DOE-EM/GJ1046-2005

Hanford Tank Farms Vadose Zone Monitoring Project

Quarterly Summary Report for Third Quarter Fiscal Year 2005

December 2005

Prepared for
U.S. Department of Energy
Office of Environmental Management
Grand Junction, Colorado

Prepared by
S.M. Stoller Corp.
Grand Junction, Colorado

Work performed under DOE Contract No. DE-AC01-02GJ79491.

Contents

Page

Signature Page ... iv

1.0 Introduction ... 1

2.0 Monitoring Results ... 2
- 2.1 A Tank Farm ... 4
- 2.2 AX Tank Farm ... 4
- 2.3 B Tank Farm ... 5
- 2.4 BX Tank Farm ... 5
- 2.5 BY Tank Farm ... 5
- 2.6 C Tank Farm ... 5
- 2.7 S Tank Farm ... 5
- 2.8 SX Tank Farm ... 6
- 2.9 T Tank Farm ... 6
- 2.10 TX Tank Farm ... 6
- 2.11 TY Tank Farm ... 6
- 2.12 U Tank Farm ... 6

3.0 Retrieval Monitoring ... 7
- 3.1 Tank C-106 Retrieval Monitoring ... 7
- 3.2 Tank S-112 Retrieval Monitoring ... 8
- 3.3 Tank S-102 Retrieval Monitoring ... 8
- 3.4 Tank S-109 Retrieval Monitoring ... 9
- 3.5 Tank C-103 Retrieval Monitoring ... 10

4.0 Retrieval Monitoring System (RMS) Status ... 10

5.0 Special Projects ... 10
- 5.1 S-102 Fluid Injection Test ... 10

6.0 Operational Issues ... 11

7.0 Summary ... 12

8.0 Future Monitoring Operations ... 13

9.0 Recommendations ... 13
- 9.1 Routine Monitoring Program ... 13
- 9.2 Centralize Responsibility for Geophysical Monitoring Technology, Equipment, and Data Interpretation ... 14
- 9.3 Perform High Rate Logging ... 15

Contents (continued)

List of Tables

Page

Table 2-1. Summary of Monitoring Operations for 3rd Quarter of FY 2005 3
2-2. Summary of Monitored Boreholes Indicating Radionuclide Contaminant Profile Changes 4
5-1. Summary of Monitoring Production (Project-to-Date) 11
5-2. Summary of Operational Down Time 12

References...15

Appendix A. Boreholes Monitored During 3rd Quarter of FY 2005 .... A-1
B. Tank S-112 Retrieval Monitoring Log Plots...B-1
C. Tank S-102 Retrieval Monitoring Log Plots...C-1
D. Tank C-106 Retrieval Monitoring Summary Report D-1
E. Boreholes Projected for Retrieval Monitoring During the Fourth Quarter of FY 2005...E-1

Hanford Tank Farms Vadose Zone Monitoring Project
Quarterly Summary Report for Second Quarter Fiscal Year 2005

Prepared by:

____________________________________ ____________________

Arron Pope Date
S.M. Stoller Corporation, Hanford

Concurrence:

____________________________________ ____________________

Rick McCain, Hanford Technical Lead Date
S.M. Stoller Corporation, Hanford

Approved by:

____________________________________ ____________________

Brian Mathis, Manager Date
S.M. Stoller Corporation, Hanford

1.0 Introduction

The Hanford Tank Farms Vadose Zone Monitoring Project (VZMP) was established in fiscal year (FY) 2001 for comprehensive routine monitoring of existing boreholes in Hanford single-shell tank farms. The logging system used for monitoring is the Radionuclide Assessment System (RAS). A baseline record of existing contamination associated with gamma-emitting radionuclides in the vadose zone was established between 1995 and 2000 using the Spectral Gamma Logging System (SGLS). Although less precise, the RAS is a simpler, faster, and more cost-effective logging system than the SGLS. Measurements collected with the RAS can be compared to the baseline data to assess the long-term stability of the radionuclide contaminant profile. When routine monitoring identifies anomalies relative to the baseline, these anomalies may be investigated using the SGLS, the High Rate Logging System (HRLS), and/or the Neutron Moisture Logging System (NMLS). The HRLS is also used to collect data in boreholes where the contaminant activity exceeds the working range of the RAS instrumentation (greater than about 100,000 picocuries per gram [pCi/g] cesium-137 [^{137}Cs]).

During FY 2003, monitoring in boreholes associated with individual tanks undergoing retrieval operations was added to the work scope detailed in the original VZMP planning documents. Retrieval monitoring requirements for specific tanks will be specified in individual work plans. Both RAS and NMLS measurements are required for monthly monitoring, and monthly monitoring is supplemented by manual moisture measurements acquired by CH2M HILL Hanford Group, Inc. (CH2M HILL) personnel over limited depth intervals once or twice per week. During FY 2004, one new retrieval project (tank S-102) was initiated. Monitoring for two retrieval projects initiated in FY 2003 (tanks C-106 and S-112) continued into FY 2005. A lack of resources (i.e., operators for the RAS) and an emphasis on retrieval monitoring negatively impacts the achievement of VZMP goals as originally set forth in 2001. Deployment of the NMLS to support retrieval operations requires an additional logging engineer and reassignment of the system from support for the RI/FS work conducted by the Department of Energy, Richland Operations Office (RL).

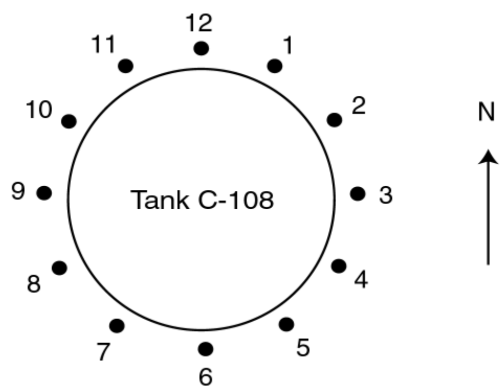
Routine quarterly reports are issued to summarize the results of monitoring activities, to provide the status of any ongoing special investigations, and to provide an updated listing of borehole intervals where monitoring is planned in the coming months. This quarterly report summarizes both routine and retrieval monitoring activities for the 3rd quarter of FY 2005 and includes project-to-date results where appropriate. Retrieval monitoring is segregated from routine monitoring so that the impact to the latter can be considered.

For readers not familiar with the Hanford Tank Farms borehole-numbering scheme, the following illustration shows how to identify the location of a borehole from its identification number:

Tank Farm Numbering Scheme

A Farm	10
AX Farm	11
B Farm	20
BX Farm	21
BY Farm	22
C Farm	30
S Farm	40
SX Farm	41
T Farm	50
TX Farm	51
TY Farm	52
U Farm	60

Tank Farm Borehole Numbering Scheme



Boreholes are identified by numbers using the format FF-TT-PP, where "FF" = tank farm, "TT" = tank, and "PP" = the position around the tank in a time-clock numeral from 1 to 12 (12 = north). For example, borehole 30-08-02 is in the C Tank Farm, around tank C-108, and at approximately the 2 o'clock position.

2.0 Monitoring Results

Summaries of monitoring operations for the 3rd quarter of FY 2005 and for the project to date are included in Table 2-1.

Table 2-1. Summary of Monitoring Operations for 3rd Quarter of FY 2005

Month	April	May	June	FY05 Total	Project-to-Date Total
Routine Monitoring Events (RAS)	0	0	0	7	857
Retrieval Monitoring Events (RAS)	0	4	1	9	119
Total RAS Events	0	4	1	16	976
Total NMLS Events	0	0	0	23	111
Total RAS & NMLS Events	0	4	1	39	1087
Routine Main Log Footage (RAS)	0	0	0	395	47972
Routine Rerun Log Footage (RAS)	0	0	0	20	2278
Retrieval Main Log Footage (RAS)	0	477	144	998	12325
Retrieval Rerun Log Footage (RAS)	0	0	0	10	280
Retrieval Main Log (NMLS)	0	0	0	2496	12231
Retrieval Rerun Log (NMLS)	0	0	0	225	1105
Total RAS Footage	0	477	144	1383	63647
Total NMLS Footage	0	0	0	2721	13336
Total RAS & NMLS Footage	0	477	144	4144	76983

Appendix A includes tables that provide further details of boreholes monitored during the 3rd quarter of FY 2005. Table A-1 presents boreholes/events for routine monitoring performed with the RAS. Table A-2 presents boreholes/events for retrieval monitoring performed with the RAS. Table A-3 presents boreholes/events for NMLS retrieval logging. These tables are derived from the project's monitoring database, which is continually updated as boreholes are monitored (DOE 2003). Boreholes are selected by a priority score (total score) that emphasizes proximity to tanks with significant drainable liquid remaining, and/or the presence of contaminant plumes, or where possible contaminant movement is suspected. The most significant change that occurs in the database is the monitoring frequency. Where monitoring results suggest possible contaminant movement, the monitoring frequency may be increased and depth intervals may be changed. Monitoring frequencies have also been increased to reflect the monthly monitoring requirement for retrieval operations in C and S Tank Farms. Some lower priority boreholes are also selected for monitoring.

The following sections describe the routine monitoring performed in each tank farm. In the interest of brevity, plots for boreholes where no apparent change was observed will not be included in this report. These logs are available upon request. Table 2-2 lists boreholes that have shown indications of possible changes to the radionuclide contaminant profile. The appendix containing maps of the individual tank farms with locations of the monitoring boreholes has been omitted from this report due to the lack of routine monitoring. For each tank farm, the number of boreholes monitored at least once since the baseline was completed in 2000 is reported, as well as the date of the last monitoring event. Originally, it was intended that each borehole would be monitored at least once in a 5-year period, but monitoring operations have been severely restricted. Site work rules require that monitoring activities be performed by Tank Farm operators, but availability of operators has been severely limited.

Table 2-2. Summary of Monitored Boreholes Indicating Radionuclide Contaminant Profile Changes

Tank Farm	Borehole Number	Radio-nuclide	Deter-mined	Number of Events	Assessment	Assigned Frequency	Qtrly/Annual Report
BX	21-12-02	^{60}Co	09/23/03	3	Possible decrease	6 mos.	FY 2003
BX	21-27-08	$^{238}U/^{235}U$	03/13/02	5	Not confirmed	6 mos.	2nd 2002
BY	22-03-04	^{60}Co	11/15/01	4	Not confirmed	6 mos.	1st 2002
BY	22-07-02	^{60}Co	11/29/01	3	Not confirmed	6 mos.	1st 2002
BY	22-07-05	^{60}Co	12/12/01	3	Not confirmed	6 mos.	1st 2002
BY	22-08-05	^{60}Co	03/30/99	4	Not confirmed	6 mos.	1st 2002
C	30-06-10	^{60}Co	03/03/97	8	Definite change	1 mos.	FY 2004
C	30-08-02	^{60}Co	09/11/02	8	Definite increase	1 mos.	FY 2004
C	30-08-03	?	01/21/03	3	Not confirmed	3 mos.	FY 2003
S	40-02-03	^{137}Cs	07/09/03	1	Definite increase	1 mos.	FY 2004
SX	41-02-02	$^{137}Cs/^{90}Sr$	09/07/01	5	Not confirmed	6 mos.	FY 2001
SX	41-10-01	^{137}Cs	02/11/03	4	Possible increase	6 mos.	FY 2003
SX	41-15-07	^{137}Cs	02/12/03	2	Not confirmed	6 mos.	FY 2003
T	50-01-09	^{60}Co	07/30/01	5	Not confirmed	6 mos.	FY 2001
T	50-02-05	^{137}Cs	05/19/03	4	Not confirmed	6 mos.	FY 2003
T	50-06-02	$^{60}Co/^{154}Eu$	07/18/01	5	Not confirmed	6 mos.	FY 2001
T	50-06-03	^{60}Co	07/18/01	5	Not confirmed	6 mos.	FY 2001
T	50-06-18	^{60}Co	09/03/02	5	Possible increase	3 mos.	FY 2002
T	50-04-10	^{60}Co	01/28/02	5	Possible confirmation	3 mos.	2nd 2002
T	50-09-01	$^{60}Co/^{154}Eu$	07/23/01	5	Not confirmed	6 mos.	FY 2001
T	50-09-02	^{60}Co	01/08/02	3	Not confirmed	12 mos.	2nd 2002
T	50-09-10	$^{60}Co/^{154}Eu$	07/23/01	5	Not confirmed	6 mos.	FY 2001
TX	51-03-11	^{60}Co	05/20/02	2	Possible increase	6 mos.	3rd 2002
TY	52-03-06	^{137}Cs	05/02/02	5	Definite change	3 mos.	3rd 2002
TY	52-06-05	^{60}Co	05/14/02	3	Possible increase	3 mos.	3rd 2002
TY	52-06-07	^{60}Co	05/22/03	2	Not confirmed	12 mos.	FY 2003
U	60-04-08	$^{238}U/^{235}U$	07/16/01	8	Not confirmed	6 mos.	FY 2001
U	60-05-05	$^{238}U/^{235}U$	08/27/02	5	Possible increase	6 mos.	FY 2002
U	60-07-01	$^{238}U/^{235}U$	07/12/01	8	Not confirmed	6 mos.	FY 2001

2.1 A Tank Farm

Routine monitoring was not performed in A Tank Farm during the 3rd quarter of FY 2005. To date, 31 of 52 (60%) boreholes in A Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in A Farm was 6/12/2003.

2.2 AX Tank Farm

Routine monitoring was not performed in AX Tank Farm during the 3rd quarter of FY 2005. To date, 16 of 31 (52%) boreholes in AX Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in AX Farm was 3/2/2005.

2.3 B Tank Farm

Routine monitoring was not performed in B Tank Farm during the 3rd quarter of FY 2005. To date, 22 of 53 (42%) boreholes in B Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in B Farm was 4/21/2003.

2.4 BX Tank Farm

Routine monitoring was not performed in BX Tank Farm during the 3rd quarter of FY 2005. To date, 50 of 74 (68%) boreholes in BX Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in BX Farm was 10/6/2003.

2.5 BY Tank Farm

Routine monitoring was not performed in BY Tank Farm during the 3rd quarter of FY 2005. To date, 52 of 70 (74%) boreholes in BY Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in BY Farm was 11/12/2003.

2.6 C Tank Farm

Routine monitoring was not performed in C Tank Farm during the 3rd quarter of FY 2005. To date, 57 of 67 (85%) boreholes in C Farm have been monitoring at least once since the baseline was completed. The date of the last routine monitoring event in C Farm was 2/20/2004.

Four of the eight boreholes associated with the C-106 Waste Retrieval Project were monitored with the RAS during the 3rd quarter of FY 2005. The other four boreholes were monitored during the 2nd quarter of FY 2005. This is the final round of monitoring associated with the C-106 Retrieval Project. The post-retrieval round of moisture logging was performed on the boreholes associated with the C-106 Retrieval Project during the 1st quarter of FY 2005. This work is discussed in more detail in Section 3.1, “Tank C-106 Retrieval Monitoring.”

2.7 S Tank Farm

Routine monitoring was not performed in S Tank Farm during the 3rd quarter of FY 2005. To date, 44 of 72 (61%) boreholes in S Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in S Farm was 10/8/2003.

One borehole associated with the S-112 Waste Retrieval Project was monitored with the RAS during the 3rd quarter of FY 2005. All S-112 boreholes were logged once with the NMLS during the 1st quarter of FY 2005. This work is discussed in detail in Section 3.2, “Tank S-112 Retrieval Monitoring.”

Boreholes associated with the S-102 Waste Retrieval Project were not monitored with the RAS during the 3rd quarter of FY 2005. The second round of moisture logging for these boreholes was completed during the 2nd quarter of FY 2005. This work is discussed in detail in Section 3.3, "Tank S-102 Retrieval Monitoring."

2.8 SX Tank Farm

Routine monitoring was not performed in SX Tank Farm during the 3rd quarter of FY 2005. To date, 69 of 100 (69%) boreholes in SX Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in SX Farm was 8/12/2003.

2.9 T Tank Farm

Routine monitoring was not performed in T Tank Farm during the 3rd quarter of FY 2005. To date, 40 of 69 (58%) boreholes in T Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in T Farm was 6/18/2003.

2.10 TX Tank Farm

Routine monitoring was not performed in TX Tank Farm during the 3rd quarter of FY 2005. To date, 29 of 94 (31%) boreholes in TX Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in TX Farm was 6/4/2003.

2.11 TY Tank Farm

Routine monitoring was not performed in TY Tank Farm during the 3rd quarter of FY 2005. To date, 13 of 22 (59%) boreholes in TY Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in TY Farm was 5/29/2003.

2.12 U Tank Farm

Routine monitoring was not performed in U Tank Farm during the 3rd quarter of FY 2005. To date, 34 of 59 (58%) boreholes in U Farm have been monitored at least once since the baseline was completed. The date of the last routine monitoring event in U Farm was 8/20/2003.

3.0 Retrieval Monitoring

3.1 Tank C-106 Retrieval Monitoring

The *Process Control Plan for Tank 241-C-106 Acid Dissolution* (Reynolds 2003) specified retrieval monitoring was to be conducted monthly: *"The wells will be monitored monthly (or before initial acid addition, monthly during retrieval, and after retrieval) to detect any changes in the radiation or moisture profiles of the soil."* Additional manual measurements are to be performed by operations personnel within specific zones at a frequency of two times per week.

RAS retrieval monitoring began in January 2003, and seven retrieval monitoring events were conducted by the end of FY 2004. A retrieval-monitoring event is described as a complete set of logs around a tank acquired at approximately the same time. Beginning in April 2003, seven NMLS log events were acquired through the end of the 1st quarter of FY 2005. SGLS logging was performed in boreholes 30-06-02, -04, -09, -10, and 30-08-02 during late February and early March 2004 to investigate regions of apparent moisture increases. This logging was performed as a result of the PER initiated on December 3, 2003, in response to the apparent increase in moisture (~1%) in the vadose zone beneath tank C-106. The only increases in gamma activity identified during this logging occurred in boreholes 30-08-02 and 30-06-10. This zone of contaminant movement had been identified before the start of retrieval activities and therefore is unrelated to the retrieval process.

One retrieval-monitoring event was completed during the 3rd quarter of FY 2005, having been started during the 2nd quarter, as described in Section 2.6 of this document. This last event marked the end of post-retrieval monitoring for C-106 as outlined in Reynolds (2003). Appendix D includes the *241-C-106 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data* (DOE-EM/GJ899-2005), which is the final report for the C-106 Tank waste retrieval operations. These data include SGLS baseline measurements (^{40}K, ^{137}Cs, ^{60}Co), seven moisture measurements, and the eight sets of RAS measurements.

The final post-retrieval moisture logging event was conducted during the 1st quarter of FY 2005. No significant moisture changes were observed during the final logging event. Slight moisture increases are shown in all boreholes, with the largest increases (approximately 1 percent) indicated in boreholes 30-05-02 and 30-06-09, located southwest of Tank C-106. These moisture increases appear to have occurred between July and September 2003, although this is not conclusive.

The post-retrieval RAS monitoring was completed in the final four of the eight boreholes during the 3rd quarter of FY 2005. No significant changes between this event and the previous event were observed in the ^{137}Cs, ^{60}Co, or gross-gamma profiles in any of the boreholes. The RAS measurements collected in boreholes around Tank C-106 do not indicate any increase in gamma activity within the intervals of moisture increases or high moisture zones in the vicinity of Tank C-106.

SGLS data collected in 2004 were compared with SGLS data collected in 1997. As with the RAS measurements, no significant changes are observed in depth intervals where slightly elevated moisture was detected. Changes were observed in boreholes 30-08-02 and 30-06-10 suggesting continuing migration of contamination that appears to originate in the vicinity of Tank C-108, following a stratigraphic dip to the east-northeast, and probably extending past borehole 30-06-12 at depths greater than 130 ft. This contamination was recognized well before retrieval operations began, and does not appear to have been impacted by retrieval activities in Tank C-106. However, the existence of this plume and its continued movement downward and to the east call into question the integrity of Tank C-108.

3.2 Tank S-112 Retrieval Monitoring

The *Process Control Plan for Saltcake Dissolution Retrieval Demonstration in Tank 241-S-112* (Barton 2003) specified retrieval monitoring requirements. *"A baseline profile will be taken prior to retrieval operations, and subsequent monitoring results will be compared with that baseline profile. Moisture monitoring using the truck-mounted system will be done before beginning, at the end, and whenever there is a shutdown of retrieval operations greater than 4 weeks. An initial baseline will be established by deploying calibrated gamma and neutron moisture probes over the full depth of each drywell. During waste retrieval operations, the truck-mounted systems will be supplemented by the use of manually deployed moisture gages at least once a week while actively retrieving the waste at depths corresponding to moist layers at or below the floor of the tank."*

Baseline moisture measurements were acquired during August 2003. Three additional moisture logging events (October, November, and February) were performed in the eight boreholes surrounding tank S-112. A fourth moisture-logging event was started in boreholes 40-11-08 and 40-12-04 in April 2004. This logging event was cut short when supplied-air entry requirements were imposed on Tank Farms, and was not completed. Moisture logging resumed during the 1st quarter of FY 2005, and all the S-112 boreholes were logged once during that quarter with the NMLS. Minor moisture increases were identified, but these may be attributable to seasonal fluctuations. Additional moisture logging events will help assess the effects of seasonal moisture variations. The last complete set of RAS measurements was acquired during February 2004. No changes in activity were observed between RAS measurements collected in November 2003 and February 2004 or relative to baseline spectral gamma data acquired in 1996. One S-112 borehole (40-12-06) was monitored during the present quarter on June 27, 2005. Additional RAS measurements will be made approximately once a week on grave or swing shifts, to continue until data have been acquired in all eight boreholes.

Log plots showing the baseline SGLS data, RAS data, and moisture data for each borehole are included in Appendix B.

3.3 Tank S-102 Retrieval Monitoring

In anticipation of future tank S-102 retrieval activities, RAS monitoring of the boreholes around tank S-102 began in September 2002. The first RAS retrieval-monitoring event was performed in July 2003. The RAS collected monitoring data from five of the nine boreholes (event 2) in April 2004. The other four boreholes were not monitored because work was halted by the respiratory protection requirements imposed on approximately April 16, 2004.

An increase in gamma activity related to increased ^{137}Cs was detected between 44 and 47 ft in borehole 40-02-03 during the first RAS monitoring event in July 2003. This increase was subsequently confirmed by SGLS data in April 2004. The ^{137}Cs anomaly was discovered prior to retrieval activities, but there are few data to assess the effect, if any, of subsequent retrieval activities on this anomaly. This increase was first reported in the *Annual Monitoring Report for Fiscal Year 2003* (DOE 2004).

Baseline moisture logging was performed in eight of the nine boreholes surrounding this tank in April 2004. Moisture logging was not performed in borehole 40-02-04 because surface equipment prevented access to this borehole. SGLS logging was performed over selected intervals in three of these boreholes (40-02-03, 40-02-07, and 40-02-08) to update the baseline in areas of known vadose zone contamination. The SGLS logging confirmed the ^{137}Cs increase in borehole 40-02-03. High rate logging was also performed in borehole 40-02-03. Log plots of the data collected above were provided to CH2M HILL via e-mail on April 12, 2004. These log plots are included in Appendix E.

No RAS monitoring has been performed since April 2004. The increase in ^{137}Cs relative to the baseline in borehole 40-02-03 occurred prior to the beginning of retrieval operations, but there is no data in the past year to determine what effect, if any, retrieval operations have had on this plume. RAS monitoring for the S-102 Retrieval Project will resume as soon as CH2M HILL provides resources to operate the system. As of June 30, 2005, this work is delayed indefinitely, pending available operator support.

The second event of moisture logging was initiated for the S-102 Retrieval Project during the 1st quarter of FY 2005. Moisture logging was completed during the 2nd quarter of FY 2005. No significant changes to the baseline moisture profiles were observed. Log plots of all the available RAS and moisture data are provided in Appendix D.

3.4 S-109 Retrieval Monitoring

CH2M HILL contacted Stoller during the 2nd quarter of FY 2005 regarding the planned start of Phase 1 of the S-109 Partial Retrieval Project in October 2005 and the associated monitoring. Borehole monitoring must be performed no more than 2 months prior to the start of the retrieval activities, approximately August 22, 2005. Stoller and CH2M HILL agreed it would be best to collect the pre-retrieval baseline measurements with the new Retrieval Monitoring System (RMS) that Stoller is currently building. Stoller hopes to have the system operational in time to support this effort, but the NMLS and RAS system may be used in its place if this deadline cannot be met. Eight boreholes were selected for S-109 retrieval monitoring: 40-08-09, 40-09-05, 40-09-06, 40-09-08, 40-09-09, 40-06-06, 40-09-01, and 40-09-02.

3.5 Tank C-103 Retrieval Monitoring

The waste retrieval for tank C-103 was scheduled to begin in early calendar year (CY) 2005. It is now scheduled to begin in late September 2005. Baseline moisture logging and pre-retrieval RAS monitoring have yet to be performed in the boreholes surrounding this tank. Stoller and CH2M HILL agreed it would be best to collect the pre-retrieval baseline measurements with the new Retrieval Monitoring System (RMS) that Stoller is currently building. Stoller hopes to have the system operational in time to support this effort, but the NMLS and RAS system may be used in its place if this deadline cannot be met. Six boreholes were selected for C-103 retrieval monitoring: 30-03-01, 30-03-03, 30-03-05, 30-03-07, 30-03-09, and 30-06-04. These activities will commence as resources and construction activities around tank C-103 allow.

4.0 Retrieval Monitoring System (RMS) Status

A new, portable logging system capable of recording gross gamma and moisture measurements simultaneously was received during the 2nd quarter of FY 2005. This system, designated as the Retrieval Monitoring System (RMS), has been mounted in a utility vehicle provided by CH2M HILL. Stoller has completed preliminary testing and calibration of the system, and provided a draft procedure manual to CH2M HILL for use in drafting a Tank Farm Plant Operating Procedure. Stoller anticipates that the RMS will be ready to begin monitoring in support of the retrieval projects during the 4th quarter of FY 2005. It is planned that the RAS be left intact for future routine monitoring.

5.0 Special Projects

There were no special projects for this quarter.

5.1 S-102 Fluid Injection Test Planned for FY 2006

CH2M HILL intends to perform a fluid injection test in one of the boreholes on the west side of tank S-102. This will be used to test the High Resolution Resistivity Leak Detection and Monitoring System (HRR-LDMS) installed around tank S-102. Stoller was contacted during the 2nd Quarter of FY 2005 by CH2M HILL regarding the deployment of the RAS to monitor boreholes near the borehole in which the fluid would be injected. This test will be conducted simultaneously with the tank S-102 retrieval activities, whereby the RAS data will be used to distinguish possible leaks from the tank from moisture increases associated with the test; NMLS measurements were not requested. The fluid injection test is currently scheduled to be conducted in December/January FY 2006.

6.0 Operational Issues

Five boreholes were monitored with the RAS during the 3rd quarter of FY 2005. The original project goal was to monitor an average of three boreholes per day. This goal has been reduced to approximately 1 borehole per day due to the new respiratory requirements imposed on Tank Farm personnel. The monitoring rate achieved this quarter was 0.1 boreholes per day.

Operators were only made available on 2 of the 59 days during the 3rd quarter of FY 2005 to operate the RAS. The RAS is generally assigned a low priority relative to other tank farm projects. RAS operators are diverted to other tasks by CH2M HILL management.

Tables 5-1 and 5-2 include summaries of production and operational issues, respectively, that affect monitoring production.

Table 5-1. Summary of Monitoring Production (Project-to-Date)

Quarter	**Total Work Days**	**Total Days Down**	**Total Monitoring Events**	**Boreholes Monitored per Day**
4th of FY01	56	29.3	84	1.5
1st of FY02	56	35.2	54	1.0
2nd of FY02	55	34.1	74	1.3
3rd of FY02	59	21.1	113	1.9
4th of FY02	66	27.6	144	2.2
1st of FY03	56	34.7	72	1.3
2nd of FY03	55	22.5	97	1.8
3rd of FY03	58	25.0	105	1.8
4th of FY03	63	22.6	103	1.6
1st of FY04	56	27.4	56	1.0
2nd of FY04	55	42.1	24	0.4
3rd of FY04	63	59.9	5	0.1
4th of FY04	62	62.0	0	0.0
1st of FY05	55	55.0	0	0.0
2nd of FY05	56	47.7	11	0.2
3rd of FY05 (current)	59	57.0	5	0.1
Cumulative Total	930	603.2	947	1.0
Average/Quarter	58.1	37.7	59.2	1.0

Table 5-2. Summary of Operational Down Time

Quarter	Equipment/ Truck Problems/Calibration (hrs)	No HPT/ Operator Support (hrs)	Security Measures (hrs)	No Charge Code or Administrative (hrs)	Moving Truck (hrs)	Weather (hrs)	Misc. / Fresh Air Requirement (hrs)	Total Down Time (hrs)
4th of FY01	64	130	20	27	20	3	0	264
1st of FY02	107	84	51	44	14	13	4	317
2nd of FY02	143	40	24	58	9	18	15	307
3rd of FY02	31	62	0	36	27	8	26	190
4th of FY02	81	122	0	0	37	0	8	248
1st of FY03	71	107	0	18	18	0	98	312
2nd of FY03	62	126	0	0	10	0	0	198
3rd of FY03	51	149	0	0	12	0	13	225
4th of FY03	45	136	0	0	16	6	0	203
1st of FY04	6	198	0	0	12	22	9	247
2nd of FY04	178	95	0	0	6	98	2	379
3rd of FY04	26	18	0	9	2	0	424	479
4th of FY04	0	0	0	0	0	0	513	513
1st of FY05	0	490	0	0	0	0	0	490
2nd of FY05	0	398	0	18	0	13	0	429
3rd of FY05 (current)	0	505	0	0	0	0	0	505
Cumulative Total	865	2660	95	210	183	181	1112	5306
Average/Quarter	54.1	166.3	5.9	13.1	11.4	11.3	69.5	331.6

7.0 Summary

A total of 857 routine monitoring logs (119 retrieval logs) have been collected since the beginning of the project in June 2001. An additional 111 logs (0 logs during the 3rd quarter of FY 2005) using the NMLS were provided. To date, most of the high priority boreholes in all tank farms have been monitored at least once, but the recommended monitoring frequency has not been met for these boreholes. Of the 769 boreholes in tank farms, 306 have not been monitored at all in the past five to ten years.

Evidence of possible contaminant movement has been detected in 29 boreholes in nine tank farms. Of these 29 boreholes, data collected from three boreholes (30-06-10, 30-08-02, and 40-02-03) indicate movement to a degree that can be confirmed over a short time interval. Of the remaining 26 boreholes, it is likely that the elapsed time between monitoring events is not sufficient to detect subtle changes in contaminant profile, suggesting relatively slow movement of contaminants in the vadose zone. In general, intervals where discernable movement of contaminants through the vadose zone is occurring within short periods of time (i.e., less than

1.5 years) appear to be very limited. However, monitoring activities have been severely curtailed, and this observation is poorly supported. Continued monitoring is important in selecting appropriate remedial actions for tank farm closure and/or removal of contaminated soil. Many boreholes with extremely high radiation levels have not been monitored at all since the baseline was completed.

8.0 Future Monitoring Operations

Due to regulatory commitments and operating limitations in tank farms, Department of Energy, Office of River Protection (ORP)and their contractor have re-focused the monitoring effort from routine monitoring to retrieval monitoring. Therefore, the monitoring schedule for the RAS will be added onto the monitoring requirements associated with the various retrieval projects. Appendix E provides a summary of boreholes scheduled for retrieval monitoring through the end of the 4^{th} quarter of FY 2005. Due to the respiratory requirements placed on personnel entering the tank farms it is unlikely this schedule will be met.

The RMS, which is capable of recording gross gamma and moisture measurements simultaneously, will replace the RAS and NMLS for retrieval monitoring, and will be operated by the Hanford Atomic Metal Trades Council (HAMTC) operators. Stoller anticipates having this system ready to begin monitoring in support of the retrieval projects by the end of the 4^{th} quarter of FY 2005. It is planned that the RAS be left intact for future routine monitoring.

9.0 Recommendations

The monitoring program in the single-shell tank farms was initiated in 2000 after the initial success of the Vadose Zone Characterization Project. Experience gained from the past baseline characterization efforts and current activities during this period suggest significant changes in the monitoring of tank farms. Based upon this experience, significant issues and recommendations for improvement are discussed below. Most of the discussion below was included in the 2^{nd} quarter FY 2005 monitoring report, but little has been done to address these issues, so the discussion will be repeated.

9.1 Routine Monitoring Program

Vadose zone monitoring activities in the single-shell tank farms are performed according to guidance from the ORP tank farm contractor with supervision and technical input from Stoller. In the past year, there has been effectively no routine monitoring in the single-shell tank farms. Routine monitoring operations are dependent upon personnel employed by the tank farms contractor, whose primary goal is waste retrieval.

The primary reasons routine monitoring activities have been discontinued are the prioritization of resources and personnel to retrieval operations and tank farm access restrictions arising from health and safety concerns. It is strongly recommended that routine monitoring activities be re-emphasized. This will require that the monitoring activity be given a higher priority for resource allocation at tank farms. At a minimum, the 29 boreholes that have exhibited contaminant movement in the past should be logged during the next quarter.

Comparison of ongoing monitoring data with baseline and historical data is important in unraveling the complex leak history in the single-shell tank farms, assessing stability of individual contaminant plumes, and determining the suitability of individual tanks for sluicing operations. In the vicinity of tank C-106, for example, routine monitoring data have detected continued downward movement in a ^{60}Co plume on the north side of the tank. Baseline data indicate that the plume likely originated between tanks C-108 and C-109. The plume appears to be moving downward and to the east in the region between tanks C-109 and C-106. Routine monitoring activities detected this movement well before retrieval operations were initiated in tank C-106, and thus established that the observed increases in subsurface activity were not related to tank C-106 retrieval operations. In the absence of a routine monitoring program, it is possible that observed changes in this plume would have been attributed to the retrieval operation, resulting in an erroneous determination that a leak had occurred. Clearly defined and uniformly implemented requirements for routine and tank-retrieval leak detection monitoring will improve credibility and the potential acceptability of future Hanford remedial actions, including closure of tank farms.

9.2 Centralize Responsibility for Geophysical Monitoring Technology, Equipment, and Data Interpretation

The RMS has been fully developed, assembled and tested. It is ready for deployment, subject to resolution of administrative issues between the tank farms contractor and Fluor Hanford, Inc. (Fluor) related to neutron source custody. It has the capability for concurrent gross-gamma and moisture logging. The RMS can be used for the monthly monitoring events now performed by the RAS and SGLS. It can also be used for more frequent measurements, replacing the existing manual moisture monitoring units. The RMS has an identical moisture gauge to the hand-held moisture gauges. This will improve overall data comparability and reduce the potential for false detections based on increases in observed moisture. Under the current tank farm contractor's monitoring approach, any increase in moisture observed with the manual moisture gauges results in an immediate need for gamma logging to determine if a leak has in fact occurred. In addition, manual moisture monitoring is subject to data transcription errors and to errors associated with slight variations in depth between successive measurements. In many cases, a specific monitoring point is selected at a peak in the neutron moisture log. When subsequent manual moisture measurements are made, slight variations in detector depth may appear as changes in moisture content. The RMS will eliminate the potential for transcription errors, and provides a continuous profile, which allows depth errors to be more readily recognized. In addition, new technologies such as High Resolution Resistivity (HRR) are being investigated without benefit of baseline comparison plans or integration into the ongoing monitoring or retrieval monitoring programs.

At present, RAS and NMLS data are processed and evaluated by Stoller, while the manual moisture measurements are reported to CH2M HILL (again, the RMS has not yet been fielded for administrative reasons). This creates a situation wherein discrepancies between the two data sets may not be immediately recognized.

Other gamma-activity measurements are being made by tank farm contractor subcontractors with no input from or consultation with Stoller, and it is not clear how (or if) the results of this work can be compared to the tank farms baseline. Moreover, the Tank Farm contractor continues to use hand-held moisture units that have not been calibrated in over 2 years. While the tank farm contractor reports that successive measurements show consistent results, with no indication of increases, only limited intervals are being monitored, and the long-term stability of the detectors is in doubt. Geophysical methods such as HRR offer some advantages over borehole logging, but the HRR program is being implemented with no apparent effort to integrate it into the existing data framework. For the immediate future, it is likely that any anomaly detected by the HRR will require some degree of investigation by borehole logging, particularly since HRR only responds to variations in subsurface moisture content, which is not by itself an unequivocal indication of a tank leak. The retrieval program has prioritized most resources away from routine monitoring, resulting in extremely limited knowledge of vadose zone conditions around most of the tanks since completion of the baseline in 2000.

