 - 24 ft : Sandy GRAVEL (sG)
24 - 38 ft : Silty Sandy GRAVEL (msG)
38 - 41.5 ft : Sandy GRAVEL (sG)
41.5 - 89 ft : SAND (S)
89 - 98.2 ft : Silt (M) Plio Pleistene top
98.2 - 102 ft : Caliche in Silty SAND (mS)
102 - 108 ft : Silty SAND (mS)
108 - 112 ft : Caliche in SAND(s)
112 - 117.5 ft : SAND (S)
117.5 - 120.5 ft : SILT (M(
120.5 - 124.5 ft : SAND (S)
124.5 - 220 ft : Silty Sandy GRAVEL (msG)- Ringold E top
220 - 225 ft : Slightly Silty Gravelly SAND
225 - 268.7 ft : Silty Sandy Gravel (msg)

Fill	*Casing*	*Screen*
0 - 10.9 ft : 12-inch hole Cement Surface Seal	0 - 256 ft : 4 inch 4" 304 SS sch 5 csg.	
10.9 - 60 ft : 12-inch hole Grannular Bentonite		
60 - 204.6 ft : 9-inch hole Grannular Bentonite		
204.6 - 210 ft : 9-inch hole 1/4" Bentonite Pellets		221 - 256 ft : 4 inch 4" 304 SS .020 Slot wirewrap scrn
210 - 257.76 ft : 9-inch hole 10/20 Silica Sand		
257.76 - 268.7 ft : 9-inch hole 10/20 Silica Sand	256 - 257.86 ft : 4 inch 4" 304L SS Sump	
263.3 - 268.7 ft : 9-inch hole Slough		

268.7 ft : Borehole drilled depth

0 - 60 ft : 12-in. 11-3/4" CS Temp. csg set w/cable tool
60 - 268.7 ft : 9-in. 8-5/8" CS Temp. csg set w/ cable tool

Drawing By:	**JEA**
Reference:	**Hanford Wells**
Revision:	**0**
Revision Date:	**16Apr01**
Print Date:	**16Apr01**

BECHTEL

Report Form: WELLS Project File: WELLS.GPJ

WELL CONSTRUCTION AND COMPLETION SUMMARY AS-BUILT

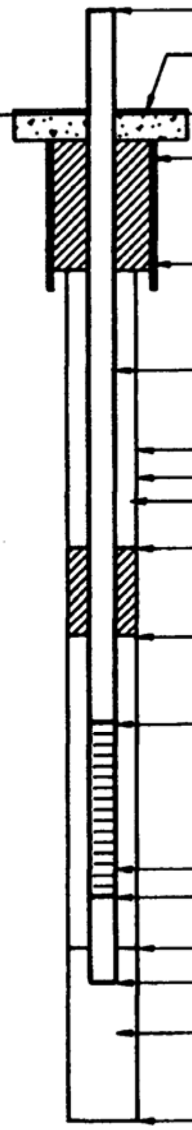
- Drilling Method: Cable Tool
- Sample Method:
- Drilling Fluid Used: Water
- Additives Used:
- Driller's Name: Evans
- WA State Lic. No.:
- Drilling Company: INF
- Company Location:
- Date Started: 12/11/73
- Date Complete: 12/4/74
- WELL NUMBER: 299-W14-6
- TEMPORARY WELL NO.:
- Hanford Coordinates: N/S N41360 E/W W75440
- State Coordinates: N E
- Start Card #: T R S
- Elevation Ground Surface (ft): INF

Depth to water: 205.0

Data source: Driller's Log

GENERALIZED STRATIGRAPHY

- 0–12: SAND
- 12–15: SAND & GRAVEL
- 15–29: COBBLES, SAND & GRAVEL
- 29–40: SAND, PEBBLES & SILT
- 40–47: SAND & SILT
- 47–49: SILT
- 49–95: SAND & SILT
- 95–103: SILT
- 103–116: CALICHE & SAND
- 116–240: COBBLES, PEBBLES, SAND & SILT



- Elevation of casing: INF
- Elevation of reference point: INF
- Concrete pad dimensions: INF
- Depth of surface seal: INF
- Type of surface seal: INF
- I.D. of surface casing (if present): INF
- Type of surface casing: INF
- Depth of surface casing: INF
- I.D. of riser pipe: 6-in.
- Type of riser pipe: INF
- Diameter of borehole: 6-in.
- Diameter of perforated borehole casing: 6-in.
- Type of filler: INF
- Elevation/depth of top of seal: INF
- Type of seal: INF
- Elevation/depth of top of gravel pack: N/A
- Type of gravel pack: N/A
- Elevation/depth of top of screen perforation: 195.0
- Description of screen/perforation: 4 cuts/round/ft.
- I.D. of screen section: N/A
- Elevation/depth of bottom of screen/perforation: 225.0
- Elevation/depth of bottom of gravel pack: N/A
- Elevation/depth of bottom of plugged blank section: N/A
- Type of filler below plugged section: INF
- Elevation/depth of bottom of borehole: 240.0
- Elevation/depth of remediated borehole: N/A

NOTES: N/A: Not Applicable
INF: Insufficient Data

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WELL SUMMARY SHEET

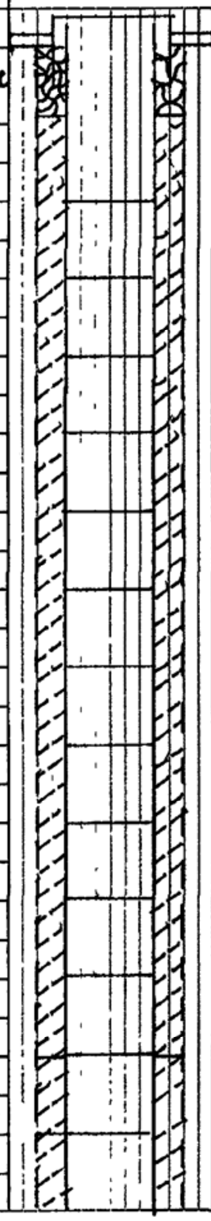
Start Date 4/14/05
Finish Date 5/11/05
Page 1 of 3

Well ID C4668	Well Name 299-W14-11
Location East of TX/TY tank farm	Project FY05 Monitoring Wells
Prepared By Jeffrey Weiss — Date 5/11/05	Reviewed By L.D. Walker — Date 5/17/05
Signature Jeffrey Weiss	Signature [signature]

CONSTRUCTION DATA

Description
6" stainless steel protective casing set 0.96' above 4" casing
6" cement pad at ground surface
Portland Cement Ground surface → 9.6'
Granular bentonite 9.6 → 222
4" ID 304 sch 5 Stainless Steel +1.85 → 261.78

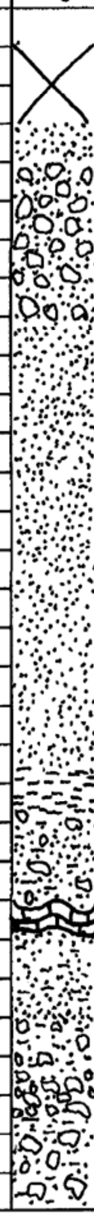
Diagram:



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 25, 50, 75, 100, 125

Graphic Log:



