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Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas S-SX at the Hanford Site

V. G. Johnson
C. J. Chou

January 1998

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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Groundwater
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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

Pacific Northwest National Laboratory (PNNL) conducted a Phase I, Resource Conservation and Recovery Act of 1976 (RCRA) groundwater quality assessment for the Richland Field Office of the U.S. Department of Energy (DOE-RL), in accordance with the Federal Facility Compliance Agreement. The purpose of the investigation was to determine if the Single-Shell Tank Waste Management Area (WMA) S-SX has impacted groundwater quality.

The WMA is located in the southern portion of the 200 West Area of the Hanford Site and consists of the 241-S and 241-SX tank farms and ancillary waste systems. The unit is regulated under RCRA interim-status regulations (40 CFR 265, Subpart F) and was placed in assessment groundwater monitoring (40 CFR 265.93 [d]) in August 1996 because of elevated specific conductance and technetium-99, a non-RCRA co-contaminant, in downgradient monitoring wells. Phase I assessment, allowed under 40 CFR 265, provides the owner-operator of a facility with the opportunity to demonstrate that the regulated unit is not the source of groundwater contamination.

Major findings of the assessment are summarized below:

- Distribution patterns for radionuclides and RCRA/dangerous waste constituents indicate WMA S-SX has contributed to groundwater contamination observed in downgradient monitoring wells. Multiple source locations in the WMA are needed to explain spatial and temporal groundwater contamination patterns.

- Drinking water standards for nitrate and technetium-99 are currently exceeded in one RCRA-compliant well (299-W22-46) located at the southeastern corner of the SX tank farm. Technetium-99, the constituent with the highest concentration relative to a standard, is currently four to five times the U.S. Environmental Protection Agency (EPA) interim drinking water standard of 900 pCi/L. Technetium-99 also recently increased to just above the drinking water standard in an older well (299-W23-1) inside the S tank farm.

- Technetium-99, nitrate, and chromium concentrations in downgradient well 299-W22-46 (the well with the highest current concentrations) appear to be declining after reaching maximum concentrations in May 1997. Observations during the next four quarters are needed to confirm the apparent declining trend in this well.

- Cesium-137 and strontium-90, major constituents of concern in single-shell tank waste, were not detected in any of the RCRA-compliant wells in the WMA network, including the well with the highest current technetium-99 concentrations (299-W22-46). This observation is consistent with the low expected mobilities of these constituents under Hanford Site conditions.

- Low but detectable strontium-90 and cesium-137 were found in one old well (2-W23-7), located inside and between the S and SX tank farms. Additional investigation is needed to determine if the low level contamination is borehole related or is more broadly distributed in the aquifer.

- Preliminary results for groundwater samples collected on 1/13/98 from a new borehole (41-09-39), drilled through the primary contaminant zone down to groundwater in the SX tank farm, suggest little if any tank waste reached the water table at this location. Gross alpha and gross beta concentrations, 2.3 ± 0.7 and 16.6 ± 4.0 pCi/L (based on 10 sample results), respectively, are within the range of Hanford Site natural groundwater background and hexavalent chromium, an important indicator of mobile constituents in tank waste, was not detected (<10 µg/L).

- Infiltration of snow melt runoff and/or artificial sources of water near vadose zone contamination sites within the WMA are possible causes of the short-term transients in contaminant concentrations observed in WMA groundwater monitoring wells between 1986 and the present. Continuing efforts are underway to identify and eliminate potential water sources around tank farms.

- A Phase II investigation of the nature, extent and source(s) of recurrent groundwater contamination at this WMA is indicated.

Acknowledgments

A large number of excellent review comments on the working draft of this report were received. We are especially grateful for the insightful and critical reviews provided by John Brodeur, Dr. Evan Dresel, Phil Rogers, Dr. Glendon Gee, Bob Lober, and Marv Furman. As many of the comments as possible were addressed in the revised draft. Comments that could not be resolved will be reconsidered in the proposed Phase II investigation plan.

Geologic and stratigraphic data included in this report were compiled and interpreted by the Pacific Northwest National Laboratory (PNNL) Vadose Zone and Stratigraphic Working Group. Special thanks are due to Bruce Williams and Dr. Stephen Reidel for the stratigraphic and geophysical correlations, and the geologic interpretations. George Last and Jeff Serne shared information from a related investigation and provided helpful review comments.

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1.0 Introduction

This report presents the findings and conclusions of a Phase I, *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater quality assessment of Single-Shell Tank Waste Management Area (WMA) S-SX as required by 40 CFR 265.93 9(d). Pacific Northwest National Laboratory[a] conducted the assessment from August 1996 to July 1997. The WMA S-SX is located in the southern portion of the 200 West Area of the Hanford Site (Figure 1.1). The area encompasses the 241-S and 241-SX tank farms consisting of:

- 27 single-shell tanks (fifteen 1,000,000-gal capacity tanks in the SX farm and twelve 750,000-gal tanks in the S farm) that contain highly radioactive nuclear fuel reprocessing and chemical wastes
- ancillary waste systems (e.g., tank farm transfer lines, diversion boxes, valve pits, and saltwell pumping pipeline network).

1.1 Background

Although decommissioned in 1980, the single-shell tanks are considered to be "actively" storing hazardous and radioactive wastes and have been designated as RCRA facilities, which require groundwater monitoring in accordance with interim-status regulations. The tanks in WMA S-SX are RCRA treatment and storage units and will be closed in accordance with Washington Administrative Code (WAC) 173-303-610.

A detection-level groundwater monitoring program for WMA S-SX was initiated in 1990. This regulated unit was placed in assessment-level monitoring status in May 1996 in response to a directive from the State of Washington Department of Ecology (see Appendix A, Caggiano 1996). The directive cited anomalous trends in technetium-99 and elevated specific conductance in vicinity groundwater as primary reasons for the assessment. A groundwater quality assessment plan was written in response to the Ecology directive (Caggiano 1996) and was submitted in August 1996.

The first determination (referred to herein as Phase I), and the subject of this report, is a short-term sampling program intended to provide the owner/operator an opportunity to substantiate a false positive claim. If the owner/operator determines, based on the results of Phase I determination, that no dangerous waste or dangerous waste constituents from the facility have entered the groundwater, then he may reinstate the detection-level monitoring program. If, however, contamination is confirmed (i.e., the regulated unit is the source of groundwater contamination), then a second part of the groundwater quality assessment plan (referred to herein as Phase II) should be written and implemented to fully characterize sources, driving forces, and to define the rate and the extent of migration of contaminants in the groundwater, and concentration of contaminants. In addition, information gained during Phase II investigations could be used to decide whether corrective measures are warranted.

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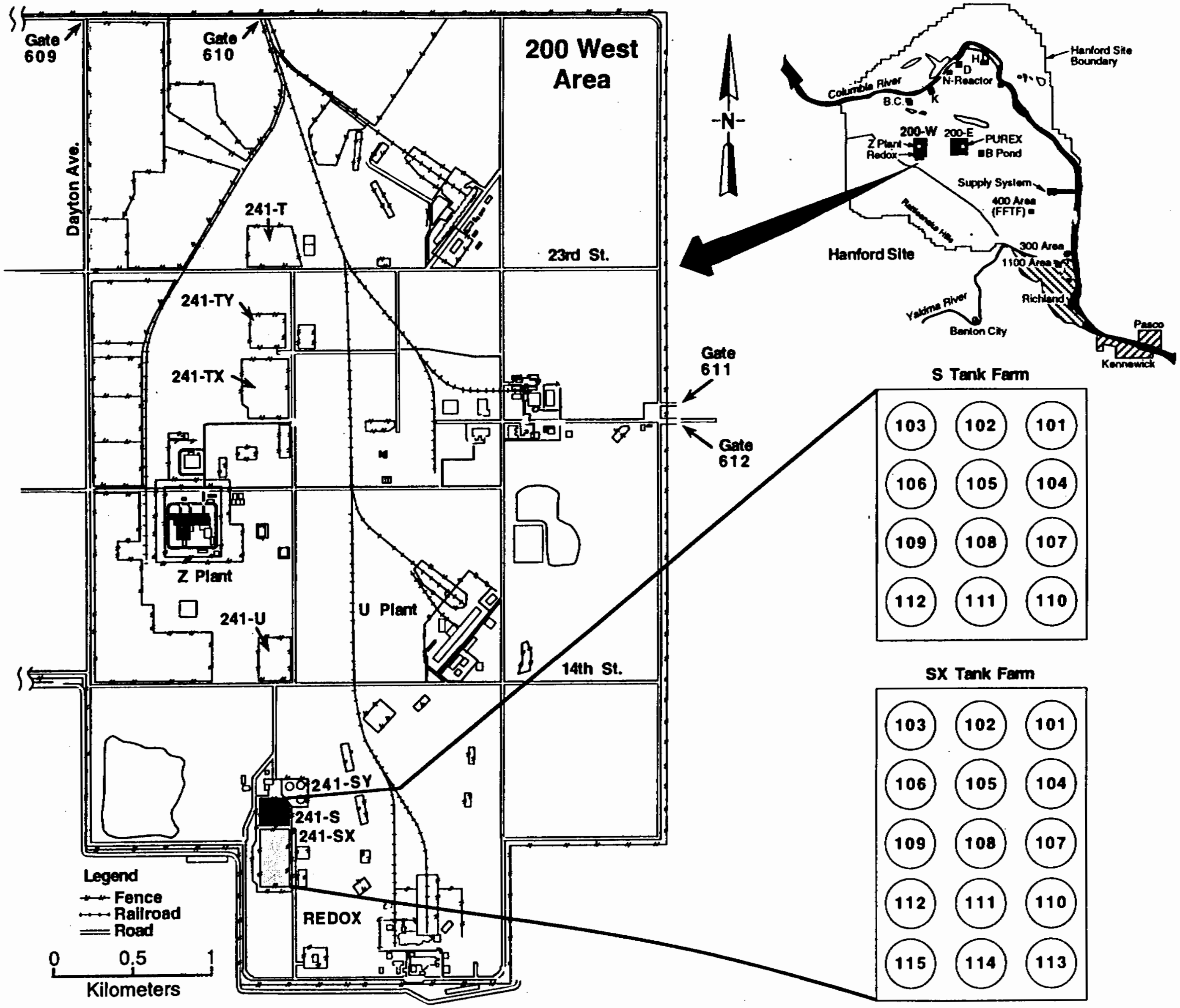

Figure 1.1. Location Map of Single-Shell Tank WMA S-SX and Surrounding Facilities in 200 West Area (inset shows individual tank farms and tank numbers in WMA S-SX)

1.2 Objectives and Scope

The primary objectives of this assessment were to determine if observed changes in groundwater quality are due to WMA S-SX, and if so, identify sources, driving forces, and pathways to groundwater. Figure 1.2 shows monitoring well locations for the Phase I assessment.

The scope of this report is limited to description of new information acquired in connection with the assessment. Background information concerning hydrogeology of the area, monitoring network and descriptions, physical and chemical description of sources, and related background information are included in the assessment plan (Caggiano 1996) and are incorporated in this report primarily by reference.

Parallel to this investigation, an expert panel (the "Panel;" DOE 1997), was convened to independently assess the likelihood that tank waste liquor and associated contaminants, especially cesium-137, had migrated to greater depths in the vadose zone than expected. The Panel's findings and recommendations are incorporated and referenced as appropriate.

1.3 Report Contents

Section 2.0 of this report describes the conceptual model used for the Phase I assessment, including a summary of source characteristics, pathways, and driving forces. Results of the data evaluation are described in Section 3.0 and include discussion of stratigraphy, driving forces, isotopic and chemical ratios, groundwater flow directions, moisture content, and co-contaminants. Section 4.0 discusses postulated contaminant source, pathway, and driving force scenarios. Source, pathway, and driving forces also are correlated with monitoring data in Section 4.0. Conclusions and a proposed approach for further investigation are provided in Sections 5.0 and 6.0.

Stratigraphic correlations and analytical results for groundwater samples collected during 1996 and 1997 are presented and discussed in Appendix A and Appendix B, respectively. Appendix C provides a discussion of chemical fractionation in single-shell tanks in the SX tank farm. A summary of tank compositions is beyond the scope of this report but are available in Agnew (1997) and from the Hanford TWRS web page.

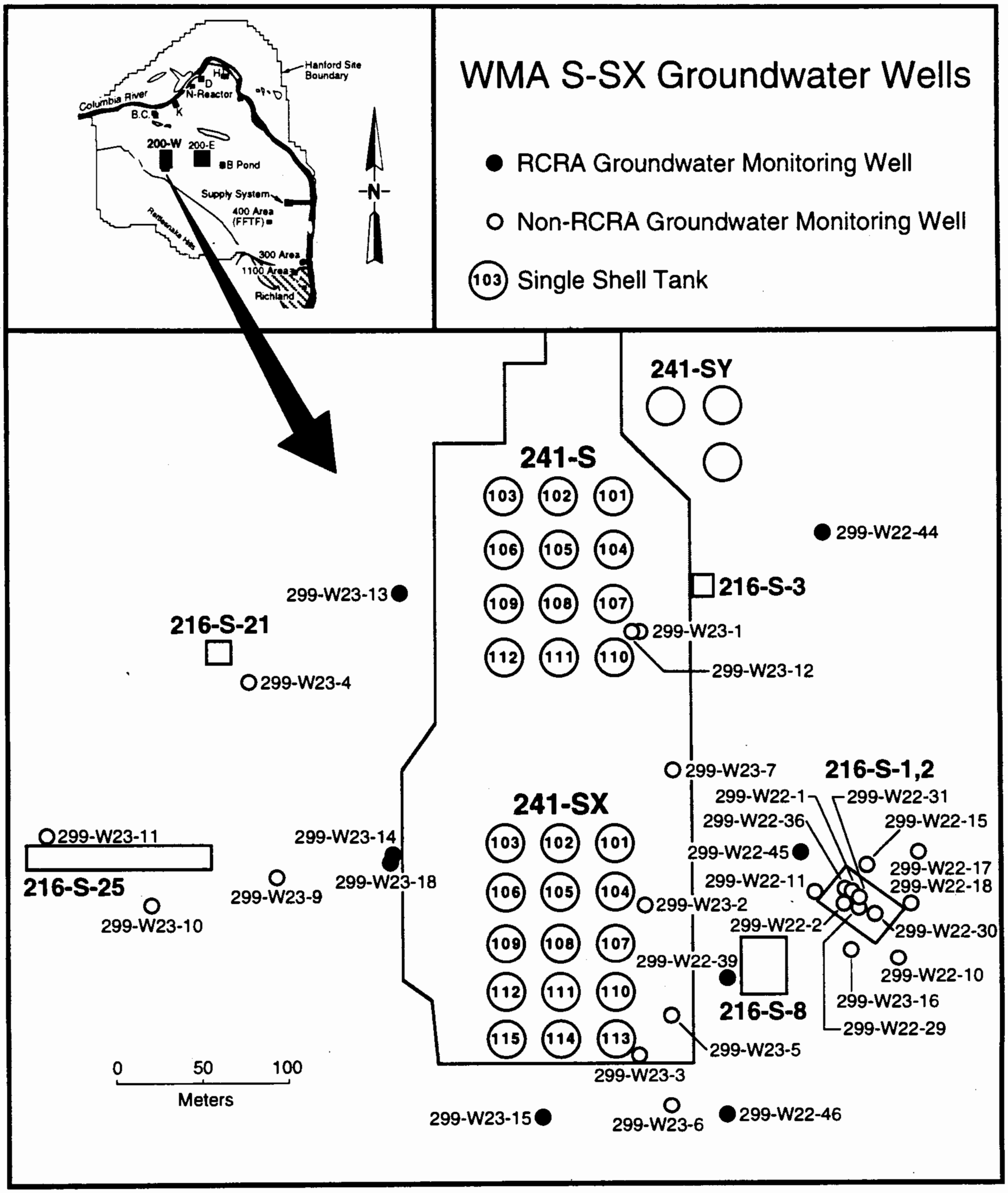

Figure 1.2. Location Map of Groundwater Monitoring Wells Around WMA S-SX (the WMA, shown as the outlined area surrounding the S and SX tank farm, consists of the single-shell tanks and associated transfer lines, diversion boxes, and other related waste-handling equipment)

2.0 Conceptual Model

The conceptual model is part of the Data Quality Objectives (DQO) process that was used in developing a sampling and analysis plan for the Phase I assessment (Caggino 1996). Also, in accordance with the DQO process, conceptual models are updated as an investigation evolves.

This section describes the soil pathway conceptual model of hypothetical sources, constituents of interest, driving forces, and pathways to groundwater considered during the Phase I investigation. Figure 2.1 shows the model as presented in the assessment plan (Caggiano 1996). The primary features of the conceptualization are discussed in the following subsections, along with additional considerations from the Panel (DOE 1997) and from the Tank Waste Remediation System (TWRS) vadose zone characterization program (DOE 1996, 1998).

2.1 Nature of the Source

The source term for WMA S-SX is dependent on both nuclear and chemical aspects of the process that generated the waste and on tank construction and operating conditions. The manner in which the waste entered the soil column, as illustrated in Figure 2.1, and discussed in the following subsections, is also important in understanding potential sources within the WMA and the likelihood of mobile tank waste constituents reaching groundwater.

2.1.1 Chemical Processing and Tank Conditions

Chemical processing. Irradiated nuclear fuel from the Hanford plutonium production reactors contained fission products and lesser amounts of neutron activation products as well as the unspent uranium and transuranic radionuclides. The plutonium was chemically extracted from the fuel matrix at T plant and S plant in the 200 West Area, and B plant and A plant in the 200 East Area.

The S and SX tank farms contain aqueous waste generated from the REDOX process that was conducted in S plant from 1952 to 1966 (Agnew 1997). The chemical processing steps and waste routing are illustrated schematically in Figure 2.2. The aluminum cladding was first removed from the fuel with caustic in the dissolver vessel. Waste from this step is referred to as coating wastes or CWR waste. Some fission product activity and uranium were associated with this waste type, but less than generated during the subsequent dissolution of the declad fuel with concentrated nitric acid. After the initial dissolution of the fuel, ozone, permanganate and dichromate were used to adjust the oxidation state of the plutonium to facilitate its separation in solvent extraction columns. Aluminum nitrate was also added to enhance the transfer of plutonium ("salting out") from the aqueous to the organic phase. The highly acidic waste stream was then over neutralized with sodium hydroxide and routed to tanks in the S and SX tank farms. This process generated a much smaller volume of waste than was generated by the older bismuth phosphate process used at T plant. Thus fission product concentrations were higher in the S plant waste. The high pH also resulted in formation of precipitates of uranium, heavy metals, and strontium-90 that eventually settled to the bottom of the tanks.

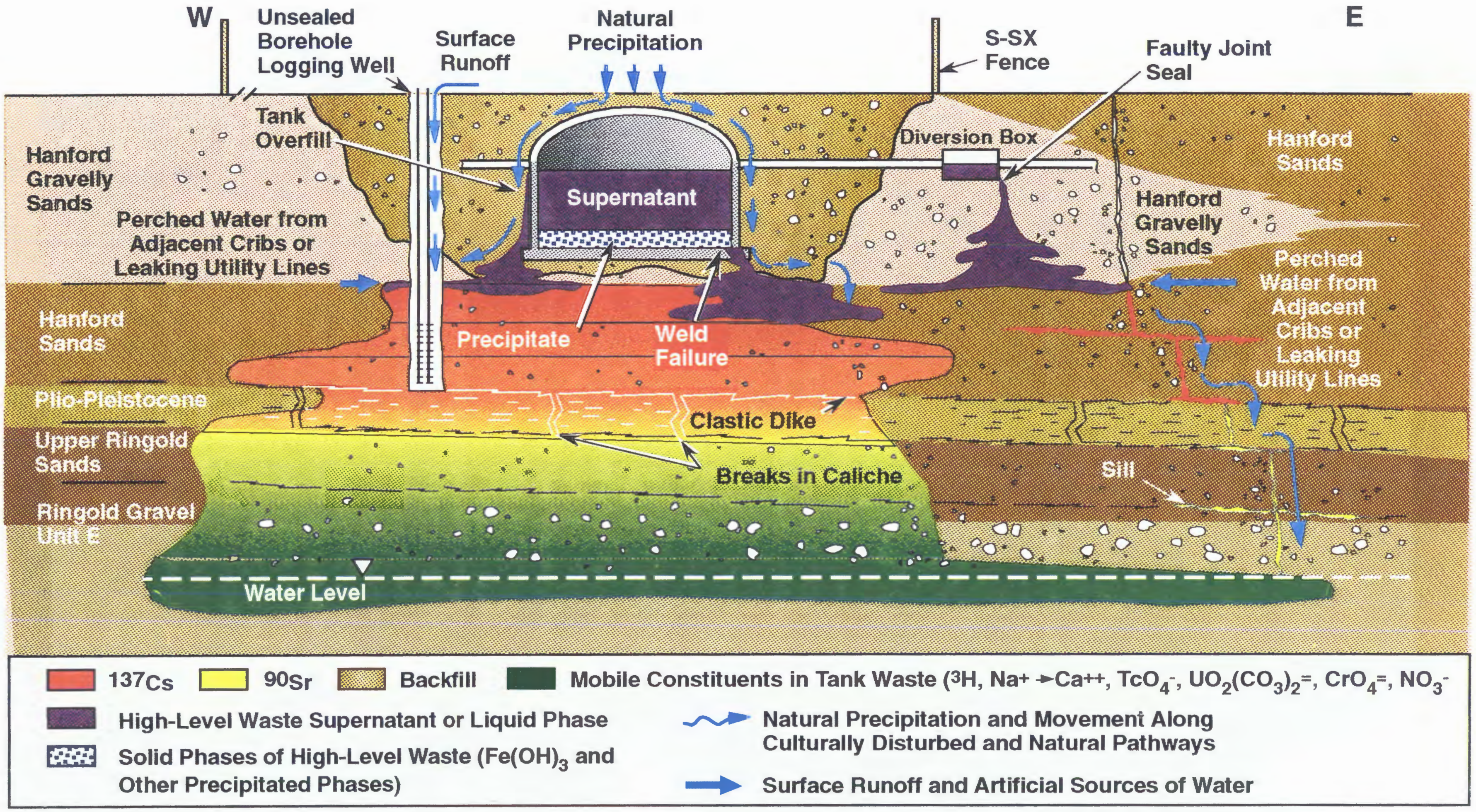

Figure 2.1. Soil Pathway Conceptual Model. Purple depicts tank waste and leakage during early operations in the 1960s. Subsequent hypothetical movement of contaminants through the vadose zone, shown in red, yellow, and green, covers a time period from early operations to the present. As a result of volume reduction measures, a much smaller volume of free liquid remains in the tanks today. Depth to groundwater is 210 ft (64 m). The tank base elevation is about 50 ft (15 m) below ground surface. The geologic strata shown are simplified for illustration purposes. Detailed stratigraphic descriptions are provided in Appendix A.

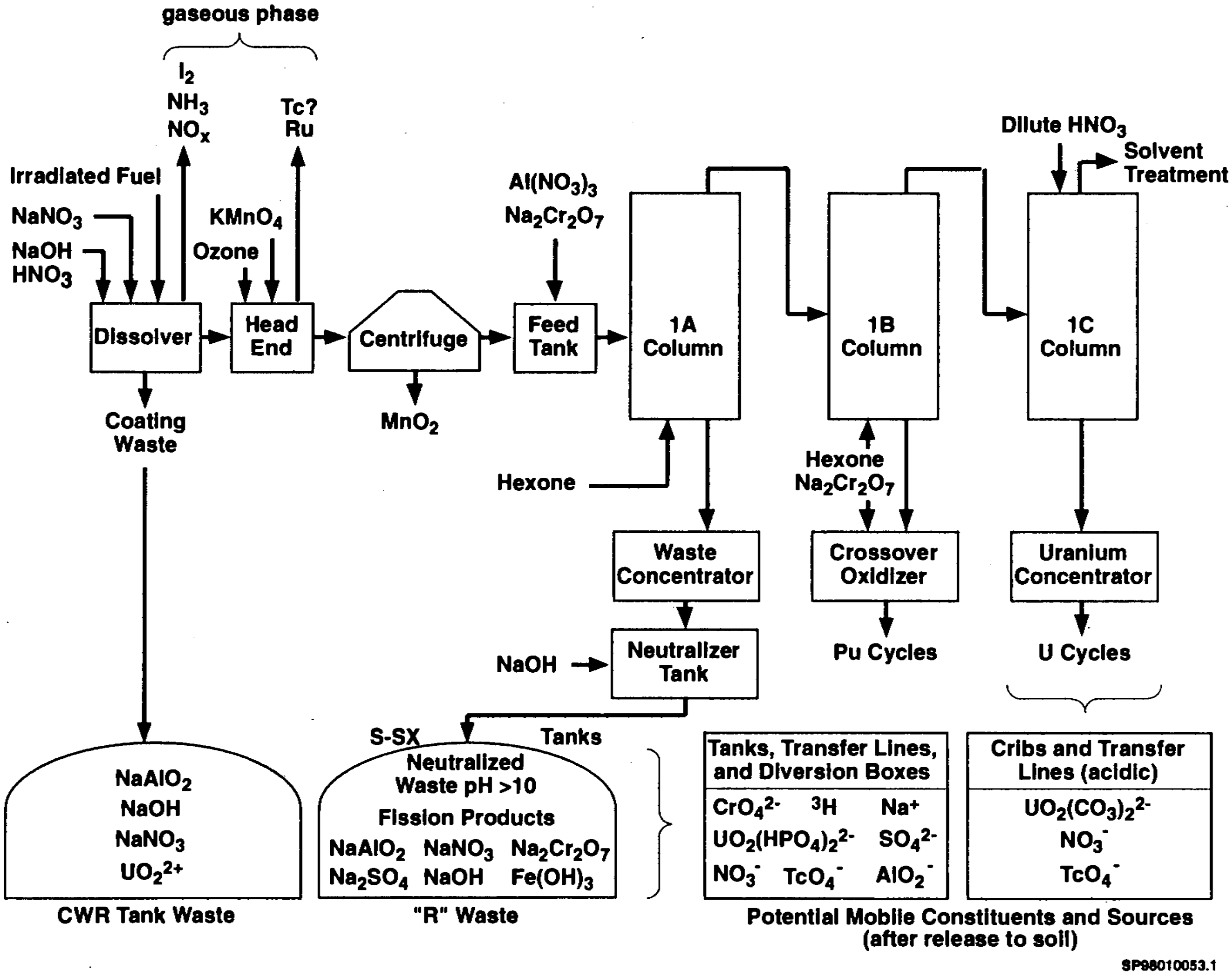

Figure 2.2. REDOX Process and Waste Stream Flow Sheet with Expected Mobile Waste Constituents. Molar proportions of nitrate, aluminum and chromium based on inventory estimates for tanks SX-109 and SX-115 are: N:Al:Cr = 1/0.5/0.1 and corresponding mass of solids is 1.45E+6 kg and 6.75E+4 kg, respectively (from Agnew 1997).

Classification of the REDOX waste stored in the S and SX tank farms as a RCRA/dangerous waste (or hazardous waste) is primarily because of the hexavalent chromium, the corrosive (high pH) nature of the waste, aluminum and nitrate. The principal radioactive components of concern, although not explicitly regulated under RCRA, are cesium-137 and strontium-90, initially present in the 0.1 to 1 Ci/L range. Long-lived mobile constituents, technetium-99 and iodine-129, were on the order of 10's of μCi/L or less. A large fraction of the latter two fission products, especially iodine-129 may have been separated as a gaseous phase during fuel dissolution. In addition, the low burn up of the fuel (short irradiation times) results in relatively low inventories of iodine-129 as compared to high burn up commercial reactor fuel. Transuranic radionuclides (e.g., neptunium-237, plutonium-238, -239, americium-241) are also present as either a byproduct of the separation step or due to incomplete removal during the solvent extraction step. The chemical state of the transuranics is uncertain due to the elevated pH of the stored waste. Much of the transuranic inventory should be associated with solids in the tanks. There may be a tendency, however, for the formation of soluble oxyanions at elevated pH. Neptunium-237 is expected to have the greatest tendency to form soluble anionic chemical species.

Because of tank waste chemical conditions, the transuranics, as well as strontium-90, are expected to be predominantly particulate or associated with a solid phase or chemical precipitates. Complexants (e.g., EDTA), that may still be present in some tanks, however, could alter this generalization. Single-shell tank sludge/core samples and fractionation results should provide more definitive information about chemical states of tank waste constituents. (Results for tanks are posted on the Hanford/TWRS web page as they become available). Chemical fractionation is discussed in more detail in Appendix C.

Tank related considerations. The single-shell tanks are constructed of a single layer of carbon steel surrounded by a layer of reinforced concrete which forms the roof and sidewall support. The tanks shown as leakers in the SX farm (Figure 1.2) were unique. The bottom edge of the walls of these tanks were welded directly to the floor of the tanks. Other tanks in the S and SX farms were constructed with a curved bottom edge. The welds in the former case apparently failed due to accelerated corrosion and or physical stress induced by buckling beneath the center regions of the tank bottoms. The buckling caused the floor to pull away from the wall at the welded seam. The buckling was attributed to decay heat that generated intense pressures between the concrete base and the carbon steel floor. This condition may have also contributed to expulsion of superheated steam and liquid waste into the surrounding soil (DOE 1997).

The subject tanks were operated in a self boiling mode to reduce tank waste volumes. This involved condensing the water vapor, driven off as tritiated steam, from exit ports at the top of the tanks. The condensate was discharged to upgradient cribs; no high salt tank waste supernate was discharged to adjacent disposal facilities.

Waste transfers. Chemical processing waste from S plant was routed to diversion boxes and then to individual tanks in S and SX tank farms. Waste was also transferred from tank to tank. The waste entered the tank farms from the east side where the diversion boxes were located, as indicated in Figure 2.1. The transfer lines were not double contained so failures would have resulted in losses to the soil.

Based on tank construction and operating conditions, as discussed above, the tanks in the SX tank farm, especially the tanks designated as leakers (Figure 1.2), are the largest sources of potential groundwater contamination in WMA S-SX. Previous studies (WHC 1992a,b,c) and recent vadose zone characterization data (DOE 1996, 1998) indicate that tanks SX-108, 109 (west central) and tank SX-115 (southwest corner) of the

SX tank farm are the largest sources of subsurface contamination. Large volume losses from transfer lines and related spills, however, cannot be ruled out as potentially significant contributors to vadose zone contamination in WMA S-SX and vicinity.

2.1.2 Release Modes and Soil/Chemical Conditions

Leaks. As indicated in Figure 2.1, and discussed above, potential tank sources that hypothetically could contribute to groundwater contamination include: 1) leaks from the base of the tanks, and 2) transfer line/diversion box leaks. As the Panel noted in their report, the multi-molar (sodium nitrate) waste liquor was hot (175°C), dense (up to 2 g/cc), and highly caustic (pH up to 14). This combination could have dissolved silica and aluminates from the soil matrix, increased the soil porosity and enhanced downward migration. However, it also is possible that the dissolved silica and aluminum from the aluminosilicate minerals could have precipitated as the mass cooled at a somewhat greater depth. If this occurred, the main mass of the initial leak, whether from a tank or other source(s), should remain relatively high in the soil column. Laboratory studies on simulated tank waste confirm the formation of aluminum hydroxide gels in high pH media in contact with basaltic material and Hanford soils, and the plugging action it has on laboratory leaching columns (Serne, Zachara, and Burke 1997). If the gel plugging scenario occurred in the WMA S-SX, the primary mass may still be in the vicinity of the initial emplacement volume of contaminated soil (i.e., the approximate location indicated by the initial leak in Figure 2.1).

If plugging of the soil column (by precipitation subsequent to the reaction of the caustic waste liquor with the soil) **did not** occur, then the entire mass of tank leakage should have moved downward in a broad "wetting front," with the more mobile constituents (e.g., chromate, nitrate, and technetium-99) at the leading edge, as Figure 2.1 depicts. The same type of fractionation with depth could occur from more broadly distributed, but lower level contamination, as suggested by recent vadose zone characterization efforts in the S and SX tank farms (DOE 1998). The shape of the wetted zone with depth could vary considerably from that depicted as a result of stratigraphic fine structure and or preferential pathways (DOE 1997).

Spills. Unplanned releases such as surface spills as a result of "bumping" during boiling in the SX tanks resulted in dispersal of tank waste to the surrounding ground surface. These sources were "watered in" and covered with gravel. Evidence of significant surface contamination exists over much of the tank farm, including the area outside the south fenceline of the SX farm. The contaminated area at this location occurs on a bank that slopes downward into a large barrow pit where snow melt and runoff also accumulates. Artificial sources of water have existed in this area as well (water lines and a sanitary drain field). Near-surface contamination can be transported deeper into the vadose zone more readily at such locations.

Overflows of waste (enroute to single-shell tanks) at diversion boxes and "jumpers" and at the inlet and outlets of the tanks also contributed to near-surface soil contamination in the WMA. These "spill" sources could be sources of groundwater contamination that would be indistinguishable from tank leak sources.

2.2 Pathways

The non-homogeneous nature of the sedimentary units beneath the WMA play an important role in contaminant movement. The fine sediments within the coarser material tend to spread the liquid waste over a larger area and impede downward movement, as suggested in Figure 2.1. Potential preferential vertical pathways depicted in Figure 2.1, should they exist, would accelerate movement through the sedimentary layers by providing "short circuits" for moisture movement. The prevalence of natural vertical features (e.g., clastic dikes) or macro porosity in the 200 West Area may suggest such features could exist beneath the S and SX tank farms.

Artificial pathways include the unsealed boreholes installed around each tank to depths of 75 to 130 ft (23 to 40 m) for leak detection purposes. In addition, five wells were drilled to groundwater in the S and SX farms, three of which are adjacent to tanks. Thus, manmade conduits are possible short circuits to groundwater as well.

In addition to the above pathways, the Panel (DOE 1997) pointed out that irregular moisture movement can occur even in homogenous sands that lead to flow channels through the vadose zone. These features can "siphon" the soil water and lead to more rapid transport to groundwater. Once such pathways are formed or "wetted", subsequent transport events occur more readily. Such features are difficult to depict graphically, and thus are not shown in Figure 2.1. The general concept, however, is acknowledged as a variant on preferential pathways that could shorten the travel time to groundwater.

2.3 Driving Forces

Contaminant transport through the soil column requires either an external source of water to carry the contaminants to groundwater or a leak of sufficient volume to make it to groundwater. The density of the fluid can enhance this downward movement as well.

Sources of water include both natural precipitation and artificial sources. Infiltration of natural precipitation is enhanced due to the coarse gravel cover over the tank farms. This effect is amplified around the base of the tanks as a result of runoff from the tank dome, as Figure 2.1 shows. Artificial sources include potable water line ruptures or leakage, adjacent crib sources, fire hydrant supply line leakage, and discharge testing water. Surface water runoff from roads and parking lots that accumulates in low spots near subsurface contamination associated with the WMA is another potential driving force/source combination.

2.4 Constituents of Interest

Mobile WMA-related waste constituents in groundwater, that can be distinguished from adjacent sources, could be indicative of a tank leak, spill, or related WMA source. The principal mobile tank waste co-contaminants identified for WMA S-SX are technetium-99 (as TcO_4^-), hexavalent chromium (CrO_4^{2-}) and nitrate (NO_3^-). The latter two constituents are RCRA hazardous waste constituents (or *listed wastes*). Tritium also is present in the tank waste, but there have been much larger sources of upgradient tritium because of past-practice discharges (e.g., cribs) of tritium-bearing tank condensate. Thus, tritium from sources within the WMA would be masked by upgradient tritium sources. Nevertheless, tritium is useful as an indicator of flow direction or perturbations in the expected flow direction between the upgradient source(s) and downgradient S-SX monitoring wells. In combination with other WMA waste indicators, it may help delineate source areas or constrain possible source locations.

Other non-radioactive co-contaminants include the major cation (Na^+) associated with the high salt matrix (i.e., sodium nitrate). However, the sodium could exchange for or displace other exchangeable cations in the soil column (Ca^{2+} and Mg^{2+}) and alter the major cation composition reaching groundwater. In this case, calcium and magnesium in combination with nitrate should account for the elevated total dissolved solids or specific conductance expected from a leak that reaches groundwater. Variations resulting from release conditions, leak volume, and pathway could occur. For example, if the waste liquor volume associated with a leak or discharge is very large (>> pore volume of the soil column beneath a leak area), all the naturally occurring exchangeable cations in the soil column in contact with the waste liquor should be replaced by sodium. After the initial "pulse" of displaced calcium and magnesium passes, the receiving groundwater would be dominated by sodium. If the leak is smaller than a pore volume, the "imprint" in groundwater near the source would be calcium and magnesium-dominated because the displaced cations from the soil column would not be flushed away, as would occur with multiple pore volumes of high sodium waste liquor. However, if a short circuit pathway such as an unsealed monitoring well transports the waste liquor directly to groundwater, then the dominant cation could be sodium even if the leak volume is relatively small.

Strontium-90 and cesium-137, the major radioactive tank waste constituents of concern, are not expected to be mobile under normal Hanford Site conditions. Because of findings from the TWRS vadose characterization program, suggesting cesium-137 may have migrated to greater depths than previously thought, these moderately long-lived fission products were included in the analyte list for the assessment.

In addition to the use of isotopic ratios (e.g., $^{99}Tc/U$, $^{3}H/^{99}Tc$), the relative proportions of the major cations in groundwater (e.g., Na/Ca ratio) could also be used to "fingerprint" contaminant sources. These ratios provide additional clues concerning the nature and/or location of potential sources of groundwater contamination in the vicinity of tank farm WMAs when combined with other information.

Transuranic radionuclides, although potential constituents of interest, were not analyzed for this assessment. Gross alpha concentrations, however, were measured as an indicator. When anomalous gross alpha is observed, isotope specific analyses are requested. As discussed in Appendix B, gross alpha data did not suggest the presence of above-background alpha activity in wells where maximum technetium-99 was observed. A special request, however, was made for analysis of plutonium-239, americium-241 and neptunium-237 in samples from the new borehole drilled in the SX farm.

3.0 Results

This section summarizes additional groundwater and related data acquired during the Phase I assessment (August 1996 to August 1997). A data tabulation and discussion of sampling conditions and analytical results are included in Appendix B. Interpretation of new and previous findings and consistency of observations with the conceptual model are discussed in Section 4.0.

3.1 Co-Contaminant Patterns

As discussed in Section 2.0, the primary mobile co-contaminants associated with a tank or related source should co-vary in groundwater at a specific well or wells if a WMA source is responsible for the observed change in groundwater quality. Accordingly, the quarterly results for technetium-99, chromate, and nitrate for the upgradient and downgradient RCRA-compliant network monitoring the SX tank farm are shown in Figure 3.1. As can be seen from Figure 3.1, all three constituents are co-variant and show increasing trends over time in both wells 2-W23-15 and 2-W22-46 (see Figure 1.2 for location). The abrupt increases in all three co-contaminants that began to emerge for well 2-W22-46 in 1997 mimic patterns observed in well 2-W23-15 that occurred during the 1992-1993 period.

Supplemental sampling in two older wells located between 2-W23-15 and 2-W22-46 was conducted to determine if there were any spatial relationships. Wells 2-W23-3 and 2-W23-6, which were not previously equipped with sample pumps, were first inspected and pumps installed before sampling. Initial results show that well 2-W23-3, located immediately downgradient from the primary single-shell tank leak sources (SX-108 and 109) in the SX tank farm, exhibited very low technetium-99 concentrations (60 pCi/L). This is consistent with previous measurements for this well based on bailed (non-purged) sampling results. In sharp contrast, technetium-99 in nearby well 2-W23-6 sampled in July 1997 was 2,100 pCi/L (no previous results were available in the data base for this well). The significance of these observations is discussed later (Section 4.0).

It should also be noted that technetium-99 increased from 180 pCi/L in 1996 to 1,500 pCi/L (on 8/7/97) in well 2-W23-1, located inside the S tank farm. This is the only well in the vicinity of WMA S-SX that is currently indicating an upward trend.