The designation of a single contractor responsible for geophysical logging to collect, evaluate, and manage borehole and vadose zone monitoring technological needs, equipment, and measurement data would significantly improve the effectiveness and quality of Hanford geophysical data collection and interpretation.

9.3 Perform High Rate Logging

High rate logging has not been performed in the tank farms since FY 2002. Because the areas that exhibit high activity contain the greatest contaminant inventory in the farms, it is essential to monitor these areas for changes on a more frequent basis. Approximately 25 boreholes require high rate logging, which would require a level of effort of approximately 3 months.

References

Barton, W.B., 2003. *Process Control Plan for Saltcake Dissolution Retrieval Demonstration in Tank 241-S-112*, RPP-15085, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

Reynolds, D.A., 2003. *Process Control Plan for Tank 241-C-106 Acid Dissolution*, RPP-16462, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

U.S. Department of Energy (DOE), 2003. *Hanford Tank Farms Vadose Zone Monitoring Project, Baseline Monitoring Plan*, GJO-HGLP 1.8.1, Revision 0, Grand Junction Office, Grand Junction, Colorado.

U.S. Department of Energy (DOE), 2004. *Hanford Tank Farms Vadose Zone Monitoring Project, Annual Monitoring Report for Fiscal Year 2003*, GJO-2004-554-TAC, Grand Junction Office, Grand Junction, Colorado.

U.S. Department of Energy (DOE), 2005. *241-C-106 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data*, DOE-EM/GJ899-2005, Grand Junction Office, Grand Junction, Colorado.

Appendix A
Boreholes Monitored During 3rd Quarter of FY 2005

Table A-1. Routine Boreholes Monitored During the 3rd Quarter of FY 2005

Borehole Number	Tank	Top	Bottom	Footage	Rerun Footage	Log Freq. (days)	Next Log Date	Last Event Date	Total 2nd Qrt. Events	Total Events (to date)	Comment
			Total Footage=	0	0			Total Routine Events=	0		

Table A-2. Retrieval Boreholes Monitored During the 3rd Quarter of FY 2005

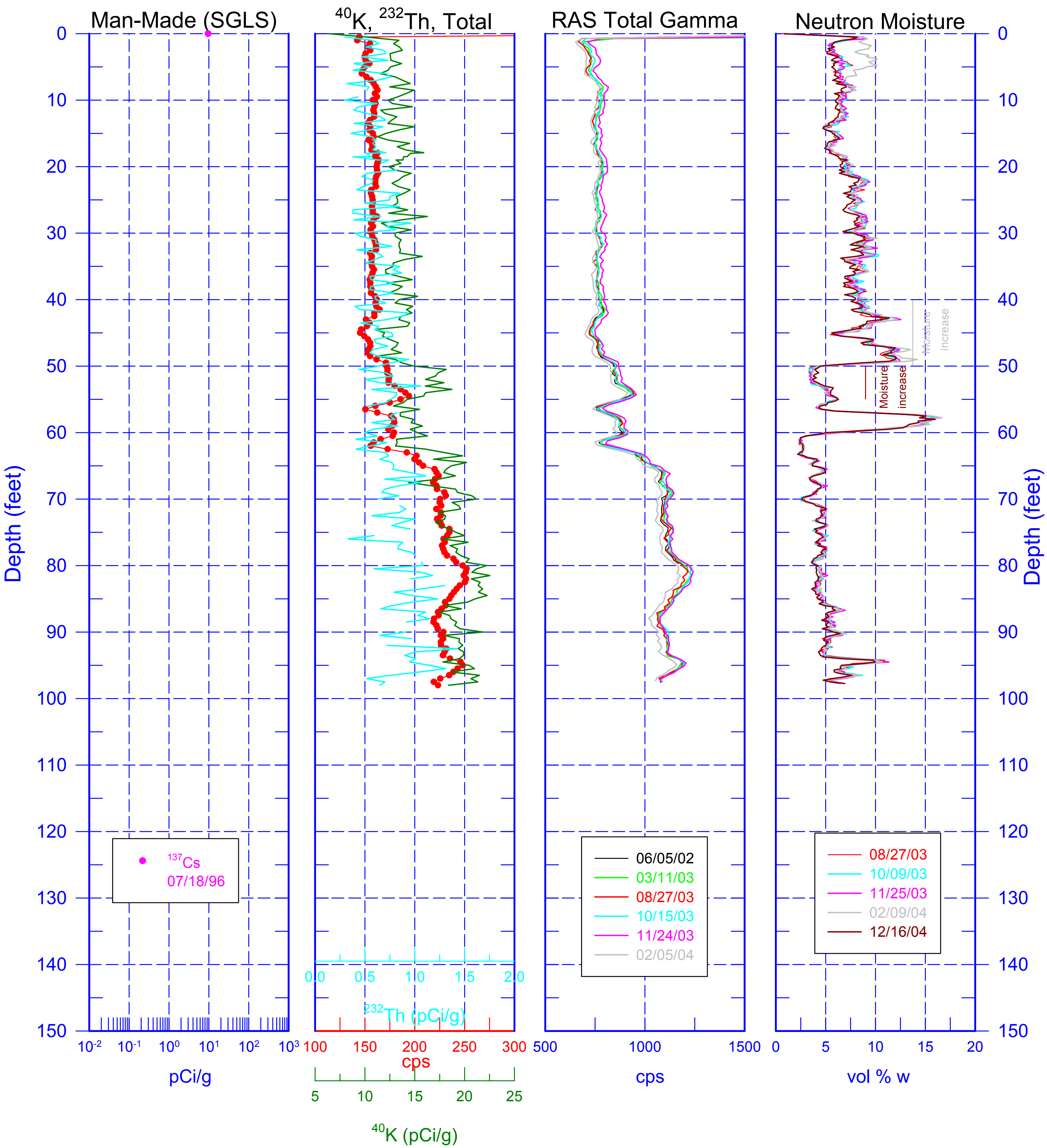
Borehole Number	Tank	Top	Bottom	Footage	Rerun Footage	Next Log Date	RAS Event A	RAS Event B	RAS Event C	RAS Event D	RAS Event E	RAS Event F	Ras Event G	Ras Event H	Ras Event I	Total 3rd Quarter Events	Total Events (to date)	Comment
30-05-02	C-105	5	127	122		06/13/05	04/22/02	01/29/03	04/29/03	07/23/03	09/17/03	10/23/03	12/15/03	02/19/04	05/08/05	1	9	No apparent change, C-106 Retrieval
30-06-04	C-106	0	129	129		06/13/05	09/11/02	01/27/03	04/29/03	07/23/03	09/17/03	10/31/03	12/22/03	02/25/04	05/08/05	1	9	No apparent change, C-106 Retrieval
30-06-10	C-106	0	128	128		06/13/05	04/23/02	01/23/03	04/22/03	07/22/03	09/08/03	11/03/03	12/22/03	02/26/04	05/08/05	1	9	Possible change 124-126 ft Co-60, C-106 Retrieval (2/27/04)
30-06-12	C-106	0	98	98		06/13/05	04/24/02	01/24/03	04/29/03	07/22/03	09/11/03	10/22/03	12/08/03	03/01/04	05/08/05	1	9	No apparent change, C-106 Retrieval
40-12-06	S-112	0	144	144		08/02/05	06/04/02	03/10/03	08/21/03	10/14/03	11/19/03	02/09/04	06/27/05			1	7	No apparent change; S-112 Retreival
	Total Footage =			621	0							Total Retrieval Events This Quarter =				5		

Table A-3. Retrieval Boreholes Logged with the Neutron Moisture Logging System During 3rd Quarter of FY 2005

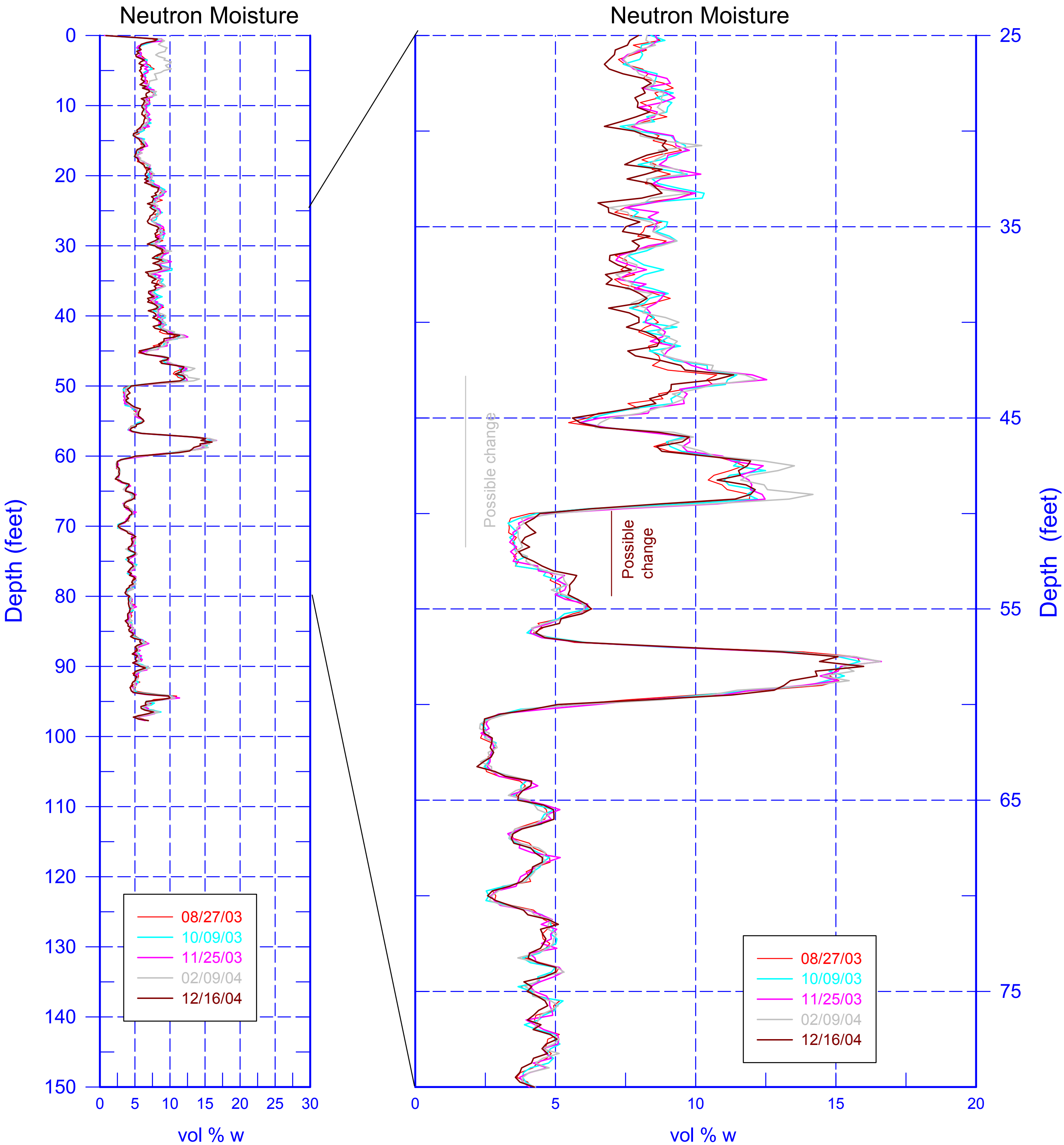
Borehole Number	Tank	Top	Bottom	Footage	Rerun Footage	Next Event	NMLS Event 1	NMLS Event 2	Total 2nd Qrt FY05 Events	Total Events (to date)	Comment
			Total Footage=	**0**	**0**			**Total Events=**	**0**		

