Stoller
Hanford Office

DOE-EM/GJ1196-2006

# 299-E13-05 (A5853)
## Log Data Report

## Borehole Information:

| Borehole: 299-E13-05 (A5853) | | | Site: 216-B-18 Crib | | |
|---|---|---|---|---|---|
| Coordinates (WA St Plane) | | GWL[1] (ft): 347.2 | | GWL Date: 08/01/05 | |
| North | East | Drill Date | Elevation (TOC) | Total Depth (ft) | Type |
| 134320 | 573607 | 08/55 | Not available | 365.5 | Cable |

## Casing Information:

| Casing Type | Stickup (ft) | Outer Diameter (in.) | Inside Diameter (in.) | Thickness (in.) | Top (ft) | Bottom (ft) |
|---|---|---|---|---|---|---|
| Welded steel | 1.7 | 6 5/8 | 6 1/8 | 1/4 | 1.7 | 100 |
| Welded steel | 0.5 | 8 5/8 | unmeasured | 5/16 | 0.5 | 365.5 |

## Borehole Notes:

Casing diameter and stickup measurements for the 6-in. and 8-in. casings were acquired using a caliper and steel tape. The inside diameter of the 8-in. casing could not be measured due to grout fill between the casings. Measurements are rounded to the nearest 1/16 inch. Logging data acquisition is referenced to the top of casing (TOC). Depth to groundwater was measured with an e-tape by the logger.

## Spectral Gamma Logging System (SGLS) Equipment Information:

| Logging System: | Gamma 1E | | Type: | SGLS (70%) SN: 34TP40587A |
|---|---|---|---|---|
| Effective Calibration Date: | 03/04/05 | Calibration Reference: | DOE/EM-GJ864-2005 | |
| | | Logging Procedure: | MAC-HGLP 1.6.5, Rev. 0 | |

## High Rate Logging System (HRLS) Equipment Information:

| Logging System: | Gamma 1C | | Type: | HRLS SN: 39-A314 |
|---|---|---|---|---|
| Effective Calibration Date: | 04/06/05 | Calibration Reference: | DOE/EM-GJ865-2005 | |
| | | Logging Procedure: | MAC-HGLP 1.6.5, Rev. 0 | |

## Spectral Gamma Logging System (SGLS) Log Run Information:

| Log Run | 1 | 2 | 3 | | |
|---|---|---|---|---|---|
| Date | 08/01/05 | 08/02/05 | 08/03/05 | | |
| Logging Engineer | Pearson | Pearson | Pearson | | |
| Start Depth (ft) | 346.0 | 233.0 | 91.0' | | |

| Log Run | 1 | 2 | 3 | | |
|---|---|---|---|---|---|
| Finish Depth (ft) | 198.0 | 90.0 | 2.0' | | |
| Count Time (sec) | 100 | 100 | 100 s | | |
| Live/Real | R | R | R | | |
| Shield (Y/N) | N | N | NA | | |
| MSA Interval (ft) | 1.0 | 1.0 | 1.0 ft | | |
| ft/min | NA | NA | NA | | |
| Pre-Verification | AE086CAB | AE087CAB | AE088CAB | | |
| Start File | AE086000 | AE087000 | AE088000 | | |
| Finish File | AE086148 | AE087143 | AE088089 | | |
| Post-Verification | AE086CAA | AE087CAA | AE088CAA | | |
| Depth Return Error (in.) | +2 | +3.5" | +1.5" | | |
| Comments | Fine gain adjustment made at bottom of borehole before logging began. | Fine gain adjustment made at bottom of borehole before logging began. Repeat from 233 to 198 ft. | Adjusted gain after file AE088078, 13ft. | | |

## High Rate Logging System (HRLS) Log Run Information:

| Log Run | 4 | | | | |
|---|---|---|---|---|---|
| Date | 08/03/05 | | | | |
| Logging Engineer | Pearson | | | | |
| Start Depth (ft) | 13.0 | | | | |
| Finish Depth (ft) | 20.0 | | | | |
| Count Time (sec) | 300 | | | | |
| Live/Real | R | | | | |
| Shield (Y/N) | N | | | | |
| MSA Interval (ft) | 0.5 | | | | |
| ft/min | NA | | | | |
| Pre-Verification | AC135CAB | | | | |
| Start File | AC135000 | | | | |
| Finish File | AC135014 | | | | |
| Post-Verification | AC135CAA | | | | |
| Depth Return Error (in.) | 0.0 | | | | |
| Comments | Adjusted gain after AC135010, 18.0'. | | | | |

## Logging Operation Notes:

Logging was conducted without a centralizer on the sonde. Measurements are referenced to the top of casing. A repeat section was collected in this borehole to evaluate the logging system's performance. Borehole was logged from approximately 1 ft. above groundwater level to surface.

## Analysis Notes:

| Analyst: | Pope | Date: | 04/18/06 | Reference: | GJO-HGLP 1.6.3, Rev. 0 |
|---|---|---|---|---|---|

Pre-run and post-run verifications for the logging systems were performed before and after each day's data acquisition. Acceptance criteria were met for all systems, with the exception of the HRLS post-survey verification measurement on 08/03/05, in which the $^{137}$Cs net count rate was slightly below the lower control limit. Source-detector geometry is a significant factor in the overall count rate during verification measurements with the HRLS. Because the pre-survey verification met the criteria, and the log data appear good, and subsequent logs with the system appear good, a minor deviation from the ideal geometry is assumed here. The HRLS post-survey verification results are therefore determined to be provisionally acceptable.

SGLS and HRLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated using the EXCEL worksheet templates identified as G1Emar05.xls and G1CApr05.xls for the SGLS and HRLS data, respectively, using efficiency functions and corrections for casing, water, and dead time as determined from annual calibrations. A casing correction for 0.5625-in.-thick casing was applied to the SGLS and HRLS data from 0.0 to 100.0 ft. A casing correction for 0.3125-in.-thick casing was applied to the SGLS data from 101.0 ft to depth. Dead time corrections are applied where dead times exceed approximately 11 percent. Where SGLS dead time exceeds 40 percent, HRLS data are substituted. Correction for water was not needed in this borehole.

## Results and Interpretations:

A continuous zone of $^{137}$Cs was detected from 13 to 100 ft, with a single gap at 95 ft. A zone of high $^{137}$Cs concentrations exists from approximately 14 to 20 ft. The maximum concentration is approximately 53,700 pCi/g at 16.5 ft. A second zone of high Cs concentrations exists between 73 and 89 ft, with a maximum concentration of approximately 1,100 pCi/g at 84 ft. $^{137}$Cs was also detected sporadically throughout the remainder of the logged section (0 to 346 ft) of the borehole at concentrations mostly just above the MDL[2] (approx. 0.2 pCi/g), up to about 0.5 pCi/g.

$^{60}$Co is detected sporadically at discrete depths, and in short, continuous zones from 41 to 246 ft, mostly at concentrations around 0.1 pCi/g. The longest continuous zone has a peak concentration of approximately 1.1 pCi/g at 81 ft. It is possible that $^{60}$Co also exists in the high rate interval from 14 to 20 ft at higher concentrations.

$^{125}$Sb was detected at 23 to 29 ft, from 33 to 43 ft, and at 47 ft. The maximum concentration is approximately 2.8 pCi/g at 28 ft. It is possible that $^{125}$Sb also exists in the high rate interval from 14 to 20 ft at higher concentrations. $^{125}$Sb emits a number of gamma rays in the detectable range of the SGLS. The 428 keV gamma ray was used to assay $^{125}$Sb because of its significantly higher yield of 0.2960 yields per decay. Peaks at 601 and 636 keV were used during analysis to confirm the identification of the isotope.

Gamma activity from uranium is usually dominated by emissions from $^{238}$U daughters such as $^{226}$Ra, $^{214}$Pb, and $^{214}$Bi. These isotopes occur in the lower part of the decay chain and achieve secular equilibrium with the parent $^{238}$U over a time frame approaching a million years. Processed uranium refers to material that has been chemically purified. The purification process removes the daughter elements and thus manmade uranium can be differentiated from natural uranium by the absence of gamma rays from long-term daughters combined with the presence of less intense gamma rays from short-term daughters.

The primary gamma activity associated with manmade uranium originates from $^{234m}$Pa. The 1001-keV gamma ray is the most intense (0.84% yield), and a confirming line occurs at 766 keV (0.29% yield). These lines are seldom strong enough to be detected in natural uranium at background levels, but can be detected when manmade uranium concentrations exceed 10 pCi/g. Natural uranium is most commonly detected and quantified from gamma rays at 1764 or 609 keV (yields of 15.4% and 44.8%, respectively), at levels below

1 pCi/g. These gamma rays originate from $^{214}$Bi, which is far down in the decay series and therefore not present in detectable amounts in manmade uranium.

Processed uranium also contains $^{235}$U in various amounts according to the enrichment used for the reactor fuel at Hanford and burn up time. This radionuclide can be measured directly from energy peaks at approximately 186, 202, and 205 keV. The highest yield (57.2 %) is from the 186 keV gamma ray, which is used to assay $^{235}$U.

Evidence of processed uranium exists from 22 to 25 ft, 34 to 39 ft, and at 48 ft. Although no detections of processed uranium exist in the high activity zone between 14 and 20 ft, it is possibly present in that interval. Every instance of uranium in this borehole was identified using the 1001 keV gamma ray of $^{234m}$Pa. The 766 keV line was mostly not identified by the analysis software, but was identified qualitatively through visual inspection of the spectra. $^{235}$U was not identified, most likely because of attenuation of the low-energy gamma rays in the double casing. $^{238}$U concentrations range from 11 to 21 pCi/g (MDL range from 8 to 14 pCi/g), with the maximum concentration occurring at 35 ft.

The repeat section for the SGLS indicates good agreement for both the naturally occurring and man-made radionuclides.

Spectral gamma data were acquired in this borehole in 1992 by Westinghouse Hanford Company, and in 1999 by Waste Management Federal Services NW using the Radionuclide Logging System (RLS). A comparison of 1992 and 1999 RLS spectral data with the current SGLS and HRLS data indicate two notable changes through time: an increase in $^{137}$Cs concentrations between 20 and 23 ft, and the previously unidentified occurrence of processed uranium between about 22 and 48 ft. These two changes are discussed in more detail below. Otherwise, there is good agreement between the three logs, and no other significant changes are noted since 1992.