3.2 Sodium/Calcium Relationships

As discussed in the assessment plan, excess calcium and magnesium showed a co-variance with the major mobile anionic co-contaminants (nitrate, chromate, and technetium-99) in well 2-W23-15 (Figure 3.2). The excess calcium and magnesium (excess = observed minus upgradient concentrations) in meq/L are also very close to the major anion (nitrate) indicating the major contributors to the total dissolved solids and/or specific conductance during the peak period were due to these constituents (Ca^{2+}, Mg^{2+}, NO_3^-). An unaltered tank waste source would be dominated by $NaNO_3$. However, as indicated in Section 2.0, the dominance of

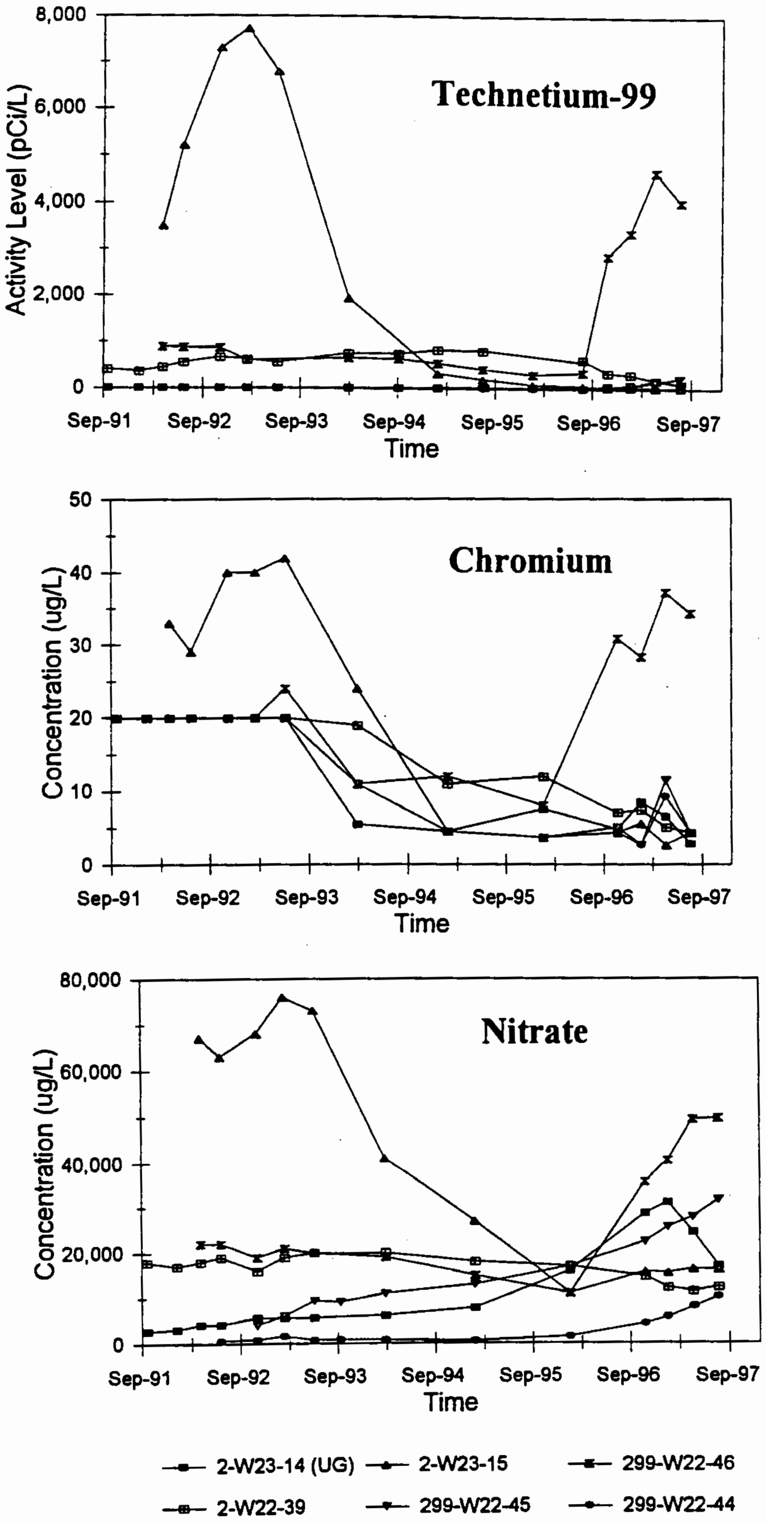

Figure 3.1. Time Series Plots of Technetium-99, Chromium, and Nitrate in the WMA S-SX Monitoring Well Network (concentrations of chromate are in micrograms per liter of chromium, as reported by the vendor; µg/L of $CrO_4 = 2.28 \times Cr$)

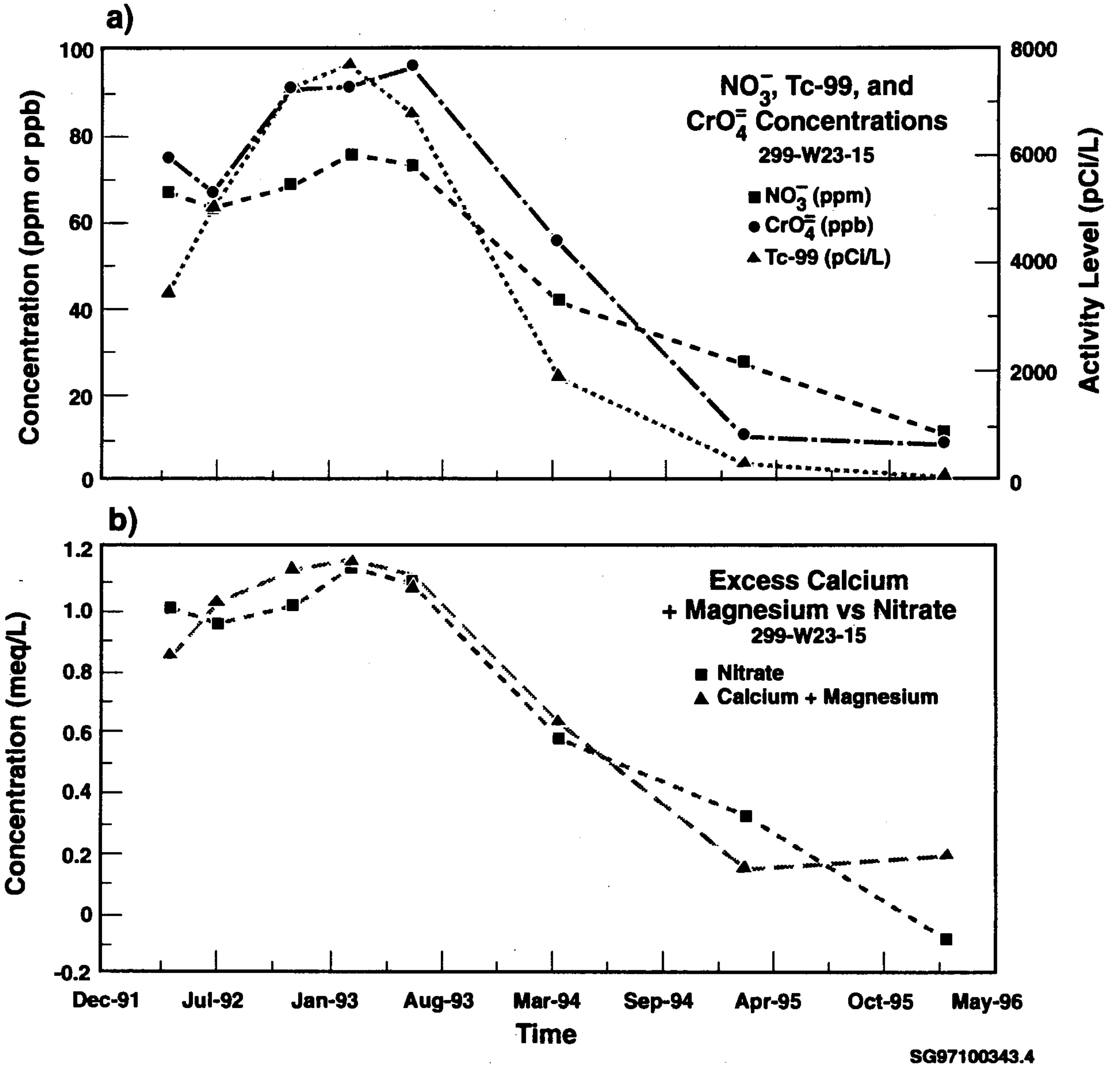

Figure 3.2. Mobile Co-Contaminant Concentrations Versus Time in Well 299-W23-15. (a) Chromate in parts per billion or micrograms per liter of $CrO_4^=$ and nitrate in parts per million or milligrams per liter of NO_3^- (b) concentrations of excess calcium + magnesium and nitrate are expressed as meq/L, obtained by dividing the constituent concentration in mg/L by its gram-atomic weight and multiplying by its ionic charge.

calcium and magnesium, rather than sodium, in groundwater beneath a hypothetical tank farm source could occur as a result of the following cation exchange reaction:

$$Na^+ + Ca,Mg\text{-soil} = Ca^{2+} + Mg^{2+} + Na\text{-soil}$$

Current trends noted in well 2-W22-46 have not developed well enough to confirm patterns recognized earlier for well 2-W23-15, but the same constituents appear to be following the trend illustrated in Figure 3.2.

It should be noted that the anion and cation relationship discussed above is not unique to a tank waste source; i.e., the anionic charge must be balanced by some cation or mix of cations regardless of the original nitrate source. Nitric acid, for example, could react with soil carbonates and result in a calcium nitrate waste that reaches groundwater. The important point to be made above, and in Figure 3.2, is that the dominance of calcium and magnesium, rather than sodium, in the downgradient monitoring wells does not rule out a sodium-dominated tank waste or related waste liquor source.

3.3 Tritium Pattern

In contrast to the co-variance noted above, tritium (Figure 3.3) in well 2-W23-15 follows a distinctly different pattern, suggesting a different origin for this waste constituent. Also, tritium currently is much higher in the upgradient well (2-W23-14) than in the downgradient wells. The most likely source is drainage of residual tritium from the major S-SX tank farm condensate disposal site (e.g., from 216-S-21 Crib) that received nearly 100 million liters of tank condensate containing tritium at concentrations of 10-100 µCi/L (see Figure 1.2) for crib location.

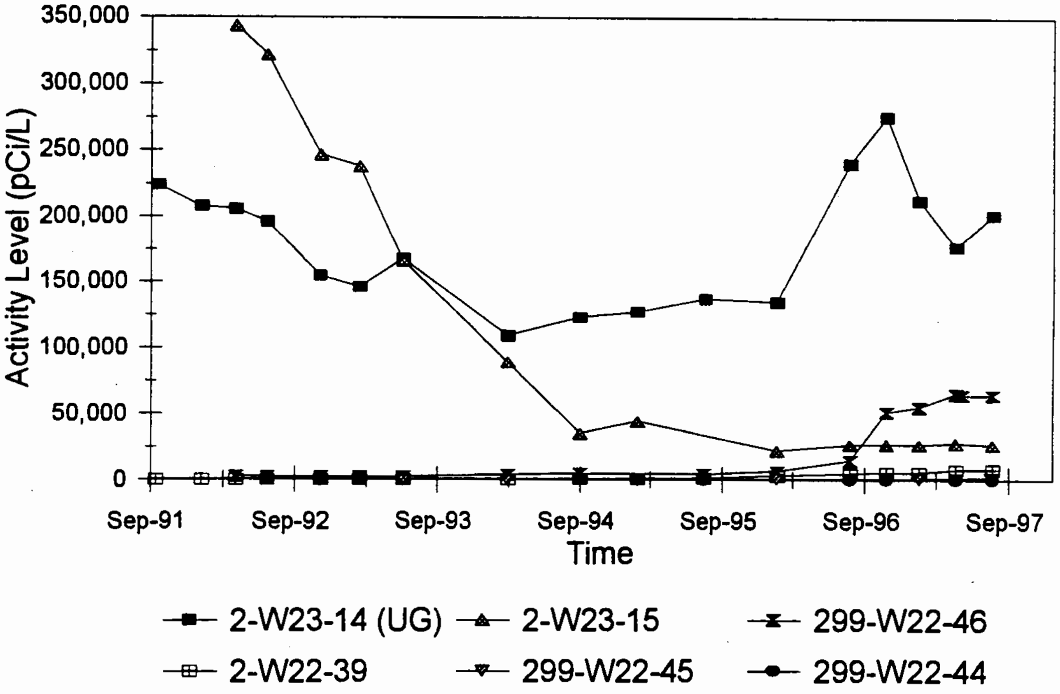

Figure 3.3. Tritium Concentrations Versus Time in WMA S-SX RCRA Monitoring Well Network

3.4 Isotopic and Chemical Ratios

The relationship of tritium and technetium observed in upgradient wells (very high tritium and very low technetium-99), reflect the separation of tritium as tritiated water vapor from the high salt, self-boiling tank waste from the S and SX tank farms. The technetium-99 and other non-volatile chemical constituents became more concentrated as the boiling progressed, and the resulting tritiated water vapor phase was condensed and discharged to adjacent cribs.

Upgradient crib sources may be distinguishable from tank sources because of the fractionation of the original tank waste liquor caused by the self-boiling operation. This process was unique to the S-SX tanks (in the 200 West Area) as a method of volume reduction to save tank space. Thus high salt tank waste supernatant was **not** discharged to adjacent upgradient cribs at the S and SX tank farms as was done elsewhere (e.g., T, TX, TY and B, BY, and BX).

The different source areas for the tritium and technetium-99 are clearly evident in the tritium and technetium-99 concentration contour plots shown in Figure 3.4. Technetium-99 appears to originate in the S and SX tank farm area while the tritium seems to originate to the west of the WMA near the upgradient crib sources noted above. It should also be noted that other major downgradient sources exist, especially for technetium-99. For example, the technetium-99 contours near the upper right corner of Figure 3.4 originated from past-practice disposal sites associated with U Plant operations.

The ratio of tritium to technetium-99 versus technetium-99 concentration for the wells in the immediate vicinity of the WMA are shown in Figure 3.5 (only wells within about 500 m of the WMA are included in order to avoid confusion with downgradient sources). The expected tritium/technetium-99 ratio from single-shell tanks in the S or SX tank farms is in the range of 1-10, based on data and considerations provided in Agnew (1997). The overall distribution of ratios in Figure 3.5 appears to be a mixture of an upgradient source with a very high ratio and a WMA-related low ratio source.

If upgradient groundwater sources were responsible for the elevated technetium-99 concentrations observed in groundwater beneath WMA S-SX, the tritium/technetium-99 ratio should be somewhat uniform both upgradient and downgradient of the WMA. The dramatically lower tritium/technetium-99 ratio in downgradient wells is attributed to an increase in the technetium-99 from a localized input source that lowers the ratio. Low concentrations of technetium-99 observed in the upgradient wells indicate that the WMA is (or was) the source of the added technetium-99.

In addition, technetium-99/uranium ratios (Figure 3.6) were used to distinguish separate source types. The average ratio for inputs to adjacent crib sources (very low ratios, Figure 3.6), and apparent high ratios for a tank waste source (>300 based on the water soluble fraction of tank waste sludge, Caggiano 1996), are more consistent with a source originating within the WMA (e.g., single-shell tanks and or ancillary waste systems) than an adjacent crib.

In addition to the indications based on isotopic ratios, the technetium-99 groundwater plume also suggests an origin somewhere within or at least in the vicinity of WMA S-SX (see Figure 3.4).

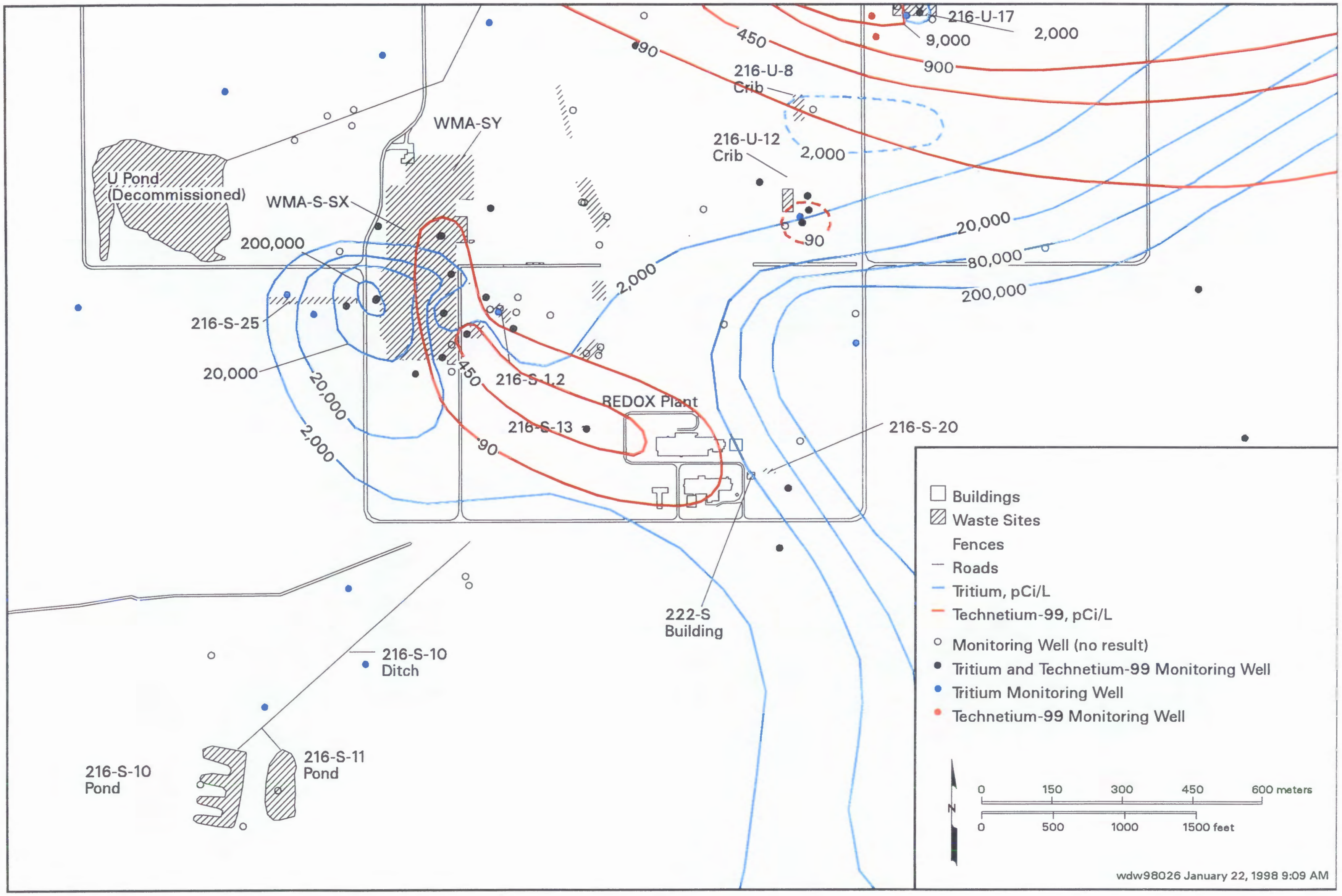

Figure 3.4. Concentration Contours for Tritium and Technetium-99 (1996)

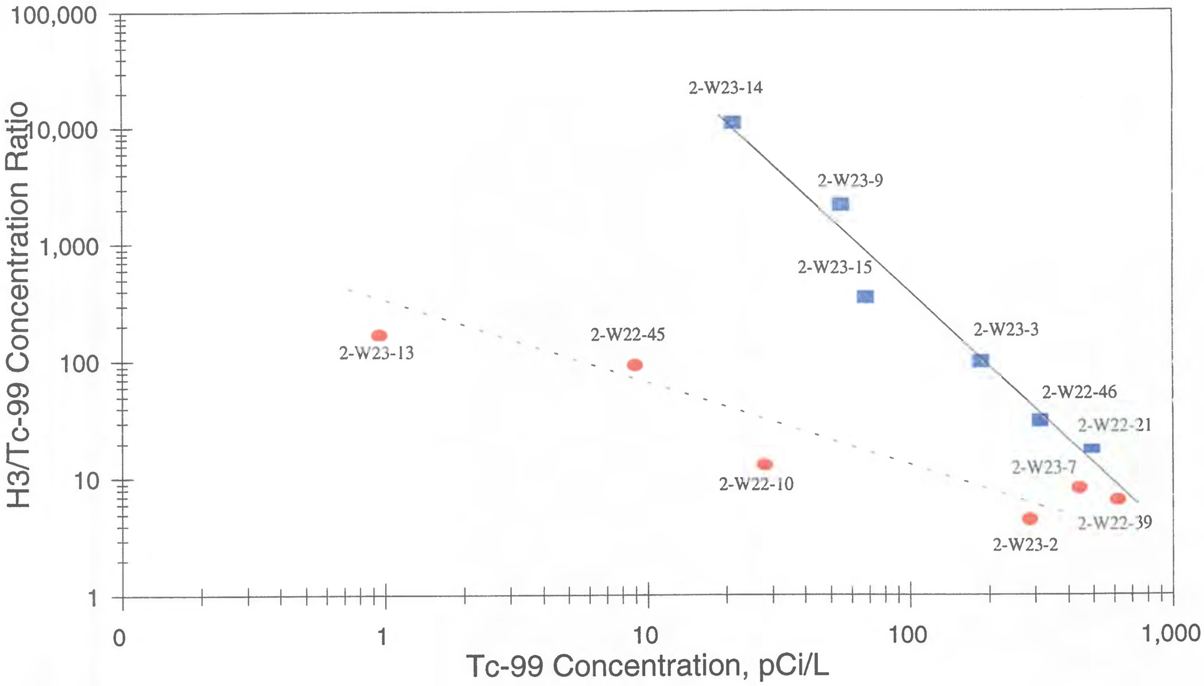

Figure 3.5. Tritium/Technetium Ratio versus Technetium Concentration in Selected Wells (data shown are the 1996 average values for 12 wells in the immediate vicinity of WMA S-SX. See Figure 1.2 for specific well locations. The two straight lines are a best visual linear fit to the data points. The data suggest there are two separate mixing regimes. One that starts with the northern upgradient RCRA well, 2-W23-13, and extends to downgradient wells in a southeasterly direction. This inferred mixing line begins with an upgradient source that has a technetium concentration of about l pCi/L and a tritium concentration of about 200 pCi/L. The other inferred mixing line begins with the south upgradient RCRA well, 2-W23-14, and a ratio of about 10,000 and appears to be associated with a mixing line consisting of data from wells at the south end of the WMA. The spatial relationship of the wells indicated along the inferred mixing lines above are consistent with inferred flow directions discussed in Section 3.6. If the technetium in downgradient wells originated from an upgradient source containing both tritium and technetium, the ratios should not vary significantly along an inferred flow path even though concentrations may vary. As illustrated by the solid mixing line above, the ratios decline by three orders of magnitude as technetium concentrations increase by nearly three orders of magnitude. Also, both mixing lines seem to converge at a ratio in the range of 1 - 10, a range consistent with a WMA S-SX tank waste or related source).

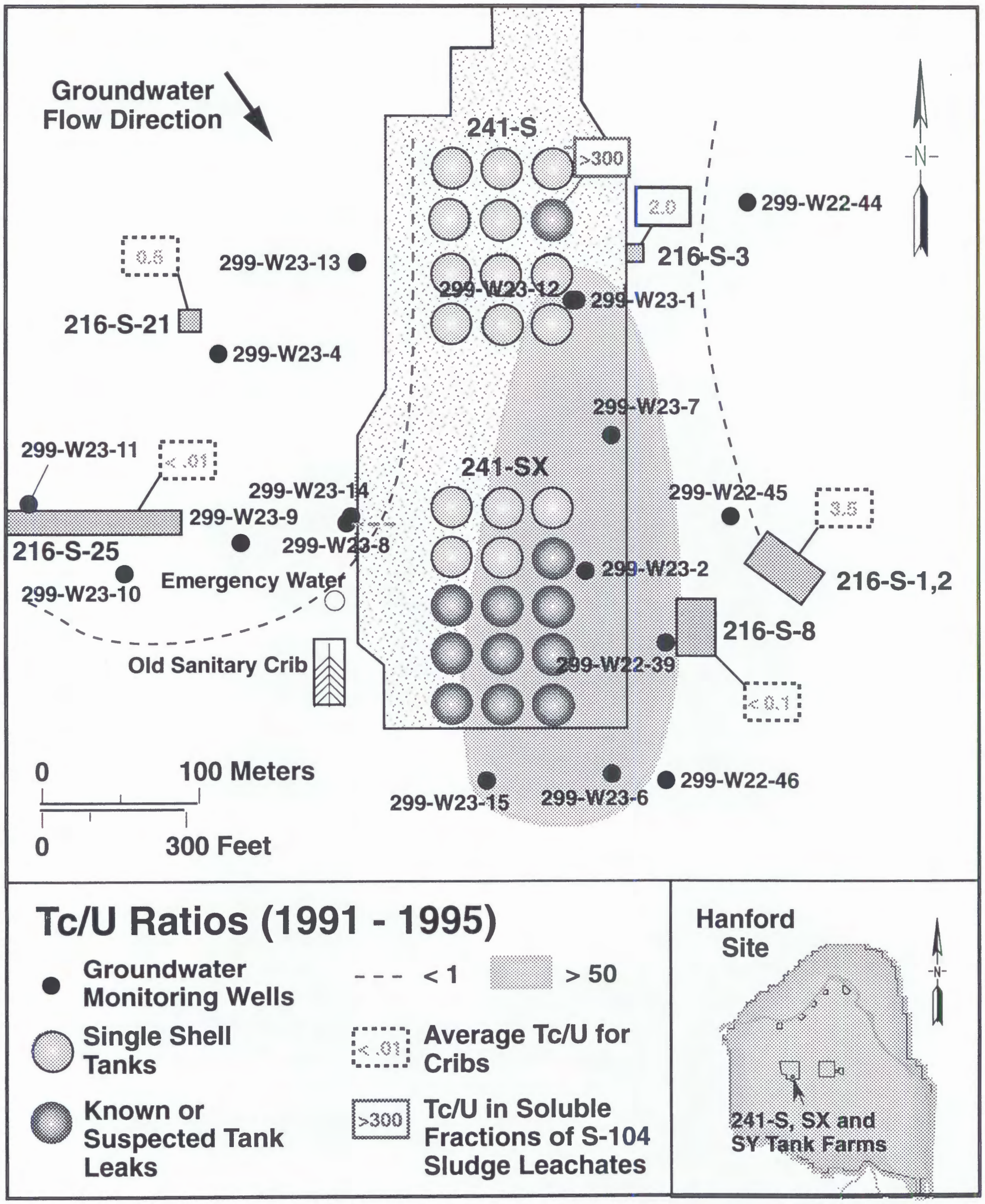

Figure 3.6. Technetium/Uranium Ratio in Groundwater Near WMA S-SX

3.5 Depth Variations

The occurrence of technetium-99 in well 2-W22-46 during 1997 offered an opportunity to examine variations with depth. A Hydrostar pump was set at about 1 ft (0.3 m) below the static water level in order to determine if concentrations were higher near the top of the aquifer as compared to the normal sample depth at 5-7 ft (1.5-2.1 m) below the static water level in the well. Table 3.1 shows a comparison of constituents of interest at two different sample pump depths.

3.5.1 Depth Relationships

There is very little difference in concentrations of constituents sampled from the very top of the aquifer as compared to the normal depth. However, because of the declining water table, due to termination of local discharges to the ground in 1995, the available monitoring wells at S-SX have less than 10 ft (3 m) of water remaining in them. New wells would be needed, or existing wells extended, to more fully evaluate distribution with depth in the upper aquifer and to replace wells that go dry.

3.5.2 Compositional Relationships

It is also noteworthy that cesium-137 and strontium-90 were undetected in the same samples (unfiltered) in which the mobile tank waste constituents are relatively high (Table 3.1). This is consistent with the expected differences in mobilities (Kds) for cesium, strontium, and technetium. The activity ratio of technetium-99 to cesium-137 or technetium-99 to strontium-90 in the soluble fraction of tank waste is on the order of 0.0001 and 0.01, respectively (Agnew 1997). That technetium-99 concentrations of up to 5,000 pCi/L were observed in well 2-W22-46 while cesium-137 and strontium-90 were undetected, suggests that if high salt waste liquor in WMA S-SX is the source of technetium-99 in well 2-W22-46, then significant fractionation of the radioactive components has occurred in the soil column and/or aquifer, as depicted in the conceptual model (see Section 2.0). If cesium were completely mobile, Kd = 0, the expected concentration in groundwater containing 5,000 pCi/L of technetium-99 would be:

$$\text{Cs-137} = C/R = (5{,}000\ \text{pCi/L})/0.0001 = 5*10^7\ \text{pCi/L}$$

where C is the observed technetium-99 concentration in groundwater and R is the ratio of technetium-99/cesium-137 in tank waste. Migration rates for cesium-137 and strontium-90 are expected to be significantly slower than for technetium-99 based on laboratory sorption studies (Serne et al. 1997). However, if sorption of cesium and strontium are greatly reduced, or are essentially not adsorbed due to the chemical matrix of the tank liquor, and/or there is a short circuit pathway to groundwater (Section 3.7), very high concentrations of cesium-137 and or strontium-90 should be observed in groundwater along with the technetium-99.

Whatever the pathway or initial and final sorption conditions, the above considerations indicate that the net effect is for significant retention of cesium-137 and strontium-90 in the vadose zone and/or on aquifer solids.

Also, based on the data in Table 3.1, either the “zero” cesium sorption conceptualization is incorrect, or the WMA is not the source of observed technetium-99 and other mobile tank waste contaminants in groundwater. However, the latter seems unlikely in view of the tritium/technetium-99 ratio pattern illustrated in

Table 3.1. Effect of Sampling Depth on Constituent Concentrations at Well 2-W22-46 (May 1997)

Constituent (Units of Measurement)	Sampled Depth	
	Shallow[a]	Normal[b]
Radionuclides[c] ^{3}H (pCi/L)	65,200 ± 4,940	NA
^{99}Tc (pCi/L)	4,280 ± 473	5,020 ± 558
^{90}Sr (pCi/L)	-0.05 ± 0.18	0.20 ± 0.22
^{129}I (pCi/L)[d]	NA	0.47 ± 0.42
^{137}Cs (pCi/L)	3.21 ± 2.52	-0.83 ± 4.92
U (μg/L)	NA	4.56 ±1.01
Gross Alpha (pCi/L)	2.65 ± 1.15	2.27 ± 1.76
Chemical Constituents (filtered) NO_3 (μg/L)	46,500	52,200
CrO_4 (μg/L)[e]	35	39
Cl (μg/L)	3,450	3,550
SO_4 (μg/L)	14,900	14,400
Al (μg/L)	97.1B	20.1U
Na (μg/L)	25,900	25,600
K (μg/L)	3,400	5,060
Ca (μg/L)	26,100	25,800
Mg (μg/L)	8,520	8,380

(a) Pump intake was set at 1 ft below the static water level in the well.
(b) Pump intake was set at 5-7 ft below the static water level in the well.
(c) Reported values are measured results ±2 sigma counting errors for unfiltered samples.
(d) Previous measurements in other monitoring wells in the vicinity of WMA S-SX also indicate non-detectable iodine-129. This is consistent with tank waste samples from SX tank farm. For example, using a median observed tank waste $^{99}Tc/^{129}I$ ratio of 10,000, the expected iodine-129 concentration in the above sample would be: (5,020 pCi/L)/(10,000) = 0.5 pCi/L. Thus even though it should be present as a mobile co-contaminant, it was not detectable.
(e) Reported as elemental chromium.
U = Non-detect; the value shown is the vendor method detection limit.
B = Analyte concentration below contractual quantitation limit but above method detection limit.
NA = Not available.

Figure 3.5 and other indicators discussed above. Alternatively, there could be an initially low or zero cesium Kd near the release point, followed by a higher Kd (Ward et al. 1997) as the salt matrix is diluted in the pore fluid by infiltration of precipitation or by groundwater after the hypothetical waste liquor enters the aquifer. Direct observation of pore fluids in soil column samples beneath a leak site are needed to help resolve this issue.

It should also be noted that gross alpha results for the samples (unfiltered) from well 2-W22-46 shown in Table 3.1 were at natural background levels (2 - 3 pCi/L) typical for the Hanford Site (see Appendix B discussion). Thus transuranic alpha emitters are not expected to be present at concentrations above the 4 mrem/yr equivalent drinking water standard (1 pCi/L).

3.6 Flow Direction

Variation in inferred flow direction was evaluated using the three point problem approach on several combinations of wells in the S-SX network, including some older wells for which water level data were available. The overall mean and standard deviation over the time period of 1992 to 1997 among all well combinations used is 116 ± 12.6° (to the southeast). Thus, a general flow direction from northwest to southeast is inferred (Figure 3.7). The values for the south end of SX farm are somewhat lower (104 ± 5°), suggesting a possible localized shift to a more easterly direction in this area. More precise water level measurements and/or some real time water level measurements to allow for barometric changes could enhance the reliability of inferred flow directions. Nevertheless, the general southeasterly flow indicated is consistent with expectations based on water table contours and general direction of contaminant plumes in this area.

Previous interpretations (Connelly, Ford, and Borghese 1992) of flow direction, groundwater flow velocity, and hydraulic conductivity (Figure 3.8) are consistent with the preliminary indications noted above. For example, a very low hydraulic conductivity is shown (based on limited slug test data) in the vicinity of the south end of the SX farm. This could act as a leaky barrier to groundwater flow, resulting in diversion of groundwater to the south around the low permeability zone and then in a more easterly direction. Contaminants from overlying vadose zone sources that enter the low hydraulic conductivity portion of the aquifer would migrate very slowly (<25 m/yr, based on Figure 3.8 time markers). The highly variable hydraulic conductivity for the Ringold Formation illustrated in Figure 3.8 is attributed to differential cementing. This feature of the unconfined aquifer must be kept in mind when considering localized groundwater flow direction and velocity in the 200 West Area. That is, because of the anisotropy in the aquifer, flow directions can deviate from expected or inferred water table elevations alone.

3.7 Stratigraphy and Vadose Zone Contaminant Distribution

Sedimentary structures play a significant role in both the movement of contaminants through the vadose zone and in controlling the distribution of natural and artificial sources of water that can mobilize contaminants. The implications of stratigraphic conditions beneath WMA S-SX summarized in this section are based on geologic and stratigraphic interpretations presented in Appendix A.

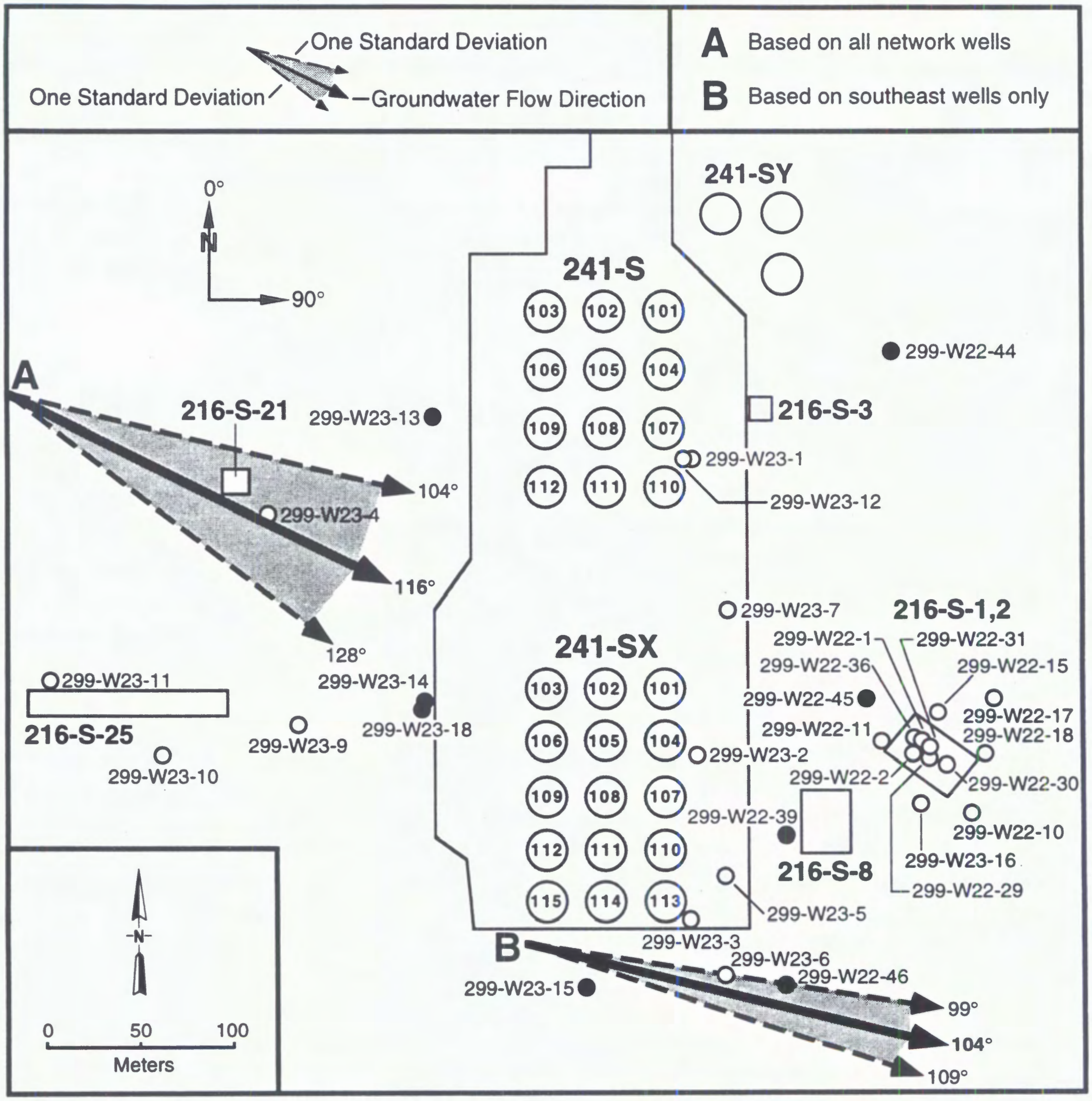

Figure 3.7. Flow Directions Based on "Three-Point" Solutions Near WMA S-SX (values were averaged over the time period 1992-1997)

3.7.1 Contaminant Distribution in Relation to Stratigraphic Units

The distribution of cesium-137 is a useful indicator of subsurface distribution of tank waste and related contaminants in the tank farms. Although mobile constituents not detected by spectral gamma logging may have migrated to greater depths, the distribution pattern of cesium-137 indicates the approximate location and spreading of the initial liquid waste.

