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REPORT OF SPECTRAL GAMMA RAY SURVEYS ACQUIRED FOR
THE 200-UP-1 PROJECT

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Report of Spectral Gamma-Ray Surveys Acquired for the 200-UP-1 Project

S. E. Kos

Westinghouse Hanford Company, Richland, WA 99352
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Abstract: Four (4) boreholes were surveyed for the 200-UP-1 project utilizing the high-purity germanium and sodium logging systems. The surveys were acquired during the period April-September, 1994.

The objectives of the surveys were to identify the presence, species, and relative activities of man-made gamma-ray emitting radionuclides, and to use log data to correlate stratigraphic features between boreholes.

No man-made radionuclides were detected in the subsurface below 2 feet in depth in any of the boreholes.

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ACRONYMS

HPGe	high-purity germanium
KUT	potassium, uranium, and thorium
NaI	sodium iodide
RLS	Radionuclide Logging System
WHC	Westinghouse Hanford Company

RADIONUCLIDE LOGGING SYSTEM SPECTRAL GAMMA-RAY SURVEY REPORT FOR THE 200-UP-1 PROJECT

1.0 INTRODUCTION

Geophysical logging was conducted in four boreholes for the 200-UP-1 Project during the period from April to September 1994. All wells/boreholes surveyed for the 200-UP-1 Project are referred to as boreholes throughout this report. Metric measurements have not been used in this report. Table 1 summarizes the boreholes, dates, and intervals logged.

Table 1. Logging Summary.

Borehole	Date logged	Interval logged (ft)
299-W19-34A	February 28, 1994	0-42.5
	March 10, 1994	41.5-186.5
	April 18, 1994	185.5-212.5
	April 19, 1994	211.5-344
299-W19-34B	July 7, 1994	330-415
	August 31, 1994	410-504
	September 1, 1994	502-556.5
299-W19-35	February 28, 1994	0-35.7
	March 9, 1994	35-178.5
	March 23, 1994	177.5-250
	March 28, 1994	248-273.5
699-38-68A	April 27, 1994	0-35.5
	May 10, 1994	35-125
	May 11, 1994	124-189.5
	June 16, 1994	184-262.5
	June 20, 1994	260-296.5

All wells/boreholes surveyed for the 200-UP-1 Project are referred to as boreholes throughout this report.

Metric measurements have not been used in this report. Conversions from inch/pound measurements to metric units are provided in Appendix E.

The objectives of the borehole surveys were to identify the presence and species of synthetic gamma-ray-emitting radionuclides and their relative activity levels and to aid in subsurface stratigraphic correlation. No synthetic radionuclides were detected in the subsurface below 2 ft in depth in any borehole.

Both the sodium iodide (NaI) and high-purity germanium (HPGe) spectral logging systems were used to conduct the borehole surveys. However, the NaI system was used only for the initial survey for Borehole 699-38-68A when the HPGe system was being repaired.

Appendix A describes both systems. Appendix B explains the borehole survey header and presents survey plots and reports. Appendix C contains surveys for each borehole. Appendix D describes the stratigraphy and a geologic cross section.

This report is limited to describing the survey results for each borehole logged. Details regarding field survey procedures (WHC-CM-7-7), equipment configuration, spectra analysis, software, data management (Koizumi 1992b), calibration, casing, and water correction factors (Brodeur 1991, 1992, and Koizumi 1991, 1992a) are discussed in separate documents.

2.0 LOCATION

Boreholes 299-W19-34A and 299-W19-34 were located 20 ft apart and at a distance of about 200 yards west of Borehole 299-W19-35. These boreholes were located east-southeast of U Plant. Borehole 699-38-68A was located outside of the 200 West Area, approximately 0.5 mile east of Borehole 299-W19-35. All the boreholes were completed as monitoring wells.

Borehole 299-W19-34A was surveyed to its entire depth. Because no radiological contamination was detected and no significant lithological changes were anticipated over the short distance to Borehole 299-W19-34B, the survey of Borehole 200-W19-34B was initiated at 330 ft and continued to the total depth of 556.5 ft.

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3.0 LOGGING PARAMETERS

All the borehole surveys were conducted in single-casing strings. The casing was schedule 40 welded-joint carbon steel.

The reference datum for the zero-depth position of each borehole was the ground surface. The center of the crystal in all the logging tools was determined in the laboratory. It also is identified on the outside of the tool housing, and is designated the tool zero position. The tool zero position was aligned with the borehole zero position (ground surface) at the commencement of logging. At the time of logging, the elevation of the surface surrounding the borehole casing and the X and Y coordinates were not known.

The NaI spectral gamma-ray data were acquired every 0.5 ft at a logging speed of 2.5 ft per minute. At present, only the gross gamma-ray activity detected by the tool is presented. No correction for steel casing or borehole fluids was applied to the recorded gamma-ray activity. The average sample time per 0.5-ft survey depth increment was 10 seconds. A centralizing device was attached to the logging tool to center the tool in the borehole and to minimize variations in response caused by nonhomogeneous sediment properties.

