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299-W10-196

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WHC Information Release Administration Specialist:

Niki L. Solis

11/03/94

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7. Abstract

Geophysical surveys were conducted in borehole 299-W10-196 during construction to profile the radionuclide contaminants in the vadose zone that leaked from single-shell tank 216-T-106. Contaminants from the tank leak were detected to 120 feet below the ground surface. A second complete geophysical survey was conducted about one year after drilling was completed to evaluate contaminant movement that may have been caused by the presence of the cased borehole. Contaminant movement would warrant plugging and abandoning the borehole. Comparison of the two surveys indicate that no contamination movement to greater depths can be identified.

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**RADIONUCLIDE LOGGING OF TANK 216-T-106,
BOREHOLE 299-W10-196**

1.0 INTRODUCTION

Geophysical well logging was performed to measure gamma radiation emitted from man-made and natural radionuclides present in the soil at borehole 299-W10-196 drilled in 1993 adjacent to single-shell tank 241-T-106, also known as 106-T. Formation samples were taken during drilling and analyzed using laboratory procedures. Comparison of geophysical well logging survey and laboratory results are presented. The Radionuclide Logging System (RLS) survey data detailed in this report shows that the majority of contamination is retained in the soil above the low permeability caliche interface. Small amounts of the mobile radionuclide, cobalt-60, penetrated the caliche at 95 feet and migrated to the depth of 120 feet. A second RLS survey was acquired in February 1994, after drilling activities were completed, to identify significant changes that would warrant abandoning borehole 299-W10-196. Comparison between the single casing drilling survey and the post-drilling borehole survey are made in this report.

2.0 GEOLOGIC CHARACTERISTICS

The Hanford Site lies within the Pasco Basin, a regional structural and topographic sediment-filled basin. The sediments for the Pasco Basin are underlain by Miocene-age basalt. The sediments overlying the basalt are from oldest to youngest: Miocene-Pliocene Ringold Formation, post-Ringold pre-Hanford sediments, glaciofluvial deposits of the Hanford Formation, and surficial Holocene eolian and fluvial sediments.

The 106-T Tank is located in the T Tank Farm in the western part of the Hanford Site in the 200 West area. Most of the vadose zone beneath the T Tank Farm is comprised primarily of unconsolidated sediments of the Hanford formation. This highly permeable unit is composed of mainly cobbles, boulders, gravel, and coarse sand. Drilling data indicate that isolated lenses of silty sand and gravel are also present. The water table is in the underlying Ringold E unit, a matrix supported fluvial pebble and cobble gravel. The tank farm was constructed over a low permeable caliche layer that extends under much of the 200 West Area and is generally considered to inhibit the downward movement of contaminants toward the ground water. The caliche layer under the T Farm occurs at approximately 95 feet and was found from 91.8 to 93.8 feet in borehole 299-W10-196.

3.0 RLS SYSTEM

The RLS is a passive, high resolution spectral gamma logging system. The RLS utilizes a semi-conducting crystal of high purity germanium. The crystal is cooled with liquid nitrogen, and an electrical potential is imposed across the crystal. Gamma ray interaction with the crystal produces sharp electronic pulses resulting in excellent energy resolution. With appropriate calibration, concentration as well as radionuclide identification can be determined. The borehole surveys were acquired according to the procedure explicitly stated in Environmental Investigation Instruction (EII) 11.1, Revision 1, of *Environmental Investigations and Site Characterization Manual* (WHC-1988). The borehole survey data were processed using the calibration coefficients presented by Koizumi (1992). System characteristics and operation are discussed in Brodeur (1991 and 1992). Calculation of the calibration factors used in data reduction depended on the calibration data and on nuclear data (half lives, branching ratios, number of gammas per decay) for the particular nuclide. All of the nuclear data were taken from Erdtmann and Soyka (1979).

4.0 RLS LOG SURVEY DATA

Appendix A contains the RLS survey results. The cover page for each well, entitled "RLS Spectral Gamma-Ray Borehole Survey Log Header," summarizes the borehole and survey information. A borehole survey report describing the radionuclides identified, their depth range, and activity level is also included. The surveys were acquired at half-foot increments along the full borehole length at 80 second acquisition times.

The plots of radionuclide activity versus depth are presented on a uniform depth scale of 20 feet per inch and two amplitude scales of 50 and 5,000 picocuries per gram (pCi/g). The experimental uncertainties in the computed radionuclide activities are calculated as described in the calibration document, but are not presented on the data plots.

