START 97 3540.2834

0045925

OCT 02 1996 (20) Sta. 37

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT № 610772

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Geophysics Group	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: LES/HTS/Geophysics	6. Design Authority/ Design Agent/Cog. Engr.: N/A	7. Purchase Order No.: N/A
8. Originator Remarks: WHC-SD-EN-TI-261, Spectral Gamma-ray Logging for the 100-N Area; Hanford, Washington, Rev 0		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
11. Receiver Remarks: 11A. Design Baseline Document? [] Yes [X] No		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-EN-TI-261		0	Spectral Gamma-ray Logging for the 100-N Area, Hanford, Washington	N/A	1/2		

16. KEY

Approval Designator (F)	Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN
		Design Authority	3		Central files (2)
		Design Agent N1-55	3		EDMC (2)
1/4	1	Cog.Eng., R. K. Price RKPrice 23Sep96			~~OSTI (2)~~
1/4	1	Cog. Mgr., R. A. Meznarich RAMeznarich 10/2/96			
		QA H6-30			
		Safety			
		Env.			

18.	19.	20.	21. DOE APPROVAL (if required)
R. K. Price RKPrice 23Sep96 Signature of EDT Originator Date	Authorized Representative for Receiving Organization Date	R. A. Meznarich RAMeznarich 10/2/96 Design Authority/ Cognizant Manager Date	Ctrl. No. N/A [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

NOV 1996 RECEIVED EDMC

BD-7400-172-1

9713540.2835

WHC-SD-EN-TI-261, Rev. 0

Spectral Gamma-ray Logging for the 100-N Area; Hanford, Washington

G. J. Szwartz
Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

EDT/ECN: 610772 UC: 630
Org Code: 8H100 Charge Code: R4V11
B&R Code: EW3120100 Total Pages: 46

Key Words: Geophysics, Gamma-ray, RLS

Abstract: The objective of this effort was to delineate the vertical distribution and concentration of anthropogenic radionuclides in the subsurface surrounding nine boreholes in the 100-N Area available for geophysical logging with the Radionuclide Logging System (RLS). Cesium was defined in eight boreholes, and the ninth hole was found to not contain any such radionuclides.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: WHC/BCS Document Control Services, P.O. Box 1970, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

Release Approval Date Release Stamp

Approved for Public Release

9713540.2836

CONTENTS

1.0 INTRODUCTION 1

2.0 GEOLOGY 1

3.0 SITE DESCRIPTION 2

4.0 PREVIOUS RLS SURVEYS IN THE AREA 4

5.0 THE SURVEY DATA 4

6.0 CONCLUSIONS 6

7.0 REFERENCES 7

FIGURE

1. Location Map 3

TABLES

1. 100-N Area Borehole Logging History 4

2. Summary of Maximum Radionuclide Depths From RLS Log Surveys of 100-N Area 5

3. Summary of Detected Radionuclide Depth Ranges and Concentrations From RLS Log Surveys of 100-N Area 6

APPENDICES

A RLS Survey Data and Spectral Gamma Plots A-1

B The RLS System B-1

9713540.2837

SPECTRAL GAMMA-RAY LOGGING FOR THE 100-N AREA; HANFORD, WASHINGTON

1.0 INTRODUCTION

The purpose of the project was to collect and analyze gamma-ray radiation detected in the nine 100-N Area boreholes listed in Table 1. The interpreted Radionuclide Logging System (RLS) data detailed in this report provides a basis for subsurface contamination characterization. Of the nine boreholes logged, eight were identified with the radioisotope cobalt in them with the majority of it in the 50- to 70-ft range. No other man-made isotope was identified. Only borehole 100-N-56 appears to be "clean".

The data were collected and analyzed from October 1992 through February 1993, and the data and results were transmitted to the appropriate group upon completion of the analysis. This report is intended to put the data in the public domain for future reference.

The contents of this report are limited to the description of the survey results for each borehole logged. A description and details of the RLS System and how it worked in this project and the limitations to radioelement analysis are contained in Appendix B. Readers unfamiliar with this logging system are referred to this appendix and urged to review it for pertinent information to familiarize themselves with the capabilities of the RLS and the data limitations.

Details of equipment configuration, calibration, logging procedures, casing- and water-correction factors, spectral analysis software, and data management have been excluded from this report. The details of these topics are described in the Koizumi, et. al. (1991, 1992) and Brodeur, et. al. (1991, 1992), papers cited in the References.

2.0 GEOLOGY

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 as follows: Miocene-Pliocene Ringold Formation, post-Ringold pre-Hanford sediments, glacio-fluvial deposits of the Hanford formation, and surficial Holocene eolian and fluvial sediments.

The vadose zone beneath the 100-N Area in the northern part of the Hanford Site is comprised primarily of unconsolidated sediments of the Hanford formation. This highly permeable unit is composed of mainly cobbles, boulders, gravel, and course sand. Drilling data indicate that isolated lenses of silty sand and gravel are also present. Moisture content ranges from 1 to 3 percent in the vadose zone (Hartman 1992a, 1993).

3.0 SITE DESCRIPTION

The 100-N Area is located adjacent to the Columbia River in the northern part of the Hanford Site (Figure 1). The 100-N Area is home to the now-retired N-Reactor and a number of waste disposal sites. Wastes discharged to the ground include radioactive cooling water and corrosive wastes. Leaking storage tanks and pipes introduced petroleum products to the ground (Hartman 1993).

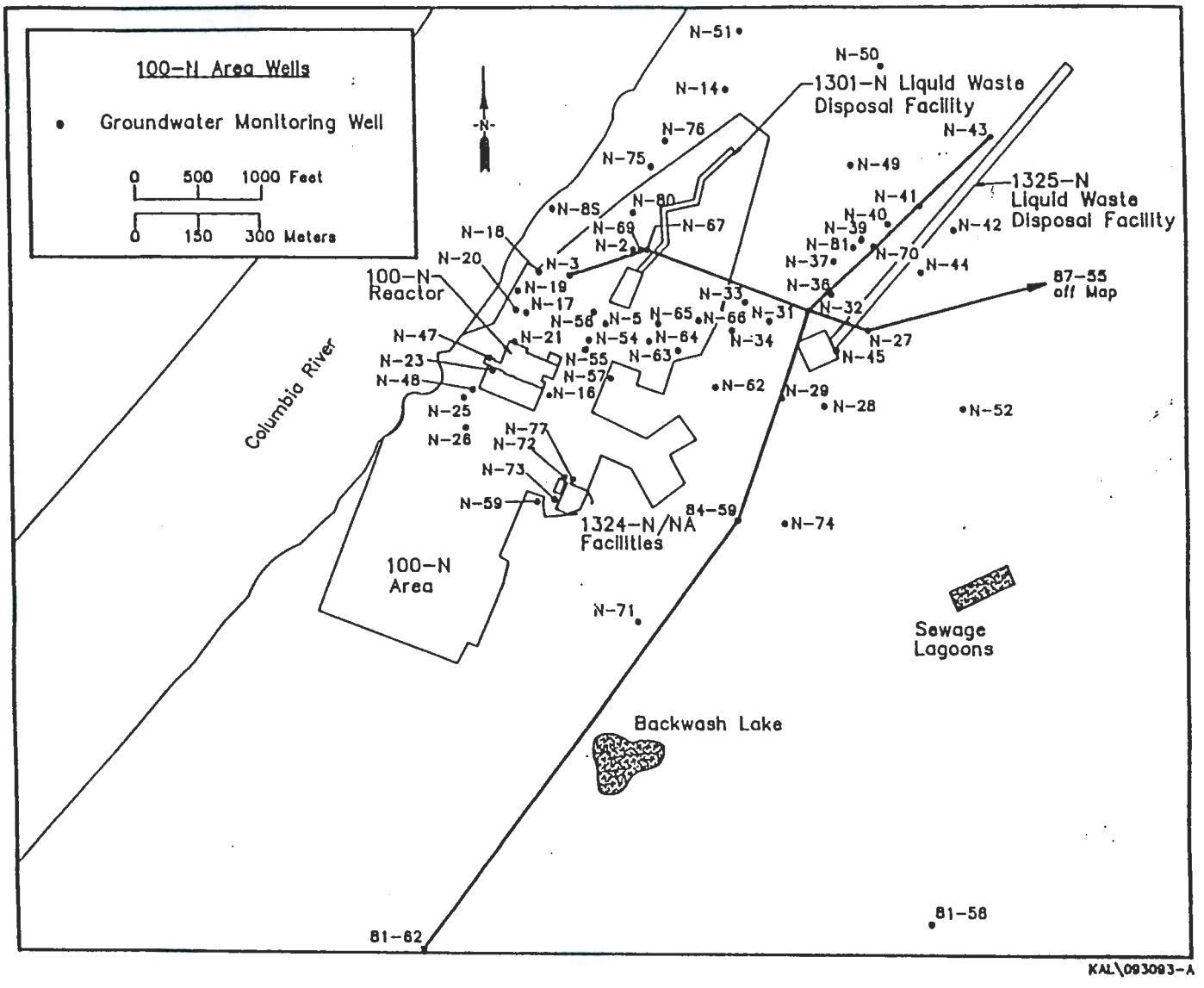
Boreholes 199-N-27, -28, -29, -39, -44, and -70 are within 300 ft of the 1325-N Liquid Waste Disposal Facility (LWDF). The 1325-N LWDF received N-Reactor cooling water and fuel-storage-basin water between 1983 and 1991 (DOE 1987a). The facility comprises a concrete-covered, rectangular basin and an unlined concrete-covered extension trench. The volume of effluent discharged to the 1325-N LWDF varied with the operational status of the N-Reactor. The effluent flow was 1000 to 1600 gal/min during normal operation (Tuck 1990a/b). The effluent contained a suite of radionuclides, many of which were present at low activities or have short half-lives. The highest activities of radionuclides included ^{90}Sr, ^{60}Co, ^{137}Cs, and ^{3}H. Cobalt and cesium emit gamma rays during beta decay. Strontium and tritium decay by beta particle emissions only, but the results of the high-energy beta particles emitted by strontium can be detected by the RLS (see Appendix B). The RLS cannot delineate the energy from the strontium beta decay, but it is detectable as unresolved higher levels of gamma-ray radiation.

Minor amounts of non-radioactive dangerous wastes were also present in the waste water stream, including hydrazine and ammonia. The presence of these dangerous constituents caused the 1325-N LWDF to be classified as a RCRA disposal unit.

Borehole 199-N-56 is in close proximity to the 1301-N LWDF. The 1301-N LWDF received N-Reactor cooling water and fuel-storage-basin water between 1962 and 1985 (DOE 1987b). The facility comprises a rectangular basin connected to a zig-zagging trench with concrete sides and cover, and with an open bottom. The effluent contained radionuclides and minor amounts of dangerous waste. Composition of this effluent is assumed to be similar to that discharged to the 1325-N LWDF described above. The 1301-N is a RCRA facility.

Boreholes 199-N-75 and -76 were drilled between the river and the 1301-N LWDF outside the boundary of the 100-N Area. Well 199-N-75 was logged during the 100-NR-2 Operable Unit studies.

Figure 1. Location Map.



4.0 PREVIOUS RLS SURVEYS IN THE 100-N AREA

Many wells have been logged in the 100 N-Area. Of the wells detailed in this report, all but one had been logged prior to 1993. The date and results of the previous surveys of each borehole are presented in Table 1.

Table 1. 100 N-Area Borehole Logging History.

Borehole	Log date	Logbase	Category
199-N-27	2/23/84	69'	contamination
199-N-28	2/23/84	84'	contamination
199-N-29	2/28/84	85'	contamination
199-N-39	5/02/84	78'	natural
199-N-44	5/04/84	82'	natural
199-N-56	6/22/87	73'	possible contamination
199-N-70	5/17/88	103'	possible Contamination
199-N-75	4/29/92	68'	contamination
199-N-76	4/28/92	82'	contamination

5.0 THE SURVEY DATA

Appendix A, made up of individual logging summary reports for each well, contains the plotted RLS data and results. Each cover page entitled "RLS Spectral Gamma-Ray Borehole Survey Log Header" summarizes the borehole and survey information. Table 2, below, also summarizes the data. Plots of the total gamma-ray counts per second (Total Gamma) along with the calculated man-made isotope concentration data are presented on the page following the log header.

