

# Phase II Final Status Survey Report Mallinckrodt Columbium-Tantalum Plant

St. Louis, Missouri


## Chapter 16

**Project No. 137131**

**Revision 0**


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**ABBREVIATIONS AND ACRONYMS**

$\sigma$	sigma; standard deviation
AECOM	AECOM Technical Services
bgs	below grade surface
C-T	columbium-tantalum
CFR	Code of Federal Regulations
cm	centimeter
cpm	counts per minute
DCGL	derived concentration guideline level
DP	decommissioning plan
DQO	data quality objectives
EMC	elevated measurement comparison
EnergySolutions, LLC	EnergySolutions
F	exposure-weighted fraction of the DCGL <sub>w</sub>
FSS	Final Status Survey
FSSR	Final Status Survey Report
ft	feet
GPS	global positioning system
GWS	gamma walk-over survey
m	meters
m <sup>2</sup>	square meters
MARSSIM	Multi-Agency Radiation and Site Investigation Manual (NUREG-1575)
MDC	minimum detectable concentration
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
pCi/g	picoCuries per gram
Ra	radium
SOF	sum of fractions
Th	thorium
U	uranium
Unc.	uncertainty
WRS	Wilcoxon Rank Sum

## 16.0 RESULTS SUMMARY FOR PLANT 5 SUBSURFACE SU10

This chapter of the Final Status Survey Report (FSSR) presents the results of the final status survey (FSS) and data assessment for Plant 5 subsurface survey unit SU10 in accordance with Columbium-Tantalum (C-T) Phase II Decommissioning Plan (DP) Section 14.5. The majority of FSS for this Class 1 survey unit was performed by EnergySolutions, LLC (EnergySolutions) in October of 2012 and completed in December. The SU10 data assessment was performed based on the assumptions, methods, and performance criteria established to satisfy the data quality objectives (DQOs) in accordance with the C-T Phase II DP Section 14.4.3.8. The summary statistics provide numerical values for measures of central tendency (i.e., mean, median), variation (i.e., standard deviation), and spread (i.e., minimum, maximum). Data evaluation and statistical analyses were performed and a separate decision was made for each survey unit of the C-T Plant as to its suitability for release for unrestricted use based upon the industrial use scenario release criterion as established in C-T Phase II DP Chapter 5.

### 16.1 OVERVIEW

SU10 is a Class 1 survey unit in the southwest portion of C-T Plant 5. The survey unit is approximately 743 square meters ( $m^2$ ) in size, which is less than the size limit of 3,000  $m^2$  for Class 1 survey units for subsurface material (per C-T Phase II DP, Table 14-4). Class 1 was the appropriate classification because the survey unit contained residual radioactivity that exceeded the derived concentration guideline value ( $DCGL_W$ ) prior to remediation. Figure 16-1 shows the location of SU10 within the Plant 5 area while Figure 16-2 depicts features within the survey unit, the extent of excavation and the locations and direction of photographs taken as presented in the following subsections to facilitate the text.