All the high-purity germanium (HPGe) spectral gamma-ray data were acquired in the move-stop-acquire mode every 0.5 ft throughout the logged interval. The acquisition time was set at 80 seconds (real "wall clock" time). Survey overlaps were performed at the beginning of the second, third, and subsequent surveys to verify depth control and provide profile features that would aid in combining individual surveys into a single survey at the completion of drilling. Repeat intervals of 2.5 ft were acquired at the completion of each survey to verify equipment performance. The repeat and overlap data are included on the plots. A centralizing device was used to center the tool in the borehole.

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4.0 OBSERVATIONS

The main objective of the borehole surveys was to identify the presence of gamma-ray-emitting synthetic radionuclides; the secondary objective was to correlate identified lithologic features between boreholes. The acquisition time determined for the surveys conducted for the 200-UP-1 Project was optimized to detect low activities of synthetic radionuclides, and to be able to log 100 ft of borehole per day. The 80-second real-time acquisition produces statistical variations of 20 percent on the potassium, uranium, and thorium (KUT) plots; it was not ideal for detailed correlation of the profiles of the naturally occurring radionuclides (KUT) with stratigraphic descriptions. Longer acquisition times of 300 seconds per depth interval would be required to reduce statistical variations to 10 percent. The 10-percent improvement in statistical variation did not justify the increased expense of drill-rig and crew standby time.

Intervals of increased count rate are observed when the logging tool encounters open hole conditions, or when the tool approaches the bottom of the borehole. Both of these conditions occurred several times during the surveys. Also, short intervals of decreased count rate at the beginning of surveys indicate detector response in multiple casing, as already discussed above.

^{137}Cs was identified in Borehole 299-W19-35 from the surface to a depth of 2.0 ft. The ^{137}Cs activity did not exceed 1 pCi/g and is most likely the result of surface contamination. ^{137}Cs is frequently detected at or near the surface throughout the 200 West Area. The ^{137}Cs contamination was not plotted because of the low activity and short interval of the zone. Because no synthetic radionuclides were detected in the subsurface in any of the boreholes, the observations were directed mainly toward correlating the borehole survey data with lithologic descriptions recorded on the borehole logs.

The uranium activity identified as naturally occurring should not be confused with processed ^{235}U or ^{238}U . Natural uranium will be in secular equilibrium with all of its daughter products and is identified by gamma-ray energies of the daughters below ^{226}Ra . The most intense gamma-ray energies from natural uranium are 352, 609, and 1,764 KeV. The most intense gamma-ray emitted for ^{235}U and ^{238}U processed for nuclear reactors are at 185.7, 1,001, and 767 KeV. Therefore, the ability to distinguish natural from processed uranium is well established.

The total or gross gamma-ray log is used primarily to identify fine-grained sediments. These sediments contain mixtures of KUT. The gamma-ray response to these sediments is an increase in count rate. Variations in the activities of the KUT radionuclides can be correlated to mineralogical characteristics of sediments (e.g., granitic or basaltic). The KUT activities in Hanford Site sediments have the following variations:

- Potassium 8-20 pCi/g
- Uranium 0.2-3 pCi/g
- Thorium 0.2-2 pCi/g.

Identifying and mapping fine-grained sediments is important. These sediments have been shown to influence vertical and lateral migration of fluids discharged to the soil column and have created conditions for localized perched water zones. They have also concentrated contamination distribution within the sediments. Several silt/silty horizons have been identified on the geophysical survey logs and will be discussed later.

A carbonate-rich (caliche) paleosol horizon was identified in both the geologic and the geophysical surveys. It is present under much of the 200 West Area, and is useful as a marker bed to correlate between boreholes. The geophysical surveys identify the caliche by decreased total gamma-ray activity and reduced potassium concentration. Thorium content is also slightly reduced in the caliche, and frequently continues at reduced concentrations for several feet below the caliche. The depth below ground surface of the paleosol horizon for three borehole surveys acquired in the 200-UP-1 Project are described in Table 2.

Table 2. Paleosol Horizons.

Well Number	Well Location	Paleosol depth interval (ft)
299-W19-34A	100 yd SE of U-Plant	187-200
299-W19-35	200 yd E of 299-W19-34B	178-210
699-38-68A	0.5 mi E of 299-W19-35	227-232

Note: The geophysical survey of Borehole 299-W19-34B commenced below the paleosol horizon.

Three silt stringers are identified on the geophysical survey logs above the paleosol caliche strata in Borehole 299-W19-35 at depths of 152, 161, and 178 ft. The geologic log confirms the silts, but also identifies multiple thin lenses of 1 ft or less that were not identifiable above the average gamma-ray activity on the geophysical log. The same three silt stringers are identified at lower amplitude on the geophysical survey of Borehole 299-W19-34A. The geologic descriptions of the drilling samples did not identify the two silt stringers at 152 and 155 ft in 299-W19-34A. The lower silt stringer at 187 ft was identified on the geologic log.