Appendix B
Tank S-112 Retrieval Monitoring Log Plots

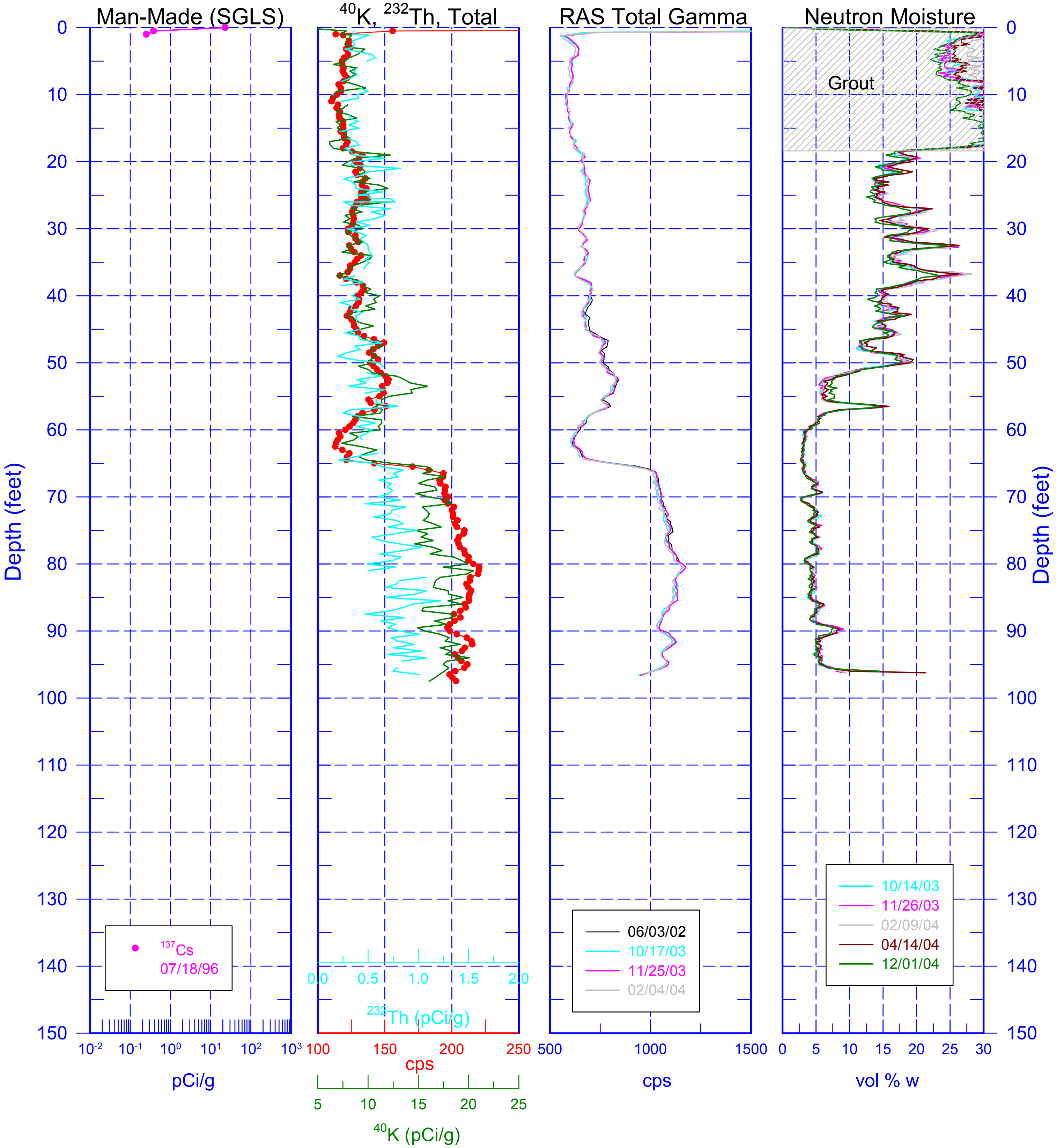
Tank S-109
40-09-06



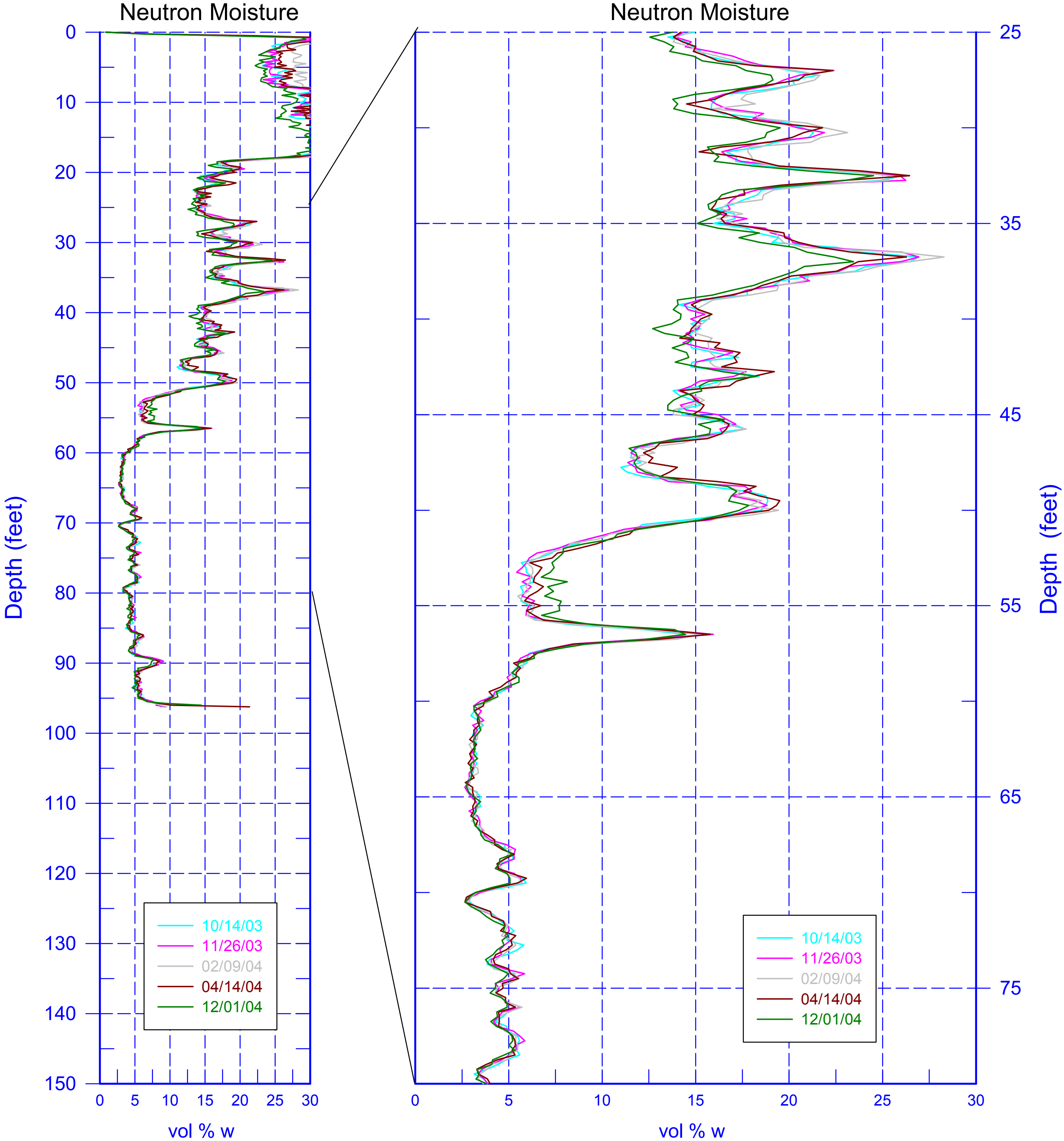
Tank S-109
40-09-06



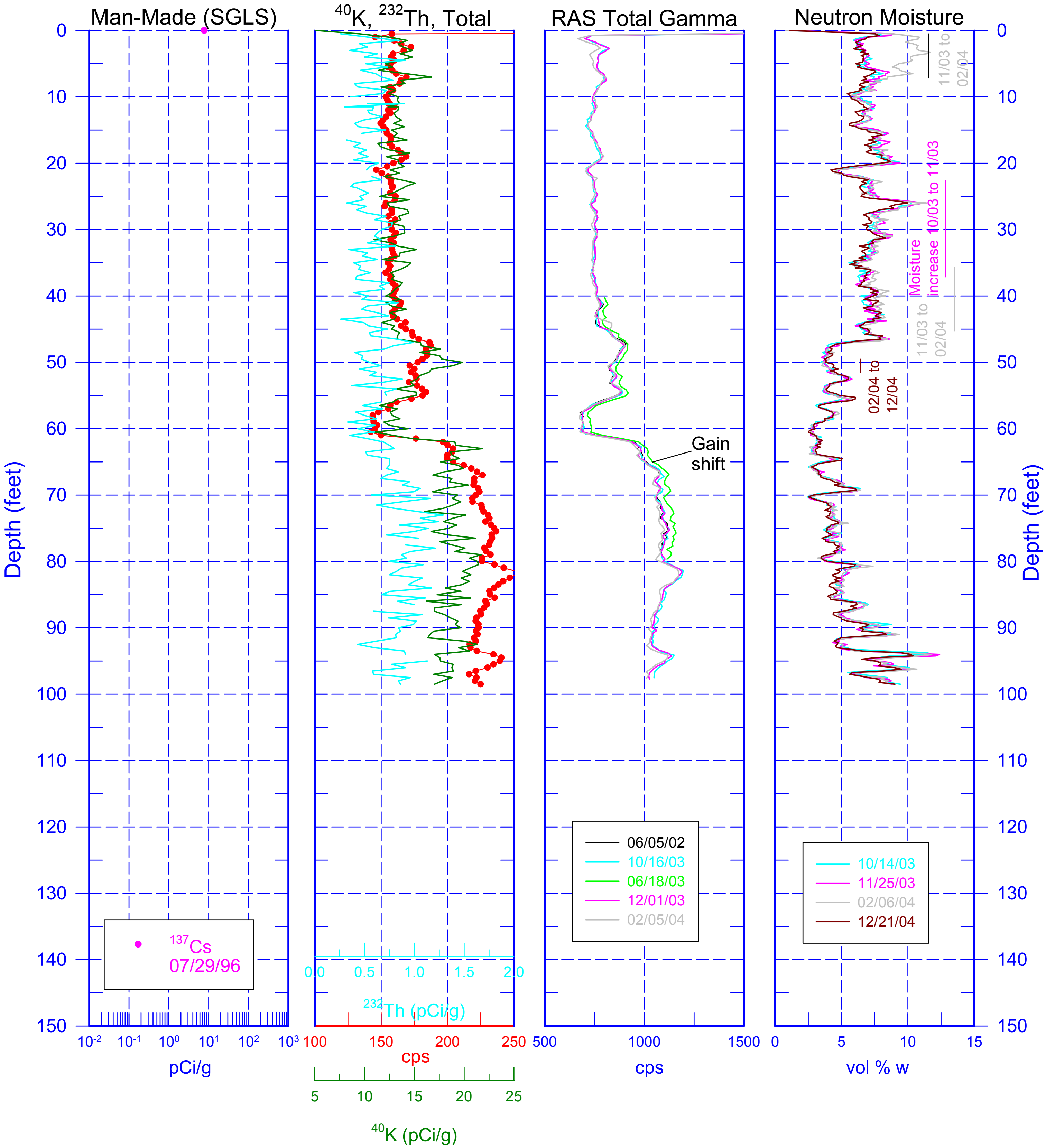
Tank S-111
40-11-08



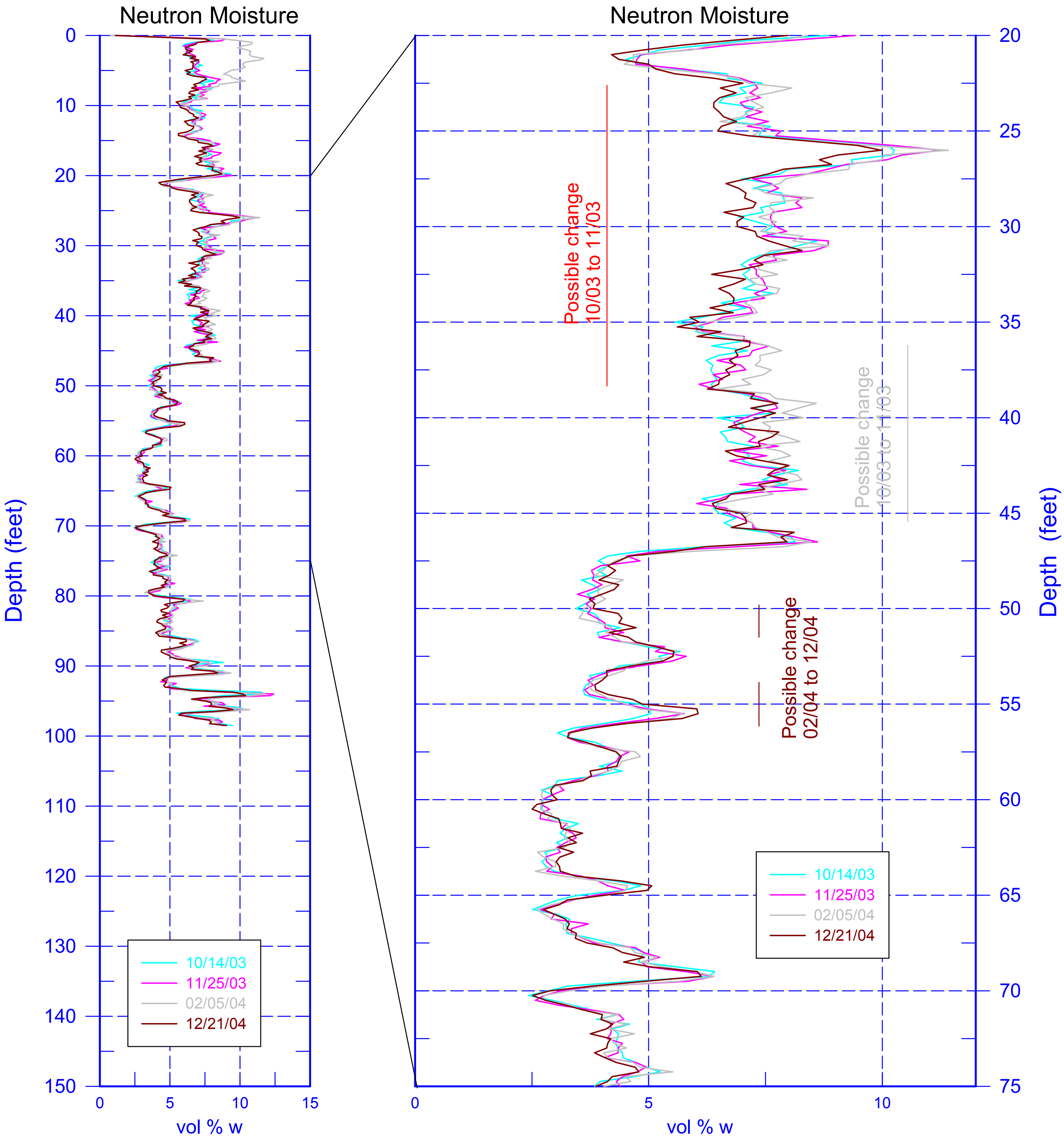
Tank S-111
40-11-08



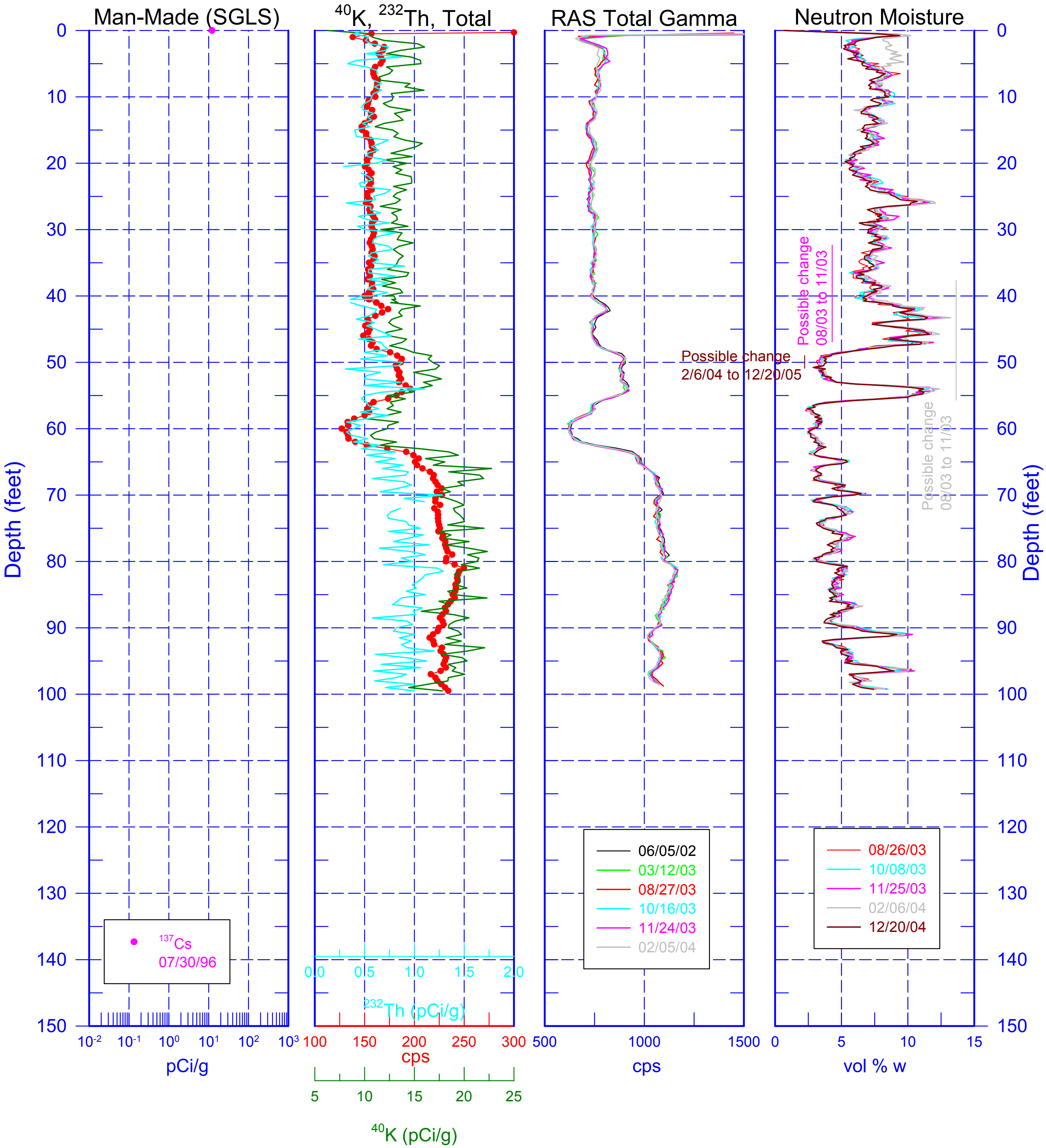
Tank S-111
40-11-09



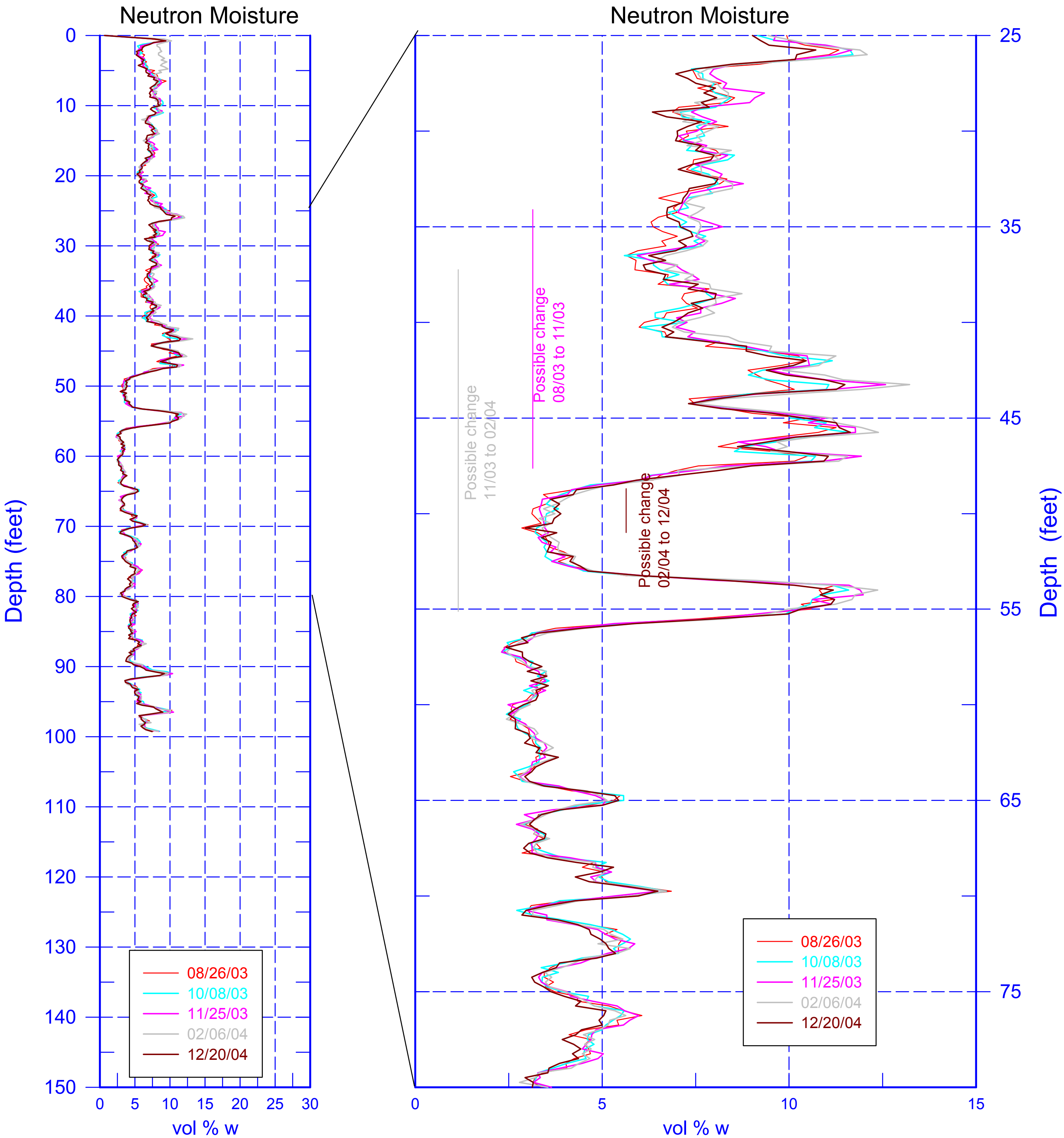
Tank S-111
40-11-09



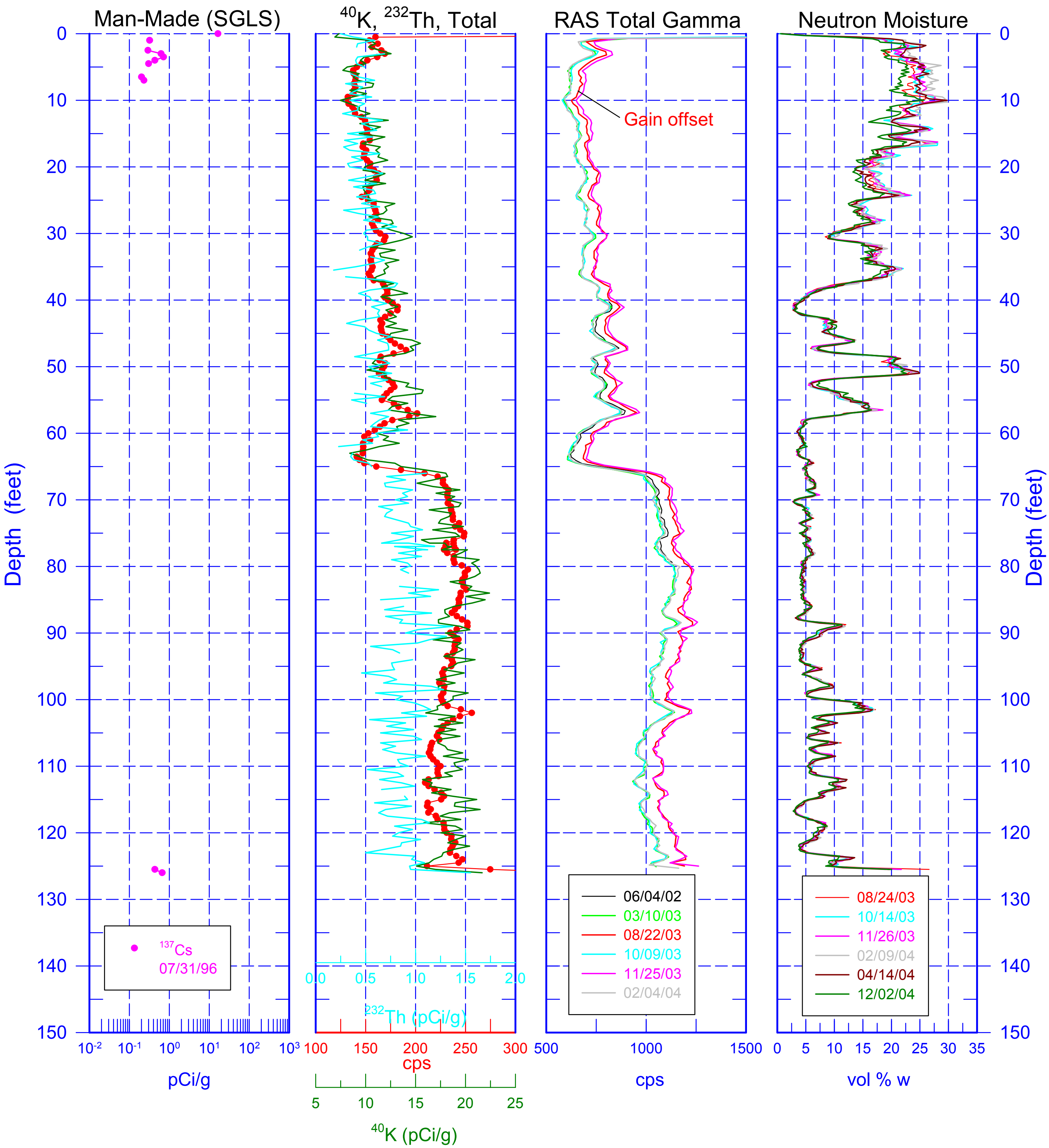
Tank S-112
40-12-02



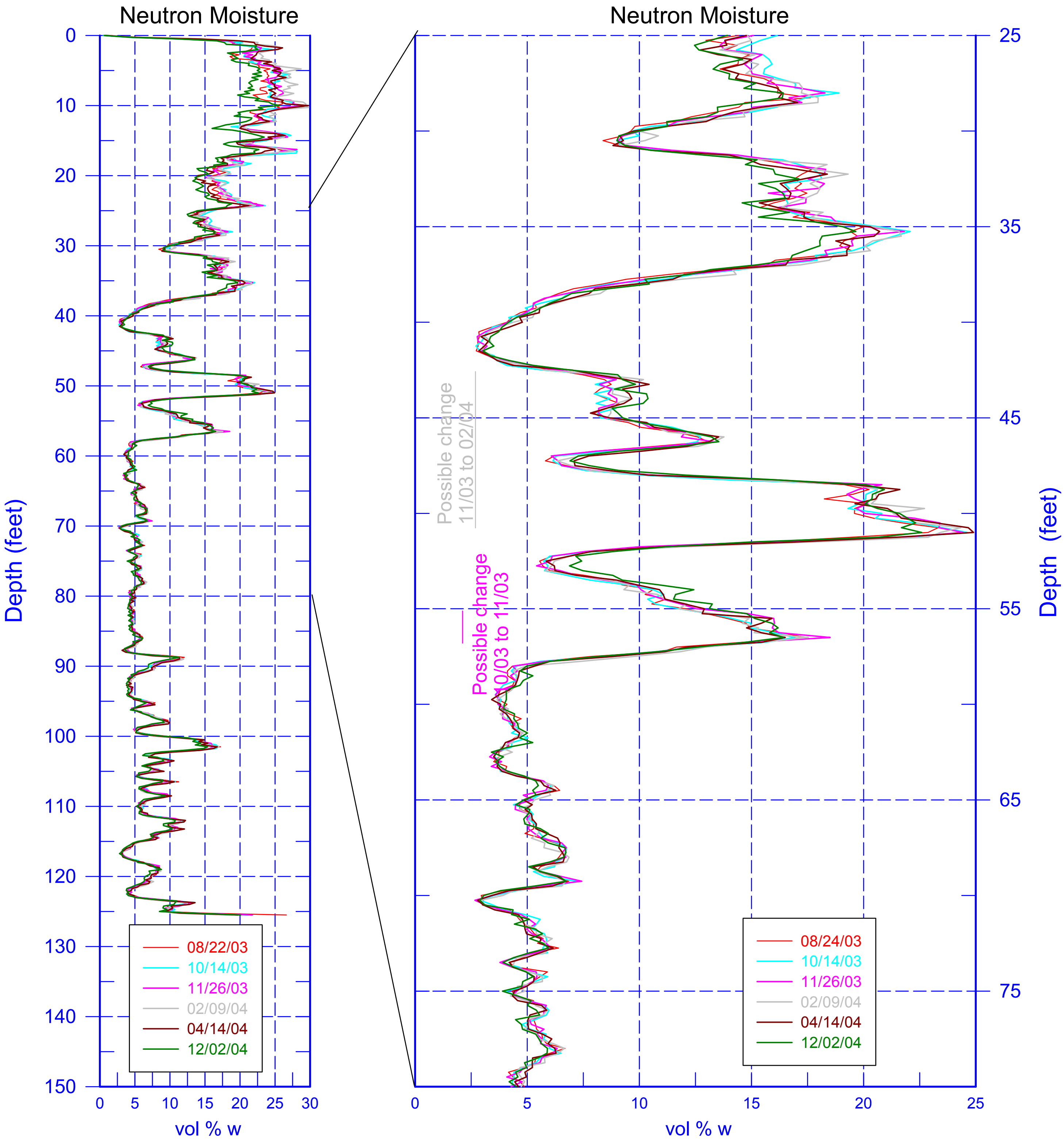
Tank S-112
40-12-02



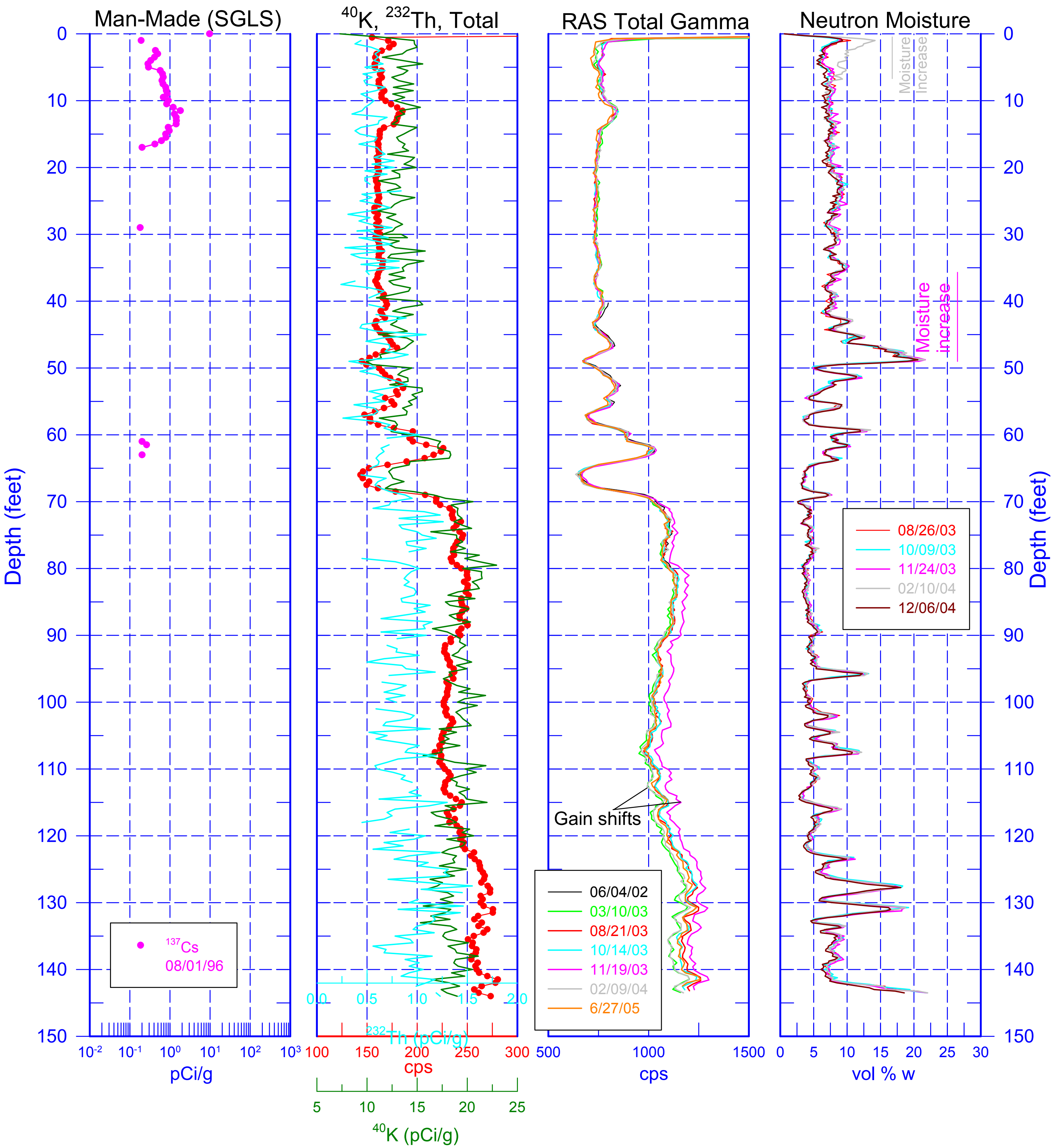
Tank S-112
40-12-04



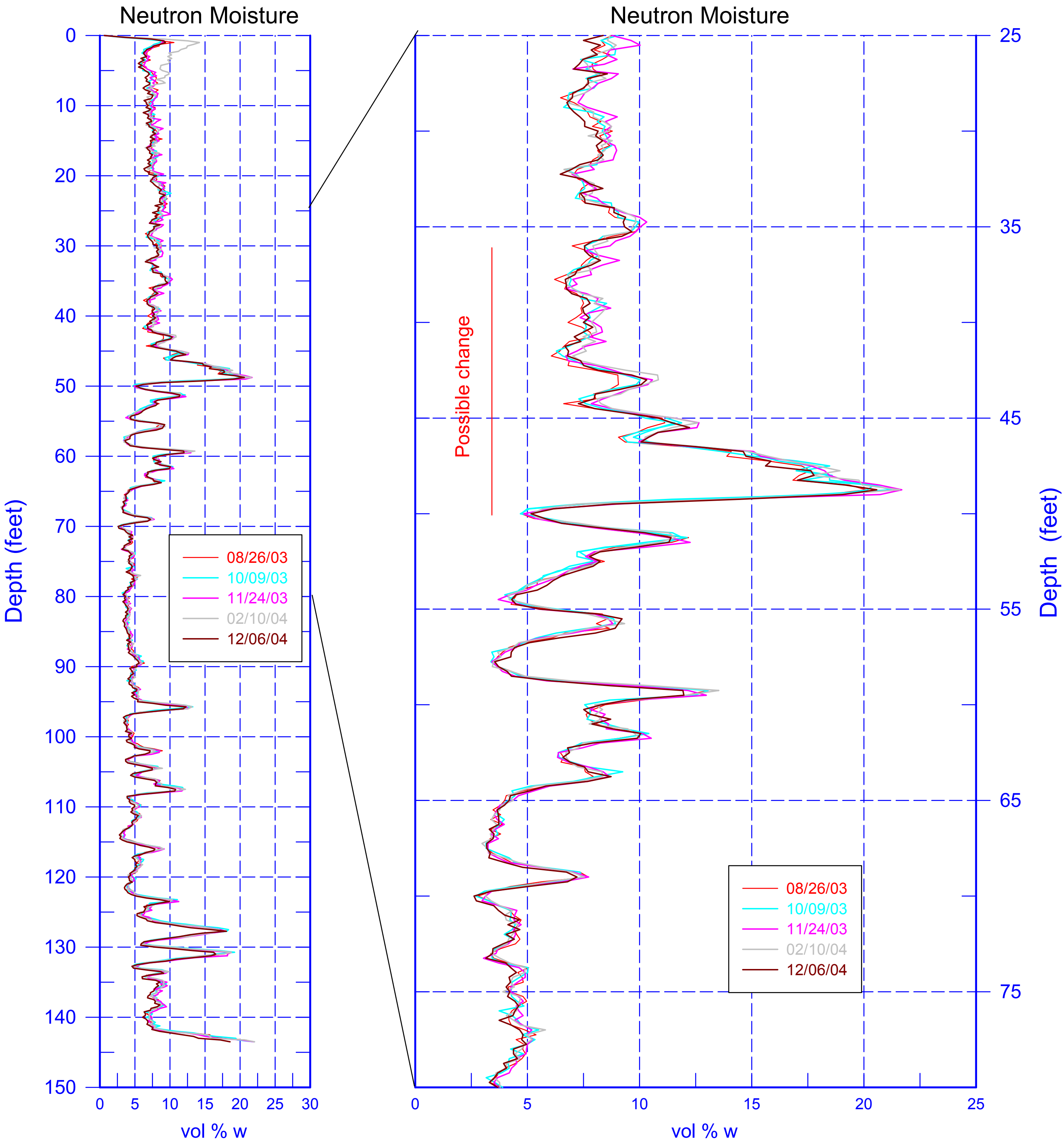
Tank S-112
40-12-04



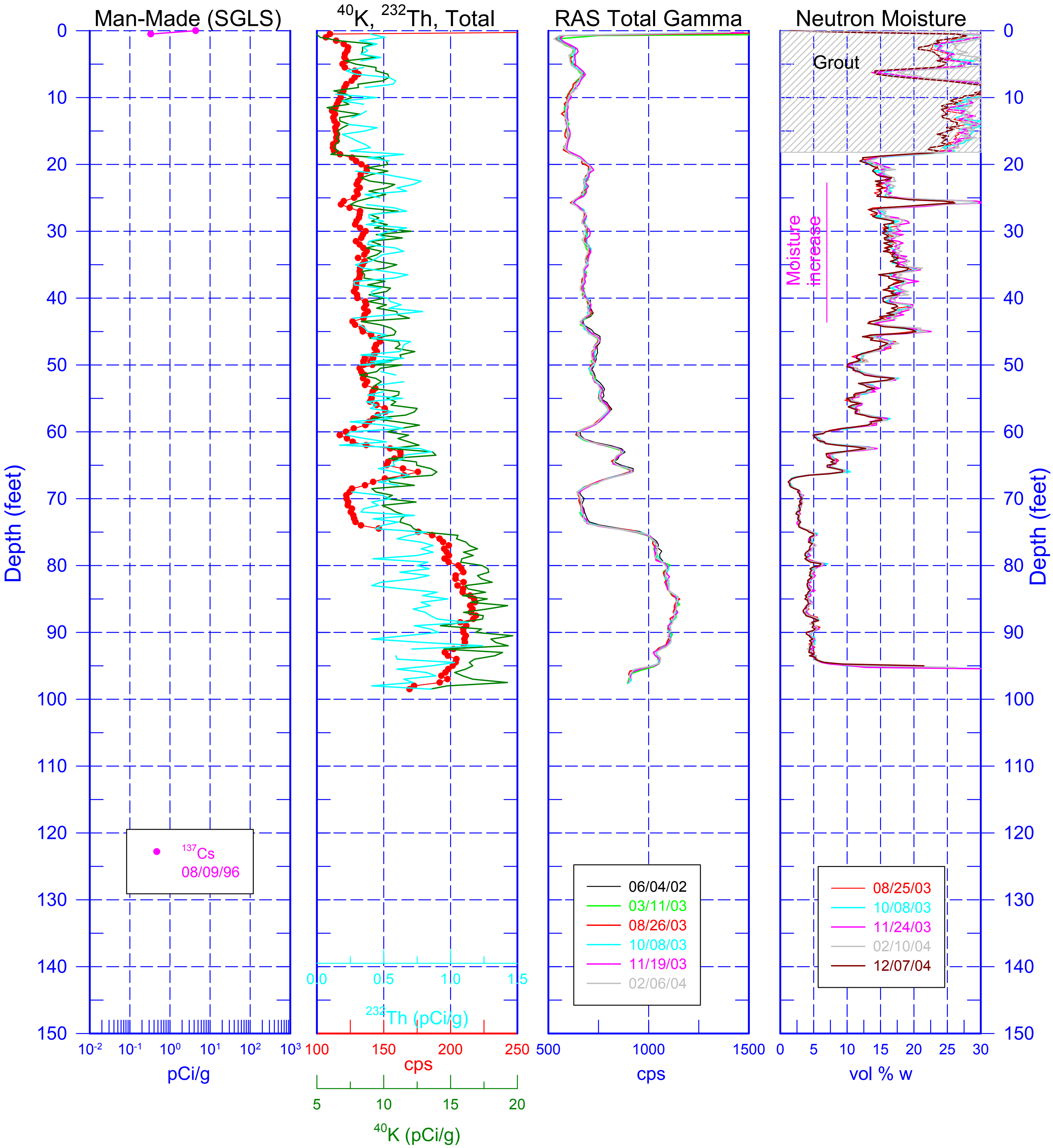
Tank S-112
40-12-06



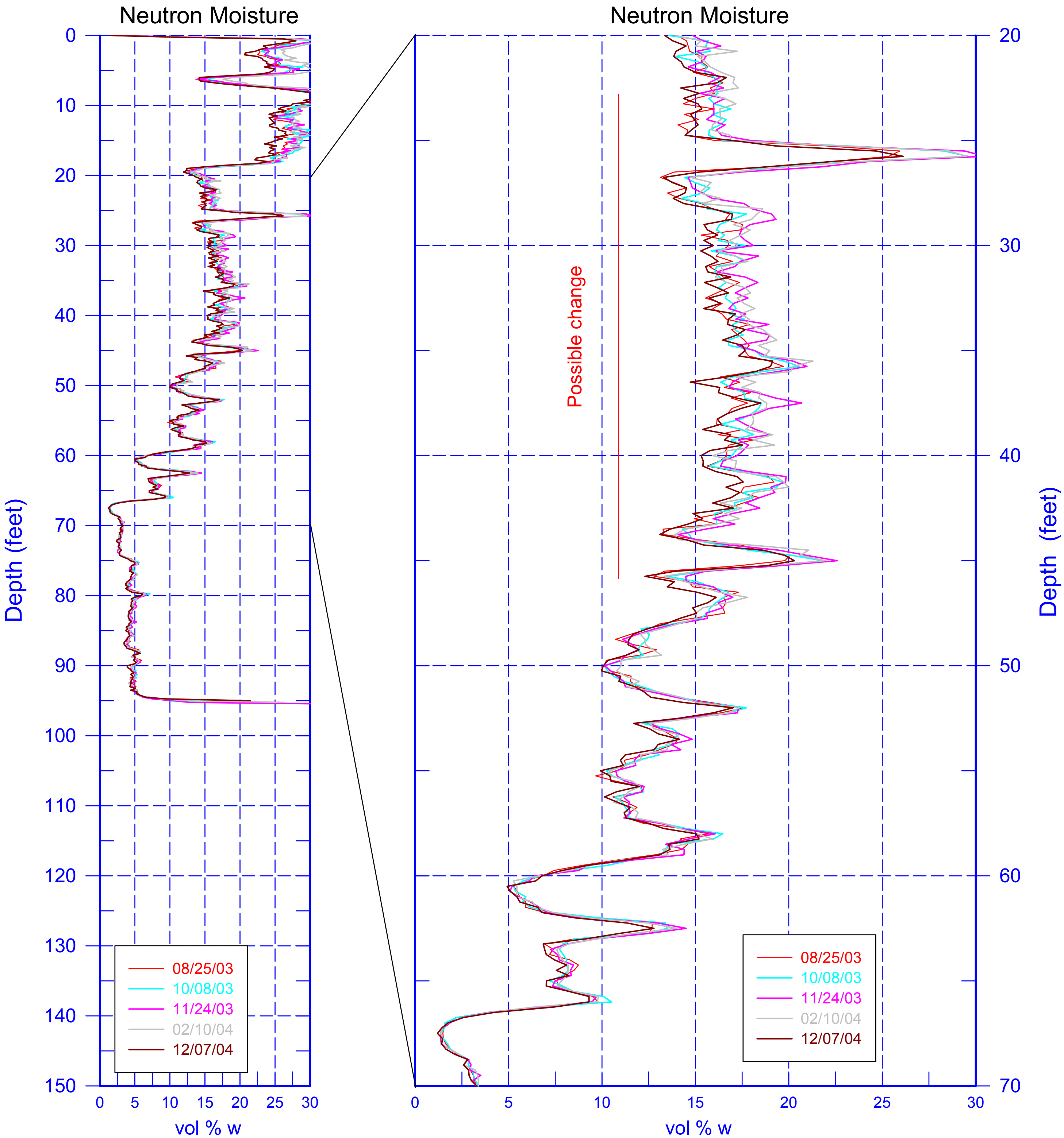
Tank S-112
40-12-06



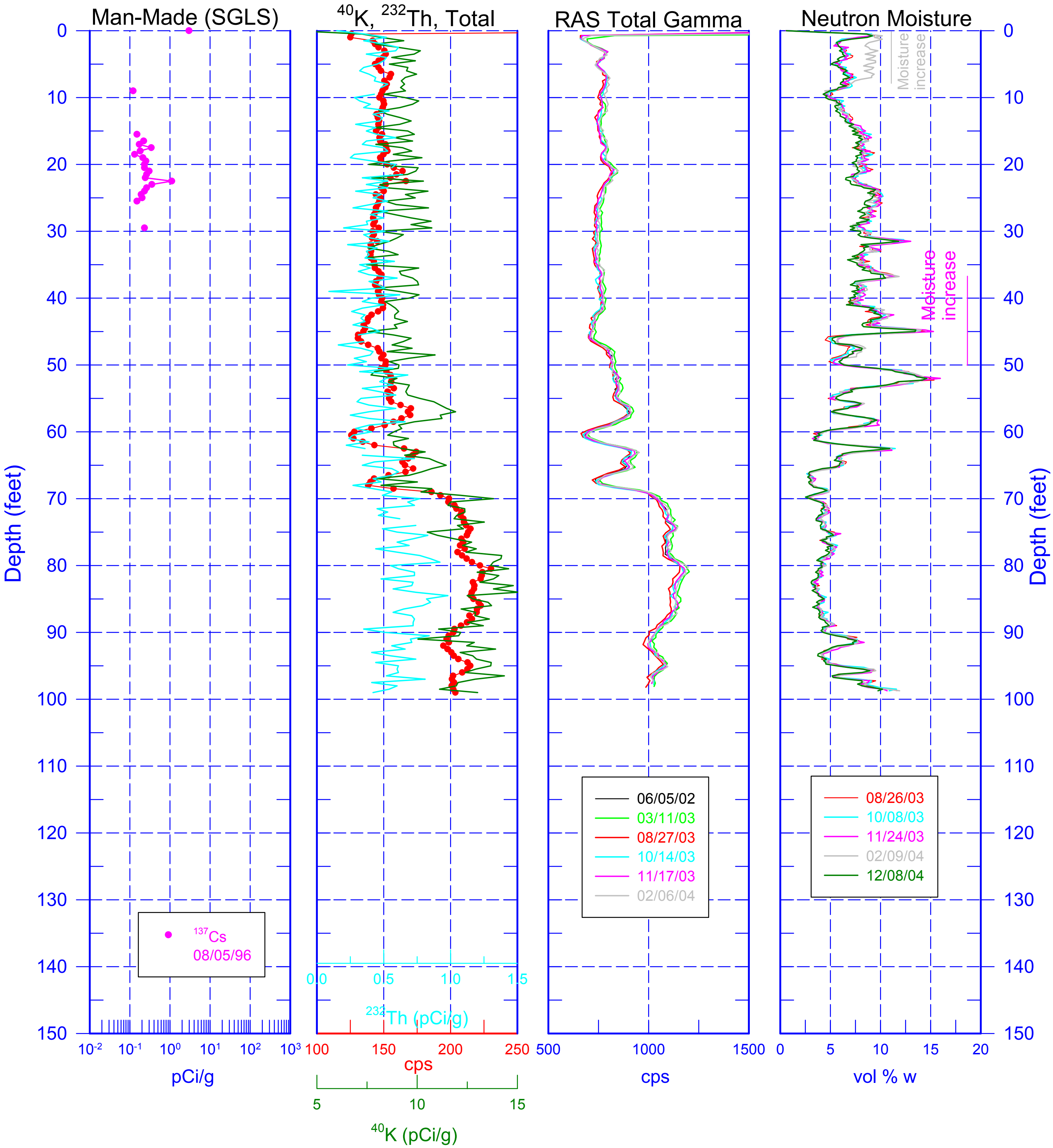
Tank S-112
40-12-07



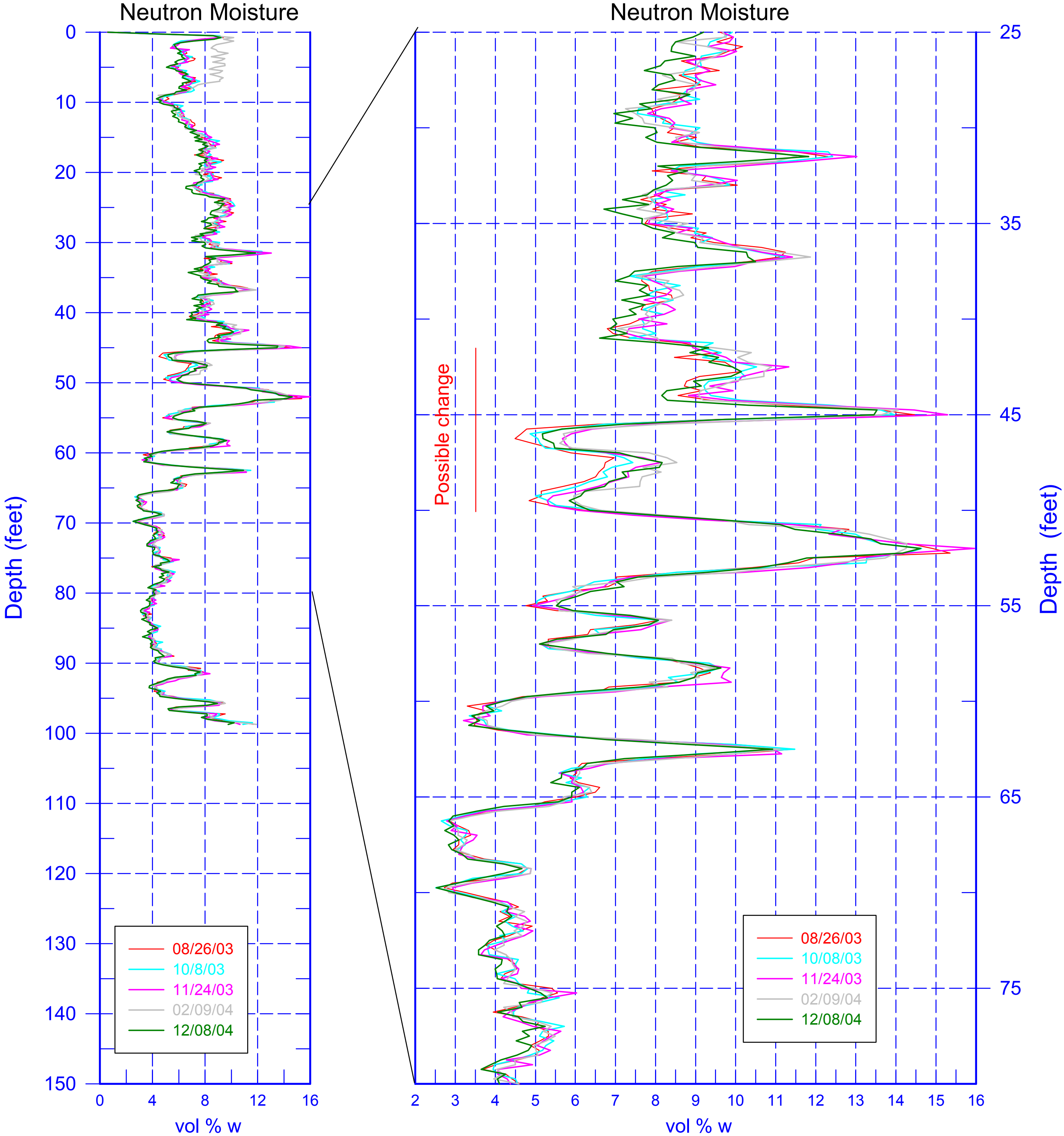
Tank S-112
40-12-07



Tank S-112
40-12-09

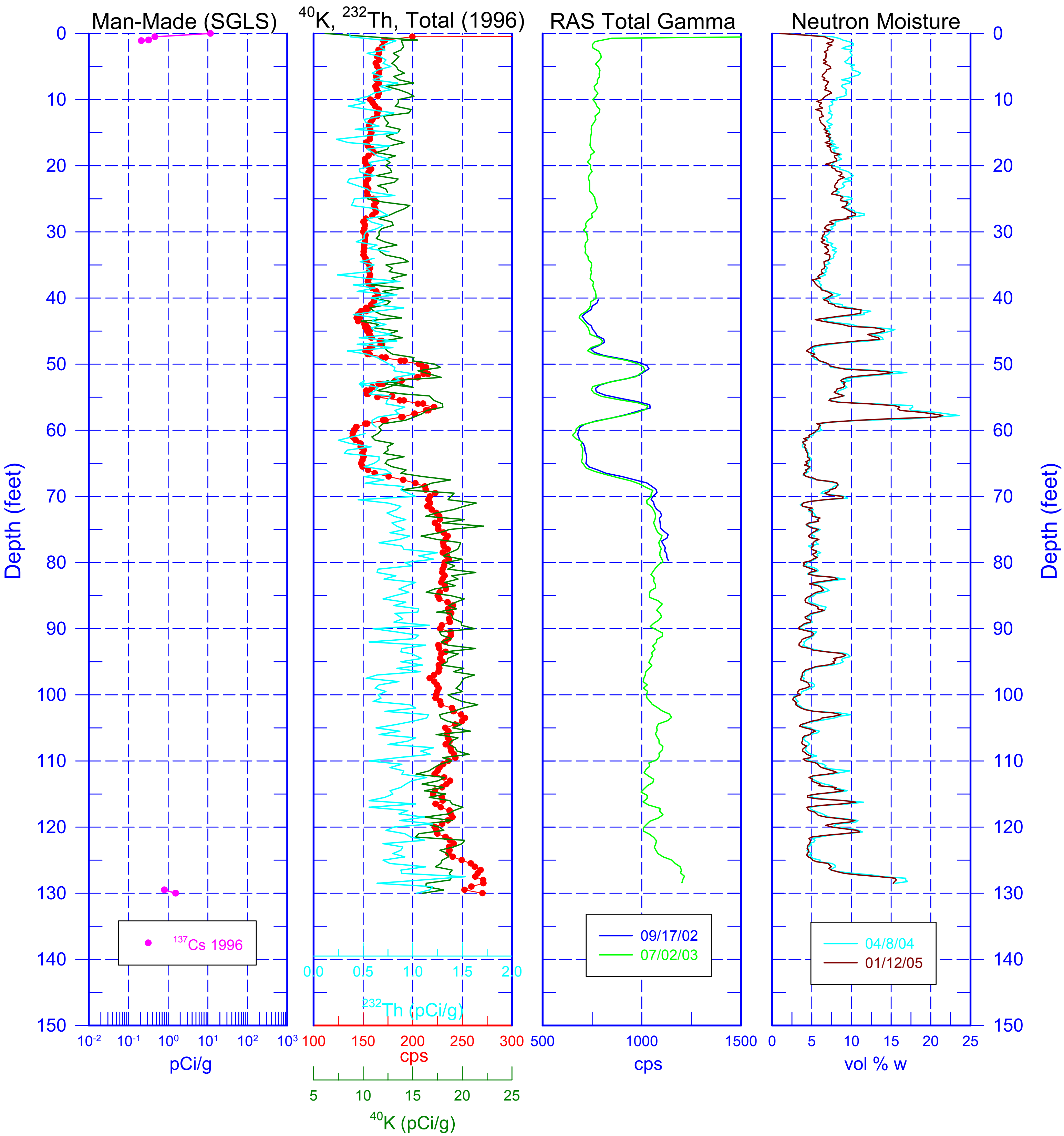


Tank S-112
40-12-09

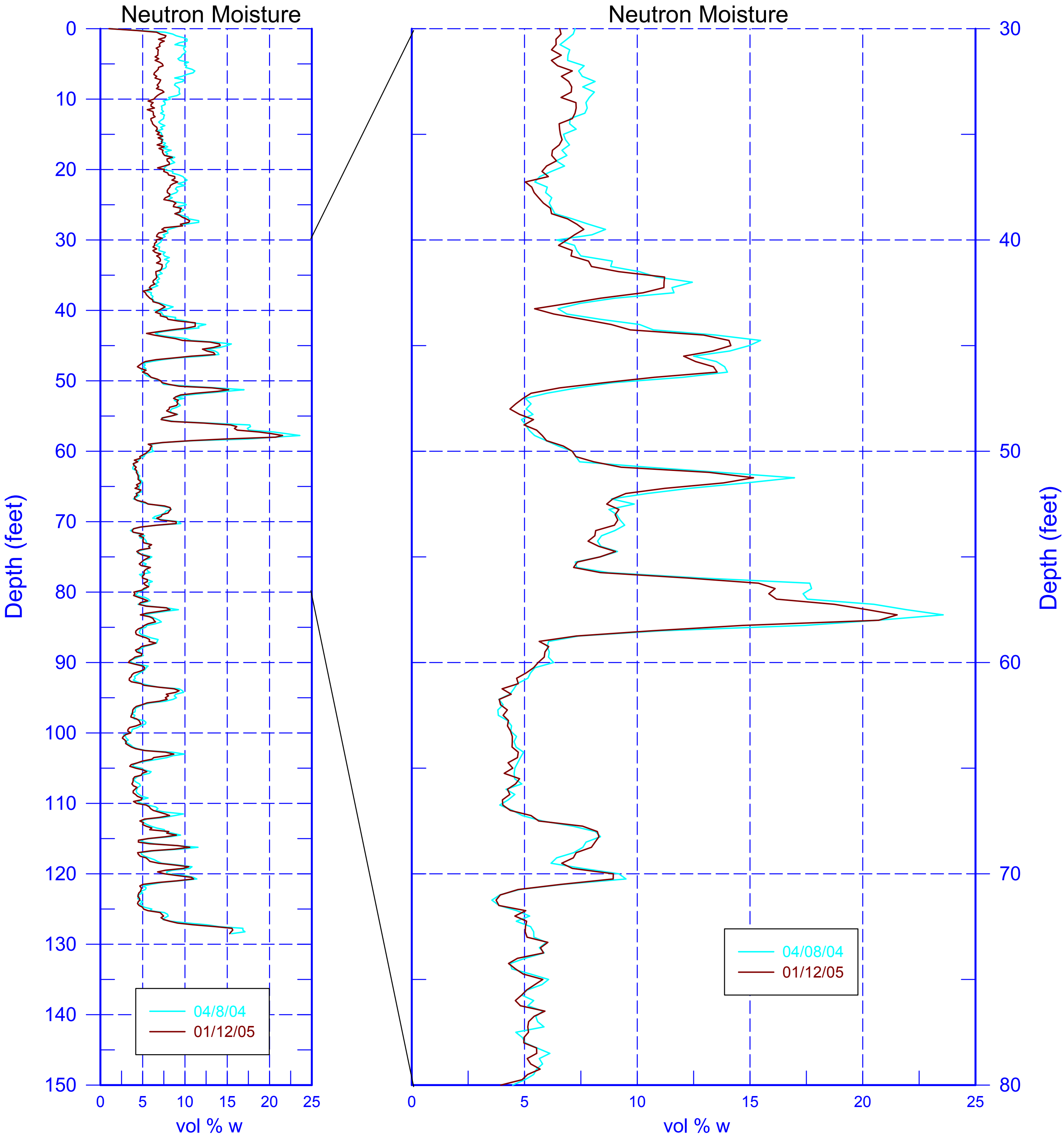


Appendix C
Tank S-102 Retrieval Monitoring Log Plots

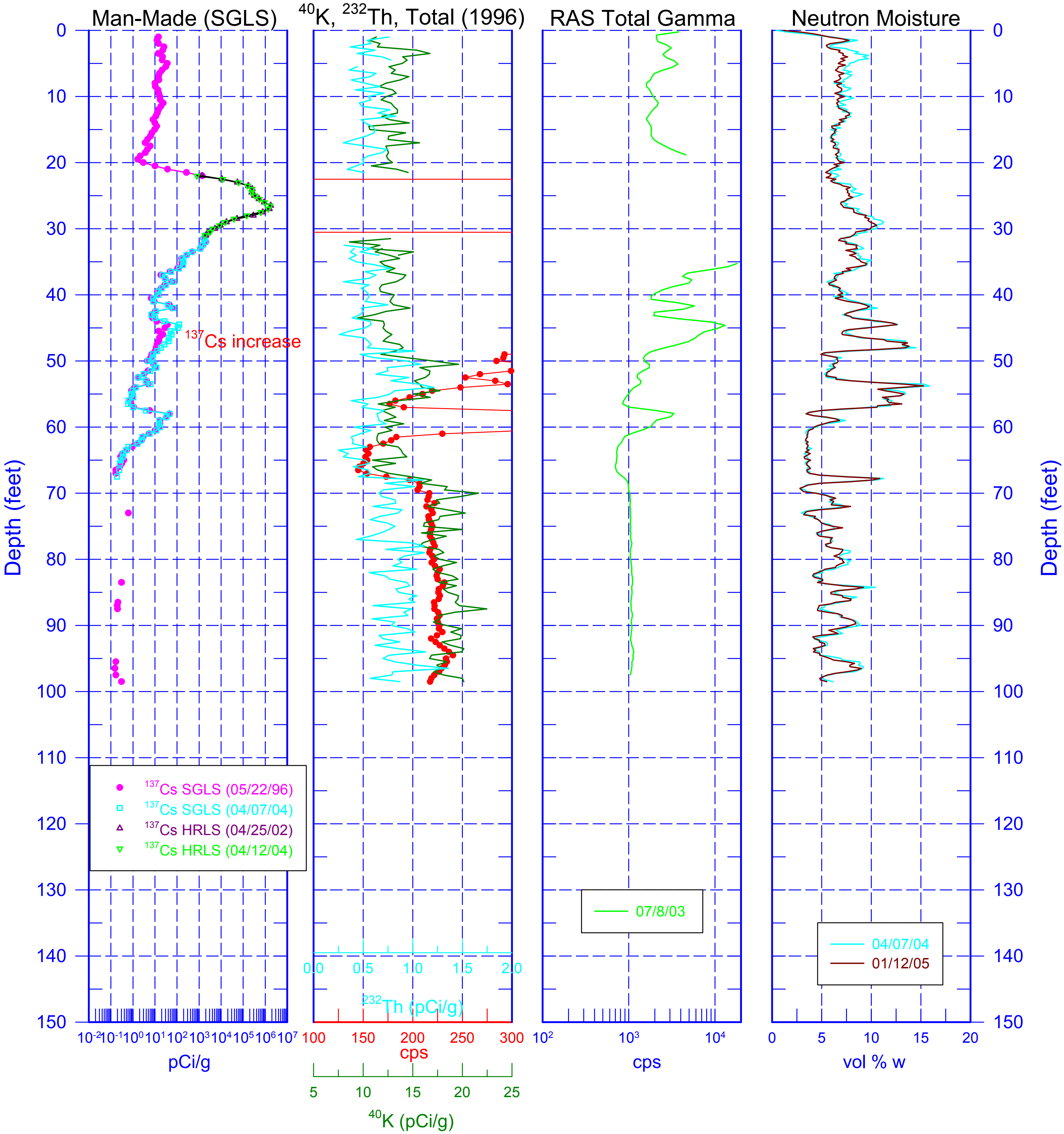
Tank S-102
40-02-01



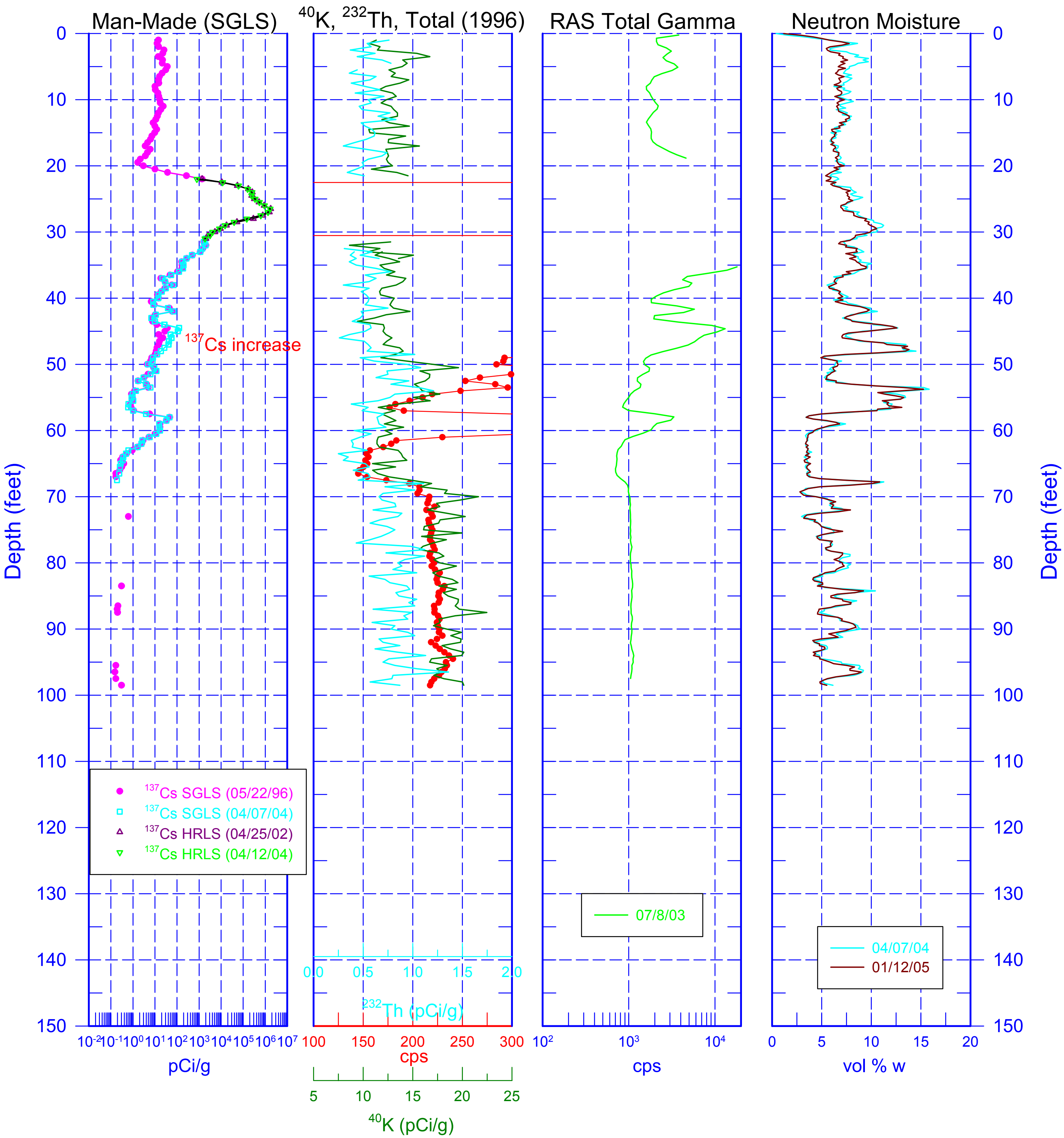
Tank S-102
40-02-01



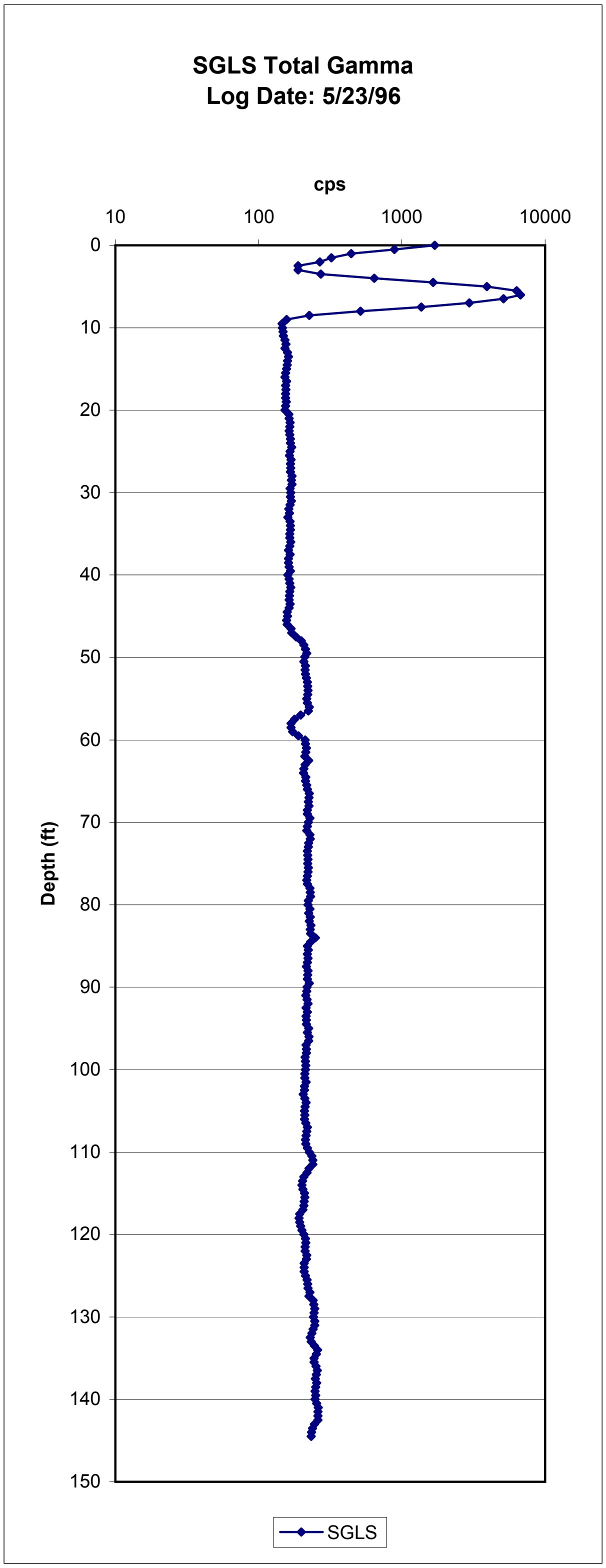
Tank S-102
40-02-03

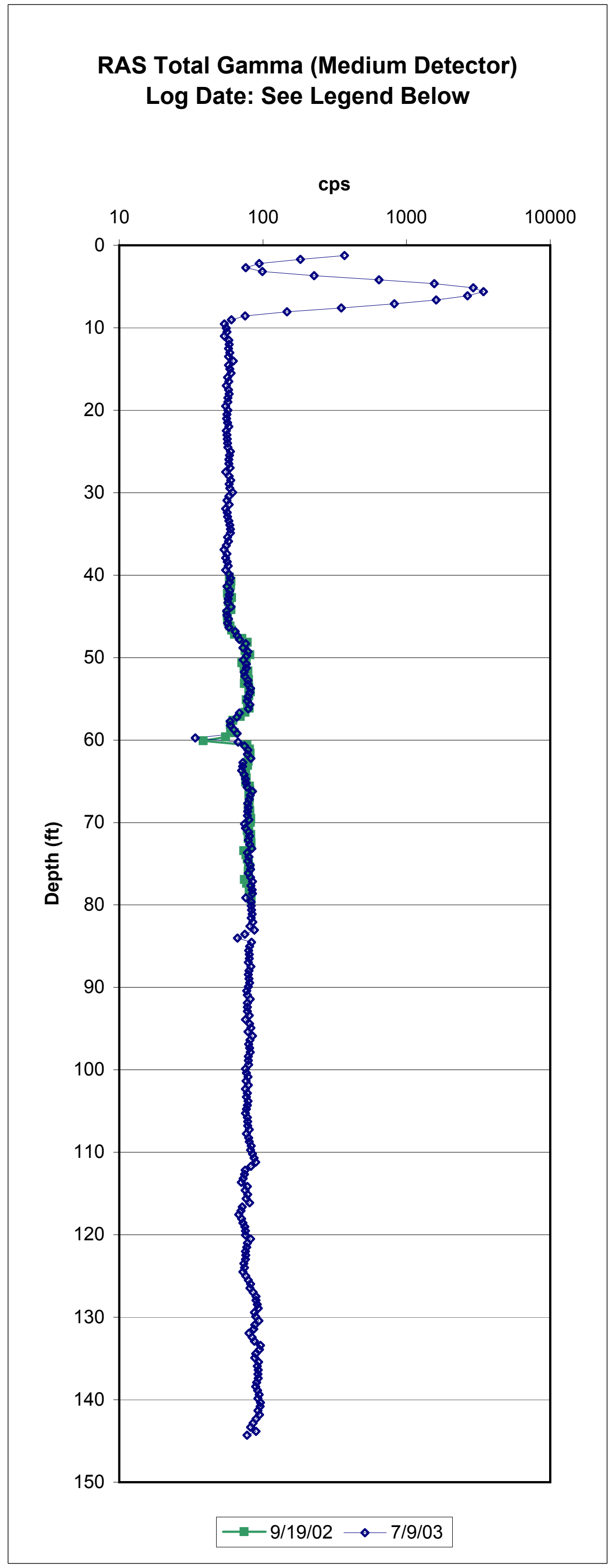


Tank S-102
40-02-03

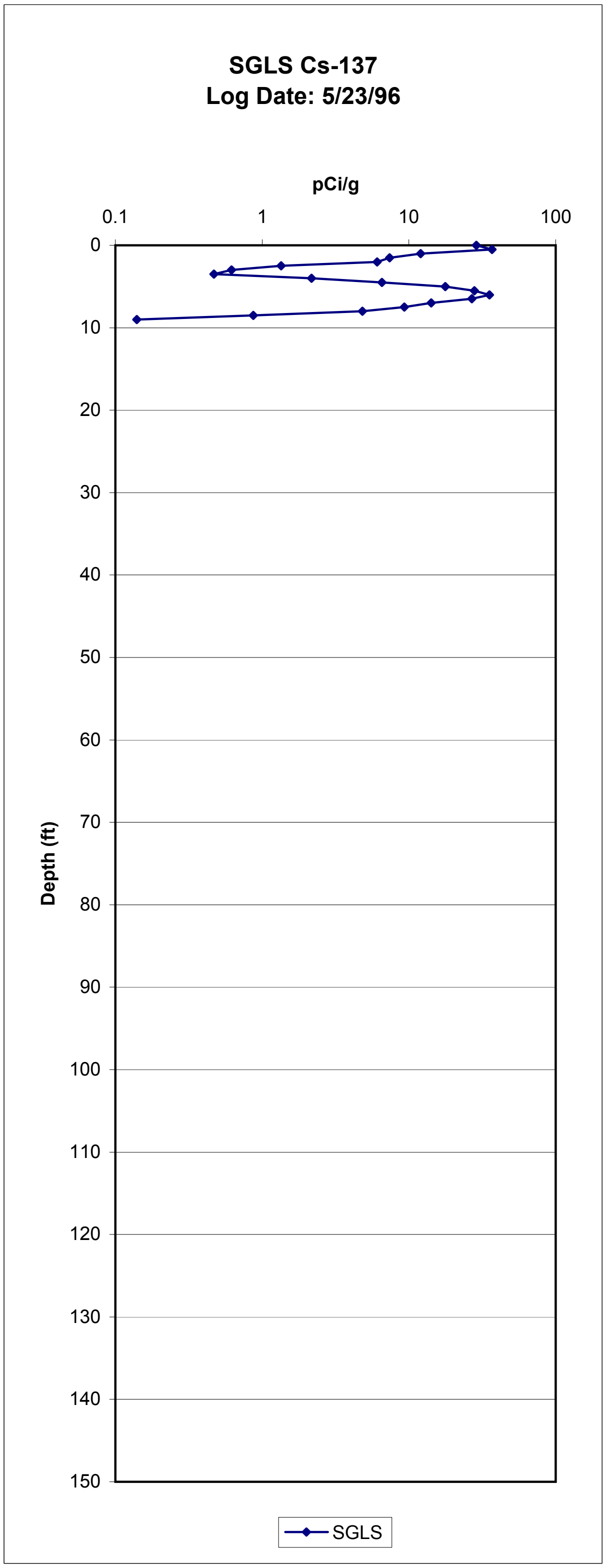


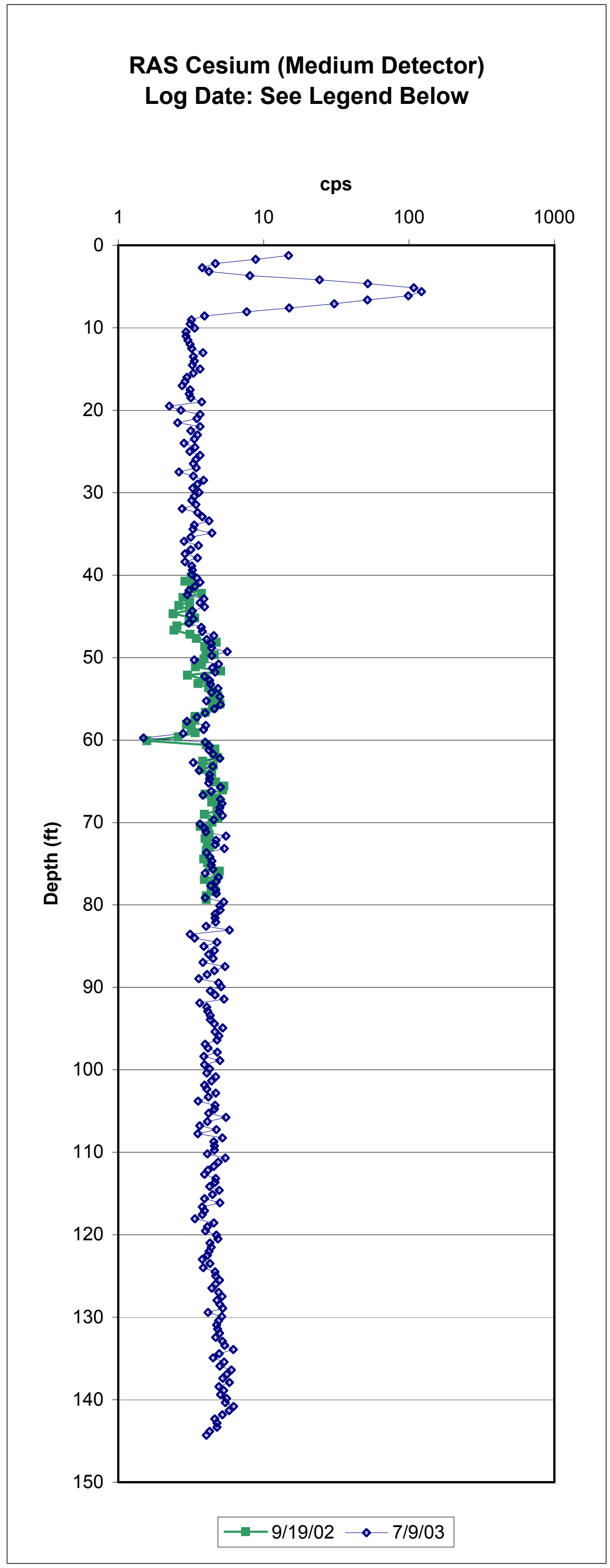
Borehole 40-02-04



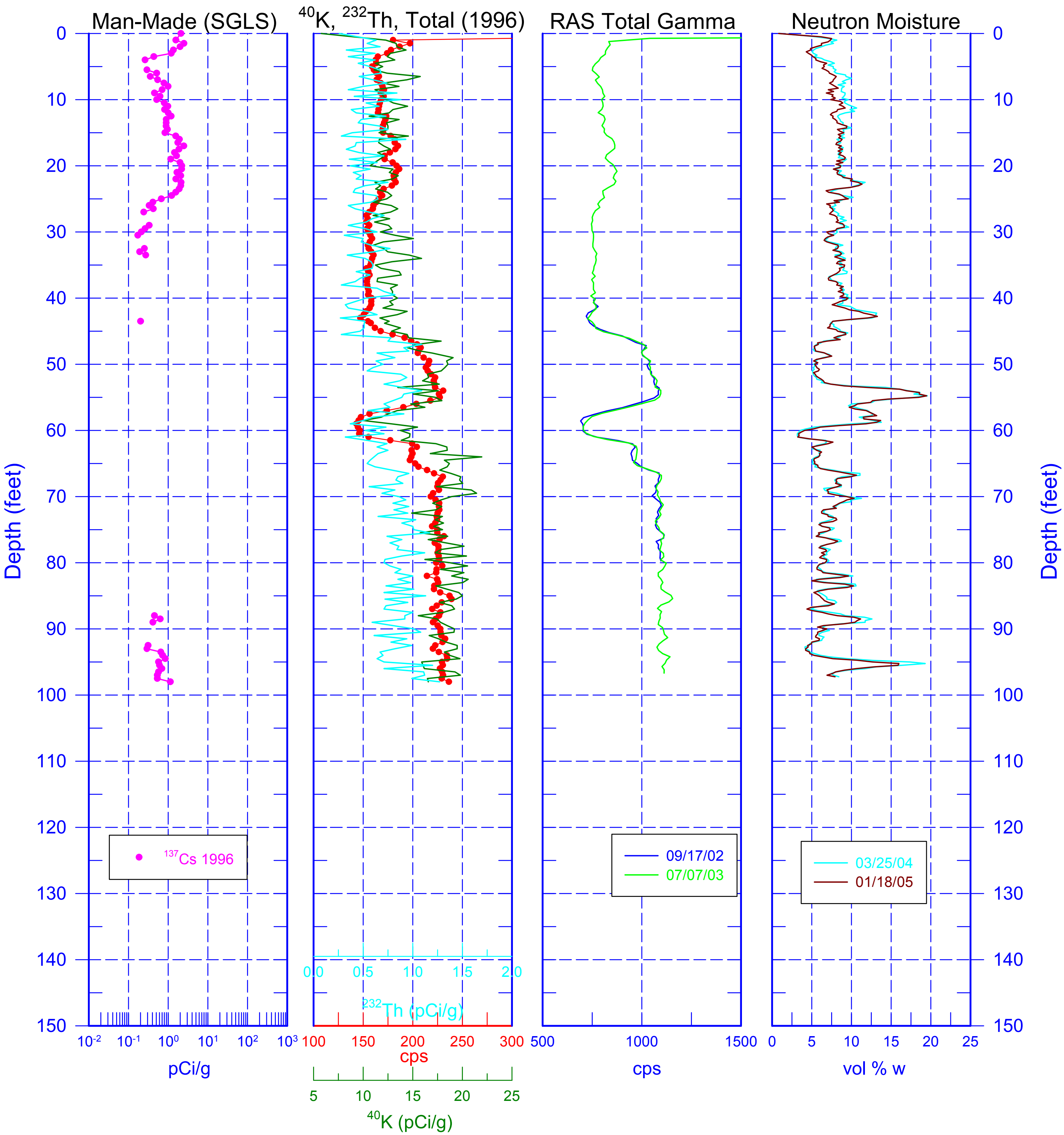


Borehole 40-02-04

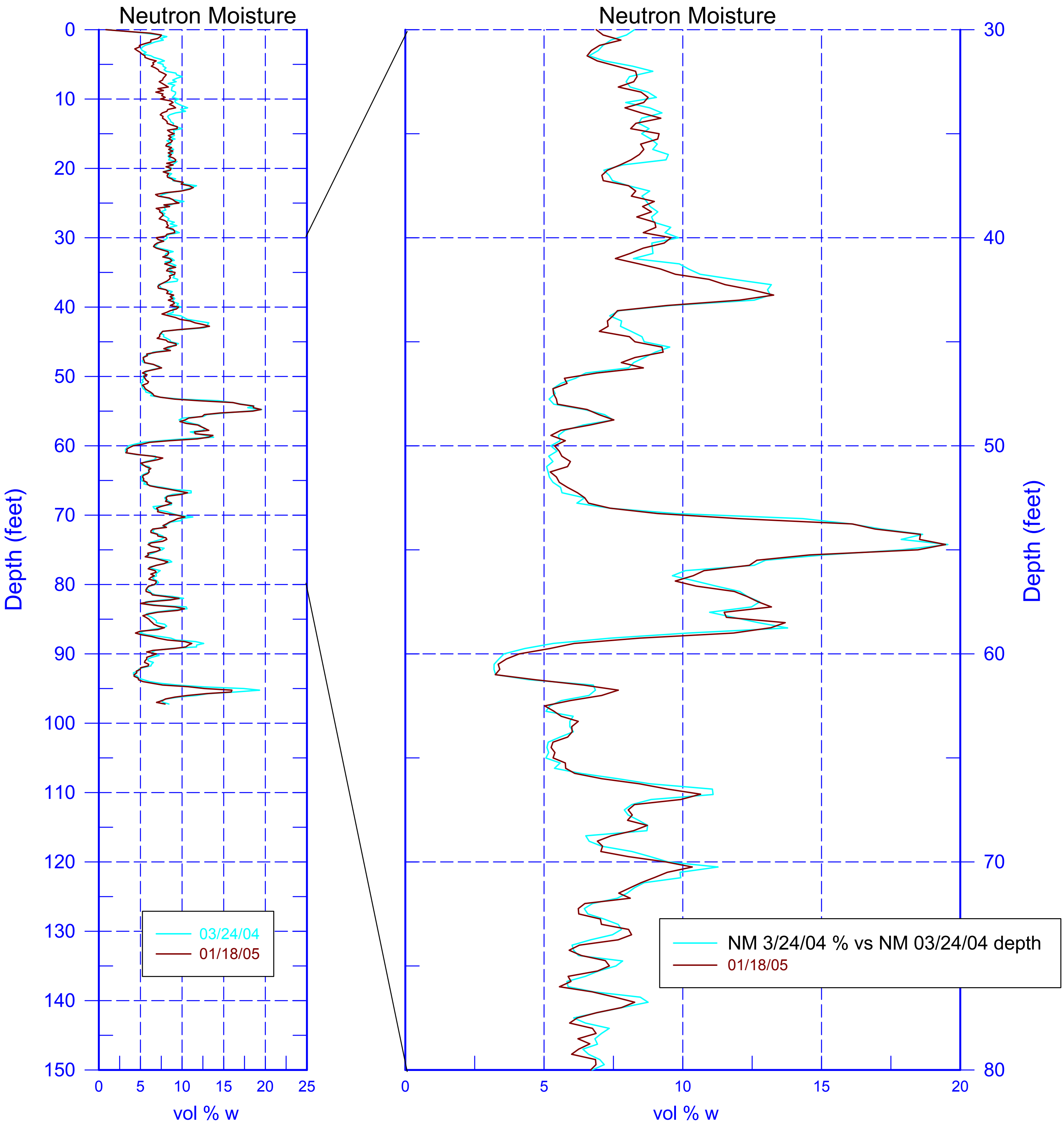




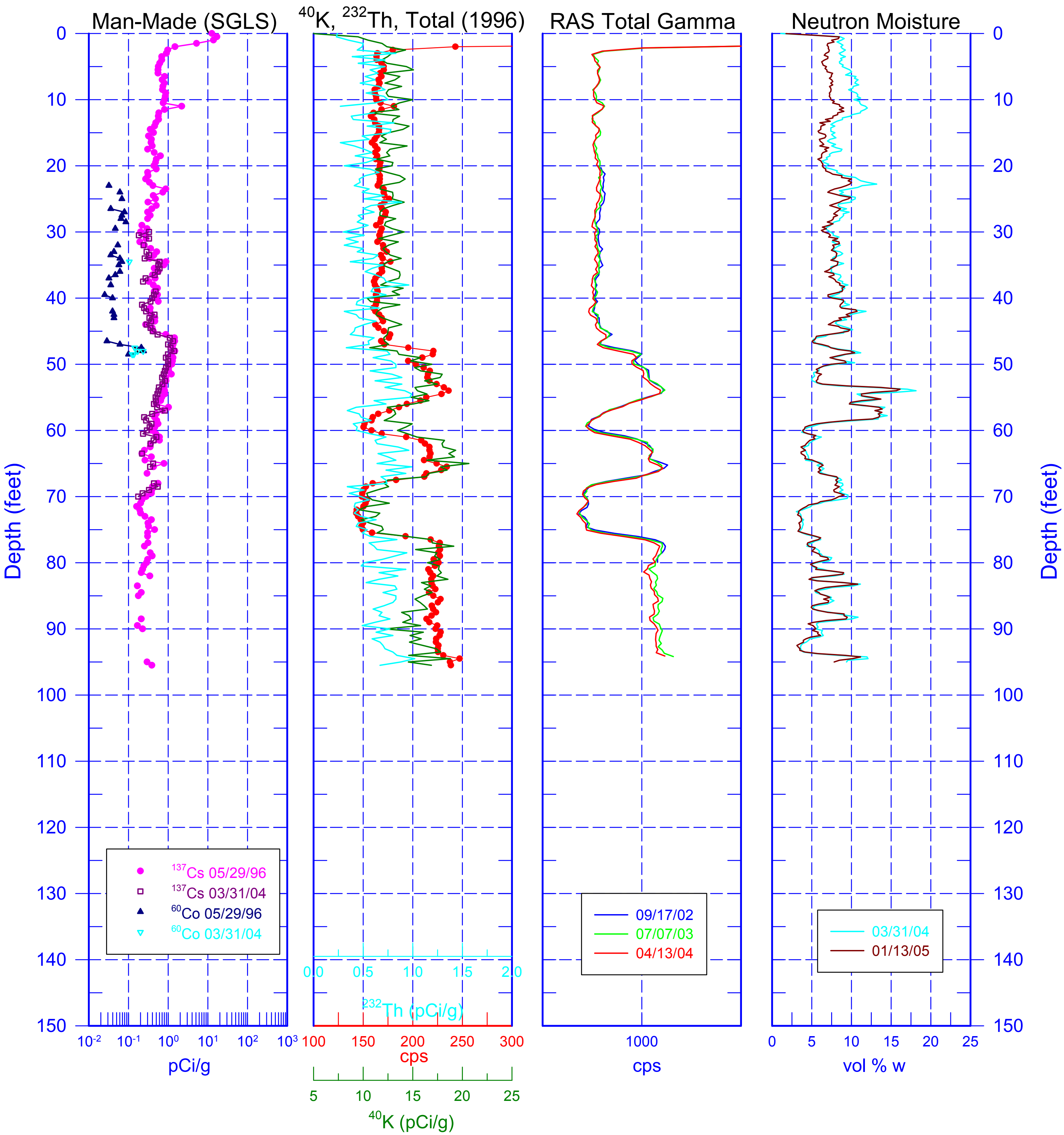
Tank S-102
40-02-05



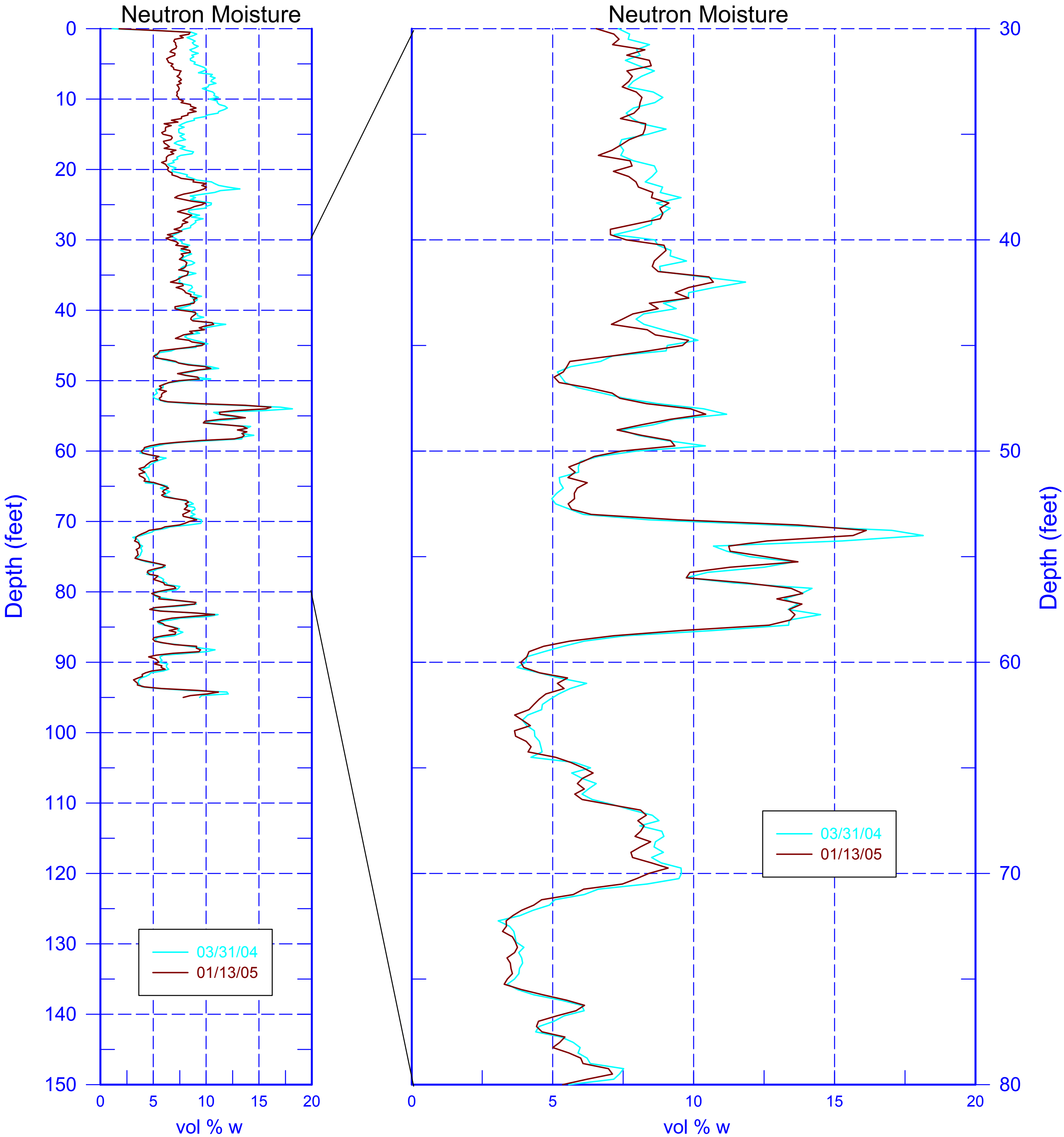
Tank S-102
40-02-05



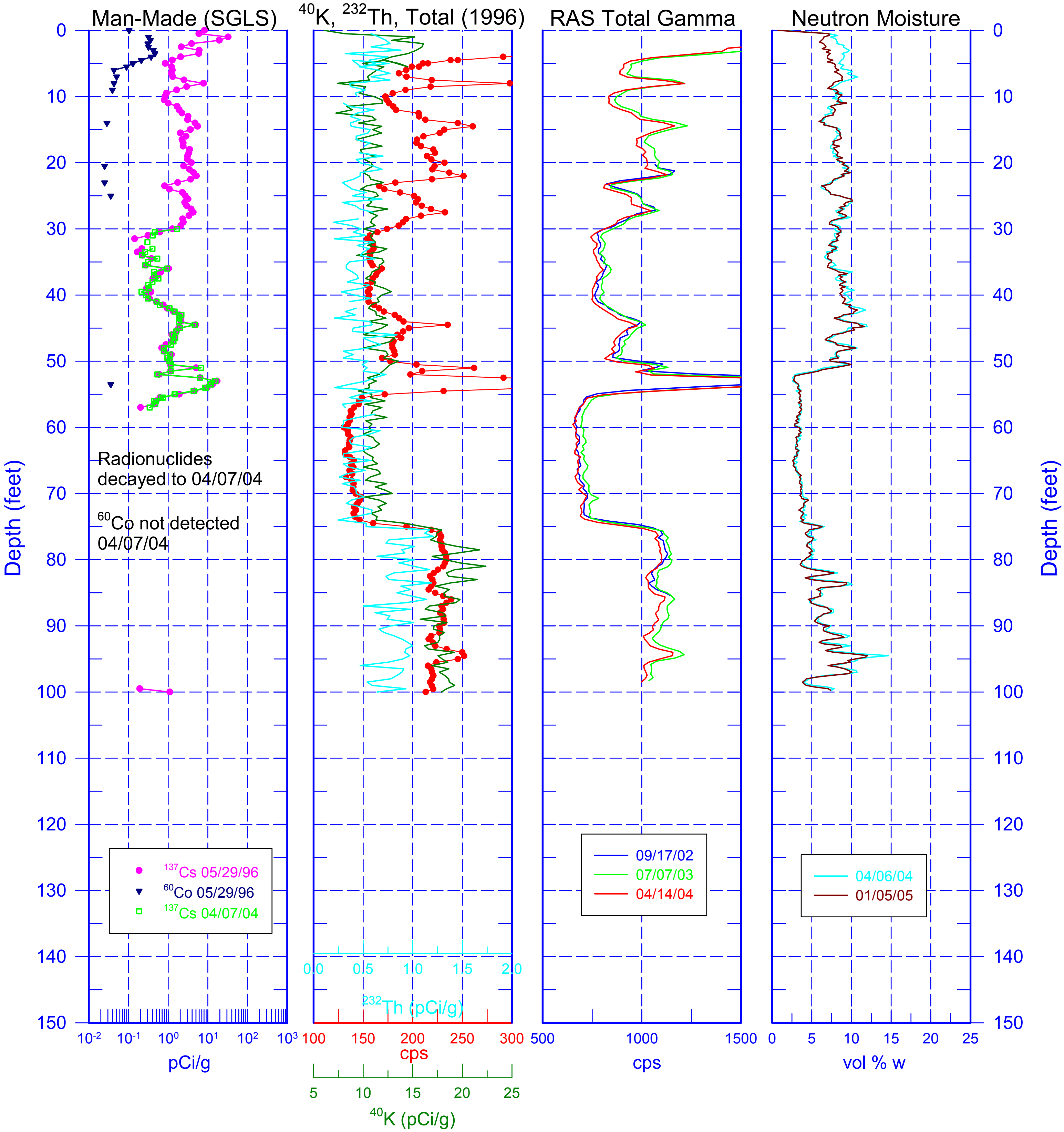
Tank S-102
40-02-07



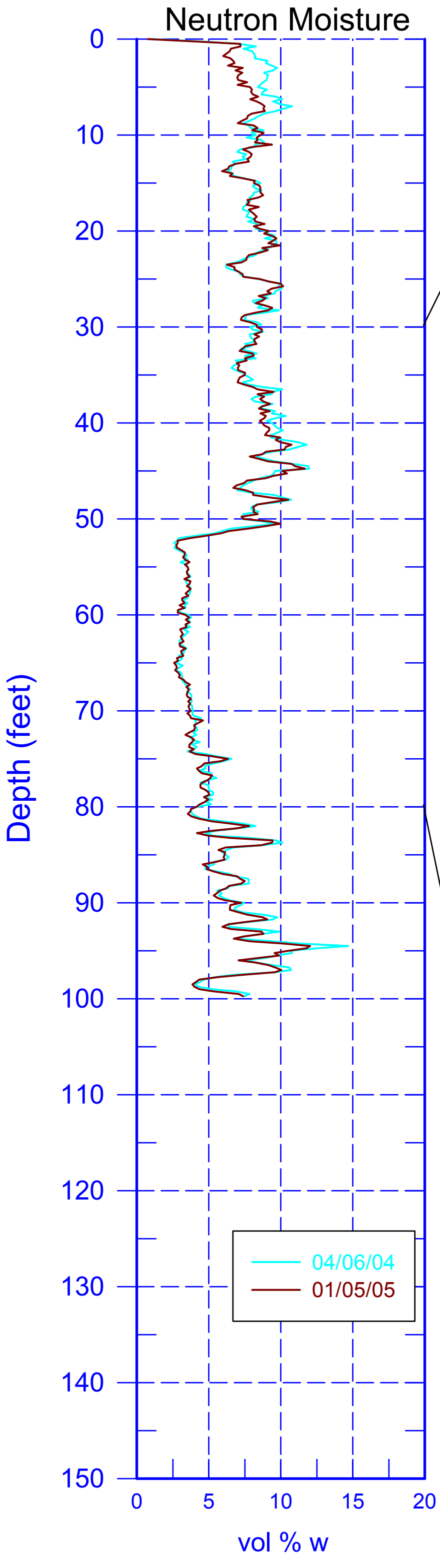
Tank S-102
40-07-02

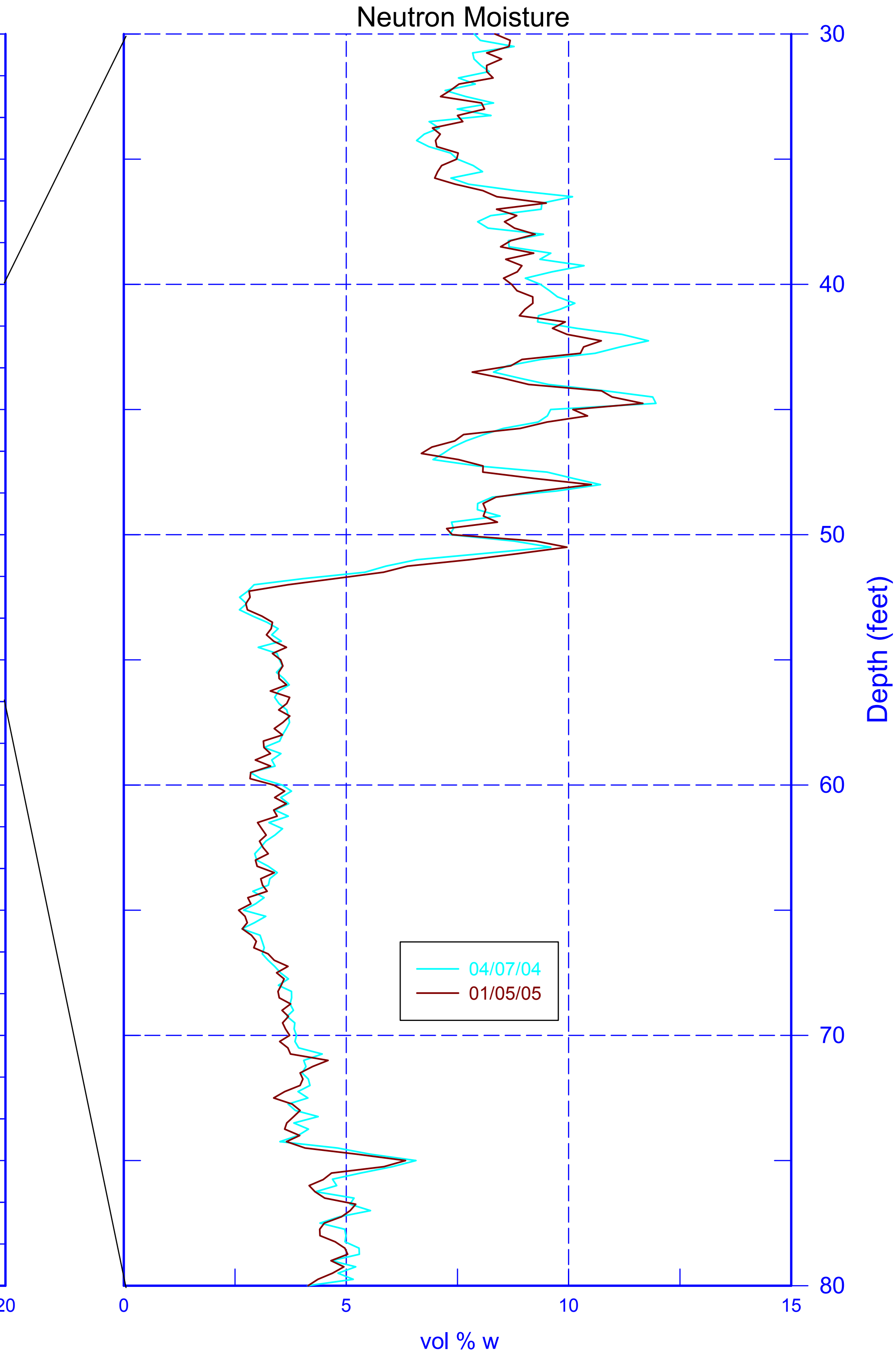


Tank S-102
40-02-08

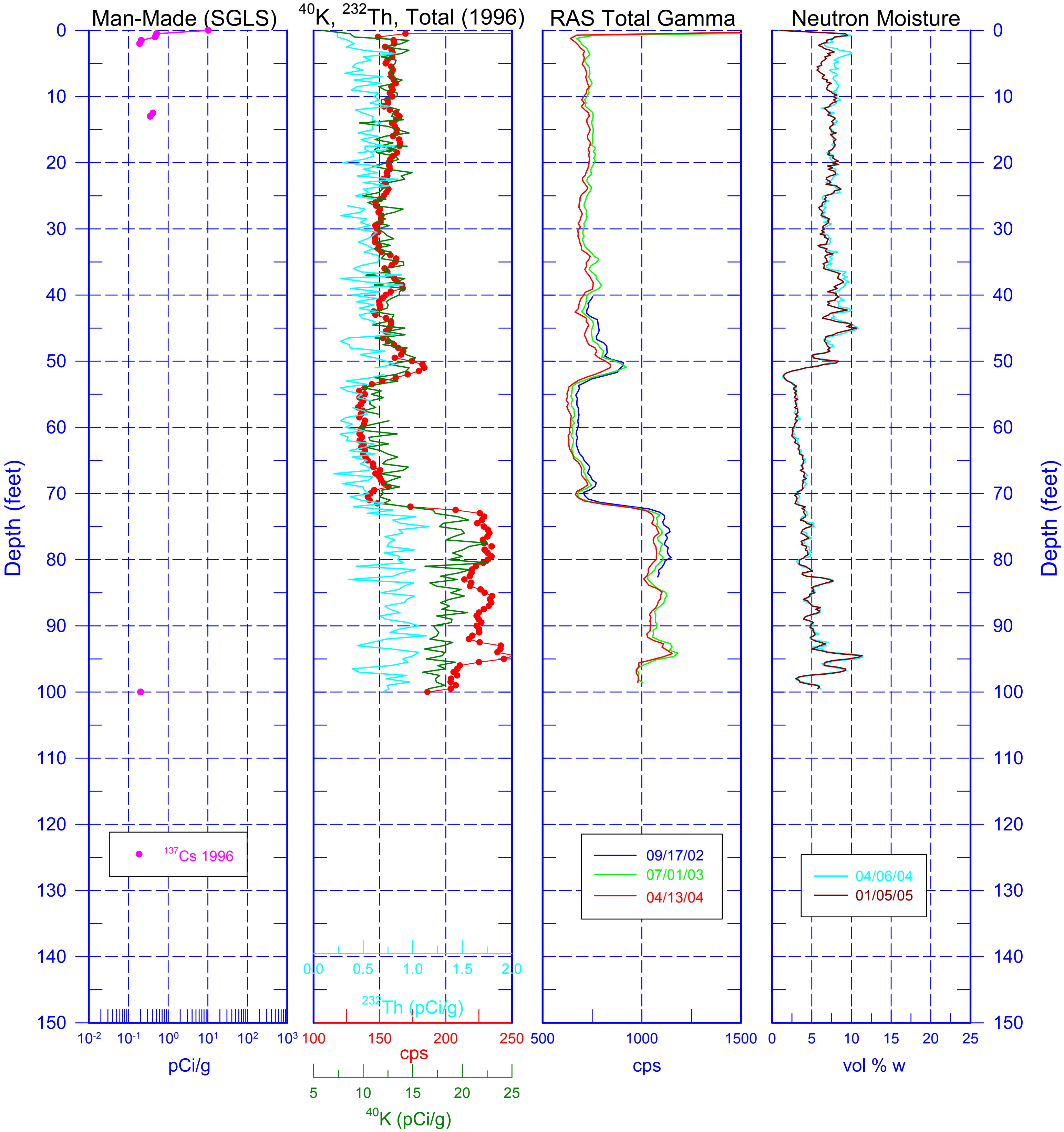


Tank S-102
40-02-08

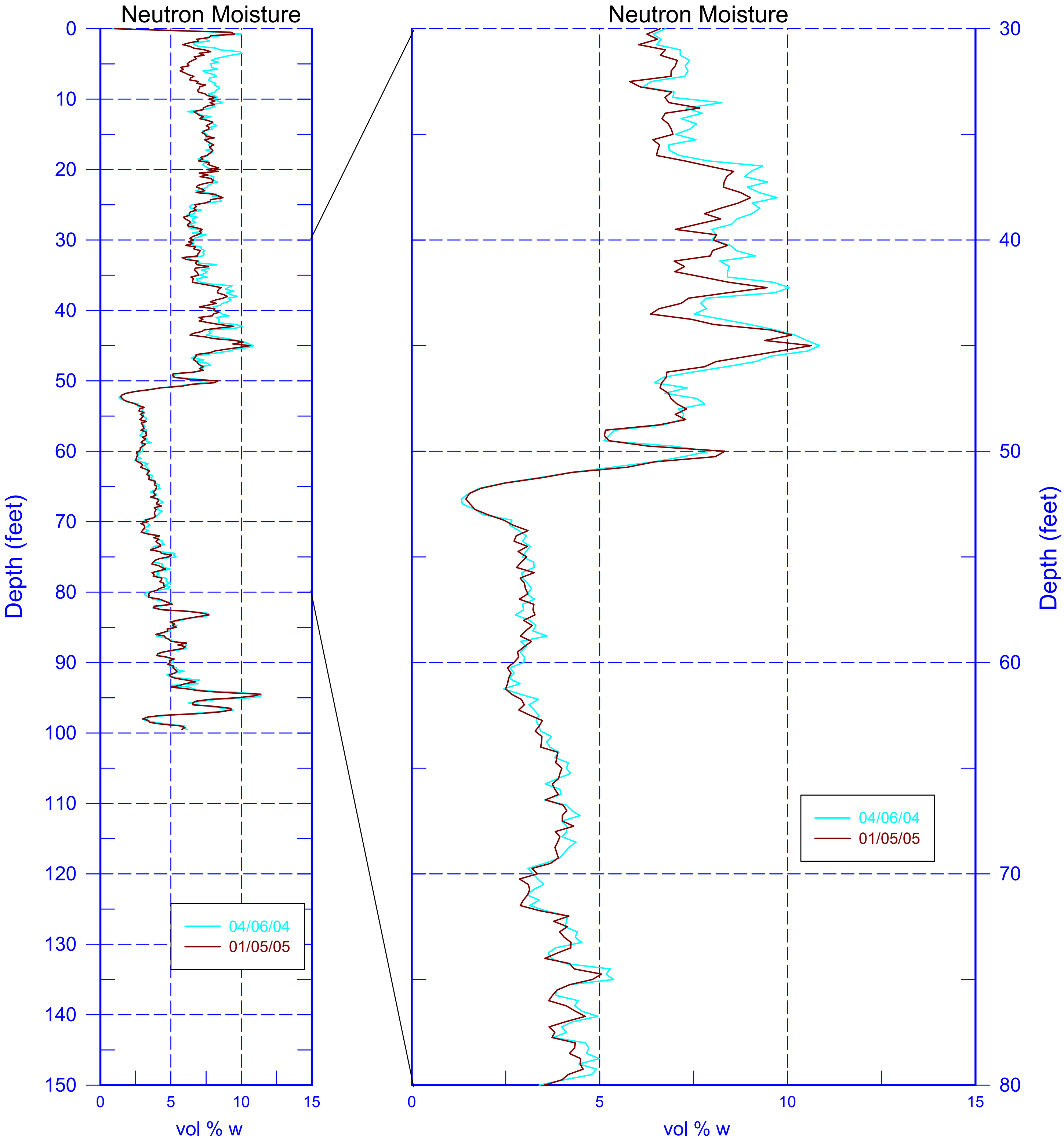




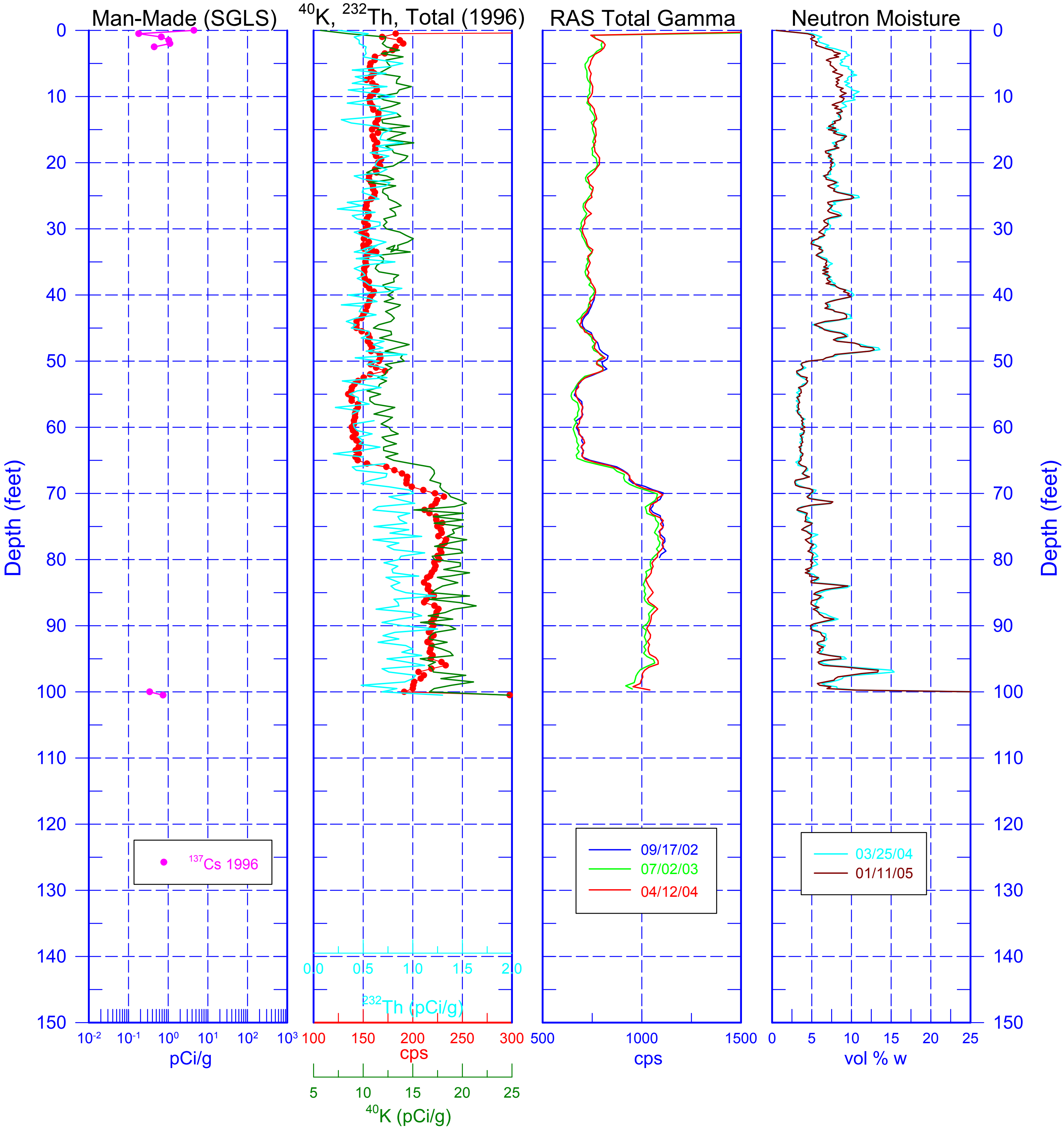
Tank S-102
40-02-10



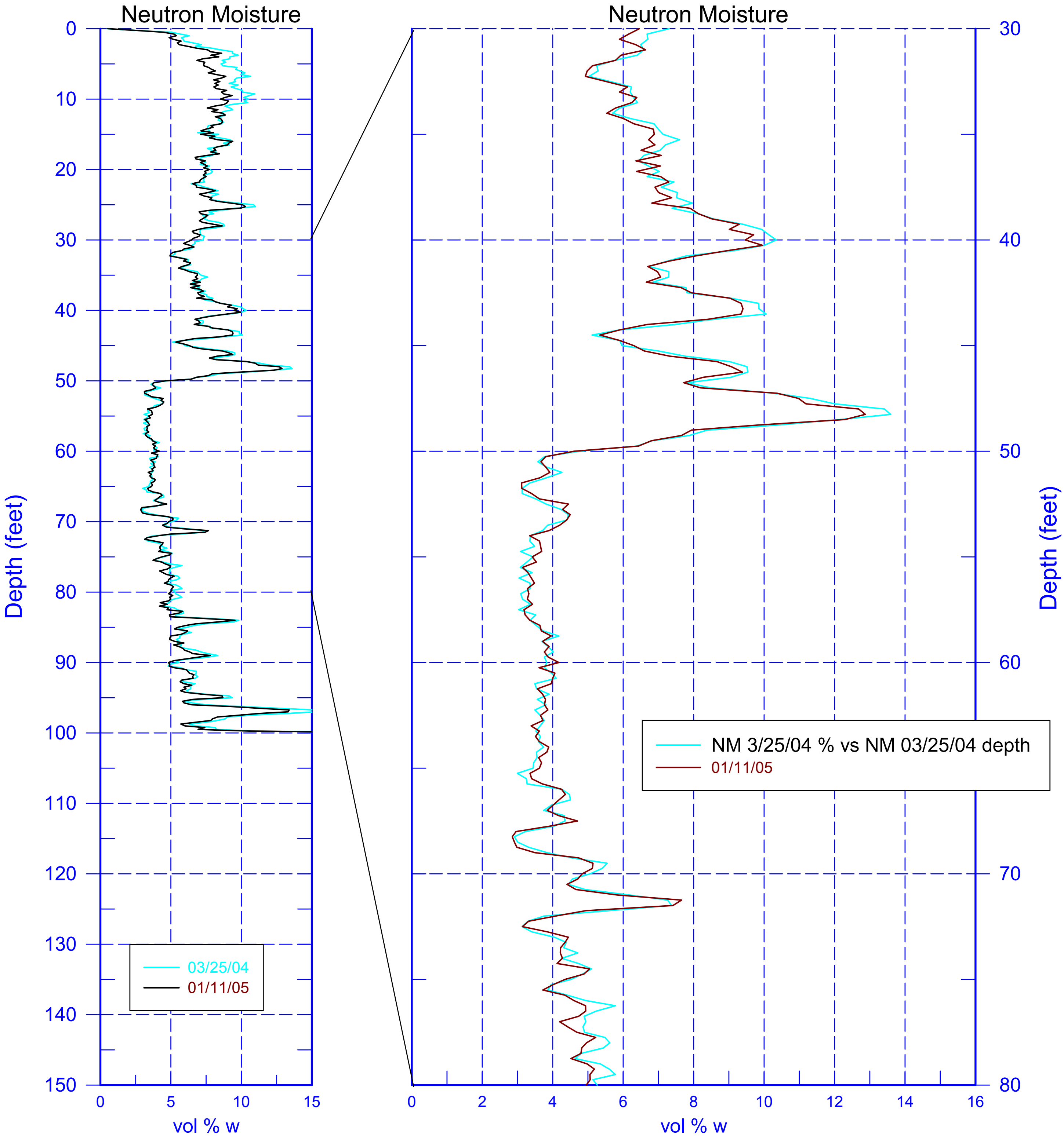
Tank S-102
40-02-10



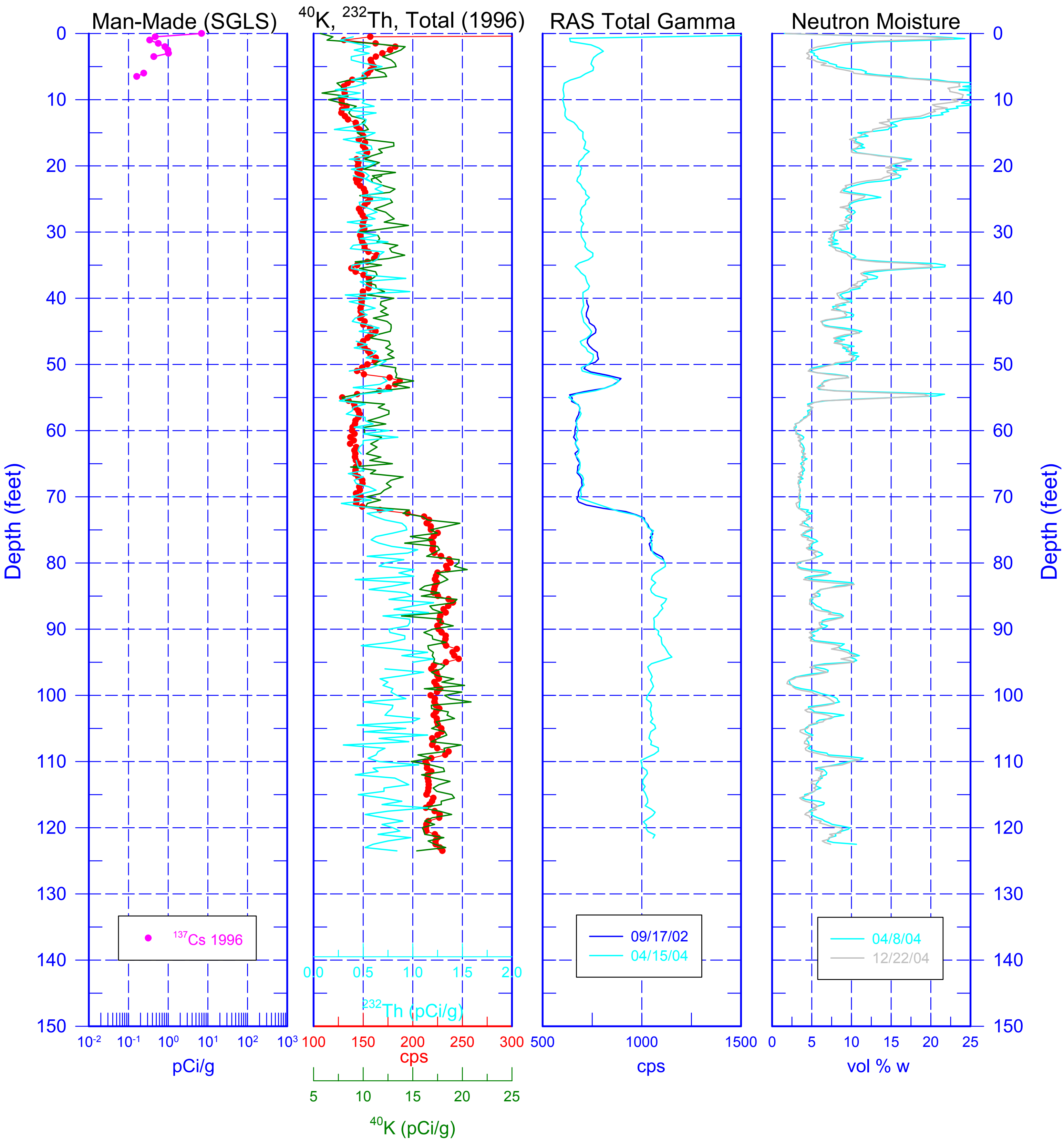
Tank S-102
40-02-11



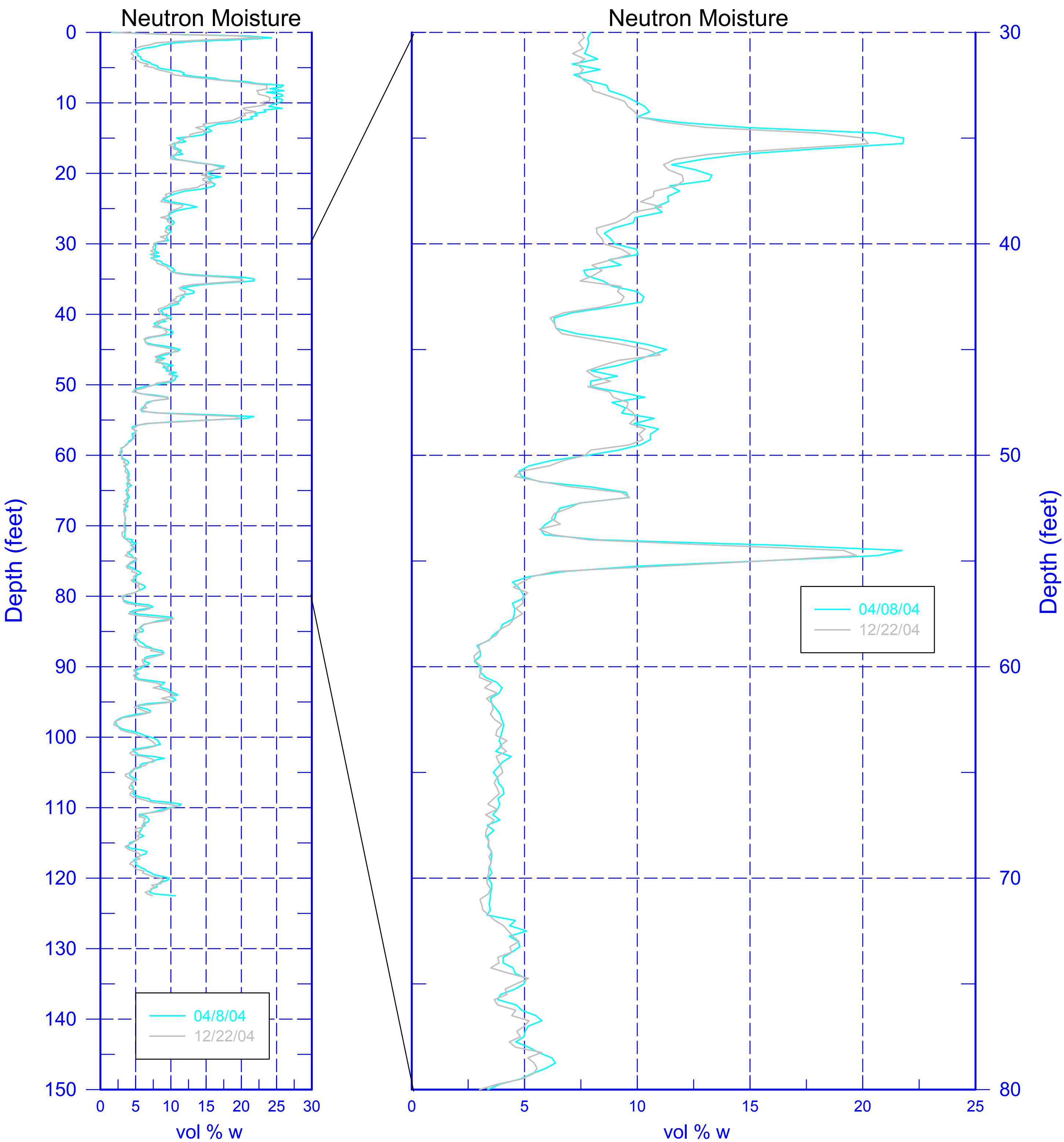
Tank S-102
40-02-11



Tank S-102
40-03-03



Tank S-102
40-03-03



Appendix D
Tank C-106 Retrieval Monitoring Summary Report

DOE-EM/GJ899-2005

Hanford Tank Farms Vadose Zone Monitoring Project

241-C-106 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data

June 2005

Prepared for
U.S. Department of Energy
Office of Environmental Management
Grand Junction, Colorado

Prepared by
S.M. Stoller Corp.