The plots of radionuclide-activity response versus depth are shown in Appendix A, with notes and a summary. On the plots in this appendix, a uniform depth scale of 20 feet per inch, and a radionuclide-concentration scale of 40 pCi/g per inch are used. The experimental uncertainties in the computed radionuclide activities are not presented on the data plots at this time. The Total Gamma is the count rate for all gamma rays detected by

the RLS detector, with no discrimination of gamma-ray energy. The Total Gamma is equivalent to the gross gamma-ray log commonly used in the past at Hanford. The remaining plot tracks contain the results of the spectral gamma-ray analysis. The natural radionuclide gamma-ray activity, that of potassium, uranium and thorium, is discerned through the normal spectral analysis and is plotted separately on the page following the concentrations of man-made elements.

Table 2. Summary of Maximum Radionuclide Depths from RLS Log Surveys of 100 N Area.

Borehole ID	Survey Date[1]	Survey Depth[2]	Cobalt-60 Depth[3]
199-N-27	11/18/92	66'	63'
199-N-28	11/03/92	80'	80'[4]
199-N-29	11/11/92	82'	82'[4]
199-N-39	12/16/92	61'	61'[4]
199-N-44	12/15/92	69'	69'[4]
199-N-56	10/14/92	70'	-
199-N-70	12/02/92	97'	97'[4]
199-N-75	05/01/92	86'	85'
199-N-76	12/03/92	78'	77'

[1]Date survey was completed
[2]Maximum survey depth
[3]Maximum depth where radionuclide was identified
[4]Maximum depth of borehole survey

Long-count, stationary measurements of at least 300 seconds were recorded at some depth points (stations) (seen as short bars in the data plots) in all holes to verify the data acquired at the 80-seconds-per-half-ft survey. Both the long and 80-second measurements were acquired at essentially some given common depth. The extended acquisition time did not identify additional radionuclides in any of these wells.

The decay activity for the natural radionuclides, potassium, uranium, and thorium, have been computed by the data reduction program and are presented on the page following the plots of the other data.

6.0 CONCLUSIONS

No man-made radionuclides were detected with the RLS in the subsurface for well 199-N-56. All other wells detailed in this report had some level of cobalt detected. The distribution and activity of cobalt in these wells is detailed in Table 3, below.

Table 3. Summary of Detected Radionuclide Depth Ranges and Concentrations from RLS Log Surveys of 100-N Area.

Borehole ID	Radionuclide Detected[1]	Range(s) Detected	Depth of Maximum Activ.[2]	Gross Gamma Results	Maximum Indicated Activity[3]
199-N-27	Cobalt-60	0-0.5' 24-63'	50'	contamin	63 pCi/g
199-N-28	Cobalt-60	58-80'	68'	contamin	13 pCi/g
199-N-29	Cobalt-60	48-82'	65'	contamin	10 pCi/g
199-N-39	Cobalt-60	45-61'	48'	natural	<1 pCi/g
199-N-44	Cobalt-60	0-51'[4] 51-69'	66'	natural	<5 pCi/g
199-N-70	Cobalt-60	1-86'[4] 87-96'	89.5'	possible contamin	2.7 pCi/g
199-N-75	Cobalt-60	52-85'	-	contamin	<1 pCi/g
199-N-76	Cobalt-60	4-77'[4] 52-62'	-	contamin	<1 pCi/g

[1]Only man-made radionuclides
[2]As analyzed in the RLS data
[3]In picoCuries per gram
[4]Discontinuous Detection.

The written assessment of the radioactivity made in the RLS Borehole Survey Reports in Appendix A are found in the General Notes for each borehole.

The site geology is characterized by the presence of gravelly sand with moisture less than 4 percent by weight. Based on this characterization, it is reasonable to assume that radionuclide travel in the horizontal direction would be limited. Wells 199-N-39 and 199-N-70 are within 30 meters of each other, yet spectral analysis plots in Appendix A do not reveal obvious correlations in cobalt-60 depth nor activity, indicating no strong horizontal movement of wastes between the two boreholes in the vadose zone.

There are numerous wells in the 100-N Area which could be studied comprehensively and simultaneously to determine the spacial relationship between detected man-made radionuclides and lithology. A geostatistical analysis of this spacial relationship could be used to develop a theoretical model of the subsurface strata and contamination. However, such studies are beyond the scope of this effort at this time.

9713540.2840

7.0 REFERENCES

Brodeur, J. R., C. J. Koizumi, W. H. Ulbricht, Jr., and R. K. Price, 1991, *Calibration of a High-Resolution Passive Gamma-Ray Logging System for Nuclear Waste Assessment*, WHC Speech Article Report, WHC-SA-1175-FP, Westinghouse Hanford Company, Richland, Washington.

Brodeur, J. R., C. J. Koizumi, R. K. Price, and R. D. Wilson, 1992, *Gamma-Ray Logging Results for the 200 Aggregate Area Management Study,* WHC-SD-EN-TI-021, Westinghouse Hanford Company, Richland, Washington.

DOE, 1987a, *Preliminary Closure/ Post-Closure Plan 1325-N Liquid Waste Disposal Facility,* U.S. Dept. of Energy, Richland Operations Office, Richland, Washington.

DOE, 1987b, *Preliminary Closure/ Post-Closure Plan 1301-N Liquid Waste Disposal Facility*, U.S. Dept. of Energy, Richland Operations Office, Richland, Washington.

Hartman, M. J., 1992a, *Borehole Completion Data Package for Wells 199-N-71, 199-N-72, 199-N-73, and 199-N-74,* WHC-SD-EN-DP-040, Westinghouse Hanford Company, Richland Washington.

Hartman, M. J., 1992b, *Results of Ground Water Quality Assessment Monitoring at the 1301-N Liquid Waste Disposal Facility and 1324-N/NA Facilities,* WHC-SD-EN-EV-030, Rev.1, Westinghouse Hanford Company, Richland, Washington.

Hartman, M. J., and K. A. Lindsey, 1993, *Hydrogeology of the 100N Area, Hanford Site, Washington*, WHC-SD-EN-EV-027, Westinghouse Hanford Company, Richland, Washington.

Koizumi, C. J., J. R. Brodeur, W. H. Ulbricht, Jr., and R. K. Price, 1991, *Calibration of the RLS HPGe Spectral Gamma-Ray Logging System,* WHC-EP-0464, Westinghouse Hanford Company, Richland, Washington.

Koizumi, C. J., R. K. Price, and R. D. Wilson, 1992, *Calibration of the RLS System for 200 Aggregate Area Management Study Screening Measurements,* WHC-SD-EN-TRP-001, Westinghouse Hanford Company, Richland, Washington.

Tuck, J. A, 1990a, *N Reactor Effluent Stream-Specific Report*, WHC-EP-0342, Addenda 3 , Westinghouse Hanford Company, Richland Washington.

Tuck, J. A., 1990b, *163N Demineralization Plant Wastewater Stream-Specific Report*, WHC-EP-0342, Addendum 4, Westinghouse Hanford Company, Richland, Washington.

9713540.2841

APPENDIX A

RLS SURVEY DATA AND SPECTRAL GAMMA PLOTS

This page intentionally left blank.

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

Project: 100-N

Borehole	199-N-27			
Coordinates	7728 N	4103 W	Feet	(Plant 200 W)
Elevation	449.08 ft		Top of casing	(Plant 200 W)

Borehole Environment Information

Borehole fluid depth 48 (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
8	0.30	0	69

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Nov 18, 92	H1N27\A286	MSA 80sec RT	0	66	0.5
		Station 300sec	66ft		

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

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

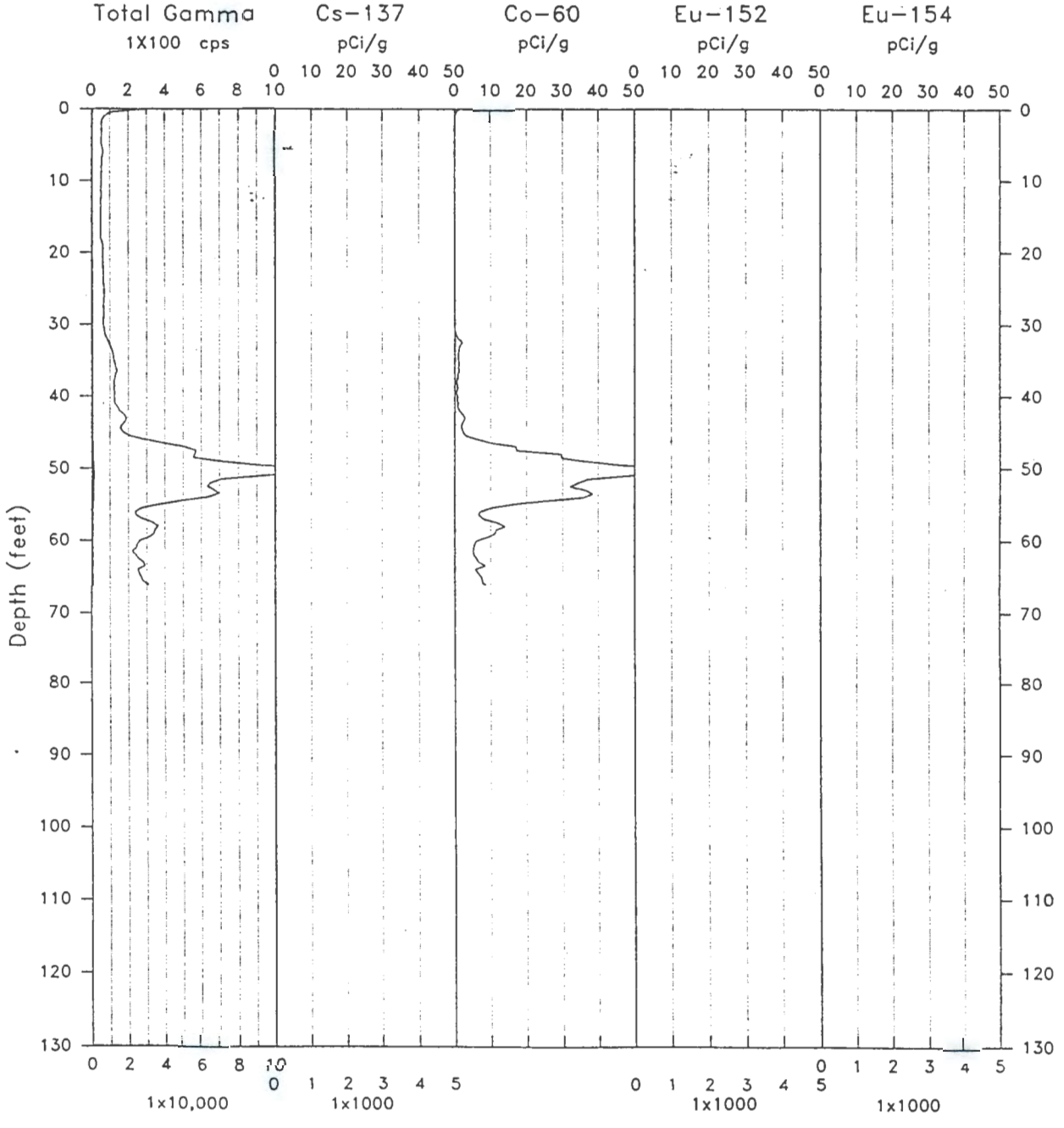
Analyst Names: J. P. Kiesler
Analysis Date: Dec 01, 1992

Analysis Notes:
Radionuclides Identified: Co-60, Cs-137 at the surface only

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole: 199-N-27

Log Date: Nov 18, 1992
Anal. Date: Dec 1, 1992



RLS Borehole Survey Report

Borehole: 199-N-27

Casing	Depth: 69′	Size: 8"	Thickness: 0.30"
Water	Depth: 48′		
Survey	Depth: 0 - 66′	Date: 11/18/92	
	Station 66′		

General Notes:

Man-made Radionuclides:
Cesium (Cs-137) was detected only at the surface near the threashold of detection.

Cobalt (Co-60) was detected at the surface, 0 to 0.5 feet, and from 24 to 63 feet. The indicated activity was less than 1 pCi/g at the surface and the maximum activity detected was 63 pCi/g at 50 feet.

No Europium (Eu-152) detected, template presented for uniformity of presentation only.

No Europium (Eu-154) detected, template presented for uniformity of presentation only.