The "Total Gamma" is the count rate for all gamma-rays detected by the RLS detector with no discrimination of gamma-ray energy and not corrected for casing attenuation. The remaining plot tracks contain the results of the spectra gamma-ray analysis. The natural radionuclide gamma activity (potassium, uranium, and thorium) is separated from the man-made responses through spectral analysis and presented on separate plots.

Borehole 299-W10-196 was constructed in 1993 and RLS surveys were acquired through single casing strings during seven logging sessions to survey the entire borehole length. The 1994 survey was unable to reproduce the single casing string surveys and had to measure the formation gamma-ray activity through as many as three casing strings. Comparison between the survey results of the 1993 construction logs and the 1994 logs are very good, and will be further discussed later in this report.

Figure 1 is a comparison plot showing the 1993 and 1994 survey together. Corrections for multiple casings have been applied to the ^{137}Cs , ^{60}Co , and ^{154}Eu data. No corrections to the Gross Gamma-Ray curve has been applied. The comparison plot indicates that the contamination has not moved down hole since drilling has stopped.

4.1 LIMITATIONS TO THE RADIOELEMENT ANALYSES

The standard logging configuration optimizes the counting system for detecting low decay activities of radioelements. The RLS has frequently detected man-made radioelement activities of 0.3 pCi/g for radionuclides like cesium (^{137}Cs) and cobalt (^{60}Co). The maximum decay activity detected for ^{137}Cs is about 5,000 pCi/g in this standard configuration. The counting system saturated in 299-W10-196 from 34 to 46 feet with ^{137}Cs concentrations greater than 1,000 pCi/g and europium (^{154}Eu) concentrations greater than 5,000 pCi/g.

The alternate logging configuration employs a lead shield and changes the counting system to maximize the count rate. Configuring the counting system to maximize the count rate compromises its ability to detect radioelements at low decay activities (concentrations). The RLS has detected ^{137}Cs activities approaching 33,000 pCi/g in this shielded configuration. The alternate logging configuration was employed for the 1993 survey from 34 to 50 feet, but the counting system continued to saturate from 35 to 44 feet. Therefore, the magnitude of the gamma activity from 35 to 44 feet can not currently be determined in the zone of equipment saturation. The last valid measurement, 0.5 feet above and below the saturation zone, measured over 6,000 pCi/g for ^{137}Cs and over 6,000 pCi/g below the saturation zone for ^{154}Eu .

Energy dependent casing corrections have been established for steel casing thicknesses up to 0.40 inches. Calibrated corrections for casings of different materials and/or cumulative thicknesses greater than 0.40 inches are not currently available for use in data reduction. The 1994 survey data will underestimate the formation radionuclide concentration for the measurements taken above 113 feet where the casing thickness exceeds 0.40 inches.

The calibration data were recorded with the detector centered in calibration zones that are uniform in density, water content, and gamma-ray source material. The dimensions of each zone are large enough that the detector always responded as though surrounded by a medium of infinite extent. Therefore, the use of the calibration results to calculate nuclide activity carries the assumption that the nuclides in the logged formation are also distributed in thick uniform layers.

Gamma-ray sources or contaminants are not normally distributed in the earth in thick uniform layers as encountered during equipment calibration. Contaminant distribution in the subsurface is variable with influences from several origins. This variability means that the detector response at each depth position likely does not exactly represent the contaminant concentration at each depth. The reason is that gamma-rays can travel significant distances before being captured by the detector. From the detectors perspective the travel distance is considered the radius of investigation which is about 20 inches in Hanford sediments. The borehole log smoothes the variations in the formation because of the radius of investigation. Source inhomogeneities

Figure 1. Comparison of 1993 Drilling Survey
and 1994 Verification Survey (Multiple
Casing Corrections Applied).

RLS Spectral Gamma-Ray Borehole Survey

Project: T-106 Drilling
Borehole: 299-W10-196

Log Dates
Nov 17, 92 thru Apr 14, 93
Feb 4, 1994

in the formation are reflected to some degree by the fluctuations observed in the amplitude variations of the log traces. There is a solution to this problem. The original formation concentrations can be extracted from the borehole log responses by mathematics; either as an inverse filter (deconvolution) or forward modeling. Conaway (1979) demonstrated an exact inverse filter for gross-gamma logs. The deconvolution technique for spectral gamma-ray systems is currently being prepared at Los Alamos National Laboratory by Conaway. The forward modeling method which is an iteration technique can be performed within WHC.

