Stoller
Grand Junction Office established 1959

C4106
Log Data Report

Borehole Information:

Borehole: C4106			**Site:** 216-A-37-1 Crib		
Coordinates (WA State Plane)		**GWL (ft)[1]:** ~ 276		**GWL Date:**	5/08/2003
North	**East**	**Drill Date**	**TOC[2] Elevation**	**Total Depth (ft)**	**Type**
135,640.2 m	575,917.32 m	March 2003	206.76 m	275	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded Steel	0.3	10 3/4	9 3/8	0.5	+0.3	69.0
Threaded Steel	1.25	9	8	0.5	+1.25	142.0
Threaded Steel	4.24	6 5/8	5 1/2	0.5625	+4.24	275
The driller provided the casing diameters and depths. The logging engineer measured the stickups using a steel tape. Casing thickness was calculated.						

Borehole Notes:

Zero reference is the ground surface. Depth to bottom and depth to water were supplied by the driller. Borehole coordinates and elevation were provided by the project lead. Depth-to-bottom is the total depth that the sonde reached measured from the ground surface. Depth-to-water was reported by the driller and is approximated because the e-tape was not working. The driller also reported they stopped advancing after the bit showed only a couple inches of moisture. This borehole was logged through the drill pipe. The pad on ground surface is a layer of coarse crushed rock that is approximately 0.5 ft thick.

Logging Equipment Information:

Logging System:	Gamma 2E		**Type:** 70% HPGe
Calibration Date:	03/2003	**Calibration Reference:**	GJO-2003-430-TAC
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Logging System:	Gamma 2F		**Type:** Moisture (H380932510)
Calibration Date:	09/2002	**Calibration Reference:**	GJO-2002-387-TAC
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2/Repeat	3	4/Repeat	5
Date	4/30/03	4/30/03	5/02/03	5/02/03	5/08/03
Logging Engineer	Pearson	Pearson	Kos	Kos	Kos
Start Depth (ft)	68.0	14.0	141.0	81.0	275.0
Finish Depth (ft)	0.0	7.0	65.0	71.0	140.0
Count Time (sec)	100	100	100	100	100

Log Run	1	2/Repeat	3	4/Repeat	5
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
ft/min	N/A	N/A	N/A	N/A	N/A
Pre-Verification	BE028CAB	BE028CAB	BE029CAB	BE029CAB	BE030CAB
Start File	BE028000	BE028069	BE029000	BE029077	BE030000
Finish File	BE028068	BE028076	BE029076	BE029087	BE030135
Post-Verification	BE028CAA	BE028CAA	BE029CAA	BE029CAA	BE030CAA
Depth Return Error (in.)	1 low	1 low	N/A	0	N/A
Comments	No fine-gain adjustments.	No fine-gain adjustments.	Fine-gain adjustment after file -066.	No fine-gain adjustment.	Fine-gain adjustment after files -055, -132.

Log Run	6/Repeat				
Date	5/08/03				
Logging Engineer	Kos				
Start Depth (ft)	159.0				
Finish Depth (ft)	145.0				
Count Time (sec)	100 s				
Live/Real	R				
Shield (Y/N)	N				
MSA Interval (ft)	1.0				
ft/min	N/A				
Pre-Verification	BE030CAB				
Start File	BE030136				
Finish File	BE030150				
Post-Verification	BE030CAA				
Depth Return Error (in.)	+1				
Comments	Repeat section.				

Neutron-Moisture Logging System (NMLS) Log Run Information:

Log Run	1	2/Repeat	3	4/Repeat
Date	4/30/03	4/30/03	5/02/03	5/02/03
Logging Engineer	Pearson	Pearson	Kos	Kos
Start Depth (ft)	0.0	60.0	65.0	71.0
Finish Depth (ft)	68.0	67.0	141.0	81.0
Count Time (sec)	N/A	N/A	N/A	N/A
Live/Real	N/A	N/A	NA	N/A
Shield (Y/N)	N/A	N/A	N/A	N/A
MSA Interval (ft)	N/A	N/A	N/A	N/A
ft/min	1.0	1.0	1.0	1.0
Pre-Verification	BF054CAB	BF054CAB	BF058CAB	BF058CAB
Start File	BF054000	BF054273	BF058000	BF058305
Finish File	BF054272	BF054301	BF058304	BF058345
Post-Verification	BF054CAA	BF054CAA	BF058CAA	BF058CAA
Depth Return Error (in.)	N/A	1.0 high	N/A	0
Comments	No fine-gain adjustment.		No fine-gain adjustment.	

Log Run	5	6/Repeat		
Date	5/12/03	5/12/03		
Logging Engineer	Kos	Kos		
Start Depth (ft)	140.0	200.0		
Finish Depth (ft)	275.0	215.0		
Count Time (sec)	N/A	N/A		
Live/Real	N/A	N/A		
Shield (Y/N)	N/A	N/A		
MSA Interval (ft)	N/A	N/A		
ft/min	1.0	1.0		
Pre-Verification	BF059CAB	BF059CAB		
Start File	BF059000	BF059541		
Finish File	BF059540	BF059601		
Post-Verification	BF059CAA	BF059CAA		
Depth Return Error (in.)	N/A	0.5 high		
Comments	No fine-gain adjustment.	Repeat section.		

Logging Operation Notes:

Zero reference was the ground surface, and the borehole was logged through drill pipe. Logging operations were conducted in three separate events as the borehole was advanced. Each time the casing was "telescoped", the borehole was logged such that each interval was logged through a single casing string. Logging was performed with a centralizer installed on the sonde. SGLS data were collected using Gamma 2E. Pre- and post-survey verification measurements employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 082.

Analysis Notes:

Analyst:	Sobczyk	Date:	5/27/03	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of the day and compared to the control limits. The verification spectra were all within the control limits. The peak counts per second (cps) at the 609-keV, 1461-keV, and 2615-keV photopeaks on the post-run verification spectra as compared to the pre-run verification spectra for the day were between 4 percent lower and 1 percent higher at the end of the day.

NMLS pre-run and post-run verification measurements were made at the beginning and end of the day and compared to the control limits established on 12/05/2002. The verification spectra were all within the control limits except for BF058CAA and BF059CAB. Verification spectrum BF058CAA registered 736 cps, which was slightly above the upper control limit of 735 cps. Verification spectrum BF059CAB registered 18 cps, which was considerably below the lower control limit of 681 cps.

SGLS log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G2EMar03.xls), using parameters determined from analysis of recent calibration data. Zero reference was the ground surface. On the basis of measurements supplied by the driller, the casing configuration was assumed to be one string of 10-in. casing to 69 ft, one string of 8-in. casing to 142 ft and one string of 6-in. casing to 275 ft. The casing correction factor was calculated using a 10-in. casing thickness of 0.5 in., an 8-in. casing thickness of 0.5 in., and a 6-in. casing thickness of 0.5625 in. Because the borehole was logged in stages, the casing correction is not additive; the borehole was logged through one string of casing during each logging run. However, the end of logging runs 3 and 5 (i.e., final

4 ft) were run in a dual string of pipe and the casing correction is additive (0.5 in. + 0.5 in = 1.0 in.). Water and dead time corrections were not needed or applied.

NMLS log spectra were processed in batch mode using APTEC SUPERVISOR to determine count rates. Zero reference was the ground surface. Calibration data are available only for 8-in. casing. The volume fraction of water was not calculated because only a portion of the borehole was logged through 8-in. casing.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, gross gamma and neutron total counts, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot rather than the ^{214}Bi peak at 609 keV because it is less affected by the presence of radon in the borehole.

Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected near the ground surface (0 to 2 ft) with a concentration of 0.3 pCi/g. ^{137}Cs was detected in the interval from 9 ft through 36 ft at concentrations ranging from 0.2 pCi/g to 30 pCi/g. The maximum concentration of ^{137}Cs was measured at 10 ft. In addition, ^{137}Cs was detected at 62, 65, and 167 ft with concentrations near the MDL of approximately 0.2 pCi/g. After examination of the spectra at these depths, it was determined that there is no evidence of a photopeak at 662 keV. These reported peaks are probably the result of statistical fluctuation.