Between 1992 and 1999, the $^{137}$Cs concentrations increased markedly between about 20 and 23 ft, with a maximum increase of about 400 pCi/g at about 20 to 21 ft. A comparison between the 2005 SGLS log and the 1999 RLS log indicates no further changes in the $^{137}$Cs contamination profile.

As discussed above, $^{238}$U ($^{234m}$Pa) was identified in the 2005 SGLS log. $^{238}$U was not identified in the log data reports for either the 1992 or 1999 logs. In order to perform a visual inspection of the 1992 and 1999 spectra, these data were reprocessed using the current log analysis software and parameters. The reprocessed spectra could not be used to quantify concentrations of $^{238}$U without further knowledge of the calibration and verification of the 1992 and 1999 systems. Results of visual inspection of reprocessed 1999 spectra indicate $^{238}$U was already present at approximately the same depths as in 2005. The 1992 spectra did not yield any convincing indication of the presence of $^{238}$U. It cannot be concluded that $^{238}$U was not present in 1992. The 1992 system and logging parameters may not have been adequate for resolving relatively low concentrations of $^{238}$U in a double-cased borehole.

A visual comparison of the log profiles of all total gamma logs acquired from 1956 to 1976, the 1992 PNL total gamma log, and the 1992 and 1999 RLS total gamma logs was performed. No effort was made to depth-correct data from the logs prior to 1992, due to lack of adequate specific information about the depth references used. The data from 1956 to 1976 were digitized from previously published plots. Downward migration of relatively short-lived radioisotopes (e.g., $^{106}$Ru, half-life of 1.02 years) can be inferred from the data from 1956 to 1963, to as deep as about 150 ft. Prior to 1963, it is likely that the total gamma detectors were saturated to a depth of at least 120 ft. Between 1968 and 1992, the gamma profiles suggest that the short-lived nuclides decayed away enough to result in a fairly stable gamma-profile dominated by the longer-lived $^{137}$Cs, as well as $^{60}$Co, $^{125}$Sb, and (by probably at least 1999) processed uranium.

This borehole represents the only known occurrence of $^{238}$U in the B/C cribs area, and detection levels are only slightly above the MDL. It is strongly recommended that selected intervals in this borehole be re-logged using a long count time to confirm the presence of processed uranium.

## List of Plots:

Man-Made Radionuclides
Natural Gamma Logs
Combination Plot
Total Gamma and Dead Time
Repeat Section of Man-Made Radionuclides
Repeat Section of Natural Gamma Logs
SGLS/RLS Man-Made Comparison Logs
Historical Total Gamma Logs

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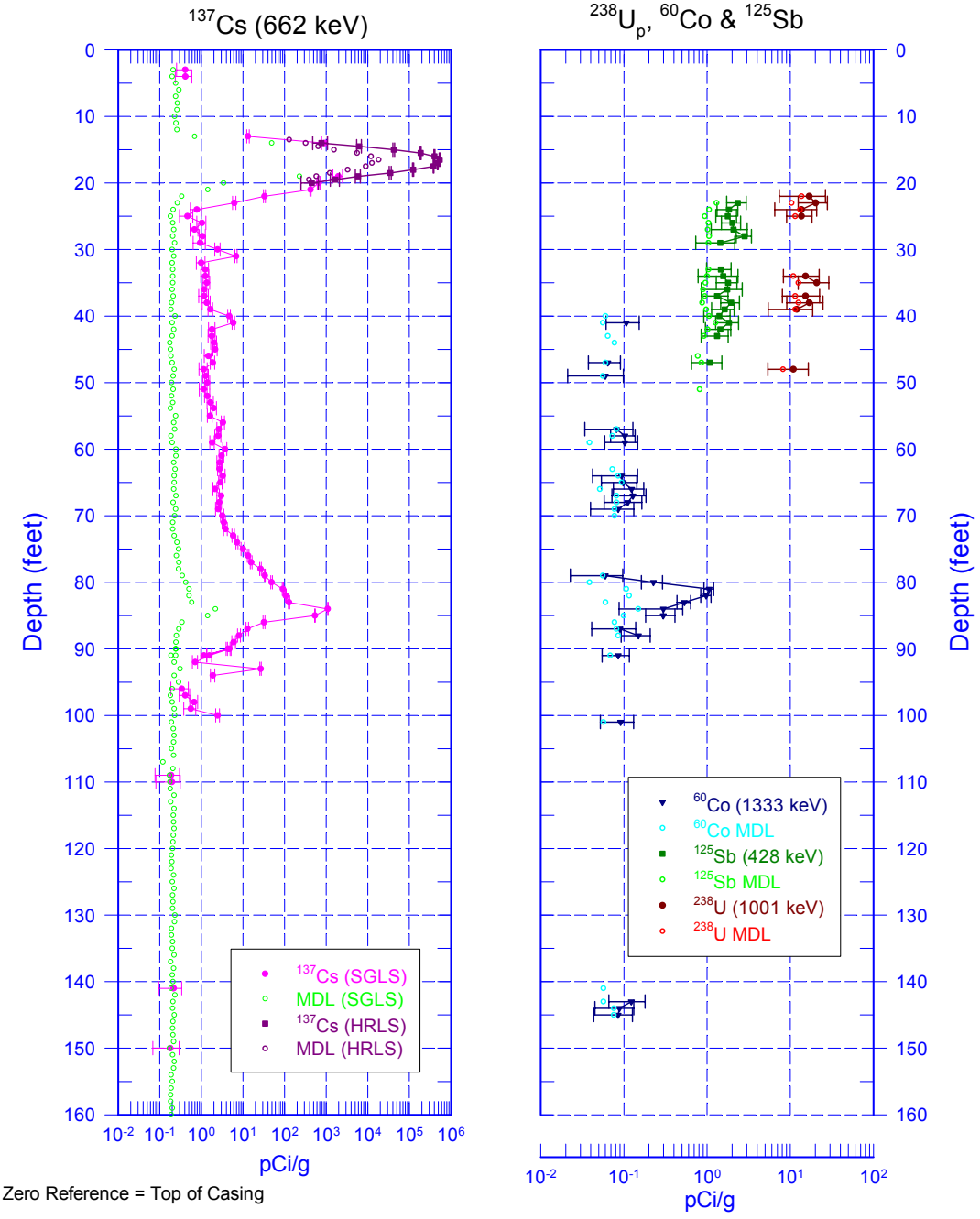
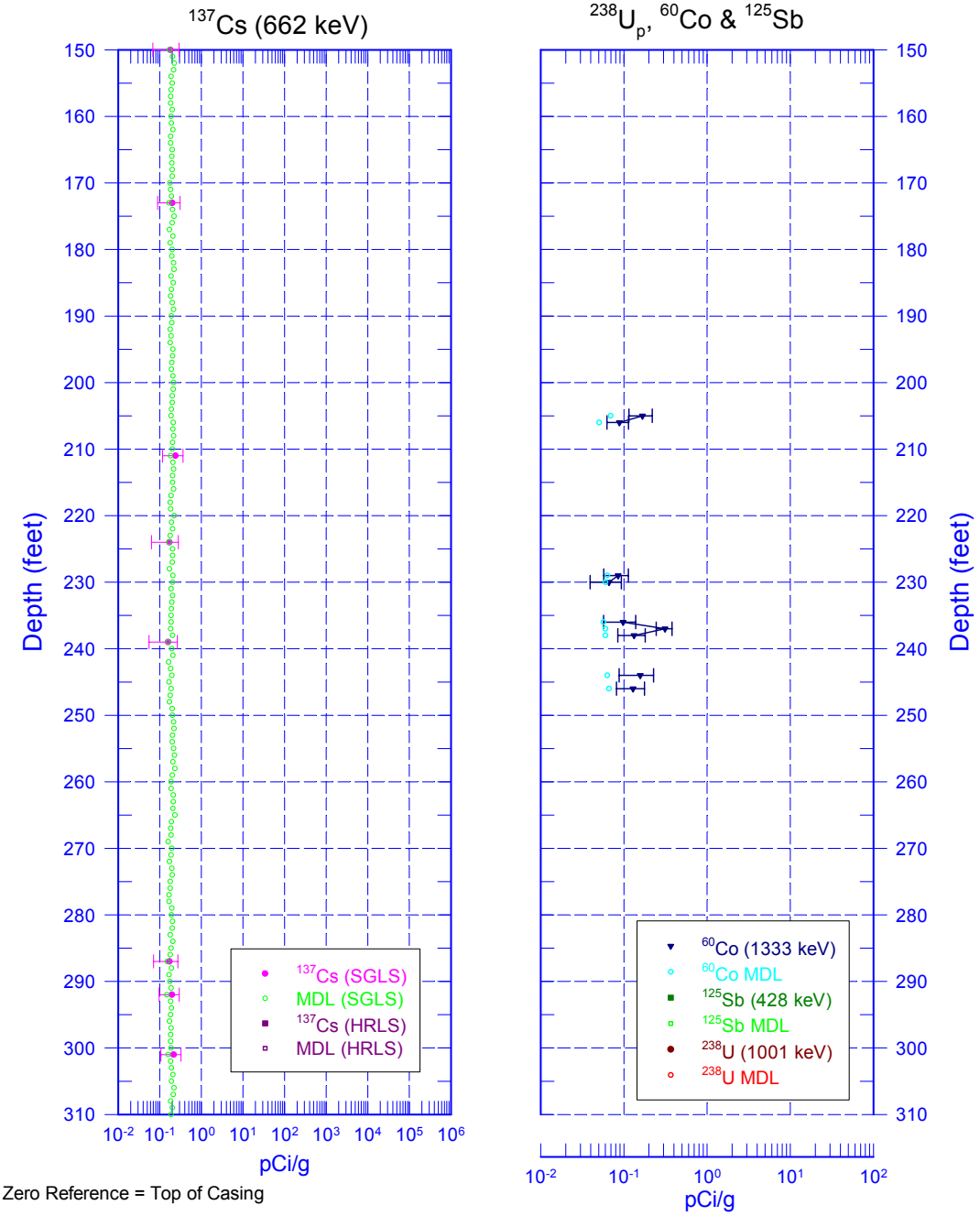
[1] GWL – groundwater level
[2] MDL – minimum detectable level