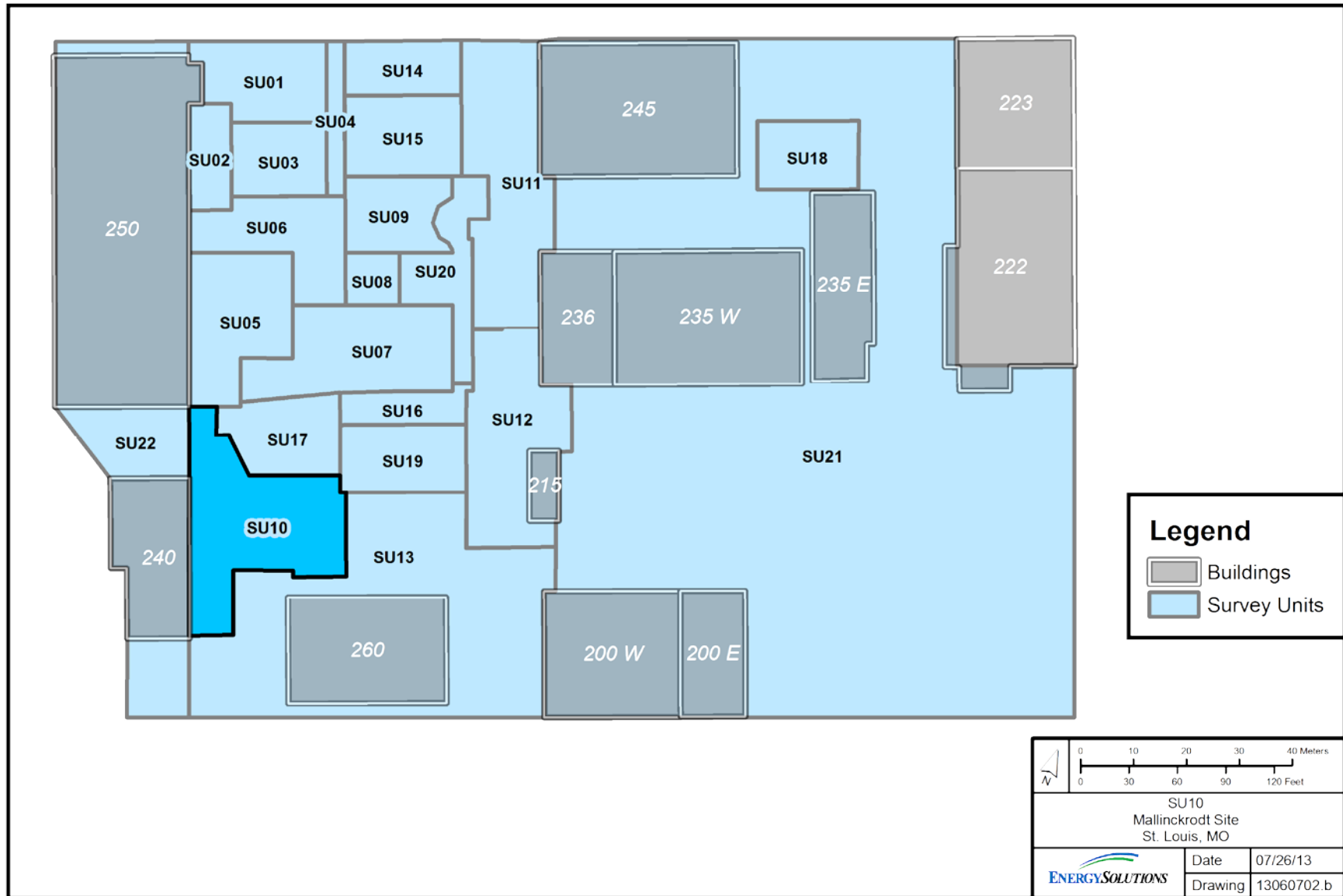


Figure 16-1 Location of SU10 in C-T Plant 5

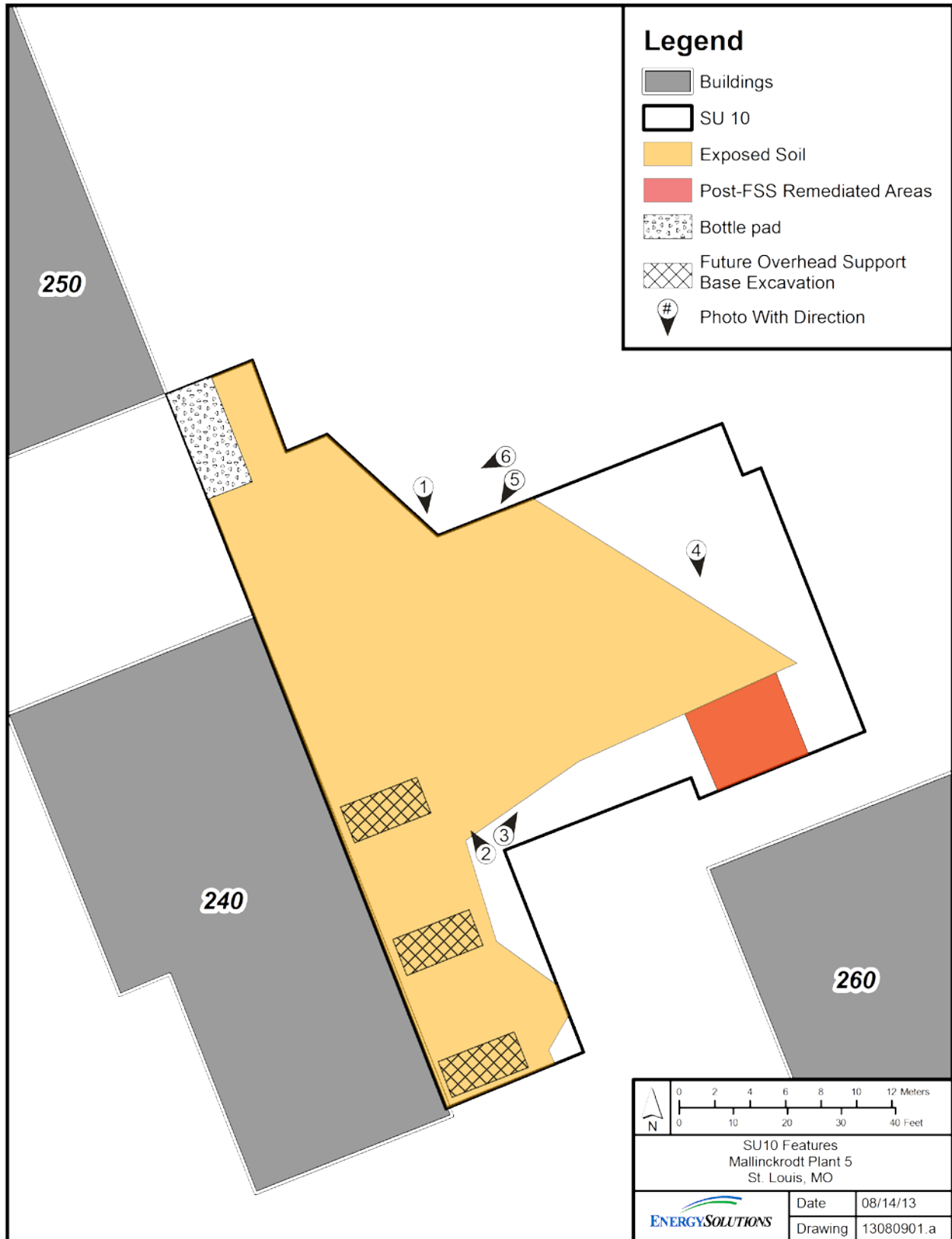


Figure 16-2 SU10 Feature Diagram

### 16.1.1 General Excavation

Figure 16-3 through Figure 16-5 are photographs of the SU10 general excavation that were taken during FSS following remediation in October of 2012 with the position and orientation of the photographs provided on Figure 16-2. Figure 16-3 (photograph 1), as viewed from the northern edge of the excavation shows the southeast corner of Building 240 to the right. Figure 16-4 (photograph 2), as viewed from the south side of the excavation looking northwest shows the northeast corner of Building 240 to the left as well as the alley between Buildings 240/250 and the Building 250 bottle pad. Figure 16-5 (photograph 3), taken from the same location as Figure 16-4 shows the excavation looking northeast toward Buildings 236/245.

General excavation depths ranged from 1 to approximately 9 feet (ft) below grade surface (bgs). The majority of the excavation ranged between 3 to 6 ft bgs as shown in the figures. The center of the excavation near the north east corner of Building 240 was the deepest at approximately 9 feet bgs within the clay layer as shown in Figure 16-4. Three additional pits were excavated along Building 240 toward the south as provided in Figure 16-2 in support of the construction of new overhead piping supports.

During excavation, two active manholes were removed from in front of the Building 240/250 alley (one sanitary and one storm sewer) as well as a combination sewer line. Upon backfill, new manholes and sewer line were installed.



**Figure 16-3 Photograph (1) of SU10 at Time of FSS (South View)**





**Figure 16-4 Photograph (2) of SU10 at Time of FSS (Northwest View)**



**Figure 16-5 Photograph (3) of SU10 at Time of FSS (Northeast View)**

### 16.1.2 SU13 Systematic Sample Location 5

During FSS and core boring of SU13 in December of 2012, a small area of subsurface contamination was identified directly adjacent to SU10 near the northwest corner of Building 260 in the general vicinity of the combination sewer. Contamination was identified at systematic sample location 5 within SU13 between 0-2 meters (m) bgs which was bounded by corebores that were collected to the east and west. This small area was subsequently segregated from SU13 due to its proximity to SU10 as shown in Figure 16-6. SU10 was expanded south to capture the area which was then remediated to an approximate depth of 5 ft bgs. Figure 16-2 shows the location of the post FSS remediation performed as part of SU10.