Grand Junction, Colorado

Approved for public release; distribution is unlimited.
Work performed under DOE Contract No. DE-AC01-02GJ79491.

1.0 Introduction

241-C-106 is an underground radioactive waste storage tank located in the 241-C Tank Farm in the 200 East Area of the Hanford Site. This tank is a 75-foot (ft)-diameter underground domed concrete structure, with a carbon steel liner on the sides and bottom. The base of the tank is approximately 38 ft below ground surface, and approximately 9 ft of backfill covers the dome. Nominal capacity of the tank is 533,000 gallons. Waste retrieval operations for this tank were successfully concluded in December 2003 with the removal of all but a nominal amount of tank waste. Before, during, and after retrieval operations, drywells in the vicinity of Tank C-106 were periodically logged for gamma activity and moisture content to identify any changes in the vadose zone near the tank that might be indicative of leaks associated with tank retrieval operations. Figure 1 shows the position of various drywells around Tank C-106, and Figure 2 shows when logging operations were conducted relative to retrieval operations. Log results are summarized in Figures 3 through 13. Gamma activity and neutron moisture data available approximately 12 to18 months after completion of retrieval operations show no evidence of leakage. However, geophysical logs only respond to conditions in the immediate vicinity of the drywell; there are relatively few drywells around the circumference of the tank, and operational constraints severely limited the scope of logging operations. These factors make it impossible to unequivocally state that no leak occurred during or after retrieval operations. The absence of evidence cannot be taken as evidence of absence.

Waste retrieval operations required limited additions of water and oxalic acid to mobilize the waste for removal. In the *Process Control Plan for Tank 241-C-106 Acid Dissolution* (May and Reynolds 2003), the baseline leak- detection method is gamma and neutron moisture logging in drywells surrounding C-106 on a 6-week schedule supplemented by moisture monitoring with hand-held instruments twice per week. Routine gamma monitoring in drywells with the radionuclide assessment system (RAS) is performed by CH2M HILL Group, Inc., (CH2M HILL) personnel with technical oversight by the S.M. Stoller Corporation (Stoller). Logging with the neutron moisture logging system (NMLS) and high-resolution spectral gamma logging system (SGLS) is performed by Stoller personnel. The hand-held moisture measurements are under the purview of CH2M HILL and will only be discussed here in the context of the log data.