# 299-E13-05 (A5853)
## Man-Made Radionuclides



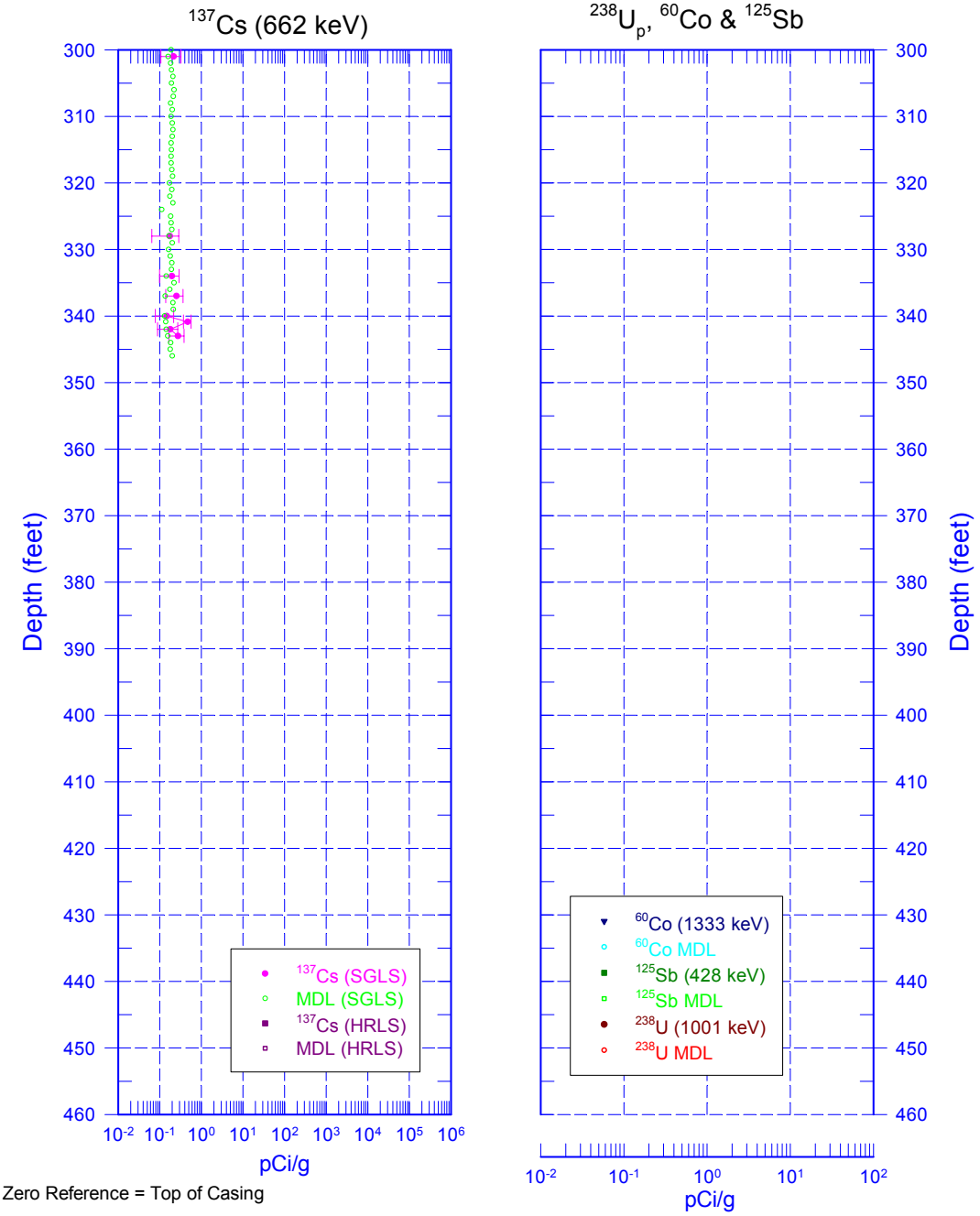

Zero Reference = Top of Casing

# 299-E13-05 (A5853)
## Man-Made Radionuclides




Zero Reference = Top of Casing

# 299-E13-05 (A5853)
## Man-Made Radionuclides