**Figure 16-6 Photograph (4) of SU13 Systematic Sample Location 5**

## 16.2 DATA COLLECTION

Data collection was performed based on the assumptions, methods, and performance criteria established to satisfy the DQOs in accordance with the C-T Phase II DP, Sections 14.4.1 and 14.4.3. Details regarding FSS design and quality assurance and quality control applicable to all survey units were discussed in Chapters 4 and 5, respectively, of this FSSR. FSS data as collected for SU10 is summarized as follows:

### 16.2.1 Gamma Scans

A gamma walk-over survey (GWS) was performed over the entire survey unit to the maximum extent practical in order to locate radiation anomalies that might indicate areas with elevated residual radioactivity where further data collection (i.e., biased soil sampling) was warranted. In general, global positioning system (GPS) coverage was good for SU10 with limited signal near Building 240 toward the Building 240/250 alley. The deepest area of excavation as shown in Figure 16-4 near the northwest corner of Building 240 was not scanned as part of the GWS due to standing water. This area was excavated to the clay layer and was surveyed as much as possible with no elevated readings noted by the surveyor. Additional inaccessible areas included locations where concrete barriers were placed for vehicle traffic safety and clean fill from the prior excavation of SU17.

Figure 16-7 provides the GWS scan results and survey unit coverage. The GWS was performed over both the exposed soil of the general excavation and the remaining asphalt. The recorded survey results ranged from 3,840 to 18,300 counts per minute (cpm) with a mean of 6,700 cpm and a median of 6,300 cpm for asphalt. The elevated readings associated with asphalt were along the edges of the general excavation and were elevated because of the proximity to soil. The recorded survey results within the excavation over soil ranged from 1,740 to 198,000 cpm with a mean of 16,500 cpm and a median of 15,000 cpm. The elevated readings for soil were concentrated along the western edge of the excavation, particularly near the northwest corner of Building 240, the alley between Building 240/250 and the Building 250 bottle pad. Upon further investigation, it was determined that these elevated readings were due to contamination along the face of the vertical wall. The characterization of the west wall is discussed within Section 16.2.4.

### 16.2.2 Soil Sampling

Soil samples to be used for the statistical testing were collected at a frequency and at representative locations throughout SU10 such that a statistically sound conclusion regarding the radiological condition of the survey unit could be developed. Biased soil samples were also collected at locations of elevated residual radioactivity identified by GWS. Samples within the excavation and exposed soil consisted of 30-centimeter (cm) surface samples. Samples outside the excavation consisted of the top 1-m composite from the core bore samples as footnoted in the data tables and as shown in the figures in red text. The FSS soil sampling locations are provided on Figure 16-7 and Figure 16-8. A total of 34 soil samples were collected throughout SU10, 28 over the areal footprint of SU10 (15 systematic and 13 GWS biased) and 6 within the remediation area of the former survey unit SU13 systematic Location 05 (1 systematic, 2 bounding and 3 biased).

All soil samples were analyzed on site via gamma spectroscopy analysis. Any remaining sieved material from each sample was analyzed separately to verify residual radioactivity was consistent with sample results. The radiological screening process did not identify any significant levels of radioactivity in the sieved materials removed from samples.

The C-T Phase II DP, Table 4-17, provided mean background activity levels of 1.3, 2.5, and 4.4 picoCuries per gram (pCi/g) for thorium-232 ( $^{232}\text{Th}$ ), radium-226 ( $^{226}\text{Ra}$ ), and uranium-238 ( $^{238}\text{U}$ ), respectively. These values were used to calculate net sum of fractions (SOF) values for

the individual sample results—note that when measured activity concentration levels were less than the background mean resulting in a negative value, the net activity concentration was set equal to zero for the net SOF calculation.

To mitigate the risk of backfilling, the on-site laboratory analytical results were reviewed to determine the likelihood of the survey unit failing to meet the criteria for radiological release. The on-site laboratory, by design, reported conservative sample results.

Table 16-1 provides the sample results and summary statistics for the 15 systematic samples as well as the former SU13 systematic sample location 5. Table 16-2 provides the sample results for the 13 GWS biased samples. Table 16-3 provides the sample results for the bounding samples to the east and west of the former SU13 systematic sample location 5. Table 16-4 provides the sample results for the 3 biased samples take following the remediation of the former SU13 systematic sample location 5.