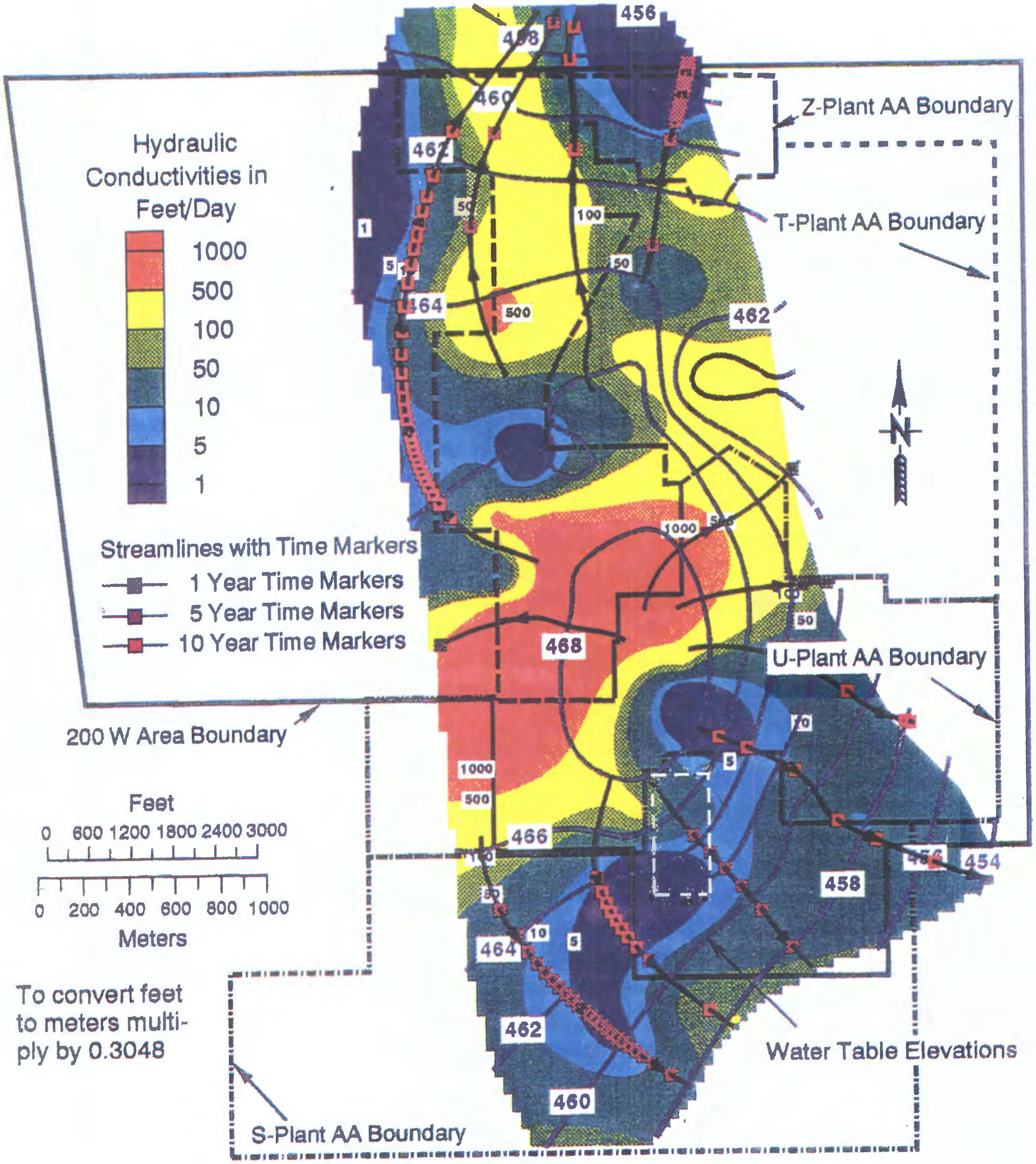

Figure 3.8. Hydraulic Conductivity in the 200 West Area (from Connelly et al. 1993; water table elevations in feet, shown as blue contour lines, and inferred flow directions or streamlines, in red, are based on 1991 data. WMA S-SX is located within the dashed white rectangle in the colored area at the bottom of the figure.)

The depth distribution of cesium-137 based on spectral gamma logging (DOE 1996, DOE 1997, DOE 1998) is shown in relation to stratigraphy for the S and SX tank farms (Figures 3.9 and 3.10, respectively). The cross sections suggest that most of the cesium-137 is located above a gravel and sand-silt sequence that occurs at depths of 20 to 50 ft (6.1 to 15.2 m) below the tank base elevation on the west side and at depths of 10 to 30 ft (3 to 9.1 m) below the tank base on the east side of the SX tank farm (Figure 3.10). The same gravel and sand-silt sequence appears to intersect the tank base elevation along the east side of the S tank farm (Figure 3.9).

A new borehole near SX-109 (41-09-39) was gamma logged down to 130 ft (40 m) below surface and then cored and sampled to groundwater (64 m). The spectral gamma log indicates cesium-137 at the 130 ft (40 m) level, but at concentrations 1,000 to 10,000 times lower than maximum concentrations (DOE 1997) that occur above the gravel sequence. Preliminary results (Jeff Serne, personal communication) suggest that little if any cesium-137 attributable to migration through the formation occurs below the 135 ft (41 m) depth. Mobile constituents (e.g., technetium-99) are also surprisingly low to absent in the deeper sections of the core. Initial groundwater samples at the top of the aquifer, collected as part of this impact assessment, indicate hexavalent chromium is non-detectable (<10 µg/L). As indicated in section 2.0, hexavalent chromium is a mobile co-contaminant present in S-SX tank farm waste. This observation is also consistent with the gross beta results for samples collected during purging for the development of the temporary well. The mean of 10 results for samples collected 1/13/98 was 16.6 ± 4.0 pCi/L. This is within the range of Hanford Site natural groundwater background for gross beta. Thus technetium-99 (a low energy beta emitter) or strontium-90 and cesium-137 (both beta emitters), if present, must be at very low concentrations. The corresponding mean value (2.3 ± 0.7 pCi/L) for gross alpha was also within natural background range for Hanford Site groundwater. Thus the alpha emitting transuranic radionuclides of interest (neptunium-237, plutonium-239, and americium-241) must be less than 1 pCi/L (the 4 mrem/yr equivalent drinking water standard).

Initial tank waste technetium-99 concentrations and predicted pore fluid concentrations (Ward et al. 1997) at the water table beneath SX-109 exceed 10,000,000 pCi/L. Thus even allowing for dilution at the water table, much higher hexavalent chromium and estimated technetium-99 concentrations should be observed if the main mass of a leak reached and is draining to groundwater. These observations suggest that either most of the waste volume leakage from SX-109 is still in the vadose zone, or that the borehole missed the path that the waste took to groundwater. The likelihood of encountering contaminant breakthrough to groundwater was enhanced by pumping a relatively large volume of water. For example, a volume of 5,000 liters was pumped from a 3-m screened interval. Thus the estimated capture zone covered an area of 10 - 20 m^2 (assuming an effective porosity of 0.1 for the cemented Ringold formation in which the aquifer occurs).

3.7.2 Stratigraphy and Potential for Lateral Movement of Water

As indicated in (Figure 2.1), adjacent sources of water could potentially come in contact with waste sources within the WMA by lateral migration along stratigraphic features. This possibility was evaluated by examination of stratigraphy near the major subsurface soil contamination sites (Figures 3.9, 3.10, and Appendix A). Figures 3.9 and 3.10 suggest that both the near-surface gravel layer and the deeper gravel layer that are underlain by finer textured sediments could act as conduits for lateral transport of water into the tank farm. One area where this could be especially significant is near Tank S-104 where the gravel unit and excavated (or disturbed) area coincide with the waste zone beneath the tank. Along the west side of the SX tank

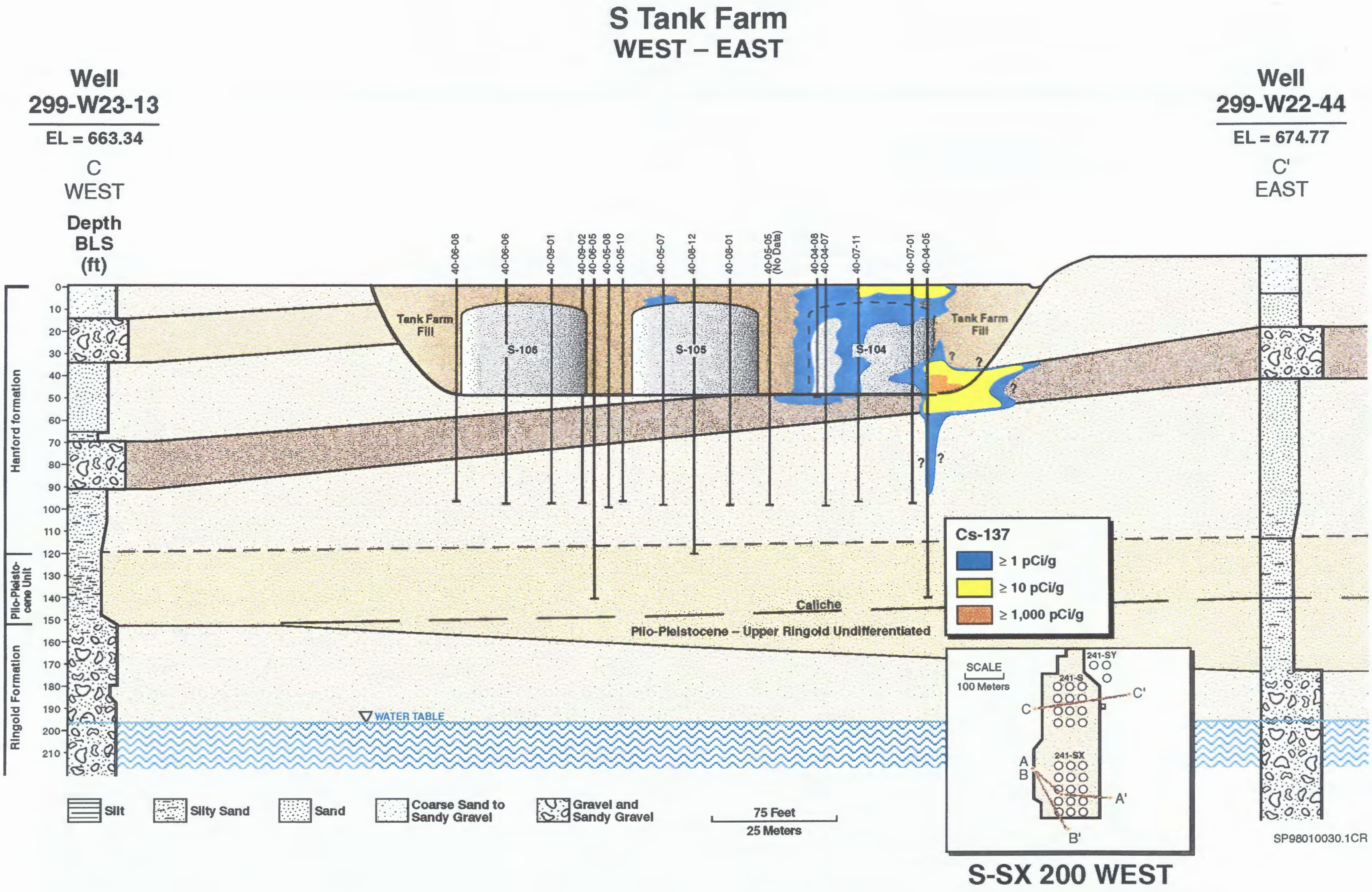

Figure 3.9 Stratigraphic and Cesium-137 Correlations for a West - East Cross Section in the S Tank Farm (based on interpretations presented in Appendix A).

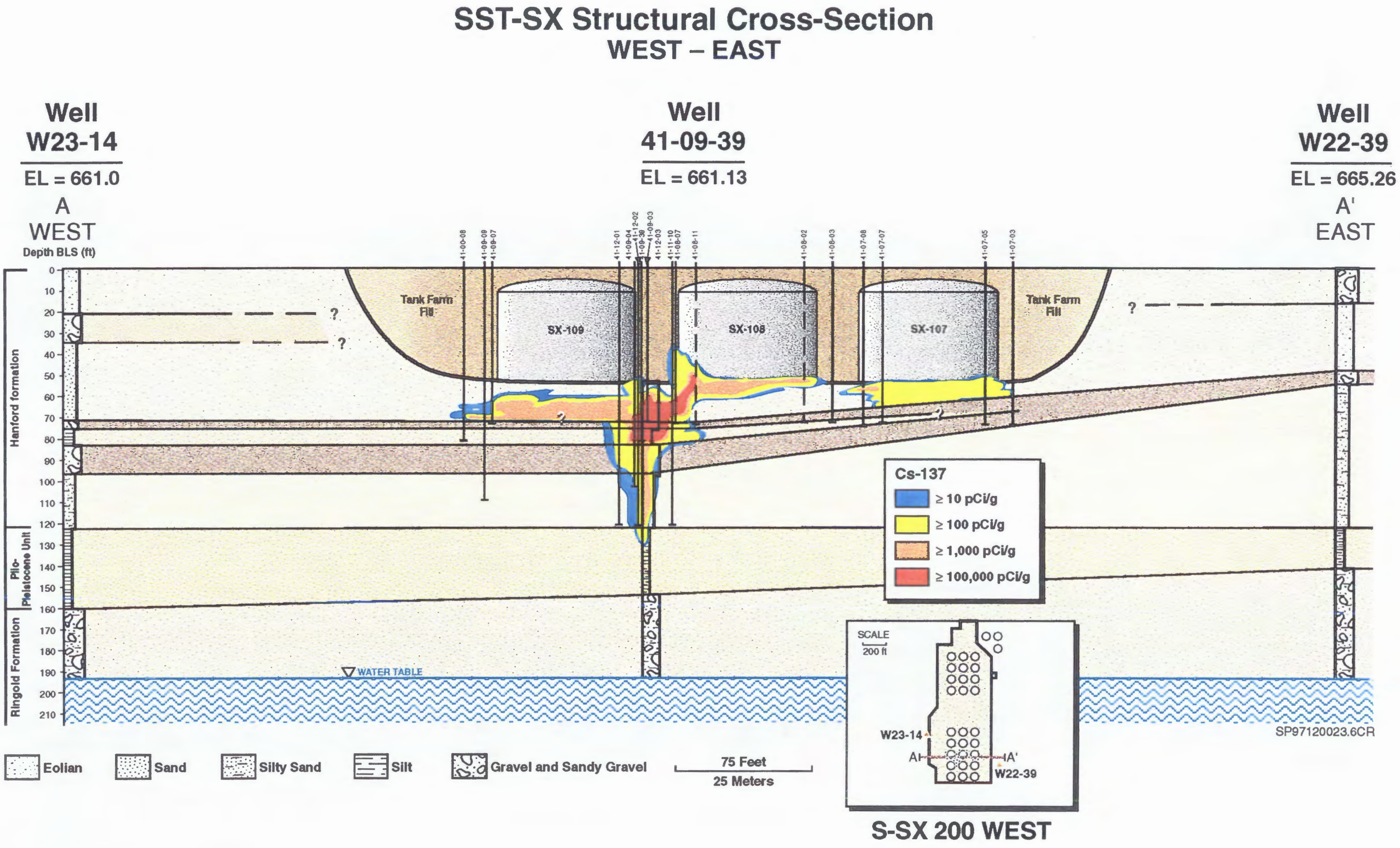

Figure 3.10. Stratigraphic and Cesium-137 Correlations for a West - East Cross Section in the SX Tank Farm (based on stratigraphic interpretations presented in Appendix A)

farm, (see Appendix A) fine sediment layers occur beneath gravel and sand layers but do not appear to be continuous (west to east) across the tank farm. Where they do occur, they could serve as perching layers that could facilitate horizontal movement of water.

A second area of potential enhanced infiltration is at the south end of SX farm, where one of the gravel units occurs just beneath the tank base elevation. One of the largest tank leaks in the WMA occurred in the southwest corner of the SX tank farm at tank SX-115. In the area immediately adjacent to the southwest corner is a large barrow pit that can accumulate surface runoff. In addition, an old water line passes through this area. Both the pit and the water line are located over the excavated (or disturbed) zone created when the single-shell tanks were constructed.

A similar potential surface water infiltration condition exists along the east side of the S tank farm. A bank slopes inward toward the farm and creates a depression running parallel (north to south) to the tanks. Surface runoff from snow melt and accidental sources of water can accumulate in this location. This possibility was demonstrated in September 1996 when a 14-in. water main separated nearby releasing 500,000 gallons (1,900,000 L) of water in less than an hour. The water flowed into the northeast side of S tank farm and ponded in the depression at the base of the slope. Accumulation of water (from snow melt) in depressions within the central area of S tank farm have also been observed. Lateral conduits of water beneath the tanks would enhance the likelihood of intersecting vertical features, such as clastic dikes, discussed in the following section.

3.7.3 Vertical Movement of Water

The textural variations in both the backfill and the sedimentary layers beneath the disturbed zone can influence the amount and timing of natural infiltration in the tank farm. The gravel surface enhances infiltration; and runoff from the domed tank structures (for example, due to snow melt events) can direct water along the outer walls down to the tank base (illustrated in Figure 2.1).

The enhanced infiltration described above could be partially offset by a combination of stratigraphy and decay heat. For example, decay heat may cause redistribution of an unknown amount of the soil moisture in the tank farms (Ward et al. 1997). Although the magnitude of this potential effect is unknown, the moisture profile (Appendix A) for the new borehole (41-09-39) near SX-109 suggests moisture contents from the surface to groundwater near tank SX-109 are not noticeably greater than observed for adjacent RCRA monitoring wells.

Preferential vertical pathways through the vadose zone have been suggested (DOE 1997) as potential short circuits to groundwater. Clastic dikes are common in the vicinity of the WMA. These vertical structures occur as polygons with cell dimensions somewhat larger than the diameter of a single-shell tank. Clastic dikes are typically near-vertical tabular fissures filled with multiple layers of unconsolidated sediments. The grain size of the layers vary from fine to coarse and are typically separated by clay-silt linings. Although clastic dikes typically are not continuous from the surface to the water table, they are common in all pre-Holocene sediments. Clastic dikes could act in combination with horizontal layers to provide a "stair-step" pathway to the water table as depicted in (Figure 2.1).

Because clastic dikes are vertical, the probability of encountering them with a vertical borehole is small. However, based on the known occurrences in the 200 West area and vicinity, the likelihood of their presence near vadose zone contamination sources in the S and SX tank farms is relatively high.

Faults, fractures and joints are structural discontinuities that can also provide potential vertical pathways to groundwater. These features are most common in competent rock near the anticlinal ridges but are not confined to only these areas. Faults have been observed throughout the Pasco Basin but are typically sparse away from the major anticlines. Joints and fractures differ from faults in that there is no offset of layers but they are very common wherever competent, brittle deforming rock has undergone folding as in the Pasco Basin. The cemented rock of the Ringold Formation (lower gravel unit near water table in Figs. 3.9 and 3.10) and caliche layers of the Plio-Pleistocene unit are typically broken by fractures and joints. The uncemented Hanford formation and ductile clay-rich beds of the Plio-Pleistocene unit are probably less susceptible to joints and fractures. However, shrinkage of clay-rich beds as they dry out will produce abundant joints and fractures.

Faults, fractures and joints are difficult to detect by most drilling methods. Significant offset of layers by faults has not been found at or near the WMA. However, joints and fractures are nearly impossible to detect even when cored because drilling usually induces joints. It is highly probable that caliche zones and the cemented Ringold Formation are cut joints and fractures and are not impermeable zones.

3.8 Contaminant Breakthrough

As noted above, circumstantial evidence exists for vertical pathways that could allow tank waste contaminants to follow short circuit pathways to groundwater. The depth distribution pattern of cesium-137 shown in Figure 3.10 also suggests some type of vertical feature, possibly a preferential pathway, in the vicinity of the new borehole (41-09-39). Reduced sorption could occur because of chemical matrix or *competing ion* effects. Or because of coarse grained (low surface area) dike or fracture in-fillings that are less sorptive. Particle-bound contaminants (or colloids) could reach groundwater more readily via coarse grained vertical pathways as well. Surface water could provide the driving force for downward movement or a large volume leak itself may be adequate to over come interstitial forces.

Some initial modeling results (Ward et al. 1997) suggested that under extreme conditions (no sorption) cesium could reach groundwater along with the mobile constituents (chromate, technetium-99, and nitrate). Bulk movement of a large volume leak (simulated leak of 500 m^3 from tank SX-109) through the geologic strata reached groundwater within about 7 years and continued to drain for tens of years (Ward et al. 1997). As previously discussed, however, once the waste is diluted in ambient groundwater, sorption and retardation of cesium-137 and strontium-90 should occur. Thus groundwater monitoring wells would have to be very near the point of entry to detect cesium-137 and strontium-90. In addition, technetium-99 should be separated from the less mobile constituents and would be observed in downgradient monitoring wells long before either cesium-137 or strontium-90. For example, assuming a K_d of 10 and a groundwater flow rate of 50 - 100 m/yr, the strontium and cesium migration rate would be only 1 - 2 m/yr, under Hanford Site conditions. Thus if breakthrough occurred soon after the tanks were filled in the late 1950's, the example case suggests after 40 years (1958 - 1998) strontium-90 and/or cesium-137 would be about 40 to 80 meters from the point where they entered groundwater. Three or four older wells within the tank farms and at least one RCRA monitoring well are within this distance from hypothetical tank leak sources (Figure 1.2). Colloidal phases may be more mobile and could even be covariant with the mobile contaminants (nitrate, technetium-99, and chromate).

The observed patterns of technetium-99, cesium-137, and strontium-90 occurrences in WMA monitoring wells are discussed with the respect to the above considerations, as follows.

3.8.1 Technetium-99

Time series data for gross beta and a recent (1995) concentration contour plot of technetium-99 in the vicinity of the WMA are shown in Figure 3.11 in relation to locations. The gross beta is used here to illustrate time response patterns because it was measured more consistently and over a longer period than was technetium-99. The earliest technetium-99 measurements were made in 1986. Technetium-99 is typically about 2 to 3 times greater in magnitude than the gross beta in wells in the vicinity of the WMA (The low energy beta emissions from technetium-99 are less efficiently detected than the strontium-yttrium-90 beta source used for calibration). The corresponding technetium-99 concentration for the maximum gross beta in well 2-W23-1 was 8,250 pCi/L on 6/27/86 versus a gross beta concentration of 3,470 pCi/L. Since this same relationship holds in other samples from wells with transient technetium-99 occurrences (e.g., see data for well 2-W22-46, Appendix B), it seems safe to assume the earlier gross beta results used in Figure 3.11 can be attributed to primarily technetium-99. For example, if significant amounts of other mobile beta emitters such as ruthenium-106 had been present in the 1986 sample for well 2-W23-1, the technetium-99 to gross beta ratio would have been much smaller than 2 to 3.

It should also be noted that most of the data plotted for the wells shown inside the WMA (wells 2-W23-1, -2, -7, -3) are for samples collected with a bailer (no well purging prior to sample collection). There may be some lag effect between changes in ambient groundwater concentrations and the water inside the well bore in these cases. However, the fact that the concentrations change fairly rapidly over a 1-2 year period in these wells suggests the wells were in communication with the aquifer. The RCRA-compliant wells (i.e., 2-W23-15 and 2-W22-46 which are equipped with submersible pumps and purged prior to sampling) exhibit transient technetium-99 concentrations that are similar to those observed in the older bailed wells. Nevertheless, efforts are underway to have permanent pumps installed in the old wells inside the S and SX tank farms.

With the sampling conditions noted above in mind (e.g., a possible lag effect or broadening in the time-concentration plots for the bailed wells), Figure 3.11 indicates short-term transients occurred in the mid-1980s in the S farm and at later dates farther to the south-southeast and at the southwest corner of SX tank farm. While variable in magnitude, the transients seem to occur over a 1-2 yr time period, but at different times from 1985 to the present. It is also noteworthy that technetium-99 is trending upward once again in well 2-W23-1 located in the S tank farm (the most recent results for duplicates collected in August, 1997 were 1,200 and 1,500 pCi/L (Appendix B) compared to 180 pCi/L in 1996 and the 1986 maximum of about 8,200 pCi/L.

The observed time response patterns (Figure 3.11) suggest a similar transport mechanism is involved for the transient occurrences, but at different times and, at least in one case (well 2-W23-1), is apparently recurrent.

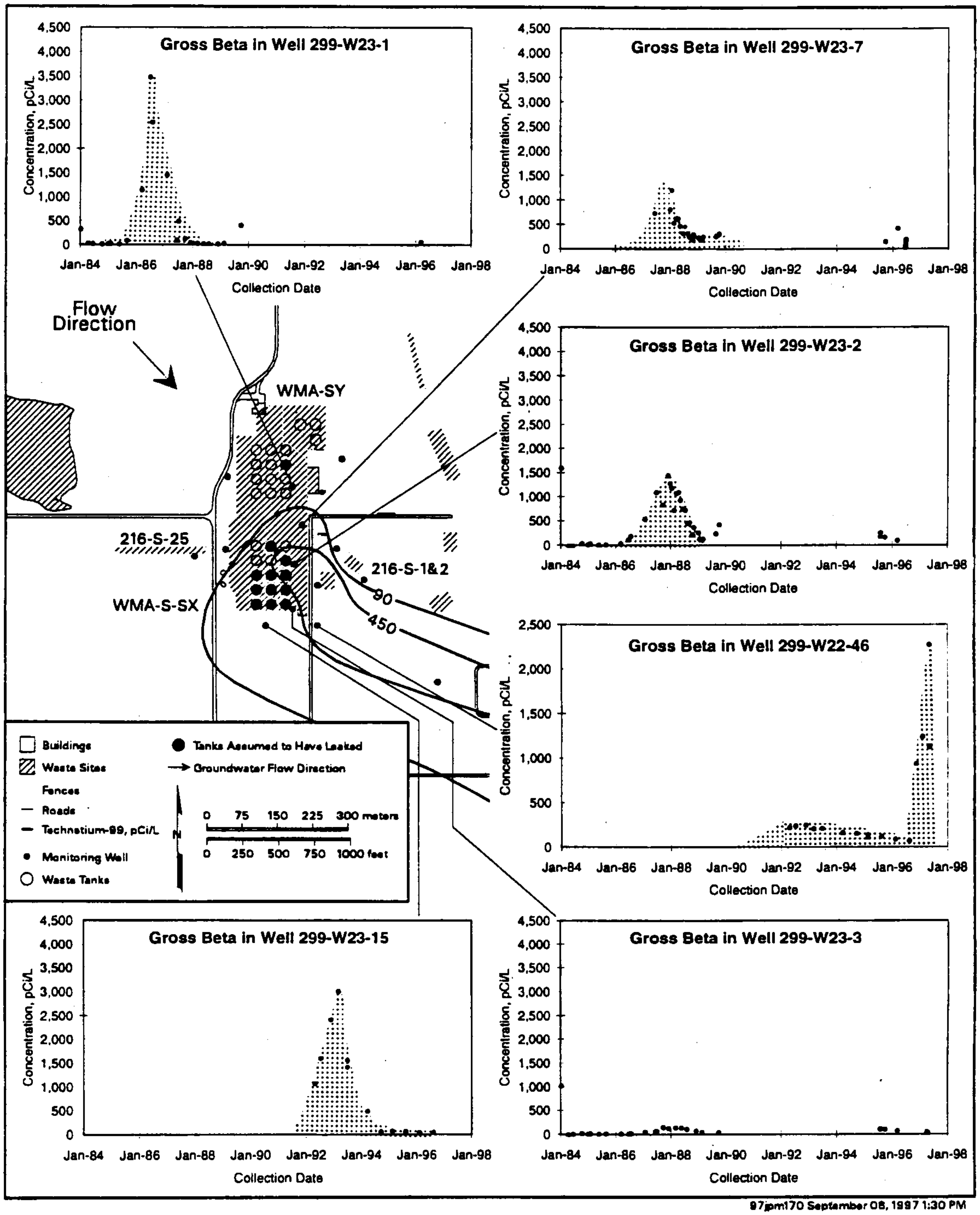

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Figure 3.11. Technetium-99 Plume (1995) and Gross Beta Time Series Plots in Selected Wells Near WMA S-SX (Technetium-99 concentrations are approximately two to three times the gross beta concentrations in these wells.)

3.8.2 Cesium-137 and Strontium-90

Cesium-137 was detected in only one well (2-W23-7) which is at a location that is not immediately adjacent to any major or known tank leak or spill (underground waste transfer line leaks, however, cannot be ruled out as potential adjacent source). Low level counting methods were used to quantify the low concentrations (~10 to 14 pCi/L) that were associated with a particulate phase (based on the difference between filtered and unfiltered samples [Table 3.2]).

Spectral gamma logging of well 2-W23-7 indicated a formation cesium-137 concentration of 1 pCi/g or less both above and within the perforated (saturated) interval of the well (John Brodeur, personal communication, 1997). The equivalent cesium-137 per gram of solids filtered from the water sample was approximately 100 pCi/g. This isolated occurrence of cesium-137 observed in groundwater may be because of contamination of the well during maintenance or sampling activities (i.e., during sealing attempts, fugitive tank farm particulates, inflow of surface contamination during snowmelt runoff into the well at the surface). The particle-bound cesium in the bottom of the well, or on the interior surfaces of the casing, probably was resuspended by the temporary installation of the bladder pump used to obtain the samples for this assessment.

Table 3.2. Cesium-137 Results of Unfiltered and Filtered Samples Obtained From 2-W23-7

	Results (pCi/L) ± 2σ counting error	
Sample Date	Unfiltered	Filtered (0.4 μm)
06/19/96	10.4 ± 3.4	1.0 ± 1.1
06/25/96	13.8 ± 2.8	2.0 ± 1.7

Strontium-90 was also detected in only one well, 2-W23-7, the same well where cesium-137 was detected. A concentration of 6.2 ± 1.6 pCi/L (unfiltered) was reported for March 1996. This sample was collected with a bailer (i.e., no purging prior to sample collection). A temporary sample pump was installed in June 1996 and two sets of filtered and unfiltered samples collected as described for the cesium-137 (Table 3.2 and see Appendix B). In the latter case, unfiltered and filtered results for strontium-90 (6/25/96 sample) were 1.7 ± 0.9 pCi/L and 0.9 ± 0.5 pCi/L, respectively. The apparent decline in strontium-90 between 3/96 and 6/96 may in part be due to the well purging conducted. Nevertheless, the lower concentrations obtained for 6/25/96 are above the detection limit based on periodic measurement of blanks (Appendix B, Table B.3), and about two times the 2 sigma counting error associated with the individual determinations. Thus the analytical results are judged to be positive detections. Although this occurrence may be associated with internal well contamination, as discussed for cesium-137, the positive detection in the filtered sample result suggests there may be some strontium-90 in solution (fraction passing through a 0.4 μm membrane filter).

Well 2-W23-7 is about 125 m downgradient from tank S-104, the location in the S tank farm with the greatest subsurface contamination (based on spectral gamma logging, DOE 1998). Other sources of contamination between the S and SX tank farm (e.g., transfer lines) would be potentially closer to the well. Whether this represents breakthrough from the vadose zone and transport in the aquifer to well 2-W23-7, or is related to well construction (old well that was originally unsealed), cannot be determined at this time. Additional investigation of this occurrence is needed to resolve this uncertainty.

Except for the one well discussed above, the general absence of cesium-137 and strontium-90 in groundwater observed to date (Appendix B), and their absence where high technetium-99 concentrations have recently occurred (i.e., well 2-W22-46, see Table 3.1), implies these two tank waste components are much less mobile than technetium-99 in groundwater beneath WMA S-SX. Also, if there were a significant colloidal phase that travels with the technetium-99, the unfiltered sample results (Table 3.1 and Appendix B) for the well with maximum technetium-99 (2-W22-46) should have accounted for this hypothetical phase. Of course, this does not rule out colloids that move more slowly than technetium-99. Given the wide range in timing of technetium-99 transients, however, colloidal cesium-137, if present, should have been detected in unfiltered samples in at least some of the wells (e.g., in well 2-W23-1 where technetium-99 recently reappeared [see Appendix B] 11 years after the first observed transient peaked in 1986).

4.0 Discussion

Presumptive evidence presented in Section 3.0 indicates a source or sources of groundwater contamination exists (or existed) within WMA S-SX. If so, possible source locations should be consistent with temporal and spatial distributions of groundwater data, and a plausible driving force is needed to account for the movement of contaminants through the vadose zone to groundwater. Three possible scenarios are discussed in this section.

4.1 Temporal and Spatial Considerations

As part of groundwater quality assessment investigations conducted during Phase I, an attempt to correlate possible source locations to observed groundwater data and known dynamics is made. For this purpose, three scenarios are considered:

1. a single (northern) source to account for all groundwater occurrences of technetium-99 and mobile co-contaminants
2. a combination of (1) plus a source at the far southern end of the SX farm
3. addition of a third source to (2), consisting of the area identified with the greatest depth distribution of cesium-137 in the S-SX tank farms (in the vicinity of tanks 108, 109, 111).

4.1.1 Scenario 1 (Single Source)

Previous contours of contaminant ratios and concentrations suggested that a source in the S tank farm area that was carried south through the WMA might account for the observation that technetium-99 seemed to "peak" here first and then later in wells to the south. While this would require a flow direction contrary to the inferred direction, preferential (lateral) flow through the aquifer is possible. The primary problem with this pathway is the timing of the peak technetium-99 occurrence in well 2-W23-15 on the southwest corner of the SX farm in 1993 and then the very recent occurrences in well 2-W22-46. These two dates make it impossible for a single path flowing north to south to intersect all the wells sequentially. In other words, a temporal discontinuity exists in a path that must pass all the wells in which technetium-99 has occurred.

4.1.2 Scenario 2 (Two Sources)

In this scenario, two sources are postulated, one at the far south end of the SX farm (from the vicinity of tanks SX-114 and SX-115, [WHC 1992c]) and the same northerly source area considered in scenario 1. For the latter, the plume path deviates from a southerly flow to a southeasterly direction to accommodate the occurrences of technetium-99. These hypothetical plume paths and source areas are illustrated in Figure 4.1. Also plotted are the approximate dates of technetium-99 (and/or gross beta) maxima. Arrival times of technetium-99 (or gross beta) maxima, assuming a single source in S farm, between wells 2-W23-1, 2-W23-7 and 2-W23-2 seem reasonable based on estimated flow rates for this area (approximately

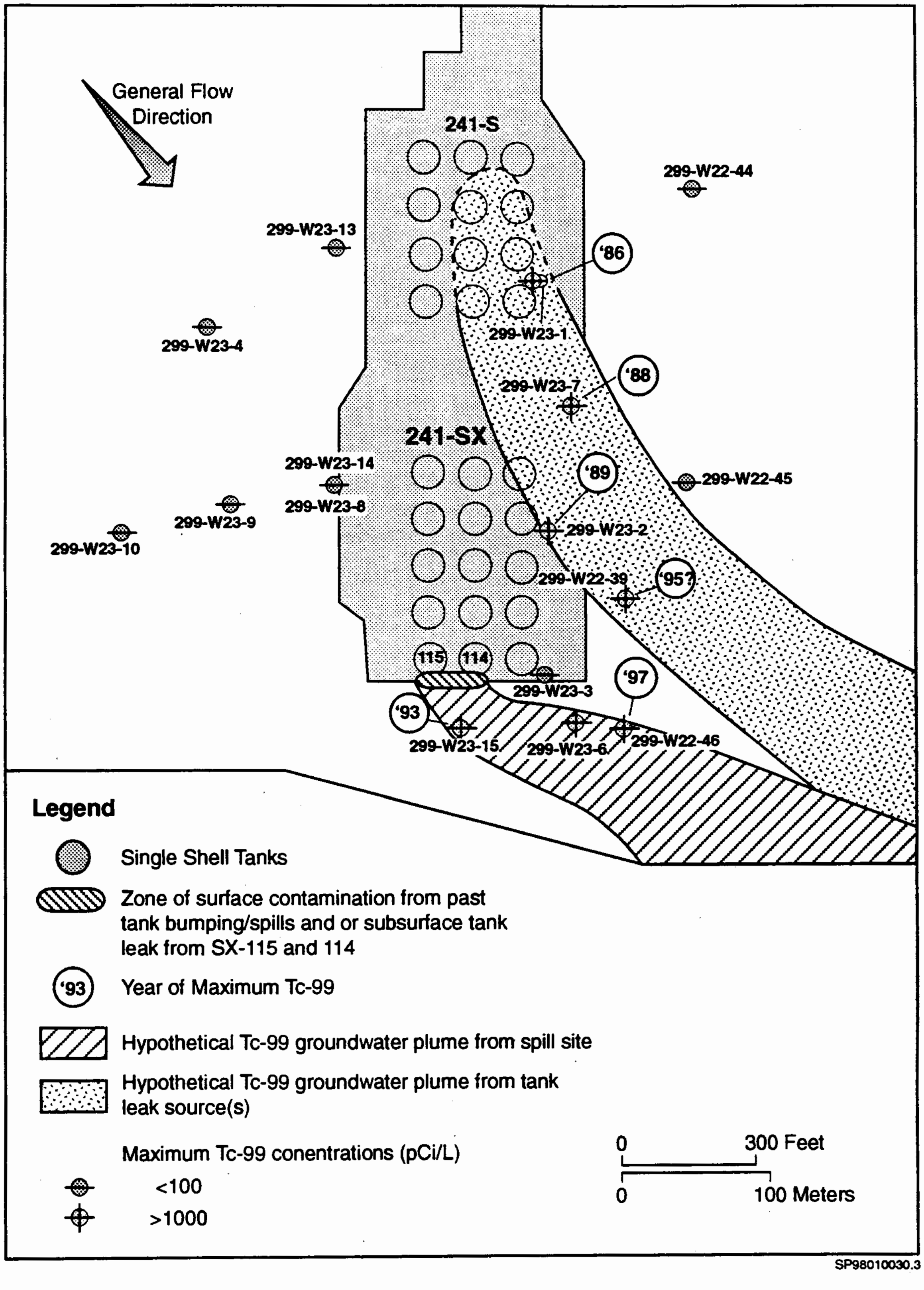

Figure 4.1. Spatial and Temporal Correlation of Observed Technetium-99 in Groundwater and Possible Contaminant Source Areas in WMA S-SX (1986-1997)

25 - 50 m/yr). The last well in the hypothetical flow path, 2-W22-39, however, is inconsistent with a flow rate of 25 - 50 m/yr, if all four monitoring wells must intercept the same source.

With a hypothetical plume path originating in the southwest corner of the WMA the observed technetium-99 occurrences in wells 2-W23-15, 2-W23-6 and 2-W22-46 are both spatially and temporally consistent. For example, the distance between wells 2-W23-15 and 2-W22-46 is about 125 m. The indicated travel time of the technetium-99 peak between the two wells is approximately 5 years or 25 m/yr (assuming the sharp upward trend in 2-W22-46 will peak in 1998). This estimated flow rate is consistent with the very low hydraulic conductivity in this area (see Figure 3.8).

4.1.3 Scenario 3 (Three Sources)

This scenario is based on the assumption that the location of greatest depth of elevated vadose zone cesium-137 in the S-SX farms (DOE 1997; WHC 1992a,b) is indicative of a groundwater source of technetium-99. This scenario is illustrated in Figure 4.2 along with the SX-114-115 hypothetical source.

Based on the inferred southeasterly groundwater flow direction, a source originating in the vicinity of tanks SX-108-109-111 should be intercepted by well 2-W23-3. It seems inconceivable that a flow path from the subject source could bypass well 2-W23-3 and still reach wells 2-W23-6 and 2-W22-46 or 2-W22-39, except for the following possibility.

The observed occurrences can be explained if the plume path originating from the vicinity of SX-109 has shifted slightly more to the north so that it misses wells 2-W23, 2-W23-6, and 2-W22-46 (shown as path 2 in Figure 4.2). This could happen if groundwater flow direction shifted from southeasterly to easterly as suggested by the three-point solutions described previously. The lower or southerly plume path (path 1 in Figure 4.2) could account for the occurrences in 2-W23-15, 2-W23-6, and 2-W22-46 as previously described for Figure 4.1.

Thus, it may be necessary to invoke three separate source areas to accommodate the observed complex spatial and temporal distributions of technetium-99 for the WMA S-SX. If the three separate source areas are responsible for observed groundwater contamination patterns in the S-SX area, multiple driving forces at different times are needed to explain the concentration history of technetium-99 and co-contaminants in vicinity groundwater, as discussed in the following section.

4.2 Driving Force Considerations

Potential driving forces for carrying contaminants to groundwater include 1) waste volume and tank-related factors (leak volume, fluid density, and enhanced infiltration/roof runoff), or 2) ponding and infiltration of surface runoff from utility line ruptures or leaking water lines and 3) natural infiltration events.