Lithologic Description
0-10' No Recovery
10'-15' SAND
15'-36' SANDY GRAVEL
36'-93' SAND
93'-97' SILT
97'-110' GRAVELY SILTY SAND
110'-114' Caliche
114'-115' SAND
115'-124' SILTY SAND
124'-126' SAND
126'-133' SILTY SANDY GRAVEL
133'-137' GRAVEL
137'-162' SILTY SANDY GRAVEL

A-6003-643 (03/03)

WELL SUMMARY SHEET

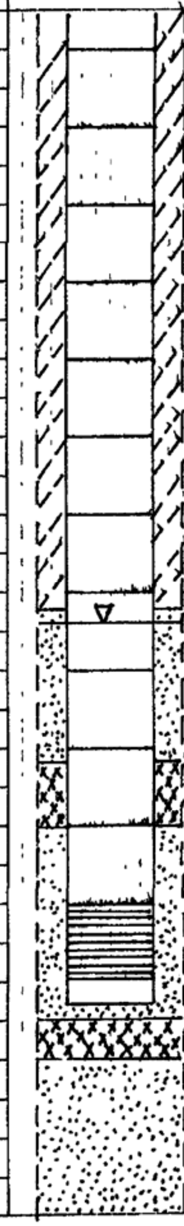
Start Date 4/14/05
Finish Date 5/11/05

Well ID C4668	Well Name 299-W14-11
Location East of TX/TY tank farm	Project FY05 Monitoring Wells
Prepared By Jeffrey Weiss Date 5/11/05	Reviewed By L.D. Walker Date 5/17/05
Signature Jeffrey Weiss	Signature [signature]

CONSTRUCTION DATA

Description
10-20 mesh Colorado Silica Sand 222'→242.5'
1/4 coated bentonite pellets 242.5'→251.6'
10-20 mesh Colorado Silica Sand 251.6→275.08
4"ID 304 sch 5 stainless steel screen 261.7→271.7
4"ID 304 sch5 stainless steel sump 271.7→273.7
1/4" coated bentonite pellets 275.08→280.75

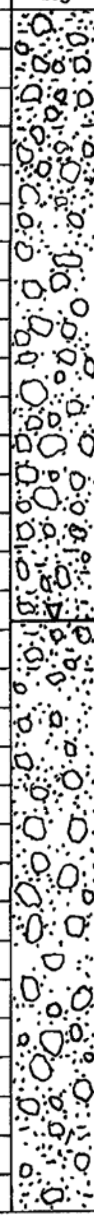
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 150, 175, 200, 225, 250, 275

Graphic Log



Lithologic Description
162'-170' SANDY GRAVEL
170'-175' GRAVELY SAND
175'-214' SANDY GRAVEL
214'-232' SILTY SANDY GRAVEL
Depth to Water 224.0 ft bgs
232'-241' GRAVELY SAND
241'-289' SANDY GRAVEL
289'-296' SLIGHTLY SILTY GRAVELY SAND

A-6003-643 (03/03)

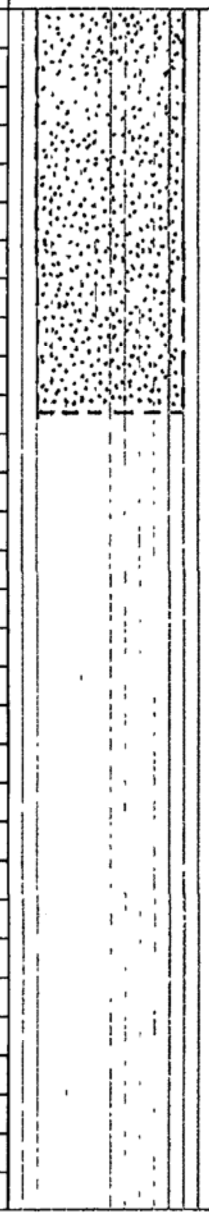
WELL SUMMARY SHEET	Start Date 4/14/05 Finish Date 5/11/05	Page 3 of 3

Well ID C4668		Well Name 299-W14-11	
Location East of TX/TY tank farm		Project FY05 Monitoring Wells	
Prepared By Jeffrey Weiss	Date 5/11/05	Reviewed By L.D. Walker	Date 5/17/05
Signature Jeffrey Weiss		Signature LD Walker	

CONSTRUCTION DATA

Description
Borehole backfilled with 10-20 mesh Colorado Silica Sand 280.75→316.8
8-12 mesh Colorado Silica Sand 316.8→348
9"/6" dual wall casing advanced to 348 ft bgs using Becker Hammer drill methods
All temporary casing removed from the ground during well construction
Measurements are in feet below ground surface

Diagram:



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Lithologic Description
300	296'-331' SANDY GRAVEL
325	
	331'-334' GRAVELY SAND
	334'-348' SANDY GRAVEL
	Total depth drilled 348 ft bgs
350	
375	
400	
425	

A-6003-643 (03/03)

0502372

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-13 B8549 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Reverse Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Willie Franklin	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Start Card #:	Not Available
Date Started:	26Aug98	Date Completed:	31Aug98	Elevation Ground Surface:	Brass Marker

Depth to Water: 215.8 ft 31Aug98
(Ground surface)

GENERALIZED STRATIGRAPHY — Geologist's Log & Geophysical Logs

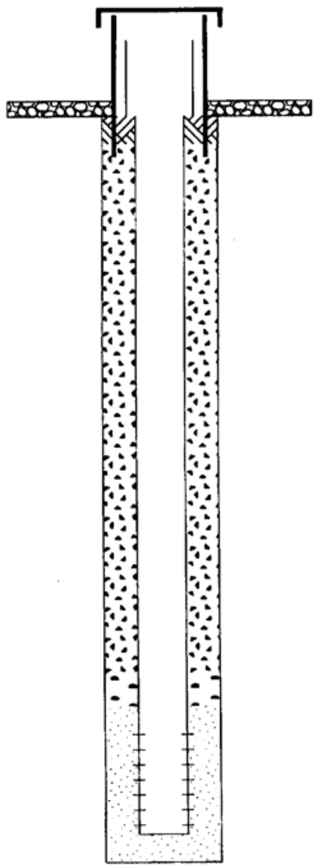
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 9.6 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 4 ft : Construction fill
4 - 14 ft : Sand
14 - 33 ft : Sandy gravel
33 - 95 ft : Sand
95 - 98 ft : Sand, sl calcareous
98 - 101 ft : Caliche
101 - 112 ft : Sandy gravel sl calcareous
112 - 125 ft : Sand
125 - 163 ft : Silty sandy gravel
163 - 210 ft : Sandy gravel
210 - 262 ft : Sandy gravel



Fill	*Casing*	*Screen*
0 - 9.6 ft : 9.125-inch hole Cement Seal	0 - 216.62 ft : 4 inch 4" SS Sch. 5 Csg.	
9.6 - 195.1 ft : 9.125-inch hole Bentonite Chips		
195.1 - 206.4 ft : 9.125-inch hole Bentonite Pellets		216.62 - 251.73 ft : 4 inch 4" Wire Wrap SS .010 Slot Screen
206.4 - 252.05 ft : 9.125-inch hole 20-40 Silica Sand		
252.05 - 262 ft : 9.125-inch hole 20-40 Silica Sand	251.73 - 252.05 ft : 4 inch 4" SS End Cap	

262 ft : Borehole drilled depth

0 - 262 ft : 9.125-in. 8-5/8" CS Temp. Csg.