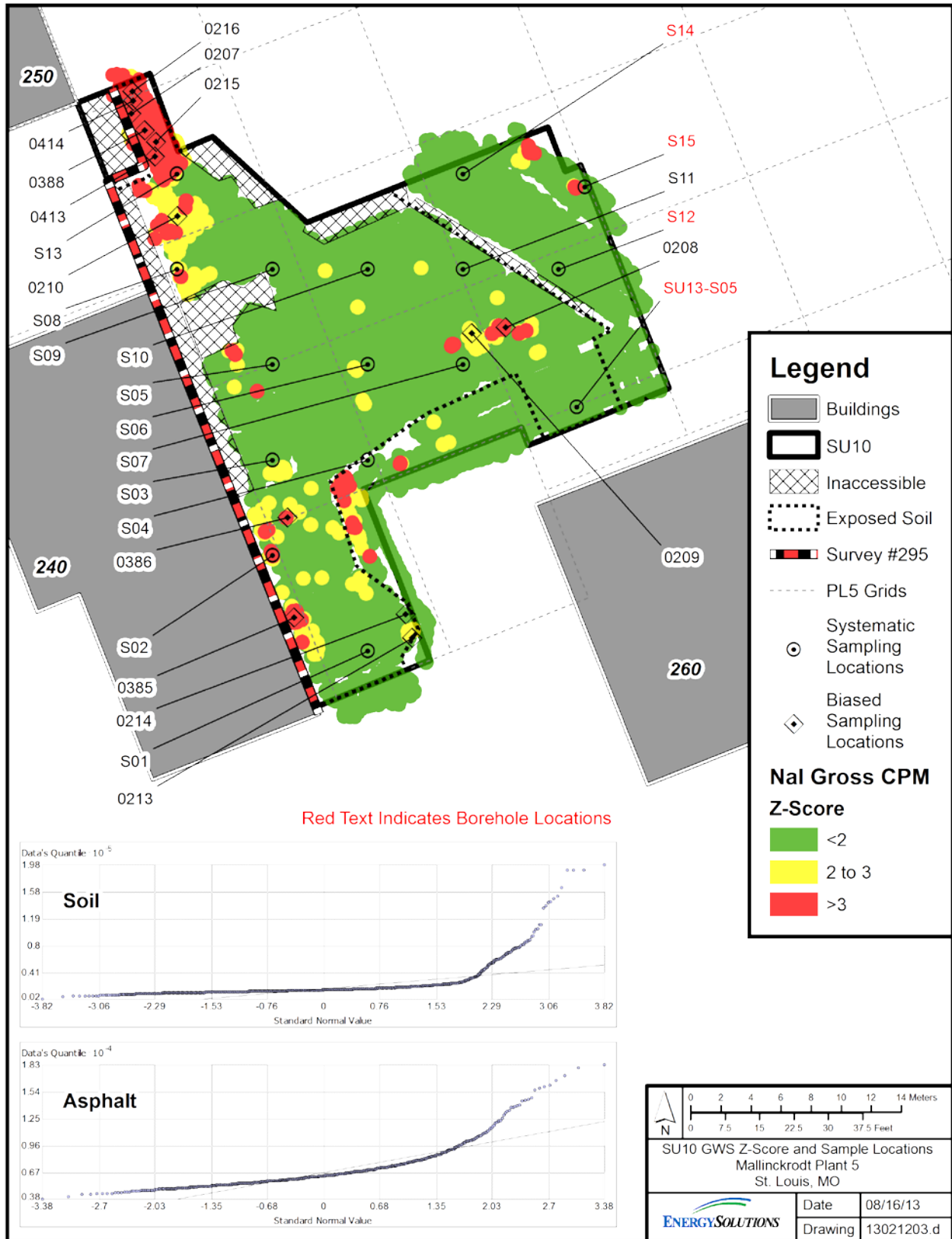
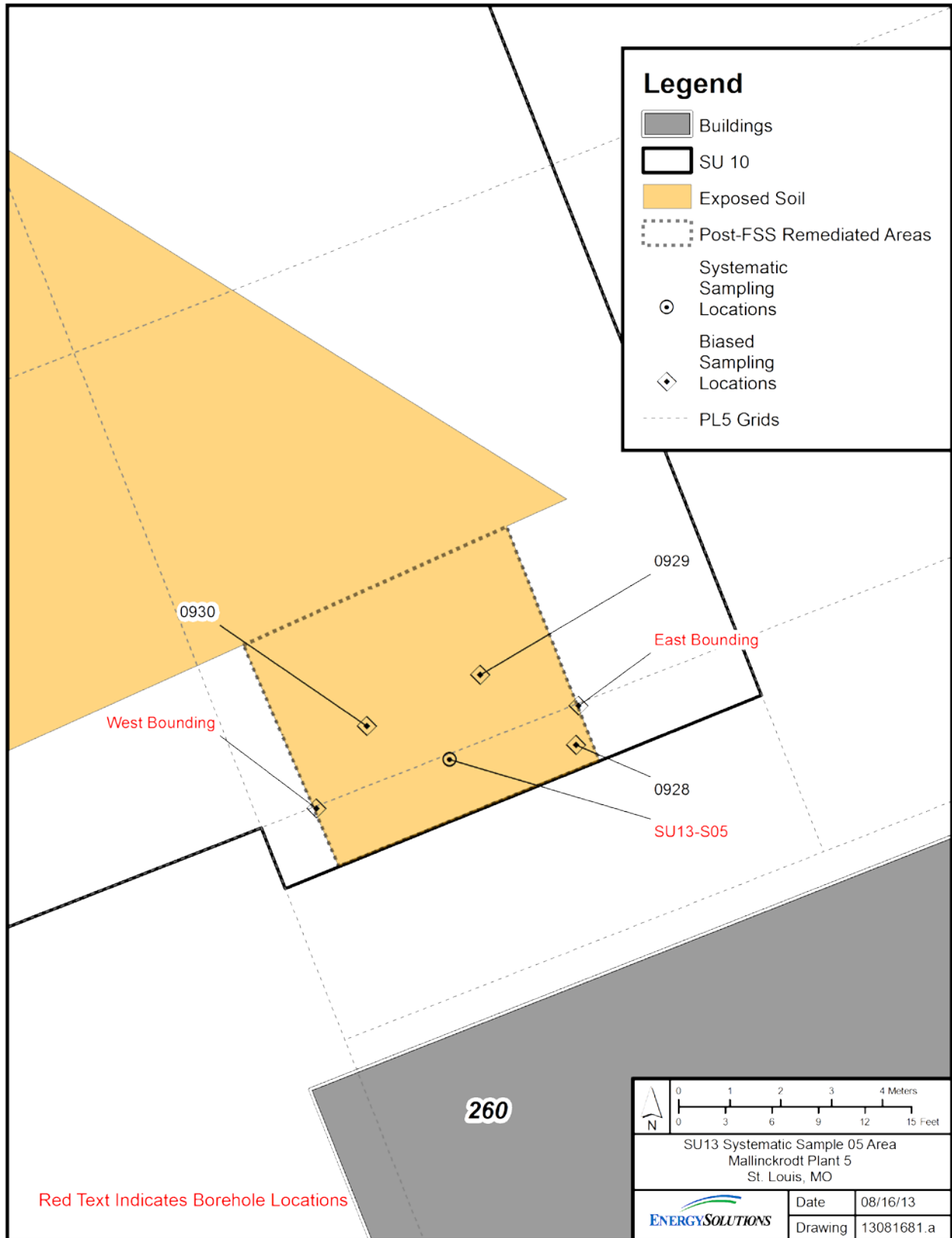