The behavior of the ^{238}U log suggests that radon may be present inside the borehole casing. Determination of ^{238}U is based on measurement of gamma activity at 609 and/or 1764 keV associated with ^{214}Bi, under the assumption of secular equilibrium in the decay chain. However, ^{214}Bi is also a short-term daughter of ^{222}Rn. When radon is present, ^{214}Bi will tend to "plate" onto the casing wall and will quickly reach equilibrium with ^{222}Rn. Because the additional ^{214}Bi resulting from radon is on the inside of the casing, the effect of the casing correction is to amplify the 609 photopeak relative to the 1764 photopeak. (The magnitude of the casing correction factor decreases with increasing energy, but gamma rays originating inside the casing are not attenuated.) This effect is observed in the upper portion of the hole (log runs 1 and 2). The effects of radon appear to be minimal in the middle portion of the hole (log runs 3 and 4). The reason for variations in radon content between log runs on successive days is not known. Variations in radon content in boreholes are probably related to variations in surface weather conditions. Radon daughters such as ^{214}Bi may also "plate" onto the sonde itself. When this occurs, there is a gradual increase in total counts as well as photopeak counts associated with ^{214}Bi and ^{214}Pb. This phenomenon appears to best explain the observed discrepancy in ^{238}U values based on 609 keV versus those based on 1764 keV during log runs 3 and 4 (65 ft to 141 ft).

The plots of the repeat logs demonstrate reasonable repeatability of the SGLS and NMLS data. ^{137}Cs and the natural radionuclides at energy levels of 662, 609, 1461, 1764, and 2614 keV are comparable between the repeat and original SGLS log runs. The neutron-moisture and its repeat are within the acceptance criteria.

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[1] GWL – groundwater level
[2] TOC – top of casing
[3] N/A – not applicable

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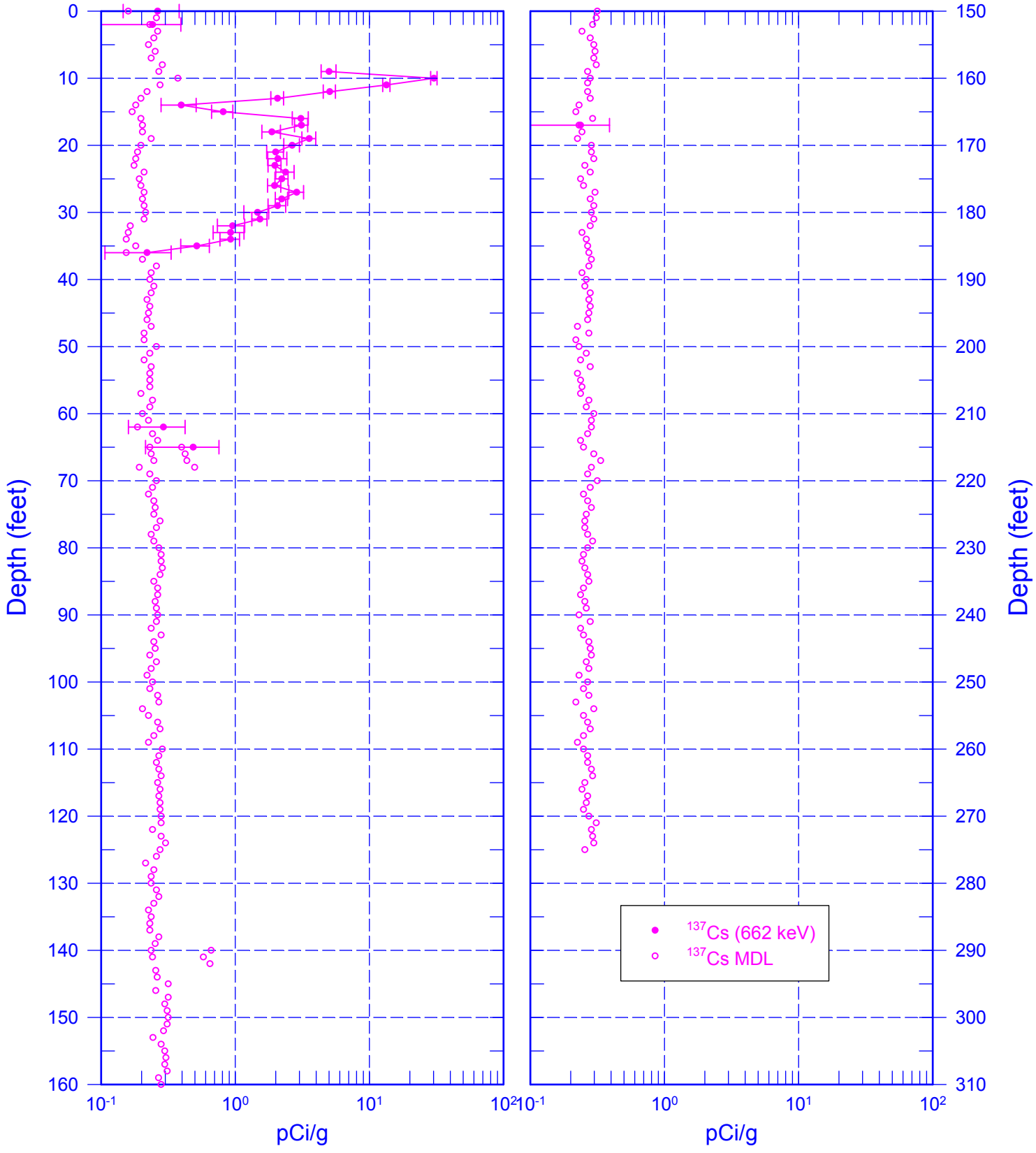
Man-Made Radionuclides