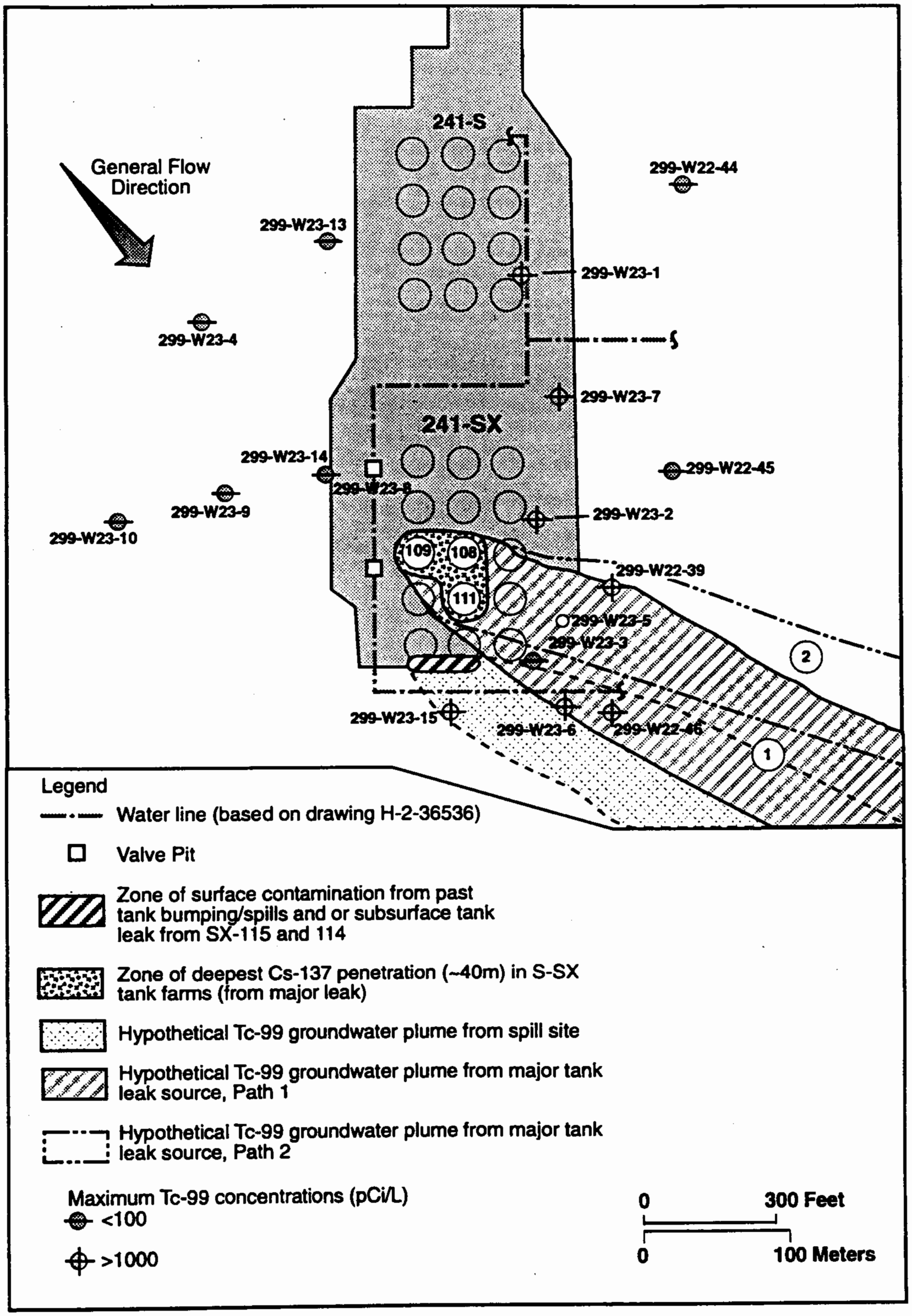

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Figure 4.2. Hypothetical Groundwater Plumes Beneath Major Known Vadose Contamination Zones in the SX Tank Farm

4.2.1 Waste Volume and Tank Related Factors

As previously discussed, the large volume, high density waste liquor scenario used by Ward, Gee, and White (1997) to model the SX-109 tank leak predicted the flux of mobile contaminants to groundwater should continue over a very long period. This implies that a slow but continuous downward trend in contaminant concentration versus time should be observed in downgradient wells from such sources. The driving force in this case is the enhanced infiltration (10 cm/yr annual average) because of: 1) the devegetated and graveled tank farm surface and runoff from the domed roof of the tanks; 2) the high tank liquor fluid density; and 3) the volume of the leak.

There is evidence at other 200 West waste disposal sites that long-term drainage of large volume, high density fluids does occur under Hanford (200 West Area) conditions. Piepho (1996) modeled the behavior of an aqueous and organic phase of carbon tetrachloride at the 216-Z-9 trench located just to the north of WMA S-SX. His model predictions showed long-term drainage from the crib source (tens of years following closure) to groundwater. This prediction agreed with groundwater monitoring results indicating there is a continuing input of carbon tetrachloride to groundwater beneath the 216-Z-9 trench. Also, at the northwest corner of the T tank farm, high specific conductance (because of sodium nitrate) persists suggesting there is a continuing input in that location. The source of this anomaly is attributed to the 216-T-7 crib and tile field, which received approximately 110 million liters of T tank farm supernate until 1955. Thus, long-term drainage could be occurring at these 200 West locations. The volumes of these sources, however, are sufficiently large to have exceeded multiple pore volumes of the sediment column beneath the disposal sites. In contrast, even the largest tank leak is near (or less) than one (vadose sediment) pore volume.

The elevated specific conductance in the 200 West Area shows the influence of tank-related waste (supernatant discharges and or leaks from tanks and ancillary systems) on vicinity groundwater. As noted above, the persistent high specific-conductance zone (because of sodium nitrate) along the northwest side of the T tank farm is attributed to the large volume of high salt waste discharged from T tank farm that apparently continues to drain to groundwater (see Figure 4.3). Thus, crib sources and tank leaks are difficult to distinguish from each other in the vicinity of the T tank farm.

4.2.2 Utility Line Ruptures and Leaks

Leakage from aging utility water lines is a widespread industry problem. The S-SX tank farms are surrounded by steam lines, raw water and potable water lines, many of which have been in the ground for over 50 years. Fire protection water lines are in close proximity to the contaminant zone in the southwest corner of the SX farm (see Figure 4.2). In addition, before about 1985 pressurized lines existed inside the tank farm for each self-boiling single-shell tank condenser. Since 1985, only pressurized feeder lines for fire hydrants entered the S and SX tank farm from a main distribution line located around the perimeter of the S-SX fenceline. The fire protection water is maintained at about 120 psi. When pressures drop, the common practice is to increase the flow of water to maintain the water pressure at 120 psi.

Thus, while only circumstantial evidence exists, water sources from pressurized lines existed near potentially significant sources of vadose zone contamination in the S and SX tank farms. Because the condenser lines were isolated prior to 1985, washout of soil column contamination by infiltrating water from a condenser water line leak could account for the 1985-1986 technetium-99/gross beta transient in

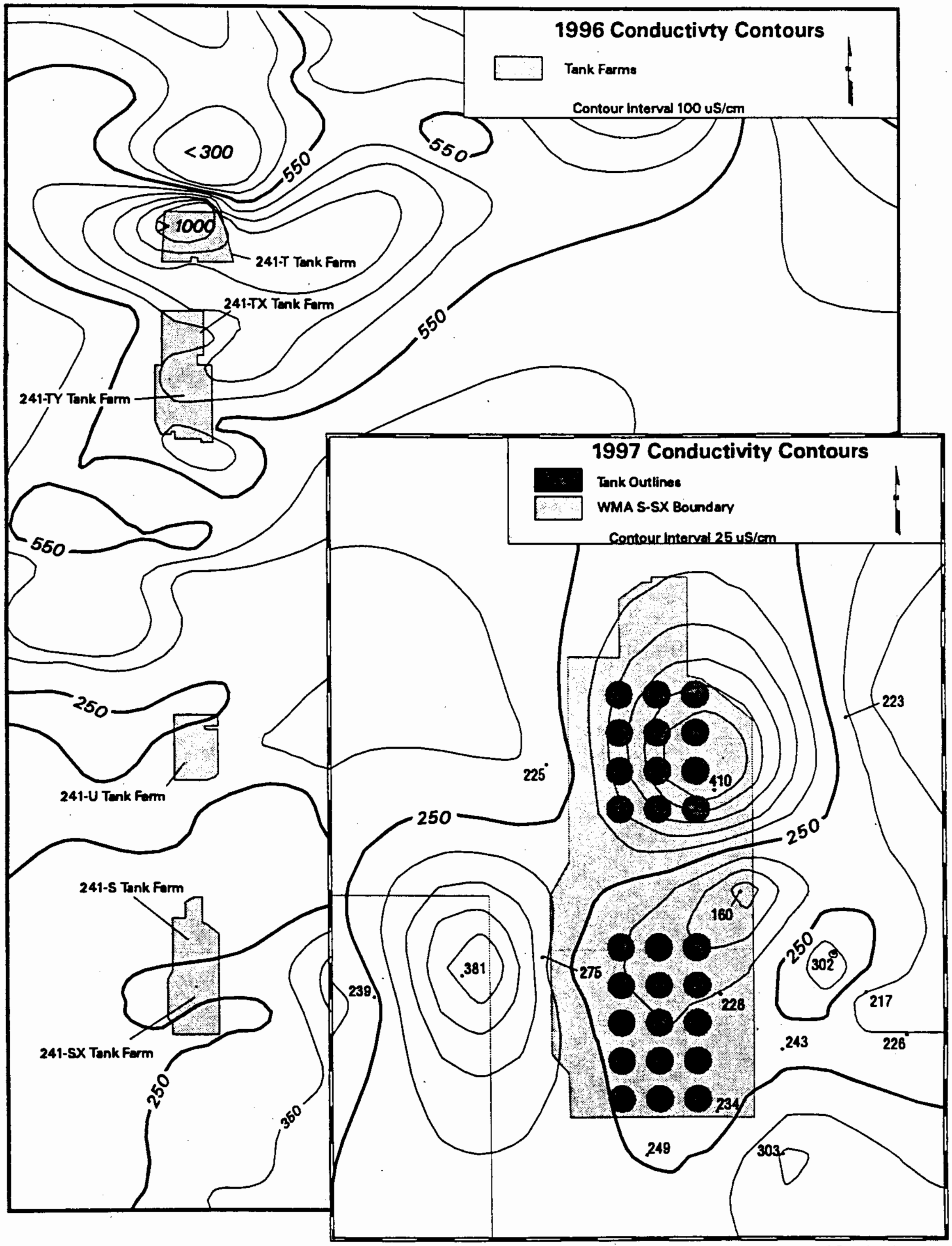

Figure 4.3. Specific Conductance Contours. Inset highlights anomalies that occurred in 1997 using a 25 μS/cm interval. The 410 μS/cm value in S farm is associated with the reappearance of technetium-99 in well 2-W23-1. The 160 μS/cm value (well 2-W23-7) suggests a raw water source of local origin.

well 2-W23-1. Because these lines were isolated permanently prior to 1985, this potential driving force has been eliminated. The fire protection water lines inside the farms theoretically were valved out as part of a program to eliminate all water sources to the tank farms (ca. 1990-1994). However, the line passing along the south fenceline of SX farm apparently was repressurized for other reasons (e.g., it was found to be unexpectedly pressurized when checked in the fall of 1996 in connection with the S-SX Phase I assessment (Doug Rohl, personal communication; there was no record of when the main supply line actually was reopened). Thus, development of a possible water leak overlying subsurface contamination from spills or tank leaks in the southwest corner of SX tank farm hypothetically could have occurred and caused the technetium-99 transient (and related co-contaminants) in well 2-W23-15.

Circumstantial or presumptive evidence of a water source or leak at this critical location (near monitoring well 2-W23-15) also is suggested by the growth of a small cottonwood tree approximately 8 ft (2.4 m) in height (Figure 4.4). Cottonwood trees require a reliable source of water to flourish. The appearance of such growth along water line runs is commonly used at Hanford to check for significant leaks (Doug Rohl, personal communication).

Specific conductance as an indicator of utility line water. As can be seen from Figure 4.3, the specific conductance in the vicinity of the S and SX tank farms is much lower than natural groundwater for the Hanford Site (approximately 340 μS/cm). This general pattern is attributed to the large volumes of relatively clean water discharged to U Pond and adjacent upgradient ditches and cribs. The raw water from the Columbia River used as makeup water is about 140 μS/cm. In sharp contrast to the T farm area, the very low groundwater specific conductance in the vicinity of S and SX tank farms indicates the absence of a large input of high salt waste, consistent with past-practice waste disposal at the S and SX farms (i.e., only tank condensate was discharged to adjacent cribs from the S and SX farms).

Against this general background of low specific conductance, a "finger" of low (<250 μS/cm for 1996 and <200 μS/cm for 1997, Figure 4.3) specific conductance occurs across the SX tank farm. Specific conductance for well 2-W23-7 on the east side of the WMA was 160 μS/cm in August 1997. As noted above, the supply water at Hanford is close to this value (i.e., Columbia River water at about 140 μS/cm). The low values noted may be the result of infiltration of water from the line rupture/flooding event that occurred in September 1996, or could be due to a subsurface leak in a utility line in this area. Whichever the case, it indicates a source of utility line surface water has passed through the vadose zone in the vicinity of the WMA. This could explain the recurrence of technetium-99 in well 2-W23-1, located just north of 2-W23-7. As previously noted, well 2-W23-1 is located near the largest known source of subsurface contamination in the S tank farm near tank S-104 (Figure 3.9) and near where ponding of the water from the line rupture in 1996 occurred.

The specific conductance considerations discussed above, and the observed short-term technetium-99 transients (see Figure 3.11) in groundwater in the vicinity of the S and SX tank farms, are not indicative of long-term drainage of a high salt source. The observations are more consistent with a near-surface leak or rupture event that washes contaminants out of the soil column relatively quickly or a random or short-term natural infiltration event, discussed as follows.

Figure 4.4. Cottonwood Tree Near Southwest Corner of SX Tank Farm (Photo taken in July 1997; approximate height of tree is 2.5 m. The bank immediately behind the tree is chained and marked as a surface or near-surface contamination zone. The tank farm fence and surface structures can be seen in the background near the top of the photo.)

Either a short-term infiltration (flooding) event, or a small continuous water line leak, perhaps coupled with short circuit pathways to groundwater, could account for the observed technetium-99 and gross beta transients shown in Figure 3.11. Even continuous small leak rates (<1 L/min) can hypothetically reach groundwater and thus are capable of transporting contaminants from the upper soil column (Collard, Davis, and Barnett 1996).

4.2.3 Short-Term Random Natural Events

Natural precipitation events have been noted in the past that could supply surface water for a "pulse" of water that conceivably could migrate through a contaminant zone and thus supply contaminants to groundwater over a relatively short period. The most likely meteoric event to supply surface water runoff and ponding at the surface is rapidly melting snow after accumulation of a significant snow pack. Snow pack and melting information have been recorded at the Hanford weather station since 1981. The total inches of snow that melted rapidly for each month since 1981 are shown in Figure 4.5. Typically, these totals comprise more than one event in years when rapid snowmelts occurred. Figure 4.5 provides an indication of possible events that may correlate with some groundwater observations.

The years 1983-1986, 1993, and 1996-1997 stand out in Figure 4.5. It has been previously noted that 1993 was a year with the largest snow pack on record. The year 1996-1997 was both wet and high in snow melt runoff. These time periods at first seemed to coincide with the appearances of technetium-99 peaks in groundwater just south of the WMA. However, the delay time between when the melting event occurs and contaminants arrive at the nearest well must be considered qualitatively. With this in mind, the times of peak technetium-99 arrival summarized in Figure 4.1, and considering the spatial and source location constraints previously discussed, only the occurrence at well 2-W23-1 seems to correlate with a snowmelt event. This well is an older well (poor or uncertain seal) and is located next to a single-shell tank that is not known to be a leaker. Tank S-104, however, is a known or suspected leaker and is located approximately 50 m north. Possible source-well-distance-travel time and snowmelt events seem consistent for this occurrence. However, if this type of event does occur it seems as though similar melting events would have occurred before 1981 and would have depleted the technetium source long ago.

Similar considerations at 2-W23-15 suggest that a snowmelt event could not account for the 1993 peak because the increase in technetium-99 actually began to rise in 1992. Thus, even if the subject well were located directly within the zone of infiltration and the contaminant zone, the timing is off by a year to be correlated with a snowmelt event. In addition, as noted above, if a major snowmelt/soil column washout is a driving force near the subject wells, this should have occurred in earlier years (prior to snowmelt records) and there would presumably be little if any residual soil column contamination in that area for subsequent events. This assumes that the soil column contamination is not replaced (i.e., as in a slow tank leak).

The above considerations point more strongly to artificial sources of water from either ruptures or intermittent utility line leaks. Nevertheless, diverting or minimizing surface water runoff is an important consideration as a general practice in controlling non-point source pollution.

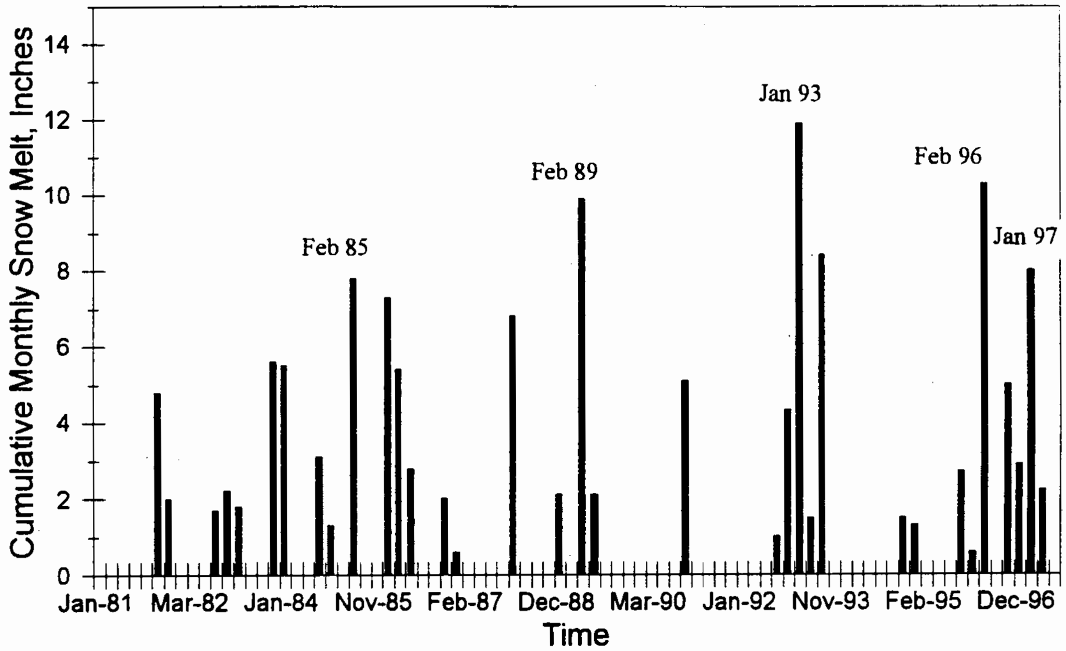

Figure 4.5. Frequency Plot of Rapid Snowmelt Events, 1981-1997 (Cumulative total snowmelt for each month comprises only snow that melted more than 0.5 in., or 1.3 cm, within 24 hours; months for which no data are shown are months when no recorded rapid snowmelt events were recorded.)

5.0 Conclusions

Based on additional groundwater measurements and related data acquired during the Phase I assessment, coupled with interpretation of new and previous findings, we arrive at the following conclusions:

- Distribution patterns for radionuclides and RCRA/dangerous waste constituents (nitrate and chromate) in the vicinity of WMA S-SX indicate this WMA has contributed to groundwater contamination observed in downgradient monitoring wells.

- Multiple sources (tank leaks or spills) in the WMA are needed to explain historical as well as recent groundwater contamination (see Figures 4.1 and 4.2). At least two WMA source areas are needed to explain the technetium-99 transients observed for 1985-1987 in well 2-W23-1 and the more recent events observed in wells 2-W23-15 and 2-W22-46.

- The drinking water standard for technetium-99 has been exceeded but is currently limited to two wells at the southeast corner of the SX tank farm (2-W22-46 and 2-W23-6) and one well (2-W23-1) located along the east side of the S tank farm. Technetium-99, the constituent with highest concentration relative to a standard, is currently 4 to 5 times the EPA interim drinking water standard of 900 pCi/L in well 2-W22-46. The drinking water standard for nitrate has been exceeded and is currently limited to one well, 2-W22-46, with concentrations at/or slightly above the 45,000 µg/L standard.

- Technetium-99, nitrate, and chromium concentrations in downgradient well 299-W22-46 (the well with the highest current concentrations) appear to be declining after reaching maximum concentrations in May 1997. Observations during the next four quarters are needed to confirm the apparent declining trend in this well.

- Circumstantial evidence suggests short-term contaminant transients in multiple wells that occurred at different times between 1985 and present may have been caused by leaking water lines, rupture events and/or ponded snow melt water adjacent to and within the WMA. Continuing efforts are underway to identify and eliminate potential water sources within or around the tank farms.

- Cesium-137 and strontium-90 were not detected in any of the RCRA-compliant monitoring wells. This observation supports the expected retention or retardation of these radionuclides in Hanford soils and/or aquifer sediments.

- Low but detectable strontium-90 and cesium-137 were found in one old well (2-W23-7) located inside and between the S and SX tank farms. Whether this occurrence represents breakthrough from a vadose zone source to groundwater, or is a result of faulty well construction cannot be determined at this time. Additional investigation is necessary to determine if the low level contamination is borehole related or is more broadly distributed in the aquifer.

- Preliminary results for groundwater samples collected on 1/13/98 from a new borehole (41-09-39), drilled through the primary contaminant zone down to groundwater in the SX tank farm, suggest little if any tank waste reached the water table at this location. Gross alpha and gross beta concentrations, 2.3 ± 0.7 and 16.6 ± 4.0 pCi/L (based on 10 sample results), respectively, are within the range of Hanford Site natural background, and hexavalent chromium, a RCRA dangerous waste constituent and indicator of mobile constituents in tank waste, was not detected (<10 µg/L).

- A Phase II investigation is needed to determine the nature, extent, and source(s) of recurrent groundwater contamination attributable to WMA S-SX.

6.0 Proposed Phase II Investigation

The objectives of the proposed Phase II investigation are: 1) to resolve uncertainties identified during the Phase I investigation; 2) to assess the fitness-for-use of older non-RCRA compliant wells within the WMA; 3) to further delineate the nature and extent of contamination to support possible corrective action options and 4) to determine if/when the site can be returned to detection monitoring status.

Specific decisions to be made in the Phase II investigation include the following:

- Whether concentrations of nitrate, chromium, and technetium-99 continue to decline in 2-W22-46;
- Whether the upward trend of technetium developing in 2-W23-1 reverses its course and declines; and
- Whether the apparent positive occurrences of cesium-137 and strontium-90 in well 2-W23-7 prove to be a borehole related effect.

If contaminant concentrations continue to decline in 2-W22-46 and a declining trend is observed in 2-W23-1, and the positive occurrences of cesium-137 and strontium-90 in well 2-W23-7 prove to be a borehole related effect, the groundwater program at this regulated unit will be recommended for return to detection monitoring status with site-specific indicators. In either case, upgrades to the network will be needed. For example, as water level continues to decline and flow direction shifts in the 200 West Area, replacement wells will be needed to maintain adequate spatial coverage and to optimize the leak detection capability of the WMA's groundwater monitoring well network.

Specific components or tasks include the following:

- Continue quarterly monitoring of constituents of interest in the existing S-SX network and extend well coverage, especially for the S tank farm using existing older wells to the fullest extent possible.
- Increase sampling frequency in well 2-W23-1 to quarterly or monthly, if necessary, to assess the upward trend in technetium-99 currently developing in this well.
- Addition of older upgradient wells (e.g., 2-W23-9) to the network to account for elevated nitrate that appears to be approaching WMA S-SX from the west-northwest.
- Test the representativeness of samples from the old monitoring wells inside the tank farms that have exhibited detectable strontium-90 and cesium-137 (2-W23-7) and technetium-99 (2-W23-1). Large volume purging (>4,000 liters) with periodic sampling is proposed for this purpose. If concentrations remain consistent over the extended purging cycle, aquifer contamination is indicated. If the concentrations decline rapidly with volume removed from the well, a borehole related effect is indicated. If the latter condition is observed, the well will be judged unsuitable for sampling and will be recommended for decommissioning to ensure downward movement around the outside of the casing is prevented.
- Investigate selected or targeted areas for indications of moisture and water sources that could account for periodic occurrences of groundwater contamination observed in monitoring wells. For this purpose,

geophysical methods to assess the presence or absence of abnormal moisture content in the southwest corner of the SX tank farm and the northeast area of S farm could be used. Evaluation of local topography to assess runoff and water accumulation potential would also be a useful adjunct to the geophysical moisture survey.

6.1 Approach -- A Path Forward

A Phase II assessment plan will be proposed and implemented in FY98, after regulator and other stakeholder comments on the Phase I report are addressed. Monitoring will continue on a quarterly schedule, supplemented by monthly as needed, during the interim while the Phase II plan is prepared and undergoes review by stakeholders. Once comments have been resolved, field activities will be coordinated with the TWRS vadose characterization activities and the sitewide integrated vadose/groundwater program.

7.0 References

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Appendix A

S-SX Tank Farm Stratigraphy and Geologic Setting

Appendix A

S-SX Tank Farm Stratigraphy and Geologic Setting

A.1 General Stratigraphy

The S-SX Tank Farm was constructed in a sequence of sedimentary units that overlie the Columbia River Basalt Group on the north limb of the Cold Creek syncline. These sedimentary units include the upper Miocene to Pliocene Ringold Formation, the Plio-Pleistocene unit, Pleistocene cataclysmic flood gravels and slack water sediments of the Hanford formation, and Holocene eolian deposits.

The Ringold Formation consists of semi-indurated clay, silt, pedogenically altered sediment, fine- to coarse-grained sand, and granule to cobble gravel. The lower half of the Ringold Formation is the main unconfined aquifer under Hanford and contains five separate stratigraphic beds dominated by fluvial gravels. These gravels are separated by intervals containing deposits typical of the overbank and lacustrine facies (Lindsey 1991). The lowermost of the fine-grained sequences is designated the lower mud sequence. The uppermost gravel unit, unit E, grades upwards into interbedded fluvial sand and overbank deposits that are in turn overlain by lacustrine-dominated strata. The fluvial sand and gravel facies is the principal facies of the upper part of the Ringold Formation under the 200 West tank farms.

Late Cenozoic age sediments, as much as 100 m thick within the Pasco Basin, overlie the Ringold Formation and are the main vadose zone units under the tank farms. The most extensive of these is the Pleistocene-aged Hanford formation (Fig. A.1). Locally the Hanford formation and underlying Ringold Formation are separated by two laterally discontinuous and informally defined units. They are the Plio-Pleistocene unit and the pre-Missoula gravels (near 200 East Area) (Fig. A.1). The Plio-Pleistocene unit unconformably overlies a tilted and truncated Ringold Formation in the vicinity of 200 West Area. The Plio-Pleistocene unit appears to be correlative to other sidestream alluvial and pedogenic deposits found near the base of the ridges bounding the Pasco Basin on the north, west, and south. These sidestream alluvial and pedogenic deposits are inferred to have a late Pliocene to early Pleistocene age on the basis of stratigraphic position and magnetic polarity of intercalating loess units.

The Hanford formation is the informal name given to all cataclysmic flood deposits of the Pleistocene. The Hanford formation consists of pebble- to boulder-gravel, fine- to coarse-grained sand, and silt- to clayey-silt. These deposits are divided into three facies: 1) gravel-dominated, 2) sand-dominated, and 3) silt. These same facies are referred to as coarse-grained deposits, plane-laminated sand facies, and rhythmite facies, respectively in Bjornstad et al. (1987). The rhythmites also are referred to as the "Touchet Beds." The Hanford formation is thickest in the vicinity of 200 West and 200 East Areas where it is up to 65 m thick.

1) **Gravel-Dominated Facies**. This facies generally consists of coarse-grained basaltic sand and granule to boulder gravel. These deposits display an open framework texture, massive bedding, plane to low-angle bedding, and large-scale planar cross-bedding in outcrop. The gravel-dominated facies was deposited by high-energy flood waters in or immediately adjacent to the main cataclysmic flood channelways.

2) **Sand-Dominated Facies**. This facies consists of fine- to coarse-grained sand and granule gravel displaying plane lamination and bedding and less commonly plane bedding and channel-fill sequences in outcrop. These sands may contain small pebbles and rip-up clasts in addition to pebble-gravel interbeds and silty interbeds less than 1 m (3 ft) thick. The silt content of these sands is variable, but where it is low a well sorted and open framework texture is common. These sands typically are basaltic, commonly being referred to as black, gray, or salt-and-pepper sands. The laminated sand facies was deposited adjacent to main flood channelways during the waning stages of flooding. The facies is transitional between the gravel-dominated facies and the rhythmite facies.

3) **Silty Facies**. This facies consists of thinly bedded, plane laminated and ripple cross-laminated silt and fine- to coarse-grained sand that commonly display normally graded rhythmites a few centimeters to several tens of centimeters thick (Myers et al. 1979, Bjornstad et al. 1987, DOE 1988). Locally clay-rich beds occur in this facies. These sediments were deposited under slack water conditions and in back flooded areas (DOE 1988).

A.2 S-SX Tank Farm Vadose Zone Geology

In the S-SX Tank Farm the vadose zone is approximately 64 m (200 ft) thick. It consists of the Ringold Formation unit E, the Plio-Pleistocene, the Hanford formation, and Holocene deposits. The vadose zone stratigraphy of the S-SX Tank Farm is illustrated in an east-to-west cross section (Fig. A.2) through the central portion of the SX Tank Farm, and a northwest-southeast cross section (Fig. A.3) through the SX Tank Farm, and an east-west cross section through the S Tank Farm (Fig. A.4). These sections include gamma log profiles, the depth of cesium-137, and the moisture contents (except A.4) in the soils relative to their stratigraphic position. Together these cross sections provide the most detailed and recent update of stratigraphy at or near the two largest areas of vadose zone contamination (and the largest potential sources of groundwater contamination) in the S and SX tank farms (i.e., near tanks S-104, SX-108/SX-109, and SX-115).

A.2.1 Methodology

The geologic interpretations presented in Figures A.2, A.3, and A.4 were determined by the following method. Initially, the well-site geologist's logs were compared to archived samples from the Hanford Geotechnical Sample Library. The logs were then modified and refined based on the archived samples (the potential for downhole sluffing was taken into consideration). Modified logs were then compared to geophysical logs for the borehole. Geophysical logs (e.g., gross gamma) allow refinement of the geologic data and permit more precise placement of geologic contacts because the geophysical logs are a continuous record whereas the geologic logs are not. Geologic logs are constrained by the drilling method and sample recovery. Sample retrieval in the vadose zone is difficult and typically does not allow the exact depth of samples and contacts to be determined. Changes in drilling blow counts can provide additional information on depth of lithological changes because of differing resistance to drilling by the different lithologies. Archived samples are from 5 ft (1.5 m) intervals and thus can induce as much as a 5 ft (1.5 m) uncertainty in lithology in either direction. Geophysical logs show subtle differences in the amount of gamma emitters in the soils which typically are proportional to clay abundance and typically reflect changes in grain size. When geophysical logs are compared to the well-site geologist's logs, the uncertainty in the depth of lithologic changes is greatly reduced, providing a more accurate representation of the stratigraphy in the borehole. In addition, the signature of the geophysical response from the borehole can provide an additional tool for correlation between boreholes.

Except for new borehole 41-09-39, moisture contents, in weight percent (%), are from (Caggiano 1992, 1993) and are based on gravimetric determination of moisture in samples of drill cuttings collected at 5-ft (1.5 m) intervals. Moisture contents for the new borehole, 41-09-39, are based on neutron probe results (DOE 1997) from 0 to 130 ft (40 m) and gravimetric results from core samples below the 130 ft (40 m) depth (Jeff Serne, personal communication, December 1997). The neutron probe moisture results were read from the original profile in counts per second at 5-ft (1.5 m) intervals. The count rate was converted to volume percent moisture based on interpolation of calibration curves for casing sizes nearest to the borehole 41-09-39 casing (Russ Randall, personal communication, October 1997). The equivalent moisture content in weight % was estimated by dividing volumetric % values by 1.5. Thus, the absolute moisture contents for the 0 - 130 ft (40 m) depth are approximated and may not be directly comparable to the more direct, gravimetric results. Plotting the gravimetric results for the core samples below the 130 ft (40 m) depth also required some judgement in avoiding those samples that were deemed to be impacted by small amounts of water added to facilitate the split spoon coring operation where gravel or highly cemented zones were encountered.

The cesium-137 profile for borehole 41-09-39 was replotted from values read from a log activity vs depth plot (DOE 1997). A linear rather than log concentration scale was used in order to more accurately indicate the depth of penetration of most of the inventory (greatest concentrations) for correlation with potential stratigraphic controls on liquid waste and or cesium-137 movement.

A.2.2 Ringold Formation

The Ringold Formation is up to 185 m (600 ft) thick in the deepest part of the Cold Creek syncline south of the 200 West Area. The vadose zone portion of the Ringold Formation thins from east to west (approximately 16 m (50 ft) to about 13 m (40 ft)) and consists primarily of a slightly silty coarse- to medium-grained sandy gravel (Ringold unit E).

In the S-SX Tank Farm area Slate (1996) interpreted the surface of the Ringold Formation as a trough-like trending northwest-southeast parallel to the Cold Creek syncline and plunging to the southeast (Fig. A.5). This trough contains two smaller troughs, one of which trends directly under the S-SX Tank Farm and one south of 200 West Area (Fig. A.5). Both smaller troughs appear to merge farther southeast. Slate (1996) interpreted the trough as a paleo-Cold Creek drainage developed in the slowly subsiding Cold Creek depression. The net effect of the trough is to give the surface of the Ringold under the tank farm a southeast dip.

A.2.3 Plio-Pleistocene Unit

The Plio-Pleistocene consists of up to 13 m (40 ft) of massive, brown yellow, and compact, silt and minor fine-grained sand and clay. Slate (1996) includes a gravel facies which occurs south of the 200 West Area in the Plio-Pleistocene unit. Granule-sized grains consisting primarily of basalt commonly occur in this unit. The unit is differentiated from overlying graded rhythmites (Hanford formation) by greater calcium carbonate content, massive structure in core, and high natural gamma response in geophysical logs (DOE 1988).

In the vicinity of the S-SX Tank Farm, the surface of the Plio-Pleistocene unit is a trough that resembles the surface of the Ringold Formation (Fig. A.6). There are, however, no obvious smaller troughs within the main trough as in the Ringold and the deepest part of the Plio-Pleistocene trough is under the S-SX Tank Farm. Slate (1996) interpreted this trough as having resulted from a combination of erosion by Cold Creek and post depositional erosion by the Missoula floods. Continued subsidence in the Cold Creek depression probably also contributed to growth of the feature.

The facies relationships in the Plio-Pleistocene have been interpreted by Slate (1996) as indicating deposition along a northwest-to-southeast trending stream channel. The gravel facies is restricted to the central portion of the trough. The eastern edge of the gravel facies occurs along the southwest boundary of 200 West Area. The S-SX Tank Farm lies above the finest grained facies which probably represents overbank deposits (Fig. A.7). It consists of mainly silty to very-fine silty sand and clay deposits.

The Plio-Pleistocene unit thins from southwest to northeast and varies from about 6 to 13 m (20 to 40 ft) in thickness across the tank farms (Figs. A.2, A.3, and A.4). This unit contains a series of paleosols with pedogenetic carbonate (caliche) zones (Slate 1996). The pedogenic carbonate zones are thought to have formed in the subsurface during hiatuses in deposition; the caliche zones can be as much as 20 m (66 ft) thick but under the S-SX Tank Farm only one has been recognized.

A.2.4 Hanford Formation

The Hanford formation at the S-SX Tank Farm consists of a series of primarily massive sands intercalated with beds of coarse sand and gravel, and thinner lens of silts and clayey silts. The basal portion of the unit consists of sandy to silty sands. Gravel lenses dominate the middle portion which are overlain by principally coarser sands with minor silt and gravel lenses.

The lower portion consists primarily of sands-to silty-sands. This sequence thins from east to west across the S and SX tank farms (Figs. A.2, A.3, and A.4) which may be the result of later scouring. A prominent silty clay bed is found at relatively the same stratigraphic position on both the west and east sides of the SX Tank Farm; how far this extends under the tank farm and if it is continuous is not presently known.

The lower sandy sequence is bounded above by one to two gravel lens and intercalated sands that can be correlated under the tank farms (Figs. A.2 and A.4). There are two gravel lens to the west but they either merge or the upper one pinches out to the east (see Fig. A.2). The sequence ranges in thickness from 3 m to

10 m (10 to 30 ft) in the SX Tank Farm but little thinning is seen under the S Tank Farm. In the S Tank Farm this gravel sequence was intersected during excavation for the tanks (Fig. A.4) and is now in contact with the backfill.

Above the gravel lenses lies an upper sandy- to silty-sand sequence. This sequence thins to the east. A thin, sandy silt, 1 to 1.5 m (3 to 5 ft) thick directly overlying the gravel forms the base of this sequence on the east and north side of the tank farms. A thin, coarse sandy unit about ten feet above the gravel is intercalated with this sequence on the west side only (Figs. A.2 and A.4).

Holocene deposits and backfill material overlie the Hanford formation.

A.3 Subsurface Moisture Distribution Beneath the SX Tank Farm

Moisture profiles are plotted in Figures A.2 and A.3 along with the lithologic profiles. While qualitative at best, the moisture correlations appear to be consistent with the stratigraphy across the tank farm and indicate that gravimetric moisture content increases with decreasing grain size. Several high moisture zones can be identified in the vadose zone.

The uppermost moisture zone occurs at approximately 25 m (80 ft drilled depth) in the Hanford formation in borehole W23-14. This zone correlates with the continuous upper sandy silt sequence above the gravel lenses. A high moisture zone occurs at the same horizon on the east side of the tank farm (Fig. A.2, W22-39). Although stratigraphically similar, this high moisture horizon does not appear to be present in borehole 41-09-39 which was drilled next to tank S-109. This suggests a discontinuity in the moisture content of this stratigraphic unit across the tank farm; higher moisture concentrations in this stratigraphic unit occur away from the tank farm. Gamma logging indicates that this stratigraphic unit has high cesium-137 activity near the S 109 tank.

A second high moisture zone occurs in well W23-14 about 2 m (7 ft) below the gravel lenses and appears to be controlled by a clayey silt zone. There is a similar high moisture zone on the east side of the tank farm at 30 m (90 ft) in well W22-39 but it is not known if this is the same horizon or just a localized bed. Similar to the upper high moisture zone, there is no high moisture zone at a similar horizon in the tank farm (see 41-09-39).

The deepest high moisture zone occurs in a clay- to silty-clay horizon at a depth of approximately 40 m (125 ft in borehole W23-14, Fig. A.2) and corresponds to the Plio-Pleistocene unit. This is the only "high" moisture zone encountered in 41-09-39 below a depth of 3 m (10 ft). Elevated Cs-137 contamination was detected at the surface of the Plio-Pleistocene in this borehole. The surface of the Plio-Pleistocene plunges southeast directly under the tank farm. Any moisture and Cs-137 reaching the Plio-Pleistocene horizon probably will have a tendency to migrate southeast along the axis of the trough.