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

Project: 100-N

Borehole	199-N-28				
Coordinates	7050 N	4165 W	Feet	(Plant 200 W)	
Elevation	464.24 ft		Top of casing	(Plant 200 W)	

Borehole Environment Information

Borehole fluid depth 63 (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
8	0.31	0	48

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Nov 03, 92	H1N28\A274	MSA 80sec RT	0	45	0.5
			45	80	0.5
		Station 300sec	80ft		

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
Analysis Date: Dec 01, 1992

Analysis Notes: No correction applied for well screen 43 to 83 feet
Radionuclides Identified: Co-60,

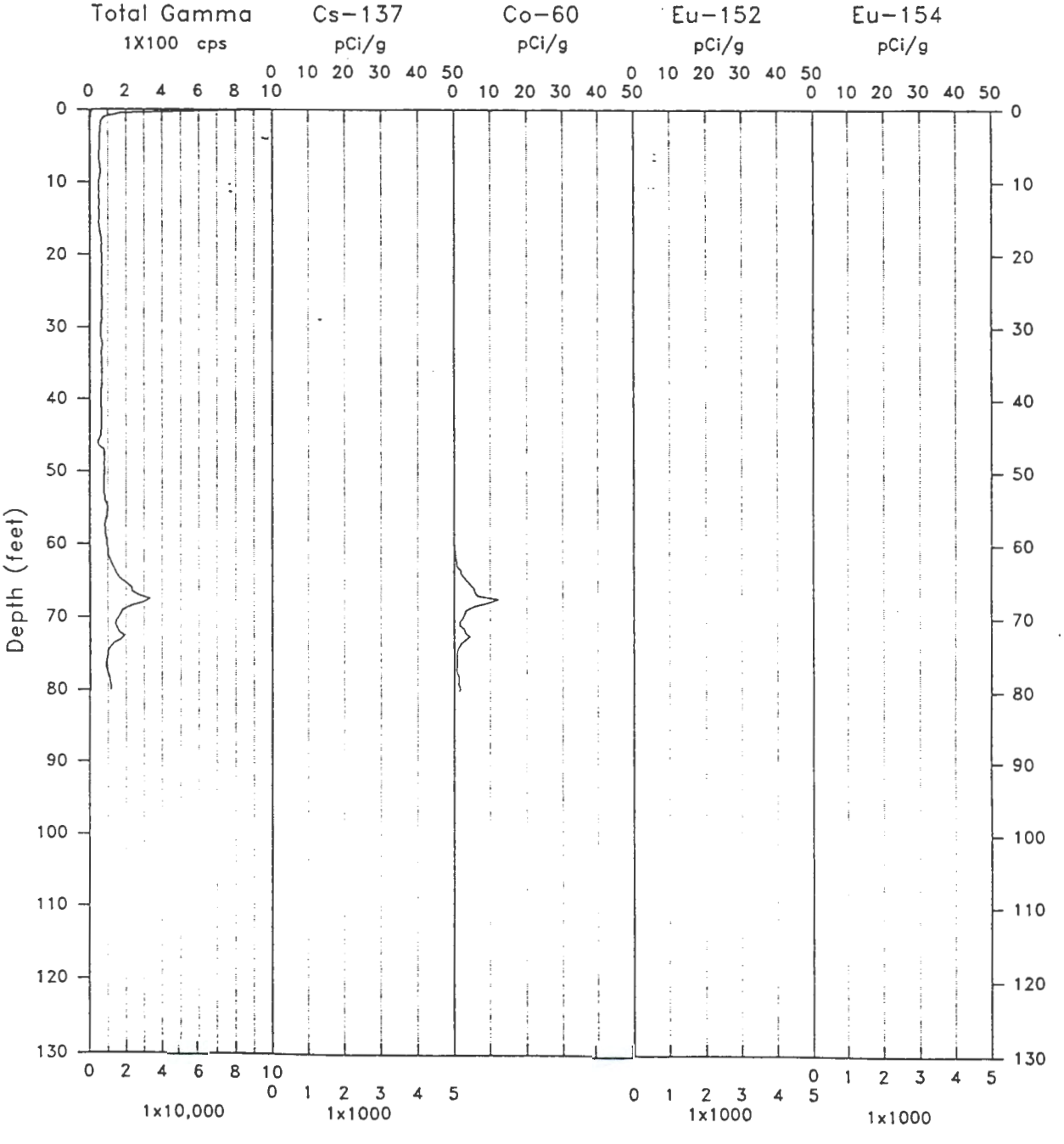
RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N

Borehole: 199-N-28

Log Date: Nov 3, 1992

Anal. Date: Dec 2. 1992



RIS Borehole Survey Report

Borehole: 199-N-28

Casing	Depth:	48′	Size: 8"	Thickness: 0.31"
Screen	Depth:	43 - 83′		
Water	Depth:	63′		
Survey	Depth:	0 - 45′	Date: 11/03/92	
		45 - 80′		

General Notes:
No correction is available for the well screen and activities may be higher than indicated.

Man-made Radionuclides:
Cobalt (Co-60) was detected at the surface and from 58 to 80 feet. The indicated activity was less than 1 pCi/g at the surface and the maximum activity detected was 13 pCi/g at 68 feet.

No Europium (Eu-152) detected, template presented for uniformity of presentration only.

No Europium (Eu-154) detected, template presented for uniformity of presentation only.

No Cesium (Ce-137) detected, template presented for uniformity of presentation only.

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

Project: 100-N

Borehole	199-N-29			
Coordinates	6943 N	4525 W	Feet	(Plant 100 Area)
Elevation	465.25 ft		Top of casing	(Plant 100 Area)

Borehole Environment Information

Borehole fluid depth 64 (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
8	0.30	0	85
telescoping screen	unknown	47.5	84

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Nov 11, 1992	H1N29\A287	MSA 80sec RT	0	82	0.5
		Station 300sec	82 ft		

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

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

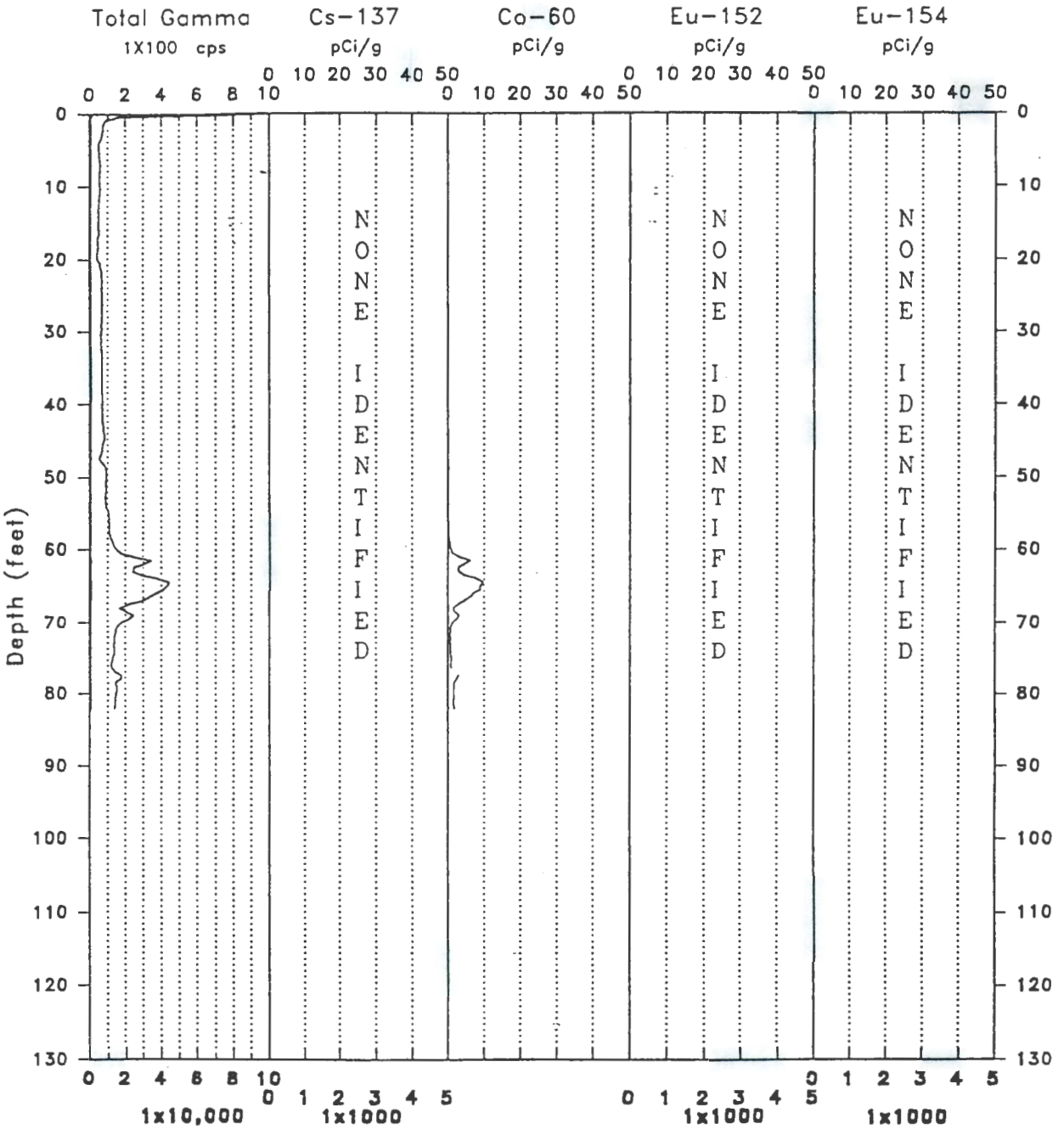
Analyst Names: J. P. Kiesler R. K. Price
Analysis Date: Feb 15, 1993

Analysis Notes: Comparison with 2/23/84 survey indicates differences.
Radionuclides Identified: Co-60

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole: 199-N-29

Log Date: Nov 19, 1992
Anal. Date: Feb 15, 1993

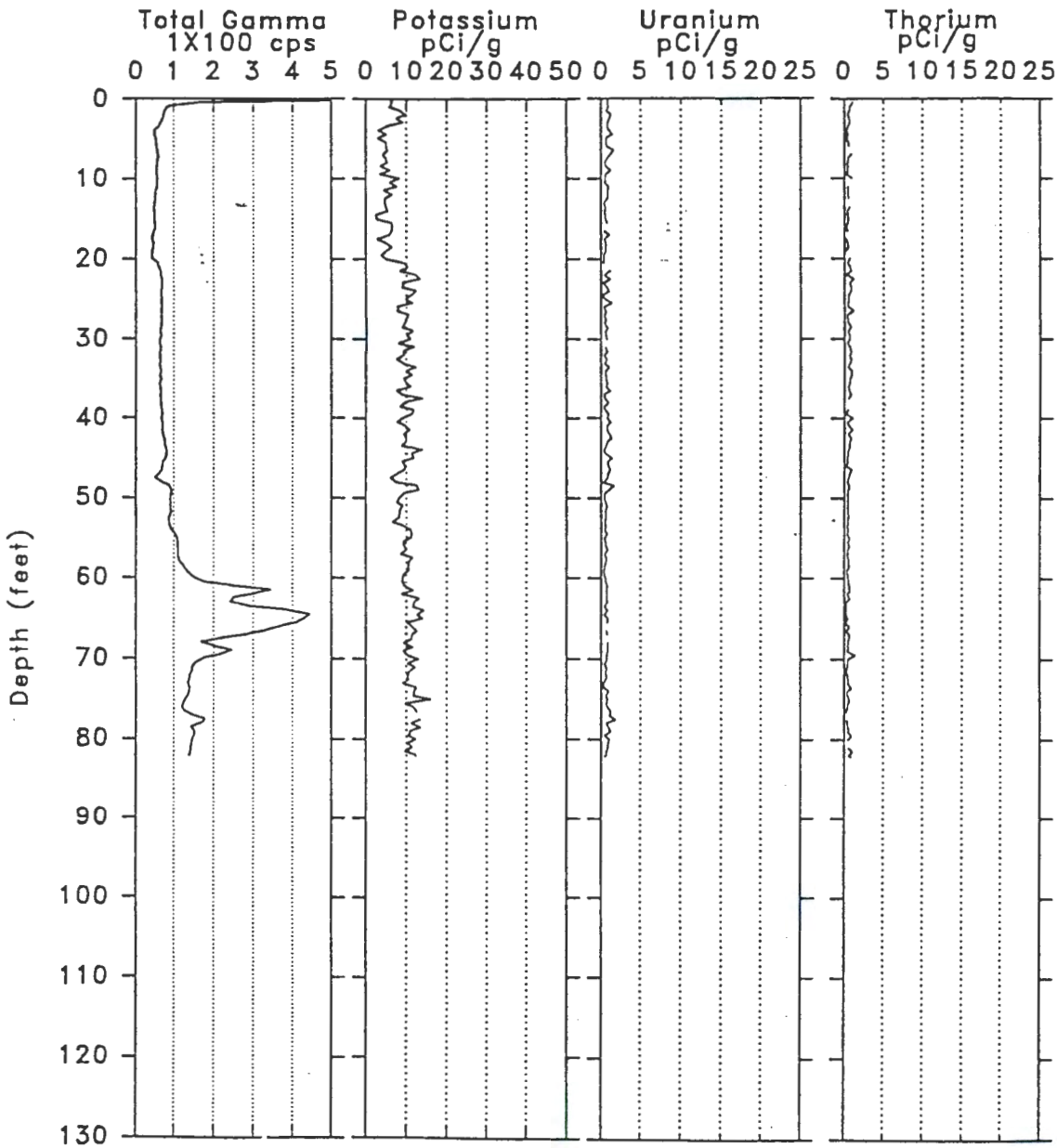


9713540.2846

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole : 100-N-29

Log Date : Nov 19, 1992
Anal Date: Feb 15, 1993



RLS Borehole Survey Report

Borehole: 199-N-29

Casing	Depth: 85′	Size: 8"	Thickness: 0.30"
Screen	Depth: 47.5 to 84′	Size: telescoping screen unknown thickness	
Water	Depth: 64′		
Survey	Depth: 0 - 82′	Date: 11/19/92	
	Station: 82′		