Zero Reference = Ground Surface

Date of Last Logging Run
5/08/2003

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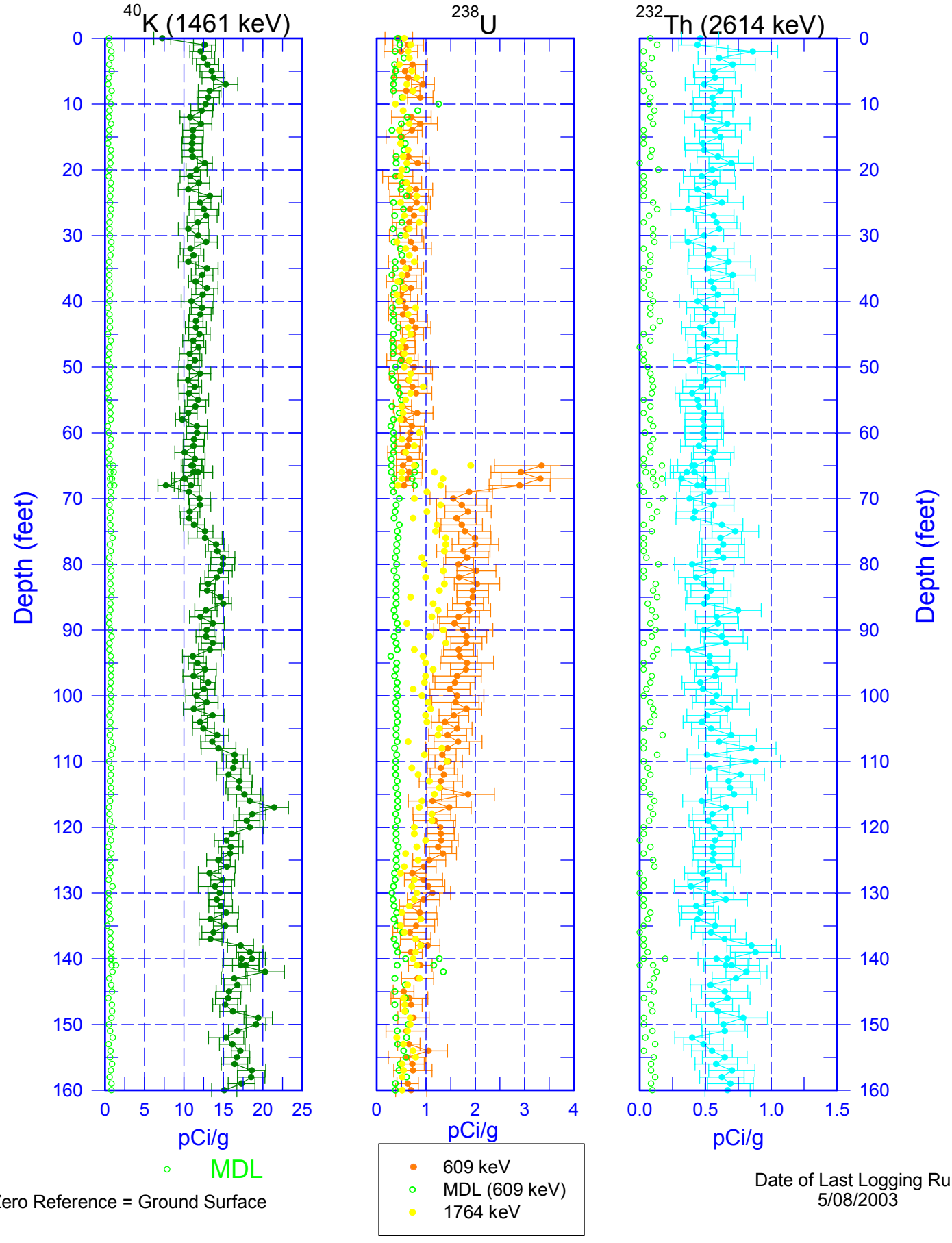
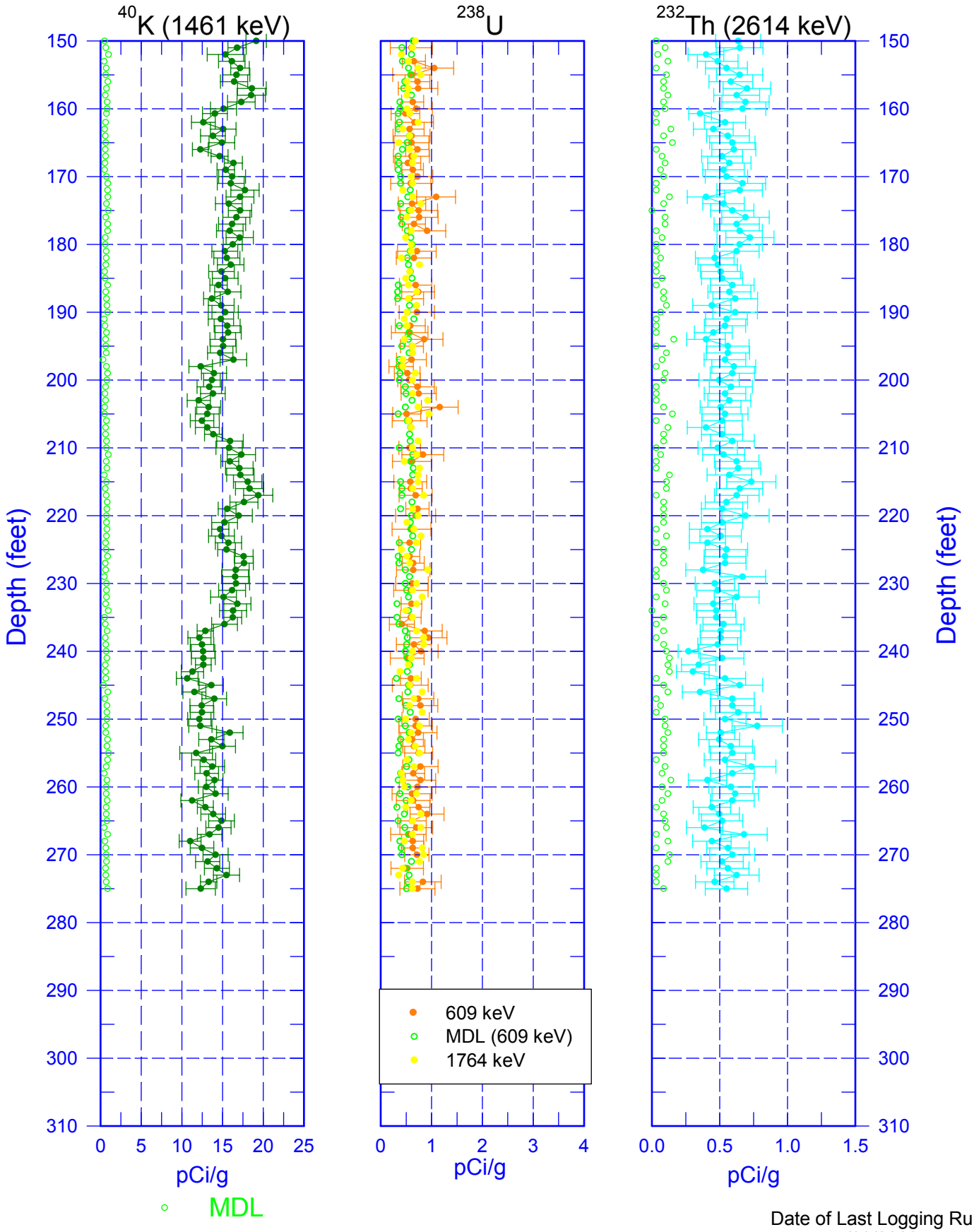
Natural Gamma Logs