Radionuclide decay activities are determined from the net area of the gamma-ray peaks. Radioelements such as strontium (^{90}Sr) which do not emit a gamma-ray when they decay will not be identified or quantified by the spectra analysis performed for this report. The decay of ^{90}Sr results in a high energy beta particle that can excite surrounding elements to emit photon radiation that can be identified by the HPGe detector. This type of radiation is called bremsstrahlung radiation. Post processing of the survey data can be performed to identify ^{90}Sr and its relative concentration, but has not been done.

5.0 COMPARISON BETWEEN RLS AND LAB SAMPLE ANALYSIS

Extensive sampling of formation materials were taken during drilling and analyzed by laboratory methods. Comparisons between the RLS in situ survey results and the drilling samples analyzed in a laboratory can be made with appropriate understanding of the limitations of each measurement method.

A brief explanation of the two measurement methods and a comparison of RLS results with drilling samples analytical results follow.

5.1 CONSIDERATIONS BETWEEN IN SITU AND LABORATORY ANALYSIS OF THE SUBSURFACE

There is a large contrast in the depth profile between the two systems (RLS in situ survey and laboratory analysis of drilling samples). The RLS is equivalent to a continuous core and analysis, with the standard depth increment of 6 inches between the survey locations. Samples collected for laboratory analysis are at best only on a very coarse grid. The depth resolution of the samples are the length of the sample tube (2.5 feet) since the location of the sample within the sample tube can range from a discrete location to a blend of the material sampled for the full length of the sample tube.

The physics of the measurements for radionuclides are the same for both methods (i.e., solid state spectroscopy) by counting gamma-ray emissions. The analysis software for both systems employ the same concept although a different implementation is used. Radioactive isotopes that decay without producing gamma-rays require other detection methods. Tritium (^3H) is an example of a radioisotope that decays by beta emission only and produces no

gamma-ray. However, the dominant radionuclides (^{137}Cs , ^{154}Eu , and ^{60}Co) encountered in the 106-T borehole and through most of the Hanford site have strong gamma-ray emissions.

The statistics of the two measurement methods are approximately equal, even though the sample size and measurement counting times are significantly different. Laboratory samples weigh about 100 grams and are counted for about an hour. The RLS sample size is determined by the average density of the material, and has a measurement radius for Hanford soils of approximately 1.5 feet. With self attenuation from the soils, the effective volume of the sample measured by the RLS is about 125 times greater than the laboratory sample. The standard 80 second sample time for the RLS is thus equivalent to 2.8 hours of data collection time for the typical laboratory system. The borehole casing, however, will reduce the intensity of the gamma-rays (and decrease the equivalent laboratory counting time) by a factor (from 1.1 to 4) depending of the gamma-ray energy and casing thickness.

The one and a half feet measurement radius of the RLS survey may appear to be a problem for detecting and examining thin zones. This is not a problem because deconvolution techniques can be applied to identify the presence of thin beds and their concentration. Radionuclide concentration profiles of layers as thin as one inch can be resolved by adequately spaced measurement locations.

Samples were taken ahead of drilling by driving a tube into the undisturbed sediments in front of the construction casing. Geologic conditions at Hanford frequently hinder the sampling program by preventing complete or continuous sample retrieval. Conditions that prevent complete sample retrieval are:

- Large cobbles may prevent insertion of the tube into the formation the desired distance.
- Formation material may fall out of the tube during its retrieval to the surface.
- The sample tube will capture nonrepresentative sediments that have accumulated in the bottom of the hole while advancing the construction casing.

The RLS survey may not represent the true formation activity because drilling operations may change the distribution of contaminants. Conditions that may redistribute contaminants are:

- Contaminants may be flushed or redistributed to lower depths when sealing materials are poured down the casing.
- Drilling operations vibrate contaminated fines in the formation allowing them to sift through open framework gravels or along the void space between casing and formation to lower depths.

The accuracy of the lab analysis is as good as the RLS system. However, sample preparation in the field introduces a bias by discarding the larger gravels (rocks) from inclusion into the material shipped to the laboratory. In situ measurements has an advantage by appropriately considering all subsurface materials within the measurement volume.

5.2 299-W10-196 RLS RESULTS AND LAB SAMPLE ANALYSIS

Results from the RLS survey and laboratory sample analysis are plotted in Figure 2, T-106 RLS and Lab Analysis. The three dominant manmade radionuclides (^{137}Cs , ^{60}Co , and ^{154}Eu) are plotted on semi-logarithmic or linear scales depending on concentration range encountered.