The geophysical survey and geologic log identified at least 7 silt lenses in Well 699-38-68A, located 0.5 mile east of Well 299-W19-35. It is probable that even though the silt lenses may not be continuous between the two wells in the 299-W19 block and the one well in the 600 area, the sediment materials that created the silts are from the same source.

A gravel channel fill near the surface is identified in the geophysical surveys for Boreholes 299-W19-34A and 299-W19-35. The gravels ranging from 45 to 75 ft in well 299-W19-35 show higher concentrations of natural uranium than the other sediments. The same depth interval in Well 299-W19-35 contains a higher concentration of uranium. The average uranium content in Well 699-38-68A above the caliche does not contain an interval of higher uranium concentration. The sediments deposited in the channel region where Boreholes

299-W19-34A and 299-W19-35 are located contained more granitic material (higher uranium content) than the sediments outside the channel.

Similarly, channel fill gravels are identified in the surveys for Boreholes 299-W19-34A, and 299-W19-35 from about 5 to 30 ft. The geophysical logs in this region show decreased concentrations of natural uranium and potassium, which is the opposite of observations for the lower gravels. These gravels are composed of less granitic and more basaltic sediments.

The lithologic features identified from the total gamma-ray surveys and the geologic logs were investigated relative to facies associations within the Ringold and Hanford Formations. The units are described in Appendix D, which also includes a stratigraphic cross section across the 200-UP-1 Operable Unit.

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5.0 REFERENCES

- Brodeur, J. R., C. J. Koizumi, W. H. Ulbricht, and R. K. Price, 1991, *Calibration of a High-Resolution Passive Gamma-Ray Logging System for Nuclear Waste Assessment*, WHC-SA-1175-FP, Westinghouse Hanford Company, Richland, Washington.
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- WHC-CM-7-7, *Environmental Investigations and Site Characterization Manual*, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX A
SYSTEMS DESCRIPTION

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APPENDIX A

SYSTEMS DESCRIPTION

SODIUM IODIDE (NAI) SYSTEM

The sodium iodide (NaI) system measures gamma-ray energy and activity emitted by sediments with a 2.5-inch-diameter by 8-inch-long NaI detector. The NaI crystal emits a flash of light when it absorbs a gamma ray. The flash is amplified and converted to an electrical charge in the form of a pulse. The pulse is sent up the logging cable and counted. At present, the NaI system is being used for gross gamma-ray measurement, which is the count rate for all gamma-rays detected at a specified interval. The system makes no distinction as to the source of the gamma-ray energies. The NaI System is equipped with a multichannel analyzer that permits the gamma-ray energies to be tabulated in a 1000-channel pulse-height analyzer for each depth interval. Software to process the spectra, apply borehole casing and fluid correction factors, and compute the concentrations of the natural radionuclides potassium, uranium, and thorium (KUT), is being developed. Data presently being collected with the NaI System is archived and can be processed later if the KUT distribution in the sediments is desired.

HIGH-PURITY GERMANIUM (HPGE) SYSTEM

The Westinghouse Hanford Company (WHC) Radionuclide Logging System (RLS) uses a high-purity germanium (HPGe) passive gamma-ray detector. Gamma ray interactions with the HPGe crystal yield very sharp electrical charge pulses corresponding to energies of the impinging gamma ray, which results in excellent energy resolution. Precise energy resolution permits absolute identification of the gamma-emitting radionuclides and, with proper calibration, an accurate assay of their decay activity.

The HPGe detector is housed in the logging tool along with the high-voltage power supply, preamplifiers, and a cryogenic system to maintain the detector at liquid nitrogen temperatures. The nitrogen is vented to the atmosphere through a conduit in the logging cable. The surface components of the system include gamma-ray spectroscopy amplifiers and counting electronics interfaced with a computer. A computer controls the hydraulic winch during logging and maintains accurate positioning and movement of the detector in the borehole.

SYSTEM AND RADIOELEMENT ANALYSES LIMITATIONS

This section describes several limitations of the borehole survey equipment, calibration, and data acquisition objectives.

The logging cable equipped on the RLS was specifically designed for the system. It suspends the detector in the well, conducts power to, and receives electrical signals from the detector, and provides the conduit for venting the liquid nitrogen component of the detector. Errors in the depth measuring

system of the RLS are mainly related to cable stretch, cable and sheave wheel contact, and electronic encoding components. The recorded depth of the detector is estimated to be accurate to 98.5 percent, with a precision (repeatability) of 99 percent. Comparisons with drilling measurements, other logging equipment, and secondary measurement systems have verified the accuracy.