Observations of increasing moisture content in the vicinity of C-106 resulted in the initiation of a "Problem Evaluation Request" (PER) on December 3, 2003 (Myers 2003). The PER specifically states *"Increased moisture content (~1%) in the vadose zone beneath Tank 241-C-106 may be indicative of a loss of tank integrity. Moisture monitoring is done because, few if any mobile gamma emitting radionuclides remain in the tank.*"

This report will summarize available drywell data collected to date and address the concerns raised in the PER.

2.0 Previous Geophysical Log Data

Gross gamma logs were routinely collected in C Tank Farm drywells until 1994. These data are available in electronic format from 1975 to 1994 and have been evaluated by Randall and Price (2001).

Other studies of Tank C-106 in the past include discussion of subsurface conditions and geophysical log data. These studies include Washington State Department of Ecology (1992), Brodeur (1993), and Barnes (2000). These reports predate the current retrieval effort and are not discussed further in this report because they provide no information regarding the impact of recent retrieval operations.

A baseline of subsurface contamination conditions in the vicinity of Tank C-106 was established in 1997 and reported in the *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank C-106* (DOE 1997). A discussion of subsurface contamination conditions and visualization of subsurface contaminant plumes was published in the *Hanford Tank Farms Vadose Zone, C Tank Farm Report* (DOE 1998) and updated in 2000 (DOE 2000).

3.0 Recent Geophysical Log Data

In response to the PER, moisture data were acquired in borehole 30-05-02 on December 8, 2003, five days after the PER was issued and six days after the previous moisture measurement. Additional boreholes (30-08-02, 30-09-07, and 30-09-06) were selected for moisture measurements to help assess changes in subsurface moisture away from the tank.

SGLS data were not acquired until February 2004 due to inclement weather and system availability. RAS measurements were acquired during December 2003. No apparent increases in gamma activity were observed. SGLS measurements were collected in late February and early March in boreholes 30-06-02, -04, -09, -10, 30-05-02, and 30-08-02.

Table 3.1 below summarizes the number of logging events with each logging system for each borehole (Figure 1) that can provide relevant information to the Tank C-106 retrieval operations. Logging depth intervals where apparent changes in gamma activity and/or moisture have been observed are indicated.