The RLS in situ survey results are plotted as heavy solid lines. The lab sample analysis results are plotted as discrete points (diamonds). Results of drilling sample analysis should not be plotted as lines, as demonstrated by this example. Fine details identified in the RLS survey are not represented in the sample results. The detection threshold values reported for the analytical results are not presented on the plot.

Overall, the basic agreement between sample analysis and the RLS survey is very good. The ^{137}Cs samples above 30 feet agree well with the RLS survey. The RLS detector was saturated between 35 and 47 feet with high concentrations of ^{137}Cs encountered above and below the region of saturation and high concentration of ^{154}Eu below the saturation region. The most dominant radionuclide in the region of detector saturation is probably ^{137}Cs . Laboratory results with concentrations less than 20 pCi/g in this same area are therefore suspect.

Agreement between the analytical results and RLS survey for ^{60}Co is the best of the three radionuclides. Sample results that appear to disagree with in situ measurements, such as 74, 83, and 98 feet, are probably concentrations that exist in thin beds surrounded by sediments whose concentration are at higher or lower concentration than the sample collected for analysis. The RLS survey has indications of thin zones at these and other depths. Note: the samples collected at 54 and 60 feet missed the interval of highest ^{60}Co contamination where concentrations approached 300 pCi/g. This is an excellent example why adequate site characterization cannot be performed with only sampling and laboratory analysis.

The ^{60}Co data plot also contains a plot of the naturally occurring radionuclide, potassium (^{40}K). Potassium is represented by the fine solid line. Variations of the geologic sediments can be correlated with changes in ^{40}K content, as noted by the decrease at about 95 feet where the caliche layer is encountered.

Analytical results of drilling samples reported ^{154}Eu in only two samples. The agreement of these two samples with the RLS survey is excellent. However, the omission of ^{154}Eu from the results for samples from 54 and 60 feet where ^{137}Cs and ^{60}Co are both reported, at lower concentrations than ^{154}Eu , is a serious concern.

Figure 2. T-106 RLS and Laboratory Analysis.

Comparison of the RLS in situ analysis and laboratory analysis of drilling samples indicates that to adequately characterize subsurface contamination, sampling and laboratory analysis must be coordinated with borehole geophysical surveys.

6.0 CONCLUSIONS

Between the depths of 65 and 73 feet, drilling problems redistributed radionuclides while placing sealing material between the formation and casing. Surveys acquired through this zone before, during, and after the problem were made to assess the conditions. Two data plots of the manmade radionuclides from 0 to 130 feet are presented. The first indicates the radiometric conditions adjacent to the borehole resulting from drilling induced changes. The second plot indicates the most probable formation radionuclide distribution before drilling operations redistributed some radionuclides.

Cobalt-60 contamination was identified below the geologic strata of caliche-rich sediments. The distribution profile from the RLS surveys indicate that the contamination below the caliche is present in the sediments and is not the result of drilling activities that allowed the contaminant to travel to 120 feet. Also, ^{60}Co was identified in the drilling samples collected below the caliche strata.

Comparisons between the analytical results of drilling samples and the RLS in situ surveys are good, but the conditions under which both measurements are taken must be considered. The use of RLS surveys in conjunction with lab sampling is necessary to adequately characterize subsurface contamination. Adequate characterization cannot be performed with only sampling and laboratory analysis.

Comparing the 1993 construction survey to the 1994 verification survey a difference in ^{137}Cs was observed at 53 feet. The magnitude of the activity encountered in January 7, 1993 survey is missing in the 1994 survey. The probable cause is that fine material migrated down the annular space between the borehole casing and the formation by vibrations introduced while drilling the hole. The downward migration of contaminants apparently stopped at about 66 feet. This same type of redistribution was also observed by the RLS while drilling the deep borehole in the 216-B-57 crib.

The comparison between the 1993 construction and 1994 post-construction surveys indicates that the contamination has not moved down hole since drilling has stopped.

The characterization surveys acquired for this project during borehole construction and the 1994 verification can determine vertical contaminant movements greater than 1 foot. However, Baseline surveys can be taken that will permit contaminant movements of 1 inch or greater to be identified and monitored. The baseline surveys appropriate for detailed monitoring should be scheduled.