Figure 16-7 GWS and Soil Sampling Locations



**Figure 16-8 Former SU13 Systematic Sample Location 5 Soil Sampling Locations**

Table 16-1 Gamma Spectroscopy Systematic Sample Analytical Results

Loc.	Sample ID	Depth (ft bgs)	On-Site Results										Off-Site Results <sup>a</sup>										On-Site/ Off-Site Gross SOF Ratio							
			Activity Concentration (pCi/g) <sup>b</sup>										SOF <sup>c</sup>		Activity Concentration (pCi/g) <sup>b</sup>										SOF <sup>c</sup>					
			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U												
			Result	Unc. (2σ)	MDC	Result	Unc. (2σ)	MDC	Result	Unc. (2σ)	MDC	Gross	Net <sup>d</sup>	Result	Unc. (2σ)	MDC	Result	Unc. (2σ)	MDC	Result	Unc. (2σ)	MDC		Gross	Net <sup>d</sup>					
S01	0195	4	0.87	0.20	0.90	6.15	1.51	1.07	10.26	0.98	0.81	0.26	0.13	0.63	0.21	0.33	3.30	0.45	0.16	10.00	1.62	2.95	0.15	0.03	1.71					
S02	0196	3	1.47	0.39	0.20	17.52	2.62	1.73	21.87	1.79	1.57	<b>0.69</b>	<b>0.54</b>	1.33	0.37	0.27	6.51	0.84	0.22	25.00	3.22	3.58	0.31	0.17	2.21					
S03	0197	4	0.90	0.19	0.79	2.00	0.84	0.59	1.91	0.63	0.70	0.11	0.00	0.56	0.25	0.32	1.39	0.27	0.14	<i>1.39</i>	0.84	2.38	0.07	0.00	1.50					
S04	0198	1	1.00	0.28	0.85	2.33	1.01	0.72	2.62	0.69	0.65	0.12	0.00	1.02	0.23	0.10	1.66	0.29	0.15	3.02	1.75	2.28	0.10	0.00	1.21					
S05	0199	8	1.12	0.22	0.13	4.21	1.01	0.64	3.02	0.60	0.61	0.19	0.06	0.77	0.25	0.33	2.03	0.36	0.18	5.09	1.29	2.65	0.11	0.00	1.79					
S06	0200	5	0.92	0.27	0.12	8.53	1.08	1.15	11.00	1.09	0.98	0.34	0.21	0.96	0.25	0.28	4.41	0.58	0.18	11.50	2.84	3.01	0.21	0.07	1.67					
S07	0201	3	2.06	0.45	0.13	15.67	2.87	1.99	29.53	1.94	1.23	<b>0.66</b>	<b>0.51</b>	2.29	0.56	0.27	4.83	0.79	0.34	32.50	4.66	6.03	0.31	0.16	2.16					
S08	0387	7	8.69	0.61	0.21	8.23	1.59	1.10	7.63	2.14	0.96	<b>0.65</b>	<b>0.51</b>	8.96	1.16	0.28	5.24	0.69	0.34	7.30	3.33	4.06	<b>0.56</b>	0.42	1.16					
S09	0203	6	1.21	0.26	0.16	6.30	1.46	0.98	7.25	0.94	0.89	0.27	0.13	1.39	0.40	0.29	3.34	0.57	0.29	11.70	3.25	3.44	0.19	0.04	1.46					
S10	0204	5	0.94	0.21	0.12	10.80	1.79	1.19	13.10	1.18	1.00	0.42	0.29	1.34	0.36	0.23	3.61	0.49	0.15	14.30	3.23	3.11	0.20	0.05	2.14					
S11	0205	5	0.97	0.26	0.86	3.46	1.14	0.82	4.39	0.70	0.74	0.16	0.03	0.62	0.22	0.28	1.75	0.30	0.11	3.58	0.94	1.96	0.09	0.00	1.82					
S12	0229	0 <sup>e</sup>	0.78	0.25	0.90	3.06	1.20	0.89	4.17	0.89	0.54	0.14	0.02	0.70	0.27	0.41	2.02	0.37	0.21	6.01	1.23	2.38	0.11	0.00	1.34					
S13	0206	6	1.61	0.35	0.13	9.74	2.02	1.24	6.63	1.26	1.36	0.41	0.26	1.96	0.52	0.37	6.95	0.93	0.33	5.66	1.64	4.26	0.33	0.18	1.25					
S14	0224	0 <sup>e</sup>	0.64	0.17	0.42	2.53	0.85	0.59	1.73	0.38	0.40	0.12	0.00	<i>0.07</i>	0.19	0.65	2.26	0.43	0.24	<i>1.58</i>	1.12	2.99	0.08	0.00	1.41					
S15	0636	0 <sup>e</sup>	1.29	0.28	0.14	2.96	1.29	0.97	3.83	0.65	0.63	0.16	0.02	0.78	0.25	0.28	2.89	0.42	0.18	5.66	2.35	2.45	0.14	0.02	1.15					
SU13 S05 (Sample 0564)		5 <sup>f</sup>	1.65	0.31	0.14	3.63	1.57	1.18	9.16	0.96	0.73	0.21	0.06	Sample not sent to off-site laboratory (gross SOF < 0.5)																
Summary Statistics																														
Count:			16			16			16			16		16		15			15			15			15		15		15	
Average:			1.63			6.70			8.63			0.31		0.17		1.56			3.48			9.62			0.20		0.08		1.60	
Median:			1.06			5.18			6.94			0.23		0.10		0.96			3.30			6.01			0.15		0.03		1.50	
Standard Dev.:			1.92			4.77			7.61			0.20		0.20		2.12			1.77			8.75			0.13		0.11		0.37	
Minimum:			0.64			2.00			1.73			0.11		0.00		0.07			1.39			1.39			0.07		0.00		1.15	
Maximum:			8.69			17.52			29.53			<b>0.69</b>		<b>0.54</b>		8.96			6.95			32.50			<b>0.56</b>		0.42		2.21	
Range:			8.05			15.51			27.80			0.58		0.54		8.89			5.56			31.11			0.49		0.42		1.05	

<sup>a</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.

<sup>b</sup> Italicized results indicate <MDC.

<sup>c</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1.

<sup>d</sup> Calculated as discussed in Section 16.2.2.

<sup>e</sup> No excavation was performed at this location. Sample is the first 1-meter segment of the borehole collected at the location.

<sup>f</sup> Sample is the 2-3 m segment of the borehole collected at the location prior to remediation.