Borehole environment correction factors have been determined for steel casing and water in the borehole. Correction factors for other borehole configurations have not been determined. Other configurations for which correction factors have not been determined, but which may be encountered at the Hanford Site include grout between multiple casing strings; formation seals containing grout, bentonite, or sand behind the casing; and drilling mud present in the borehole while logging. The calculated decay activities will be underestimated with these configurations.

Energy-dependent casing corrections have been established for steel casing thicknesses up to 0.40 inch. Corrections for casings of different materials and/or cumulative thicknesses of greater than 0.40 inch have not been determined and therefore cannot be used in the data reduction process.

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 are not normally distributed in the earth in thick uniform layers. Source inhomogeneities are reflected to some degree by the fluctuations in the amplitudes of the log traces. A factor called the vertical spacial resolution quantifies the correlation between the intensity of the log fluctuation and the depth interval over which it extends, and the intensity of the corresponding gamma-ray source and the thickness of the zone in which it is embedded. The vertical spatial resolution of the RLS HPGe logging system is scheduled for investigation.

Radionuclide decay activities are determined from the net area of the gamma-ray peaks. Radionuclides that do not emit a gamma ray when they decay, such as ^{90}Sr , will not be identified or quantified by the spectral analyses process. However, the decay of ^{90}Sr results in a high-energy beta particle that can excite surrounding elements to emit gamma-ray radiation that can be identified by the HPGe detector. This type of radiation is called "bremsstrahlung" radiation. A method to obtain estimates of the concentration of ^{90}Sr is under consideration.

APPENDIX B
BOREHOLE SURVEY DATA DESCRIPTION

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APPENDIX B

BOREHOLE SURVEY DATA DESCRIPTION

The report for each borehole survey by the radionuclide logging system (RLS) contains the following three types of information.

LOG HEADER

This form is titled "RLS Spectral Gamma-Ray Borehole Survey Log Header" and summarizes the borehole and survey information. The form contains the project name, borehole number, coordinates, and elevation and a description of the borehole environment, including casing size, wall thickness, depths, and water level (if present). This information is used during data reduction.

RLS survey information is presented and includes logging engineers' names, survey dates, file names, logging mode, and survey depths.

Data reduction information, including calibration date and report number, analyst name and analysis date, is provided. A line is included for notes and synthetic radionuclide identification.

RADIONUCLIDE PLOTS

The plots of individual radionuclide activity responses versus depth are titled "RLS Spectral Gamma-Ray Borehole Survey." They are contained on one or more pages depending on the number of radionuclide species encountered and/or depth of the borehole. A uniform depth scale of 20 ft/in. is used for all plots. Four plot tracks are usually presented for uniformity, however improvements in plotting capabilities are forthcoming.

The "Total Gamma" is the count rate for all gamma rays detected by the RLS detector with no discrimination of the source of gamma-ray energy. The total gamma is equivalent to the gross gamma log used at the Hanford Site for many years. The count rate data values are plotted on two linear scales. The scale of the narrow line is usually 0 to 1000 counts per second (c/s); the scale of the wide line is 0 to 100,000 c/s. An expanded total gamma plot is provided with the 200-UP-1 data that has a single scale of 0 to 200 c/s.

Generally the natural radionuclides, potassium, uranium, and thorium (KUT) will be plotted separately.

The remaining plot tracks contain the results of the spectra analyses. The computed activity values are generally plotted on two linear scales and, similar to the total gamma plot, the thin-line scale is indicated at the top of the plot, the wide-line scale at the bottom.

**RADIONUCLIDE LOGGING SYSTEM (RLS)
BOREHOLE SURVEY REPORT**

The RLS Borehole Survey Report describes the borehole conditions, unusual logging conditions, and possible limitations with the data and/or results. The species of radionuclides encountered, as well as their depth ranges and maximum activities, are reported.

APPENDIX C
BOREHOLE DATA PACKAGES

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

Project: 200-UP-1

Borehole	<u>299-W19-34A</u>				
Coordinates	<u>NA</u>	<u>N</u>	<u>NA</u>	<u>W</u>	Feet (Hanford System)
Elevation	<u>NA</u>	ft		Top of casing	

Borehole Environment Information

Borehole liquid depth 251.4 (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
16	0.50	0.0	43.0
12	0.375	0.0	186.0
8	0.375	0.0	343.2

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. V. Cram</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
Feb 28, 1994	H2W1934A\A530	MSA 120sec RT	0.0 42.5 0.5
Mar 10, 1994	H2W1934A\A538	MSA 80sec RT	41.5 186.5 0.5
Apr 18, 1994	H2W1934A\A555	MSA 80sec RT	185.5 212.5 0.5
Apr 19, 1994	H2W1934A\A556	MSA 80sec RT	211.5 344.0 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>May 23, 1994</u>	
Analysis Notes: <u>Double casing- exceeds max. correction factor</u>	
Radionuclides Identified: <u>No man-made radionuclides identified</u>	

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Apr 19, 1994

Borehole: 299-W19-34A

Anal Date: May 23, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Apr 19, 1994