Drawing By: TGB
Reference: Hanford Wells
Revision: 0
Revision Date: 21Sep98
Print Date: 28Dec98

BECHTEL

Report Form: WELLS Project File: WELLS.GPJ

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-13

WELL DESIGNATION	:	299-W14-13
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	262.0 ft
MEASURED DEPTH (GS)	:	
AVAILABLE LOGS	:	Data not available
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	Data not available
CURRENT USER	:	RCRA & Operations
PUMP TYPE	:	Data not available
MAINTENANCE	:	Data not available
COMMENTS	:	8-5/8" TUBEX Sys. 4-1/2" Reverse Cir. Drl. Pipe with Interchange
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	TGB
Reference:	Hanford Wells
Revision:	0
Revision Date:	21Sep98
Print Date:	28Dec98

BECHTEL

0502370

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-14 B8547 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Reverse Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Randy Smith	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Start Card #:	Not Available
Date Started:	08Oct98	Date Completed:	12Nov98	Elevation Ground Surface:	Brass Marker

Depth to Water: 216 ft 24Oct98
(Ground surface) 217.42 ft 14Nov98

GENERALIZED STRATIGRAPHY — Geologist's Log & Geophysical Logs

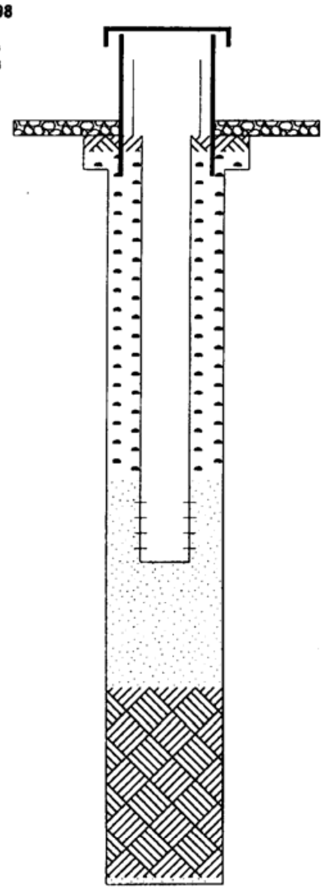
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 9.3 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 4.5 ft : Backfill - Sand and gravel
4.5 - 7 ft : Silty Gravelly SAND
7 - 14.5 ft : Silty SAND
14.5 - 16.5 ft : Silty Sandy GRAVEL
16.5 - 33 ft : Sandy GRAVEL
33 - 86.5 ft : SAND
86.5 - 93.5 ft : SAND (trace of caliche @ 86')
93.5 - 123 ft : Silty SAND (Caliche 108 to 110')
123 - 145 ft : Sandy GRAVEL
145 - 209 ft : Sandy GRAVEL
209 - 217 ft : Gravelly SAND
217 - 360 ft : Silty Sandy GRAVEL
360 - 402 ft : Sandy GRAVEL
402 - 412 ft : Silty CLAY
412 - 415.5 ft : SILT
415.5 - 424 ft : SILT (trace of gravel)
424 - 428 ft : GRAVEL
428 - 438 ft : SILT
438 - 443 ft : Sandy GRAVEL



Fill	Casing	Screen
0 - 9.3 ft : 13-inch hole Cement Seal	0 - 216.98 ft : 9.125 inch 4" SS Sch. 5 Csg.	
9.3 - 20 ft : 13-inch hole Medium Bentonite Chunks		
20 - 202.3 ft : 9.125-inch hole Medium Bentonite Chunks		
202.3 - 203.8 ft : 9.125-inch hole 3/8 Bentonite Pellets		216.98 - 252 ft : 4 inch 4" SS Wire Wrap Screen - .010 Slot
203.8 - 252.3 ft : 9.125-inch hole 20-40 Silica Sand	252 - 252.3 ft : 9.125 inch 4" SS End Cap	
252.3 - 257.3 ft : 9.125-inch hole 20-40 Silica Sand		
257.3 - 326.6 ft : 9.125-inch hole 4-10, 6-9, 8-12, 8-16 & 10-20 Silica Sand		
326.6 - 438.8 ft : 9.125-inch hole Cement Grout		
438.8 - 443 ft : 9.125-inch hole 8-16 & 10-20 Silica Sand		

443 ft : Borehole drilled depth

0 - 20 ft : 13-in. 12-3/4" Temp. Csg. set w/Cable Tool
20 - 443 ft : 9.125-in. 8-5/8" Temp. Csg. Set w/Tubex air rotary-rev. air 4-1/2" Drl. Pipe

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 16Oct98
Print Date: 28Dec98

BECHTEL

Report Form: WELLS Project File: WELLS.GPJ

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-14

WELL DESIGNATION	:	299-W14-14
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	443.0 ft
MEASURED DEPTH (GS)	:	252.30 06Nov98
AVAILABLE LOGS	:	Geologist & Geophysical Logs
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	RCRA Monitoring
CURRENT USER	:	RCRA & Operations
PUMP TYPE	:	Hydrostar
MAINTENANCE	:	Data not available
COMMENTS	:	12" Temp. Csg. to 20 ft.- Cable Tool. 20 ft. to 443 ft. 8-5/8" Temp. Csg.- Tubex Rev. Air w/4-1/2" D.P.
TV SCAN COMMENTS	:	

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 16Oct98
Print Date: 28Dec98

BECHTEL

Report Form: WELLS Project File: WELLS.GPJ

0526574

WELL SUMMARY SHEET

Page 1 of 2
Date: 9-11-00

Well ID: C3114	Well Name: 299-W14-15
Location: 25m E. of 241-TX Tank Farm/200W	Project: CY 2000 RCRA Drilling
Prepared By: L.D. Walker — Date: 9-11-00	Reviewed By: DC Weekes — Date: 9/14/00
Signature: [signature]	Signature: [signature]

CONSTRUCTION DATA

Description

6"-dia Protective casing 1.0' above the 4" casing

4.5"OD/4"ID Well Casing SS type 304 +2.6' → 219.75'

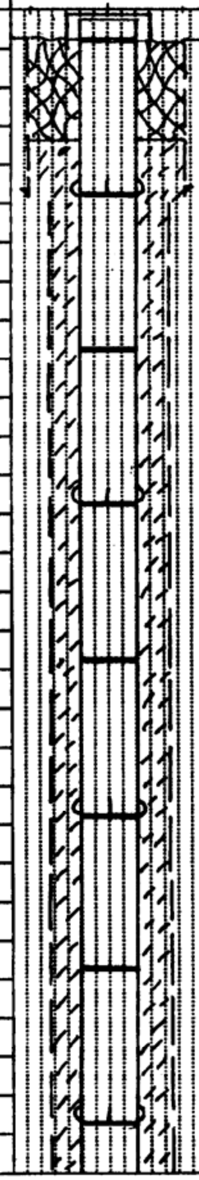
Portland Cement Grout 0' → 13.5'

Granular Bentonite 13.5' → 199.3'

Temporary Casing
11¾" / 10¼" set at 20.7'
8⅝" / 7⅝" to TD

All depths in Feet below ground surface
All temp. casing removed from ground.

