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Revision 0

Geophysical Logging Report for 200-DV-1 Operable Unit Waste Sites in the T Complex Area

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Managernent

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

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Figure 1. 200-DV-1 Operable Unit Subregions in the T Complex Area, 200 West Area 2

Terms

OU	operable unit
Stoller	S.M. Stoller Corporation

1 Introduction

The 200-DV-1 (Deep Vadose Zone) Operable Unit (OU) consists of 44 liquid waste disposal sites located on the Hanford Site Central Plateau that have been grouped, based on geographic proximity, into subregions. This OU includes the waste sites with deep contamination that cannot be remediated using typical surface-based techniques. The decision process for the 200-DV-1 OU will investigate the nature and extent of deep vadose zone contamination; evaluate potential impacts on groundwater; and evaluate, select, and implement management strategies for addressing deep vadose zone threats to the environment (DOE/RL-2010-89, *Long-Range Deep Vadose Zone Program Plan*).

There are currently 20 200-DV-1 OU wastes sites in the 200 West Area; 17 are located in the T Complex Area, and 3 are located in the S Complex Area. The T Complex Area includes six subregions, and the S Complex Area includes three subregions. In support of the 200-DV-1 OU *Resource Conservation and Recovery Act of 1976* Facility Investigation/Corrective Measures Study and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* Remedial Investigation/Feasibility Study Work Plan, S. M. Stoller Corporation (Stoller) was contracted to evaluate available geophysical logging data and existing geophysical interpretative reports within the two complex areas. Stoller prepared a 200-DV-1 OU waste site summary report (Appendix A) that provides the results of the borehole geophysical log evaluation specifically focused on addressing the extent of gamma-emitting contamination within the vadose zone for the T Complex Area (referred to as the T-TX-TY focus area in Appendix A). The following six subregions (Figure 1) are included in the T Complex Area:

- Subregion 1—216-T-3,-T-6 (includes 241-T-361, a non-200-DV-1 OU waste site)
- Subregion 2—216-T-5, -T-7, and -T-32 (includes 200-W-52 Crib)
- Subregion 3—216-T-14, -T-15,-T-16, and -T-17
- Subregion 4—216-T-18, -T-26 (includes 216-T-27 and -T-28, non-200-DV-1 OU waste sites)
- Subregion 5—216-T-19
- Subregion 6—216-T-21, -T-22, -T-23, -T-24, and -T-25

The purpose of this report is to assemble and present the interpreted extent of gamma-emitting contamination for available geophysical logging data for the 200-DV-1 OU waste sites in the T Complex Area. For each subregion, all boreholes within 100 m (328.1 ft) of the waste site(s) are considered. The effort also required information about waste site history, well construction detail, and process waste history. These data were evaluated along with the available geophysical borehole log data to assess the nature and extent of gamma-emitting contamination in the vadose zone for each subregion and to interpret the historical context. Specific areas of inquiry include the following:

- Correlating between naturally occurring radionuclides and stratigraphy
- Evaluating the effects of stratigraphic boundaries on contaminant plumes
- Evaluating changes over time in the contaminant profile that may be attributed to decay and/or migration
- Comparing observed contaminant profiles with site characteristics and operational history
- Identifying potential data gaps and providing recommendations for future characterization

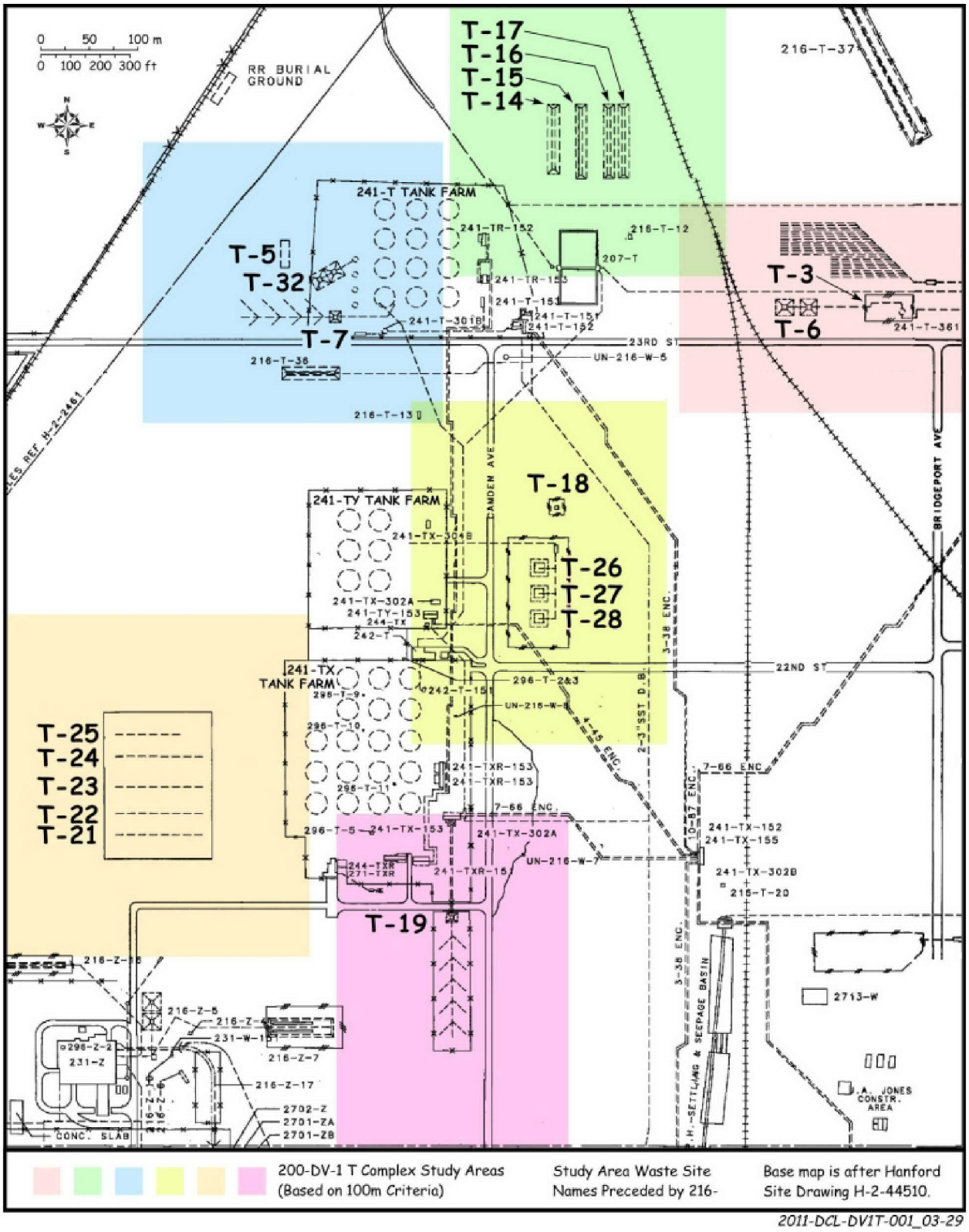

Figure 1. 200-DV-1 Operable Unit Subregions in the T Complex Area, 200 West Area

2 References

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DOE/RL-2010-89, 2010, *Long-Range Deep Vadose Zone Program Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0084131.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://epw.senate.gov/rcra.pdf.

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Appendix A

Hanford Geophysical Logging Project T-TX-TY Focus Area

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HANFORD GEOPHYSICAL LOGGING PROJECT

T-TX-TY FOCUS AREA

August 2011

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HISTORY SHEET

REV DATE	REV NO	REVISED BY	DESCRIPTION OF REVISION
04/14/11	0	P. Henwood	Initial Issue
08/31/11	1	P. Henwood	Incorporate revisions

ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CCu	Cold Creek Unit
CCuc	Cold Creek Unit – calcic geosol
CCuz	Cold Creek Unit – silt dominated
CMS	Corrective Measures Study
DVZ	Deep Vadose Zone
FI	Facility Investigation
gw	groundwater
HEIS_GPL	Hanford Environmental Information System- Geophysical Log database
MDL	Minimum Detectable Limit
MPT	Multi-Project Team
PW	Process Waste
REDOX	Reduction Oxidation
RFtf	Ringold Formation – Taylor Flat
RFwie	Ringold Formation – Wooded Island Unit E
RI/FS	Remedial Investigation/Feasibility Study
SGLS	Spectral Gamma Logging System
TW	Tank Waste
WIDL	Well Information Data Lookup
WIDS	Waste Information Data System

Executive Summary

An evaluation of geophysical log data to detect and assess deep vadose zone contamination in the vicinity of the T-TX-TY Focus Area of the Deep Vadose Zone Operable Unit (200-DV-1 OU) has been performed. The T-TX-TY Focus Area includes seventeen liquid waste disposal sites assigned to the 200-DV-1 OU, and is in addition to the three single-shell tank farms (T-TX-TY). These 17 200-DV-1 OU waste sites have been grouped into six subregions on the basis of proximity, and available geophysical logs from existing boreholes in or near each subregion have been evaluated in the context of geological conditions, site conditions, and operational history. Each subregion chapter (Sections 4 through 9) summarizes available site information and log data, defines current and, and past gamma-emitting radionuclide contaminant impacts, identifies data gaps, and provides recommendations for further investigation.

Boreholes and wells within 100 meters of the 200-DV-1 OU waste site were identified. A master list (Appendix A) of available geophysical logs from these boreholes was created. The list includes information as to the form (electronic data or hard copy) of the log and its location (i.e., WIDL, HEIS_GPL, or hard copy in files). As part of the tasks for this report, logs that were not already referenced in WIDL have been scanned and provided for downloading to WIDL.

Historical gross gamma logs acquired prior to the early 1990s provide a special insight into the history of Hanford waste sites. Although they can be very difficult to interpret in their current form (typically paper strip charts with multiple scale changes to cope with a wide range of gamma activity), they allow interpretations to be made as to the time of arrival, depth and extent of gamma-emitting contamination. Qualitative comparison of total gamma logs over time provides information as to the half-life of dominant radionuclides, and can detect migration of contaminants. These interpretations can be critical in assessing potential impacts to the deep vadose zone and groundwater over the past sixty years. Development of high resolution spectral gamma logging in the early 1990s allows identification and assay of individual natural and manmade gamma emitting radionuclides. These data can be compared to historical gamma profiles. The geophysical logging data represents an important source of information because there is generally very little sediment sample data from the vadose zone within these areas. In some cases, geophysical log data is available both during and post 200-DV-1 waste site operational periods.

Spectral gamma logging also provides useful information for stratigraphic correlation. Concentrations of the naturally occurring radionuclides K-40, U-238, and Th-232 can be determined. Variations in these radionuclides can be used to identify and correlate stratigraphic units.

During preparation of this report, existing documents relevant to each site were reviewed and discrepancies were found regarding waste site location and configuration, process history, and even borehole names and locations. It was not always possible to resolve these issues in the time allowed. Significant observations and conclusions are identified for consideration.

Brief summaries of the major findings for each subregion are provided below:

Sub Region 1

<u>216-T-3 Reverse Well and 216-T-6 Cribs</u>

- Based on geophysical borehole log data evaluation for wells near the 216-T-3 Reverse Well and 216-T-6 Cribs it appears that contaminants have possibly impacted groundwater at both sites. Detectable gamma contamination is clearly defined down to and in some cases below the CCu. Most wells do not extend deep enough to assess the deeper portion of the vadose zone below the CCu. The 216-T-3 reverse well cannot be adequately evaluated by existing boreholes, which are at least 25 ft (7.6 m) away. Prior investigators apparently assumed the reverse well contaminated groundwater because the bottom of the well, perforated across the CCu and into the Ringold Formation, is within

50 ft (15.2 m) of the groundwater level. However, gamma profiles in nearby wells suggest relatively low activity waste with maximum Cs-137 concentrations at or less than 1000 pCi/g at the top or just within the CCu. The maximum Cs-137 concentration is approximately 46,000 pCi/g at 15 ft (4.6 m) in one borehole. It is assumed that plutonium would be present in waste discharged to 216-T-3, but SGLS logs failed to detect Pu-239 at levels above the detection limit (10 nCi/g). A characterization borehole within 5 to 10 ft (1.5 to 3.1 m) of the reverse well is recommended. This will enable investigators to assess the lateral deposition of contaminants, if any, and determine the nature and extent of alpha emitting contaminants.

- Prior investigations at 216-T-6 Cribs (#1 and #2) have focused on the #1 crib. A 1948 report summarizes the results of 13 boreholes and presents an evaluation of the nature and extent of subsurface contamination based on sample analysis for fission products and plutonium. The general profile (contaminant extent) based on 2003 SGLS logs is slightly smaller in size relative to the 1948 profile, probably as a result of decay of short-lived fission products. Available data suggest that significant gamma-emitting contamination (primarily Cs-137) does not extend below 70 ft (21.3 m) depth at Crib #1.
- Geophysical logs from 299-W11-1 (A7275), located east of the 216-T-6 Crib #1, provide evidence of contamination in the deep vadose zone. Gamma profiles suggest contamination may have extended to groundwater by 1963. By 1968, high gamma activity is reported in the groundwater. By 1976, gamma activity in 299-W11-1 had decayed away, except for a minor peak at 25 ft (7.6 m). A 1995 RLS log detected Co-60 near the historical groundwater level.
- The 241-T-361 Settling Tank and associated piping are an important component of waste delivery to both the 216-T-3 reverse well and the 216-T-6 cribs, and may have contributed to vadose zone contamination. There are no boreholes in the immediate vicinity of the tank, but three wells near the 216-T-3 reverse well have detectable gamma contamination in the shallow subsurface that strongly suggests a pipeline source rather than the 216-T-3 reverse well.
- Since plutonium is a component of the waste discharged to these sites, future characterization activities should consider appropriate geophysical logging criteria for adequate assessment. Criteria include using the high-resolution spectral gamma log, which can detect Pu-239, Am-241, and Pu-241 at levels below 100 nCi/g. The passive neutron log should also be considered as a qualitative indicator of TRU.

Sub Region 2

<u>216-T-5 Trench, 216-T-7 Crib (200-W-52) and Tile Field, and 216-T-32 Cribs</u>

- Based on geophysical borehole log data evaluation for wells in and near sub-region 2 it appears that contaminants impacted groundwater below the 216-T-7 (200-W-52) crib and tile field. Beneath the 216-T-32 crib it appears contaminants (Pu-239, Am-241, Cs-137, and Eu-154) largely remained in a silty sand unit approximately 35 ft (10.7 m) bgs. Significant lateral migration along this sand unit to the south at least to the northern portion of the 216-T-7 tile field is observed, with no significant vertical migration. Detectable gamma contamination is clearly defined down to and in some cases below the CCu at the 216-T-7 crib.
- Existing boreholes at the 216-T-5 Trench are not optimally located or deep enough to characterize the deep vadose zone. However, this site received relatively little waste volume compared to the other two sites. Only one well, 299-W10-1, was drilled in this area and contamination was detected to the upper Ringold Fm, beneath the CCU. There are no other data available to assess the extent of potential contamination in the deep vadose zone.
- The 216-T-7 Crib (200-W-52) and Tile Field have been extensively evaluated with multiple boreholes and wells, and geophysical log data strongly indicate past impacts to groundwater. .
- The 216-T-32 Crib was reasonably well characterized in 1948, and shallow contamination above the CCu was defined. However, available subsurface data are limited to the upper 150 ft (45.7 m). The

extent of potential contamination in the deep vadose zone both immediately above the CCu and down into the Ringold Fm is not known. Current interpretations of borehole geophysical log contaminant data between known 241-T Tank Farm leaks and contamination identified in Sub-region 2 indicate no overlapping or impacting contamination. However, there are no boreholes deep enough to completely assess this possibility.

Sub Region 3

216-T-14, -T-15, -T-16, and -T-17 Trenches

- Based on geophysical borehole log data evaluation for wells in and near sub-region 3 it appears unlikely that contaminants disposed to the trenches have impacted groundwater. There are no boreholes directly beneath the trenches to assess deep vadose zone contamination potential, however, nearby wells reveal that detectable gamma contamination exists at very shallow depths today, indicating some lateral migration. There is no indication from existing boreholes that contamination has reached the CCu outside the boundaries of the trench excavations; detectable contamination has impacted the upper Hanford fm.
- These specific retention trenches were operated sequentially to dispose of 1st cycle bismuth phosphate reprocessing waste that had been stored in the T 241-T-104/T-105/T-106 cascade series in 1954. This waste may contain significant fission products, and may represent a source of Tc-99. Given the quantity of liquid involved (approximately a million gallons or 3.8 million liters); it is likely that the vadose zone has been significantly contaminated. However, there are only two boreholes at the margins of these four trenches, and two additional boreholes near the periphery of the subregion. Significant data gaps exist regarding waste dispersal, and nature and extent of deep vadose zone contamination.
- The relationship between Co-60 and Tc-99 should be investigated in detail. Both are associated with process waste, and both have relatively low adsorption potential in the Hanford vadose zone sediments. Tc-99 is a "pure" beta emitter and impossible to detect through steel casing. Co-60 emits two distinct and penetrating gamma rays that are easily detectable. Although it has a relatively short half life and thus does not represent a contaminant of concern over the long term, Co-60 may serve as a surrogate for Tc-99 in the vadose zone.

Sub Region 4

216-T-18, T-26, T-27, and T-28 Cribs

- Based on geophysical borehole log data evaluation for wells in and near sub-region 4 it appears that contaminants impacted groundwater below the 216-T-28 crib. It is possible that the 216-T-26 and 216-T-27 cribs also impacted groundwater, but data are insufficient to assess the deeper vadose zone within the Ringold Fm below the cribs and most likely contamination has commingled with 216-T-28 crib contamination in the deeper vadose zone. Geophysical log data at the 216-T-18 crib indicate contamination to at least the CCu and into the upper Ringold Fm. Data are insufficient to determine impacts to the deep vadose zone beneath the 216-T-18 Crib. Overall, detectable gamma contamination is clearly defined down to and in some cases below the CCu throughout this sub-region.
- These sites are grouped together because of proximity. Many documents seem to assume the same configuration, but 216-T-18 is distinctly different from the other three cribs. 216-T-26, -T-27, and T-28 were constructed as engineered crib structures whereas 216-T-18 was a "hole in the ground" used for one-time disposal of liquid waste.
- Multiple logs in 299-W11-11 (A7280) near 216-T-18 show elevated gamma activity from about 10 ft (3.1 m) bgs to the top of the Cold Creek unit at 84 ft (25.6 m) depth. Activity has decreased over time, consistent with decay of short-lived radionuclides. When an RLS log was run in 1992, Cs-137

and Co-60 were detected, with a maximum Cs-137 concentration of less than 10,000 pCi/g at a depth of 30 ft (9.1 m) bgs. This relatively low concentration is consistent with scavenged waste.

- Three direct push holes were drilled in the 216-T-18 Crib in 2008 and logged with small-diameter detectors. Results show contamination at the margin of the crib between 28 to 31 ft (8.5 to 9.5 m) depth, and from 28 to 39 ft (8.5 to 11.9 m) depth near the center of the crib. In terms of contamination associated with gamma emitting fission products, 216-T-18 appears to have little or no impact on the deep vadose zone
- WIDS indicates that 1800 g of plutonium was discharged to 216-T-18. However, the 1992 RLS log and the small diameter gamma log used in the direct push investigations are not well-suited to detection of low yielding gamma rays associated with plutonium. All boreholes within or proximal to the 216-T-18 crib have been decommissioned. If plutonium remains an issue, additional characterization using high-resolution spectral gamma logs is suggested. This system can detect Pu-239, Am-241, and Pu-241 at levels below 100 nCi/g.
- 216-T-26, -T-27, and -T-28 were constructed as engineered units. Discrepancies exist in the waste disposal records. Available log data indicate that contamination at 216-T-26 extends at least into the Ringold Formation. 216-T-28 likely contaminated a large portion of the vadose zone down to groundwater. Boreholes, to the southeast and southwest, show evidence of lateral migration into the Cold Creek unit and below.

Sub Region 5

<u>216-T-19 Crib and Tile Field</u>

- The 216-T-19 Crib and Tile Field received a relatively large volume of liquid waste over an extended time frame and previous investigators have recognized it as a potential source of groundwater contamination. In spite of this, little is known of the nature and extent of potential deep vadose zone contamination proximal to the 216-T-19 facility. Waste site configuration and history seem to be well-known, but significant data gaps exist with regard to contamination in the deep vadose zone.
- Four boreholes with geophysical logs are located within the area of the tile field, but only two penetrate deep enough to be useful in determining a contaminant profile in the vadose zone. Even these two boreholes do not extend down to the CCu. Data from the borehole nearest the crib (299-W14-51) indicate possible contamination to the bottom of the borehole, essentially within the lower Hanford fm. There is very little other evidence of shallow gamma-emitting contamination. Borehole 299-W15-4 (A4929) was installed approximately 122 ft (37 m) southwest of the 216-T-19 crib. It encountered elevated gamma activity from approximately 40 ft (12 m) bgs (at the Hanford fm Hf1/Hf2 contact extending to groundwater. If the contamination in 299-W15-4 originated from 216-T-19, this implies a high degree of lateral migration within the upper Hanford fm.
- 299-W15-762 (C3122) was located approximately 12.5 ft (3.8 m) to the northwest of 299-W15-4 as a replacement monitoring well. During drilling, unanticipated radiological contamination was encountered at 37 ft (11.3 m) depth bgs, and the well was terminated. Gross gamma and RLS logs in 299-W15-4 clearly showed evidence of high gamma activity at this depth.

Sub Region 6

<u>216-T-21, -T-22, -T-23, -T-24, and -T-25 Trenches</u>

- Based on disposal waste volumes and geophysical borehole log data in and near sub-region 6, it is not conclusive that contaminants disposed to the trenches have not impacted groundwater. Based on specific retention capacity estimates, it is possible that sufficient volumes of waste were introduced to some of these trenches to potentially impact groundwater. There are only shallow vadose boreholes at the trenches which do not allow assessment of deep vadose contaminant potential near or beneath the CCu. Nearby surrounding wells outside the trench excavations reveal no current detectable

gamma contamination throughout the upper vadose zone down to the CCu. There are some data that indicates contamination has reached the CCu beneath trench 216-T-23.

- Specific retention trenches 216-T-21, -T-22, -T-23, -T-24, and -T-25 are similar in many respects to the 216-T-14, -T-15, -T-16 and -T-17 Trenches. Besides the fact that the 216-T-21 to 216-T-25 trenches received more waste than the 216-T-14 to -17 trenches, one major difference is the 216-T-25 trench received only evaporator bottoms waste and the largest single waste volume of all the trenches. Both sets of trenches appear to have significant data gaps regarding waste dispersal, and nature and extent of deep vadose zone contamination.

1.0 INTRODUCTION

This work is being performed to support the 200-DV-1 OU RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) and CERCLA Remedial Investigation/Feasibility Study (RI/FS) work plan for the 200-DV-1 (deep vadose zone) Operable Unit due September 30, 2012 (TPA milestone M-015-110A). Creation of the 200-DV-1 OU brings a centralized focus and systematic approach to the challenges presented by contamination in the deep vadose zone (CHPRC-01056-VA). This operable unit includes the waste sites that require specialized remediation approaches and cannot be remediated using typical surface-based techniques. The decision process for the 200-DV-1 OU will investigate the nature and extent of deep vadose zone contamination; evaluate potential impacts on groundwater; and evaluate, select, and implement management strategies for addressing deep vadose zone threats to the environment (CHPRC-01056-VA).

Forty-seven waste sites are included in the 200-DV-1 operable unit. These waste sites previously were included in the tank waste (200-TW-1, 200-TW-2) and process waste (200-PW-5) operable units. The 200-DV-1 operable unit includes cribs and trenches associated with WMAs B-BX-BY and T and TX-TY along with a few reduction oxidation (REDOX) cribs located in the vicinity of the WMA S and SX. Geophysical log data associated with WMA B-BX-BY have been evaluated and reported in several waste site summary reports prepared by the Hanford Geophysical Logging Project in 2002. This report will address published log data associated with specific waste sites in the T and TX-TY "Focus Area." This Focus Area has been further subdivided into six subregions (Figure 1-1):

Sub Region 1 - 216-T-3, -T-6 (includes 241-T-361, a non-200-DV-1 Waste Site)
Sub Region 2 - 216-T-5, -T-7, and -T-32 (includes 200-W-52 Crib, a non-200-DV-1 Waste Site)
Sub Region 3 - 216-T-14, -T-15, -T-16, and -T-17
Sub Region 4 - 216-T-18, –T-26, -T-27, and -T-28
Sub Region 5 - 216-T-19
Sub Region 6 - 216-T-21, -T-22, -T-23, -T-24, and -T-25

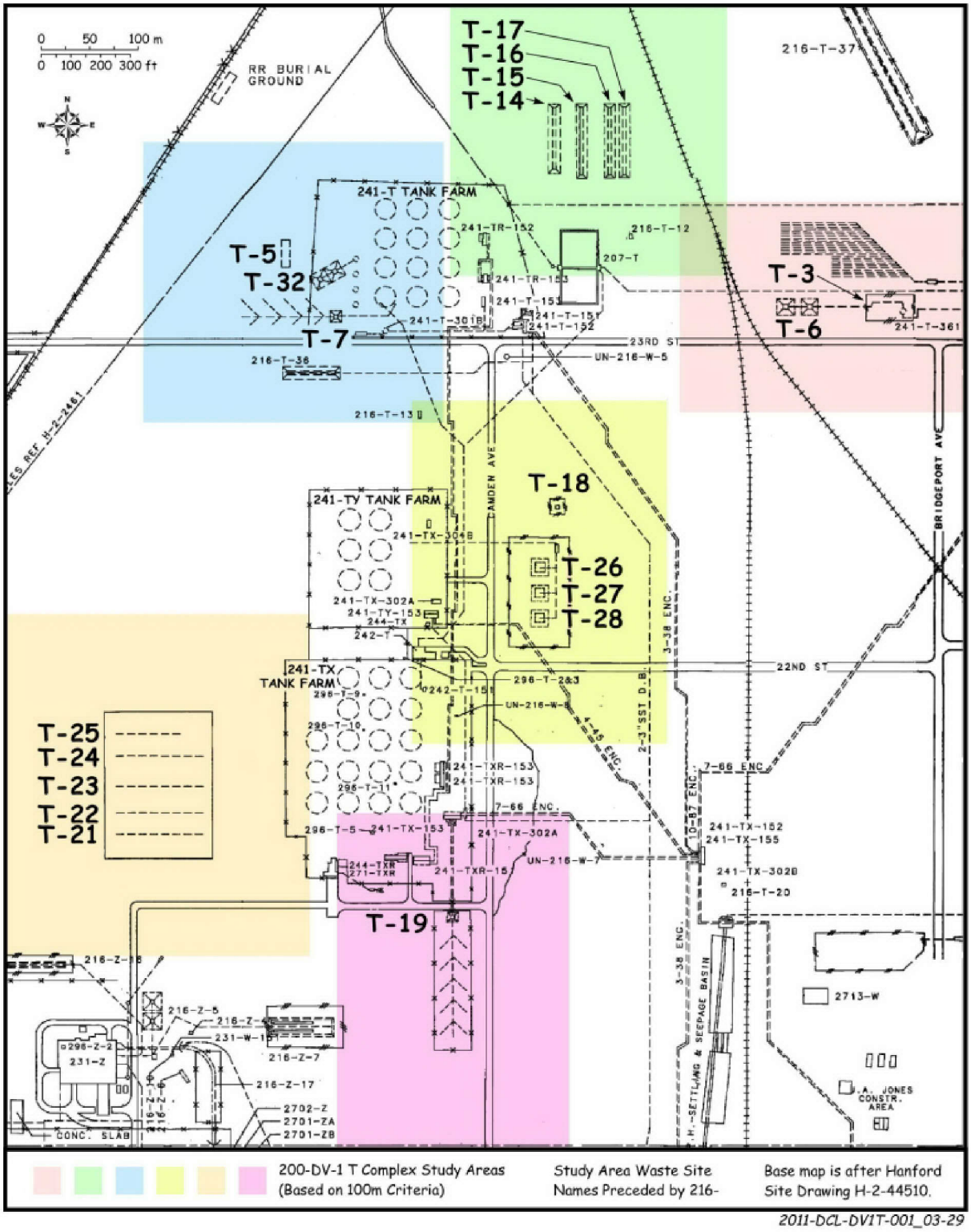
The purpose of this report is to assemble and present the interpreted extent of gamma emitting contamination for available geophysical logging data for the Focus area. For each subregion, all boreholes that lie within 100 meters of the waste site(s) are considered. This effort will require additional information about the waste sites' history, well construction detail, and process waste history. These data are evaluated to assess the nature and extent of gamma-emitting contamination in the vadose zone for each subregion, and to interpret the historical context. Specific areas of inquiry include: 1) correlations between naturally occurring radionuclides and stratigraphy; 2) evaluating the effects of stratigraphic boundaries on contaminant plumes; 3) evaluating changes over time in the contaminant profile that may be attributed to decay and/or migration; 4) comparing observed contaminant profiles with site characteristics and operational history; 5) identifying potential data gaps; and 6) providing recommendations for future characterization. Manmade radionuclides reported from log data are decayed to September 30, 2010.

For each subregion, a brief background section is provided that includes waste site characteristics, process history, and geology. Cross sections that include the current contamination profile in relation to the waste site and lithostratigraphy are provided. Where appropriate and data are available, 3-dimensional visualizations and interpretations are provided. Following the subregions discussion is an integrated interpretation of the entire T-TX-TY 200-DV-1 OU focus area. Appendix A to the report includes a master list of all the geophysical logs used in the interpretations in this report.

1.1 REFERENCES

CHPRC-01056-VA, Hanford Site – Deep Vadose Zone Cleanup Challenge, Rev. 3, U.S. Department of Energy Richland Operations Office, Richland, Washington.

FIGURE 1-1. 200-DV-1 OU SUBREGIONS, 200 WEST AREA



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2.0 LOG MEASUREMENTS

Since the inception of the Hanford Site in World War II, borehole measurements have been used to assess and monitor subsurface radiological contamination. Over the years, a variety of geophysical log measurements have been made in boreholes, but the dominant measurements have been gamma activity and moisture content due to the cased hole nature of the boreholes and wells. Early measurements consisted of point by point measurements from instruments suspended in a borehole and recorded into log books or onto data sheets. As instrumentation and electronics have increased in sophistication and capability, logging equipment has also improved, from strip chart recordings to digital data acquisition. Although they may be considered crude by today's standards, early logs provide important information regarding the nature and extent of subsurface contamination throughout the operational history of the Hanford Site. Last and Horton (2000) provide a review of geophysical methods used at Hanford, including geophysical logging. Table 2 of their report includes a summary of significant logging activity up to 2000. A bibliography of publications related to surface and borehole geophysics is also provided.

Logs provide a record of the nature and distribution of subsurface activity throughout Hanford's operational period to the present. Many boreholes that were logged in the early days are still available for logging, but the recent emphasis on decommissioning "unnecessary" boreholes means that opportunities to collect additional data may be limited. Gamma logs and moisture logs can be generated at regular intervals in a borehole and thus offer one of the few opportunities to monitor contaminant conditions over time in the vadose zone. An understanding of past and current geophysical logs is therefore important to evaluating the deep vadose zone.

The majority of waste disposal operations occurred in the Hanford 200 Areas (200W and 200E) where irradiated uranium was processed to recover plutonium. Depth to groundwater in this area is on the order of 240 feet. The Hanford formation and most of the Ringold Formation that comprise the vadose zone are poorly consolidated. Most boreholes and wells, particularly in or near areas of suspected contamination, are drilled with cable tool methods. Steel casing is required to maintain borehole integrity. Drilling methods involving mud to stabilize the borehole are not used because of the difficultly of dealing with radiological contamination and potential spreading. The presence of steel casing precludes the use of most electromagnetic logging methods. Acoustic logging methods require water or other fluid between the sonde and the borehole wall, and thus cannot function above groundwater level in most Hanford boreholes. A major exception is the borehole seismic survey, which employs a stationary geophone clamped to the casing and a surface seismic source to measure seismic wave velocities in the surrounding formation. The primary logging methods for vadose zone investigation rely on radiation transport. The steel casing blocks alpha and beta radiation, so only gamma rays and neutrons can be measured in most applications. Passive measurement of gamma activity is the most common logging method. Measurement of moisture content by neutron backscatter is also performed. Gamma density logs and neutron porosity logs have also been run, but interpretation of these logs is complicated by the presence of steel casing and annular material such as grout or bentonite. Since the gamma density log measures scattering of gamma rays from a Cs-137 source, its use in contaminated zones where Cs-137 is the dominant contaminant is problematic. Efforts have also been made to use neutrons from radioisotope sources (Am-241/Be or Cf-252) or neutron generators to interrogate the vadose zone sediments. These include neutron capture logs, prompt fission logging, and neutron capture cross section logs. There has also been some success in using passive neutron logs to detect neutron activity originating from (α, n) reactions or spontaneous fission - this is interpreted as an indication of the presence of transuranic (TRU) elements, such as Pu-239, Pu-240, Pu-241, Np-237, or Am-241 (Bauer, et al, 2000). In some boreholes, high-resolution spectral gamma logs have also detected prompt gammas originating from (α, n) reactions or neutron capture (Henwood and McCain, 2009). At present, a subsurface probe using a scintillation detector to assay Tc-99 from in-situ measurement of beta activity is being developed (Skorska, 2010). This probe will be emplaced with a direct push drilling system. It will measure beta activity immediately below the direct push rods and thus provide a profile as the rods are withdrawn.

Gamma logs and moisture logs provide the bulk of available subsurface data for investigation of the deep vadose zone, and the remainder of this section will focus on those logs.

2.1 TOTAL GAMMA LOGS

Total gamma logs or gross gamma logs refer to passive measurement of gamma activity without regard to energy level. Naturally occurring radionuclides, such as K-40, U-238 and Th-232 contribute to background gamma activity in each measurement. These radionuclides have extremely long half lives, such that their activity or concentration can be considered constant over any time scale related to human activity. Variations in naturally occurring radionuclides result in detectable variations in background or natural gamma activity which can be used for lithologic identification and stratigraphic correlation.

Hanford waste includes fission products, uranium, and TRU radionuclides. Many of these emit detectable gamma rays. In general, the presence of gamma activity significantly in excess of a "typical" background count rate for a specific detector can be interpreted as a qualitative indication of the presence of Hanford related gamma-emitting contamination.

Fission products are radionuclides created by fission of U-235 and less commonly Pu-239. When the U-235 atom undergoes fission, it tends to break up into two unequal fragments with atomic mass numbers of approximately 95 and 137, with the remainder of the mass as neutrons. Many fission fragments are highly unstable (short half life) and they undergo successive radioactive decay by beta emission or electron capture. Gamma rays are also emitted with most of these decay reactions. The short half lives associated with many fission fragments means that overall gamma activity will decrease rapidly over time. Where multiple logs are available over an extended time period, it may be possible to identify dominant radionuclides from the observed rate of decay. Typical short-lived radionuclides of interest that may be detectable by total gamma logs are listed below.

Radionuclide	Half-Life
Ru-106	371.8 days (1.018 years)
Cs-134	2.0652 years
Sb-125	2.75856 years
Co-60	5.271 years
Eu-154	8.601 years
Eu-152	13.537 years
Sr-90[a]	28.79 years
Cs-137	30.08 years

[a]Sr-90 does not emit gamma but its Bremstrahlung radiation is detected by gamma sondes as a broad peak.

When specific radionuclides are known or can be assumed to be present and sufficient data are available, it may be possible to use regression analysis of the decay curve to estimate the relative proportions of each radionuclide.

Manmade uranium and TRU are much less likely to be detected with total gamma logs because gamma emission rates associated with decay are very low. It is possible that significant concentrations of uranium or TRU may exist in intervals where total gamma activity is comparable to background levels. Since uranium and most TRU have much longer half-lives, radiation associated with these elements is more persistent.

Total gamma logs are generally reported in terms of count rate, which is determined by dividing total counts by the elapsed time over which the counts are accumulated. This may be reported in units of counts per minute (cpm) or counts per second (cps). It can be difficult to compare results between two different detectors, because the ability of a specific detector to count an incident gamma ray depends on the gamma energy, attenuation through the sonde housing, any shielding or collimation, and the borehole environment (casing and the presence of water).

Most gamma detectors exhibit linear response, at least at low count rates. As radiation levels increase, count rates increase proportionally. However, at high count rates, detector response becomes increasingly non-linear. With each gamma interaction, there is a small time period during which the detector is unable to detect an additional gamma. This time period is known as the dead time (τ). The magnitude of τ is a characteristic of both the detector and associated pulse processing electronics. At low activity, it can be assumed that the measured count rate, m, is reasonably close to the "true" count rate, n. As gamma activity increases, the average time between gammas decreases so that the next gamma is more likely to arrive during a dead period and thus is not counted. At high activity, detector response becomes increasingly non-linear and the "true" count rate may be much higher than the measured count rate. In logging practice, a "dead time correction" based on the non-paralyzable model (Knoll, 2010) is applied:

$$n=m/(1-m\tau) \qquad (1)$$

The concept of dead time has implications regarding the maximum credible count rate from any logging system. Obviously, the maximum recordable count rate is $m = 1/\tau$. As the quantity $m\tau$ approaches 1, the "true" count rate (n) increases rapidly. Equation 1 is based on a hypothetical detector, with the basic assumption that gammas arriving during a dead period have no effect. In practice, it is reasonably reliable for values of $m\tau$ up to about 1/3. Therefore $m = 1/3\tau$ represents a credible maximum count rate for most detectors. Scott (1980) discusses the importance of accurate dead time values in correcting gamma logs, and provides equations to determine dead time using two sources of approximately equal magnitude. Unfortunately, dead time characteristics of older logging systems used at Hanford may not be known, and the systems are no longer available for testing. However, it is possible to make general assumptions based on detector type. Where response data exists, it is preferable to establish maximum credible count rates based on actual detector performance.

Dead time effects and behavior at high count rates are important factors in evaluating log data near Hanford waste sites. Radiation levels in contaminated intervals may range over about 9 to 10 orders of magnitude. This is well beyond the dynamic range of any single detector. Many detectors will become "saturated" or "paralyzed" in moderate to high levels of contamination.

Total gamma logs may be "standardized" in terms of equivalent concentrations of a specific radionuclide. By the early 1990's the scintillation logging system was calibrated in terms of "equivalent uranium" (eU) (Brodeur and Koizumi, 1989, Arthur, 1990, 1991, 1992, 1993). This calibration was based on the field calibration facilities developed by DOE (Steele and George, 1986). The borehole calibration models consisted of concrete cylinders 4 ft (1.2 m) in diameter and 4 ft (1.2 m) tall with a borehole along the axis. Uranium ore, monazite sand and/or orthoclase sand were used to provide varying concentrations of uranium, thorium, and potassium. The field calibration standards were originally located in Spokane. They were moved to Hanford in the early 1990's and are now installed at the Hanford Borehole Calibration Facility, located outside the 200W area near the central weather station. Table 2-1 provides information on the calibration models.

Use of "equivalent uranium" as a log unit at Hanford is not recommended, because it has the potential to be highly misleading. Nearly all gamma activity from "natural" uranium originates from Bi-214 or Pb-214. These daughters are located well down in the U-238 decay series. Secular equilibrium develops very slowly in the U-238 decay series, and gamma activity from Bi-214 or Pb-214 will require hundreds of thousands of years to reach equilibrium with the parent U-238. Uranium used as reactor fuel at Hanford was separated from the ore and enriched (generally to 2 wt% U-235 or less). During processing, the daughter radionuclides were removed, and the "processed" or "manmade" uranium actually exhibits significantly less gamma activity than "natural" uranium. Presenting log results in terms of eU will give the impression that uranium is present everywhere even though naturally occurring uranium in geologic materials is completely unrelated to Hanford contamination. Moreover, the total gamma log results will seriously underestimate concentrations where uranium is present as a contaminant.

Recently, a convention has been established to report total gamma log results in terms of 'equivalent radium" (eRa). Ra-226 is a member of the U-238 decay series. With the exception of low intensity gammas from Pa-234m, nearly all gamma activity associated with the U-238 decay series originates from Ra-226 and subsequent daughters (notably Pb-214 and Bi-214). Even if secular equilibrium is not fully established in the calibration models, the decay series from Ra-226 to the stable end product Pb-206 will be in equilibrium. Ra-226 is not present at detectable levels in "manmade" or processed uranium and it was not produced at Hanford or used in significant quantities. eRa is therefore preferable to eU as a standard unit for total gamma logs. Background activity for total gamma logs should be on the order of 2.5 pCi/g eRa- this includes contributions from K-40 and the Th-232 decay series as well. Values above about 5 to 10 pCi/g eRa can be interpreted as an indication of contamination. However, anomalously high eRa levels may be misleading, because the observed gamma activity is almost certainly not related to radium; however, there are zones, such as the lower caliche in the Cold Creek unit, where high natural uranium levels exist. At the same time, eRa levels less than 5 pCi/g cannot be uniformly interpreted as "clean" because gamma activity from manmade uranium or TRU is relatively weak and may not contribute to a detectable difference in total gamma activity.

Cs-137 is the most common gamma emitting fission product remaining today at the Hanford Site, and total gamma logs may also be expressed in terms of "equivalent cesium" (eCs). This conversion is generally established by comparing the total gamma log with spectral gamma log results from the same borehole.

When total gamma logs are presented in terms of "equivalent concentrations" (eU, eRa, eCs), it must be understood that this in no way "confirms" that the indicated radionuclide is actually detected. The log should be interpreted to mean that the observed gamma activity is comparable to that associated with a uniform and homogeneous distribution of the indicated radionuclide.

One approach to standardize response of total gamma logs is to establish an empirical unit for gamma response. In well logging practice, the API gamma unit was established by the American Petroleum Institute for gamma logs. It is based on measurements in the API Calibration Facility at the University of Houston, Texas, where a concrete cylinder contains potassium, uranium, and thorium –bearing minerals at levels representing approximately twice the radioactivity of a typical midcontinent shale. The API gamma unit is defined as 1/200th of the difference in gamma activity between this cylinder and a similar cylinder of "barren" concrete. Since calibration models have been installed on the Hanford site, it is possible to define an empirical gamma unit on the basis of measurements in those models. The Hanford Gamma Unit (HGU) is defined on the basis of gamma activity at the midpoint between the SBT and SBK models. This was chosen because gamma activity at this point is very close to average background activity in shallow sediments. Converting total gamma log results to HGU thus expresses gamma activity in terms of multiples of background. This makes it relatively easy to identify intervals of possible contamination without providing any (possibly false) implication as to the source of the gamma activity. This simplifies comparisons of gamma measurements and trends over time using different sensors.

Two general types of detectors are used for total gamma logs. These are the Geiger-Mueller (GM) and scintillation detectors.

2.1.1 GEIGER-MUELLER

A GM detector is one of the oldest radiation detectors in existence, having been introduced in 1928. Simplicity, low cost, ruggedness, high-amplitude output, and ease of use make the GM detector useful in well logging applications. Because of the physical process inside a GM tube, all pulses are of the same amplitude, regardless of the energy level of the incident gamma. A major disadvantage of GM detectors is relatively high dead time. After a pulse is generated, a finite time period is required for the detector to recover. This time period is typically on the order of 20 to 100 microseconds. In a practical sense, GM detectors are limited to a maximum count rates on the order of about 3400 to 20,000 cps (the exact value depends on the dead time). Because the high voltage across the GM tube must recover after each event, GM detectors may become paralyzed at high count rates. In detector paralysis, a gamma arriving during the dead time after a

pulse is not counted but may extend the time necessary for the tube to recover. Count rates may become "saturated" or actually decrease with increasing gamma activity.

2.1.2 SCINTILLATION LOGS

In a scintillation detector, incident gamma rays create a brief flash of light, which is amplified and detected by a photomultiplier or photodiode. In logging applications, common scintillation materials include sodium iodide (NaI) or bismuth germanate (BGO). NaI crystals typically include trace amounts of thallium to improve response, and it should be understood that NaI is equivalent to the notation NaI(Tl) seen in other publications. Other scintillation materials that can be used in logging applications include cesium iodide (CsI) and lanthanum bromide (LaBr). The intensity of the light (and the voltage of the resultant output from the photomultiplier or photodiode) is proportional to the energy of the gamma ray. Depending on the electronics, it may be possible to capture spectral data. In other cases, the system may operate in a total count mode. In most systems, discriminators are used to reject pulses when the energy (voltage) is above or below a pre-set limit. Scintillation detectors generally have dead times on the order of 5 to 30 microseconds, meaning that the maximum credible count rate is on the order of 12,000 to 70,000 cps. Scintillation detectors may also become paralyzed in extremely high gamma activity.

2.2 SPECTRAL GAMMA LOGS

Spectral gamma logs provide information regarding the energy level of each of the detected gammas. Modern systems use a multi-channel analyzer (MCA) wherein individual pulses are counted and assigned to channels by energy level. When a gamma at a specific energy is detected, the value in the corresponding MCA channel is incremented. After the count time is completed, the resulting histogram of counts as a function of channel number (energy) is referred to as the gamma energy spectrum. Since radionuclides emit gammas at characteristic energy levels during decay, the gamma energy spectra can be used to identify and assay specific radionuclides.

As a historical note, some of the older scintillation total gamma logging systems had limited "spectral" capability as early as 1955. The "2nd generation scintillation logging system" and "3rd generation logging system" (Last and Horton, 2000) are described by Speer and Rankin (1956) and Raymond (1964). Both of these systems employed NaI detectors. Pulse height analyzers with adjustable discriminator circuits were used. In normal logging mode, the discriminators were off and total counts were recorded. Spectral information could be obtained by making stationary measurements and adjusting the discriminators to "bracket" energy ranges of interest. By today's standards, this method would be very cumbersome, and there is little evidence it was used extensively in the early logging at Hanford.

Spectral gamma logs can be classified as "conventional" or "high-resolution" depending on the energy resolution of the detector. Conventional spectral gamma logs employ scintillation detectors such as NaI or BGO. These systems are typically rugged and sensitive, but they have relatively poor energy resolution. Analysis is generally performed using relatively wide energy "windows" representing selected radionuclides. High resolution spectral gamma logs employ semiconductor detectors such as high-purity germanium (HPGe). Although these detectors are more difficult to employ in a logging environment and tend to be less sensitive than scintillators, they provide excellent energy resolution (2-4 keV peak width). Figure 2-1 shows a comparison between gamma energy spectra collected with a NaI detector (conventional log) and an HPGe detector (high resolution log).

2.2.1 CONVENTIONAL SPECTRAL GAMMA LOGS

Conventional spectral gamma logs have long been used for lithologic evaluation. Analysis and interpretation methods employed in the logging industry are based on the premise that gamma activity originates from natural sources (K-40, U-238 and Th-232, or "K U T"), and that variations in concentrations of these radionuclides are diagnostic of lithology. The logs generally include total count rate, with additional estimates for potassium, uranium, and thorium concentrations. These concentrations are computed from

count rates in three or more relatively broad energy windows, using a coefficient matrix obtained from measurements in calibration models containing known amounts of potassium, uranium, and thorium-bearing minerals. In theory, windows can be added for additional radionuclides, but this poses practical problems. For one thing, only a relatively limited number of radionuclides can be added, and each additional radionuclide complicates calibration and analysis. Natural radionuclides are present in all sediments within a relatively limited range of concentrations. Manmade radionuclides are not present in uncontaminated sediments, but concentration values may vary over several orders of magnitude in contaminated intervals. The matrix approach will tend to generate false positives in uncontaminated intervals and may not accurately calculate concentrations in severely contaminated intervals. Other non-routine methods such as full spectrum analysis can be applied to achieve better results. Individual gamma energy spectra can be examined to identify radionuclides and calculations of equivalent concentration can be made from total count rate or window count rate.

Since the mid 1990's, high-resolution spectral gamma logging has been available at Hanford and these logs have displaced conventional spectral gamma logs from most applications. However, conventional spectral gamma logs still offer an important advantage: equipment required can be much smaller than that required for the high resolution logging equipment. The HPGe detectors and liquid nitrogen Dewar flasks that are required for high resolution spectral gamma logging constrain the minimum borehole diameter to about 4 inches. Increased use of small-diameter direct push units for shallow subsurface investigation has created a need for logging tools that can operate in borehole diameters as small as 2 inches, and this had led to deployment of small diameter conventional spectral gamma logging systems.

2.2.2 HIGH-RESOLUTION SPECTRAL GAMMA LOGS

The high resolution spectral gamma logging system (SGLS) employs cryogenically cooled HPGe detectors to acquire laboratory-quality gamma energy spectra in boreholes. The SGLS is a modification of the radionuclide logging system (RLS) that was deployed in the early 1990's. Both logging systems are very similar. The primary differences are in count time, data analysis, and log presentation.

Gamma energy resolution for the SGLS is between 2 and 4 keV. This allows natural and manmade radionuclides to be identified on the basis of characteristic decay gammas, and assay values are calculated from net counts for specific gamma peaks. Tables 2-2 and 2-3 lists prominent gamma energy lines for manmade and natural radionuclides. Because assay values are calculated from specific gamma energy peaks, the SGLS has the capability to detect contamination at levels well below those required to significantly affect total gamma counts.

The SGLS uses coaxial P-type HPGe detectors with relative efficiencies between 35% and 70% (100% is equivalent to a 2-inch by 2-inch NaI detector) for measurements from background levels up to the equivalent to several thousand pCi/g Cs-137. For high activity levels, a small planar HPGe detector, designated the high rate logging system (HRLS) is used. With additional shielding, the HRLS is capable of logging in Cs-137 levels up to 1 E8 pCi/g.

The SGLS is deployed in move-stop –acquire mode, meaning that the sonde is held stationary for a measurement and then moved up or down in the borehole casing to the next measurement point. Count times are typically between 100 and 200 seconds (clock time) but the detector can make much longer counts if necessary. The Dewar flask contains sufficient liquid nitrogen for 8 to 12 hours of operation: this represents the practical maximum count time. Calibration is performed on an annual basis in the Hanford Borehole Calibration Models, where radionuclides in the U-238 and Th-232 decay series provide a wide range of gamma peaks between 185 and 2615 keV with well-known activity levels. The calibration data are used to define a calibration function ("inverse efficiency" or I(E)), which provides detector response as a function of gamma energy, under the assumption of a uniform distribution of the gamma source around the detector ("4-pi" geometry).

The minimum detectable level (MDL) for the SGLS depends on background activity levels, detector efficiency, count time, and gamma yield (gammas per decay), as well as environmental factors such as casing thickness or the presence of water. An MDL can be calculated at each point for any energy, regardless of whether a gamma peak is detected. Table 2-2 shows typical MDLs for manmade radionuclides. For most fission products, the MDL is typically 1 pCi/g or better. For manmade uranium, the MDL is on the order of 10 to 20 pCi/g. (about 30 to 60 ppm U). For TRU, the MDL for individual radionuclides ranges from 10 to 50 nCi/g. The disparity in MDLs is related primarily to the wide range in gamma yields for the target radionuclides (see Table 2-2).

2.3 NEUTRON MOISTURE LOG

The neutron moisture probe bombards the formation with neutrons and measures the degree to which they are scattered back to the detector. The primary mechanism for neutrons scattering in geologic media is interaction with hydrogen atoms, so the neutron moisture log response is dominated by hydrogen. Since the hydrogen is primarily a constituent of water, the neutron moisture log effectively measures the moisture content. The neutron moisture probe currently in use at Hanford employs a 50 mCi Am-241/Be neutron source and a He-3 detector. Source to detector spacing is about 3 inches. For this system, count rates increase with increasing moisture. The probe responds to all hydrogen, including that contained in "bound" water associated with clays or bentonite, or water of hydration in cement. The moisture probe is sensitive to variations in moisture content associated with thin fine-grained layers, but depth of investigation is limited. Other than to assess the integrity of the annular seals, the neutron moisture detector cannot be run in borehole intervals where there is annular grout or bentonite, and it cannot be run below the water table. Neutron moisture log response is strongly affected by the casing inside diameter. Neutron moisture calibration models are available at the Hanford borehole calibration facility. These consist of large drums filled with a mixture of silica sand and hydrated alumina to provide equivalent moisture contents of approximately 5, 12, and 20 percent by volume (Englemann et al, 1995), with typical steel casings of 6-inch and 8-inch diameter. Since the moisture log is very sensitive to casing diameter, conversion of count rate to moisture content should only be made when borehole ID is close to either 6 or 8 inches. In most applications the neutron count rate is an excellent qualitative indicator of relative moisture content in the surrounding sediments. For a given moisture content, count rates decrease with increasing borehole diameter, and the log may not be effective in holes larger than 12 inches.

The neutron moisture log is calibrated to report moisture content in percent by volume. Most laboratory results for soil samples report moisture content in terms of percent by weight or gravimetric moisture content. If an accurate measure of the formation dry bulk density is available, the gravimetric moisture content can be converted to volumetric moisture content by the equation

$$MC_{vol} = MC_{grav} * \text{bulk density} \qquad (2)$$

2.4 PASSIVE NEUTRON LOG

The passive neutron log measures ambient neutron activity in the formation. In general, the log is run using the He-3 detector in the moisture gage without the Am-241/Be neutron source, with a longer count time and larger depth increment (60 to 100 sec count time and 1 ft (0.3 m) depth increment, compared to 15 sec count time and 0.25 ft (0.08 m) depth increment for the moisture log). (α, n) reactions occur when alpha particles emitted from transuranic (TRU) elements (Pu-239, Pu-240, and Am-241) interact with light elements in the surrounding soil. To a lesser extent, spontaneous fission, primarily from Pu-240, may also contribute to neutron activity. Most TRU elements are present in the soil as oxides or nitrates, and the primary (α, n) reaction will tend to be with oxygen or nitrogen. Fluoride compounds are also possible, and fluorine has a much higher alpha capture cross section than either oxygen or nitrogen. Proof-of-principle tests carried out in the 216-Z-1A trench (Bauer et al, 2000) indicated very high neutron activity, and suggested that passive neutron logs could be used to detect TRU in the subsurface. Subsequent analysis of log data from 216-Z-1A (Henwood and McCain, 2009) indicates that at least part of the TRU contamination may be present in the

form of fluoride compounds. Under normal circumstances, passive neutron activity in uncontaminated soil is an indication of TRU contamination, but it should only be used in a qualitative sense. It must also be noted that the He-3 detector may be subject to interference in intervals of extremely high gamma activity: measured passive neutron activity in a sediment zone where Cs-137 contamination is greater than about 100,000 pCi/g may not be indicative of TRU. For quantitative assay of highly contaminated sediments, the high resolution spectra gamma is recommended.

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TABLE 2-1. HANFORD BOREHOLE CALIBRATION MODELS

Gamma Calibration Models

	Radionuclide Content			eU	Total Gamma Activity	
	K-40	U-238	Th-232			
Model	pCi/g	pCi/g	pCi/g	ppm	mR/h	HGU
SBT	10.6 ± 1.3	10.02 ± 0.48	58.1 ± 1.4		0.298 ± 0.019	29.1 ± 2.8
barren					0.0102 ± 0.0009	**1.00**
SBK	53.5 ± 1.7	1.16 ± 0.11	0.11 ± 0.02		0.0187 ± 0.0014	1.83 ± 0.18
SBU	10.7 ± 0.8	190.5 ± 5.8	0.66 ± 0.06	567 ± 17	0.760 ± 0.096	74.3 ± 7.2
SBM	41.8 ± 1.8	125.8 ± 4.0	39.1 ± 1.1		0.664 ± 0.065	64.9 ± 6.2
SBL		324.0 ± 9.0		964 ± 27	1.351 ± 0.197	132 ± 13
SBH		3126 ± 180		9303 ± 536	10.86 ± 1.09	1062 ± 121
SBA		61.2 ± 1.7		182 ± 5	0.257 ± 0.037	25.1 ± 2.4
SBB		902.0 ± 27.0		2684 ± 80	3.59 ± 0.45	351 ± 34

Moisture Calibration Models

Model		Hole ID, in	Casing Thickness, in	vol % moisture	Density (g/cm^3)
A		8	0.32	5	1.76
B		8	0.32	19.7	1.70
C		8	0.32	11.9	1.76
D1	upper 2.25 ft	8	0.32	5.0	1.63
D2	middle 1.5 ft			40.9	1.32
D3	lower 2.25 ft			5.0	1.55
E		6	0.28	11.7	1.74
F		6	0.28	5.0	1.76
G		6	0.28	19.8	1.70

TABLE 2-2. MAN-MADE GAMMA EMITTING RADIONUCLIDES

RADIONUCLIDE	HALF LIFE (YEARS)	PRIMARY GAMMA RAYS		SECONDARY GAMMA RAYS		TYPICAL MDL, PCI/G
		E, KEV	YIELD (FRACTION)	E, KEV	YIELD (FRACTION)	
CO-60	5.2714	1332.50	0.9998	1173.24	0.9990	0.15
RU-106	1.0238	511.86	0.2040	621.93	0.0993	
SB-125	2.7582	427.88	0.2960	600.60 635.95 463.37	0.1786 0.1131 0.1049	
SN-126	1.E+05	414.50	0.86	666.10 694.80	0.86 0.8256	
CS-137	30.07	661.66	0.851			0.2
EU-152	13.542	1408.01	0.2087	344.28 964.13 1112.12 778.90	0.2658 0.1434 0.1354 0.1296	
EU-154	8.593	1274.44	0.3519	723.31 1004.73 873.19	0.2022 0.1801 0.1227	0.2
^{235}U	7.04E+08	185.72	0.5720	205.31	0.0501	0.6
PA-234M (U-238)[1]	4.47E+09	1001.03	0.0084	766.36	0.0029	10-15
NP-237[1]	2.14E+06	312.17	0.386	300.34 340.81 415.76	0.0662 0.0447 0.01745	1
PU-239	24110	375.05 413.71	1.554E-5 1.466E-5	203.55 345.01 332.85	5.69E-6 5.56E-6 4.94E-6	13000
PU-241 (U-237)	14.3 6.75D	159.96 208.005	6.54E-8 5.19E-6[3]	164.61 332.35	4.56E-7 2.94E-7	
AM-241[4]	432.2	208.01 335.37 662.40[4] 722.01	7.91E-6 4.96E-6 3.64E-6 1.96E-6	368.05 376.65 322.52 332.35	2.17E-6 1.38E-6 1.52E-6 1.49E-6	50000

MDL based on routine analysis with Spectral Gamma Logging System (SGLS).

[1] Pa-234m is a short-term daughter of U-238. The yield is relatively low, and these gamma lines are generally not seen in "natural" uranium. Within the uranium decay series, secular equilibrium is achieved slowly, and gamma activity from Pb-214 or Bi-214 will not reach significant levels in less than several hundred thousand years. Hence, the presence of gamma activity originating from Pa-234m, without much higher levels of activity from Pb-214 and Bi-214 is an indication of the presence of anthropogenic U-238, which has been chemically separated from its decay products.

[2] Np-237 is created by alpha decay of Am-241 and by successive neutron capture in U-235 during reactor operations. Np-237 may also have been used as a source material for production of P-238.

[3] U-237 decay line corrected for branching ratio of 0.0000245

[4] The intense 59.53 keV gamma from Am-241 is unlikely to penetrate steel casing. The 662 keV gamma line from Am-241 may be easily mistaken for Cs-237, a common fission product. Identification of Am-241 must be based on consideration of the waste stream involved and the presence of confirming gamma lines. Note that activity at 662 keV associated with 1 pCi/g Cs-137 is equivalent to234,000 pCi/g Am-241.

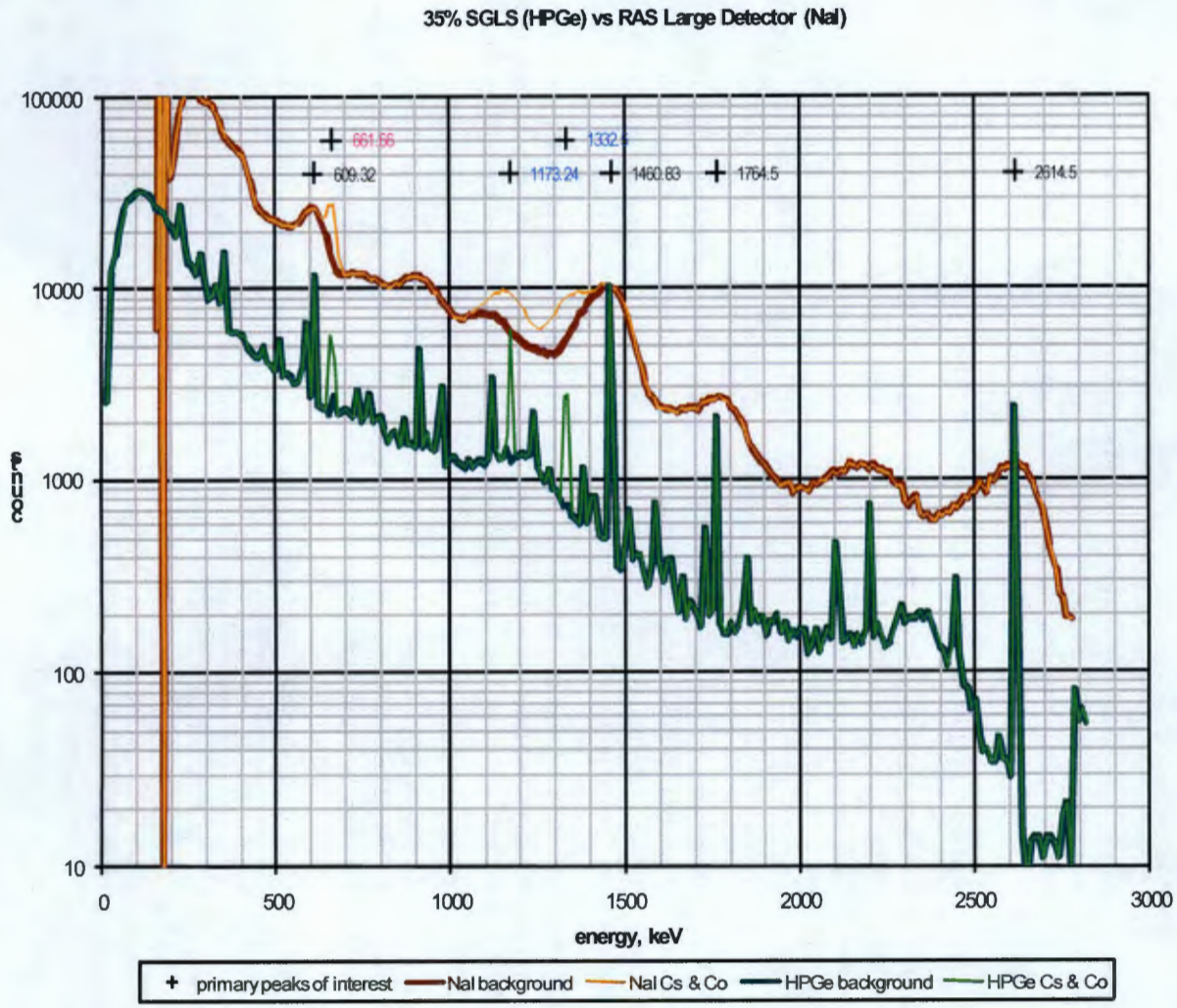
TABLE 2-3. NATURALLY OCCURRING RADIONUCLIDES

	PRIMARY GAMMA RAYS			SECONDARY GAMMA RAYS		
RADIONUCLIDE	DAUGHTER	E, KEV	Y	DAUGHTER	E, KEV	Y
K-40	AR-40	1460.83	0.1067			
TH-232[1]	TL -208	2614.53	0.3534	^{228}AC	911.21	0.266
	PB-212	238.63	0.433	^{228}AC	968.97	0.1617
	TL-208	583.19	0.3011	^{228}AC	338.32	0.1125
				^{208}TL	510.77	0.0806
U-238[2]	PB-214	351.92	0.358	^{214}PB	295.21	0.185
	BI-214	609.31	0.4479	^{214}BI	1120.29	0.148
	BI-214	1764.49	0.1536	^{214}PB	241.98	0.0750
				^{214}BI	1238.11	0.0586
				^{214}BI	2204.21	0.0486
				^{214}BI	2447.86	0.0150

[1] Th-232 occurs naturally in geologic materials. At Hanford "background" values are generally in the range of 0.5 to 1 pCi/g. Th-232 will establish secular equilibrium throughout the decay series relatively quickly. Hence, anomalous values may indicate the presence of anthropogenic Th-232. Concentrations above 2 pCi/g warrant further evaluation.

[2] U-238 occurs naturally in geologic materials. At Hanford "background" values are generally in the range of 0.5 to 2.5 pCi/g. For anthropogenic U-238, the decay series will not be in secular equilibrium, and the peaks shown above will not be elevated. Elevated Bi-214 and Pb-214 concentrations are an indication that radon Rn-222 may be present.

FIGURE 2-1. COMPARISON OF GAMMA ENERGY SPECTRA



3.0 BACKGROUND AND PHYSICAL SETTING

3.1 GEOLOGY

A discussion of geology in the area is provided in Appendix A of the Long Range Deep Vadose Zone Program Plan (U.S. Department of Energy 2010). Brief excerpts are included in this section and are included as they relate to geology that can be observed using geophysical logging data.

3.1.1 STRATIGRAPHY

Generally, the vadose zone beneath 200 West Area consists of the Hanford formation, Cold Creek unit, and Ringold Formation. The 200 West Area vadose zone ranges from 160 to 260 ft (49 to 79 m) thick. The recommended suprabasalt-sediment lithostratigraphic nomenclature for 200-DV-1 is shown in Table 3-1.

3.1.2 STRATIGRAPHY INTERPRETED USING GEOPHYSICAL LOG DATA

Borehole 299-W11-1 (A7275) located in 200 West near the 216-T-3 Reverse Well and the 216-T-6 cribs is used to illustrate a "type log" for identifying stratigraphic units (Figure 3-1). Naturally occurring K-40, U-238, and Th-232 concentrations in conjunction with total gamma data (and where available neutron moisture data) are invaluable for detecting variations in grain size or mineralogy. The units described in Table 3-1 are designated on the log and a short description of the radiological signature used for the selections is included below listed from oldest (deepest) to most shallow (i.e., most recent).

RFwie Ringold Formation member of Wooded Island – unit E: The top of this subunit is selected at a log depth of approximately 158 ft (48 m) bgs. It is characterized by changes (decreasing) in the K-40 and Th-232 concentrations and slight decreases in total gamma from overlying finer-grained silty/sand sediments to more gravel dominated sediment below.

RFtf Ringold Formation member of Taylor Flat: The top of this unit is indicated at approximately 142 ft (43.3 m) bgs. An interval of finer-grained silt to sand size sediments occurs between 142 and 158 ft (43.3 and 48.2 m) bgs. K-40 and Th-232 concentrations both increase with a corresponding increase in total gamma.

CCu Cold Creek unit - undifferentiated: This unit consisting of two subunits occurs from 103 to 142 ft (31.4 to 43.3 m). The CCu represents one of the most significant barriers to fluid migration vertically beneath the 200 West Area and is a known perching horizon for large effluent disposal volumes. Within the 200 West Area, geophysical log signatures provide the best methodology for accurately defining the thickness and extent of this interval. The lower unit between 121 and 142 ft (36.9 and 43.3 m) bgs is referred to as the Cold Creek unit calcic geosol (caliche) (CCuc). The dominant features in geophysical logs are reflected by up to two caliche layers. These are shown by a 5 to 10 pCi/g decrease in K-40 and an approximate 0.5 pCi/g decrease in Th-232. The lower caliche layer is also characterized by a 2 to 3-fold increase in naturally occurring U-238. This increase causes the total gamma activity to increase even though the K-40 and Th-232 decrease. This is a consistent signature for the lower caliche layer throughout 200 West Area. The upper caliche reflects lower concentrations in K-40, Th-232, and the total gamma. The upper unit is defined by a predominance of silt and designated the Cold Creek silt dominated unit (CCuz) that is identified by an increase of Th-232 concentrations of 1 to 1.5 pCi/g.

Hf2 Hanford formation – unit 2 (sand dominated) is identified by moderate K-40 and Th-232 increases at the top of the formation at approximately 38 ft (11.6 m) bgs. This log type is reflective of the relatively thick sand-dominated sequence of unconsolidated basalt rich fine to coarse sand. It exhibits gradational characteristics that have been compared to grain-size increasing down to the top of the CCu.

Hf1 Hanford formation - unit 1 represents the youngest lithostratigraphic unit beneath the waste sites and is characteristically gravel to coarse sand dominant. The geophysical log inflection at the Hf1-Hf2 boundary can exhibit, gradational to sharp contact transitions dependent on grain size variability.

3.2 WASTE SITE DESCRIPTIONS

The locations of the six subregions are shown in Figure 3-2, 200-DV-1 OU Waste Site Evaluations by Sub-Region, T Complex. The T Plant Aggregate Area Management Study Report (U.S. Department of Energy 1992) addresses these sites in subgroups. Subgroups and the number applicable to this report include:

Tanks and Vaults - Selected single shell tanks, primarily in T Farm; one settling tank

Cribs and Drains - 7 cribs, two with associated tile fields

Reverse Wells - One reverse well

Ponds, Ditches, and Trenches - 10 trenches

Septic Tanks - One located near the 216-T-3 and 216-T-6 subregion

Transfer Facilities, Diversion Boxes, and Pipelines - Pipelines associated with identified sites

Unplanned Releases - If associated with these facilities

Several types of tanks are present in the T-TX-TY area including catch tanks, a settling tank, receiver tanks, a vault, and forty single shell tanks. For the T-TX-TY focus area, evaluation of log data will be conducted only for the settling tank and selected single-shell tanks that are determined by boreholes that lie within 100 m of a 200-DV-1 waste site.

This report will focus specifically on the six subregions shown in Figure 3-2. The impact of the single-shell tanks of the vadose zone, and the nature and extent of vadose zone contamination in the vicinity of the tank farms has been addressed in SST Baseline Tank Summary Data Reports, Tank Farm Reports and Addenda prepared by the Hanford Geophysical Logging Project, and in additional reports prepared by or for the tank farms contractor. Data from these reports and boreholes or drywells associated with the tanks will be discussed only in relation to subsurface conditions in or near the 200-DV-1 OU subregions. Appendix A provides a listing of all logs assembled and evaluated for this report. In addition, the tank farm specific borehole logs and associated data are contained in referenced reports included in Appendix A.

Cribs were designed to percolate wastewater into the ground without exposing it to the open air. Cribs are generally shallow excavations that are either backfilled with permeable material or held open by wood structures. Water flows directly into the backfilled material or open space and percolates into the vadose zone soils. Cribs typically received low-level liquid waste for disposal. Disposal operations to cribs were based on groundwater impact: "the amount of radioactive material that can be cribbed to any one site is limited by the concentration of any critical nuclide in the groundwater (Thomas 1956). A critical isotope may be defined as any radioactive isotope with a half-life greater than three years that exceeds one-tenth of the maximum permissible concentration (M.P.C.) in drinking water for occupational exposure." When this limit was exceeded, disposal to a crib apparently was suspended.

Reverse wells were used for disposal of low-level liquid wastes in the very early phases of the Hanford Site operations. They are buried or covered, encased boreholes with the lower end perforated to allow liquid to seep into the vadose zone. Reverse wells were generally constructed of steel or concrete pipe and were either open or filled with gravel. They proved unsatisfactory because they plugged easily and introduced the waste into the vadose zone at or near the water table. Consequently, by 1954, all reverse wells had been removed from service (U.S. Department of Energy 1992).

Trenches were generally long, narrow unlined shallow excavations, usually about 10 ft (3.1 m) deep. Trenches were used for the disposal of limited quantities of liquid and/or solid (sludge) wastes and were

backfilled after use. Employment of this type of disposal has been limited to wastes which are not suitable for disposal by conventional cribbing techniques or to small volumes of non-routine wastes where construction of a crib cannot be economically justified (Haney and Honstead 1958). Most of the trenches at Hanford are referred to as "specific retention" trenches. This term is defined as that volume of water that may be disposed to the soil and be held against the force of gravity by the surface tension characteristic of the soil surfaces and pores, when expressed as percent of the volume of the trench soil column (cross-sectional area of the trench times the depth between the trench bottom and the water table. In practice it represents the volume of liquid that may be discharged to a pit of known dimensions without leakage to the groundwater, expressed as a percent of the total volume of a column of soil extending from the bottom of the pit to groundwater. Haney and Honstead (1958) recommended a value of 6% by volume for specific retention capacity in 1958 even though the value of 10% by volume was being used in 1958. In the early days of Hanford, what are now called trenches were sometimes referred to as "graves." Graves were described as "an excavation for "one shot" (few days) disposal, promptly backfilled" (Clukey 1956). This designation may provide an important clue as to the activity of the waste and the volume of deposition in some of the retired Hanford disposal facilities.

Septic tanks are not generally considered sources of significant radioactive contamination. However, discharge of large quantities of water to septic tanks and drain fields may mobilize contaminants in the vadose zone sediments below nearby waste sites.

Pipelines transferred water and liquid wastes. As such they are considered accessories to waste sites. They have the potential to leak, and must be considered when assessing a waste site.

3.3 WASTE SITE PROCESS HISTORY

The primary waste generating processes for the 200-DV-1 OU T-TX-TY focus area are associated with the original separations operations conducted in the 221-T Building and its ancillary support facilities. Figure 3-3 presents a flow diagram of the basic process steps, waste streams generated, and disposal options (U.S. Department of Energy 1992).

Coating Removal Waste: The first step in the bismuth phosphate process was to remove the metal cladding on the fuel. This resulted in coating removal waste that was subsequently combined with the first-cycle decontamination waste for storage in single shell tanks.

Metal Waste: The next step in the process was to dissolve the uranium and extract the plutonium. This step resulted in the metal waste stream that contained the bulk of the uranium and approximately 90 percent of the long-lived fission products (e.g., Cs-137 and Sr-90). It was sent to underground single-shell tanks for storage.

First and Second Cycle Waste: Once the plutonium had been extracted, the Pu purification process included two decontamination cycles for further purification. The first cycle decontamination waste contained almost 10 percent of the long-lived fission products and was sent to single-shell tanks for storage. The second-cycle decontamination waste, which contained less than 0.1 percent of the fission products, was sent to single-shell tanks for storage until mid-1948. At that time it was decided to discharge the second-cycle waste supernatant to cribs and trenches from 1948 to the shutdown of T Plant in 1956. This included the second-cycle wastes that had been stored in the single-shell tanks prior to 1948. The second-cycle wastes discharged to cribs were combined with two other waste streams. These combined waste streams accounted for more than 85 percent of the volume discharged to the ground from single-shell tanks but less than 20 percent of the radionuclides.

Cell Drainage Waste: Starting in 1951 until T Plant was shut down in 1956; the cell drainage (referred to as 5-6 waste) was routed along with second-cycle waste and 224 facility wastes through a single-shell tank for settling before discharging to cribs. Prior to 1951, these wastes were settled within the plant and discharged directly to the ground.

224 Waste: The 224 Building near T Plant was the final plutonium decontamination facility before the plutonium was sent to the Plutonium Isolation Facility. The waste from this facility was the primary contributor of plutonium to the ground from all waste discharges in the T Complex. From 1945 to 1947, this waste was held in small, separate underground settling tanks before being discharged to reverse wells or cribs. Beginning in 1946, 224 Building wastes were routed to the 200 series single shell tanks for settling prior to discharging to cribs.

Evaporator Bottoms: To provide tank space needed to support continued production operations, first-cycle waste that had been stored in single-shell tanks was discharged to specific retention trenches in 1953 and 1954. In 1954, evaporator bottoms (from the evaporation of first-cycle wastes in the 242-T evaporator) also were discharged to the specific retention trenches. The discharge of evaporator bottoms to specific retention trenches ceased in the B- and T-Plant areas after one campaign, each. This resulted in the largest discharge of radionuclides to the ground from the fuel reprocessing mission.

Scavenged Waste: Beginning in 1955, the newly generated first-cycle waste in T Plant was scavenged before sending to single-shell tanks for settling and subsequent discharge to the ground. The scavenging involved adding ferrocyanide to the waste to cause the normally soluble Cs-137 to precipitate in the settling process before discharge. The scavenging of the first-cycle waste was designed to significantly reduce the quantity of long- lived fission products discharged to the ground.

Equipment Decontamination and Laboratory Wastes: Beginning in 1959, steam condensate, decontamination waste, and miscellaneous effluents were sent from T Plant to single-shell tanks. These and other waste streams continued to be discharged to the 216-T-28 crib until 1966. A total of 11 million gallons (41.6 million liters) of waste containing 594 curies of fission products was routed through single-shell tanks to this crib.

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TABLE 3-1. 200-DV-1 SUPRABASALT-SEDIMENT LITHOSTRATIGRAPHIC NOMENCLATURE

RECOMMENDED SUPRASALT-SEDIMENT LITHOSTRATIGRAPHIC NOMENCLATURE FOR 200-DV-1*									
	Group	*Formation or Equivalent Rank*	*Member or Unit Symbol*	*Submember or Subunit Symbol*	*Descriptive Name*	*Previous Designation(s)*	*Hydrostratigraphic Unit (HSU)*	*Basis for Recommended Name/Symbol Choice*	
Relative Stratigraphic Position		Holocene deposits	Hd		Holocene deposits - undifferentiated			Holocene is a formal geologic epoch (0 - 12,000 yrs B.P.) and therefore capitalized	Sequence boundary
			Hde		eolium	HD, eolian		Neither deposits nor eolium/ eolian are proper names and therefore lowercase	
			Hdb		backfill	HD, backfill		Neither deposits nor backfill are proper names and therefore lowercase	
		Hanford formation[1]	Hf		Hanford formation - undifferentiated	HF	Unit 1	Hanford is a proper geographic name and therefore capitalized; formation is an informal stratigraphic designation and therefore lowercase	Sequence boundary
			Hf1		Hanford formation - unit 1 (upper gravel-dominated unit)	H1, HF1			
			Hf2		Hanford formation - unit 2 (sand-dominated unit)	H2, HF2			
			Hf3		Hanford formation - unit 3 (lower gravel-dominated unit)	H3, HF3			
		Cold Creek unit[2]	CCu		Cold Creek unit - undifferentiated	CCU		Cold Creek is a proper geographic name and thus capitalized; the Cold Creek unit is an informal stratigraphic name and therefore "unit" is lowercase	Sequence boundary
			CCuz		Cold Creek unit - silt dominated	Early Palouse soil, CCUz, CCUu, PPUz, PPlz	Unit 2		

TABLE 3-1. 200-DV-1 SUPRABASALT-SEDIMENT LITHOSTRATIGRAPHIC NOMENCLATURE

RECOMMENDED SUPRASALT-SEDIMENT LITHOSTRATIGRAPHIC NOMENCLATURE FOR 200-DV-1*									
	Group	*Formation or Equivalent Rank*	*Member or Unit Symbol*	*Submember or Subunit Symbol*	*Descriptive Name*	*Previous Designation(s)*	*Hydrostratigraphic Unit (HSU)*	*Basis for Recommended Name/Symbol Choice*	
			CCuc		Cold Creek unit - calcic geosol (caliche)	caliche, calcrete, calcic paleosol, carbonate, CCUc, CCUl, PPUc, PPlc	Unit 3		
		Ringold Formation[3]	RF		Ringold Formation - undifferentiated	R, Rf		Ringold Formation is a **formalized** stratigraphic name and therefore always CAPITALIZED	Sequence boundary
			RFtf		Ringold Formation member of Taylor Flat	upper Ringold unit, Rtf	Unit 4	Ringold Formation members are informal and therefore "member" is lowercase; however Taylor Flat and Wooded Island are geographic features, recognized on published topographic maps, and therefore capitalized.	
			RFwi		Ringold Formation member of Wooded Island - undifferentiated	middle Ringold unit, Rwi			
				RFwie	Ringold Formation member of Wooded Island - unit e	Rwie, Unit E, Ringold E	Unit 5		
				RFlm	Ringold Formation - lower mud unit	Rlm, Ringold lower mud	Unit 8		
				RFwia	Ringold Formation member of Wooded Island - unit a	Rwia, Unit A, Ringold A	Unit 9		
	Columbia River Basalt (CRBG)	Saddle Mountains Basalt	Elephant Mountain Member		Basalt bedrock				Sequence boundary

TABLE 3-1. 200-DV-1 SUPRABASALT-SEDIMENT LITHOSTRATIGRAPHIC NOMENCLATURE

RECOMMENDED SUPRASALT-SEDIMENT LITHOSTRATIGRAPHIC NOMENCLATURE FOR 200-DV-1*									
	Group	*Formation or Equivalent Rank*	*Member or Unit Symbol*	*Submember or Subunit Symbol*	*Descriptive Name*	*Previous Designation(s)*	*Hydrostratigraphic Unit (HSU)*	*Basis for Recommended Name/Symbol Choice*	

[1] *Hanford formation,* first defined in Tallman et al. (1979) is an informal unit for deposits of the Ice Age floods on the Hanford Site. Codes of stratigraphic nomenclature strongly discourage using "formation" with informal units. Therefore, to be incompliance with stratigraphic standards "formation" should be replaced with something else. So far, PNNL has not arrived at a satisfactory alternate term to replace "formation". Another option is to formalize the unit but it does not appear to satisfy all the criteria of a "Formation" and if it did would require a major effort of time and resources to publish in a peer-reviewed journal - a requirement to formalization. For the time being PNNL recommends the continued informal use of Hanford formation until a satisfactory substitute is agreed upon by a majority of Hanford geologists.