Table 16-2 Gamma Spectroscopy Biased Sample Analytical Results

Sample ID	Depth (ft bgs)	On-Site Results											Off-Site Results <sup>a</sup>											On-Site/ Off-Site Gross SOF Ratio
		Activity Concentration (pCi/g) <sup>b</sup>									SOF <sup>c</sup>		Activity Concentration (pCi/g) <sup>b</sup>									SOF <sup>c</sup>		
		<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			Gross	Net <sup>d</sup>	<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			Gross	Net <sup>d</sup>	
		Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC			
0207	6	4.31	0.46	0.16	11.06	2.20	1.54	22.35	1.54	1.04	<b>0.59</b>	0.44	4.25	0.64	0.22	2.48	0.42	0.21	27.90	4.81	4.17	0.30	0.16	1.95
0208	3	1.98	0.45	0.18	13.09	3.17	2.34	36.93	2.32	1.39	<b>0.58</b>	0.43	1.95	0.39	0.28	4.09	0.62	0.25	40.00	5.15	5.31	0.28	0.13	2.10
0209	4	1.74	0.42	0.20	24.23	4.22	3.04	61.87	3.35	1.70	<b>0.98</b>	<b>0.84</b>	1.49	0.42	0.46	6.64	0.85	0.27	61.80	7.20	5.55	0.37	0.23	2.63
0210	6	1.79	0.45	0.21	10.56	2.35	1.61	10.97	1.34	1.21	0.45	0.30	1.82	0.46	0.35	6.67	0.82	0.21	12.60	3.31	3.59	0.32	0.17	1.40
0385	4	1.11	0.26	0.10	25.53	3.41	2.39	57.25	3.65	1.39	<b>0.99</b>	<b>0.86</b>	0.84	0.51	0.77	3.83	0.73	0.41	81.70	10.90	6.47	0.28	0.15	3.57
0386	4	1.58	0.28	0.12	21.64	3.52	2.57	61.87	3.61	1.23	<b>0.89</b>	<b>0.74</b>	1.72	0.39	0.27	4.68	0.70	0.32	85.50	11.00	6.10	0.35	0.20	2.54
0213	3	1.58	0.48	0.21	22.79	4.80	3.61	82.61	4.26	2.10	<b>0.96</b>	<b>0.81</b>	1.46	0.53	0.93	6.29	1.01	0.50	103.00	14.60	10.20	0.42	0.27	2.29
0214	3	1.47	0.38	0.19	18.38	3.05	2.13	28.60	2.04	1.56	<b>0.73</b>	<b>0.58</b>	1.95	0.58	0.52	9.18	1.14	0.31	32.20	5.93	5.31	0.44	0.29	1.66
0215	6	1.72	0.30	0.14	7.69	1.81	1.25	11.96	1.20	1.13	0.35	0.20	1.68	0.37	0.23	2.60	0.40	0.17	13.70	3.29	3.11	0.18	0.03	1.97
0216	6	5.71	0.48	0.14	2.34	1.42	1.10	3.41	2.01	0.93	0.32	0.18	5.25	0.74	0.39	2.10	0.45	0.31	4.48	3.29	4.04	0.30	0.17	1.09
0388	6	28.61	1.41	0.27	10.45	2.53	1.92	16.50	4.36	1.79	<b>1.58</b>	<b>1.43</b>	26.40	2.88	0.71	6.00	0.81	0.41	15.60	4.89	5.87	<b>1.33</b>	<b>1.18</b>	1.18
0413	6	1.88	0.37	0.08	5.28	1.90	1.36	9.85	1.20	1.02	0.27	0.13	1.78	0.38	0.25	2.53	0.43	0.15	13.50	3.24	3.19	0.18	0.03	1.52
0414	6	6.85	0.56	0.19	6.07	1.93	1.44	11.70	1.25	1.09	<b>0.51</b>	0.36	5.79	0.74	0.23	2.57	0.41	0.24	12.10	3.99	4.29	0.35	0.20	1.47

<sup>a</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.

<sup>b</sup> Italicized results indicate <MDC.

<sup>c</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1 and **bolded red** SOF values indicate a result >1.

<sup>d</sup> Calculated as discussed in Section 16.2.2.



Table 16-3 Gamma Spectroscopy Former SU13 Systematic Sample Location 5 Bounding Sample Analytical Results

Sample Location	Sample ID	Sample Depth (m) <sup>a</sup>	On-Site Results											Off-Site Results <sup>b</sup>										Column SOF <sup>d</sup>		
			Activity Concentration (pCi/g) <sup>c</sup>									Sample SOF <sup>c</sup>		Activity Concentration (pCi/g) <sup>c</sup>									Sample SOF <sup>c</sup>			
			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U						
			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>e</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>e</sup>	Gross	Net <sup>e</sup>
SU13 SYS05 West Bounding	0565	0 - 1	2.11	0.37	0.22	19.51	2.26	1.24	7.59	1.05	0.97	<b>0.76</b>	<b>0.62</b>	Sample not sent to off-site laboratory (sample inadvertently disposed)										<b>0.76</b>	<b>0.62</b>	
	0566	1 - 2	1.33	0.24	0.12	6.45	1.36	0.87	3.73	0.70	0.68	0.28	0.14	Samples not sent to off-site laboratory (gross SOF < 0.5)										<b>0.52</b>	0.38	
	0567	2 - 3	1.50	0.33	0.12	3.51	1.23	0.86	3.69	0.64	0.60	0.19	0.04											0.41	0.26	
SU13 SYS05 East Bounding	0568	0 - 1	1.39	0.46	0.26	21.75	3.20	2.15	29.73	2.31	1.79	<b>0.84</b>	<b>0.69</b>	0.58	0.31	0.43	7.59	0.95	0.26	35.70	7.09	6.74	0.33	0.22	0.33	0.22
	0569	1 - 2	1.02	0.20	0.12	16.31	2.70	1.90	32.15	2.52	1.04	<b>0.64</b>	<b>0.51</b>	0.71	0.26	0.22	2.49	0.37	0.17	34.00	3.97	3.35	0.16	0.04	0.25	0.13
	0570	2 - 3	0.66	0.19	0.10	4.96	1.29	0.91	4.44	0.95	0.52	0.20	0.08	Sample not sent to off-site laboratory (gross SOF < 0.5)										0.23	0.11	

<sup>a</sup> Sampling was stopped when native clay soil was reached or refusal encountered.  
<sup>b</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.  
<sup>c</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1.  
<sup>d</sup> Calculated per Section 14.4.3.7 of C-T Phase II DP. Calculation of column SOF used on-site results unless off-site results were available.  
<sup>e</sup> Calculated as discussed in Section 16.2.2.