Table 3.1. Summary of Logging Measurements Acquired for Evaluation of the C-106 Retrieval Operations

Borehole	SGLS	RAS	NMLS	Gamma Change	Moisture Change
30-06-02	2	8	7	None	56-72 ft
30-06-03	1	8	7	None	55-67 ft
30-06-04	2	9	7	85-91 ft	46-55 ft
30-05-02	2	9	8	None	41-62 ft
30-06-09	2	9	7	None	50-72 ft
30-06-10	3	8	7	116-130 ft	42-54 ft
30-06-12	1	8	7	None	50-60 ft
30-08-02	2	7	2	47-80 ft	None
30-09-07	1	7	2	None	None
30-09-06	1	7	2	78-87 ft	None

Figures 3a through 12a present a graphical summary of these data. These data include man-made radionuclide (^{137}Cs and ^{60}Co) concentrations, ^{40}K, ^{232}Th concentrations, and total gamma collected with the SGLS and RAS, as well as NMLS measurements.

Figures 3b through 12b show the NMLS data with depth intervals expanded so that subtle changes in moisture can be viewed. A limited number of handheld moisture measurements are also included that span the time period from July to October 2003.

Figure 13 shows a cross section (A-A') from borehole 30-08-02 west of Tank C-106 to borehole 30-00-01 east of the tank. The cross section indicates a slight east-northeast stratigraphic dip in the vicinity of Tank C-106.

4.0 Observations and Findings

Available log data for boreholes associated with C-106 do not exhibit significant changes in either moisture or gamma activity up to May 2005, except for borehole 30-06-10, where gamma activity shows evidence of downward and lateral contaminant movement below the 86-ft depth. This contaminant plume was recognized in the tank summary data report (DOE 1997). It was subsequently confirmed by SGLS logging and reported to DOE in March 1999 (Bertsch 1999). The dominant gamma-emitting radionuclide is ^{60}Co. Available data suggest the contaminant plume originates from the vicinity of Tank C-108, with movement downward and to the east.

Slight moisture increases are shown in all boreholes, with the largest increases (approximately 1 percent) indicated in boreholes 30-05-02 and 30-06-09, located southwest of Tank C-106. These moisture increases appear to have occurred between July and September 2003, although this is not conclusive.

Generally, the top 10 to 15 ft of the boreholes show decreasing moisture content in the sediments between April and December 2003 with increases between December 2003 and March 2004.

The decrease is likely due to evapotranspiration during the warmer months, and the increase is likely the result of infiltration from rain and snowmelt. No changes are apparent between this upper zone and the depths below the tanks where moisture changes have been observed.

The RAS measurements collected in boreholes around Tank C-106 do not indicate any increase in gamma activity within the intervals of moisture increases or high moisture zones in the vicinity of Tank C-106. The numerous thin zones of relatively high moisture appear to be "perched" above fine-grained sediment layers, some of which can be correlated across the area of the cross section. For example, the excavation surface at an elevation of approximately 612 ft (log depth 38 ft) appears to be associated with relatively thin intervals of higher moisture content (Figure 12). Another significant layer is observed at an elevation of 570 ft (log depth 80 ft). This layer appears to influence lateral movement of contamination, but it may not be continuous across the tank farm.

SGLS measurements were collected in boreholes 30-06-02, -04, -09, -10, 30-05-02, and 30-08-02. These data were compared to SGLS data collected in 1997. As with the RAS measurements, no significant changes are observed in depth intervals where slightly elevated moisture was detected. Changes were observed in boreholes 30-08-02 and 30-06-10. In borehole 30-08-02 (Figures 10 and 13), ^{60}Co contamination continued to increase between elevations of 602 and 576 ft (log depths 47 to 73 ft). In borehole 30-06-10, ^{60}Co contamination is encountered at an elevation of 564 ft (86-ft log depth). After accounting for decay, ^{60}Co concentrations appear to be relatively stable between 86 ft and 112 ft, but the lower extent of the ^{60}Co plume has moved downward from 116 ft in 1997 to at least the bottom of the borehole at 129 ft by 2004. Figure 13 shows the relationships between the boreholes. The ^{60}Co contamination appears to originate from the vicinity of Tank C-108 and follows a stratigraphic dip to the east-northeast, and probably extends past borehole 30-06-12 at depths greater than 130 ft. This contamination was recognized well before retrieval operations began, and does not appear to have been impacted by retrieval activities in Tank C-106. However, the existence of this plume and its continued movement downward and to the east call into question the integrity of Tank C-108.

5.0 Conclusions

The premise stated in the PER for moisture logging in support of the Tank C-106 retrieval is that *"few if any mobile gamma emitting radionuclides remain in the tank."* However, when moisture increases were observed, requests for gamma logging were made to confirm or deny the existence of a tank leak. If the assumption is made that there are in fact no mobile gamma-emitting radionuclides present in the waste material, then the observed zones of moisture increase could be an indication of a tank leak associated with retrieval operations. However, Stoller's experience with tank farm logging suggests that even though radionuclides such as ^{137}Cs and ^{60}Co are not considered highly mobile, detectable gamma activity would be associated with any tank waste in the vadose zone. No long-term baseline has been established for neutron moisture data, and the observed increases in moisture content may simply be related to seasonal fluctuations. In Stoller's opinion, the lack of observable increases in gamma activity associated with the moisture increases strongly suggests that the moisture increases are related to seasonal fluctuations, but available data are not sufficient to conclusively prove that no tank leak occurred.

Subsurface contamination may not necessarily be associated with high moisture content. For example, the ^{60}Co contamination movement in boreholes 30-08-02 and 30-06-10 (Figure 12) does not appear to be associated with moisture anomalies. It appears that if moisture is driving contaminant movement, the magnitude of the changes may be very small (e.g., approximately 1% volumetric fraction) such as observed around Tank C-106.

Experience with leak-detection monitoring around Tank C-106 strongly suggests that moisture measurements alone are not sufficient. Gamma activity measurements in the existing boreholes remain an important component of leak-detection monitoring because a significant increase in gamma activity provides unequivocal evidence of a leak.

Currently, gamma measurements with the RAS that can be compared with the SGLS baseline have been acquired in all but a few boreholes in C Tank Farm. Results of these measurements indicate that only three boreholes (30-08-02, -03, and 30-06-10) have shown evidence of contaminant movement since 1997. These boreholes are all in the same general vicinity, and appear to intersect a contaminant plume that is unrelated to retrieval operations in Tank C-106.

6.0 Recommendations

Continued reliance solely on neutron moisture measurements as the primary means of leak detection is not recommended because no long-term baseline of neutron moisture measurements has been established, and it is impossible to determine if small increases are related to waste retrieval operations or simply to normal seasonal fluctuations. Logging systems capable of concurrent measurement of both gamma activity and moisture content are available and should be incorporated into leak detection, monitoring, and mitigation (LDMM) requirements for tank retrieval operations as soon as possible. Other geophysical methods, such as high-resolution resistivity (HRR), also may play an important role in leak detection. However, methods such as HRR also respond primarily to changes in moisture content, which are not necessarily related to tank leaks. Therefore, it is likely that any anomalies detected by HRR will require investigation by gamma logging.

It is important to note that the on-going contaminant migration in borehole 30-06-10 was detected by the baseline characterization project and subsequent monitoring measurements well in advance of retrieval operations. This makes it possible to show that the observed contaminant movement is not a result of current retrieval operations and highlights the importance of a routine monitoring program to identify and track anomalies in the vadose zone over extended periods. If only limited measurements associated with the retrieval program were available, it is entirely likely that observable movement in 30-06-10 would have been attributed to the effects of the retrieval activity. Therefore it is critical that the routine monitoring program be carried out in all single shell tank farms independent of the retrieval program.

References

Barnes, D.A., 2000. *Spectral Drywell Scans Around C-106 During Retrieval Operations*, RPP-7305, CH2M HILL Hanford Group, Inc., Richland, Washington.

Berstch, J.F, 1999. Letter to DOE-RL Project Manager John Silko, Subject: "Contaminant Movement in C Tank Farm," MACTEC-ERS, Richland, Washington, March 10, 1999.

Brodeur, J.R., 1993. *Assessment of Unsaturated Zone Radionuclide Contamination Around Single-Shell Tanks 241-C-105 and 241-C-106*, WHC-SD-EN-TI-185, Westinghouse Hanford Company, Richland, Washington.

Hanlon, B.M, 2003. *Waste Tank Summary Report for Month Ending December 31, 2003*, HNF-EP-0182, Rev. 189, CH2M HILL Hanford Group, Inc., Richland, Washington.

Hertzel, J.S. 1996. *Operational Tank Leak Detection and Minimization During Retrieval*, WHC-SD-WM-ES-377, Rev 0, Westinghouse Hanford Company, Richland, Washington.

May, T.H., and D.A. Reynolds, 2003. *Process Control Plan for Tank 241-C-106 Acid Dissolution,* RPP-16462, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

May, T.H , 2003. *Process Control Plan for Tank 241-C-106 Closure*, RPP-13707, Rev 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Myers, D.A., 2003. Problem Evaluation Request, PER-2003-4818, CH2M HILL Hanford Group, Inc., Richland, Washington, December 3, 2003.

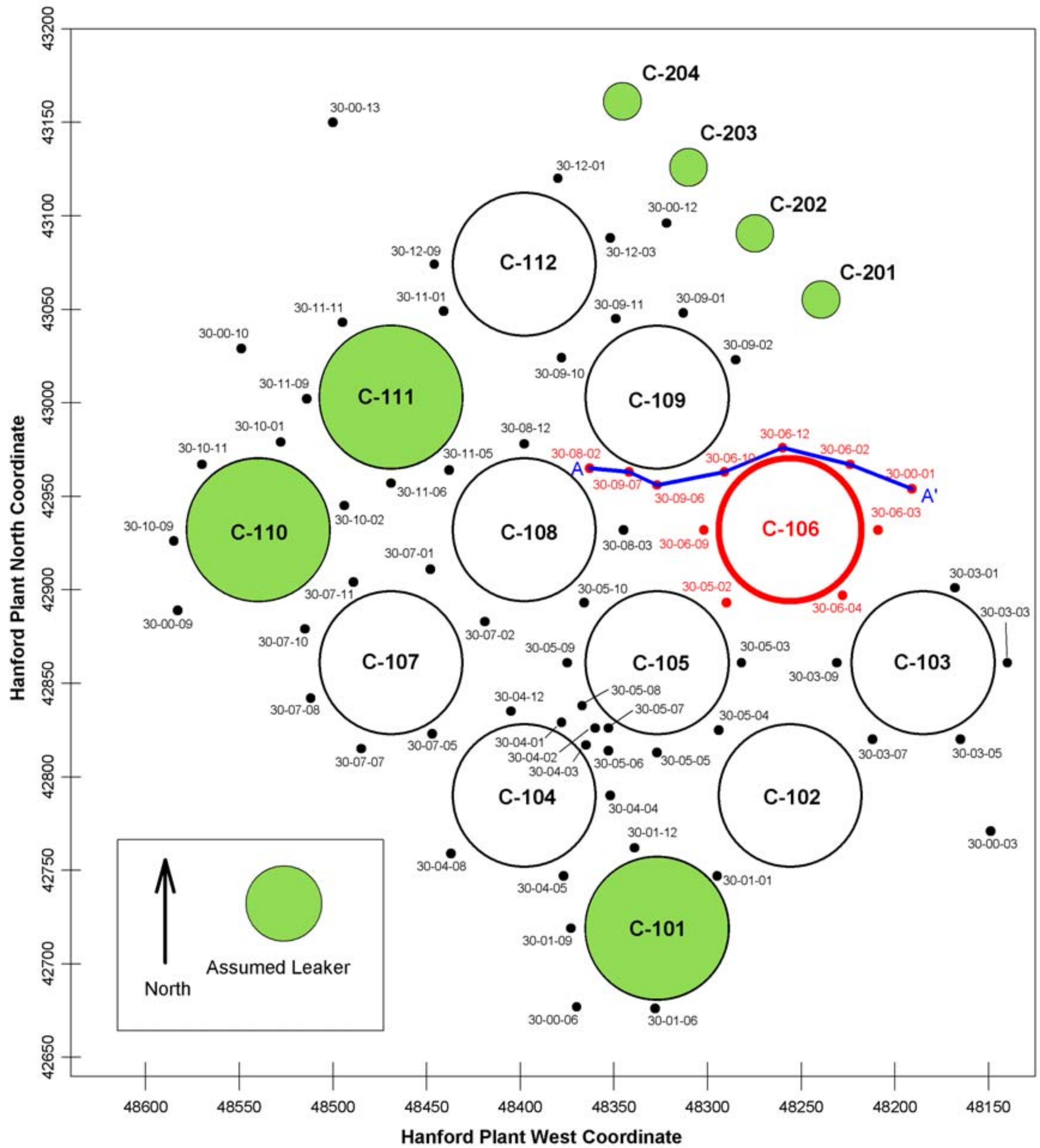
Randall, R., and R. Price, 2001. *Analysis and Summary Report of Historical Dry Well Gamma Logs for 241-C Tank Farm – 200 East*, RPP-8321, Three Rivers Scientific, West Richland, Washington.

U.S. Department of Energy (DOE), 1997. *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank C-106*, GJ-HAN-84, prepared by MACTEC-ERS for the Grand Junction Office, Grand Junction, Colorado.

U.S. Department of Energy (DOE), 1998. *Hanford Tank Farms Vadose Zone, C Tank Farm Report*, GJO-98-39-TAR, GJO-HAN-18, prepared by MACTEC-ERS for the Grand Junction Office, Grand Junction, Colorado.

U.S. Department of Energy (DOE), 2000. *Hanford Tank Farms Vadose Zone, Addendum to the C Tank Farm Report*, GJO-98-39-TARA, GJO-HAN-18, prepared by MACTEC-ERS for the Grand Junction Office, Grand Junction, Colorado.

Washington State Department of Ecology, 1992. *241-C-106 Waste Tank Investigation*, prepared by Department of Ecology Nuclear and Mixed Waste Management RCRA Unit, Kennewick, Washington.



C-204
C-203
C-202
C-201
C-112
C-111
C-109
C-110
C-108
C-106
C-107
C-105
C-103
C-104
C-102
C-101
A
A'
Assumed Leaker
North
Hanford Plant North Coordinate
Hanford Plant West Coordinate

Figure 1

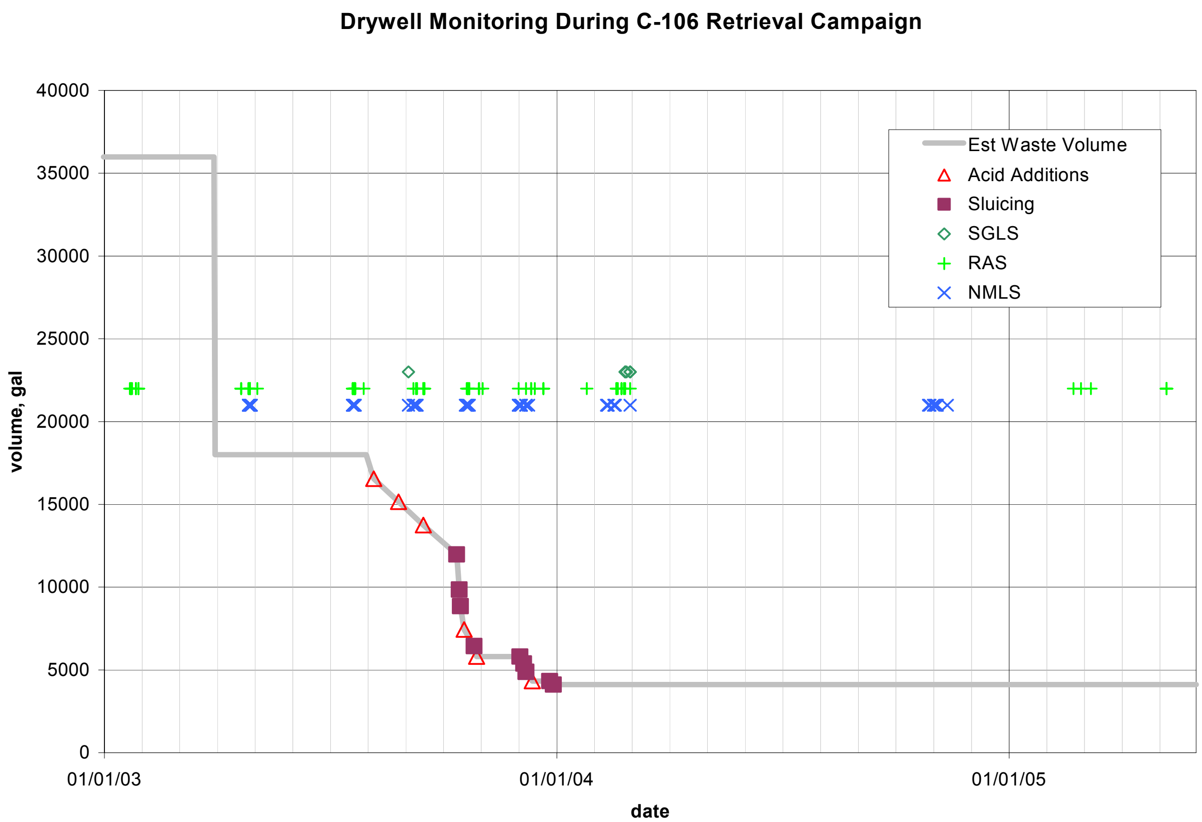

Drywell Monitoring During C-106 Retrieval Campaign
40000
35000
30000
25000
20000
15000
10000
5000
0
volume, gal
01/01/03
01/01/04
01/01/05
date
Est Waste Volume
Acid Additions
Sluicing
SGLS
RAS
NMLS

Figure 2

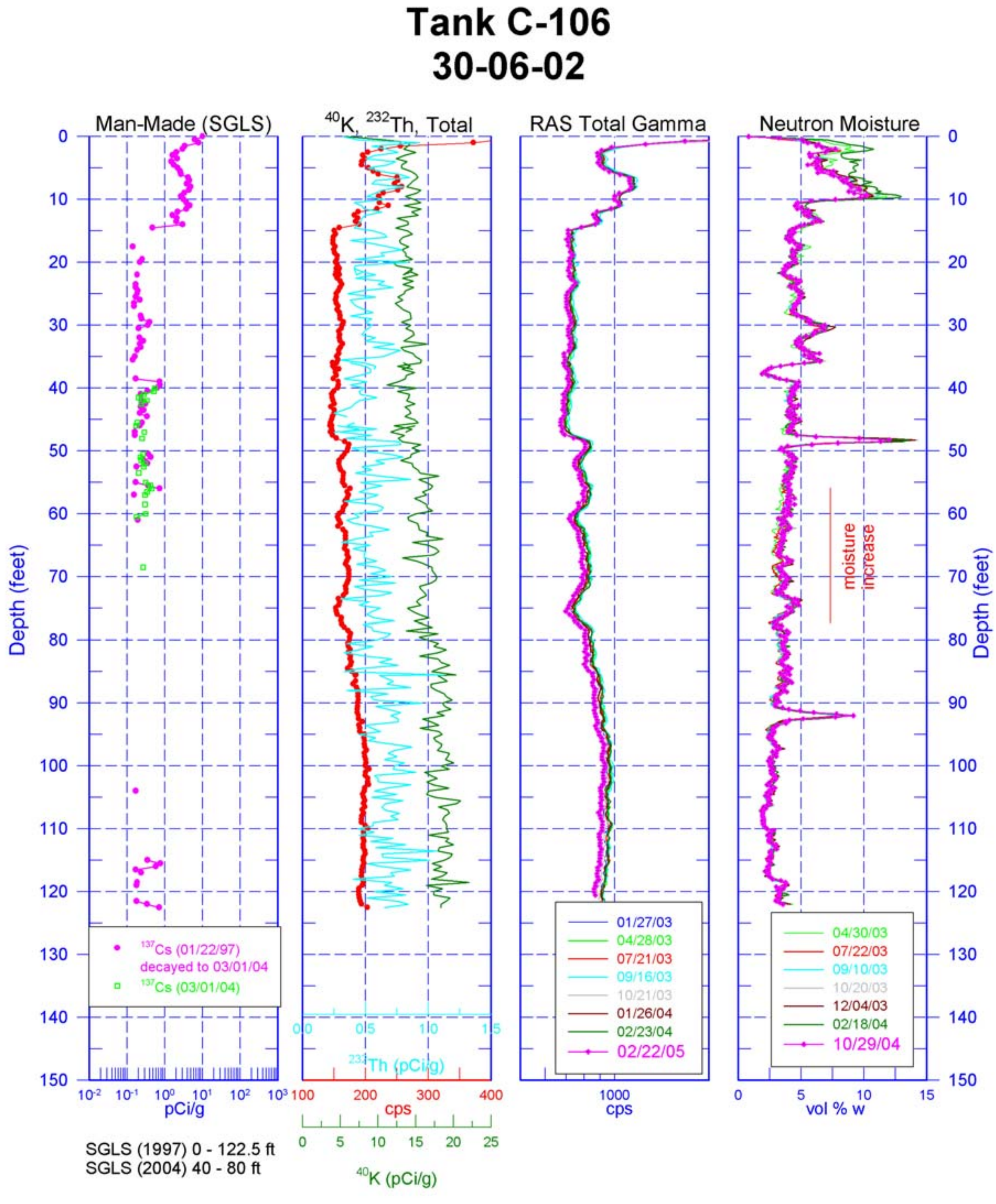
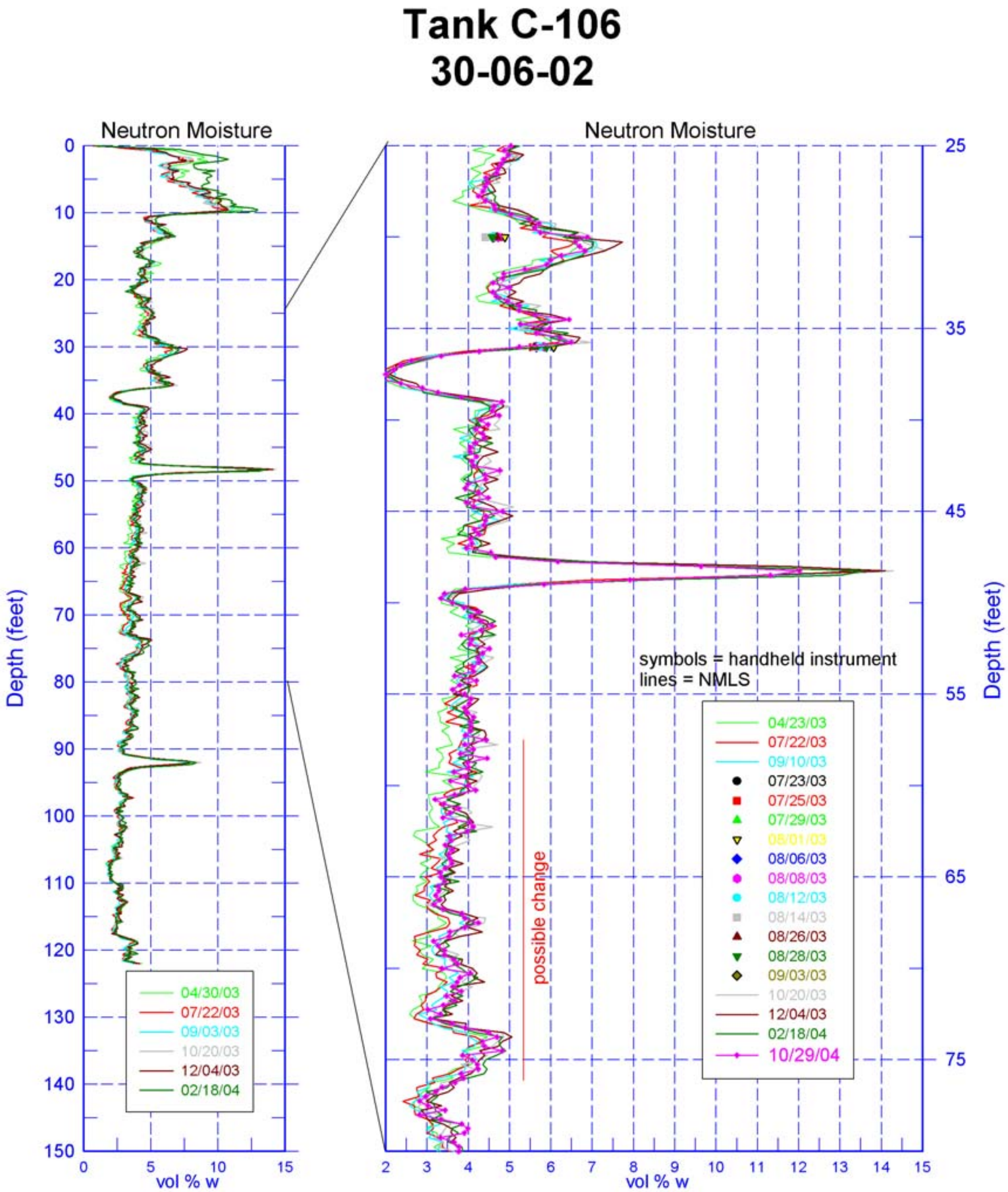
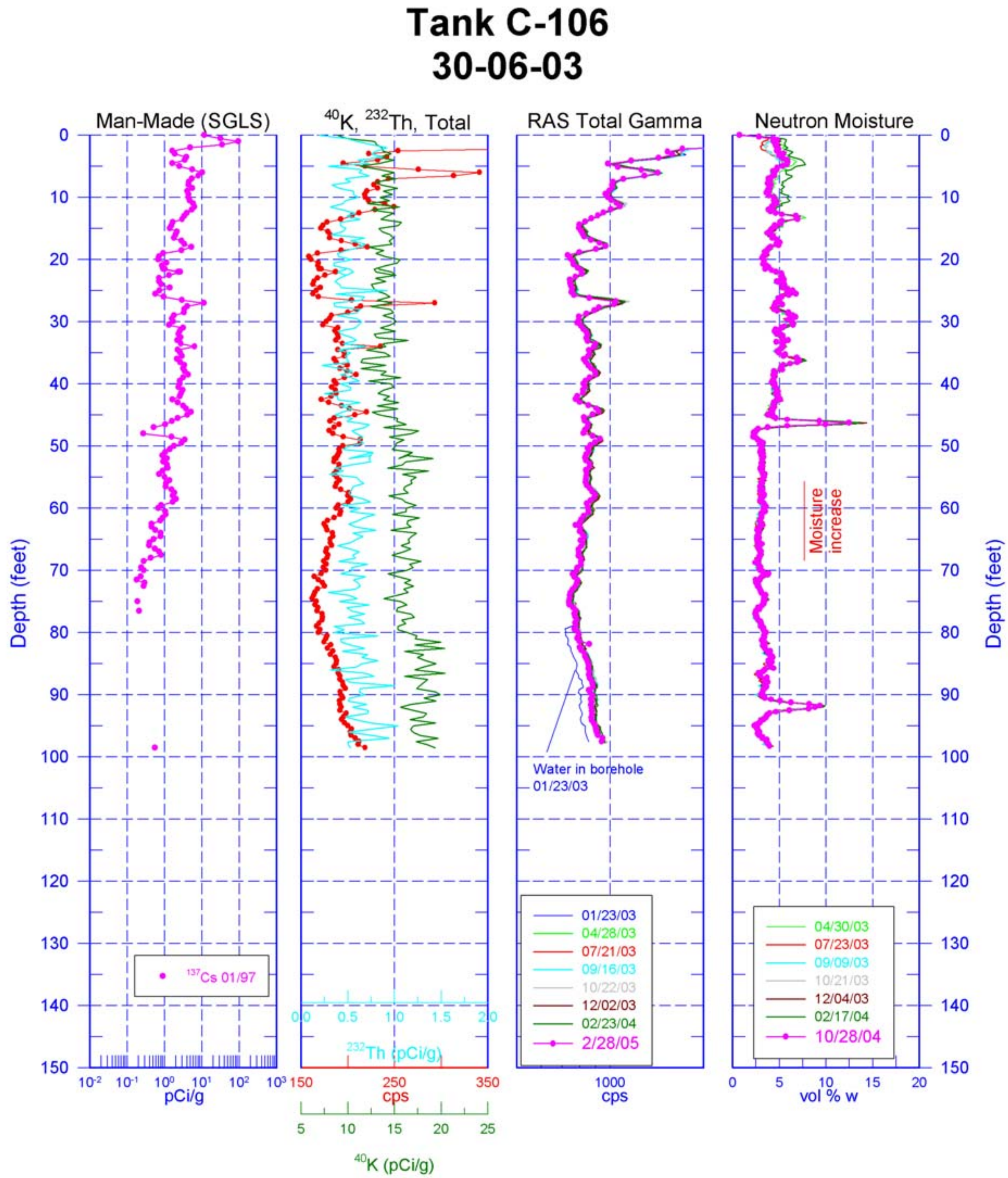

Tank C-106
30-06-02
Man-Made (SGLS)
^{40}K, ^{232}Th, Total
RAS Total Gamma
Neutron Moisture
Depth (feet)
^{137}Cs (01/22/97) decayed to 03/01/04
^{137}Cs (03/01/04)
pCi/g
SGLS (1997) 0 - 122.5 ft
SGLS (2004) 40 - 80 ft
^{232}Th (pCi/g)
cps
^{40}K (pCi/g)
01/27/03
04/28/03
07/21/03
09/16/03
10/21/03
01/26/04
02/23/04
02/22/05
moisture increase
04/30/03
07/22/03
09/10/03
10/20/03
12/04/03
02/18/04
10/29/04
vol % w

Figure 3a



Tank C-106
30-06-02
Neutron Moisture
Neutron Moisture
Depth (feet)
vol % w
04/30/03
07/22/03
09/03/03
10/20/03
12/04/03
02/18/04
symbols = handheld instrument
lines = NMLS
04/23/03
07/22/03
09/10/03
07/23/03
07/25/03
07/29/03
08/01/03
08/06/03
08/08/03
08/12/03
08/14/03
08/26/03
08/28/03
09/03/03
10/20/03
12/04/03
02/18/04
10/29/04
possible change

Figure 3b



Tank C-106
30-06-03
Man-Made (SGLS)
40K, 232Th, Total
RAS Total Gamma
Neutron Moisture
Depth (feet)
137Cs 01/97
pCi/g
232Th (pCi/g)
cps
40K (pCi/g)
Water in borehole 01/23/03
01/23/03
04/28/03
07/21/03
09/16/03
10/22/03
12/02/03
02/23/04
2/28/05
Moisture increase
04/30/03
07/23/03
09/09/03
10/21/03
12/04/03
02/17/04
10/28/04
vol % w

Figure 4a

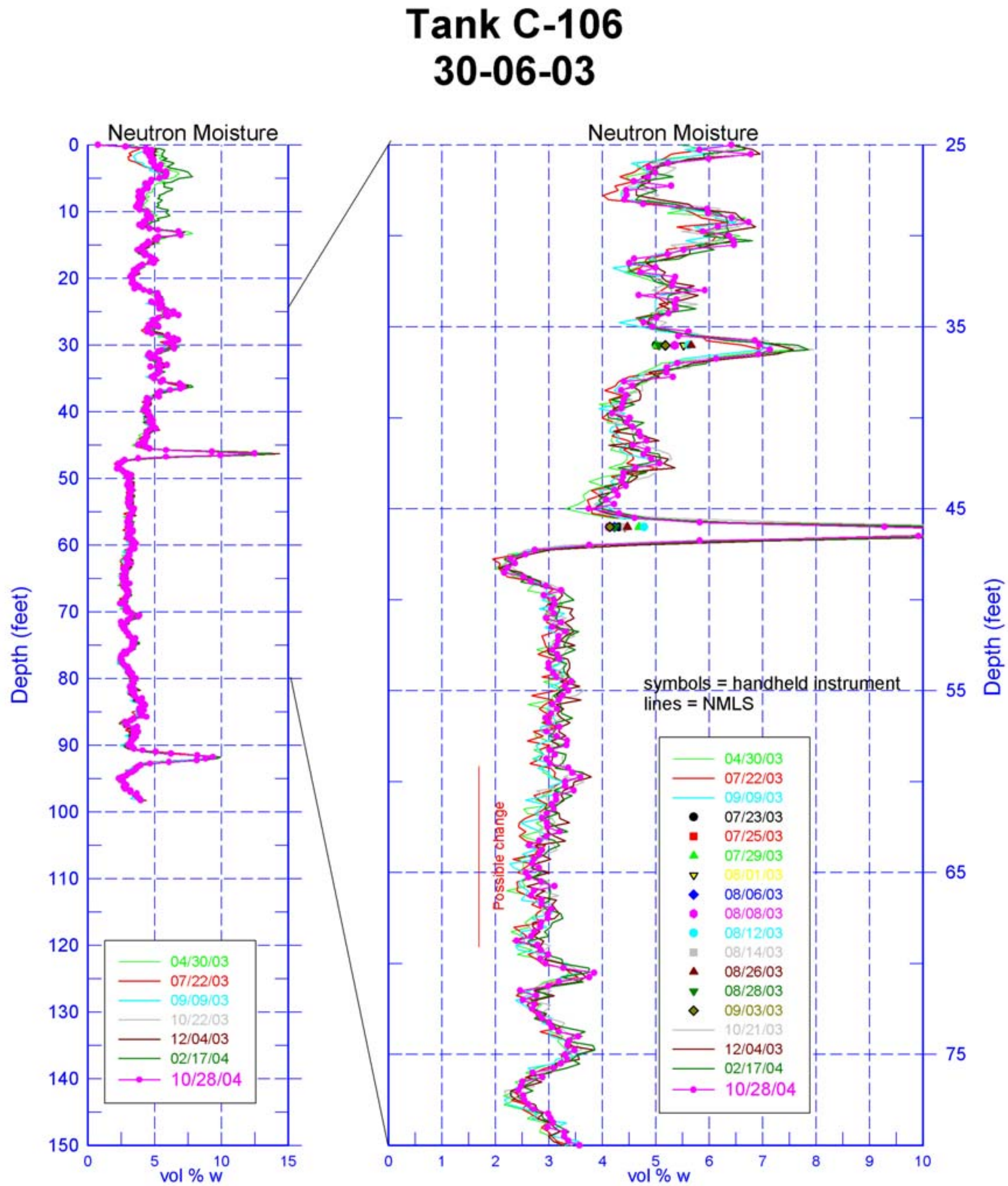

Tank C-106
30-06-03
Neutron Moisture
Depth (feet)
vol % w
04/30/03
07/22/03
09/09/03
10/22/03
12/04/03
02/17/04
10/28/04
Neutron Moisture
symbols = handheld instrument
lines = NMLS
Possible change
04/30/03
07/22/03
09/09/03
07/23/03
07/25/03
07/29/03
08/01/03
08/06/03
08/08/03
08/12/03
08/14/03
08/26/03
08/28/03
09/03/03
10/21/03
12/04/03
02/17/04
10/28/04
Depth (feet)
vol % w