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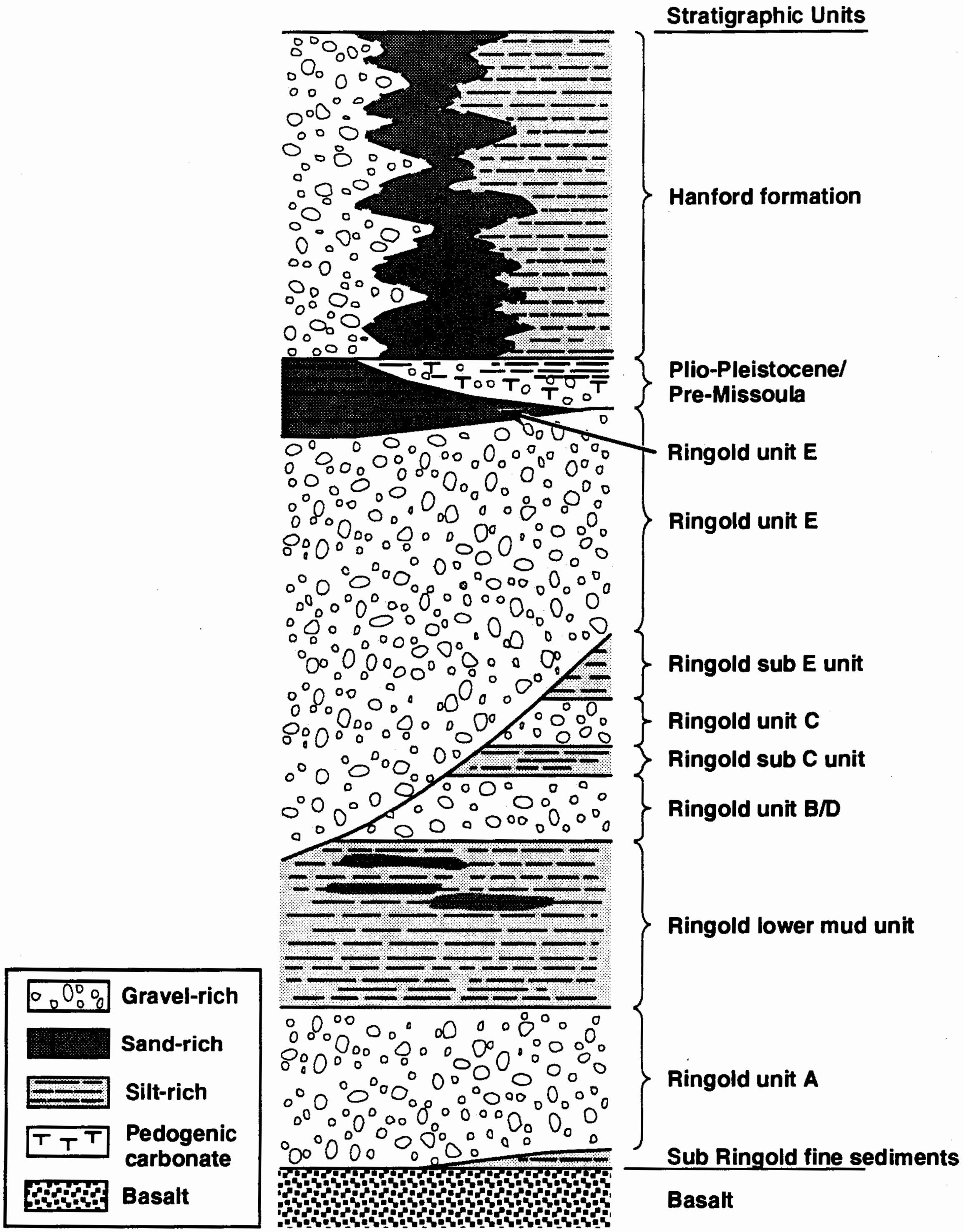

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Figure A.1. Generalized, Composite Stratigraphy for the Late Cenozoic Sediments Overlying the Columbia River Basalt Group on the Hanford Site. Typically the Hanford formation forms the majority of the vadose zone and the Ringold Formation dominates the saturated zone.

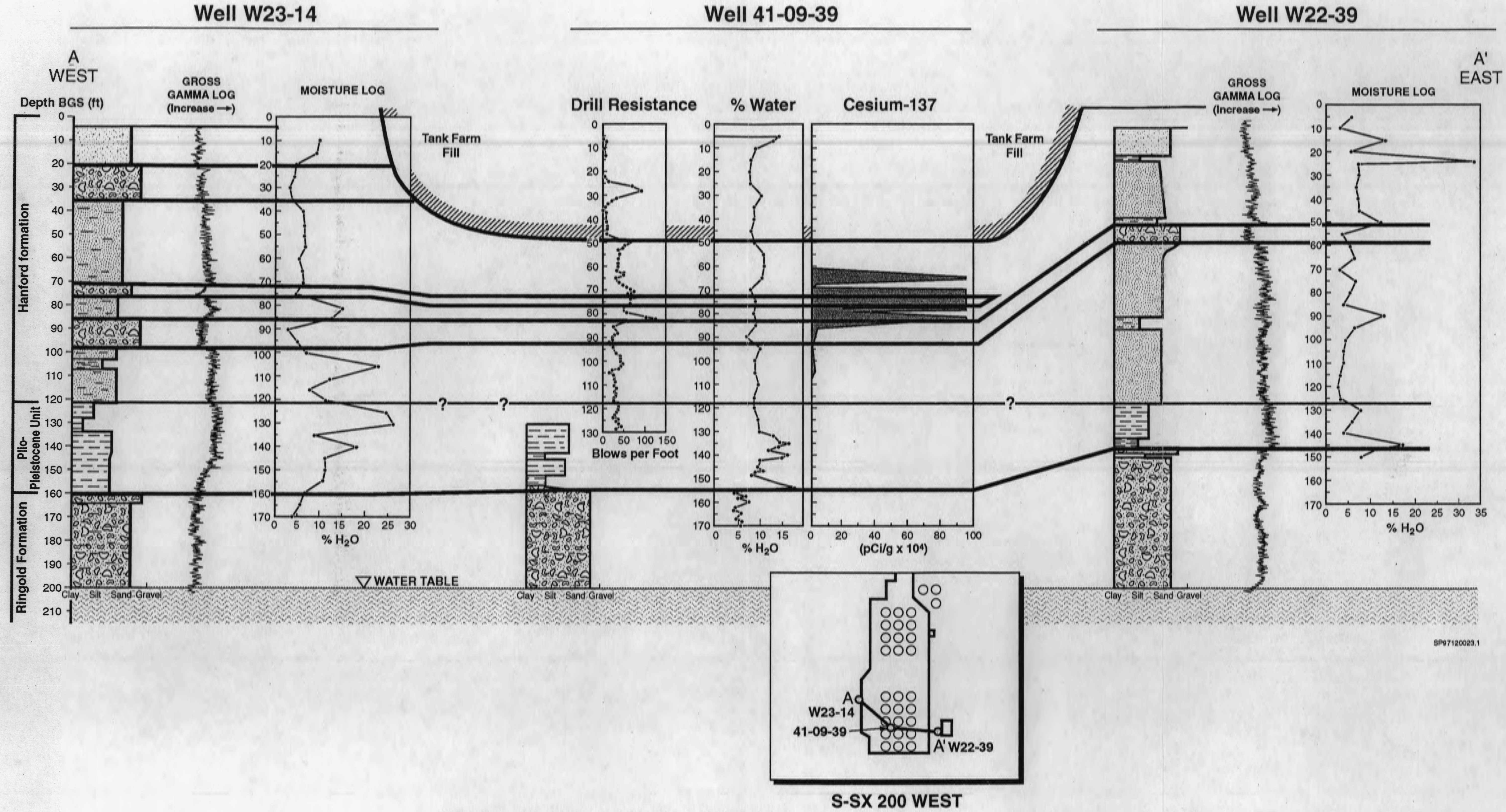

Figure A.2. East-West Cross Section Through SX Tank Farm. Shown are selected logs for the stratigraphic units from Figure A.1, texture, moisture content, drilling resistance, and gamma profiles. The logs for each well are grouped together under each well. Horizontal lines between the wells show correlation of units.

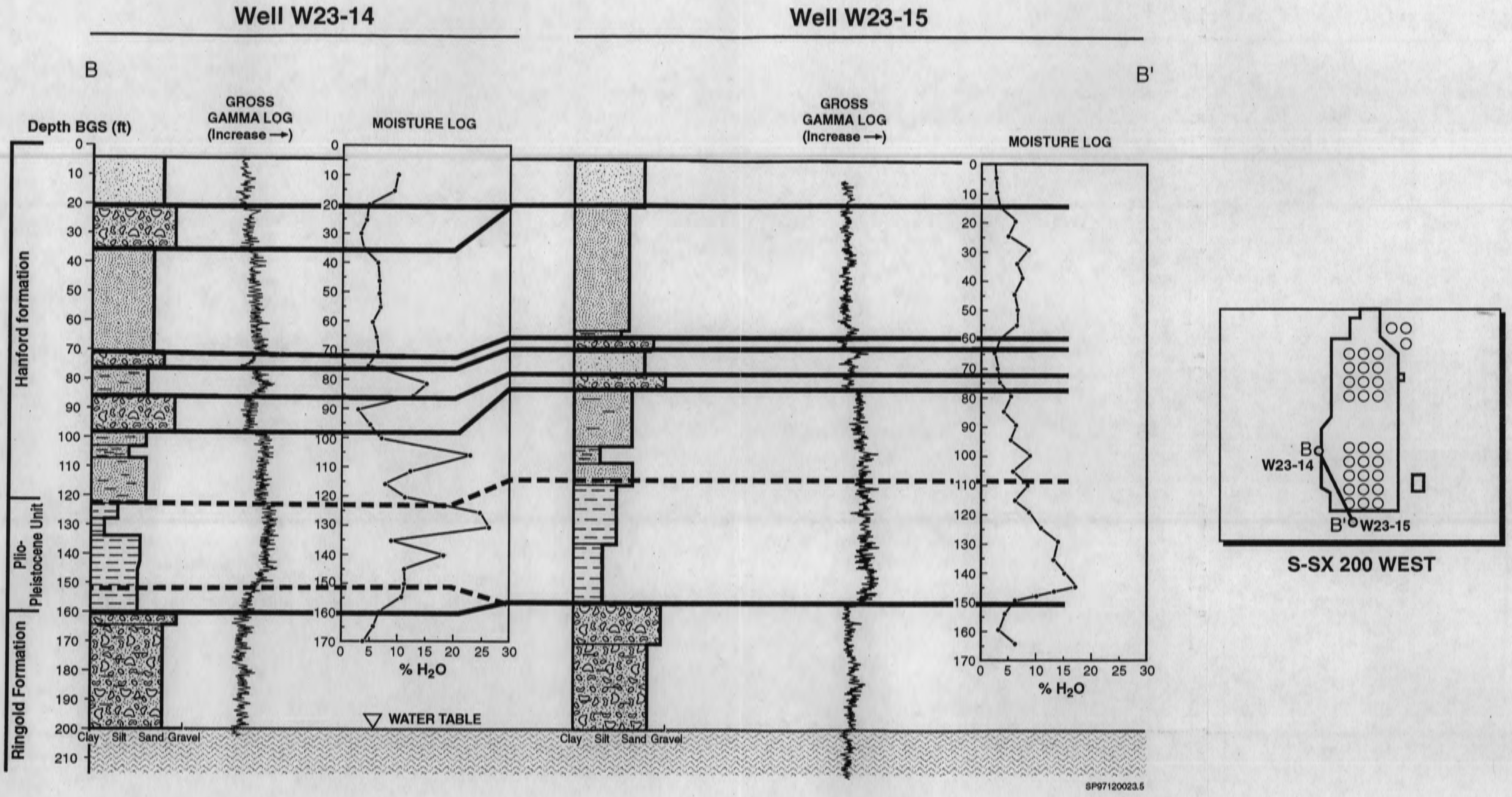

Figure A.3. Northwest-Southeast Cross Section Through SX Tank Farm. Shown are selected logs for the stratigraphic units from Figure A.1, texture, moisture content, and gamma profiles. The logs for each well are grouped together. Horizontal lines between the wells show correlation of units.

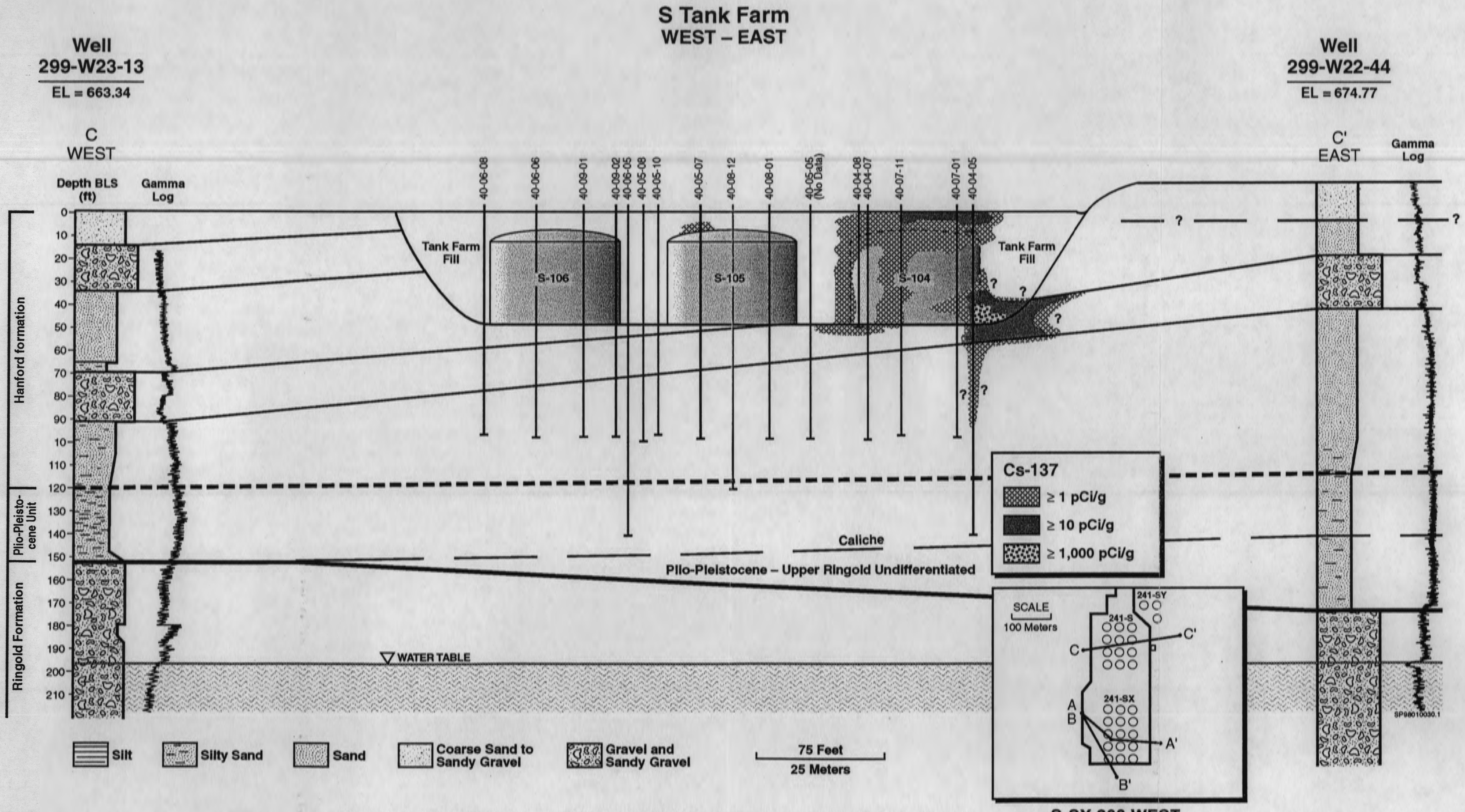

Figure A.4. East-West Cross Section Through S Tank Farm. Shown are selected logs for the stratigraphic units from Figure A.1, texture, gamma profiles, and distribution of Cs-137 in the soil. The logs are grouped together under each well. Horizontal lines between the wells show correlation of units.

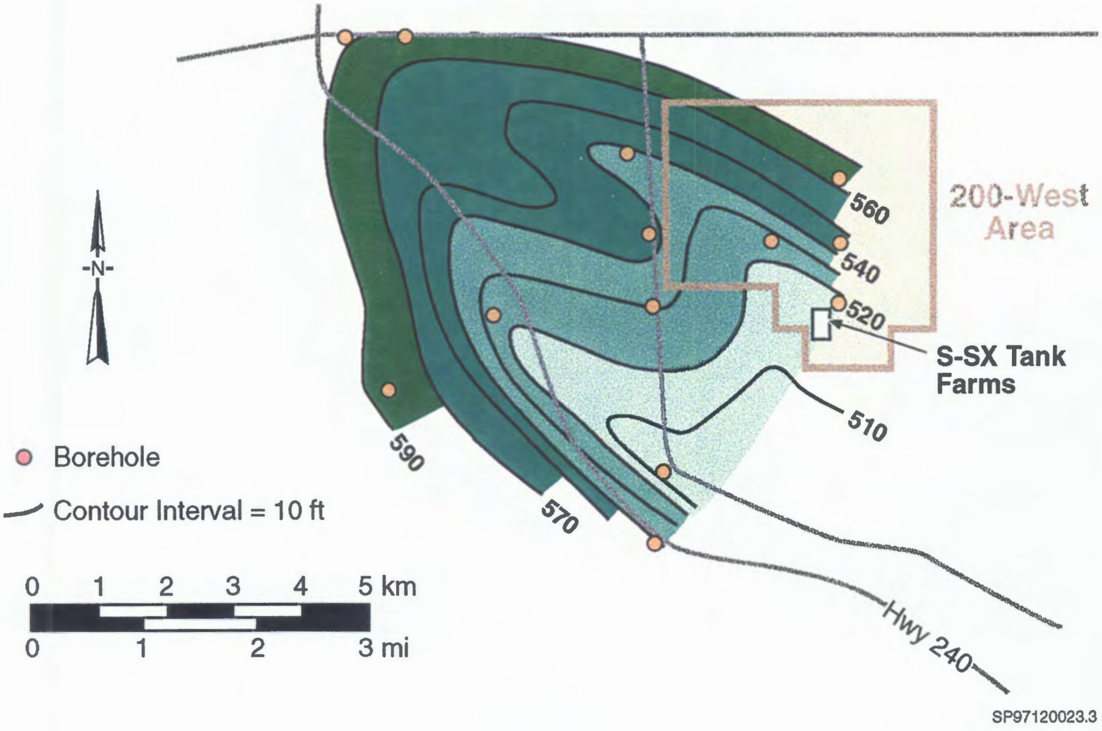

Figure A.5. Contour Map on the Surface of the Ringold Formation in the S-SX Tank Farm and Surrounding Area (from Slate 1997). Note that the surface of the Ringold Formation forms a southeast plunging trough centered under the SX Tank Farm. Depths are in feet above mean sea level.

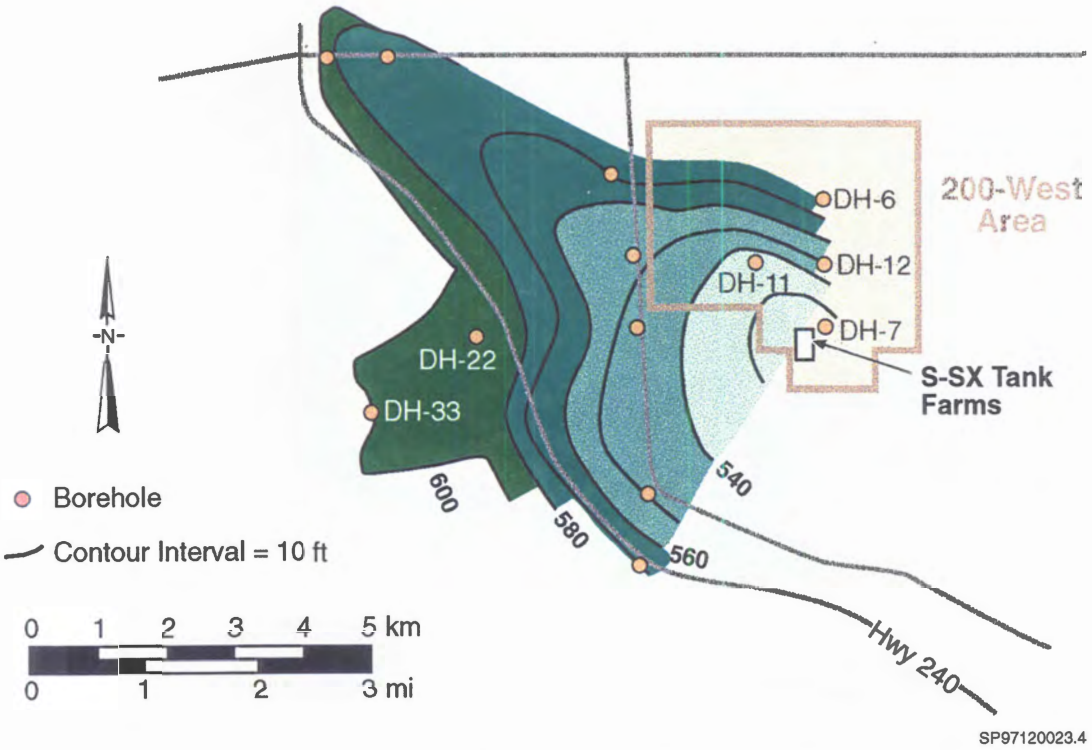

Figure A.6. Contour Map on the Surface of the Plio-Pleistocene Unit in the S-SX Tank Farm Area (from Slate 1997). Note that the surface of the Plio-Pleistocene unit forms a southeast plunging trough under the tank farm. A comparison of Figures A.5 and A.6 shows that the axes of both troughs coincide and provide a potential southeast lateral pathway for contaminant spreading. Depths are in feet above mean sea level.

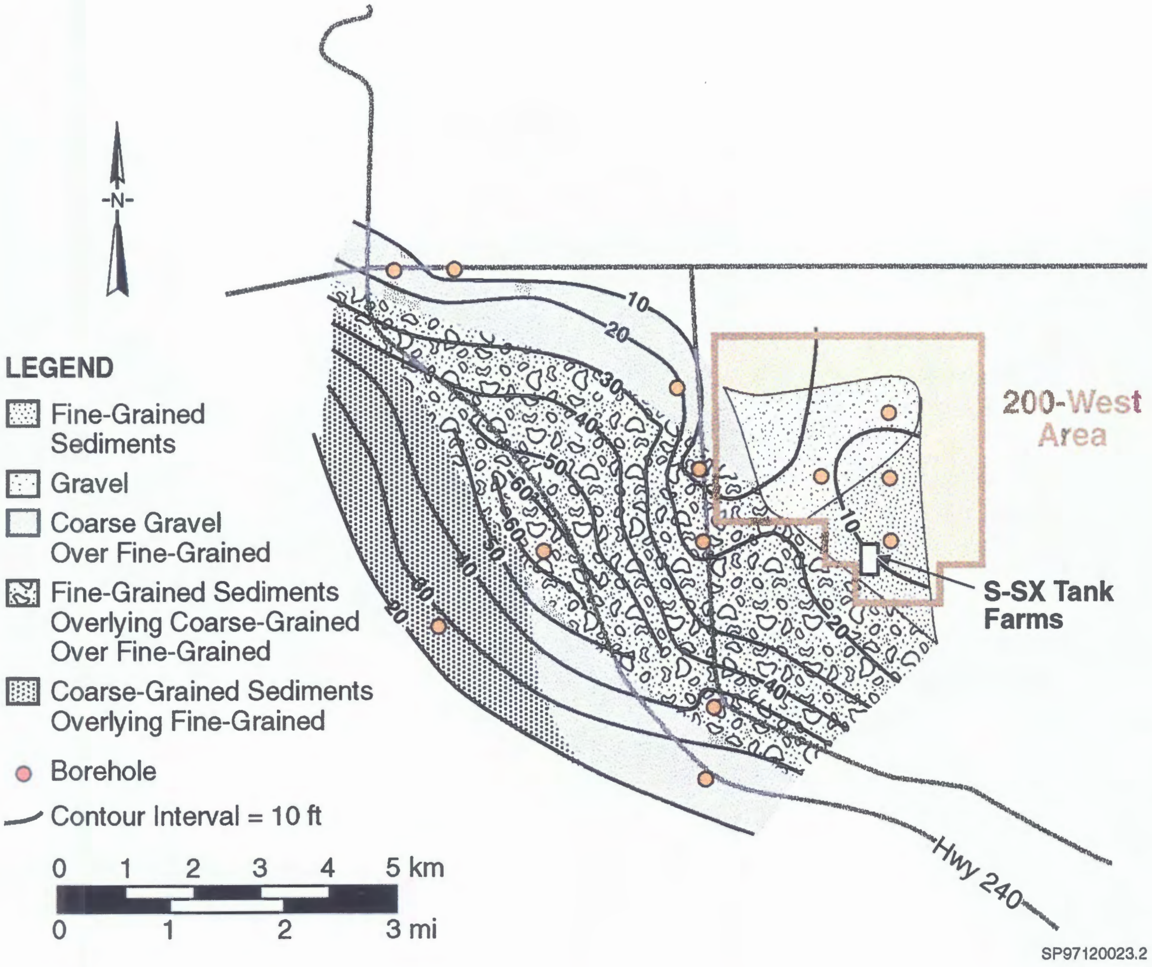

Figure A.7. Plio-Pleistocene Unit Textural Variations in the S-SX Tank Farm Area (from Slate 1997). The Plio-Pleistocene Unit is interpreted to be the sediments from the ancestral Cold Creek. The textural variations through the area are summarized here. Under the S-SX Tank Farm area the Plio-Pleistocene Unit is primarily fine-grained silts and sands deposited as overbank sediments by the ancestral Cold Creek.

Appendix B

Analytical Results

Appendix B

Analytical Results

B.1 Introduction

This appendix contains 1996 and 1997 analytical results for monitoring wells associated with WMA S-SX. Samples collected during this Phase I assessment from the Resource Conservation and Recovery Act (RCRA) monitoring network, as well as for selected older wells, are included. The data listed here, as well as for previous years, are available in the Hanford Environmental Information System (HEIS) data base. The samples were collected and analyzed in accordance with the procedures and quality assurance program described in Hartman and Dresel (1997). Special conditions associated with assessment sample collection during the 1996-1997 time period are described in the following narrative. References cited are included in Section 7.0 of the main text.

B.2 Data Tables

Results are listed separately for radionuclides (Table B.1) and chemical constituents (Table B.2). Limits of detection and limits of quantitation (Table B.3) for the primary constituents of interest are based on analysis of blank samples submitted (for radionuclides) or are based on method detection limit information requested (for chemical constituents) as part of the quality assurance program for the Hanford Site groundwater monitoring program. Methods for calculating these limits are described in Hartman and Dresel (1997).

Column headings (indicated in bold) for Tables B.1 and B.2 are described as follows:

Well: Well name descriptor as used in the Hanford Environmental Information System (HEIS) data base. The RCRA compliant wells are listed first in the tables and are followed by the non-RCRA wells.

Well Standard: Indicates if the well was constructed in accordance with RCRA standards (i.e., 20-ft stainless steel screens with nominally 15 ft in the saturated zone, sandpack around the screened section, bentonite annular seals, surface cement and guards). Non-RCRA wells are of an older design consisting of 6 to 8 inch diameter carbon steel casings that were perforated in the saturated zone and may or may not have annular seals. Attempts were made to seal older wells located near waste sources during the 1975-1985 time period. Because of the construction of these wells, results for certain metal constituents may not be reliable. The older well construction is not expected to impact radionuclides, pH, conductivity or major constituent results.

Constituent: Radioactive and chemical constituent names are spelled out and results are listed chronologically for each constituent.

Date: The date the sample was collected. Multiple entries for the same date are for replicate samples.

Result: Results from the HEIS data base were rounded to no more than three significant figures.

Total Error: The error terms for radionuclide results consist of the 2 sigma counting error and any associated processing error. Counting error is the dominant contributor to the overall error. Error estimates listed for chemical constituents are based on periodic analysis of replicates in the laboratory.

Units: Radionuclide results are in pCi/L except for uranium which is given in µg/L. Results for chemical constituents are in µg/L and mg/L.

Qualifier: Conditional indicators used in the HEIS data base for a result are defined as follows:

> U: indicates result is a "non-detect;" the value shown is the vendor assigned method detection limit. These may vary from the values shown in Table B.3 which are derived from periodic analysis of blanks submitted to the vendor as samples.
>
> **J**: Estimated value
>
> **B or L**: Analyte concentration below contractual quantitation limit but above method detection limit
>
> C: blank associated with analyte is elevated
>
> **D:** result is based on analysis of a diluted sample (final result is dilution corrected)
>
> **E:** exceeded calibration range

Filtered: A "Y" indicates the sample was filtered in the field as the sample bottles were filled. A "N" indicates the sample was not filtered. An unfiltered sample is acidified in the field and may solubilize particle-bound constituents if particulate debris is present in the sample. Generally, samples are not collected until the turbidity is less the 5 NTU (equivalent to about 5 mg/L of particulates). An elevated metal result, especially from a non-RCRA well, may be high as a result of the particle dissolution effect.

B.3 Sampling Procedures

Each RCRA compliant monitoring well is constructed to meet the Washington Administrative Code (WAC 173-160) (e.g., stainless steel casing and screen, sand pack, and full annular seal). Samples are collected after three casing volumes are withdrawn and after indicator parameters (pH, temperature and specific conductance) have stabilized. Indicator parameters are measured in a flow through chamber.

Turbidities must be equal to or below 5 NTU (nephelometric turbidity units; 1 NTU ≅ 1 mg/L of solids) prior to sample collection. Non-RCRA wells are sampled with the same protocol except that the type of pump may vary. A bailer was used in a few cases were access is restricted (e.g., inside tank farms).

Samples for metal analysis are filtered but all other analyses are generally for unfiltered samples. Thus all radionuclide results are for unfiltered samples unless otherwise indicated in the data tables. Filtered samples may be used if there is a turbidity problem or to determine the particulate nature of a positive occurrence or anomaly. Filtered samples are obtained at the well head with an in-line membrane filter (0.4 µm).

Sample preservatives are added to the collection bottles in the laboratory prior to their use in the field. Duplicates, travel blanks and field equipment blanks are collected as part of the general quality control program. The sampling and analysis methods and procedures and associated quality control results are described in more detail in Hartman and Dresel (1997).

B.4 Special Conditions:

Sampling conditions that deviated from the standard protocol for the groundwater monitoring program (Hartman and Dresel 1997) are indicated as follows.

Well 299-W23-7. The 6/19/96 and 6/25/96 sample results for this non-RCRA well, located inside the S-SX Tank Farm fenceline and between the S and SX Tank Farms, are for samples collected with a bladder pump. The pump was lowered to about 12 ft below the static water level and pumped at 0.4 L/min. Even with this slow pumping rate, the water level was drawn down to the pump intake within a few hours. The water was highly turbid which was attributed to resuspension of sediments at the bottom of the well during attempts to position the pump at an optimum depth. After the well recovered from the first evacuation, the 6/19/96 samples were collected. The well was allowed to recover again and was resampled on 6/25/96. Both filtered and unfiltered water samples were collected as indicated in the "filtered" column in Tables B.1 and B.2. Turbidity of the samples (100 - 200 NTU) suggest cesium-137 associated with particulate material inside the well was 50 - 100 pCi/g. Spectral gamma log results for the well indicated about 1 pCi/g of cesium-137 suggesting the cesium-137 was associated with fine sediments inside the well.

Sample results listed for other than the above date are for bailed samples.

Well 299-W23-3. This well is located in the southeast corner of the SX Tank Farm and inside the tank farm fence. Samples for 7/10/97 were collected using a submersible pump after removal of three borehole dead volumes. Results for other dates in Tables B.1 and B.2 are for bailed samples.

Well 299-W23-6. This older well, located outside the SX fenceline along the southeast corner, had not been previously sampled, or at least no data were available in the Hanford groundwater data base. The well was cleaned (interior brushed), developed and a submersible pump set at 40 ft below the static water level. Approximately 20 ft of drawdown occurred during purging and sampling. Because of the deviation in sampling conditions compared to the other wells (sample depth), results from this well should be considered as a qualitative indicator of the presence (or absence) of contaminants. Additional work is needed to remediate this well and to assess contaminant variation with depth.

Wells 299-W23-1 and -W23-2. These wells, located inside the S-SX fenceline, were both sampled with bailers. Attempts are being made to install permanent pumps in the older wells inside the S-SX Tank Farms that can be rehabilitated.

Replicate Analysis Study. Twelve replicate samples were collected on 8/8/96 from well 299-W23-14 to evaluate overall sampling and analysis variability for selected constituents (i.e., gross alpha, gross beta, and tritium).

B.5 Overview of Analytical Results

Results for the primary constituents of interest are discussed by individual constituent as follows. Note that for most chemical constituents units reported are µg/L or mg/L, however, for discussion purpose ppb and ppm are used, respectively.

B.5.1 Radionuclides

Tritium. Very high concentrations of tritium occur in upgradient wells. This is attributed to the past disposal operations that discharged tritium bearing condensate from self boiling single-shell tanks to upgradient cribs.

Gross alpha and uranium. Except for two apparent outliers, the gross alpha results are near natural background of 2.5 ± 1.5 pCi/L (see Johnson 1993, Table A-1-2) or slightly above in a few cases. The outliers (200 pCi/L for the 8/6/97 sample for downgradient well 299-W22-45 and 75.8 pCi/L for the 5/7/97 sample from upgradient well 299-W23-13 appear to be off by 100 fold and 10 fold, respectively, from the previous and following sample results. Therefore, these results are attributed to a decimal point shift in either data entry or the laboratory computation. The mean gross alpha concentration for the most recent four quarters for well 299-W22-46 (well with covarying tank waste indicators) was 2.7 ± 0.3 pCi/L. Thus natural background can account for all of the gross alpha during the period when the tank waste indicators in this well were at a maximum. Also, it is unlikely that significant concentrations of transuranics (e.g., neptunium-237, a potential mobile constituent of interest in tank waste [DOE 1997]) was present in these samples since gross alpha is almost identical to the natural background for Hanford groundwater upgradient of the 200 Areas. Other slightly elevated gross alpha results can be accounted for by the uranium present. For example, the gross alpha concentration for upgradient well 299-W23-9 was 13 ± 4 pCi/L on 5/22/96 as compared to uranium concentration of 21 ug/L which is equivalent to a total alpha concentration of 14.2 pCi/L (21 µg/L * 0.68 pCi/µg [conversion factor] = 14.2 pCi/L). The conversion factor accounts for the two alpha emissions from uranium-238 and its daughter, uranium-234.

Cesium-137, cobalt-60, and strontium-90. These constituents are not expected to be very mobile in groundwater because of sorption on mineral grain surfaces. Complexing agents could modify this expectation. Thus, samples were analyzed to check for their presence. With few exceptions, these constituents are at or below limits of detection indicated in Table B.3. The notable exception was cesium-137 in well 299-W23-7 located inside the S-SX Tank Farm complex, as previously discussed under "special sampling conditions." Strontium-90 (at about 1 pCi/L in the most recent samples) may also have been detected in this well. Additional evaluation of this low-level occurrence may be warranted during Phase II assessment period.

Technetium-99. This constituent was detectable in nearly all samples. Low concentrations (<100 pCi/L) are widespread in the vicinity of WMA S-SX because of upgradient sources. The highest concentration during the Phase I assessment occurred in well 299-W22-46 in which technetium-99 reached a maximum of 5,000 pCi/L on 5/8/97. Other downgradient wells were also elevated compared to upgradient wells (e.g., 299-W23-6, -W22-45, W22-39, -W23-1). An upward trend appears to be developing in well 299-W23-1 in the S Tank Farm. This well will be added to the quarterly schedule as soon as a pump can be installed.

Iodine-129. This mobile fission product is expected in tank waste; however, it was not detected in the sample with the highest technetium-99 concentration. Based on ratios of iodine-129 to technetium-99 in tank waste, it could be present but at concentrations below the detection limit.

B.5.2 Chemical Constituents

pH. Elevated pH might be indicative of a tank waste because of the excess sodium hydroxide added to neutralize the waste. The only anomalous pH value (above a pH of 8.5) was 9.3 in well 23-W23-7 located inside the S-SX Tank Farms. Since this occurred for two separate sampling events (one in 1996 and again in August 1997), data entry error or sampling/calibration problems are unlikely explanations. Cement, however, (from the earlier attempts to seal this well) may have come in contact with the perforated zone (which could also explain the extremely slow recovery of the well during pumping). Water in contact with cement can cause the pH to increase above ambient groundwater levels.

Conductivity. Specific conductance or conductivity is a measure of the salt content of the sample. For Hanford groundwater, 1.7 µmho/cm is equivalent to approximately 1 mg/L of dissolved salt. The values for the RCRA compliant monitoring wells are all generally below the mean natural background value of 344 umhos/cm for groundwater upgradient of Hanford facilities (see Johnson 1993, Table A-1-2). This is attributable to past discharges of large amounts of cooling water (Columbia River water with an average specific conductance of about 140 µmho/cm). The addition of nitrate to this general background from a waste source would increase the low ambient conductivity (approximately 225-260 µmhos/cm for upgradient RCRA wells 299-W23-13 and 299-W23-14 during the most recent two quarters). The only increase in downgradient conductivity relative to the nearest upgradient well for the 1996-97 period was for well 299-W22-46. This well peaked at 322 µmhos/cm in May 1997 and appears to be declining after this date. This pattern is consistent with the time series results for other mobile constituents for this well. If large amounts of tank waste were migrating to groundwater in this area, conductivity should be greatly elevated (as well as other constituents). Even the highest conductivities are within the range of natural levels for the Hanford Site (i.e., natural background upgradient of the 200 Areas).

Aluminum. Large amounts of aluminum are present in tank waste from dissolution of the aluminum alloy cladding used for much of the older nuclear fuel used in the Hanford plutonium production reactors. Anionic species of aluminum can theoretically exist at the high pH of tank waste. Thus, this is another potential mobile tank waste co-contaminant. There does not appear to be any pattern, however, in the aluminum results and most are at or near detection limit. Elevated values occur for the two unfiltered samples for well 299-W23-7 but this result is attributed to acid (preservative) dissolution of aluminosilicate mineral phases resulting from the high turbidities induced during attempts to use a pump in this well.

Nitrate. Large amounts of sodium nitrate are present in tank waste from the addition of excess sodium hydroxide to neutralize the nitric acid in the waste from the nuclear fuel dissolution and plutonium separation process. Because of its high mobility, nitrate should be a good indicator of tank waste. Other upgradient sources of nitrate from past disposal operations, however, contribute to a general background of nitrate in the vicinity of WMA S-SX. The highest concentration (130 ppm) attributable to an upgradient source occurred in well 299-W23-9, located west of the SX Tank Farm. The only consistent pattern observed during the report period was for well 299-W22-46 that showed an increase with a maximum of 52 ppm that occurred in May 1997 and then appeared to decline after this date. This pattern follows the specific conductance discussed previously. Although nitrate by itself is not a definitive tank waste indicator, it can be indicative in those cases where it covaries with other indicators (e.g., chromate and technetium-99).

Chromium. Hexavalent chromium was used in the REDOX process to change oxidation states of the plutonium to facilitate its separation. It is theoretically soluble as an oxyanion even at the high pH of tank waste (up to a pH of 13 - 14). Because of its mobility in the anionic state, it is also a good indicator of S-SX tank farm waste. The only significant pattern of anomalous occurrences for this indicator are in well 299-W22-46 where it appears to be covariant with the nitrate, technetium-99, and conductivity. The maximum concentration (39 ppb) in this well occurred in May 1997, along with other tank waste indicators (conductivity, nitrate, and technetium-99). Values for upgradient wells are at or below the quantitation limit (11 ppb). Also, one elevated value (53 ppb) occurred in an unfiltered sample from 299-W23-7.