[2] Cold Creek unit first defined (informally) in DOE (2002)

[3] Ringold Formation formally defined in Newcomb (1958) and Newcomb, Strand and Frank (1972)

*This stratigraphic nomenclature conforms to most of the guidelines presented in:

(1) North American Stratigraphic Code (2005), *AAPG Bulletin,* v. 89, No. 11, pp. 1547-1591
(2) International Stratigraphic Guide (1994), International Subcommittee on Stratigraphic Classification, co-published International Union of Geological Sciences and Geological Society of America, 2nd edition
(3) Owen, DE (2009) "How to use stratigraphic terminology in papers, illustrations, and talks", *Stratigraphy,* v. 6, No. 2, p. 106-116.
(4) Stratigraphic Nomenclature and Description, http://www.nwrc.usgs.gov/techrpt/sta08.pdf

FIGURE 3-1. STRATIGRAPHIC UNITS AT THE 216-T-3 AND 216-T-6 WASTE SITES

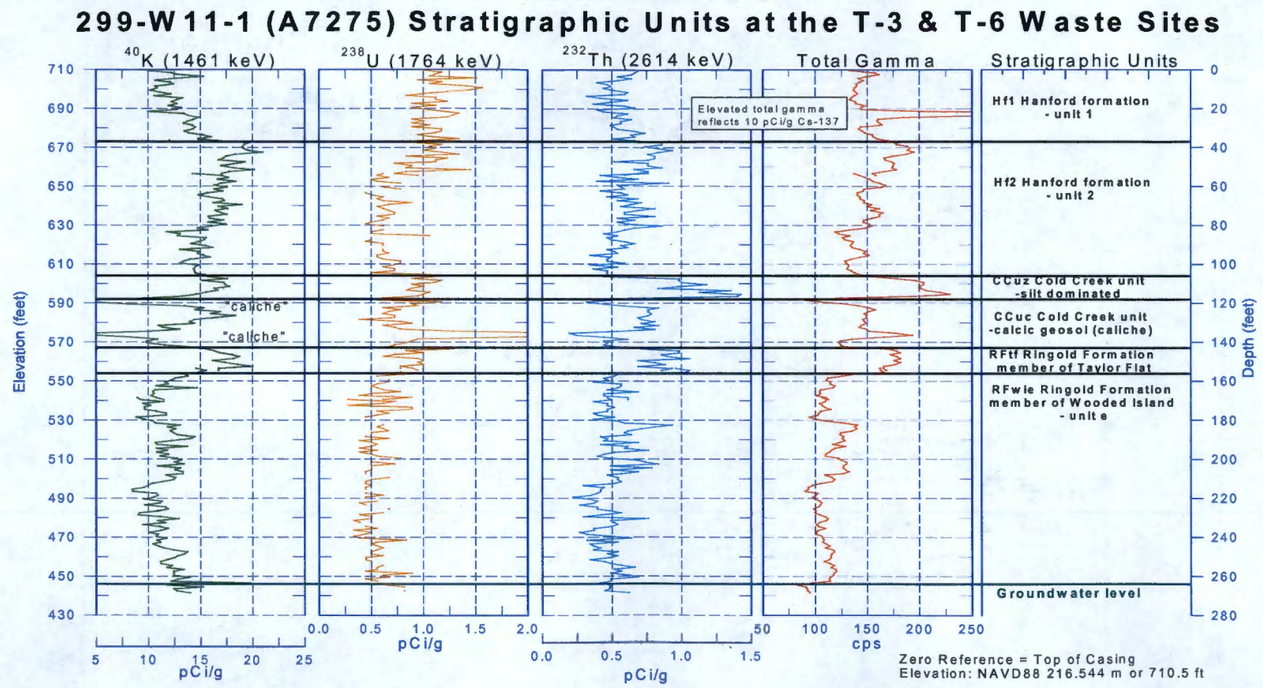


FIGURE 3-2. 200-DV-1 OU WASTE SITE EVALUATIONS BY SUB-REGION, T COMPLEX

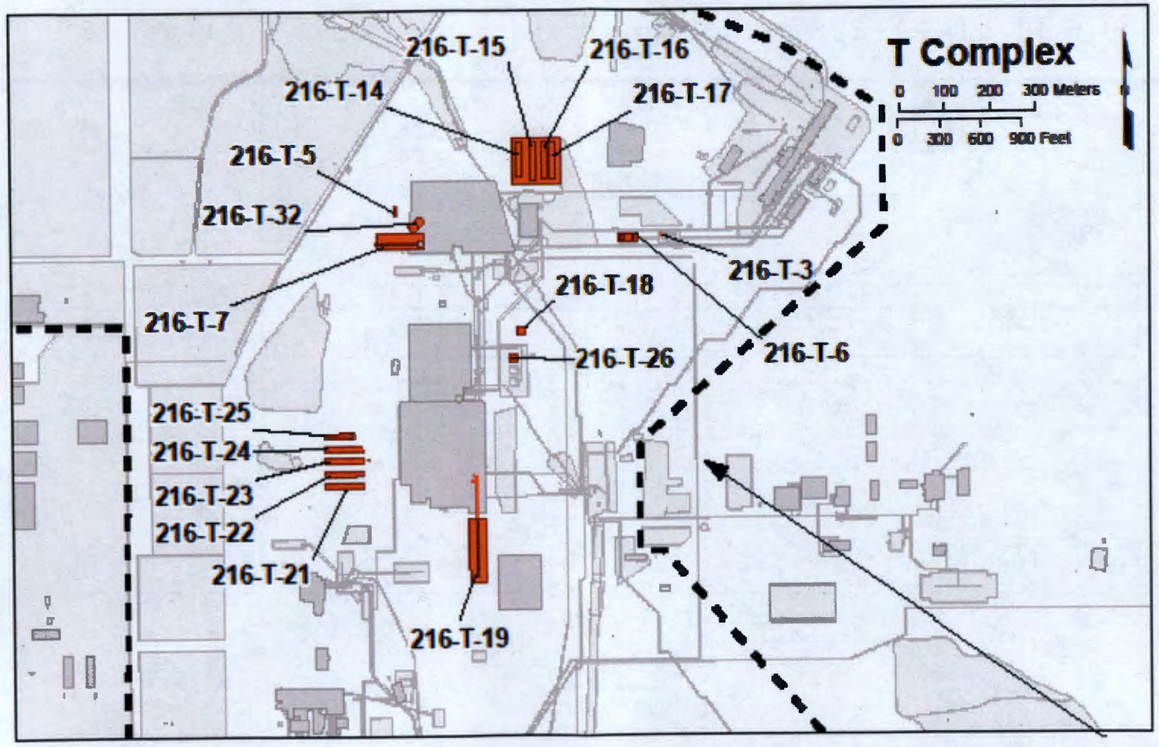
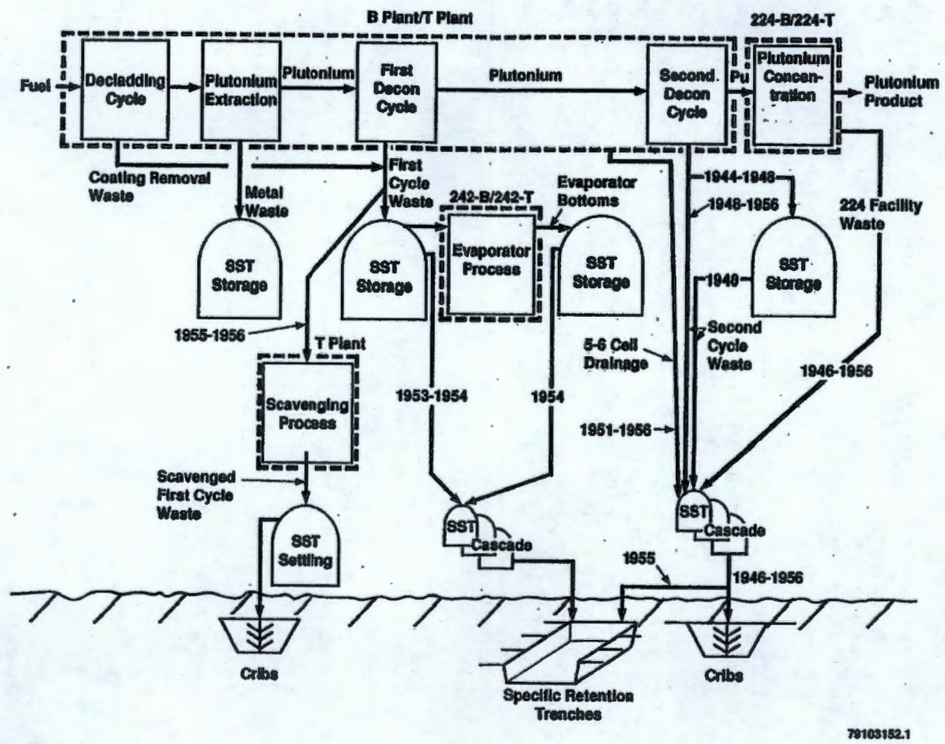


FIGURE 3-3. WASTE PROCESS FLOW DIAGRAM



4.0 216-T-3 REVERSE WELL, AND 216-T-6 # 1 AND #2 CRIBS (INCLUDING NON-200-DV-1 WASTE SITE 241-T-361 SETTLING TANK)

The 216-T-3 and 216-T-6 subregion includes the 216-T-3 Reverse Well and the 216-T-6 #1 and #2 Cribs. In addition, the 241-T-361 Settling Tank and ancillary pipelines (Figure 4-1) are included in the discussion below because they are closely associated in terms of both proximity and process history (but are not defined as 200-DV-1 waste sites). A brief background section is provided that includes waste site characteristics, process history, and geology. Cross sections that include the current contamination profile in relation to the waste site and stratigraphy, 3-dimensional data visualizations, and interpretations are provided in Section 4.4.

4.1 GEOLOGY

The general geology and stratigraphy for this area are described in Section 3.1. Stratigraphic relationships are depicted on cross sections of log data. Key Stratigraphic intervals defined within the vadose zone, from shallowest to deepest include the Hf1, Hf2, CCu, RFtf, and RFwie. Overall, the vadose zone is approximately 264 ft (80.5 m) thick in this area. The contact between the Hf1 and Hf2 occurs relatively shallow and is usually situated within or just below the bottom of the facility. The top of the Hf2 (Hanford formation – unit 2) is at approximately 672 ft (204.8 m) in elevation or 38 ft (11.6 m) bgs) and the CCu lies between elevations of approximately 605 ft (184.4 m) or 105 ft (32 m) bgs and 570 ft (173.7 m) or 140 ft (43.6 m) bgs. The Hf2 averages approximately 68 ft (20.7 m) in thickness and the CCu averages approximately 35 ft (10.7 m) in thickness beneath the area. The CCu contact appears to slope gently from east to west.

4.2 WASTE SITE PROCESS HISTORY

4.2.1 241-T-361 SETTLING TANK

The 241-T-361 settling tank is located about 700 ft (213 m) southwest of the 221-T building. WIDS states it has a capacity of 36,000 gallons (136,275 L). Process waste from the 224-T building was directed to 241-T-361. The following description of the tank is based on "Soil and Groundwater Contamination from 200 and 300 Area Process Water," (Parker 1944). The tank had a system of baffles which were designed to settle out precipitates and allow clear effluent to discharge to the 216-T-3 Reverse Well. This method of disposal was used, rather than permanent storage because the 224 process waste has much lower fission activity than that from the 221-T building. It was estimated that the monthly discharge to the 241-T-361 tank was 400 grams of plutonium and 80 curies of fission products (F.P) per month. The plutonium was associated with lanthanum hydroxide and bismuth phosphate precipitates which were supposed to settle out in the settling tank and not go to the reverse well. An analysis of the 241-T-361 tank supernatant waste indicated 6 grams of plutonium product and 0.3 curies of fission products were discharged monthly to the 216-T-3 reverse well. Under the full operating conditions it was anticipated that these masses would increase to about 24 g of plutonium and 1.2 curies of F.P per month. In addition to 224 process waste, the 241-T-361 tank also received 221-Waste from wash down of hot cells and floors in the 221 Canyon Building. In terms of radioactivity, the 221-Waste was relatively small compared to 224 process waste.

The 241-T-361 settling tank apparently received waste for a period of time before the 216-T-3 Reverse Well was placed in operation. The reverse well was placed in operation in June 21, 1945 (Brown and Ruppert 1950). Because sand entered and partially plugged the perforations in the 216-T-3 reverse well, two cribs were installed (216-T-6 #1 and #2 cribs. On August 15, 1946 overflow into the cribs was noted (Brown and Ruppert 1950). The sludge depth in the 361-T settling tank had almost reached the overflow line (200 Area Monthly Production Report 26 June 1946 thru July 1946, HAN-45800) by June 1946. New pipeline construction, which permitted flow of 224 process waste to tank 241-T-201 thus by-passing tank 241-T-361, was completed on 14 October 1946. After this time, the 241-T-361 tank was used only

for cell sewer waste from the Canyon building (Hanford Engineer Works 1944). Drawing H-2-951 indicates the by-pass where the line to and from the settling tank has been blanked. A process line was joined from the older T plant process line to the 216-T-6 crib line (Figure 4-2).

The 241-T-361 Settling Tank is cylindrical and is made of reinforced, pre-stressed concrete. WIDS states it is 20 ft (6.1 m) in diameter and 25 ft (7.6 m) high with a capacity of 36,000 gallons (136,274 L). The tank is underground with 6 ft (1.8 m) of cover. According to drawing H-2-951, the pipe inlet is on the south side of the tank at approximately 9 ft (2.7 m) depth bgs (703 ft (214.3 m) elevation (converted to NAVD88)). The outlet pipe exits the north side at approximately 703.3 ft (214.4 m). The outlet pipe originally entered the 216-T-3 reverse well. It was subsequently re-routed to the 216-T-6 cribs, by-passing the reverse well.

4.2.2 216-T-3 REVERSE WELL

The 216-T-3 reverse well received effluent from the 241-T-361 settling tank (Figure 4-2). It was in use from June 1945 to August 1946 (WIDS). The primary waste entering the reverse well was T-224 building process waste. This waste is considered to be low in fission product activity and to contain some plutonium. In addition to T-224 building process waste, the reverse well may have received T-221 building process waste from wash down of hot cells and floors in the T-221 Canyon building.

The well was drilled in October 1944 (WIDS) to a depth of 206 ft (62.8 m) bgs. According to the driller's log, a 12-in. (30.5 cm) casing was placed to 100.25 ft (30.6 m) bgs, a 10-in. (25.4 cm) to 175 ft (53.3 m) bgs, and an 8-in. (20.3 cm) to 206 ft (62.8 m) bgs. The 8-in. (20.3 cm) casing was cut at 172.5 ft (52.6 m) bgs and the upper part was removed. The driller's log does not indicate that the 10-in. (25.4 cm) casing was also cut and removed from within the 12-in. (30.5 cm) casing. The 12-in. (30.5 cm) casing was not perforated. The 8-in. (20.3 cm) casing was perforated with 1/2 x 2-in. slots, 6 around on 6-in. (15 cm) centers from 204 to 172.5 ft (62.2 to 52.6 m) bgs. The 10-in. (25.4 cm) casing was perforated with 1/2 x 2-in. slots, 8 around on 6-in. (15 cm) centers from 171.5 to 104.5 ft (52.3 to 31.8 m) bgs. The elevation of the top perforation at 104.5 ft (31.9 m) is at approximately 606 ft (184.7 m) elevation and is just above the top of the Cold Creek unit– silt dominated (CCuz). One-half sack of cement was placed in the bottom of the 8-in. (20.3 cm) casing at 206 ft (62.8 m) bgs. According to the driller's log, the well was tested in November 1944 by pumping 2100 gallons (7,949 L) of water at a rate of 90 gallons (341 L) per minute. There was no water remaining in the well after 5 minutes.

The 2.0-in. stainless steel outlet line from the settling tank exits at approximately 9 ft (2.7 m) bgs (Drawing H-2-951). It apparently ties into the reverse well at approximately the same depth. When the settling tank overflowed, waste entered the reverse well. Figure 4-3 depicts the 216-B-5 Reverse Well that was built at approximately the same time and is supposed to be similar in design to the 216-T-3 reverse well.

4.2.3 216-T-6 #1 AND # 2 CRIBS

These cribs were built to replace the 216-T-3 Reverse Well when it was abandoned in August 1946. From August 1946 to October 1946, the cribs received cell drainage from Tank 5-6 in the 221-T building and waste from the 224-T building via the overflow from the 241-T-361 Settling Tank. In October 1946, a construction project was completed that by-passed the settling tank and re-routed the 224 waste to the 241-T 200 series tanks (Drawing H-2-951). The cribs continued to receive 5-6 cell waste from the 221-T building until 1951 (WIDS).

The 12-ft (8.7 m) by 12-ft (8.7 m) wooden cribs are 62 ft (18.9 m) apart (BHI 1994), and each was placed in an excavation with 14 ft (4.3 m) by 14 ft (4.3 m) bottom dimensions with sloping sides (Hanford drawing H-2-353). The bottom depth of the cribs is approximately 20 ft (6.1 m) bgs at an approximate elevation of 689 ft or 210 m (NAVD88). The inlet pipeline is approximately 10 ft (3.0 m) bgs. Crib #1 was designed in such a way that any overflow would discharge into crib #2 (BHI 1994).

4.3 PREVIOUS INVESTIGATIONS

Brown and Ruppert (1948) conducted an investigation in the area of the 216-T-3 and 216-T-6 #1 and #2 cribs. Thirteen boreholes were drilled in 1947 and soil samples were collected to determine the nature and extent of contamination. Table 4-1 indicates the borehole name used, the current naming convention, drill date, and the existence of total gamma logs acquired in 1951; other boreholes drilled in 1944, 1951, and 1983 are also included. Geologic cross sections were drawn. The contamination was drawn as to the type, location, and intensity in the well to correlate the type and extent of plutonium and fission product contamination in the area. It was concluded that the plutonium, in contrast to the fission products, was generally sorbed by the sediments and removed from the disposed waste solutions within a short distance of the crib and in no case was found greater than 20 ft (6.1 m) below the bottom of the crib. Its lateral movement was also less than that of the fission products. The plutonium contamination was summarized as being contained within 20 ft (6.1 m) below the crib with a lateral spread of 32 ft (9.8 m). Fission product contamination was summarized as extending to 107 ft (32.6 m) in depth with a 95 ft (29.0 m) lateral spread. The lower limit of contamination used for the cross sections was 0.04 micrograms/kg Pu (equivalent to 2.5 pCi/g Pu-239) and 0.05 microcuries/kg for fission products (equivalent to 50 pCi/g).

Brown and Ruppert (1950) provided an update of the area in 1950. Sediment samples were obtained in October 1949 from the bottoms of wells 361-T-1 through –T-13, from the boreholes originally drilled in 1947. Contamination was found in only two of these sediment samples, those obtained from 361-T-5 at 75 ft (22.9 m) bgs and 361-T-6 at 102 ft (31.1 m) bgs. Note: The current names of these boreholes are 299-W11-58 (A7300) and 299-W11-62 (A7304), respectively. About 0.08 microcurie of beta-gamma activity/kilogram of sediment was detected in each sample (detection limit of 0.05 microcurie/kilogram). No significant alpha contamination was detected in any of the sediment samples obtained in 1949. Samples from the bottom of the 6 wells penetrating through the silt-clay bed (likely the CCuz) showed no evidence of contamination.

Brown and Ruppert (1950) also discussed the potential of groundwater contamination in the area. Well 241-T-361 (now known as 299-W11-22 (A9794)), 27 ft (8.2 m) from the 241-T-361A (now known as the 216-T-3 reverse well), originally was reported to have penetrated to the ground water (Brown and Ruppert 1950). However, after drilling was completed, the well dried up and no samples of groundwater could be obtained. Well 241-T-361 was cleaned out and deepened in October 1949. The well was deepened as an open hole to a depth of 325 ft (99.1 m), about 38 ft (11.6 m) beyond the bottom of the casing. Water was encountered at a depth of 278 ft (84.7 m), seven ft (2.1 m) higher than originally reported when drilled in 1944. This probably reflects artificially elevated groundwater mounding associated with existing liquid waste disposal at this and other waste sites. No contamination was found in the sediments but alpha and beta activity above the probable natural level of activity were found in the groundwater samples. Water samples analyzed by fluorophotometer indicate that all the alpha activity in the well was due to uranium, not plutonium. Brown and Ruppert (1950) concluded that groundwater was contaminated by the 216-T-3 reverse well. Groundwater contamination may also have been sourced from the nearby 216-T-6 cribs.

Three wells, 299-W11-66 (A7308), 299-W11-67 (A7309), and 299-W11-7 (A4910) were drilled in the area in 1951. Geophysical log data from 1951 have been located for these three boreholes, as well as, nine boreholes that had been drilled in 1947. The logs from the new boreholes 299-W11-66 and 299-W11-67, along with 299-W11-1, appear to extend the footprint of vadose zone contamination determined by Brown and Ruppert (1948) in the south and southeast directions from the 216-T-6 # 1 crib. Borehole 299-W11-66 that is located 75 ft (22.9 m) southwest of the 216-T-6 # 1 crib, indicates gamma contamination at 40 ft (12.2 m) bgs. 299-W11-67, approximately 100 ft (30.5 m) southeast of crib # 1 indicates gamma contamination from 35 ft (10.7 m) bgs to the bottom of the borehole at 75 ft (22.9 m) bgs. 299-W11-1 suggests contamination from 20 ft (6.1 m) bgs to the bottom of the logged interval at 75 ft (22.9 m). Brown and Ruppert (1948) did not have this borehole inside their interpreted contaminated area according to cross sections. In general, the 1951 logs suggest gamma contamination

extended deeper and farther laterally away from the cribs than originally reported in Brown and Ruppert (1948). However, as depicted in the interpretations of the history of all log data (Table 4-2), this contamination appears to have consisted of short-lived radionuclides that may have mostly decayed away by 1976. The remaining gamma footprint in the area in 2003 is actually smaller than Brown and Ruppert showed (Figure 4-12).

In 1983, a borehole 299-W11-79 (A7321) was drilled southeast of the 216-T-3 Reverse Well to approximately 150 ft (45.7 m) bgs. A total gamma log acquired soon after the time of drilling indicates possible contamination throughout the borehole. High activity intervals are detected at approximately 20 (6.1 m), 60 (18.3 m), and 105 ft (32.0 m) bgs; the highest count rate is at 20 ft (6.1 m) bgs. The driller noted lots of moisture at 17 to 20 ft (5.2 to 6.1 m) bgs and contamination from 17 to 28 ft (5.2 to 8.5 m) bgs and from 100 to 110 ft (30.5 to 33.5 m) bgs.

Fecht et al (1978) evaluated the 216-T-3 Reverse Well contamination distribution using logs from borehole 299-W11-7 that lies just north of the reverse well. Logs acquired in 1959, 1970, and 1976 suggested that contamination existed between 4.6 and 33.5 m (15 and 110 ft) bgs. Fecht et al. concluded the log profiles do not agree with the recorded history of the disposal site. The contamination above 110 ft (33.5 m) was inconsistent with contamination expected from the reverse well that was not perforated at these shallow depths. It was suggested this more shallow contamination was derived from the 216-T-6 cribs or the 241-T-361 settling tank near the reverse well. On the basis of the scintillation probe data from well 299-W11-7, Fecht et al. concluded no migration of radionuclides has been detected between 1959 and 1976 and stated "breakthrough to the groundwater occurred at this site because radioactive waste was discharged directly into the groundwater via the reverse well." This appears to be a misstatement, as the reverse well was not drilled to groundwater and had a cement plug placed in the bottom. However, groundwater levels at the time of active disposal may have been much higher and could have been very close to the bottom of the reverse well. Although variations of this statement have been carried through to the present time, there appears to be no direct evidence from geophysical logs that discharges to the reverse well have contaminated groundwater.

The 216-T-6 cribs were also evaluated in Fecht et al. (1978). It was determined that most of the radioactive contaminants are concentrated beneath crib #1 in the upper 15.5 m (50.9 ft) of the sediment column. The gamma profiles from wells to the north of Crib #1 show near background radiation levels as do the profiles from wells in Crib #2. Fecht et al. (1978) concluded that no measurable migration of radionuclides beneath the 216-T-6 cribs had been detected between 1959 and 1976 and that breakthrough of liquid waste disposed at the 216-T-6 cribs to groundwater had not occurred.

Additon et al. (1978) used gamma log data to construct maps of the extent of contamination around the 216-T-6 #1 and #2 cribs (Figure 4-4). Their interpretation suggests deposition of contamination more to the southeast than indicated in Brown and Ruppert (1948). This is most likely based on gamma activity noted in logs acquired in 299-W11-1 subsequent to the Brown and Ruppert report.

All previous investigations consistently interpreted the contamination in the 216-T-6 cribs as having been deposited at relatively shallow depths with no migration over time. Brown and Ruppert were the only investigators to determine plutonium concentrations from direct analysis of sediment samples.

No investigation of the vadose zone in close proximity to 241-T-361 Settling Tank, its associated pipelines, or the 216-T-3 Reverse Well has been performed.

4.4 SUMMARY OF LOG DATA

Figure 4-5 shows the location of eighteen boreholes relative to the three waste sites that have been evaluated for this subregion. All geophysical logging data acquired since 1951 have been considered and are included in Table 4-2. A brief evaluation of the significance of each log as compared to earlier logs in the same borehole is made. This evaluation is intended to describe any significant changes in the gamma

profile during intervening years. A more accurate quantitative analysis will require detailed comparison, taking into account the relative efficiencies of the various detection systems. This will require a detailed assessment of the older logging systems, which depends on reports and other information that are difficult to locate. This is beyond the scope of the current effort. The "historical" record is important to determine the past existence of very short-lived radionuclides, the maximum extent of contamination at depth, and whether any influx or migration of contaminants has occurred over time since active disposal stopped. The Brown and Ruppert (1948, 1950) reports, which discussed direct sediment measurements, should be used as the baseline extent of plutonium and fission product contamination in this subregion.

The locations of cross sections A-D are shown in Figure 4-5. The cross sections (Figures 4-6, 4-8, 4-9, and 4-10 are included to depict important relationships between stratigraphy and the detected gamma contamination.

4.4.1 241-T-361 SETTLING TANK

There are no boreholes in the immediate proximity of the settling tank. Three boreholes that are 75 ft (22.9 m) or greater in distance from the settling tank are shown in cross section A-A', Figure 4-6. In the past these boreholes have been primarily used to discuss the 216-T-3 Reverse Well. However, contamination above the depth of perforations in the reverse well may be related to leaks from the settling tank or its associated piping.

4.4.2 216-T-3 REVERSE WELL

All three boreholes at this site are located within 30 ft (9.1 m) of Reverse Well 216-T-3 and approximately 75 ft (22.9 m) or greater from the 241-T-361 Settling Tank as shown in Figure 4-5. After settling, waste supernate was routed from the settling tank to the Reverse Well 216-T-3 during 1945 and 1946 (WIDS). For purposes of discussion, the contamination is characterized by two intervals: an interval from ground surface to the top of the perforations in the reverse well at approximately 606 ft (184.7 m) in elevation and the interval below this depth (Figure 4-6). Contamination above the perforations is presumed to be unrelated to the designed function of the reverse well. Relatively high concentrations of Cs-137 are shown at approximately 695 ft (211.8 m) elevation or 15 ft (4.6 m) bgs in all three boreholes (Figure 4.6). Two of the boreholes indicate contamination throughout the sediments to the approximate top of the CCu where the perforations begin in the 216-T-3 reverse well. All three boreholes indicate increases in Cs-137 concentrations at a level equivalent to the top of the perforations. This contamination appears to perch on top of the CCuz silt dominated unit in boreholes A4910 and A7321, while in borehole A9794 the contamination lies within the silt dominated unit. This is based on the location of the open interval in the reverse well, the depth of the top of the CCuz unit, and the magnitude and vertical extent of the Cs-137 detected in the well logs. The data suggest that all three boreholes may be impacted by the reverse well based on lateral spreading and perching on top of the CCuz, as well as contamination detected below the CCu interval (Figure 4-6). All three boreholes exhibit Cs-137 contamination below the CCu interval that continues into the upper Ringold Fm. However, continuous shallow contamination suggests another shallower source; perhaps leaking transfer lines in and around the area could have deposited contaminated liquid to the shallow vadose interval. Another factor to consider is the existence of a septic field just north of the area that may have contributed significant amounts of water, potentially mobilizing contamination. Figures 4-6 and 4-7 indicate the relationships of the Cs-137 contamination, stratigraphy, and reverse well perforations.

Based on SGLS logging, the highest level of Cs-137 was 46,000 pCi/g at 694 ft (211.5 m) elevation in 299-W11-79 (A7321). This borehole is located approximately 27 ft (8.2 m) southeast of the reverse well and approximately 75 ft (22.9 m) from the settling tank. The tank inlet and outlet are at approximately 9 ft (2.7 m) bgs, and the base of the tank is at 25 ft (7.6 m) bgs. It is postulated the shallow interval of contamination in 299-W11-79 (A7321) is most likely related to the settling tank or the pipeline between the settling tank and the reverse well. No additional information is available at this time in regards to leaks associated with the settling tank and its pipelines that would confirm either as a source of the upper

zone of contamination. The lower most contaminated zone roughly corresponds with the depth of the perforations in the reverse well. However, it cannot be determined with the available data if contamination entering near the top of the CCu originated from above or from the perforated intervals in the reverse well, or both.

The top of the CCu in the 216-T-3 area is approximately 3 ft (0.9 m) higher than near the 216-T-6 crib area (Figure 4-8). This suggests a downward slope for the vadose zone units to the west. It also suggests the contamination in the 216-T-3 reverse well area is unrelated to the 216-T-6 crib contamination because 216-T-3 is upgradient to the dip in the vadose zone units. Regardless, contamination has reached the CCu in both areas. Low levels of Cs-137 at less than 1 pCi/g are indicated to a maximum depth of 185 ft (56.4 m) bgs or 525 ft (160 m) in elevation in the Ringold Formation in borehole 299-W11-7 (A4910). However, only three boreholes in the area completely penetrate the CCu, so that defining the maximum vertical extent of Cs-137 penetration is problematic.

There are no data to determine the maximum depth or extent of the more mobile contaminants in the 216-T-3 area but it is assumed that mobile contamination would extend at least as far as the relatively immobile Cs-137. This may suggest that there were impacts to the unconfined aquifer during and possibly shortly following operations at 216-T-3. However, because the dominant waste entering the reverse well was 224 waste, large quantities of fission products would not be expected.

4.4.3 216-T-6 #1 AND #2 CRIBS

The B-B' (Figure 4-8), C-C' (Figure 4-9), and D-D' (Figure 4-10) cross sections show the Cs-137, U-238 (manmade), total gamma, potassium-40, and thorium-232 values for each borehole in the vicinity of the 216-T-6 cribs. Figure 4-11 is a visualization of the contaminant profile for the 216-T-3 and 216-T-6 waste sites. Figure 4-9 displays information for the same boreholes Brown and Ruppert used in their cross sections; Figure 4-12 shows an overlay of the current Cs-137 data over the area Brown and Ruppert designated as contaminated. Cs-137 contamination was detected in all 15 boreholes; however one dominant elevated zone was identified from approximately 690 to 650 ft (210.3 to 198.1 m) in elevation or20 to 60 ft (6.1 to 18.3 m) bgs with the highest Cs-137 concentrations between 690 and 670 ft (210.3 and 204.2 m) elevation. The highest Cs-137 concentrations are located adjacent to the # 1 crib. Only one borehole (299-W11-60 {A7302}) is located near the # 2 crib which shows a maximum concentration of only 10 pCi/g Cs-137. The maximum concentration of Cs-137 was 9600 pCi/g at 34 ft (10.4 m) bgs in 299-W11-54 (A7296). 34 pCi/g of man-made U-238 was also identified in this borehole at 45 ft (13.7 m) bgs.

Minor amounts of Cs-137 (less than 1 pCi/g) are observed in the CCu in two boreholes, 299-W11-54 (A7296) and 299-W11-56 (A7298).

Historical logs (Table 4-2) indicate short lived contaminants may have invaded the vadose zone to the bottoms of some of the boreholes and spread beyond the lateral boundaries of the currently detectable gamma activity. For example, Borehole 299-W11-1 (A7275) used to draw the contamination profile depicted in Figure 4-4, indicated contamination from 10 to 115 ft (3 to 35.1 m) bgs and possibly all the way to groundwater in 1959. In 1968, gross gamma logs suggest significant contamination is in the groundwater. It is not known if the groundwater contamination is the result of waste at the 216-T-6 site or from another more distant source. However, by 1987, the radionuclides responsible for the deeper vadose zone contamination displayed in 299-W-11-1 (A7275) had decayed away leaving the current gamma profile that shows only 100 pCi/g Cs-137 at 18 ft (5.5 m) bgs.

The current gamma profiles are generally consistent with the Brown and Ruppert report in 1948. Figure 4-12 is a projection of the 2003 logging data for Cs-137 over plate 4 of the Brown and Ruppert report (Brown and Ruppert 1948) from 1948. This comparison suggests short lived contaminants existed at greater depths and lateral extent but the currently detectable Cs-137 has not migrated deeper at any appreciable amounts into the vadose zone over the past 60 years. The 2003 logging events did not detect

plutonium; the MDL for Pu-239 is approximately 10 nCi/g. In 1948, the maximum plutonium contamination depth was approximately 20 ft (6.1 m) below the bottom of the crib and the fission products vertical extent was approximately 60 ft (18.3 m) beyond the bottom of the crib. Shorter-lived radionuclides were detected deeper in 1948 than is shown by the Cs-137 profiles in 2003.

4.5 SUMMARY OF SUBREGION AND CONCLUSIONS

The 241-T-361 Settling Tank cannot be effectively evaluated because the nearest boreholes are greater than 75 ft (22.9 m) away. However, two of the three closest boreholes (Figures 4-6 and 4-7) indicate contamination from the near surface extending through the CCu. It is not known if the contamination below the top of the CCuz is caused from percolation through the vadose zone from above, from contamination entering the sediments through perforations in the casing of the 216-T-3 Reverse Well, or both. The 241-T-361 Settling Tank and/or its associated piping that leads to the 216-T-3 Reverse Well may be the cause of the near surface contamination observed in these nearby boreholes. The contamination is characterized as low activity, consistent with T-224 and T-221 5-6 cell waste. Small concentrations of plutonium may also exist in the contaminated intervals delineated by the gamma logging and even small concentrations of americium and neptunium may have grown in since the original deposition of plutonium.

The 216-T-3 Reverse Well has been evaluated in the past using the three boreholes mentioned above. These boreholes may also be too far away from the reverse well (approximately 25 ft or 7.6 m) to assess its contribution of contamination to the vadose zone between approximately 104 and 206 ft (31.7 and 62.8 m) bgs. The reverse well contains a cement plug at its bottom. It appears that prior investigators assumed the reverse well contaminated groundwater in the area possibly only because the bottom of the well is only 50 ft (15.2 m) above the water table. However, geophysical logs in the area cannot confirm that waste disposed to the reverse well has reached the groundwater using the available gamma contamination profiles. The profile of the three nearby boreholes suggests low activity waste with the maximum Cs-137 concentrations less than 1000 pCi/g. It should be assumed 224 waste that entered the reverse well would also contain plutonium. The minimum detectable level for Pu-239 is greater than 10 nCi/g using the SGLS. Unless the Pu quickly adsorbed to the sediments and concentrated nearby the well, Pu-239 levels are probably below the MDL for the SGLS and will require laboratory analysis of sediment samples. Am-241 and Np-237 are decay products of Pu-241 that would have grown in since the original deposition of the 224 waste.

Most of the boreholes in the area are distributed around the 216-T-6 #1 Crib. Brown and Ruppert (1948) report data from the drilling of 13 boreholes in 1947. Sediment samples were acquired and analyzed for fission product and plutonium content. Brown and Ruppert (1948) present the only direct sediment measurement data set for determining the nature and extent of the contamination in the 216-T-6 Cribs area that the 200-DV-1 project has been able to find. It is the only information available regarding plutonium content that was deposited in the area. The general profile (vertical and lateral spread) of contaminants in 2003 based on spectral gamma logs is slightly compressed relative to the distribution depicted in the graphics presented in Brown and Ruppert. The 1948 footprint was larger in lateral and vertical extent than is represented by gamma emitting contaminants in 2003 because short lived fission products that were measurable in 1948 and 1951 have subsequently decayed away, many as quickly as 1976 based on the historical field logs. The current condition (based on being able to detect only Cs-137 in the vadose zone sediments) suggests significant gamma contamination does not exceed 70 ft (21.3 m) in depth; although Cs-137 is known to be highly attenuated in its migration within the Hanford Site sediments.

Borehole 299-W11-1 (A7275) is an example of fairly extensive contamination that has mostly decayed away in the deep vadose zone. This borehole was drilled to 75 ft (22.9 m) bgs in 1947 and deepened in 1951 to 315 ft (96.0 m) bgs. Contamination may have extended to groundwater in 1963. In 1968, the groundwater indicates high gamma activity. An RLS log acquired in 1995 indicated Co-60 near the

historical water table elevation. This suggests it may have been a component of the groundwater contamination observed by logging in 1968. By 1976, the gamma contamination measured by logging had decayed away except for a peak at approximately 25 ft (7.6 m) bgs. This peak is determined to be the result of Cs-137 that was measured at less than 10 pCi/g.

4.6 RECOMMENDATIONS

In terms of the deep vadose zone there are three potentially significant data gaps identified by geophysical logging: Contamination associated with the 241-T-361 Settling Tank and related piping; 216-T-3 Reverse Well; and the source of contamination that resulted in elevated gamma activity in groundwater in the 299-W11-1 (A7275) borehole.

An estimated 3 million gallons (11 million liters) of 224 and 5-6 waste entered the settling tank and was dispersed to the reverse well and the 216-T-6 cribs (Healy 1953). No investigation of the settling tank and piping has been conducted. Additional characterization is recommended to evaluate this non-200-DV-1 waste site as a potential source of the shallow contamination.

The 216-T-3 Reverse Well region also has not been adequately investigated. Because of the design and intent of the reverse well to disperse contamination deep into the vadose zone, characterization should focus as near as possible to the reverse well perforated interval below the CCu (within 5 to10 ft or 1.5 or 3.0 m)). This will enable further assessment of the lateral deposition of contaminants, if any, and determine the nature and extent of alpha emitting contaminants.

There is some evidence from historical logs that short-lived radionuclides may have impacted groundwater in the vicinity of borehole 299-W11-1 (A7275) near the 216-T-6 Crib #1. It is recommended older gamma logs from this borehole and other select borehole logs be carefully evaluated to establish comparability. This may provide information that refutes the current interpretation that contaminants from 216-T-3 and/or 216-T-6 may have affected groundwater.

All three sites are related to the same process waste streams which include T-224 building waste that is known to contain plutonium. It is recommended that spectral gamma logs acquired in 2003 be re-processed to force minimum detectable activities for Pu-239, Am-241, and Np-237. Although the MDLs are relatively high for Am-241 and Pu-239 (nCi range), this would provide a cursory but detailed evaluation for these radionuclides and provide documentation that the radionuclides do not exist above certain levels. Additional extended SGLS measurements should be made in key boreholes near waste sites where the Cs-137 concentrations are relatively low so that an optimal MDL for TRU can be achieved. Longer count times at selected depths can provide lower MDLs. It is also recommended that any future borehole investigation use a minimum 4-in. inside diameter casing. This will allow spectral gamma logging with the lowest detection limit available. Small diameter detection systems do not have comparable detection capabilities for transuranic radionuclides.

4.7 REFERENCES

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TABLE 4-1. SUMMARY OF BOREHOLES IN THE 216-T-3 AND -T-6 AREA

Borehole (1948)	Current Name	Current ID	Drill Date	1951 Logs
241-T-361	299-W11-22	A9794	1944; deepened 1949	
241-T-361A	216-T-3 Reverse Well	NA	1944	
361-T-1	299-W11-55	A7297	1947	X
361-T-2	299-W11-54	A7296	1947	
361-T-3	299-W11-56	A7298	1947	
361-T-4	299-W11-57	A7299	1947	X
361-T-5	299-W11-58	A7300	1947	
361-T-6	299-W11-62	A7304	1947	
361-T-7	299-W11-59	A7301	1947	X
361-T-8	299-W11-60	A7302	1947	X
361-T-9	299-W11-61	A7303	1947	X
361-T-10	299-W11-63	A7305	1947	X
361-T-11	299-W11-64	A7306	1947	X
361-T-12	299-W11-1	A7275	1947 to 76 ft; Deepened to 315 ft in 1950	X
361-T-13	299-W11-65	A7307	1947	X
361-T-19	299-W11-7	A4910	1951	X
361-T-20	299-W11-66	A7308	1951	X
361-T-21	299-W11-67	A7309	1951	X
	299-W11-79	A7321	1983	

TABLE 4-2. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1951 (WASTE SITE DESIGNATION PREFIX - 216)

Waste Site	Well Name	Well ID	Alias	IDMS	Total Depth	Date	Log Type	Contamination History	Summary
T-6	299-W11-1	A7275	361-T-12	YES	76	7-Aug-51	GG	elevated gamma 20-60 ft, max at 32 ft	1951 contamination from 20-60 ft (Log depth 70 ft), maximum at 32 ft; possible activity increase from 100 ft to gw in 1963; 1968 shows gw contamination; gw contamination not indicated after 1976; data from 1976 to 2003 shows decay to near background levels except at 23 ft which shows 9 pCi/g Cs.
	299-W11-1	A7275		SUBMITTED	229	26-Feb-58	GG	elevated gamma 16-98 ft, max at 16 ft	
	299-W11-1	A7275		SUBMITTED	229	8-Jun-59	GG	elevated gamma 16-98 ft, max at 16 ft, rapid decay shown from 17 to 39 ft	
	299-W11-1	A7275		YES	229	25-Apr-63	GG	possible increase in activity since 1959 from 100 to 230 ft	
	299-W11-1	A7275		YES	264	27-Feb-68	GG	possible increases in activity to 230 ft; interval from 240 to 262 ft suggests gw cont.	
	299-W11-1	A7275		YES	264	6-May-76	GG	decay to near bg levels except at 16 ft; decay in gw but still remains contaminated	
	299-W11-1	A7275		YES	270	21-Jul-87	GG	gamma peak at 22 ft, remainder of borehole indicates background levels	
	299-W11-1	A7275		SUBMITTED	270	13-Oct-94	NaI	gamma peak at 22 ft, remainder of borehole indicates background levels	
	299-W11-1	A7275		SUBMITTED	269.5	8-May-95	RLS	8 pCi/g Cs at 23 ft; Co between 244 and 270 ft; suggests cont. gw in 1968 contained Co	
	299-W11-1	A7275		YES	270	17-Dec-76	Neutron	not interpreted	
	299-W11-1	A7275		YES	270	29-Nov-76	Density	not interpreted	
	299-W11-1	A7275		YES	270	9-Jun-95	Neutron	not interpreted	
	299-W11-1	A7275		YES	314.5	22-Jan-03	SGLS	Cs: 1, 22-29 ft, max 9.3 pCi/g @ 23 ft	
T-6	299-W11-54	A7296	361-T-2	SUBMITTED	148	26-Feb-58	GG	elevated gamma from 0-137 ft, max 33 ft	1958 suggests possible low activity contamination to 137 ft and higher activity contamination at 33 ft. Contamination below 33 ft had decayed away by 1976. Activity at 33 ft decayed consistent with Cs that was detected at 10,000 pCi/g at 34 ft in 2003. Less than 1 pCi/g Cs found in CCu in 2003 consistent with the 1958 log suggesting contamination to the bottom of the borehole. The 2003 SGLS also detected 34 pCi/g of U-238 at 34 ft. U-238 probably exists in the high activity interval of Cs-137 from 28 to 42 ft.
	299-W11-54	A7296		SUBMITTED	148	26-Apr-63	GG	shows decay consistent with Cs contamination at 33 ft; below 33 ft decay consistent with short lived radionuclides	
	299-W11-54	A7296		YES	148	6-May-76	GG	shows decay consistent with Cs contamination; near background levels below 30 ft	
	299-W11-54	A7296		SUBMITTED	149	19-Oct-93	RLS	18,331 pCi/g at 31 ft (tool out of calibration range)	
	299-W11-54	A7296		YES	149	01-Mar-77	Density	not interpreted	
	299-W11-54	A7296		SUBMITTED	150	25-Oct-94	NaI	shows decay consistent with Cs	
	299-W11-54	A7296		SUBMITTED	150	17-May-95	RLS	28,000 pCi/g at 34 ft (tool out of calibration range)	
	299-W11-54	A7296		YES	150	12-Feb-03	SGLS	Cs: 0-154 ft; max 9600 pCi/g @ 34 ft, < 1 pCi/g Cs in Ccu; U-238: 34 pCi/g at 45 ft	
T-6	299-W11-55	A7297	361-T-1	YES	76	9-Aug-51	GG	elevated gamma 23-40, max at 26 ft	1951 activity is indicated from 23 to 40 ft with a maximum at 26 ft. 1958 activity appears to reach the bottom of borehole. 1963 data suggest contamination below 36 ft decayed significantly indicating predominately short lived radionuclides. By 1976 significant contamination is shown only at about 30 ft. Current data indicate Cs from 29 to 73 ft.
	299-W11-55	A7297		SUBMITTED	150	26-Feb-58	GG	elevated activity throughout borehole to 144 ft; max. peak between 13 and 36 ft	
	299-W11-55	A7297		SUBMITTED	150	26-Apr-63	GG	activity decayed indicating short lived contaminants from 36 to 144 ft, max. peak at 30 ft	
	299-W11-55	A7297		YES	150	6-May-76	GG	activity below 30 ft mostly decayed away, max. peak remains at 30 ft	
	299-W11-55	A7297		SUBMITTED	148.5	08-Oct-93	RLS	Cs 6 to 8 ft at 1 pCi/g; Cs 29 to 67 ft, max. 200 pCi/g at 31 ft	
	299-W11-55	A7297		SUBMITTED	150	27-Oct-94	NaI	elevated activity 28- 39 ft	
	299-W11-55	A7297		YES	150	08-Aug-51	GG	not interpreted	
	299-W11-55	A7297		YES	150	01-Mar-77	Neutron	not interpreted	
	299-W11-55	A7297		YES	150	29-Nov-76	Density	not interpreted	
	299-W11-55	A7297		SUBMITTED	155	15-May-95	RLS	Cs 29-68 ft	
	299-W11-55	A7297		YES	150	10-Feb-03	SGLS	decay consistent with Cs; Cs: 6-8, 29-73 ft; max 187 pCi/g @ 31 ft	
T-6	299-W11-56	A7298	361-T-3	SUBMITTED	131	26-Feb-58	GG	elevated gamma 10 to 43 ft; possible contamination to bottom of borehole at 75 ft.	Elevated gamma activity indicated to the bottom of the borehole in 1963. Activity below 30 ft mostly decayed away by 1976. Prominent peak observed from 1958 to 2003 at approximately 31 ft. Spectral gamma measurements confirm Cs is the dominant contaminant at this depth. Minor Cs indicated in bottom of the CCu suggesting possible contaminants shown in 1963 included short lived radionuclides as well as minor amounts of Cs.
	299-W11-56	A7298		SUBMITTED	131	26-Apr-63	GG	elevated gamma 10 to 43 ft; possible contamination to bottom of borehole at 140 ft.	
	299-W11-56	A7298		YES	131	6-May-76	GG	decay consistent with short lived contaminants below 43 ft, peak at 30 ft remains	
	299-W11-56	A7298		YES	131	1-Mar-77	N	not interpreted	
	299-W11-56	A7298		YES	131	29-Nov-76	Density	not interpreted	
	299-W11-56	A7298		SUBMITTED	138	16-Sep-94	NaI	elevated activity from 18 to 50 ft consistent with prior logs	
	299-W11-56	A7298		SUBMITTED	142.5	17-Apr-95	RLS	Cs identified in the peak at 32 ft at 5000 pCi/g; Cs < 1 pCi/g from 136 to 142 ft	
	299-W11-56	A7298		YES	150	21-Oct-03	SGLS	Cs: 6-65 ft and 133-143 ft, max 7100 pCi/g @ 31 ft; Cs from 133 to 143 lies within Ccu	
T-6	299-W11-57	A7299	361-T-4	YES	90	9-Aug-51	GG	slight elevated gamma 10-12 ft, with no outstanding peak	No significant contamination detected. Possible deposition of low level activity between 1958 and 1963 but could be due to detector efficiency changes. By 1976, activity was near background levels suggesting any contamination consisted of short lived radionuclides.
	299-W11-57	A7299		SUBMITTED	91	26-Feb-58	GG	No obvious contamination	
	299-W11-57	A7299		SUBMITTED	91	26-Apr-63	GG	Possible increase since 1958 throughout bh; may be difference in detector efficiency	
	299-W11-57	A7299		YES	91	6-May-76	GG	Decay indicated since 1963 to near background levels	

TABLE 4-2. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1951 (WASTE SITE DESIGNATION PREFIX - 216)

Waste Site	Well Name	Well ID	Alias	IDMS	Total Depth	Date	Log Type	Contamination History	Summary
	299-W11-57	A7299		YES	88	22-Jul-87	GG	No indication of contamination	
	299-W11-57	A7299		SUBMITTED	88	09-Nov-93	RLS	Cs 3 to 5 ft, max 2.2 pCi/g; Cs at 27.5 ft at less than 0.4 pCi/g	
	299-W11-57	A7299		SUBMITTED	94.5	11-May-95	RLS	Cs 5 to 7 ft, max 3.1 pCi/g; Cs at 30 ft less than 1 pCi/g	
	299-W11-57	A7299		YES	163	3-Feb-03	SGLS	Cs: 6-7 maximum of 1 pCi/g; 30 ft max 0.2 pCi/g	
T-6	299-W11-58	A7300	361-T-5	SUBMITTED	69	26-Apr-63	GG	elevated gamma 0-69 ft, max approx. 30 ft	1963-1976 SN logs indicate elevated gamma levels from 0-69 ft with maximum peak at approximately 30 ft. The gamma profiles are consistent with Cs decay between 1963 and 2003. Cs contamination is indicated from 5 to 15 ft and from 26 to 76 ft (total logging depth) with a maximum of 4700 pCi/g at 34 ft.
	299-W11-58	A7300		YES	69	6-May-76	GG	decay since 1963 consistent with Cs	
	299-W11-58	A7300		SUBMITTED	74	22-Oct-93	RLS	Cs 2 to 12 ft max. 14 pCi/g; Cs from 21 to 74 ft, max, > 7200 pCi/g at 30 ft	
	299-W11-58	A7300		SUBMITTED	72	25-Oct-94	NaI	elevated activity 2 to 12 ft and from 21 to 72 ft	
	299-W11-58	A7300		SUBMITTED	77.3	18-Apr-95	RLS	Cs greater than 2000 pCi/g @ 34 ft (tool saturated); Cs contamination 30 to 74 ft	
	299-W11-58	A7300		SUBMITTED	72	22-May-95	Neutron	not interpreted	
	299-W11-58	A7300		YES	72	01-Mar-77	Neutron	not interpreted	
	299-W11-58	A7300		YES	72	29-Nov-76	Density	not interpreted	
	299-W11-58	A7300		YES	75	20-Oct-03	SGLS	Cs: 4-17 ft, 26-75 ft, max 4740 pCi/g at 34 ft	
T-6	299-W11-59	A7301	361-T-7	YES	86	8-Aug-51	GG	elevated gamma 16-75 ft, max at 23 ft	1951 GRL indicates contamination from 16 to 75 ft with maximum activity at 23 ft. Elevated activity below 35 ft had decayed away by 1963 and the maximum activity remained between 15 and 35 ft. This activity is attributed to Cs with a maximum concentration of 410 pCi/g at 24 ft.
	299-W11-59	A7301		SUBMITTED	85	26-Feb-58	GG	elevated activity from 15 to 72 ft; peak at 24 ft	
	299-W11-59	A7301		SUBMITTED	85	26-Apr-63	GG	Elevated activity from 0 to 85 ft, peak activity from 15 to 35 ft	
	299-W11-59	A7301		YES	85	6-May-76	GG	Elevated activity from 30 to 85 ft decayed since 1963; peak remains between 15 and 35 ft	
	299-W11-59	A7301		YES	85	1-Mar-77	Neutron	not interpreted	
	299-W11-59	A7301		YES	85	22-Jul-87	GG	Elevated activity from 20 to 35 ft	
	299-W11-59	A7301		SUBMITTED	85	12-Oct-94	NaI	Activity between 20-35 ft	
	299-W11-59	A7301		SUBMITTED	87.5	17-Apr-95	RLS	Cs from 0-44.5 ft, max 445 pCi/g at 24 ft.	
	299-W11-59	A7301		YES	90	24-Jan-03	SGLS	Cs :1-44 ft, max 410 pCi/g at 24 ft	
T-6	299-W11-60	A7302	361-T-8	YES	50	8-Aug-51	GG	elevated gamma 26-48 ft, max at 32.5 ft	A peak indicated at 32.5 ft in 1951 was not apparent in 1958 or 1963. A possible influx of contamination may have occurred between 1963 and 1976 throughout the borehole. This apparent increase may be the result of different detector efficiencies. However in 1976, the peak near 30 ft is again evident. The logs since 1976 indicate decay consistent with Cs. This peak is determined to be the result of Cs with a maximum concentration of 28 pCi/g.
	299-W11-60	A7302		SUBMITTED	128	26-Feb-58	GG	Indicates no elevated activity	
	299-W11-60	A7302		SUBMITTED	128	26-Apr-63	GG	Indicates no elevated activity	
	299-W11-60	A7302		YES	128	6-May-76	GG	Increases activity 0 to 147 ft - may be detector efficiency changes; peak at 30 ft.	
	299-W11-60	A7302		SUBMITTED	151	27-Oct-94	NaI	Elevated activity between 27 and 32 ft	
	299-W11-60	A7302		SUBMITTED	149.5	15-Nov-93	RLS	Cs 1 to 8 ft max. 3.2 pCi/g; Cs 27 to 36 ft max. 37 pCi/g at 29 ft	
	299-W11-60	A7302		YES	149.5	01-Mar-77	Neutron	not interpreted	
	299-W11-60	A7302		SUBMITTED	155	27-Mar-95	RLS	Same profile as in 1993	
	299-W11-60	A7302		YES	155	21-Jun-76	Density	not interpreted	
	299-W11-60	A7302		YES	150	22-Oct-03	SGLS	Cs: 6-12 ft, 28-39 ft, 84 ft, max 28 pCi/g at 33 ft.	
T-6	299-W11-61	A7303	361-T-9	YES	76	9-Aug-51	GG	elevated gamma 25-77 ft, max at 28 ft	1951 GRL profile peak appears similar to the other logging events listed. Profiles suggest decay consistent with Cs since 1951.
	299-W11-61	A7303		SUBMITTED	69	26-Feb-58	GG	elevated activity from 15 to 60 ft; peak at 30 ft	
	299-W11-61	A7303		SUBMITTED	69	26-Apr-63	GG	elevated activity from 15 to 60 ft; peak at 30 ft	
	299-W11-61	A7303		YES	69	6-May-76	GG	Indicates decay since 1963; peak remains at 30 ft.	
	299-W11-61	A7303		SUBMITTED	77	24-Apr-92	RLS	Cs from 0 to 6 ft max. 1 pCi/g; Cs from 16 to 55 ft max 2800 pCi/g at 27 ft	
	299-W11-61	A7303		YES	80	15-May-92	GG	activity elevated from 16 to 50 ft	
	299-W11-61	A7303		SUBMITTED	56.5	25-Oct-93	RLS	Cs 1.5-53.5 ft, max 2940 at 29.5 ft.	
	299-W11-61	A7303		SUBMITTED	80	18-Oct-94	NaI	shows decay, 27-43 ft	
	299-W11-61	A7303		SUBMITTED	80	25-Oct-94	NaI	shows decay, 27-43 ft	
	299-W11-61	A7303		SUBMITTED	86	23-Mar-95	RLS	Cs 5-14 ft max 3 pCi/g; Cs 27 to 58 ft max 2500 pCi/g @ 33.5 ft	
	299-W11-61	A7303		SUBMITTED	86	22-May-95	Neutron		
	299-W11-61	A7303		YES	85	13-Feb-03	SGLS	Cs: 6-13 ft, 23-66 ft, max 1970 pCi/g @ 34 ft	
T-6	299-W11-62	A7304	361-T-6	SUBMITTED	98	26-Feb-58	GG	elevated gamma from 16-49 ft, max at ~17 ft	Earliest log data suggest contamination predominantly from 16 to 49 ft. A possible

TABLE 4-2. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1951 (WASTE SITE DESIGNATION PREFIX - 216)

Waste Site	Well Name	Well ID	Alias	IDMS	Total Depth	Date	Log Type	Contamination History	Summary
	299-W11-62	A7304		SUBMITTED	98	26-Apr-63	GG	Increase in activity since 1963 throughout borehole, max at 17 ft	influx of short lived radionuclides between 1958 and 1963 throughout borehole. Decayed mostly away below 50 ft by 1976. 2003 data suggest Cs is the dominant radionuclide and the contamination may have extended throughout the borehole as the 1963 data suggested. The maximum concentration is 8600 pCi/g at 30 ft.
	299-W11-62	A7304		YES	98	6-May-76	GG	Decayed since 1963	
	299-W11-62	A7304		SUBMITTED	96	22-Sep-94	NaI	Highest activity peak lies between 15 and 40 ft	
	299-W11-62	A7304		SUBMITTED	102	16-May-95	RLS	Cs identified 5 to 11, 15-18, 19-63 and 81 to 101.5 ft, max between 22 and 41 ft	
	299-W11-62	A7304		YES	102	20-Feb-03	SGLS	Cs: 20-60 ft, max 8600 pCi/g @ 30 ft; Cs 82 to 100 ft, max 1 pCi/g	
T-6	299-W11-63	A7305	361-T-10	YES	76	7-Aug-51	GG	elevated gamma 28-68 ft; peak at 40 ft	1951 GRL profile appear similar to recent logging events, with a maximum peak at approximately 40 ft. Since, 1995, Cs-137 activities appear to have decreased as predicted by radioactive decay. The maximum Cs-137 concentration in 2003 was 23 pCi/g at 40 ft.
	299-W11-63	A7305		SUBMITTED	140	26-Feb-58	GG	peak activities at 16 and 40 ft	
	299-W11-63	A7305		SUBMITTED	140	26-Apr-63	GG	peak activity between 32 and 40 ft	
	299-W11-63	A7305		YES	140	6-May-76	GG	peak activity between 32 and 40 ft	
	299-W11-63	A7305		SUBMITTED	154	21-Jun-76	Density	not interpreted	
	299-W11-63	A7305		YES	154	22-Jul-87	GG	peak activity at approximately 40 ft	
	299-W11-63	A7305		YES	154	01-Mar-77	Neutron	not interpreted	
	299-W11-63	A7305		SUBMITTED	153	24-Oct-94	NaI	peak activity at 40 ft	
	299-W11-63	A7305		SUBMITTED	153	27-Apr-95	RLS	max 27.5 pCi/g @ 39.5 ft	
	299-W11-63	A7305		YES	160	28-Jan-03	SGLS	Cs: 0-1 ft at 0.8 pCi/g;, Cs from 33-48 ft, max 23 pCi/g @ 40 ft	
T-6	299-W11-64	A7306	361-T-11	YES	50	8-Aug-51	GG	elevated gamma 38-78 ft, max 38 ft	1951 profile has a distinct elevated peak at approximately 38 ft. This peak appears to be nonexistent in the 1958 and subsequent logs suggesting a short lived contaminant existed in 1951. SN log. The maximum concentration of Cs-137 in 2003 is 0.43 pCi/g at 7 ft.
	299-W11-64	A7306		SUBMITTED	131	26-Feb-58	GG	Indicates near background levels	
	299-W11-64	A7306		SUBMITTED	65	26-Apr-63	GG	Indicates near background levels	
	299-W11-64	A7306		YES	65	6-May-76	GG	Indicates near background levels	
	299-W11-64	A7306		SUBMITTED	75	12-Oct-93	RLS	Cs 1 to 3 ft at max of 1.5 pCi/g	
	299-W11-64	A7306		SUBMITTED	75	07-Nov-94	NaI	indicates background activity	
	299-W11-64	A7306		SUBMITTED	79	18-Apr-95	RLS	max 2 pCi/g @ 7 ft	
	299-W11-64	A7306		YES	75	18-Feb-03	SGLS	Cs: 5-7 ft, max 0.5 pCi/g	
T-6	299-W11-65	A7307	361-T-13	YES	100	7-Aug-51	GG	elevated gamma 33-90 ft, max at 40 ft	1951 GRL profile shows elevated gamma from approximately 33 to 90 ft, with a peak at 40 ft. The 1963 log indicates possible contamination to 130 ft that decayed away by 1976. Background activity indicated since 1976 to present except at 41 where a maximum concentration of Cs is 3 pCi/g.
	299-W11-65	A7307		SUBMITTED	145	26-Apr-63	GG	Possible contamination to 130 ft; peak activity at 40 ft	
	299-W11-65	A7307		SUBMITTED	145	26-Feb-58	GG	Possible contamination to 130 ft; peak activity at 40 ft	
	299-W11-65	A7307		YES	145	6-May-76	GG	Short lived contamination decayed to near background levels; peak remains at 40 ft	
	299-W11-65	A7307		YES	153	22-Jul-87	GG	Indicates near background levels; peak remains at 40 ft	
	299-W11-65	A7307		SUBMITTED	152	12-Oct-94	NaI	Indicates near background levels; peak remains at 40 ft	
	299-W11-65	A7307		SUBMITTED	154.5	19-Apr-95	RLS	max 3.7 pCi/g Cs at 41ft; less than 2 pCi/g near surface	
	299-W11-65	A7307		YES	160	21-Jan-03	SGLS	shows decay, Cs: 1-3 ft, 40-43 ft, max 3.3 pCi/g at 41 ft	
T-6	299-W11-66	A7308	361-T-20	YES	70	9-Aug-51	GG	elevated gamma 0-10, 38-46 ft	1951 GRL profile shows elevated gamma from 39-45 ft, with a peak at 40 ft. The peak is absent in the 1963 SN log, with elevated gamma from approximately 33 to 72 ft. SN logs from 1963 to 1976 show decay. Cs-137 was detected in 2003, at 1.5, 40.5, and 74.5 ft. The maximum Cs-137 concentration in 2003 was 2.3 pCi/g at 74.5 ft.
	299-W11-66	A7308		SUBMITTED	72	26-Apr-63	GG	shows decay	
	299-W11-66	A7308		SUBMITTED	72	26-Feb-58	GG	elevated gamma 35-55 ft.	
	299-W11-66	A7308		YES	72	22-Jul-87	GG	not interpreted	
	299-W11-66	A7308		YES	72	1-Mar-77	Neutron	not interpreted	
	299-W11-66	A7308		YES	72	6-May-76	GG	shows decay	
	299-W11-66	A7308		YES	75	29-Jan-03	SGLS	shows decay, Cs: 1.5 ft, 40.5 ft, 74.5 ft, max 2.3 pCi/g @ 74.5	
T-6	299-W11-67	A7309	361-T-21	YES	75	10-Oct-51	GG	elevated gamma 35-75 ft	1951 GRL profile shows elevated gamma from 35-75 ft. SN logs show elevated gamma from 32-66 ft with decrease in gamma activity after 1958 to background levels. The maximum Cs-137 concentration in 2003 is 1.7 pCi/g at 1 ft.
	299-W11-67	A7309		SUBMITTED	77	26-Feb-58	GG	possible elevated gamma 30 to 66 ft that could be related to lithology change at 30 ft	
	299-W11-67	A7309		SUBMITTED	77	26-Apr-63	GG	decayed to background levels	
	299-W11-67	A7309		YES	77	6-May-76	GG	background indicated	
	299-W11-67	A7309		YES	74	21-Jul-87	GG	background	
	299-W11-67	A7309		SUBMITTED	76	18-Oct-94	NaI	background	
	299-W11-67	A7309		SUBMITTED	76	15-Feb-95	RLS	max 2.0 pCi/g @ 1 ft	

TABLE 4-2. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1951 (WASTE SITE DESIGNATION PREFIX - 216)

Waste Site	Well Name	Well ID	Alias	IDMS	Total Depth	Date	Log Type	Contamination History	Summary
	299-W11-67	A7309		YES	76	9-Jan-03	SGLS	Cs: 1-2 ft, max 1.7 pCi/g @ 1 ft	
T-3	299-W11-7	A4910	361-T-19	YES	40	10-Oct-51	GG	elevated gamma max 10 to 38 ft, peak at ~16 ft	1951 data show elevated activity to the bottom of borehole at 40 ft. Contamination indicated to 246 ft in 1958 and by 1970 groundwater contamination is indicated. RLS data shows Cs-137 contamination to 187.5 ft, with 3 distinct elevated peaks. The elevated peaks are at approximately 15.5 ft, 45 ft and 104 ft. The maximum Cs-137 concentration detected was 1221 pCi/g at 15.5 ft, followed by 828 pCi/g at 104 ft and >200 pCi/g at 45 ft.
	299-W11-7	A4910		SUBMITTED	308	8-Jun-58	GG	indicates contamination to 246 ft; peak activities centered at 13, 50, and 105 ft	
	299-W11-7	A4910		YES	308	25-Apr-63	GG		
	299-W11-7	A4910		YES	308	24-Feb-70	GG	peaks remain at 13, 50, and 105; possibility of groundwater contamination indicated.	
	299-W11-7	A4910		YES	315	23-Feb-76	GG	peaks remain; possible groundwater contamination decayed away	
	299-W11-7	A4910		YES	305	12-Apr-68	GG	elevated gamma at 17 ft	
	299-W11-7	A4910		YES	305	9-Jun-65	GG	elevated gamma at 17 ft	
	299-W11-7	A4910		YES	305	17-Dec-76	Neutron	not interpreted	
	299-W11-7	A4910		YES	305	29-Nov-76	Density	not interpreted	
	299-W11-7	A4910		YES	305	20-Feb-74	Temp	not interpreted	
	299-W11-7	A4910		YES	305	02-Jul-86	GG	Identified peaks remain; possibly contaminated to 240 ft	
	299-W11-7	A4910		YES	306	12-Aug-87	GG	Identified peaks remain; possibly contaminated to 240 ft	
	299-W11-7	A4910		SUBMITTED	280	15-May-92	RLS	Cs from 3 to 169 ft, max 1000 pCi/g at 15 ft; three peaks seen in prior years remain	
	299-W11-7	A4910		SUBMITTED	280	24-Oct-95	RLS	Identified Cs to 187.5 ft; max 1221 pCi/g at 15.5 ft; ,	
T-3	299-W11-79	A7321		YES	145	03-Apr-84	GG	Drilled in 1983. Elevated gamma 0-146 ft (TD); peaks at 18, 62, and 110 ft	Drilled in 1983 and contamination existed. GG logs from 1984 to 1987 and the 2003 SGLS logging show elevated gamma from 0-146 ft, with peaks at approximately 18, 62, and 110 ft. The maximum Cs-137 is 54,100 pCi/g at 19 ft, followed by 1000 pCi/g at 106 ft., and 50 pCi/g at 63 ft. Cs-137 was detected to the total logging depth of 144.1. Water was encountered at this depth due to a cement plug in the bottom of the borehole.
	299-W11-79	A7321		YES	141	02-Jul-86	GG	Similar profile as in 1984	
	299-W11-79	A7321		SUBMITTED	142	13-Aug-87	GG	Similar profile as in 1984	
	299-W11-79	A7321		YES	146	27-Oct-03	SGLS	Cs: 0-146 ft (TD), max 54100 pCi/g @ 19 ft, also 1000 pCi/g @ 106 ft	
T-3	299-W11-22	A9794	241-T-36 1	YES	240	9-Jun-65	N	not interpreted	Cs-137 was detected from 15-20 ft, 103-138 ft, and 142-174 ft. The maximum concentration was 280 pCi/g at 109 ft. The contamination from 103 to 138 may be the result of waste that was injected into the reverse well that spread out laterally to this location. No available historical logs.
	299-W11-22	A9794		YES	245	20-Dec-05	SGLS	Cs: 15-20 ft, 103-138 ft, 142-160 ft, 161-174 ft, max 280 pCi/g at 109 ft.	

ft to m = ft x 0.3048

FIGURE 4-1. 216-T-3 AND 241-T-361 LOCATION MAP

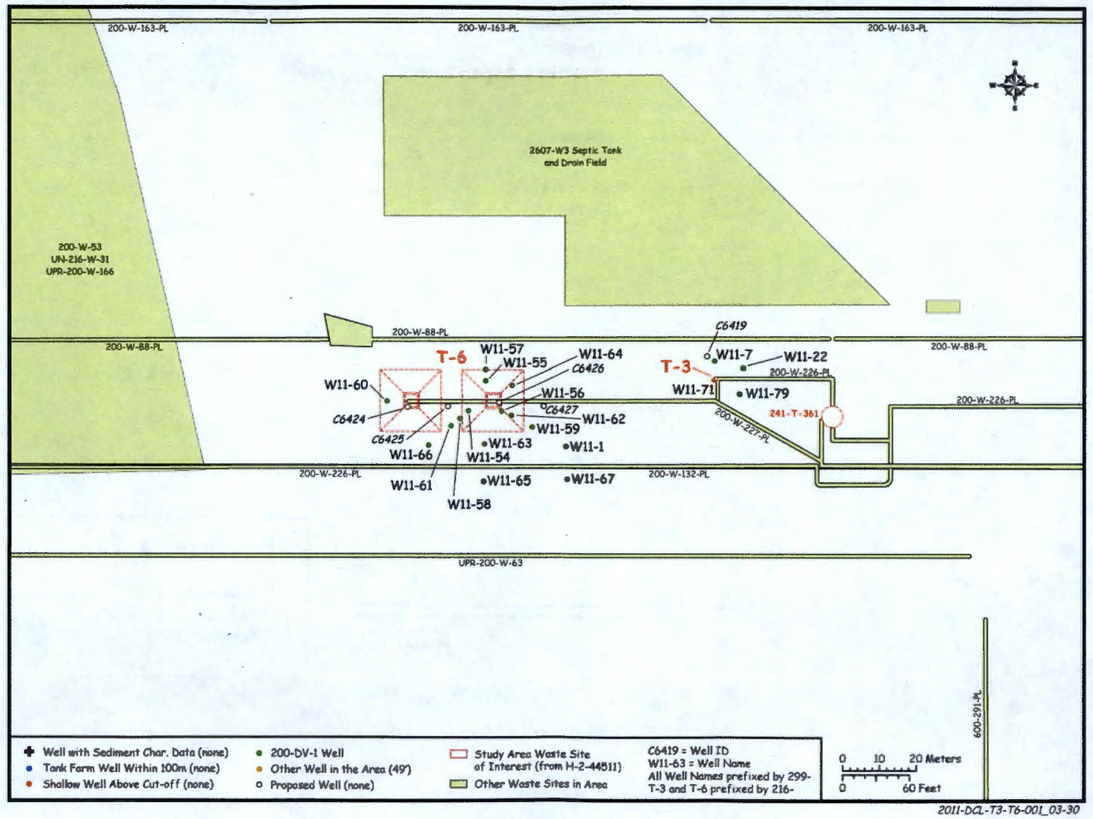


FIGURE 4-2. 216-T-3 AND 241-T-361 LOCATION MAP WITH PIPING

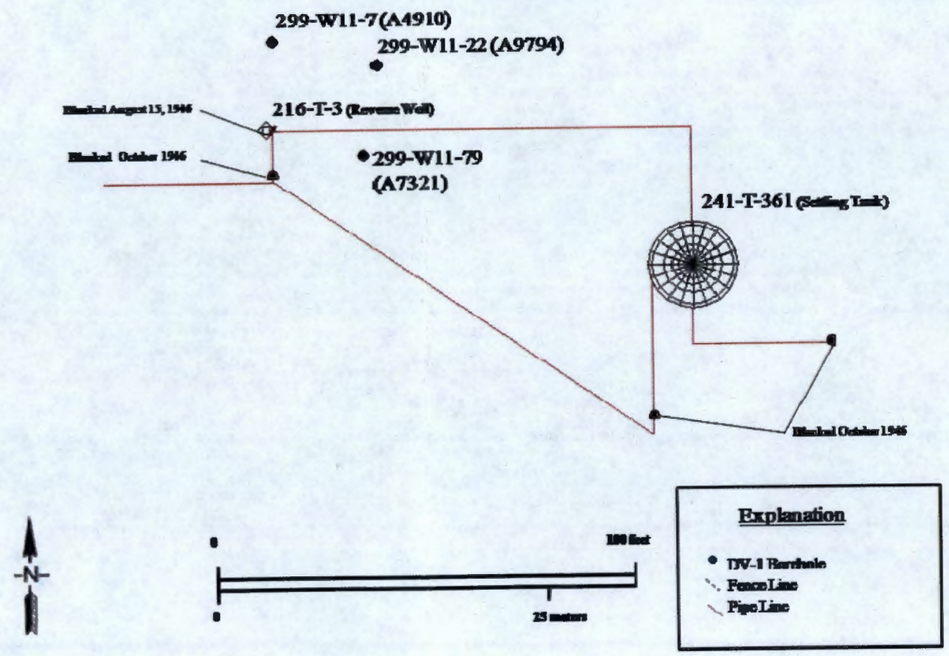


FIGURE 4-3. 216-B-5 REVERSE WELL DESIGN (SIMILAR TO THE 216-T-3 REVERSE WELL)

WHC-SD-DD-TI-057 Rev. 0

Figure 2. 216-B-5 Reverse Well Disposal System.