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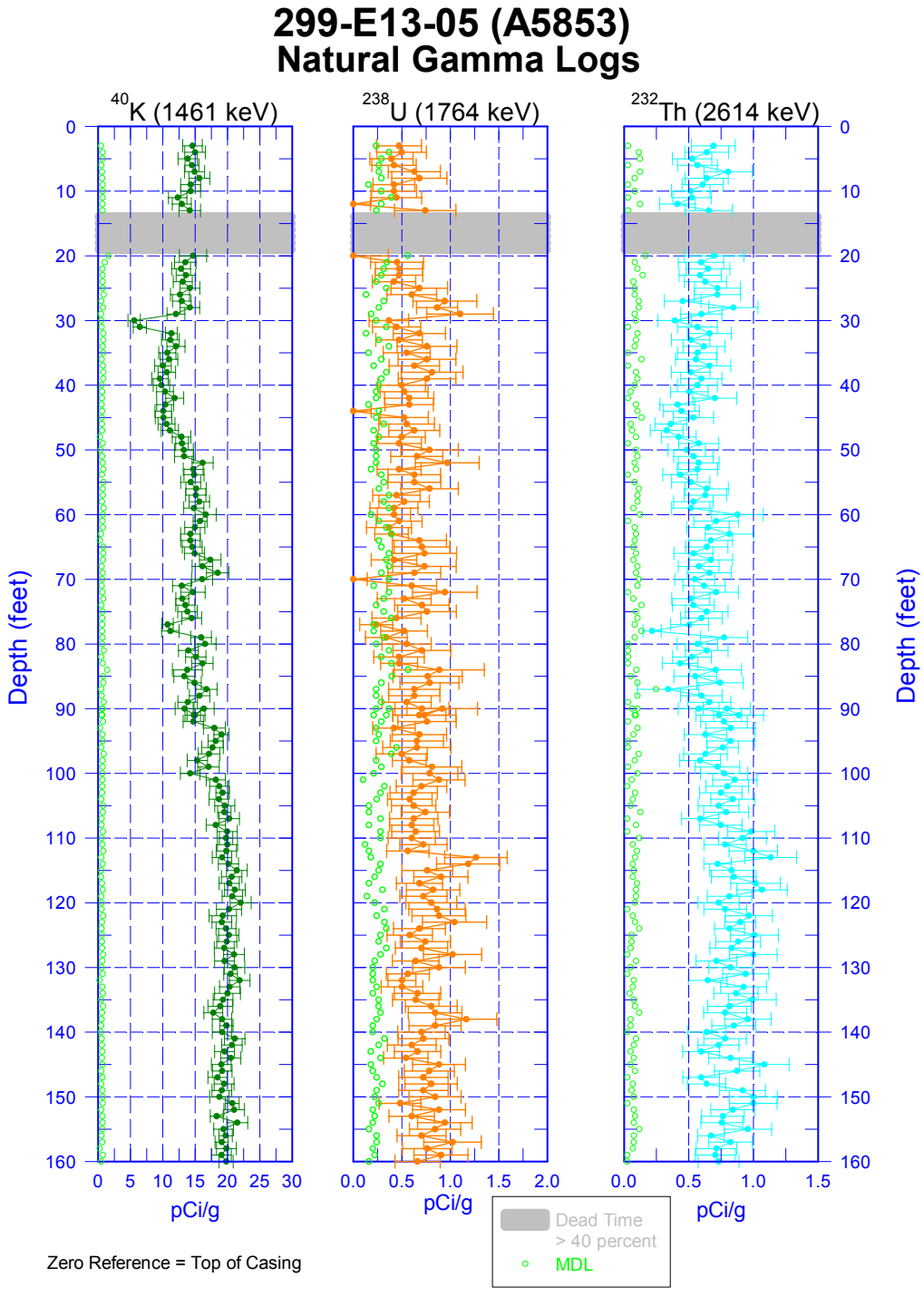
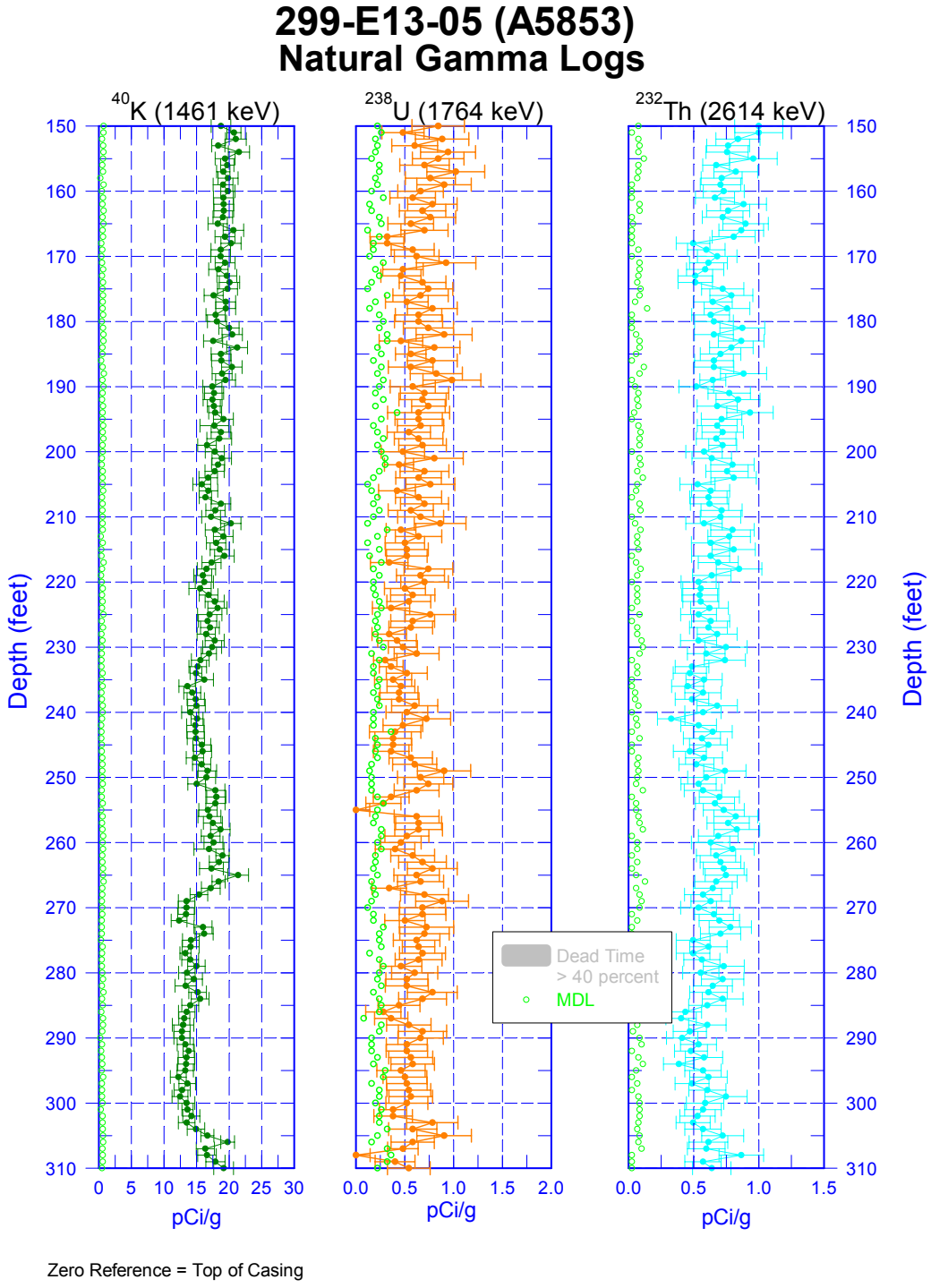
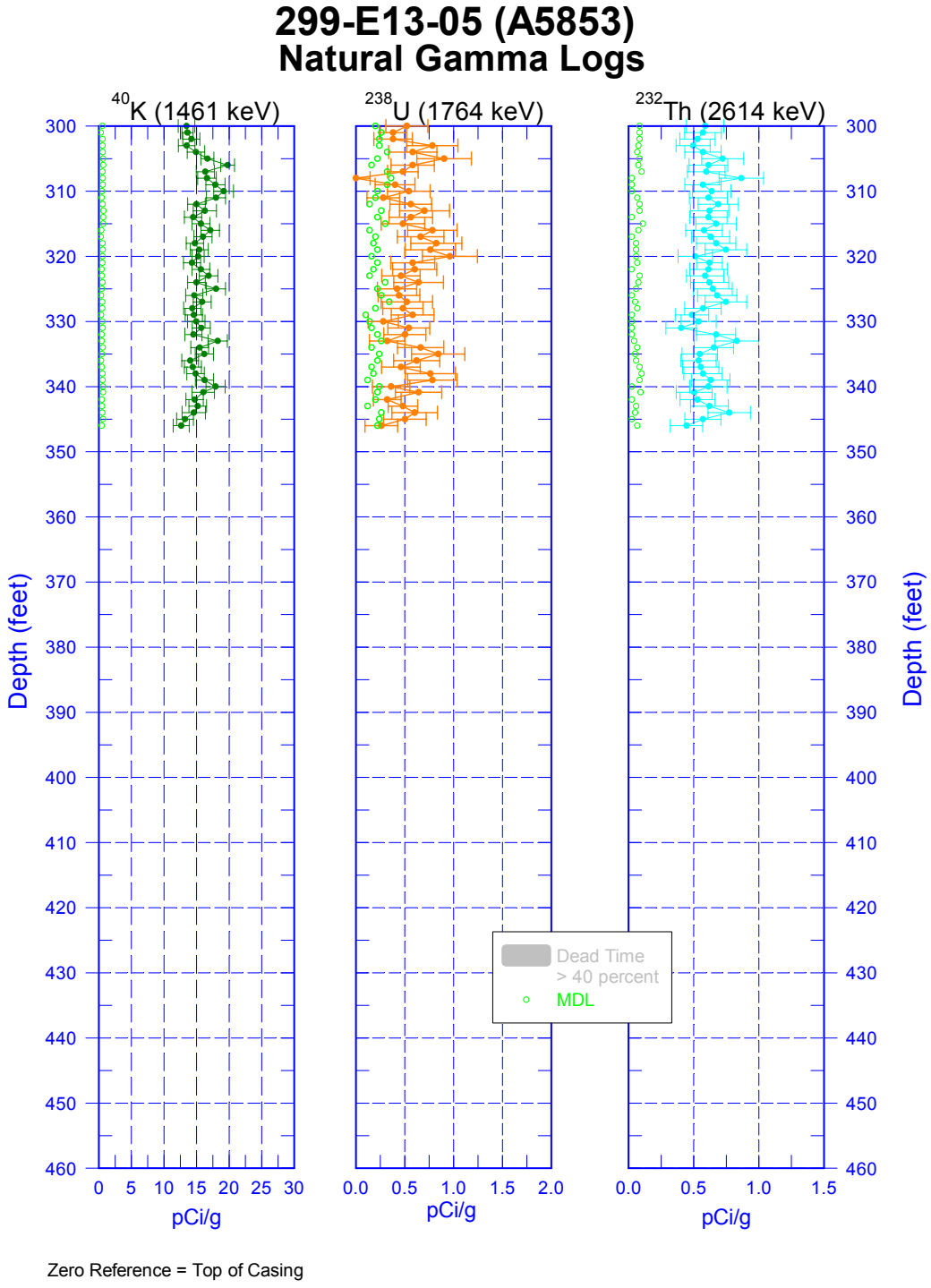
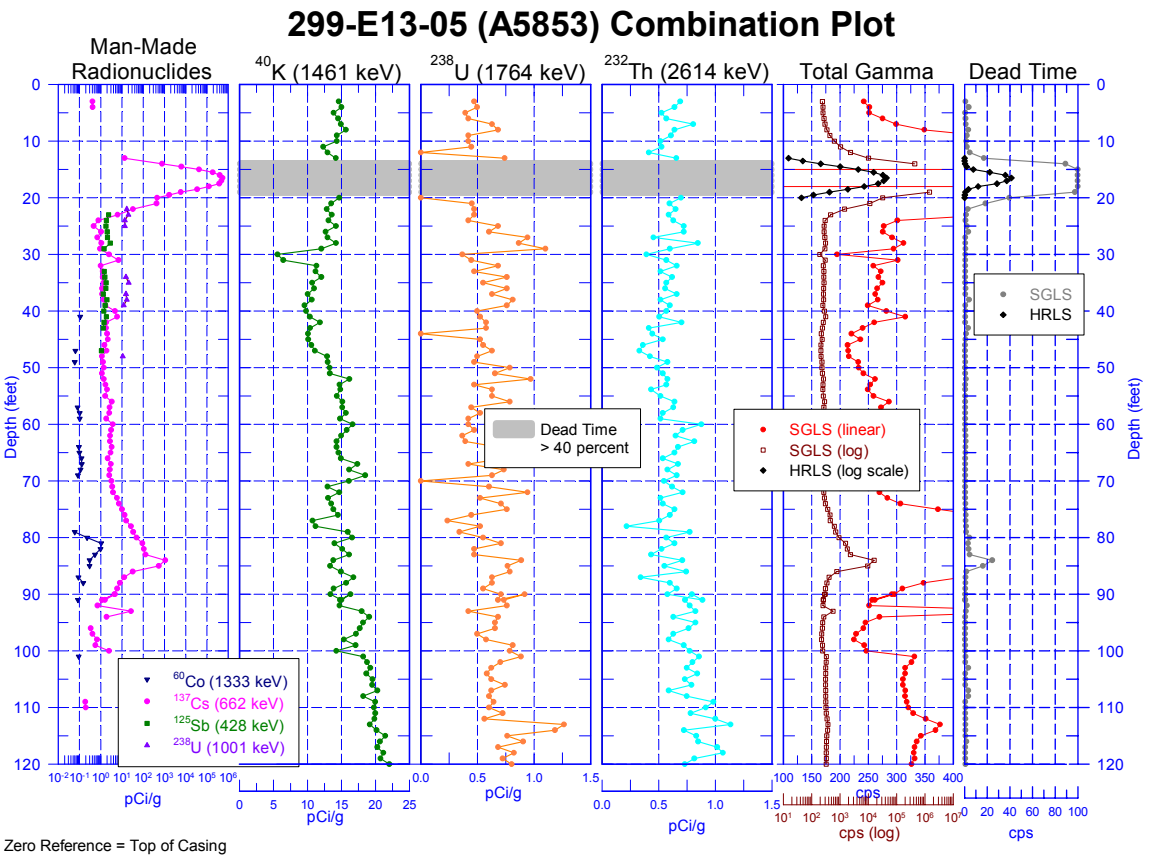
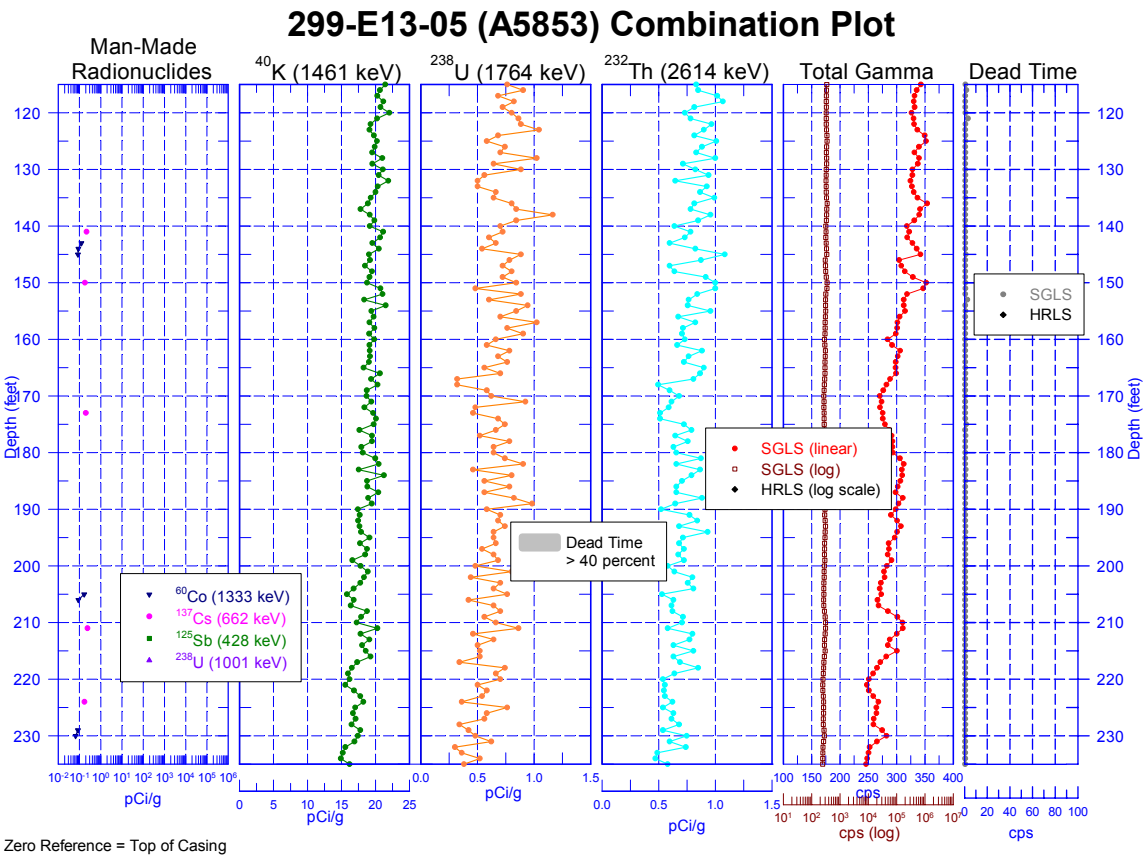
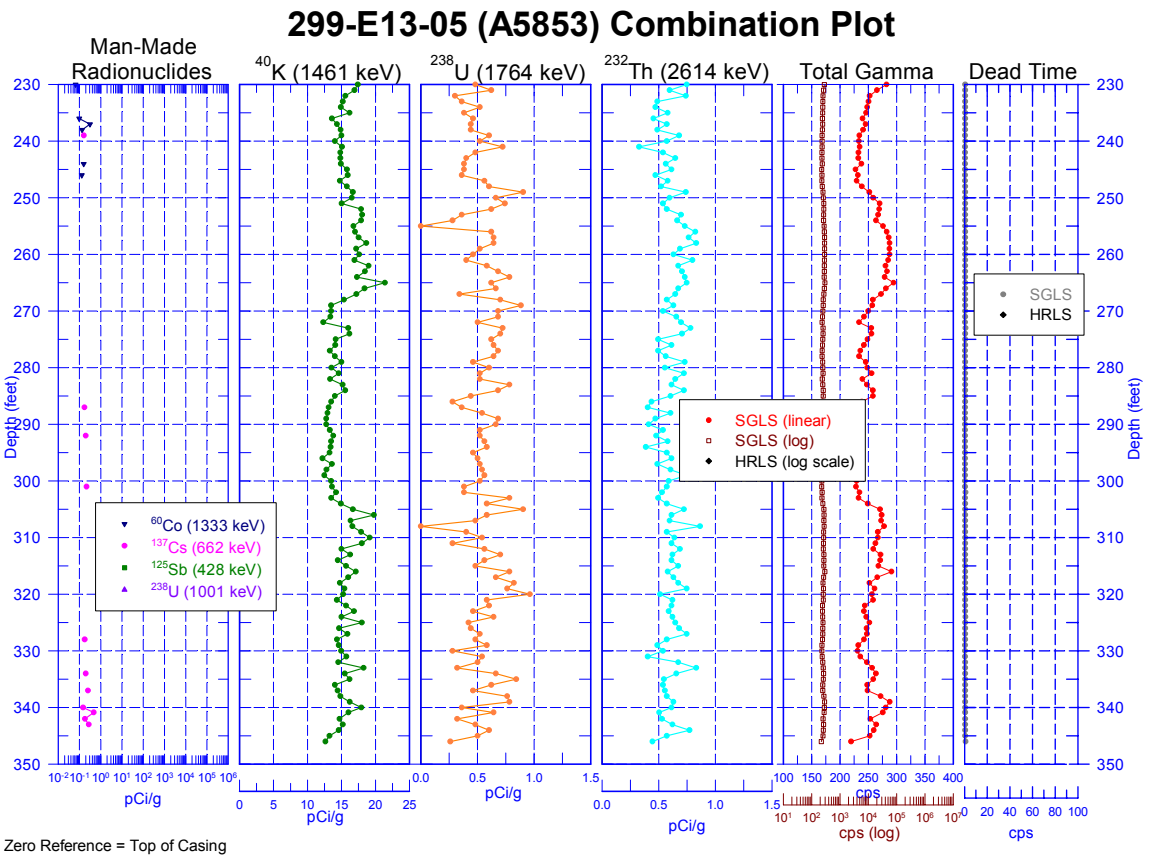