Table B.1. Analytical Results for Radionuclides of Interest in WMA S-SX Monitoring Wells

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W22-39	RCRA	Gross Alpha	2/8/96	3.0	1.6	pCi/L		N
299-W22-39	RCRA	Gross Alpha	8/12/96	2.1	1.3	pCi/L		N
299-W22-39	RCRA	Gross Alpha	11/12/96	3.3	1.2	pCi/L		N
299-W22-39	RCRA	Gross Alpha	2/4/97	2.7	1.2	pCi/L	J	N
299-W22-39	RCRA	Gross Alpha	5/13/97	1.8	1.0	pCi/L	J	N
299-W22-39	RCRA	Gross Alpha	8/7/97	1.5	0.9	pCi/L	J	N
299-W22-39	RCRA	Gross Alpha	11/11/97	2.3	1.0	pCi/L	J	N
299-W22-39	RCRA	Gross Beta	2/8/96	249.1	20.2	pCi/L		N
299-W22-39	RCRA	Gross Beta	8/12/96	132.6	14.3	pCi/L		N
299-W22-39	RCRA	Gross Beta	11/12/96	120.0	11.9	pCi/L		N
299-W22-39	RCRA	Gross Beta	2/4/97	87.7	9.1	pCi/L		N
299-W22-39	RCRA	Gross Beta	5/13/97	104.0	12.4	pCi/L		N
299-W22-39	RCRA	Gross Beta	8/7/97	40.1	4.9	pCi/L		N
299-W22-39	RCRA	Gross Beta	11/11/97	34.2	4.3	pCi/L		N
299-W22-39	RCRA	Cobalt-60	11/12/96	-1.1	5.6	pCi/L	U	N
299-W22-39	RCRA	Cobalt-60	2/4/97	1.1	3.8	pCi/L	U	N
299-W22-39	RCRA	Cobalt-60	5/13/97	3.0	2.7	pCi/L	U	N
299-W22-39	RCRA	Cobalt-60	8/7/97	-2.1	3.3	pCi/L	UJ	N
299-W22-39	RCRA	Cobalt-60	11/11/97	0.6	3.4	pCi/L	U	N
299-W22-39	RCRA	Cesium-137	11/12/96	3.3	3.9	pCi/L	U	N
299-W22-39	RCRA	Cesium-137	2/4/97	0.1	4.3	pCi/L	U	N
299-W22-39	RCRA	Cesium-137	5/13/97	4.9	3.3	pCi/L	U	N
299-W22-39	RCRA	Cesium-137	8/7/97	-1.4	2.3	pCi/L	UJ	N
299-W22-39	RCRA	Cesium-137	11/11/97	7.8	4.1	pCi/L	U	N
299-W22-39	RCRA	Strontium-90	2/4/97	0.2	0.3	pCi/L	U	N
299-W22-39	RCRA	Strontium-90	5/13/97	0.1	0.2	pCi/L	U	N
299-W22-39	RCRA	Strontium-90	8/7/97	0	0.2	pCi/L	U	N
299-W22-39	RCRA	Strontium-90	11/11/97	-0.1	0.2	pCi/L	U	N
299-W22-39	RCRA	Technetium-99	2/8/96	74	10	pCi/L		N
299-W22-39	RCRA	Technetium-99	8/12/96	620	69	pCi/L		N
299-W22-39	RCRA	Technetium-99	11/12/96	340	41	pCi/L		N
299-W22-39	RCRA	Technetium-99	2/4/97	300	36	pCi/L		N
299-W22-39	RCRA	Technetium-99	5/13/97	180	23	pCi/L		N
299-W22-39	RCRA	Technetium-99	8/7/97	100	25	pCi/L		N
299-W22-39	RCRA	Technetium-99	11/11/97	94	25	pCi/L		N
299-W22-39	RCRA	Tritium	2/8/96	3100	390	pCi/L		N
299-W22-39	RCRA	Tritium	8/12/96	4900	550	pCi/L		N
299-W22-39	RCRA	Tritium	11/12/96	5500	600	pCi/L		N
299-W22-39	RCRA	Tritium	2/4/97	5800	610	pCi/L		N
299-W22-39	RCRA	Tritium	5/13/97	8000	770	pCi/L		N
299-W22-39	RCRA	Tritium	8/7/97	8400	800	pCi/L		N
299-W22-39	RCRA	Tritium	11/11/97	11000	960	pCi/L		N
299-W22-44	RCRA	Gross Alpha	2/13/96	2.6	1.5	pCi/L		N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W22-44	RCRA	Gross Alpha	8/12/96	1.8	1.2	pCi/L		N
299-W22-44	RCRA	Gross Alpha	11/12/96	2.0	0.8	pCi/L	J	N
299-W22-44	RCRA	Gross Alpha	2/4/97	2.6	1.1	pCi/L	J	N
299-W22-44	RCRA	Gross Alpha	5/13/97	2.6	1.1	pCi/L	J	N
299-W22-44	RCRA	Gross Alpha	8/7/97	2.7	1.1	pCi/L	J	N
299-W22-44	RCRA	Gross Beta	2/13/96	2.2	2.3	pCi/L	U	N
299-W22-44	RCRA	Gross Beta	8/12/96	4.1	2.5	pCi/L		N
299-W22-44	RCRA	Gross Beta	11/12/96	6.0	1.9	pCi/L		N
299-W22-44	RCRA	Gross Beta	2/4/97	6.4	1.9	pCi/L		N
299-W22-44	RCRA	Gross Beta	5/13/97	6.3	1.7	pCi/L		N
299-W22-44	RCRA	Gross Beta	8/7/97	6.3	1.7	pCi/L		N
299-W22-44	RCRA	Cobalt-60	11/12/96	-6.1	5.8	pCi/L	U	N
299-W22-44	RCRA	Cobalt-60	2/4/97	-4.1	5.4	pCi/L	U	N
299-W22-44	RCRA	Cobalt-60	5/13/97	1.7	4.6	pCi/L	U	N
299-W22-44	RCRA	Cobalt-60	8/7/97	-2.2	2.9	pCi/L	UJ	N
299-W22-44	RCRA	Cesium-137	11/12/96	2.5	4.4	pCi/L	U	N
299-W22-44	RCRA	Cesium-137	2/4/97	0.1	3.6	pCi/L	U	N
299-W22-44	RCRA	Cesium-137	5/13/97	5.0	4.0	pCi/L	U	N
299-W22-44	RCRA	Cesium-137	8/7/97	2.2	1.6	pCi/L	J	N
299-W22-44	RCRA	Strontium-90	2/4/97	0	0.2	pCi/L	U	N
299-W22-44	RCRA	Strontium-90	5/13/97	0.1	0.2	pCi/L	U	N
299-W22-44	RCRA	Strontium-90	8/7/97	0.1	0.2	pCi/L	U	N
299-W22-44	RCRA	Technetium-99	2/13/96	2.6	2.5	pCi/L		N
299-W22-44	RCRA	Technetium-99	8/12/96	2.6	2.5	pCi/L		N
299-W22-44	RCRA	Technetium-99	11/12/96	5.6	5.0	pCi/L	J	N
299-W22-44	RCRA	Technetium-99	2/4/97	3.0	4.6	pCi/L	U	N
299-W22-44	RCRA	Technetium-99	5/13/97	6.6	4.8	pCi/L	J	N
299-W22-44	RCRA	Technetium-99	8/7/97	-0.6	15.9	pCi/L	U	N
299-W22-44	RCRA	Tritium	2/13/96	-82	200	pCi/L	U	N
299-W22-44	RCRA	Tritium	8/12/96	53	210	pCi/L		N
299-W22-44	RCRA	Tritium	11/12/96	61	220	pCi/L	U	N
299-W22-44	RCRA	Tritium	2/4/97	-100	200	pCi/L	U	N
299-W22-44	RCRA	Tritium	5/13/97	220	220	pCi/L	U	N
299-W22-44	RCRA	Tritium	8/7/97	230	220	pCi/L	U	N
299-W22-45	RCRA	Gross Alpha	2/13/96	4.5	2.1	pCi/L		N
299-W22-45	RCRA	Gross Alpha	8/14/96	2.8	1.5	pCi/L		N
299-W22-45	RCRA	Gross Alpha	11/12/96	3.6	1.3	pCi/L		N
299-W22-45	RCRA	Gross Alpha	2/4/97	3.3	1.3	pCi/L		N
299-W22-45	RCRA	Gross Alpha	5/20/97	3.2	1.2	pCi/L		N
299-W22-45	RCRA	Gross Alpha	8/6/97	200(a)	33	pCi/L		N
299-W22-45	RCRA	Gross Alpha	11/11/97	2.9	1.2	pCi/L	J	N
299-W22-45	RCRA	Gross Beta	2/13/96	8.4	2.9	pCi/L		N
299-W22-45	RCRA	Gross Beta	8/14/96	11	3	pCi/L		N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W22-45	RCRA	Gross Beta	11/12/96	13	3	pCi/L		N
299-W22-45	RCRA	Gross Beta	2/4/97	31	4	pCi/L		N
299-W22-45	RCRA	Gross Beta	5/20/97	79	10	pCi/L		N
299-W22-45	RCRA	Gross Beta	8/6/97	65	7	pCi/L		N
299-W22-45	RCRA	Gross Beta	11/11/97	83	9	pCi/L		N
299-W22-45	RCRA	Cobalt-60	11/12/96	-2.1	4.0	pCi/L	U	N
299-W22-45	RCRA	Cobalt-60	2/4/97	3.4	4.1	pCi/L	U	N
299-W22-45	RCRA	Cobalt-60	5/20/97	0.2	4.4	pCi/L	U	N
299-W22-45	RCRA	Cobalt-60	8/6/97	-0.4	2.2	pCi/L	UJ	N
299-W22-45	RCRA	Cobalt-60	11/11/97	-1.0	4.4	pCi/L	U	N
299-W22-45	RCRA	Cesium-137	11/12/96	-0.1	4.4	pCi/L	U	N
299-W22-45	RCRA	Cesium-137	2/4/97	5.4	3.7	pCi/L	U	N
299-W22-45	RCRA	Cesium-137	5/20/97	-3.9	4.6	pCi/L	U	N
299-W22-45	RCRA	Cesium-137	8/6/97	1.0	2.5	pCi/L	UJ	N
299-W22-45	RCRA	Cesium-137	11/11/97	2.8	3.8	pCi/L	U	N
299-W22-45	RCRA	Strontium-90	2/4/97	0.2	0.3	pCi/L	U	N
299-W22-45	RCRA	Strontium-90	5/20/97	0.3	0.3	pCi/L	U	N
299-W22-45	RCRA	Strontium-90	8/6/97	0.3	0.2	pCi/L	U	N
299-W22-45	RCRA	Strontium-90	11/11/97	0	0.2	pCi/L	U	N
299-W22-45	RCRA	Technetium-99	2/13/96	15	4	pCi/L		N
299-W22-45	RCRA	Technetium-99	8/14/96	3	2	pCi/L		N
299-W22-45	RCRA	Technetium-99	11/12/96	48	9	pCi/L		N
299-W22-45	RCRA	Technetium-99	2/4/97	80	12	pCi/L		N
299-W22-45	RCRA	Technetium-99	5/20/97	140	19	pCi/L		N
299-W22-45	RCRA	Technetium-99	8/6/97	210	36	pCi/L		N
299-W22-45	RCRA	Technetium-99	11/11/97	260	41	pCi/L		N
299-W22-45	RCRA	Tritium	2/13/96	900	270	pCi/L		N
299-W22-45	RCRA	Tritium	8/14/96	780	260	pCi/L		N
299-W22-45	RCRA	Tritium	11/12/96	860	270	pCi/L		N
299-W22-45	RCRA	Tritium	2/4/97	1200	290	pCi/L		N
299-W22-45	RCRA	Tritium	5/20/97	1500	300	pCi/L		N
299-W22-45	RCRA	Tritium	8/6/97	2000	350	pCi/L		N
299-W22-45	RCRA	Tritium	11/11/97	3800	460	pCi/L		N
299-W22-46	RCRA	Gross Alpha	2/8/96	5.8	2.5	pCi/L		N
299-W22-46	RCRA	Gross Alpha	8/12/96	0.5	0.8	pCi/L		N
299-W22-46	RCRA	Gross Alpha	11/11/96	1.6	0.8	pCi/L	J	N
299-W22-46	RCRA	Gross Alpha	2/4/97	2.4	1.1	pCi/L	J	N
299-W22-46	RCRA	Gross Alpha	5/8/97	2.3	1.8	pCi/L	U	N
299-W22-46	RCRA	Gross Alpha	5/8/97	2.7	1.2	pCi/L	J	N
299-W22-46	RCRA	Gross Alpha	8/7/97	3.0	2.0	pCi/L		N
299-W22-46	RCRA	Gross Alpha	11/11/97	2.9	1.2	pCi/L	J	N
299-W22-46	RCRA	Gross Beta	2/8/96	85	9	pCi/L		N
299-W22-46	RCRA	Gross Beta	8/12/96	67	9	pCi/L		N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W22-46	RCRA	Gross Beta	11/11/96	940	84	pCi/L		N
299-W22-46	RCRA	Gross Beta	2/4/97	1200	110	pCi/L		N
299-W22-46	RCRA	Gross Beta	5/8/97	2300	210	pCi/L		N
299-W22-46	RCRA	Gross Beta	5/8/97	1100	100	pCi/L		N
299-W22-46	RCRA	Gross Beta	8/7/97	1800	150	pCi/L		N
299-W22-46	RCRA	Gross Beta	11/11/97	1200	110	pCi/L		N
299-W22-46	RCRA	Cobalt-60	2/26/96	0.7	0.7	pCi/L		N
299-W22-46	RCRA	Cobalt-60	11/11/96	0.8	3.3	pCi/L	U	N
299-W22-46	RCRA	Cobalt-60	2/4/97	4.1	5.2	pCi/L	U	N
299-W22-46	RCRA	Cobalt-60	5/8/97	0.3	5.4	pCi/L	U	N
299-W22-46	RCRA	Cobalt-60	5/8/97	-1.7	3.5	pCi/L	UJ	N
299-W22-46	RCRA	Cobalt-60	8/7/97	1.6	2.6	pCi/L	UJ	N
299-W22-46	RCRA	Cobalt-60	11/11/97	2.4	5.1	pCi/L	U	N
299-W22-46	RCRA	Cesium-137	2/26/96	0.6	0.9	pCi/L	U	N
299-W22-46	RCRA	Cesium-137	11/11/96	-4.1	5.4	pCi/L	U	N
299-W22-46	RCRA	Cesium-137	2/4/97	-0.3	5.3	pCi/L	U	N
299-W22-46	RCRA	Cesium-137	5/8/97	-0.8	4.9	pCi/L	U	N
299-W22-46	RCRA	Cesium-137	5/8/97	3.2	2.5	pCi/L	J	N
299-W22-46	RCRA	Cesium-137	8/7/97	-0.7	2.4	pCi/L	UJ	N
299-W22-46	RCRA	Cesium-137	11/11/97	-0.7	5.2	pCi/L	U	N
299-W22-46	RCRA	Iodine-129	2/26/96	0.27	0.27	pCi/L		N
299-W22-46	RCRA	Iodine-129	5/8/97	0.47	0.42	pCi/L	U	N
299-W22-46	RCRA	Strontium-90	2/4/97	0.08	0.24	pCi/L	U	N
299-W22-46	RCRA	Strontium-90	5/8/97	0.20	0.22	pCi/L	U	N
299-W22-46	RCRA	Strontium-90	5/8/97	-0.05	0.18	pCi/L	U	N
299-W22-46	RCRA	Strontium-90	8/7/97	0.02	0.19	pCi/L	U	N
299-W22-46	RCRA	Strontium-90	11/11/97	0.02	0.20	pCi/L	U	N
299-W22-46	RCRA	Technetium-99	2/8/96	290	33	pCi/L		N
299-W22-46	RCRA	Technetium-99	8/12/96	340	39	pCi/L		N
299-W22-46	RCRA	Technetium-99	11/11/96	2800	310	pCi/L		N
299-W22-46	RCRA	Technetium-99	2/4/97	3400	370	pCi/L		N
299-W22-46	RCRA	Technetium-99	5/8/97	5000	560	pCi/L		N
299-W22-46	RCRA	Technetium-99	5/8/97	4300	470	pCi/L		N
299-W22-46	RCRA	Technetium-99	8/7/97	4000	450	pCi/L		N
299-W22-46	RCRA	Technetium-99	11/11/97	3600	400	pCi/L		N
299-W22-46	RCRA	Tritium	2/8/96	6410	631	pCi/L		N
299-W22-46	RCRA	Tritium	8/12/96	14400	1240	pCi/L		N
299-W22-46	RCRA	Tritium	11/11/96	51300	3910	pCi/L		N
299-W22-46	RCRA	Tritium	2/4/97	55100	4190	pCi/L		N
299-W22-46	RCRA	Tritium	5/8/97	65200	4940	pCi/L		N
299-W22-46	RCRA	Tritium	5/23/97	64400	4880	pCi/L		N
299-W22-46	RCRA	Tritium	8/7/97	64700	4900	pCi/L		N
299-W22-46	RCRA	Tritium	11/11/97	60700	4600	pCi/L		N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W22-46	RCRA	Uranium	2/26/96	3.6	2.3	ug/L		N
299-W22-46	RCRA	Uranium	5/8/97	4.6	1.0	ug/L		N
299-W23-13	RCRA	Gross Alpha	2/7/96	8.4	2.8	pCi/L		N
299-W23-13	RCRA	Gross Alpha	8/8/96	9.1	2.9	pCi/L		N
299-W23-13	RCRA	Gross Alpha	11/7/96	6.5	1.8	pCi/L		N
299-W23-13	RCRA	Gross Alpha	2/6/97	7.2	1.6	pCi/L		N
299-W23-13	RCRA	Gross Alpha	5/7/97	75.8(a)	12.5	pCi/L		N
299-W23-13	RCRA	Gross Alpha	8/7/97	7.7	2.1	pCi/L		N
299-W23-13	RCRA	Gross Alpha	11/11/97	10.9	2.6	pCi/L		N
299-W23-13	RCRA	Gross Beta	2/7/96	6	3	pCi/L		N
299-W23-13	RCRA	Gross Beta	8/8/96	10	3	pCi/L		N
299-W23-13	RCRA	Gross Beta	11/7/96	5	2	pCi/L		N
299-W23-13	RCRA	Gross Beta	2/6/97	11	2	pCi/L		N
299-W23-13	RCRA	Gross Beta	5/7/97	11	2	pCi/L		N
299-W23-13	RCRA	Gross Beta	8/7/97	14	3	pCi/L		N
299-W23-13	RCRA	Gross Beta	11/11/97	9	2	pCi/L		N
299-W23-13	RCRA	Cobalt-60	11/7/96	1.9	4.0	pCi/L	U	N
299-W23-13	RCRA	Cobalt-60	2/6/97	6.6	4.0	pCi/L	U	N
299-W23-13	RCRA	Cobalt-60	5/7/97	4.7	3.4	pCi/L	U	N
299-W23-13	RCRA	Cobalt-60	8/7/97	2.3	2.2	pCi/L	J	N
299-W23-13	RCRA	Cobalt-60	11/11/97	-1.5	5.7	pCi/L	U	N
299-W23-13	RCRA	Cesium-137	11/7/96	-1.2	4.8	pCi/L	U	N
299-W23-13	RCRA	Cesium-137	2/6/97	-1.6	4.8	pCi/L	U	N
299-W23-13	RCRA	Cesium-137	5/7/97	3.7	3.6	pCi/L	U	N
299-W23-13	RCRA	Cesium-137	8/7/97	3.4	2.2	pCi/L	J	N
299-W23-13	RCRA	Cesium-137	11/11/97	5.2	3.4	pCi/L	U	N
299-W23-13	RCRA	Strontium-90	2/6/97	0.46	0.31	pCi/L	J	N
299-W23-13	RCRA	Strontium-90	5/7/97	0.10	0.25	pCi/L	U	N
299-W23-13	RCRA	Strontium-90	8/7/97	0.10	0.20	pCi/L	U	N
299-W23-13	RCRA	Strontium-90	11/11/97	0.09	0.21	pCi/L	U	N
299-W23-13	RCRA	Technetium-99	2/7/96	1.7	2.4	pCi/L	U	N
299-W23-13	RCRA	Technetium-99	8/8/96	0.2	2.2	pCi/L		N
299-W23-13	RCRA	Technetium-99	11/7/96	0.8	4.6	pCi/L	U	N
299-W23-13	RCRA	Technetium-99	2/6/97	1.3	4.6	pCi/L	U	N
299-W23-13	RCRA	Technetium-99	5/7/97	1.9	4.5	pCi/L	U	N
299-W23-13	RCRA	Technetium-99	8/7/97	0.3	16.0	pCi/L	U	N
299-W23-13	RCRA	Technetium-99	11/11/97	0.8	16.5	pCi/L	U	N
299-W23-13	RCRA	Tritium	2/7/96	150	200	pCi/L	U	N
299-W23-13	RCRA	Tritium	8/8/96	160	230	pCi/L		N
299-W23-13	RCRA	Tritium	11/7/96	-81	220	pCi/L	U	N
299-W23-13	RCRA	Tritium	2/6/97	160	220	pCi/L	U	N
299-W23-13	RCRA	Tritium	5/7/97	180	220	pCi/L	U	N
299-W23-13	RCRA	Tritium	8/7/97	220	220	pCi/L	U	N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W23-13	RCRA	Tritium	11/11/97	140	200	pCi/L	U	N
299-W23-14	RCRA	Gross Alpha	2/7/96	8.2	3.0	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	6.6		pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	9.7		pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	8.6		pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	10.2	2.8	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	7.3	2.5	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	7.4	2.5	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	7.6	2.6	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	4.6	1.9	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	4.8	2.0	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	7.5	2.5	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	5.7	2.2	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/8/96	7.6		pCi/L		N
299-W23-14	RCRA	Gross Alpha	11/7/96	7.6	2.0	pCi/L		N
299-W23-14	RCRA	Gross Alpha	2/4/97	8.3	2.2	pCi/L		N
299-W23-14	RCRA	Gross Alpha	5/8/97	7.3	1.6	pCi/L		N
299-W23-14	RCRA	Gross Alpha	8/7/97	7.7	2.1	pCi/L		N
299-W23-14	RCRA	Gross Alpha	11/11/97	7.9	2.1	pCi/L		N
299-W23-14	RCRA	Gross Beta	2/7/96	15	3	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	33		pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	32		pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	36		pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	48	4	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	45	4	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	45	4	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	47	4	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	23	4	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	23	4	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	22	4	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	20	4	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/8/96	34		pCi/L		N
299-W23-14	RCRA	Gross Beta	11/7/96	22	3	pCi/L		N
299-W23-14	RCRA	Gross Beta	2/4/97	15	3	pCi/L		N
299-W23-14	RCRA	Gross Beta	5/8/97	43	6	pCi/L		N
299-W23-14	RCRA	Gross Beta	8/7/97	20	3	pCi/L		N
299-W23-14	RCRA	Gross Beta	11/11/97	16	3	pCi/L		N
299-W23-14	RCRA	Cobalt-60	11/7/96	-2.3	4.9	pCi/L	U	N
299-W23-14	RCRA	Cobalt-60	2/4/97	-1.4	4.5	pCi/L	U	N
299-W23-14	RCRA	Cobalt-60	5/8/97	2.7	3.6	pCi/L	U	N
299-W23-14	RCRA	Cobalt-60	8/7/97	0	1.9	pCi/L	UJ	N
299-W23-14	RCRA	Cobalt-60	11/11/97	2.7	4.0	pCi/L	U	N
299-W23-14	RCRA	Cesium-137	11/7/96	-0.6	4.0	pCi/L	U	N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W23-14	RCRA	Cesium-137	2/4/97	1.6	4.5	pCi/L	U	N
299-W23-14	RCRA	Cesium-137	5/8/97	1.8	3.5	pCi/L	U	N
299-W23-14	RCRA	Cesium-137	8/7/97	-0.7	2.4	pCi/L	UJ	N
299-W23-14	RCRA	Cesium-137	11/11/97	2.1	3.9	pCi/L	U	N
299-W23-14	RCRA	Strontium-90	2/4/97	0.31	0.31	pCi/L	U	N
299-W23-14	RCRA	Strontium-90	5/8/97	0.09	0.21	pCi/L	U	N
299-W23-14	RCRA	Strontium-90	8/7/97	0.15	0.21	pCi/L	U	N
299-W23-14	RCRA	Strontium-90	11/11/97	0.08	0.18	pCi/L	U	N
299-W23-14	RCRA	Technetium-99	2/7/96	27	5	pCi/L		N
299-W23-14	RCRA	Technetium-99	8/8/96	16	4	pCi/L		N
299-W23-14	RCRA	Technetium-99	11/7/96	51	9	pCi/L		N
299-W23-14	RCRA	Technetium-99	2/4/97	31	7	pCi/L		N
299-W23-14	RCRA	Technetium-99	5/8/97	179	23	pCi/L		N
299-W23-14	RCRA	Technetium-99	8/7/97	97	25	pCi/L		N
299-W23-14	RCRA	Technetium-99	11/11/97	25	18	pCi/L		N
299-W23-14	RCRA	Tritium	2/7/96	135000	9980	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	230000		pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	230000		pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	220000		pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	243000	12400	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	241000	12300	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	243000	12500	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	244000	12500	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	256000	18800	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	256000	18900	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	254000	18700	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	254000	18700	pCi/L		N
299-W23-14	RCRA	Tritium	8/8/96	230000		pCi/L		N
299-W23-14	RCRA	Tritium	11/7/96	276000	20300	pCi/L		N
299-W23-14	RCRA	Tritium	2/4/97	213000	15700	pCi/L		N
299-W23-14	RCRA	Tritium	5/8/97	177000	13000	pCi/L		N
299-W23-14	RCRA	Tritium	8/7/97	202000	14900	pCi/L		N
299-W23-14	RCRA	Tritium	11/11/97	263000	19300	pCi/L		N
299-W23-15	RCRA	Gross Alpha	2/8/96	8.0	3.0	pCi/L		N
299-W23-15	RCRA	Gross Alpha	8/12/96	3.9	1.8	pCi/L		N
299-W23-15	RCRA	Gross Alpha	11/11/96	3.0	1.1	pCi/L		N
299-W23-15	RCRA	Gross Alpha	2/4/97	6.2	1.8	pCi/L		N
299-W23-15	RCRA	Gross Alpha	5/8/97	2.8	0.8	pCi/L	J	N
299-W23-15	RCRA	Gross Alpha	8/7/97	5.3	1.7	pCi/L		N
299-W23-15	RCRA	Gross Alpha	11/11/97	7.5	2.0	pCi/L		N
299-W23-15	RCRA	Gross Alpha	11/11/97	8.3	2.2	pCi/L		N
299-W23-15	RCRA	Gross Beta	2/8/96	26	4.4	pCi/L		N
299-W23-15	RCRA	Gross Beta	8/12/96	37	5.7	pCi/L		N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W23-15	RCRA	Gross Beta	11/11/96	20	3.1	pCi/L		N
299-W23-15	RCRA	Gross Beta	2/4/97	17	2.9	pCi/L		N
299-W23-15	RCRA	Gross Beta	5/8/97	21	3.2	pCi/L		N
299-W23-15	RCRA	Gross Beta	8/7/97	15	2.7	pCi/L		N
299-W23-15	RCRA	Gross Beta	11/11/97	15	2.5	pCi/L		N
299-W23-15	RCRA	Gross Beta	11/11/97	13	2.3	pCi/L		N
299-W23-15	RCRA	Cobalt-60	11/11/96	1.9	3.9	pCi/L	U	N
299-W23-15	RCRA	Cobalt-60	2/4/97	-0.9	5.6	pCi/L	U	N
299-W23-15	RCRA	Cobalt-60	5/8/97	0.9	4.8	pCi/L	U	N
299-W23-15	RCRA	Cobalt-60	8/7/97	1.3	2.6	pCi/L	UJ	N
299-W23-15	RCRA	Cobalt-60	11/11/97	1.5	6.2	pCi/L	U	N
299-W23-15	RCRA	Cobalt-60	11/11/97	0.7	4.5	pCi/L	U	N
299-W23-15	RCRA	Cesium-137	11/11/96	0.4	4.7	pCi/L	U	N
299-W23-15	RCRA	Cesium-137	2/4/97	2.1	3.7	pCi/L	U	N
299-W23-15	RCRA	Cesium-137	5/8/97	-3.5	4.7	pCi/L	U	N
299-W23-15	RCRA	Cesium-137	8/7/97	-1.6	2.1	pCi/L	UJ	N
299-W23-15	RCRA	Cesium-137	11/11/97	4.4	4.2	pCi/L	U	N
299-W23-15	RCRA	Cesium-137	11/11/97	0.6	4.7	pCi/L	U	N
299-W23-15	RCRA	Strontium-90	2/4/97	0	0.27	pCi/L	U	N
299-W23-15	RCRA	Strontium-90	5/8/97	-0.04	0.19	pCi/L	U	N
299-W23-15	RCRA	Strontium-90	8/7/97	0.04	0.18	pCi/L	U	N
299-W23-15	RCRA	Strontium-90	11/11/97	0.08	0.20	pCi/L	U	N
299-W23-15	RCRA	Strontium-90	11/11/97	0.08	0.22	pCi/L	U	N
299-W23-15	RCRA	Technetium-99	2/8/96	87	11	pCi/L		N
299-W23-15	RCRA	Technetium-99	8/12/96	50	7	pCi/L		N
299-W23-15	RCRA	Technetium-99	11/11/96	33	7	pCi/L		N
299-W23-15	RCRA	Technetium-99	2/4/97	37	8	pCi/L		N
299-W23-15	RCRA	Technetium-99	5/8/97	20	6	pCi/L		N
299-W23-15	RCRA	Technetium-99	8/7/97	20	18	pCi/L		N
299-W23-15	RCRA	Technetium-99	11/11/97	20	18	pCi/L		N
299-W23-15	RCRA	Technetium-99	11/11/97	20	18	pCi/L		N
299-W23-15	RCRA	Tritium	2/8/96	22200	1780	pCi/L		N
299-W23-15	RCRA	Tritium	8/12/96	26800	2140	pCi/L		N
299-W23-15	RCRA	Tritium	11/11/96	27200	2150	pCi/L		N
299-W23-15	RCRA	Tritium	2/4/97	26600	2120	pCi/L		N
299-W23-15	RCRA	Tritium	5/8/97	28000	2230	pCi/L		N
299-W23-15	RCRA	Tritium	8/7/97	26700	2130	pCi/L		N
299-W23-15	RCRA	Tritium	11/11/97	24700	1980	pCi/L		N
299-W23-15	RCRA	Tritium	11/11/97	24200	1940	pCi/L		N
299-W23-15	RCRA	Uranium	2/27/96	14	5.4	ug/L		N
299-W23-15	RCRA	Uranium	5/8/97	14	2.0	ug/L		N
299-W23-1	Non-RCRA	Gross Beta	3/11/96	52*	6	pCi/L		N
299-W23-1	Non-RCRA	Gross Beta	8/28/97	330*	37	pCi/L		N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W23-1	Non-RCRA	Gross Beta	8/28/97	350*	37	pCi/L		N
299-W23-1	Non-RCRA	Cobalt-60	3/11/96	-1.0*	1.0	pCi/L	U	N
299-W23-1	Non-RCRA	Cobalt-60	8/28/97	0.0*	1.5	pCi/L	UJ	N
299-W23-1	Non-RCRA	Cobalt-60	8/28/97	1.5*	2.3	pCi/L	UJ	N
299-W23-1	Non-RCRA	Cesium-137	3/11/96	2.0*	1.0	pCi/L		N
299-W23-1	Non-RCRA	Cesium-137	8/28/97	-0.2*	2.1	pCi/L	UJ	N
299-W23-1	Non-RCRA	Cesium-137	8/28/97	0.7*	2.4	pCi/L	UJ	N
299-W23-1	Non-RCRA	Technetium-99	3/11/96	180*	21	pCi/L		N
299-W23-1	Non-RCRA	Technetium-99	8/28/97	1500*	170	pCi/L		N
299-W23-1	Non-RCRA	Technetium-99	8/28/97	1200*	140	pCi/L		N
299-W23-1	Non-RCRA	Tritium	3/11/96	-37*	200	pCi/L		N
299-W23-1	Non-RCRA	Tritium	8/28/97	2500*	400	pCi/L		N
299-W23-1	Non-RCRA	Tritium	8/28/97	2600*	410	pCi/L		N
299-W23-2	Non-RCRA	Gross Beta	3/11/96	91*	9	pCi/L		N
299-W23-2	Non-RCRA	Gross Beta	8/27/97	43*	5	pCi/L		N
299-W23-2	Non-RCRA	Cobalt-60	3/11/96	-0.2*	1.6	pCi/L	U	N
299-W23-2	Non-RCRA	Cobalt-60	8/27/97	1.0*	2.5	pCi/L	UJ	N
299-W23-2	Non-RCRA	Cesium-137	3/11/96	1.5*	1.3	pCi/L		N
299-W23-2	Non-RCRA	Cesium-137	8/27/97	1.6*	2.5	pCi/L	UJ	N
299-W23-2	Non-RCRA	Strontium-90	3/11/96	0.16*	0.29	pCi/L		N
299-W23-2	Non-RCRA	Strontium-90	8/27/97	0.25*	0.26	pCi/L	U	N
299-W23-2	Non-RCRA	Technetium-99	3/11/96	290*	33	pCi/L		N
299-W23-2	Non-RCRA	Technetium-99	8/27/97	110*	26	pCi/L		N
299-W23-2	Non-RCRA	Tritium	3/11/96	1300*	300	pCi/L		N
299-W23-2	Non-RCRA	Tritium	8/27/97	4500*	520	pCi/L		N
299-W23-3	Non-RCRA	Gross Beta	3/11/96	63*	7.2	pCi/L		N
299-W23-3	Non-RCRA	Cobalt-60	3/11/96	1.2*	1.5	pCi/L	U	N
299-W23-3	Non-RCRA	Cesium-137	3/11/96	2.6*	2.0	pCi/L		N
299-W23-3	Non-RCRA	Technetium-99	3/11/96	190*	22	pCi/L		N
299-W23-3	Non-RCRA	Technetium-99	7/30/97	63	21	pCi/L		N
299-W23-3	Non-RCRA	Tritium	3/11/96	18700*	1550	pCi/L		N
299-W23-3	Non-RCRA	Uranium	3/11/96	7.3*	2.3	ug/L		N
299-W23-6	Non-RCRA	Gross Alpha	7/10/97	2.5	1.4	pCi/L	J	N
299-W23-6	Non-RCRA	Gross Beta	7/10/97	1400	140	pCi/L		N
299-W23-6	Non-RCRA	Technetium-99	7/10/97	2100	240	pCi/L		N
299-W23-6	Non-RCRA	Tritium	7/10/97	52500	4000	pCi/L		N
299-W23-7	Non-RCRA	Gross Alpha	6/18/96	0.2	0.6	pCi/L	U	N
299-W23-7	Non-RCRA	Gross Alpha	6/25/96	4.2	2.0	pCi/L		N
299-W23-7	Non-RCRA	Gross Alpha	6/25/96	5.9	2.4	pCi/L		N
299-W23-7	Non-RCRA	Gross Alpha	6/25/96	2.1	1.4	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	3/11/96	420*	34	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/18/96	20	4	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/19/96	86	10	pCi/L		N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W23-7	Non-RCRA	Gross Beta	6/19/96	71	9	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/19/96	67	9	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/25/96	150	16	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/25/96	180	18	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/25/96	150	16	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/25/96	180	18	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/25/96	180	18	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/25/96	180	19	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	6/25/96	160	17	pCi/L		N
299-W23-7	Non-RCRA	Gross Beta	8/27/97	24*	3	pCi/L		N
299-W23-7	Non-RCRA	Cobalt-60	3/11/96	-0.7*	1.4	pCi/L	U	N
299-W23-7	Non-RCRA	Cobalt-60	6/19/96	0.2	1.7	pCi/L	U	N
299-W23-7	Non-RCRA	Cobalt-60	6/19/96	-0.6	1.5	pCi/L	U	Y
299-W23-7	Non-RCRA	Cobalt-60	6/25/96	0.5	1.0	pCi/L	U	N
299-W23-7	Non-RCRA	Cobalt-60	6/25/96	1.7	1.6	pCi/L		Y
299-W23-7	Non-RCRA	Cobalt-60	8/27/97	2.3*	2.4	pCi/L	UJ	N
299-W23-7	Non-RCRA	Cesium-137	3/11/96	19*	3.6	pCi/L		N
299-W23-7	Non-RCRA	Cesium-137	6/19/96	10	3.4	pCi/L		N
299-W23-7	Non-RCRA	Cesium-137	6/19/96	1.0	1.1	pCi/L	U	Y
299-W23-7	Non-RCRA	Cesium-137	6/25/96	14	2.8	pCi/L		N
299-W23-7	Non-RCRA	Cesium-137	6/25/96	2.0	1.7	pCi/L		Y
299-W23-7	Non-RCRA	Cesium-137	8/27/97	2.5*	2.4	pCi/L	J	N
299-W23-7	Non-RCRA	Strontium-90	3/11/96	6.2*	1.6	pCi/L		N
299-W23-7	Non-RCRA	Strontium-90	6/19/96	1.2	0.5	pCi/L		Y
299-W23-7	Non-RCRA	Strontium-90	6/25/96	1.7	0.9	pCi/L		N
299-W23-7	Non-RCRA	Strontium-90	6/25/96	0.9	0.5	pCi/L		Y
299-W23-7	Non-RCRA	Technetium-99	3/11/96	540*	61	pCi/L		N
299-W23-7	Non-RCRA	Technetium-99	6/19/96	570	64	pCi/L		N
299-W23-7	Non-RCRA	Technetium-99	6/25/96	220	25	pCi/L		N
299-W23-7	Non-RCRA	Technetium-99	8/27/97	54*	20	pCi/L		N
299-W23-7	Non-RCRA	Tritium	3/11/96	5690*	600	pCi/L		N
299-W23-7	Non-RCRA	Tritium	6/19/96	2240	370	pCi/L		N
299-W23-7	Non-RCRA	Tritium	6/25/96	2810	380	pCi/L		N
299-W23-7	Non-RCRA	Tritium	8/27/97	450*	230	pCi/L		N
299-W23-7	Non-RCRA	Uranium	3/11/96	86*	27	ug/L		N
299-W23-7	Non-RCRA	Uranium	8/27/97	1.2*	0.2	ug/L		N
299-W23-9	Non-RCRA	Gross Alpha	5/22/96	13	4	pCi/L		N
299-W23-9	Non-RCRA	Gross Beta	5/22/96	21	4	pCi/L		N
299-W23-9	Non-RCRA	Technetium-99	5/22/96	55	8	pCi/L		N
299-W23-9	Non-RCRA	Technetium-99	8/12/97	120	27	pCi/L		N

Table B.1. (contd)

Well	Well Standard	Constituent	Date	Result	Total Error	Unit	Qualifier	Filtered
299-W23-9	Non-RCRA	Tritium	5/22/96	119000	8870	pCi/L		N
299-W23-9	Non-RCRA	Uranium	5/22/96	21	5.9	ug/L		N
299-W23-9	Non-RCRA	Uranium	8/12/97	21	4.7	ug/L		N

(a) Suspect data currently under review.
*Bailed sample.