Table 16-4 Gamma Spectroscopy Former SU13 Systematic Sample Location 5 Biased Sample Analytical Results

Sample ID	Depth (ft bgs)	On-Site Results											Off-Site Results <sup>a</sup>										On-Site/ Off-Site Gross SOF Ratio	
		Activity Concentration (pCi/g) <sup>b</sup>									SOF <sup>c</sup>		Activity Concentration (pCi/g) <sup>b</sup>									SOF <sup>c</sup>		
		<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					
		Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>d</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross		Net <sup>d</sup>
0928	1	1.19	0.31	0.15	16.17	2.60	1.80	16.22	1.63	1.66	<b>0.62</b>	0.48	1.00	0.35	0.43	7.99	0.95	0.22	17.40	4.07	4.75	0.34	0.20	1.84
0929	5	1.07	0.29	0.19	10.89	2.51	1.85	28.33	1.72	1.07	0.45	0.32	1.31	0.34	0.15	3.08	0.48	0.18	37.70	5.88	4.48	0.21	0.07	2.15
0930	3	0.95	0.25	0.08	4.71	1.09	0.76	6.95	0.67	0.53	0.21	0.08	0.88	0.22	0.14	0.92	0.18	0.14	8.91	1.46	2.32	0.08	0.01	2.61

<sup>a</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.  
<sup>b</sup> Italicized results indicate <MDC.  
<sup>c</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1 and **bolded red** SOF values indicate a result >1.  
<sup>d</sup> Calculated as discussed in Section 16.2.2.

### 16.2.3 Core Boring

C-T Phase II DP Tables 4-7, 4-15, and 4-16 provided characterization borehole results. Of the locations provided in the tables, nine were collected within the extent of SU10. Table 16-5 provides the data for these locations.

**Table 16-5 Characterization Borehole Results**

Location ID	Sample Depth (ft)	Activity Concentration (pCi/g) <sup>a</sup>			SOF <sup>b</sup>	
		<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>c</sup>
BH-025	2.5 - 3.5	0.66	4.10	81.80	0.28	0.16
	4 - 5	0.71	2.33	65.10	0.20	0.08
	8 - 9	0.76	1.60	76.00	0.19	0.10
BH-026	3 - 4		13.70	8.15	0.48	0.39
	4 - 5	0.48	21.90	17.80	<b>0.79</b>	<b>0.68</b>
	5 - 6		1.29	13.30	0.06	0.01
	7 - 8		<i>0.64</i>	11.30	0.04	0.01
	9 - 10		1.21	2.23	0.04	0.00
	12 - 13	0.96	8.50	8.20	0.34	0.21
	15 - 16	1.10	1.20	1.00	0.09	0.00
BH-085	1 - 1.5	0.69	1.48	2.10	0.08	0.00
	3 - 4.5	0.96	1.60	2.89	0.10	0.00
	6 - 7.5	0.45	0.54	0.63	0.04	0.00
	7.5 - 9	0.93	0.55	0.93	0.06	0.00
JA-02	0 - 1	2.16	13.44	89.96	<b>0.67</b>	<b>0.53</b>
JA-03	0 - 1	3.07	28.08	28.39	<b>1.12</b>	<b>0.98</b>
JA-04	0 - 1	8.24	132.80	33.46	<b>4.91</b>	<b>4.76</b>
JA-05	0 - 1	1.95	4.79	26.87	0.28	0.14
JA-06	0 - 1	5.88	242.70	36.27	<b>8.55</b>	<b>8.41</b>
JA-07	0 - 1	2.50	2.49	51.91	0.26	0.12

<sup>a</sup> Italicized results indicate <MDC. No value indicates no result was provided.

<sup>b</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1 and **bolded red** SOF values indicate a result >1.

<sup>c</sup> Calculated as discussed in Section 16.2.2.

AECOM Technical Services (AECOM) also collected numerous supplemental characterization core boring samples within the extent of SU10. Table 16-6 provides these results. During the sampling effort, AECOM noted that the clay layer depth ranged between 7 and 16 ft bgs.

Table 16-6 AECOM Supplemental Characterization Borehole Results

Location ID	Sample ID	Sample Depth (m)	Activity Concentration (pCi/g)			Sample SOF <sup>a</sup>		Column SOF <sup>a, b</sup>	
			<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>c</sup>	Gross	Net <sup>c</sup>
A11-1	4533	0 - 1	1.49	4.64	6.89	0.23	0.08	0.23	0.08
	4534	1 - 2	1.66	5.04	11.65	0.26	0.11	0.24	0.10
	4535	2 - 3	0.88	4.54	14.12	0.21	0.08	0.23	0.09
	4536	3 - 4	0.76	1.83	11.54	0.11	0.01	0.20	0.06
	4537	4 - 5	1.42	1.81	5.85	0.13	0.01	0.19	0.04
B9-2	4675	0 - 1	0.82	1.44	4.38	0.09	0.00	0.09	0.00
	4676	1 - 2	0.90	3.12	4.42	0.15	0.02	0.12	0.00
	4677	2 - 3	1.02	1.68	3.33	0.10	0.00	0.11	0.00
	4678	3 - 4	0.87	0.94	0.93	0.07	0.00	0.10	0.00
	4679	4 - 5	1.09	1.64	1.40	0.10	0.00	0.10	0.00
	4680	5 - 6	1.17	1.81	0.74	0.11	0.00	0.10	0.00
C9-2	4660	0 - 1	0.96	1.68	5.07	0.10	0.00	0.10	0.00
	4661	1 - 2	0.83	1.02	2.45	0.07	0.00	0.09	0.00
	4662	2 - 3	0.76	3.84	16.80	0.19	0.06	0.12	0.01
	4663	3 - 4	0.85	1.14	4.50	0.08	0.00	0.11	0.00
	4664	4 - 5	1.17	0.93	2.28	0.08	0.00	0.11	0.00
C9-6	4691	0 - 1	1.02	1.85	7.33	0.12	0.00	0.12	0.00
	4692	1 - 2	0.77	1.25	3.16	0.08	0.00	0.10	0.00
	4693	2 - 3	0.65	1.83	4.10	0.10	0.00	0.10	0.00
	4694	3 - 4	0.87	2.86	10.73	0.15	0.02	0.11	0.00
	4695	4 - 5	1.06	1.54	2.74	0.10	0.00	0.11	0.00
C10-1	4570	0 - 1	1.31	4.23	10.31	0.21	0.07	0.21	0.07
	4571	1 - 2	1.16	3.40	7.00	0.17	0.03	0.19	0.05
	4572	2 - 3	0.97	2.42	7.74	0.13	0.00	0.17	0.03
	4573	3 - 4	1.34	3.48	12.69	0.19	0.05	0.18	0.04
	4574	4 - 5	1.54	8.19	12.21	0.36	0.21	0.21	0.07
	4575	5 - 6	1.38	9.87	12.81	0.41	0.27	0.25	0.10
C11-1	4518	0 - 1	0.84	1.97	3.33	0.11	0.00	0.11	0.00
	4519	1 - 2	1.32	3.77	2.66	0.19	0.04	0.15	0.01
	4520	2 - 3	1.31	6.48	19.96	0.30	0.16	0.20	0.06
	4521	3 - 4	1.29	1.72	5.38	0.12	0.00	0.18	0.04
Clay layer reached at 12.25 ft bgs									
C11-2	4522	0 - 1	0.98	2.43	2.16	0.13	0.00	0.13	0.00
	4523	1 - 2	0.88	1.88	1.96	0.10	0.00	0.12	0.00
	4524	2 - 3	1.03	1.74	2.26	0.11	0.00	0.11	0.00
	4525	3 - 4	0.93	1.17	2.41	0.08	0.00	0.10	0.00
	4526	4 - 5	1.13	1.24	3.23	0.09	0.00	0.10	0.00
D9-3	4632	0 - 1	0.86	4.42	4.73	0.19	0.07	0.19	0.07
	Refusal at 5 ft bgs								
D9-3A	4633	0 - 1	0.99	1.85	3.59	0.11	0.00	0.11	0.00
	4634	1 - 2	0.99	2.79	3.31	0.14	0.01	0.13	0.00
	4635	2 - 3	1.20	5.50	14.37	0.26	0.12	0.17	0.03
	4636	3 - 4	5.34	26.94	31.52	<b>1.18</b>	<b>1.04</b>	0.42	0.28
	4637	4 - 5	0.83	2.31	3.69	0.12	0.00	0.36	0.22
D10-2	Refusal at 2 ft bgs								