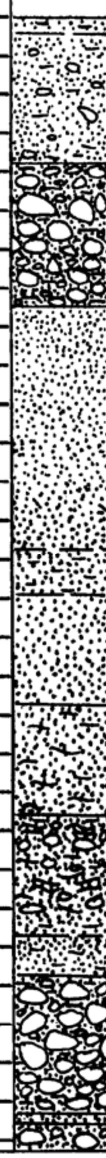
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 25, 50, 75, 100, 125

Graphic Log



Lithologic Description

0 → 2': Silty SAND

2' → 19': Gravelly Silty SAND

19' → 37': Silty Sandy GRAVEL

37' → 68': SAND

68' → 74': Silty SAND

74' → 88': SAND

88' → 103': Silty SAND

103' → 118': Slightly Silty Gravelly SAND
caliche frags at 103', 112'

118' → 123': Slightly Silty SAND

123' → 142': Silty Sandy GRAVEL

142' → 143': SAND

BHI-EE-189 (12/97)

WELL SUMMARY SHEET

Page 2 of 2
Date: 9-11-00

Well ID: C 3114	Well Name: 299-W14-15
Location: 25 m. East of 241-TX Tank Farm	Project: CY 2000 RCRA Drilling
Prepared By: L.D. Walker — Date: 9-11-00	Reviewed By: DC Weekes — Date: 9/14/00
Signature: [signature]	Signature: [signature]

CONSTRUCTION DATA

Description

Bentonite Pellets
199.3' → 209.9'

Silica Sand, 10-20 mesh
209.9' → 260.0'

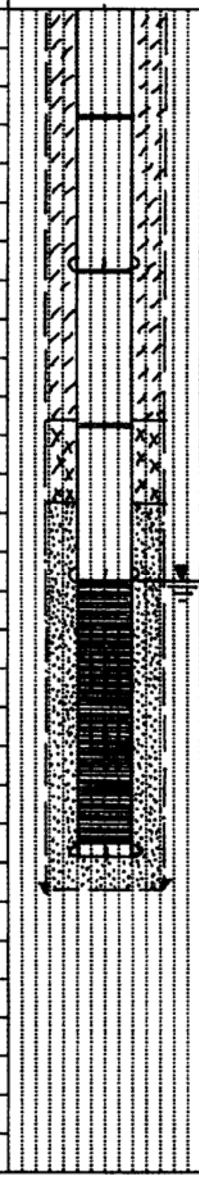
Well Screen, 4" ID, 0.020-in slot continuous wire-wrap, SS type 304
219.75' → 254.62'

Sump, 4" ID SS type 304,
254.62' → 256.7'

Total SS 4" ID material is 259.30' (+2.6' → 256.7')

All depths in feet below ground surface
All temp. casing removed from ground.

Diagram

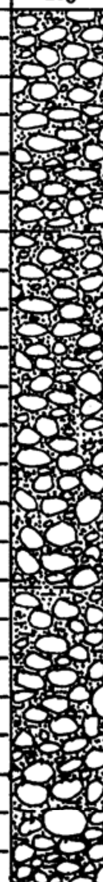


Depth in Feet

150, 175, 200, 225, 250, 275

GEOLOGIC/HYDROLOGIC DATA

Graphic Log



Lithologic Description

143' → 175': Sandy GRAVEL

175' → 221': Sandy GRAVEL

221' → 260': Silty Sandy GRAVEL

TD = 260.0'

W.L. = 219.80' bgs (9-5-00)

BHI-EE-189 (12/97)

0532873

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Drill and Drive Air Rotary	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-16 C3120
Drilling Fluid Used:	Air	Additives Used:	None	TEMPORARY WELL NO:	Not Allowed
Driller's Name:	K.Cowen	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	25Oct00	Date Completed:	08Nov00	Start Card #:	Data not available
				Elevation Ground Surface:	

Depth to Water: **222.55 ft. ft 08Nov00**
(Ground surface)

Elevation of Reference Point: m

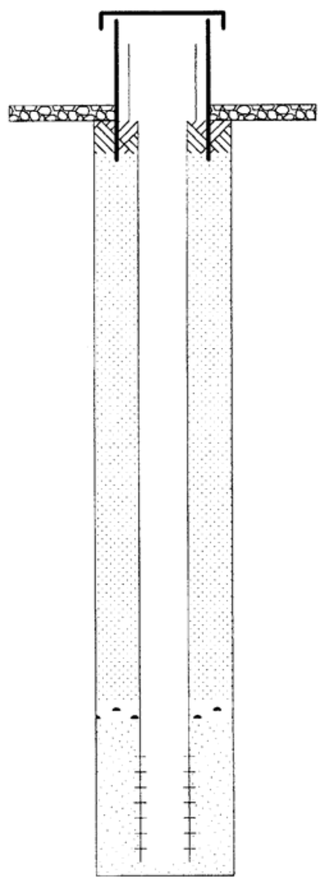
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **11.3 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 1.5 ft : Sandy GRAVEL
1.5 - 8 ft : Slightly Silty SAND
8 - 13.5 ft : SAND
13.5 - 34 ft : Silty Sandy GRAVEL
34 - 89 ft : SAND
89 - 99 ft : Sandy SILT
99 - 113 ft : Silty Sandy GRAVEL w/caliche
113 - 124 ft : Silty SAND
124 - 179 ft : Silty Sandy GRAVEL
179 - 184 ft : Gravelly SAND
184 - 265 ft : Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 11.3 ft : 10.75-inch hole Cement surface seal	0 - 222.94 ft : 4 inch 4" 304L SS	
11.3 - 204.5 ft : 10.75-inch hole Granular Bentonite		
204.5 - 210.4 ft : 10.75-inch hole 1/4" Bentonite pellets		222.94 - 257.88 ft : 4 inch 4" SS Wire Wrap .020 Slot Scrn.
210.4 - 260.06 ft : 10.75-inch hole 10/20 Silica Sand		
260.06 - 265 ft : 10.75-inch hole 10/20 Silica Sand	257.88 - 260.06 ft : 4 inch 4" SS Sump	

265 ft : Borehole drilled depth

0 - 265 ft : 10.75-in. 10-3/4" CS Temp. csg set A.R. Drl. & Drive

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **19Mar01**
Print Date: **19Mar01**

BECHTEL

0532872

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Drill and Drive Air Rotary	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-17 C3121 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	K. Cowden	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Start Card #:	Not Available
Date Started:	10Oct00	Date Completed:	24Oct00	Elevation Ground Surface:	

Depth to Water: **221.69 ft 24Oct00**
(Ground surface)