299-E13-05 (A5853)
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
pCi/g
Dead Time
> 40 percent
MDL
Zero Reference = Top of Casing


299-E13-05 (A5853)
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
0 5 10 15 20 25 30
pCi/g
0.0 0.5 1.0 1.5 2.0
pCi/g
0.0 0.5 1.0 1.5
pCi/g
Dead Time
> 40 percent
MDL
Zero Reference = Top of Casing

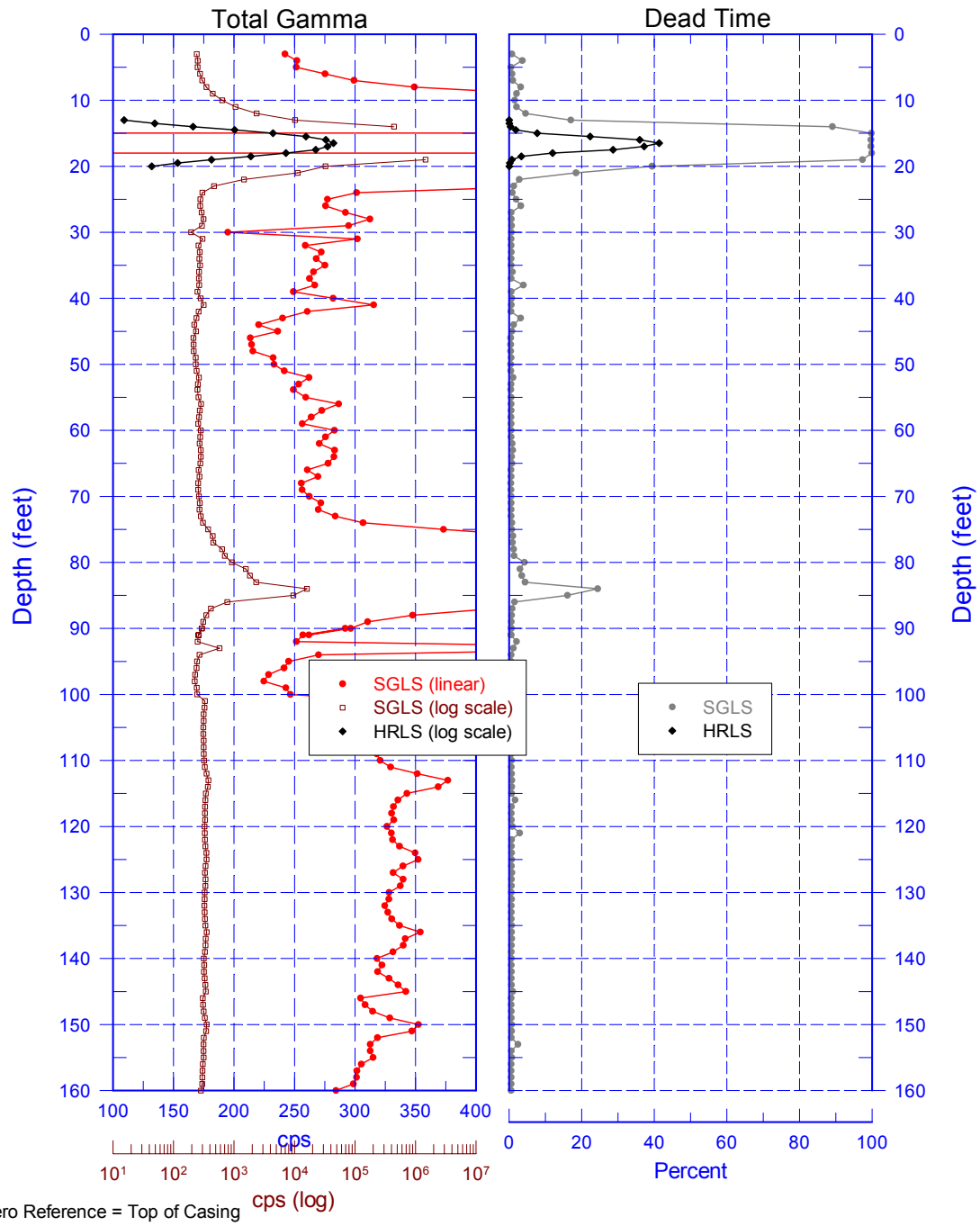

299-E13-05 (A5853)
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
460
0 5 10 15 20 25 30
pCi/g
0.0 0.5 1.0 1.5 2.0
pCi/g
0.0 0.5 1.0 1.5
pCi/g
Dead Time
> 40 percent
MDL
Zero Reference = Top of Casing


299-E13-05 (A5853) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
60Co (1333 keV)
137Cs (662 keV)
125Sb (428 keV)
238U (1001 keV)
pCi/g
Dead Time > 40 percent
SGLS (linear)
SGLS (log)
HRLS (log scale)
cps
cps (log)
SGLS
HRLS
Zero Reference = Top of Casing


299-E13-05 (A5853) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
60Co (1333 keV)
137Cs (662 keV)
125Sb (428 keV)
238U (1001 keV)
Dead Time > 40 percent
SGLS (linear)
SGLS (log)
HRLS (log scale)
SGLS
HRLS
pCi/g
cps
cps (log)
Zero Reference = Top of Casing