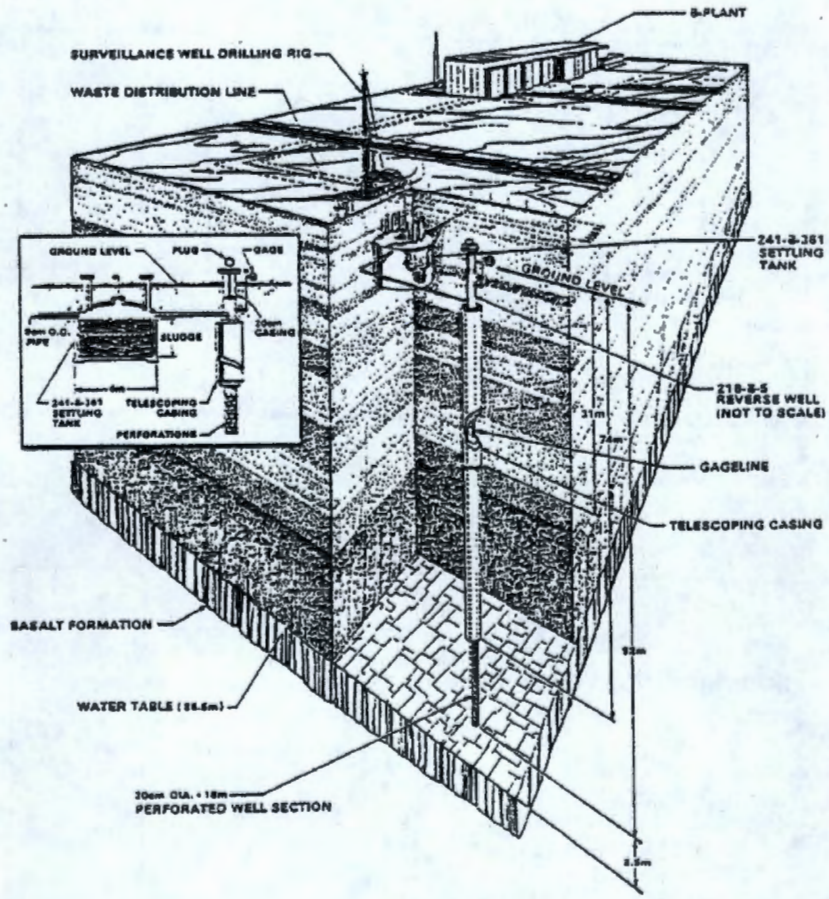


FIGURE 4-4. 216-T-6 #1 AND #2 CRIB CONTAMINATION

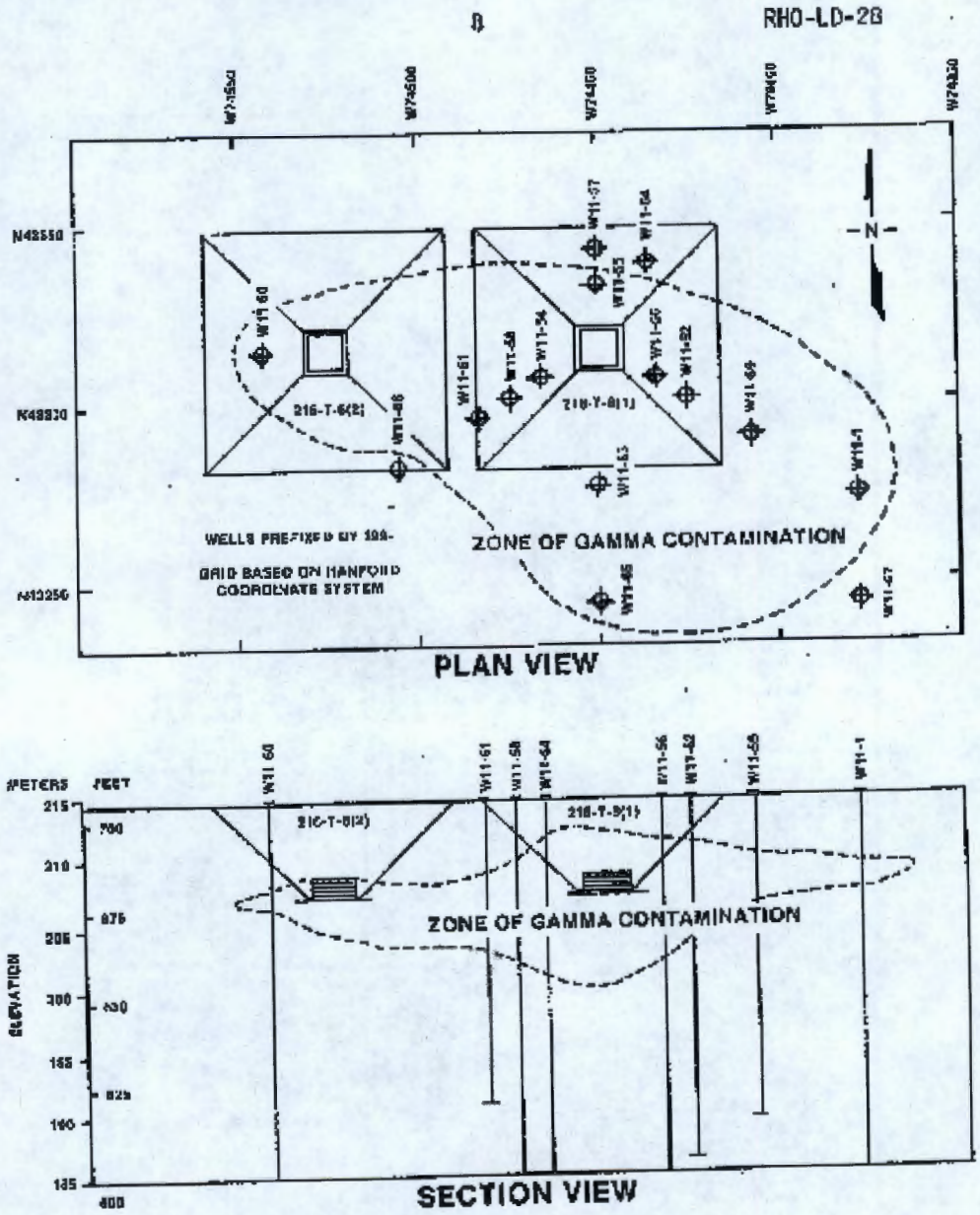
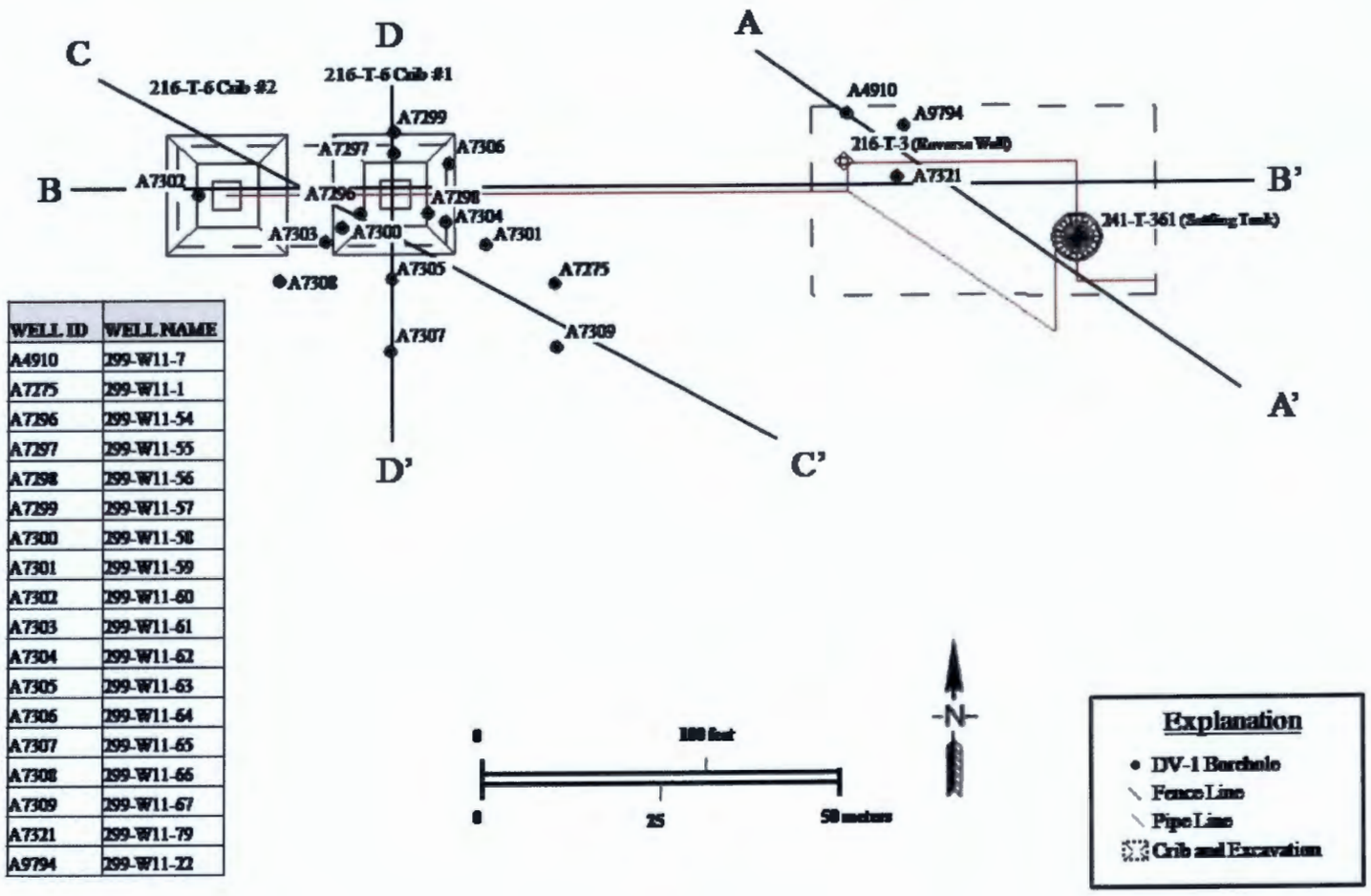


FIGURE 4-5. 216-T-3 AND 216-T-6 CROSS SECTION LOCATIONS



WELL ID	WELL NAME
A4910	299-W11-7
A7275	299-W11-1
A7296	299-W11-54
A7297	299-W11-55
A7298	299-W11-56
A7299	299-W11-57
A7300	299-W11-58
A7301	299-W11-59
A7302	299-W11-60
A7303	299-W11-61
A7304	299-W11-62
A7305	299-W11-63
A7306	299-W11-64
A7307	299-W11-65
A7308	299-W11-66
A7309	299-W11-67
A7321	299-W11-79
A9794	299-W11-22

FIGURE 4-6. 216-T-3 CROSS SECTION A-A'

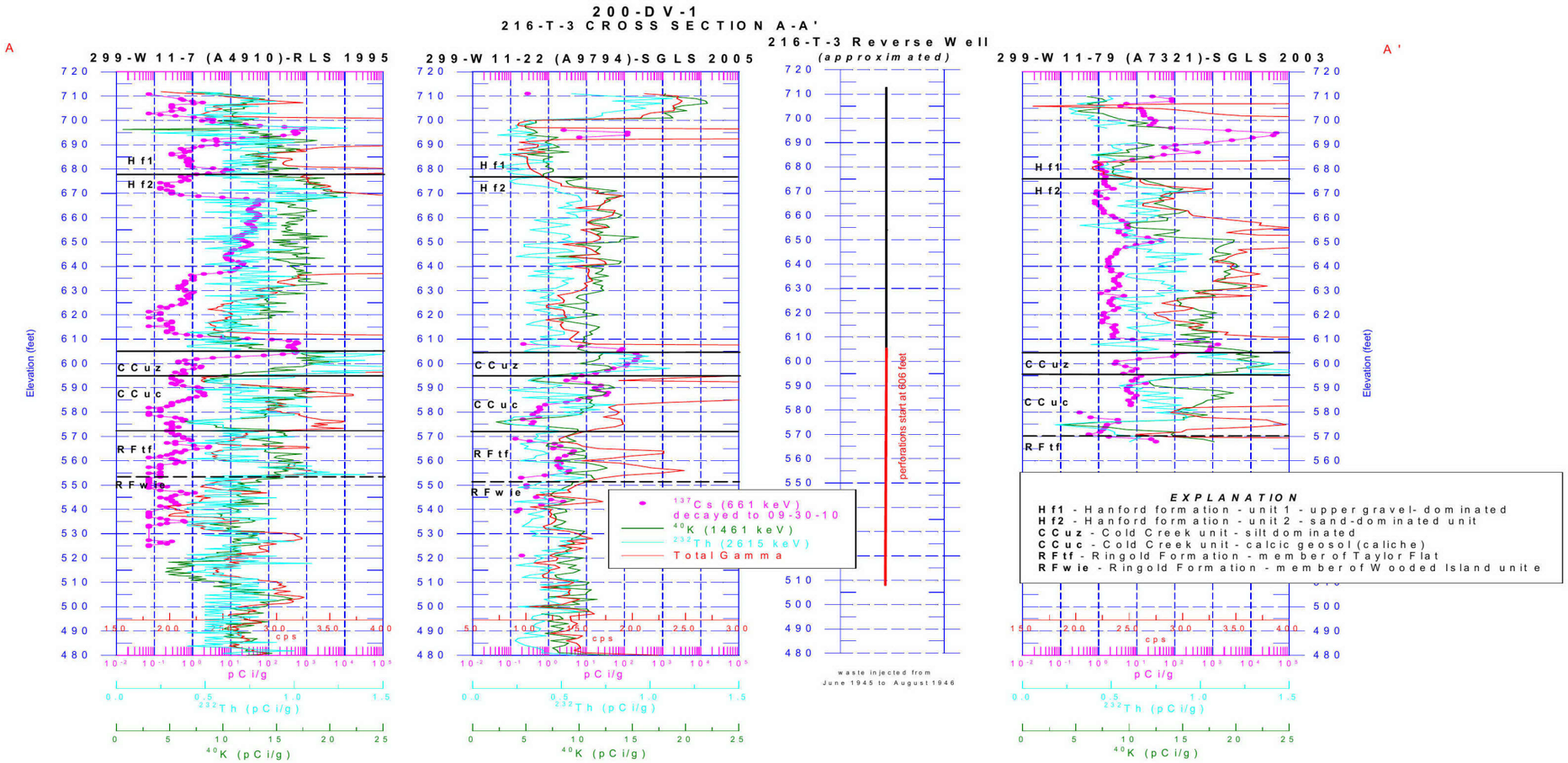


FIGURE 4-7. 216-T-3 VISUALIZATION OF CS-137 CONTAMINATION

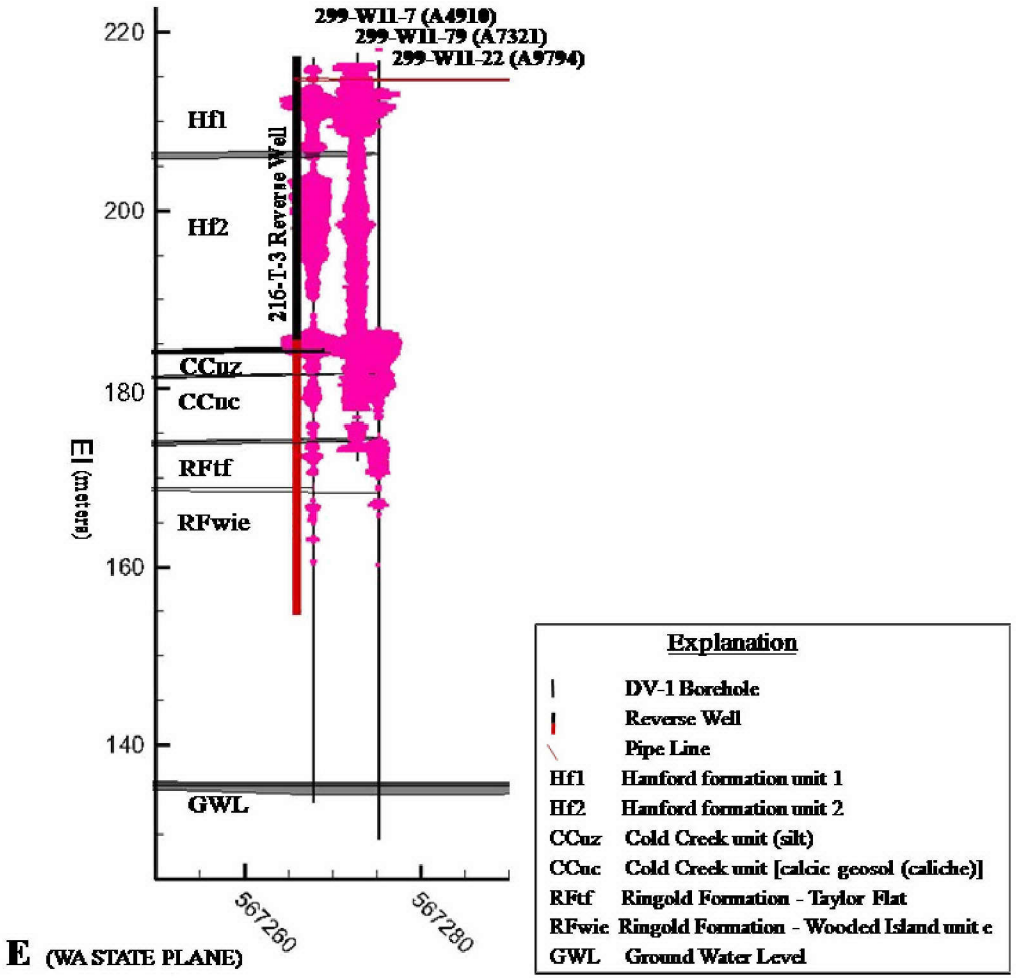


FIGURE 4-8. 216-T-3 & 216-T-6 CROSS SECTION B-B'

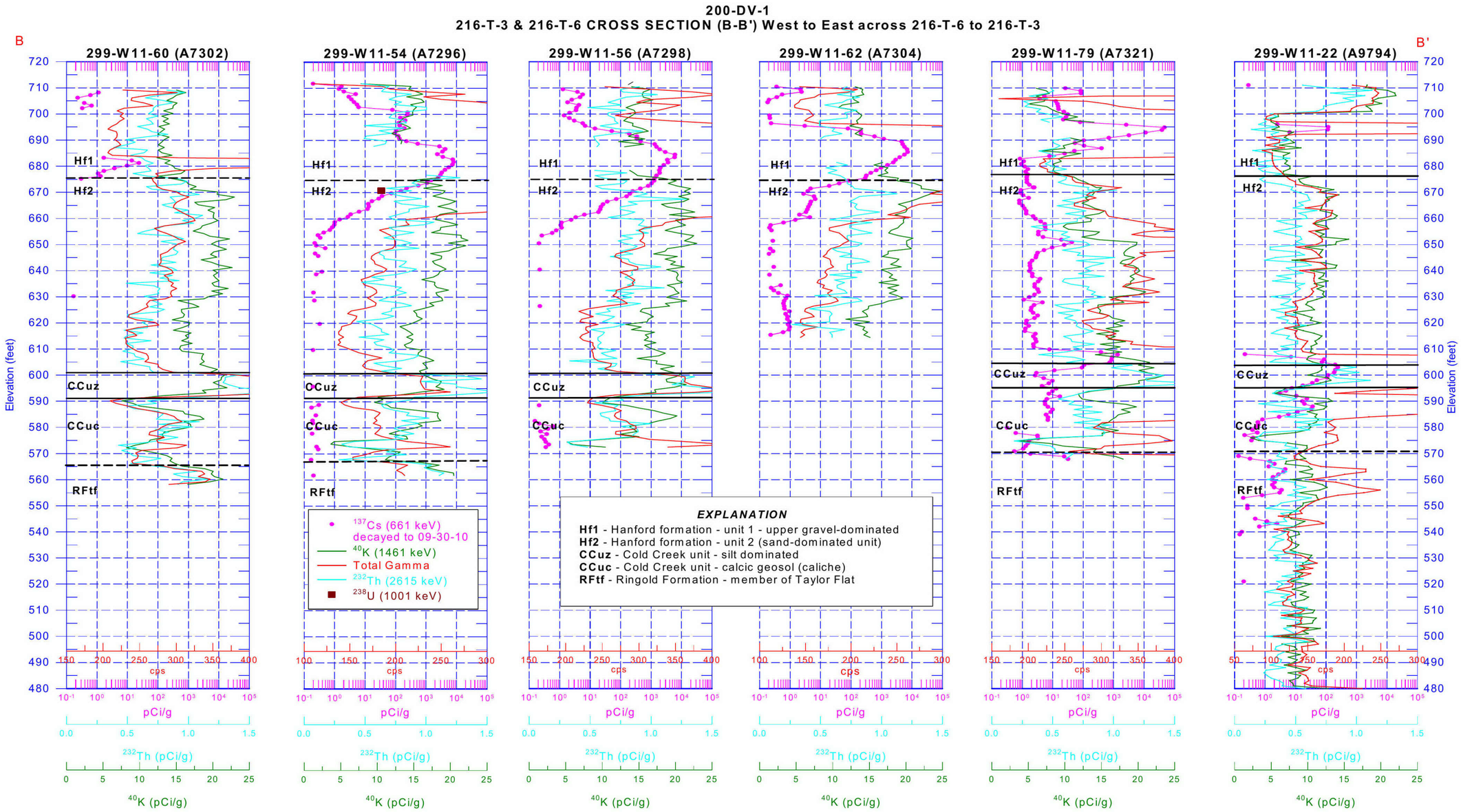


FIGURE 4-9. 216-T-6 CROSS SECTION C-C'

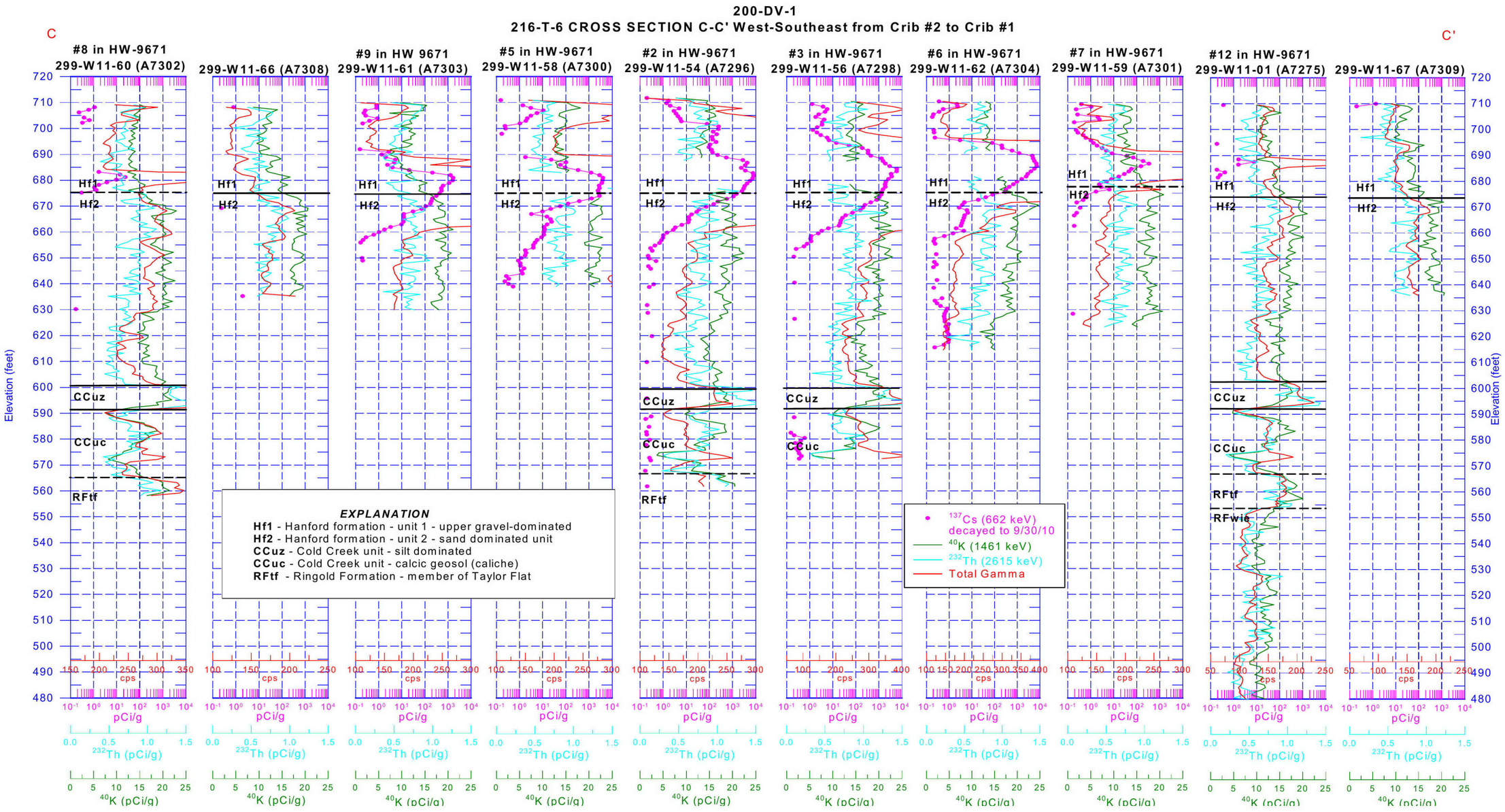


FIGURE 4-10. 216-T-6 CROSS SECTION D-D'

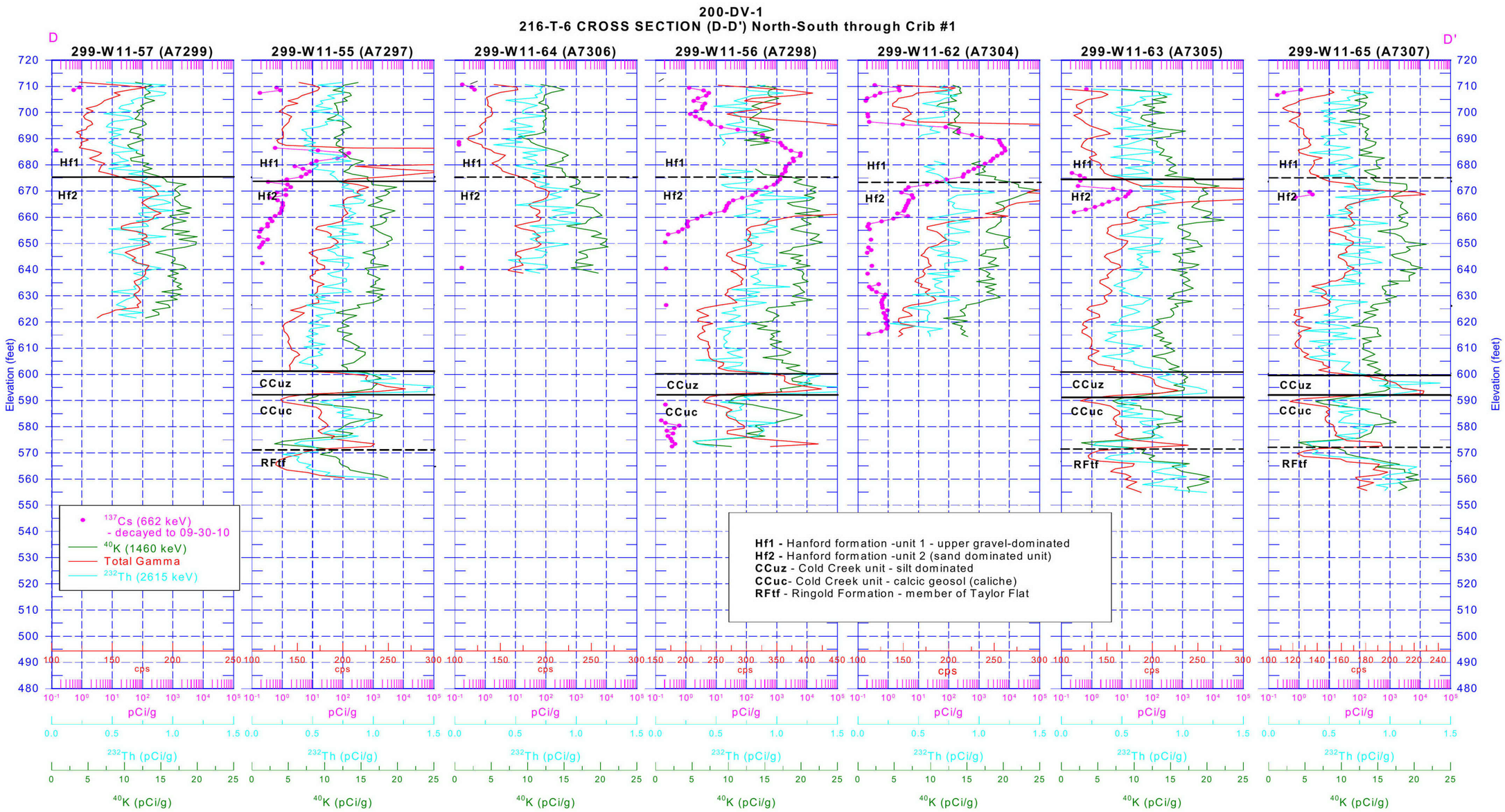


FIGURE 4-11. VISUALIZATION OF CS-137 CONTAMINATION VIEWED FROM THE SOUTH OF 216-T-3 & 216-T-6

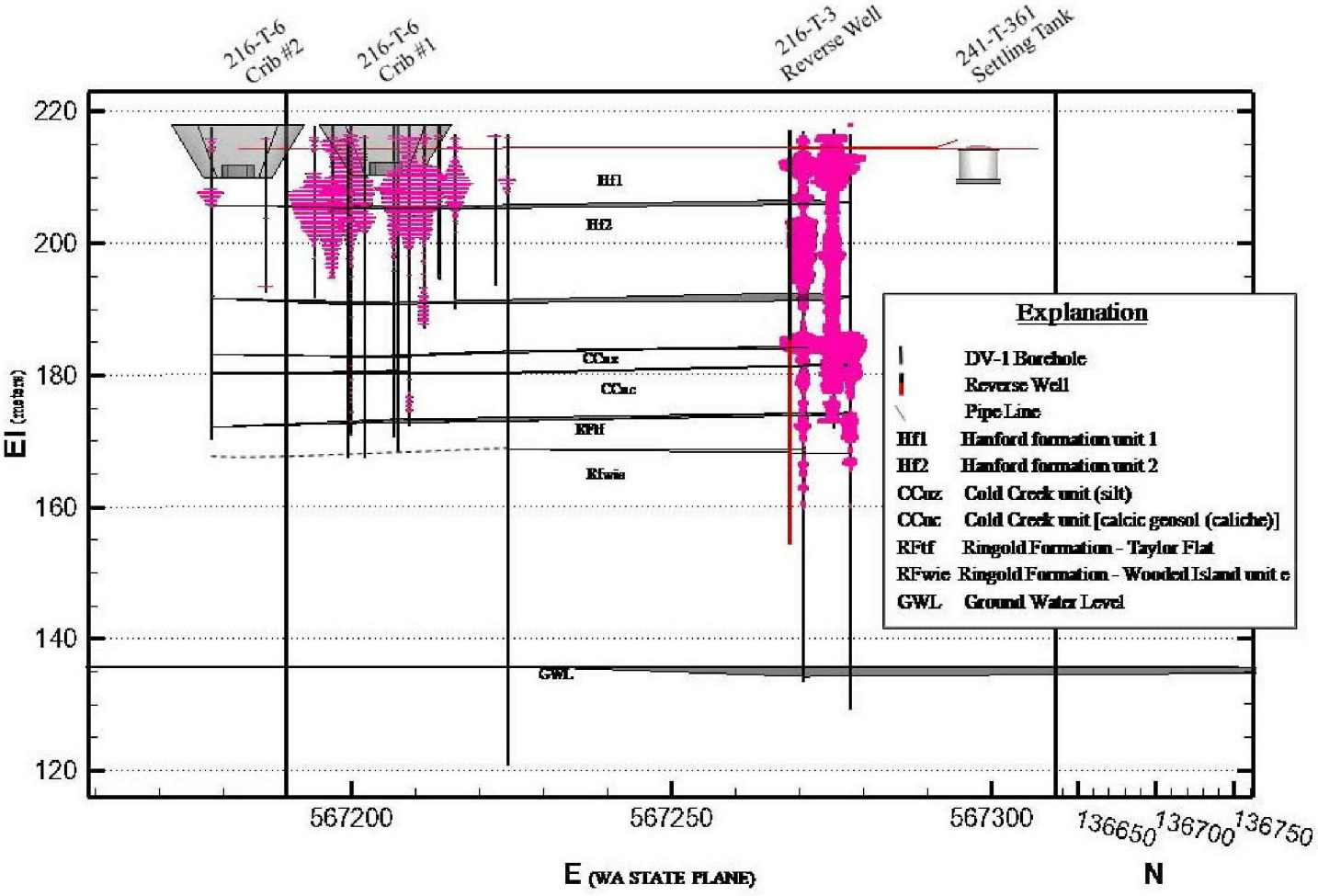
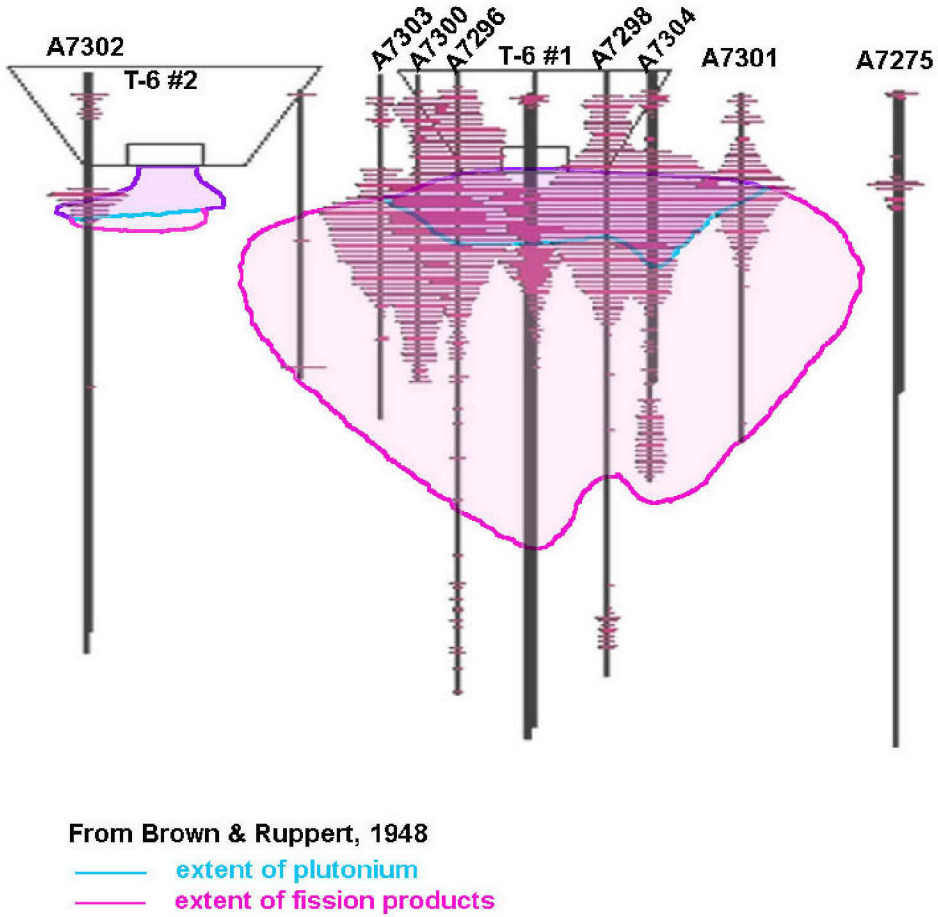


FIGURE 4-12. 2003 CS-137 CONTAMINATION OVERLAYED ON BROWN AND RUPPERT (1948) CONTAMINATION DRAWING



5.0 216-T-5, -T-32, AND -T-7 WASTE SITES

This subregion includes the 216-T-5 Trench, the 216-T-32 Crib, and the 216-T-7 Crib (AKA, 200-W-52) and Tile Field (Figure 5-1). These waste sites are interrelated in proximity and geology and process history. 241-T-Farm lies immediately to the east of the waste sites and is considered to have potential impact to the deep vadose zone. A brief background section is provided that includes waste site characteristics, process history, and geology. Cross sections that include the current contamination profile in relation to the waste site and stratigraphy, 3-dimensional data visualizations, and interpretations are provided in Section 5.4.

5.1 GEOLOGY

The general geology and stratigraphy for this area are described in Section 3.1. Stratigraphic relationships are depicted on cross sections of log data. Key Stratigraphic intervals defined within the vadose zone, from shallowest to deepest include the Hf1, Hf2, CCu, RFtf, and RFwie. Overall, the vadose zone is approximately 68.6 m (225 ft) thick in this area. The contact between the Hf1 and Hf2 occurs relatively shallow and is usually situated within or just below the bottom of the facility. The top of the Hf2 (Hanford formation – unit 2) is at approximately 672 ft (204.8 m) in elevation (38 ft or 11.6 m bgs) and the CCu lies between approximately 605 ft (184.4 m) or 105 ft (32 m) bgs and 570 ft (173.7 m or 140 ft (42.7 m) bgs. The Hf2 averages 67 ft (20.4 m) thick and the CCu averages 35ft (10.7 m) thick beneath the area. The 216-T-32 crib area also appears to contain a fine grained zone referred to as Hf1a sand. This unit is defined near the boundary of the HF1 and HF2 and appears to be local, ranging in thickness from 10 ft (3.0 m) to less than 4 ft (1.2 m) in the southerly direction. The top of the CCu is at an approximate elevation of 592 ft (180.4 m) and slopes south and west as depicted by cross sections (Section 5.4.3).

5.2 WASTE SITE PROCESS HISTORY

5.2.1 216-T-5 TRENCH

The 216-T-5 trench is located west of the 241-T Tank Farm and northwest of the 216-T-32 cribs. It was used in May 1955 to accept 221-T second cycle supernate from the 214-T-112 tank (Clukey 1956). In 1956 it was referred to as a "grave." This terminology reflected an excavation for "one shot" (few days) disposal, that was promptly backfilled. The waste was transferred to the trench using an over ground pipeline. WIDS states the trench bottom is 50 ft (15.2 m) in length by 10 ft (3.1 m) wide and located 12 ft (3.7 m) bgs.

5.2.2 216-T-32 #1 & #2 CRIBS

The 216-T-32 #1 and #2 (also referred to as the 241-T #1 & #2 cribs and the 201 tank crib) cribs received effluent from the 241-T-201 tank. The 241-T-361 settling tank (Section 4.2.1) originally received 224 supernate waste from the 224-T building. New construction was completed in October 1946 that by-passed the settling tank and re-routed the 224 waste to tank 241-T-201 in the 241 T Tank Farm. The 216-T-32 cribs received supernate waste from November 1946 until May 1952 when they were deactivated due to sludge buildup in tanks 241- T-201, -202, -203, and -204. Supernate waste was rerouted to the 216-T-7 crib and tile field. The primary waste entering the cribs was 224 process waste. This is considered to be low in fission product activity and to contain small quantities of plutonium. The two square cribs have bottom dimensions of 12 ft (3.7 m) by 12 ft (3.7 m) and are separated by 40 ft (12.2 m) edge to edge. The crib bottoms are 26 ft (7.9 m) bgs and the cribs were 4 ft (1.2 m) tall with 22 ft (6.7 m) of backfill. There appears to be some discrepancy as to the exact location of the cribs. Drawing H-2-558 shows the centers of the cribs on a line extending from the center of 241-T-201, in the direction S60W (azimuth 240 degrees). The center of the first crib is located 66 ft (20.1 m) along this line from the edge of the 241-T-201 tank, and the center of the second crib is located along the same line

118 ft (36.0 m) from the edge of 241-T-201. Accounting for the 20-ft (6.1 m) ID of the 241-T-201 tank and allowing 1 ft (0.3 m) wall thickness, the centers of the cribs are 77 ft (23.5 m) and 129 ft (39.3 m) along a line S60W (240 deg) from the center of tank 241-T-201. Figure 5-2 shows two outlines for the footprint of 216-T-32. The outer footprint is based on the assumption of a 1.5:1 slope from the cribs located as described above. The inner footprint is taken from coordinates in Qmap. Note that the discrepancy in crib location is roughly the same magnitude as crib dimensions.

5.2.3 216-T-7 CRIB & TILE FIELD

The 216-T-7 Crib and Tile Field (also referred to as the 241-T #3 crib, the 2nd cycle crib, No. 1 crib, and the 241-T-3 Tile Field) began operation in April 1948 and was deactivated in November 1955 when it reached the prescribed radionuclide disposal guide limit. The pipeline to the crib was capped and the effluent was rerouted to the 216-T-19 Crib (WIDS). The 216-T-7 crib received second cycle supernate from 221-T, 224-T, and tank 5-6 waste after these waste streams cascaded through the 241-T-110, -111, and -112 single shell tanks. This effluent is sometimes referred to as T-112 waste. Honstead (1953) sampled the 241-T-112 tank effluent to determine the range and frequency of concentration fluctuations in the T-plant cribbed wastes. The sampling results revealed a mean crib waste concentration of 0.070 uc/cc (~5.6 E05 pCi/g) of beta emitters. An example from one sample of percentages of total beta emitters in the waste were: Ru (50.4), Cs (35.9), Ce, Y, and rare earths (7.6), and not determined (6.3).

The 216-T-7 crib is constructed of 6-in. (15.2 cm by 6-in. (15.2 cm) timbers on approximate 4 ft (1.2 m) centers and is 12 ft (3.7 m) by 12 ft (3.7 m). A slope of 1.5:1 was used for the excavation. The top of the crib is at an elevation of approximately 654 ft (199.3 m), (converted to NAVD88, and the bottom at 647 ft (197.2 m) or 26 ft (7.9 m) bgs. Ground elevation is at approximately 673 ft (205.1 m). A pipe enters the crib at approximately 653.5 ft (199.2 m) with the overflow pipe to the tile field exiting at approximately 652 ft (198.7 m). The Tile Field is 310 ft (94.5 m) in length by 84 ft (25.6 m) wide. Medium coarse gravel was placed a minimum of 4 ft (1.2 m) below the pipe and 6-in. (15.2 cm) above. There was to be a uniform downward slope of 1 degree to the west (drawing H-2-578).

5.3 PREVIOUS INVESTIGATION

Brown and Ruppert (1948)) conducted an investigation in the area of the 216-T-7 and 216-T-32 #1 and #2 cribs. Eight boreholes were drilled in the 216-T-32 area and 15 in the 216-T-7 crib and tile field area. These boreholes drilled in 1947 were referred to as 224-T-xx for the 216-T-32 (201 tank crib) cribs and as 241 or 221- T-xx for the 216-T-7 crib and tile field (2nd cycle crib). Three additional boreholes were drilled in 1951 and are included in Table 5-1. The same nomenclature was used in 1951 although borehole 224-T-9 is located in the tile field and probably should have been labeled with a 241 prefix. Also, included are the boreholes where a 1951 geophysical log is available.

The investigation concluded that plutonium existed 34 ft (10.4 m) below the depth of the 216-T-32 crib with a lateral spread of 197 ft (60.0 m) and that fission products existed 28 ft (8.5 m) below the crib depth with a lateral spread of 280 ft (85.3 m). Figure 5-2 is a plan view of the lateral extent of the contamination as digitized from the report. The lower limit of contamination used for the cross sections was 0.04 micrograms/kg Pu (equivalent to 2.5 pCi/g Pu-239) and 0.05 microcuries/kg for fission products (equivalent to 50 pCi/g). Brown and Ruppert described an influx of 1 to 1.5 million gallons (5.6 million liters) of sanitary water discharged daily to the ground just north (approximately 1500 ft or 457.2 m) of the 241-T area. It was thought this volume of water would cause contaminants to move downward from the 216-T-32 crib and laterally down dip for some distance. It is important to note that the 216-T-7 crib area did not indicate any significant contamination during the 1947 investigation, suggesting the tile field contamination was all from the 216-T-32 cribs because the 216-T-7 crib and tile field had not yet received effluent in any significant amounts.

Brown and Ruppert (1950) provided an update of the area in 1950. Efforts to acquire additional samples near the 216-T-7 Crib are discussed. Thirty-four sediment samples were obtained from the bottom of

well 241-T-1 (299-W10-74 {A7164}) at a depth of 20 ft (6.1 m) below the crib to check the downward migration of activity. No alpha activity was detected on any of the samples, and the maximum beta-gamma activity was 0.1 microcurie/kilogram of sediment. Well casings 241-T-2 ({299-W10-59) {A7149}), 241-T-3 ((299-W10-60) {A7150}, 241-T-4 ((299-W10-66) {A7156}, 241-T-5 ((299-W10-61) {A7151}), and 241-T-9 ((299-W10-68) {A7158}) contain open holes or perforations. Wells 241-T-2, 3, 4, and 5 have two perforations at a depth of 30 ft from the ground surface and two at a depth of 35 ft from the surface. These perforations, 2 ½ in. (6.4 cm) long and ¼ in. (0.6 cm) wide, were made during attempts to obtain sediment samples in September 1947. Casings 241-T-2 and 5 also have a 1-in. (2.5 cm) diameter hole at a depth of 35 ft (10.7 m) from the ground surface and casing 241-T-9 , drilled in September 1951, has a 1-in. (2.5 cm) diameter hole at a depth of 45 ft (13.7 m) bgs. Concrete was used to seal the well bottoms and prevent introduction of radioactive wastes into the ground at depth of 150 ft (45.7 m). Brown and Ruppert state that radioactive waste seeped through the perforations and was found in wells 241-T-2, -3, and -5, 18 ft (5.5 m) from the center of the crib. Similar contamination was later found in well T-9 (not drilled or perforated until September 1951) which is 28 ft (8.5 m) from the crib. Fission product contamination was reported at about 1 million pCi/L 18 ft from the crib and 500,000 pCi/L 28 ft (8.5 m) from the crib. No plutonium was detected.

Fecht et al. (1977) evaluated the 216-T-5, 216-T-7 and 216-T-32 waste sites using scintillation probe profiles obtained from 1958 through 1976. Only one borehole ((299-W10-1) {A7136}) was available to evaluate the 216-T-5 trench. Radioactivity detected in 1959 from the surface to the 38.1 m (125 ft) depth bgs decayed away to near background by 1976. Fecht concludes that breakthrough to the ground water did not occur at this site which would be supported by the low volume of waste disposed to this specific retention trench in May 1955.

Fecht evaluated 5 of 8 boreholes that had scintillation data within 28 ft (8.5 m) of the center of the 216-T-7 (200-W-52) crib (not the entire tile field). It was stated that most of the radioactive contaminants were below the crib bottom and above 30.4 meters (100 ft bgs). However, the boreholes did not fully penetrate the zone of contamination. Radioactive contaminants were detected in borehole 299-W10-3 between 10.1 and 38.7 meters (33 and 127 ft) below the ground surface. Fecht concluded from borehole 299-W10-3 that the radionuclides beneath the 216-T-7 crib moved downward in the sediment column 1.8 meters (6 ft) between 1959 and 1976. Fecht also suggested the data from this well indicates that breakthrough to the groundwater could have occurred at this site. Two boreholes used to monitor the tile field 299-W10-72 (A7162) and 299-W10-80 (A7170) indicated high activity from 15.2 meters (50 ft) below ground surface to the bottoms of the cement-plugged boreholes at approximately 135 and 100 ft (41.1 and 30.5 m), respectively. Borehole 299-W10-69 shows radiation peaks at the 11.9 (39 ft) and 24.1 (79 ft) meter depths. Other boreholes in the tile field indicated near background levels.

An evaluation by Fecht (1977) for boreholes surrounding the 216-T-32 crib indicated low levels of radiation between 8 (26 ft) and 35 meters (115 ft) below the ground surface. Fecht concluded no measurable migration of radionuclides has been detected and the data do not indicate breakthrough to groundwater despite the fact that the calculated pore volumes of waste disposed through the footprints of the 216-T-32 and 216-T-7 facilities are similar and greater than 5 times the estimated moisture holding capacity of each facilities footprint.

The T Plant source Aggregate Area Management Study Report (U.S. Department of Energy 1992) evaluated these sites and created cross sections using scintillation profiles. An isopach map of elevated gamma radiation from this study is included as Figure 5-3.

5.4 SUMMARY OF LOG DATA

Figure 5.4 shows the location of 200-DV-1 study boreholes relative to the three waste sites and 241-T tank farm that have been evaluated for this subregion. Spectral gamma log cross sections A to D are included in this report in Figures 5.5, 5.8, 5.9, and 5.10, respectively. All geophysical logging data acquired since 1951 have been considered and are included in Table 5-2. A brief evaluation of the

significance of each log as compared to earlier logs in the same borehole is shown in the last column of Table 5-2. This evaluation is intended to describe any significant changes in the gamma profile during intervening years. A more accurate quantitative analysis will require detailed comparison, taking into account the relative efficiencies of the various detection systems. This will require a detailed assessment of the response characteristics of the older logging systems, which is beyond the scope of the current effort but it is strongly recommended for key boreholes before final decisions are made on future field characterization activities. The "historical" record is important to determine the past existence of very short-lived radionuclides, the maximum extent of contamination at depth, and whether any influx or migration of contaminants has occurred over time. The Brown and Ruppert report is used as the baseline extent of plutonium and fission product contamination in this subregion.

5.4.1 216-T-5 TRENCH

There are three shallow boreholes in the northwest section of the trench excavation and one deeper borehole further northwest. There are no current geophysical log data for these boreholes. The shallow boreholes were placed in the 216-T-5 trench in 1985. Boreholes 299-W10-189, -190, and -191 in the northwest portion of the trench were drilled and cuttings were measured for gamma activity. According to driller's logs, each borehole indicated contamination at 11 ft (3.4 m) bgs with a maximum at 12 ft (3.7 m) and extending to 28, 20, and 20 ft (8.5, 6.1, and 6.1 m) bgs, respectively. The contamination readings decreased with depth although two of the boreholes (299-W10-190 and -191) did not completely penetrate the vertical extent of the gamma contamination; borehole 299-W10-189 may have penetrated the contamination at 28 ft (8.5 m) although the driller's log is not considered definitive.

The deeper borehole---299-W10-1 (A7136)--- indicated contamination from approximately 10 ft (3.0 m) to possibly 160 ft (48.8 m) bgs with a maximum count rate at 40 ft (12.2 m) bgs in 1959. The contamination decayed to background levels by 1968 (Table 5-2). The peak at 40 ft (12.2 m) bgs is likely related to naturally occurring gamma activity in fine-grained sediments as the count rate is approximately the same as the count rate in the CCu below 80 ft (24.3 m) bgs. At this borehole, an interval at approximately 40 ft (12.2 m) bgs (elevation 635 ft or 193.6 m) exhibits relatively high K-40 concentrations (Figure 5-5). This fine grained interval is also present in other nearby boreholes.

5.4.2 216-T-32 #1 & #2 CRIBS

Figure 5-2, based on discussion in Section 5.3, reproduces the plume maps drawn by Brown and Ruppert (1948) for plutonium and fission products. Figure 5-5 indicates four boreholes (299-W10-58 {A7148}, 299-W10-64 {A7154}, 299-W10-73 {A7163}, and 299-W10-69 {A7303}) where Pu-239 was detected recently (2006 and 2008 spectral gamma logging events) that lie within and also help define the Brown and Ruppert plutonium plume boundary. All four boreholes also indicate minor concentrations of fission products such as Cs-137 and Eu-154. Note: The intervals indicating Cs-137 probably also contain Pu-239 at concentrations just below their MDLs of the spectral gamma system. On the basis of the Cs-137 profile, the Pu-239 contamination ranges from a thickness of approximately 15 ft (4.6 m) close to the #1 crib to about 5 ft (1.5 m) southeast of the # 2 crib at a location below the 216-T-7 tile field area. Note: Brown and Ruppert stated the plutonium reached a depth of 35 ft (10.7 m) below the cribs which would be 26 ft (bottom of excavation) + 35 ft = 61 ft (18.6 m) bgs. The current profile suggests the plutonium is at approximately 35 ft (10.7 m) below the ground surface and is bound in a sediment interval of relatively high K-40, possibly indicating a silty sand sediment. It is possible that Brown and Ruppert actually meant 35 ft (10.7 m) from the ground surface.

The current contamination profile with very low fission product activity (Figure 5-5) strongly suggests the fission product plume represented by Brown and Ruppert (1948), primarily contained short-lived gamma emitting radionuclides. Another factor to consider is that Pu-241 along with Pu-240 and Pu-239 exist in fresh weapons grade plutonium. Although Pu-241 is less than one percent by weight of fresh weapons grade plutonium, it exhibits over 80 % of the activity (14 year half life). Pu-241 emits a gamma ray at the 208 keV energy level. This gamma activity and perhaps that from numerous relatively low

yielding Pu-239 and Am-241 gamma rays may have interfered with the method (beta-gamma counting using a Geiger-Mueller tube) used by Brown and Ruppert, resulting in overestimation of fission product activity.

Figure 5-6 shows a visualization of Pu-239 as it exists today based on more recent spectral gamma logging and Figure 5-7 indicates the relative differences in Cs-137 concentrations between the 216-T-32 cribs and the 216-T-7 crib and tile field. These figures suggest that contamination that may have affected the deep vadose zone (i.e., below the CCu) probably originating from the 216-T-7 crib and tile field. However, any Pu-239 that may exist below the MDL for spectral gamma logging of approximately 10 nCi/g, is not portrayed in Figure 5-6.

5.4.3 216-T-7 CRIB AND TILE FIELD

The B-B' (Figure 5-8), C-C' (Figure 5-9), and D-D' (Figure 5-10) cross sections show the relationships of contamination and stratigraphy from the 241-T-106 tank in T Farm (northeast to southwest), from 241-T-112 east to west through the 216-T-7 crib and tile field, and from a borehole south of 241-T-farm, through the 216-T-7 (200-W-52) crib and to the northwest of the 216-T-32 cribs, respectively. Figure 5-11 shows the interrelationships between major sources of contamination. This visualization suggests a Co-60 plume from the 241-T-106 tank that is trending deeper in the southwest direction toward the 216-T-32 and 216-T-7 crib and tile field. Contamination originating from the 216-T-32 cribs also appears to trend to the southwest. The significant Cs-137 vadose plume appears to originate from the 216-T-7 (200-W-52) crib and extends into the tile field.

Eight boreholes surround the 216-T-7 crib. Unfortunately, several were not accessible for current logging due to potentially contaminated water within the boreholes or because sand had accumulated over the boreholes preventing access to some boreholes. Table 5-3 describes some of the depths where significant contamination is exhibited in the current SGLS logs and in the 1963 total gamma logs.

Borehole 299-W10-3 is also included because it exhibits a similar contamination profile although it is approximately70 ft (21.3 m) north of the 216-T-7 crib.

The boreholes are located `along the diagonals of the crib. Four boreholes are within 18 ft (5.5 m) of the center of the crib and the other four are about 28 ft (8.5 m) from the crib. The bottom of the crib is at approximately 26 ft (7.9 m) bgs. On the east inlet side, the boreholes 18 ft (5.5 m) from the crib indicate contamination beginning at 16 and 28 ft (4.9 and 8.5 m) bgs, while the outer boreholes at 28 ft (8.5 m) distance from the crib both indicate significant contamination beginning at 40 ft (12.2 m) bgs. Borehole 299-W10-3 north of the crib also shows contamination beginning at 40 ft (12.2 m) bgs. In the west side, three of the four indicate significant contamination near the bottom of the crib. Only 299-W10-62 shows it deeper at 36 ft (11.0 m), 28 ft (8.5 m) northwest of the crib. This steep gradient from about 25 ft (7.6 m) to 40 ft (12.2 m) in depth east and north of the crib suggests significant lateral and downward movement of Cs-137 that suggests borehole 299-W10-3 was contaminated from the 216-T-7 crib. Borehole 299-W10-3 shows Cs-137 to the bottom of the borehole near groundwater.

The 216-T-7 tile field is monitored by boreholes 299-W10-80 (A7170), 299-W10-69 (A7159), 299-W10-72 (A7162, 299-W10-70 (A7160), and 299-W10-71 (A7161). A 1951 gamma log shows contamination in borehole 299-W10-80 from 40 to 45 ft (12.2 to 13.7 m) bgs (low activity) and from 60 ft (18.3 m) to total depth at 100 ft (30.5 m) (high activity). 299-W10-69 shows relatively low activity between 40 and 45 ft (12.2 and 13.7 m) bgs in 1951 while in 1963 additional activity is noted from 80 to 120 ft (24.4 to 36.6 m) bgs. By 1976, the contamination below 40 ft (12.2 m) bgs had decayed to background levels. It is postulated the contamination at 40 ft (12.2 m) bgs originated from the 216-T-32 cribs and below 80 ft (24.4 m) bgs from the 216-T-7 tile field. Borehole 299-W10-72 (Figure 5-12) indicates total gamma logs acquired since 1951 plotted with the Cs-137 concentration determined recently using spectral gamma logging. The count rates from the different detection systems are normalized based on background count rates from 20 to 30 ft (6.1 to 9.1 m) bgs, using a unit referred to as the Hanford

Gamma Unit (HGU). The HGU is an empirical unit of gamma activity proposed as a means to standardize gamma log response across multiple logging systems with different response characteristics. 1 HGU is chosen to be approximately equal to background gamma activity. Count rates from the 1963, 1976, and 1987 logging events between 45 and 75 ft (13.7 and 22.9 m) bgs suggest the detectors were saturated. Thus, it cannot be determined if the profiles at this depth zone are showing increases over the 1951 log. However, below the high activity zone at approximately 84 ft (25.5 m) bgs, the logs indicate an influx of Cs-137 contamination from 84 ft (25.5 m) to the bottom of the borehole (~135 ft or 41.1 m bgs) between 1951 and 1963. It is postulated that the contamination at 84 ft (25.5 m) bgs and below in both 299-W10-69 and -72 between 1951 and 1963 was caused from use of the 216-T-7 tile field. Prior to the August 1951 first logging event, the total volume of waste disposed to the 216-T-7 crib and tile field was ~23.6 ML and, after August 1951 through the end of disposal in November 1955, an additional 82.6 ML was disposed (see Appendix A of the main T Complex Conceptual Model report). Thus the disposal history supports the possibility of a significant influx of gamma activity between August 1951 and the next logging event in 1963. Boreholes 299-W10-70 and 299-W10-71 both indicate no contamination at any time suggesting this portion of the tile field (the western end farthest from the waste inlet pipe) received very little effluent overflowing from the 216-T-7 crib and that no lateral migration of contaminants has occurred at these locations from the 216-T-32 or 216-T-5 waste sites.

5.4.4 241-T FARM

The 241- T tank farm is currently managed by Washington River Protection Solutions and numerous reports have been issued regarding contamination from various sources in the farm." Although 241-T Farm is not part of the 200-DV-1 OU, there is a potential for contamination originating in the farm to migrate below nearby 200-DV-1 waste sites in the deep vadose zone. For the purpose of depicting possible relationships of logging data relative to the farm and the waste sites, three boreholes were selected that are generally associated with tank farm contamination and are spatially related by cross sections and visualizations to the 200-DV-1 waste sites contamination. Refer to Appendix A-2 for a list of references for all borehole geophysical logging data that have been acquired in 241-T Farm. Myers (2005) contains a comprehensive evaluation of contamination in 241-T-Farm.

Figure 5-8 shows a cross section beginning near the 241-T-106 tank and extending southwest to the 216-T-7 crib. Figure 5-11 is a visualization of the contaminant relationships between 241-T-106 and the waste sites. Although there appears to be no commingling of waste from the T tank farm with the waste sites, it is possible the boreholes are not deep enough to intercept deep contaminant plumes. Figure 5-13 is a visualization of contamination below 241-T Farm at a depth of 71 ft derived from a baseline spectral gamma data set acquired in the late 1990's and early 2000s (DOE 2000). Figure 5-14 is a plan view of Co-60 that is in or below the CCu strata that suggests Co-60 contamination (and possibly other mobile contaminants such as nitrate and Tc-99) is continuing to migrate downward in the vadose zone below the T tank farm. This information of apparent Co-60 continued migration is derived from a re-baseline of 30 boreholes acquired in 2008 prior to a barrier being placed over portions of the farm (Field 2010).

5.5 SUMMARY OF SUBREGION AND CONCLUSIONS

The 216-T-5 trench does not have sufficient boreholes to adequately characterize the site. The existing boreholes are not deep enough or are not optimally located. However, this trench was used on a specific retention basis in May 1955 to free up tank space in T Farm (241-T-110, -111, -112 cascade) and did not receive significant volumes of waste (3.15 ML or 832,000 gallons) compared to the other two facilities in the subregion 216-T-32 (29 ML) and 216-T-7 (107 ML).

The 216-T-32 cribs #1 & #2 received T-224 building waste from tank 241-T-201. As presented by Brown and Ruppert (1948), plutonium and fission product contamination extended laterally for large distances. However, it is believed the fission products consisted mainly of short-lived radionuclides and the plutonium and fission products did not migrate below 35 to 45 ft (10.7 to 13.7 m) in depth through

1950. This early work by Brown and Ruppert are the only direct measurements of contamination in the sediments below and proximal to the 216-T-32 cribs, thus after 1950 only field logging information is available to track migration in the vadose zone. . The field logging suggests that the contamination in the vadose zone migrated to the southwest in a lateral fashion from the 216-T-32 cribs down the dip of a geologic subunit identified as Hf1a, silty sandy layer. This silty unit is relatively thin and defined near the geologic contact between of the Hf1 and Hf2 and appears to be local in extent, ranging in thickness from 10 ft (3.1 m) to less than 4 ft (1.2 m) in the southerly direction. Pu-239 and Am-241 and low concentrations of Cs-137 and Eu-154 appear to be contained within this unit and probably originated from the 216-T-32 cribs. Near the 216-T-7 tile field, the top of the Cs-137 contamination may correspond with this unit but the majority of the contamination exhibits much higher concentrations and extends to much greater depths. The current vadose zone conceptualization for the vadose zone proximal and below the waste sites is shown in Figures 5.2, 5.3 5-5, 5.6, 5.7, and 5.11. Figures 5.2 and 5.3 suggest that vadose zone contamination and fluids from 216-T-32 may have commingled with fluids from the 216-T-7 (200-200-W-52) crib and tile field. However, Figure 5.3 suggests that higher concentrations of gamma emitters are found in the 216-T-7 crib. Figure 5.5 suggests that the deepest penetration of significant concentrations of Cs-137 is found at borehole 299-W10-72 in the southern extent of the 216-T-7 tile field. Figure 5.6 (Pu) suggests most of the Pu is between the 216-T-32 and 216-T-7 facilities in a region down dip from 216-T-32. There appears to be some Pu directly below the 216-T-32 facility. Based on the Pu inventories found in the SIM data base, 216-T-32 received 5.4 curies of Pu-239 and 216-T-7 received 236 Ci of Pu-239. Because both facilities are calculated to have received similar pore volumes of effluent, the concentrations of Pu in the waste fluids should have been similar and thus one would expect 216-T-7 to be a much more likely source of the bulk of the plutonium. Note: The MDL using spectral gamma logging for Pu is relatively high at about 10 nCi/g in the absence of other significant gamma emitters. In intervals of high concentrations of Cs-137 as exhibited in the 216-T-7 area, the MDL can be much higher and would likely not be detected by logging. Therefore, the apparent absence of Pu in high activity zones is not conclusive. In a similar fashion based on 216-T-7 receiving 340 curies of Cs-137 (decayed to 9-30-2010) and 216-T-32 receiving only 2.3 curies, it would seem that most of the Cs-137 observed in the vadose zone below and between these two facilities would have originated from wastes disposed to the 216-T-7 crib and tile field. The visualizations in Figures 5.7 and 5-11 seem to support 216-T-7 as having more Cs-137 close by.

The 216-T-7 crib and tile field appears to have contaminated a large portion of the vadose zone in the subregion, with gamma contamination extending to the bottoms of many nearby boreholes. One borehole, 299-W10-3, suggests contaminants may have reached groundwater by 1963. Fecht (1977) used this borehole to conclude that groundwater could have been contaminated by this facility. An influx of Cs-137 contamination (a relatively well sorbing radionuclide) occurred below 80 ft (24.4 m) bgs in two boreholes in the 216-T-7 tile field between 1951 and 1963. This suggests that other more mobile contaminants could have migrated to greater depths and may have spread laterally to cover a larger area in the vadose zone.

The lack of characterization data for actual sediments proximal and between the 216-T-32 and 216-T-7 crib and tile field makes it difficult to objectively determine whether both facilities or just one (more likely the 216-T-7 crib and tile field) have impacted groundwater. Based on the mass estimates (see discussion in the main T Complex conceptual model report and its Appendix A) disposed in this subregion, the 216-T-7 crib and tile field received the vast majority of the total masses disposed to the three facilities (excluding the T tank farm). Thus we would conclude that the 216-T-7 crib and tile field is the current facility in the subregion that warrants the most vadose zone characterization and has likely been a source of the historical and current groundwater contamination below the subregion.

5.6 RECOMMENDATIONS

In terms of the deep vadose zone there are potentially significant data gaps identified by geophysical logging: Contamination associated with the 216-T-5 trench is poorly defined as to nature and extent. An

investigation of the deep vadose zone southwest (downdip) of the trench is recommended to evaluate this data gap.

The 216-T-32 area was reasonably well characterized by Brown and Ruppert (1948) in 1948. However, additional waste disposal continued until May of 1952. From the start of operations through 1948, 216-T-32 cribs received 9.6 ML of waste but from 1949 through the end of disposal the 216-T-32 cribs received an additional 19.4 ML of waste. Based on the available data and estimates of mass disposed to the 216-T-32 crib and 216-T-7 crib and tile field, a deep vadose zone investigation is recommended.

Much speculation has occurred in the past as to the impact of the 216-T-7 crib and tile field to the deep vadose zone. 216-T-7 likely was the most significant contributor to residual vadose zone contamination, excluding the T tank farm. The eight boreholes immediately surrounding the crib should be decommissioned because they currently serve no useful purpose for monitoring contamination, and may act as pathways for downward migration. There is evidence that contaminated fluids entered the casings through perforations in the past. Today, most of these boreholes are inaccessible due to potentially contaminated water retained in their casings or they have been buried by windblown sand. The depth of the boreholes is not sufficient to adequately characterize the deep vadose zone.

The 216-T-7 facility appears to be the most significant contributor to the groundwater plume below the subregion.

The impact, if any, from the 241-T-Farm to the deep vadose zone beneath the Cold Creek unit in the areas near the 216-T-32, -T-7, and -T-5 and under these waste sites is not well known. It is clear that the 1973 leak from 241-T-106 has placed significant masses of contamination in the sediments below tank 241-T-106 and has spread to the south and west (ARCHO 1973, Routson et al. 1979, Brown et al. 1979, and Serne et al. (2004).

The conceptual model for the 241-T-106 leak presented in Serne et al. (2004) suggests that tank fluids descended with a strong vertical component from the tank bottom down to the Cold Creek unit where it started to spread laterally to the west with perhaps a southern component with some continued vertical descent into the fine grained RFtf unit where a capillary break seems to be holding the fluid and contaminants from deeper penetration (at least at the location of the three boreholes). Over the approximate ten years between the drilling of boreholes 299-W10-196 and C4104 there appears to have been a vertical descent of mobile contaminants of a few feet deeper into the RFtf unit.

It is recommended that additional characterization data be obtained between C4105 (associated with the leaking tank) and the 216-T-32 and 216-T-7 cribs to further assess and differentiate the vadose waste sources. The characterization would differentiate whether fluids from the 241-T-106 leak may have reached and commingled with fluids that may have spread upgradient from hydraulic forces caused by mounding and the active disposal of large volumes of waste to the 216-T-32 and 216-T-7 cribs.

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TABLE 5-1. SUMMARY OF BOREHOLES IN THE 216-T-32 AND 216-T-7 SUBREGION

Brown & Ruppert ID	ID #	Well Number	Date Drilled	Depth	1951 Log
224-T-1	A7146	299-W10-56	6/47	150	
224-T-2	A7147	299-W10-57	6/47	150	
224-T-3	A7148	299-W10-58	7/47	150	
224-T-4	A7136	299-W10-1	8/47	306	
224-T-5	A7154	299-W10-64	7/47	75	
224-T-6	A7155	299-W10-65	8/47	75	
224-T-7	A7165	299-W10-75	10/47	75	
224-T-8	A7166	299-W10-76	10/47	75	
224-T-9	A7170	299-W10-80	9/51	115	10/10/51
224-T-10	A4896	299-W10-2	12/51	229	
241-T-1	A7164	299-W10-74	10/47	49	
241-T-2	A7149	299-W10-59	7/47	150	
241-T-3	A7150	299-W10-60	7/47	150	
241-T-4	A7156	299-W10-66	9/47	125	
241-T-5	A7151	299-W10-61	7/47	150	
241-T-6	A7152	299-W10-62	7/47	150	
241-T-7	A7157	299-W10-67	8/47	150	
241-T-8	A7153	299-W10-63	7/47	150	9/5/51
241-T-9	A7158	299-W10-68	8/47	150	
241-T-10	A7159	299-W10-69	8/47	150	9/5/51
241-T-11	A7160	299-W10-70	8/47	150	
241-T-12	A7161	299-W10-71	8/47	150	
241-T-13	A7162	299-W10-72	8/47	150	8/23/51
241-T-14	A7163	299-W10-73	10/47	75	9/5/51
241-T-15	A4897	299-W10-3	11/51	239	

TABLE 5-2. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1951 (WASTE SITE DESIGNATION PREFIX - 216)

WASTE SITE	WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	DATE	LOG TYPE	CONTAMINATION HISTORY	SUMMARY
T-5	299-W10-1	A7136	224-T-4	SUBMITTED	305	09-JUN-59	GG	elevated gamma approximately 10-160 ft, max at 40 ft	1959 and 1963 data indicate contamination from 10 ft to approximately 80 ft with a peak near 40 ft. By 1968 appears to have decayed to near background levels. A peak at 40 ft remains at a count rate similar to that of the CCu below 80 ft, suggesting no remaining contamination.
	299-W10-1	A7136		YES	305	01-MAY-63	GG	shows decay of elevated gamma activity; maximum count rate at 40 ft	
	299-W10-1	A7136		YES		10-APR-68	TEMP.	Nine temperature logs in water between 1962 and 1968; not interpreted	
	299-W10-1	A7136		YES	305	12-APR-68	GG	shows decay of elevated gamma activity; peak remains at approximately 40 ft which could be natural	
	299-W10-1	A7136		YES	305	09-APR-70	GG	decayed to near background levels; peak at 40 ft appears natural	
	299-W10-1	A7136		YES	305	23-FEB-76	GG	decayed to near background levels; peak at 40 ft appears natural	
	299-W10-1	A7136		YES	305	22-JUN-76	DENSITY	Not interpreted	
	299-W10-1	A7136		SUBMITTED	305	01-MAR-77	NEUTRON	Not interpreted	
	299-W10-1	A7136		YES	305	13-AUG-87	GG	decayed to near background levels; peak at 40 ft appears natural	
T-106	299-W10-168	A7251	50-00-09	SUBMITTED	122	10-FEB-98	SGLS	Cs: 0.946 pCi/g at 0 ft; Co: 47-58.5 ft, 61-95 ft, 97-108.5 ft, 111-119.5 ft, max 33.73 pCi/g at 51.5 ft; Eu-154: 46.5-56.5 ft, 67.5-75.5 ft, 106-118.5 ft, max 199.54 at 48 ft; Eu-152: 47.5-53.5 ft max 5.0 pCi/g at 48 ft	
	299-W10-168	A7251		SUBMITTED	122	7-AUG-08	SGLS	Cs: 0.4 pCi/g at 77 ft; Co: 47-90 ft, max 7.8 pCi/g at 51.5 ft; Eu-154: 46.5-56 ft, 66.5-73 ft, max 107.5 pCi/g at 48 ft; Eu-152: 47.5-54.5 ft, max 3.5 pCi/g at 48 ft	
	299-W10-2	A4896		YES	215	7-MAY-76	GG	Elevated 75-102 ft, max at 87 ft	Contamination indicated in CCu before 1976; by 1987 had decayed to background levels
	299-W10-2	A4896		YES	215	21-JUN-76	DENSITY	Not interpreted	
	299-W10-2	A4896		YES	215	29-NOV-76	DENSITY	Logged without source; not interpreted	
	299-W10-2	A4896		YES	215	25-FEB-77	NEUTRON	Not interpreted	
	299-W10-2	A4896		YES	230	21-JUL-87	GG	shows decay since 1976; remaining elevated activity between 85 and 98 ft is interpreted to be the Ccu	
	299-W10-28	C3400		YES	277	29-SEP-01	NMLS	Relatively higher from 111-128 ft and 175-227 ft	No contamination indicated
T-32	299-W10-28	C3400		YES	277	02-OCT-01	SGLS	No manmade radionuclides detected; drilled September 2001	
T-7	299-W10-3	A4897	221-T-15, 241-T-15	SUBMITTED	227	9-JUN-59	GG	elevated gamma 35 to total depth of borehole with a max at approximately 41 ft	The 1959 log indicates contamination to total depth of the borehole. Between 1959 and 1986 gamma logs shows gradual decay consistent with Cs decay. SGLS detected Cs over most of the logging event with a max of 873.95 pCi/g at 41.5 ft, Co at 214-229 ft with a max of 0.22 pCi/g at 228.5 ft, Eu-154 at 45-52 ft with a max of 0.95 pCi/g at 46.5 ft. Co appears to be associated with groundwater of various historical depths. Co in groundwater may have originated from more distant location as no Co was detected in current SGLS logs higher in the vadose zone.
	299-W10-3	A4897		YES	227	1-MAY-63	GG	shows decay but probably contaminated to TD; highest activity between 40 and 100 ft	
	299-W10-3	A4897		YES	227	9-JUN-65	NEUTRON	Relatively higher moisture from 84 to 120 ft in the Ccu	
	299-W10-3	A4897		YES	227	9-APR-70	GG	shows decay; highest activity remains between 40 and 100 ft	
	299-W10-3	A4897		YES	227	7-MAY-76	GG	profile remains the same as in 1970 with some decay	
	299-W10-3	A4897		YES	227	21-JUN-76	DENSITY	Not interpreted	
	299-W10-3	A4897		YES	227	29-NOV-76	DENSITY	Measurement without the gamma source reflects the Cs in borehole from 40 to 55 ft	
	299-W10-3	A4897		YES	227	1-MAR-77	NEUTRON	No interpretation	
	299-W10-3	A4897		YES	227	3-JUL-86	GG	High activity from 50 to 90 ft; remainder of borehole might be slightly contaminated	
	299-W10-3	A4897		YES	239	27-JUL-98	SGLS	Cs: 0-36 ft, 38.5-196 ft, 204-222 ft, max 873.95 pCi/g at 41.5 ft; Co: 214-229 ft, max 0.22 pCi/g at 228.5 ft, Eu-154: 45-52 ft, max 0.95 pCi/g at 46.5 ft	
	299-W10-52	A7142		YES	148	30-APR-63	GG	Not interpreted	
	299-W10-52	A7142	241-T-134	SUBMITTED	148	23-MAR-98	SGLS	Cs: 0-0.5 ft & 75 ft. max 0.66 pCi/g at 0.5 ft	
T-32	299-W10-56	A7146	224-T-1	YES	138	1-MAY-63	GG	Elevated gamma 32-40 ft and 82-85 ft, reflects relatively high K-40 and possibly low level Cs.	1963 & 1976 logs show elevated gamma 32-40 ft and 85-92 ft. The interval from 32 to 40 represents mostly K-40 although current data indicate Cs at approximately 1.5 pCi/g. The interval from 83 to 92 is the CCuz - silt dominated unit.
	299-W10-56	A7146		YES	138	7-MAY-76	GG	Near background activity	
	299-W10-56	A7146		YES	138	25-JUN-76	DENSITY	Not interpreted	
	299-W10-56	A7146		YES	145	4-NOV-08	PNLS	No evidence of alpha emitting radionuclides	
	299-W10-56	A7146		YES	145	4-NOV-08	NMLS	Relatively high in Ccu from 85-123 ft.	
	299-W10-56	A7146		YES	145	04-NOV-08	SGLS	Cs: 0-1 ft, 32-40 ft, max 1.4 pCi/g at 33.5 ft	
T-32	299-W10-57	A7147	224-T-2	YES	147	01-MAY-63	GG	elevated gamma at approximately 83-92 ft attributed to Ccuz silt dominated unit	1963 & 1976 scintillation show elevated gamma 83-92 ft that represents the Ccuz- silt dominated unit. Cs exists at 0-1 ft with a max concentration of 0.3 pCi/g at 0.5 ft.
	299-W10-57	A7147		YES	147	07-MAY-76	GG	elevated gamma at approximately 83-92 ft attributed to Ccuz silt dominated unit	
	299-W10-57	A7147		YES	147	25-JUN-76	DENSITY	Not interpreted	
	299-W10-57	A7147		YES	147	01-MAR-77	NEUTRON	Not interpreted	
	299-W10-57	A7147		YES	145	07-NOV-08	PNLS	None	
	299-W10-57	A7147		YES	145	07-NOV-08	NMLS	Relative moisture increase 85-120 ft that includes the Ccu and RFtf	
	299-W10-57	A7147		YES	145	07-NOV-08	SGLS	Cs: 0-1 ft, max 0.3 pCi/g at 0.5 ft.	
T-32	299-W10-58	A7148	224-T-3	SUBMITTED	137	1-MAY-63	GG	elevated gamma 32-42 ft, 85-92 ft	1963 & 1976 logs show elevated gamma from approximately 32-42 ft and 85-92 ft, with gradual decay in the interval from 32 to 42 ft. The 85-92 ft
	299-W10-58	A7148		YES	137	7-MAY-76	GG	Elevated 33-44 ft, 84-96 ft, max at 43 ft	

TABLE 5-2. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1951 (WASTE SITE DESIGNATION PREFIX - 216)

WASTE SITE	WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	DATE	LOG TYPE	CONTAMINATION HISTORY	SUMMARY
	299-W10-58	A7148		YES	137	24-NOV-76	DENSITY	Not interpreted	interval results from the CCuz - silt dominated unit. The 2008 SGLS shows Cs at 33.5-51 ft with a max concentration of 1.3 pCi/g at 43.5 ft, Pu-239 at 34, 42.5 & 43 ft with a max concentration of 26,000 pCi/g at 42.5 ft, Eu-154 at 34 & 42.5 ft with a max concentration of 0.3 pCi/g at 42.5 ft.
	299-W10-58	A7148		YES	136	12-NOV-08	SGLS	Cs: 33.5-51 ft, max 1.3 pCi/g at 43.5 ft.; Pu-239: 34, 42.5 & 43 ft, max 26,000 pCi/g at 42.5 ft; Eu-154: 34, & 42.5 ft, max 0.3 pCi/g at 42.5 ft.	
	299-W10-58	A7148		YES	136	16-JAN-09	PNLS	Possible Pu-239: 34 ft, 42-45 ft	
	299-W10-58	A7148		YES	136	19-JAN-09	NMLS	Relatively high moisture in Ccu from approximately 85-130 ft	
T-7	299-W10-59	A7149	221-T-2, 241-T-2	YES	130	1-MAY-63	GG	elevated gamma 20-140 ft, detector saturated from 28 to 36 ft and from 60 to 84 ft	1963 & 1976 scintillation show elevated gamma from approximately 20-140 ft. Saturation of detectors possible from 28 to 36 ft and from 60 to 84 ft. 2008 SGLS detected Cs over the total depth of the borehole. High rate logging between 44 and 82 ft not performed due to water in borehole. HRLS detected a max concentration of 357,000 pCi/g at 37 ft although activity could be higher between 44 and 82 ft.
	299-W10-59	A7149		YES	135	6-DEC-76	GG	Similar profile as 1963; Possible detector saturation between 28 and 84 ft.	
	299-W10-59	A7149		YES		1-MAR-77	NEUTRON	Not interpreted	
	299-W10-59	A7149		SUBMITTED	137	20-NOV-08	SGLS	Cs: 24-136.5 ft, TD. Cs approximately 1 pCi/g at bottom of borehole.	
	299-W10-59	A7149		SUBMITTED	42	31-DEC-08	HRLS	Cs: max 357,000 pCi/g at 37 ft. Due to water in the borehole, interval from 44 to 82 ft not measured.	
	299-W10-59	A7149		SUBMITTED	37	22-JAN-09	PNLS	Did not log below 37 ft where water exists in borehole. No apparent neutron activity. Elevated count rate at 37 ft due to high Cs activity.	
	299-W10-59	A7149		SUBMITTED	37	26-JAN-09	NMLS	Did not log below 36 ft where water exists in borehole. No significant changes apparent.	
T-7	299-W10-60	A7150	221-T-3, 241-T-3	YES	139	1-MAY-63	GG	elevated gamma 0-139 ft, very high activity between 28 and 84 ft	1963 & 1976 gamma logs show elevated gamma at approximately 30-122 ft.
	299-W10-60	A7150		YES	139	06-DEC-76	GG	elevated gamma 0-139 ft, very high activity between 28 and 84 ft	
T-7	299-W10-61	A7151	221-T-5, 241-T-5	YES	115	1-MAY-63	GG	elevated gamma to bottom of borehole 0-115; ft Very high activity from 20 to 84 ft.	1963 & 1976 gamma logs show elevated gamma from approximately 20 ft to bottom of logging event. Very high gamma activity exists from 24 to 84 ft.
	299-W10-61	A7151		YES	110	6-DEC-76	GG	elevated gamma to bottom of borehole 0-115; ft Very high activity from 20 to 84 ft.	
T-7	299-W10-62	A7152	221-T-6, 241-T-6	YES	141	1-MAY-63	GG	elevated activity from ground surface to 140 ft; very high activity from 28 to 80 ft	Contamination observed from 28 ft to bottom of borehole in earliest logs. Current profile indicates Cs-137 from 30 to 107 ft with a maximum concentration of 600,000 pCi/g
	299-W10-62	A7152		YES	141	24-NOV-76	DENSITY	Not interpreted	
	299-W10-62	A7152		YES	141	6-DEC-76	GG	elevated activity from 30-102 ft; very high activity from 28 to 80 ft	
	299-W10-62	A7152		YES	141	1-MAR-77	NEUTRON	Not interpreted	
	299-W10-62	A7152		SUBMITTED	133	21-NOV-08	SGLS	Cs: 30-107 ft	
	299-W10-62	A7152		SUBMITTED	81	23-DEC-08	HRLS	Cs: max 660,000 pCi/g at 38 ft	
	299-W10-62	A7152		SUBMITTED	133	27-JAN-09	PNLS	No indication of neutron activity that would suggest the existence of TRU	
	299-W10-62	A7152		SUBMITTED	133	28-JAN-09	NMLS	relative increase in the Ccu and RFtf	
T-7	299-W10-63	A7153	221-T-8, 241-T-8	YES	74	5-SEP-51	GG	Elevated 36-52 ft, max at 41 ft	Elevated activity from 36 to 52 ft in 1951. An influx of contamination since 1951 is shown in 1963 from 58 to bottom of the borehole at 130 ft. The deep contamination below 90 ft appears to have decayed away by 1976.
	299-W10-63	A7153		YES	130	30-APR-63	GG	elevated gamma 40-130 ft, very high activity from 40 to 100 ft	
	299-W10-63	A7153		YES	139	6-DEC-76	GG	elevated gamma 40-96 ft, high activity from 58 to 80 ft	
	299-W10-63	A7153		YES	130	1-MAR-77	NEUTRON	Not interpreted	
T-32	299-W10-64	A7154	224-T-5	YES	65	01-MAY-63	GG	elevated gamma 32-40 ft, max at 36 ft	Elevated gamma in 1963 between 35 and 47.5 ft. Cs-137 exists at 1 pCi/g and Pu-239 at 19,000 pCi/g.
	299-W10-64	A7154		YES	65	07-MAY-76	GG	elevated 36-45 ft, max at 38 ft	
	299-W10-64	A7154		YES	65	01-MAR-77	NEUTRON	Not interpreted	
	299-W10-64	A7154		SUBMITTED	65	13-NOV-08	SGLS	Cs: ground surface & 34-47.5 ft, max 1.15 pCi/g at 37 ft; Pu-239: 19,000 pCi/g at 37.5 ft.	
	299-W10-64	A7154		SUBMITTED	65	20-JAN-09	NMLS	relatively higher from 34-65 ft	
	299-W10-64	A7154		SUBMITTED	65	20-JAN-09	PNLS	Possible Pu-239: 34-40 ft	
T-32	299-W10-65	A7155	224-T-6	YES	75	01-MAY-63	GG	elevated gamma 38-58 ft	Low activity contamination from 38 to 58 ft in 1963. Cs-137 currently exists in this interval at less than 2 pCi/g
	299-W10-65	A7155		YES	75	07-MAY-76	GG	Elevated 38-58 ft, max at 38 ft	
	299-W10-65	A7155		SUBMITTED	72	01-MAR-77	NEUTRON	Not interpreted	
	299-W10-65	A7155		SUBMITTED	72	17-NOV-08	SGLS	Cs: 0 ft, 34.5-57 ft, max 1.3 pCi/g at 45 ft;	
	299-W10-65	A7155		SUBMITTED	72	21-JAN-09	NMLS	relatively high 49-57 ft & 69 ft	
	299-W10-65	A7155		YES	72	21-JAN-09	PNLS	No indication of neutron activity that would suggest the existence of TRU	
	299-W10-66	A7156		YES	104	5-SEP-51	GG	Not interpreted	Borehole is contaminated to bottom.
T-7	299-W10-66	A7156	221-T-4, 241-T-4	YES	104	30-APR-63	GG	elevated gamma 5-104 ft, very high activity from 20 to 78 ft	
	299-W10-66	A7156		YES	102	6-DEC-76	GG	Elevated 18-96 ft, high activity from 20 to 80 ft and 102 ft at bottom of borehole	
	299-W10-66	A7156		YES	104	1-MAR-77	NEUTRON	Not interpreted	