Figure 4b

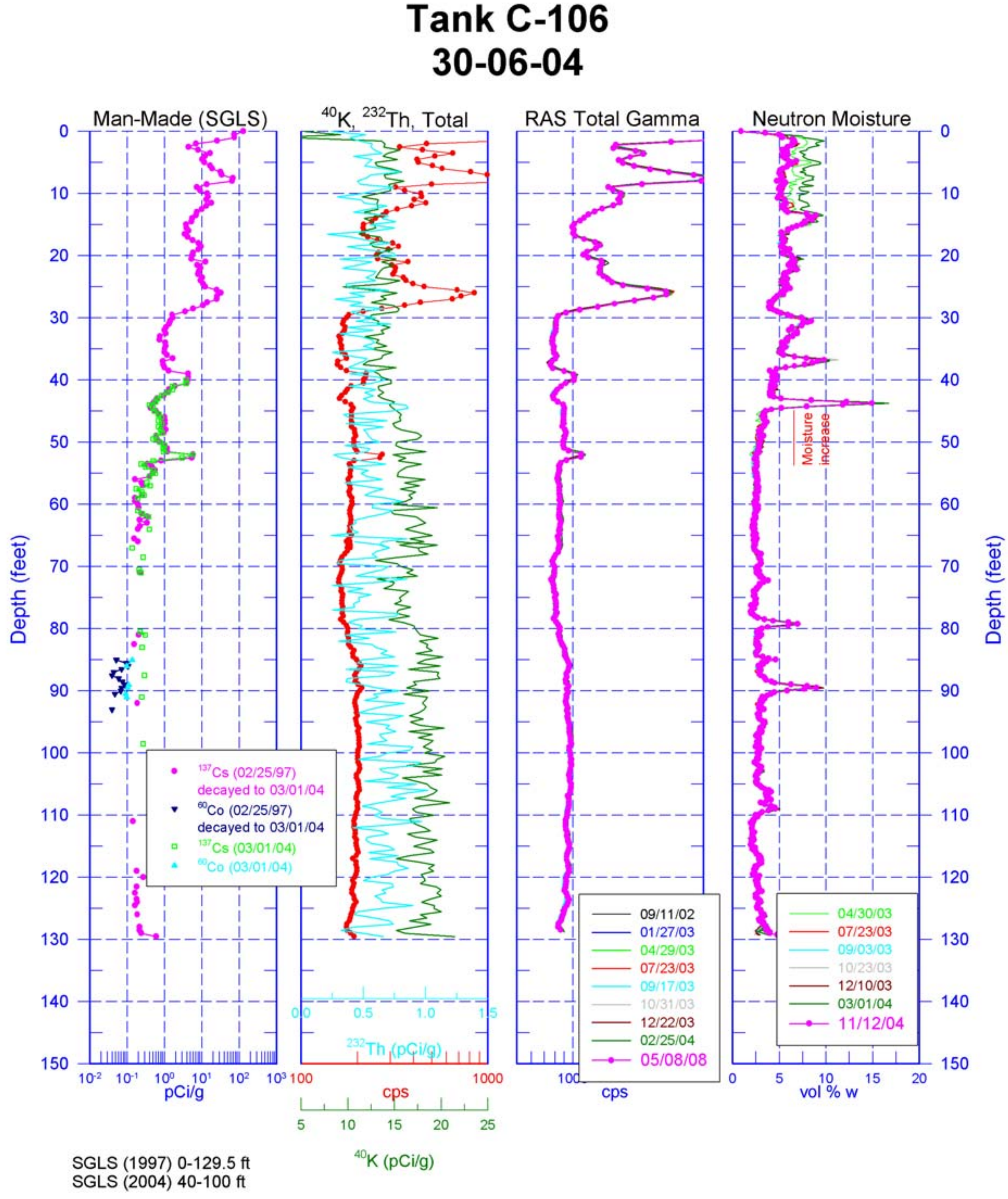

Tank C-106
30-06-04
Man-Made (SGLS)
40K, 232Th, Total
RAS Total Gamma
Neutron Moisture
Depth (feet)
pCi/g
cps
vol % w
232Th (pCi/g)
40K (pCi/g)
137Cs (02/25/97) decayed to 03/01/04
60Co (02/25/97) decayed to 03/01/04
137Cs (03/01/04)
60Co (03/01/04)
09/11/02
01/27/03
04/29/03
07/23/03
09/17/03
10/31/03
12/22/03
02/25/04
05/08/08
04/30/03
07/23/03
09/03/03
10/23/03
12/10/03
03/01/04
11/12/04
Moisture increase
SGLS (1997) 0-129.5 ft
SGLS (2004) 40-100 ft

Figure 5a

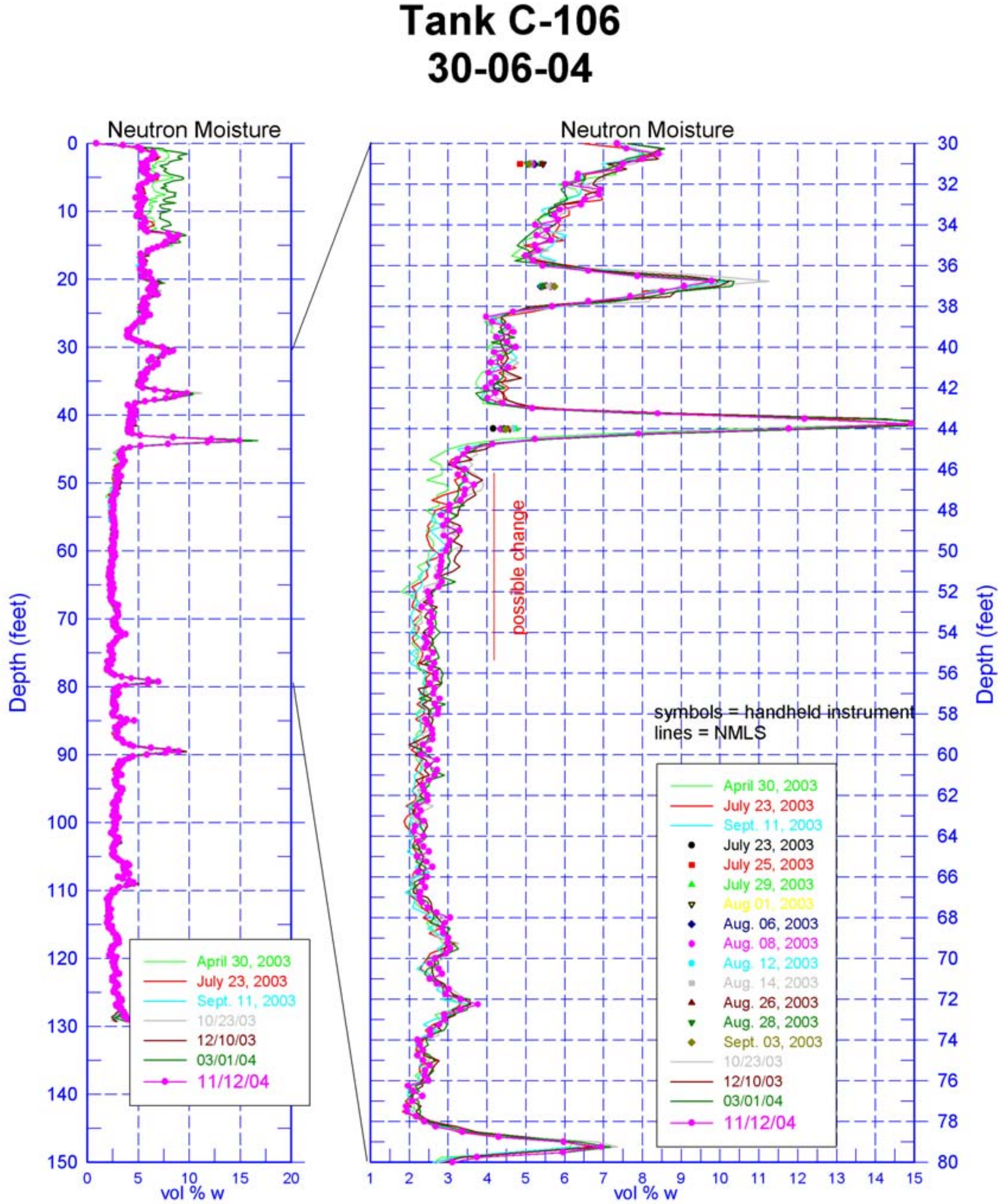

Tank C-106
30-06-04
Neutron Moisture
Depth (feet)
vol % w
April 30, 2003
July 23, 2003
Sept. 11, 2003
10/23/03
12/10/03
03/01/04
11/12/04
Neutron Moisture
possible change
symbols = handheld instrument
lines = NMLS
July 23, 2003
July 25, 2003
July 29, 2003
Aug. 01, 2003
Aug. 06, 2003
Aug. 08, 2003
Aug. 12, 2003
Aug. 14, 2003
Aug. 26, 2003
Aug. 28, 2003
Sept. 03, 2003

Figure 5b

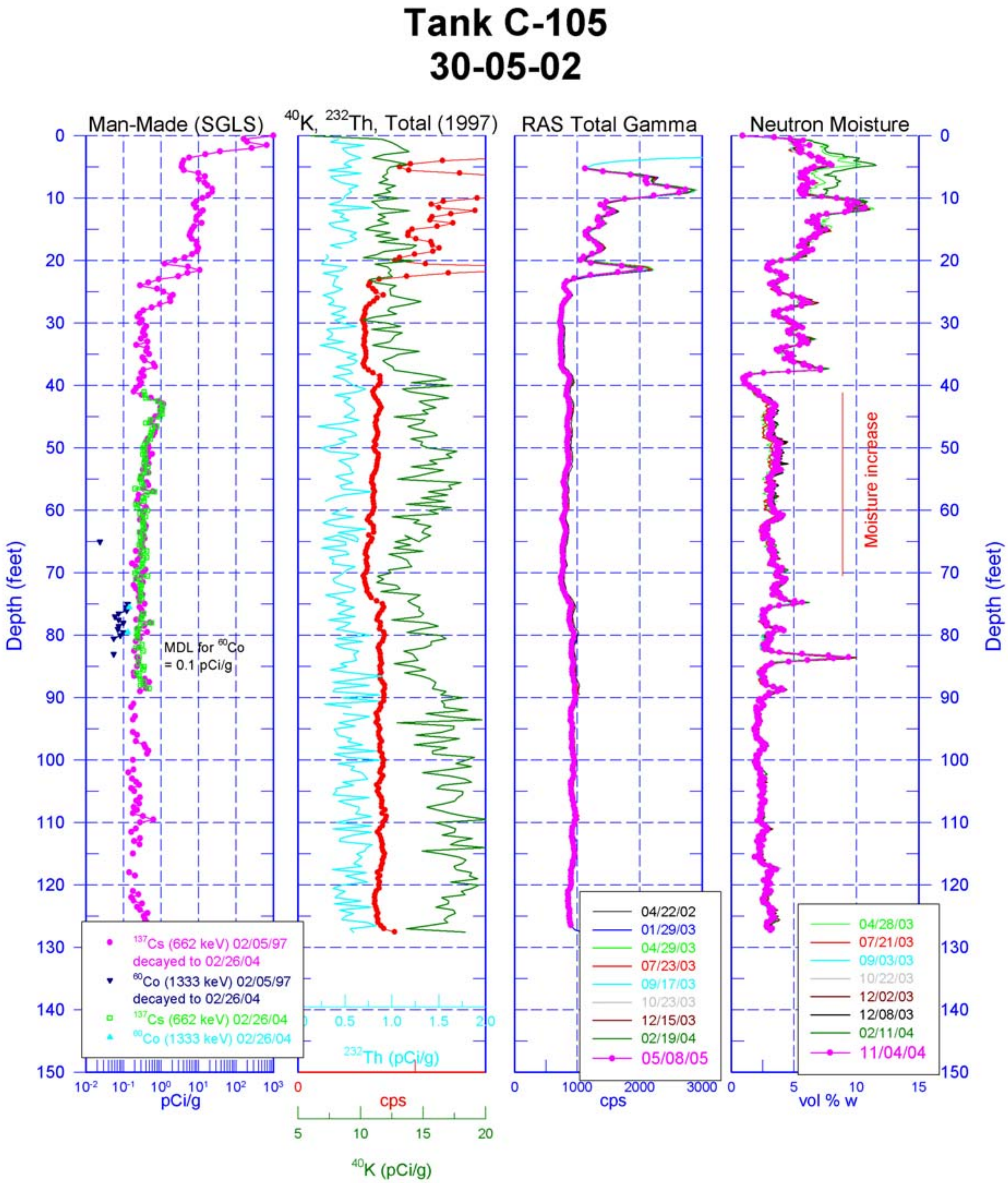

Tank C-105
30-05-02
Man-Made (SGLS)
^{40}K, ^{232}Th, Total (1997)
RAS Total Gamma
Neutron Moisture
Depth (feet)
MDL for ^{60}Co = 0.1 pCi/g
^{137}Cs (662 keV) 02/05/97 decayed to 02/26/04
^{60}Co (1333 keV) 02/05/97 decayed to 02/26/04
^{137}Cs (662 keV) 02/26/04
^{60}Co (1333 keV) 02/26/04
pCi/g
^{232}Th (pCi/g)
cps
^{40}K (pCi/g)
04/22/02
01/29/03
04/29/03
07/23/03
09/17/03
10/23/03
12/15/03
02/19/04
05/08/05
Moisture increase
04/28/03
07/21/03
09/03/03
10/22/03
12/02/03
12/08/03
02/11/04
11/04/04
vol % w

Figure 6a

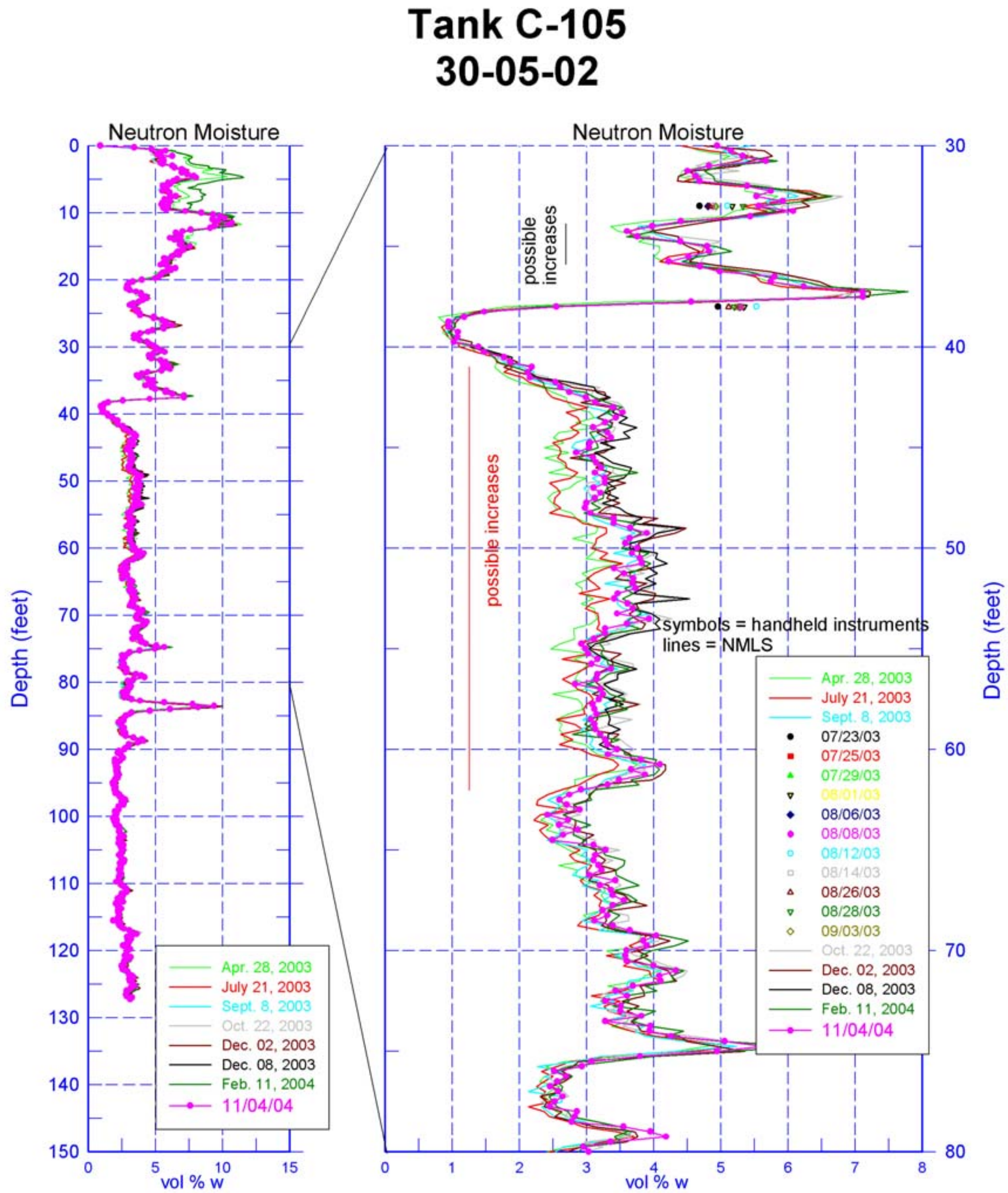
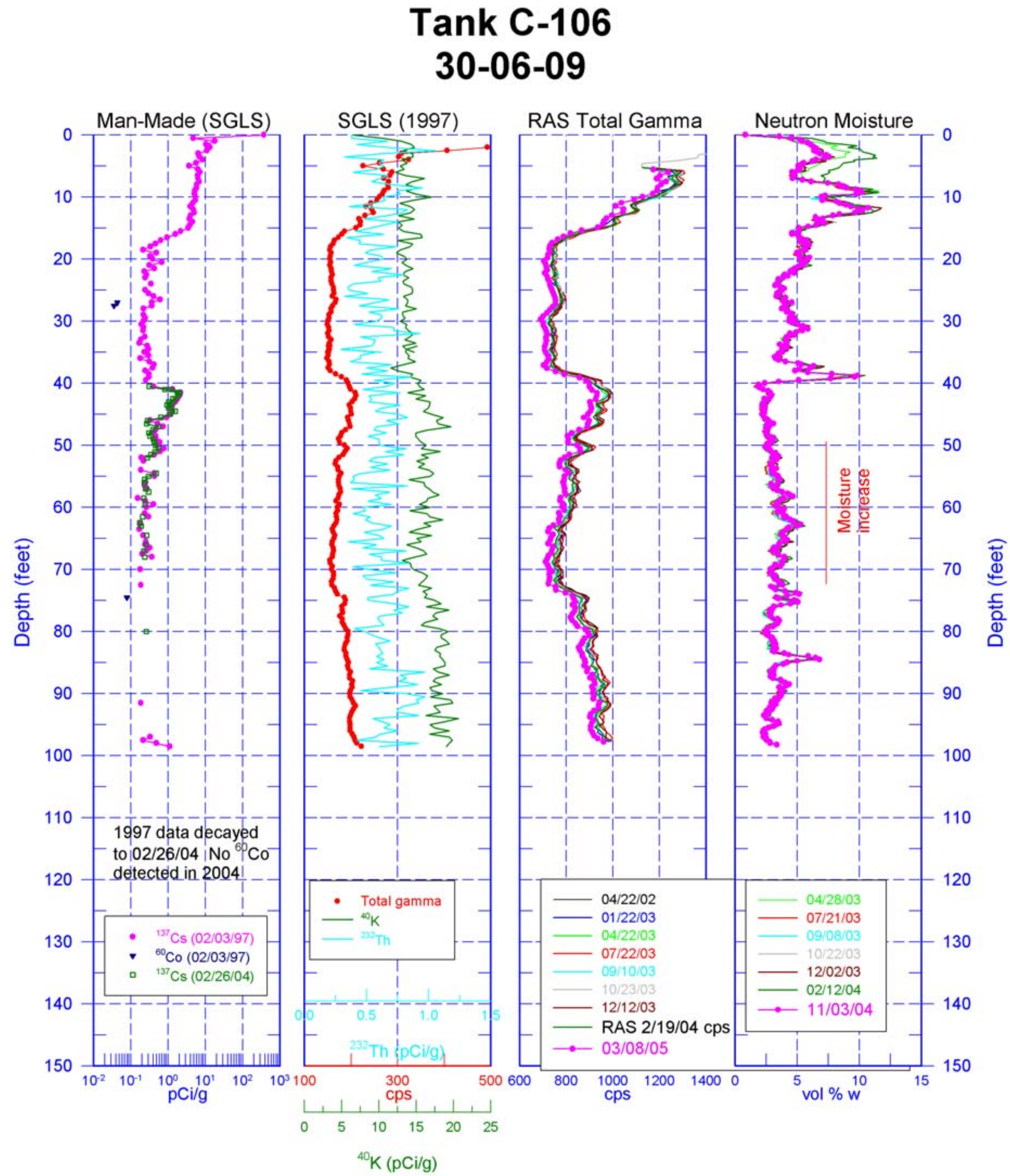

Tank C-105
30-05-02
Neutron Moisture
Depth (feet)
vol % w
Apr. 28, 2003
July 21, 2003
Sept. 8, 2003
Oct. 22, 2003
Dec. 02, 2003
Dec. 08, 2003
Feb. 11, 2004
11/04/04
Neutron Moisture
possible increases
possible increases
symbols = handheld instruments
lines = NMLS
07/23/03
07/25/03
07/29/03
08/01/03
08/06/03
08/08/03
08/12/03
08/14/03
08/26/03
08/28/03
09/03/03

Figure 6b



Tank C-106
30-06-09
Man-Made (SGLS)
SGLS (1997)
RAS Total Gamma
Neutron Moisture
Depth (feet)
1997 data decayed to 02/26/04 No 60Co detected in 2004
137Cs (02/03/97)
60Co (02/03/97)
137Cs (02/26/04)
pCi/g
Total gamma
40K
232Th
232Th (pCi/g)
cps
40K (pCi/g)
04/22/02
01/22/03
04/22/03
07/22/03
09/10/03
10/23/03
12/12/03
RAS 2/19/04 cps
03/08/05
Moisture increase
04/28/03
07/21/03
09/08/03
10/22/03
12/02/03
02/12/04
11/03/04
vol % w

Figure 7a

Tank C-106
30-06-09

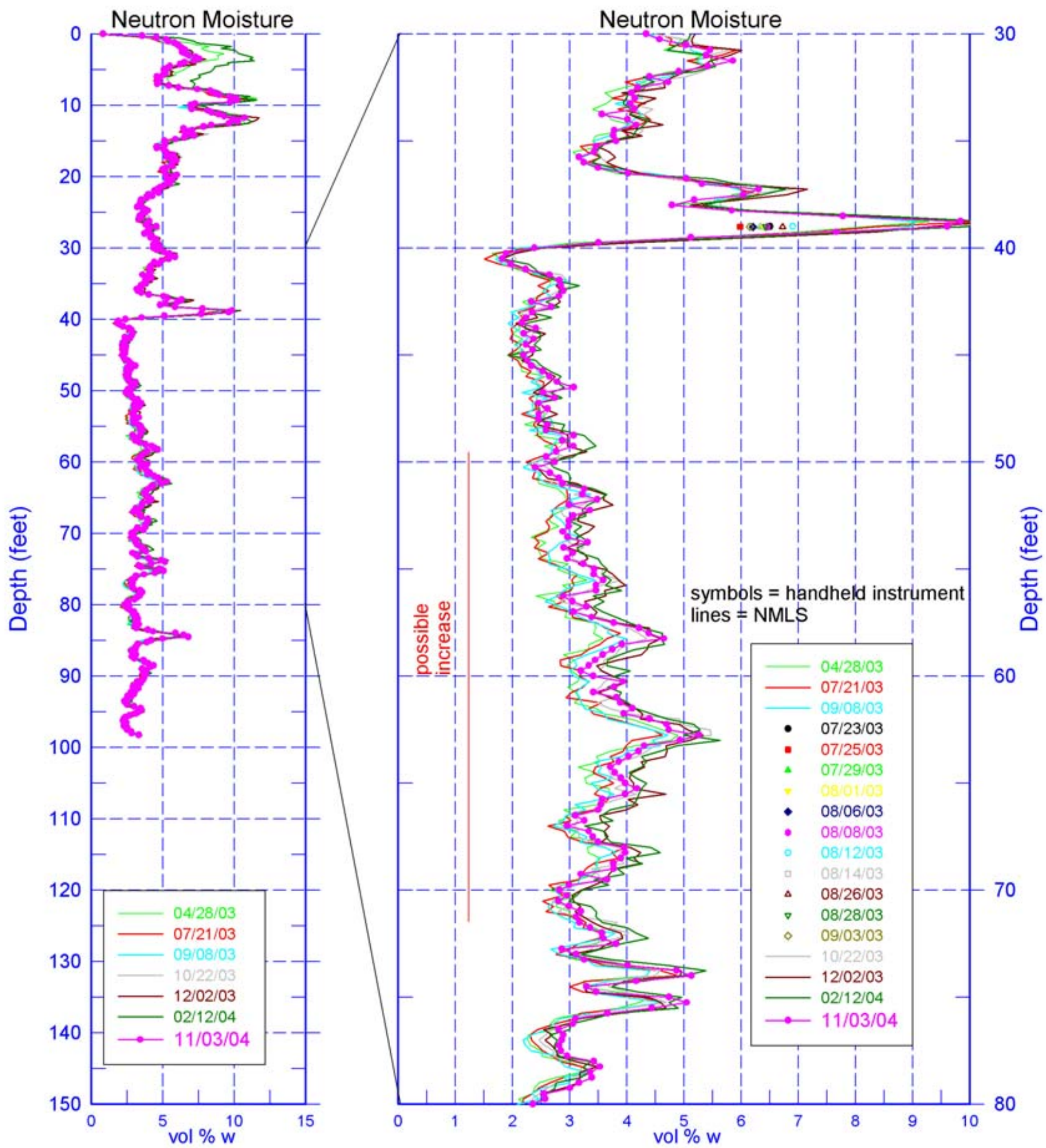


Figure 7b

Tank C-106
30-06-10

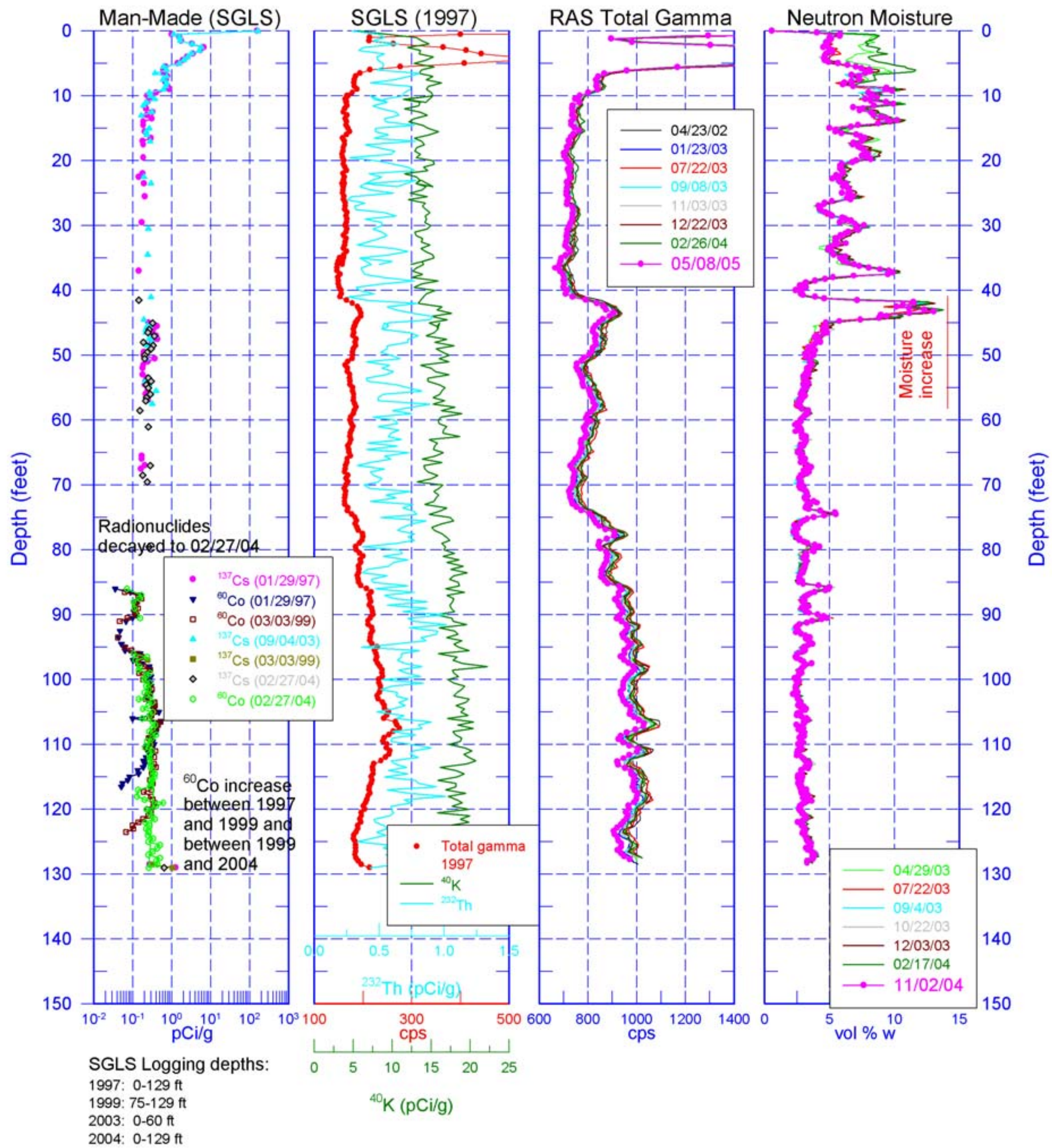
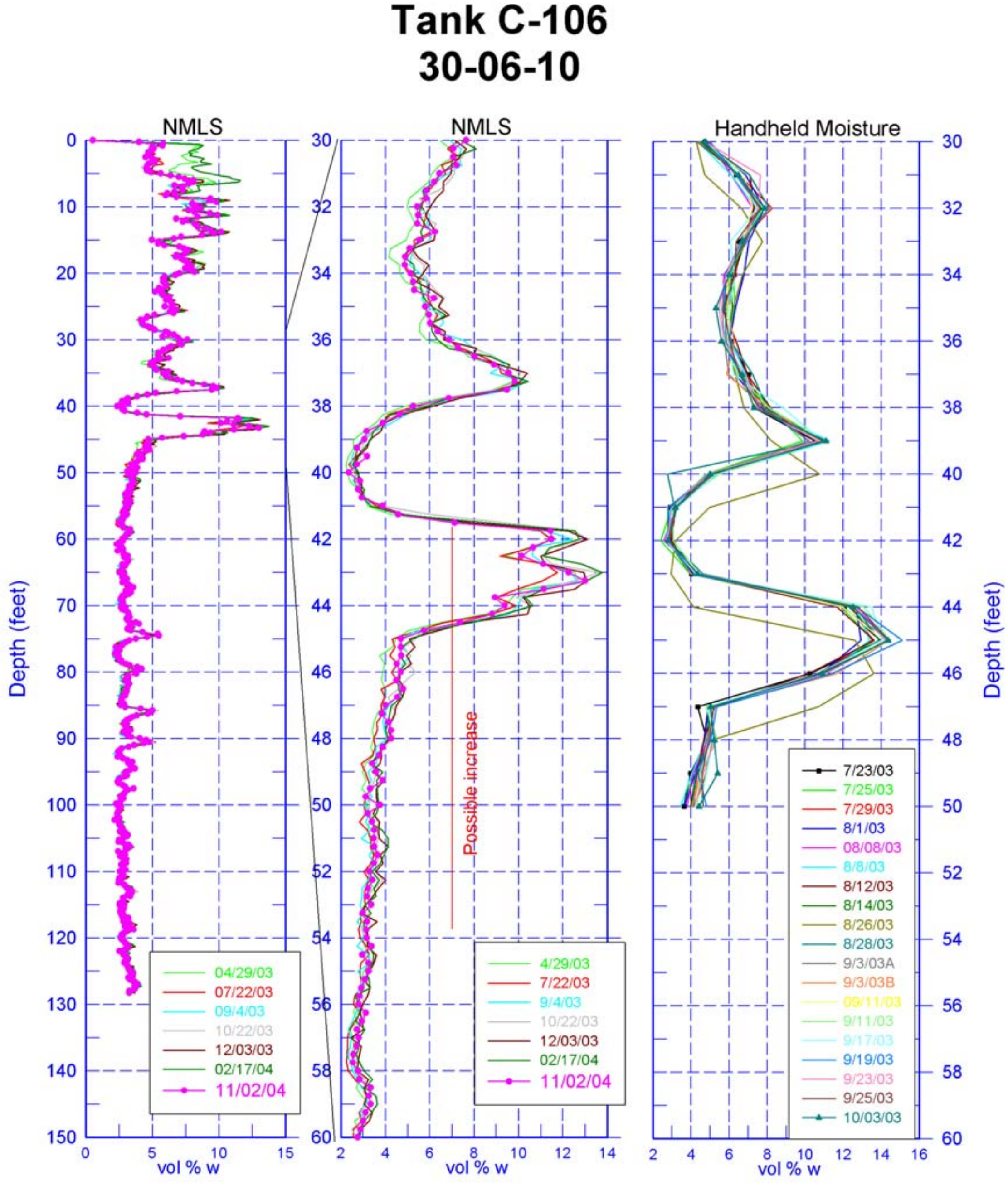


Figure 8a



Tank C-106
30-06-10
NMLS
NMLS
Handheld Moisture
Depth (feet)
Depth (feet)
vol % w
vol % w
vol % w
Possible increase
04/29/03
07/22/03
09/4/03
10/22/03
12/03/03
02/17/04
11/02/04
4/29/03
7/22/03
9/4/03
10/22/03
12/03/03
02/17/04
11/02/04
7/23/03
7/25/03
7/29/03
8/1/03
08/08/03
8/8/03
8/12/03
8/14/03
8/26/03
8/28/03
9/3/03A
9/3/03B
09/11/03
9/11/03
9/17/03
9/19/03
9/23/03
9/25/03
10/03/03

Figure 8b

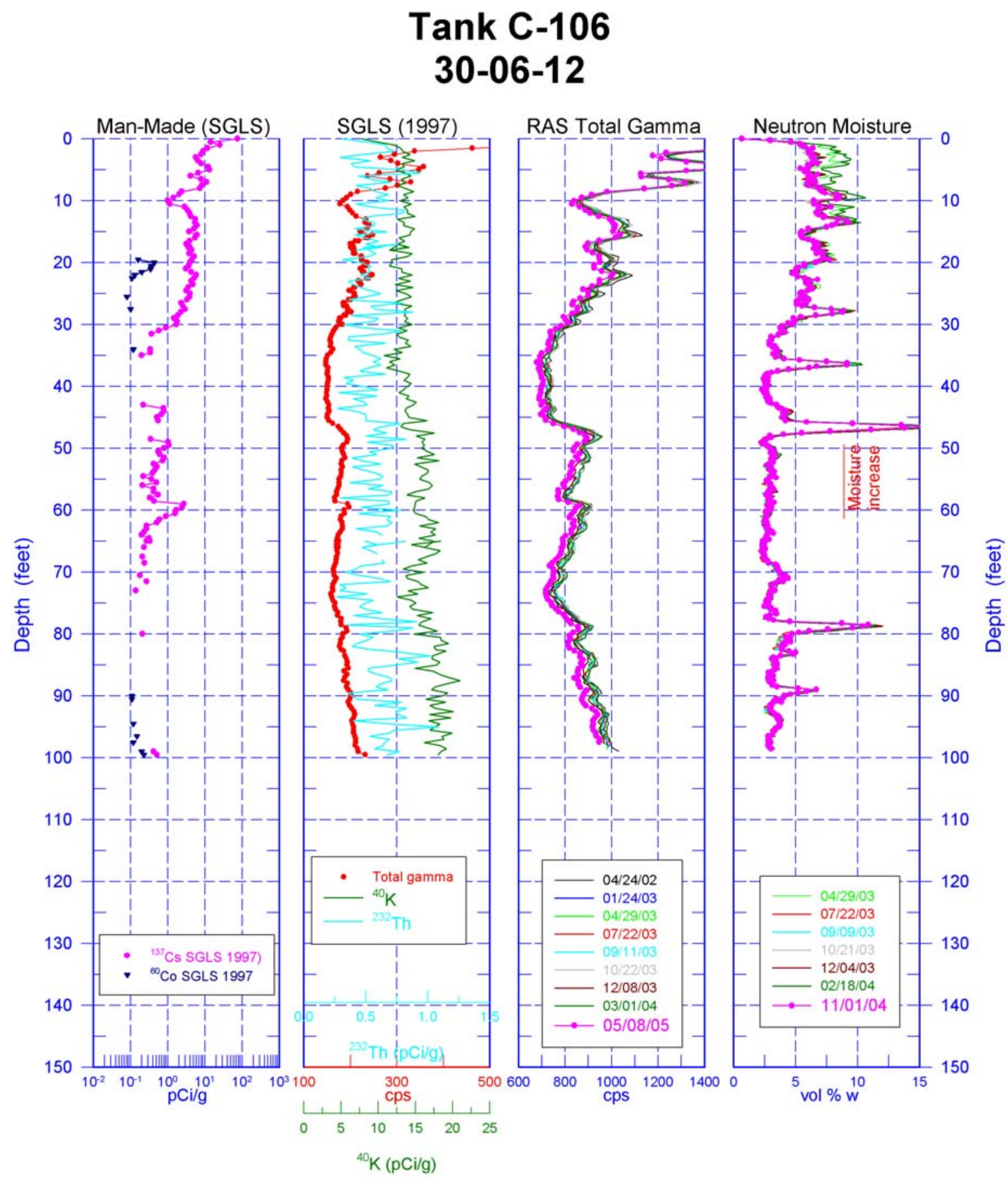

Tank C-106
30-06-12
Man-Made (SGLS)
SGLS (1997)
RAS Total Gamma
Neutron Moisture
Depth (feet)
137Cs SGLS 1997)
60Co SGLS 1997
pCi/g
Total gamma
40K
232Th
232Th (pCi/g)
cps
40K (pCi/g)
04/24/02
01/24/03
04/29/03
07/22/03
09/11/03
10/22/03
12/08/03
03/01/04
05/08/05
04/29/03
07/22/03
09/09/03
10/21/03
12/04/03
02/18/04
11/01/04
Moisture increase
vol % w