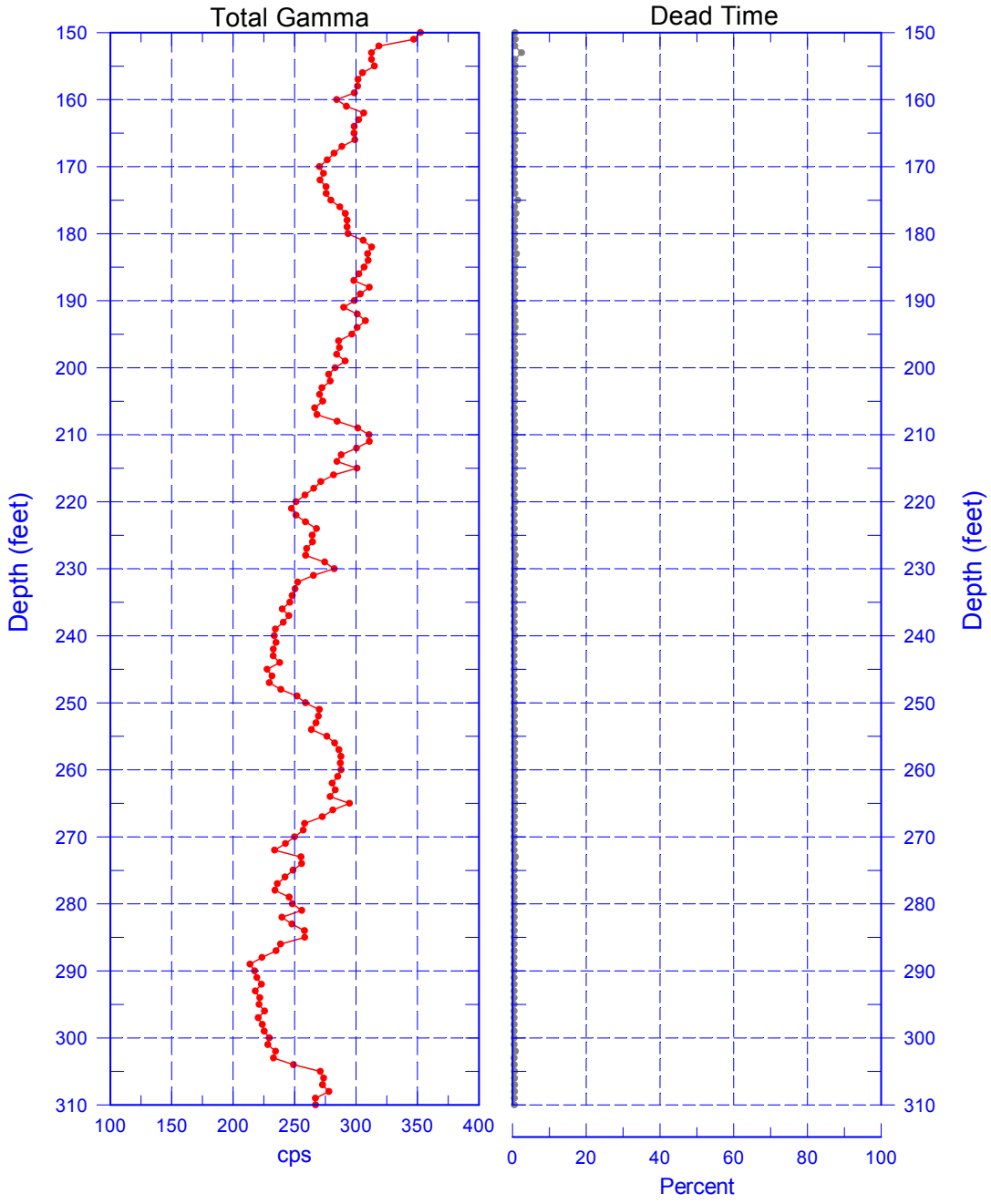

299-E13-05 (A5853) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
60Co (1333 keV)
137Cs (662 keV)
125Sb (428 keV)
238U (1001 keV)
SGLS (linear)
SGLS (log)
HRLS (log scale)
SGLS
HRLS
pCi/g
cps
cps (log)
Zero Reference = Top of Casing