TABLE 5-2. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1951 (WASTE SITE DESIGNATION PREFIX - 216)

WASTE SITE	WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	DATE	LOG TYPE	CONTAMINATION HISTORY	SUMMARY
T-7	299-W10-67	A7157	221-T-7, 241-T-7	YES	138	1-MAY-63	GG	elevated gamma 42-132 ft, max at 72 ft	Borehole shows contamination from 40 ft to the bottom since 1963.
	299-W10-67	A7157		YES	138	29-NOV-76	DENSITY	Not interpreted	
	299-W10-67	A7157		YES	138	6-DEC-76	GG	elevated gamma 42-120 ft, 129-131 ft	
	299-W10-67	A7157		SUBMITTED	142	25-NOV-08	SGLS	Cs: 0 ft, 43-135 ft	
	299-W10-67	A7157		SUBMITTED	76	30-DEC-08	HRLS	Cs: max 86,000 pCi/g at 54 ft	
	299-W10-67	A7157		SUBMITTED	142	28-JAN-09	PNLS	No indication of neutron activity that would suggest the existence of TRU	
	299-W10-67	A7157		SUBMITTED	142	29-JAN-09	NMLS	relatively higher in Ccu and RFtf 83-124 ft	
T-7	299-W10-68	A7158	221-T-9, 241-T-9	YES	133	01-MAY-63	GG	elevated gamma 20-136 ft, max at 78 ft, very high activity from 20 to 84 ft	Contamination extends to bottom of the borehole since 1963. SGLS logging not permitted in water below 49 ft.
	299-W10-68	A7158		YES	133	06-DEC-76	GG	elevated gamma 20-136 ft, max at 78 ft, very high activity from 20 to 84 ft	
	299-W10-68	A7158		SUBMITTED	44	02-FEB-08	SGLS	Cs: 0 ft, 25-49 ft	
	299-W10-68	A7158		SUBMITTED	44	29-DEC-08	HRLS	Cs: 25 to 49 ft; could not log below water at 49 ft	
	299-W10-68	A7158		SUBMITTED	45	26-JAN-09	PNLS	Elevated count rate 32-45 ft due to high gamma activity.	
	299-W10-68	A7158		SUBMITTED	45	26-JAN-09	NMLS	Elevated 0-10 ft	
	299-W10-69	A7159	221-T-10, 241-T-10	YES	100	5-SEP-51	GG	Elevated 37-46 ft, max at 43 ft	Elevated activity in 1951 between 37 and 44 ft. An influx of contamination occurred from 80 to 120 ft between 1951 and 1963. By 1976 most contamination below 90 ft decayed away. Peaks remain at about 40 and 92 ft. By 1987 contamination had decayed away except for area around 40 ft. Minor amounts of Cs-137, Eu-154 and Pu-239 and Am-241 remain.
	299-W10-69	A7159		YES	138	1-MAY-63	GG	elevated gamma 40-46 ft, 82-120 ft, max at approximately 92 ft	
	299-W10-69	A7159		YES	138	7-MAY-76	GG	shows decay	
	299-W10-69	A7159		YES	138	25-JUN-76	DENSITY	Not interpreted	
	299-W10-69	A7159		YES	138	1-MAR-77	NEUTRON	Not interpreted	
	299-W10-69	A7159		YES	138	13-AUG-87	GG	shows decay	
	299-W10-69	A7159		SUBMITTED	134	1-JUN-06	SGLS	Cs: 39-45 ft, max 0.25 pCi/g at 39 ft; Pu-239: 39-45 ft, max 29,000 pCi/g at 42 ft; Am: 39-44.5 ft, max 83456.6 pCi/g at 41.5 ft; Eu-154 40-43 ft, max 0.3 pCi/g at 42 ft	
	299-W10-69	A7159		SUBMITTED	54	5-JUN-06	PNLS	Possible TRU 40 ft	
T-7	299-W10-70	A7160	221-T-11, 241-T-11	YES	135	2-MAY-63	GG	Background	No contaminants observed except at the surface.
	299-W10-70	A7160		YES	135	7-MAY-76	GG	Background	
	299-W10-70	A7160		YES	138	25-JUN-76	DENSITY	Not interpreted	
	299-W10-70	A7160		YES	138	01-MAR-77	NEUTRON	Not interpreted	
	299-W10-70	A7160		SUBMITTED	138	13-AUG-87	GG	Background	
	299-W10-70	A7160		YES	131	30-MAY-06	SGLS	Cs: 0-6 ft, max 0.6 pCi/g at 4 ft	
T-7	299-W10-71	A7161	221-T-12, 241-T-12	YES	135	02-MAY-63	GG	Background	No contaminants observed.
	299-W10-71	A7161		YES	135	07-MAY-76	GG	Background	
	299-W10-71	A7161		YES	135	25-JUN-76	DENSITY	Not interpreted	
	299-W10-71	A7161		YES	135	01-MAR-77	NEUTRON	Not interpreted	
	299-W10-71	A7161		YES	138	13-AUG-87	GG	Background	
T-7	299-W10-72	A7162	221-T-13, 241-T-13	YES	120	23-AUG-51	GG	Elevated 50-72 ft, 83-86 ft, max at 62 ft	In 1951 contamination observed from 50 to 86 ft. An influx of contaminants occurred between 1951 and 1963 from 80 to bottom of borehole. Cs-137 detected from 47 to 130 ft. Profile consistent with 1963.
	299-W10-72	A7162		YES	135	2-MAY-63	GG	elevated gamma 50-68 ft and 80-136, influx of contaminants below 80 ft since 1951	
	299-W10-72	A7162		YES	135	7-MAY-76	GG	elevated gamma 50-68 ft and 80-136, no apparent changes except decay since 1963	
	299-W10-72	A7162		YES		1-MAR-77	NEUTRON	Not interpreted	
	299-W10-72	A7162		YES	135	14-AUG-87	GG	elevated gamma 50-68 ft and 80-136, no apparent changes except decay since 1976	
	299-W10-72	A7162		YES	95	23-SEP-93	NAI	elevated gamma 40-136 ft	
	299-W10-72	A7162		YES	130	10-MAY-05	SGLS	Cs detected 47-130 ft, max concentration of 40,000 pCi/g at 54 and 86 ft; same profile as 1976	
	299-W10-72	A7162		YES	126	11-MAY-05	HRLS	Cs 40,000 pCi/g at 54 and 86 ft	
	299-W10-72	A7162		YES	130	13-MAY-05	PNLS	No detection of TRU, instrument influenced by high gamma activity	
	299-W10-72	A7162		YES	130	17-MAY-05	NMLS	Relatively higher in the Ccu. High gamma activity influences detector at some depths.	
T-7	299-W10-73	A7163	221-T-14, 241-T-14	YES	66	5-SEP-51	GG	Elevated activity 37-47 ft, max at 40 ft	Relatively low activity observed between 38 and 42 ft that remains approximately the same to the current time. Cs and Eu-154 detected in the

TABLE 5-2. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1951 (WASTE SITE DESIGNATION PREFIX - 216)

WASTE SITE	WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	DATE	LOG TYPE	CONTAMINATION HISTORY	SUMMARY
	299-W10-73	A7163		YES	65	2-MAY-63	GG	elevated gamma 38-44 ft	interval at less than 1 pCi/g. Am-241 and Pu-239 also detected.
	299-W10-73	A7163		YES	65	7-MAY-76	GG	elevated gamma 38-44 ft	
	299-W10-73	A7163		YES	50	23-SEP-93	NaI	elevated 38-42 ft	
	299-W10-73	A7163		YES	55	05-JUN-06	SGLS	Cs: 37.5 ft, 39-40 ft, 41.5 ft, 46 ft, max 0.98 pCi/g at 40 ft; Pu-239: 37.5-40 ft, max 62,000 pCi/g at 39.5 ft; Am: 37.5 ft, 39-40 ft, 41.5 ft, max 64,000 pCi/g at 39.5 ft; Eu-154: 38-40 ft, max 0.8 pCi/g at 39.5 ft	
	299-W10-73	A7163		YES	45	05-JUN-06	PNLS	Possible TRU at 38 ft	
T-32	299-W10-75	A7165	224-T-7	YES	65	01-MAY-63	GG	slightly elevated gamma 32-42 ft	Slight elevated activity from 32 to 42 ft is caused by an interval of sand exhibiting relatively higher K-40 concentrations.
	299-W10-75	A7165		YES	65	07-MAY-76	GG	slightly elevated gamma 32-42 ft	
	299-W10-75	A7165		YES	64	22-JUN-76	DENSITY	Not interpreted	
	299-W10-75	A7165		SUBMITTED	65	05-NOV-08	SGLS	Cs: 0.2 pCi/g at 0 ft; the slight elevation in activity from 32 to 42 ft is caused by elevated naturally occurring K-40	
	299-W10-75	A7165		SUBMITTED	64	22-JAN-09	PNLS	None	
	299-W10-75	A7165		SUBMITTED	65	22-JAN-09	NMLS	Relatively high from 50-59 ft	
T-32	299-W10-76	A7166	224-T-8	YES	72	2-MAY-63	GG	no contamination	No contamination.
	299-W10-76	A7166		YES	70	6-JUN-06	SGLS	Cs: 0-1 ft at less than 1 pCi/g	
T-7	299-W10-80	A7170	224-T-9	YES	115	10-OCT-51	GG	Elevated 40-45 ft and 60 to 100 ft, max at 90 ft	
	299-W10-80	A7170		YES	105	10-OCT-51	GG	Not interpreted	Borehole contaminated to the bottom at 104 ft. Highest activity is from 60 to 100 ft.
	299-W10-80	A7170		YES	105	1-MAY-63	GG	elevated gamma at 40 ft; high activity from 60 to 104 ft	
	299-W10-80	A7170		YES	105	7-MAY-76	GG	shows some decay; Peak at 40 ft and from 60 to 100 ft	
T-109	299-W10-114	A7264	50-09-10	YES	120	6-JAN-98	SGLS	Cs-137, Co-154, Eu152, and Co-60 detected. Co, Eu, and Cs exists to bottom or borehole.	Low concentration of Cs from 82 ft to 122 ft. Co and Eu essentially from 38 ft to 122 ft.
	299-W10-120	A7210	50-09-09	YES	118	12-DEC-97	SGLS	No contamination detected	No contamination detected
T-112	299-W10-52	A7142	50-00-08	SUBMITTED	148	30-APR-63	GG	No elevated gamma	No Detections
	299-W10-52	A7142	50-00-08	SUBMITTED	148	3-MAR-98	SGLS	No detections	
T-112	299-W10-140	A7230	50-12-07	SUBMITTED	90	10-DEC-97	SGLS	Cs-137 0-24 ft	Cs 0-24ft
T-112	N/A	C4104		YES	122	6-JUN-03	SGLS	Cs-137, Eu-154, Eu-152, and Co-60 detected. Co exists from 36.5 ft to 122 ft (bottom of borehole).	Minor amounts of Cs-137 from 45 to 50 ft. Eu detected from 35 to 85 ft and Co-60 from 36 – 122 ft.

Waste area designation contains a 216- prefix except for tanks which are 241-.

TABLE 5-3. BOREHOLES IMMEDIATELY SURROUNDING THE 216-T-7 CRIB

Borehole Name	ID	SGLS Depth of contamination ft bgs)	1963 total gamma Depth of Contamination ft bgs
299-W10-67	A7157	43 to 135	40 to 143
299-W10-60	A7150		28 to 139
299-W10-66	A7156		16 to 100
299-W10-63	A7153		40 to 140
299-W10-62	A7152	35 to 100	36 to 140
299-W10-59	A7149	25 to 135	24 to 140
299-W10-61	A7151		20 to 112
299-W10-68	A7158	30 to unknown	24 to 136
299-W10-3	A4897	40 to 220	38 to 212

FIGURE 5-1. 216-T-5, -T-32, AND -T-7 LOCATION MAP

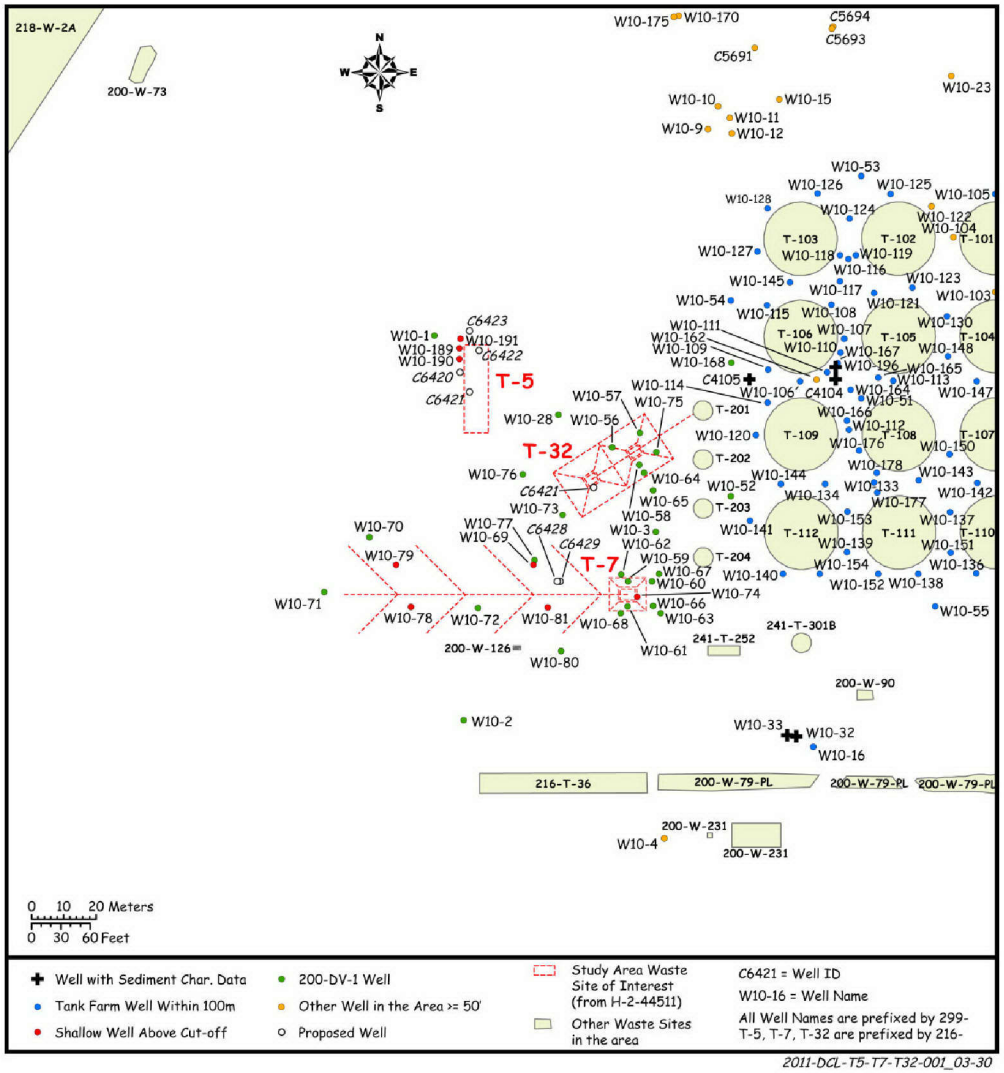


FIGURE 5-2. PLUME MAP DIGITIZED FROM BROWN AND RUPPERT (1948)

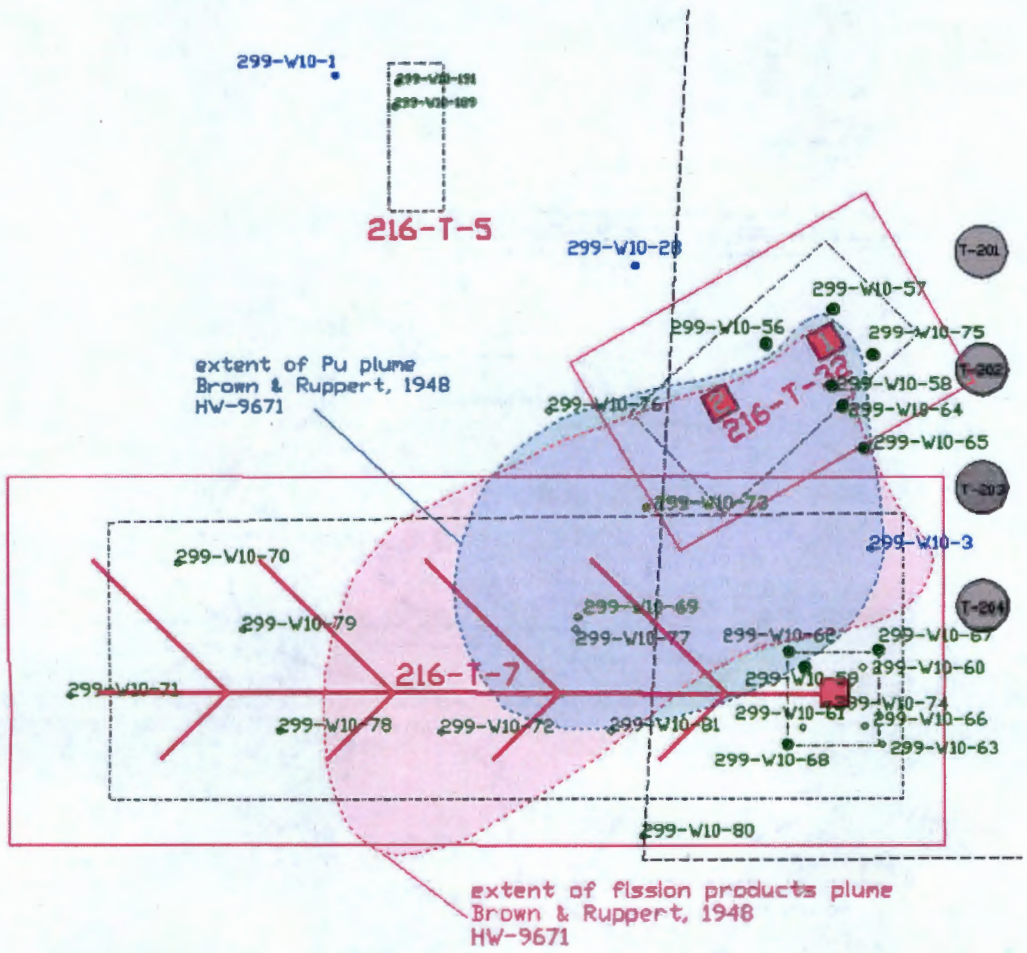


FIGURE 5-3. ISOPACH INTERPRETED AGGREGATE AREA MANAGEMENT STUDY (CONTOURS IN FT)

DOE/RL-91-61, Rev. 0

Figure A-15. 216-T-7, -32, and -36 Cribs, and 216-T-5 Trench - Elevated Gamma Radiation Isopach Map

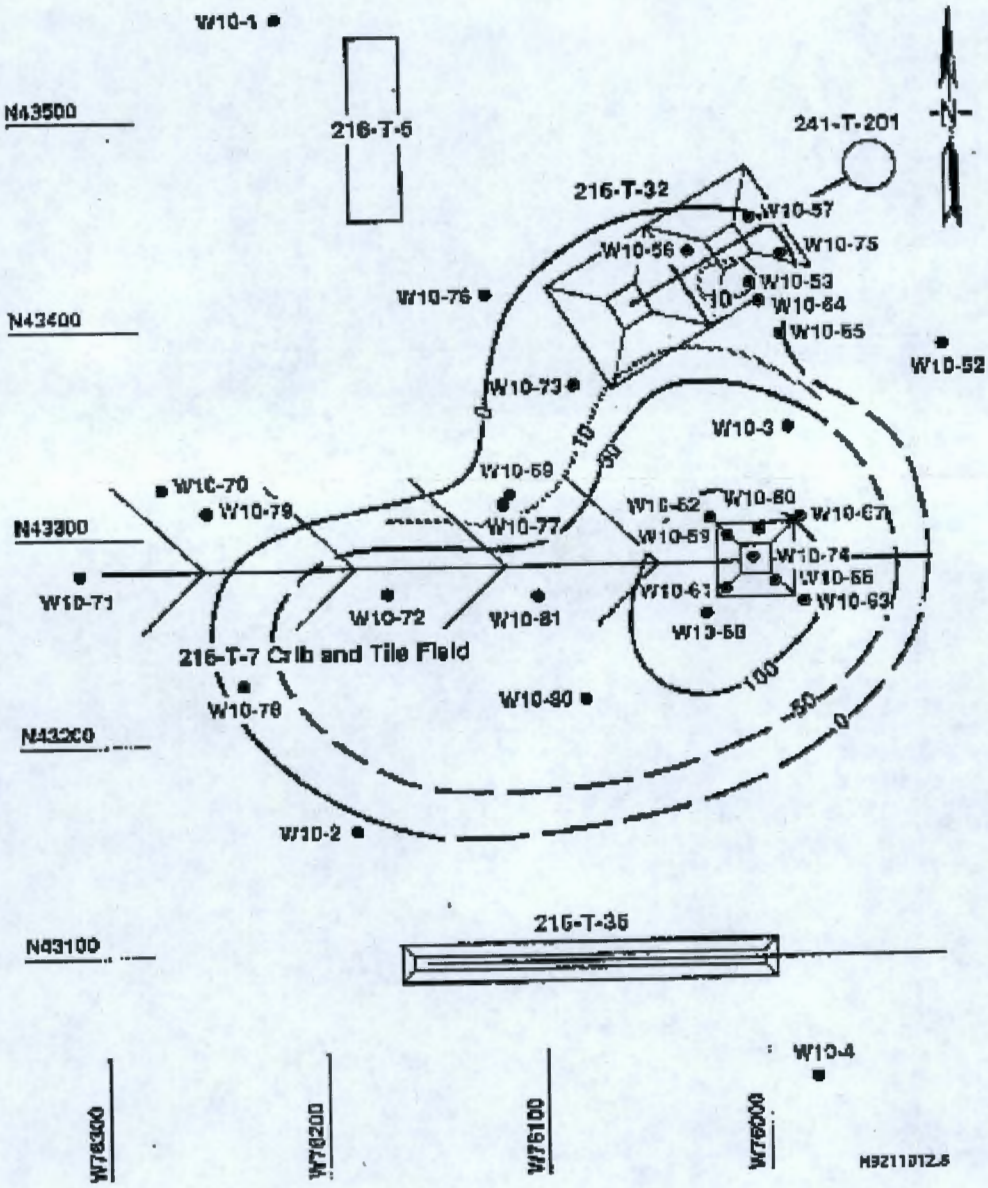
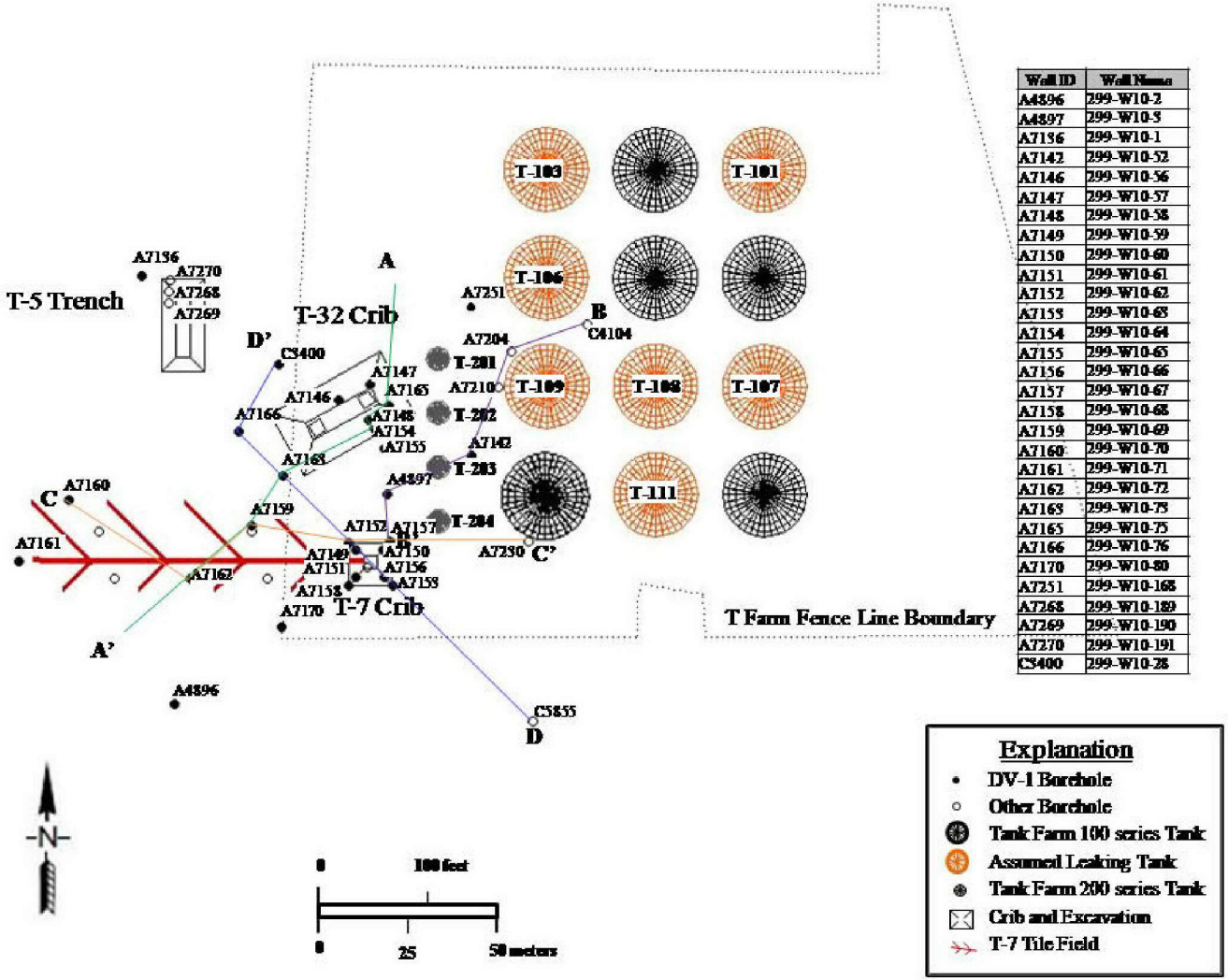


FIGURE 5-4. 216-T-5, -T-32, AND -T-7 BOREHOLE AND CROSS-SECTION LOCATIONS



Well ID	Well Name
A4896	299-W10-2
A4897	299-W10-5
A7156	299-W10-1
A7142	299-W10-52
A7146	299-W10-56
A7147	299-W10-57
A7148	299-W10-58
A7149	299-W10-59
A7150	299-W10-60
A7151	299-W10-61
A7152	299-W10-62
A7153	299-W10-63
A7154	299-W10-64
A7155	299-W10-65
A7156	299-W10-66
A7157	299-W10-67
A7158	299-W10-68
A7159	299-W10-69
A7160	299-W10-70
A7161	299-W10-71
A7162	299-W10-72
A7163	299-W10-73
A7165	299-W10-75
A7166	299-W10-76
A7170	299-W10-80
A7251	299-W10-168
A7268	299-W10-189
A7269	299-W10-190
A7270	299-W10-191
C5400	299-W10-28

FIGURE 5-5. 216-T-32 AND 216-T-7 CROSS SECTION (A-A')

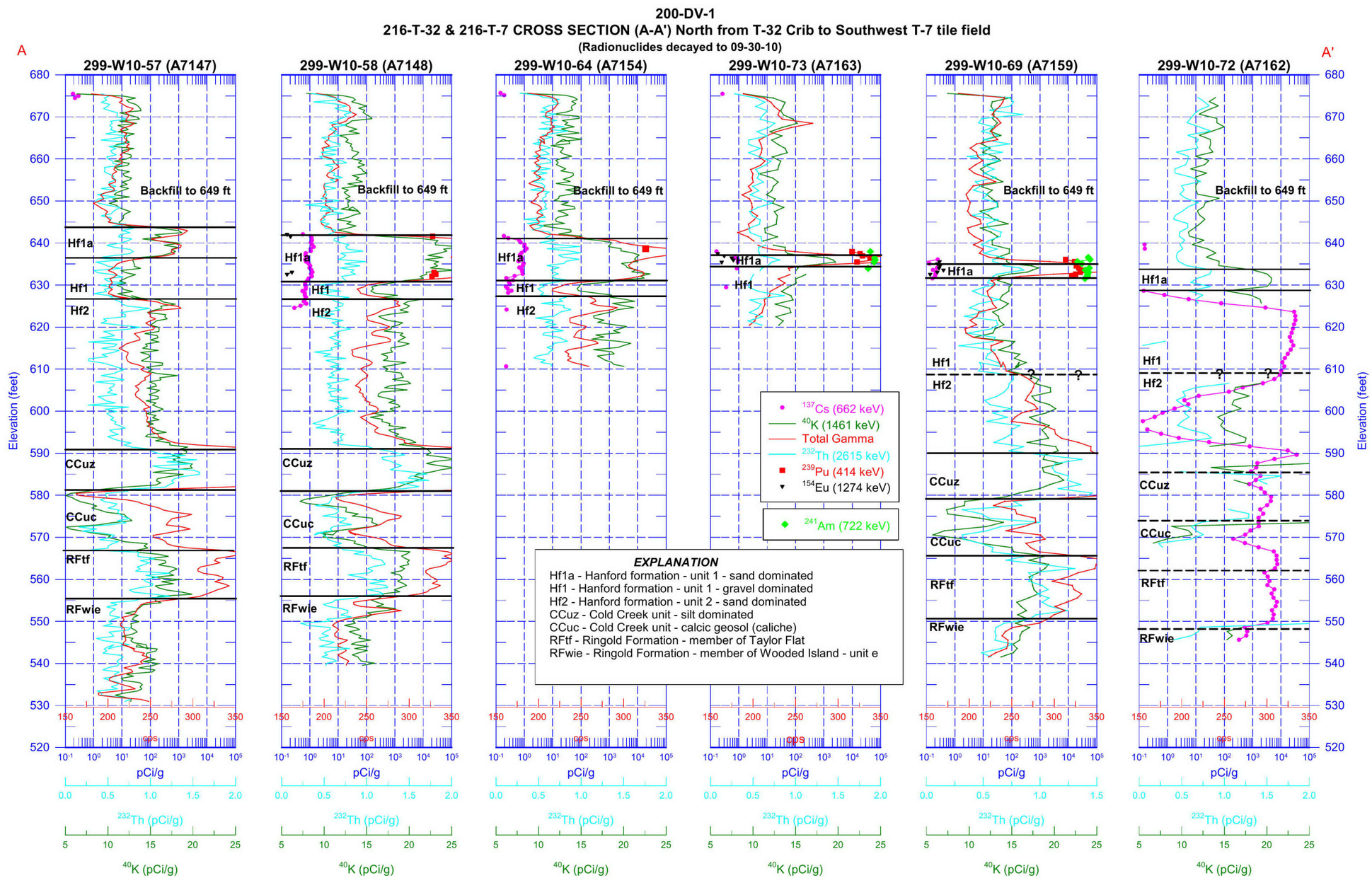


FIGURE 5-6. VISUALIZATION OF PU-239 CONTAMINATION NEAR THE 216-T-32 CRIB VIEWED FROM THE EAST

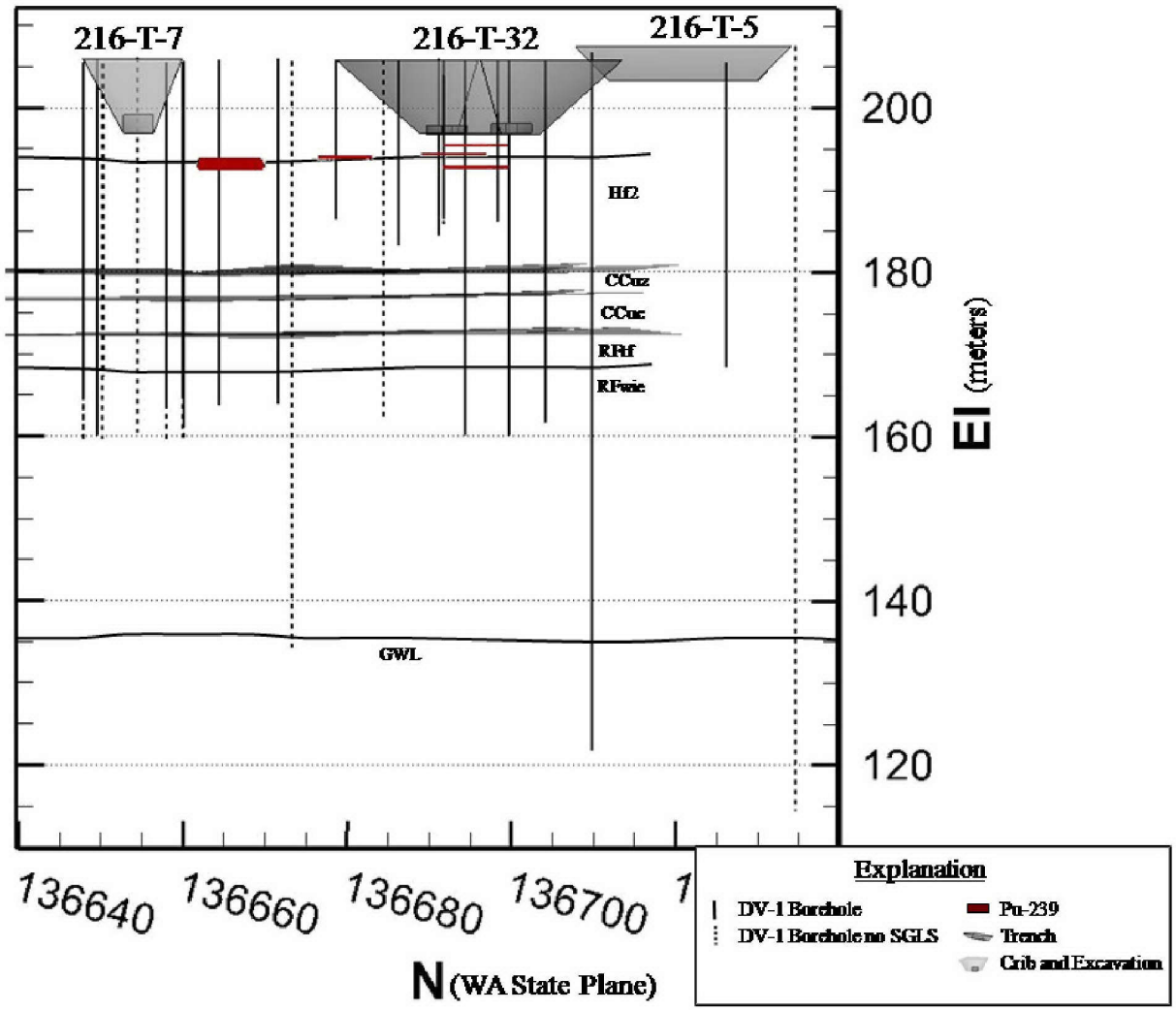


FIGURE 5-7. VISUALIZATION OF CS-137 CONTAMINATION VIEWED FROM THE EAST

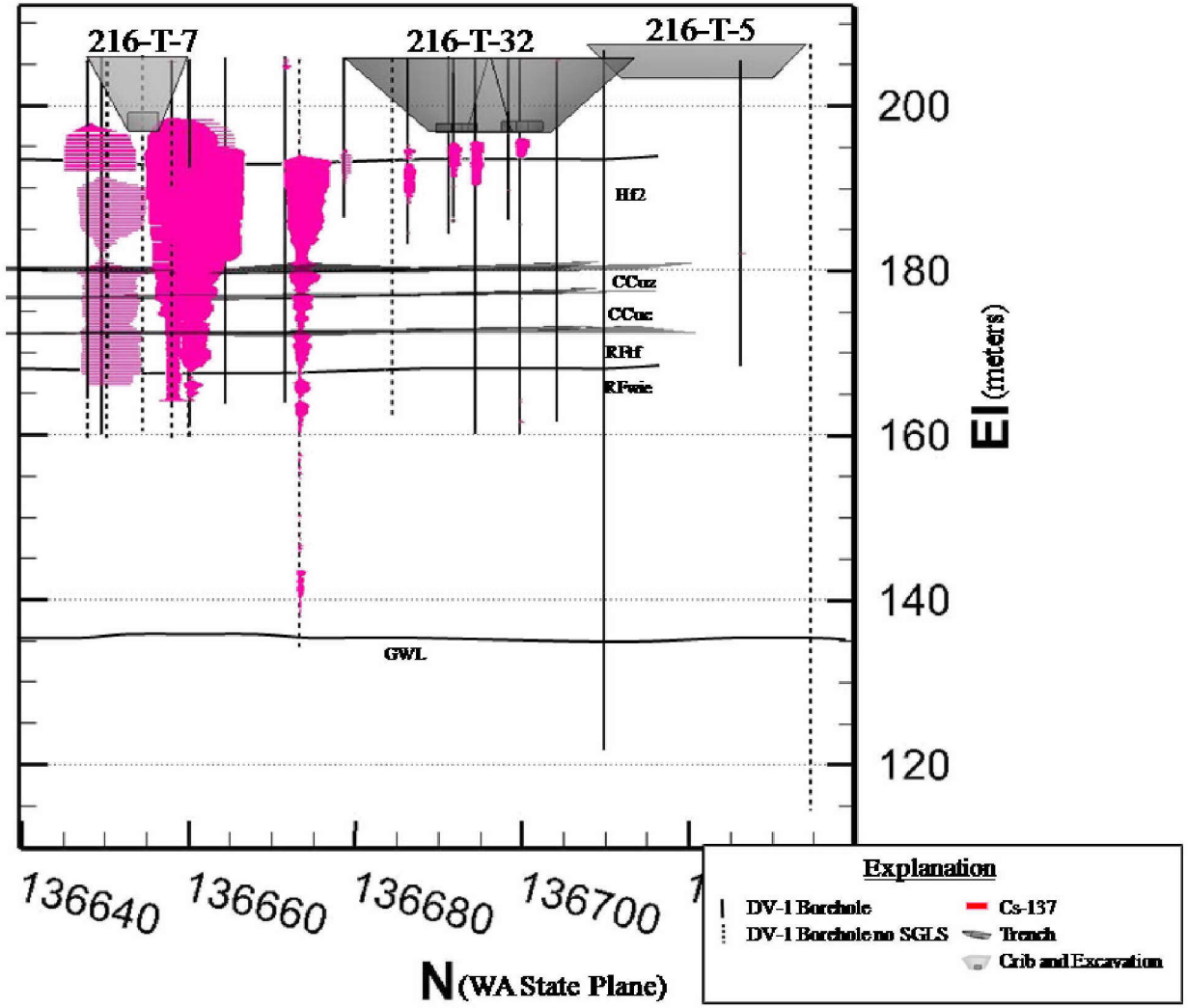


FIGURE 5-8. 241-T FARM & 216-T-7 CROSS SECTION (B-B')

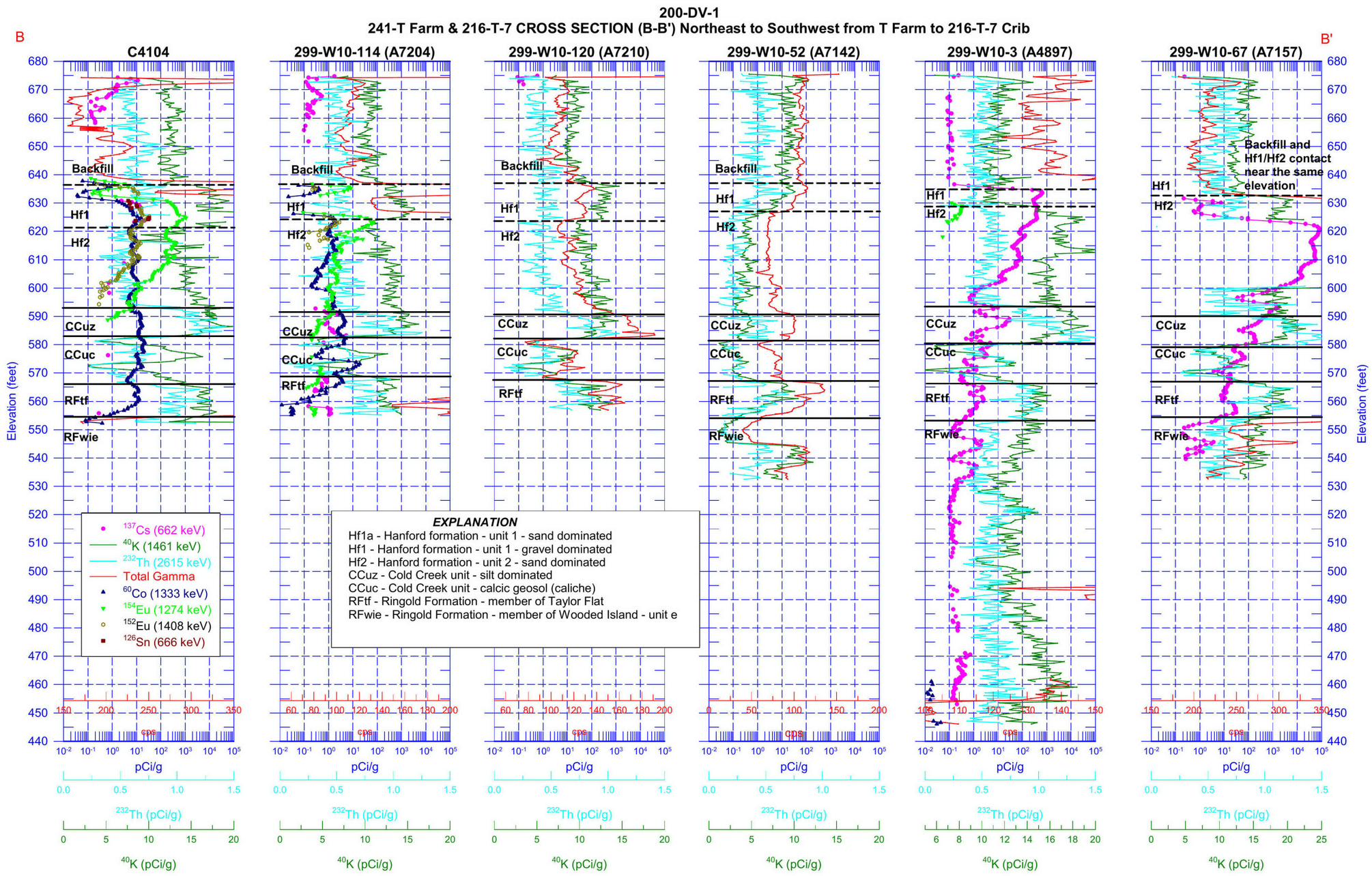


FIGURE 5-9. 241-T-112 TO 216-T-7 CRIB & TILE FIELD CROSS SECTION C-C')

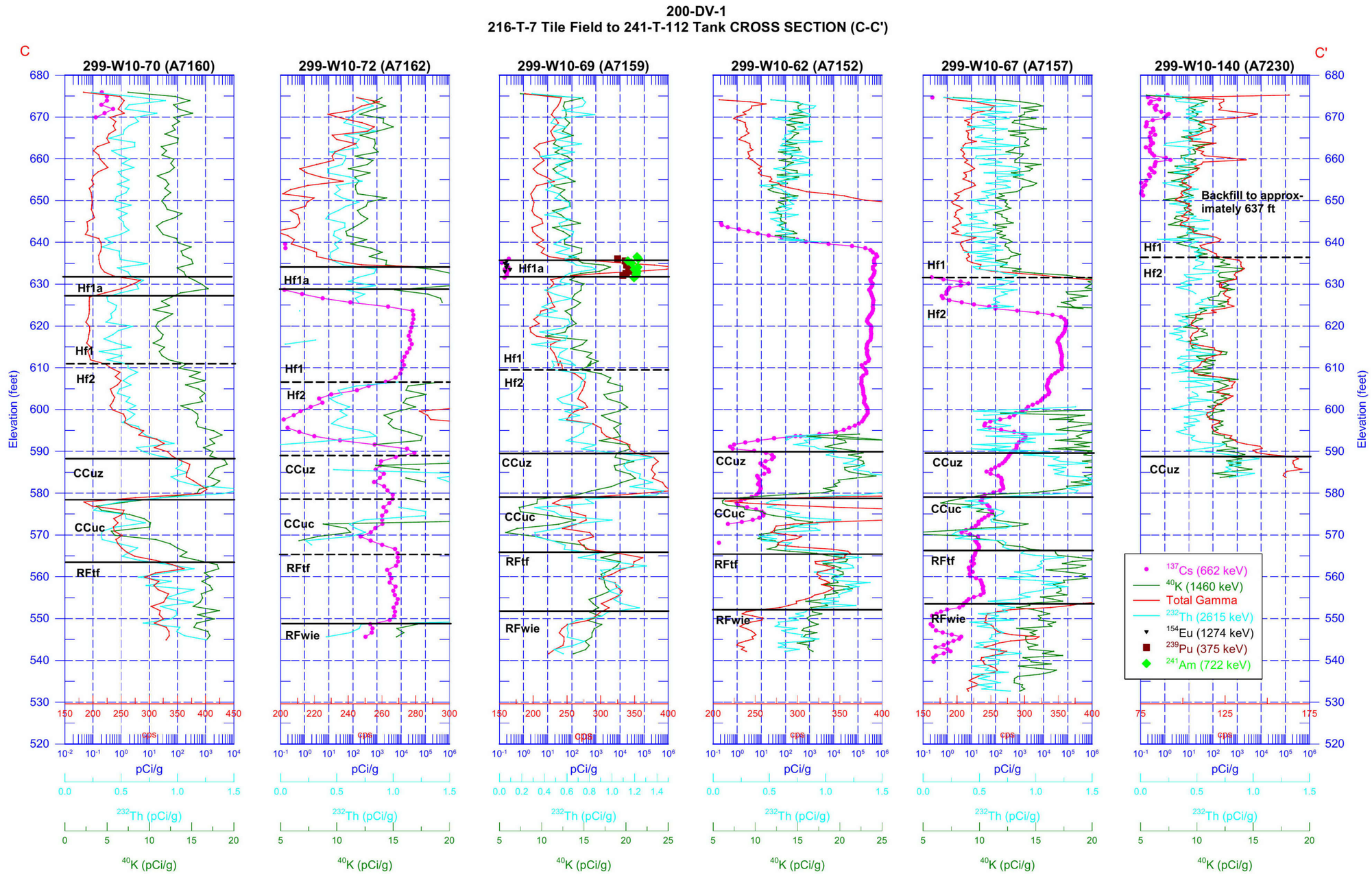


FIGURE 5-10. 241-T-112 TO 216-T-7 CRIB & TILE FIELD CROSS SECTION (D-D')

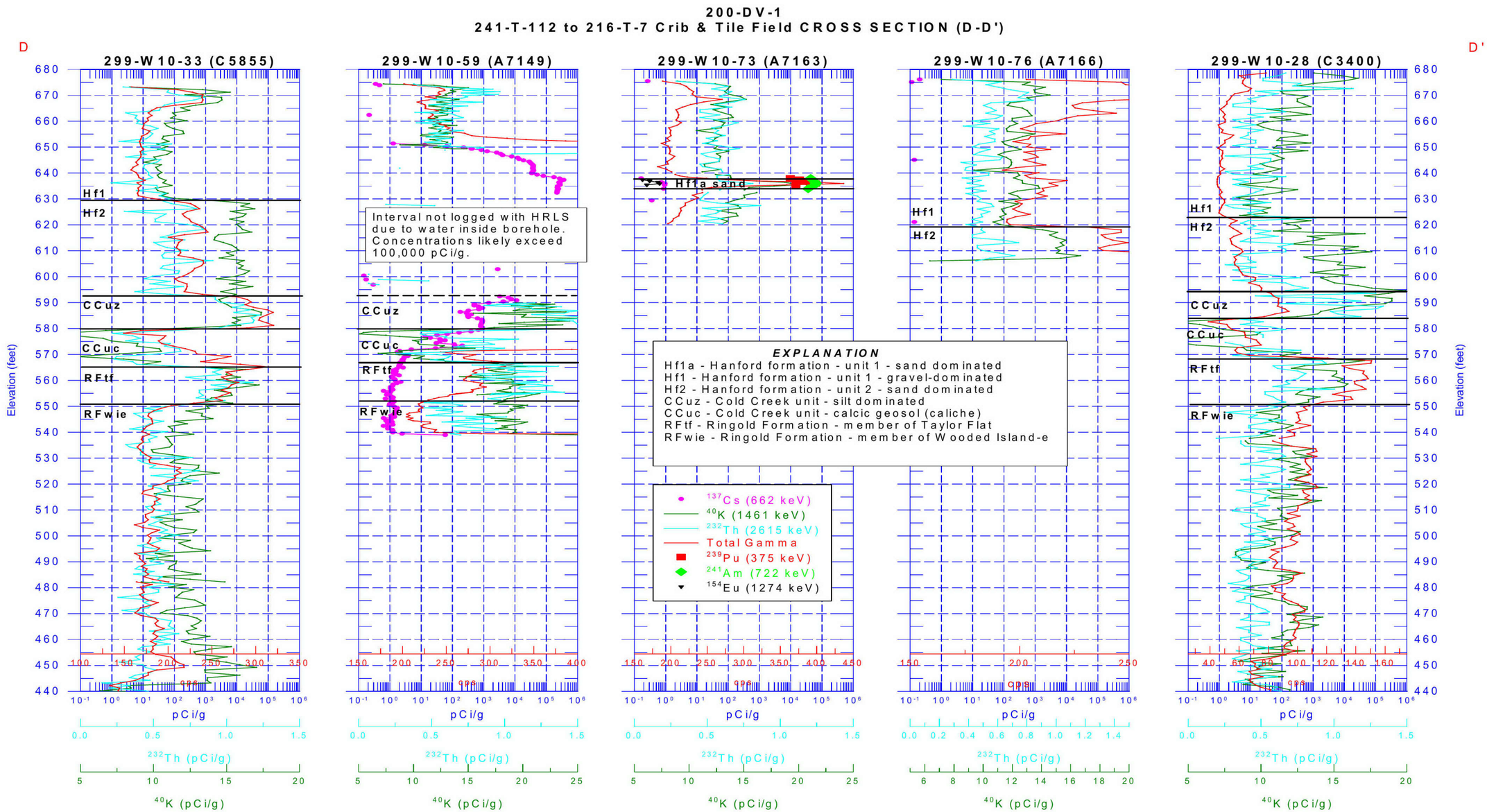


FIGURE 5-11. VISUALIZATION OF CONTAMINANTS VIEWED FROM THE WEST FOR 241-T-106, 216-T-5, 216-T-32, AND 216-T-7

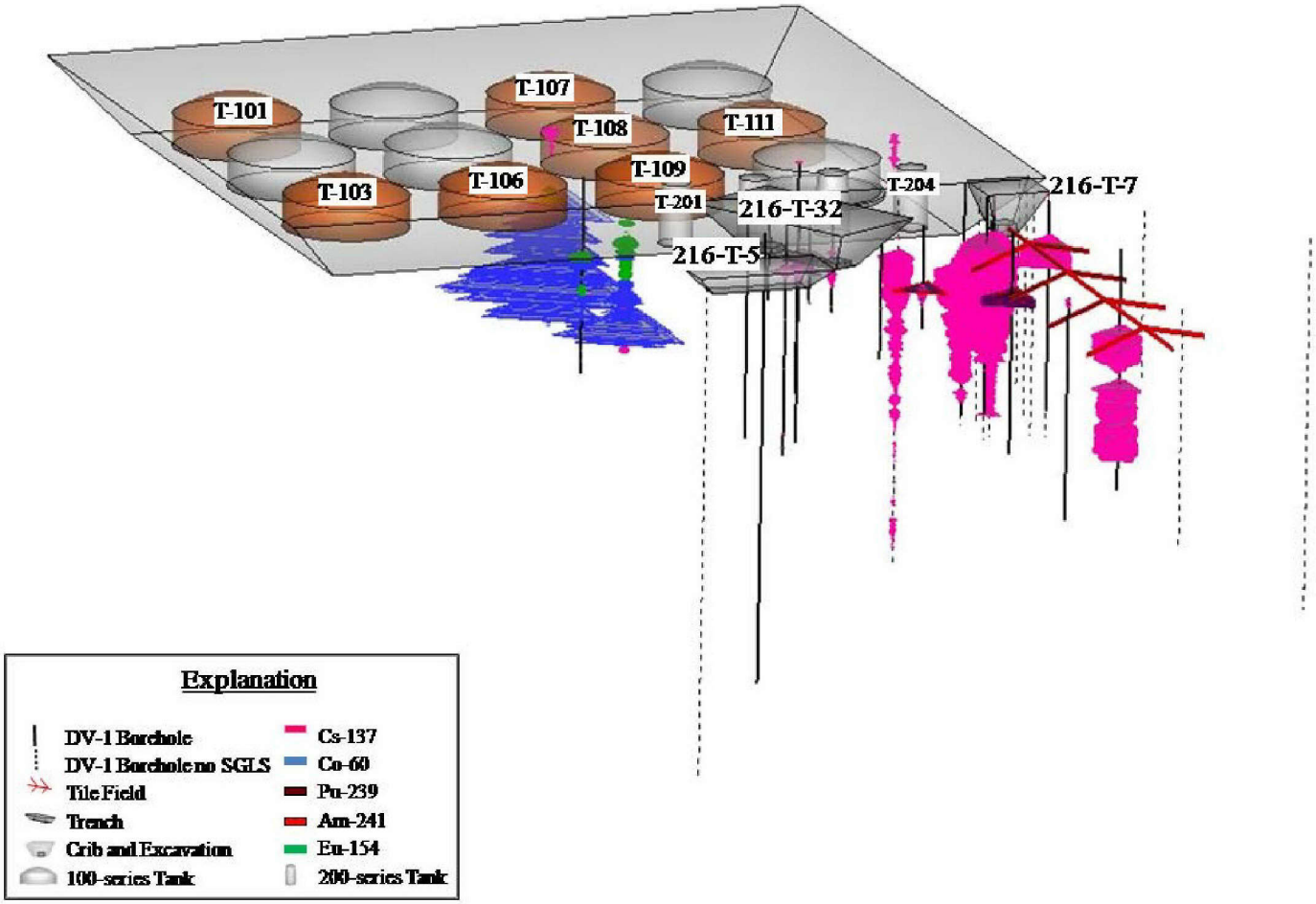


FIGURE 5-12. COMPARISON OF TOTAL GAMMA LOGS AND CS-137 IN 299-W10-72

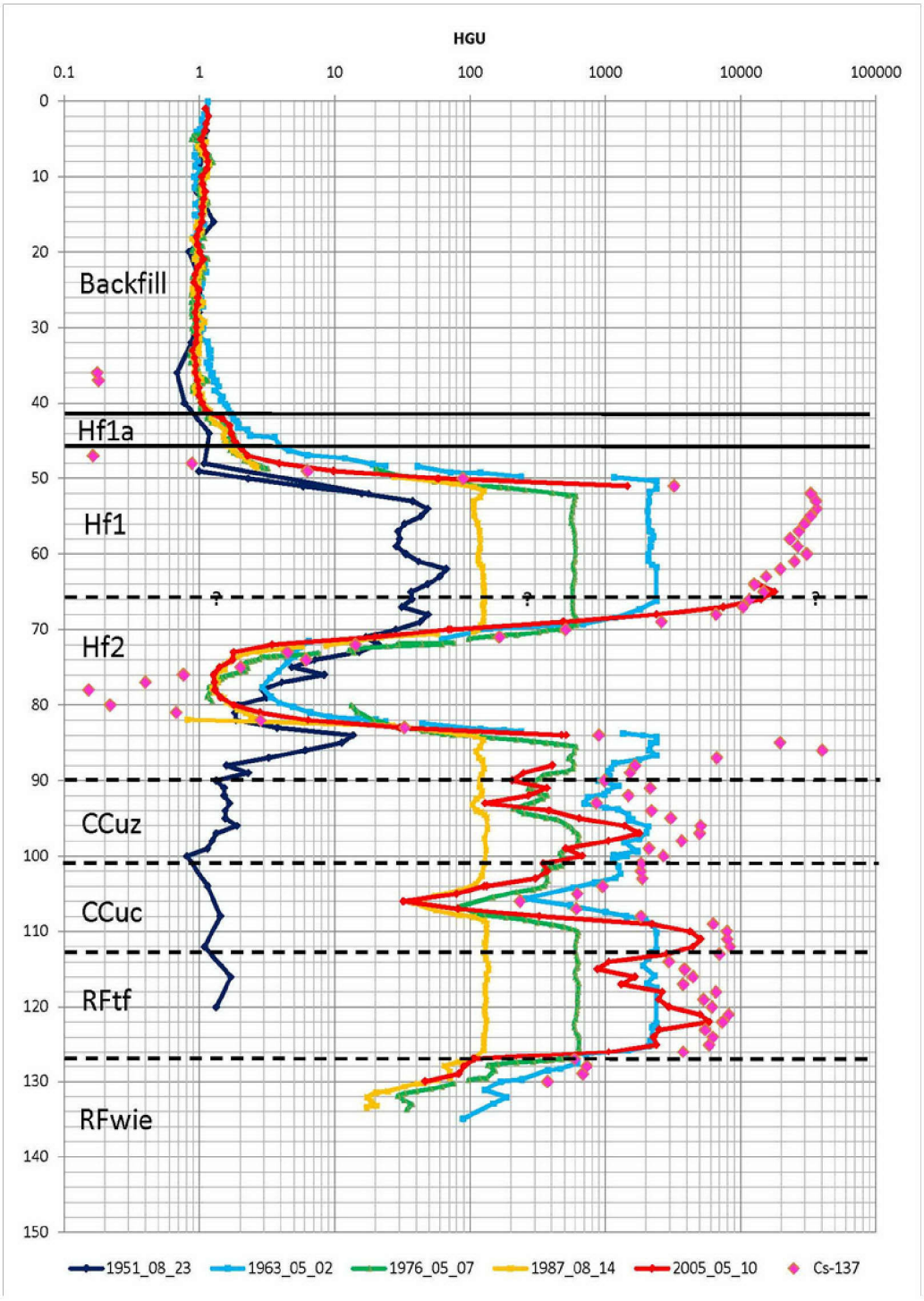


FIGURE 5-13. VISUALIZATION OF 241-T FARM CONTAMINATION AT 71 FEET

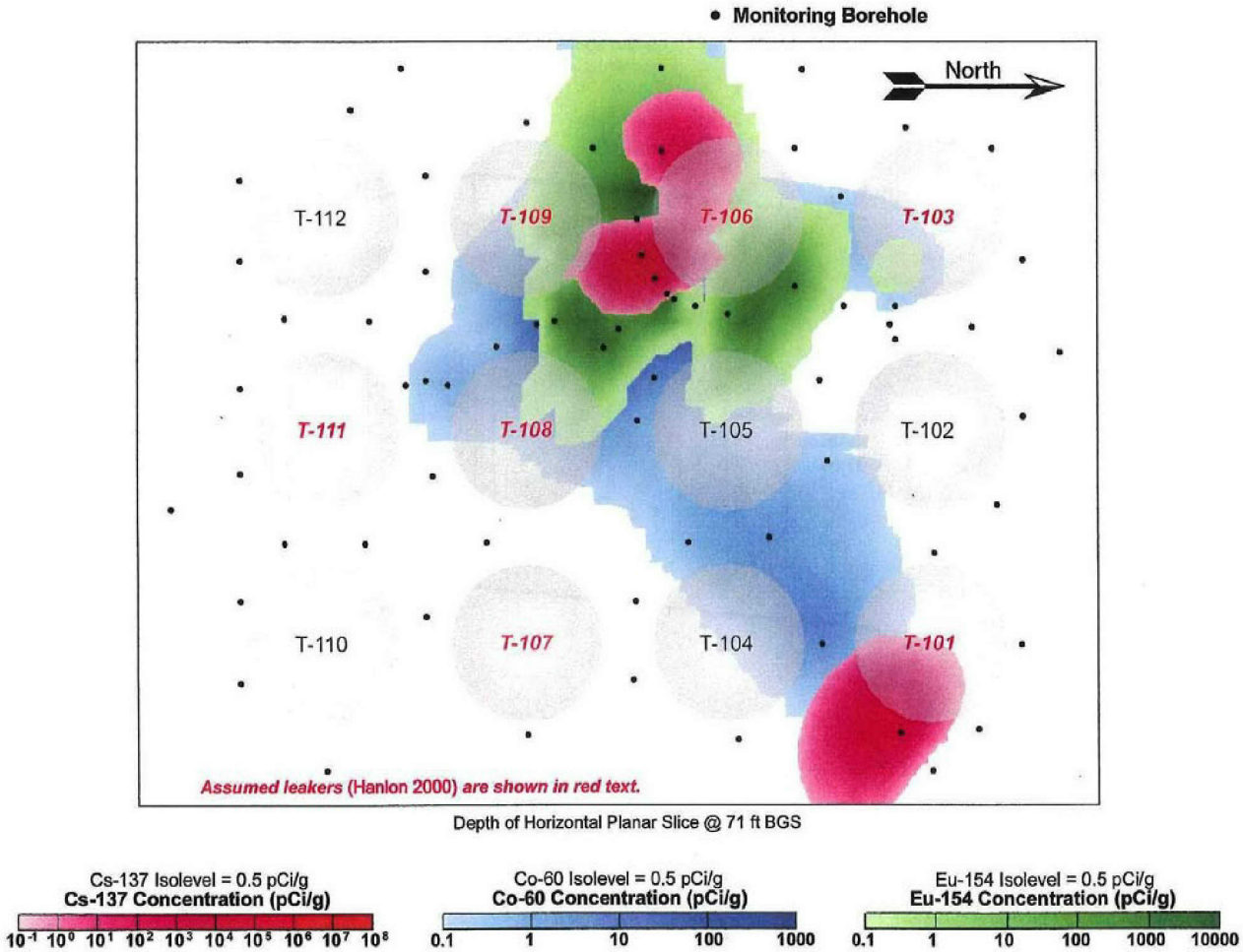
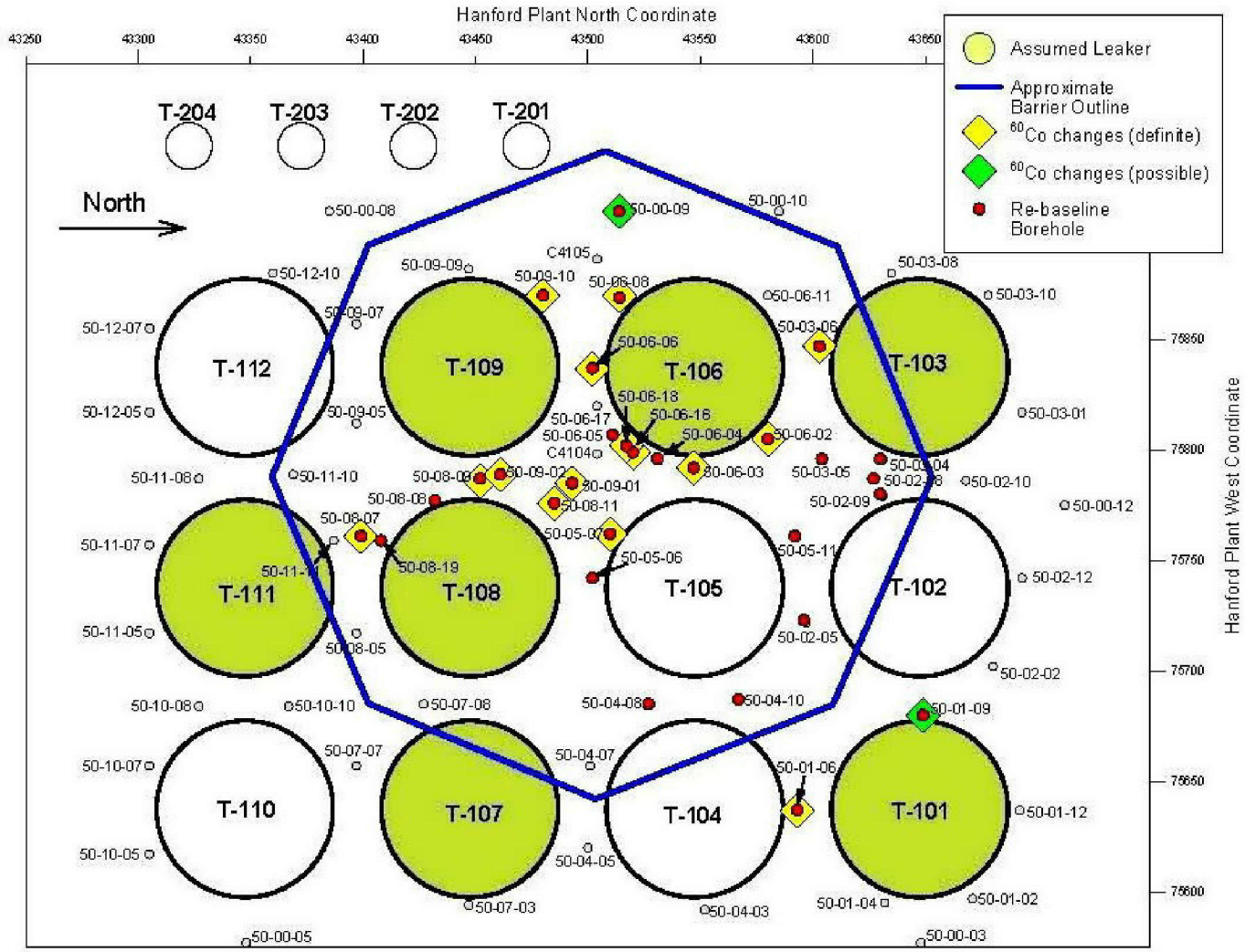


FIGURE 5-14. CO-60 CHANGES BELOW 80 FEET AT 241-T FARM



6.0 216-T-14, -T-15, -T-16, AND -T-17 TRENCHES

The T-14, -15, -16, and -17 subregion comprises four parallel trenches located approximately 150 ft northeast of WMA T (241-T Tank Farm, Figure 6-1). These trenches have similar dimensions, process history, and function. 216-T-14, -15, -16, and -17 are also known as the 216-T-1, -2, -3, and -4 graves. Also, early documentation refers to them as 216-T-13 to -16, and elsewhere as 216-T-15 to -18. Caution is advised when referring to earlier documentation. A brief background section is provided that includes waste site characteristics, process history, and geology. A cross section that includes the current contamination profile in relation to the waste site and stratigraphy, relevant individual borehole contaminant plots, 3-dimensional data visualizations, and interpretations are provided in Section 6.4.

6.1 GEOLOGY

The general geology and stratigraphy for this area are described in Section 3.1. Stratigraphic relationships are depicted on a cross section of log data (Figure 6-3). Key Stratigraphic intervals defined within the vadose zone, from shallowest to deepest include the Hf1, Hf2, CCu, RFtf, and RFwie. Hf2 upper and lower subunits are also identified by a relative increase in K-40 concentrations in the upper interval and relatively lower K-40 concentrations in the lower interval. The upper unit ranges in thickness from approximately 13 ft (4 m) in the T tank farm to approximately 38 ft (11.5 m) west of the 216-T-14 trench. The lower unit is approximately 30 ft (9.1 m) across the area. Overall, the vadose zone is approximately 242 ft (73.8 m) thick in this area. The contact between the Hf1 and Hf2 occurs relatively shallow, ranging in elevation from 638 ft (194.5 m) or 37 ft (11.3 m) bgs near T farm to 668 ft (203.6 m) or 27 ft (8.3 m) bgs west of the 216-T-14 trench. The top of the CCu ranges in elevation from approximately 595 ft (181.4 m) or 80 ft (24.4 m) bgs near T farm to 601 ft (183.2 m) or 94 ft (28.7 m) bgs near 216-T-14. The CCu averages 28 ft (8.5 m) in thickness beneath the area. A slope is indicated from east to west.

6.2 WASTE SITE PROCESS HISTORY

The 216-T-14, -15, -16, and -17 trenches are located northeast of the 241-T Tank Farm. Because these trenches were constructed approximately the same, were used at approximately the same time, and received similar waste, they will be considered as a single unit for this report. WIDS states that all four trenches are 10 ft (3.0 m) deep and 10 ft (3.0 m) wide at the bottom. It further indicates that the lengths of the bottom dimensions of the trenches 216-T-14 through 216-T-17 are 220 ft (67.1 m), 240 ft (73.2 m), 240 ft (73.2 m), and 275 ft (83.8 m), respectively. However, drawing H-2-36849, which voids temporary drawing SK-2-2409 from which WIDS apparently derived dimensions, indicates the bottom length dimension for 216-T-14 is 220 ft (67.1 m) and for the other three cribs is 240 ft (73.2 m). The excavation was sloped at 1.5:1, making the boundary of the excavation at the surface approximately 30 ft (9.1 m) longer for each trench. According to drawing H-2-36849, the center lines of the 216-T-14, -T-15, and -T-16 trenches are 90 ft (27.4 m) apart; the distance between the center lines of the 216-T-16 and -17 trenches is 50 ft (15.2 m). A 720 ft (219.5 m) long 3-in. (7.6 cm) diameter over-ground steel pipeline is shown on drawing H-2-36849 to extend from tank 241-T-106 to the 216-T-14 trench. This pipeline distributed the waste from the 241-T-104, -105, -106 tank cascade. However, the method of distribution or the inlet points to each trench is not known.

Drawing H-2-36849 also designates the coordinates of two boreholes that were apparently drilled in September and October 1953 during or shortly after construction. There are some discrepancies in past and current information regarding the location of boreholes 299-W11-68 and 299-W11-69.

299-W11-68 is shown in drawing H-2-44511 as west of the 216-T-14 trench and borehole 299-W11-69 as south of the 216-T-15 trench. Current maps indicate borehole 299-W11-68 is located south of the 216-T-15 trench and borehole 299-W11-69 is located west of the 216-T-14 trench. A review of the logging data for these boreholes indicates the same wells have been logged consistently since 1968. For

purposes of this report the current information will be used for location of the two boreholes. The boreholes will also be designated as west of 216-T-14 for borehole 299-W11-69 and south of the 216-T-15 trench for borehole 299-W11-68.

The trenches were used in 1954 for disposal of 221-T first-cycle supernatant waste via the 241-T-104, -T-105, and -T-106 single-shell tanks. Table 6.1 indicates the waste stream that was disposed to the 216-T-14, -T-15, -T-16, and -T-17 (241- T- 1, -2, -3, and -4) trenches (Paas and Heid 1955). The date filled relates to the tank and the date emptied is the disposal date to the trench. See Table 6.1 for disposal history.

In 1956, these waste sites were referred to as "graves." This terminology reflected an excavation for "one shot" (few days) disposal that was promptly backfilled. V.W. Wood also referred to these trenches as "graves" (Wood 1958). Later documentation (e.g., WIDS) refers to them as "specific retention trenches." Wood et al. (2001)states that in May 1953, direct disposal of first-cycle waste to specific retention trenches was approved at a maximum discharge rate of 5,289 L/square meter (150 gallons/ square ft). Note: Conversion (5280 L x .26417205gal/L)/10.7639 square ft/square m = 129.6 gallons/square ft suggests a miscalculation of approximately 20 gal/sq ft). Table 6-2 shows a comparison of this guideline and the actual dimensions of the trenches and waste disposed.

Thus, all of the trenches appear to have met the guidelines for specific retention if the entire trench were utilized. A hypothetical, considering if only half of the trench actually received waste, is also included in Table 6-2 and shows that the volume disposed to each specific retention trench would have exceeded the guideline if only half the footprint were wetted by waste. These calculations should be considered when evaluating whether waste liquid reached the groundwater.

6.3 PREVIOUS INVESTIGATION

Fecht et al (1977) evaluated the distribution of gamma contaminants below the 216-T-14 and 216-T-15 waste sites using scintillation probe profiles from 1963 and 1976. Only two boreholes, 299-W11-68 (A7310) south of the 216-T-15 trench and 299-W11-69 (A7311) west of the 216-T-14 trench, were available to evaluate the trenches, neither of which was located directly within the waste site foot prints. Radioactivity was detected in 1963 in 299-W11-68 from approximately 9 to 12 meter (about 29.5 to 39.4 ft) bgs, but decayed away significantly by 1976. Fecht concludes that breakthrough to the ground water did not occur at this site. This conclusion relates to gamma-emitting contaminants only. Note: These boreholes may not be located where Fecht et al. (1977) believed (see Section 6.2).

The T Plant Source Aggregate Area Management Study Report (U.S. Department of Energy 1992) evaluated these sites as well. By the time of this study, two additional boreholes had been emplaced: one along the northwestern margin of 216-T-16 (299-W11-80), and one along the southeastern margin of 216-T-17 (299-W11-81). Their conclusions were: "The scintillation probe profiles from the well monitoring the 216-T-17 Trench indicate that currently high levels of gamma radiation are found within the coarse- grained sequence of the Hanford formation. There is no evidence that radionuclides have penetrated to the groundwater. Data are inadequate to delineate the extent of contamination."

Furthermore, probe data from the well near 216-T-14 (299-W11-68 south of the 216-T-15 trench) indicated moderate to low levels of gamma radiation which has since decayed to background levels, but that "based on mapping by Last et al. (1989), this well may not be in an optimal position to monitor the crib."

Lastly, the boreholes used to monitor 216-T-15 and -16 "have never showed any evidence of gamma emitting radionuclides in the subsurface." These boreholes, too, may not be in a suitable position to monitor for possible contaminant migration from these waste sites, according to Last et al. (1989).

6.4 SUMMARY OF LOG DATA

Figure 6-1 shows the location of 200-DV-1 study boreholes relative to the four waste sites and portions of 241-T tank farm that have been evaluated for this subregion. Refer to Table 6-4 and Figure 6-2 for which boreholes are evaluated with respect to the 216-T-14 to -17 Trenches. One cross section (A-A') is included in this report, which is oriented roughly SW to NE approximately across the stratigraphic dip in the vadose zone. Geophysical logging data acquired since 1963 have been summarized in Table 6-4. A brief evaluation of the significance of each log and comparison to earlier logs in the same borehole is made. This evaluation is intended to describe any significant qualitative changes in the gamma profile during intervening years. A quantitative analysis would require more careful comparison, taking into account the relative efficiencies of the various detection systems. The quantitative analysis would require a detailed assessment of the response characteristics of the older logging systems, which is beyond the scope of the current effort. The "historical" record is important to determine the past existence of very short-lived radionuclides, the maximum extent of contamination at depth, and whether any influx or migration of contaminants has occurred over time. Geophysical log data from specific boreholes are discussed below based on the relevance of each borehole to the four waste sites.

6.4.1 216-T-14, -15, -16, AND -17 TRENCHES

Five boreholes are in the general vicinity of the four trenches. Nearest and due west is borehole 299-W11-69 (A7311), which is 110 ft (33.5 m) deep. First logged in 1963, elevated gamma was detected from 30 to 45 ft (9.1 to 13.7 m) bgs, which appears to have decayed away by 1976. In 2005, SGLS logging identified Cs-137 from 0 to 11 ft (3.4 m), with a maximum activity of 16 pCi/g at 5.5 ft (1.7 m) bgs. No contamination was detected between 30 and 40 ft (9.1 and 12.2 m) bgs.

Four boreholes have been drilled in the area southwest of 216-T-14. Most northerly is 299-W11-23 (A4905). To the south of 299-W11-23, there is a cluster of three boreholes: 299-W11-39 (C3117), 299-W11-25B (C4669), and 299-W11-46 (C4950). From SGLS logging in 1998, 299-W11-23 exhibited Cs-137 contamination from 0 to about 42 ft (12.8 m) bgs and from about 60 to 140 ft (18.3 to 42.7 m) bgs with a maximum concentration of 74 pCi/g at 1.5 ft (0.5 m) bgs. No manmade gamma-emitting radionuclides were detected in Borehole 299-W11-39 (except for minor Cs-137 contamination to 2 ft or 0.6 m bgs) when it was logged in 2000.

Groundwater well 299-W11-25B was drilled (and logged with the SGLS) in 2005 (Figure 6-5). Co-60 was the only gamma-emitting contaminant detected in this borehole. It was observed in the spectra intermittently from below the water table at approximately 242 ft (73.7 m) bgs to the total depth of the borehole at approximately 408 ft (124.4 m) bgs at levels just above the minimum detectable limit (DOE-EM/GJ837-2005). Because the activity was so near to the MDL, it was not continuously detected over this interval. One interpretation is that the Co-60 was present in the water inside the well casing at an approximate concentration of 50 pCi/L. Problems were encountered during completion and the borehole was subsequently decommissioned. Groundwater well 299-W11-46 was drilled to replace 299-W11-25B, but it was not logged prior to completion as a RCRA-compliant groundwater monitoring well.

South of 216-T-15, borehole 299-W11-68 (A7310) exhibited high gross gamma activity in 1968 (about 500,000 cpm) between 30 and 40 ft (9.1 and 12.2 m) bgs. In 1976, gross gamma logging exhibited a reduction in count rate to about 20,000 cpm. In 1986 and 1987 count rates over these depths were still higher than background. An SGLS log in 2005 indicated no gamma-emitting contamination between 30 to 40 ft (9.1 and 12.2 m) bgs. This progression suggests a short-lived isotope was present from 30 to 40 ft (9.1 and 12.2 m) bgs in the 1960s through 1980s that had decayed to below detectable levels by 2005. Cs-137 was identified between 0 and 8 ft (2.4 m) bgs in 2005 at a maximum concentration of 230 pCi/g at 4 ft (1.2 m).

Located on the margin of the 216-T-16 trench near the northeast corner, borehole 299-W11-80 (A7322) was used to monitor the trench. It was drilled in 1982 to a depth of 52 ft (15.9 m) bgs. Gross gamma logging in 1984 and 1986 did not identify any zones with high count rates. An SGLS log in 2005

indicated Cs-137 contamination from 0 to about 12 ft (3.7 m) bgs, with a maximum concentration of 1 pCi/g at 10 ft (3.0 m) bgs. The borehole was subsequently decommissioned.

Groundwater well 299-W11-45 (C4948) is located about 65 to 70 ft (19.8 to 21.3 m south-southwest of the 216-T-16 trench, and was drilled and logged in 2005. SGLS data indicate no gamma-emitting contaminants at this location.