General Notes:
High activity at surface contributed to the borehole survey spectra to the depth of 1 foot. No gamma-ray photo peaks were associated with the elevated count rate. It is unclear whether the source is backscattered gamma rays or bremsstrahlung radiation induced from the high-energy beta emissions of strontium-90.

A cement grout extends from the surface to approximately 20 feet and its effect is detected as a zone of decreased gamma activity as indicated in the total gamma plot curve. The 8 inch diameter casing extends to 49 feet and a telescoping screen extends from 47.5 to 84 feet.

No correction factor is applied for the telescoping screen thus calculated gamma activities are probably higher than those present in the formation.

This RLS survey indicates a change has occured in the subsurface conditions since the previous survey, a gross-gamma log acquired by PNL on 2/23/84. The change is identifiable inspite of the differences in the survey specifications that include logging speed, time constant averaging, detector response characteristics, sample increment, and recording format. The 1984 survey indicated three depths of elevated gamma activity. They are located at 64, 67 and the maximum survey depth of 85 feet. The RLS survey terminated at 82 feet due to detector location within the probe. Consequently the elevated gamma activity at 85 feet was not evaluated. The RLS survey identified four depths of elevated activity. They are located at 61.5, 64.5, 69 and 77.5 feet. The depths do not match identically between the two surveys but are within 3 precent of each other.

The primary depth zone at 64 feet appears to be unchanged when compared with the background interval from 30 to 40 feet. The 8.5 year time difference and the source radionuclide of cobalt-60 with a 5.3 year half live is apparently being replenished from some source. The depth zone at 61.5 feet is indicated on the gross gamma survey but was not resolved as a separate peak. The depth zone at 69 feet appears to have moved from 67 feet on the gross gamma. The depth zone at 77.5 feet appears to correlate with the beginnings of an elevated count at 80 feet. The indicated peak depths correlate well between the two surveys but the observed activity in the peaks are significantly different. A copy of the gross gamma survey is included.

Man-made Radionuclides:
Cobalt (Co-60) was detected from 48 to 82 feet. The maximum calculated activity was less than 10 pCi/g at 65 feet.

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

Project: 100-N

Borehole	199-N-39		
Coordinates	8388 N	4431 W	Feet (Plant 100 Area)
Elevation	454.31 ft	Top of casing (Plant 100 Area)	

Borehole Environment Information

Borehole liquid depth none (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
8	0.254	0	64.5

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Dec 16, 1992	H1N39\A299	MSA 80sec RT	0	61	0.5
		Station 300sec	58.5, 61 ft		

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

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

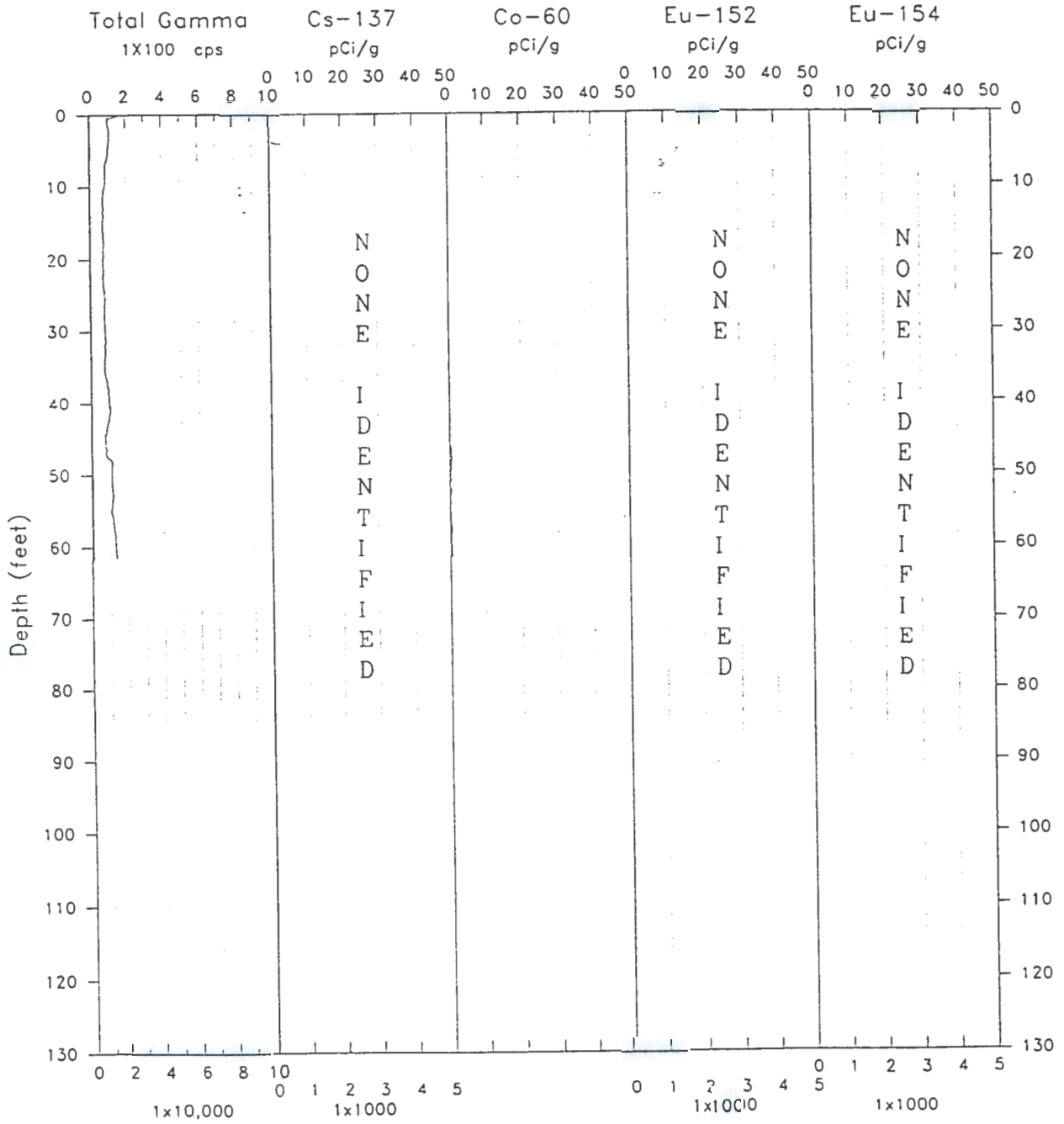
Analyst Names: W. F. Nicaise
Analysis Date: Jan. 07, 1993

Analysis Notes:
Radionuclides Identified: Co-60

RLS Spectral Gamma–Ray Borehole Survey

Project: 100–N
Borehole: 199–N–39

Log Date: Dec 16, 92
Anal. Date: Jan 07, 93

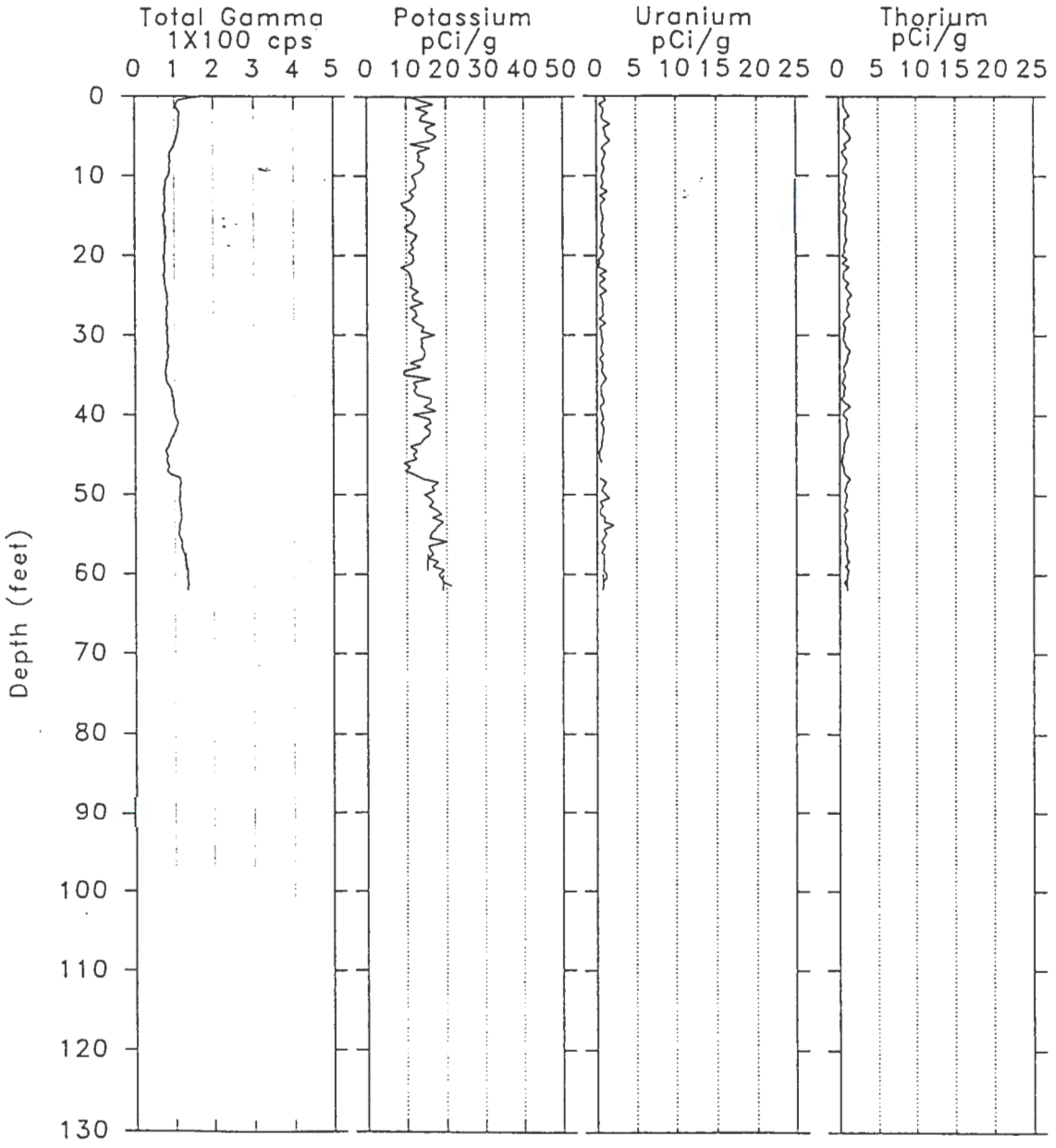


9713540.2848

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole : 199-N-39

Log Date : Dec 16, 1992
Anal Date: Jan 07, 1993



RLS Borehole Survey Report

Borehole: 199-N-39

Casing	Depth: 64.5′	Size: 8"	Thickness: 0.254"
Water	Depth: none		
Survey	Depth: 0 - 61′	Date: 12/16/92	
	Stations: 58.5′, 61′		

General Notes:
The well was monitored at fixed positions at 0.5-foot intervals from ground level (0 ft) to 61.5 feet, for real counting times of 80 seconds. Naturally occurring thorium and uranium are present at normal Hanford activities of less than one pCi/g. Potassium is observed at slightly elevated near the bottom of the log survey from about 50 feet to 61.5 feet. As shown on the second plot the total gamma count rate follows the potassium activity profile closely.