Table B.2. Analytical Results for Chemical Constituents in WMA S-SX Monitoring Wells

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W22-39	RCRA	Aluminum	2/8/96	31		ug/L	U	Y
299-W22-39	RCRA	Aluminum	11/12/96	59		ug/L	U	Y
299-W22-39	RCRA	Aluminum	2/4/97	34		ug/L	U	Y
299-W22-39	RCRA	Aluminum	5/13/97	20		ug/L	U	Y
299-W22-39	RCRA	Aluminum	8/7/97	25		ug/L	UC	Y
299-W22-39	RCRA	Aluminum	11/11/97	58		ug/L	U	Y
299-W22-39	RCRA	Alkalinity	2/8/96	91.0		mg/L		N
299-W22-39	RCRA	Alkalinity	11/12/96	88.0		mg/L		N
299-W22-39	RCRA	Alkalinity	2/4/97	95.5		mg/L		N
299-W22-39	RCRA	Alkalinity	5/13/97	88.0		mg/L		N
299-W22-39	RCRA	Alkalinity	8/7/97	88.1		mg/L		N
299-W22-39	RCRA	Alkalinity	11/11/97	86.9		mg/L		N
299-W22-39	RCRA	Calcium	2/8/96	18000	3240	ug/L		Y
299-W22-39	RCRA	Calcium	11/12/96	18000		ug/L		Y
299-W22-39	RCRA	Calcium	2/4/97	18500		ug/L	CE	Y
299-W22-39	RCRA	Calcium	5/13/97	17900		ug/L		Y
299-W22-39	RCRA	Calcium	8/7/97	18100		ug/L	C	Y
299-W22-39	RCRA	Calcium	11/11/97	18400		ug/L		Y
299-W22-39	RCRA	Chloride	2/8/96	3.9		mg/L		N
299-W22-39	RCRA	Chloride	11/12/96	3.7		mg/L		N
299-W22-39	RCRA	Chloride	2/4/97	3.4		mg/L		N
299-W22-39	RCRA	Chloride	5/13/97	3.5		mg/L		N
299-W22-39	RCRA	Chloride	8/7/97	4.4		mg/L	C	N
299-W22-39	RCRA	Chloride	11/11/97	3.1		mg/L	C	N
299-W22-39	RCRA	Conductivity	2/8/96	256		umhos/cm		N
299-W22-39	RCRA	Conductivity	2/8/96	256		umhos/cm		N
299-W22-39	RCRA	Conductivity	2/8/96	256		umhos/cm		N
299-W22-39	RCRA	Conductivity	2/8/96	256		umhos/cm		N
299-W22-39	RCRA	Conductivity	8/12/96	256		umhos/cm		N
299-W22-39	RCRA	Conductivity	8/12/96	256		umhos/cm		N
299-W22-39	RCRA	Conductivity	8/12/96	256		umhos/cm		N
299-W22-39	RCRA	Conductivity	8/12/96	256		umhos/cm		N
299-W22-39	RCRA	Conductivity	11/12/96	251		umhos/cm		N
299-W22-39	RCRA	Conductivity	2/4/97	236		umhos/cm		N
299-W22-39	RCRA	Conductivity	5/13/97	249		umhos/cm		N
299-W22-39	RCRA	Conductivity	8/7/97	241		umhos/cm		N
299-W22-39	RCRA	Conductivity	11/11/97	244		umhos/cm		N
299-W22-39	RCRA	Chromium	2/8/96	12	5.0	ug/L		Y
299-W22-39	RCRA	Chromium	11/12/96	7		ug/L	B	Y
299-W22-39	RCRA	Chromium	2/4/97	7		ug/L	B	Y
299-W22-39	RCRA	Chromium	5/13/97	5		ug/L	B	Y
299-W22-39	RCRA	Chromium	8/7/97	4		ug/L	B	Y
299-W22-39	RCRA	Chromium	11/11/97	4		ug/L	U	Y

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W22-39	RCRA	Iron	2/8/96	66	5.9	ug/L	B	Y
299-W22-39	RCRA	Iron	11/12/96	44		ug/L	C	Y
299-W22-39	RCRA	Iron	2/4/97	69		ug/L	C	Y
299-W22-39	RCRA	Iron	5/13/97	42		ug/L	C	Y
299-W22-39	RCRA	Iron	8/7/97	27		ug/L	BC	Y
299-W22-39	RCRA	Iron	11/11/97	44		ug/L		Y
299-W22-39	RCRA	Potassium	2/8/96	3500	735	ug/L		Y
299-W22-39	RCRA	Potassium	11/12/96	3450		ug/L		Y
299-W22-39	RCRA	Potassium	2/4/97	2330		ug/L	U	Y
299-W22-39	RCRA	Potassium	5/13/97	3520		ug/L		Y
299-W22-39	RCRA	Potassium	8/7/97	3600		ug/L		Y
299-W22-39	RCRA	Potassium	11/11/97	2640		ug/L	U	Y
299-W22-39	RCRA	Magnesium	2/8/96	5700	1200	ug/L		Y
299-W22-39	RCRA	Magnesium	11/12/96	5800		ug/L		Y
299-W22-39	RCRA	Magnesium	2/4/97	6000		ug/L	E	Y
299-W22-39	RCRA	Magnesium	5/13/97	5700		ug/L		Y
299-W22-39	RCRA	Magnesium	8/7/97	5700		ug/L	C	Y
299-W22-39	RCRA	Magnesium	11/11/97	5900		ug/L		Y
299-W22-39	RCRA	Manganese	2/8/96	6.2	0.93	ug/L		Y
299-W22-39	RCRA	Manganese	11/12/96	3.5		ug/L	B	Y
299-W22-39	RCRA	Manganese	2/4/97	3.4		ug/L	B	Y
299-W22-39	RCRA	Manganese	5/13/97	0.6		ug/L	B	Y
299-W22-39	RCRA	Manganese	8/7/97	2.3		ug/L	B	Y
299-W22-39	RCRA	Manganese	11/11/97	2.8		ug/L	B	Y
299-W22-39	RCRA	Sodium	2/8/96	23000	6210	ug/L		Y
299-W22-39	RCRA	Sodium	11/12/96	24300		ug/L		Y
299-W22-39	RCRA	Sodium	2/4/97	24200		ug/L		Y
299-W22-39	RCRA	Sodium	5/13/97	23800		ug/L		Y
299-W22-39	RCRA	Sodium	8/7/97	23500		ug/L		Y
299-W22-39	RCRA	Sodium	11/11/97	24200		ug/L		Y
299-W22-39	RCRA	Nitrate	2/8/96	17000		ug/L	D	N
299-W22-39	RCRA	Nitrate	11/12/96	14700		ug/L	D	N
299-W22-39	RCRA	Nitrate	2/4/97	12300		ug/L	D	N
299-W22-39	RCRA	Nitrate	5/13/97	8900		ug/L	D	N
299-W22-39	RCRA	Nitrate	8/7/97	12400		ug/L	D	N
299-W22-39	RCRA	Nitrate	11/11/97	12400		ug/L	D	N
299-W22-39	RCRA	pH	2/8/96	7.9		pH		N
299-W22-39	RCRA	pH	2/8/96	7.9		pH		N
299-W22-39	RCRA	pH	2/8/96	7.9		pH		N
299-W22-39	RCRA	pH	2/8/96	7.9		pH		N
299-W22-39	RCRA	pH	8/12/96	7.9		pH		N
299-W22-39	RCRA	pH	8/12/96	7.9		pH		N
299-W22-39	RCRA	pH	8/12/96	7.9		pH		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W22-39	RCRA	pH	8/12/96	7.9		pH		N
299-W22-39	RCRA	pH	11/12/96	8.1		pH		N
299-W22-39	RCRA	pH	2/4/97	8.0		pH		N
299-W22-39	RCRA	pH	5/13/97	8.0		pH		N
299-W22-39	RCRA	pH	8/7/97	8.2		pH		N
299-W22-39	RCRA	pH	11/11/97	8.0		pH		N
299-W22-39	RCRA	Sulfate	2/8/96	14.0		mg/L	D	N
299-W22-39	RCRA	Sulfate	11/12/96	14.4		mg/L		N
299-W22-39	RCRA	Sulfate	2/4/97	14.2		mg/L		N
299-W22-39	RCRA	Sulfate	5/13/97	14.4		mg/L		N
299-W22-39	RCRA	Sulfate	8/7/97	14.6		mg/L		N
299-W22-39	RCRA	Sulfate	11/11/97	13.0		mg/L		N
299-W22-44	RCRA	Aluminum	2/13/96	31		ug/L	U	Y
299-W22-44	RCRA	Aluminum	11/12/96	59		ug/L	U	Y
299-W22-44	RCRA	Aluminum	2/4/97	34		ug/L	U	Y
299-W22-44	RCRA	Aluminum	5/13/97	18300		ug/L		Y
299-W22-44	RCRA	Aluminum	8/7/97	32		ug/L	BC	Y
299-W22-44	RCRA	Aluminum	11/12/97	58		ug/L	U	Y
299-W22-44	RCRA	Alkalinity	2/13/96	87.0		mg/L		N
299-W22-44	RCRA	Alkalinity	11/12/96	84.0		mg/L		N
299-W22-44	RCRA	Alkalinity	2/4/97	95.5		mg/L		N
299-W22-44	RCRA	Alkalinity	5/13/97	84.0		mg/L		N
299-W22-44	RCRA	Alkalinity	8/7/97	86.1		mg/L		N
299-W22-44	RCRA	Alkalinity	11/12/97	83.0		mg/L		N
299-W22-44	RCRA	Calcium	2/13/96	15000		ug/L		Y
299-W22-44	RCRA	Calcium	11/12/96	15900		ug/L		Y
299-W22-44	RCRA	Calcium	2/4/97	15800		ug/L	CE	Y
299-W22-44	RCRA	Calcium	8/7/97	18900		ug/L	C	Y
299-W22-44	RCRA	Calcium	11/12/97	16500		ug/L		Y
299-W22-44	RCRA	Chloride	2/13/96	1.6		mg/L		N
299-W22-44	RCRA	Chloride	11/12/96	2.0		mg/L		N
299-W22-44	RCRA	Chloride	2/4/97	2.2		mg/L		N
299-W22-44	RCRA	Chloride	5/13/97	2.6		mg/L		N
299-W22-44	RCRA	Chloride	8/7/97	2.9		mg/L	C	N
299-W22-44	RCRA	Chloride	11/12/97	2.6		mg/L	C	N
299-W22-44	RCRA	Conductivity	2/13/96	207		umhos/cm		N
299-W22-44	RCRA	Conductivity	2/13/96	207		umhos/cm		N
299-W22-44	RCRA	Conductivity	2/13/96	207		umhos/cm		N
299-W22-44	RCRA	Conductivity	2/13/96	207		umhos/cm		N
299-W22-44	RCRA	Conductivity	8/12/96	212		umhos/cm		N
299-W22-44	RCRA	Conductivity	8/12/96	212		umhos/cm		N
299-W22-44	RCRA	Conductivity	8/12/96	211		umhos/cm		N
299-W22-44	RCRA	Conductivity	8/12/96	211		umhos/cm		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W22-44	RCRA	Conductivity	11/12/96	213		umhos/cm		N
299-W22-44	RCRA	Conductivity	2/4/97	209		umhos/cm		N
299-W22-44	RCRA	Conductivity	5/13/97	228		umhos/cm		N
299-W22-44	RCRA	Conductivity	8/7/97	220		umhos/cm		N
299-W22-44	RCRA	Conductivity	11/12/97	234		umhos/cm		N
299-W22-44	RCRA	Chromium	2/13/96	4		ug/L	U	Y
299-W22-44	RCRA	Chromium	11/12/96	4		ug/L	U	Y
299-W22-44	RCRA	Chromium	2/4/97	3		ug/L	U	Y
299-W22-44	RCRA	Chromium	8/7/97	4		ug/L	B	Y
299-W22-44	RCRA	Chromium	11/12/97	4		ug/L	U	Y
299-W22-44	RCRA	Iron	2/13/96	33		ug/L	B	Y
299-W22-44	RCRA	Iron	11/12/96	34		ug/L	C	Y
299-W22-44	RCRA	Iron	2/4/97	52		ug/L	C	Y
299-W22-44	RCRA	Iron	8/7/97	27		ug/L	BC	Y
299-W22-44	RCRA	Iron	11/12/97	54		ug/L	C	Y
299-W22-44	RCRA	Potassium	2/13/96	2500		ug/L		Y
299-W22-44	RCRA	Potassium	11/12/96	1960		ug/L		Y
299-W22-44	RCRA	Potassium	2/4/97	2330		ug/L	U	Y
299-W22-44	RCRA	Potassium	8/7/97	2960		ug/L		Y
299-W22-44	RCRA	Potassium	11/12/97	2640		ug/L	U	Y
299-W22-44	RCRA	Magnesium	2/13/96	4700		ug/L		Y
299-W22-44	RCRA	Magnesium	11/12/96	4970		ug/L		Y
299-W22-44	RCRA	Magnesium	2/4/97	4960		ug/L	E	Y
299-W22-44	RCRA	Magnesium	8/7/97	5830		ug/L	C	Y
299-W22-44	RCRA	Magnesium	11/12/97	5130		ug/L		Y
299-W22-44	RCRA	Manganese	2/13/96	0.8		ug/L	L	Y
299-W22-44	RCRA	Manganese	11/12/96	2.4		ug/L	B	Y
299-W22-44	RCRA	Manganese	2/4/97	2.9		ug/L	B	Y
299-W22-44	RCRA	Manganese	8/7/97	2.8		ug/L	B	Y
299-W22-44	RCRA	Manganese	11/12/97	1.7		ug/L	B	Y
299-W22-44	RCRA	Sodium	2/13/96	20000		ug/L		Y
299-W22-44	RCRA	Sodium	11/12/96	20800		ug/L		Y
299-W22-44	RCRA	Sodium	2/4/97	19500		ug/L		Y
299-W22-44	RCRA	Sodium	8/7/97	21100		ug/L		Y
299-W22-44	RCRA	Sodium	11/12/97	19700		ug/L		Y
299-W22-44	RCRA	Nitrate	2/13/96	1500		ug/L		N
299-W22-44	RCRA	Nitrate	11/12/96	4300		ug/L	D	N
299-W22-44	RCRA	Nitrate	2/4/97	5800		ug/L	D	N
299-W22-44	RCRA	Nitrate	5/13/97	8100		ug/L	D	N
299-W22-44	RCRA	Nitrate	8/7/97	10300		ug/L	D	N
299-W22-44	RCRA	Nitrate	11/12/97	9000		ug/L	D	N
299-W22-44	RCRA	pH	2/13/96	8.0		pH		N
299-W22-44	RCRA	pH	2/13/96	8.0		pH		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W22-44	RCRA	pH	2/13/96	8.0		pH		N
299-W22-44	RCRA	pH	2/13/96	8.0		pH		N
299-W22-44	RCRA	pH	8/12/96	8.0		pH		N
299-W22-44	RCRA	pH	8/12/96	8.0		pH		N
299-W22-44	RCRA	pH	8/12/96	8.0		pH		N
299-W22-44	RCRA	pH	8/12/96	8.0		pH		N
299-W22-44	RCRA	pH	11/12/96	8.2		pH		N
299-W22-44	RCRA	pH	2/4/97	8.0		pH		N
299-W22-44	RCRA	pH	5/13/97	8.0		pH		N
299-W22-44	RCRA	pH	8/7/97	8.1		pH		N
299-W22-44	RCRA	pH	11/12/97	8.0		pH		N
299-W22-44	RCRA	Sulfate	2/13/96	11.0		mg/L	D	N
299-W22-44	RCRA	Sulfate	11/12/96	11.4		mg/L		N
299-W22-44	RCRA	Sulfate	2/4/97	11.8		mg/L		N
299-W22-44	RCRA	Sulfate	5/13/97	12.4		mg/L		N
299-W22-44	RCRA	Sulfate	8/7/97	13.2		mg/L		N
299-W22-44	RCRA	Sulfate	11/12/97	12.6		mg/L		N
299-W22-45	RCRA	Aluminum	2/13/96	31		ug/L	U	Y
299-W22-45	RCRA	Aluminum	11/12/96	59		ug/L	U	Y
299-W22-45	RCRA	Aluminum	2/4/97	34		ug/L	U	Y
299-W22-45	RCRA	Aluminum	5/20/97	60		ug/L	B	Y
299-W22-45	RCRA	Aluminum	8/6/97	25		ug/L	BC	Y
299-W22-45	RCRA	Aluminum	11/11/97	58		ug/L	U	Y
299-W22-45	RCRA	Alkalinity	2/13/96	88.0		mg/L		N
299-W22-45	RCRA	Alkalinity	11/12/96	86.0		mg/L		N
299-W22-45	RCRA	Alkalinity	2/4/97	91.5		mg/L		N
299-W22-45	RCRA	Alkalinity	5/20/97	86.0		mg/L		N
299-W22-45	RCRA	Alkalinity	8/6/97	87.8		mg/L		N
299-W22-45	RCRA	Alkalinity	11/11/97	87.3		mg/L		N
299-W22-45	RCRA	Calcium	2/13/96	20000		ug/L		Y
299-W22-45	RCRA	Calcium	11/12/96	21300		ug/L		Y
299-W22-45	RCRA	Calcium	2/4/97	21700		ug/L	CE	Y
299-W22-45	RCRA	Calcium	5/20/97	23100		ug/L	C	Y
299-W22-45	RCRA	Calcium	8/6/97	23300		ug/L	C	Y
299-W22-45	RCRA	Calcium	11/11/97	26300		ug/L		Y
299-W22-45	RCRA	Chloride	2/13/96	4.7		mg/L		N
299-W22-45	RCRA	Chloride	11/12/96	5.3		mg/L	D	N
299-W22-45	RCRA	Chloride	2/4/97	5.4		mg/L	D	N
299-W22-45	RCRA	Chloride	5/20/97	6.3		mg/L	D	N
299-W22-45	RCRA	Chloride	8/6/97	6.7		mg/L	CD	N
299-W22-45	RCRA	Chloride	11/11/97	7.6		mg/L	CD	N
299-W22-45	RCRA	Conductivity	2/13/96	273		umhos/cm		N
299-W22-45	RCRA	Conductivity	2/13/96	271		umhos/cm		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W22-45	RCRA	Conductivity	2/13/96	271		umhos/cm		N
299-W22-45	RCRA	Conductivity	2/13/96	273		umhos/cm		N
299-W22-45	RCRA	Conductivity	8/14/96	271		umhos/cm		N
299-W22-45	RCRA	Conductivity	8/14/96	271		umhos/cm		N
299-W22-45	RCRA	Conductivity	8/14/96	270		umhos/cm		N
299-W22-45	RCRA	Conductivity	8/14/96	270		umhos/cm		N
299-W22-45	RCRA	Conductivity	11/12/96	285		umhos/cm		N
299-W22-45	RCRA	Conductivity	2/4/97	277		umhos/cm		N
299-W22-45	RCRA	Conductivity	5/20/97	312		umhos/cm		N
299-W22-45	RCRA	Conductivity	8/6/97	304		umhos/cm		N
299-W22-45	RCRA	Conductivity	11/11/97	314		umhos/cm		N
299-W22-45	RCRA	Chromium	2/13/96	4		ug/L	U	Y
299-W22-45	RCRA	Chromium	11/12/96	5		ug/L	B	Y
299-W22-45	RCRA	Chromium	2/4/97	3		ug/L	U	Y
299-W22-45	RCRA	Chromium	5/20/97	12		ug/L		Y
299-W22-45	RCRA	Chromium	8/6/97	4		ug/L	B	Y
299-W22-45	RCRA	Chromium	11/11/97	6		ug/L	B	Y
299-W22-45	RCRA	Iron	2/13/96	23		ug/L	BL	Y
299-W22-45	RCRA	Iron	11/12/96	40		ug/L	C	Y
299-W22-45	RCRA	Iron	2/4/97	42		ug/L	C	Y
299-W22-45	RCRA	Iron	5/20/97	77		ug/L	C	Y
299-W22-45	RCRA	Iron	8/6/97	17		ug/L	BC	Y
299-W22-45	RCRA	Iron	11/11/97	29		ug/L	B	Y
299-W22-45	RCRA	Potassium	2/13/96	2900		ug/L		Y
299-W22-45	RCRA	Potassium	11/12/96	3190		ug/L		Y
299-W22-45	RCRA	Potassium	2/4/97	2330		ug/L	U	Y
299-W22-45	RCRA	Potassium	5/20/97	4180		ug/L		Y
299-W22-45	RCRA	Potassium	8/6/97	3540		ug/L		Y
299-W22-45	RCRA	Potassium	11/11/97	4980		ug/L		Y
299-W22-45	RCRA	Magnesium	2/13/96	6300		ug/L		Y
299-W22-45	RCRA	Magnesium	11/12/96	6720		ug/L		Y
299-W22-45	RCRA	Magnesium	2/4/97	6800		ug/L	E	Y
299-W22-45	RCRA	Magnesium	5/20/97	7090		ug/L		Y
299-W22-45	RCRA	Magnesium	8/6/97	7120		ug/L		Y
299-W22-45	RCRA	Magnesium	11/11/97	8150		ug/L		Y
299-W22-45	RCRA	Manganese	2/13/96	0.6		ug/L	U	Y
299-W22-45	RCRA	Manganese	11/12/96	2.6		ug/L	B	Y
299-W22-45	RCRA	Manganese	2/4/97	3.1		ug/L	B	Y
299-W22-45	RCRA	Manganese	5/20/97	1.9		ug/L	B	Y
299-W22-45	RCRA	Manganese	8/6/97	2.2		ug/L	B	Y
299-W22-45	RCRA	Manganese	11/11/97	2.5		ug/L	B	Y
299-W22-45	RCRA	Sodium	2/13/96	24000		ug/L		Y
299-W22-45	RCRA	Sodium	11/12/96	24300		ug/L		Y

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result(a)	Total Error	Unit	Qualifier	Filtered
299-W22-45	RCRA	Sodium	2/4/97	23900		ug/L		Y
299-W22-45	RCRA	Sodium	5/20/97	25900		ug/L		Y
299-W22-45	RCRA	Sodium	8/6/97	24400		ug/L		Y
299-W22-45	RCRA	Sodium	11/11/97	26800		ug/L		Y
299-W22-45	RCRA	Nitrate	2/13/96	17000		ug/L	D	N
299-W22-45	RCRA	Nitrate	11/12/96	22400		ug/L	D	N
299-W22-45	RCRA	Nitrate	2/4/97	25600		ug/L	D	N
299-W22-45	RCRA	Nitrate	5/20/97	27800		ug/L	D	N
299-W22-45	RCRA	Nitrate	8/6/97	31600		ug/L	D	N
299-W22-45	RCRA	Nitrate	11/11/97	34000		ug/L	D	N
299-W22-45	RCRA	pH	2/13/96	8.1		pH		N
299-W22-45	RCRA	pH	2/13/96	8.1		pH		N
299-W22-45	RCRA	pH	2/13/96	8.1		pH		N
299-W22-45	RCRA	pH	2/13/96	8.1		pH		N
299-W22-45	RCRA	pH	8/14/96	8.0		pH		N
299-W22-45	RCRA	pH	8/14/96	8.0		pH		N
299-W22-45	RCRA	pH	8/14/96	8.0		pH		N
299-W22-45	RCRA	pH	8/14/96	8.0		pH		N
299-W22-45	RCRA	pH	11/12/96	8.3		pH		N
299-W22-45	RCRA	pH	2/4/97	8.1		pH		N
299-W22-45	RCRA	pH	5/20/97	8.1		pH		N
299-W22-45	RCRA	pH	8/6/97	8.1		pH		N
299-W22-45	RCRA	pH	11/11/97	7.9		pH		N
299-W22-45	RCRA	Sulfate	2/13/96	21.0		mg/L	D	N
299-W22-45	RCRA	Sulfate	11/12/96	20.1		mg/L	D	N
299-W22-45	RCRA	Sulfate	2/4/97	21.6		mg/L	D	N
299-W22-45	RCRA	Sulfate	5/20/97	22.2		mg/L	D	N
299-W22-45	RCRA	Sulfate	8/6/97	23.8		mg/L	D	N
299-W22-45	RCRA	Sulfate	11/11/97	26.5		mg/L	D	N
299-W22-46	RCRA	Aluminum	2/8/96	31		ug/L	U	Y
299-W22-46	RCRA	Aluminum	11/11/96	60		ug/L	B	Y
299-W22-46	RCRA	Aluminum	2/4/97	34		ug/L	U	Y
299-W22-46	RCRA	Aluminum	5/8/97	20		ug/L	U	Y
299-W22-46	RCRA	Aluminum	5/8/97	20		ug/L	U	N
299-W22-46	RCRA	Aluminum	5/8/97	97		ug/L	B	Y
299-W22-46	RCRA	Aluminum	8/7/97	26		ug/L	BC	Y
299-W22-46	RCRA	Aluminum	11/11/97	58		ug/L	U	Y
299-W22-46	RCRA	Alkalinity	2/8/96	92.0		mg/L		N
299-W22-46	RCRA	Alkalinity	11/11/96	89.6		mg/L		N
299-W22-46	RCRA	Alkalinity	2/4/97	97.5		mg/L		N
299-W22-46	RCRA	Alkalinity	5/8/97	88.0		mg/L		N
299-W22-46	RCRA	Alkalinity	8/7/97	89.9		mg/L		N
299-W22-46	RCRA	Alkalinity	11/11/97	87.0		mg/L		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[(a)]	Total Error	Unit	Qualifier	Filtered
299-W22-46	RCRA	Calcium	2/8/96	17000	3060	ug/L		Y
299-W22-46	RCRA	Calcium	11/11/96	20900		ug/L		Y
299-W22-46	RCRA	Calcium	2/4/97	23700		ug/L	CE	Y
299-W22-46	RCRA	Calcium	5/8/97	25600		ug/L		Y
299-W22-46	RCRA	Calcium	5/8/97	24600		ug/L		N
299-W22-46	RCRA	Calcium	5/8/97	25900		ug/L		Y
299-W22-46	RCRA	Calcium	8/7/97	24400		ug/L	C	Y
299-W22-46	RCRA	Calcium	11/11/97	25600		ug/L		Y
299-W22-46	RCRA	Chloride	2/8/96	3.3		mg/L		N
299-W22-46	RCRA	Chloride	11/11/96	3.2		mg/L		N
299-W22-46	RCRA	Chloride	2/4/97	3.2		mg/L		N
299-W22-46	RCRA	Chloride	5/8/97	3.6		mg/L		N
299-W22-46	RCRA	Chloride	5/8/97	3.5		mg/L		N
299-W22-46	RCRA	Chloride	8/7/97	3.5		mg/L	C	N
299-W22-46	RCRA	Chloride	11/11/97	3.1		mg/L	C	N
299-W22-46	RCRA	Conductivity	2/8/96	239		umhos/cm		N
299-W22-46	RCRA	Conductivity	2/8/96	239		umhos/cm		N
299-W22-46	RCRA	Conductivity	2/8/96	239		umhos/cm		N
299-W22-46	RCRA	Conductivity	2/8/96	239		umhos/cm		N
299-W22-46	RCRA	Conductivity	2/26/96	222		umhos/cm		N
299-W22-46	RCRA	Conductivity	8/12/96	237		umhos/cm		N
299-W22-46	RCRA	Conductivity	8/12/96	237		umhos/cm		N
299-W22-46	RCRA	Conductivity	8/12/96	237		umhos/cm		N
299-W22-46	RCRA	Conductivity	8/12/96	237		umhos/cm		N
299-W22-46	RCRA	Conductivity	11/11/96	284		umhos/cm		N
299-W22-46	RCRA	Conductivity	2/4/97	283		umhos/cm		N
299-W22-46	RCRA	Conductivity	5/8/97	315		umhos/cm		N
299-W22-46	RCRA	Conductivity	5/8/97	317		umhos/cm		N
299-W22-46	RCRA	Conductivity	5/23/97	322		umhos/cm		N
299-W22-46	RCRA	Conductivity	8/7/97	304		umhos/cm		N
299-W22-46	RCRA	Conductivity	11/11/97	292		umhos/cm		N
299-W22-46	RCRA	Chromium	2/8/96	8.1	3.4	ug/L	L	Y
299-W22-46	RCRA	Chromium	11/11/96	31		ug/L		Y
299-W22-46	RCRA	Chromium	2/4/97	28		ug/L		Y
299-W22-46	RCRA	Chromium	5/8/97	39		ug/L		Y
299-W22-46	RCRA	Chromium	5/8/97	38		ug/L		N
299-W22-46	RCRA	Chromium	5/8/97	35		ug/L		Y
299-W22-46	RCRA	Chromium	8/7/97	34		ug/L		Y
299-W22-46	RCRA	Chromium	11/11/97	33		ug/L		Y
299-W22-46	RCRA	Iron	2/8/96	37	3.3	ug/L	B	Y
299-W22-46	RCRA	Iron	11/11/96	59		ug/L	C	Y
299-W22-46	RCRA	Iron	2/4/97	68		ug/L	C	Y
299-W22-46	RCRA	Iron	5/8/97	20		ug/L	B	Y

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result(a)	Total Error	Unit	Qualifier	Filtered
299-W22-46	RCRA	Iron	5/8/97	96		ug/L		N
299-W22-46	RCRA	Iron	5/8/97	26		ug/L	B	Y
299-W22-46	RCRA	Iron	8/7/97	83		ug/L	C	Y
299-W22-46	RCRA	Iron	11/11/97	87		ug/L		Y
299-W22-46	RCRA	Potassium	2/8/96	3000	630	ug/L		Y
299-W22-46	RCRA	Potassium	11/11/96	3080		ug/L		Y
299-W22-46	RCRA	Potassium	2/4/97	2330		ug/L	U	Y
299-W22-46	RCRA	Potassium	5/8/97	5060		ug/L		Y
299-W22-46	RCRA	Potassium	5/8/97	4220		ug/L		N
299-W22-46	RCRA	Potassium	5/8/97	3400		ug/L		Y
299-W22-46	RCRA	Potassium	8/7/97	4010		ug/L		Y
299-W22-46	RCRA	Potassium	11/11/97	3260		ug/L		Y
299-W22-46	RCRA	Magnesium	2/8/96	5600	1180	ug/L		Y
299-W22-46	RCRA	Magnesium	11/11/96	6960		ug/L		Y
299-W22-46	RCRA	Magnesium	2/4/97	7960		ug/L	E	Y
299-W22-46	RCRA	Magnesium	5/8/97	8380		ug/L		Y
299-W22-46	RCRA	Magnesium	5/8/97	8020		ug/L		N
299-W22-46	RCRA	Magnesium	5/8/97	8520		ug/L		Y
299-W22-46	RCRA	Magnesium	8/7/97	8030		ug/L	C	Y
299-W22-46	RCRA	Magnesium	11/11/97	8560		ug/L		Y
299-W22-46	RCRA	Manganese	2/8/96	0.82	0.12	ug/L	L	Y
299-W22-46	RCRA	Manganese	11/11/96	1.8		ug/L	B	Y
299-W22-46	RCRA	Manganese	2/4/97	3.6		ug/L	B	Y
299-W22-46	RCRA	Manganese	5/8/97	1.4		ug/L	B	Y
299-W22-46	RCRA	Manganese	5/8/97	2.8		ug/L	B	N
299-W22-46	RCRA	Manganese	5/8/97	2.3		ug/L	B	Y
299-W22-46	RCRA	Manganese	8/7/97	2.5		ug/L	B	Y
299-W22-46	RCRA	Manganese	11/11/97	3.1		ug/L	B	Y
299-W22-46	RCRA	Sodium	2/8/96	22000	5940	ug/L		Y
299-W22-46	RCRA	Sodium	11/11/96	23100		ug/L		Y
299-W22-46	RCRA	Sodium	2/4/97	24600		ug/L		Y
299-W22-46	RCRA	Sodium	5/8/97	25800		ug/L		Y
299-W22-46	RCRA	Sodium	5/8/97	25100		ug/L		N
299-W22-46	RCRA	Sodium	5/8/97	26100		ug/L		Y
299-W22-46	RCRA	Sodium	8/7/97	24500		ug/L		Y
299-W22-46	RCRA	Sodium	11/11/97	25600		ug/L		Y
299-W22-46	RCRA	Nitrate	2/8/96	11000		ug/L	D	N
299-W22-46	RCRA	Nitrate	11/11/96	35500		ug/L	D	N
299-W22-46	RCRA	Nitrate	2/4/97	40400		ug/L	D	N
299-W22-46	RCRA	Nitrate	5/8/97	52200		ug/L	D	N
299-W22-46	RCRA	Nitrate	5/8/97	46500		ug/L	D	N
299-W22-46	RCRA	Nitrate	8/7/97	49600		ug/L	D	N
299-W22-46	RCRA	Nitrate	11/11/97	44300		ug/L	D	N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W22-46	RCRA	pH	2/8/96	8.0		pH		N
299-W22-46	RCRA	pH	2/8/96	8.0		pH		N
299-W22-46	RCRA	pH	2/8/96	8.0		pH		N
299-W22-46	RCRA	pH	2/8/96	8.0		pH		N
299-W22-46	RCRA	pH	2/26/96	7.9		pH		N
299-W22-46	RCRA	pH	8/12/96	7.9		pH		N
299-W22-46	RCRA	pH	8/12/96	7.9		pH		N
299-W22-46	RCRA	pH	8/12/96	7.9		pH		N
299-W22-46	RCRA	pH	8/12/96	7.9		pH		N
299-W22-46	RCRA	pH	11/11/96	8.1		pH		N
299-W22-46	RCRA	pH	2/4/97	8.1		pH		N
299-W22-46	RCRA	pH	5/8/97	7.9		pH		N
299-W22-46	RCRA	pH	5/8/97	8.0		pH		N
299-W22-46	RCRA	pH	5/23/97	7.9		pH		N
299-W22-46	RCRA	pH	8/7/97	8.2		pH		N
299-W22-46	RCRA	pH	11/11/97	7.9		pH		N
299-W22-46	RCRA	Sulfate	2/8/96	14.0		mg/L	D	N
299-W22-46	RCRA	Sulfate	11/11/96	13.6		mg/L		N
299-W22-46	RCRA	Sulfate	2/4/97	13.7		mg/L		N
299-W22-46	RCRA	Sulfate	5/8/97	14.4		mg/L		N
299-W22-46	RCRA	Sulfate	5/8/97	14.9		mg/L		N
299-W22-46	RCRA	Sulfate	8/7/97	14.2		mg/L		N
299-W22-46	RCRA	Sulfate	11/11/97	13.1		mg/L		N
299-W23-13	RCRA	Aluminum	2/7/96	31		ug/L	U	Y
299-W23-13	RCRA	Aluminum	11/7/96	59		ug/L	U	Y
299-W23-13	RCRA	Aluminum	2/6/97	34		ug/L	UC	Y
299-W23-13	RCRA	Aluminum	5/7/97	20		ug/L	U	Y
299-W23-13	RCRA	Aluminum	8/7/97	584		ug/L	C	Y
299-W23-13	RCRA	Aluminum	11/11/97	58		ug/L	U	Y
299-W23-13	RCRA	Alkalinity	2/7/96	93.0		mg/L		N
299-W23-13	RCRA	Alkalinity	11/7/96	90.5		mg/L		N
299-W23-13	RCRA	Alkalinity	2/6/97	99.5		mg/L		N
299-W23-13	RCRA	Alkalinity	5/7/97	100.0		mg/L		N
299-W23-13	RCRA	Alkalinity	8/7/97	93.5		mg/L		N
299-W23-13	RCRA	Alkalinity	11/11/97	89.9		mg/L		N
299-W23-13	RCRA	Calcium	2/7/96	18000	3240	ug/L		Y
299-W23-13	RCRA	Calcium	11/7/96	18600		ug/L		Y
299-W23-13	RCRA	Calcium	2/6/97	17700		ug/L	C	Y
299-W23-13	RCRA	Calcium	5/7/97	19800		ug/L		Y
299-W23-13	RCRA	Calcium	8/7/97	19000		ug/L	C	Y
299-W23-13	RCRA	Calcium	11/11/97	19600		ug/L		Y
299-W23-13	RCRA	Chloride	2/7/96	2.7		mg/L		N
299-W23-13	RCRA	Chloride	11/7/96	2.7		mg/L		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W23-13	RCRA	Chloride	2/6/97	2.8		mg/L		N
299-W23-13	RCRA	Chloride	5/7/97	2.9		mg/L		N
299-W23-13	RCRA	Chloride	8/7/97	2.8		mg/L	C	N
299-W23-13	RCRA	Chloride	11/11/97	2.6		mg/L	C	N
299-W23-13	RCRA	Conductivity	2/7/96	227		umhos/cm		N
299-W23-13	RCRA	Conductivity	2/7/96	226		umhos/cm		N
299-W23-13	RCRA	Conductivity	2/7/96	226		umhos/cm		N
299-W23-13	RCRA	Conductivity	2/7/96	226		umhos/cm		N
299-W23-13	RCRA	Conductivity	8/8/96	220		umhos/cm		N
299-W23-13	RCRA	Conductivity	8/8/96	220		umhos/cm		N
299-W23-13	RCRA	Conductivity	8/8/96	220		umhos/cm		N
299-W23-13	RCRA	Conductivity	8/8/96	220		umhos/cm		N
299-W23-13	RCRA	Conductivity	11/7/96	219		umhos/cm		N
299-W23-13	RCRA	Conductivity	2/6/97	220		umhos/cm		N
299-W23-13	RCRA	Conductivity	5/7/97	231		umhos/cm		N
299-W23-13	RCRA	Conductivity	8/7/97	226		umhos/cm		N
299-W23-13	RCRA	Conductivity	11/11/97	221		umhos/cm		N
299-W23-13	RCRA	Chromium	2/7/96	4	1.7	ug/L	L	Y
299-W23-13	RCRA	Chromium	11/7/96	9		ug/L	B	Y
299-W23-13	RCRA	Chromium	2/6/97	5		ug/L	B	Y
299-W23-13	RCRA	Chromium	5/7/97	3		ug/L	U	Y
299-W23-13	RCRA	Chromium	8/7/97	3		ug/L	B	Y
299-W23-13	RCRA	Chromium	11/11/97	5		ug/L	B	Y
299-W23-13	RCRA	Iron	2/7/96	44	4.0	ug/L	B	Y
299-W23-13	RCRA	Iron	11/7/96	50		ug/L		Y
299-W23-13	RCRA	Iron	2/6/97	43		ug/L	C	Y
299-W23-13	RCRA	Iron	5/7/97	17		ug/L	BC	Y
299-W23-13	RCRA	Iron	8/7/97	536		ug/L	C	Y
299-W23-13	RCRA	Iron	11/11/97	36		ug/L		Y
299-W23-13	RCRA	Potassium	2/7/96	3700	780	ug/L		Y
299-W23-13	RCRA	Potassium	11/7/96	5040		ug/L		Y
299-W23-13	RCRA	Potassium	2/6/97	3750		ug/L		Y
299-W23-13	RCRA	Potassium	5/7/97	1900		ug/L	U	Y
299-W23-13	RCRA	Potassium	8/7/97	3750		ug/L		Y
299-W23-13	RCRA	Potassium	11/11/97	2640		ug/L	U	Y
299-W23-13	RCRA	Magnesium	2/7/96	5500	1160	ug/L		Y
299-W23-13	RCRA	Magnesium	11/7/96	5910		ug/L		Y
299-W23-13	RCRA	Magnesium	2/6/97	5660		ug/L		Y
299-W23-13	RCRA	Magnesium	5/7/97	6060		ug/L		Y
299-W23-13	RCRA	Magnesium	8/7/97	6840		ug/L	C	Y
299-W23-13	RCRA	Magnesium	11/11/97	6150		ug/L		Y
299-W23-13	RCRA	Manganese	2/7/96	1.4	0.21	ug/L	L	Y
299-W23-13	RCRA	Manganese	11/7/96	4.5		ug/L	B	Y