Zero Reference = Ground Surface

Date of Last Logging Run
5/08/2003

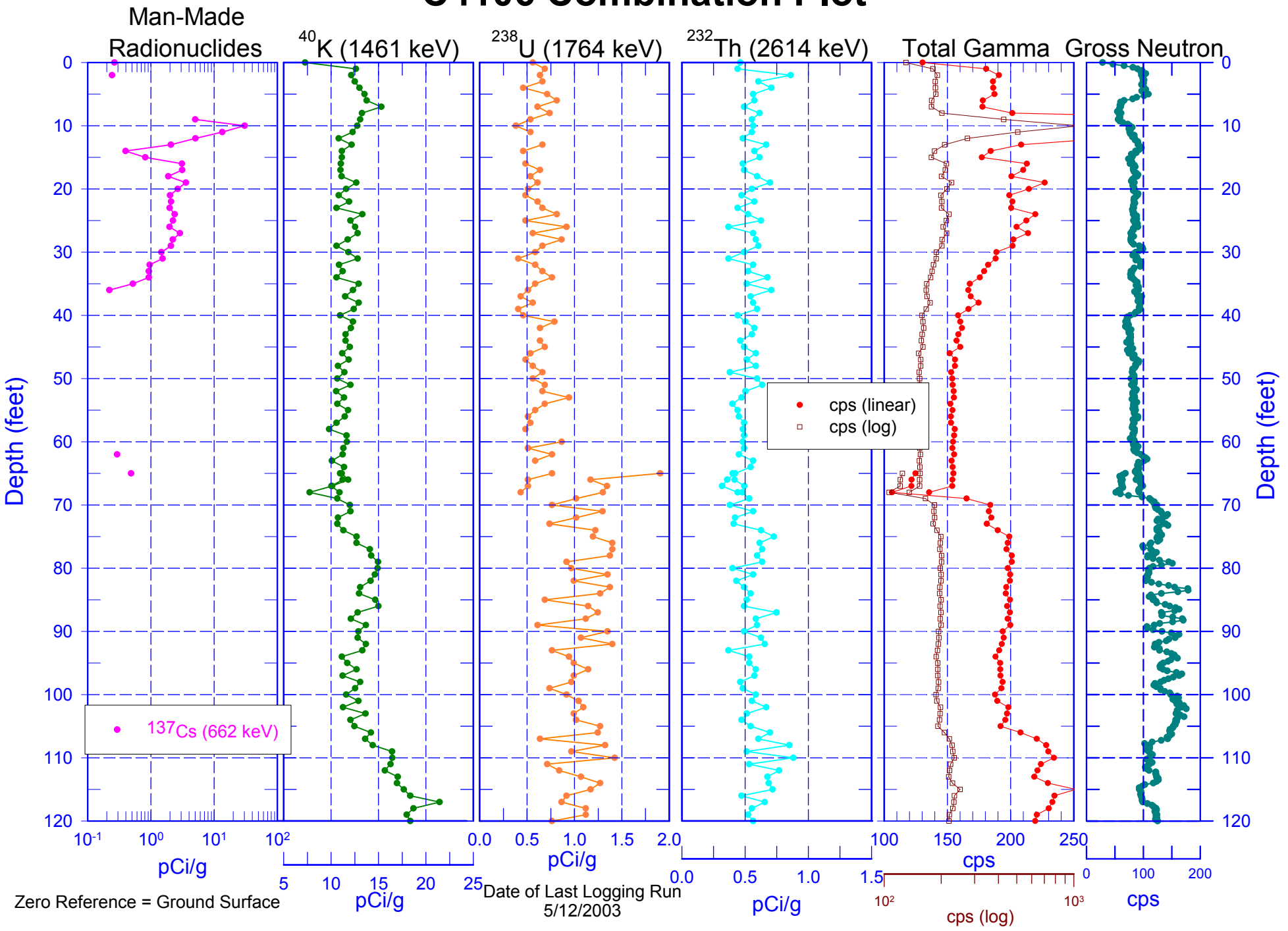
C4106
Natural Gamma Logs



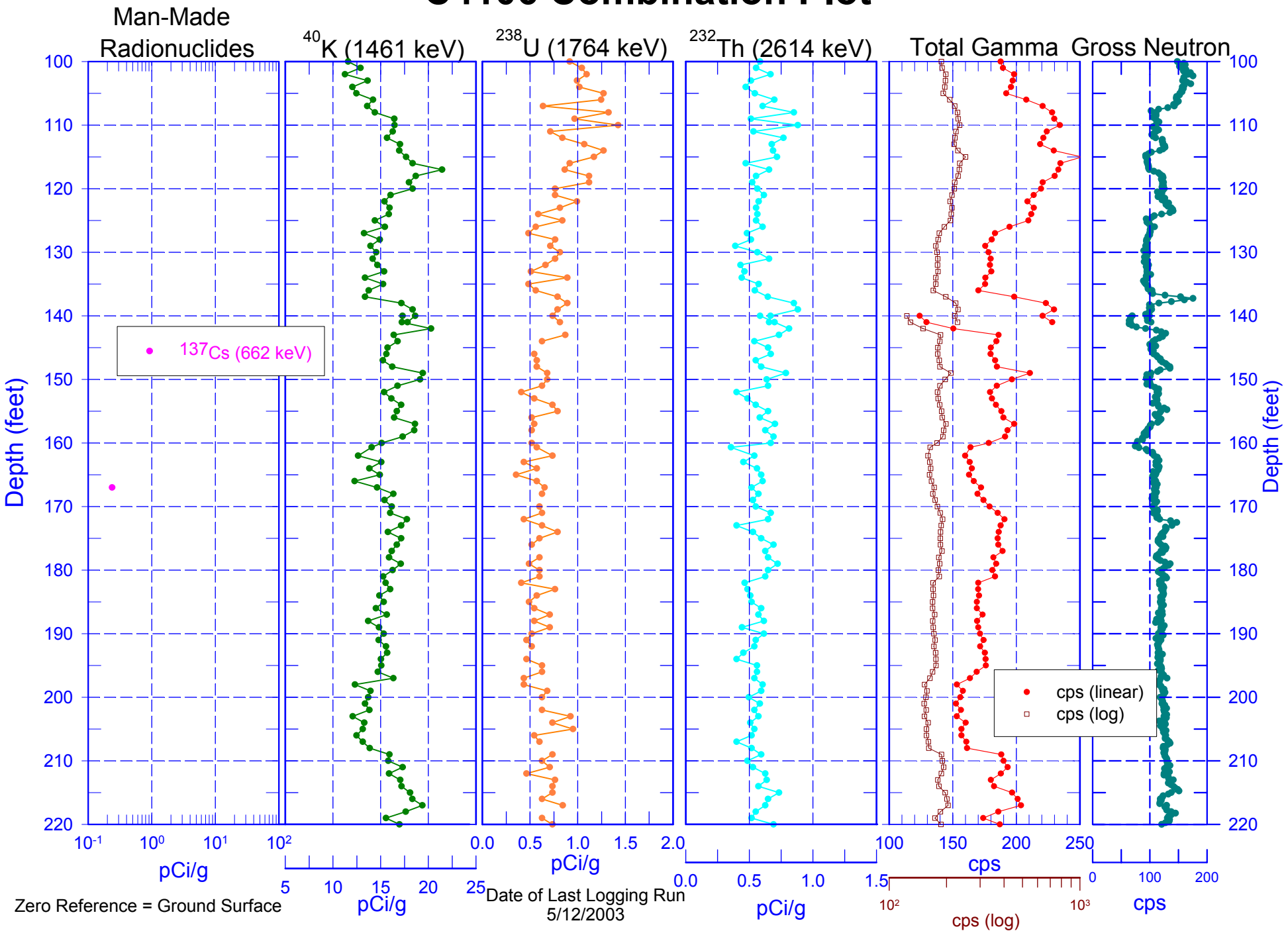
Zero Reference = Ground Surface

Date of Last Logging Run
5/08/2003

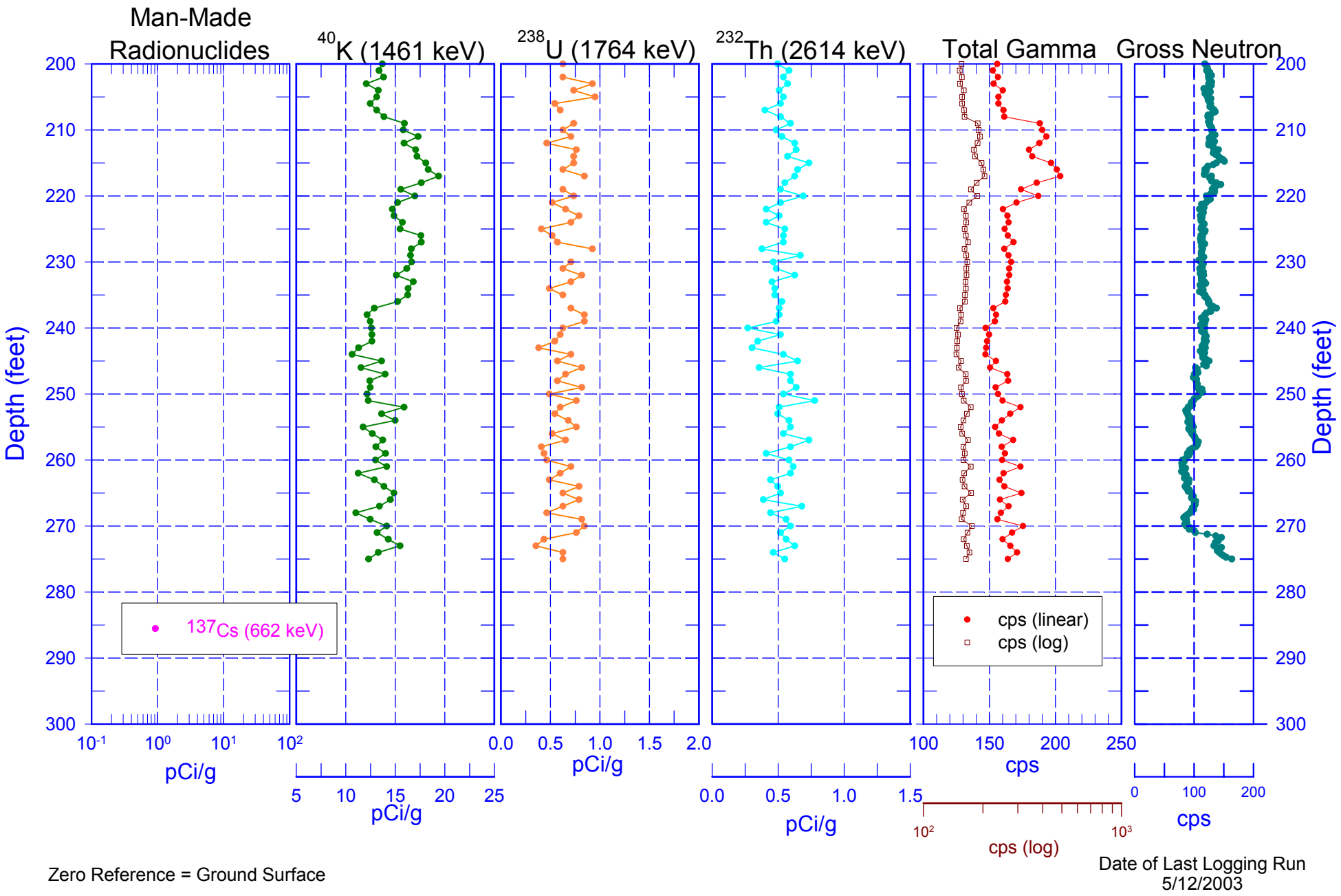