Elevation of Reference Point: m

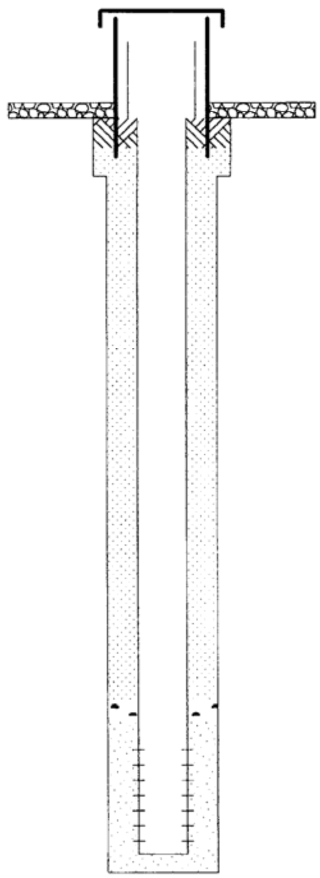
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.6 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 2.5 ft : Sandy GRAVEL
2.5 - 12.5 ft : Slightly Silty SAND
12.5 - 25 ft : Silty Sandy GRAVEL
25 - 34 ft : Gravelly SAND
34 - 48 ft : SAND
48 - 52 ft : Slightly Silty SAND
52 - 93 ft : SAND
93 - 98 ft : Silty SAND
98 - 109 ft : Gravelly Silty SAND
109 - 113 ft : Silty Sandy GRAVEL
113 - 122 ft : SAND
122 - 153 ft : Silty Sandy GRAVEL
153 - 159 ft : Sandy GRAVEL
159 - 168 ft : Silty Sandy GRAVEL
168 - 193 ft : Sandy GRAVEL
193 - 197 ft : Gravelly SAND
197 - 265.5 ft : Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 10.6 ft : 10.75-inch hole Cement Surface Seal	0 - 221.94 ft : 4 inch 4" 304L SS	
10.6 - 20.6 ft : 10.75-inch hole Granular Bentonite		
20.6 - 204.7 ft : 8.625-inch hole Granular Bentonite		
204.7 - 211.9 ft : 8.625-inch hole 3/8" Bentonite pellets		221.94 - 256.96 ft : 4 inch 4" 304 SS Wire Wrap .020 slot scrn.
211.9 - 259.01 ft : 8.625-inch hole 10/20 Silica Sand		
259.01 - 265.5 ft : 8.625-inch hole 10/20 Silica Sand	256.96 - 259.01 ft : 4 inch 4" SS Sump	

265.5 ft : Borehole drilled depth

0 - 20.6 ft : 11.75-in. 11-3/4" CS Temp. csg. set w/Cable Tool
20.6 - 265.5 ft : 8.625-in. 8-5/8" CS Temp. csg. set A.R. Drl & Drive

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **19Mar01**
Print Date: **19Mar01**

BECHTEL

Report Form: WELLS Project File: WELLS.GPJ

0540441

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-18 C3396 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	None	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	M. Waspir	WA State Lic Nr:	1909	Coordinates: E	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Start Card #:	R037816
Date Started:	30Aug01	Date Completed:	01Nov01	Elevation Ground Surface:	

Depth to Water: 220.45 ft 07Nov01
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

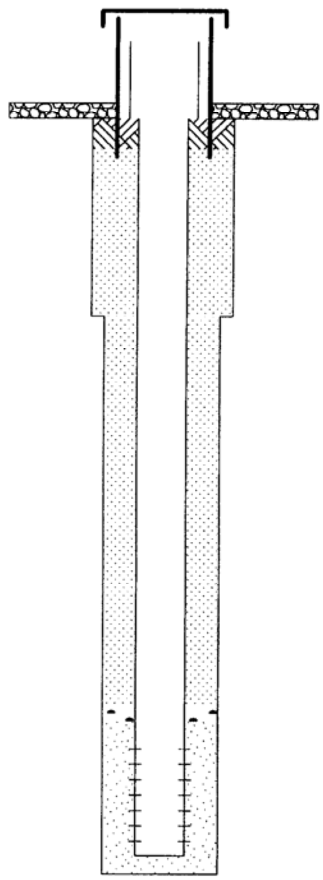
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.5 ft

Type of Surface Seal: 4x4 Concrete Pad

0 - 0.5 ft : Drill Pad Material
0.5 - 8 ft : Silty Sand
8 - 13 ft : Sand
13 - 34 ft : Sandy Gravel
34 - 88.5 ft : Sand
88.5 - 114 ft : Sandy Silt
114 - 120 ft : Silty Sand
120 - 125 ft : Sandy Silt
125 - 145 ft : Gravelly Silt
145 - 155 ft : Silty Gravel
155 - 160 ft : Gravelly Silt
160 - 165 ft : Silty Gravel
165 - 190 ft : Gravelly Silt
190 - 200 ft : Sandy Silt
200 - 205 ft : Gravelly Sandy Silt
205 - 210 ft : Silty Gravel
210 - 215 ft : Sandy Silt
215 - 220 ft : Gravelly Silt
220 - 235 ft : Gravelly Sandy Silt
235 - 240 ft : Gravelly Silt
240 - 261.5 ft : Gravelly Sandy Silt



Fill	Casing	Screen
0 - 10.5 ft : 11-inch hole Cement Surface Seal	0 - 218.06 ft : 4 inch 304L SS sch 5 csg	
10.5 - 68.6 ft : 11-inch hole Granular Bentonite		
68.6 - 203.3 ft : 9-inch hole Granular Bentonite		
203.3 - 208.4 ft : 9-inch hole 1/4" Bentonite Pellets		218.06 - 253.05 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
208.4 - 255.05 ft : 9-inch hole 10/20 Silica Sand		
255.05 - 261.5 ft : 9-inch hole 10/20 Silica Sand	253.05 - 255.05 ft : 4 inch 304L SS Sump	

261.5 ft : Borehole drilled depth

0 - 68.6 ft : 11-in. Cable Tool 10-3/4" CS Temp csg to 68.6 ft
68.6 - 261.5 ft : 9-in. Cable Tool 8-5/8" CS Temp csg to 261.5 ft

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 13Nov01
Print Date: 13Nov01

BECHTEL

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-18

WELL DESIGNATION	:	299-W14-18
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	261.5 ft
MEASURED DEPTH (GS)	:	255.05 07Nov01
AVAILABLE LOGS	:	Geologist & Geophysical
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	RCRA Monitoring
CURRENT USER	:	RCRA & Operations
PUMP TYPE	:	Not Documented
MAINTENANCE	:	Data not available
COMMENTS	:	Cable Tool 10-3/4" CS csg to 68.6 ft & 8-5/8" CS csg to 261.5 ft
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 13Nov01
Print Date: 13Nov01

BECHTEL

AS-BUILT WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Becker Hammer	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W14-19 C3957 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Paul Lodder	WA State Lic Nr:	1628	Coordinates: E	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Start Card #:	Not Available
Date Started:	24Oct02	Date Completed:	13Nov02	Elevation Ground Surface:	

Depth to Water: 223.55 ft ft 04Nov02
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