The first plot shows the total gamma count rate along with the activity profile for Co-60, which is described below. By comparing these results with the well-construction diagram for well 199-N-39 on page 232 of document WHC-SD-ER-TI-006, Rev. 0, it may be seen that increased readings of potassium, Co-60, and total gamma begin at a depth of about 50 feet, where the well casing ends and a telescoping screen begins, extending to the bottom of the well. This depth also denotes the interface between the Hanford and Ringold formations. An increase of Potassium activity is expected in the Ringold formation. Both of these structural effects likely elevate the calculated activity values.

Man-made Radionuclides:
Cobalt (Co-60) decay activity was observed from approximately 45 to 61 feet. The maximum activity, which occurred at 48 feet, is less than one pCi/g.

No Cesium (Cs-137) was observed in the well. The template is shown for uniformity of presentation only.

No Europium (Eu-154) was observed in the well. The template is shown for uniformity of presentation only.

No Europium (Eu-152) was observed in the well. The template is shown for uniformity of presentation only.

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

Project: 100-N

Borehole	199-N-44			
Coordinates	8,329 N	3,901 W	Feet	(Plant 100 N)
Elevation	460.70 ft		Top of casing	(Plant 100 N)

Borehole Environment Information

Borehole fluid depth none (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
8	0.28	0	82

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram J. P. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode	speed	Depth interval (ft) Top	Base	Incr
Dec 15, 1992	H1N44\A298	MSA	80sec RT	0	69	0.5
		Stations	300sec	50 & 69		

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

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

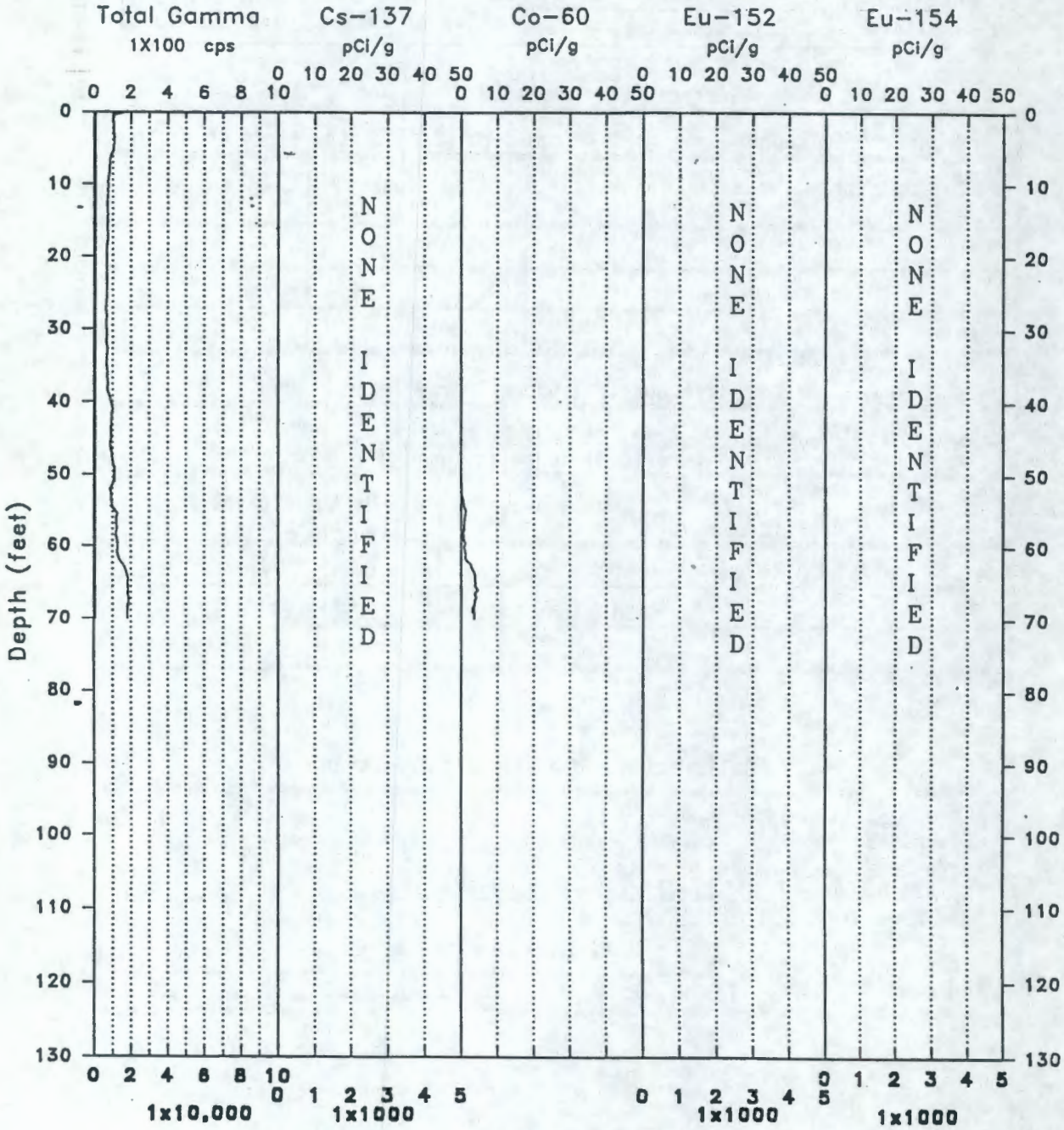
Analyst Names: J. P. Kiesler R. K. Price
Analysis Date: Jan 19, 1993

Analysis Notes:
Radionuclides Identified: Co-60

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole: 199-N-44

Log Date: Dec 15, 1992
Anal. Date: Jan 19, 1993

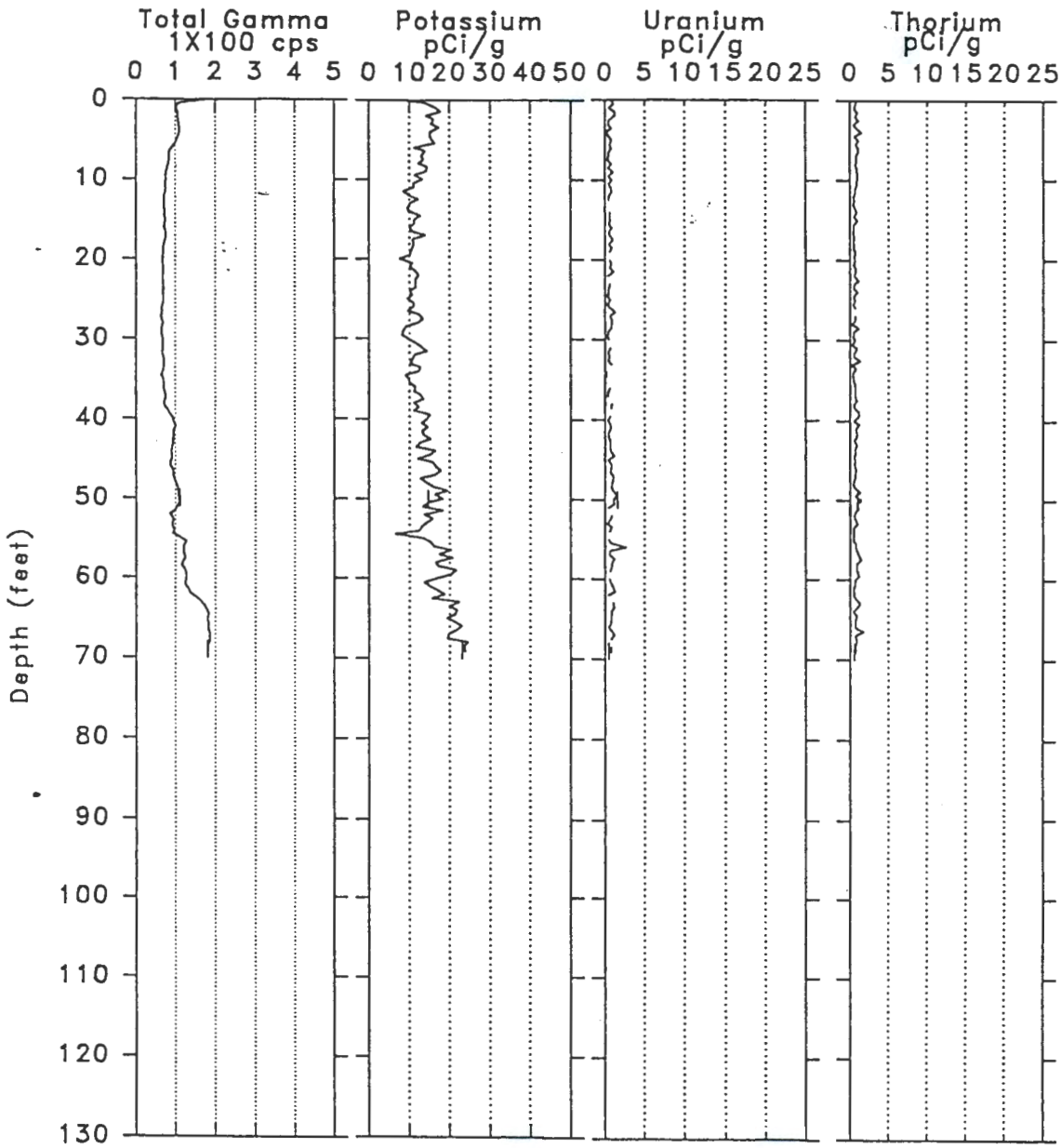


9713540.2850

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole : 199-N-44

Log Date : Dec 15, 1992
Anal Date: Jan 19, 1993



RLS Borehole Survey Report

Borehole: 199-N-44 100-N Area

Casing	Depth: 82′	Size: 8"	Thickness: 0.28"
Water	Depth: none		
Survey	Depth: 0 - 69′	Date: 12/15/92	
	Stations: 50 & 69′		

General Notes:
The plots for potassium, thorium, and uranium show that the calculated potassium activities vary between about 7 and 25 pCi/g over the logged interval, and the thorium and uranium activities are much smaller than 5 pCi/g over the logged interval. The activity variations are within the statistical uncertainties of the measurements. The Potassium, uranium, and thorium activities are typical of background due to naturally occurring radioelements in the sediments in the area.

Man-made Radionuclides:
Cobalt-60 (Co-60) was identified in the borehole from 0 to 51 feet with the only continuous zone being 51 to the maximum depth of 69 feet. The decay activity detected was less than 5 pCi/g at 66 feet.