Borehole: 299-W19-34A

Anal Date: May 23, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Apr 19, 1994

Borehole: 299-W19-34A

Anal Date: May 23, 1994

RLS Borehole Survey ReportBorehole: 299-W19-34A

Casing	Depth:	0.0' - 43.0'	Size: 16"	Thickness: 0.500"
		0.0 - 186.0'	12"	0.375"
		0.0 - 343.2'	8"	0.375"

Water 251.4'

Survey	Interval:	0.0' - 42.5'	Date: Feb 28, 1994
		41.5' - 186.5'	Mar 10, 1994
		185.5' - 212.5'	Apr 18, 1994
		211.5' - 344.0'	Apr 19, 1994

General Notes:

The well was surveyed during drilling. The surveys were conducted in three casing sizes. Short casing overlaps occurred at 41.5 to 43.0 feet, and from 185.5 to 186.0 feet. The overlaps did not impair the quality of the surveys and are depicted on the total gamma-ray logs as sharp decreases in the countrate. The casing thickness in these overlap intervals exceeded the maximum correction factor for the RLS system. The first survey was conducted with acquisition time of 120 seconds real time; successive surveys were acquired at 80 seconds real time.

The naturally occurring radionuclides potassium, uranium, and thorium were identified at concentrations which, for the most part, are consistent with Hanford sediments. Naturally occurring uranium concentration exceeded 4 pCi/g from approximately 55 to 82 feet, and several spikes over 4 pCi/g occurred from 178 to 185 feet. A review of the borehole lithology log in these areas indicates that the sediments varied from 100% gravel at 50 feet to gravelly sand and sandy gravel at 82 feet. All of the lithologic changes are gradual. The composition for the sand and gravel is mainly basalt and intrusive igneous and metamorphic rocks. Observations of the sediments recorded during drilling do not reveal the nature of the high uranium concentration.

Several responses on the total gamma profile can be correlated to lithologic characteristics on the borehole log. Abrupt lithologic changes occur from 0 to 40 feet and are indicated on the total gamma profile; the sediments range from sand, to gravelly sand and sandy gravel. At the bottom of the borehole, the peak on the total gamma profile at 333 to 335 feet is representative of an interval of hard tool drilling where no samples were recorded. The sediments above this zone are sand with trace gravel; below, the sediments are gravelly sand.

Detailed lithologic correlation is difficult where lithologic changes are subtle and horizons are thin. However gross features can be recognized from the total gamma profile.

No man-made radionuclides were identified from the survey.

Westinghouse Hanford Company

RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-1

Borehole	<u>299-W19-34B</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>273</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
12	0.50	0.0	275.6
10	0.375	0.0	413.4
8	0.322	0.0	554.5

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. K. Price</u> <u>S. E. Kos</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
July 7, 1994	H2W1934B\A588	MSA	80sec RT	330	415	0.5
Aug 31, 1994	H2W1934B\A600	MSA	80sec RT	410	504	0.5
Sep 01, 1994	H2W1934B\A601	MSA	80sec RT	502	556.5	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>Sep 2, 1994</u>
Analysis Notes: <u>Double casing- exceeds max. correction factor</u>	
Radionuclides Identified: <u>No man-made radionuclides identified</u>	

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Sep 1, 1994

Borehole: 299-W19-34B

Anal Date: Sep 2, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Sep 1, 1994

Borehole: 299-W19-34B

Anal Date: Sep 2, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Sep 1, 1994

Borehole: 299-W19-34B

Anal Date: Sep 2, 1994

RLS Borehole Survey ReportBorehole: 299-W19-34B

Casing	Depth:	0.0' - 275.6'	Size:	12"	Thickness:	0.500"
		0.0 - 413.4'		10"		0.375"
		0.0 - 554.5'		8"		0.322"

Water 273'

Survey	Interval:	330' - 415'	Date:	Jul 07, 1994
		410' - 504'		Aug 31, 1994
		502' - 556.5'		Sep 01, 1994

General Notes:

This borehole is in close proximity to borehole 299-W19-34A. Since no contamination was identified in borehole 299-W19-34A, and no significant lithological change was anticipated over the short distance between the boreholes, geophysical logging in borehole 299-W19-34B was not initiated until a depth of 330 feet was achieved (depth of final survey in borehole 299-W19-34A - 344.0 ft).

The well was surveyed during drilling, in three casing sizes. All surveys were conducted in single casing intervals. Short overlaps occurred at the beginning of surveys, and open hole conditions were logged at the end of some surveys. Decreased count rate was observed in overlaps, while increased count rate identified open hole intervals. All data were collected at an acquisition time of 80 seconds real time. Repeat intervals were conducted at the conclusion of each survey to verify equipment performance. The repeat data is included on the plots.

The naturally occurring radionuclides potassium, uranium, and thorium were identified at concentrations which are consistent with Hanford sediments.