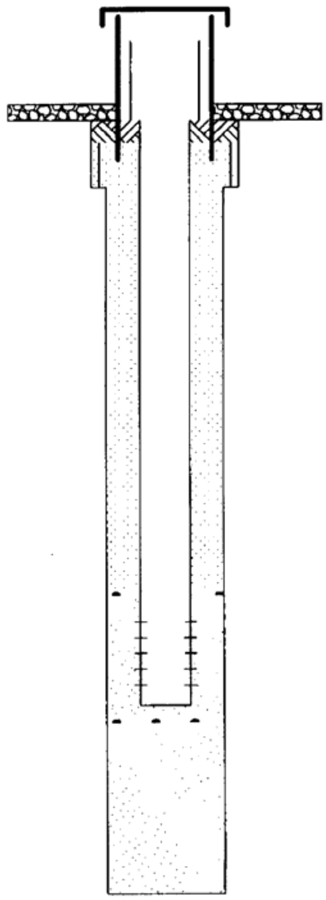
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 0 ft

Type of Surface Seal: 4x4 Concrete Pad

0 - 3 ft : Backfill
3 - 41 ft : silty SAND (mS)
41 - 50 ft : sandy GRAVEL (sG)
50 - 95 ft : SAND (S)
95 - 100 ft : silty SAND (mS)
100 - 109 ft : SILT (m)
109 - 115 ft : CALICHE
115 - 125 ft : silty SAND (mS)
125 - 130 ft : silty sandy GRAVEL (msG)
130 - 135 ft : sandy GRAVEL (sG)
135 - 145 ft : GRAVEL (G)
145 - 150 ft : silty sandy GRAVEL (msG)
150 - 175 ft : sandy GRAVEL (sG)
175 - 185 ft : silty sandy GRAVEL (msG)
185 - 190 ft : sandy GRAVEL (sG)
190 - 200 ft : silty sandy GRAVEL (msG)
200 - 205 ft : SAND (S)
205 - 220 ft : sandy GRAVEL (sG)
220 - 225 ft : silty sandy GRAVEL (msG)
225 - 285 ft : sandy GRAVEL (sG)
285 - 295 ft : silty sandy GRAVEL (msG)
295 - 344 ft : sandy GRAVEL (sG)



Fill

0 - 10 ft : 11.25-inch hole Cement surface seal
10 - 30 ft : 11.25-inch hole Granular Bentonite
30 - 208.3 ft : 9-inch hole Granular Bentonite
208.3 - 213.5 ft : 9-inch hole 1/4" Bentonite Pellets
213.5 - 260.5 ft : 9-inch hole 10/20 Silica sand
260.5 - 264.9 ft : 9-inch hole 10/20 Silica sand
264.9 - 269.5 ft : 9-inch hole 1/4" Bentonite Pellets
269.5 - 344.3 ft : 9-inch hole 4/8 Silica sand

Casing

0 - 223.5 ft : 4 inch
10 - 30 ft : 10.75 inch Left in hole
258.5 - 260.5 ft : 4 inch 304L SS csg and sump

Screen

223.5 - 258.5 ft : 4 inch

344.3 ft : Borehole drilled depth

0 - 30 ft : 11.5-in. Auger 10-3/4" Temp CS csg
30 - 344.3 ft : 9-in. Becker Hammer 9" x 7" Temp CS csg

Drawing By: JEA
Reference: Hanford Wells
Revision:
Revision Date: 16Dec02
Print Date: 16Dec02

Report Form: WELLS Project File: WELLS.GPJ

0502373

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon
Drilling Fluid Used:	Reverse Air	Additives Used:	None
Driller's Name:	Willie Franklin	WA State Lic Nr:	Not Available
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut
Date Started:	25Aug98	Date Completed:	10Sep98

WELL NUMBER: 299-W15-40 B8550 TEMPORARY WELL NO: Not Allowed

Coordinates: N Not documented

Coordinates: E Not documented

Start Card #: Not Available

Elevation Ground Surface: Brass Marker

Depth to Water: 218.08 ft 10Sep98
(Ground surface)

Elevation of Reference Point: m

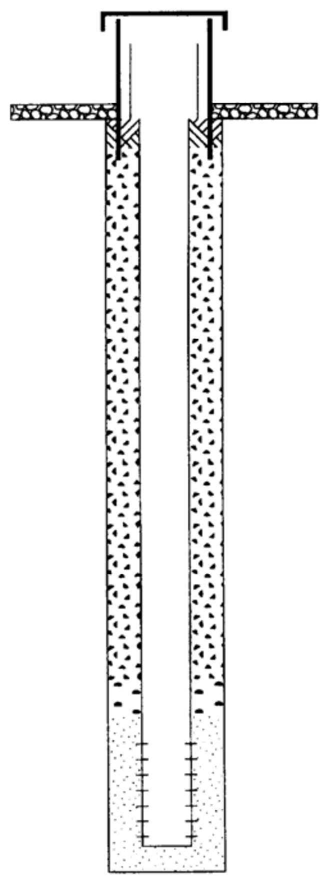
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.1 ft

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY — Geologist's Log & Geophysical Logs

0 - 1 ft : Backfill (silty sandy gravel)
1 - 2 ft : Sand
2 - 7 ft : Sand
7 - 67 ft : Sandy gravel
67 - 80 ft : Sand (vc-vf)
80 - 97 ft : Sand (m-vf)
97 - 98 ft : Sand
98 - 98.3 ft : Silty sandy gravel
98.3 - 101 ft : Slightly silty sand
101 - 107 ft : Silt
107 - 113.5 ft : Silty sand
113.5 - 118 ft : Gravelly sandy silt
118 - 125 ft : Silty gravelly sand
125 - 132 ft : Silty sand
132 - 167 ft : Silty sandy gravel
167 - 183 ft : Sandy gravel
183 - 187 ft : Silty sand
187 - 220 ft : Silty sandy gravel
220 - 262 ft : Sandy gravel



Fill	Casing	Screen
0 - 10.1 ft : 9.125-inch hole Cement Seal	0 - 217.95 ft : 4 inch 4" Sch. 5 SS Csg.	
10.1 - 195.4 ft : 9.125-inch hole Bentonite Chips		
195.4 - 208.3 ft : 9.125-inch hole Bentonite Pellets		217.95 - 253.08 ft : 4 inch 4" Wire Wrap SS Screen .010 Slot
253.4 - 208.3 ft : 9.125-inch hole 20-40 Silica Sand		
253.4 - 262.4 ft : 9.125-inch hole 20-40 Silica Sand	253.08 - 253.4 ft : 4 inch 4" SS End Cap	

262.4 ft : Borehole drilled depth

0 - 262.4 ft : 9.125-in. 8-5/8" CS Temp. Csg.