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result(a)	Total Error	Unit	Qualifier	Filtered
299-W23-13	RCRA	Manganese	2/6/97	1.8		ug/L	B	Y
299-W23-13	RCRA	Manganese	5/7/97	1.1		ug/L	B	Y
299-W23-13	RCRA	Manganese	8/7/97	5.6		ug/L		Y
299-W23-13	RCRA	Manganese	11/11/97	2.2		ug/L	B	Y
299-W23-13	RCRA	Sodium	2/7/96	19000	5130	ug/L		Y
299-W23-13	RCRA	Sodium	11/7/96	20600		ug/L		Y
299-W23-13	RCRA	Sodium	2/6/97	19400		ug/L		Y
299-W23-13	RCRA	Sodium	5/7/97	20700		ug/L		Y
299-W23-13	RCRA	Sodium	8/7/97	20000		ug/L		Y
299-W23-13	RCRA	Sodium	11/11/97	20900		ug/L		Y
299-W23-13	RCRA	Nitrate	2/7/96	2700		ug/L		N
299-W23-13	RCRA	Nitrate	11/7/96	2500		ug/L		N
299-W23-13	RCRA	Nitrate	2/6/97	2500		ug/L		N
299-W23-13	RCRA	Nitrate	5/7/97	2400		ug/L		N
299-W23-13	RCRA	Nitrate	8/7/97	2500		ug/L		N
299-W23-13	RCRA	Nitrate	11/11/97	2500		ug/L		N
299-W23-13	RCRA	pH	2/7/96	8.1		pH		N
299-W23-13	RCRA	pH	2/7/96	8.1		pH		N
299-W23-13	RCRA	pH	2/7/96	8.1		pH		N
299-W23-13	RCRA	pH	2/7/96	8.1		pH		N
299-W23-13	RCRA	pH	8/8/96	8.1		pH		N
299-W23-13	RCRA	pH	8/8/96	8.1		pH		N
299-W23-13	RCRA	pH	8/8/96	8.1		pH		N
299-W23-13	RCRA	pH	8/8/96	8.1		pH		N
299-W23-13	RCRA	pH	11/7/96	8.2		pH		N
299-W23-13	RCRA	pH	2/6/97	8.2		pH		N
299-W23-13	RCRA	pH	5/7/97	8.2		pH		N
299-W23-13	RCRA	pH	8/7/97	8.3		pH		N
299-W23-13	RCRA	pH	11/11/97	8.1		pH		N
299-W23-13	RCRA	Sulfate	2/7/96	14.0		mg/L	D	N
299-W23-13	RCRA	Sulfate	11/7/96	13.6		mg/L		N
299-W23-13	RCRA	Sulfate	2/6/97	13.8		mg/L		N
299-W23-13	RCRA	Sulfate	5/7/97	14.1		mg/L		N
299-W23-13	RCRA	Sulfate	8/7/97	14.1		mg/L		N
299-W23-13	RCRA	Sulfate	11/11/97	13.6		mg/L		N
299-W23-14	RCRA	Aluminum	2/7/96	31		ug/L	U	Y
299-W23-14	RCRA	Aluminum	11/7/96	59		ug/L	U	Y
299-W23-14	RCRA	Aluminum	2/4/97	65		ug/L	B	Y
299-W23-14	RCRA	Aluminum	5/8/97	29		ug/L	B	Y
299-W23-14	RCRA	Aluminum	8/7/97	64		ug/L	BC	Y
299-W23-14	RCRA	Aluminum	11/11/97	58		ug/L	U	Y
299-W23-14	RCRA	Alkalinity	2/7/96	87.0		mg/L		N
299-W23-14	RCRA	Alkalinity	11/7/96	83.4		mg/L		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W23-14	RCRA	Alkalinity	2/4/97	89.6		mg/L		N
299-W23-14	RCRA	Alkalinity	5/8/97	84.0		mg/L		N
299-W23-14	RCRA	Alkalinity	8/7/97	88.2		mg/L		N
299-W23-14	RCRA	Alkalinity	11/11/97	82.1		mg/L		N
299-W23-14	RCRA	Calcium	2/7/96	18000	3240	ug/L		Y
299-W23-14	RCRA	Calcium	11/7/96	22000		ug/L		Y
299-W23-14	RCRA	Calcium	2/4/97	24500		ug/L	CE	Y
299-W23-14	RCRA	Calcium	5/8/97	23400		ug/L		Y
299-W23-14	RCRA	Calcium	8/7/97	19900		ug/L	C	Y
299-W23-14	RCRA	Calcium	11/11/97	22800		ug/L		Y
299-W23-14	RCRA	Chloride	2/7/96	4.2		mg/L		N
299-W23-14	RCRA	Chloride	11/7/96	6.9		mg/L	D	N
299-W23-14	RCRA	Chloride	2/4/97	9.6		mg/L	D	N
299-W23-14	RCRA	Chloride	5/8/97	9.0		mg/L	D	N
299-W23-14	RCRA	Chloride	8/7/97	6.4		mg/L	CD	N
299-W23-14	RCRA	Chloride	11/11/97	8.7		mg/L	CD	N
299-W23-14	RCRA	Conductivity	2/7/96	247		umhos/cm		N
299-W23-14	RCRA	Conductivity	2/7/96	247		umhos/cm		N
299-W23-14	RCRA	Conductivity	2/7/96	247		umhos/cm		N
299-W23-14	RCRA	Conductivity	2/7/96	246		umhos/cm		N
299-W23-14	RCRA	Conductivity	8/8/96	263		umhos/cm		N
299-W23-14	RCRA	Conductivity	8/8/96	263		umhos/cm		N
299-W23-14	RCRA	Conductivity	8/8/96	263		umhos/cm		N
299-W23-14	RCRA	Conductivity	8/8/96	262		umhos/cm		N
299-W23-14	RCRA	Conductivity	11/7/96	272		umhos/cm		N
299-W23-14	RCRA	Conductivity	2/4/97	291		umhos/cm		N
299-W23-14	RCRA	Conductivity	5/8/97	286		umhos/cm		N
299-W23-14	RCRA	Conductivity	8/7/97	265		umhos/cm		N
299-W23-14	RCRA	Conductivity	11/11/97	256		umhos/cm		N
299-W23-14	RCRA	Chromium	2/7/96	8	3.2	ug/L	L	Y
299-W23-14	RCRA	Chromium	11/7/96	5		ug/L	B	Y
299-W23-14	RCRA	Chromium	2/4/97	9		ug/L	B	Y
299-W23-14	RCRA	Chromium	5/8/97	7		ug/L	B	Y
299-W23-14	RCRA	Chromium	8/7/97	3		ug/L	B	Y
299-W23-14	RCRA	Chromium	11/11/97	8		ug/L	B	Y
299-W23-14	RCRA	Iron	2/7/96	27	2.4	ug/L	BL	Y
299-W23-14	RCRA	Iron	11/7/96	36		ug/L		Y
299-W23-14	RCRA	Iron	2/4/97	59		ug/L	C	Y
299-W23-14	RCRA	Iron	5/8/97	35		ug/L	C	Y
299-W23-14	RCRA	Iron	8/7/97	77		ug/L	C	Y
299-W23-14	RCRA	Iron	11/11/97	46		ug/L		Y
299-W23-14	RCRA	Potassium	2/7/96	2900	609	ug/L		Y
299-W23-14	RCRA	Potassium	11/7/96	3020		ug/L		Y

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[a]	Total Error	Unit	Qualifier	Filtered
299-W23-14	RCRA	Potassium	2/4/97	2330		ug/L	U	Y
299-W23-14	RCRA	Potassium	5/8/97	4410		ug/L		Y
299-W23-14	RCRA	Potassium	8/7/97	4030		ug/L		Y
299-W23-14	RCRA	Potassium	11/11/97	2640		ug/L	U	Y
299-W23-14	RCRA	Magnesium	2/7/96	5800	1220	ug/L		Y
299-W23-14	RCRA	Magnesium	11/7/96	7090		ug/L		Y
299-W23-14	RCRA	Magnesium	2/4/97	7890		ug/L	E	Y
299-W23-14	RCRA	Magnesium	5/8/97	7520		ug/L	C	Y
299-W23-14	RCRA	Magnesium	8/7/97	6270		ug/L	C	Y
299-W23-14	RCRA	Magnesium	11/11/97	7270		ug/L		Y
299-W23-14	RCRA	Manganese	2/7/96	1.7	0.26	ug/L	L	Y
299-W23-14	RCRA	Manganese	11/7/96	3.0		ug/L	B	Y
299-W23-14	RCRA	Manganese	2/4/97	4.5		ug/L	B	Y
299-W23-14	RCRA	Manganese	5/8/97	2.4		ug/L	B	Y
299-W23-14	RCRA	Manganese	8/7/97	2.4		ug/L	B	Y
299-W23-14	RCRA	Manganese	11/11/97	3.1		ug/L	B	Y
299-W23-14	RCRA	Sodium	2/7/96	20000	5400	ug/L		Y
299-W23-14	RCRA	Sodium	11/7/96	23100		ug/L		Y
299-W23-14	RCRA	Sodium	2/4/97	23300		ug/L		Y
299-W23-14	RCRA	Sodium	5/8/97	22900		ug/L		Y
299-W23-14	RCRA	Sodium	8/7/97	21100		ug/L		Y
299-W23-14	RCRA	Sodium	11/11/97	23600		ug/L		Y
299-W23-14	RCRA	Nitrate	2/7/96	16000		ug/L	D	N
299-W23-14	RCRA	Nitrate	11/7/96	28600		ug/L	D	N
299-W23-14	RCRA	Nitrate	2/4/97	31000		ug/L	D	N
299-W23-14	RCRA	Nitrate	5/8/97	24400		ug/L	D	N
299-W23-14	RCRA	Nitrate	8/7/97	16900		ug/L	D	N
299-W23-14	RCRA	Nitrate	11/11/97	19500		ug/L	D	N
299-W23-14	RCRA	pH	2/7/96	8.1		pH		N
299-W23-14	RCRA	pH	2/7/96	8.1		pH		N
299-W23-14	RCRA	pH	2/7/96	8.1		pH		N
299-W23-14	RCRA	pH	2/7/96	8.1		pH		N
299-W23-14	RCRA	pH	8/8/96	7.9		pH		N
299-W23-14	RCRA	pH	8/8/96	7.9		pH		N
299-W23-14	RCRA	pH	8/8/96	7.9		pH		N
299-W23-14	RCRA	pH	8/8/96	7.9		pH		N
299-W23-14	RCRA	pH	11/7/96	8.2		pH		N
299-W23-14	RCRA	pH	2/4/97	8.2		pH		N
299-W23-14	RCRA	pH	5/8/97	8.2		pH		N
299-W23-14	RCRA	pH	8/7/97	8.4		pH		N
299-W23-14	RCRA	pH	11/11/97	8.4		pH		N
299-W23-14	RCRA	Sulfate	2/7/96	13.0		mg/L	D	N
299-W23-14	RCRA	Sulfate	11/7/96	14.0		mg/L	D	N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result(a)	Total Error	Unit	Qualifier	Filtered
299-W23-14	RCRA	Sulfate	2/4/97	16.8		mg/L		N
299-W23-14	RCRA	Sulfate	5/8/97	16.9		mg/L		N
299-W23-14	RCRA	Sulfate	8/7/97	15.4		mg/L		N
299-W23-14	RCRA	Sulfate	11/11/97	15.4		mg/L		N
299-W23-15	RCRA	Aluminum	2/8/96	31		ug/L	U	Y
299-W23-15	RCRA	Aluminum	11/11/96	59		ug/L	U	Y
299-W23-15	RCRA	Aluminum	2/4/97	34		ug/L	U	Y
299-W23-15	RCRA	Aluminum	5/8/97	20		ug/L	U	Y
299-W23-15	RCRA	Aluminum	8/7/97	68		ug/L	BC	Y
299-W23-15	RCRA	Aluminum	11/11/97	58		ug/L	U	Y
299-W23-15	RCRA	Aluminum	11/11/97	58		ug/L	U	Y
299-W23-15	RCRA	Alkalinity	2/8/96	97.0		mg/L		N
299-W23-15	RCRA	Alkalinity	11/11/96	93.1		mg/L		N
299-W23-15	RCRA	Alkalinity	2/4/97	95.5		mg/L		N
299-W23-15	RCRA	Alkalinity	5/8/97	92.0		mg/L		N
299-W23-15	RCRA	Alkalinity	8/7/97	95.1		mg/L		N
299-W23-15	RCRA	Alkalinity	11/11/97	89.9		mg/L		N
299-W23-15	RCRA	Alkalinity	11/11/97	91.0		mg/L		N
299-W23-15	RCRA	Calcium	2/8/96	20000	3600	ug/L		Y
299-W23-15	RCRA	Calcium	11/11/96	20000		ug/L		Y
299-W23-15	RCRA	Calcium	2/4/97	21500		ug/L	CE	Y
299-W23-15	RCRA	Calcium	5/8/97	22100		ug/L		Y
299-W23-15	RCRA	Calcium	8/7/97	22500		ug/L	C	Y
299-W23-15	RCRA	Calcium	11/11/97	21800		ug/L		Y
299-W23-15	RCRA	Calcium	11/11/97	23000		ug/L		Y
299-W23-15	RCRA	Chloride	2/8/96	2.6		mg/L		N
299-W23-15	RCRA	Chloride	11/11/96	2.3		mg/L		N
299-W23-15	RCRA	Chloride	2/4/97	2.3		mg/L		N
299-W23-15	RCRA	Chloride	5/8/97	2.6		mg/L		N
299-W23-15	RCRA	Chloride	8/7/97	2.7		mg/L	C	N
299-W23-15	RCRA	Chloride	11/11/97	2.6		mg/L	C	N
299-W23-15	RCRA	Chloride	11/11/97	2.4		mg/L	C	N
299-W23-15	RCRA	Conductivity	2/8/96	245		umhos/cm		N
299-W23-15	RCRA	Conductivity	2/8/96	245		umhos/cm		N
299-W23-15	RCRA	Conductivity	2/8/96	245		umhos/cm		N
299-W23-15	RCRA	Conductivity	2/8/96	245		umhos/cm		N
299-W23-15	RCRA	Conductivity	2/27/96	252		umhos/cm		N
299-W23-15	RCRA	Conductivity	8/12/96	251		umhos/cm		N
299-W23-15	RCRA	Conductivity	8/12/96	250		umhos/cm		N
299-W23-15	RCRA	Conductivity	8/12/96	250		umhos/cm		N
299-W23-15	RCRA	Conductivity	8/12/96	250		umhos/cm		N
299-W23-15	RCRA	Conductivity	11/11/96	241		umhos/cm		N
299-W23-15	RCRA	Conductivity	2/4/97	242		umhos/cm		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[(a)]	Total Error	Unit	Qualifier	Filtered
299-W23-15	RCRA	Conductivity	5/8/97	254		umhos/cm		N
299-W23-15	RCRA	Conductivity	8/7/97	248		umhos/cm		N
299-W23-15	RCRA	Conductivity	11/11/97	250		umhos/cm		N
299-W23-15	RCRA	Chromium	2/8/96	4		ug/L	U	Y
299-W23-15	RCRA	Chromium	11/11/96	4		ug/L	U	Y
299-W23-15	RCRA	Chromium	2/4/97	6		ug/L	B	Y
299-W23-15	RCRA	Chromium	5/8/97	3		ug/L	U	Y
299-W23-15	RCRA	Chromium	8/7/97	4		ug/L	B	Y
299-W23-15	RCRA	Chromium	11/11/97	4		ug/L	U	Y
299-W23-15	RCRA	Chromium	11/11/97	4		ug/L	B	Y
299-W23-15	RCRA	Iron	2/8/96	29	2.6	ug/L	BL	Y
299-W23-15	RCRA	Iron	11/11/96	39		ug/L	C	Y
299-W23-15	RCRA	Iron	2/4/97	79		ug/L	C	Y
299-W23-15	RCRA	Iron	5/8/97	25		ug/L	BC	Y
299-W23-15	RCRA	Iron	8/7/97	46		ug/L	C	Y
299-W23-15	RCRA	Iron	11/11/97	32		ug/L		Y
299-W23-15	RCRA	Iron	11/11/97	43		ug/L		Y
299-W23-15	RCRA	Potassium	2/8/96	3500	735	ug/L		Y
299-W23-15	RCRA	Potassium	11/11/96	4160		ug/L		Y
299-W23-15	RCRA	Potassium	2/4/97	3820		ug/L		Y
299-W23-15	RCRA	Potassium	5/8/97	3280		ug/L		Y
299-W23-15	RCRA	Potassium	8/7/97	3160		ug/L		Y
299-W23-15	RCRA	Potassium	11/11/97	2640		ug/L	U	Y
299-W23-15	RCRA	Potassium	11/11/97	2640		ug/L	U	Y
299-W23-15	RCRA	Magnesium	2/8/96	6700	1410	ug/L		Y
299-W23-15	RCRA	Magnesium	11/11/96	6570		ug/L		Y
299-W23-15	RCRA	Magnesium	2/4/97	7180		ug/L	E	Y
299-W23-15	RCRA	Magnesium	5/8/97	7280		ug/L	C	Y
299-W23-15	RCRA	Magnesium	8/7/97	7360		ug/L	C	Y
299-W23-15	RCRA	Magnesium	11/11/97	7220		ug/L		Y
299-W23-15	RCRA	Magnesium	11/11/97	7650		ug/L		Y
299-W23-15	RCRA	Manganese	2/8/96	1.5	0.23	ug/L	L	Y
299-W23-15	RCRA	Manganese	11/11/96	1.4		ug/L	B	Y
299-W23-15	RCRA	Manganese	2/4/97	4.6		ug/L	B	Y
299-W23-15	RCRA	Manganese	5/8/97	2.0		ug/L	B	Y
299-W23-15	RCRA	Manganese	8/7/97	3.0		ug/L	B	Y
299-W23-15	RCRA	Manganese	11/11/97	2.4		ug/L	B	Y
299-W23-15	RCRA	Manganese	11/11/97	3.3		ug/L	B	Y
299-W23-15	RCRA	Sodium	2/8/96	19000	5130	ug/L		Y
299-W23-15	RCRA	Sodium	11/11/96	17600		ug/L		Y
299-W23-15	RCRA	Sodium	2/4/97	18300		ug/L		Y
299-W23-15	RCRA	Sodium	5/8/97	18700		ug/L		Y
299-W23-15	RCRA	Sodium	8/7/97	18800		ug/L		Y

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result(a)	Total Error	Unit	Qualifier	Filtered
299-W23-15	RCRA	Sodium	11/11/97	18200		ug/L		Y
299-W23-15	RCRA	Sodium	11/11/97	19100		ug/L		Y
299-W23-15	RCRA	Nitrate	2/8/96	11000		ug/L	D	N
299-W23-15	RCRA	Nitrate	11/11/96	15800		ug/L	D	N
299-W23-15	RCRA	Nitrate	2/4/97	15600		ug/L	D	N
299-W23-15	RCRA	Nitrate	5/8/97	16400		ug/L	D	N
299-W23-15	RCRA	Nitrate	8/7/97	16200		ug/L	D	N
299-W23-15	RCRA	Nitrate	11/11/97	15600		ug/L	D	N
299-W23-15	RCRA	Nitrate	11/11/97	14500		ug/L	D	N
299-W23-15	RCRA	pH	2/8/96	8.1		pH		N
299-W23-15	RCRA	pH	2/8/96	8.1		pH		N
299-W23-15	RCRA	pH	2/8/96	8.1		pH		N
299-W23-15	RCRA	pH	2/8/96	8.1		pH		N
299-W23-15	RCRA	pH	2/27/96	7.7		pH		N
299-W23-15	RCRA	pH	8/12/96	8.0		pH		N
299-W23-15	RCRA	pH	8/12/96	8.0		pH		N
299-W23-15	RCRA	pH	8/12/96	8.0		pH		N
299-W23-15	RCRA	pH	8/12/96	8.0		pH		N
299-W23-15	RCRA	pH	11/11/96	8.2		pH		N
299-W23-15	RCRA	pH	2/4/97	8.0		pH		N
299-W23-15	RCRA	pH	5/8/97	7.9		pH		N
299-W23-15	RCRA	pH	8/7/97	8.3		pH		N
299-W23-15	RCRA	pH	11/11/97	7.9		pH		N
299-W23-15	RCRA	Sulfate	2/8/96	12.0		mg/L	D	N
299-W23-15	RCRA	Sulfate	11/11/96	12.1		mg/L		N
299-W23-15	RCRA	Sulfate	2/4/97	12.4		mg/L		N
299-W23-15	RCRA	Sulfate	5/8/97	13.0		mg/L		N
299-W23-15	RCRA	Sulfate	8/7/97	12.9		mg/L		N
299-W23-15	RCRA	Sulfate	11/11/97	13.1		mg/L		N
299-W23-15	RCRA	Sulfate	11/11/97	12.0		mg/L		N
299-W23-1	Non-RCRA	Conductivity	3/11/96	231*		umhos/cm		N
299-W23-1	Non-RCRA	Conductivity	8/28/97	410*		umhos/cm		N
299-W23-1	Non-RCRA	pH	3/11/96	7.9*		pH		N
299-W23-1	Non-RCRA	pH	8/28/97	7.1*		pH		N
299-W23-2	Non-RCRA	Chloride	3/11/96	6.4*	1.2	mg/L		N
299-W23-2	Non-RCRA	Chloride	8/27/97	4.1*		mg/L		N
299-W23-2	Non-RCRA	Conductivity	3/11/96	245*		umhos/cm		N
299-W23-2	Non-RCRA	Conductivity	8/27/97	228*		umhos/cm		N
299-W23-2	Non-RCRA	Nitrate	3/11/96	15000*	3160	ug/L	D	N
299-W23-2	Non-RCRA	Nitrate	8/27/97	7700*		ug/L	D	N
299-W23-2	Non-RCRA	pH	3/11/96	8.3*		pH		N
299-W23-2	Non-RCRA	pH	8/27/97	8.0*		pH		N
299-W23-2	Non-RCRA	Sulfate	3/11/96	15.0*	5.4	mg/L	D	N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[(a)]	Total Error	Unit	Qualifier	Filtered
299-W23-2	Non-RCRA	Sulfate	8/27/97	13.6*		mg/L		N
299-W23-3	Non-RCRA	Aluminum	7/30/97	42		ug/L	BC	Y
299-W23-3	Non-RCRA	Calcium	7/30/97	17700		ug/L	C	Y
299-W23-3	Non-RCRA	Chloride	7/30/97	3.2		mg/L		N
299-W23-3	Non-RCRA	Conductivity	3/11/96	210*		umhos/cm		N
299-W23-3	Non-RCRA	Conductivity	7/30/97	234		umhos/cm		N
299-W23-3	Non-RCRA	Chromium	7/30/97	3		ug/L	U	Y
299-W23-3	Non-RCRA	Iron	7/30/97	142		ug/L	C	Y
299-W23-3	Non-RCRA	Potassium	7/30/97	2060		ug/L		Y
299-W23-3	Non-RCRA	Magnesium	7/30/97	5500		ug/L		Y
299-W23-3	Non-RCRA	Manganese	7/30/97	6.7		ug/L		Y
299-W23-3	Non-RCRA	Sodium	7/30/97	23500		ug/L		Y
299-W23-3	Non-RCRA	Nitrate	7/30/97	8600		ug/L	D	N
299-W23-3	Non-RCRA	pH	3/11/96	7.0*		pH		N
299-W23-3	Non-RCRA	pH	7/30/97	8.4		pH		N
299-W23-3	Non-RCRA	Sulfate	7/30/97	14.2		mg/L		N
299-W23-6	Non-RCRA	Aluminum	7/10/97	26		ug/L	B	Y
299-W23-6	Non-RCRA	Calcium	7/10/97	23900		ug/L	C	Y
299-W23-6	Non-RCRA	Chloride	7/10/97	3.3		mg/L		N
299-W23-6	Non-RCRA	Conductivity	7/10/97	290		umhos/cm		N
299-W23-6	Non-RCRA	Chromium	7/10/97	13		ug/L		Y
299-W23-6	Non-RCRA	Iron	7/10/97	179		ug/L	C	Y
299-W23-6	Non-RCRA	Potassium	7/10/97	2800		ug/L		Y
299-W23-6	Non-RCRA	Magnesium	7/10/97	8170		ug/L	C	Y
299-W23-6	Non-RCRA	Manganese	7/10/97	123		ug/L		Y
299-W23-6	Non-RCRA	Sodium	7/10/97	22900		ug/L		Y
299-W23-6	Non-RCRA	Nitrate	7/10/97	37400		ug/L	D	N
299-W23-6	Non-RCRA	pH	7/10/97	7.6		pH		N
299-W23-6	Non-RCRA	Sulfate	7/10/97	14.0		mg/L	C	N
299-W23-7	Non-RCRA	Aluminum	6/19/96	1400	378	ug/L		N
299-W23-7	Non-RCRA	Aluminum	6/19/96	34	9.2	ug/L	L	Y
299-W23-7	Non-RCRA	Aluminum	6/25/96	630	170	ug/L		N
299-W23-7	Non-RCRA	Aluminum	6/25/96	15		ug/L	U	Y
299-W23-7	Non-RCRA	Calcium	6/19/96	17000	3060	ug/L		N
299-W23-7	Non-RCRA	Calcium	6/19/96	13000	2340	ug/L		Y
299-W23-7	Non-RCRA	Calcium	6/25/96	26000	4680	ug/L		N
299-W23-7	Non-RCRA	Calcium	6/25/96	24000	4320	ug/L		Y
299-W23-7	Non-RCRA	Chloride	3/11/96	14.0*	2.5	mg/L	D	N
299-W23-7	Non-RCRA	Chloride	6/19/96	14.0	2.5	mg/L	D	N
299-W23-7	Non-RCRA	Chloride	6/25/96	12.0	2.2	mg/L	D	N
299-W23-7	Non-RCRA	Chloride	8/27/97	6.7		mg/L	D	N
299-W23-7	Non-RCRA	Conductivity	3/11/96	300*		umhos/cm		N
299-W23-7	Non-RCRA	Conductivity	6/19/96	234		umhos/cm		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result(a)	Total Error	Unit	Qualifier	Filtered
299-W23-7	Non-RCRA	Conductivity	6/19/96	236		umhos/cm		N
299-W23-7	Non-RCRA	Conductivity	6/19/96	242		umhos/cm		Y
299-W23-7	Non-RCRA	Conductivity	6/19/96	235		umhos/cm		N
299-W23-7	Non-RCRA	Conductivity	6/25/96	315		umhos/cm		N
299-W23-7	Non-RCRA	Conductivity	6/25/96	326		umhos/cm		Y
299-W23-7	Non-RCRA	Conductivity	6/25/96	284		umhos/cm		N
299-W23-7	Non-RCRA	Conductivity	6/25/96	326		umhos/cm		N
299-W23-7	Non-RCRA	Conductivity	6/25/96	322		umhos/cm		N
299-W23-7	Non-RCRA	Conductivity	8/27/97	160*		umhos/cm		N
299-W23-7	Non-RCRA	Chromium	6/19/96	53	22.3	ug/L		N
299-W23-7	Non-RCRA	Chromium	6/19/96	3	1.2	ug/L	L	Y
299-W23-7	Non-RCRA	Chromium	6/25/96	13	5.5	ug/L		N
299-W23-7	Non-RCRA	Chromium	6/25/96	3	1.2	ug/L	L	Y
299-W23-7	Non-RCRA	Iron	6/19/96	18000	1620	ug/L		N
299-W23-7	Non-RCRA	Iron	6/19/96	94	8.5	ug/L		Y
299-W23-7	Non-RCRA	Iron	6/25/96	9900	890	ug/L		N
299-W23-7	Non-RCRA	Iron	6/25/96	26	2.3	ug/L	L	Y
299-W23-7	Non-RCRA	Potassium	6/19/96	11000	2310	ug/L		N
299-W23-7	Non-RCRA	Potassium	6/19/96	5600	1180	ug/L		Y
299-W23-7	Non-RCRA	Potassium	6/25/96	4800	1010	ug/L		N
299-W23-7	Non-RCRA	Potassium	6/25/96	5000	1050	ug/L		Y
299-W23-7	Non-RCRA	Magnesium	6/19/96	3900	819	ug/L		N
299-W23-7	Non-RCRA	Magnesium	6/19/96	1900	399	ug/L		Y
299-W23-7	Non-RCRA	Magnesium	6/25/96	6200	1300	ug/L		N
299-W23-7	Non-RCRA	Magnesium	6/25/96	5500	1160	ug/L		Y
299-W23-7	Non-RCRA	Manganese	6/19/96	270	40.5	ug/L		N
299-W23-7	Non-RCRA	Manganese	6/19/96	24	3.6	ug/L		Y
299-W23-7	Non-RCRA	Manganese	6/25/96	160	24	ug/L		N
299-W23-7	Non-RCRA	Manganese	6/25/96	19	2.9	ug/L		Y
299-W23-7	Non-RCRA	Sodium	6/19/96	20000	5400	ug/L		N
299-W23-7	Non-RCRA	Sodium	6/19/96	21000	5670	ug/L		Y
299-W23-7	Non-RCRA	Sodium	6/25/96	25000	6750	ug/L		N
299-W23-7	Non-RCRA	Sodium	6/25/96	25000	6750	ug/L		Y
299-W23-7	Non-RCRA	Nitrate	3/11/96	1200(b)*	260	ug/L		N
299-W23-7	Non-RCRA	Nitrate	6/19/96	2500(b)	525	ug/L		N
299-W23-7	Non-RCRA	Nitrate	6/25/96	21000	4410	ug/L	D	N
299-W23-7	Non-RCRA	Nitrate	8/27/97	250*		ug/L		N
299-W23-7	Non-RCRA	pH	3/11/96	8.08*		pH		N
299-W23-7	Non-RCRA	pH	6/19/96	7.9		pH		N
299-W23-7	Non-RCRA	pH	6/19/96	8.4		pH		N
299-W23-7	Non-RCRA	pH	6/19/96	8.3		pH		Y
299-W23-7	Non-RCRA	pH	6/19/96	7.7		pH		N
299-W23-7	Non-RCRA	pH	6/25/96	9.2		pH		N

Table B.2. (contd)

Well	Well Standard	Constituent	Date	Result[(a)]	Total Error	Unit	Qualifier	Filtered
299-W23-7	Non-RCRA	pH	6/25/96	9.3		pH		Y
299-W23-7	Non-RCRA	pH	6/25/96	9.2		pH		N
299-W23-7	Non-RCRA	pH	6/25/96	9.3		pH		N
299-W23-7	Non-RCRA	pH	6/25/96	9.3		pH		N
299-W23-7	Non-RCRA	pH	8/27/97	9.3*		pH		N
299-W23-7	Non-RCRA	Sulfate	3/11/96	60000*	21600	ug/L	D	N
299-W23-7	Non-RCRA	Sulfate	6/19/96	33000	11900	ug/L	D	N
299-W23-7	Non-RCRA	Sulfate	6/25/96	41000	14800	ug/L	D	N
299-W23-7	Non-RCRA	Sulfate	8/27/97	21.5*		mg/L	D	N
299-W23-9	Non-RCRA	Chloride	5/22/96	3.0	0.5	mg/L		N
299-W23-9	Non-RCRA	Chloride	8/12/97	5.8		mg/L	CD	N
299-W23-9	Non-RCRA	Conductivity	5/22/96	295		umhos/cm		N
299-W23-9	Non-RCRA	Conductivity	8/12/97	381		umhos/cm		N
299-W23-9	Non-RCRA	Nitrate	5/22/96	42000	8820	ug/L	D	N
299-W23-9	Non-RCRA	Nitrate	8/12/97	129700		ug/L	D	N
299-W23-9	Non-RCRA	pH	5/22/96	7.9		pH		N
299-W23-9	Non-RCRA	pH	8/12/97	7.8		pH		N
299-W23-9	Non-RCRA	Sulfate	5/22/96	14.0	5.0	mg/L	D	N
299-W23-9	Non-RCRA	Sulfate	8/12/97	15.1		mg/L		N

(a) Excluding results of ICP metals (aluminum, calcium, chromium, iron, potassium, maganese, magnesium, and sodium) on filtered samples collected on 5/13/97 and analyzed on 6/2/97 (i.e., outliers).

(b) Decimal point error suspected, data currently under review.

*Bailed sample.

Appendix C

Chemical Fractionation of Tank Waste

The chemical inventory estimates for single shell tanks (Agnew 1996) provide an indication of tank contents or total inventory based on process history. An understanding of the relative distribution of constituents of interest in the liquid phase versus the total (or solids plus liquids) provides some indication of the constituent solubility (or initial mobility) prior to release into the soil column. The reactivity of tank waste supernate with the soil or sediment matrix can also influence the relative mobility of constituents of concern. Serne et al. 1997 evaluated both sorption and chemical reactions between tank waste supernate and Hanford soils with emphasis on cesium (and strontium) mobility. The following discussion is limited to the major RCRA-related constituents and key radionuclides and is based on information from Serne et al. 1997 and Agnew (1996; 1997) and other literature as cited.

C.1 Major RCRA Constituents

The principal RCRA-related chemical components are nitrate, aluminum, hexavalent chromium, and hydroxide (due to its corrosiveness). We will assume that nitrate was unfractionated (it remained completely in solution and thus other chemical constituents, when normalized by dividing by the molar concentration of nitrate, provide an indication of deviation from the initial makeup chemical composition or inventory. The molar ratios observed in groundwater samples with the highest recent technetium-99, chromium, and nitrate concentrations (well 2-W22-46), are used for comparison with the tank waste ratios. Table C.1 summarizes this approach with some available analytical results for Tanks S-102 and S-110. Other recent analytical data on tank sample fractions (drainable liquid, salt cake, sludge) may also be useful for this type of comparison. Recent single shell tank analytical data is accessible on the Hanford Web page as it becomes available.

The molar ratios shown in Table C.1 suggest that the total inventory composition for Tanks S-102/110 are not markedly different than the supernate measurements. The aluminum and chromium appear to have about the same proportions in supernate as in the estimated total that went into the tanks based on process knowledge. This is consistent with the amphoteric nature of aluminum (formation of anionic aluminate at high pH) and the chemical thermodynamics of hexavalent chromium suggesting it should remain as a soluble species at high pH.

Table C.1. Molar Ratios of Major RCRA Dangerous Waste Constituents (normalized to nitrate)

Phase	Molar Ratio		
	Nitrate[(a)]	Aluminum	Chromium
Estimated Total Tank Inventories[(b)] (solid & liquid):			
S Tanks (mean of 12 tanks)	1	0.44	0.03
SX Tanks (mean of 15 tanks)	1	0.79	0.26
S-SX Tanks (overall mean)	1	0.6	0.14
Measured Supernatant:[(c)]			
Tanks S-102/S-110 (mean)	1	0.4	0.03
Groundwater:[(d)]			
Well 2-W22-46	1	<0.002	0.001

(a) Nitrite and nitrate listed in Agnew (1996) were combined.
(b) Agnew (1996); based on process knowledge and campaign history.
(c) From Schulz (1978); based on analysis of drainable liquid from sludge samples.
(d) Appendix B data; based on results from sample with the highest nitrate.

The higher mean chromium-to-nitrate ratio (total) for the SX tanks than for the S tanks is of potential significance. For example, the ten-fold difference between the two tank farms may be useful in differentiating S and SX farm sources of groundwater contamination (provided this difference is borne out by analytical results for all the tanks).

The aluminum concentrations in groundwater were above detection limits but below the quantitation limit (Appendix B). Thus the result is of only qualitative value. Nevertheless, aluminum was detected and it suggests significant fractionation occurred in the vadose zone. Chromium in groundwater also indicates fractionation as compared to the original tank waste, especially as compared to SX tank waste. These marked departures from the tank waste composition may be attributable to soil chemical reactions, discussed as follows.

C.1.1 Soil Chemical Reactions

The marked depletion of aluminum relative to nitrate in the groundwater sample with elevated nitrate and technetium-99 can be explained as follows. As long as the pH remains high, the aluminum remains soluble as the aluminate anion. As Serne et al. 1997 point out, however, as the tank waste supernate reacts with the soil aluminosilicate mineral phases, the hydroxide is consumed and the pH drops. Upon reaching the water table and mixing with groundwater, the pH would approach the ambient level of around 8. At this much lower pH (relative to tank liquor at up to a pH of 14), aluminum hydroxide [$Al(OH)_3$], a gelatinous precipitate should form. The waste liquor-soil matrix reaction both consumes hydroxide and results in formation of a non-mobile phase of aluminum. The preliminary or scoping laboratory studies conducted by Serne et al. 1997 using simulated SX tank waste tend to support this explanation.

A different mechanism is required to explain the apparent fractionation of hexavalent chromium outside the tanks as suggested by the ratios shown in Table C.1. The anionic hexavalent chromium (as CrO_4^{2-} in natural environments) should not form precipitates and should remain anionic over the natural pH of groundwater and soil moisture under Hanford subsurface conditions (pH of around 8.0). The ability of soils to adsorb anions is quite low, especially soils with natural pH values of 8 or above. The presence of Cr in the shallow groundwaters along the Columbia River at several 100 Area inactive reactor sites is an indication that adsorption is not strong.

One possibility is that reducing conditions may occur at the surface of basaltic sand grains prevalent in Hanford soils. Reducing conditions attributable to Fe(II) in some minerals such as basaltic sand grains could lead to reduction of Cr(VI) to immobile Cr(III). James and Bartlett (1983), Leckie et al. (1980), Masscheleyn et al. (1992), Powell et al. (1995), and Rai et al. (1988) showed that iron oxides and organic matter in soil can reduce Cr(VI) to Cr(III) and precipitate Cr(III) as a $(Fe, Cr)(OH)_3$ mineral and/or increase adsorption of the Cr(III) cation. Also, studies conducted by Rai et al. (1988) show that DCB extractable Fe content is a good indicator as to whether a soil can reduce significant quantities of Cr(VI) which results in higher K_d values. It is important to note the total iron oxide content is a poor indicator of a soil's Cr(VI) reducing capacity and that DCB extractable Fe better represents the fraction of Fe content that would reduce Cr(VI) to Cr(III).

If this type of reduction occurs, it could explain why the chromium observed in groundwater is less than expected based on the tank inventory or supernate concentrations relative to nitrate. Another explanation could be that the source of the chromium observed in groundwater from well 2-W22-46 (located at the southeast corner of SX tank farm) is from a source with a different composition than that used for Table C.1. Confirmatory analytical data for all the tanks and neighboring liquid disposal facilities (cribs, trenches, and ponds) would be needed to determine if there are certain tanks or liquid disposal facilities with unusually low chromium to nitrate ratios.

The above considerations and the work of Serne et al. 1997 suggest the soil column may attenuate the impact of the RCRA/dangerous waste components of tank waste by chemical reactions that consume the hydroxide, precipitate the aluminum and possibly reduce some of the hexavalent chromium.

C.1.2 Radionuclides

Radionuclides in tank waste are also subject to chemical fractionation effects. Comparison of supernate and sludge predicted composition and sample analytical measurements indicate that most of the technetium-99 and cesium-137 remain in solution or are present in tank solids in a readily soluble form while strontium-90 is associated with solids and not readily resolubilized.

Based on total inventory estimates (Agnew 1997) for tanks S-102 and 110 (tanks used for the fractionation example given Table C.1), the cesium-137/strontium-90 ratio should be about 1.3. The observed ratio in supernate or drainable liquids (mean of results for both tanks) is 33 (from Schulz 1978). Thus significant depletion of strontium-90 apparently occurred from the liquid phase. Americium-241, an important transuranic constituent of concern, has an apparent fractionation factor similar to strontium-90.

The phase separation noted above probably occurred soon after sodium hydroxide was added to neutralize the highly acidic waste stream generated from the REDOX process in S plant. Thus strontium-90 and americium-241 in liquids lost to the soil from either transfer lines and distribution boxes or from tank leaks should be predominantly associated with a particulate or solid phase. Deviations could occur, however, depending on specific tank conditions (for example the presence of complexing agents). Thus analytical results for each tank, as they become available, are needed to check the generalization noted above.

After release from tanks or the waste distribution system, attenuation due to sorption and chemical reactions in the soil column are expected to further alter the proportions reaching groundwater (Serne et al. 1997). Studies are underway at Pacific Northwest National Laboratory to elucidate sorption mechanisms and waste liquor-soil chemical reactions that influence contaminant mobility in the vadose zone beneath the S and SX tank farms.

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