Figure 9a

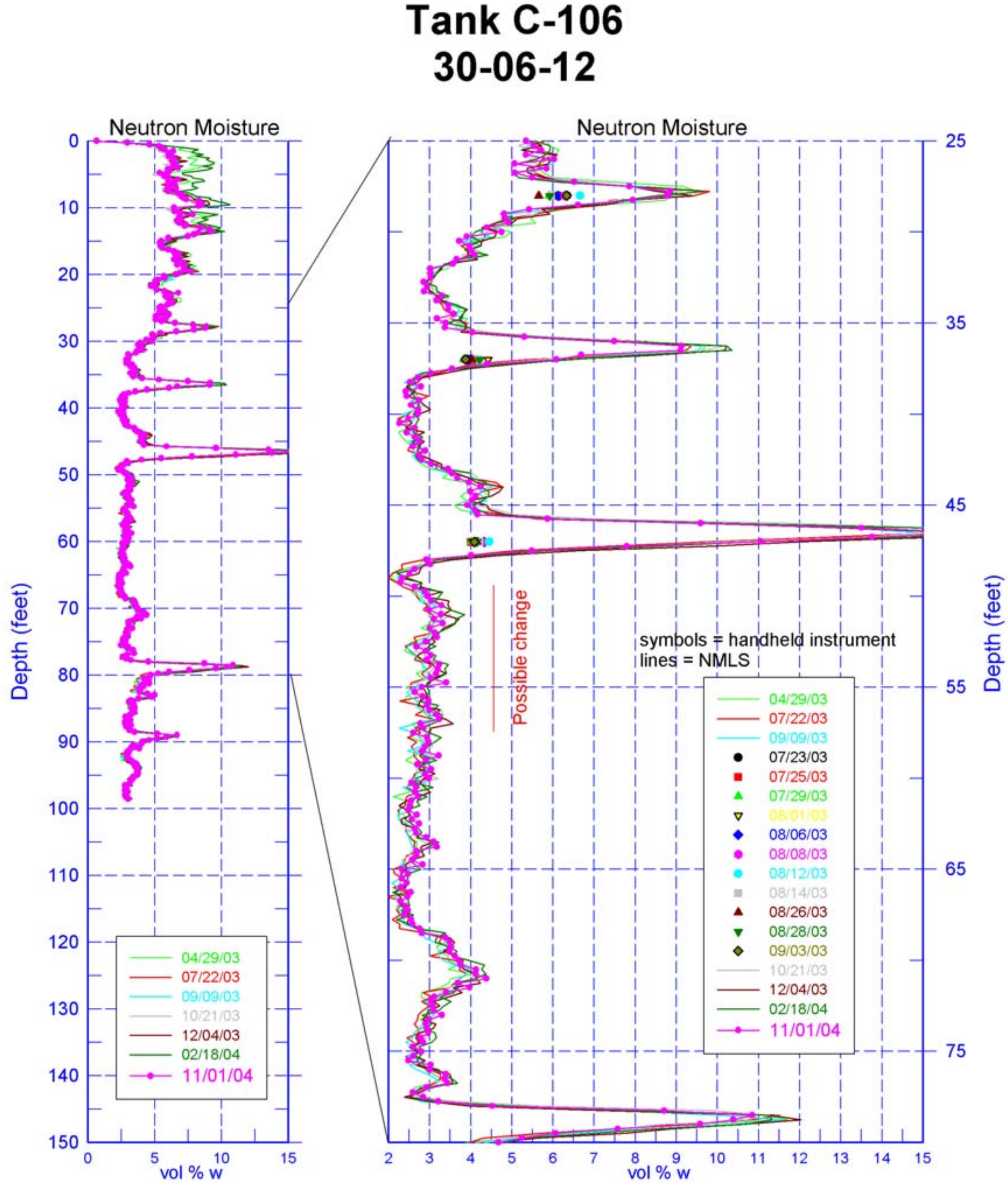
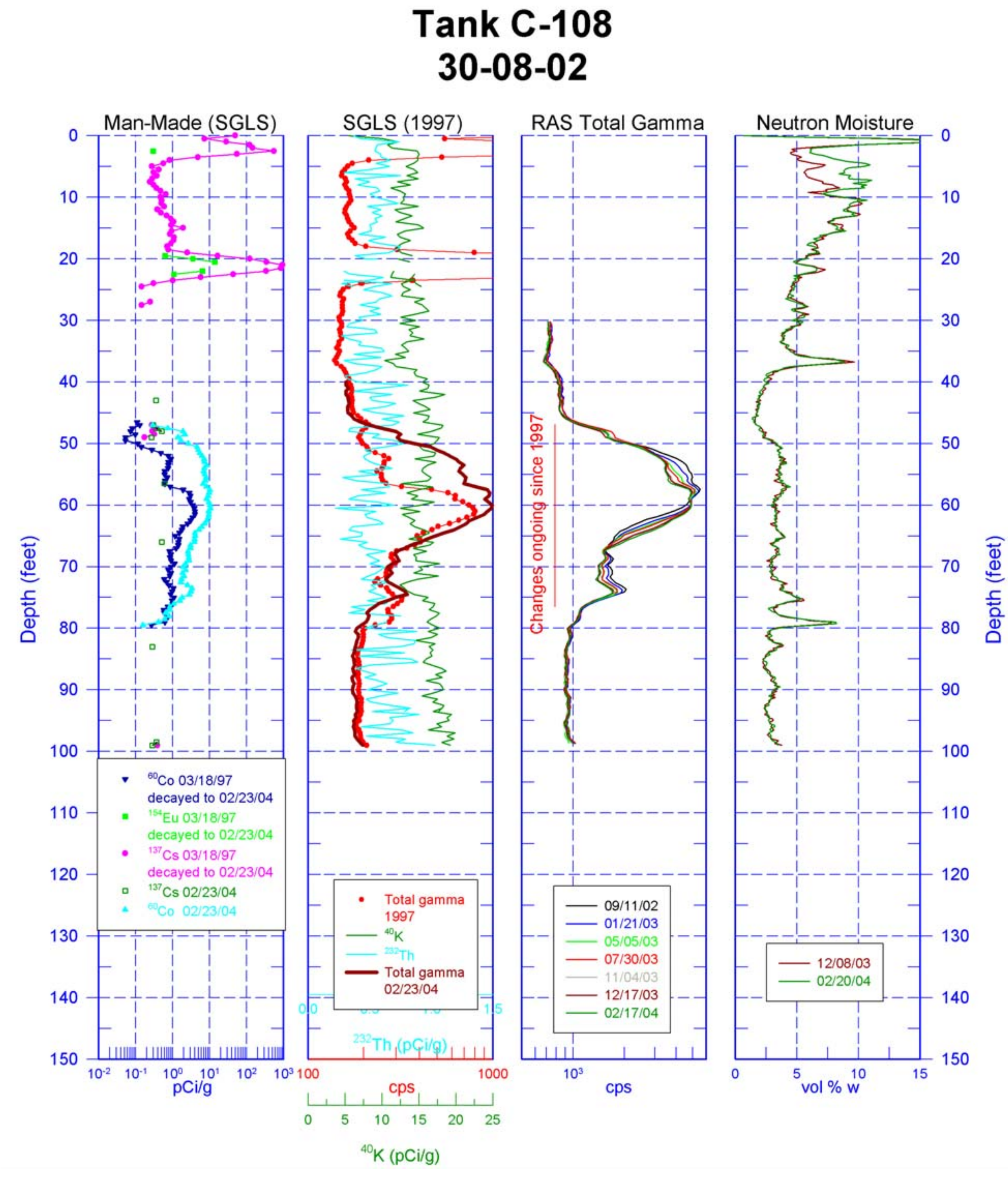

Tank C-106
30-06-12
Neutron Moisture
Depth (feet)
vol % w
04/29/03
07/22/03
09/09/03
10/21/03
12/04/03
02/18/04
11/01/04
Neutron Moisture
Possible change
symbols = handheld instrument
lines = NMLS
07/23/03
07/25/03
07/29/03
08/01/03
08/06/03
08/08/03
08/12/03
08/14/03
08/26/03
08/28/03
09/03/03

Figure 9b



Tank C-108
30-08-02
Man-Made (SGLS)
SGLS (1997)
RAS Total Gamma
Neutron Moisture
Depth (feet)
Changes ongoing since 1997
60Co 03/18/97 decayed to 02/23/04
154Eu 03/18/97 decayed to 02/23/04
137Cs 03/18/97 decayed to 02/23/04
137Cs 02/23/04
60Co 02/23/04
Total gamma 1997
40K
232Th
Total gamma 02/23/04
09/11/02
01/21/03
05/05/03
07/30/03
11/04/03
12/17/03
02/17/04
12/08/03
02/20/04
pCi/g
cps
232Th (pCi/g)
40K (pCi/g)
vol % w

Figure 10a

Tank C-108
30-08-02

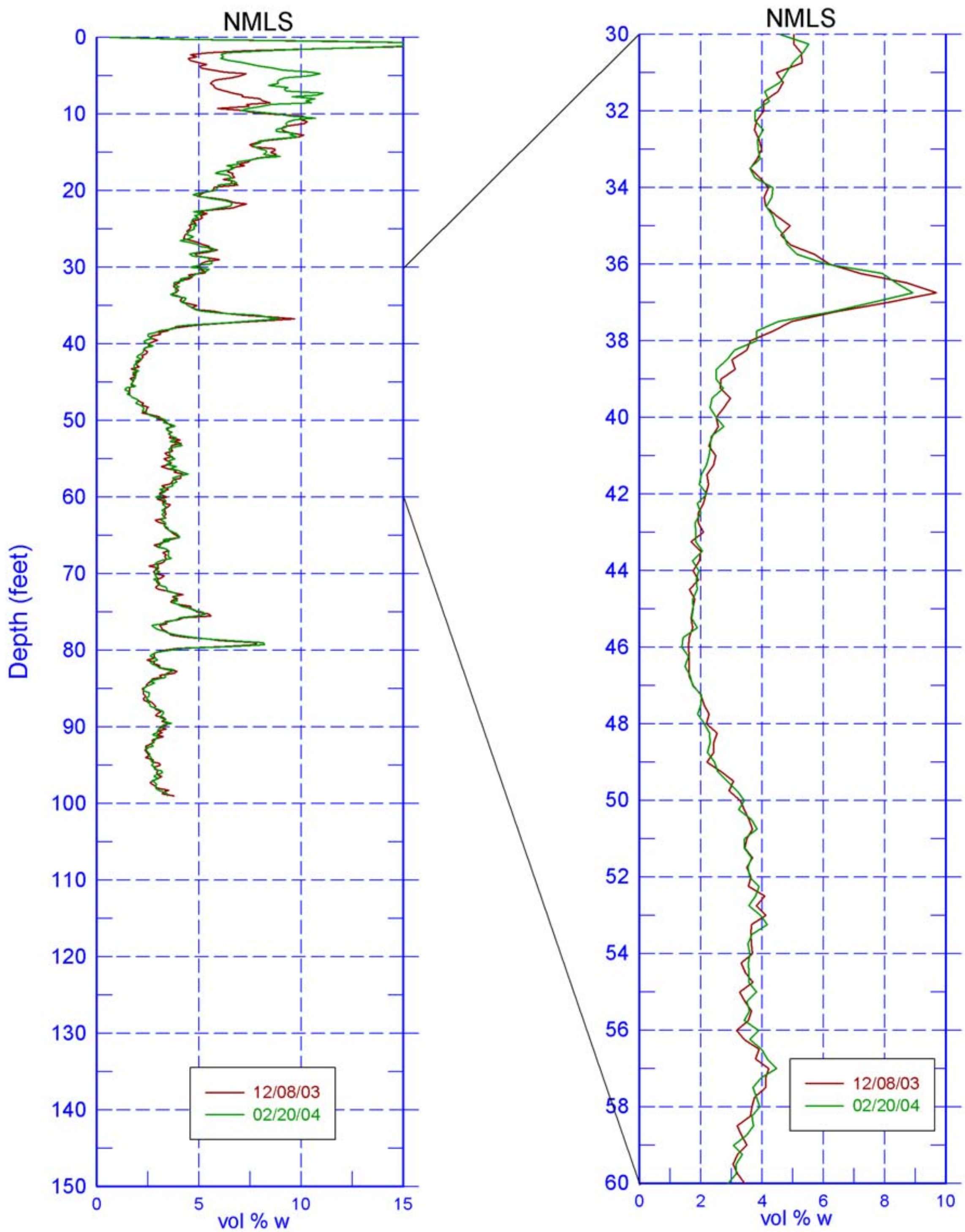
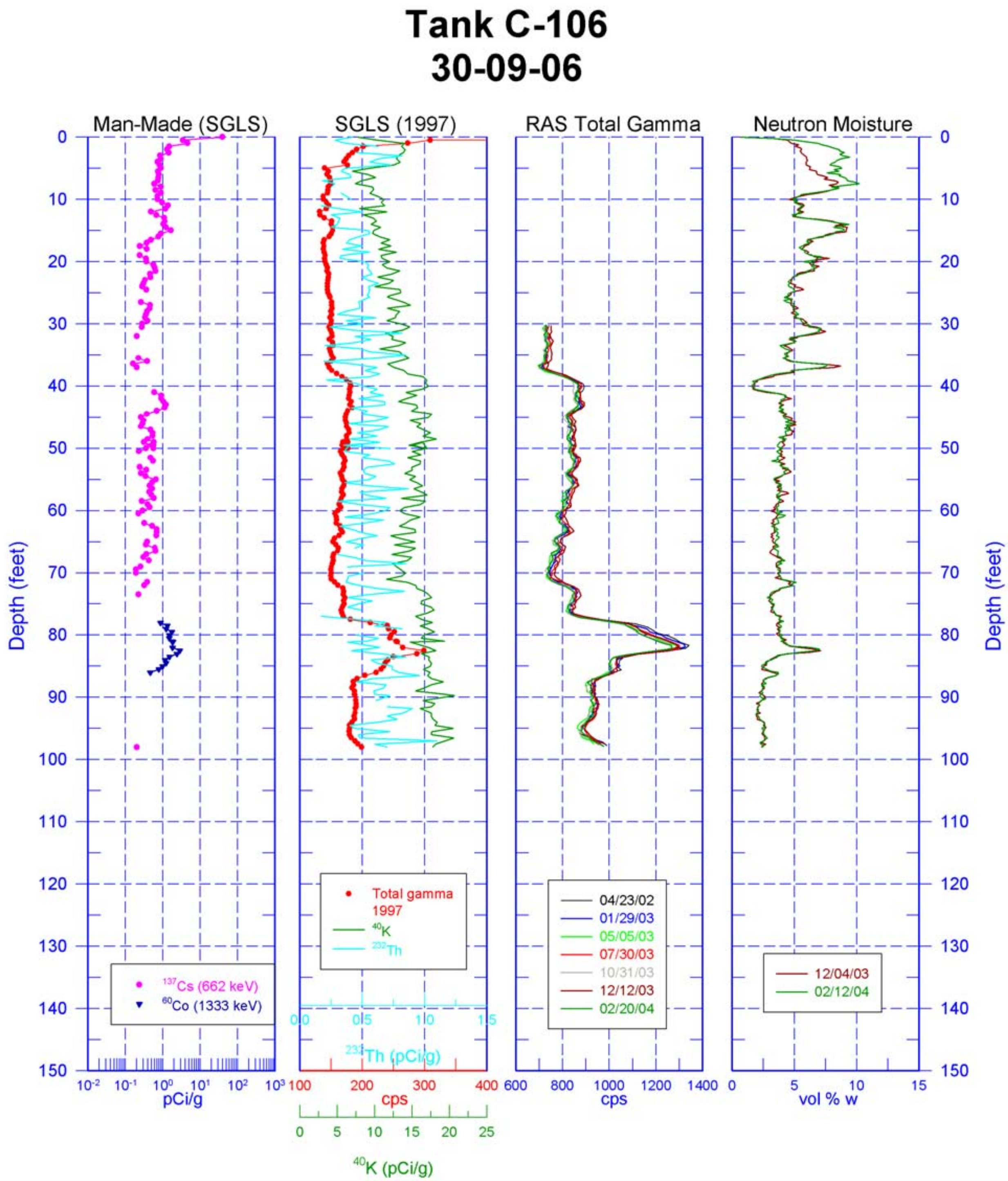


Figure 10b



Tank C-106
30-09-06
Man-Made (SGLS)
SGLS (1997)
RAS Total Gamma
Neutron Moisture
Depth (feet)
137Cs (662 keV)
60Co (1333 keV)
pCi/g
Total gamma 1997
40K
232Th
232Th (pCi/g)
cps
40K (pCi/g)
04/23/02
01/29/03
05/05/03
07/30/03
10/31/03
12/12/03
02/20/04
12/04/03
02/12/04
vol % w

Figure 11a

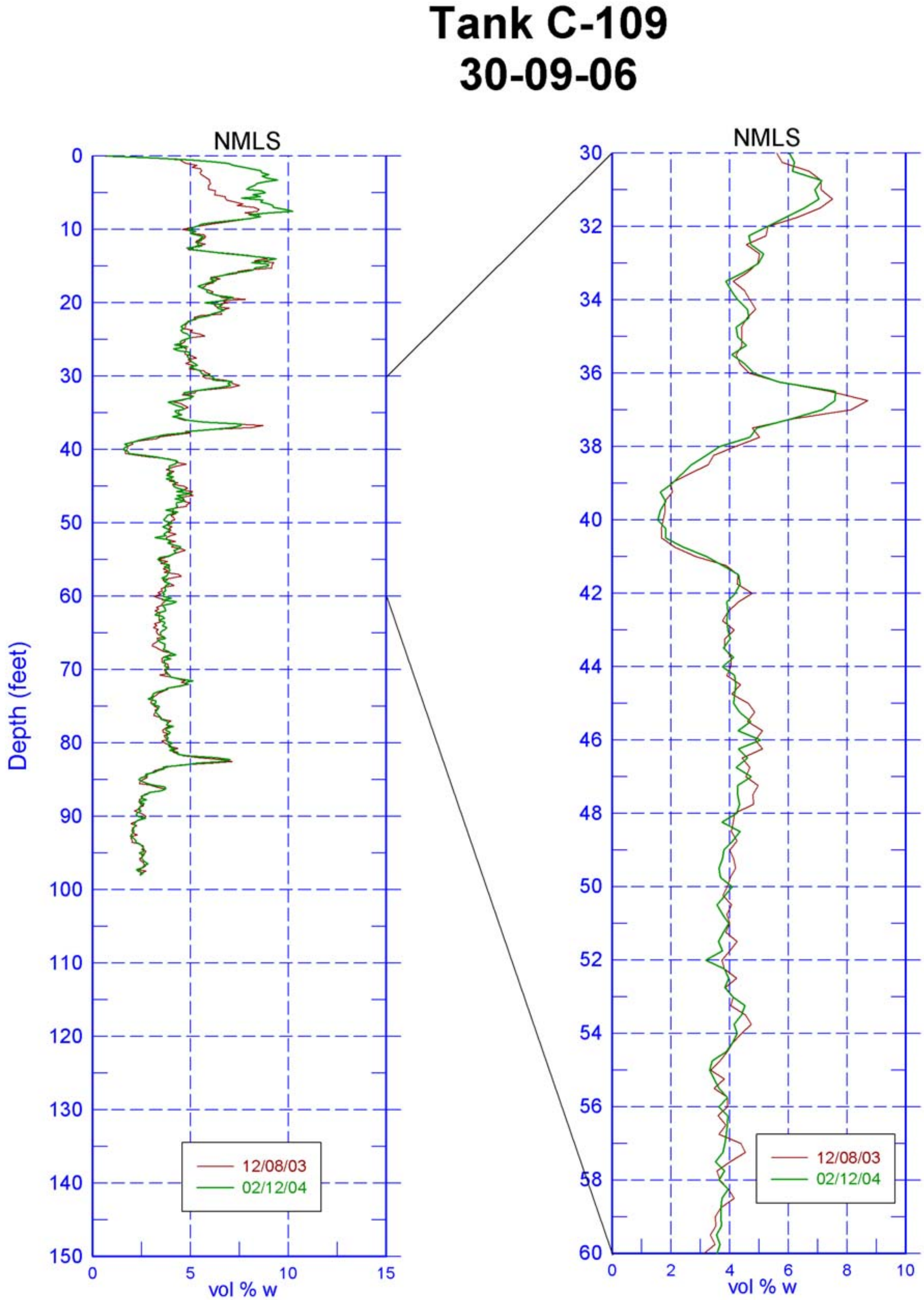

Tank C-109
30-09-06
NMLS
Depth (feet)
vol % w
12/08/03
02/12/04
NMLS
vol % w
12/08/03
02/12/04

Figure 11b

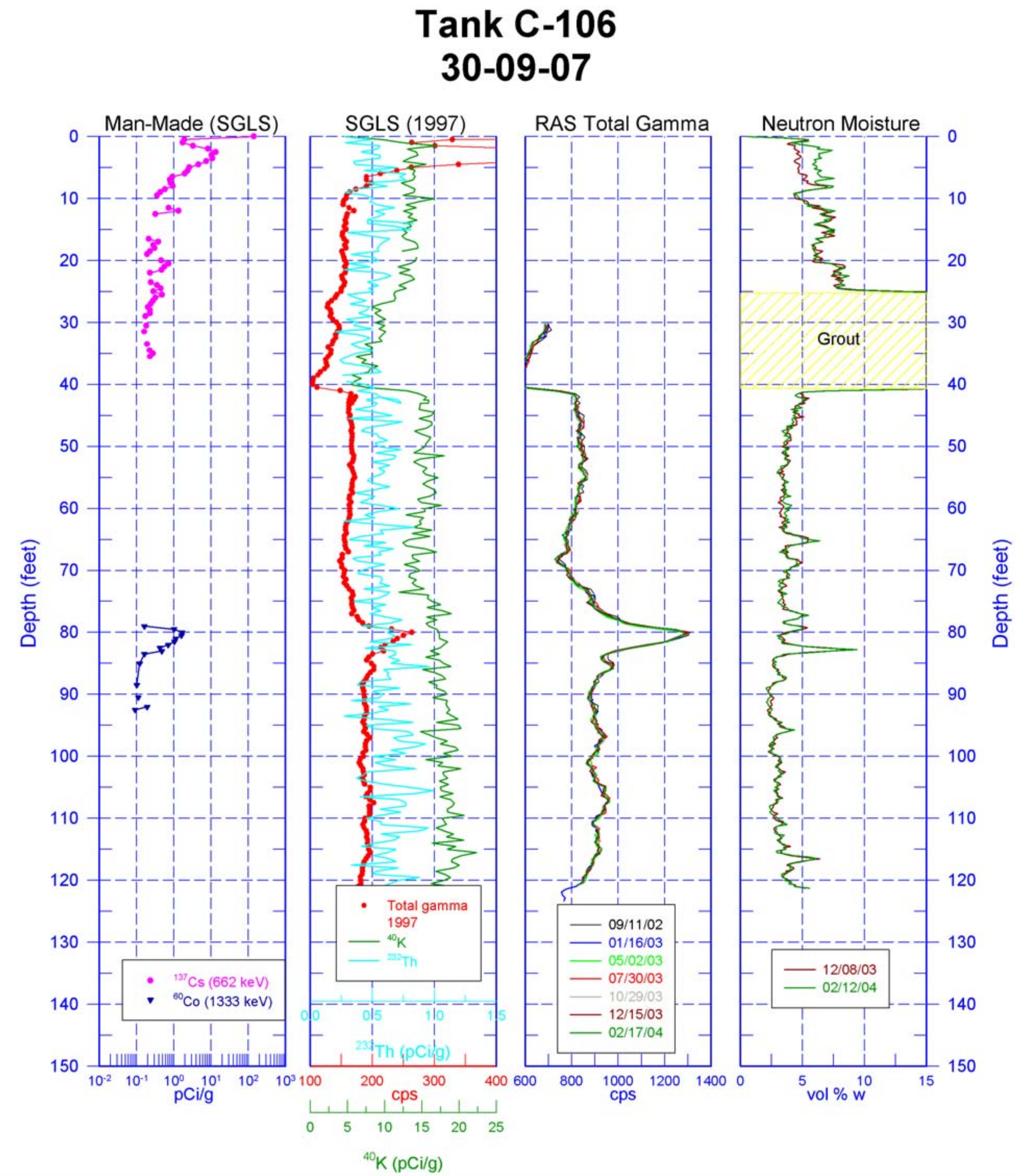

Tank C-106
30-09-07
Man-Made (SGLS)
SGLS (1997)
RAS Total Gamma
Neutron Moisture
Depth (feet)
Grout
137Cs (662 keV)
60Co (1333 keV)
Total gamma 1997
40K
232Th
232Th (pCi/g)
cps
40K (pCi/g)
pCi/g
09/11/02
01/16/03
05/02/03
07/30/03
10/29/03
12/15/03
02/17/04
12/08/03
02/12/04
vol % w

Figure 12a

Tank C-109
30-09-07

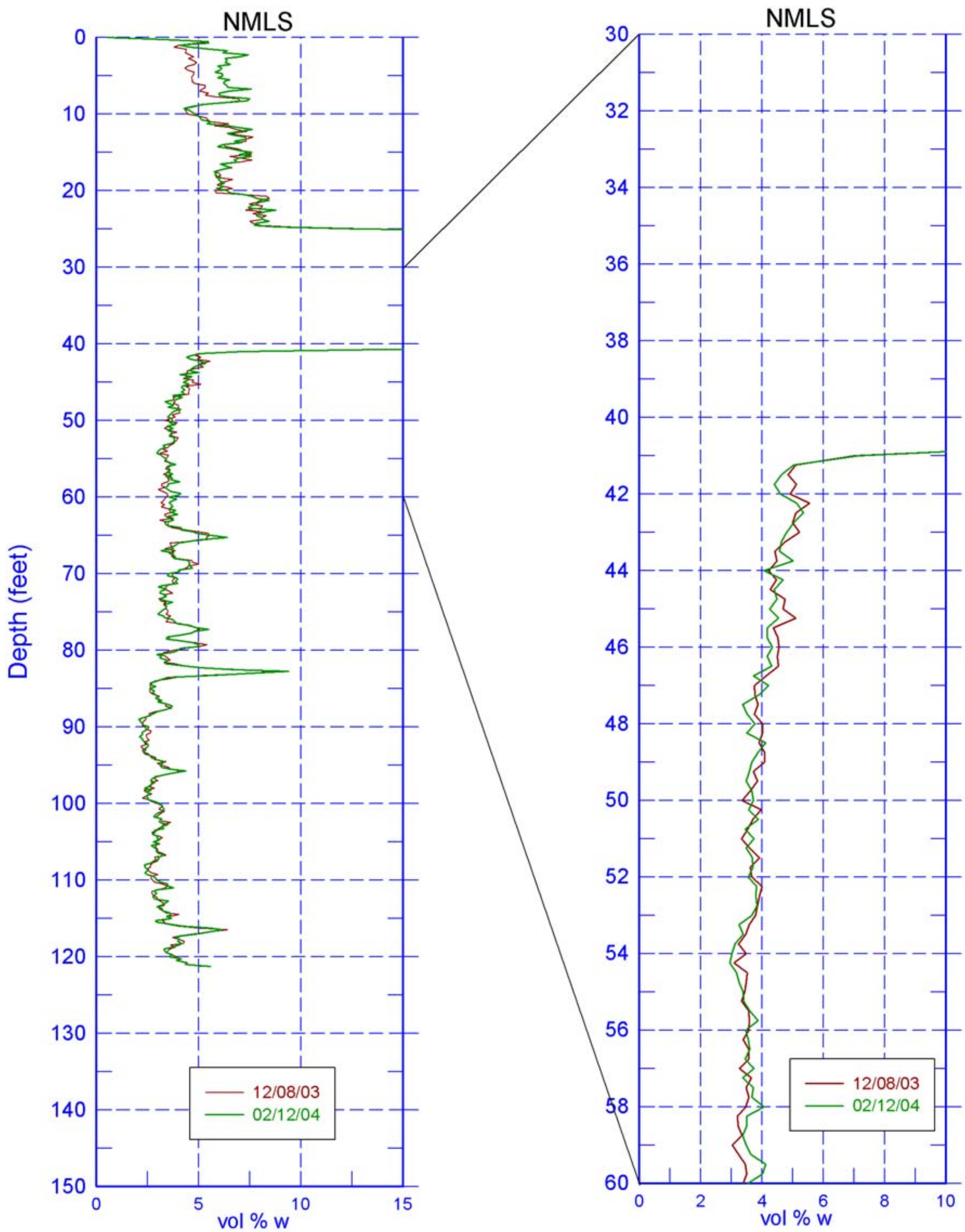
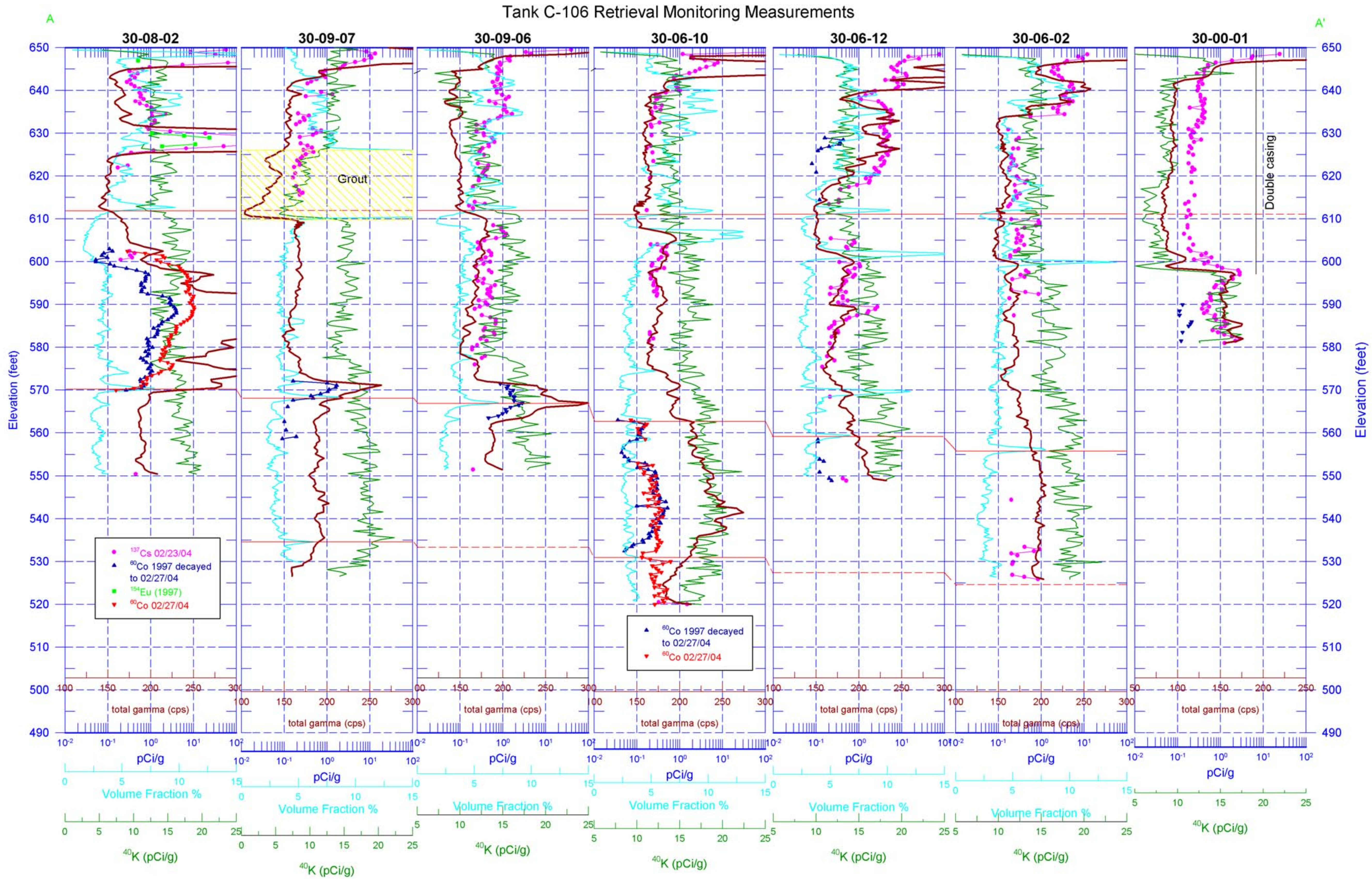


Figure 12b



Tank C-106 Retrieval Monitoring Measurements
A
A'
30-08-02
30-09-07
30-09-06
30-06-10
30-06-12
30-06-02
30-00-01
Elevation (feet)
Grout
Double casing
137Cs 02/23/04
60Co 1997 decayed to 02/27/04
154Eu (1997)
60Co 02/27/04
total gamma (cps)
pCi/g
Volume Fraction %
40K (pCi/g)

Figure 13

Appendix E
Boreholes Projected for Retrieval Monitoring During the Third Quarter of FY 2005

Table E-1. Boreholes Projected for Retrieval Monitoring During the 4th Quarter of FY 2005

Borehole Number	Tank	Top	Bottom	Footage	Next Log Date	Last Event Date	Projected 4th Qtr. Events	Total Events (to date)	Comment
30-06-04	C-106	0	129	129	06/07/05	05/08/05	1	9	No apparent change, C-103 Retrieval
30-03-01	C-103	0	124	124	05/17/97	04/17/97	1	0	Cannot log because of stairwell; C-103 Retrieval
30-03-03	C-103	0	97	97	05/11/97	04/11/97	1	0	Water in borehole 10/01, C-103 Retrieval
30-03-05	C-103	0	99	99	10/11/02	09/11/02	1	1	No apparent change, C-103 Retrieval
30-03-07	C-103	0	96	96	10/11/02	09/11/02	1	1	No apparent change, C-103 Retrieval
30-03-09	C-103	0	98	98	06/05/03	05/06/03	1	2	No apparent change, C-103 Retrieval
40-02-01	S-102	0	129	129	08/01/03	07/02/03	1	2	No apparent change, S-102 Retrieval
40-02-03	S-102	0	98	98	08/07/03	07/08/03	1	1	Apparent Cs-137 increase at 44-47 ft., S-102 Retrieval
40-02-04	S-102	0	144	144	08/08/03	07/09/03	1	2	No apparent change, S-102 Retrieval
40-02-05	S-102	0	97	97	08/06/03	07/07/03	1	2	No apparent change, S-102 Retrieval
40-02-07	S-102	0	95	95	05/13/04	04/13/04	1	3	No apparent change, S-102 Retrieval
40-02-08	S-102	0	99	99	05/14/04	04/14/04	1	3	No apparent change, S-102 Retrieval
40-02-10	S-102	0	100	100	05/13/04	04/13/04	1	3	No apparent change, S-102 Retrieval
40-02-11	S-102	0	100	100	05/12/04	04/12/04	1	3	No apparent change, S-102 Retrieval
40-03-03	S-103	0	122	122	05/15/04	04/15/04	1	2	No apparent change, S-102 Retrieval
40-09-06	S-109	0	98	98	03/06/04	02/05/04	1	6	No apparent change; S-112 Retrieval
40-11-08	S-111	0	97	97	03/05/04	02/04/04	1	4	No apparent change, S-112 Retrieval
40-11-09	S-111	0	98	98	03/06/04	02/05/04	1	5	No apparent change, S-112 Retrieval
40-12-02	S-112	0	99	99	03/06/04	02/05/04	1	6	No apparent change; S-112 Retrieval
40-12-04	S-112	0	126	126	03/05/04	02/04/04	1	6	No apparent change; S-112 Retrieval
40-12-07	S-112	0	98	98	03/07/04	02/06/04	1	6	No apparent change; S-112 Retrieval
40-12-09	S-112	0	98	98	03/07/04	02/06/04	1	6	No apparent change; S-112 Retrieval
		Total Projected 3rd Quarter Events =					**22**		