No man-made radionuclides were identified from the surveys.

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

Project: 200-UP-1

Borehole	<u>299-W19-35</u>				
Coordinates	<u>NA</u>	<u>N</u>	<u>NA</u>	<u>W</u>	Feet (Hanford System)
Elevation	<u>NA</u>	<u>ft</u>	<u>Top of casing</u>		

Borehole Environment Information

Borehole liquid depth 241.74 (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
16	0.500	0	36
12	0.375	0	179
10	0.375	0	273.4

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. V. Cram</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
Feb 28, 1994	H2W19035\A529	MSA	120sec RT	0.0	35.7
Mar 09, 1994	H2W19035\A537	MSA	80sec RT	35.0	178.5
Mar 23, 1994	H2W19035\A546	MSA	80sec RT	177.5	250.0
Mar 28, 1994	H2W19035\A548	MSA	80sec RT	248.0	273.5

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>Mar 29, 1994</u>	
Analysis Notes: _____	
Radionuclides Identified: <u>Cs-137</u>	

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Mar 28, 1994

Borehole: 299-W19-35

Anal Date: Mar 29, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Mar 28, 1994

Borehole: 299-W19-35

Anal Date: Mar 29, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Mar 28, 1994

Borehole: 299-W19-35

Anal Date: mar 29, 1994

RLS Borehole Survey Report

Borehole: 299-W19-35

Casing	Depth:	0.0' - 36.0'	Size: 16"	Thickness: 0.500"
		0.0 - 179.0'	12"	0.375"
		0.0 - 273.4'	10"	0.375"

Water 240.0'

Survey	Interval:	0.0' - 35.7'	Date: Feb 28, 1994
		35.0' - 178.5'	Mar 09, 1994
		177.5' - 250.0'	Mar 23, 1994
		248.0' - 373.5'	Mar 28, 1994

General Notes:

The well was surveyed during drilling. The surveys were conducted in three casing sizes. Short casing overlaps occurred at 35.0 to 36.0 feet, and from 177.5 to 179.0 feet. The overlaps did not impair the quality of the surveys and are depicted on the total gamma-ray logs as sharp decreases in the countrate. The casing thickness in these overlap intervals as well as in the 16 inch diameter casing exceeded the maximum correction factor for the RLS system. The first survey was conducted with acquisition time of 120 seconds real time; successive surveys were acquired at 80 seconds real time.

The naturally occurring radionuclides potassium, uranium, and thorium were identified at concentrations which, for the most part, are consistent with Hanford sediments.

Man-made Radionuclides:

Cesium (Cs-137) was identified at the surface of the borehole from 0.0 to 2.0 feet. The maximum activity observed was less than 1 pCi/g.

Cobalt (Co-60) was analyzed but was not identified. The Co-60 plot is included for uniformity in presentation.

Europium (Eu-152, Eu-154) were not analyzed; the plots are included for uniformity in presentation.

Westinghouse Hanford Company

NaI Spectral Gamma-Ray Borehole Survey Log Header

Project Information

Borehole	<u>699-38-68A</u>
Project	<u>200-UP-1</u>

Borehole Environment Information

Borehole liquid depth <u>NA</u> (ft) from zero (0.0) depth reference of log			
Casing size (inch)	Casing thickness (inch)	Top depth (feet)	Base depth (feet)
12	.375	0	36.5

NaI Passive Spectral Gamma Survey Information

Logging Engineer(s) <u>A. W. Pearson</u> Log depth reference at zero (0.0) depth is <u>ground level</u> Depth return error recorded at zero depth reference. ☒ Pre log energy calibration spectra recorded with field verifier. ☒ Logging Equipment was cleaned as described in WHC-CM-7-7 EII 11.1 Section 5.4 Signed <u>Steve E. Kim</u> Date <u>10/7/94</u> Detector Type: <u>NaI Spectra</u> Detector ID: <u>RLSN3</u> Calibration Date: _____ Notes: <u>Total Gamma-ray activity is computed from each recorded spectra.</u> <u>Casing thickness and borehole fluid corrections are not applied.</u>							
Log Date	Archive File Names	Log Mode	Speed ft/m	Depth interval (ft) Top Base Incr			Return Error (inch)
4/27/94	N122	Fixed	2.5	0	35.5	0.5	NA

Fixed: Constant Winch Speed

Nal Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date Depth Range

Borehole: 699-38-68A

Apr 27, 1994 0 - 35'

No Corrections Applied

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

Project: 200-UP-1

Borehole	<u>699-38-68A</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>255.0</u> (ft) from zero (0.0) depth reference of log			
Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
12	0.375	0.0	36.5
10	0.375	0.0	184.0
8	0.313	0.0	304.5