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APPENDIX A

RLS SURVEY DATA AND SPECTRAL GAMMA PLOTS

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Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: Tank T-106 Soil Sampling

Borehole	<u>299-W10-196</u>		
Coordinates	<u>136,724.78 N</u>	<u>566,787.83 W</u>	meters (Lambert NAD'83)
Elevation	<u>671.87</u>	ft	Brass Cap (NGVD'29)

Borehole Environment Information

Borehole liquid depth <u>none</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
10	0.365	0	73
8	0.322	0	113.5
6	0.280	0	175.3

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. V. Cram</u> <u>S. E. Kos</u> <u>J. P. Kiesler</u>						
Log depth reference at zero (0.0) depth is <u>ground level</u>						
Log Date	Archive file names	Log mode speed	Depth interval (ft)			
			Top	Base	Incr	
Nov 17, 1992	H2W10196\A285	MSA 80sec RT	0	8	0.5	
Jan 7, 1993	H2W10196\A307	MSA 80sec RT	7	69	0.5	
Feb 2, 1993	H2W10196\A322	MSA 80sec RT	65	73	0.5	
Feb 17, 1993	H2W10196\A330	MSA 80sec RT	60	97	0.5	
Feb 26, 1993	H2W10196\A335	MSA 80sec RT	95	122	0.5	
Mar 18, 1993	H2W10196\A350	MSA 80sec RT	120	148	0.5	
Apr 14, 1993	H2W10196\A352	MSA 80sec RT	146	176	0.5	

MSA: Move-Stop-Acquire

RT: Real time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

Analyst Names: J. P. Kiesler R. K. Price
Analysis Date: Apr. 29, 1993

Analysis Notes: Casing seal problems at 73 ft moved some contamination
Radionuclides Identified: Cs-137, Co-60, Eu-154, Eu-152

RLS Borehole Survey ReportBorehole: 299-W10-196

Casing	Depth: 73'	Size: 10"	Thickness: 0.365"
	Depth: 113'	Size: 8"	Thickness: 0.322"
	Depth: 175'	Size: 6"	Thickness: 0.280"
Water Survey	Depth: none		
	Depth: 0 - 8'	Date: 11/17/92	
	Depth: 7 - 69'	Date: 1/07/93	
	Depth: 65 - 73'	Date: 2/02/93	
	Depth: 60 - 97'	Date: 2/17/93	
	Depth: 95 - 122'	Date: 2/26/93	
	Depth: 120 - 148'	Date: 3/18/93	
	Depth: 146 - 176'	Date: 4/14/93	
Stations: 300 seconds		Depths: 8.1, 69, 73.5, 97.8, 122.5, 175 ft	

General Notes:

The well was monitored from 0 to 176.5 feet in increments of 0.5 feet for counting periods of 80 seconds, through single casings when possible. Casing seal problems above 73 feet prompted additional log surveys. Contamination inside the casing was flushed into the bentonite seal when water was added. Multiple plots of the man-made radionuclides show the problem from 60 to 73 feet. The formation concentrations are expected to be the lower calculated result and are presented in the plot with no special heading.

The gamma-ray activity exceeded the count rate capability of the system (saturated) from 34 to 45 feet while configured for detecting low radionuclide concentrations. No gamma-ray photo peaks can be processed in saturated intervals. The interval was relogged with a lead shield and optimized count rate capability. Saturation reoccurred from 35.5 to 43.5 feet with count rates exceeding 800,000 cps. Before saturation occurred at 35 and 44 feet the concentration of cesium-137 exceeded 6000 pCi/g and the europium-154 exceeded 6000 pCi/g at 44 feet and 280 pCi/g at 35 feet.

The natural radionuclides, potassium, uranium, and thorium, were observed at activities normal for Hanford soils except from 72 to 79 feet where elevated thorium and uranium and reduced potassium resulted from the bentonite seal.

Man-made Radionuclides:

Cesium (Cs-137) was detected in the borehole from the surface to 72.5 feet. The calculated decay activity exceeded 200 pCi/g in three zones: 11.5-13, 34-54.5, and 61.5-66 feet. The high activity from 61.5 to 66 feet is likely the result of contamination being washed from higher depths when water was poured down the casing to activate the bentonite. Cesium activity exceeded 5000 pCi/g from 35 to 44 feet.

Cobalt (Co-60) was detected from 34 to 120.5 feet. The calculated decay activity exceeded 200 pCi/g from 55 to 57.5 feet.

Europium-152 (Eu-152) was detected from 45 to 73 feet. The maximum decay activity was 74 pCi/g at 46 feet.

Europium-154 (Eu-154) was detected from 31 to 86 feet. The decay activity exceeded 200 pCi/g from 35 to 68 feet.