Borehole 299-W11-81 (A7323) is located along the margin of the 216-T-17 trench near the southeast corner. It was drilled in 1982 to a depth of 52 ft (15.9 m) bgs. Gross gamma logs from 1984, 1986, and 1992 exhibit tool saturation at about 15 ft (4.6 m) in 1984 and 16 ft (4.9 m) in 1986 and 1992, and increasing count rates at the bottom of the borehole at approximately 49 ft (14.9 m) bgs). An RLS log from 1992 identifies both Cs-137 and Co-60 as contaminants. Cs-137 contamination was continuous throughout the borehole, with a maximum concentration of about 19,000 pCi/g at 15 ft (4.6 m) bgs. Co-60 was identified from 16 to 48 ft (4.9 to 14.6 m) bgs with a maximum concentration of 2 pCi/g at 18 ft (5.5 m) bgs. In 2005, this borehole was logged with the SGLS. Cs-137 was identified continuously from 0 to 52 ft (15.9 m) bgs, with a maximum concentration of 13,000 pCi/g at 20 ft (6.1 m) bgs. Co-60 was identified from 22 to 30 ft (6.7 to 9.1 m) bgs, with a maximum concentration of about 0.2 pCi/g at 28 ft (8.5 m) bgs.

6.5 SUMMARY OF SUBREGION AND CONCLUSIONS

All four trenches are reported to have received 221-T first-cycle supernatant waste via the 241-T-104, -105, and -106 tank cascade series in 1954. First-cycle waste is expected to contain up to 10% of the fission products produced during irradiation of fuel rods. Given the quantity of liquid waste disposed at the four trenches (approximately 1 million gallons or 3.8 million liters), it is likely that the vadose zone below each waste site is significantly contaminated. However, only two boreholes have been drilled at the margins of the waste sites, and data from only one of those exhibits appreciable contamination being present in the vadose zone. One borehole west of the 216-T-14 trench shows lateral migration of short lived contamination between 30 and 40 ft (9.1 to 12.2 m) bgs.

The dispersal of the wastes to each trench is unknown. As summarized in Section 6.2, the specific retention guidelines for disposal to these cribs were met if the total area of the bottoms of the trenches were used to compare with guidelines. However, experience suggests that most of the waste volume may have infiltrated into the subsurface relatively close to the discharge point. Existing drawings or documents do not show the location of the discharge points. Given the geometry of the trenches with respect to the 241-T-106 tank, it is most likely the waste was discharged at or near the south end of each trench. If it is assumed that the waste infiltrated over half the active area of each trench, then disposal limits based on specific retention capacity were likely exceeded.

The 216-T-14 to -17 trenches do not have sufficient boreholes to characterize the vadose zone below the site. There are no boreholes within the trenches, and only two that are within 15 ft (4.6 m) of the trench bottom's foot print.

Attempts were made using a cross section (Figure 6-3) and data visualization (Figure 6-4) to relate contamination within the 241-T Farm and the 216-T-14 to -17 trenches. These presentations show the dominant contamination originating in the tank farm with very little detected contamination or lateral extent defined at the trenches. Without further characterization of the trenches, this visualization cannot be verified.

The Co-60 contamination detected within the groundwater in borehole 299-W11-25B may be a significant finding that identifies a likely source. Co-60 contamination is mobile in the deep vadose zone below the 241-T Tank Farm. While it may have originated from tank leaks, the T trenches are also a possible source. Additional characterization efforts for the 216-T-14 to -17 trenches (drilling, logging,

and sampling), will greatly help to assess the impact of waste disposal at these sites on the deep vadose zone.

6.6 RECOMMENDATIONS

The 216-T-14 through -17 trenches are not adequately characterized for either the shallow or deep vadose zone. Data gaps exist for the types of contaminants, their concentration, depth, and lateral extent of contamination.

It is recommended additional subsurface characterization be completed along the long axis of the trenches to determine the waste dispersal patterns and to identify the potential vertical extent and distribution of contaminants.

There is an existing characterization plan in place for three direct-push holes in the 216-T-15 trench, followed by a fourth push hole to be located based on the logging results from the first three (Figure 6-1). Presumably the reason for choosing this trench rather than one of the others is that 216-T-15 received a slightly larger volume of the 1st cycle waste. If this approach is used, it is recommended that the comparability of the trenches be confirmed with some additional characterization in the other three trenches.

Another data gap exists to the south and west of the trenches, where there are no nearby boreholes. Stratigraphic dip is to the west-southwest, and it is possible that lateral migration in the vadose zone may be in this direction, which is more or less opposite the current groundwater flow direction.

Borehole 299-W11-25B, between 216-T-14 and T Tank Farm, exhibited Co-60 in the groundwater. It is possible that Co-60 may serve as a surrogate for Tc-99 contamination. This possibility should be evaluated, since Co-60 is readily detectable through steel casing with geophysical logging methods, whereas Tc-99 requires direct sediment sampling and analysis. Co-60 has a short half life (5.27 years) but it has two distinct and penetrating characteristic gamma lines that are easily detected with high-resolution gamma detectors. A cursory evaluation of groundwater sample data from 299-W11-46 (no Co-60 results could be found for299-W11-25B) shows a relatively strong correlation between Tc-99 and Co-60 in groundwater, where Tc-99 values are above 20,000 pCi/L. This suggests that Co-60 observed in the vadose zone may be indicative that Tc-99 is also present. A borehole probe is under development for in situ assay of Tc-99, but this requires intimate contact with the soil. For now, it is strongly recommended that all groundwater and soil samples obtained from boreholes in the vicinity of the T-TX-TY waste complex be analyzed for Co-60 and Tc-99.

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TABLE 6-1. DISPOSAL HISTORY FOR THE 216-T-14, -15, -16, AND -17 TRENCHES (PAAS AND HEID 1955)

Trench	Volume (E05 L)	Pu (g)	U (g)	Gross Beta (Ci)	Cs (Ci)	Sr (Ci)	Tank #	Start Date Tank Filled	Date Emptied to Trenches
T1	4.60	0.36	14,500	547	230	1.01	T-104	8/51	1/15/54
T1	5.46	0.42	14,700	437	229	4.75	T-105	10/26/51	1/22/54
T2	9.15	0.75	23,300	686	403	20.1	T-105	10/26/51	1/29/54
T2	1.27	0.08	2,850	108	610	1.00	T-106	10/22/51	2/4/54
T3	10.2	0.58	21,400	878	510	8.67	T-106	10/22/51	2/10/54
T4	3.48	0.21	9,400	278	157	0.42	T-106	10/22/51	2/13/54
T4	4.37	0.26	10,100	367	208	2.54	T-106	10/22/51	6/10/54
Total	**38.5**	**2.66**	**96,300**	**3,300**	**2,350**	**38.5**			

Trench T-1 is 216-T-14
Trench T-2 is 216-T-15
Trench T-3 is 216-T-16
Trench T-4 is 216-T-17

Tank # has a 241- prefix

TABLE 6-2. TABLE COMPARISON OF SPECIFIC RETENTION GUIDELINES WITH ACTUAL DISPOSAL

Trench	Trench bottom (ft^2)	Volume (gallons)	Guideline (full trench area) (gallons)	Guideline (half trench area) (gallons)
216-T-14	2200	265,757	330,000	165,000
216-T-15	2400	275,266	360,000	180,000
216-T-16	2400	269,455	360,000	180,000
216-T-17	2400	207,374	360,000	180,000

TABLE 6-3. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1963 (WASTE SITE DESIGNATION PREFIX - 216)

WASTE SITE	WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH (FT)	DATE	LOG TYPE	CONTAMINATION HISTORY	COMMENTS
T-14-17	299-W10-24	B8546		YES	432.5	17-OCT-98	RLS	Cs-137 was detected from 1-10 ft, max 3 pCi/g @ 5 ft.	No deep vadose zone contamination
T-14-17	299-W11-23	A4905	50-00-02	SUBMITTED	242	23-SEP-98	SGLS	Cs-137 was detected from 0 to 42 ft, and from 60 to 140 ft, max 74 pCi/g @ 1.5 ft.	Cs-137 was detected (<10 pCi/g) throughout the borehole. Logging depth was 242 ft.
T-14-17	299-W11-25 B	C4669		YES	408	15-MAR-05	SGLS	Cs-137 and Co-60 were detected throughout the borehole and in the ground water.	No significant Cs-137 contamination in the vadose zone. Co-60 in GW at approximately 241.8 ft.
T-14-17	299-W11-27	A4907		YES	4-107	21-OCT-91	GG	No evidence of elevated gamma associated with contaminants	"liquid level" was recorded as 232.4 ft in 1991.
	299-W11-27	A4907		YES	70-235	13-NOV-91	GG	No evidence of elevated gamma associated with contaminants	
T-14-17	299-W11-39	C3117		YES	280.5	06-DEC-00	SGLS	Dual casing from 0-51 ft. Cs-137: 0-1 ft and at 21 ft. max 2 pCi/g @ ground surface	2 pCi/g Cs-137 was detected in upper 21 ft (dual casing 0-51 ft). Water level was 237.6 ft with no evidence of contamination.
	299-W11-39	C3117		YES	237.75	7-DEC-00	NMLS	Water level at 237.6 ft	
T-14-17	299-W11-45	C4948		YES	438	18-NOV-05	SGLS	No gamma-emitting contamination identified	No deep vadose zone contamination
T-14-17	299-W11-46	C4950		YES	286	N/A	N/A	No Data Available	No Data Available
T-14-17	299-W11-48	C5243		YES	409	7-JUN-07	SGLS	No gamma-emitting contamination identified	No deep vadose zone contamination, GWL was 242.25 ft in 2007.
T-14-17	299-W11-68	A7310		SUBMITTED	108	29-APR-68	GG	500,000 cpm at 34 ft. with possible increase in contamination at bottom of borehole at 108 ft.	Cs-137 was detected to 23 ft and from 105 to 108 ft in 2005. Contamination in groundwater was not determined. The borehole was logged to 108 ft.
	299-W11-68	A7310		YES	108	07-MAY-76	GG	Elevated gamma between 30 and 45 ft, and at approximately 100 ft.	
	299-W11-68	A7310		YES	108	21-JUN-76	DENSITY	Not interpreted	
	299-W11-68	A7310		YES	108	1-MAR-77	NEUTRON	Not interpreted	
	299-W11-68	A7310		YES	108	24-JUN-86	GG	Elevated gamma from 32 to 70 ft, max peak at 32 ft; lesser peak at 66 ft; elevated gamma at approx. 100 ft.	
	299-W11-68	A7310		YES	108	21-JUL-87	GG	Elevated gamma from 32 to 70 ft, max peak at 34 ft; elevated gamma at approximately 100 ft.	
	299-W11-68	A7310		YES	108	08-AUG-05	SGLS	Cs-137: 0 to 8 ft, max 230 pCi/g @ 4 ft, and 0.6 pCi/g @ 108 ft;	
T-14-17	299-W11-69	A7311		SUBMITTED	110	29-APR-63	GG	Elevated gamma between 30 and 45 ft, and at approximately 100 ft.	Cs-137 was detected from 0 - 11 ft, and sporadically to bottom of borehole. Historical logs also show deep contamination, with elevated KUT. Contamination in groundwater was not determined. The borehole was logged to 111 ft.
	299-W11-69	A7311		YES	110	7-MAY-76	GG	Elevated gamma near bottom of borehole at approximately 100 ft.	
	299-W11-69	A7311		YES	110	21-JUN-76	DENSITY	Not interpreted	
	299-W11-69	A7311		YES	110	1-MAR-77	NEUTRON	Not interpreted	
	299-W11-69	A7311		YES	110	21-JUL-87	GG	Elevated gamma from 90 to 100 ft.	
	299-W11-69	A7311		YES	110	20-JUN-05	SGLS	Cs-137: 0 to 11 ft, max 16 pCi/g @ 5.5 ft, with lower detections at 28, 36, 65 and	

TABLE 6-3. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1963 (WASTE SITE DESIGNATION PREFIX - 216)

WASTE SITE	WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH (FT)	DATE	LOG TYPE	CONTAMINATION HISTORY	COMMENTS
								110 ft.	
T-16	299-W11-80	A7322		YES	52	14-MAR-84	GG	No clear evidence of elevated gamma associated with contaminants	Cs-137 was detected from 0-12 ft. Contamination to ground water was not determined. The borehole was logged to 52 ft.
	299-W11-80	A7322		YES	52	24-JUN-86	GG	Elevated gamma at 42 ft.	
	299-W11-80	A7322		YES	52	9-AUG-05	SGLS	Cs-137 was detected from 0 to 12 ft, max ~1 pCi/g @ 10 ft	
T-17	299-W11-81	A7323		SUBMITTED	51	14-MAR-84	GG	Elevated gamma throughout borehole, tool saturated to 30 ft.	Cs-137 was detected to the total depth of 52 ft. Co-60 was detected from 23 to 34 ft. Contamination to ground water was not determined. The borehole was logged to 52 ft.
	299-W11-81	A7323		YES	49	24-JUN-86	GG	Elevated gamma throughout borehole, tool saturated to 30 ft.	
	299-W11-81	A7323		YES	48	22-MAY-92	RLS	Cs-137 similar to 2005 profile.	
	299-W11-81	A7323		YES	52	26-MAY-92	GG	Elevated gamma throughout borehole, tool saturated to 30 ft.	
	299-W11-81	A7323		YES	52	29-AUG-05	SGLS/ HRLS	Cs-137 was detected from 0 to 52 ft, max ~13,000 pCi/g @ 20 ft; Co-60 was detected from 22 to 30 ft, max ~0.2 pCi/g @ 28 ft.	

HG High Resolution Spectral Gamma (HPGe) e.g. SGLS, HRLS, RLS
SG "Conventional" Spectral Gamma e.g. NaI, BGO, CsI
GG Gross Gamma e.g. GM, Scintillation
NM Neutron Moisture
N Neutron (unspecified)
PN Passive Neutron
OTH other (Density, Temperature, Caliper)

The waste sites have a 216- prefix

FIGURE 6-1. 216-T-14, -T-15, -T-16 AND -T-17 LOCATION MAP

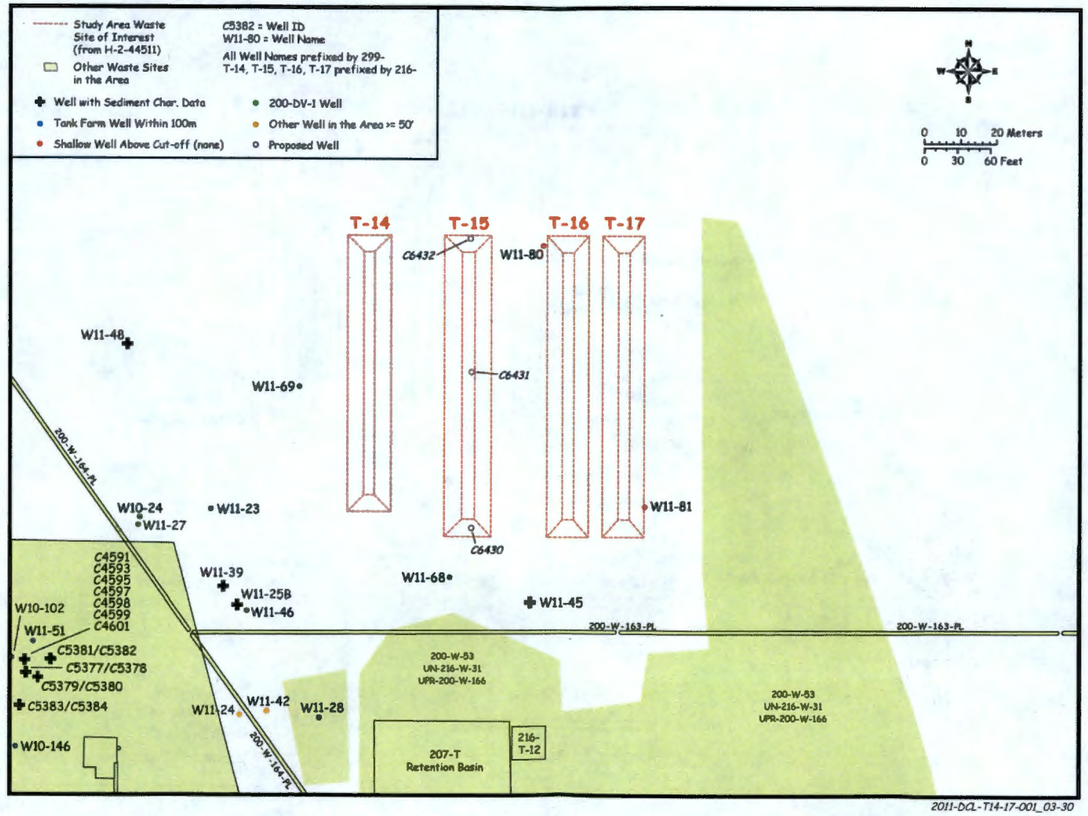


FIGURE 6-2. 216-T-14, -T-15, -T-16, AND -T-17 BOREHOLE AND CROSS-SECTION LOCATIONS

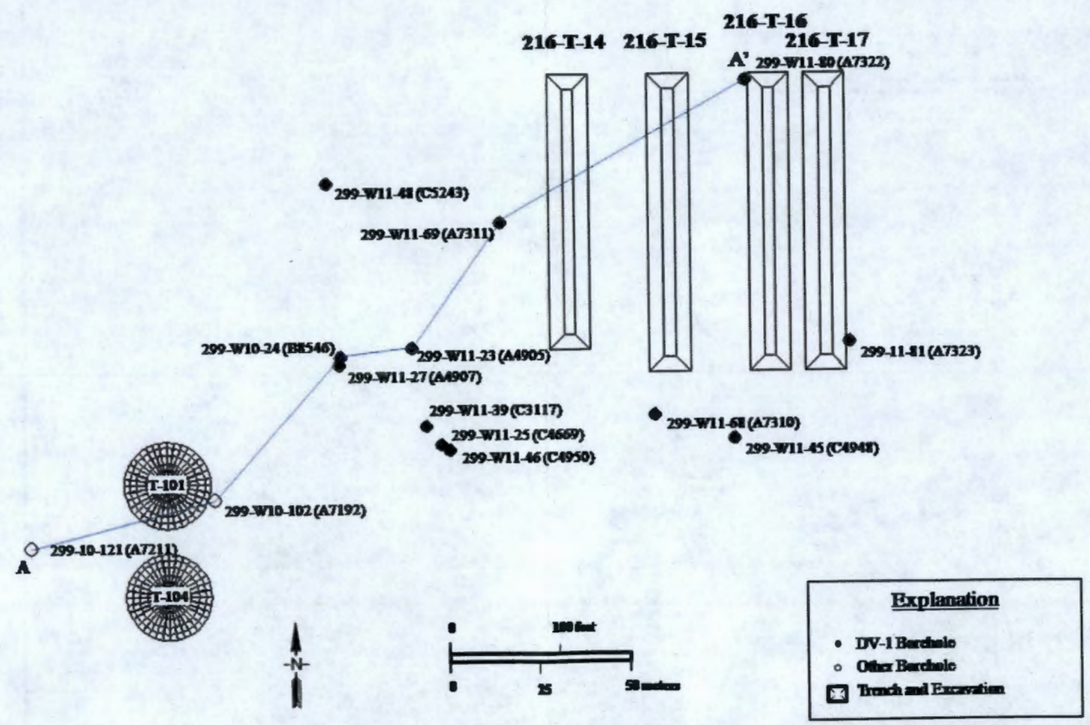


FIGURE 6-3. 216-T-14, -T-15, -T-16 AND -T-17 - CROSS-SECTION (A-A')

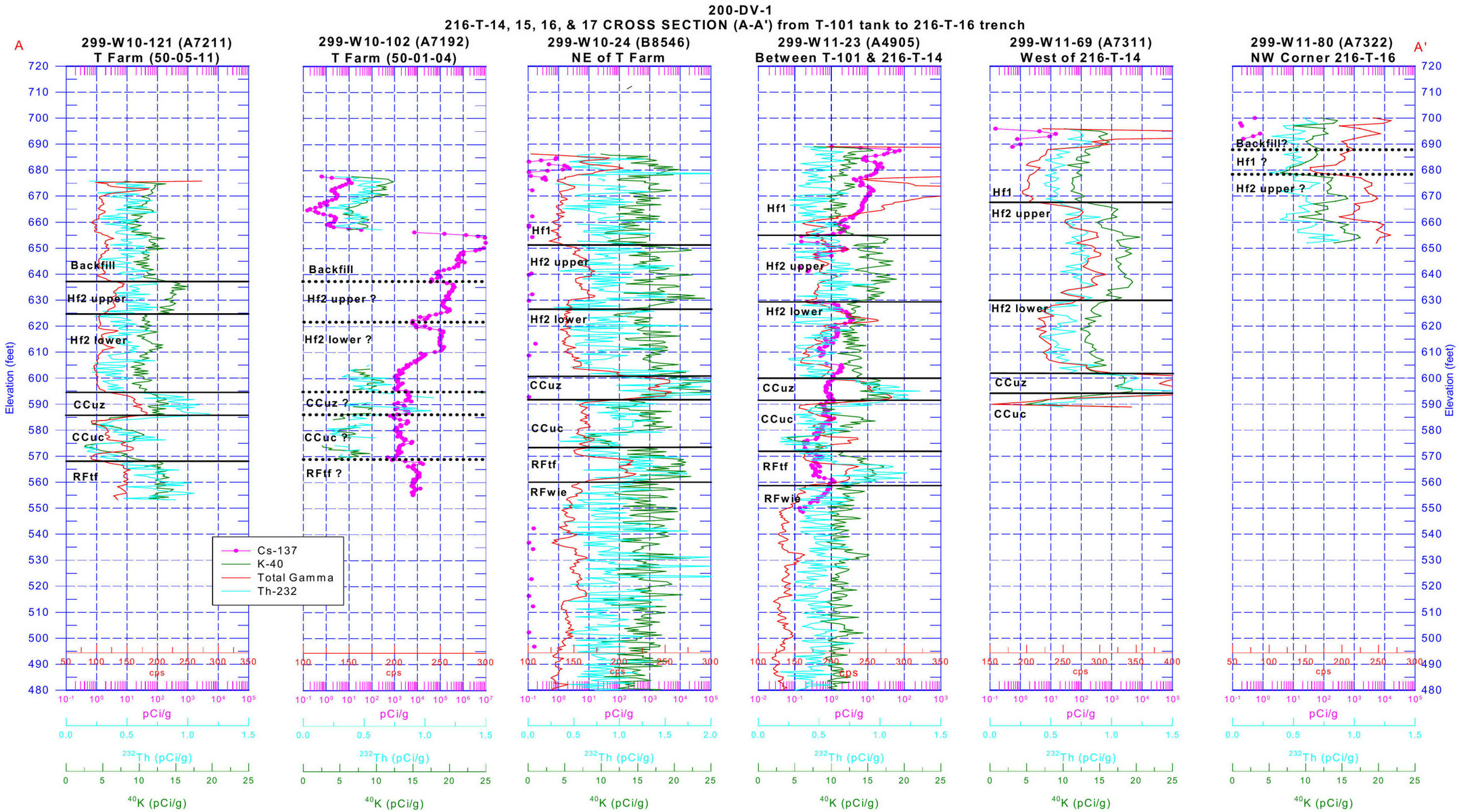


FIGURE 6-4. VISUALIZATION OF CS-137 CONTAMINATION AROUND THE 216-T-14 TO 216-T-17 TRENCHES VIEWED FROM THE SOUTH

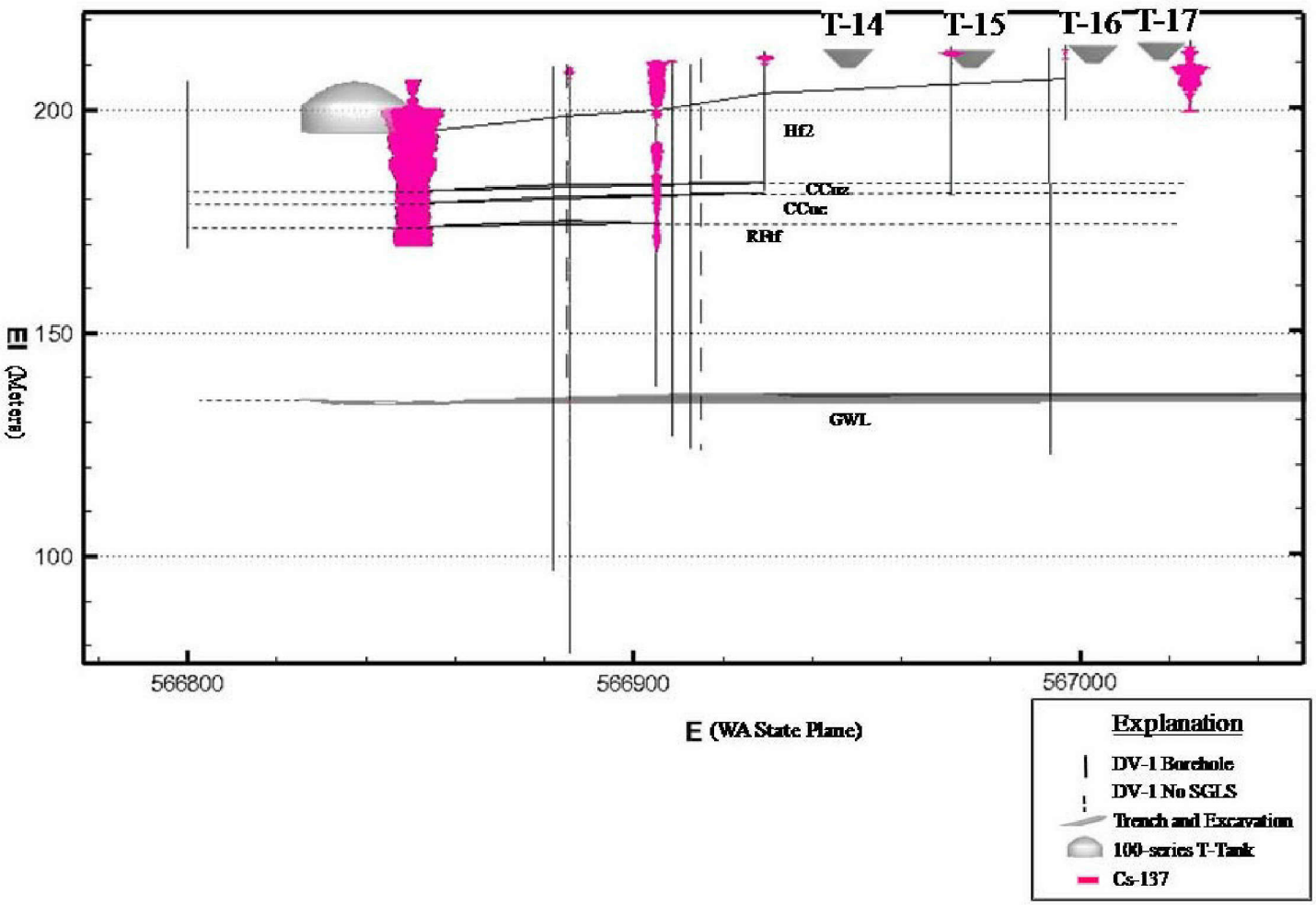
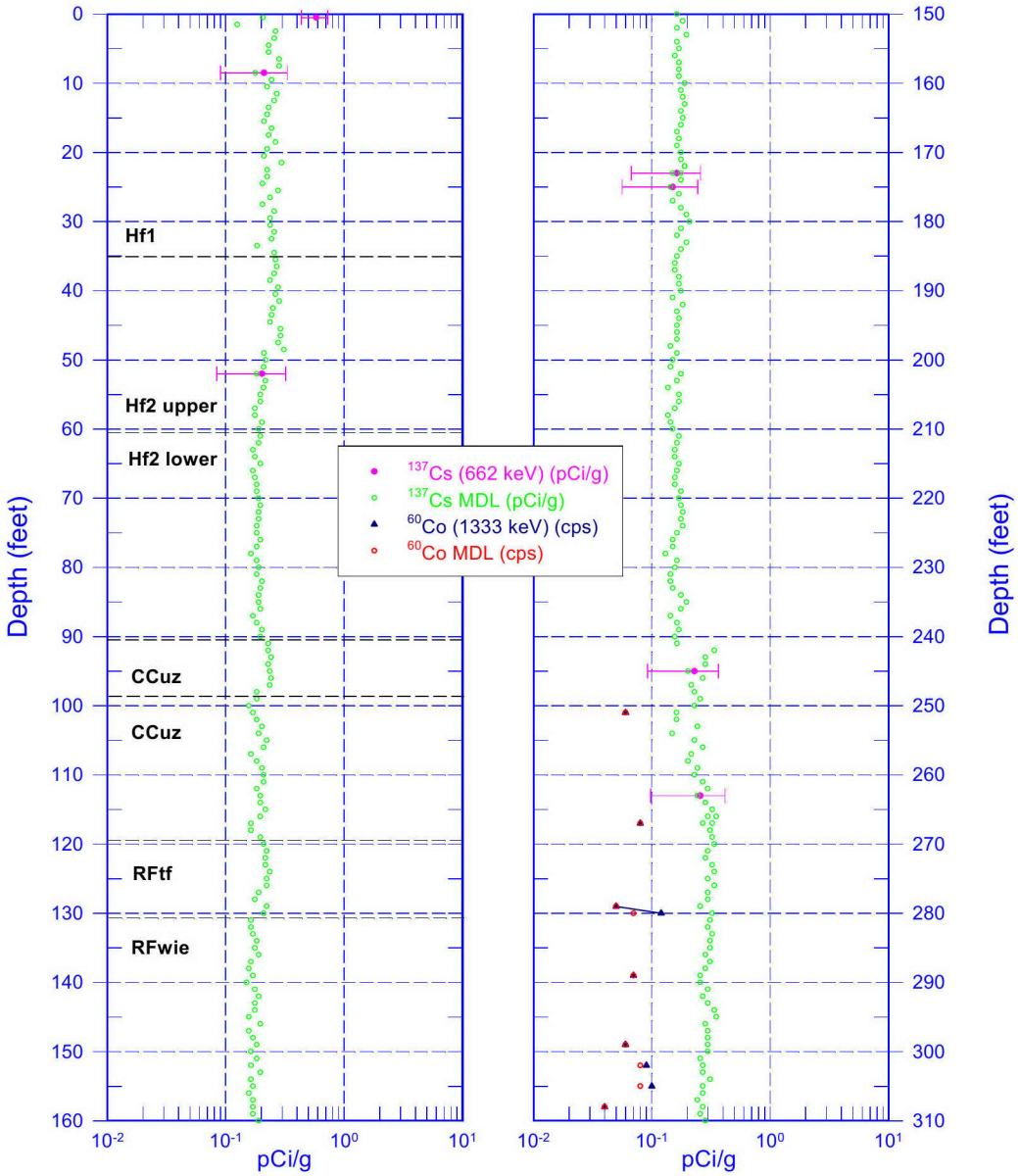


FIGURE 6-5. MANMADE CONTAMINATION PLOTS FROM 299-W11-25B

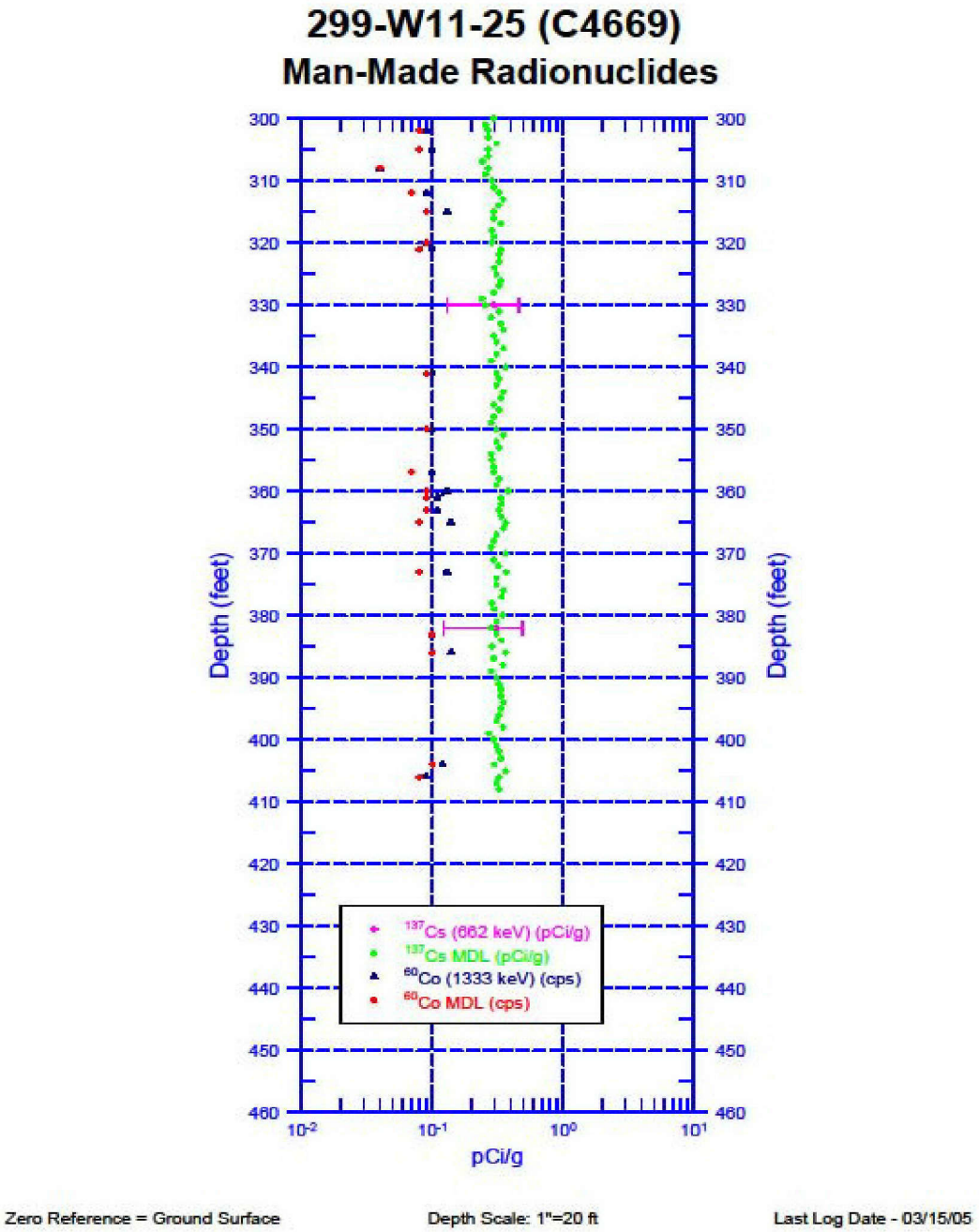


Geology is based on data from B8546 and A4905
GWL is not available
Zero Reference = Ground Surface

Depth Scale: 1"=20 ft

Last Log Date - 03/15/05

FIGURE 6-5. MANMADE CONTAMINATION PLOTS FROM 299-W11-25B (CONTINUED)



7.0 216- T-18, -T-26, -T-27, AND -T-28 CRIBS

This subregion includes the 216-T-18, -26, -27, and -28 Cribs (Figure 7-1). These waste sites are related in terms of proximity and geology, but the 216-T-18 crib has a different history than the 216-T-26, -27, and -28 cribs. It also likely has a different configuration, although many references assume it is the same. 241-TY-Farm lies immediately to the west with a pipeline exiting to the 216-T-26, -27, and -28 cribs. Cross sections that include the current contamination profile in relation to the waste site and stratigraphy, 3-dimensional data visualizations, and interpretations are provided in Section 7.4.

7.1 GEOLOGY

The general geology and stratigraphy for this area are described in Section 3.1. Stratigraphic relationships are depicted on cross sections of log data in Section 7.4. Key Stratigraphic intervals defined within the vadose zone, from shallowest to deepest include the Hf1, Hf2, CCu, RFtf, and RFwie. The top of the CCu is at an approximate elevation of 586 ft (178.6 m) or 85 ft (25.9 m) bgs in the north at the 216-T-18 crib and 584 ft (178.6 m) or 86 ft (25.9 m) bgs in the south. The CCu is approximately one ft higher in the east than the west. Thus there is a dip in the top of the CCu unit toward the southwest.

7.2 WASTE SITE PROCESS HISTORY

7.2.1 216-T-18 CRIB

The 216-T-18 Crib is located northeast of the 241-TY Tank Farm and approximately 108 ft (32.9 m) north of the 216-T-26, -27, and -28 cribs. It has also been known as the "Test Crib for 221-U Building", 216-T-17, and 217-T-17 Crib. It was used in December 1953 on a test basis (sometimes referred to as the Test Crib or grave) to accept scavenged TBP waste. The term "grave" generally reflected an excavation for "one shot" (few days) disposal, that was promptly backfilled. Drawing number M2600, sheet 11 (Wood 1958), has the dimensions of the 216-T-18 crib as 10 ft (3.1 m) by 10 ft (3.1 m) by 10 ft (3.1 m). However, WIDS states the crib has dimensions and construction similar to that of 216-T-26, -T-27, and -T-28 (see below). Since this crib was apparently excavated for a one-time use it is highly unlikely that the description of an engineered facility constructed at 216-T-26, -27, and -28 is accurate for 216-T-18.

Ruppert and Heid (1954) report approximately 256,000 gallons (969,062 liters) (SIM uses 256,275 gallons) of tributyl phosphate scavenged waste was pumped from 241-T-101 tank to a 10x10x10 ft (3.1x3.1x3.1 m) "hole in the ground" (referred to as the 241-T-17 crib), 10 ft (3.1 m) north of monitoring well 241-T-17 (299-W11-70 {A7312}). The waste was sent to the crib during December 1953. Shortly thereafter, the site was deactivated. Above-ground piping from the 241-T Tank farm was removed and the unit was backfilled. Based on seven samples from the 241-T-101 tank supernate, the average analysis on January 14, 1954 indicated 0.85 uc/cc total beta and 840 Curies total beta with a pH of 9.7. The primary beta emitters were Cs, Sr, Ru, Sb, rare earths, and Y. Cs-137 was the dominant radioelement in terms of activity.

7.2.2 216-T-26, -27, AND -28 CRIBS

The 216-T-26, -27, and -28 Cribs are also referred to as the 216-TY #1, 2, and 3 Cribs/Caverns and are directly east of 241-TY Farm. Originally, the plan was to build 6 cribs but 216-T-29, -30, and -31 were never built. These cribs also have been referred to as caverns. A cavern is described as "earth –covered large hollow, bottom open to ground" (Clukey 1956). This definition was in contrast to a crib which was "earth-covered structure for liquid disposal, with box(es), horizontal pipe, or uniform-sized gravel to provide distribution and surge space." Drawing H-2-2735 shows construction details for the three cribs. They each consisted of a 15-ft (4.6 m) deep excavation with a bottom area of 30-ft (9.1 m) by 30 ft (9.1 m) and 1:1 side slopes. This was backfilled with a 5-ft (1.5 m) layer of 3-in. (7.6 cm) minimum gravel into which four 48-in. (121.9 cm) diameter by 4 ft (1.2 m) concrete culvert pipes were embedded

vertically in a 15-ft (4.6 m) square pattern. This was followed by a 2-ft (0.6 m) layer of ¾ (1.9 cm)- to 1.5-in. (3.8 cm) gravel and a layer of ¾-in. (1.9 cm) gravel to the top of the culvert pipe. The excavation was backfilled to grade with existing material. Each crib is fed from the east by a 14-in. (35.6 cm) diameter steel pipe, with an 8-in. (20.3 cm) steel pipe in a chevron pattern feeding each culvert pipe. The pipe to each crib connects to a 14-in. (35.6 cm) steel pipe running south from the 216-TY-201 Flush Tank. Valves were provided to isolate each crib. The piping layout is shown in H-2-2733.

First cycle scavenged waste was sent through a pipeline from the 241-TY Farm to the 216-TY-201 Flush Tank before being sent to the 216-T-26 crib (WIDS discussion for the 216-TY-201 flush tank). This discussion suggested the flush tank received waste from the 241-TY Farm from 1953 to 1955 and discharged the overflow to the 216-T-26 crib. However, the WIDS discussion for the 216-T-26 crib states the crib was used from August 1955 to November 1956. These dates are supported by Ludlow and Poucher (1954), whose document described planning for constructing the flush tank and cribs sometime after December 1954. After 1955, the flush tank received waste via another pipeline from tank 241-T-112 in the 241-T Farm. WIDS records indicate that waste from the flush tank was then discharged to the 216-T-27 and -28 cribs. However, WIDS also states the 216-T-27 crib received no waste until 1965. This would imply that waste after 1955 was sent to 216-T-28, bypassing the 216-T-27 crib. The concrete flush tank is located northeast of the 216-T-26 crib and is 23.3 ft (7.1 m) long by 10 ft (3.1 m) wide with a height of 9.5 ft (2.9 m). It is buried by 5 ft (1.5 m) of overburden. Capacity is 9500 gallons or 35,961 liters (WIDS).

WIDS reports the 216-T-26 crib was in use from August 1955 to November 1956. T Farm waste (241-T-112 waste) was apparently sent to the 216-T-28 crib, bypassing the 216-T-27 crib after 1955. However, WIDS claims the 216-T-28 dates of service were from 1960 to 1965.

The WIDS General Summary Report indicates a start and end date of 1965 for the 216-T-27 crib. This also appears to contradict the general summary report for the flush tank that indicates waste was first routed to the 216-T-27 crib in 1955.

In addition to the 241-T-112 waste, 2706-T equipment decontamination waste was added to the waste stream. In 1960, it was recommended that the 216-T-28 crib receive the vehicle and in- building wastes from T-Plant decontamination facilities (Linderoth 1960). However, it is not known if the recommendation was implemented. In 1964, 300 Area laboratory waste was trucked to the 200 West area. WIDS states the 300 Area waste was combined with the T-Plant waste that was discharged to the 216-T-27 and -28 cribs. Apparently, a crib riser was used for disposal of the 300 Area waste.

Additional 300 Area waste that was sent to the 216-T-27 and –T-28 cribs was a result of a rupture in the PRTR test reactor September 29, 1965 (IDMS ascension # 1006070422). The liquid waste from the loop in which the rupture occurred was diverted to three 15,000 gallon tanks for temporary storage. It was estimated 48,000 gallons (181,699 liters)/ 24 hr period would need to be trucked to the 200 areas for disposal. WIDS states that more than 100 truck loads (500,000 gallons or 1.9 million liters) of liquid waste from the test reactor incident was discharged to the 216-T-28 crib during September and October 1965. McMurray (1956) reports that "300 Area Laboratories effluent (340 facility)" was discharged to the 216-T-28 crib from October 1963 to August 1965, with a total volume of 30 million liters (8 million gallons). In September, October and November of 1965 the 300 area waste was sent to the 216-T-27 crib. The total volume over this period is reported to be 41.8 million liters (11 million gallons).

Haney (1965) provides some further insight regarding the 216-T-28 crib in 1965. This letter, dated September 7, 1965 prior to the test reactor fuel rupture, states that Cs-137 and Ru-106 were measured in the groundwater in well 299-W14-3 at a concentration of 10E-04 and 5 E-03 uCi/cc, respectively. The recommended Cs-137 groundwater limit was 2E-05 uCi/cc. Haney recommended that the TY-3 crib (216-T-28) facility be abandoned and the waste be routed to the TY-2 crib (216-T-27 crib). This implied that the 216-T-27 crib had not been used before. Haney further stated the TY-3 crib (216-T-28 crib) had been receiving both 300 Area and T-Plant waste for about two years. It was predicted, assuming no

appreciable changes in waste characteristics or disposal rate, that the identically-sized TY-2 (216-T-27) crib will have a useful life of no longer than two years. The crib life may be shortened due to the horizontal spread of wastes from the adjacent TY-1 (216-T-26) and TY-3 (216-T-28) facilities. In a December 1966 letter, Ritter (1966) stated that breakthrough of radiostrontium and radiocesium into the ground water beneath the 216-T-28 crib necessitated diverting waste to the 216-T-27 crib on November 15, 1965. He notes that "BNWL waste that was routed to this crib does not react favorably with the 200 West Area soil and the crib life may be shorter than previously estimated." He recommends that the 216-T-27 Crib be retired before Feb 1, 1967. Based on this time line, most of the waste produced by the incident with the test reactor would have entered the 216-T-28 crib (this contradicts McMurray, above). The cribs were inactive by 1966 (WIDS).

7.3 PREVIOUS INVESTIGATION

Operational experience and groundwater data discussed above strongly indicated that radionuclide contamination had been detected in the vicinity of the T-26, T-27, and T-28 cribs by late 1965 and waste disposal to these cribs was terminated.

Brown (1971) conducted a qualitative study to estimate inventories of ruthenium, strontium, and cesium in the vadose zone within 50 ft (15.2 m) of the current groundwater level for waste sites in the 200E and 200W areas. These estimates were based on discharge volumes and the sorptive capacity of the underlying sediments (as a function of waste category). Discharges to the 216-T-26, -27, and -28 cribs were reported to include 5100 curies of ruthenium and 1630 curies of strontium and cesium. Inventory within 50 ft (15.2 m) of the groundwater level was estimated to be 44.1 Ci Ru and 14.1 Ci Sr and Cs. Next to the 216-S-1 and –S-2 cribs, these estimates represented the greatest estimated impact to the deep vadose zone from liquid waste disposal sites in 200W at the time of the analysis. No effort was made to confirm these estimates.

Fecht et al. (1977) evaluated 216-T-18 using log data from one borehole (299-W11-11 {A7280}). Contaminants were observed from 2.1 to 26.1 meters (7 to 86 ft) below the ground surface in 1954 and 1976. Fecht et al. concluded no measurable movement of radionuclides could be detected and that breakthrough to groundwater probably did not occur at the site.

Fecht et al. also evaluated the 216-T-26 crib using borehole 299-W11-70 (A7312). Activity was detected from near the ground surface to a depth of 28.9 meters (95 ft). It was concluded no breakthrough to the groundwater had occurred at this site.

The evaluation by Fecht for 216-T-27 suggested the crib was not used until 1965. Therefore, Fecht concluded that activity in borehole 299-W14-53 (A7737) measured in 1963, originated from the 216-T-28 crib. Fecht states that discharges to the crib in 1965 began increasing the zone of contamination and the radiation intensity through 1970. By 1976, radiation intensity had begun to decrease from radioactive decay. It was concluded no breakthrough to groundwater had occurred below the T-27 crib.

Boreholes 299-W14-2 (A7328), 299-W14-3 (A7329), and 299-W14-4 (A7330) adjacent to the 216-T-28 crib showed radioactivity from the ground surface to the water table (Fecht 1977). Borehole 299-W14-4 showed contamination in the groundwater as early as 1967. The radiation intensity increased through the entire sediment column during disposal to the crib. Borehole 299-W14-1 (A4913), located approximately 125 ft (38.1 m) southeast of the crib, showed lateral spreading of contaminants. Fecht states that these data indicate breakthrough to the groundwater could have occurred at this site.

The 216-T-26, -27, and -28 waste sites were evaluated in the Aggregate Area Management Study Report in 1992 (U.S. Department of Energy 1992). Cross sections of contamination and stratigraphy were created to show the approximate locations of regions in the subsurface contaminated by anthropogenic radionuclides. It was stated that there was insufficient data to fully characterize the extent of radiation levels in the subsurface proximal to 216-T-26 through 216-T-28. An elongate plume of elevated gamma

activity following the stratigraphic dip to the south was identified. It was also stated that 216-T-28 was the major source of contaminants, followed by 216-T-26 and -27, respectively. It was also stated that contaminants probably entered the groundwater during the time span of 1967 to 1970 from 216-T-28. The data were considered inadequate to evaluate the possibility that 216-T-26 and -27 cribs were also sources of contamination to groundwater. An isopach map generated at this time is included as Figure 7-2.

7.4 SUMMARY OF LOG DATA

Figure 7-3 shows the location of twenty three boreholes relative to the four cribs that have been evaluated for the 216-T-18 and 216-T-26 sub region and the cross section lines. All geophysical logging data acquired since 1954 are included in Table 7-1. A brief evaluation of the significance of each log as compared to earlier logs in the same borehole is made. This evaluation is intended to describe any significant changes in the gamma profile during intervening years. A more accurate quantitative analysis will require detailed comparison, taking into account the relative efficiencies of the various detection systems. This will require a detailed assessment of the older logging systems, which depends on calibration data, reports, and other information that are difficult to locate. This is beyond the scope of the current effort but it is strongly recommended for assessment of key boreholes. The "historical" record is important to determine the past distribution of very short-lived radionuclides in the vadose zone, the maximum extent of contamination at depth, and whether any influx or migration of contaminants has occurred over time. This is particularly important in dealing with sites that received significant quantities of "scavenged" waste, where efforts were made to reduce or remove cesium before disposal. Cs-137 (half life 30.17 years) represents the most common gamma-emitting radionuclide associated with fission products. Many short-lived fission products, such as Ru-106 (half life 1.02 years) have decayed below detectable levels within 10 years after creation such that there are few instances where Ru-106 would be detected in any significant amounts today.

Cross sections A-D (Figures 7-4, 7-6, 7-7, and 7-8) and visualizations (Figures 7-5, 7-13, 7-14, 7-15, and 7-16) are included to show the relationships of stratigraphy to contaminants.

7.4.1 216-T-18 CRIB

299-W11-11 (A7280) is the only deep borehole (248 ft or 75.6 m)) within the 216-T-18 crib original excavation footprint. Three direct-push probes (C6410, C6411, and C6412) were inserted into the crib primarily for investigation of Pu-239. They were logged with the small diameter logging system (SDLS) in 2008 with gamma, moisture, and passive neutron capabilities (Figure 7-4).

Borehole 299-W11-11 was logged with total gamma detectors in 1954, 1963, 1968, and 1976 and with the spectral gamma RLS in 1992. The log profiles are similar, detecting activity from approximately 10 to 84 ft (3.1 to 25.6 m) at the top of the CCuz. Activity has decreased, suggesting the decay of short lived radionuclides throughout this time period. By 1992, Cs-137 and Co-60 were the only detectable gamma emitting radionuclides present as indicated by the RLS. The maximum Cs-137 concentration is less than10,000 pCi/g. This level is consistent with waste that has been scavenged of Cs-137 before deposition. 299-W11-11 (A7280) was decommissioned in 2005 and is no longer available for logging.

Three direct push holes were placed along the edges and within the crib and logged with the SDLS to determine lateral extent of the contamination. Interpretations of the SDLS results are based primarily on total gamma count rate. Gamma activity recorded by the SDLS is stated in terms of equivalent cesium (eCs), meaning the gamma activity resulting from a uniform distribution of Cs-137 around the borehole. Other radionuclides may be contributing to the total gamma activity, but not explicitly detected. SDLS data show contamination at the margin of the crib between approximately 28-31 ft (8.5-8.5 m) bgs and from 28 to 39 ft (8.5 to 11.9 m) bgs near the center of the crib (S.M. Stoller 2009). Figure 7-5 shows a view of the contamination profile for the 216-T-18 crib. No significant contamination appears to have penetrated to the top of the CCu. However, low levels of Co-60 are detected in the RFwie.

WIDS states that about 1800 g of plutonium discharged to the crib. The RLS detector used in 1992 has about half the intrinsic efficiency of the SGLS used today, with about half the count time. Therefore, the detection capability for Pu-239 and other transuranic radionuclides is relatively poor. The small diameter logging system employs conventional spectral gamma detectors, which are not well-suited to identification of weak gammas required for plutonium assay. Therefore, existing log data are not adequate to assess plutonium contamination at the threshold level of 100 nCi/g. Unfortunately, the boreholes have been decommissioned.

7.4.2 216-T-26 CRIB

Figure 7-6 is a cross section B-B' from north to south through the 216-T-26, -27, and -28 cribs and ending at borehole 299-W14-1 (A4913) approximately 125 ft (38.1 m) southeast of the 216-T-28 crib. Cross section C-C' (Figure 7-7 is a west to east cross section through the 216-T-28 crib. Cross section D-D' (Figure 7-8) includes three closely spaced boreholes, approximately 150 ft (45.7 m) southwest of the 216-T-28 crib.

The original excavation footprint of 216-T-26 is characterized by the two deepest boreholes, 299-W11-70 (A7312) and C3102. Borehole 299-W11-82 A7324) lies at the northern margin of the crib and is approximately 70 ft (21.3 m) deep (Figure 7-1). Both deep boreholes show contamination, and 299-W11-70 terminates in contamination at 150 ft (45.7 m) bgs. Logging of this borehole has resulted in detector saturation since 1963 in the interval from 15 to 100 ft (4.6 to 30.5 m) bgs. This high activity interval is beyond the range of the SGLS. Cs-137 concentrations are underestimated by up to 3 orders of magnitude and are not included in data visualizations. In 1983, the borehole was deepened to 150 ft (45.7 m). A 6-in. (15.2 cm) liner was placed in the borehole and the interval from ground surface to 100 ft (30.5 m) was perforated and grouted between the annulus. Co-60, Eu-154, and Eu-152 were detected in this borehole and probably exist in the high activity zone at a level below the MDL that is raised in the high activity interval. Re-logging with the HRLS is recommended. Cs-137 and Co-60 were detected in the CCu and below in the RFwie at the bottom of the borehole. Borehole C3102 exhibits significantly less Cs-137 concentrations than 299-W11-70. However remnants of Co-60 exist in the CCu and RFwie. The more shallow borehole (299-W11-82) indicates near surface Cs-137 contamination at concentrations less than 10 pCi/g from approximately 5 to 25 ft (1.5 to 7.6 m) bgs. Higher concentrations (maximum of 1000 pCi/g) are observed from 30 ft (9.1 m) to the total depth of the borehole at 70 ft (21.3 m) bgs. The ground water level was 225 ft (68.6 m) at the time of logging C3102 in 2001. Based on these three boreholes, it appears that contamination resides mostly in the southern portion of the crib and it cannot be evaluated if contamination has reached the groundwater because the boreholes do not reach the water table.

Crib 216-T-27 is characterized by borehole 299-W14-53 (A7337). High activity was exhibited in this borehole as early as 1963 from approximately 30 ft (9.1 m) bgs to the bottom of the borehole at 100 ft (30.5 m). This activity existed before the crib was activated in 1965 and probably originated from the 216-T-28 crib. After the 216-T-27 crib became active, the 1970 log data indicate a significant influx of contamination from approximately 10 ft to 30 ft (3.1 to 9,1 m) bgs between 1963 and 1970. The borehole was deepened in 1983 to 150 ft (45.7 m) bgs and subsequent logs in the 1980s suggest the deeper contaminants (below 65 ft or 19.8 m) bgs) were relatively short lived and the dominant contamination existed between 10 and 65 ft (3.1 and 19.8 m). Cs-137, Co-60, Eu-154, and Eu-152 were identified in this borehole by spectral gamma logging in 1992. Comparison of the 1992 RLS with the 2006 SGLS logging shows similar profiles and concentrations. The 1992 log also identified 10 pCi/g of Sb-125 from 67.5 t to 77.5 ft (20.6 to 23.6 m) bgs. Sb-125 has a short half-life (2.8 years) and apparently decayed away by 2006. Currently, Co-60 is shown within the CCu and into the RFwie to the bottom of the borehole at 150 ft (45.7 m) bgs.

216-T-28 is characterized by boreholes included in cross sections B-B' (Figure 7-6) and C-C' (Figure 7-7). Boreholes 299-W14-2 (A7328), 299-W14-3 (A7329), and 299-W14-4 (A7330) were drilled in 1955, 1961, and 1966, respectively. The first two are within the original excavation footprint and the

latter is just to the west. Each was "remediated" in 1983. Remediation consisted of placing a packer at about 160 ft (48.8 m) bgs and placing a 6-in. (15.2 cm) casing inside the existing 8-in. (20.3 cm) casing to that depth. Perforations were made from ground surface to 160 ft (48.8 m) bgs in the 6-in. (15.2 cm) casing and grout emplaced between the 6- and 8-in. (15.2 and 20.3 cm) casings.

Figures 7-9, 7-10, and 7-11 display historical logs for boreholes 299-W14-2 (A47328), 299-W14-3 (A7329), and 299-W14-4 (A7330). The historical record of logs is important to understand the depth of contamination and the nature of contamination as it relates to short-lived or longer lived contaminants. Log data for these boreholes reported in Fecht (1977) were digitized and plotted side by side with the latest total gamma from spectral gamma logging and the manmade radionuclides that were detected. Although the total gamma log count rates cannot be compared directly because of different detector characteristics, general observations can be made. For example, the history of borehole 299-W14-02 (A7328), Figure 7-9, suggests initial deposition of gamma emitting contaminants mostly from 25 to 70 ft (7.6 to 21.3 m) bgs with a maximum depth of 115 ft (35.1 m) bgs. An influx of additional contamination from 70 to 115 ft (21.3 to 35.1 m) bgs had occurred by 1963. By 1970, elevated gamma activity is evident to the bottom of the borehole. Particularly noteworthy is the increase from 200 to 220 ft (61.0 to 67.1 m) bgs which probably represents contamination in the groundwater. A comparison between the 1976 and 1970 logs suggests that significant decay has occurred in the interval below 160 ft (48.8 m) bgs. The 2004 log indicates that Cs-137 and Co-60 remain in the vadose zone to the bottom of the borehole. The relatively uniform Co-60 profile from 200 to 220 ft (61.0 to 67.1 m) bgs is consistent with residual Co-60 that is adsorbed to the casing as contaminated water migrated by and/or receded. This is sometimes referred to as a "bathtub ring." It is relatively common in older boreholes.

Borehole 299-W14-03 (A7329) shown in figure 7-10 can be similarly interpreted even though the log dates are different. Initial deposition prior to 1963, indicates significant contamination to 110 ft (33.5 m) bgs as evidenced by detector saturation, with lower contamination levels to approximately 150 ft (45.7 m) bgs. By 1976, contamination is detected in the groundwater below approximately 205 ft (62.5 m) bgs. Contamination from 40 to 120 ft (12.2 to 36.6 m) bgs in 1976 is generally consistent with the Eu-154 profile in the 2004 SGLS log. Below 120 ft (36.6 m), the 2004 total gamma mostly reflects the low concentrations of Cs-137 and Co-60 to the bottom of the borehole. Borehole 299-W14-04 (A7330), Figure 7-11, is similar to 299-W14-3 although the concentrations of radionuclides are much lower.

Log profiles in these boreholes can be interpreted as evidence that contamination reached groundwater between 1963 and 1970 below 216-T-28. This includes Cs-137, Co-60, and possibly other shorter-lived radionuclides. Borehole C4175, located just north of these boreholes and drilled in 2004, indicates contamination to approximately 110 ft (33.5 m) bgs. Unlike the other boreholes in the crib, significant contamination is not observed in the Ringold Formation at borehole C4175 (see Figure 7-7).

Borehole 299-W14-16 (C3120) located approximately 200 ft (61.0 m) southeast of the 216-T-28 crib indicates no contamination (Figure 7-7). Borehole 299-W14-1 (A4913) is located about 125 ft (38.1 m) southeast of the crib. It appears to show evidence of lateral spreading of radioactive contaminants. Figure 7-12 shows historical logs for Borehole 299-W14-1 plotted with the currently detected manmade radionuclides. These data indicate an influx of contaminants at the depth zone from 30 to 50 ft (9.1 to 15.2 m) bgs prior to 1963. Between 1963 and 1968 contamination appears to increase between 30 and 50 ft (9.1 to 15.2 m) bgs, and to have invaded the interval between 50 ft (15.2 m) and the bottom of the logged interval at 225 ft (68.6 m) bgs. By 1976, much of the contamination appears to have decayed away. The 2004 SGLS log shows only scattered contamination at low concentrations.

299-W14-01 exhibits a zone of uniform Cs-137 concentration at approximately 10 pCi/g between 150 and 160 ft (45.7 and 48.8 m) bgs. This appears to be related to borehole completion details. In February 1983, the borehole was remediated. The 8-in. (20.3 cm) casing was perforated from 20 to 150 ft (6.1 to 45.7 m) bgs. A packer was set at 158 ft (48.2 m) and a 6-in. (15.2 cm) casing was installed. 15 gallons of sand was placed in the annular space above the packer, followed by 218 gallons of cement grout. It appears that Cs-137 has accumulated in the "sandpack" interval between the top of the packer and the

bottom of the grout. The source of this cesium is not known, but there is no evidence of elevated gamma activity in this interval in the 1963, 1968, or 1976 logs.

A cluster of four boreholes (Figure 7-8 cross section D-D') approximately 200 ft (61.0 m) southwest of the 216-T-28 crib has one borehole (299-W14-13) with Cs-137, Co-60, and Eu-154 identified. 299-W14-13 was logged in 1998 and identified two zones of low-level contamination: Co-60 from 90-96 ft (27.4-29.3 m) and 110-112 ft (33.5-34.1 m), and Eu-154 from 90-92 ft (27.4-28.0 m) bgs. The source of the contamination is hypothesized to be the 216-T-26, -27, -28 cribs. Most of the contamination lies in the CCuz fine grained zone with small amounts of Co-60 in the CCuc. Similar contamination was not detected in either 299-W14-11 (C4668) or 299-W14-20 (C7018), both of which are located generally between the 216-T-28 crib and 299-W14-13. However, 299-W14-11 was logged in 2005 and 299-W14-20 was logged in 2009. Both Co-60 and Eu-154 have short half lives (5.27 and 8.59 years, respectively), and it is possible that these radionuclides are present in the same depth zone but had decayed below detectable levels in the intervening years (between 1998 and 2005-2009).

Figures 7-13, 7-14, and 7-15 show visualizations of the four cribs for Cs-137, Eu-154, and Co-60, respectively, and their relationship to stratigraphy and the current groundwater level. Figure 7-16 shows a view from the west that shows the relationships of all contaminants. The lateral spreading from the cribs to boreholes south of 216-T-28 is shown by the Co-60, Eu-154, and Cs-137 in borehole 299-W14-1 (A4913) and Co-60 and Eu-154 in 299-W14-13 (B8549).

7.4.3 241-TY FARM

Although some boreholes in the 241-TY Farm are within 100 m of the 216-T-26 to -28 waste sites (Figure 7-1), documented (Myers 2005) contamination in the farm is not expected to impact the vadose zone below the waste sites. The stratigraphic dip is generally to the southwest in this area. Reports that include geophysical logging data and interpretations within the tank farm are included in Appendix A-2.

7.5 SUMMARY OF SUBREGION AND CONCLUSIONS

Four boreholes in the 216-T-18 crib excavation suggest most contamination currently exists in a thin interval at approximately 30 ft (9.1 m) bgs. Older total gamma logs suggest the possibility of short-lived radionuclides extending to approximately 80 ft (24.4 m) bgs. More current spectral gamma logging indicates that Cs-137 and Co-60 exist predominantly above the CCu at approximately 90 ft (27.4 m) bgs. However, trace levels of Co-60 are detected at sporadic locations deeper in the vadose zone in the Ringold Formation indicating contamination may have migrated to those depths within the vadose zone. (Although it has a relatively short half life of 5.27 years, Co-60 has two distinct gamma lines at 1173 and 1332 keV, which make it easy to identify with high-resolution spectral gamma logging systems.) The 216-T-18 crib may be sufficiently characterized to assess the deep vadose zone. This crib received low volumes of waste, the total inventory of chemicals and long-lived mobile radionuclides disposed of were small (<6%) in comparison to the other 3 cribs (see Appendix A in main report), and waste was deposited over a short period of time in December 1953 and was immediately backfilled. 1800 grams of plutonium are reported to have been included in the waste stream discharged to the crib. The log data acquired to date are inadequate to address the distribution of plutonium contamination in the vadose zone because the detection limit of the logging system used is high (at or near 100 nCi/g).

Two boreholes were used to evaluate the 216-T-26 crib. The contamination extends into the RFwie in the southern portion of the crib. The northern portion is less contaminated but detectable gamma contamination also extends to the CCu and just into the RF. First cycle scavenged waste was sent through a pipeline from the 241-TY Farm to the 216-TY-201 Flush Tank before being sent to the 216-T-26 crib. The flush tank received waste from the 241-TY Farm from 1955 to 1956 and discharged the overflow to the 216-T-26 crib. After 1955, the flush tank received waste via another pipeline from tank 241-T-112 in the 241-T Farm.

The 216-T-27 crib was not opened until November 1965. One borehole is available to evaluate this site. This borehole indicated gamma activity from 30 ft to the bottom of the borehole at 100 ft in 1963. After the crib was activated in 1965, additional contamination that saturated the detection system was observed between 10 and 30 ft. After deepening the borehole to 150 ft (45.7 m) bgs in 1983, subsequent logs showed decay of radionuclides below 65 ft. Current spectral gamma log data show Co-60 contamination to the bottom of the borehole.

The 216- T-28 crib most likely contaminated a large portion of the vadose zone, extending to groundwater. Boreholes to the southeast (299-W14-1 {A4913}) and 299-W14-13 {B8549}) indicate lateral movement of contamination into and along the CCu and below. Borehole 299-W14-1 indicates low concentrations of Cs-137 extending to groundwater. Borehole 299-W14-13 indicates Co-60 and Eu-154 migrated down to and into the CCu. Boreholes closer to the crib (299-W14-2 {A7328}) and 299-W14-3 {A7329}) both indicate Cs-137 and Co-60 extending to groundwater.

As a consequence of the September 1965 fuel element rupture in the Plutonium Recycle Test Reactor (PRTR), a significant volume (at least 500,000 gallons or 1.9 million liters) of low-level waste was trucked from the 300 area to the 21-T-27 and 216-T-28 cribs during September, October, and November 1965. There is some uncertainty as to which crib received the bulk of the waste. In early September, 1965 (prior to the PRTR rupture) Cs-137 and Ru-106 had been detected in groundwater from well 299-W14-03, prompting a recommendation to abandon 216-T-28 and activate 216-T-27. (Haney, 1965) However, there is evidence to suggest that 216-T-28 was not closed until November 1965. By December 1966, it was noted "data have been developed which indicate the BNWL waste that was routed to this crib does not react favorably with the 200 West Area soil" and the recommendation was made to retire the 216-T-27 crib by February 1967 (Ritter, 1966). This provides evidence that operational personnel were aware that contamination in the 216-T-27 and 216-T-28 vicinity had impacted groundwater.

7.6 RECOMMENDATIONS

WIDS records and other available information provide contradictory interpretations as to the history of the 216-T-18, -26, -27, and -28 waste sites. It is recommended that an effort be made to investigate and resolve these apparent discrepancies prior to any further field investigations.

The 216-T-18 crib appears to have been adequately characterized. This crib received a low volume waste stream for only a few week period in 1953 and is not expected to have contaminated the deep vadose zone. However, the disposed plutonium has not been located. Available log data are not adequate to detect plutonium at levels comparable to the 100 nCi/g criterion. It is recommended that the waste stream be re-assessed to confirm that Pu was discharged. Additional boreholes with high resolution spectral gamma and passive neutron logging along with sediment sampling may be required to assess the nature and extent of plutonium contamination. This logging would require boreholes and/or direct push casings with inner diameters greater that 4 inches to accommodate the SGLS.

In this report it is interpreted that the 216-T-26 crib received Cs-137 scavenged waste for two years (from1955 to 1956), the 216-T-27 received 300 Area waste for one year (1965) and possibly waste associated with a fuel rupture from an experimental reactor in the 300 Area, and the 216-T-28 crib received a combination of waste from 241-T-112 (after 1955), T plant decontamination waste, 300 Area waste, and contaminated water related to an incident of a fuel rupture in a reactor in the 300 area over a time span of 1960 through 1966. It is recommended the 216-T-28 crib be further investigated to determine the characteristics of the commingled waste streams and the mobility of the different constituents.

There is evidence that significant lateral migration of contaminants from 216-T-28 may have occurred to the southeast and southwest of the 216-T-28 crib. Additional characterization is recommended to assess the nature and extent of lateral spreading plumes that emanated from the 216-T-28 crib.

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TABLE 7-1. GEOPHYSICAL LOGGING DATA ACQUIRED SINCE 1954

WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	LOG DATE	LOG TYPE	CONTAMINATION HISTORY	SUMMARY
299-W10-18	A4895		YES	144	30-NOV-90	GG	GAMMA ELEVATED FROM 45 TO 96 FT, 100 CPM FROM 90-96 FT, AND AT 115 FT	NO MAN-MADE RADIONUCLIDES WERE DETECTED IN 1990 GROSS GAMMA LOGGING.
299-W10-18	A4895		YES	222.6	12-DEC-90	GG	ELEVATION OF GAMMA FROM145-225 FT.	
299-W10-26	B8548		YES	262	22-AUG-98	RLS	NO MAN-MADE RADIONUCLIDES WERE DETECTED.	NO MAN-MADE RADIONUCLIDES WERE DETECTED IN RLS LOGGING IN 1998.
299-W10-27	C3125		YES	268.5	26-MAR-01	RLS	NO MAN-MADE RADIONUCLIDES WERE DETECTED, WATER IN CASING AT 187.5 FT.	NO MAN-MADE RADIONUCLIDES WERE DETECTED IN RLS LOGGING IN 2001. MAXIMUM MOISTURE WAS 25% AT 110 FT.
299-W10-27	C3125		YES	187.5	15-MAR-01	NEUTRON	MOISTURE DATA IS NOT VALID FROM 0-56 FT DUE TO THE 12.75 INCH DUAL CASING, MAX MOISTURE WAS 25% AT 110 FT.	
299-W10-7	A7139		N/A	220	N/A	N/A	NO DATA AVAILABLE	NO DATA AVAILABLE
299-W11-11	A7280	241-T-17	SUBMITTED	248	31-MAR-92	RLS	CS-137 MAX 12,000 PCI/G AT 2* FT, CO-60 MAX 5 PCI/G AT 75 FT. WITH LEAD SHIELD	THE 1954 SN LOG SHOWS HIGH DEAD TIME FROM 10-85 FT, WITH DECAY BY 1976. TOTAL GAMMA PROFILES FROM 1976 TO 1992 ARE SIMILAR, AND SHOW CONTINUED DECAY. THE 1992 RLS LOGGING SHOWS CS-137 CONTAMINATION THROUGHOUT THE BOREHOLE, WITH CO-60 FROM 10 TO 85 FT. PLUTONIUM CONTAMINATION IN 1953, RLS COUNT TIME WAS NOT LONG ENOUGH TO DETECTED. GWL WAS NOT AVAILABLE.
299-W11-11	A7280		SUBMITTED	248	22-MAR-54	GG	ELEVATED GAMMA WITH HIGH DT FROM 10-82 FT,	
299-W11-11	A7280		YES	248	23-FEB-76	GG	ELEVATED GAMMA FROM 14-80 FT, MAX AT APPROXIMATELY 33 FT, ELEVATED PEAK AT 75 FT.	
299-W11-11	A7280		YES	240	29-APR-63	GG	ELEVATED GAMMA FROM 10-20 FT, MAX AT APPROXIMATELY 30 FT, ELEVATED PEAK AT 75 FT.	
299-W11-11	A7280		YES	200	09-APR-65	NEUTRON	WATER LEVEL AT 200 FT.	
299-W11-11	A7280		YES	244	12-APR-68	GG	ELEVATED GAMMA WITH PEAKS AT 10, 28 FT 75 FT.	
299-W11-11	A7280		YES	240	29-NOV-76	DENSITY	NOT INTERPRETED	
299-W11-11	A7280		YES	240	25-FEB-77	NEUTRON	WATER LEVEL AT 200 FT.	
299-W11-70	A7312	241-TY-7	YES	150	27-FEB-92	GG	HIGH DT	HIGH DEAD TIME WAS EXPERIENCED FROM APPROXIMATELY 20-93 FT IN EACH LOGGING EVENT, THEREFORE ACTUAL CONTAMINATION VALUES ARE UNDERESTIMATED IN THIS RANGE. CS-137, CO-60, EU152, AND EU-154 WERE DETECTED BELOW 93 FT. EU IS CONSIDERED TO BE RELATIVELY IMMOBILE, HOWEVER IT IS DETECTED AT APPROXIMATELY 97 FT. CS AND CO APPEAR TO HAVE PENETRATED THE RFWIE, WHILE THE EU-152 AND EU-154 REMAIN ABOVE THIS UNIT IN 2001. CO-60 WAS DETECTED TO TOTAL LOGGING DEPTH TO 150 FT. GWL IS NOT AVAILABLE.
299-W11-70	A7312		YES	150	14-AUG-87	GG	HIGH DT	
299-W11-70	A7312		YES	150	03-APR-84	GG	HIGH DT	
299-W11-70	A7312		YES	150	29-NOV-76	DENSITY	NOT INTERPRETED	
299-W11-70	A7312		YES	100	25-FEB-77	NEUTRON	NOT INTERPRETED	
299-W11-70	A7312		YES	98	29-APR-63	GG	HIGH DT FROM 0-98 FT (TOTAL LOGGING DEPTH).	
299-W11-70	A7312		SUBMITTED	98	02-SEP-65	GG	HIGH DT FROM 0-98 FT (TOTAL LOGGING DEPTH).	
299-W11-70	A7312		YES	98	07-MAY-76	GG	HIGH DT FROM 0-98 FT (TOTAL LOGGING DEPTH), WITH DECAY FROM 1976 TO 1965 TO 1963, OF DIFFERENT RADIONUCLIDES.	
299-W11-70	A7312		SUBMITTED	148	20-SEP-95	RLS	HIGH DT 21-68 FT. CS, CO, AND EU-154 ARE UNDERESTIMATED. EU-152 WAS NOT ID.	
299-W11-70	A7312		SUBMITTED	150	27-FEB-92	RLS	HIGH DT (18-62 FT), CS, CO, EU-152, AND EU-154 ARE UNDERESTIMATED.	
299-W11-70	A7312		YES	150	14-JUN-01	SGLS	HIGH DT 20-93 FT; CS, CO, EU-152, AND EU-154 ARE UNDERESTIMATED.	
299-W14-1	A4913	241-T-19	YES	240	17-AUG-04	SGLS	CS, CO, EU-152, EU-154, AND SN-126 ARE DETECTED THROUGHOUT THE BOREHOLE.	GAMMA LEVELS INCREASED FROM 1963 TO 1968 SHOWING POSSIBLE INFLUX OF MATERIAL. NOTE: WIDS-RITTER 1966, REPORTS THAT CONTAMINATION EXISTED IN THE GROUNDWATER BENEATH THE CRIB IN 1965. BY 1976 SIGNIFICANT DECAY IS INDICATED IN SN LOG. THE 1992 RLS HAS A SIMILAR PROFILE TO THE 2004 SGLS DATA, SUGGESTING STABILITY OF THE CONTAMINATION. BOTH SGLS AND RLS LOGS SHOW 10 PCI/G OF CS OVER A SAND PACK ZONE FROM 149-160 FEET. CS-137 WAS DETECTED AT LESS THAN 1 PCI/G FROM 160-228 FT IN THE 2004 SGLS LOGGING (APPROXIMATELY 7 ABOVE GWL). AN ACCUMULATION OF CS-137 AT ~150 MAY SHOW "BATHTUB RING" OF 1989 WATER TABLE OR LATERAL SPREAD OF CONTAMINANTS.
299-W14-1	A4913		SUBMITTED	240	29-APR-63	GG	ELEVATED GAMMA FROM 28-40 AND AT APPROX. 130 FT.	
299-W14-1	A4913		SUBMITTED	240	23-FEB-68	GG	1968 GAMMA LEVELS ARE STRONGLY ELEVATED SINCE 1963, SUGGESTING INFLUX OF WASTE.	
299-W14-1	A4913		YES	240	07-MAY-76	GG	GAMMA LEVELS ARE STRONGLY DECAYED FROM 1968 AT VARYING RATES, SUGGESTING DIFFERENT CONTAMINANT DECAY.	
299-W14-1	A4913		YES	240	29-NOV-76	DENSITY	NOT INTERPRETED	
299-W14-1	A4913		YES	240	13-JAN-93	RLS	PROFILE IS SIMILAR TO 2004 SGLS	
299-W14-1	A4913		YES	240	23-SEP-86	GG	ELEVATED GAMMA THROUGHOUT BOREHOLE	
299-W14-1	A4913		YES	240	21-JUL-87	GG	ELEVATED GAMMA THROUGHOUT BOREHOLE	
299-W14-1	A4913		YES	200	09-JUN-65	NEUTRON	NOT INTERPRETED	
299-W14-1	A4913		YES	200	25-FEB-77	NEUTRON	NOT INTERPRETED	
299-W14-11	C4668	AHE269	YES	348	02-MAY-05	SGLS	NO MAN-MADE RADIONUCLIDES WERE DETECTED.	NO MAN-MADE RADIONUCLIDES WERE DETECTED IN SGLS LOGGING IN 2005.
299-W14-12	A4914		YES	3.5-161	03-OCT-91	GG	ANOMALOUS PEAK AT 159.5 FT.	RLS LOGGING RECOMMENDED ADDITIONAL LOGGING TO CLEAR UP AN UNEXPLAINED PEAK AT 159.5 FT IN THE GG LOGGING. THIS WELL IS ADJACENT TO THE TX TANK FARM AND NEAR THE T-26 CRIB.
299-W14-12	A4914		YES	130-221.6	16-OCT-91	GG	ANOMALOUS PEAK AT 159.5 FT.	
299-W14-13	B8549		YES	262	28-AUG-98	RLS	CS DETECTED AT SHALLOW DEPTHS, WHILE CO-60 AND EU154 WERE DETECTED AT DEPTH.	CS-137 WAS DETECTED FROM 3.75 TO 5.25 FT, WHILE CO-60 AND EU-154 WERE DETECTED TOGETHER FROM 90 TO 111 FT; APPROXIMATELY 80 FEET ABOVE WATER TRAPPED IN CASING AT 193 FT IN 1998.
299-W14-16	C3120		YES	265	01-NOV-00	RLS	UNEXPLAINED ELEVATED (20 PCI/G) K-40 FROM 30-95 FT AND 115-120 FT.	NO MAN-MADE RADIONUCLIDES WERE DETECTED IN RLS LOGGING IN 2000.
299-W14-16	C3120		YES	265	02-NOV-00	NEUTRON	NEUTRON MOISTURE, MAXIMUM 120 CPS AT 112 FT.	
299-W14-18	C3396		YES	261.5	25-SEP-01	SGLS	CS-50 PCI/G AT 35 FT, CO, EU-152 AND EU-154 WITH NO MM BELOW 100 FT, GLW IS 218.5 FT.	CS, CO, AND EU CONTAMINATION APPEARS TO BE ABOVE THE CCUC IN 2001. NO MM'S WERE DETECTED BELOW 100 FT. GWL IS 218.5 FT IN 2001 LOGGING EVENT.
299-W14-18	C3396		YES	261.5	25-SEP-01	NMLS	~15% MOISTURE FROM 87-112 FT IN THE CCUC.	