RLS Passive Spectral Gamma Survey Information

Logging Engineers <u>R. Cram</u> <u>J. Kunk</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
May 10, 1994	N638068A\A561	MSA	80sec RT	35.0	125.0 0.5
May 11, 1994	N638068A\A562	MSA	80sec RT	124.0	189.5 0.5
Jun 16, 1994	N638068A\A576	MSA	80sec RT	184.0	262.5 0.5
Jun 20, 1994	N638068A\A578	MSA	80sec RT	260.0	296.5 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>
Analysis Date: <u>Jun 24, 1994</u>
Analysis Notes: _____
Radionuclides Identified: <u>No man-made radionuclides were identified</u>

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Jun 20, 1994

Borehole: 699-38-68A

Anal Date: Jun 24, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Jun 20, 1994

Borehole: 699-38-68A

Anal Date: Jun 24, 1994

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-1

Log Date : Jun 20, 1994

Borehole: 699-38-68A

Anal Date: Jun 24, 1994

RLS Borehole Survey Report

Borehole: 699-38-68A

Casing	Depth:	0.0' - 36.5'	Size: 12"	Thickness: 0.375"
		0.0 - 184.0'	10"	0.375"
		0.0 - 304.5'	8"	0.313"

Water 255.0'

Survey	Interval:	35.0' - 125.0'	Date: May 10, 1994
		124.0' - 189.5'	May 11, 1994
		184.0' - 262.5'	Jun 16, 1994
		260.0' - 296.5'	Jun 20, 1994

General Notes:

The RLS surveys were acquired through three casing strings at acquisition times of 80 seconds RT.

Repeat sections were acquired at 122.5 to 125.0 feet, 185.0 to 187.5 feet, 260.0 to 262.5 feet, and from 294.0 to 296.5 feet. The data acquired during repeat surveys are included on the plots.

The concentrations of the naturally occurring radionuclides potassium, uranium, and thorium are typical for Hanford sediments.

No man-made radionuclides were identified.

APPENDIX D
GEOLOGIC DATA

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Lithologic Descriptions

Ringold Fm unit A - Pebble to cobble gravel with a fine- to coarse-grained sand matrix is the dominant lithology. Lenticular, interbedded silt paleosols are found locally, interstratified sand horizons are common, and cemented zones are present in the gravel.

Ringold Fm, lower mud unit - The lower mud unit consists of silt-rich lake deposits and paleosols. Sand beds may be present locally in the unit but are of limited lateral extent and continuity.

Ringold Fm, unit E - Pebble to cobble gravel with a fine- to coarse-grained sand matrix is the dominant lithology. Lenticular, interbedded silt paleosols and sand horizons are found locally and cemented zones are present in the gravels.

Ringold Formation, upper unit - The unit consists of interbedded silt, sand, and gravel that is uncemented to calcareous. Clastic dikes may also be present.

Plio-Pleistocene unit - This unit consists of a combination of calcareous sand, silty sand, silt, and gravelly sand. Individual beds are lenticular, commonly pinching out between boreholes. The upper part of the unit (referred to in many reports as the early Palouse Soil) is a massive-to-stratified silt to sandy silt. Pedogenic calcium carbonate (caliche) horizons characterize the lower half of the Plio-Pleistocene unit beneath the site. Subvertical clastic dikes may cross-cut the unit, and iron oxide stained intervals may occur.

Hanford fm., unit 2 (fine unit) - It consists of unconsolidated sand, gravelly sand, silty sand, and silt. Some sediment packages may have lenticular geometries. The unit typically shows a large-scale tendency to fine downward into more silt-rich sediments. Individual beds, particularly in the lower parts of the unit, tend to be normally graded with a thin silt at the top of each bed. Widely scattered clastic dikes have been observed within the unit, and calcareous (but not cemented) intervals are common.

Hanford fm., unit 1 (upper coarse) - This unit consists of unconsolidated gravel, sandy gravel, gravelly sand, sand, and rare silt stringers. Sand fractions typically have a distinctive salt-and-pepper texture. Gravels may locally exhibit open framework textures.

Hanford fm., unit 1a (upper fine) - This unit gradationally overlies unit 1 and consists dominantly of fine- to coarse-grained sand. Gravel beds (probably open framework) a few cm's to m's thick are intercalated in this unit. Silt-rich beds a few cm's thick also may be present. Note: This unit is assigned to unit 1 in Kelly et al. (in prep).