RLS Spectral Gamma-Ray Borehole Survey

Drilling Induced Changes to Log Survey (62-67 ft)

Project: T-106 Soil Sampling

Log Date: Apr 14, 1993

Borehole: 299-W10-196

Anal. Date: Jan 31, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: T-106 Soil Sampling
Borehole: 299-W10-196

Log Date: Apr 14, 1993
Anal. Date: Jan 31, 1994

RLS Spectral Gamma-Ray Borehole Survey

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Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: T-106

Borehole	<u>299-W10-196</u>		
Coordinates	<u>NA</u> N	<u>NA</u> W	Feet (Hanford System)
Elevation	<u>NA</u> ft	Top of casing	

Borehole Environment Information

Borehole liquid depth <u>None</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
10	0.365	0.0	73.0
8	0.322	0.0	113.3
6	0.280	0.0	176.3

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. Cram</u> <u>J. Kiesler</u>						
Log depth reference at zero (0.0) depth is <u>ground level</u>						
Log Date	Archive file names	Log mode	speed	Depth interval (ft)		
				Top	Base	Incr
Feb 03, 1994	H2W10196\A515	MSA	80sec RT	0.0	98.0	0.5
Feb 04, 1994	H2W10196\A516	MSA	80sec RT	97.0	176.5	0.5

MSA: Move Stop Acquire
RT: Real Time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991	
Calibration Report: WHC-SD-EN-TRP-001	
Analyst Names: <u>S. E. Kos</u>	<u>R. K. Price</u>
Analysis Date: <u>Feb 07, 1994</u>	
Analysis Notes: <u>Exceeded maximum casing correction</u>	
Radionuclides Identified: <u>Cs-137, Co-60, Eu-152, Eu-154</u>	

RLS Borehole Survey ReportBorehole: 299-W10-196

Casing	Depth: 0.0' - 73.0'	Size: 10"	Thickness: 0.365"
	0.0 - 113.3'	8'	0.322"
	0.0 - 176.3'	6'	0.280"

Water None

Survey	Interval: 0.0' - 98.0'	Date: Feb 03, 1994
	97.0' - 176.5'	Feb 04, 1994

General Notes:

The RLS surveys were acquired at acquisition times of 80 seconds Real-Time and through up to three casing strings. The casing thickness above 113.3 feet exceeded the maximum calibrated correction factor of 0.40". Therefore, computed concentrations above 113.3 feet will be lower than actually present in the formation. Reprocessing with updated correction factors can be performed at a later date. Repeat sections were acquired at 95.5'-98.0' and 174.0'-176.5', and are included on the plots.

The detector was saturated during the interval from 34.5 to 44.5 feet, even through three casing strings. No gamma-ray photo peaks were recorded or identified within this interval.

High total gamma activity above 10,000 counts/second, from 32 to 66 feet, frequently prevented adequate detection and calculation of the gamma-rays emitted by the natural radionuclides. High count rates masked the energy peaks for these natural radionuclides and prevents identification by the LGCALC program. Where the natural radionuclides are identified, their concentrations are consistent for Hanford soils.

Man-made Radionuclides:

Cs-137 was identified in the intervals 0'-34.5', 44.5'-72.5', and at 94.5' and 154.0'. Saturation of the detection system from 34.5' to 44.5' prevented identification or quantification of the radionuclides in this interval. The computed activity for 0.40-inch casing exceeded 200 pCi/g from 34.5' to 48.0'.

Co-60 was identified in the interval 44.5'-120.5'. The maximum computed activity for 0.40-inch casing was 135 pCi/g at 94.0'.

Eu-152 was identified in the interval 44.5'-68.5' and at 69.5' and 71.5'. The maximum activity of 30 pCi/g was observed at 57.5'.

Eu-154 was identified above the detector saturation interval, from 33.0'-34.5', and below from 44.5'-76.0', and 79.5'-86.5'. The activity exceeded 200 pCi/g from 44.5' to 66.5'.

RLS Spectral Gamma-Ray Borehole Survey

Project: T-106

Log Date: Feb 04, 1994

Borehole: 299-W10-196

Anal. Date: Feb 07, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: T-106

Log Date: Feb 04, 1994

Borehole: 299-W10-196

Anal. Date: Feb 07, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: T-106

Log Date : Feb 04, 1994

Borehole : 299-W10-196

Anal Date: Feb 07, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: T-106

Borehole : 299-W10-196

Log Date : Feb 04, 1994

Anal Date: Feb 07, 1994

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