TABLE 7-1. GEOPHYSICAL LOGGING DATA ACQUIRED SINCE 1954

WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	LOG DATE	LOG TYPE	CONTAMINATION HISTORY	SUMMARY
299-W14-2	A7328	241-TY-5	YES	223	12-AUG-04	SGLS	HIGH DT 8-108 FT (VALUES AND CONTAMINANTS UNDERESTIMATED), CONTAMINANTS DETECTED BELOW 108 FT: DRY WELL	HIGH DT WAS ENCOUNTERED FROM 0-120 FT. THE 1970 SN LOG SHOWS CONTAMINATION IN GW. WIDS: 1965, CS-137 AND SR-90 CONTAMINATION IS IN GW BELOW THE CRIB. CS AND CO ARE DETECTED TO TOTAL LOGGING DEPTH (223 FT) IN 2004. COMPARISON OF RLS (1992) TO SGLS (2004) SUGGESTS STABILITY OF CONTAMINANTS SINCE 1992, EXCEPT FROM 145 TO 155 FT, WHERE A SLIGHT INCREASE IN CO-60 AND CS-137 HAS OCCURRED. THIS COINCIDES WITH 1989 GWL AT 150 FT, MAY BE "BATHTUB RING" OR LATERAL SPREAD. THE BH WAS DRY AT THE TIME OF LOGGING IN 2004.
299-W14-2	A7328		SUBMITTED	223	15-APR-58	GG	HIGH DT FROM 30-95 FT.	
299-W14-2	A7328		SUBMITTED	223	19-JUN-59	GG	HIGH DT FROM 30-95 FT.	
299-W14-2	A7328		SUBMITTED	223	29-APR-63	GG	HIGH DT FROM 0-120 FT, INCREASE IN GAMMA SINCE 1959	
299-W14-2	A7328		SUBMITTED	223	09-APR-70	GG	HIGH DT FROM 0-120 FT, INCREASE IN GAMMA SINCE 1963 WITH CONTAMINANTS POSSIBLY IN GW.	
299-W14-2	A7328		YES	223	23-FEB-76	GG	HIGH DT FROM 5-25 FT, WITH DECAY SINCE 1970 LOGGING EVENT	
299-W14-2	A7328		SUBMITTED	223	12-MAY-93	RLS	THE DECAYED PROFILE IS SIMILAR TO THE 2004 SGLS	
299-W14-2	A7328		YES	220	25-FEB-77	NEUTRON	NOT INTERPRETED	
299-W14-2	A7328		YES	220	09-JUN-65	NEUTRON	NOT INTERPRETED	
299-W14-2	A7328		YES	220	29-NOV-76	DENSITY	NOT INTERPRETED	
299-W14-20	C7018		YES	439	29-JUL-09	SGLS	NO MAN-MADE RADIONUCLIDES WERE DETECTED.	NO MAN-MADE RADIONUCLIDES WERE DETECTED IN SGLS LOGGING IN 2009.
299-W14-3	A7329		YES	270	10-AUG-04	SGLS	HIGH DT 10-31 (CONTAMINANTS UNDERESTIMATED) WITH CS, CO, EU-152, EU-154, AND SN-126 THROUGHOUT BH, IN GW.	HIGH DT WAS ENCOUNTERED FROM 0 TO 110 FT IN 1963, FROM 10-31 FT IN 2004. ELEVATED GAMMA AT THE END OF THE LOGGING EVENT IN 1976 MAY INDICATE CONTAMINATION IN GROUNDWATER. PROFILES OF THE RLS (1992) DATA AND SGLS (2004) DATA ARE SIMILAR, SUGGESTING STABILITY OF CONTAMINANTS SINCE 1992. ALL OF THE CONTAMINANTS (CS, CO, EU-152, AND EU-154) APPEAR TO BREACH THE CCUC (CALICHE UNIT). CS, CO, AND EU-154 WERE DETECTED BELOW THIS UNIT WITH CS AND CO IN GROUNDWATER IN 2004.
299-W14-3	A7329		SUBMITTED	270	11-JAN-93	RLS	HIGH DT 8-19 FT. PROFILES COMPARE TO 2004 DATA, SUGGESTING STABILITY OF CONTAMINANTS SINCE 1992.	
299-W14-3	A7329		YES	230	07-MAY-76	GG	ELEVATED GAMMA 0-112 FT, INTERVAL FROM 197-226 SUGGEST GW CONTAMINATION.	
299-W14-3	A7329		SUBMITTED	270	29-APR-63	GG	HIGH DT 0-108 FT. DECREASING TO END OF BH.	
299-W14-3	A7329		YES	270	19-SEP-86	GG	HIGH DT 0-18 FT, ELEVATED GAMMA 50-70 FT, 100-118, 150-156, 210-230	
299-W14-3	A7329		YES	270	25-FEB-77	DENSITY	NOT INTERPRETED	
299-W14-3	A7329		YES	270	19-AUG-87	GG	HIGH DT 0-18 FT, ELEVATED GAMMA 50-70 FT, 100-118, 150-156, 210-230	
299-W14-4	A7330	299-W14-2A	YES	205	14-SEP-04	SGLS	CS 0-205, CO 21-205, SN 29-47, EU-154 17-131, EU-152 11-102; WELL IS DRY IN 2004 LOGGING EVENT.	AN INFLUX OF CONTAMINATION MAY HAVE OCCURRED BETWEEN 1967 AND 1976. PROFILES OF THE RLS (1992) AND SGLS (2004) SUGGEST STABILITY OF THE CONTAMINANTS SINCE 1992. IN 2004, DEEP CONTAMINATION WAS DETECTED WITH CS-137 THROUGHOUT THE LOGGING EVENT (207 FT), CO-60 WAS DETECTED BETWEEN 22-200 FT, EU-154 WAS DETECTED BETWEEN 17 AND 131 FT, EU-152 FROM 77-102 FT AND SN-126 FROM 28-84 FT. GWL IS NOT AVAILABLE. CS-137 AND CO-60 WAS VERY DEEP, BUT THE WELL WAS DRY AT THE TIME OF LOGGING IN 2004.
299-W14-4	A7330		SUBMITTED	143	10-MAR-92	RLS	CS 1-140 FT, MAX 1450 PCI/G 34 FT, CO 16-140 FT, MAX 6 PCI/G 37 FT, EU-152 83-94 FT, MAX 4 PCI/G 93FT, EU-154 130 PCI/G 96 FT.	
299-W14-4	A7330		SUBMITTED	139.5	23-MAY-95	RLS	CS 1-140 FT, MAX 2000 PCI/G, CO 19-140, MAX 3 PCI/G AT 40 FT, EU-154 1-140 FT, MAX 100 PCI/G AT 100 FT, EU-152	
299-W14-4	A7330		YES	205	14-AUG-87	GG	ELEVATED GAMMA 24, 73, 88-100 FT, INDICATING A DECREASE SINCE 1986.	
299-W14-4	A7330		YES	205	07-MAY-76	GG	ELEVATED GAMMA FROM 26-108 FT, POSSIBLE INCREASE NEAR BOTTOM OF BH AT 200 FT; POSSIBLE DECAY SINCE 1967.	
299-W14-4	A7330		YES	205	07-FEB-67	GG	ELEVATED GAMMA FROM 26-115 FT, POSSIBLE INCREASE NEAR BOTTOM OF BH AT 185 FT,	
299-W14-4	A7330		YES	205	19-SEP-86	GG	ELEVATED GAMMA 35, 73, AND 94-98 FT	
299-W14-53	A7337	241-TY-6	SUBMITTED	150	09-JUN-06	SGLS	HIGH DT (CONTAMINATION UNDERESTIMATED), CS, CO, EU-152, AND EU-154 THROUGHOUT BH WITH CS AND CO OVER TD.	HIGH DT WAS EXPERIENCED FROM APPROXIMATELY 10-50 FT, THEREFORE CONTAMINANTS AND VALUES ARE UNDER-ESTIMATED IN THIS RANGE. THE 2006 SGLS LOG HAS A SIMILAR PROFILE TO THE 1992 EVENT WITH SB-125 DECAY AS EXPECTED, SUGGESTING CONTAMINANT STABILITY SINCE 1992. CS-137 AND CO-60 WERE DETECTED TO TOTAL LOGGING DEPTH (146 FT), BREACHING THE RFWIE. GWL IS NOT AVAILABLE.
299-W14-53	A7337		SUBMITTED	150	10-NOV-92	RLS	HIGH DT 13-34 FT, CS, CO, EU-154, EU-152, AND SB-125 THROUGHOUT THE BOREHOLE.	
299-W14-53	A7337		SUBMITTED	150	4/29/1963	GG	HIGH DT 10-40 FT	
299-W14-53	A7337		SUBMITTED	150	09-APR-70	GG	HIGH DT 11-29 FT	
299-W14-53	A7337		YES	150	07-MAY-76	GG	HIGH DT 11-29 FT	
299-W14-53	A7337		YES	150	29-NOV-76	DENSITY	NOT INTERPRETED	
299-W14-53	A7337		YES	100	25-FEB-77	NEUTRON	NOT INTERPRETED	
299-W14-53	A7337		YES	150	14-AUG-87	GG	ELEVATED GAMMA IN TOP 118 FT OF BOREHOLE, INDICATING DECAY SINCE 1986.	
299-W14-53	A7337		YES	150	03-APR-84	GG	HIGH DT, ELEVATED GAMMA IN TOP 120 FT OF BOREHOLE.	
299-W14-53	A7337		YES	150	02-JUL-86	GG	ELEVATED GAMMA IN TOP 117 FT OF BOREHOLE, INDICATING DECAY SINCE 1984.	
299-W15-13	A4918		N/A	225	N/A	N/A	NO DATA AVAILABLE	NO DATA AVAILABLE
C3102	C3102		YES	227	19-JUL-01	SGLS	HIGH DT 18-22 AND 33-42 FT. CS 0-61 FT, CO 90-135 FT, EU-154 35-52 FT.	HIGH DEAD TIME WAS EXPERIENCED IN THIS BOREHOLE. CS-137 AND EU-154 ARE CONFINED TO THE HF2, WHILE CO-60 WAS DETECTED BETWEEN 90-135 FT, IN THE RFWIE, APPROXIMATELY 90 FT ABOVE THE GWL IN 2001.
C3102	C3102		YES	227	19-JUL-01	NMLS	CO APPEARS TO BE ASSOCIATED WITH ELEVATED MOISTURE 90 TO 133 FT.	CO IS BELOW THE CCUC AT 93 FT, AND ASSOCIATED WITH ELEVATED MOISTURE.
C4175	C4175	216-T-28	YES	227.5	06-DEC-04	SGLS	HIGH DT 5-36 FT, CS 0-70 FT, MAX 3.9 E06 PCI/G AT 17.5 FT, CO 5-83, 115 FT, EU 5-83, AND 111 FT	HIGH DT FROM 5 TO 36 FT, (VALUES AND RADIONUCLIDES MAY BE UNDERESTIMATED). CS-137 AND EU-154 BREACH THE RFWIE IN 2004. GWL IS NOT AVAILABLE.
C6410	C6410		SUBMITTED	95.9	07-OCT-08	BGO	DATA PUBLISHED IN REPORT HGLP-LDR-309. ECS FROM 28-34 FT, MAX 9000 PCI/G AT 29 FT.	ECS WAS DETECTED BY THE BGO LOGGING FROM 28 TO 39 FT, HOWEVER,

TABLE 7-1. GEOPHYSICAL LOGGING DATA ACQUIRED SINCE 1954

WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	LOG DATE	LOG TYPE	CONTAMINATION HISTORY	SUMMARY
C6410	C6410		SUBMITTED	95.9	07-OCT-08	NMLS	NM IRREGULAR, MAX 31% AT 68 FT.	299-W11-11 (A7280) MONITORING WELL NEARBY SHOWS CONTAMINATION WITH Co-60 BELOW THIS DEPTH. GWL IS NOT AVAILABLE. NO TRU WAS DETECTED.
C6410	C6410		SUBMITTED	95.9	07-OCT-08	PNLS	NO TRU DETECTIONS	
C6411	C6411		SUBMITTED	96	21-OCT-08	BGO	DATA PUBLISHED IN REPORT HGLP-LDR-309. ECS FROM 28-30 FT, MAX 450 PCI/G AT 29 FT.	ECS WAS DETECTED BY THE BGO LOGGING FROM 28 TO 30 FT, HOWEVER, 299-W11-11 (A7280) MONITORING WELL NEARBY SHOWS CONTAMINATION WITH Co-60 BELOW THIS DEPTH. GWL IS NOT AVAILABLE. IRREGULAR MOISTURE DOES NOT APPEAR TO CORRELATE WITH MM. NO TRU WAS DETECTED.
C6411	C6411		SUBMITTED	96	21-OCT-08	NMLS	NM IRREGULAR, MAX 29% AT 93 FT.	
C6411	C6411		SUBMITTED	96	21-OCT-08	PNLS	NO TRU DETECTIONS	
C6412	C6412		SUBMITTED	95.95	21-OCT-08	BGO	DATA PUBLISHED IN REPORT HGLP-LDR-309. ECS FROM 28-32 FT, MAX 2500 PCI/G AT 30 FT.	ECS WAS DETECTED BY THE BGO LOGGING FROM 29 TO 31 FT, HOWEVER, 299-W11-11 (A7280) MONITORING WELL NEARBY SHOWS CONTAMINATION WITH Co-60 BELOW THIS DEPTH. GWL IS NOT AVAILABLE. IRREGULAR MOISTURE DOES NOT APPEAR TO CORRELATE WITH MM. NO TRU WAS DETECTED.
C6412	C6412		SUBMITTED	95.95	21-OCT-08	NMLS	NM IRREGULAR, MAX 26% AT 90 FT.	
C6412	C6412		SUBMITTED	95.95	21-OCT-08	PNLS	NO TRU DETECTIONS	

FIGURE 7-1. LOCATION MAP OF THE 216-T-18, -26, -27, AND -28 SUBREGION

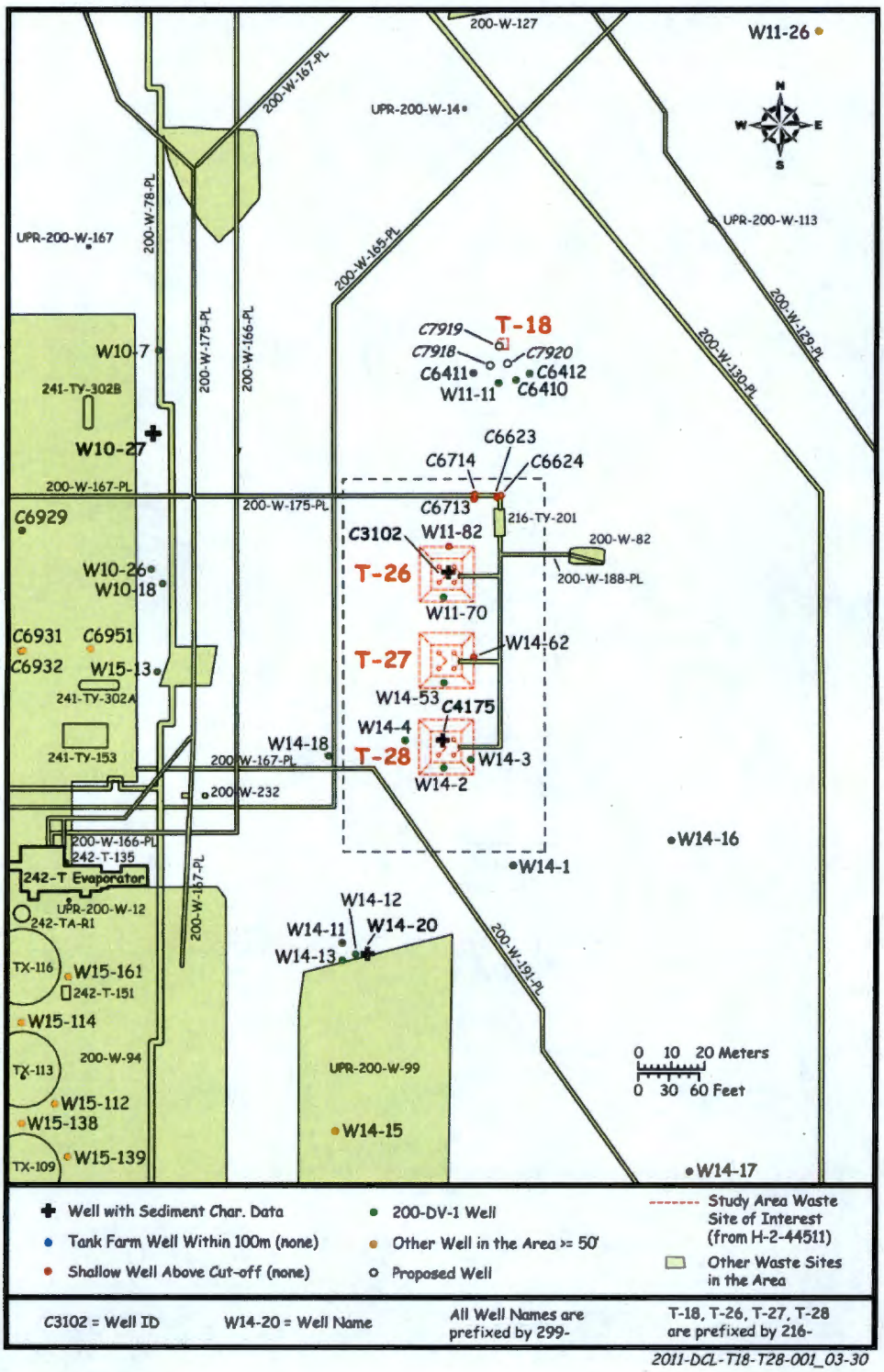

FIGURE 7-2. 216-T-26, -27, AND -28 GAMMA CONTAMINATION ISOPACH MAP (THICKNESS IN FEET)

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Figure A-5. 216-T-26, 27, and 28 Cribs - Elevated Gamma Radiation Isopach Map.

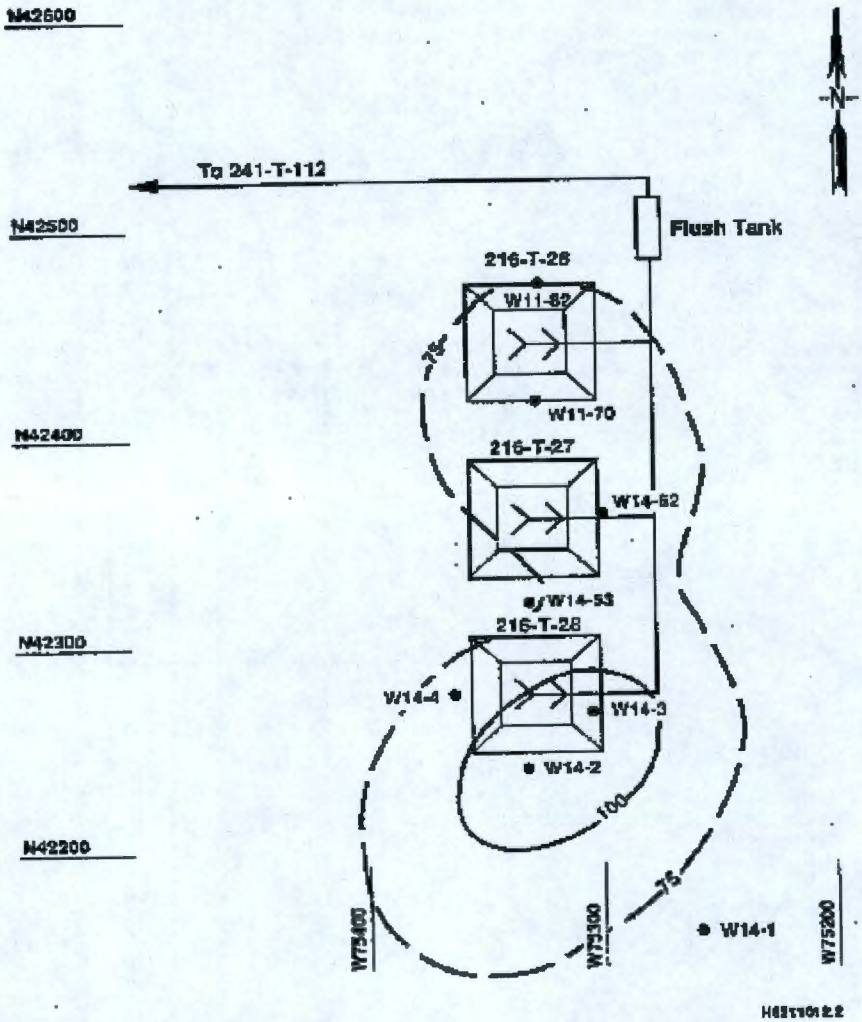
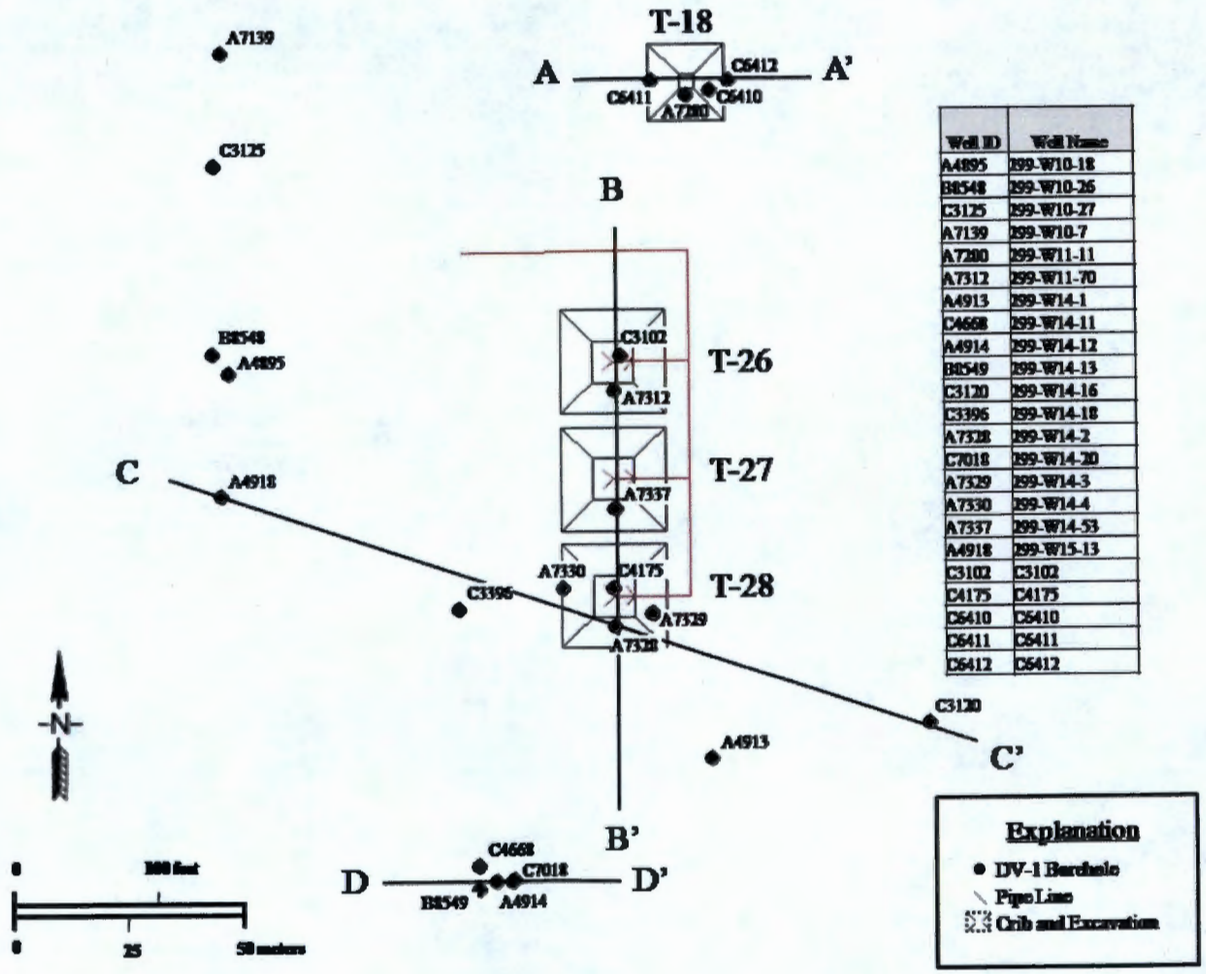


FIGURE 7-3. LOCATION AND CROSS SECTION MAP FOR 216-T-18, -26, -27, AND -28 CRIBS



Well ID	Well Name
A4895	299-W10-18
B8548	299-W10-26
C3125	299-W10-27
A7139	299-W10-7
A7280	299-W11-11
A7312	299-W11-70
A4913	299-W14-1
C4668	299-W14-11
A4914	299-W14-12
B8549	299-W14-13
C3120	299-W14-16
C3396	299-W14-18
A7328	299-W14-2
C7018	299-W14-20
A7329	299-W14-3
A7330	299-W14-4
A7337	299-W14-53
A4918	299-W15-13
C3102	C3102
C4175	C4175
C5410	C5410
C5411	C5411
C5412	C5412

FIGURE 7-4. CROSS SECTION OF THE 216-T-18 CRIB

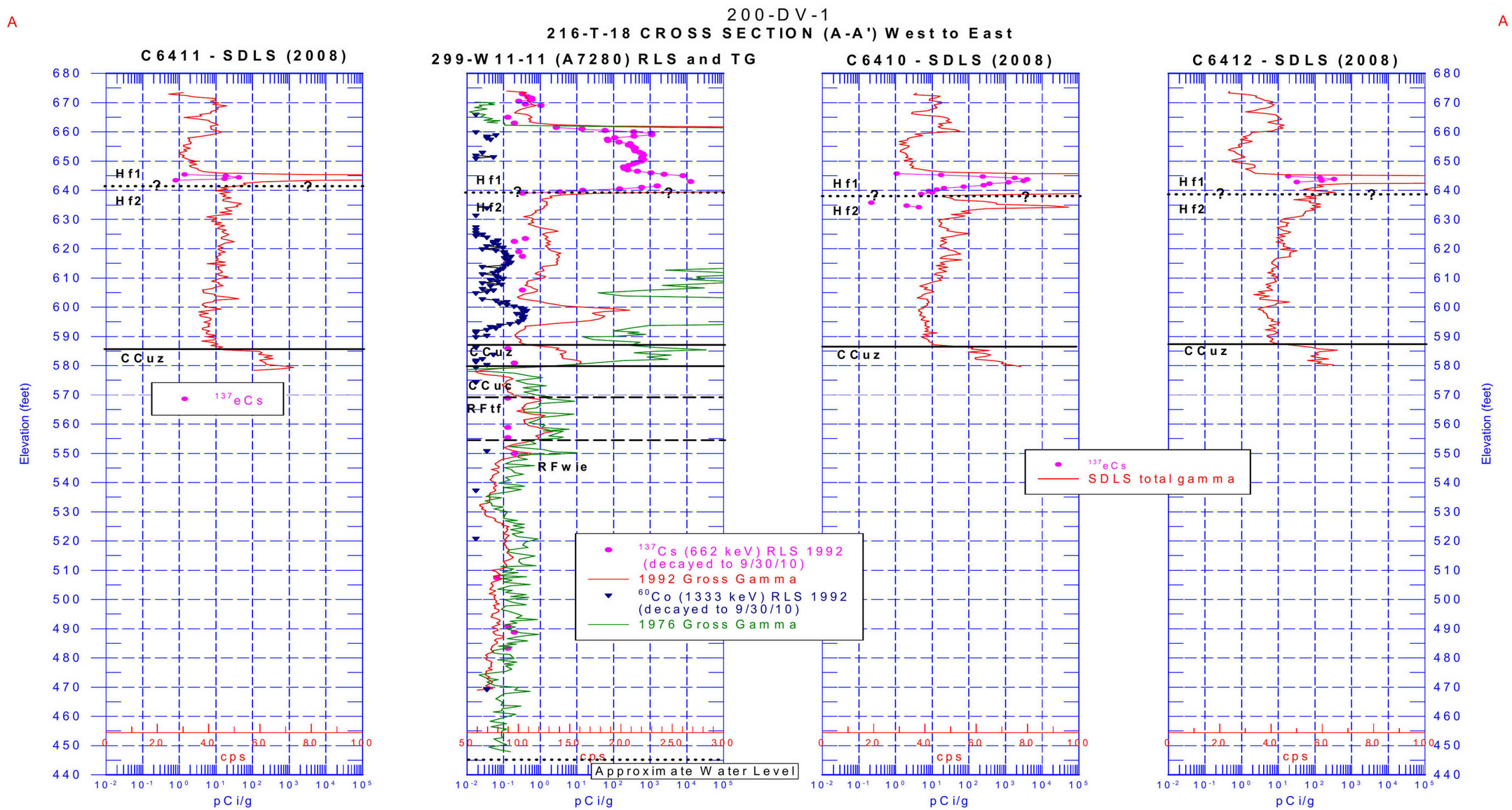


FIGURE 7-5. VISUALIZATION OF CONTAMINATION AT THE 216-T-18 CRIB

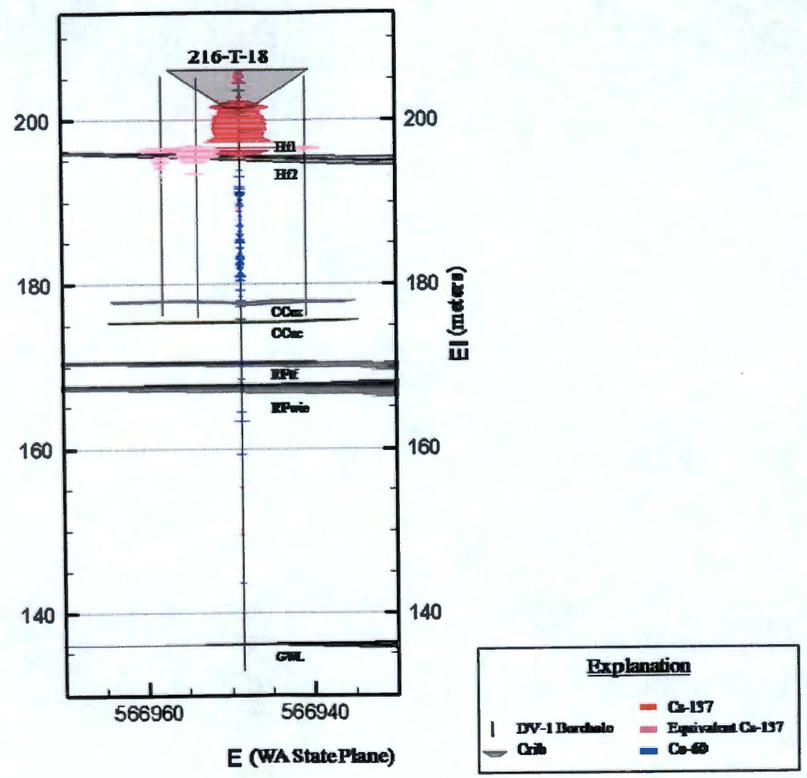


FIGURE 7-6. NORTH TO SOUTH CROSS SECTION OF THE 216-T-26, -27, AND -28 CRIBS

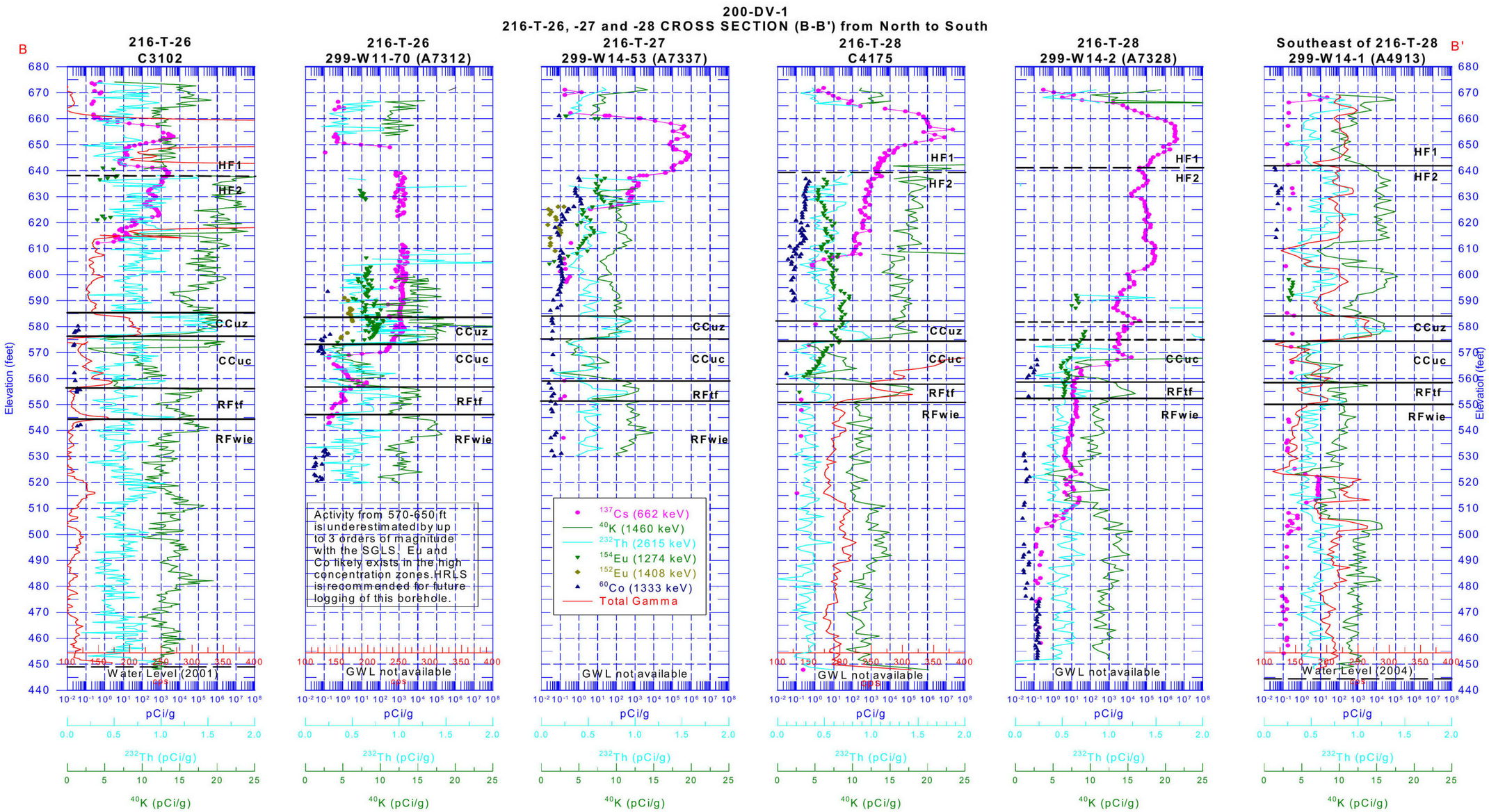


FIGURE 7-7. WEST TO EAST CROSS SECTION THROUGH THE 216-T-28 CRIB

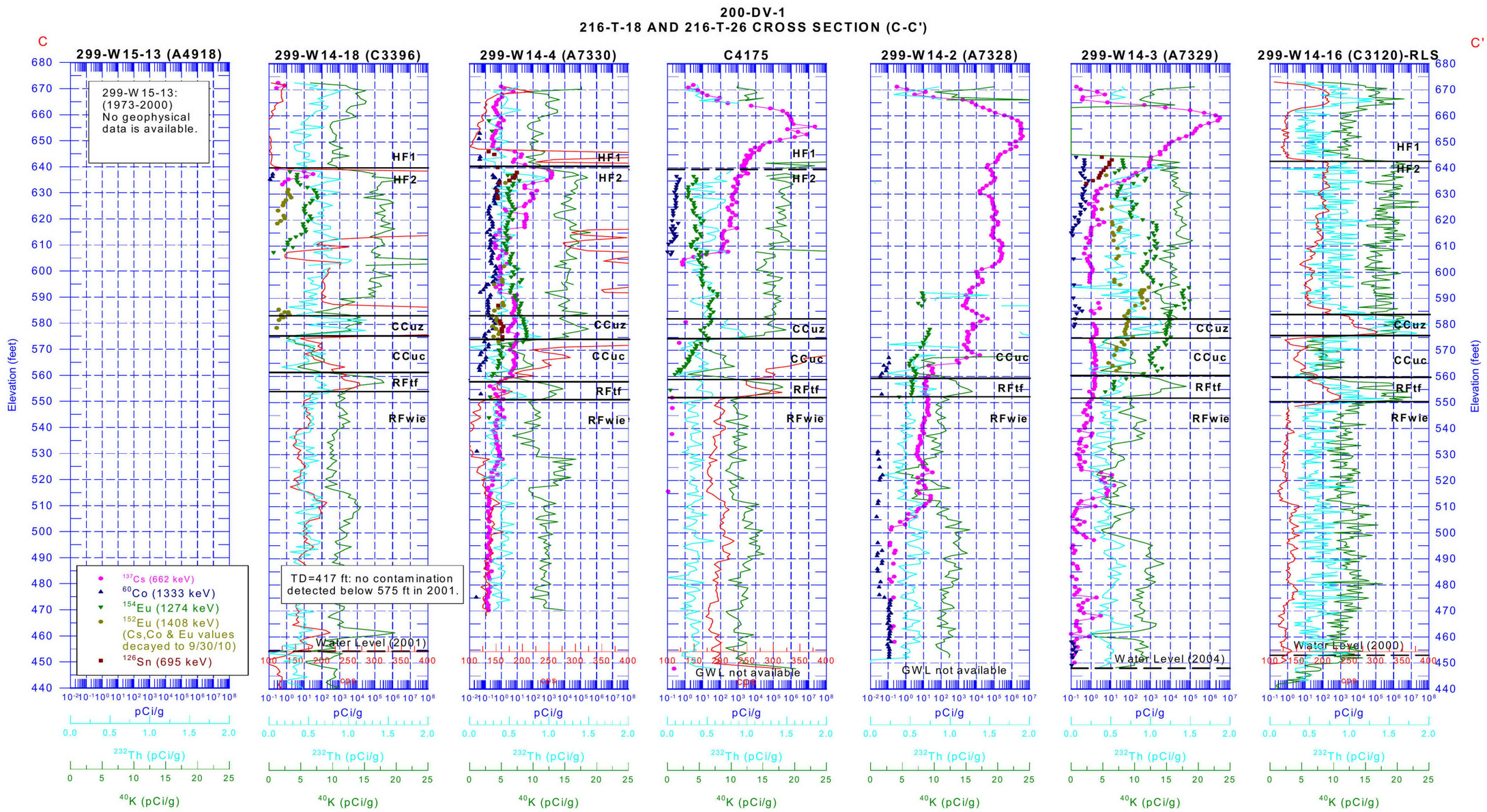


FIGURE 7-8. CROSS SECTION OF BOREHOLES SOUTH OF THE 216-T-28 CRIB

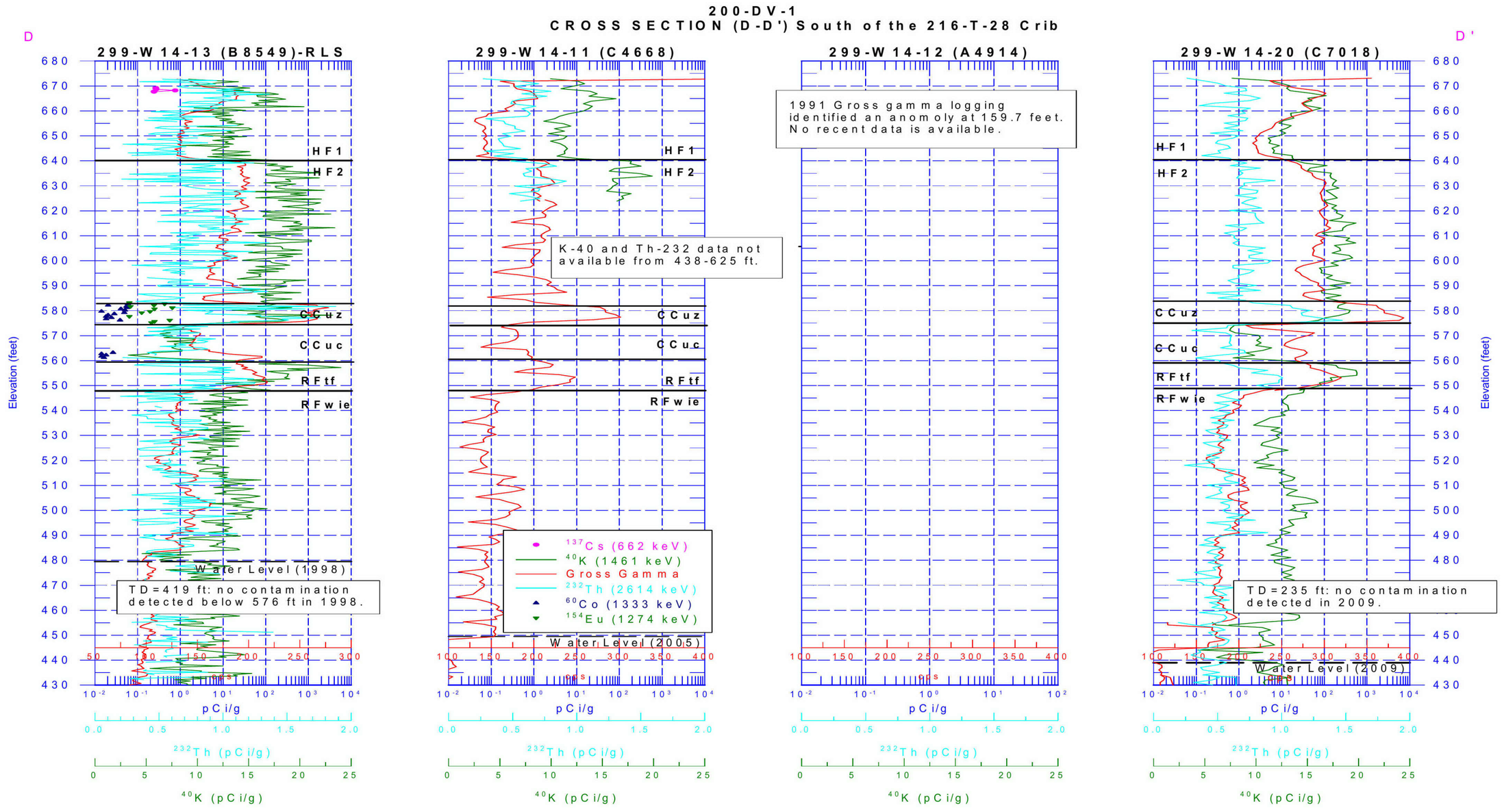
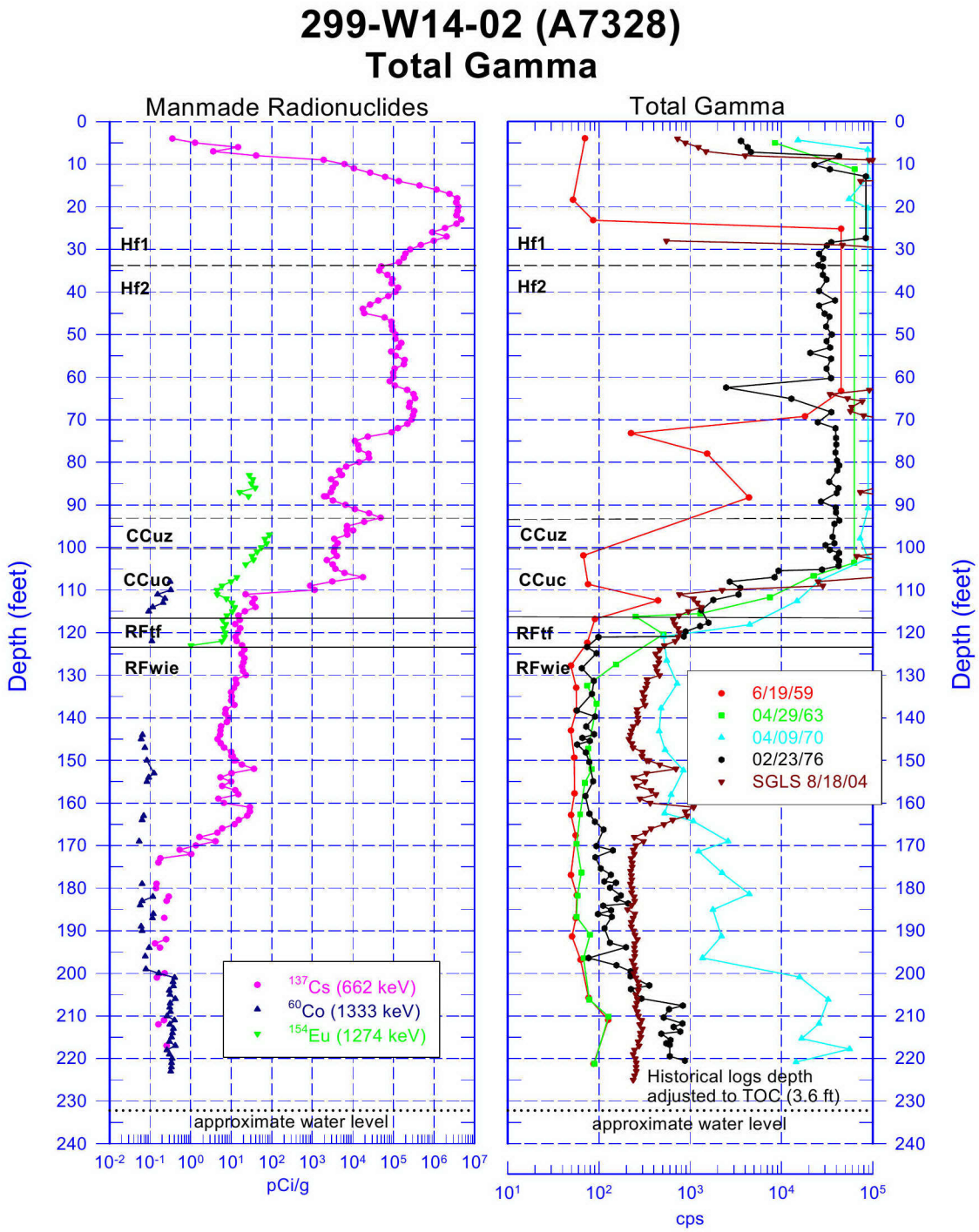


FIGURE 7-9. COMPARISON OF HISTORICAL TOTAL GAMMA LOGS



Zero Reference = Top of Casing

Last Logging Date - 08/18/04

FIGURE 7-10. COMPARISON OF HISTORICAL TOTAL GAMMA LOGS

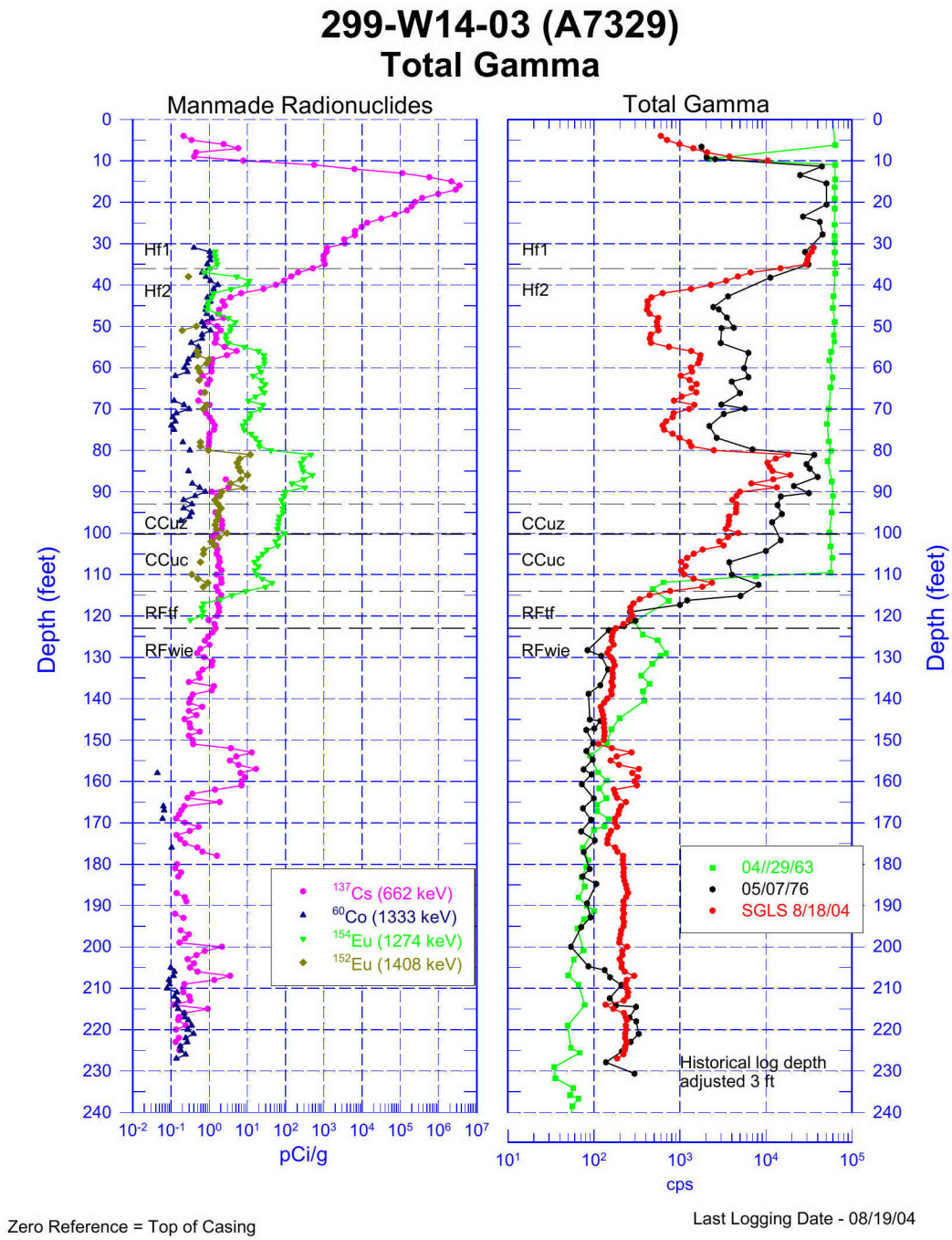


FIGURE 7-11. COMPARISON OF HISTORICAL TOTAL GAMMA LOGS

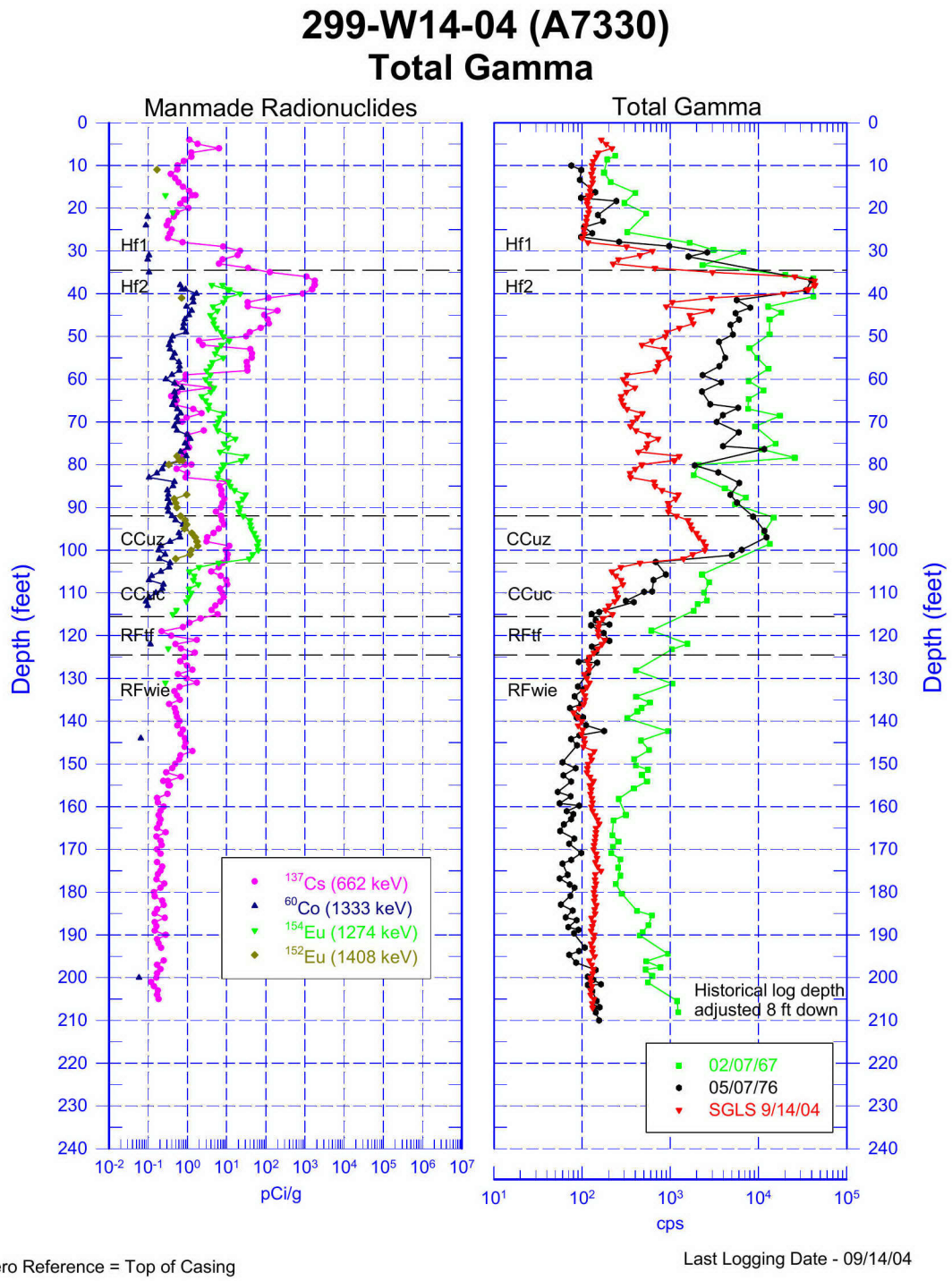


FIGURE 7-12. COMPARISON OF HISTORICAL TOTAL GAMMA LOGS

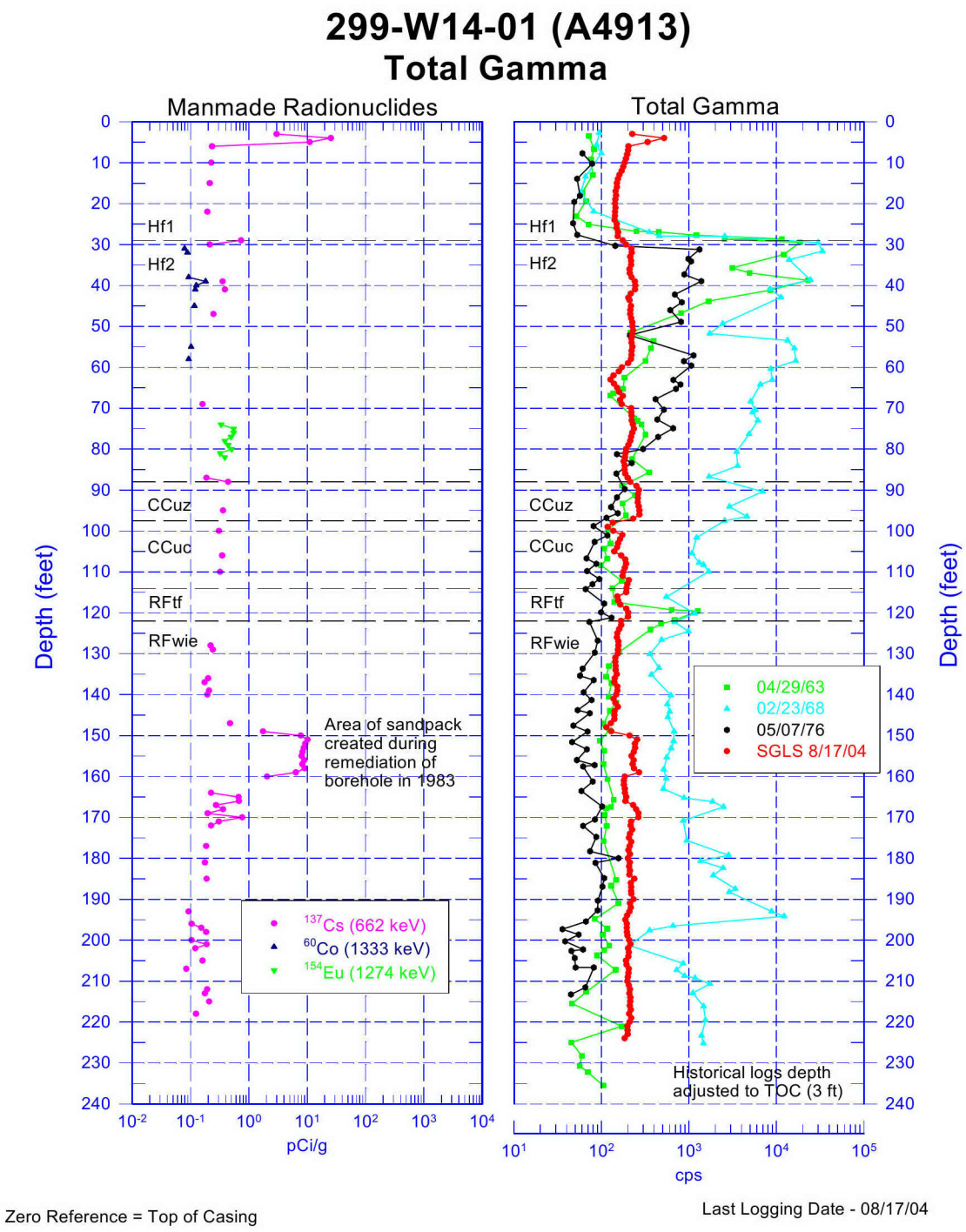


FIGURE 7-13. VISUALIZATION OF CS-137 FOR THE 216-T-18, -26, -27, AND -28 CRIBS

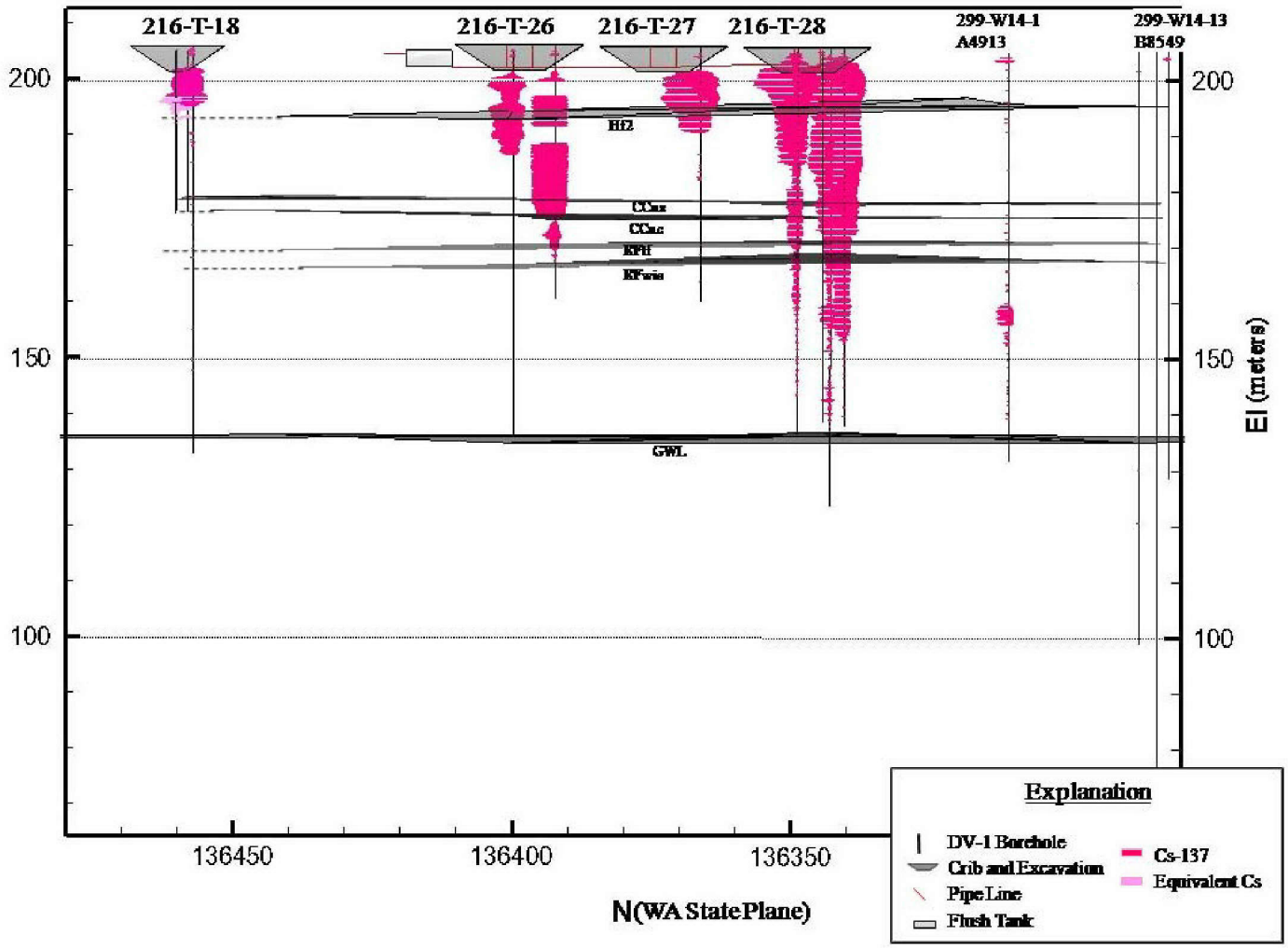


FIGURE 7-14. VISUALIZATION OF EU-154 FOR THE 216-T-18, -26, -27, AND -28 CRIBS

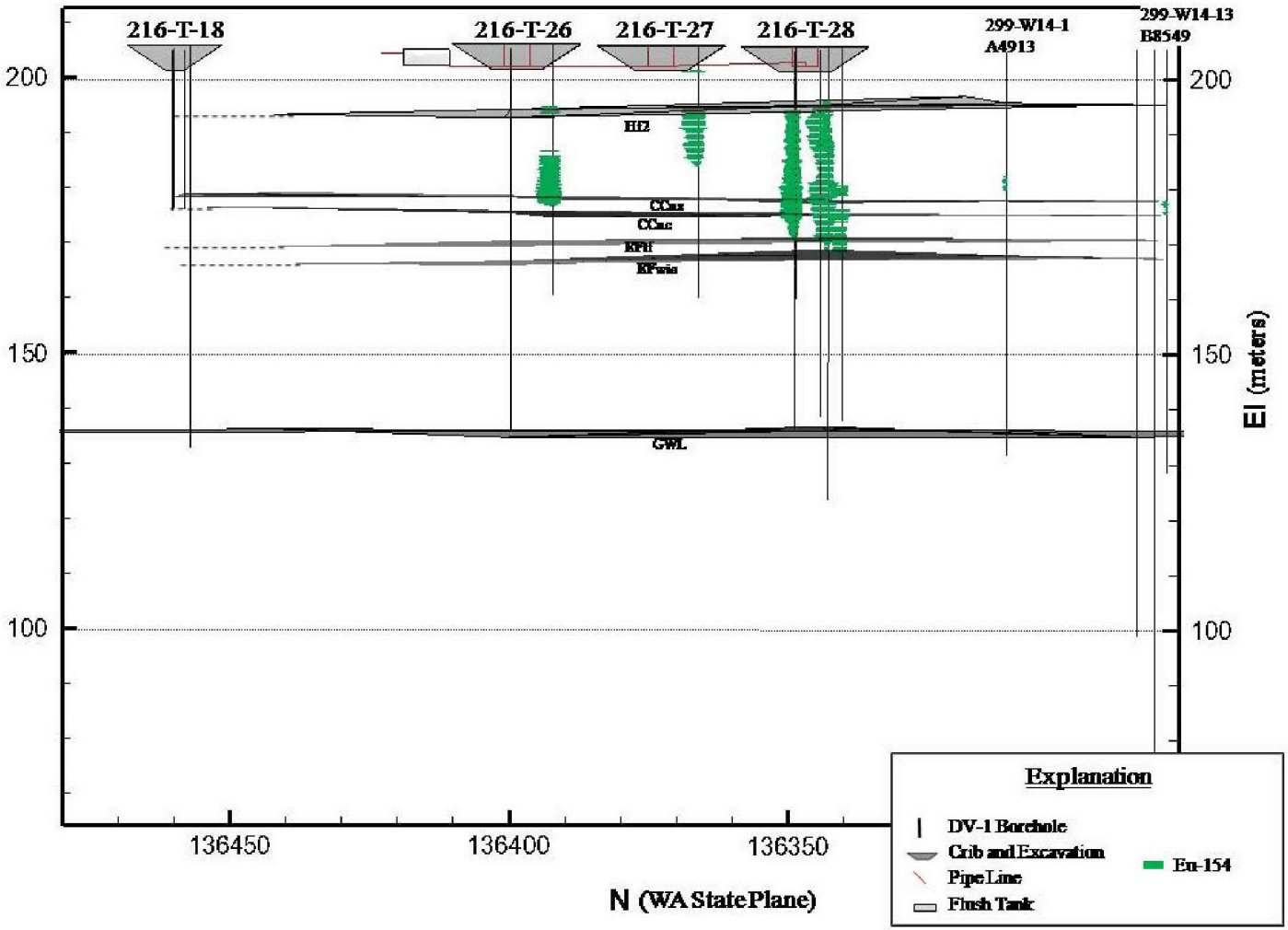


FIGURE 7-15. VISUALIZATION OF CO-60 FOR THE 216-T-18, -26, -27, AND -28 CRIBS

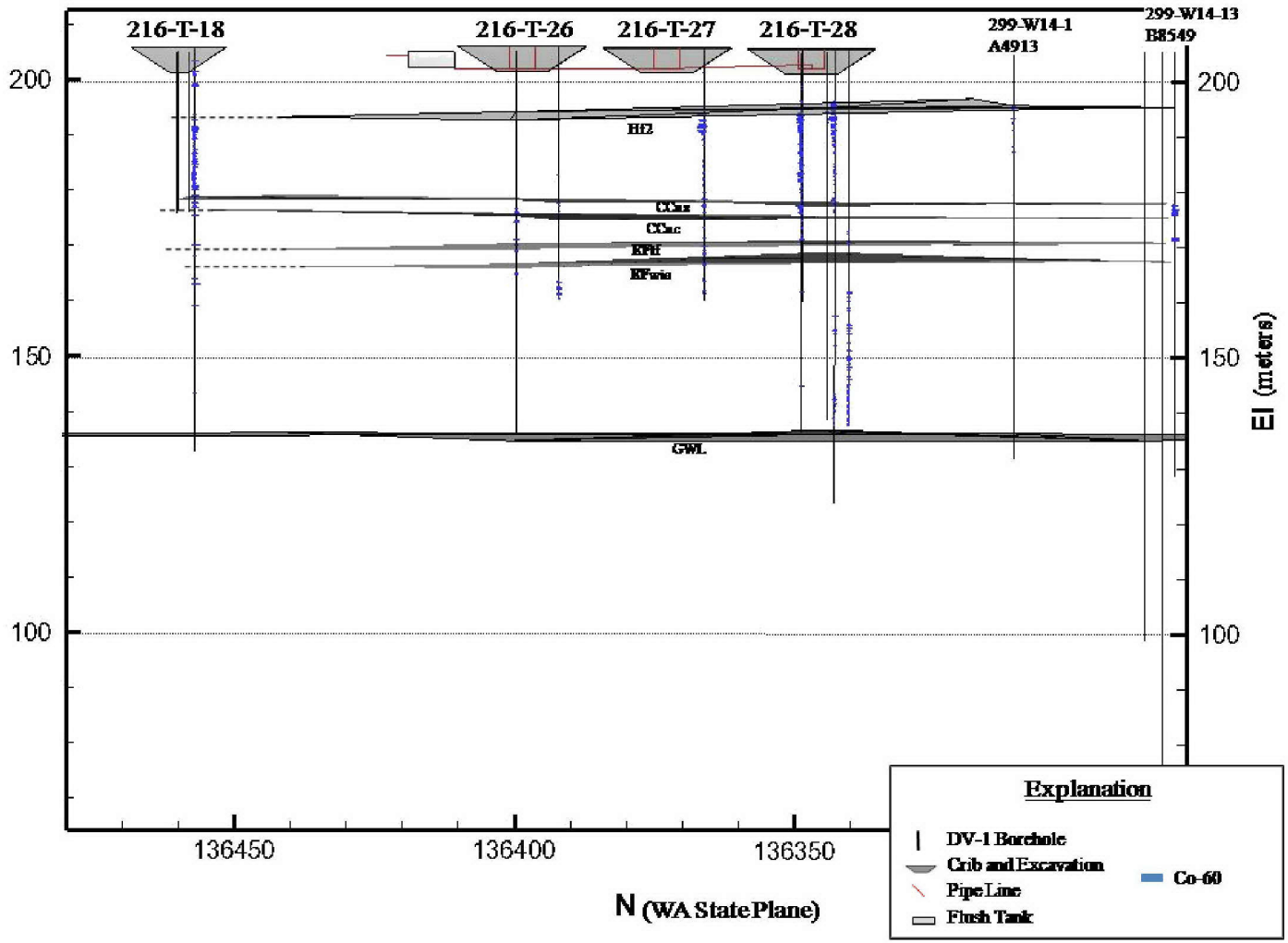
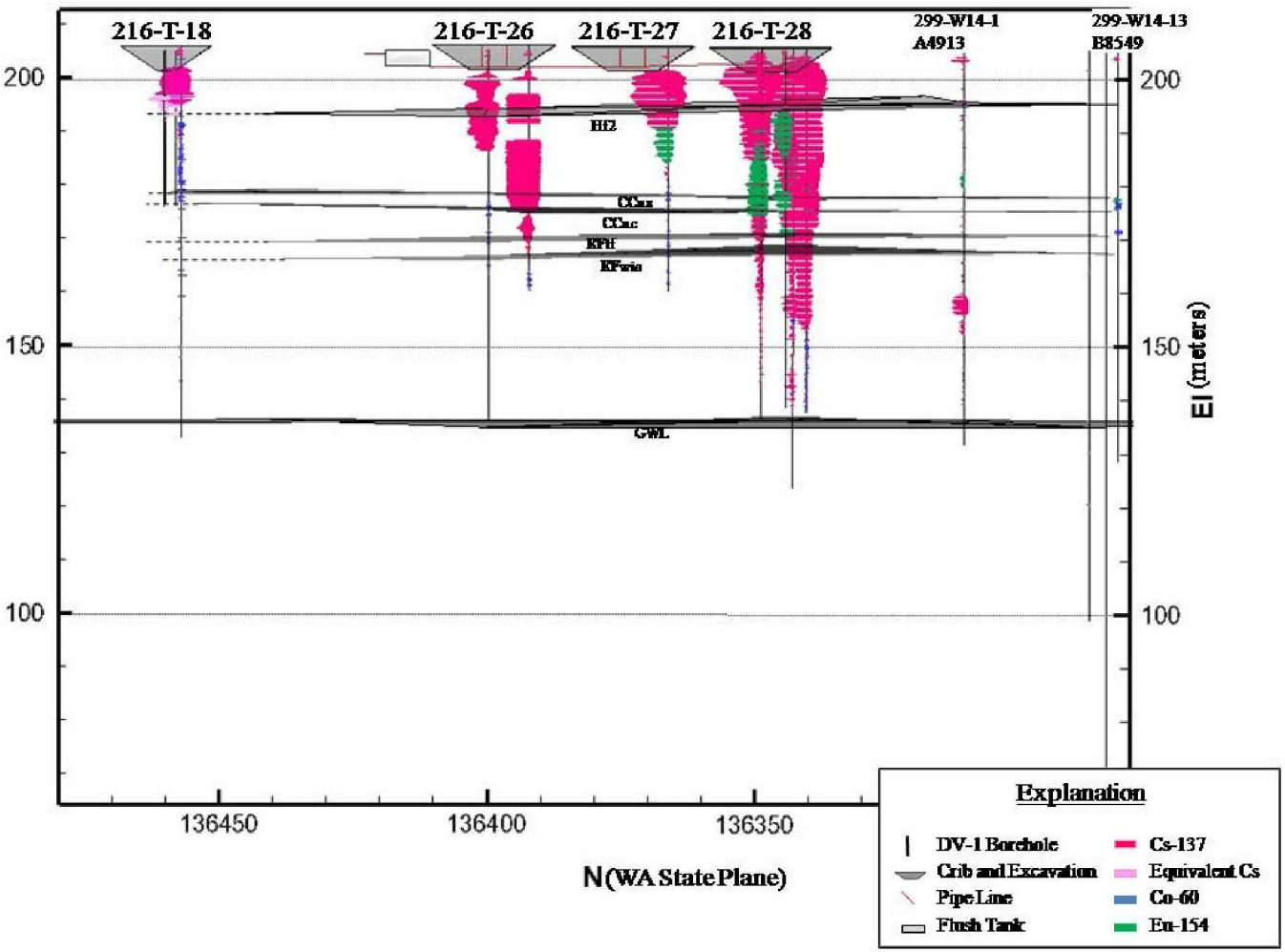


FIGURE 7-16. VISUALIZATION OF CS-137, EU-154, AND CO-60 FOR THE 216-T-18, -26, -27, AND -28 CRIBS



8.0 216-T-19 CRIB

The 216-T-19 Crib and Tile Field is located in the Hanford 200W Area, southwest of the intersection between 20th St and Camden Ave. It has also been known as the 241-TX-153 Crib and Tile Field, 216-TX-1, 241-TX-3, and 216-T-19TF. 216-T-19 consists of a 12-ft (3.7 m) by 12-ft (3.7 m) by 9-ft (2.7 m) timber crib structure installed in a 30-ft (9.1 m) deep excavation, which was subsequently backfilled. The crib is equipped with a 3-in. (7.6 cm) riser pipe at the center. It is fed by a 6-in. (15.2 cm) steel pipe from the 241-TX-153 Diversion Box (located about 350 ft (106.7 m) north of the crib, near the southeastern corner of the 241-TX Tank Farm). The pipeline to the crib is designated 200-W-213-PL. The pipe is inside a concrete encasement, which ends approximately 12 ft (3.7 m) north of the crib structure. The pipe discharges near the top of the crib. Overflow from the crib passes into an 8-in. (20.3 cm) vitrified clay trunk line 23 ft (7.0 m) below ground surface and extending 394 ft (120.1 m) to the south. The trunk line feeds ten 6-in. (15.2 cm) vitrified clay laterals arranged in a 45-degree chevron pattern at intervals of 70 ft (21.3 m). Each lateral is 60 ft (18.3 m) long. A 1% grade is maintained on both the trunk line and the laterals, and the bottom of the pipes is perforated. The drainage area of the tile field is reported as 390 by 85 ft (118.9 by 25.9 m) or approximately 33,150 square feet (3080 square meters). After a cave-in to the crib in 1956, piping was installed to route the discharge around the crib directly to the tile field.

The crib and tile field are enclosed within a light chain barricade and posted with a sign indicating underground radioactive material. The crib area is enclosed by a second inner chain barricade with signs indicating cave-in potential and surface contamination.

8.1 GEOLOGY

The general geology and stratigraphy for this area are discussed in Section 3.1. Stratigraphic relationships are depicted on cross sections of log data. Key Stratigraphic intervals defined within the vadose zone, from shallowest to deepest include the Hf1, Hf2, CCu, RFtf, and RFwie. Available log data for 216-T-19 are limited to shallow depth. The top of the Hf2 (Hanford formation – unit 2) occurs at approximately 620 ft (189.0 m) in elevation (42 ft (12.8 m) bgs) in well 299-W15-4 southwest of the crib. The contact appears to be dipping gently to the west-northwest. Data from widely separated boreholes indicate the contact with the CCu lies between approximately an elevation of 580 ft (176.8 m) or 82 ft (25.0 m) bgs near the 216-T-19 crib and about elevation 575 ft (175.3 m) or85 ft (25.9 m) bgs near the distal end of the tile field. The contact appears to be dipping to the south-southwest at about 2 degrees.

8.2 WASTE SITE PROCESS HISTORY

From September 1951 to August 1956, 216-T-19 received process condensate from the waste evaporator in 242-T, cell drainage from tank 5-6, 2nd cycle supernatant waste from 221-T, and wastes from the 224-T building. A cave-in occurred in 1956 that resulted in abandonment of the wooden crib. From August 1956 to December 1965 the site was inactive because T Plant production was shutdown. In December 1965, a line was installed to route effluent around the crib directly to the tile field. From January 1966 to April 1976 the tile field received process and steam condensate from the 242-T waste evaporator. Between May 1973 and April 1976, 460,000 gallons (1.7 million liters) of aqueous waste saturated in carbon tetrachloride from Z-Plant was sent to the 242-T Evaporator (Rohay et al, 1993). This represents an estimated 3,100 lb (1400 kg) of carbon tetrachloride, which would have been discharged to the 216-T-19 tile field in the evaporator condensate.

The site received liquid cold cell drainage from 1976 to 1980. Piping to the site was routed through the 241-TX-153 diversion box, and the 241-TX-302A and 241-TX-302X catch tanks. (BHI-00177). In July 1980, the line was blanked and the site retired. Total volume discharged to the site is reported to be 455,000,000 liters (120,000,000 gallons) (WIDS). The site surface was interim stabilized in 1991. In

July 2000, the vent risers were sealed as a preventive measure against potential passive radioactive emissions.

8.3 PREVIOUS INVESTIGATION

The 216-T-19 Crib and Tile Field received a large volume of aqueous waste 455.04 million liters (120,000,000 gallons) over a relatively long operational history (29 years). It is mentioned in most studies of waste disposal sites in the Hanford 200W area and is frequently cited as a potential source of groundwater contamination, including nitrate, Co-60, Tc-99, and carbon tetrachloride.

Raymond and McGhan (1964) discuss gamma log results from 299-W15-4:

> *Well 299-W15-4 ... monitors the 216-T-19 crib and tile field (241-TX-153). The 1963 log shows moderate contamination from 40 to 85 feet and low level contamination throughout the rest of the soil column.*

Brown (1971) conducted a qualitative study to estimate inventories of ruthenium-106, strontium-90, and cesium-137 in the vadose zone within 50 ft (15.2 m) of the current groundwater level for waste sites in the 200E and 200W areas. These estimates were based on discharge volumes and the sorptive capacity of the underlying sediments (as a function of waste category). Discharges to the 216-T-19 crib and tile field were reported to include 1003 curies of ruthenium-106 and 424 curies of strontium-90 and cesium-137. Inventory within 50 ft of the groundwater level was estimated to be 9.6 Ci Ru-106 and 4 Ci Sr-90 and Cs-137. No effort was made to confirm these estimates.

Fecht, Last and Price (1977) evaluated gross gamma logs from boreholes in the vicinity of 216-T-19. (ARH-ST-156):

> *"Well 299-W15-4 monitors the 216-T-19 crib. Wells 299-W14-51, 299-W14-52, 299-W15-65, and 299-W15-66 monitor the 216-T-19 tile field. In 1959, three years after the disposal to the crib was temporarily terminated, radioactive contaminants were detected in Well 299-W15-4 from 8.2 meters below the ground surface to the water table, 56.7 meters beneath the ground surface. Reuse of the crib started in 1966 and by 1976 the lower portion of the zone of contamination decreased presumably by radionuclide decay and some soil drainage to the groundwater. The four shallow wells monitoring the tile field show background levels of radioactivity.*
>
> *On the basis of the scintillation probe profiles some soil drainage is detected in the sediments beneath the 216-T-19 crib. These data indicate possible breakthrough to the groundwater occurred at this site from waste disposal to crib prior to 1957."*

Gross gamma log plots are presented in ARH-ST-156 and in RHO-LD-29. However, the plots in both documents are poorly reproduced and very difficult to read. Furthermore, the logs have been "normalized" or "scaled" such that the count rates shown on the plots in ST-156 and LD-29 are not the values actually measured in the field.

> *Required scale changes during logging make direct observation and interpretation of the chart somewhat difficult. Therefore, as was done in this report, the recorder chart data may be digitized, processed by computer, and plotted in logarithmic format (count rate plotted against well depth) for easier examination. The data were also normalized to adjust the background level of the pre-1976 logs to the 1976 values to allow easier direct comparison of the various logs. <u>The data were normalized by applying appropriate correction factors during computer processing</u>.*

In 2002, a cone penetrometer (CPT) was used to push 3 holes in the vicinity of the 216-T-19 Crib and Tile Field for soil gas sampling. (DOE/RL-2001-67). Carbon tetrachloride (CCl4) was detected in two locations: C3858 west of the tile field, and C3859, near the southern (distal) end of the tile field. The

greatest concentration was 1.5 ppm(v) from a depth of 32 to 33 ft (9.8 to 10.1 m) bgs in C3858. A fourth hole, C3874, was driven at the south end of the tile field near C3859 for long-term monitoring purposes. Three additional, deeper holes were planned for soil vapor sampling in 2004-2005 using the enhanced access penetration system (EAPS). These holes were not drilled, apparently because of concerns over the potential to encounter radiological contamination at shallow depths and the relatively low CCl4 concentrations.

Myers (2005) compiled a field investigation report for the T and TX-TY Waste Management Areas. He notes that the 216-T-19 Crib and Tile Field received waste volume "probably sufficient to reach the unconfined aquifer" and suggests that the site may have contributed to tritium, nitrate, and Tc-99 groundwater plumes in the vicinity. He notes that the tritium plume appears to be more localized than nitrate and to have been initiated under crib 216-T-19.