Drawing By: TGB
Reference: Hanford Wells
Revision: 0
Revision Date: 21Sep98
Print Date: 28Dec98

BECHTEL

Report Form: WELLS Project File: WELLS.GPJ

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W15-40

WELL DESIGNATION	:	299-W15-40
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	262.4 ft
MEASURED DEPTH (GS)	:	
AVAILABLE LOGS	:	Data not available
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	Data not available
CURRENT USER	:	Data not available
PUMP TYPE	:	Data not available
MAINTENANCE	:	Data not available
COMMENTS	:	
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	TGB
Reference:	Hanford Wells
Revision:	0
Revision Date:	21Sep98
Print Date:	28Dec98

BECHTEL

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool/Air Rotary	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W15-41 B8815 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	water as needed	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Wes Worth	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	Resonant Sonic Intl.	Company Location:	Woodland, Ca.	Start Card #:	R43396
Date Started:	30Nov99	Date Completed:	17Jan00	Elevation Ground Surface:	Brass Marker

0515334

Depth to Water: 213.3 ft. ft 17Jan00
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

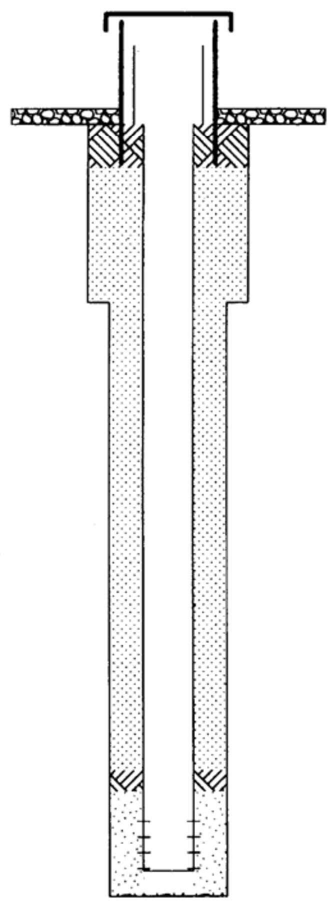
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 13.5 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 2 ft : Gravel drill pad
2 - 5 ft : Gravelly SAND
5 - 48 ft : Sandy GRAVEL
48 - 55 ft : Gravelly SAND
55 - 93 ft : SAND
93 - 104 ft : Silty SAND
104 - 112 ft : Calcareous Silty SAND
112 - 121 ft : Silty SAND
121 - 132 ft : Silty Sandy GRAVEL
139 - 147 ft : Gravelly SAND
147 - 180 ft : Sandy GRAVEL
180 - 199 ft : Silty Sandy GRAVEL
199 - 202 ft : Gravelly SAND
202 - 215 ft : Silty Sandy GRAVEL
215 - 227 ft : Sandy GRAVEL
227 - 239 ft : Silty Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 13.5 ft : 12.25-inch hole Cement Surface Seal	0 - 215.92 ft : 4 inch 4" 304 SS Sch. 5 well csg.	
13.5 - 55 ft : 12.25-inch hole Granular Bentonite		
55 - 200.1 ft : 9-inch hole Granular Bentonite		
200.1 - 206.6 ft : 9-inch hole Cement well seal		215.92 - 230.94 ft : 4 inch 4" 304 SS .010 Slot Wire Wrap Scrn.
206.6 - 238.1 ft : 9-inch hole 20/40 Silica Sand	230.94 - 231.29 ft : 4 inch 4" PVC End Cap	
238.1 - 239 ft : 9-inch hole Slough		

239 ft : Borehole drilled depth

0 - 55 ft : 12.25-in. Cable Tool 11-3/4" CS Temp. Csg. to 55 ft.
55 - 239 ft : 9-in. Air Rotary 8-5/8" CS Temp. Csg. to 239 ft.

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 07Mar00
Print Date: 06Mar00

BECHTEL

AS-BUILT WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Becker Hammer	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W15-44 C3956 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Air	Additives Used:	Not Documented	Coordinates: N	Not documented
Driller's Name:	Chris Dean	WA State Lic Nr:	2554	Coordinates: E	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Start Card #:	Not Documented
Date Started:	10Oct02	Date Completed:	23Oct02	Elevation Ground Surface:	

Depth to Water: 220.24 ft 17Oct02
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

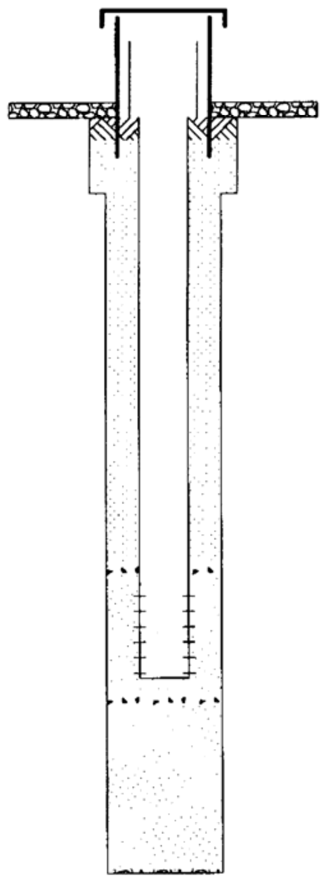
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.1 ft

Type of Surface Seal: 4x4 Concrete Pad

0 - 15 ft : No Returns
15 - 27 ft : gravelly Sand (gS)
27 - 28.5 ft : Gravel (G)
28.5 - 35 ft : sandy Gravel (sG)
35 - 50 ft : silty Sand (mS)
50 - 105 ft : Sand (S)
105 - 125 ft : silty Sand (mS) - trace of caliche 113-114 ft
125 - 126.5 ft : gravelly Sand (gS)
126.5 - 141 ft : sandy Gravel (sG)
141 - 143 ft : Sand (S)
143 - 150 ft : sandy Gravel (sG)
150 - 165 ft : silty sandy Gravel (msG)
165 - 180 ft : sandy Gravel (sG)
180 - 185 ft : silty sandy Gravel (msG)
185 - 205 ft : sandy Gravel (sG)
205 - 210 ft : gravelly Sand (gS)
210 - 255 ft : sandy Gravel (sG)
255 - 285 ft : silty sandy Gravel (msG)
285 - 292 ft : SAND (S) - heaving
292 - 342 ft : sandy Gravel (sG)



Fill	*Casing*	*Screen*
0 - 10.1 ft : 11.5-inch hole Cement Surface Seal	0 - 216.25 ft : 4 inch 304L SS sch 5 csg	
10.1 - 34.5 ft : 11.5-inch hole Granular Bentonite		
34.5 - 201.4 ft : 9-inch hole Granular Bentonite		
201.4 - 206.3 ft : 9-inch hole 1/4" Bentonite pellets		216.25 - 251.25 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
206.3 - 253.25 ft : 9-inch hole 10/20 Silica Sand	251.25 - 253.25 ft : 4 inch SS sump	
253.25 - 260.3 ft : 9-inch hole 10/20 Silica Sand		
260.3 - 265.6 ft : 9-inch hole 1/4" Bentonite pellets		
265.6 - 340.3 ft : 9-inch hole 4/8 Silica Sand		
340.3 - 342 ft : 9-inch hole Muddy slough		

342 ft : Borehole drilled depth

0 - 34.5 ft : 11.5-in. Auger 10-3/4" Temp CS csg
34.5 - 342 ft : 9-in. Becker Hammer 9" Dual Wall CS csg

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 06Nov02
Print Date: 06Nov02

Report Form: WELLS Project File: WELLS.GPJ

0532887

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W15-763 C3339 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	none	Additives Used:	water	Coordinates: N	Not documented
Driller's Name:	M. Wraspir	WA State Lic Nr:	1909	Coordinates: E	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Start Card #:	Not Available
Date Started:	30Nov00	Date Completed:	17Jan01	Elevation Ground Surface:	

Depth to Water: **216.97 ft ft 10Apr01**
(Ground surface)