C4106 Combination Plot



C4106 Combination Plot



C4106 Combination Plot



Zero Reference = Ground Surface

Date of Last Logging Run
5/12/2003

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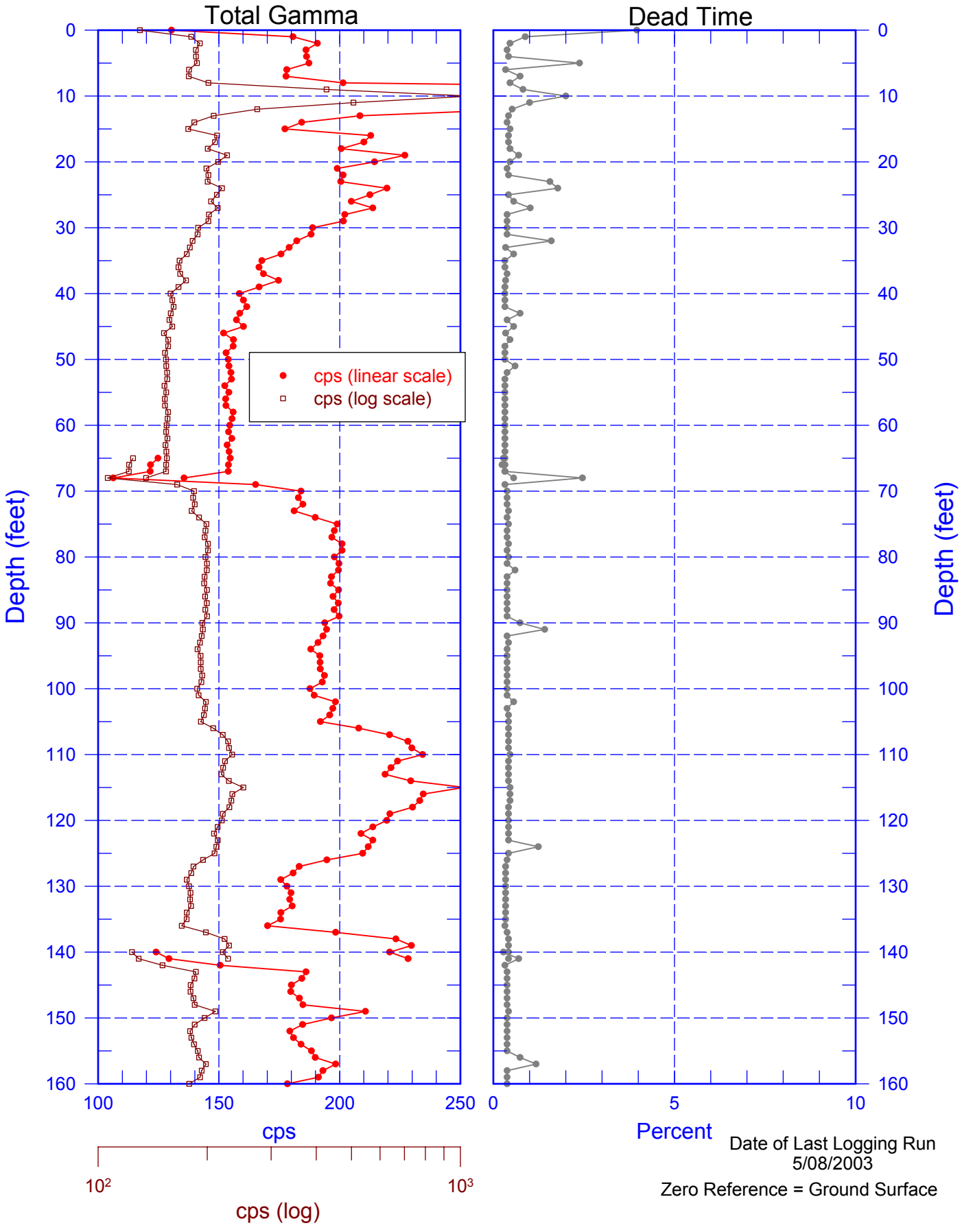
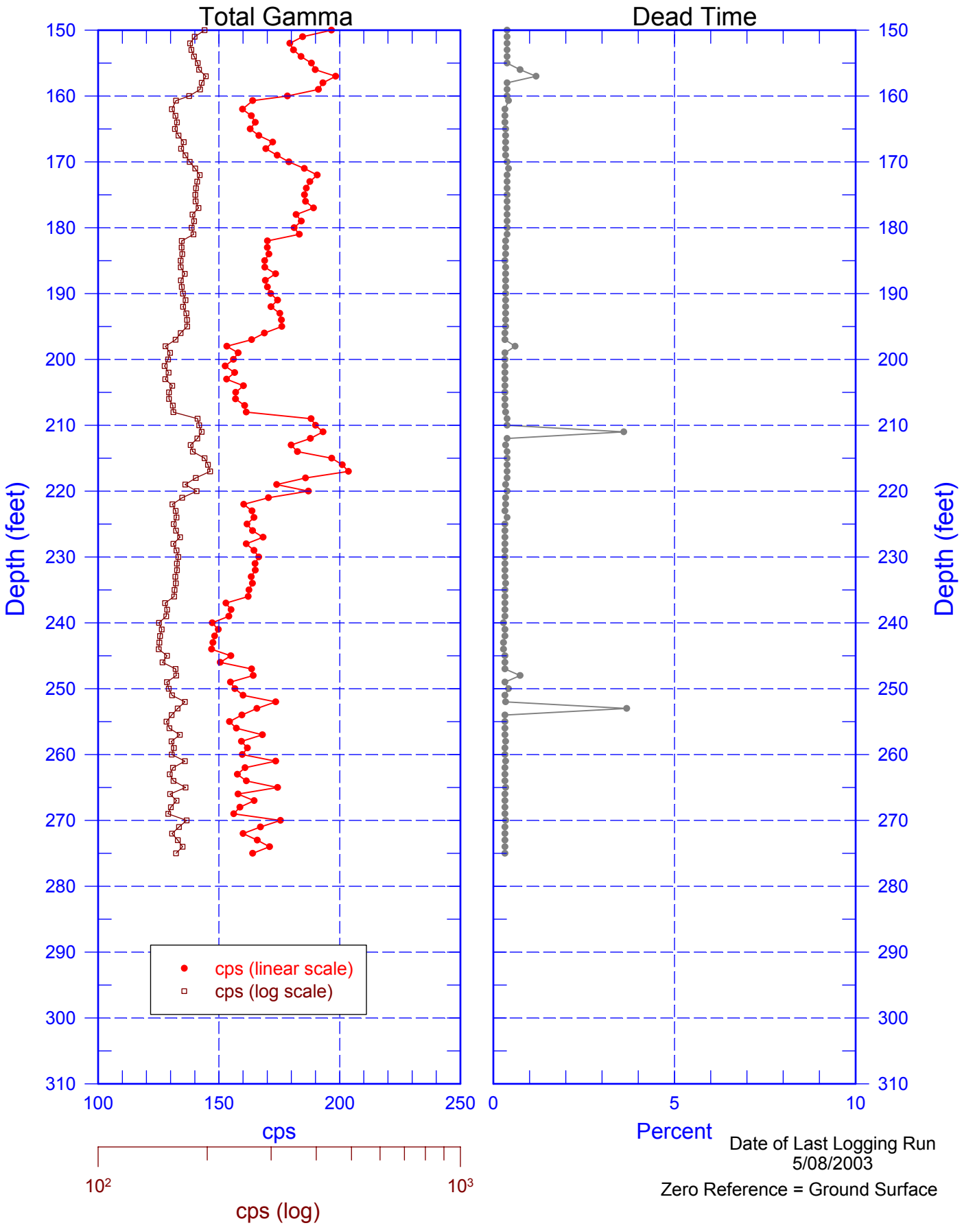
Total Gamma & Dead Time