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

Project: 100-N

Borehole	199-N-56		
Coordinates	6,998 N	6,206 W	Feet (Plant 100 N)
Elevation	458.09 ft		Top of casing (Plant 100 N)

Borehole Environment Information

Borehole fluid depth 72.4 (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
6	0.28	0	73

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Oct 14, 1992	H1N56\A297	MSA 80sec RT	0	70	0.5
		Stations 300sec	48,50 & 70		

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

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

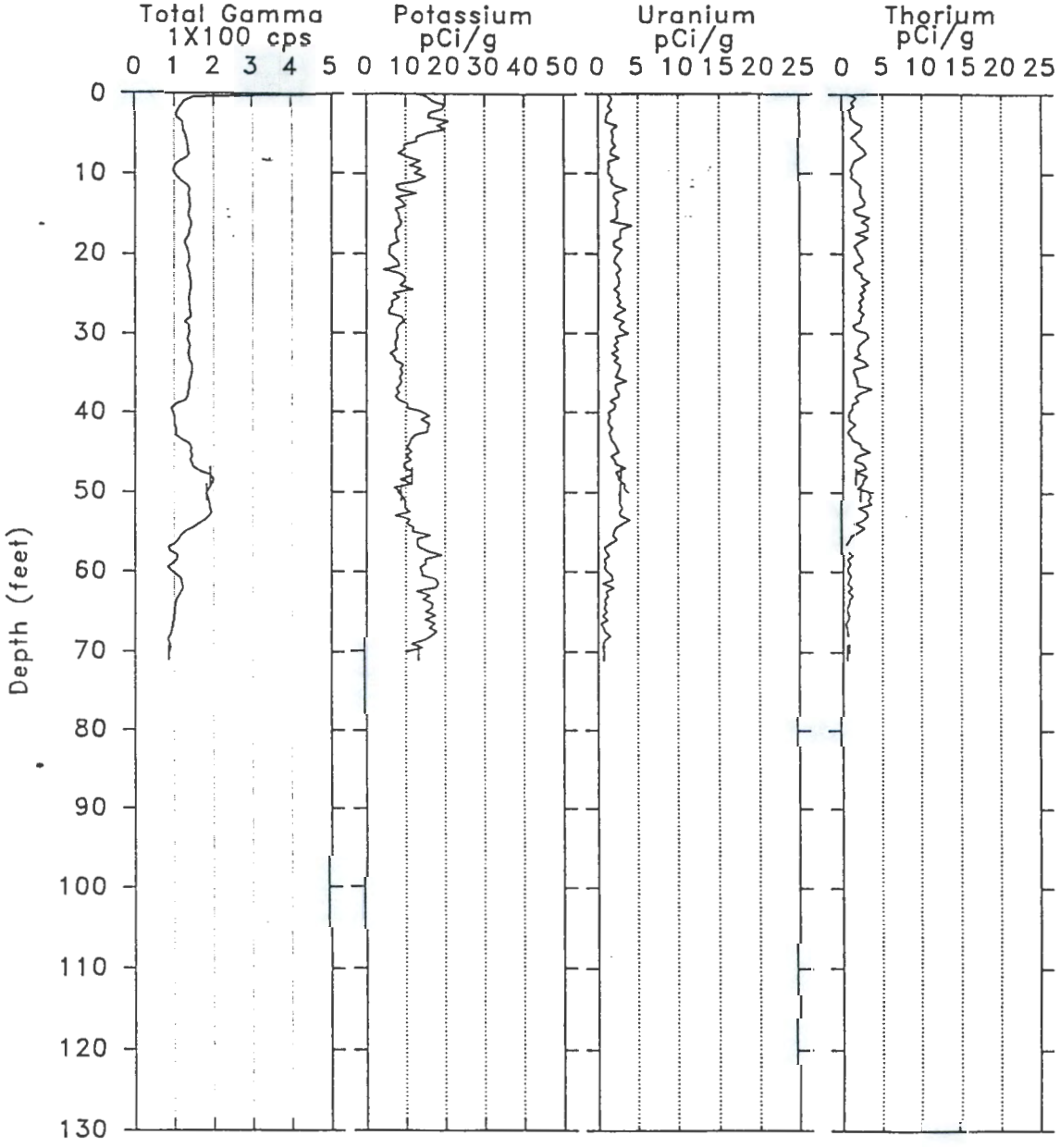
Analyst Names: J. P. Kiesler R. K. Price
Analysis Date: Jan 19, 1993

Analysis Notes:
Radionuclides Identified: No man-made nuclides identified

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole : 100-N-56

Log Date : Oct 14, 1992
Anal Date: Jan 19, 1993



RLS Borehole Survey Report

Borehole: 199-N-56

Casing	Depth: 73′	Size: 6"	Thickness: 0.28"
Water	Depth: 72.4′		
Survey	Depth: 0 - 70′	Date: 10/14/92	
	Stations: 48,50 & 70′		

General Notes:
The plots for potassium, uranium and thorium show that the calculated potassium decay activities vary between about 5 and 20 pCi/g over the logged interval, and the uranium and thorium decay activities are less than 5 pCi/g. The computed potassium decay activity varies inversely with the uranium and thorium activities, which is not common to the Hanford environment. The elevated uranium and thorium decay activity is believed to orginate from the bentonite sealing material.

The total gamma activity did not exceed 200 cps in the borehole survey with the exception of the spectrum at 0.0 feet with total activity of 580 cps, which is believed to be shine from another source.

Man-made Radionuclides:
No man-made radionuclides identified

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

Project: 100-N

Borehole	199-N-70		
Coordinates	8375 N	4414 W	Feet (Plant 100 Area)
Elevation	454.21 ft		Top of casing (Plant 200 Area)

Borehole Environment Information

Borehole liquid depth 59 (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
6	0.25	0	103

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode	speed	Depth interval (ft) Top	Base	Incr
Dec 02, 92	H1N70\A291	MSA	80sec RT	0	97	0.5
		Station	300sec	96 ft		

MSA: Move-Stop-Acquire
RT: Real Time

Calibration and Analysis Information

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

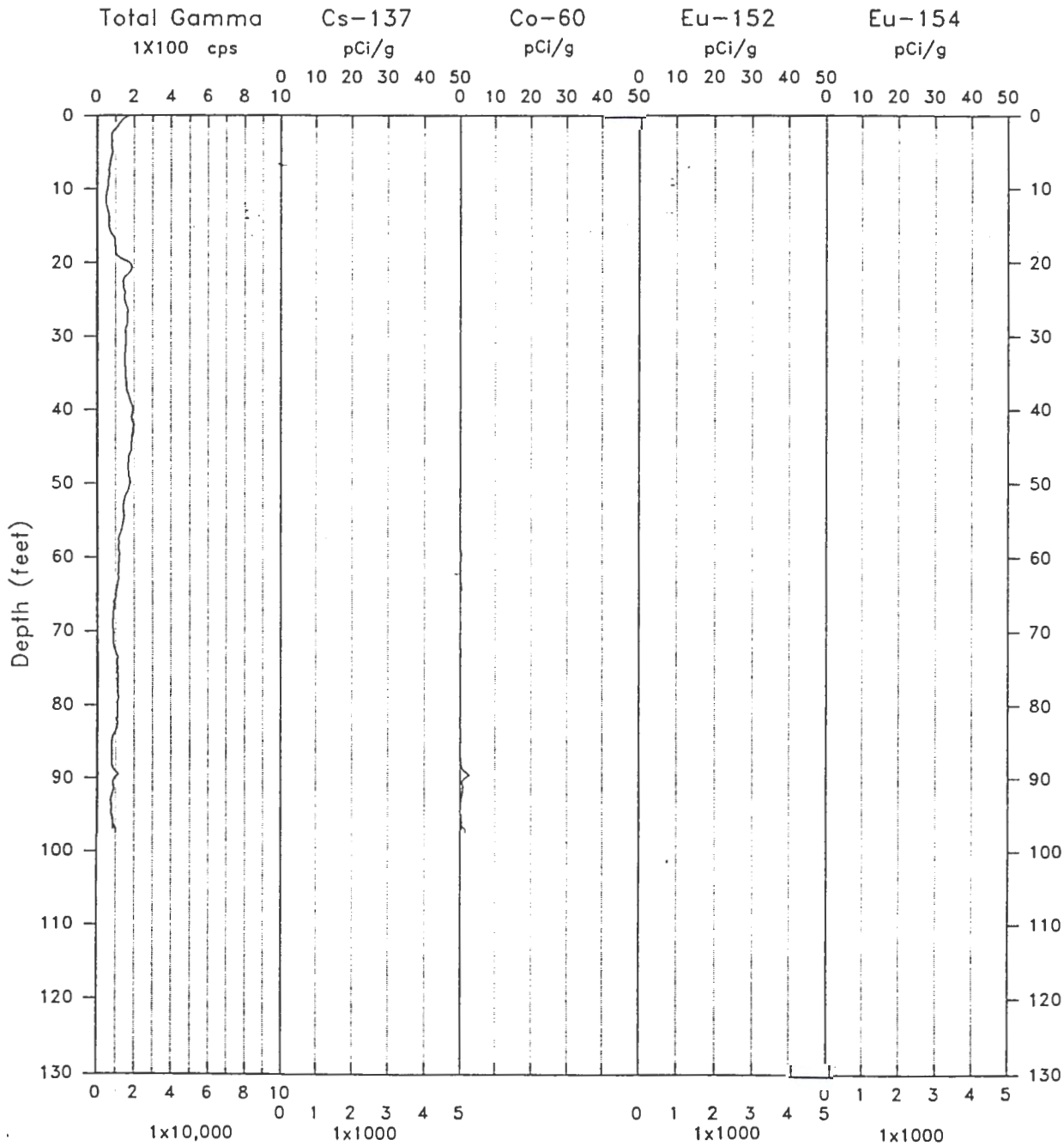
Analyst Names: J. P. Kiesler
Analysis Date: Dec 3, 1992

Analysis Notes: Elevated Total Gamma activity identifies Bentonite seal.
Radionuclides Identified: Co-60

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole: 199-N-70

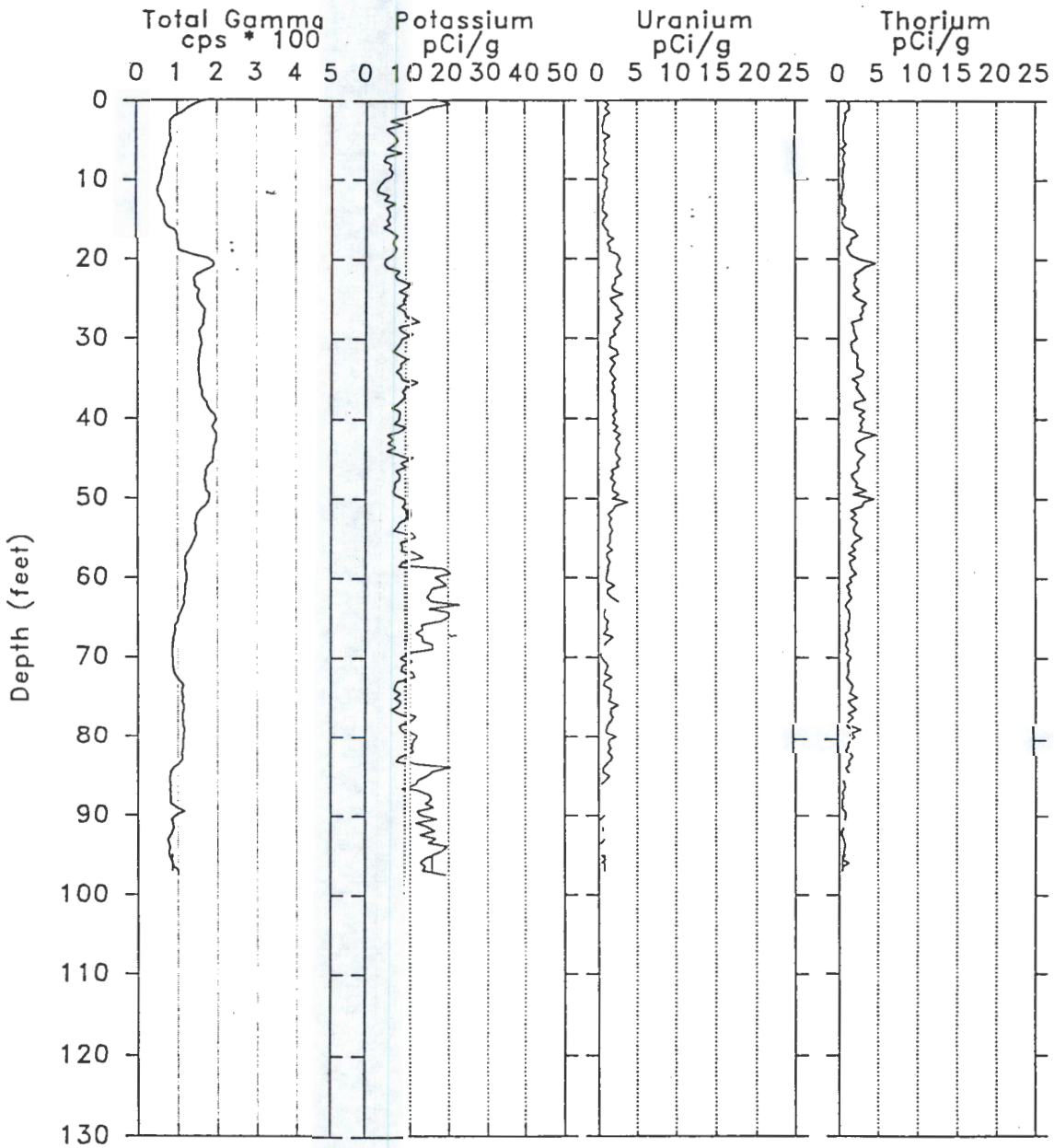
Log Date: Dec 2, 1992
Anal. Date: Dec 3, 1992



RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole : 199-N-70

Log Date : Dec 2, 1992
Anal Date: Dec 3, 1992



RLS Borehole Survey Report

Borehole: 199-N-70

Casing	Depth: 103'	Size: 6"	Thickness: 0.25"
Water	Depth: 59'		
Survey	Depth: 0 - 98'	Date: 12/02/92	
	Station 96'		

General Notes:
Survey of this borehole was based on a gross gamma survey containing elevated activity acquired earlier.