Elevation of Reference Point: m

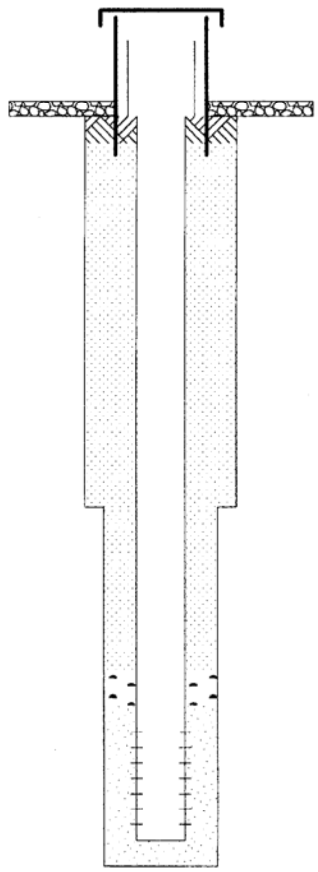
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **9.2 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 4 ft : Gravelly SAND
4 - 4.5 ft : Gravel
4.5 - 8 ft : Slightly Silty SAND
8 - 10.5 ft : Sandy GRAVEL
10.5 - 20 ft : Silty Sandy GRAVEL
20 - 40.5 ft : Sandy GRAVEL
40.5 - 42.5 ft : Silty SAND
42.5 - 94 ft : SAND
94 - 100 ft : SILT
100 - 101.5 ft : Silty SAND
101.5 - 117 ft : Gravelly Silty SAND
117 - 120 ft : Sandy GRAVEL
120 - 142 ft : Silty Sandy GRAVEL
142 - 170 ft : Sandy GRAVEL
170 - 209 ft : Silty Sandy GRAVEL
209 - 211 ft : Gravelly Silty SAND
211 - 230 ft : Silty Sandy GRAVEL
230 - 235 ft : Sandy GRAVEL
235 - 257 ft : Silty Sandy GRAVEL



Fill

0 - 9.2 ft : 12-inch hole Cement Surface Seal

9.2 - 134.2 ft : 12-inch hole Granular Bentonite

134.2 - 191.1 ft : 9-inch hole Granular Bentonite

191.1 - 202.4 ft : 9-inch hole Bentonite Pellets

202.4 - 248.82 ft : 9-inch hole 10/20 Silica Sand

248.82 - 257.6 ft : 9-inch hole 10/20 Silica Sand

Casing

0 - 211.75 ft : 4 inch 4" 304 SS sch 5 csg.

246.82 - 248.82 ft : 4 inch 4" 304 SS Sump

Screen

211.75 - 246.82 ft : 4 inch 4" 304 SS Wirewrap .020 Slot scrn.

257.6 ft : Borehole drilled depth

0 - 134.2 ft : 12-in. Cable Tool 11-3/4" CS Temp. csg.
134.2 - 257.6 ft : 9-in. Cable Tool 8-5/8" CS Temp. csg.

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	JEA
Reference:	Hanford Wells
Revision:	0
Revision Date:	17Apr01
Print Date:	17Apr01

BECHTEL

0540436

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary Drl & Drive	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W15-765 C3397 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Mike Gomez	WA State Lic Nr:	Not Documented	Coordinates: E	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Start Card #:	R037816
Date Started:	19Sep01	Date Completed:	04Oct01	Elevation Ground Surface:	

Depth to Water: 219.8 ft 27Sep01
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

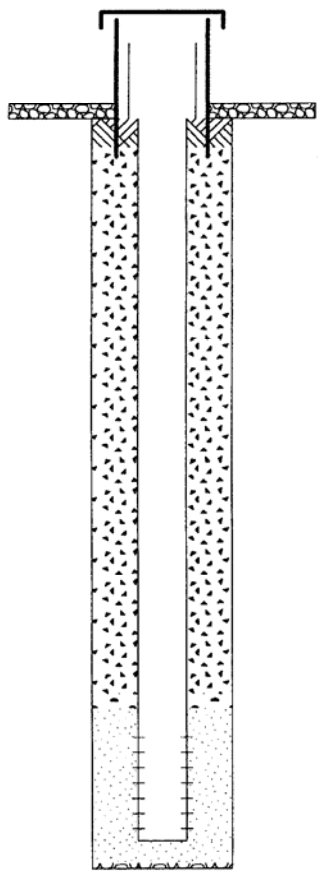
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.2 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 2 ft : Drill Pad
2 - 5 ft : Gravelly Sand
5 - 25 ft : Sandy Gravel
25 - 30 ft : Gravel
30 - 35 ft : Silty Gravel
35 - 40 ft : Slightly Silty Gravelly Sand
40 - 92 ft : Sand
92 - 93 ft : Silty Sand
93 - 105 ft : Silt
105 - 110 ft : Gravelly Silt
110 - 117 ft : Sandy Silt
117 - 120 ft : Sand
120 - 125 ft : Sandy Silt
125 - 130 ft : Silt
130 - 135 ft : Sand
135 - 136 ft : Silty Gravel
136 - 140 ft : Gravel
140 - 150 ft : Sandy Gravel
150 - 151 ft : Gravelly Silty Sand
151 - 155 ft : Gravel
155 - 157 ft : Gravelly Sandy Silt
157 - 160 ft : Gravel
160 - 170 ft : Sandy Gravel
170 - 175 ft : Gravel
175 - 180 ft : Silty gravel
180 - 195 ft : Gravelly Sand
195 - 200 ft : Sandy gravel
200 - 220 ft : Silty Gravel
220 - 230 ft : Silty Sandy Gravel
230 - 235 ft : Gravel
235 - 240 ft : Silty Gravel
240 - 250 ft : Silty Sandy Gravel
250 - 255 ft : Gravel
255 - 265 ft : Sandy Gravel



Fill	Casing	Screen
0 - 10.2 ft : 11-inch hole Cement Surface Seal	0 - 220 ft : 4 inch 304L SS sch 5 csg	
10.2 - 204.8 ft : 11-inch hole 8/20 Bentonite Crumbles		
204.8 - 209.5 ft : 11-inch hole 1/4" Bentonite Pellets		220 - 255 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
209.5 - 257.1 ft : 11-inch hole 10/20 Silica Sand		
257.1 - 265 ft : 11-inch hole 10/20 Silica Sand	255 - 257.1 ft : 4 inch 304L SS Sump	
265 - 267 ft : 11-inch hole Slough		

267 ft : Borehole drilled depth

0 - 267 ft : 11-in. air Rotary Drl & Drive
10-5/8" CS Temp csg to 267 ft

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 08Nov01
Print Date: 08Nov01

BECHTEL

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W15-765

WELL DESIGNATION	:	299-W15-765
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	267.0 ft
MEASURED DEPTH (GS)	:	257.1 27Sep01
AVAILABLE LOGS	:	Geologist & Geophysical
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	RCRA Monitoring
CURRENT USER	:	RCRA & Operations
PUMP TYPE	:	Not Documented
MAINTENANCE	:	Data not available
COMMENTS	:	Air Rotary Drg & Drive 10-5/8" CS Temp csg to 265 ft
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 08Nov01
Print Date: 08Nov01

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