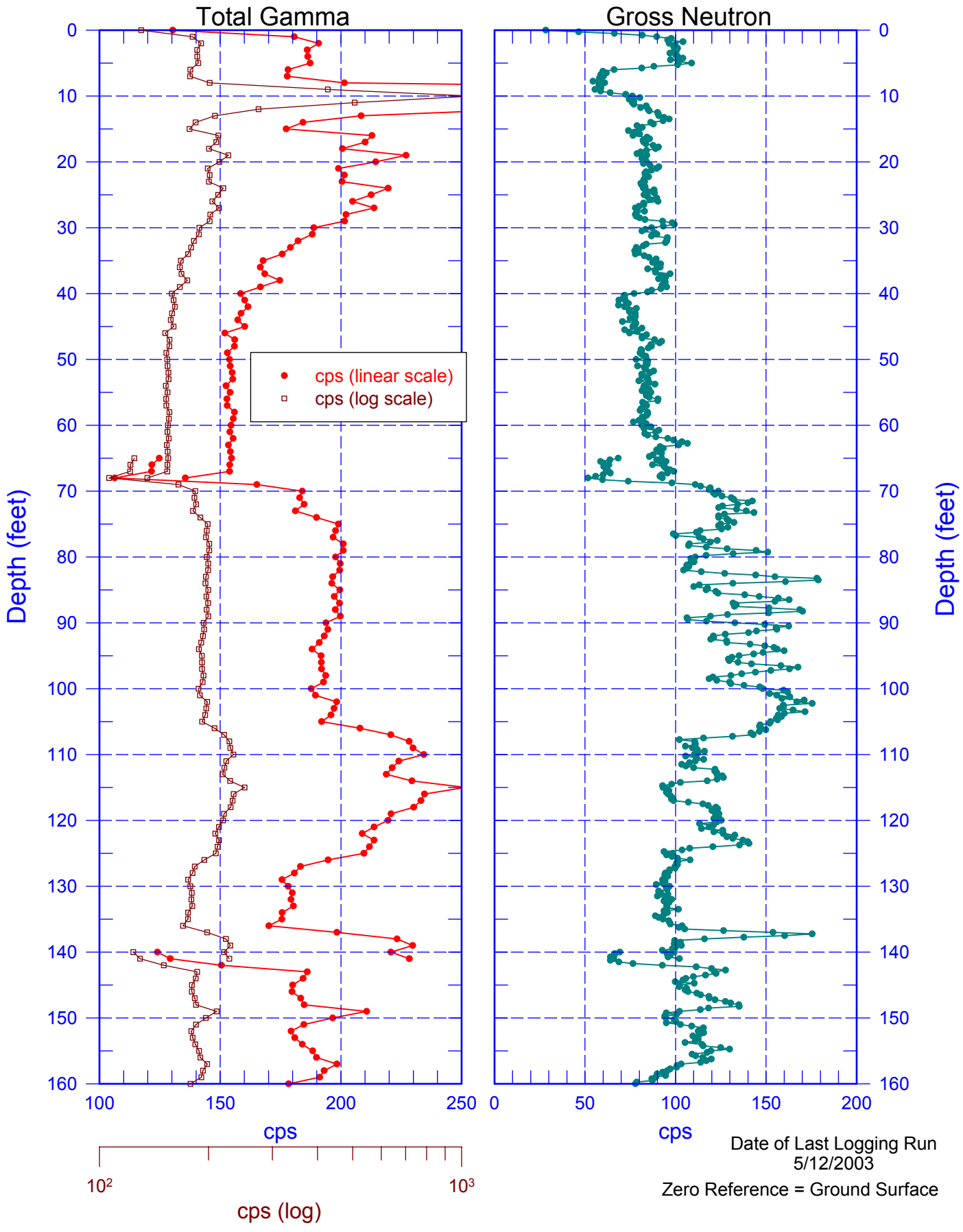
Date of Last Logging Run
5/08/2003

Zero Reference = Ground Surface

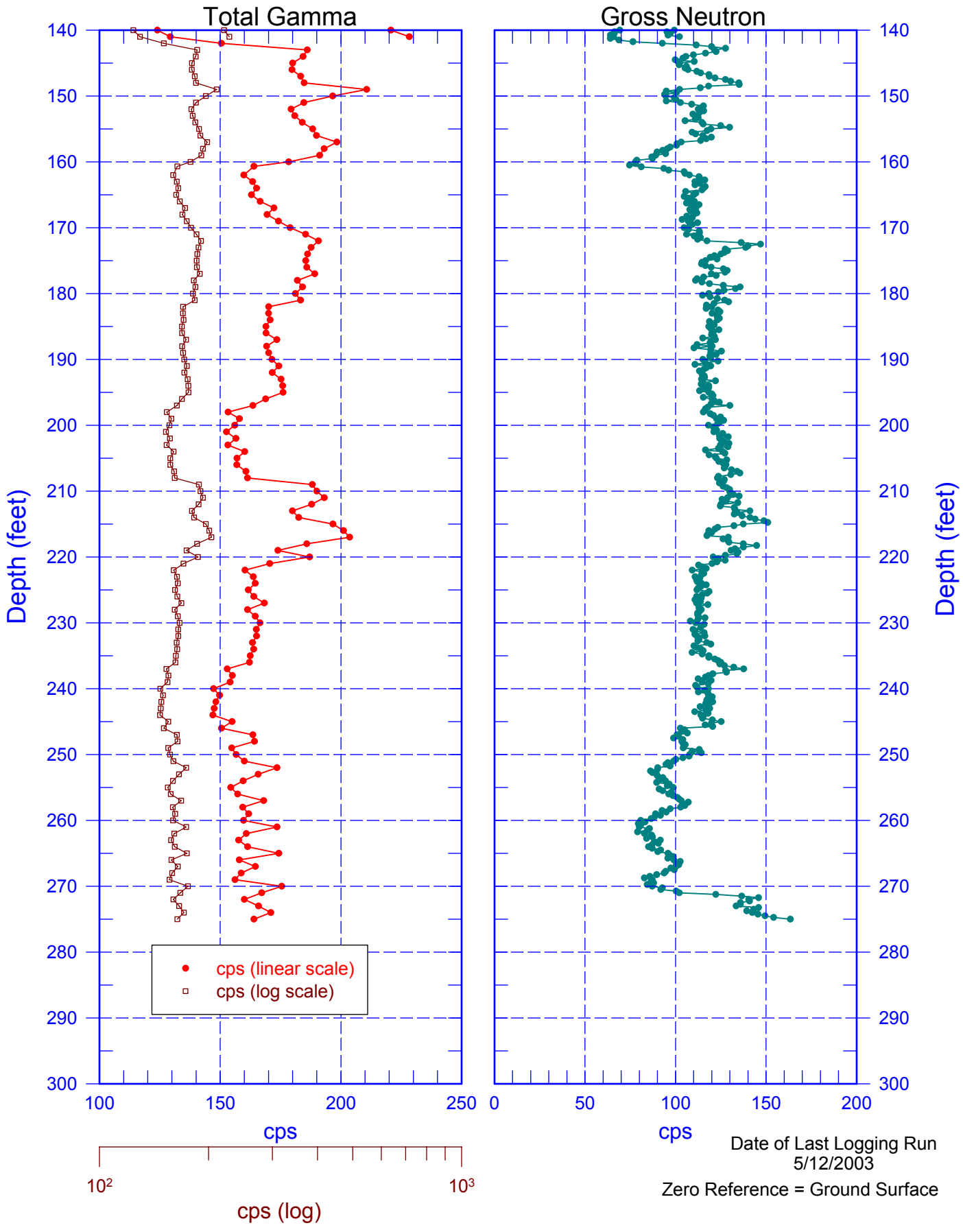
C4106
Total Gamma & Dead Time



C4106
Total Gamma & Neutron



C4106
Total Gamma & Neutron



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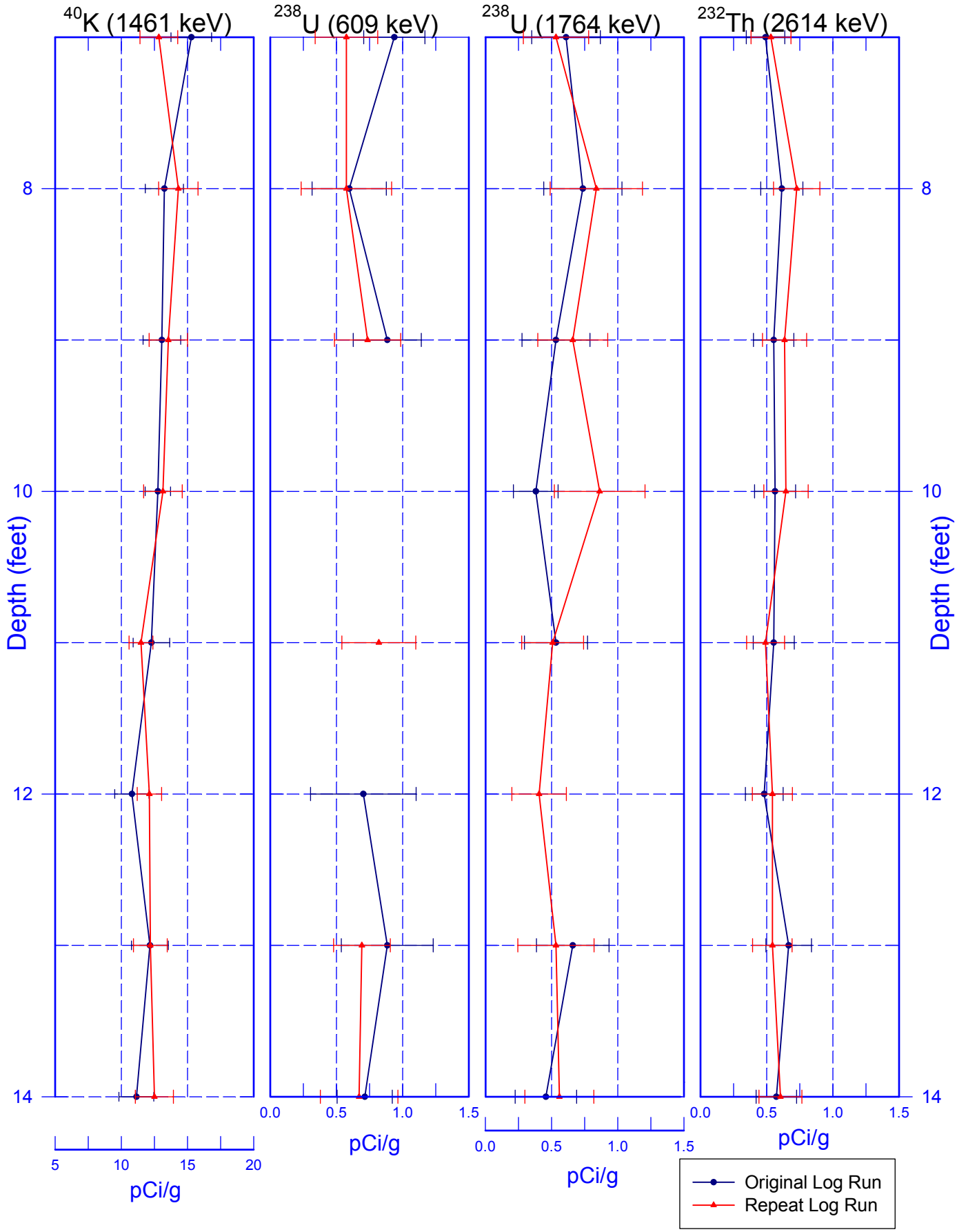
Rerun of Natural Gamma Logs (7.0 to 14.0 ft)