# 299-E13-05 (A5853)
# Total Gamma & Dead Time



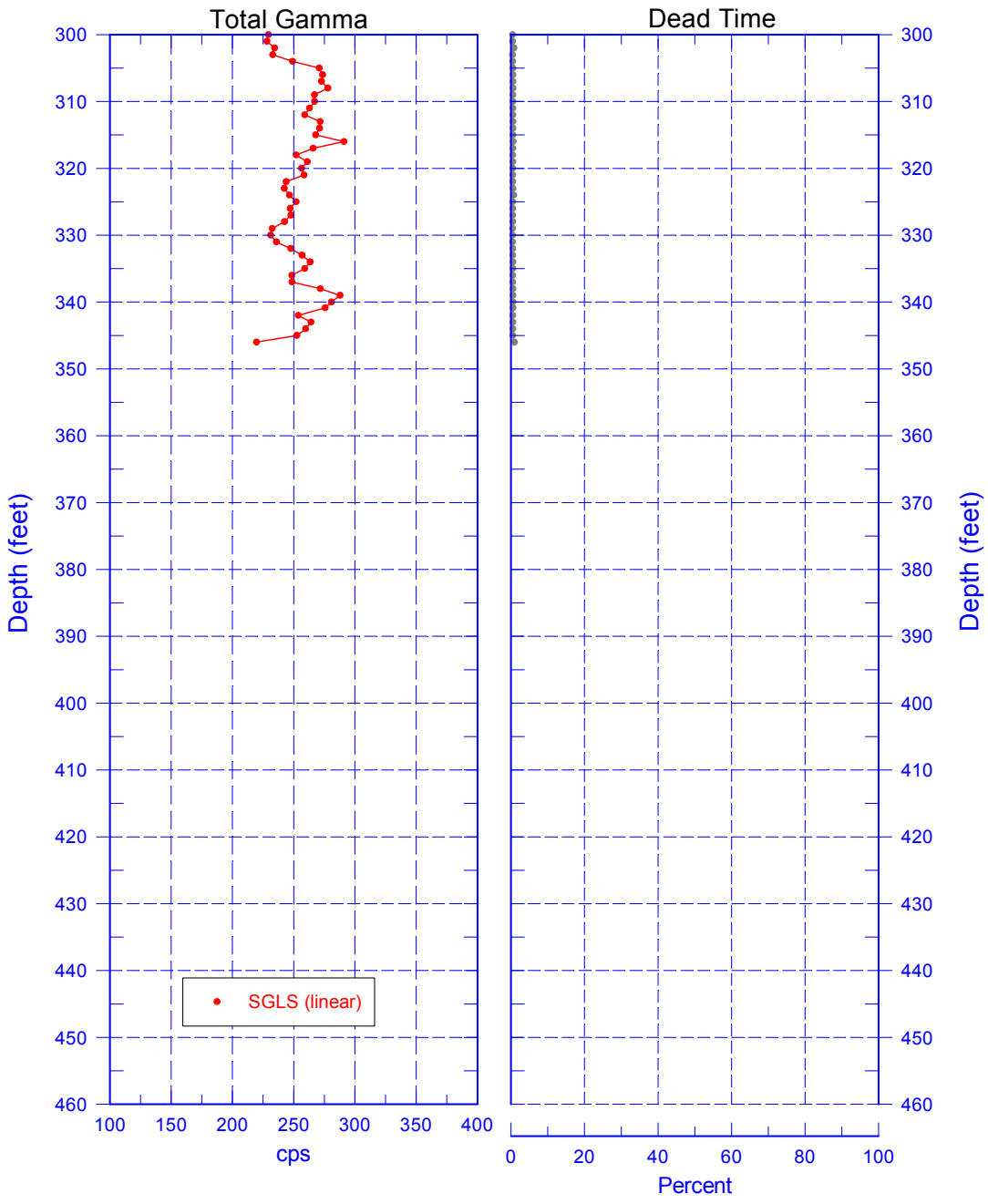

Zero Reference = Top of Casing

# 299-E13-05 (A5853)
# Total Gamma & Dead Time



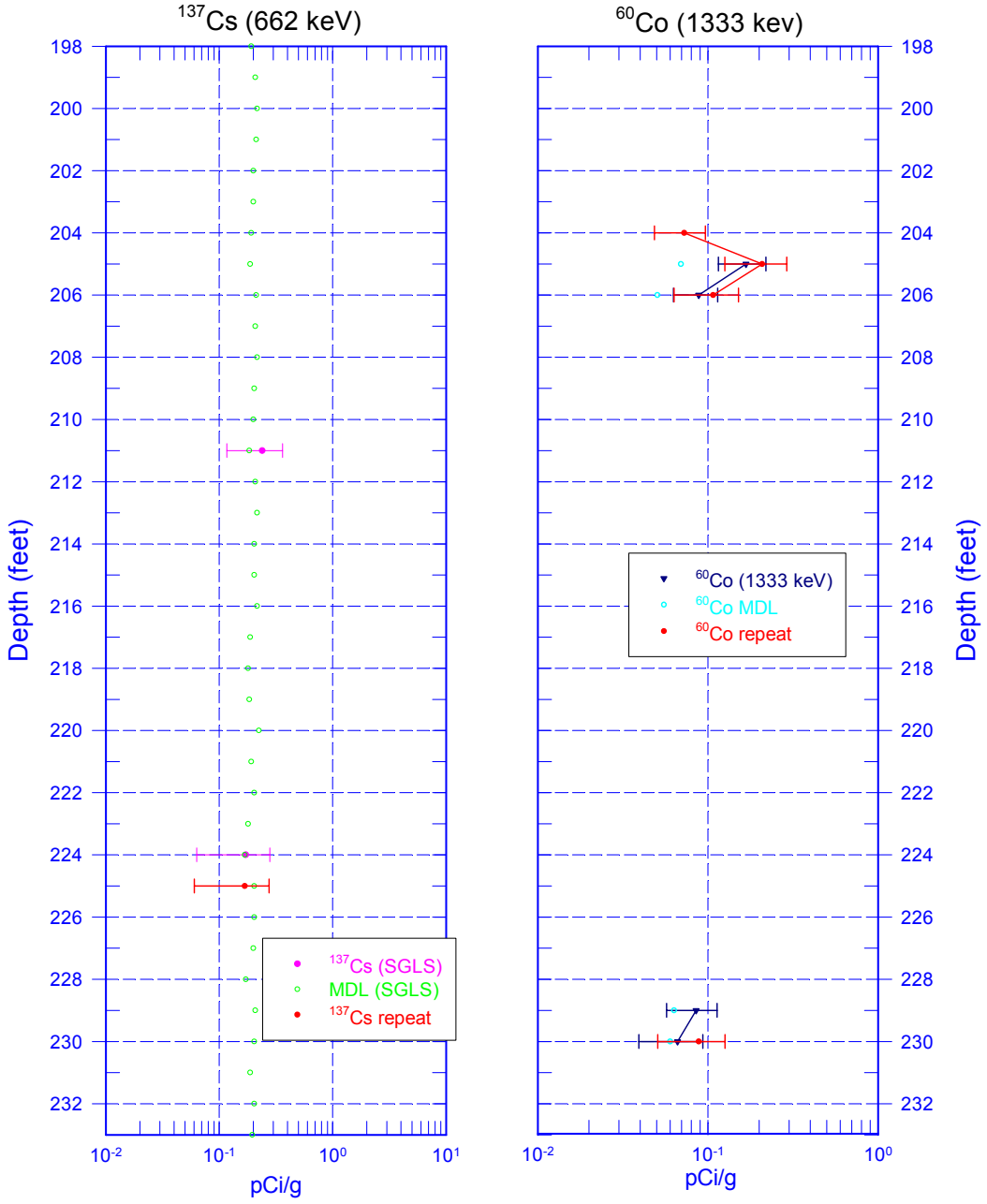

Zero Reference = Top of Casing

# 299-E13-05 (A5853)
## Total Gamma & Dead Time




Zero Reference = Top of Casing

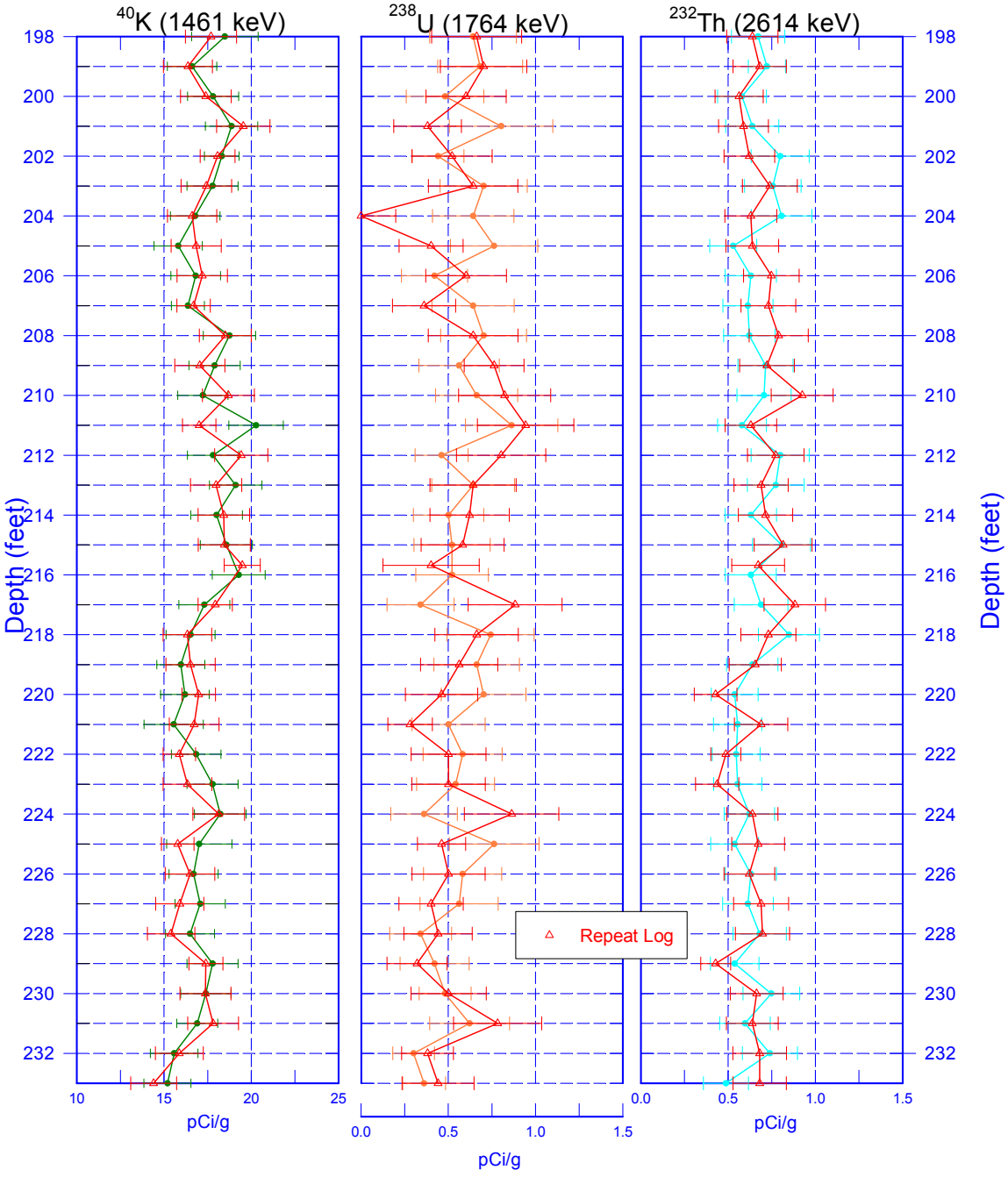
# 299-E13-05 (A5853)
## Man-Made Radionuclides Repeat Section