Horton (2007) evaluated groundwater data from monitoring wells in the vicinity of 216-T-19. He suggests 216-T-19 as a possible source for Co-60, Tc-99, and nitrate contamination observed in the groundwater.

8.4 SUMMARY OF LOG DATA

There are a total of twelve boreholes in close proximity to the 216-T-19 Crib and Tile Field. An additional borehole 299-W15-41 (B8815) located approximately 315 ft (96.0 m) west of 216-T-19 is included for stratigraphic correlation. Figure 8-1 shows the location of boreholes with respect to the 216-T-19 Crib and Tile Field.

Four of the 12 borings (C3858, C3859, C3864, and C3874) are cone penetrometer / direct push borings for soil gas samples: they generated no cuttings, soil samples, or geophysical logs. Four additional boreholes are located within the area of the tile field. Boreholes 299-W14-52 (A7336) and 299-W15-65 (A7366) are less than 30 ft (9.1 m) deep. Although both have geophysical logs, including SGLS logs, they are too shallow to provide useful information, since the tile field itself is located 23 ft (7.0 m) below grade. Two additional boreholes, 299-W14-51 (A7335) and 299-W15-66 (A7367) reach 75 and 80 ft (22.9 and 24.4 m) depth, and total gamma and SGLS logs are available. These logs show no evidence of gamma-emitting contaminants in the vicinity of the tile field. They are not deep enough to reach the Cold Creek unit. Figure 8-2 shows the cross section locations. Figure 8-3 shows a north-south cross section comparing logs from these boreholes.

299-W14-5 (A5475) is a groundwater monitoring well located 167 ft (50.9 m) east of the 216-T-19 Crib. No log data could be located for this borehole. The remaining three boreholes are located to the west of the 216-T-19 Crib and Tile Field. These are the groundwater monitoring well 299-W15-4 (A4929) and two boreholes drilled nearby as replacements: 299-W15-762 (C3122) was terminated at 37 ft (11.3 m) depth when unanticipated contamination was encountered. 299-W15-763 replaced 299-W15-4. Older geophysical logs are available for 299-W15-4, including total gamma and RLS, but no logs were run in either 299-W15-762 and 299-W15-763.

Well 299-W15-4 (A4929) was completed to 217 ft (66.1 m) depth bgs in February 1956 as a monitoring well for the 216-T-19 crib. The casing was perforated from 170 to 216 ft (51.8 to 65.8 m) bgs. Tc-99 was detected in groundwater taken from this well in February 1988, at 46 pCi/L. Between 1988 and 1993, Tc-99 levels appeared to be declining, to a level of about 17 pCi/L in April 1993. By October 1994, Tc-99 levels had begun to increase. The increase continued to October 1999, reaching a maximum of 641 pCi/L. By March 2000, the groundwater level had declined below the bottom of the well.

Borehole 299-W15-762 (C3122) was planned as a replacement well. It is located approximately 12.5 ft (3.8 m) northwest of 299-W15-4. C3122 was drilled with cable-tool methods to 23 ft (7.0 m) under "medium risk" conditions and then switched to air rotary drilling. The borehole encountered "difficult drilling" at 37 ft (11.3 m) bgs. The cuttings were described as a "discolored soil that resembled ground

up asphalt in appearance and texture." This was classified as crushed basalt by the site geologist. Shortly thereafter, a routine PM survey of material in the hopper found 1,800,000 dpm direct beta/gamma, and 10,400 dpm direct alpha. Dose rates were 25 mR/hr at contact and 1.5 mR/hr at 30 cm (1 ft). The contamination appeared to be associated with the discolored material. Subsequent evaluation in the Radiological Counting Facility determined that no alpha contamination was present and the actual dose rate at contact was 8 mR/hr. (RL-BHI-GROUNDWTR-2000-0009).

Gross gamma logs were run in 299-W15-4 (A4929) on 4/15/1958, 7/15/1959, 5/02/1963, 2/23/1968, 6/24/1968, 2/24/1970, and 2/23/76. All logs show evidence of very high gamma activity between approximately 35 and 50 ft 10.7 and 15.2 m) bgs. On Nov 15, 1995, 299-W15-4 was logged with the RLS. The detector was saturated from 42 ft to 52.5 ft (12.8 to 16.0 m) bgs. Cs-37 was detected above and below the saturated interval. 299-W15-4 was not logged with either the SGLS or the HRLS. The driller's log (January 1956) reports "gravel, coarse black sand, caves" between 30 and 45 ft (9.1 and 13.7 m) bgs, and notes "radiation in well – 40,000 c/m". Therefore, the contamination encountered in C3122 was likely present at that location prior to 1956. The root cause analysis (RCA-2000-047) for the contamination incident concluded:

> *"In the case of C3122, the original risk was determined to be "medium risk," down to a depth of 20 ft based on project experience obtained in drilling in similar situations as well as the distance of the crib to other waste site locations known to the radiological engineer. However, the location of well 299-W15-4 was not considered when the radiological engineer was preparing the risk assessment. Factoring in well 299-W-15-4 would likely have resulted in a classification of "medium risk" to a drilling depth of at least 50 ft from the ground surface, rather than 20 ft."*

Borehole C3339 (299-W15-763) is located 56 ft (17.1 m) west of 299-W15-4, or about 170 ft (51.8 m) west-southwest of the 216-T-19 crib. The hole was drilled with cable tool methods to a depth of 257.6 ft (78.5 m). No evidence of radioactivity above background levels was reported during drilling. However, no logs were run. The hole has since been completed with 4-in. (10.2 cm) casing as a RCRA monitoring well with the screened interval at 211.75 to 246.82 ft (64.5 to 75.2 m).

299-W15-41(B8815) is located 225 ft (68.6 m) west of 299-W-15-4 (A4929) and about 330 ft (100.6 m) west of the 216-T-19 Crib. This borehole is included in the study for stratigraphic correlation. Figure 8-4 shows an east-west section comparing logs from 299-W15-41 and 299-W15-4.

Of the 13 boreholes discussed above, 8 have been decommissioned. The remaining boreholes include one vadose borehole: 299-W14-51, which is listed as a candidate for decommissioning. One soil gas point (C3874) remains in use, but no sample results could be found after 2004. The three remaining groundwater wells are 299-W14-5 (A5475), 299-W15-763 (C3339), and 299-W15-41 (B8815). Well 299-W15-4 (A4959) has been decommissioned.

8.5 SUMMARY OF SUB-REGION AND CONCLUSIONS

The 216-T-19 Crib and Tile Field operated from 1951 to 1980, and received a total of about 120,000,000 gallons (454 million liters) of liquid waste over that period. The site is primarily associated with T-Plant and the 242-T Evaporator. Most prior investigations of groundwater or deep vadose zone contamination in the Hanford 200W area have identified 216-T-19 as a likely source of groundwater contamination. The waste site is associated with T-Plant, and primary contaminants include fission products, tritium, and nitrate. Historical records and waste inventory estimates include minor quantities of uranium and plutonium. The site received waste from the 242-T Evaporator, which processed aqueous waste from plutonium finishing operations at Z-Plant, so carbon tetrachloride is also a potential contaminant.

There are a dozen boreholes in or near the 216-T-19 crib, but little useful information exists as to the nature and extent of contamination in the deep vadose zone. Since numerous investigators have attributed

groundwater contamination to the site, the lack of information regarding contaminant extent in the deep vadose zone is a significant data gap.

Available log data show no evidence of gamma-emitting contaminants in the immediate vicinity of the tile field, but none of the borings within the site boundary were deep enough to reach the Cold Creek unit. For the latter half of its operational life, discharge was routed around the 216-T-19 crib directly to the tile field, so the absence of detectable contamination in the vicinity of the tile field is surprising, but may be due to the fact that most of the existing boreholes are very shallow in depth and actual effluent may have moved downward below the bottom of these wells at their respective locations. Soil gas investigation did detect traces of carbon tetrachloride.

299-W15-4 is located 122 ft (37.2 m) southwest of the center of the 216-T-19 crib and 92 ft (28.0 m) west of the centerline of the tile field. The fact that significant contamination was present at that location within five years after waste disposal began at 216-T-19 implies extensive lateral migration and spreading within the shallow vadose zone. The contamination detected when 299-W15-4 was drilled indicates that contamination would have moved over 120 ft (36.6 m) laterally and less than 10 ft (3.1 m) vertically in a period of less than 5 years, if it originated from the 216-T-19 crib.

8.6 RECOMMENDATIONS

A basic observation derives from the C3122 contamination incident in 2000. Numerous available gamma logs from the nearby borehole 299-W15-4 clearly showed the presence of elevated gamma activity at 35 to 40 ft (10.7 to 12.2 m) bgs, and the contamination encountered in C3122 should not have been a surprise. It is strongly recommended that future risk assessments for all proposed boreholes or excavations in the Hanford operating areas include an evaluation of log data from nearby boreholes by a qualified geologist or geophysicist.

The shallow gamma-emitting contamination encountered in 299-W15-4 (A4929) and 299-W15-762 (C3122) should be investigated. In particular, the area between and beneath the 216-T-19 crib and 299-W15-4 should be investigated to confirm that the shallow contamination present at 299-W15-4 does originate from 216-T-19.

In spite of the number of borings, there is little data regarding deep vadose zone conditions in the immediate vicinity of the 216-T-19 tile field. Since numerous investigators have attributed groundwater contamination to the site, the lack of information regarding contaminants in the deep vadose zone is a significant data gap.

8.7 REFERENCES

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TABLE 8-1. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1954 (WASTE SITE DESIGNATION PREFIX - 216)

Waste Site	Well Name	Well ID	Alias	IDMS	Total Depth (ft)	Date	Log Type	Contamination History	Summary
T-19	299-W14-51	A7335	241-TXSW-2	YES	33	7-May-76	GG	No visible signs of contamination	< 1 pCi/g Cs-137 was detected at 0 and 45 ft in 2008.
	299-W14-51	A7335		Submitted	33	24-Jun-68	GG	No visible signs of contamination	
	299-W14-51	A7335		Submitted	33	20-Aug-63	GG	No visible signs of contamination	
	299-W14-51	A7335		YES	77	29-Jan-08	HG	<1pCi/g Cs-137 at 0, 5, 36 and 55 ft.	
	299-W14-51	A7335		YES	20	24-Feb-68	N	not interpreted	
	299-W14-51	A7335		YES	77	3-Apr-84	GG	No visible signs of contamination	
	299-W14-51	A7335		YES	77	3-Jul-86	GG	No visible signs of contamination	
T-19	299-W14-52	A7336	241-TXSW-4	Submitted	20	24-Jun-68	N	not interpreted	< 1 pCi/g Cs-137 was detected at ground surface in 2006.
	299-W14-52	A7336		YES	27	11-May-06	HG	<1 pCi/g Cs-137 detected at ground surface	
	299-W14-52	A7336		Submitted	27	20-Aug-63	GG	possible ground surface contamination	
	299-W14-52	A7336		YES	27	24-Jun-68	GG	possible ground surface contamination	
	299-W14-52	A7336		YES	27	07-May-76	GG	No visible signs of contamination	
	299-W14-52	A7336		YES	27	03-Jul-86	GG	No visible signs of contamination	
T-19	299-W15-41	B8815		YES	239	6-Jan-00	HG	Slightly elevated gamma from 94-120 ft coincides with the CCu; No man-made radionuclides detected	No man-made radionuclides were detected in 2000 RLS event.
	299-W15-41	B8815		YES	239	7-Jan-00	NM	not interpreted	
T-19	299-W15-65	A7366	241-TXSW-1	YES	26	10-May-06	HG	<1 pCi/g Cs-137 was detected at 0 and 8 ft.	< 1 pCi/g Cs-137 was detected at 0 and 8 ft in 2006.
	299-W15-65	A7366		YES	26	10-May-06	NM	not interpreted	
	299-W15-65	A7366		Submitted	26	20-Aug-63	GG	No visible signs of contamination	
	299-W15-65	A7366		Submitted	26	24-Jun-68	GG	No visible signs of contamination	
	299-W15-65	A7366		YES	26	7-May-76	GG	No visible signs of contamination	
	299-W15-65	A7366		YES	26	24-Feb-68	GG	not interpreted	
	299-W15-65	A7366		YES	26	7-May-76	GG	No visible signs of contamination	
	299-W15-65	A7366		YES	26	23-Jun-76	D	not interpreted	
	299-W15-65	A7366		YES	26	03-Jul-86	GG	No visible signs of contamination	
T-19	299-W15-66	A7367	241-TXSW-3	YES	77	03-Jul-86	GG	No visible signs of contamination	1 pCi/g Cs-137 was detected at ground surface in 2008.
	299-W15-66	A7367		Submitted	27	20-Aug-63	GG	No visible signs of contamination	
	299-W15-66	A7367		Submitted	27	24-Jun-68	GG	No visible signs of contamination	
	299-W15-66	A7367		YES	77	07-May-76	GG	No visible signs of contamination	
	299-W15-66	A7367		YES	77	25-Feb-77	N	not interpreted	
	299-W15-66	A7367		YES	77	3-Apr-84	GG	No visible signs of contamination	
	299-W15-66	A7367		YES	77	24-Jan-08	NM	affected by grout in double cased borehole from 0 to 33 ft	
	299-W15-66	A7367		YES	77	24-Jan-08	HG	<1 pCi/g Cs-137 detected at ground surface	
T-19	299-W14-5	A5475		N/A	N/A	N/A	N/A	No data available	No Data Available
T-19	299-W15-4	A4929	241-TX-12	Submitted	180	4/15/1958	GG	elevated gamma 30 to 213 ft (end of logging event), tool saturated from approximately 35-50 ft.	Contamination is extensive in the 1960s from approximately 30 ft to groundwater at approximately 213 ft. A high activity interval exists from 40 to 60 ft and is predominantly the result of Cs-137 with concentrations in excess of 10,000 pCi/g. Cs-137 was detected in 1992 between 148 and 158 ft. Borehole was only logged to 140 ft in 1995 so that confirmation of the Cs-137 was not possible. Groundwater appears to have been contaminated in the 1960s although the source is unknown.
	299-W15-4	A4929		Submitted	213	15-Jul-59	GG	elevated gamma 30-186 ft (end of logging event), tool saturated from 35-50 ft, water contaminated at 213 ft.	
	299-W15-4	A4929		Submitted	213	2-May-63	GG	elevated gamma 30-207 ft (end of logging event), water contaminated at 213 ft. Significant decay since 1959	
	299-W15-4	A4929		Submitted	213	23-Feb-68	GG	elevated gamma 30-213 ft (end of logging event), tool saturated from 35-50 ft, water contaminated at 213 ft.	
	299-W15-4	A4929		YES	213	24-Jun-68	GG	elevated gamma from 32 to 80 ft, tool saturated from 32-40 ft, water contaminated at 213 ft.	
	299-W15-4	A4929		Submitted	213	23-Feb-76	GG	elevated gamma 30 to 80 ft, tool saturated from 32-40 ft, water contaminated at 213 ft. significant decay since 1968 below 60 ft	
	299-W15-4	A4929		YES	213	25-Feb-77	N	not interpreted	
	299-W15-4	A4929		YES	210	29-Nov-76	GG	elevated gamma from 40-75 ft. Near background levels below 75 ft.	
	299-W15-4	A4929		Submitted	140	15-Nov-95	HG	Cs detected 2-5.5 ft, 40-59 ft, trace detections from 51-83 ft, tool saturated 42-52.5 ft; GWL at 202.9 ft.	
	299-W15-4	A4929		Submitted	192	02-Apr-92	HG	Cs detected 0-1.5 ft, 37-6-162 ft, tool saturated 39-49 ft; detections below 75 ft are probably not valid except from 148 to 158 ft at 8 pCi/g.	

TABLE 8-1. GEOPHYSICAL LOG DATA ACQUIRED SINCE 1954 (WASTE SITE DESIGNATION PREFIX - 216)

Waste Site	Well Name	Well ID	Alias	IDMS	Total Depth (ft)	Date	Log Type	Contamination History	Summary
	299-W15-4	A4929		YES	140	24-Jun-68	N	not interpreted	
T-19	299-W15-763	C3339		N/A	N/A	N/A	N/A	No data available	No Data Available

FIGURE 8-1. LOCATION MAP OF THE 216-T-19 SUBREGION

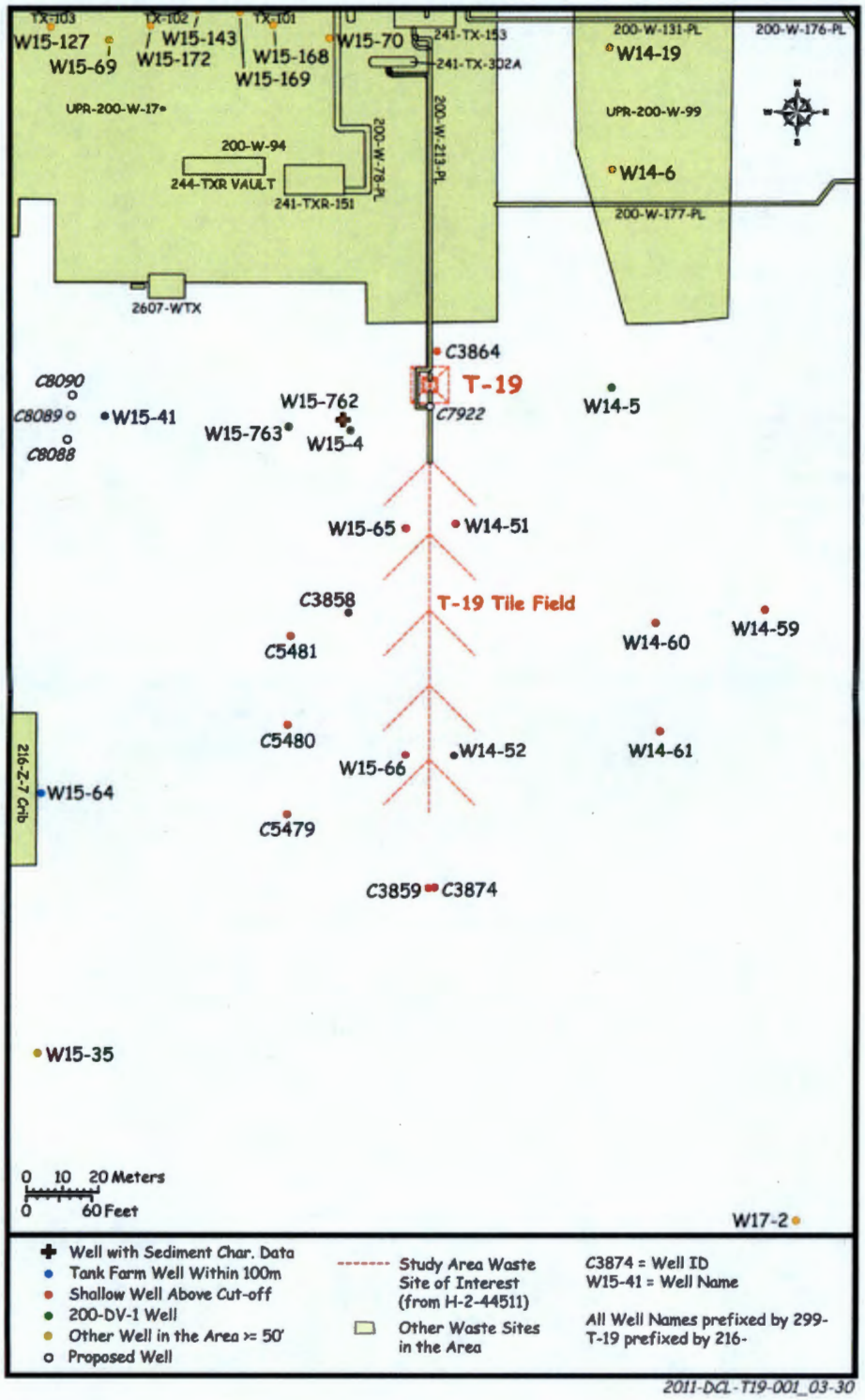


FIGURE 8-2. LOCATION AND CROSS SECTION MAP FOR 216-T-19 CRIB AND TILE FIELD

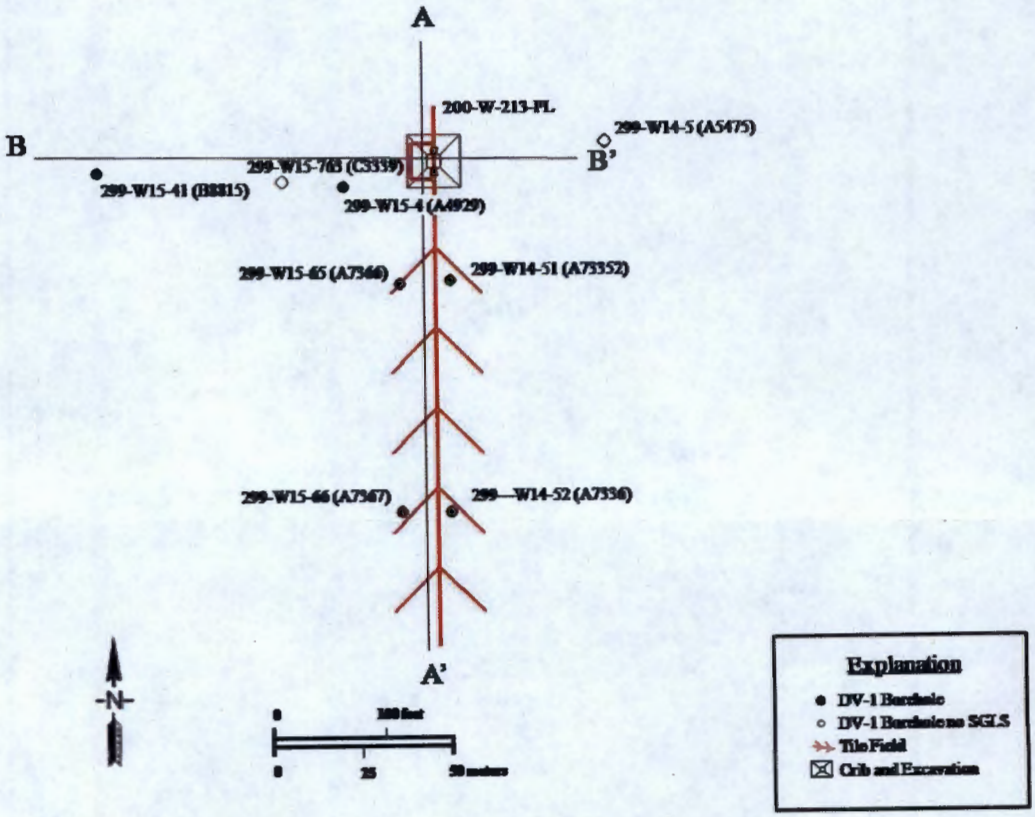


FIGURE 8-3. NORTH TO SOUTH CROSS SECTION OF THE 216-T-19 CRIB

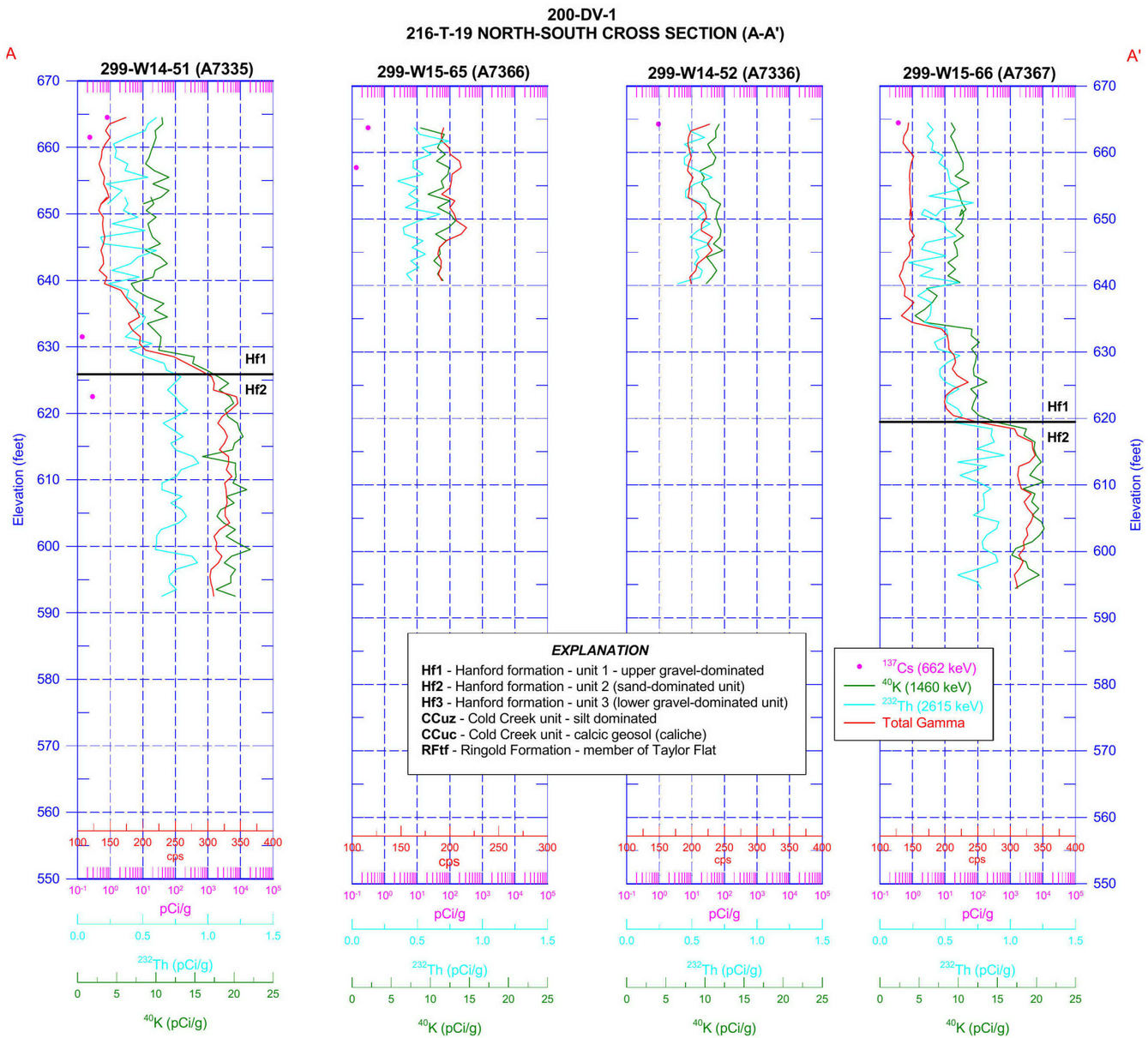
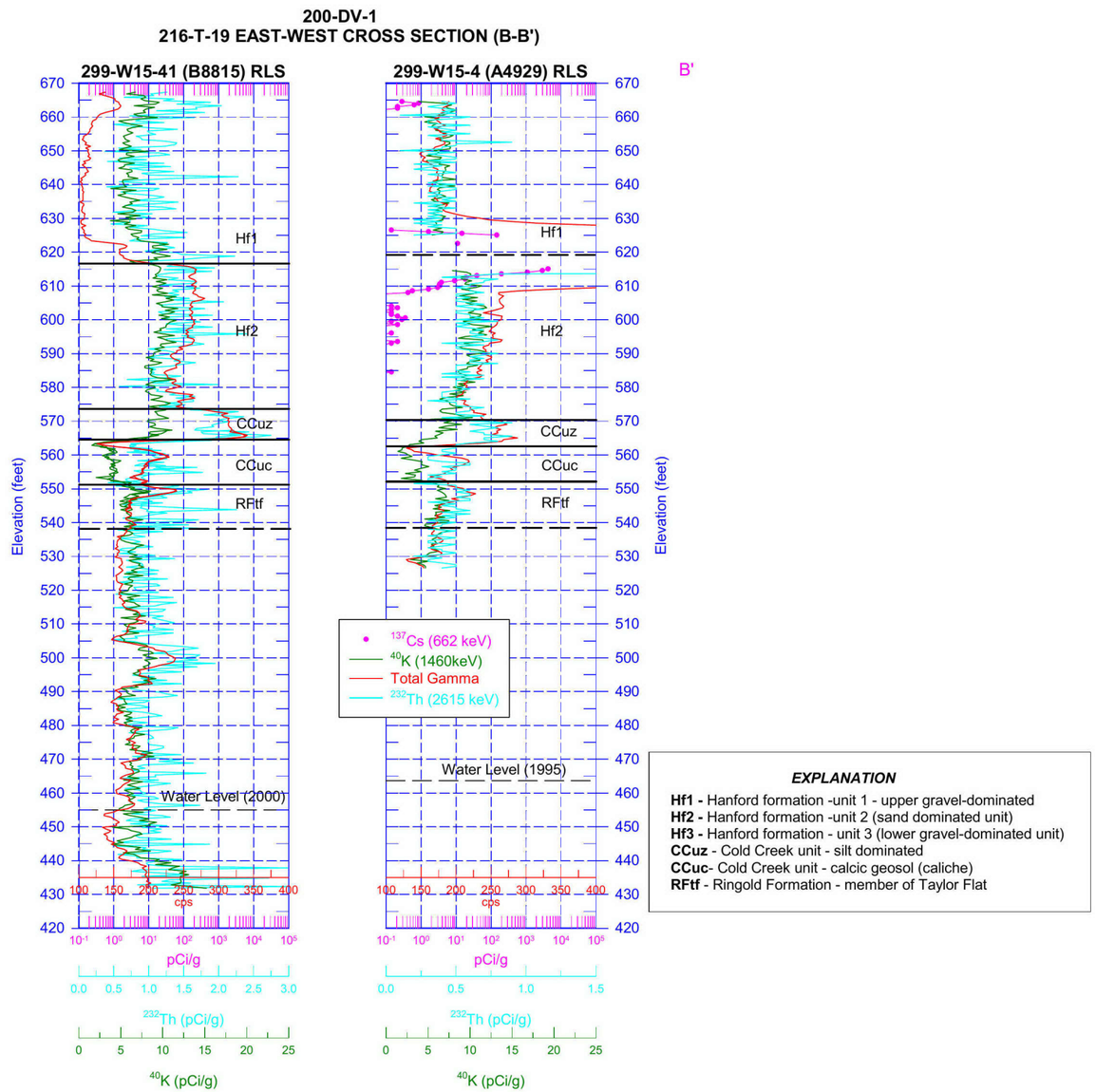


FIGURE 8-4. EAST TO WEST CROSS SECTION OF THE 216-T-19 CRIB



9.0 216 T-21, -T-22, -T-23, -T-24 AND -T-25 TRENCHES

The 216-T-21, -22, -23, -24, and -25 sub-region comprises five trenches located approximately 200 ft (61.0 m) west of 241-TX Tank Farm (Figure 9-1). These trenches have similar dimensions, process history, and function. 216-T-21, -22, -23, -24, and -25 are also known as the 216-TX-1, -2, -3, 4, and -5 graves. A brief background section is provided that includes waste site characteristics, process history, and geology. Cross sections that include the current contamination profile in relation to the waste site and stratigraphy, relevant individual borehole contaminant plots, 3-dimensional data visualizations, and interpretations are provided in Section 9.4.

9.1 GEOLOGY

The general geology and stratigraphy for this area are described in Section 3.1. Stratigraphic relationships are depicted in cross sections of log data. Key Stratigraphic intervals defined within the vadose zone, from shallowest to deepest include the Hf1, Hf2, CCu, RFtf, and RFwie. There is also a series of apparent inter-fingering fine-grained sediment layers within the upper Hanford fm that do not appear to have much lateral extent or correlation. Figure 9-2 is a location map showing the boreholes used for the cross sections. There is a westward dip in the region from TX Tank Farm and the 216-T-21 to -25 trenches, as indicated by distinctive characteristics of the K-40, Th-232, and gross gamma plots. The top of the CCu is at an approximate elevation of 572 ft (174.4 m) or 100 ft (30.5 m) bgs just west of TX Farm decreasing to approximately 568 ft (173.1 m) or 111 ft (33.8 m) west of 216-T-24, as depicted by the cross section B-B' (Figure 9-5) in Section 9.4.3.

9.2 WASTE SITE PROCESS HISTORY

The 216-T-21, -22, -23, and -24 trenches are located west of the 241-TX Tank Farm. Because these trenches were constructed approximately the same, were used at approximately the same time, and received similar waste, they will be considered as a unit for this report. WIDS states that all four trenches are 10 ft (3.1 m) deep and 10 ft (3.1 m) wide at the bottom. It further indicates that the lengths of the bottom dimensions of the trenches are 240 ft (73.2 m). Drawing H-2-3849 indicates the excavations were sloped at 1.5:1, making the boundary of the excavation at the surface approximately 30 ft (9.1 m) longer for each trench. According to drawing H-2-36849, the center lines of the 216-T-21, -T-22, -T-23, and -T-24 trenches are 90 ft (27.4 m) apart. An over-ground steel pipeline extends from tank 241-TX-110 to the nearest trench which is the 216-T-24 trench.

Drawing H-2-3849 does not show the 216-T-25 trench. Another drawing (H-2-44511, sheet 119) created in 1964, shows the center line of this trench to be 90 ft (27.4 m) north of the center line of the 216-T-24 trench. This trench is 60 ft (18.3 m) less in length (180 ft or 54.9 m) than the other four trenches (240 ft or 73.2 m). Tabasinske (1958) shows the 216-T-25 trench (taken from drawing M-2892, sheet 15) oriented north to south rather than east to west for the other four trenches. The center of this trench is indicated as 180 ft (54.9 m) south of the center line of the 216-T-21 trench. Tabasinske also has the names of the trenches reversed with 216-T-21 as the northernmost trench rather than in the south as in Figure 9-1. It is concluded in this report that the trench is located properly in Figure 9-1, based on contamination in borehole 299-W15-212 (A7510) that suggests it is very near a waste site.

The 216-T-21, -22, -23, and -24 trenches were used in 1954 to accept first cycle supernatant waste from the 241-TX-109, -110, and -111 single-shell tanks. Table 6.1 indicates the waste stream that was disposed to the 241- TX- 1, -2, -3, and -4 (216-T-21, -22, -23, and -24) trenches (Paas and Heid 1955). The date filled relates to the tank and the date emptied is the disposal date to the trench. The 216-T-25 trench received evaporator bottoms waste from the T-242 evaporator via the 241-TY-101 and -102 single shell tanks. See Table 9-1 for disposal history.

In 1956, these waste sites were referred to as "graves." This terminology reflected an excavation for "one shot" (few days) disposal that was promptly backfilled. V.W. Wood also referred to these trenches as "graves" ((Wood 1958). Later documentation (e.g., WIDS) refers to them as "specific retention trenches." Wood et al. (2001) states that in May 1953, direct disposal of first-cycle waste to specific retention trenches was approved at a maximum discharge rate of 5,289 L/square meter (150 gallons/ square ft). Note: Conversion (5280 L x .26417205gal/L)/10.7639 square ft/square m = 129.6 gallons/square ft suggests a miscalculation of approximately 20 gal/sq ft). Table 9-2 shows a comparison of this guideline and the actual dimensions of the trenches and waste disposed.

Four of the five trenches may have exceeded the specific retention guidelines. 216-T-25 received the highest volume although it was the smallest trench A hypothetical, considering if only half of the trench actually received waste is also included, and shows that the volume disposed to 216-T-21 would not have exceeded the guideline if only half the footprint were wetted by waste. These calculations should be considered when evaluating whether waste liquid reached the groundwater.

9.3 PREVIOUS INVESTIGATION

Fecht et. al. (1977) did not evaluate the 216-T-21 to -25 trenches.

The T Plant source Aggregate Area Management Study Report (U.S. Department of Energy 1992) evaluated these sites. This evaluation considered boreholes 299-W15-209, -210, and -211. It was concluded there was "insufficient information available to determine the lateral extent of radionuclide contamination. However, it appears that the plume is thickening toward the south, controlled by the south dipping beds." It was also stated that there was no evidence that the contaminants reached the groundwater table in this area.

9.4 SUMMARY OF LOG DATA

Figure 9-1 shows the location of 200-DV-1 study boreholes relative to the five waste sites that have been evaluated for this subregion. Refer to Table 9-3 and Figure 9-2 for which boreholes are evaluated with respect to the 216-T-21 to -25 Trenches. All available geophysical logging data have been summarized in Table 9-3. A brief evaluation of the significance of each log and comparison to earlier logs in the same borehole is made. This evaluation is intended to describe any significant qualitative changes in the gamma profile during intervening years. A quantitative analysis would require more careful comparison, taking into account the relative efficiencies of the various detection systems. This analysis would require a detailed assessment of the response characteristics of the older logging systems, which is beyond the scope of the current effort. The "historical" record is important to determine the past existence of very short-lived radionuclides, the maximum extent of contamination at depth, and whether any influx or migration of contaminants has occurred over time. Geophysical log data from specific boreholes are discussed below based on the relevance of each borehole to the five waste sites.

9.4.1 216-T-21, -22, -23, -24, AND -25 TRENCHES

Five boreholes are in the general vicinity of the five trenches. A north to south cross section for five of these boreholes is included as Figure 9-3. This cross section shows the relationships of contamination detected near the five trenches and the stratigraphy. The boreholes are all shallow (i.e., less than 120 ft (36.6 m) in depth) except for 299-W15-80 (A7381) that was deepened in 1982 to 170 ft (51.8 m) bgs. Locations of the boreholes are generally just outside the area of excavation and not within the center line of the trenches.

All five boreholes intersected Cs-137 contamination. The elevation of the bottom of the trenches should be at approximately 668 ft (203.6 m) or 10 ft (3.1 m) bgs. However, these boreholes exhibit the dominant contamination occurring at an elevation of 650 ft (198.1 m) or 28 ft (8.5 m) bgs or less. These wells are not drilled directly through the trenches but are situated adjacent to the trenches which may account for

the deeper initial detection of contamination. The maximum Cs-137 concentration observed is approximately 100,000 pCi/g in borehole 299-W15-209 (A7507) at an elevation of 645 ft (196.6 m). Boreholes 299-W15-210 (A7508) and 299-W15-212 (A7510) show two separate intervals of lateral Cs-137 spreading. The first interval is about 10 ft (3.1 m) thick between the elevations of 650 and 640 ft (198.1 and 195.1 m). A second interval appears at approximately 630 ft (192.0 m); borehole 299-W15-209 (A7507) is not deep enough to observe this pattern of deposition. Contamination is observed at the greatest depth (120 ft or 36.6 m) in borehole 299-W15-210 (A7508). The borehole farthest to the south (299-W15-80 (A7381) shows only slight Cs-137 contamination at an elevation of 643 ft (196.0 m). Figure 9-4 shows a visualization of the Cs-137 contamination associated with the waste sites.

The top of the CCu in this area is at approximately 565 ft (172.2 m) in elevation. Because of the high Cs-137 concentrations, the stratigraphy is difficult to discern for the boreholes in Figure 9-3 using spectral gamma logs. However, there appears to be a sequence of fine-grained sediment within the Hanford fm that is closely associated with the highest gamma contamination detected in each of the wells.

Cross section B-B' (Figure 9-5) presents boreholes from west of the 216-T-24 trench to south of the 241-TX tank farm. It is useful for determining the elevations of the CCu that appears to slope from east to west. The Hf1 and Hf2 interface is difficult to correlate using the log data. For example, boreholes 299-W15-43 (C3955) and 299-W15-44 (C3956) were drilled with the Becker drilling method. Thick joints in the dual wall casing at 10 ft (3.1 m) intervals cause severe gamma attenuation creating interpretation difficulties. Borehole 299-W15-80 (A7381) was remediated in 1982 so that double casing and grout are in the borehole to approximately 120 ft (36.6 m). Based on boreholes 299-W15-225 and possibly 299-W15-43, the Hf1/H2 may be at approximately 619 ft (188.7 m) in elevation although this should be confirmed by geologic sediment evaluations.

9.4.2 241-TX FARM

Although some boreholes in 241-TX Farm are within 100 m of the 216-T-21 to -25 trenches, there is no evidence contamination in the farm has impacted the deep vadose zone beneath the waste sites. Four boreholes (299-W15-40, 299-W15-22, 299-W15-44, and 299-W15-225) that lie between the 241-TX Farm and the waste sites were considered (Table 9-3). These boreholes are greater than 220 ft (76.1 m) deep and none exhibited any gamma contamination. Reports that include geophysical logging data and interpretations within the tank farm are included in Appendix A. Myers (2005) contains a comprehensive evaluation of contamination in 241-TX-Farm.

9.5 SUMMARY OF SUBREGION AND CONCLUSIONS

The 216-T-21, -22, -23, and -24 trenches are reported to have received first-cycle supernatant waste via the 214-TX-109, -110, and -111 tank cascade series in 1954. First-cycle waste is expected to contain up to 10% of the fission products produced during irradiation of fuel rods. Also, Rohay (2007) suggests a significant amount of Tc-99 could exist if evaporator bottoms waste were disposed. 216-T-25 waste was solely evaporator bottoms waste. All trenches may have exceeded the volume guidelines for specific retention except for 216-T-21 (Table 9-2). Given the quantity of liquid waste disposed at the five trenches, it is likely that that the vadose zone below each waste site is significantly contaminated. However, no boreholes have been drilled within the trenches. Borehole data adjacent to the five trenches indicate significant vertical and some lateral migration of Cs-137. The data show the migration is below 28 ft (8.5 m) bgs, 18 ft (5.5 m) below the reported depths of the trenches. There appears to be fine grained sand to silty sand layers at this depth beneath several of the trenches based on log data from the surrounding boreholes that could be the cause of the lateral spreading of contaminants or the trenches were actually excavated to 28 ft (8.5 m) rather than the reported 10 ft (3.1 m).

The dispersal of the wastes to each trench is unknown. As summarized in Section 9.2, the specific retention guidelines for disposal to these cribs may not have been met. The smallest trench (216-T-25)

may have received a waste volume three times in excess of the guideline for specific retention capacity, if the total area of the bottom of the trench were used. However, geophysical log data and experience suggests that most of the waste volume may have infiltrated into the subsurface relatively close to the discharge point. Existing drawings or documents do not show the locations of the discharge points. If it is assumed that the waste infiltrated over half the active area of each trench, then disposal limits based on specific retention capacity were significantly exceeded.

The 216-T-21 to -25 trenches do not have sufficient boreholes to characterize the contaminant distribution within the deeper vadose zone below the sites. Although the adjacent boreholes show downward and lateral migration of Cs-137, there are no boreholes within the trenches. It is probable, based on the available data, that new boreholes drilled within the trenches would indicate a maximum depth of contamination that exceeds the depth indicated by the adjacent boreholes that lie outside the excavation.

9.6 RECOMMENDATIONS

The 216-T-21 to -25 trenches are not adequately characterized for either the shallow or deep vadose zone. Data gaps exist for types of contaminants, their depth, and lateral extent of contamination.

It is recommended that additional characterization within the trenches be completed to assess the extent and magnitude of contamination within the vadose zone.

Because the 216-T-25 trench may have received the most volume of waste and is a different waste stream (evaporator bottoms), it is recommended additional characterization be completed beneath this trench.

9.7 REFERENCES

Fecht, K.R., Last, G.V., and Price, K.R. 1977. *Evaluation of Scintillation Probe Profiles From 200 Area Crib Monitoring Wells* Volume III. ARH-ST-156. Atlantic Richfield Hanford Company. Richland, Washington.

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H.J. Paas and K.R. Heid. 1955. *Radioactive Contamination in Liquid Wastes Discharged to Ground at Separation Facilities Thru June 1955.* HW-38562. General Electric Hanford Atomic Products Operation. Richland Washington.

Wood, M.I., et al. 2001. *Surface Conditions Description of the T-TX-TY Waste Management Area.* RPP-7123, Rev. 0. CH2MHILL Hanford Group, Inc. Richland, Washington.

Wood, V.W. April 29, 1958. *Index of CPD Crib Building Numbers, Designs of CPD Radioactive Waste Disposal Sites, Part V, Process Technology – Study Report.* HW-55176, Part 5. General Electric Hanford Atomic Products Operation. Richland, Washington.

U.S. Department of Energy. 1992. *T Plant Source Aggregate Area Management Study Report.* DOE/RL-91-61, Rev. 0. U.S. Department of Energy. Richland, Washington.

TABLE 9-1. DISPOSAL HISTORY FOR THE 216-T-21 TO -25 TRENCHES (PAAS AND HEID 1955)

Trench	Volume (E05 L)	Pu (g)	U (g)	Gross Beta (Ci)	Cs (Ci)	Sr (Ci)	Tank #	Date Filled	Date Emptied
TX 1	4.63	1.25	521	7,920	389	7.87	TX-100	7/25/52	6/24/54
TX 2	15.4	1.90	2,170	3,800	1,850	49.3	TX-110	6/14/53	7/23/54
TX 3	7.48	0.21	842	935	591	16.5	TX-110	6/14/53	7/30/54
TX 3	7.38	0.66	244	2,440	738	23.6	TX-111	2/23/54	8/6/54
TX 4	15.4	2.48	8,320	4,200	1,420	38.5	TX-111	2/23/54	8/13/54
TX 5	24.8	0.58	855	11,000	7,190	3.97	TY-101	N/A	9/19/54
TX 5	5.07	0.02	258	3,240	1,700	0.14	T-106	N/A	9/22/54
Total	**80.20**	**7.1**	**13,210**	**33,500**	**13,880**	**140.11**			

TX-1 corresponds to 216-T-21
TX-2 corresponds to 216-T-22
TX-3 corresponds to 216-T-23
TX-4 corresponds to 216-T-24
TX-5 corresponds to 216-T-25

Tank # has a 241- prefix

TABLE 9-2. TABLE COMPARISON OF SPECIFIC RETENTION GUIDELINES WITH ACTUAL DISPOSAL

Trench	Trench bottom (ft^2)	Volume (gallons)	Guideline (full area) (gallons)	Guideline (half area) (gallons)
216-T-21	2400	122,311	360,000	180,000
216-T-22	2400	406,825	360,000	180,000
216-T-23	2400	392,560	360,000	180,000
216-T-24	2400	406,825	360,000	180,000
216-T-25	1800	789,875	270,000	135,000

TABLE 9-3. GEOPHYSICAL LOGGING DATA ACQUIRED FOR THE 216-T-21 THROUGH THE 216-T-25 SUBREGION

WASTE SITE	WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	LOG DATE	CONTAMINATION HISTORY	SUMMARY
T-23	299-W15-210	A7508		YES	100	14-MAR-84	Contamination at 20 ft to total depth	Cs-137 contamination throughout this borehole from 1984 to 2002.
	299-W15-210	A7508		YES	100	24-JUN-86	Contamination at 20 ft to total depth	
	299-W15-210	A7508		YES	100	06-MAY-92	Contamination at 20 ft to total depth	
	299-W15-210	A7508		SUBMITTED	100	07-MAY-92	Cs-137 detected from 30 to 75 ft	
	299-W15-210	A7508		YES	100	23-DEC-02	Cs-137 from 0-10 ft, 20 ft to total depth.	
T-24	299-W15-211	A7509		YES	100	14-MAR-84	Contamination at 32 - 60 ft	Cs-137 and Co-60 contamination was identified in 2002 logging event
	299-W15-211	A7509		YES	100	24-JUN-86	Contamination at 28 - 58 ft	
	299-W15-211	A7509		YES	100	26-DEC-02	Cs-137 4.5-6.5 ft, 24.5 - 26.5 ft, 33.5 -64 ft, 68 ft, 70 ft; Co-60 77-79 ft, 85 ft	
T-25	299-W15-212	A7510		YES	100	14-MAR-84	Contamination at 25 - 74 ft	Cs-137 and Co-60 contamination was identified in 2002 logging event
	299-W15-212	A7510		YES	100	24-JUN-86	Contamination at 25 to 76 ft	
	299-W15-212	A7510		YES	100	30-DEC-02	Cs-137 4-9 ft, 30-82 ft; Co-60 43-54 ft	
SE OF CRIBS	299-W15-22	A4925		YES	0-150	05-DEC-90	No elevated gamma activity	No evidence of radionuclide contamination in 1990.
	299-W15-22	A4925		YES	110-220	17-DEC-90	No elevated gamma activity	
SE OF CRIBS	299-W15-225	C7017		YES	465	11-MAY-09	No visible signs of contamination.	No evidence of radionuclide contamination in 2009.
NE OF CRIBS	299-W15-40	B8550		SUBMITTED	262.4	04-SEP-98	No man-made radionuclides detected.	No evidence of radionuclide contamination in 1998.
	299-W15-40	B8550		YES	0-125	28-AUG-98	Not interpreted	
	299-W15-40	B8550		YES	110-220	04-SEP-98	Not interpreted	
NW OF CRIBS	299-W15-43	C3955		YES	347	13-NOV-02	No contamination	No evidence of radionuclide contamination in 2002.
SE OF CRIBS	299-W15-44	C3956		YES	341	18-FEB-02	No man-made radionuclides detected.	No evidence of radionuclide contamination in 2002.
NE OF CRIBS	299-W15-74 (51-00-09)	A7375	241-TX-5	SUBMITTED	150	15-FEB-96	Cs-137 from 45-110 ft	Cs-137 was detected from 45-111 ft in 1996.
T-21	299-W15-80	A7381	241-TX-10	SUBMITTED	120	02-MAY-63	Contamination from 30 to 55 ft and in CCuc at 111 ft.	Cs137 was detected from 38.5 to 40 ft in 2002.
	299-W15-80	A7381		YES	110	02-DEC-76	Contamination at 40 ft	
	299-W15-80	A7381		YES	120	14-MAR-84	Contamination at 40 ft	
	299-W15-80	A7381		YES	120	24-JUN-86	Contamination at 40 ft	
	299-W15-80	A7381		YES	120	18-DEC-02	Cs-137 from 38.5 - 40 ft	
T-22	299-W15-81	A7382	241-TX-11	SUBMITTED	115	02-MAY-63	No contamination	No evidence of radionuclide contamination in 1986.
	299-W15-81	A7382		YES	115	02-DEC-76	No contamination	
	299-W15-81	A7382		YES	115	02-JAN-03	Cs-137 at 5 ft	
T-22	299-W15-209	A7507		YES	50	14-MAR-84	Contamination throughout borehole	Cs-137 was detected throughout borehole, max 98,300 pCi/g at 35 ft.

TABLE 9-3. GEOPHYSICAL LOGGING DATA ACQUIRED FOR THE 216-T-21 THROUGH THE 216-T-25 SUBREGION

WASTE SITE	WELL NAME	WELL ID	ALIAS	IDMS	TOTAL DEPTH	LOG DATE	CONTAMINATION HISTORY	SUMMARY
	(SHALLOW LIST)							
	299-W15-209	A7507		YES	50	24-APR-86	Contamination throughout borehole	
	299-W15-209	A7507		YES	50	19-DEC-02	CS-137 throughout borehole with max concentration of 98,300 pCi/g @ 35 ft.	

Waste Sites have a 216- prefix

FIGURE 9-1. 216-T-21, -T-22, -T-23, -T-24, AND -T-25 LOCATION MAP

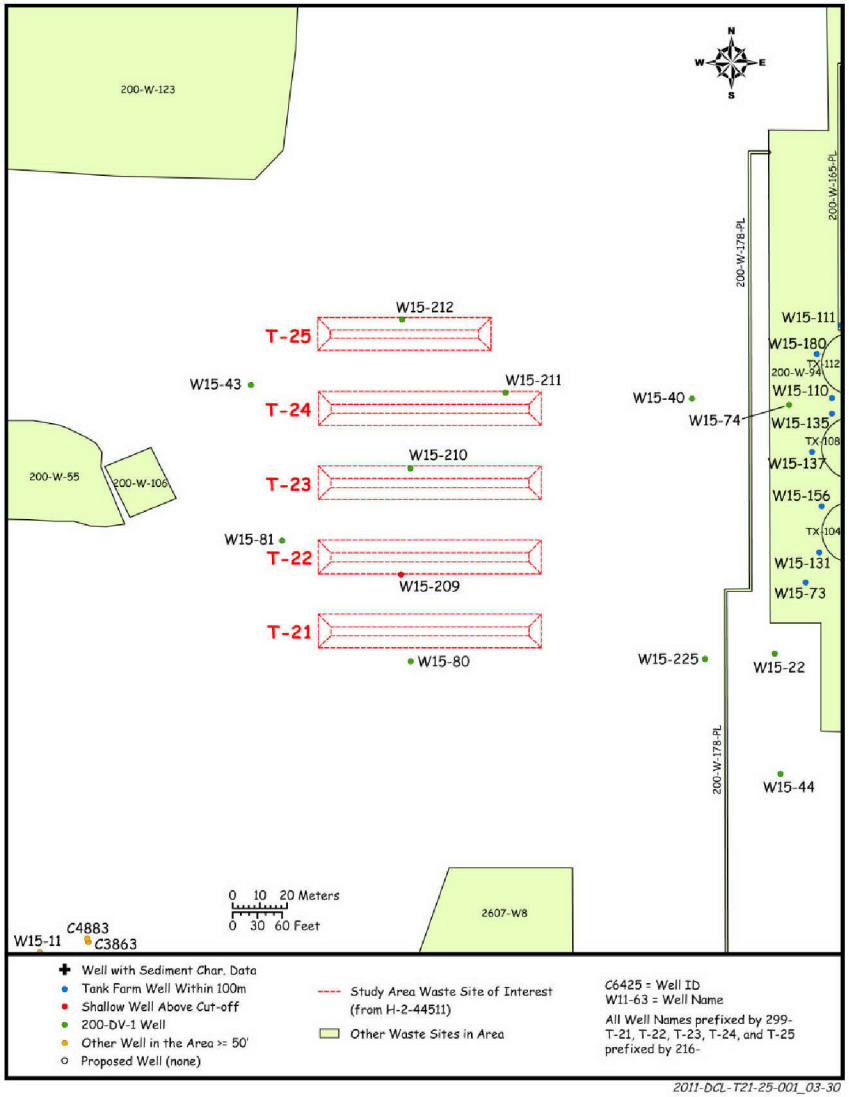


FIGURE 9-2. 216-T-21, -T-22, -T-23, -T-24, AND -T-25 BOREHOLE AND CROSS-SECTION LOCATIONS

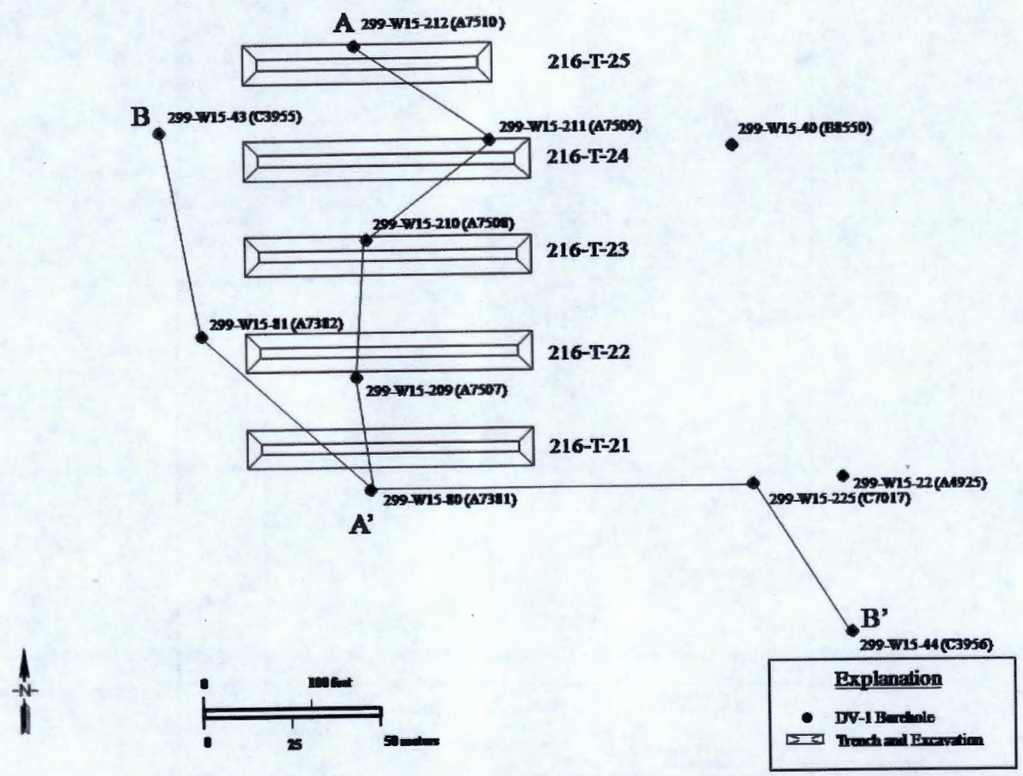


FIGURE 9-3. 216-T-21, -T-22, -T-23, -T-24, AND -T-25 CROSS-SECTION (A-A')

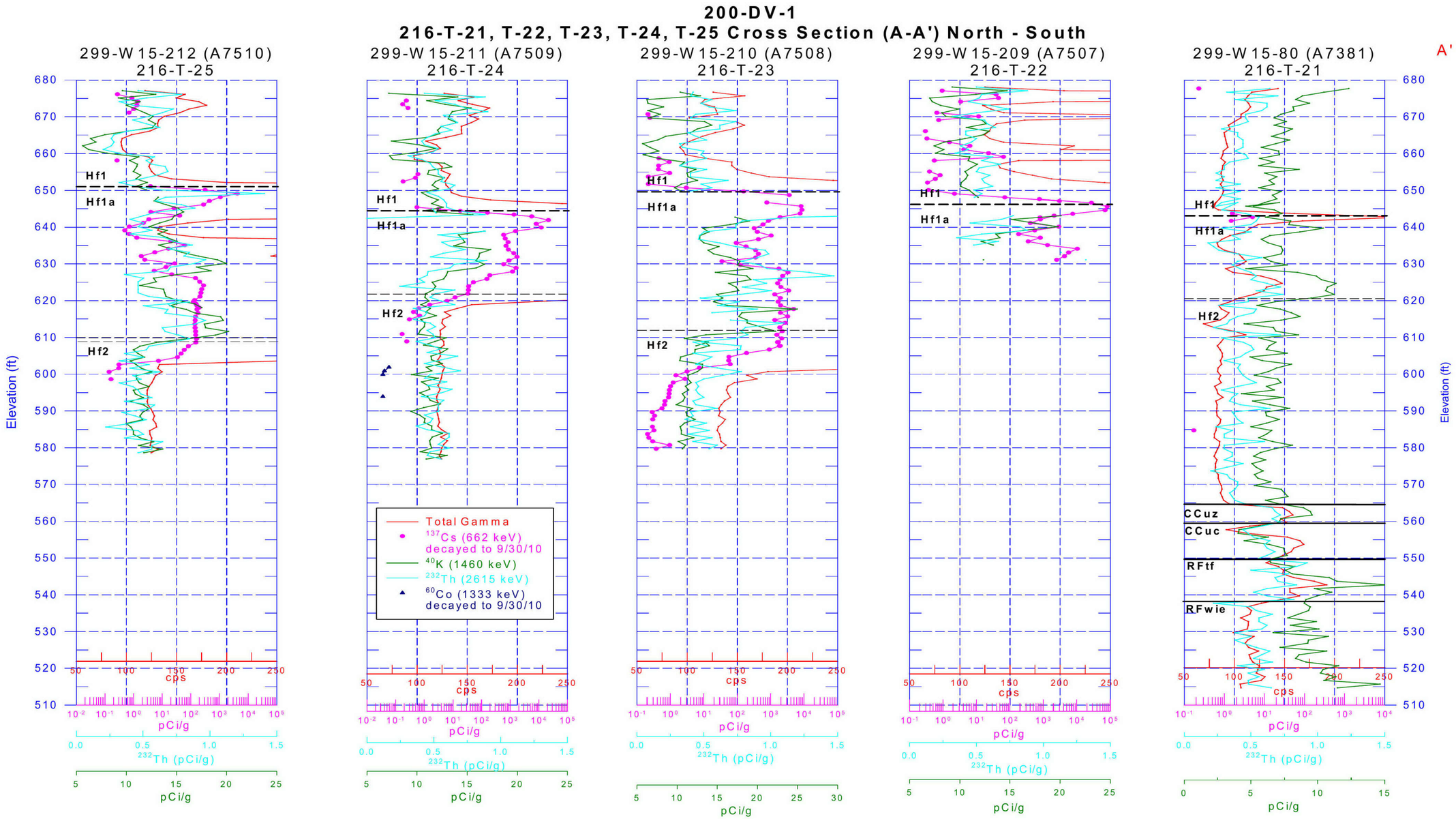


FIGURE 9-4. VISUALIZATION OF CS-137 CONTAMINATION AROUND THE 216-T-21 TO 216-T-25 TRENCHES VIEWED FROM THE EAST

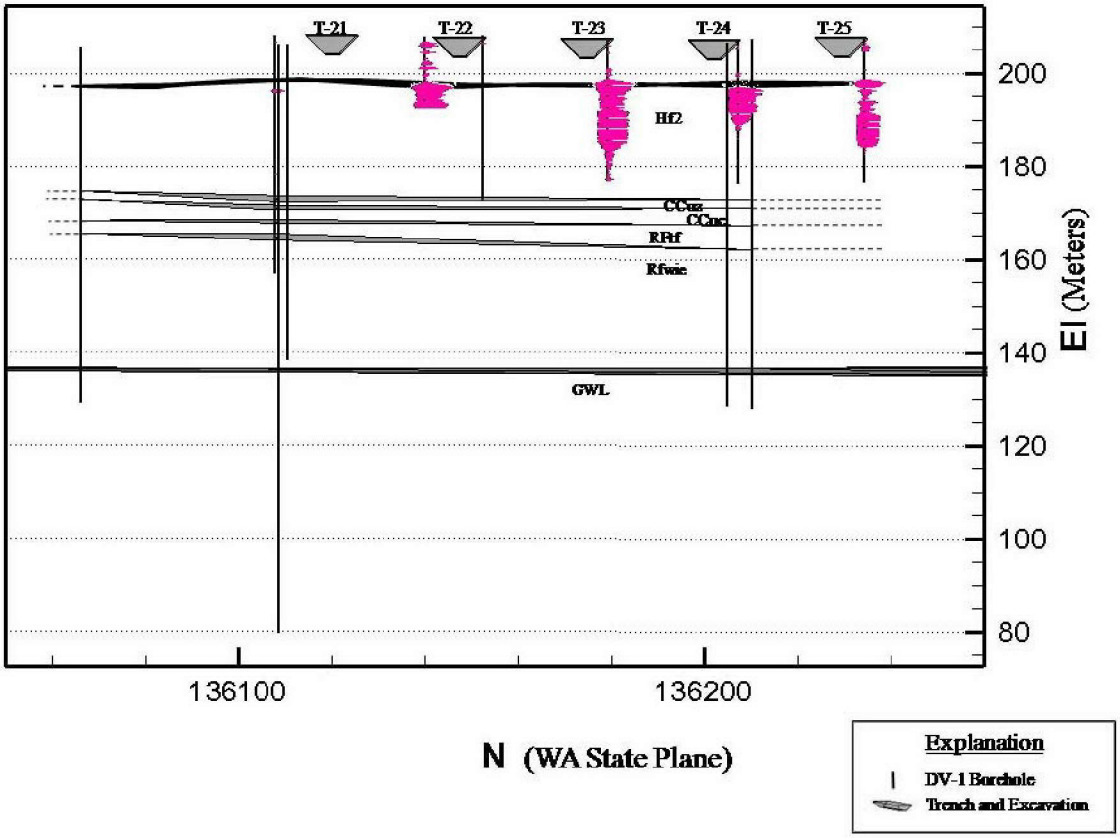
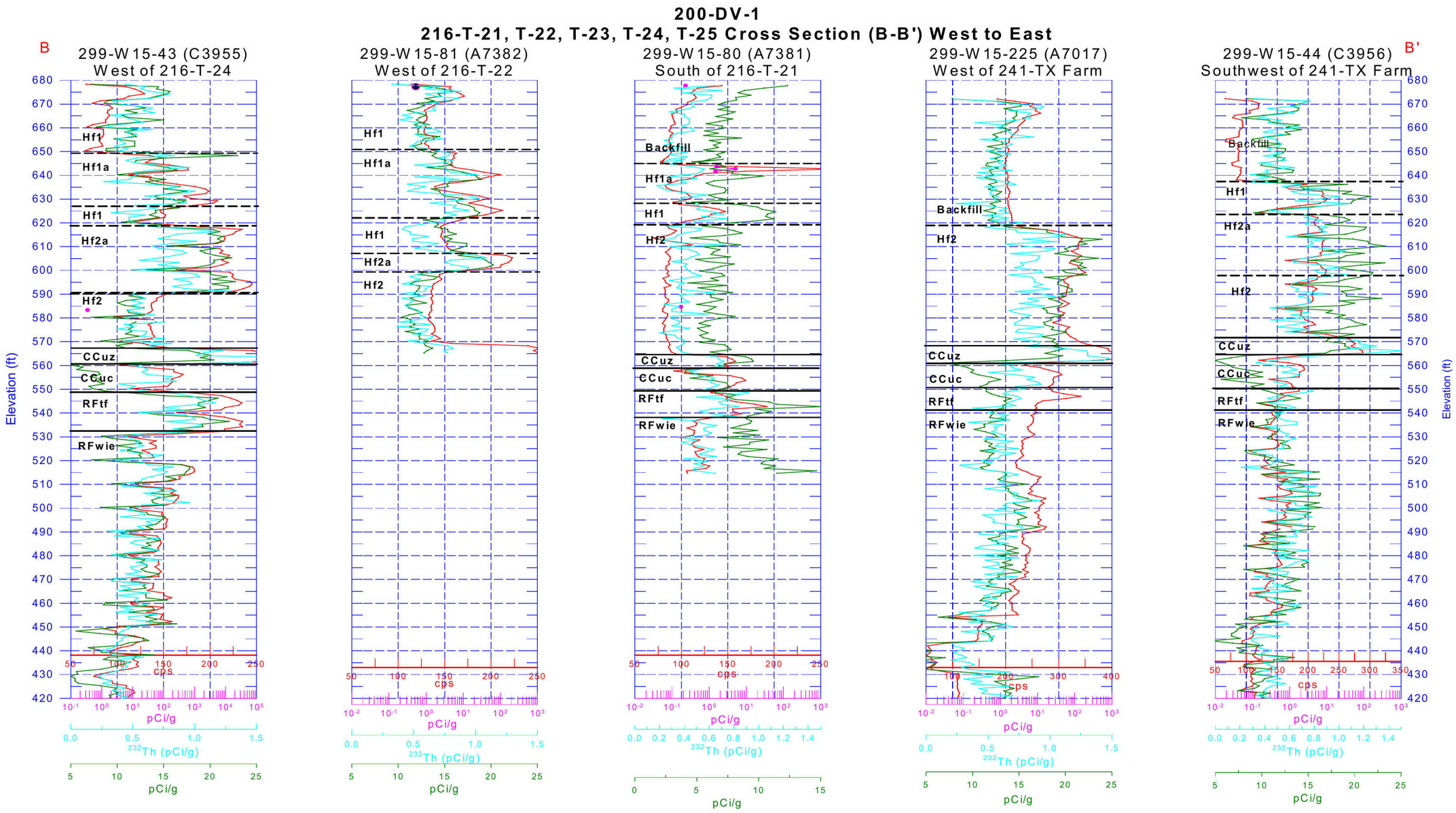


FIGURE 9-5. 216-T-21 TO 216-T-25 CROSS-SECTION B-B'



10.0 SUMMARY AND CONCLUSIONS

An evaluation of geophysical log data has been completed for the 200-DV-1 OU liquid waste sites in the vicinity of the T, TX, and TY Tank Farms in the Hanford 200W area. The primary focus of this effort is to assess the probable impact of gamma-emitting contaminants on the deep vadose zone and ultimately groundwater. To facilitate evaluation, the sites were grouped into six subregions based on proximity. Boreholes and wells located within 100 meters (328 ft) of each subregion were identified. A master list (Appendix A) of available geophysical logs from these boreholes was created. The list includes information as to the form (electronic data or hard copy) of the log and its location. (i.e., WIDL, HEIS_GPL, or hard copy in files). Logs that are not already referenced in WIDL have been scanned and submitted to WIDL as part of this task.

Historical gross gamma logs acquired prior to the early 1990s provide a special insight into the history of Hanford waste sites. Although they can be very difficult to interpret in their current form (typically paper strip charts with multiple scale changes to cope with a wide range of gamma activity), they allow interpretations to be made as to the time of arrival, depth and extent of gamma-emitting contamination. Qualitative comparison of total gamma logs over time provides information as to the half-life of dominant radionuclides, and can detect migration of contaminants. These interpretations can be critical in assessing potential impacts to the deep vadose zone and groundwater over the past sixty years. Development of high resolution spectral gamma logging in the early 1990s allows identification and assay of individual natural and manmade gamma emitting radionuclides. These data can be compared to historical gamma profiles. The geophysical logging data represents an important source of information because there is generally very little sample data from the vadose zone during the operational period for the waste sites.

Spectral gamma logging also provides useful information for stratigraphic correlation. Concentrations of the naturally occurring radionuclides K-40, U-238, and Th-232 can be determined. Variations in these radionuclides can be used (when supported by good quality geologic data) to identify and correlate stratigraphic units.

For this report, existing documents relevant to each site were reviewed and some discrepancies were found regarding waste site location and configuration, process history, and even borehole names and locations. It was not always possible to resolve these issues in the time allowed.

Brief summaries of the major findings and significant issues for each subregion are provided below. Generally, these include the extent and nature of radiological contaminants that can be determined with the borehole geophysical logging tools available. If available, the maximum detected depth and identification of the radiological contaminant(s) are provided by 200-DV-1 waste site.

216-T-3 Reverse Well and 216-T-6 Cribs

- Based on a review of available geophysical log data, and site liquid effluent disposal history it appears likely that the 216-T-3 and 216-T-6 waste sites impacted groundwater. The 216-T-3 reverse well cannot be adequately evaluated by existing geophysical borehole log data; existing boreholes are at least 25 ft away. Prior investigators apparently assumed the reverse well contaminated groundwater because the bottom of the well is within 50 ft (15.2 m) of the groundwater level. However, gamma profiles in nearby wells suggest relatively low activity waste with maximum Cs-137 concentrations less than 1000 pCi/g at the top or just within the CCu. The maximum Cs-137 concentration is approximately 46,000 pCi/g at 15 ft (4.6 m) in one borehole. It is assumed that plutonium would be present in the T-224 building waste, but SGLS logs failed to detect Pu-239 at levels above 10 nCi/g in any of the nearby boreholes. Because 216-T-3 is a disposal well and monitoring wells nearby do not detect any deep contamination associated with this site, there is a data gap about contaminant extent in the deep vadose near the perforated interval.

- Prior investigations at 216-T-6 Cribs (#1 and #2) have focused on the #1 crib. A 1948 report summarizes the results of 13 boreholes and presents an evaluation of the nature and extent of subsurface contamination based on sample analysis for fission products and plutonium. The general profile based on more recent 2003 SGLS logs is slightly compressed relative to the 1948 profile, interpreted to be the result of decay of short-lived fission products. Available data suggest that significant gamma-emitting contamination (primarily Cs-137) currently does not extend below 70 ft (21.3 m) bgs.
- Geophysical logs near the 216-T-6 Cribs from borehole 299-W11-1 (A7275) provide evidence of contamination in the deep vadose zone. In 1951, elevated gamma activity extends to at least 80 ft (24.4 m) bgs. Gamma profiles suggest contamination may have extended to groundwater by 1963. By 1968, high gamma activity is reported in the groundwater. By 1976, gamma activity in 299-W11-1 had decayed away, except for a minor peak at 25 ft (7.6 m) bgs. An RLS log in 1995 detected Co-60 near the historical groundwater level.
- The 241-T-361 Settling Tank and associated piping are an important component of waste delivery to both the 216-T-3 reverse well and the 216-T-6 cribs, and based on nearby borehole geophysical data, may have contributed to vadose zone contamination. There are no boreholes in the immediate vicinity of the tank, but three wells near the 216-T-3 reverse well have detectable gamma contamination in the shallow subsurface that strongly suggests a pipeline source rather than the 216-T-3 reverse well. Plutonium is a component of the 224 waste discharged to these sites and a contaminant of concern and was not detected in any of the existing geophysical data. The detection level of the older equipment most likely did not allow determination of the existence of plutonium in the vadose zone. Future characterization activities should consider appropriate geophysical logging criteria for adequate assessment. Criteria include using the high-resolution spectral gamma log, which can detect Pu-239, Am-241, and Pu-241 at levels below 100 nCi/g. The passive neutron log should also be considered as a qualitative indicator of TRU.

216-T-5 Trench, 216-T-7 Crib (200-W-52) and Tile Field, and 216-T-32 Cribs

- Based on geophysical borehole log data evaluation for wells in and near this sub-region it appears that contaminants impacted groundwater below the 216-T-7 (200-W-52) crib and tile field. Beneath the 216-T-32 crib, it appears contaminants (Pu-238, am-241, Cs-137, and Eu-154) largely remained in a silty sand unit approximately 35 ft (10.7 m) bgs. Significant lateral migration along this sand unit to the south at least to the northern portion of the 216-T-7 tile field is observed, with no significant vertical migration. Detectable gamma contamination is clearly defined down to and in some cases below the CCu at the 216-T-7 crib.
- Existing boreholes at the 216-T-5 Trench are not optimally located or deep enough to characterize the deep vadose zone. However, this site received relatively little waste volume compared to the other two sites. Only one well, 299-W10-1, was drilled in this area and contamination was detected to the upper Ringold Fm, beneath the CCu. There are no other data available to assess the extent of potential contamination in the deep vadose zone.
- At the 216-T-7 (200-W-52) crib and tile field, contamination has been detected to the bottoms of many boreholes at approximately 150 ft (45.7 m) bgs at approximately 75 ft (22.9 m) above the current water table. One deep borehole (299-W10-3 {A4897}) indicates contamination to the groundwater. In spite of the level of effort in prior investigations of the 216-T-7 Crib and Tile Field, there is no deep vadose zone data available to determine gamma contaminant impacts to groundwater. Contamination has been detected deep in the vadose zone and into the upper Ringold Fm, but data do not exist to determine the extent of potential contamination in the Ringold Fm. The 8 boreholes in the vicinity of the crib had contamination to the total depth of the boreholes, a depth of 150 ft (45.7 m) bgs. These boreholes are no longer useful for monitoring and may act as conduits for downward migration.

- The 216-T-32 Crib was reasonably well characterized in 1948, and shallow contamination above the CCu was defined. However, available subsurface data are limited to the upper 150 ft (45.7 m). The extent of potential contamination in the deep vadose zone both immediately above the CCu and down into the Ringold Fm is not known. Current interpretations of borehole geophysical log contaminant data between known 241-T Tank Farm leaks and contamination identified in Sub-region 2 indicate no overlapping or impacting contamination. However, there are no boreholes deep enough to completely assess this possibility.

216-T-14, T-15, T-16, and T-17 Trenches

- Based on geophysical borehole log data evaluation for wells in and near sub-region 3 it appears unlikely that contaminants disposed to the trenches have impacted groundwater. There are no boreholes directly beneath the trenches to assess deep vadose zone contamination potential, however, nearby wells reveal that detectable gamma contamination exists at very shallow depths today. There is no indication from existing boreholes that contamination has reached the CCu outside the boundaries of the trench excavations; detectable contamination has impacted the upper Hanford fm.
- These specific retention trenches were operated sequentially to dispose of 1st cycle bismuth phosphate reprocessing waste that had been previously stored in the 241-T-104/T-105/T-106 cascade series in 1954. This waste may contain significant fission products, and may represent a source of Tc-99. Given the quantity of liquid involved (approximately a million gallons or 3.8 million liters); it is likely that the vadose zone has been significantly contaminated. However, there are only two boreholes at the margins of these four trenches, and two additional boreholes near the periphery of the subregion. Significant data gaps exist regarding waste dispersal, and nature and extent of deep vadose zone contamination.
- The relationship between Co-60 and Tc-99 should be investigated in detail. Both are associated with process waste, and both have relatively low adsorption potential in the Hanford vadose zone sediments. Tc-99 is a "pure" beta emitted and impossible to detect through steel casing. Co-60 emits two distinct and penetrating gamma rays that are easily detectable. Although it has a relatively short half life and thus does not represent a contaminant of concern over the long term, Co-60 may serve as a surrogate for Tc-99 in the vadose zone

216-T-18, -T-26, -T-27, and -T-28 Cribs

- Based on geophysical borehole log data evaluation for wells in and near this sub-region, it appears that contaminants impacted groundwater below the 216-T-28 crib. It is possible that the 216-T-26 and 216-T-27 cribs also impacted groundwater, but data are insufficient to assess the deeper vadose zone within the Ringold Fm below the cribs and most likely contamination has commingled with 216-T-28 Crib contamination in the deeper vadose zone. Geophysical log data at the 216-T-18 Crib indicate contamination to at least to the CCu and into the upper Ringold Fm. Data are insufficient to determine impacts to the deep vadose zone beneath the 216-T-18 Crib. Overall, detectable gamma contamination is clearly defined down to and in some cases below the CCu throughout this sub-region.
- These sites are grouped together because of geographic proximity. Many documents seem to assume the same configuration, but 216-T-18 is distinctly different from the three other cribs. 216-T-26, -T-27, and -T-28 were constructed as engineered crib structures whereas 216-T-18 was described as a "hole in the ground" used for one-time disposal of liquid waste.
- Multiple logs in 299-W11-11 (A7280) near 216-T-18, show elevated gamma activity from about 10 ft (3.1 m) below grade to the top of the Cold Creek unit at 84 ft (25.6 m) depth. Activity has decreased over time, consistent with decay of short-lived radionuclides. An RLS log was run in 1992 and Cs-137 and Co-60 were detected, with a maximum Cs-137 concentration of less than 10,000 pCi/g at

a depth of 30 ft (9.1 m) bgs. The waste profile seen in the vadose zone with a relatively low concentration of Cs-137 is consistent with scavenged waste where much of the Cs-137 was removed.

- Three direct push holes were drilled in 2008 at the 216-T-18 Crib and logged with small-diameter detectors. Results show contamination at the margin of the 216-T-18 crib between 28 to 31 ft (8.5 to 9.5 m) depth, and from 28 to 39 ft (8.5 to 11.9 m) depth near the center of the crib. This contamination is closely associated with the depth of the geologic contact between the coarse Hf1 and underlying Hf2 finer grained sediment. In terms of contamination associated with gamma emitting fission products, 216-T-18 appears to have little or no impact on the deep vadose zone
- WIDS indicates that 1800 g of plutonium was discharged to 216-T-18. However, the 1992 RLS log and the small diameter gamma log used in the direct push investigations are not well-suited to detection of low yielding gamma rays associated with plutonium. All boreholes within or proximal to the 216-T-18 crib have been decommissioned. The existence and extent of potential plutonium contamination beneath this location remains a data gap. If plutonium remains an issue, additional characterization using high-resolution spectral gamma logs is suggested. This system can detect Pu-239, Am-241, and Pu-241 at levels below 100 nCi/g.
- 216-T-26, -T-27, and -T-28 were constructed as engineered units. Discrepancies exist in the waste disposal records. Available log data indicate that contamination at 216-T-26 extends at least to the bottom of the borehole in well 299-W11-70 (150 ft or 45.7 m bgs) which is into the Ringold Formation. Log data also indicate 216-T-28 likely contaminated a large portion of the vadose zone down to groundwater. Boreholes to the southeast show evidence of lateral migration along and into the Cold Creek unit and below.