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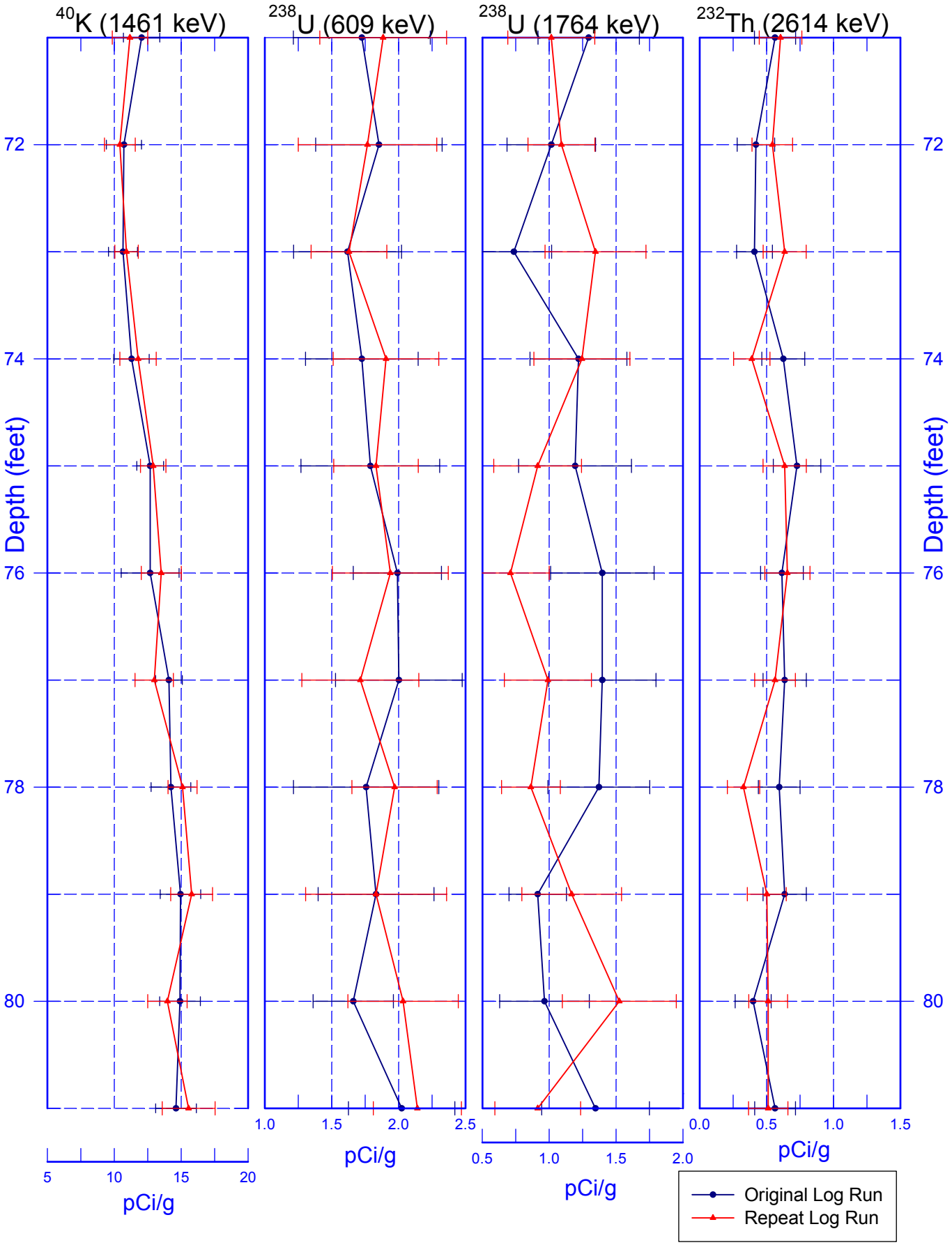
Rerun of Natural Gamma Logs (81.0 to 68.0 ft)