Zero Reference = Top of Casing

# 299-E13-05 (A5853)

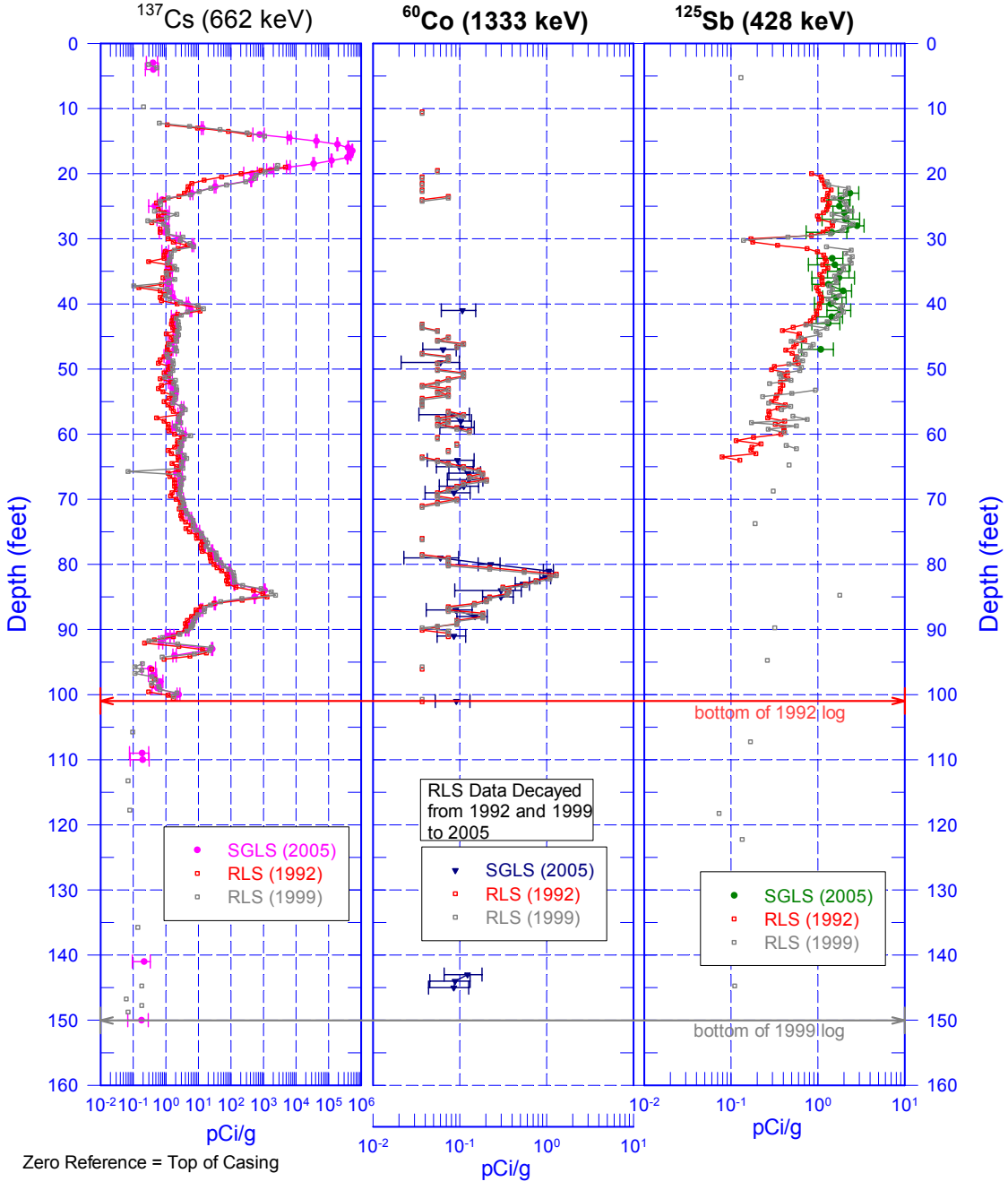
## Repeat Section of Natural Gamma Logs



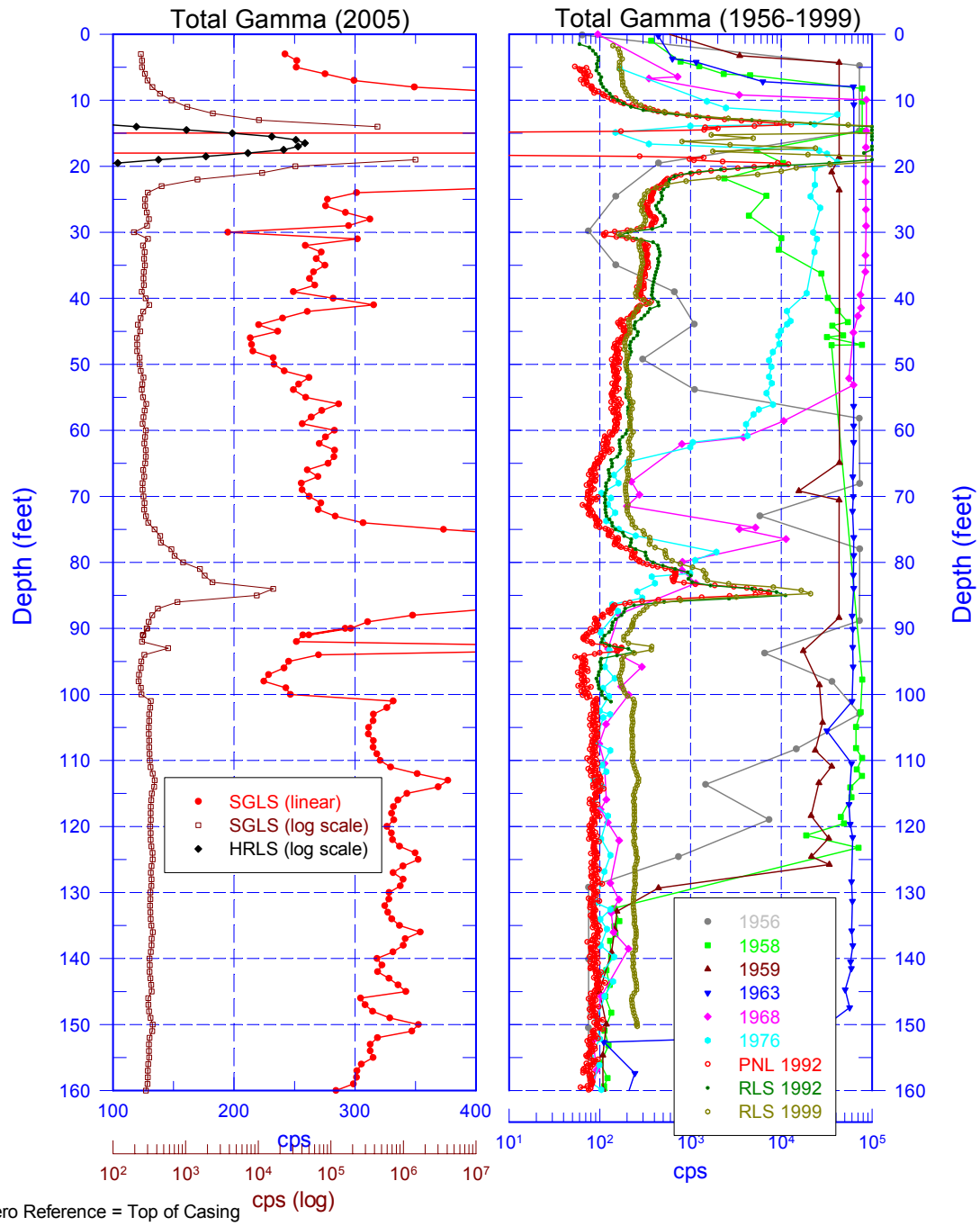

Zero Reference = Top of Casing

# 299-E13-05 (A5853)

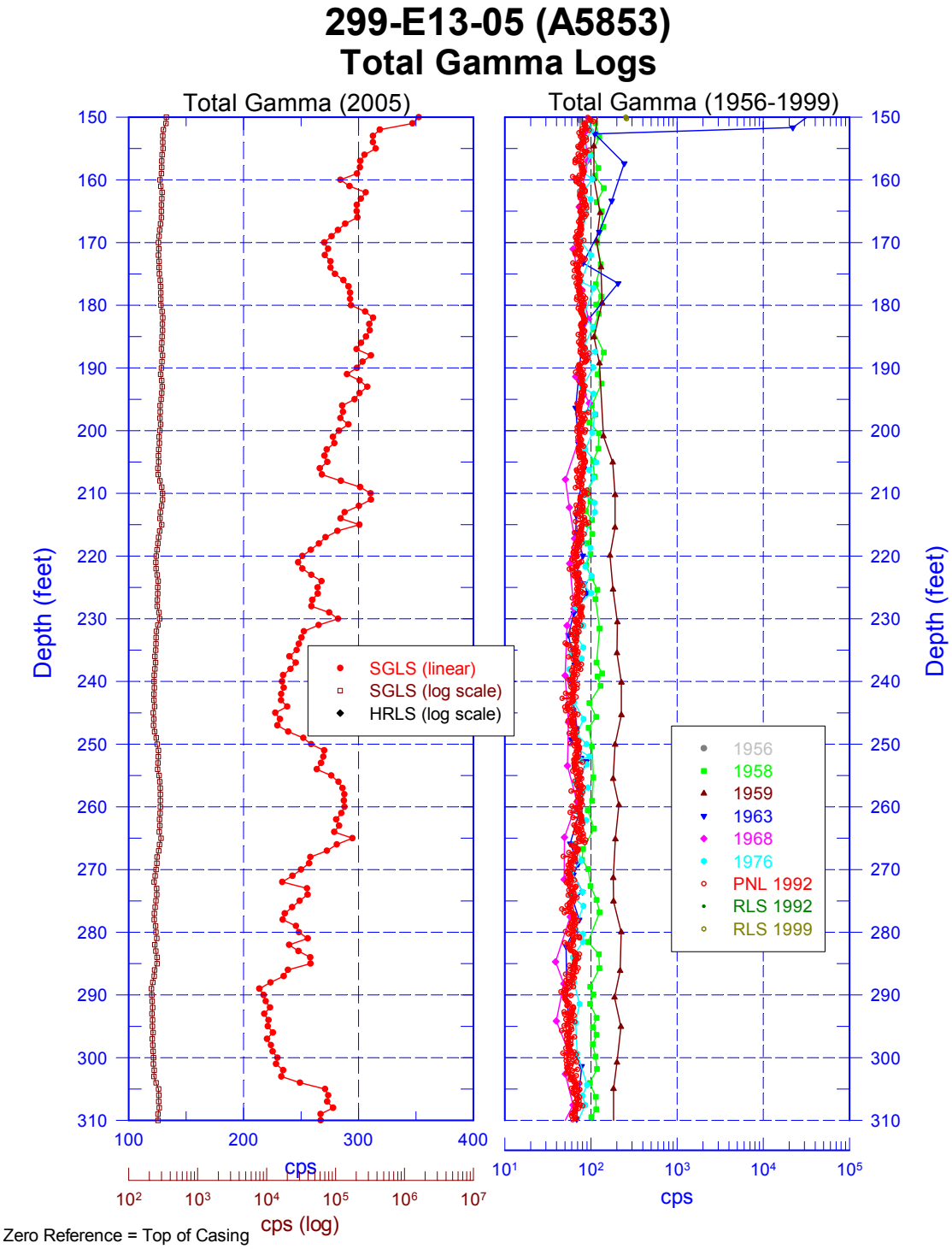
## SGLS & RLS Man-Made Radionuclide Comparison



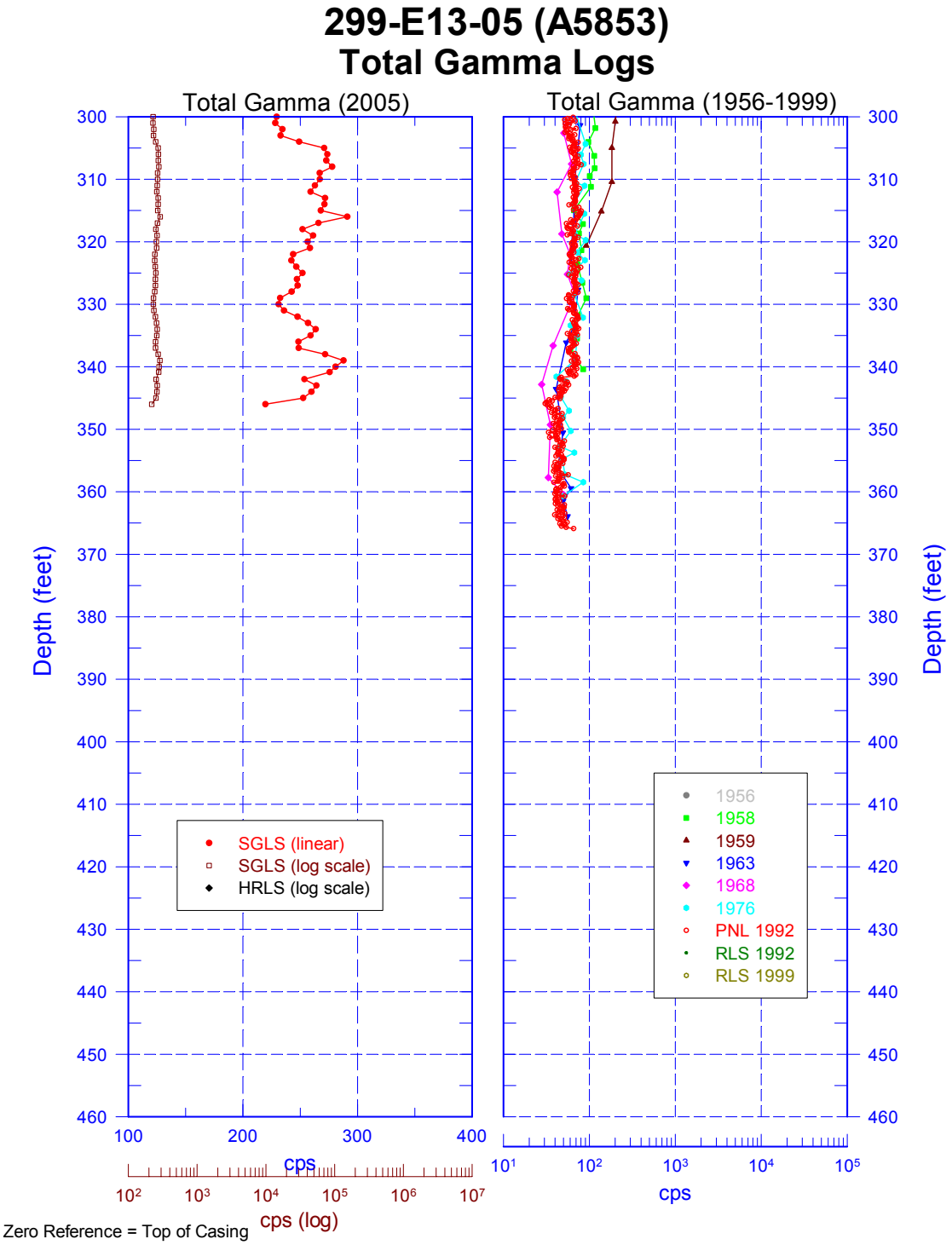
# 299-E13-05 (A5853)
## Total Gamma Logs




Zero Reference = Top of Casing




Zero Reference = Top of Casing


299-E13-05 (A5853)
Total Gamma Logs
Total Gamma (2005)
Total Gamma (1956-1999)
Depth (feet)
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
460
SGLS (linear)
SGLS (log scale)
HRLS (log scale)
100
200
300
400
cps
$10^2$
$10^3$
$10^4$
$10^5$
$10^6$
$10^7$
cps (log)
1956
1958
1959
1963
1968
1976
PNL 1992
RLS 1992
RLS 1999
$10^1$
$10^2$
$10^3$
$10^4$
$10^5$
cps
Zero Reference = Top of Casing