APPENDIX E
METRIC CONVERSIONS

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To Convert	Multiply By	To Convert	Multiply By
LINEAR MEASURE (LENGTH)			
inches to millimeters	25.4	millimeters to inches	0.0394
inches to centimeters	2.54	centimeters to inches	0.394
feet to meters	0.305	meters to feet	3.281
yards to meters	0.914	meters to yards	1.094
miles to kilometers	1.609	kilometers to miles	0.621
SQUARE MEASURE (AREA)			
square inches to square centimeters	6.452	square centimeters to square inches	0.155
sq feet to sq meters	0.0929	sq meters to sq feet	10.764
sq yards to sq meters	0.836	sq meters to sq yards	1.196
acres to hectares	0.405	hectares to acres	2.471
CUBIC MEASURE (VOLUME)			
cubic inches to cubic centimeters	16.387	cubic centimeters to cubic inches	0.0610
cu feet to cu meters	0.0283	cu meters to cu feet	35.315
cu yards to cu meters	0.765	cu meters to cu yards	1.308
LIQUID MEASURE (CAPACITY)			
fluid ounces to liters	0.0296	liters to fluid ounces	33.814
quarts to liters	0.946	liters to quarts	1.057
gallons to liters	3.785	liters to gallons	0.264
imperial gallons to liters	4.546	liters to imperial gallons	0.220
WEIGHTS (MASS)			
ounces avoirdupois to grams	28.35	grams to ounces avoirdupois	0.0353
pounds avoirdupois to kilograms	0.454	kilograms to pounds avoirdupois	2.205
tons to metric tons	0.907	metric tons to tons	1.102
TEMPERATURE			
32 °F (freezing point of water)		0 °C	
212 °F (boiling point of water)		100 °C	
98.6 °F (body temperature)		37 °C	
To find degrees Celsius, subtract 32 degrees Fahrenheit and divide by 1.8. To find degrees Fahrenheit, multiply degrees Celsius by 1.8 and add 32.			

To convert from >> to <<	to >> To convert from <<	multiply by divide by
PRESSURE and STRESS		
pounds force per square inch (lbf/in ² or psi)	kilopascals (kPa)	6.895
thousand pounds force per square inch (kip/in ² or ksi)	megapascals (MPa)	6.895
inches of water (60 °F)	pascals (Pa)	248.8
millimeters of mercury (0 °C)	pascals (Pa)	133.3
ENERGY and WORK		
British thermal units (Btu), International Table	kilojoules (kJ)	1.055
Calories (kilocalories), Int'l	kilojoules (kJ)	4.187
electronvolts (eV)	joules (J)	1.602×10^{-19}
kilowatt hours (kW·h)	megajoules (MJ)	3.600
POWER		
British thermal units (Int'l) per hour (Btu/h)	watts (W)	0.293
horsepower (electric)	watts (W)	746.0
horsepower (boiler)	kilowatts (kW)	9.81
tons of refrigeration	kilowatts (kW)	3.517
TORQUE and BENDING MOMENT		
ounce force inches (ozf·in) ("inch-ounces")	millinewton meters (mN·m)	7.062
pound force inches (lbf·in) ("inch-pounds")	newton meters (N·m)	0.113
pound force feet (lbf·ft) ("foot-pounds")	newton meters (N·m)	1.356
FLOW RATES		
cubic feet per minute (ft ³ /min or cfm)	liters per second (L/s)	0.472
cubic feet per minute (ft ³ /min or cfm) [flow > 20,000 cfm]	cubic meters per second (m ³ /s)	0.000 472
gallons per minute (gpm) [flow rate < 30 gpm]	milliliters per second (mL/s)	63.1
gallons per minute (gpm)	liters per second (L/s)	0.063 1
pounds mass per hour (lbm/h)	kilograms per second (kg/s)	0.000 126

To convert from to <<	>> to To convert from <<	multiply by divide by
NUCLEAR and RADIATION UNITS		
barns (b) [neutron absorption cross-section]	square meters (m ²)	1.00×10^{-28}
curies (Ci)	becquerels (Bq)	3.70×10^{10}
microcuries (μCi)	becquerels (Bq)	3.70×10^4
picocuries (pCi)	becquerels (Bq)	0.037 0
rad *	gray (Gy) *	0.010 0
rad *	centigray (cGy) *	1.000
millirad (mrad) *	microgray (μGy) *	10.000
rem *	sievert (Sv) *	0.010 0
rem *	millisievert (mSv) *	10.0
millirem (mrem) *	millisievert (mSv) *	0.010 0
millirem (mrem) *	microsievert (μSv) *	10.000
roentgen (R) *	coulombs per kilogram * (C/kg)	0.000 258
milliroentgen (mR) *	microcoulombs per kilogram (μC/kg) *	0.258
* The same "per unit time" (e.g., per hour, per year) may be added to obtain rate units with the same multipliers. For example, 1 rem <i>per year</i> is equal to 10 millisieverts <i>per year</i> .		
ELECTRICITY and MAGNETISM		
NOTE: The following units of electricity and magnetism, including their multiples and submultiples, are SI units needing no conversion.		
ampere (A)		
candela (cd) [1 cd = 1 candlepower]		
coulomb (C)		
farad (F)		
henry (H)		
hertz (Hz) [1 Hz = 1 cycle per second]		
lumen (lm)		
ohm (Ω)		
siemens (S) [1 S = 1 mho]		
tesla (T)		
volt (V)		
watt (W)		
weber (Wb)		

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To Distribution	From J. W. Fassett	Page 1 of 1			
		Date 12/04/95			
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		ECN No. N/A			
Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
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