The lower zone at 89 feet, below the water depth of 59 feet, containing the maximum cobalt-60 activity is not the depth of the maximum total gamma activity.

The high total gamma activity from 17 to 57 feet correlates with an increase in natural uranium and thorium activity that is greater than normally present in Hanford environment. The presence of stainless steel casing may indicated bentonite sealing material between casing and formation. Bentonite contains natural uranium and thorium at higher concentrations than common to Hanford.

The plots for potassium, uranium and thorium show that the calculated potassium decay activities vary between about 3 and 23 pCi/g over the logged interval, and the uranium and thorium decay activities are less than 4 pCi/g. The computed potassium decay activity varies inversely with the uranium and thorium activities, which is not common to the Hanford environment. The elevated uranium and thorium decay activity is believed to originate from the bentonite sealing material.

Man-made Radionuclides:
Cobalt (Co-60) was discontinuous from 1 foot to 86 feet with calculated activities less than 1 pCi/g. Cobalt was indentified continuously from 87 to 96 feet with a maximum detected activity of 2.7 pCi/g at 89.5 feet.

No Cesium (Cs-137) detected, template presented for uniformity of presentation only.

No Europium (Eu-152) detected, template presented for uniformity of presentation only.

No Europium (Eu-154) detected, template presented for uniformity of presentation only.

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

Project: 100-NR-2

Borehole	199-N-75		
Coordinates	N	E	Meters
Elevation	feet		Brass Cap

Borehole Environment Information

Borehole Fluid Depth 68.7 (Feet) from Zero (0.0) Depth Reference of Log

Casing Size I.D. (inch)	Casing Thickness (inch)	Top Depth (feet)	Base Depth (feet)
12	0.40	0	20
10	0.38	0	89.2

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos
Log Depth Reference at Zero (0.0) depth is Ground Level

Log Date	Archive File Names	Log Mode[1], Speed	Depth Interval (feet) Top	Base	Incr
May 1, 92	H1N75\A175	MSA 80sec LT Station: 500 s	0 Depth: 68, 70'	86	0.5

[1]MSA: Move-Stop-Acquire Lt: Live Time

Calibration and Analysis Information

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

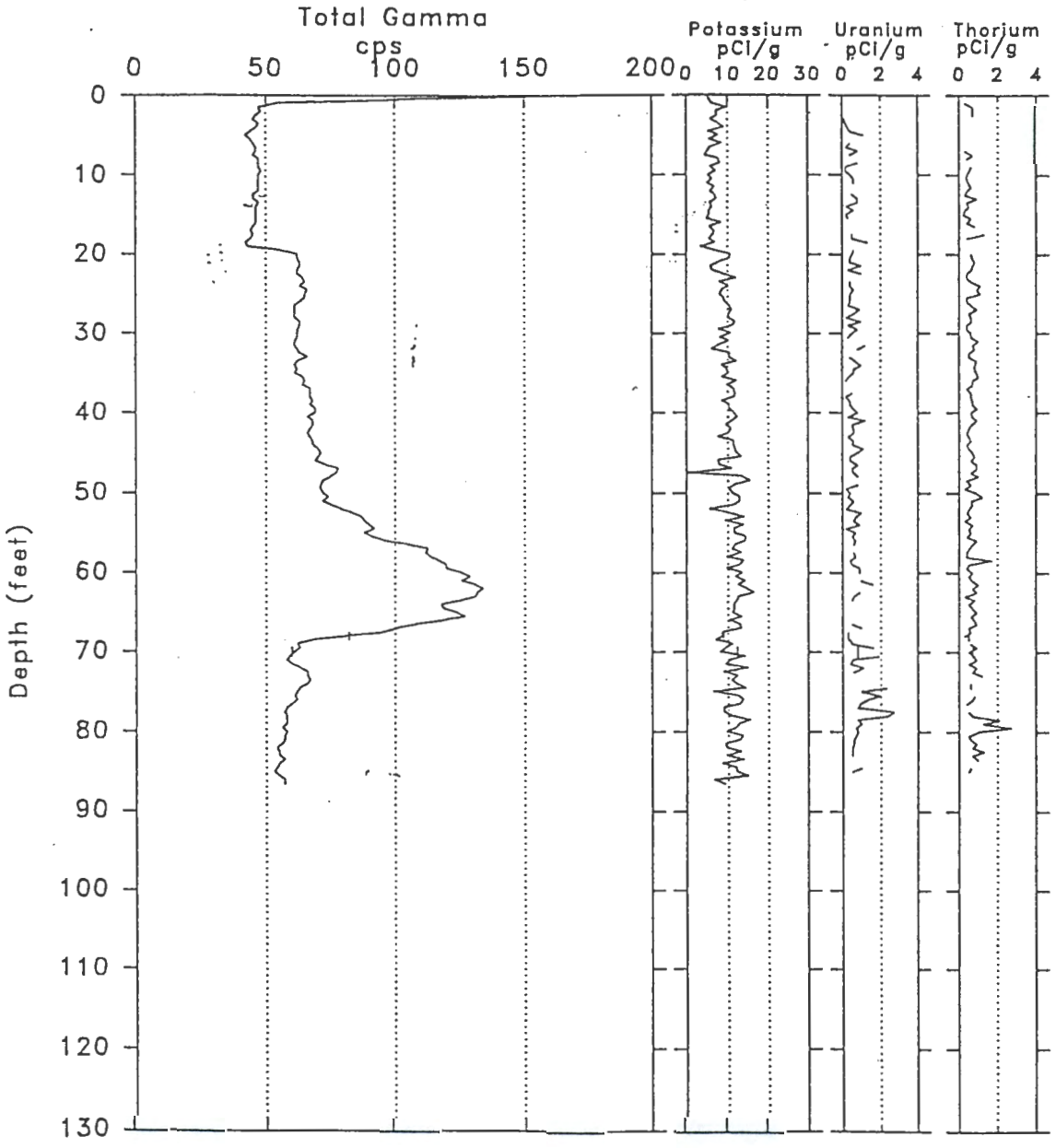
Analyst Names: G. K. Jaeger R. K. Price
Analysis Date: Aug 18, 1992

Analysis Notes: Very high background activity at surface to 1 foot
Radionuclides identified: Co-60

RLS Spectral Gamma-Ray Borehole Survey

Project: 100-NR-2
Borehole: 199-N-75

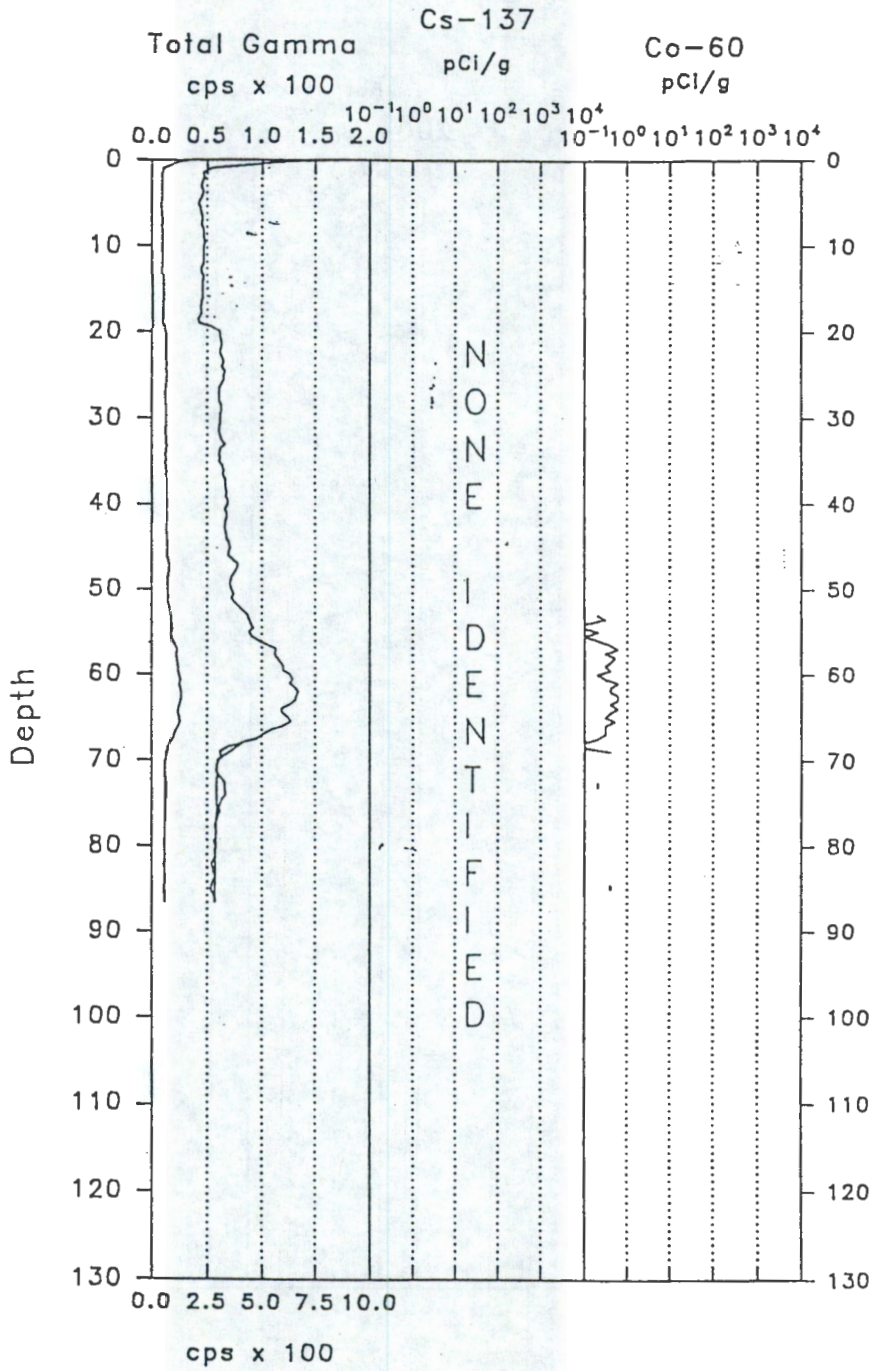
Log Date : May 1, 1992
Anal Date: Aug 18, 1992



RLS Spectral Gamma-Ray Borehole Survey

Project: 100-NR-2 Log Date: May 1, 1992

Borehole: 199-N-75 Analysis Date: Aug 18, 1992



RLS Borehole Survey Report

199-N-75

Casing	Depth: 20'	Size: 12"	Thickness: 0.40"
	Depth: 89'	Size: 10"	Thickness: 0.38"
Water	Depth: 68.7'		
Survey	Depth: 0 - 86'	Mode: MSA 80sec LT	Date: 5/01/92

General Notes:
Very high total gamma activity observed on the surface is identified in the borehole survey from 0 feet to 1 feet.

Man-made Radionuclides:
No Cesium (Cs-137) was encountered in the borehole survey. The plot track is present only for uniformity of the displayed data.

Cobalt (Co-60) was encountered in the borehole from 52 feet to 85 feet. The cobalt decay activity detected is less than 1 pCi/g.

No Europium-152 (Eu-152) was encountered in the borehole survey. The plot track is present only for uniformity of the displayed data.

No Europium-154 (Eu-154) was encountered in the borehole survey. The plot track is present only for uniformity of the displayed data.