216-T-19 Crib and Tile Field

- The 216-T-19 Crib and Tile Field received a relatively large volume of liquid waste over an extended time frame and previous investigators have recognized it as a potential source of groundwater contamination. In spite of this, little is known of the nature and extent of contamination in the vadose zone. Waste site configuration and history seem to be well known, but significant data gaps exist with regard to contamination in the deep vadose zone.
- Four boreholes with geophysical logs are located within the area of the tile field, but only two penetrate deep enough to be useful, even though they do not reach the Cold Creek unit. Data from the borehole nearest the crib (299-W14-51) indicate possible contamination to the bottom of the borehole, essentially within the lower Hanford fm. There is little evidence of shallow gamma-emitting contamination.
- Borehole 299-W15-4 (A4929) was installed approximately 122 ft (37.2 m) southwest of the 216-T-19 crib outside of the tile field area. It encountered elevated gamma activity above 40 ft (12.2 m) when it was drilled in 1956, only 5 years after 216-T-19 began operation. This contamination is closely associated and may be influenced by the changing hydraulic properties at the geologic contact between the coarse Hf1 and the finer grained Hf2 units in the shallow vadose zone. If the contamination in 299-W15-4 originated from 216-T-19, this implies a high degree of lateral migration near the crib. This shallow contaminant interval is not indicated in the tile field because data are not available.
- 299-W15-762 (C3122) was located approximately 12.5 ft (3.8 m) to the northwest of 299-W15-4 as a replacement monitoring well. During drilling unanticipated radiological contamination was encountered at 37 ft (11.3 m) depth and the well was terminated. Gross gamma and RLS logs in 299-W15-4 clearly showed evidence or high gamma activity at this depth before 299-W15-762 was ever drilled. With even a cursory review of the 299-W15-4 logs, the contamination in 299-W15-762 would not have been a surprise. This leads to a recommendation that risk assessments for all boreholes and excavations in or near waste disposal sites include a review of available log data by a competent geologist or geophysicist.

216-T-21, -T-22, -T-23, -T-24, and -T-25 Trenches

- Based on disposal waste volumes and geophysical borehole log data in and near sub-region 6 it appears unlikely that contaminants disposed to the trenches have impacted groundwater. There are only shallow vadose boreholes at the trenches which do not allow assessment of deep vadose contaminant potential near or beneath the CCu. Nearby surrounding wells reveal no current detectable gamma contamination throughout the upper vadose zone down to the CCu. There is some data that indicates contamination has reached the CCu beneath trench 216-T-23.
- Specific retention trenches 216-T-21, -T-22, -T-23, -T-24, and -T-25 are similar in many respects to the 216-T-14, -T-15, -T-16, and -T-17 Trenches. One vadose borehole was drilled into/near each trench. Gamma contamination was detected in each of these boreholes from ground surface and closely associated with a thick sequence of fine grained silty sandy sediment lenses that occur very near the Hf2 contact roughly 20 to 30 ft (6.1 to 9.1 m) bgs. The contamination extends through the entire fine grained lens in four of five boreholes, and to the bottom of the borehole in 216-T-23 at a depth of ~100 ft (30.5 m) bgs. The southernmost trench, 216-T-21 has very thin and small concentrations of contamination detected along the top of the silty lens suggesting lateral spreading on top of this lens from the northern 216-T-22 Trench and does not appear to be from 216-T-21 at that location.
- No data exists deeper in this area to determine the deep vadose zone extent of the contamination detected at the bottom of the 216-T-25 borehole.
- Borehole data at the margins of the five trenches indicate some lateral migration of Cs-137.

Based on the findings for the individual areas discussed above, it is evident that the state of knowledge with regard to contamination conditions in the deep vadose zone varies widely. For some sites, such as the 216-T-5 Crib and the 216-T-18 crib it appears that available data are adequate and that these sites likely have had minimal impact on the deep vadose zone and/or groundwater. Other sites, such as the 216-T-7 Crib (including the 200-W-52 Crib) and Tile Field and the 216-T-26, -T-27, and -T-28 Cribs have abundant data to suggest deep contamination of the vadose zone. Sites such as the 216-T-3 Reverse Well and the 216-T-19 Crib and Tile Field, probably impacted groundwater and appear to be reasonably well documented in terms of site configuration and process history. However, subsurface data are lacking to assess the deep vadose zone extent of contamination and potential impacts to groundwater. In addition, two subregions: 216-T-14, -T-15, -T-16 and -T-17 Trenches and 216-T-21, -T-22, -T-23, -T-24, and T-25 Trenches have significant data gaps with regard to site configuration and little or no deep vadose zone data are available to assess deep vadose contamination. Also, the 241-T-361 Tank may have contributed to vadose zone contamination in the vicinity of 216-T-3 and 216-T-6 based on nearby log data, but there is very little subsurface data to confirm or refute this assertion. Although the 216-T-32 crib appears to have received significant volumes of waste, the geophysical log data suggest a very low activity waste consisting of Pu and minor amounts of fission products such as Cs-137 and Eu-154. These contaminants are observed below the crib as significant in lateral extent, migrating along a silty sand unit approximately 35 ft (10.7 m) bgs, but have not been measured deep in the vadose zone.

A

Appendix A - Geophysical Logs

A.1 Description of T-TX-TY Focus Area for Boreholes

Appendix Table A-1 contains an inventory of 565 geophysical logs for the 109 boreholes and wells in the 200-DV-1, T-TX-TY focus area. This list is based on the 6 sub-regions identified above. Shallow boreholes were eliminated from the list unless located in, or immediately adjacent to a 200-DV-1 subregion waste site. The table below shows the cutoff depths for selecting wells within each of the sub regions at the sites.

200-DV-1 Waste Sites by Sub region:

Sub Regions E-J	Sub Region	Minimum Depth*
E	216-T-3 & -T-6	75 ft
F	216-T-5, -T-7, & -T-32	75 ft
G	216-T-14, -T-15, -T-16 & -T-17	75 ft
H	216-T-18 & 216-T-26	75 ft
I	216-T-19	80 ft
J	216-T-21, -T-22, -T-23, -T-24, -T-25	80 ft

*Minimum depth per B Williams email 8/11/2010

The 200-DV-1, T-TX-TY table includes the well identification number, well name, tank farm number, and alias for each of the 109 boreholes. The sub regions were assigned an alphabetical letter (E-J for the T-TX-TY sub regions) for sorting purposes in the table. The "Depth" is the total logging depth or range for each logging event. The "Log Type" is identified with the following abbreviations:

LOG TYPE	EXPLANATION
HG	High Resolution Spectral Gamma (HPGe) e.g. SGLS, HRLS, RLS
SG	"Conventional "Spectral Gamma e.g. NaI, BGO, CsI
GG	Gross Gamma, e.g. GM, Scintillation
NM	Neutron Moisture
N	Neutron (unspecified)
PN	Passive Neutron
OTH	Other (Density, Temperature, Caliper)

Log sub type is a further description of the specific log, e.g., RLS, scintillation, etc.

Descriptions of the logging methods are described in section 2 of this report.

The IDMS_ID column contains the IDMS file numbers for 384 logs, indicating that these files are available in WIDL. The 176 files that were not in WIDL were copied or scanned and have been submitted for placement into WIDL. These files do not yet have a WIDL identifying number but are identified with "Submitted." in the IDMS_ID column.

The file name in the "WIDL DATA AVAILABLE" column was assigned to the file in WIDL.

All of the 128 SGLS files on this list have been submitted to HEIS, and are identified in the HEIS_GPL column.

N/A is placed in the column of five boreholes where no data is available.

A.2 Geophysical Borehole Logging Reports for the 241 T-TX-TY Tank Farms

SST Baseline Publications (by tank farm)

DOE-GJO, 1999. *Hanford Tank Farms Vadose Zone, T Tank Farm Report*. GJO-99-101-TAR, GJO-HAN-27, prepared by MACTEC-ERS for the U.S. Dept. of Energy, Grand Junction Office.

DOE-GJO, 2000. *Hanford Tank Farms Vadose Zone, Addendum to the T Tank Farm Report*. GJO-99-101-TARA, GJO-HAN-27, prepared by MACTEC-ERS for the U.S. Dept. of Energy, Grand Junction Office.

DOE-GJO, 1997. *Hanford Tank Farms Vadose Zone, TX Tank Farm Report*. GJO-97-13-TAR, GJO-HAN-11, prepared by MACTEC-ERS for the U.S. Dept. of Energy, Grand Junction Office.

DOE-GJO, 2000. *Hanford Tank Farms Vadose Zone, Addendum to the TX Tank Farm Report*. GJO-97-13-TARA, GJO-HAN-11, prepared by MACTEC-ERS for the U.S. Dept. of Energy, Grand Junction Office.

DOE-GJO, 1998. *Hanford Tank Farms Vadose Zone, TY Tank Farm Report*. GJO-97-30-TAR, GJO-HAN-16, prepared by MACTEC-ERS for the U.S. Dept of Energy, U.S. Dept. of Energy, Grand Junction Office.

DOE-GJO, 2000. *Hanford Tank Farms Vadose Zone, Addendum to the TY Tank Farm Report*. GJO-97-30-TARA, GJO-HAN-16, prepared by MACTEC-ERS for the U.S. Dept. of Energy, Grand Junction Office.

Tank Summary Data Reports

Tank Farm	Tank	Report Number	Date
241-T	T-101	GJ-HAN-115	3/99
	T-102	GJ-HAN-116	2/99
	T-103	GJ-HAN-117	3/99
	T-104	GJ-HAN-118	3/99
	T-105	GJ-HAN-119	7/99
	T-106	GJ-HAN-120	6/99
	T-107	GJ-HAN-1	8/95
	T-108	GJ-HAN-121	12/98
	T-109	GJ-HAN-122	11/98
	T-110	GJ-HAN-1	8/95
	T-111	GJ-HAN-123	12/98
	T-112	GJ-HAN-124	11/98
241-TX	TX-101	GJ-HAN-42	10/96
	TX-102	GJ-HAN-43	10/96
	TX-103	GJ-HAN-44	11/96
	TX-104	GJ-HAN-45	10/96
	TX-105	GJ-HAN-46	10/96
	TX-106	GJ-HAN-47	3/97
	TX-107	GJ-HAN-48	12/96
	TX-108	GJ-HAN-53	1/97
	TX-109	GJ-HAN-54	1/97
	TX-110	GJ-HAN-55	2/97
	TX-111	GJ-HAN-56	1/97
	TX-112	GJ-HAN-57	1/97
	TX-113	GJ-HAN-58	1/97
	TX-114	GJ-HAN-59	3/97
	TX-115	GJ-HAN-60	1/97
	TX-116	GJ-HAN-61	3/97

Tank Farm	Tank	Report Number	Date
	TX-117	GJ-HAN-62	4/97
	TX-118	GJ-HAN-63	4/97
241-TY	TY-101	GJ-HAN-64	4/97
	TY-102	GJ-HAN-65	3/97
	TY-103	GJ-HAN-66	5/97
	TY-104	GJ-HAN-67	5/97
	TY-105	GJ-HAN-68	4/97
	TY-106	GJ-HAN-69	5/97
	U-111	GJ-HAN-40	8/96
	U-112	GJ-HAN-41	9/96

Other Publication

Field, J.G. 2010. *Hanford Geophysical Logging Project Spectral Gamma Re-Baseline Logging for the T-Farm Interim Surface Barrier*, RPP-RPT-44202, Washington River Protection Solutions, Richland, Washington.

Direct Push Characterization

Randall, R. and R. Price 2007. *Small Diameter Geophysical Logging in the 241-T Tank Farm*, RPP-34645, Rev. 0, CH2M HILL Hanford Group Inc., Richland, Washington.

Steffler, R. 2009. *Completion Report for TY Single-Shell Tanks Direct Push Barrier Investigation*, RPP-RPT-41100, Rev. 0, Energy Solutions, Richland, Washington.

Steffler, R.Z. 2008. *Completion Report for T Tank Farm Hydraulic Rotary Hammer Direct Push Drilling and Instrumentation Installation*, RPP-36947, Revision 0, CH2M HILL Hanford Group Inc., Richland, Washington.

Sydnor, H. 2007. *Small Diameter Geophysical Logging North of the 241-T Tank Farm*, RPP-34897, Rev. 0, CH2M HILL Hanford Group Inc., Richland, Washington.

Sydnor, H. 2007. *Small Diameter Geophysical Logging North of the 241-T Tank Farm – Moisture Array (FY 2007)*, RPP-34898, Rev. 0, CH2M HILL Hanford Group Inc., Richland, Washington.

Sydnor, H. 2007. *Small Diameter Geophysical Logging in the 241-TY Tank Farm*, RPP-RPT-34870, Rev. 0, CH2M HILL Hanford Group Inc., Richland, Washington.

SST Gross Gamma Log Summaries

200W	
Tank farm	**Report No**
T	RPP-6088
TX	RPP-6353
TY	HNF-3831

Summary of Tank Farms RCRA Facility Investigation and Supporting Data

Mann, F.M. (editor). 2008. *Phase 1 RCRA Facility Investigation Report for the Hanford Single-Shell Tank Waste Management Areas*. (DVD-ROM) DOE/ORP-2008-001. U.S. Department of Energy. Office of River Protection. Richland, Washington.

Myers, D.A. 2005. *Field Investigation Report for Waste Management Areas T and TX-TY*. RPP-23752, Rev. 0. CH2M HILL Hanford Group, Inc. Richland, Washington.

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A4893	299-W10-16			F	220	GG		10/11/89		149162919	Log Data Report - Gamma 299-W10-16 (A4893)
A4893	299-W10-16			F	220	GG		09/22/89		149162918	Log Data Report - Gamma 299-W10-16 (A4893)
A4895	299-W10-18			H	222.6	GG		12/12/90		149162923	Log Data Report - Gamma 299-W10-18 (A4895)
A4895	299-W10-18			H	222.6	GG		11/30/90		149162922	Log Data Report - Gamma 299-W10-18 (A4895)
A4896	299-W10-2			F	230	GG		07/21/87		149162925	Log Data Report - Gamma 299-W10-2 (A4896)
A4896	299-W10-2			F	230	N		02/25/77		149162926	Log Data Report - Neutron 299-W10-2 (A4896)
A4896	299-W10-2			F	230	OTH	density	11/29/76		153781136	Log Data Report - Density 299-W10-2 (A4896)
A4896	299-W10-2			F	230	OTH	density	06/21/76		153781135	Log Data Report - Density 299-W10-2 (A4896)
A4896	299-W10-2			F	230	GG		05/07/76		149162924	Log Data Report - Gamma 299-W10-2 (A4896)
A4897	299-W10-3			F	239	HG	SGLS	02/02/00		SUBMITTED	
A4897	299-W10-3		221-T-15, 241-T-15	F	239	HG	SGLS	04/01/99	YES	SUBMITTED	
A4897	299-W10-3			F	239	GG		07/03/86		149162930	Log Data Report - Gamma 299-W10-3 (A4897)
A4897	299-W10-3			F	239	N		03/01/77		153439231	Log Data Report - Neutron 299-W10-3 (A4897)
A4897	299-W10-3			F	239	OTH	density	06/22/76		153781409	Log Data Report - Density 299-W10-3 (A4897)
A4897	299-W10-3			F	239	GG		02/23/76		149162929	Log Data Report - Gamma 299-W10-3 (A4897)
A4897	299-W10-3			F	239	GG		04/09/70		149162928	Log Data Report - Gamma 299-W10-3 (A4897)
A4897	299-W10-3			F	239	N		06/09/65		153439230	Log Data Report - Neutron 299-W10-3 (A4897)
A4897	299-W10-3			F	239	GG		05/01/63		149162927	Log Data Report - Gamma 299-W10-3 (A4897)
A4897	299-W10-3			F	239	GG		06/09/59		SUBMITTED	
A4905	299-W11-23	50-00-02		G	242	SG	SGLS	09/23/98	YES	SUBMITTED	
A4907	299-W11-27			G	235	GG		11/13/91		149172151	Log Data Report - Gamma 299-W11-27 (A4907)
A4907	299-W11-27			G	235	GG		10/21/91		149172150	Log Data Report - Gamma 299-W11-27 (A4907)
A4907	299-W11-27			G	235	GG		06/12/91		149172148	Log Data Report - Gamma 299-W11-27 (A4907)
A4908	299-W11-28			G	248	OTH	caliper	12/07/91		153325418	Log Data Report - Caliper 299-W11-28 (A4908)
A4908	299-W11-28			G	248	GG		11/07/91		149174161(48439008)	Log Data Report - Gamma 299-W11-28 (A4908)
A4908	299-W11-28			G	248	GG		10/11/91		149172152	Log Data Report - Gamma 299-W11-28 (A4908)
A4910	299-W11-7		361-T-19	E	315	HG	RLS	10/24/95		SUBMITTED	
A4910	299-W11-7			E	315	HG	RLS	05/15/92		SUBMITTED	
A4910	299-W11-7			E	315	GG		08/12/87		149171662	Log Data Report - Gamma 299-W11-7 (A4910)
A4910	299-W11-7			E	315	GG		07/02/86		149172055	Log Data Report - Gamma 299-W11-7 (A4910)
A4910	299-W11-7			E	315	N		12/17/76		153495750	Log Data Report - Neutron 299-W11-7 (A4910)
A4910	299-W11-7			E	315	OTH	density	11/29/76		153781329	Log Data Report - Density 299-W11-7 (A4910)
A4910	299-W11-7			E	315	GG		02/23/76		149172054	Log Data Report - Gamma 299-W11-7 (A4910)

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A4910	299-W11-7			E	315	OTH	temp	02/20/74		153929095	Log Data Report - Temperature 299-W11-7 (A4910)
A4910	299-W11-7			E	315	GG		02/24/70		149172053	Log Data Report - Gamma 299-W11-7 (A4910)
A4910	299-W11-7			E	315	GG		04/12/68		149172052	Log Data Report - Gamma 299-W11-7 (A4910)
A4910	299-W11-7			E	315	N		06/09/65		153495749	Log Data Report - Neutron 299-W11-7 (A4910)
A4910	299-W11-7			E	315	GG		04/25/63		149172051	Log Data Report - Gamma 299-W11-7 (A4910)
A4910	299-W11-7			E	315	GG		06/08/58		SUBMITTED	
A4910	299-W11-7			E	315	GG		10/10/51		149172050	Log Data Report - Gamma 299-W11-7 (A4910)
A4910	299-W11-7			E	315	GG		10/10/51		149172049	Log Data Report - Gamma 299-W11-7 (A4910)
A4910	299-W11-7			E	315	GG		10/10/51		149172048	Log Data Report - Gamma 299-W11-7 (A4910)
A4913	299-W14-1		241-T-19	H	240	HG	SGLS	08/17/04	YES	154302357(50203252)	Log Data Report 299-W14-1 (A4913)
A4913	299-W14-1			H	240	HG	RLS	01/13/93		50203252	Log Data Report
A4913	299-W14-1			H	240	GG		07/21/87		149171665	Log Data Report - Gamma 299-W14-1 (A4913)
A4913	299-W14-1			H	240	GG		09/23/86		149182049	Log Data Report - Gamma 299-W14-1 (A4913)
A4913	299-W14-1			H	240	N		02/25/77		153495754	Log Data Report - Neutron 299-W14-1 (A4913)
A4913	299-W14-1			H	240	OTH	density	11/29/76		153781330	Log Data Report - Density 299-W14-1 (A4913)
A4913	299-W14-1			H	240	GG		05/07/76		149171664	Log Data Report - Gamma 299-W14-1 (A4913)
A4913	299-W14-1			H	240	GG		02/23/68		SUBMITTED	
A4913	299-W14-1			H	240	N		06/09/65		153495753	Log Data Report - Neutron 299-W14-1 (A4913)
A4913	299-W14-1			H	240	GG		04/29/63		SUBMITTED	
A4914	299-W14-12			H	222.5	GG		10/16/91		149171667	Log Data Report - Gamma 299-W14-12 (A4914)
A4914	299-W14-12			H	222.5	GG		10/03/91		149171666(48440031)	Log Data Report - Gamma 299-W14-12 (A4914)
A4918	299-W15-13			H	225	N/A	N/A	N/A		N/A	
A4925	299-W15-22			J	221.9	GG		12/17/90		149172075	Log Data Report - Gamma 299-W15-22 (A4925)
A4925	299-W15-22			J	221.9	GG		12/05/90		149172074	Log Data Report - Gamma 299-W15-22 (A4925)
A4929	299-W15-4		241-TX-12	I	217	HG	RLS	11/15/95		SUBMITTED	
A4929	299-W15-4			I	217	HG	RLS	04/02/92		SUBMITTED	
A4929	299-W15-4			I	217	GG		02/25/77		153495764	Log Data Report - Gamma 299-W15-4 (A4929)
A4929	299-W15-4			I	217	OTH	density	11/29/76		153781075	Log Data Report - Density 299-W15-4 (A4929)
A4929	299-W15-4			I	217	GG		02/23/76		149174177	Log Data Report - Gamma 299-W15-4 (A4929)
A4929	299-W15-4			I	217	N		06/24/68		153495763	Log Data Report - Neutron 299-W15-4 (A4929)
A4929	299-W15-4			I	217	GG		02/23/68		SUBMITTED	
A4929	299-W15-4			I	217	GG		05/02/63		SUBMITTED	
A4929	299-W15-4			I	217	GG		07/15/59		SUBMITTED	
A4929	299-W15-4			I	217	GG		04/15/58		SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A5475	299-W14-5			I	240	N/A	N/A	N/A		N/A	
A7136	299-W10-1		224-T-4	F	305	GG		08/13/87		149436728	Log Data Report - Gamma 299-W10-1 (A7136)
A7136	299-W10-1			F	305	N		03/01/77		SUBMITTED	
A7136	299-W10-1			F	305	OTH	density	06/22/76		153787105	Log Data Report - Density 299-W10-1 (A7136)
A7136	299-W10-1			F	305	GG		02/23/76		149436556	Log Data Report - Gamma 299-W10-1 (A7136)
A7136	299-W10-1			F	305	GG		04/09/70		149437120	Log Data Report - Gamma 299-W10-1 (A7136)
A7136	299-W10-1			F	305	GG		04/12/68		149436456	Log Data Report - Gamma 299-W10-1 (A7136)
A7136	299-W10-1			F	305	OTH	temp	04/10/68		154116224	Log Data Report - Temperature 299-W10-1 (A7136)
A7136	299-W10-1			F	305	N		06/09/65		153563587	Log Data Report - Neutron 299-W10-1 (A7136)
A7136	299-W10-1			F	305	GG		05/01/63		149436727	Log Data Report - Gamma 299-W10-1 (A7136)
A7136	299-W10-1			F	305	GG		06/09/59		SUBMITTED	
A7139	299-W10-7			H	220	N/A	N/A	N/A		N/A	
A7142	299-W10-52	50-00-08	241-T-134	F	148	HG	SGLS	03/23/98	YES	SUBMITTED	
A7142	299-W10-52	50-00-08		F	148	GG		04/30/63		149437122	Log Data Report - Gamma 299-W10-52 (A7142)
A7146	299-W10-56		224-T-1	F	150	HG	SGLS	11/04/08	YES	SUBMITTED	
A7146	299-W10-56			F	150	NM	NMLS	11/04/08	YES	SUBMITTED	
A7146	299-W10-56			F	150	PN	PNLS	11/04/08	YES	SUBMITTED	
A7146	299-W10-56			F	150	OTH	density	06/25/76		153787008	Log Data Report - Density 299-W10-56 (A7146)
A7146	299-W10-56			F	150	GG		05/07/76		149437123	Log Data Report - Gamma 299-W10-56 (A7146)
A7146	299-W10-56			F	150	GG		05/01/63		149436459	Log Data Report - Gamma 299-W10-56 (A7146)
A7147	299-W10-57		224-T-2	F	150	HG	SGLS	11/07/08	YES	149436559	Log Data Report - Gamma 299-W10-57 (A7147)
A7147	299-W10-57			F	150	NM	NMLS	11/07/08	YES	149436559	Log Data Report - Gamma 299-W10-57 (A7147)
A7147	299-W10-57			F	150	PN	PNLS	11/07/08	YES	149436559	Log Data Report - Gamma 299-W10-57 (A7147)
A7147	299-W10-57			F	150	N		03/01/77		153563488	Log Data Report - Neutron 299-W10-57 (A7147)
A7147	299-W10-57			F	150	OTH	density	06/25/76		153787009	Log Data Report - Density 299-W10-57 (A7147)
A7147	299-W10-57			F	150	GG		05/07/76		149436731	Log Data Report - Gamma 299-W10-57 (A7147)
A7147	299-W10-57			F	150	GG		05/01/63		SUBMITTED	
A7148	299-W10-58		224-T-3	F	150	NM	NMLS	01/19/09	YES	149436460	Log Data Report - Gamma 299-W10-58 (A7148)
A7148	299-W10-58			F	150	PN	PNLS	01/19/09	YES	149436460	Log Data Report - Gamma 299-W10-58 (A7148)
A7148	299-W10-58			F	150	HG	SGLS	11/12/08	YES	SUBMITTED	
A7148	299-W10-58			F	150	HG	SGLS	11/12/08	YES	149436460	Log Data Report - Gamma 299-W10-58 (A7148)
A7148	299-W10-58			F	150	NM	NMLS	11/12/08	YES	149436460	Log Data Report - Gamma 299-W10-58 (A7148)
A7148	299-W10-58			F	150	PN	PNLS	11/12/08	YES	149436460	Log Data Report - Gamma 299-W10-58 (A7148)
A7148	299-W10-58			F	150	N		03/01/77		153563590	Neutron

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7148	299-W10-58			F	150	OTH	density	11/24/76		153786726	Log Data Report - Density 299-W10-58 (A7148)
A7148	299-W10-58			F	150	GG		05/07/76		149437124	Log Data Report - Gamma 299-W10-58 (A7148)
A7148	299-W10-58			F	150	GG		05/01/63		SUBMITTED	
A7149	299-W10-59		221-T-2, 241-T-2	F	150	HG	HRLS	11/20/08	YES	SUBMITTED	
A7149	299-W10-59			F	150	HG	SGLS	11/20/08	YES	SUBMITTED	
A7149	299-W10-59			F	150	NM	NMLS	11/20/08	YES	SUBMITTED	
A7149	299-W10-59			F	150	PN	PNLS	11/20/08	YES	SUBMITTED	
A7149	299-W10-59			F	150	N		03/01/77		153563489	Log Data Report - Neutron 299-W10-59 (A7149)
A7149	299-W10-59			F	150	GG		12/06/76		149436732	Log Data Report - Gamma 299-W10-59 (A7149)
A7149	299-W10-59			F	150	GG		05/01/63		149436560	Log Data Report - Gamma 299-W10-59 (A7149)
A7150	299-W10-60		221-T-3, 241-T-3	F	150	GG		12/06/76		149436562	Log Data Report - Gamma 299-W10-60 (A7150)
A7150	299-W10-60			F	150	GG		05/01/63		149436561	Log Data Report - Gamma 299-W10-60 (A7150)
A7151	299-W10-61		221-T-5, 241-T-5	F	150	GG		12/06/76		149442266	Log Data Report - Gamma 299-W10-61 (A7151)
A7151	299-W10-61			F	150	GG		05/01/63		149442265	Log Data Report - Gamma 299-W10-61 (A7151)
A7152	299-W10-62			F	150	HG	HRLS	11/21/08	YES	SUBMITTED	
A7152	299-W10-62			F	150	HG	SGLS	11/21/08	YES	SUBMITTED	
A7152	299-W10-62			F	150	NM	NMLS	11/21/08	YES	SUBMITTED	
A7152	299-W10-62			F	150	PN	PNLS	11/21/08	YES	SUBMITTED	
A7152	299-W10-62			F	150	N		03/01/77		153563018	Log Data Report - Neutron 299-W10-62 (A7152)
A7152	299-W10-62			F	150	GG		12/06/76		149442268	Log Data Report - Gamma 299-W10-62 (A7152)
A7152	299-W10-62		221-T-6, 241-T-6	F	150	OTH	density	11/24/76		153786727	Log Data Report - Density 299-W10-62 (A7152)
A7152	299-W10-62			F	150	GG		05/01/63		149442267	Log Data Report - Gamma 299-W10-62 (A7152)
A7153	299-W10-63		221-T-8, 241-T-8	F	150	N		03/01/77		153563392	Log Data Report - Neutron 299-W10-63 (A7153)
A7153	299-W10-63			F	150	GG		12/06/76		149442272	Log Data Report - Gamma 299-W10-63 (A7153)
A7153	299-W10-63			F	150	GG		04/30/63		149442271	Log Data Report - Gamma 299-W10-63 (A7153)
A7153	299-W10-63			F	150	GG		09/05/51		149442270	Log Data Report - Gamma 299-W10-63 (A7153)
A7153	299-W10-63			F	150	GG		09/05/51		149442269	Log Data Report - Gamma 299-W10-63 (A7153)
A7154	299-W10-64		224-T-5	F	75	HG	SGLS	11/13/08	YES	SUBMITTED	
A7154	299-W10-64			F	75	NM	NMLS	11/13/08	YES	SUBMITTED	
A7154	299-W10-64			F	75	PN	PNLS	11/13/08	YES	SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7154	299-W10-64			F	75	N		03/01/77		153563591	Log Data Report - Neutron 299-W10-64 (A7154)
A7154	299-W10-64			F	75	GG		05/07/76		149442274	Log Data Report - Gamma 299-W10-64 (A7154)
A7154	299-W10-64			F	75	GG		05/01/63		149442273	Log Data Report - Gamma 299-W10-64 (A7154)
A7155	299-W10-65		224-T-6	F	75	HG	SGLS	11/17/08	YES	SUBMITTED	
A7155	299-W10-65			F	75	NM	NMLS	11/17/08	YES	SUBMITTED	
A7155	299-W10-65			F	75	PN	PNLS	11/17/08	YES	SUBMITTED	
A7155	299-W10-65			F	75	N		03/01/77		153563490	Log Data Report - Neutron 299-W10-65 (A7155)
A7155	299-W10-65			F	75	N		03/01/77		153563019	Log Data Report - Neutron 299-W10-65 (A7155)
A7155	299-W10-65			F	75	GG		05/07/76		149442276	Log Data Report - Gamma 299-W10-65 (A7155)
A7155	299-W10-65			F	75	GG		05/01/63		149442275	Log Data Report - Gamma 299-W10-65 (A7155)
A7156	299-W10-66		2241-T-4, 241-T-4	F	125	N		03/01/77		153563393	Log Data Report - Neutron 299-W10-66 (A7156)
A7156	299-W10-66			F	125	GG		12/06/76		149442279	Log Data Report - Gamma 299-W10-66 (A7156)
A7156	299-W10-66			F	125	GG		04/30/63		149442278	Log Data Report - Gamma 299-W10-66 (A7156)
A7156	299-W10-66			F	125	GG		09/05/51		149442277	Log Data Report - Gamma 299-W10-66 (A7156)
A7157	299-W10-67		221-T-7, 241-T-7	F	150	HG	HRLS	11/25/08	YES	SUBMITTED	
A7157	299-W10-67			F	150	HG	SGLS	11/25/08	YES	SUBMITTED	
A7157	299-W10-67			F	150	NM	NMLS	11/25/08	YES	SUBMITTED	
A7157	299-W10-67			F	150	PN	PNLS	11/25/08	YES	SUBMITTED	
A7157	299-W10-67			F	150	GG		12/06/76		149442281	Log Data Report - Gamma 299-W10-67 (A7157)
A7157	299-W10-67			F	150	OTH	density	11/29/76		153786728	Log Data Report - Density 299-W10-67 (A7157)
A7157	299-W10-67			F	150	GG		05/01/63		149442280	Log Data Report - Gamma 299-W10-67 (A7157)
A7158	299-W10-68		221-T-9, 241-T-9	F	150	HG	HRLS	02/02/08	YES	SUBMITTED	
A7158	299-W10-68			F	150	HG	SGLS	02/02/08	YES	SUBMITTED	
A7158	299-W10-68			F	150	NM	NMLS	02/02/08	YES	SUBMITTED	
A7158	299-W10-68			F	150	PN	PNLS	02/02/08	YES	SUBMITTED	
A7158	299-W10-68			F	150	GG		12/06/76		149442283	Log Data Report - Gamma 299-W10-68 (A7158)
A7158	299-W10-68			F	150	GG		05/01/63		149442282	Log Data Report - Gamma 299-W10-68 (A7158)
A7159	299-W10-69		221-T-10, 241-T-10	F	150	HG	SGLS	06/01/06	YES	50203634(154368631)	Log Data Report 299-W10-69 (A7159)
A7159	299-W10-69			F	150	PN	PNLS	06/01/06	YES	50203634	Geophysical Log Data Report
A7159	299-W10-69			F	150	GG		08/13/87		149442288	Log Data Report - Gamma 299-W10-69 (A7159)
A7159	299-W10-69			F	150	N		03/01/77		153563592	Log Data Report - Neutron 299-W10-69 (A7159)

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS ID	WIDL Data Available
A7159	299-W10-69			F	150	OTH	density	06/25/76		153786729	Log Data Report - Density 299-W10-69 (A7159)
A7159	299-W10-69			F	150	GG		05/07/76		149442287	Log Data Report - Gamma 299-W10-69 (A7159)
A7159	299-W10-69			F	150	GG		05/01/63		149442286	Log Data Report - Gamma 299-W10-69 (A7159)
A7159	299-W10-69			F	150	GG		09/05/51		149442285	Log Data Report - Gamma 299-W10-69 (A7159)
A7159	299-W10-69			F	150	GG		09/05/51		149442284	Log Data Report - Gamma 299-W10-69 (A7159)
A7160	299-W10-70		221-T-11, 241-T-11	F	150	HG	SGLS	05/30/06	YES	154368632	Log Data Report 299-W10-70 (A7160)
A7160	299-W10-70			F	150	GG		08/13/87		SUBMITTED	
A7160	299-W10-70			F	150	N		03/01/77		153563491	Log Data Report - Neutron 299-W10-70 (A7160)
A7160	299-W10-70			F	150	OTH	density	06/25/76		153786730	Log Data Report - Density 299-W10-70 (A7160)
A7160	299-W10-70			F	150	GG		05/07/76		149442290	Log Data Report - Gamma 299-W10-70 (A7160)
A7160	299-W10-70			F	150	GG		05/02/63		149442289	Log Data Report - Gamma 299-W10-70 (A7160)
A7161	299-W10-71		221-T-12, 241-T-12	F	150	GG		08/13/87		149630316	Log Data Report - GAMMA 299-W10-71 (A7161)
A7161	299-W10-71			F	150	N		03/01/77		153563020	Log Data Report - Neutron 299-W10-71 (A7161)
A7161	299-W10-71			F	150	OTH	density	06/25/76		153786731	Log Data Report - Density 299-W10-71 (A7161)
A7161	299-W10-71			F	150	GG		05/07/76		149630315	Log Data Report - GAMMA 299-W10-71 (A7161)
A7161	299-W10-71			F	150	GG		05/02/63		149630314	Log Data Report - GAMMA 299-W10-71 (A7161)
A7162	299-W10-72			F	150	PN	PNLS	05/10/05	YES	154306059(50203309)	Log Data Report 299-W10-72 (A7162)
A7162	299-W10-72		221-T-13, 241-T-13	F	150	HG	HRLS	05/10/05	YES	154306059	Log Data Report 299-W10-72 (A7162)
A7162	299-W10-72			F	150	HG	SGLS	05/10/05	YES	154306059	Log Data Report 299-W10-72 (A7162)
A7162	299-W10-72			F	150	NM	NMLS	05/10/05	YES	154306059	Log Data Report 299-W10-72 (A7162)
A7162	299-W10-72			F	150	SG	NaI	09/23/93		SUBMITTED	
A7162	299-W10-72			F	150	GG		08/14/87		149630321	Log Data Report - GAMMA 299-W10-72 (A7162)
A7162	299-W10-72			F	150	N		03/01/77		153563593	Log Data Report - Neutron 299-W10-72 (A7162)
A7162	299-W10-72			F	150	GG		05/07/76		149630320	Log Data Report - GAMMA 299-W10-72 (A7162)
A7162	299-W10-72			F	150	GG		05/02/63		149630319	Log Data Report - GAMMA 299-W10-72 (A7162)
A7162	299-W10-72			F	150	GG		08/23/51		149630318	Log Data Report - GAMMA 299-W10-72 (A7162)
A7162	299-W10-72			F	150	GG		08/23/51		149630317	Log Data Report - GAMMA 299-W10-72 (A7162)
A7163	299-W10-73		221-T-14, 241-T-14	F	75	HG	SGLS	06/05/06	YES	154368633	Log Data Report 299-W10-73 (A7163)
A7163	299-W10-73			F	75	SG	NaI	09/23/93		SUBMITTED	
A7163	299-W10-73			F	75	GG		05/07/76		149630324	Log Data Report - GAMMA 299-W10-73 (A7163)
A7163	299-W10-73			F	75	GG		05/02/63		149630323	Log Data Report - GAMMA 299-W10-73 (A7163)

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7163	299-W10-73			F	75	GG		09/05/51		149630322	Log Data Report - GAMMA 299-W10-73 (A7163)
A7165	299-W10-75		224-T-7	F	75	HG	SGLS	11/05/08	YES	SUBMITTED	
A7165	299-W10-75			F	75	NM	NMLS	11/05/08	YES	SUBMITTED	
A7165	299-W10-75			F	75	PN	PNLS	11/05/08	YES	SUBMITTED	
A7165	299-W10-75			F	75	OTH	density	06/22/76		153786906	Log Data Report - Density 299-W10-75 (A7165)
A7165	299-W10-75			F	75	GG		05/07/76		149630328	Log Data Report - GAMMA 299-W10-75 (A7165)
A7165	299-W10-75			F	75	GG		05/01/63		149630327	Log Data Report - GAMMA 299-W10-75 (A7165)
A7166	299-W10-76		224-T-8	F	75			12/04/06		154368634	Log Data Report 299-W10-76 (A7166)
A7166	299-W10-76			F	75	HG	SGLS	06/06/06	YES	50203983	Geophysical Log Data Report
A7166	299-W10-76			F	75	GG		05/02/63		149630329	Log Data Report - GAMMA 299-W10-76 (A7166)
A7170	299-W10-80		224-T-9	F	115	GG		05/07/76		149630341	Log Data Report - GAMMA 299-W10-80 (A7170)
A7170	299-W10-80			F	115	GG		05/01/63		149630340	Log Data Report - GAMMA 299-W10-80 (A7170)
A7170	299-W10-80			F	115	GG		10/10/51		149630339	Log Data Report - GAMMA 299-W10-80 (A7170)
A7170	299-W10-80			F	115	GG		10/10/51		149630338	Log Data Report - GAMMA 299-W10-80 (A7170)
A7170	299-W10-80			F	115	GG		10/01/51		149630337	Log Data Report - GAMMA 299-W10-80 (A7170)
A7251	299-W10-168	50-00-09		F	122	HG	SGLS	08/07/08	YES	SUBMITTED	
A7251	299-W10-168	50-00-09		F	122	HG	SGLS	02/10/98	YES	SUBMITTED	
A7252	299-W10-169			G	122	HG	SGLS	02/21/08	YES	138395944(154368639)	Log Data Report 299-W10-169 (A7252)
A7252	299-W10-169			G	122	NM	NMLS	02/21/08	YES	138395944(154368639)	Log Data Report
A7275	299-W11-1		361-T-12	E	314.5	HG	SGLS	01/22/03	YES	154306060	Log Data Report 299-W11-1 (A7275)
A7275	299-W11-1			E	314.5	HG	RLS	05/08/95		Submitted to WIDL	
A7275	299-W11-1			E	314.5	GG	NaI	10/13/94		Submitted to WIDL	
A7275	299-W11-1			E	314.5	GG		07/21/87		149572870	Log Data Report - Gamma 299-W11-1 (A7275)
A7275	299-W11-1			E	314.5	N		12/17/76		153563021	Log Data Report - Neutron 299-W11-1 (A7275)
A7275	299-W11-1			E	314.5	OTH	density	11/29/76		153786818	Log Data Report - Density 299-W11-1 (A7275)
A7275	299-W11-1			E	314.5	GG		05/06/76		149572869	Log Data Report - Gamma 299-W11-1 (A7275)
A7275	299-W11-1			E	314.5	GG		02/27/68		149572868	Log Data Report - Gamma 299-W11-1 (A7275)
A7275	299-W11-1			E	314.5	N		06/09/65		153563492	Log Data Report - Neutron 299-W11-1 (A7275)
A7275	299-W11-1			E	314.5	GG		04/26/63		149572867	Log Data Report - Gamma 299-W11-1 (A7275)
A7275	299-W11-1			E	314.5	GG		06/08/59		Submitted to WIDL	
A7275	299-W11-1			E	314.5	GG		02/20/58		SUBMITTED	
A7275	299-W11-1			E	314.5	GG		08/07/51		149572866	Log Data Report - Gamma 299-W11-1 (A7275)
A7280	299-W11-11		241-T-17	H	248	HG	RLS	03/31/92		SUBMITTED	
A7280	299-W11-11			H	248	N		02/25/77		153563694	Log Data Report - Neutron 299-W11-11 (A7280)

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7280	299-W11-11			H	248	OTH	density	11/29/76		153786907	Log Data Report - Density 299-W11-11 (A7280)
A7280	299-W11-11			H	248	GG		02/23/76		149631732	Log Data Report - GAMMA 299-W11-11 (A7280)
A7280	299-W11-11			H	248	GG		04/12/68		149631731	Log Data Report - GAMMA 299-W11-11 (A7280)
A7280	299-W11-11			H	248	N		06/09/65		153563397	Log Data Report - Neutron 299-W11-11 (A7280)
A7280	299-W11-11			H	248	GG		04/29/63		149631730	Log Data Report - GAMMA 299-W11-11 (A7280)
A7280	299-W11-11			H	248	GG		03/22/54		SUBMITTED	
A7296	299-W11-54		361-T-2	E	150	HG	SGLS	02/12/03	YES	154306061	Log Data Report 299-W11-54 (A7296)
A7296	299-W11-54			E	150	HG	HRLS	02/12/03	YES	154306061	Log Data Report 299-W11-54 (A7296)
A7296	299-W11-54			E	150	HG	RLS	05/17/95		SUBMITTED	
A7296	299-W11-54			E	150	SG	NaI	10/25/94		SUBMITTED	
A7296	299-W11-54			E	150	HG	RLS	10/19/93		SUBMITTED	
A7296	299-W11-54			E	150	N		03/01/77		153563597	Log Data Report - Neutron 299-W11-54 (A7296)
A7296	299-W11-54			E	150	GG		05/06/76		149631979	Log Data Report - GAMMA 299-W11-54 (A7296)
A7296	299-W11-54			E	150	GG		04/26/63		SUBMITTED	
A7296	299-W11-54			E	150	GG		02/26/58		SUBMITTED	
A7297	299-W11-55		361-T-1	E	150	HG	SGLS	02/10/03	YES	154306062	Log Data Report 299-W11-55 (A7297)
A7297	299-W11-55			E	150	HG	RLS	05/15/95		SUBMITTED	
A7297	299-W11-55			E	150	SG	NaI	10/27/94		SUBMITTED	
A7297	299-W11-55			E	150	HG	RLS	10/08/93		SUBMITTED	
A7297	299-W11-55			E	150	N		03/01/77		153563400	Log Data Report - Neutron 299-W11-55 (A7297)
A7297	299-W11-55			E	150	OTH	density	11/29/76		153787111	Log Data Report - Density 299-W11-55 (A7297)
A7297	299-W11-55			E	150	GG		05/06/76		149631982	Log Data Report - GAMMA 299-W11-55 (A7297)
A7297	299-W11-55			E	150	GG		04/26/63		SUBMITTED	
A7297	299-W11-55			E	150	GG		02/26/58		SUBMITTED	
A7297	299-W11-55			E	150	GG		08/09/51		149631981	Log Data Report - GAMMA 299-W11-55 (A7297)
A7297	299-W11-55			E	150	GG		08/08/51		149631980	Log Data Report - GAMMA 299-W11-55 (A7297)
A7298	299-W11-56		361-T-3	E	150	HG	SGLS	10/21/03	YES	154306063	Log Data Report 299-W11-56 (A7298)
A7298	299-W11-56			E	150	HG	RLS	04/17/95		SUBMITTED	
A7298	299-W11-56			E	150	SG	NaI	10/20/94		SUBMITTED	
A7298	299-W11-56			E	150	N		03/01/77		153563697	Log Data Report - Neutron 299-W11-56 (A7298)
A7298	299-W11-56			E	150	OTH	density	11/29/76		153787112	Log Data Report - Density 299-W11-56 (A7298)
A7298	299-W11-56			E	150	GG		05/06/76		149631983	Log Data Report - GAMMA 299-W11-56 (A7298)
A7298	299-W11-56			E	150	GG		04/26/63		SUBMITTED	
A7298	299-W11-56			E	150	GG		02/26/58		SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7299	299-W11-57		361-T-4	E	163	HG	SGLS	02/03/03	YES	154306064	Log Data Report 299-W11-57 (A7299)
A7299	299-W11-57			E	163	HG	RLS	05/11/95		SUBMITTED	
A7299	299-W11-57			E	163	HG	RLS	11/09/93		SUBMITTED	
A7299	299-W11-57			E	163	GG		07/22/87		149631987	Log Data Report - GAMMA 299-W11-57 (A7299)
A7299	299-W11-57			E	163	GG		05/06/76		149631986	Log Data Report - GAMMA 299-W11-57 (A7299)
A7299	299-W11-57			E	163	GG		04/26/63		SUBMITTED	
A7299	299-W11-57			E	163	GG		02/26/58		SUBMITTED	
A7299	299-W11-57			E	163	GG		08/08/51		149631985	Log Data Report - GAMMA 299-W11-57 (A7299)
A7299	299-W11-57			E	163	GG		08/08/51		149631984	Log Data Report - GAMMA 299-W11-57 (A7299)
A7300	299-W11-58			E	75	HG	SGLS	10/20/03	YES	154306065	Log Data Report 299-W11-58 (A7300)
A7300	299-W11-58			E	75	N		05/22/95		SUBMITTED	
A7300	299-W11-58			E	75	SG	NaI	04/27/95		SUBMITTED	
A7300	299-W11-58			E	75	HG	RLS	04/18/95		SUBMITTED	
A7300	299-W11-58			E	75	SG	NaI	10/25/94		SUBMITTED	
A7300	299-W11-58			E	75	HG	RLS	10/22/93		SUBMITTED	
A7300	299-W11-58			E	75	N		03/01/77		153563497	Log Data Report - Neutron 299-W11-58 (A7300)
A7300	299-W11-58			E	75	OTH	density	11/29/76		153787011	Log Data Report - Density 299-W11-58 (A7300)
A7300	299-W11-58			E	75	GG		05/06/76		149634551	Log Data Report - GAMMA 299-W11-58 (A7300)
A7300	299-W11-58		361-T-5	E	75	GG		04/26/63		SUBMITTED	
A7300	299-W11-58			E	75	GG		02/26/58		SUBMITTED	
A7301	299-W11-59		361-T-7	E	90	HG	SGLS	01/24/03	YES	154306066	Log Data Report 299-W11-59 (A7301)
A7301	299-W11-59			E	90	HG	RLS	04/17/95		SUBMITTED	
A7301	299-W11-59			E	90	SG	NaI	10/12/94		SUBMITTED	
A7301	299-W11-59			E	90	GG		07/22/87		149634555	Log Data Report - GAMMA 299-W11-59 (A7301)
A7301	299-W11-59			E	90	GG		05/06/76		149634554	Log Data Report - GAMMA 299-W11-59 (A7301)
A7301	299-W11-59			E	90	GG		04/26/63		SUBMITTED	
A7301	299-W11-59			E	90	GG		02/26/58		SUBMITTED	
A7301	299-W11-59			E	90	GG		08/08/51		149634553	Log Data Report - GAMMA 299-W11-59 (A7301)
A7301	299-W11-59			E	90	GG		08/07/51		149634552	Log Data Report - GAMMA 299-W11-59 (A7301)
A7302	299-W11-60		361-T-8	E	150	HG	SGLS	10/22/03	YES	154306067	Log Data Report 299-W11-60 (A7302)
A7302	299-W11-60			E	150	NM	RLS	05/23/95		SUBMITTED	
A7302	299-W11-60			E	150	HG	RLS	03/27/95		SUBMITTED	
A7302	299-W11-60			E	150	SG	NaI	10/27/94		SUBMITTED	
A7302	299-W11-60			E	150	HG	RLS	11/15/93		SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7302	299-W11-60			E	150	N		03/01/77		153563598	Log Data Report - Neutron 299-W11-60 (A7302)
A7302	299-W11-60			E	150	OTH	density	06/21/76		153787012	Log Data Report - Density 299-W11-60 (A7302)
A7302	299-W11-60			E	150	GG		05/06/76		149634558	Log Data Report - GAMMA 299-W11-60 (A7302)
A7302	299-W11-60			E	150	GG		04/26/63		SUBMITTED	
A7302	299-W11-60			E	150	GG		02/26/58		SUBMITTED	
A7302	299-W11-60			E	150	GG		08/07/51		149634557	Log Data Report - GAMMA 299-W11-60 (A7302)
A7302	299-W11-60			E	150	GG		08/07/51		149634556	Log Data Report - GAMMA 299-W11-60 (A7302)
A7303	299-W11-61		361-T-9	E	85	HG	SGLS	02/13/03	YES	154306068	Log Data Report 299-W11-61 (A7303)
A7303	299-W11-61			E	85	N		05/22/95		SUBMITTED	
A7303	299-W11-61			E	85	HG	RLS	03/23/95		SUBMITTED	
A7303	299-W11-61			E	85	SG	NaI	10/25/94		SUBMITTED	
A7303	299-W11-61			E	85	HG	RLS	10/25/93		SUBMITTED	
A7303	299-W11-61			E	85	GG		05/15/92		149634562	Log Data Report - GAMMA 299-W11-61 (A7303)
A7303	299-W11-61			E	85	HG	RLS	04/24/92		SUBMITTED	
A7303	299-W11-61			E	85	GG		05/06/76		149634561	Log Data Report - GAMMA 299-W11-61 (A7303)
A7303	299-W11-61			E	85	GG		04/26/63		SUBMITTED	
A7303	299-W11-61			E	85	GG		02/26/58		SUBMITTED	
A7303	299-W11-61			E	85	GG		08/08/51		149634560	Log Data Report - GAMMA 299-W11-61 (A7303)
A7303	299-W11-61			E	85	GG		08/08/51		149634559	Log Data Report - GAMMA 299-W11-61 (A7303)
A7304	299-W11-62			E	102	HG	SGLS	02/20/03	YES	154306069	Log Data Report 299-W11-62 (A7304)
A7304	299-W11-62			E	102	HG	RLS	05/16/95		SUBMITTED	
A7304	299-W11-62			E	102	SG	NaI	11/22/94		SUBMITTED	
A7304	299-W11-62			E	102	SG	NaI	09/22/94		SUBMITTED	
A7304	299-W11-62		361-T-6	E	86	GG		05/06/76		SUBMITTED	
A7304	299-W11-62			E	102	GG		05/06/76		149634563	Log Data Report - GAMMA 299-W11-62 (A7304)
A7304	299-W11-62			E	150	GG		04/26/63		SUBMITTED	
A7304	299-W11-62			E	150	GG		02/26/58		SUBMITTED	
A7305	299-W11-63		361-T-10	E	160	HG	SGLS	01/28/03	YES	154306070	Log Data Report 299-W11-63 (A7305)
A7305	299-W11-63			E	160	HG	RLS	04/27/95		SUBMITTED	
A7305	299-W11-63			E	160	SG	NaI	10/24/94		SUBMITTED	
A7305	299-W11-63			E	160	GG		07/22/87		149634567	Log Data Report - GAMMA 299-W11-63 (A7305)
A7305	299-W11-63			E	160	N		03/01/77		153563401	Log Data Report - Neutron 299-W11-63 (A7305)
A7305	299-W11-63			E	160	OTH	density	06/21/76		153786733	Log Data Report - Density 299-W11-63 (A7305)
A7305	299-W11-63			E	160	GG		05/06/76		149634566	Log Data Report - GAMMA 299-W11-63 (A7305)

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS ID	WIDL Data Available
A7305	299-W11-63			E	160	GG		04/26/63		SUBMITTED	
A7305	299-W11-63			E	160	GG		02/26/58		SUBMITTED	
A7305	299-W11-63			E	160	GG		08/07/51		149634565	Log Data Report - GAMMA 299-W11-63 (A7305)
A7305	299-W11-63			E	160	GG		08/07/51		149634564	Log Data Report - GAMMA 299-W11-63 (A7305)
A7306	299-W11-64			E	75	HG	SGLS	02/18/03	YES	154306071	Log Data Report 299-W11-64 (A7306)
A7306	299-W11-64			E	75	HG	RLS	04/18/95		SUBMITTED	
A7306	299-W11-64			E	75	SG	NaI	11/07/94		SUBMITTED	
A7306	299-W11-64			E	75	HG	RLS	10/12/93		SUBMITTED	
A7306	299-W11-64			E	75	GG		05/06/76		149634570	Log Data Report - GAMMA 299-W11-64 (A7306)
A7306	299-W11-64		361-T-11	E	75	GG		04/26/63		SUBMITTED	
A7306	299-W11-64			E	75	GG		02/26/58		SUBMITTED	
A7306	299-W11-64			E	75	GG		08/08/51		149634569	Log Data Report - GAMMA 299-W11-64 (A7306)
A7306	299-W11-64			E	75	GG		08/07/51		149634568	Log Data Report - GAMMA 299-W11-64 (A7306)
A7307	299-W11-65			E	160	HG	SGLS	01/21/03	YES	154306072	Log Data Report 299-W11-65 (A7307)
A7307	299-W11-65			E	160	HG	RLS	04/19/95		SUBMITTED	
A7307	299-W11-65			E	160	SG	NaI	10/12/94		SUBMITTED	
A7307	299-W11-65			E	160	GG		07/22/87		149634573	Log Data Report - GAMMA 299-W11-65 (A7307)
A7307	299-W11-65			E	160	GG		05/06/76		149634572	Log Data Report - GAMMA 299-W11-65 (A7307)
A7307	299-W11-65			E	160	GG		04/26/63		SUBMITTED	
A7307	299-W11-65		361-T-13	E	162	GG		02/26/58		SUBMITTED	
A7307	299-W11-65			E	160	GG		08/07/51		149634571	Log Data Report - GAMMA 299-W11-65 (A7307)
A7308	299-W11-66			E	75	HG	SGLS	01/29/03	YES	154306073	Log Data Report 299-W11-66 (A7308)
A7308	299-W11-66			E	75	GG		07/22/87		149634578	Log Data Report - GAMMA 299-W11-66 (A7308)
A7308	299-W11-66			E	75	N		03/01/77		153563698	Log Data Report - Neutron 299-W11-66 (A7308)
A7308	299-W11-66			E	75	GG		05/06/76		149634577	Log Data Report - GAMMA 299-W11-66 (A7308)
A7308	299-W11-66		361-T-20	E	77	GG		04/26/63		SUBMITTED	
A7308	299-W11-66			E	161	GG		02/26/58		SUBMITTED	
A7308	299-W11-66			E	75	GG		10/01/51		149634576	Log Data Report - GAMMA 299-W11-66 (A7308)
A7308	299-W11-66			E	75	GG		08/09/51		149634575	Log Data Report - GAMMA 299-W11-66 (A7308)
A7308	299-W11-66			E	75	GG		08/08/51		149634574	Log Data Report - GAMMA 299-W11-66 (A7308)
A7309	299-W11-67		361-T-21	E	76	HG	SGLS	01/09/03	YES	154306074	Log Data Report 299-W11-67 (A7309)
A7309	299-W11-67			E	76	HG	RLS	02/15/95		SUBMITTED	
A7309	299-W11-67			E	76	SG	NaI	10/18/94		SUBMITTED	
A7309	299-W11-67			E	76	GG		07/21/87		149634584	Log Data Report - GAMMA 299-W11-67 (A7309)

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7309	299-W11-67			E	76	GG		05/06/76		149634583	Log Data Report - GAMMA 299-W11-67 (A7309)
A7309	299-W11-67			E	162	GG		04/26/63		SUBMITTED	
A7309	299-W11-67			E	76	GG		02/26/58		SUBMITTED	
A7309	299-W11-67			E	76	GG		10/10/51		149634582	Log Data Report - GAMMA 299-W11-67 (A7309)
A7309	299-W11-67			E	76	GG		10/10/51		149634581	Log Data Report - GAMMA 299-W11-67 (A7309)
A7309	299-W11-67			E	76	GG		10/10/51		149634580	Log Data Report - GAMMA 299-W11-67 (A7309)
A7309	299-W11-67			E	76	GG		10/10/51		149634579	Log Data Report - GAMMA 299-W11-67 (A7309)
A7310	299-W11-68		241-T-137	G	100	HG	SGLS	08/08/05	YES	50203545(154306075)	Geophysical Log Data Report
A7310	299-W11-68			G	100	GG		07/21/87		149634587	Log Data Report - GAMMA 299-W11-68 (A7310)
A7310	299-W11-68			G	100	GG		06/24/86		149634586	Log Data Report - GAMMA 299-W11-68 (A7310)
A7310	299-W11-68			G	100	N		03/01/77		153563599	Log Data Report - Neutron 299-W11-68 (A7310)
A7310	299-W11-68			G	100	OTH	density	06/21/76		153786734	Log Data Report - Density 299-W11-68 (A7310)
A7310	299-W11-68			G	100	GG		05/07/76		149634585	Log Data Report - GAMMA 299-W11-68 (A7310)
A7310	299-W11-68			G	100	GG		04/29/68		SUBMITTED	
A7311	299-W11-69		241-T-138	G	105	HG	SGLS	06/20/05	YES	154306076(50203541)	Log Data Report 299-W11-69 (A7311)
A7311	299-W11-69			G	105	GG		07/21/87		149634589	Log Data Report - GAMMA 299-W11-69 (A7311)
A7311	299-W11-69			G	105	N		03/01/77		153563402	Log Data Report - Neutron 299-W11-69 (A7311)
A7311	299-W11-69			G	105	OTH	density	06/21/76		153786912	Log Data Report - Density 299-W11-69 (A7311)
A7311	299-W11-69			G	105	GG		05/07/76		149634588	Log Data Report - GAMMA 299-W11-69 (A7311)
A7311	299-W11-69			G	105	GG		04/29/63		SUBMITTED	
A7312	299-W11-70		241-TY-7	H	150	HG	SGLS	06/14/01	YES	154306077	Log Data Report 299-W11-70 (A7312)
A7312	299-W11-70			H	150	HG	RLS	06/28/95		SUBMITTED	
A7312	299-W11-70			H	150	HG	RLS	02/27/92		SUBMITTED	
A7312	299-W11-70			H	150	GG		02/27/92		149634594	Log Data Report - GAMMA 299-W11-70 (A7312)
A7312	299-W11-70			H	150	GG		08/14/87		149634593	Log Data Report - GAMMA 299-W11-70 (A7312)
A7312	299-W11-70			H	150	GG		04/03/84		149634591	Log Data Report - GAMMA 299-W11-70 (A7312)
A7312	299-W11-70			H	150	N		02/25/77		153563024	Log Data Report - Neutron 299-W11-70 (A7312)
A7312	299-W11-70			H	150	OTH	density	11/29/76		153786913	Log Data Report - Density 299-W11-70 (A7312)
A7312	299-W11-70			H	150	GG		05/07/76		149634590	Log Data Report - GAMMA 299-W11-70 (A7312)
A7312	299-W11-70			H	150	GG		09/02/65		SUBMITTED	
A7312	299-W11-70			H	150	GG		04/29/63		149634592	Log Data Report - GAMMA 299-W11-70 (A7312)
A7321	299-W11-79			E	150	HG	SGLS	10/27/03	YES	154306078	Log Data Report 299-W11-79 (A7321)
A7321	299-W11-79			E	150	GG		08/13/87		SUBMITTED	
A7321	299-W11-79			E	150	GG		07/02/86		149643210	Log Data Report - GAMMA 299-W11-79 (A7321)

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7321	299-W11-79			E	150	GG		04/03/84		149643209	Log Data Report - GAMMA 299-W11-79 (A7321)
A7322	299-W11-80			G	50	HG	SGLS	08/09/05	YES	154306079(50203546)	Log Data Report 299-W11-80 (A7322)
A7322	299-W11-80			G	50	GG		06/24/86		149643212	Log Data Report - GAMMA 299-W11-80 (A7322)
A7322	299-W11-80			G	50	GG		03/14/84		149643211	Log Data Report - GAMMA 299-W11-80 (A7322)
A7323	299-W11-81			G	50	HG	SGLS	08/29/05	YES	154306080(50203547)	Log Data Report 299-W11-81 (A7323)
A7323	299-W11-81			G	50	HG	HRLS	08/29/05	YES	154306080	Log Data Report 299-W11-81 (A7323)
A7323	299-W11-81			G	50	GG		05/26/92		149643214	Log Data Report - GAMMA 299-W11-81 (A7323)
A7323	299-W11-81			G	50	HG	RLS	05/22/92		SUBMITTED	
A7323	299-W11-81			G	50	GG		06/24/86		149643213	Log Data Report - GAMMA 299-W11-81 (A7323)
A7323	299-W11-81			G	50	GG		03/14/84		SUBMITTED	
A7328	299-W14-2			H	223	HG	SGLS	08/12/04	YES	154306083(50203250)	Log Data Report 299-W14-2 (A7328)
A7328	299-W14-2		241-TY-5	H	223	HG	HRLS	08/12/04	YES	154306083	Log Data Report 299-W14-2 (A7328)
A7328	299-W14-2			H	223	HG	RLS	05/12/93		SUBMITTED	
A7328	299-W14-2			H	223	N		02/25/77		153563600	Log Data Report - Neutron 299-W14-2 (A7328)
A7328	299-W14-2			H	223	OTH	density	11/29/76		153786914	Log Data Report - Density 299-W14-2 (A7328)
A7328	299-W14-2			H	223	GG		02/23/76		149643218	Log Data Report - GAMMA 299-W14-2 (A7328)
A7328	299-W14-2			H	223	GG		04/09/70		SUBMITTED	
A7328	299-W14-2			H	223	N		06/09/65		153563500	Log Data Report - Neutron 299-W14-2 (A7328)
A7328	299-W14-2			H	223	GG		04/29/63		SUBMITTED	
A7328	299-W14-2			H	223	GG		06/19/59		SUBMITTED	
A7328	299-W14-2			H	223	GG		04/15/58		SUBMITTED	
A7329	299-W14-3			H	270	HG	SGLS	08/10/04	YES	154306084(50203253)	Log Data Report 299-W14-3 (A7329)
A7329	299-W14-3			H	270	HG	HRLS	08/10/04	YES	154306084	Log Data Report 299-W14-3 (A7329)
A7329	299-W14-3			H	270	HG	RLS	01/11/93		SUBMITTED	
A7329	299-W14-3			H	270	GG		08/19/87		149643221	Log Data Report - GAMMA 299-W14-3 (A7329)
A7329	299-W14-3			H	270	GG		09/19/86		149643220	Log Data Report - GAMMA 299-W14-3 (A7329)
A7329	299-W14-3			H	270	N		02/25/77		153563403	Log Data Report - Neutron 299-W14-3 (A7329)
A7329	299-W14-3			H	270	OTH	density	11/29/76		153787114	Log Data Report - Density 299-W14-3 (A7329)
A7329	299-W14-3			H	270	GG		05/07/76		149643219	Log Data Report - GAMMA 299-W14-3 (A7329)
A7329	299-W14-3			H	270	GG		04/29/63		SUBMITTED	
A7330	299-W14-4		299-W14-2 A	H	205	HG	SGLS	09/14/04	YES	50203261	Geophysical Log Data Report
A7330	299-W14-4			H	205	HG	RLS	05/23/95		SUBMITTED	
A7330	299-W14-4			H	205	HG	RLS	03/13/92		SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7330	299-W14-4			H	205	GG		03/13/92		149643225	Log Data Report - GAMMA 299-W14-4 (A7330)
A7330	299-W14-4			H	205	GG		08/14/87		149643224	Log Data Report - GAMMA 299-W14-4 (A7330)
A7330	299-W14-4			H	205	GG		09/19/86		149643223	Log Data Report - GAMMA 299-W14-4 (A7330)
A7330	299-W14-4			H	205	N		02/25/77		153563601	Log Data Report - Neutron 299-W14-4 (A7330)
A7330	299-W14-4			H	205	OTH	density	11/29/76		153787013	Log Data Report - Density 299-W14-4 (A7330)
A7330	299-W14-4			H	205	GG		05/07/76		149643222	Log Data Report - GAMMA 299-W14-4 (A7330)
A7330	299-W14-4			H	206	GG		02/07/67		SUBMITTED	
A7330	299-W14-4			H	205	N		02/07/67		153563699	Log Data Report - Neutron 299-W14-4 (A7330)
A7335	299-W14-51		241-TXSW -2	I	75	HG	SGLS	01/29/08	YES	154368643(106482044)	Log Data Report 299-W14-51 (A7335)
A7335	299-W14-51			I	75	NM	NMLS	01/29/08	YES	154368643	Log Data Report 299-W14-51 (A7335)
A7335	299-W14-51			I	75	GG		07/03/86		149643229	Log Data Report - GAMMA 299-W14-51 (A7335)
A7335	299-W14-51			I	75	GG		04/03/84		149643228	Log Data Report - GAMMA 299-W14-51 (A7335)
A7335	299-W14-51			I	75	GG		05/07/76		149643227	Log Data Report - GAMMA 299-W14-51 (A7335)
A7335	299-W14-51			I	75	GG		06/24/68		SUBMITTED	
A7335	299-W14-51			I	75	GG		08/20/63		SUBMITTED	
A7336	299-W14-52		241-TXSW -4	I	27	HG	SGLS	05/11/06	YES	50203632/154368644	Geophysical Log Data Report
A7336	299-W14-52			I	27	GG		07/03/86		149643231	Log Data Report - GAMMA 299-W14-52 (A7336)
A7336	299-W14-52			I	27	GG		05/07/76		149643230	Log Data Report - GAMMA 299-W14-52 (A7336)
A7336	299-W14-52			I	27	N		06/24/68		153563700	Log Data Report - Neutron 299-W14-52 (A7336)
A7336	299-W14-52			I	27	GG		08/20/63		SUBMITTED	
A7337	299-W14-53		241-TY-6	H	100	HG	HRLS	06/09/06	YES	SUBMITTED	
A7337	299-W14-53			H	100	HG	SGLS	06/09/06	YES	SUBMITTED	
A7337	299-W14-53			H	100	HG	RLS	11/10/92		SUBMITTED	
A7337	299-W14-53			H	100	GG		08/14/87		149643235	Log Data Report - GAMMA 299-W14-53 (A7337)
A7337	299-W14-53			H	100	GG		07/02/86		149643234	Log Data Report - GAMMA 299-W14-53 (A7337)
A7337	299-W14-53			H	100	GG		04/03/84		149643233	Log Data Report - GAMMA 299-W14-53 (A7337)
A7337	299-W14-53			H	100	N		02/25/77		153563602	Log Data Report - Neutron 299-W14-53 (A7337)
A7337	299-W14-53			H	100	OTH	density	11/29/76		153786824	Log Data Report - Density 299-W14-53 (A7337)
A7337	299-W14-53			H	100	GG		05/07/76		149643232	Log Data Report - GAMMA 299-W14-53 (A7337)
A7337	299-W14-53			H	100	GG		04/09/70		SUBMITTED	
A7337	299-W14-53			I	27	GG		08/20/63		SUBMITTED	
A7337	299-W14-53			H	100	GG		04/29/63		SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS ID	WIDL Data Available
A7365	299-W15-64			I	200	HG	SGLS	07/21/04	YES	154306096(50203262)	Log Data Report 299-W15-64 (A7365)
A7365	299-W15-64			I	200	HG	RLS	04/07/95		SUBMITTED	
A7365	299-W15-64			I	200	GG		07/03/86		149647386	Log Data Report - GAMMA 299-W15-64 (A7365)
A7365	299-W15-64			I	200	GG		03/14/84		149647317	Log Data Report - GAMMA 299-W15-64 (A7365)
A7365	299-W15-64			I	200	N		02/25/77		153563503	Log Data Report - Neutron 299-W15-64 (A7365)
A7365	299-W15-64			I	200	OTH	density	06/25/76		153786736	Log Data Report - Density 299-W15-64 (A7365)
A7365	299-W15-64			I	200	GG		05/12/76		149647316	Log Data Report - GAMMA 299-W15-64 (A7365)
A7366	299-W15-65		241-TXSW -1	I	25	HG	SGLS	01/29/08	YES	154378132(104027436, 119580146)	Log Data Report 299-W15-65 (A7366)
A7366	299-W15-65			I	25	HG	SGLS	05/10/06	YES	154378131	Log Data Report 299-W15-65 (A7366)
A7366	299-W15-65			I	25	GG		07/03/86		149647388	Log Data Report - GAMMA 299-W15-65 (A7366)
A7366	299-W15-65			I	25	N		02/25/77		153563604	Log Data Report - Neutron 299-W15-65 (A7366)
A7366	299-W15-65			I	25	OTH	density	06/23/76		153786737	Log Data Report - Density 299-W15-65 (A7366)
A7366	299-W15-65			I	25	GG		05/07/76		149647387	Log Data Report - GAMMA 299-W15-65 (A7366)
A7366	299-W15-65			I	25	GG		06/24/68		153563702	Log Data Report - Gamma 299-W15-65 (A7366)
A7366	299-W15-65			I	25	GG		02/24/68		SUBMITTED	
A7366	299-W15-65			I	25	GG		08/20/63		SUBMITTED	
A7367	299-W15-66		241-TXSW -3	I	80	HG	SGLS	01/24/08	YES	154378134(104028328, 119748221)	Log Data Report 299-W15-66 (A7367)
A7367	299-W15-66			I	80	NM	NMLS	01/24/08	YES	154378134	Log Data Report 299-W15-66 (A7367)
A7367	299-W15-66			I	80	GG		07/03/86		149647391	Log Data Report - GAMMA 299-W15-66 (A7367)
A7367	299-W15-66			I	80	GG		04/03/84		149647390	Log Data Report - GAMMA 299-W15-66 (A7367)
A7367	299-W15-66			I	80	GG		05/07/76		149647389	Log Data Report - GAMMA 299-W15-66 (A7367)
A7367	299-W15-66			I	80	GG		06/24/68		SUBMITTED	
A7367	299-W15-66			I	80	GG		08/20/63		SUBMITTED	
A7375	299-W15-74	51-00-09	241-TX-5	J	150	HG	SGLS	02/15/96	YES	SUBMITTED	
A7381	299-W15-80		241-TX-10	J	120	HG	SGLS	12/18/02	YES	154306099	Log Data Report 299-W15-80 (A7381)
A7381	299-W15-80			J	120	GG		06/24/86		149647402	Log Data Report - GAMMA 299-W15-80 (A7381)
A7381	299-W15-80			J	120	GG		03/14/84		149647401	Log Data Report - GAMMA 299-W15-80 (A7381)
A7381	299-W15-80			J	120	GG		12/02/76		149647400	Log Data Report - GAMMA 299-W15-80 (A7381)
A7381	299-W15-80			J	120	GG		05/02/63		SUBMITTED	
A7382	299-W15-81		241-TX-11	J	115	HG	SGLS	01/02/03	YES	154306100	Log Data Report 299-W15-81 (A7382)
A7382	299-W15-81			J	115	GG		12/02/76		149647403	Log Data Report - GAMMA 299-W15-81 (A7382)
A7382	299-W15-81			J	115	GG		05/02/63		SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
A7507	299-W15-209			J	50	HG	HRLS	12/19/02	YES	154306106(50362742)	Log Data Report 299-W15-209 (A7507)
A7507	299-W15-209			J	50	HG	SGLS	12/19/02	YES	154306106	Log Data Report 299-W15-209 (A7507)
A7507	299-W15-209			J	50	GG		04/24/86		149651892	Log Data Report - GAMMA 299-W15-209 (A7507)
A7507	299-W15-209			J	50	GG		03/14/84		149651891	Log Data Report - GAMMA 299-W15-209 (A7507)
A7508	299-W15-210			J	100	HG	SGLS	12/23/02	YES	154306107(50362741)	Log Data Report 299-W15-210 (A7508)
A7508	299-W15-210			J	100	HG	HRLS	12/23/02	YES	154306107	Log Data Report 299-W15-210 (A7508)
A7508	299-W15-210			J	100	HG	RLS	05/07/92		SUBMITTED	
A7508	299-W15-210			J	100	GG		05/06/92		149651895	Log Data Report - GAMMA 299-W15-210 (A7508)
A7508	299-W15-210			J	100	GG		06/24/86		149651894	Log Data Report - GAMMA 299-W15-210 (A7508)
A7508	299-W15-210			J	100	GG		03/14/84		149651893	Log Data Report - GAMMA 299-W15-210 (A7508)
A7509	299-W15-211			J	100	HG	HRLS	12/26/02	YES	154306108(50362740)	Log Data Report 299-W15-211 (A7509)
A7509	299-W15-211			J	100	HG	SGLS	12/26/02	YES	154306108	Log Data Report 299-W15-211 (A7509)
A7509	299-W15-211			J	100	GG		06/24/86		149651897	Log Data Report - GAMMA 299-W15-211 (A7509)
A7509	299-W15-211			J	100	GG		03/14/84		149651896	Log Data Report - GAMMA 299-W15-211 (A7509)
A7510	299-W15-212			J	100	HG	HRLS	12/30/02	YES	154306109(50362739)	Log Data Report 299-W15-212 (A7510)
A7510	299-W15-212			J	100	HG	SGLS	12/30/02	YES	154306109	Log Data Report 299-W15-212 (A7510)
A7510	299-W15-212			J	100	GG		06/24/86		149651013	Log Data Report - GAMMA 299-W15-212 (A7510)
A7510	299-W15-212			J	100	GG		03/14/84		149651012	Log Data Report - GAMMA 299-W15-212 (A7510)
A9794	299-W11-22		241-T-361	E	325	HG	SGLS	12/08/05	YES	154300377(30985953)	Log Data Report 299-W11-22 (A9794)
A9794	299-W11-22			E	325	N		06/09/65		153575957	Log Data Report - Neutron 299-W11-22 (A9794)
A9890	299-W10-22			G	300	HG	RLS	10/07/94		SUBMITTED	
A9890	299-W10-22			G	300	SG	NaI	10/04/94		SUBMITTED	
A9890	299-W10-22			G	300	SG	NaI	08/15/94		48447101	Gross Gamma
B8546	299-W10-24			G	432.5	HG	RLS	10/17/98		50208711	Geophysical Logs
B8548	299-W10-26			H	262	HG	RLS	08/22/98		150145814(48434281)	Log Data Report - RLS GAMMA 299-W10-26 (B8548)
B8549	299-W14-13			H	262	HG	RLS	08/28/98		48434283	RLS Spectral KUT Processed Data
B8550	299-W15-40			J	262.4	HG	RLS	09/04/98		SUBMITTED	
B8550	299-W15-40			J	262.4	GG		09/04/98		150145815	Log Data Report - GAMMA 299-W15-40 (B8550)
B8550	299-W15-40			J	262.4	N		08/28/98		48434276	Formation (Neutron) Moisture Borehole Survey
B8815	299-W15-41			I	239	N		01/07/00		150146135(48578532)	Log Data Report - GAMMA 299-W15-41 (B8815)
B8815	299-W15-41			I	239	HG	RLS	01/06/00		150146134	Log Data Report - GAMMA 299-W15-41 (B8815)
C3102	C3102			H	227	HG	SGLS	07/19/01	YES	154300051(48631126)	Log Data Report C3102 (C3102)
C3102	C3102			H	227	NM	NMLS	07/19/01	YES	154300051	Log Data Report C3102 (C3102)
C3117	299-W11-39			G	282.31	N	RLS	12/07/00		SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
C3117	299-W11-39			G	282.31	HG	RLS	12/06/00		150146035	Log Data Report - RLS 299-W11-39 (C3117)
C3120	299-W14-16			H	265	NM	NMLS	11/02/00	YES	48631846	Log Data Report
C3120	299-W14-16			H	265	HG	RLS	11/01/00		48609737	RLS Total Gamma Ray
C3125	299-W10-27			H	268.7	NM	NM	03/15/01		48610770(48611096)	RLS Spectral Gamma Ray Borehole Survey
C3125	299-W10-27			H	268.7	SG	RLS	03/15/01		48610769	RLS Spectral Gamma Ray Borehole Survey- LOG Header
C3339	299-W15-763			I	257.6	N/A	N/A	N/A		N/A	
C3396	299-W14-18			H	261.5	HG	SGLS	09/25/01	YES	48631846	Log Data Report
C3396	299-W14-18			H	261.5	NM	NMLS	09/25/01	YES	48631846	Log Data Report
C3400	299-W10-28			F	277	HG	SGLS	10/02/01	YES	48629324	Log Data Report
C3400	299-W10-28			F	277	NM	NMLS	10/02/01	YES	48629324	Log Data Report
C3955	299-W15-43			J	347	HG	SGLS	11/13/02	YES	154306176	Log Data Report 299-W15-43 (C3955)
C3956	299-W15-44			J	342	HG	SGLS	10/18/02	YES	154300160	Log Data Report 299-W15-44 (C3956)
C4104	C4104			F	126	HG	HRLS	06/02/03	YES	154303427	Log Data Report C4104 (C4104)
C4104	C4104			F	126	HG	SGLS	06/02/03	YES	154303427	Log Data Report C4104 (C4104)
C4104	C4104			F	126	NM	NMLS	06/02/03	YES	154303427	Log Data Report C4104 (C4104)
C4105	C4105			F	131	HG	SGLS	02/19/03	YES	154303428	Log Data Report C4105 (C4105)
C4105	C4105			F	131	NM	NMLS	02/19/03	YES	154303428	Log Data Report C4105 (C4105)
C4175	C4175		216-T-28	H	227.5	HG	HRLS	12/06/04	YES	50203280	Geophysical Log Data Report
C4175	C4175			H	227.5	HG	SGLS	12/06/04	YES	50203280	Geophysical Log Data Report
C4668	299-W14-11		AHE269	H	348	HG	SGLS	05/02/05	YES	154300184(50203304)	Log Data Report 299-W14-11 (C4668)
C4669	299-W11-25			G	409.5	HG	SGLS	03/14/05	YES	154300185	Log Data Report 299-W11-25B (C4669)
C4948	299-W11-45			G	438	HG	SGLS	11/18/05	YES	154309293(30985950)	Log Data Report 299-W11-45 (C4948)
C4950	299-W11-46			G	285.75	N/A	N/A	N/A		N/A	
C4990	299-W11-47			G	407	HG	SGLS	03/21/06	YES	154378189(50203633)	Log Data Report 299-W11-47 (C4990)
C5243	299-W11-48			G	409	HG	SGLS	06/07/07	YES	154458685	Log Data Report 299-W11-48 (C5243)
C5855	299-W10-33			F	427	HG	SGLS	08/30/07	YES	154458708	Log Data Report 299-W10-33 (C5855)
C6410	C6410			H	95.9	NM	NMLS	10/07/08		SUBMITTED	
C6410	C6410			H	95.9	PN	PNLS	10/07/08		SUBMITTED	
C6410	C6410			H	95.9	SG	BGO	10/07/08		SUBMITTED	
C6411	C6411			H	96	NM	NMLS	10/21/08		SUBMITTED	
C6411	C6411			H	96	PN	PNLS	10/21/08		SUBMITTED	
C6411	C6411			H	96	SG	BGO	10/21/08		SUBMITTED	
C6412	C6412			H	95.95	NM	NMLS	10/21/08		SUBMITTED	
C6412	C6412			H	95.95	PN	PNLS	10/21/08		SUBMITTED	

TABLE A-1. 200-DV-1 OPERABLE UNIT T-TX-TY FOCUS AREA BOREHOLES AND AVAILABLE GEOPHYSICAL LOG DATA

Well ID	Well Name	Tank Farm #	Alias	Sub Regions E-J	Depth (feet)	Log Type	Log Sub-Type	Log Date	HEIS GPL	IDMS_ID	WIDL Data Available
C6412	C6412			H	95.95	SG	BGO	10/21/08		SUBMITTED	
C7017	299-W15-225			J	465	HG	SGLS	05/11/09	YES	143655906	Log Data Report
C7018	299-W14-20			H	439	HG	SGLS	07/29/09	YES	144341167	Log Data Report