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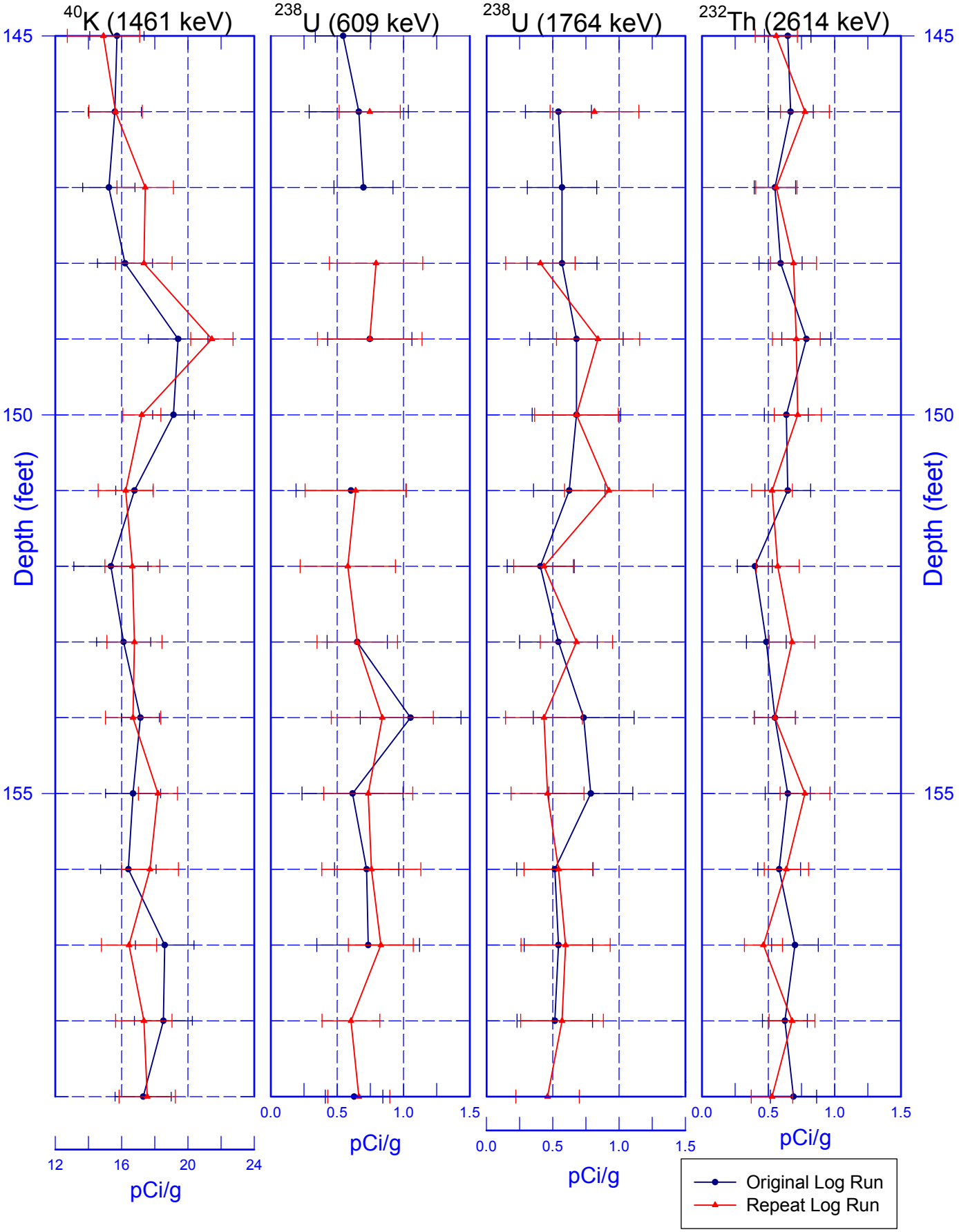
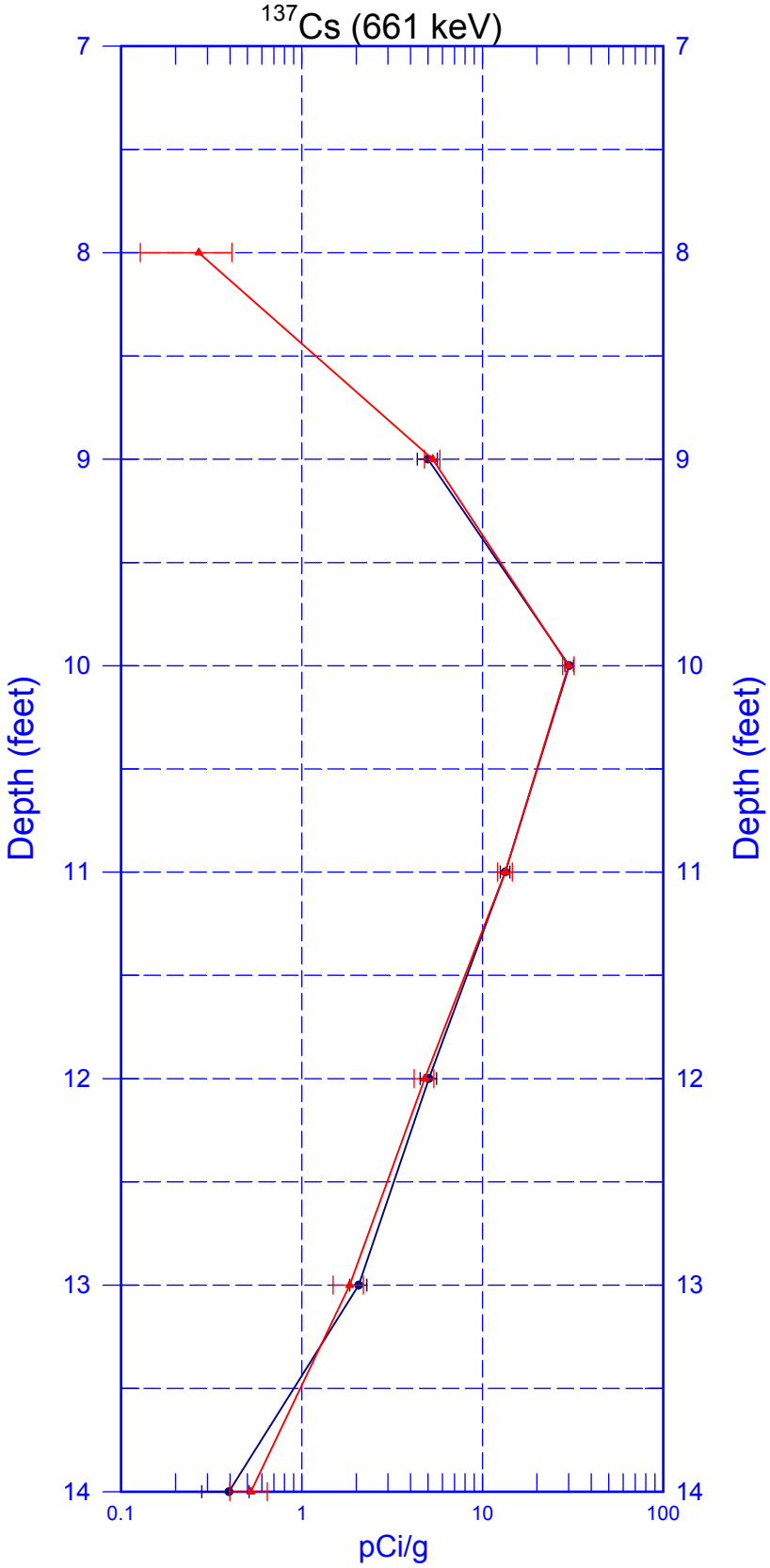
Rerun of Natural Gamma Logs (145.0 to 159.0 ft)



C4106

Rerun of Man-Made Radionuclides



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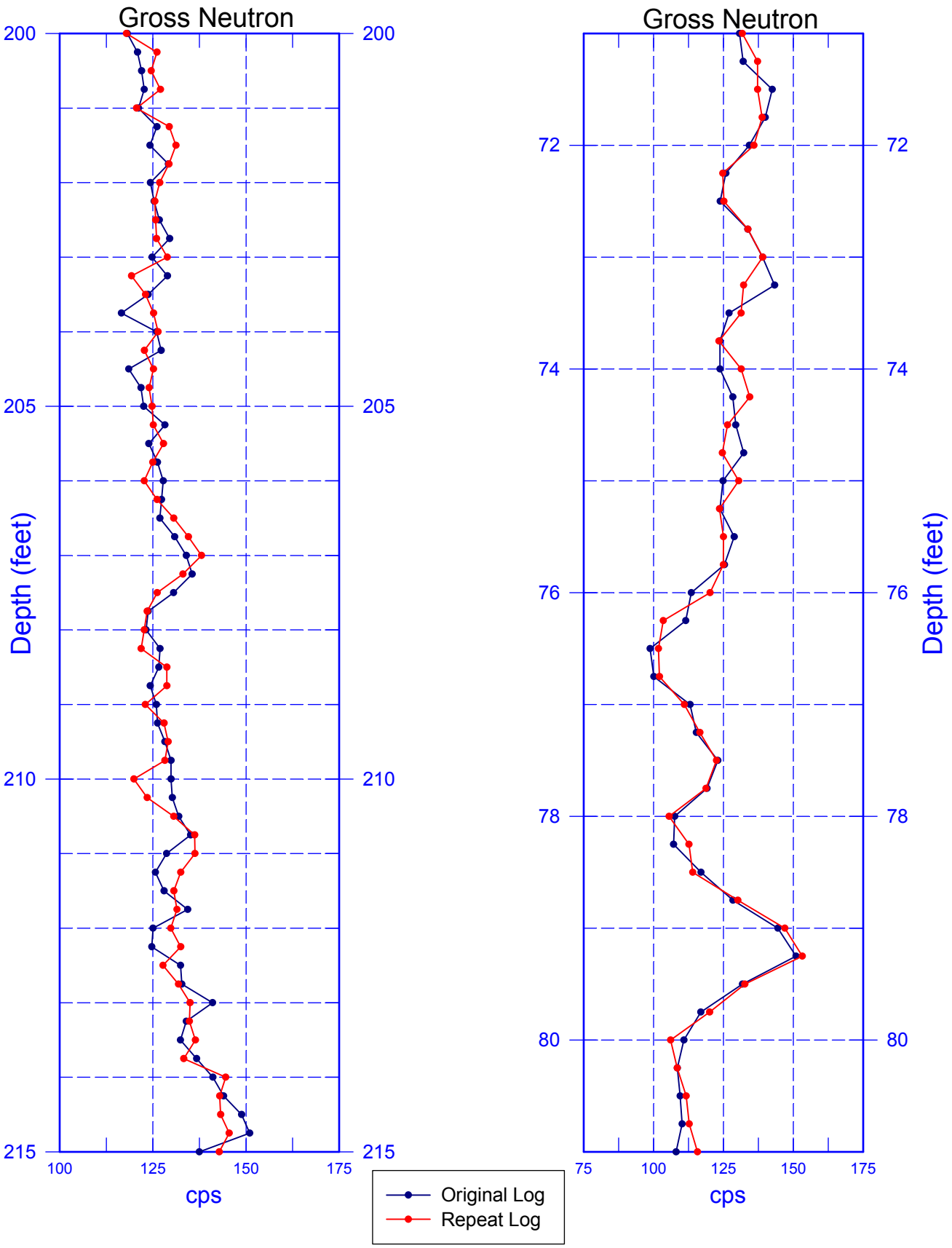
Reruns of Neutron-Moisture Log



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Rerun of Neutron-Moisture Log (60.0 to 67.0 ft)