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

Project: 100-N

Borehole	199-N-76		
Coordinates	150,622.12 N 571,560.08 E		(Lambert NAD'83)
Elevation	448.83 ft	Brass Cap	(NGVD'29)

Borehole Environment Information

Borehole fluid depth 67.1 (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
4	0.28	0	82

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Dec 03, 1992	H1N76\A292	MSA 80sec RT	0	78	0.5
		Stations 300sec	56 & 78		

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
Analysis Date: Jan 19, 1993

Analysis Notes:
Radionuclides Identified: Co-60

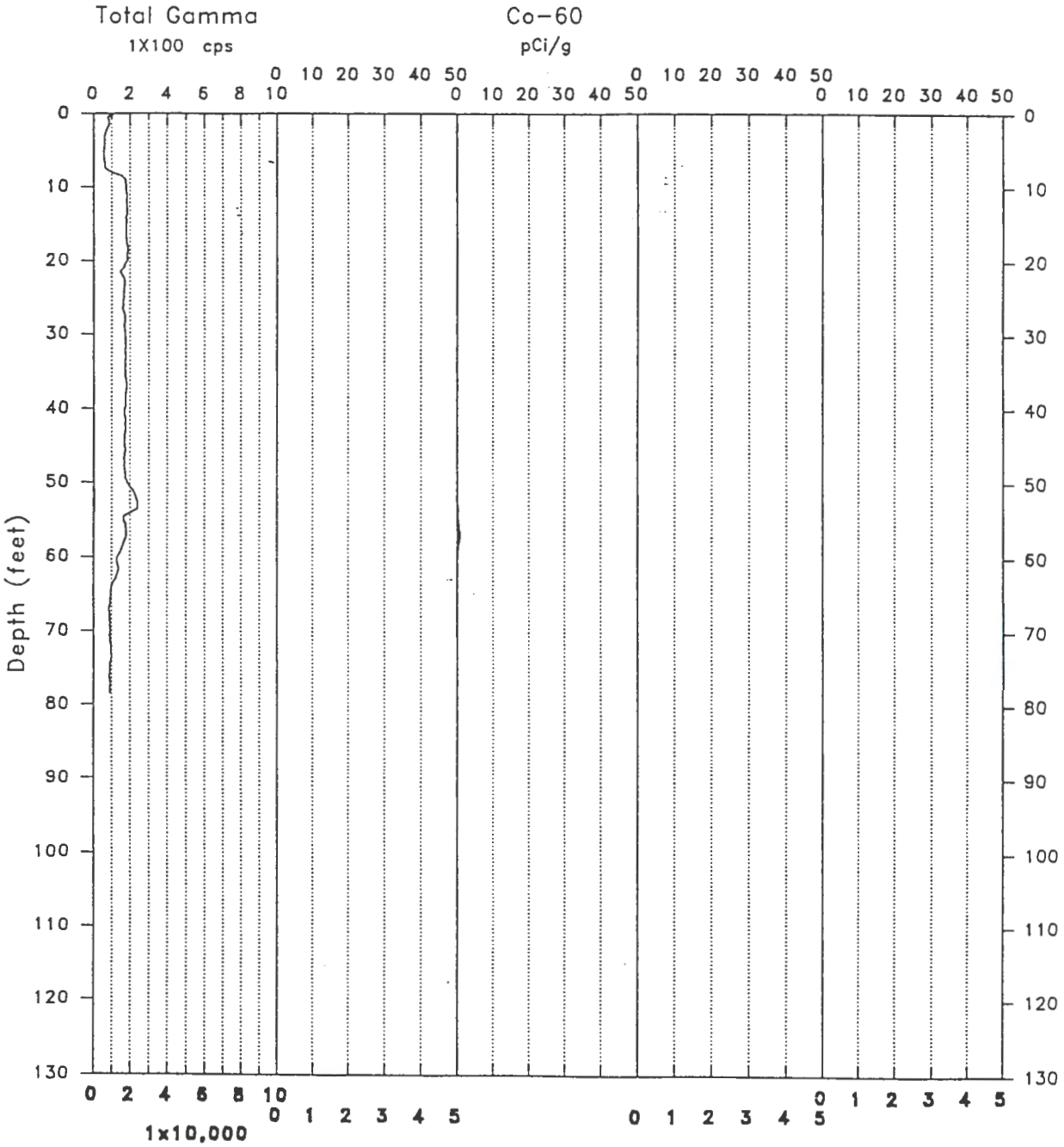
RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N

Borehole: 199-N-76

Log Date: Dec 03, 1992

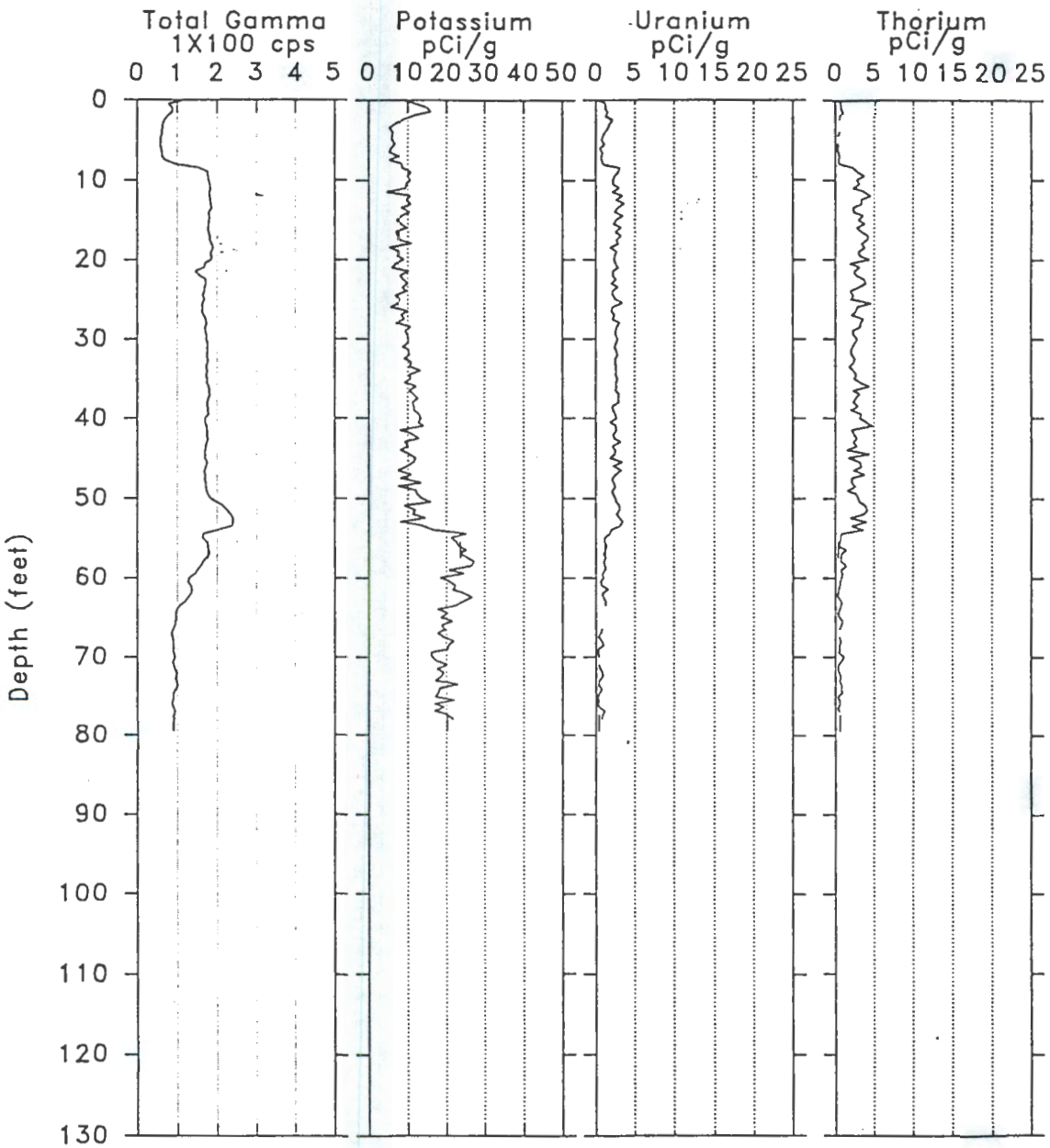
Anal. Date: Jan 19, 1993



RLS Spectral Gamma-Ray Borehole Survey

Project: 100-N
Borehole : 199-N-76

Log Date : Dec 03, 1992
Anal Date: Jan 19, 1993



RLS Borehole Survey Report

Borehole: 199-N-76

Casing	Depth: 82′	Size: 4"	Thickness: 0.28"
Water	Depth: 67.1′		
Survey	Depth: 0 - 78′	Date: 12/03/92	
	Stations: 56 & 78′		

General Notes:
The plots for potassium, uranium and thorium show that the calculated potassium decay activities vary between about 5 and 27 pCi/g over the logged interval, and the uranium and thorium decay activities are less than 5 pCi/g. The computed potassium decay activity varies inversely with the uranium and thorium activities, which is not common to the Hanford environment. The elevated uranium and thorium decay activity is believed to orginate from the bentonite sealing material.

The total gamma activity did not exceed 225 cps in the borehole survey.

Man-made Radionuclides:
Cobalt-60 (Co-60) was identified in the borehole from 4 to 77 feet with the only continuous zone being 52 to 62 feet, with all calculated activities less than 1 pCi/g.

9713540.2859

APPENDIX B

THE RLS SYSTEM

The Radionuclide Logging System (RLS) is a passive, high-resolution gamma-ray energy-spectrum logging system. The system utilizes a semi-conducting crystal of high-purity germanium (HPGe); the crystal is cooled during logging with liquid nitrogen, and an electrical potential is imposed across the crystal. Gamma-ray interaction with the crystal produces sharp electrical charge pulses with amplitudes in relation to the gamma-ray energy. Since each radionuclide emits a gamma ray with a distinct energy for that element, the charge pulse is recorded at a distinct point along the energy axis of the spectrum and thus permits the discrete identification of each radioelement present. (See Figure B-1.) With appropriate calibration, radioelement assay concentrations, as well as radionuclide identification, can be determined.

The logging cable equipped on the RLS was specifically designed for the system. It suspends the detector in the well, conducts power to the detector, receives electrical signals from the detector, and provides the conduit for venting the gaseous nitrogen from cooling the logging sonde. 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 measuring systems have verified the accuracy.

There are two configuration in which the logging sonde can be used. One is in the as-built state (standard) and the other (alternate) is with an external "shield" (gamma-ray-absorbing material) placed around it.

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 nuclides emitting gamma rays having energies greater than 500 keV and the number of gamma rays emitted per decay being at least one for each two decays (greater than 50 percent. The maximum decay activity the RLS has detected is about 10,000 pCi/g in this standard configuration.

The alternate logging configuration at present 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 frequently detected man-made radioelement activities exceeding 33,000 pCi/g in this shielded configuration. The alternate logging configuration was not employed for the surveys included in this report because of the low count rates encountered.

LIMITATIONS TO THE RADIOELEMENT ANALYSES

Borehole-environment correction factors have been determined for steel casing and water in the borehole. Correction factors for other borehole configurations have not been investigated. Borehole configurations for which no correction is available include: (1) grout between multiple casing strings, (2) formation seals containing bentonite, sand, or grout behind the casing, and (3) drilling mud remaining inside the borehole during logging. The calculated decay activity for man-made radionuclides will be underestimated for boreholes with these configurations.

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

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 (1) the amplitude of the log fluctuation and the depth interval over which it extends, and (2) the intensity of the corresponding gamma-ray source and the thickness of the zone in which the source 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, see Figure x+1. Radioelements such as strontium-90 which do not emit a gamma ray when they decay will not be identified or quantified by the spectral analysis performed for this report. The decay of strontium-90 results in a high-energy beta particle that can excite surrounding elements to emit photon (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 concentrations of strontium-90 is under consideration.

9713540.2860

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	J. W. Fassett	Date 9/19/96
Project Title/Work Order		EDT No. 610772
WHC-SD-EN-TI-261, Spectral Gamma-Ray Logging Report for the 100-N Area; Hanford, Washington		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
J. W. Fassett	H6-06	X			
J. I. Feaster	H6-06	X			
R. K. Price	N1-55	X			
Central Files ~~(2)~~ (1) + orig	A3-88	X			
EDMC (2)	H6-08	X			

A-6000-135 (01/93) WEF067