Table 16-6 AECOM Supplemental Characterization Borehole Results (continued)

Location ID	Sample ID	Sample Depth (m)	Activity Concentration (pCi/g)			Sample SOF <sup>a</sup>		Column SOF <sup>a, b</sup>		
			<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>c</sup>	Gross	Net <sup>c</sup>	
SA-240-01	4896	0 - 1	3.61	907.99	22.39	<b>31.07</b>	<b>30.92</b>	<b>31.07</b>	<b>30.92</b>	
	4897	1 - 2	1.83	192.92	28.43	<b>6.68</b>	<b>6.53</b>	<b>18.87</b>	<b>18.73</b>	
	4902	2 - 3	1.84	158.07	7.45	<b>5.46</b>	<b>5.32</b>	<b>14.40</b>	<b>14.26</b>	
	--	3 - 4	No recovery							
	4903	4 - 5	1.31	30.12	2.67	<b>1.08</b>	<b>0.94</b>	<b>11.07</b>	<b>10.93</b>	
SA-240-02	4898	0 - 1	0.79	6.23	6.49	0.25	0.13	0.25	0.13	
	4899	1 - 2	0.60	2.77	8.22	0.13	0.01	0.19	0.07	
	4904	2 - 3	1.06	2.81	4.13	0.15	0.01	0.18	0.05	
	4905	3 - 4	1.14	1.30	3.05	0.10	0.00	0.16	0.03	
	4906	4 - 5	1.00	1.49	1.71	0.09	0.00	0.14	0.01	
SA-240-03	4900	0 - 1	0.80	10.60	4.73	0.40	0.28	0.40	0.28	
	4901	1 - 2	0.53	1.50	2.05	0.08	0.00	0.24	0.12	
	4909	2 - 3	1.11	2.21	2.91	0.13	0.00	0.20	0.08	
	--	3 - 4	No recovery							
SA-240-04	4910	4 - 5	1.16	1.43	1.67	0.10	0.00	0.18	0.05	
	4907	0 - 1	0.84	2.23	2.41	0.11	0.00	0.11	0.00	
	4908	1 - 2	0.78	3.32	3.13	0.15	0.03	0.13	0.01	
	4911	2 - 3	1.13	1.71	3.58	0.11	0.00	0.12	0.00	
	4912	3 - 4	1.11	1.97	2.60	0.12	0.00	0.12	0.00	
SA-240-05	4913	4 - 5	0.93	1.41	1.20	0.09	0.00	0.12	0.00	
	4914	0 - 1	Field screening indicated very high activity; sample not analyzed							
	--	1 - 2	No recovery							
	--	2 - 3	No recovery							
	4917	3 - 4	3.30	526.49	41.86	<b>18.10</b>	<b>17.96</b>	<b>18.10</b>	<b>17.96</b>	
SA-240-06	4918	4 - 5	1.74	71.74	8.25	<b>2.52</b>	<b>2.38</b>	<b>10.31</b>	<b>10.17</b>	
	4915	0 - 1	0.87	44.22	5.67	<b>1.55</b>	<b>1.42</b>	<b>1.55</b>	<b>1.42</b>	
	4916	1 - 2	0.79	8.22	8.02	0.32	0.20	<b>0.94</b>	<b>0.81</b>	
	4919	2 - 3	1.32	2.94	13.36	0.17	0.03	<b>0.68</b>	<b>0.55</b>	
	4920	3 - 4	1.09	2.93	1.90	0.15	0.01	<b>0.55</b>	0.41	
	4921	4 - 5	0.94	1.28	1.79	0.09	0.00	0.46	0.32	
SB-041	4982	0 - 1	1.17	8.53	17.24	0.36	0.22	0.36	0.22	
	4983	1 - 2	1.44	6.63	7.48	0.30	0.15	0.33	0.18	
	4984	2 - 3	1.34	1.66	2.00	0.12	0.00	0.26	0.11	
	4985	3 - 4	1.09	0.98	2.27	0.08	0.00	0.21	0.07	
	4986	4 - 5	1.07	1.54	1.49	0.10	0.00	0.19	0.05	
SB-042	4987	0 - 1	4.88	45.31	64.59	<b>1.84</b>	<b>1.69</b>	<b>1.84</b>	<b>1.69</b>	
	4988	1 - 2	5.11	42.26	34.34	<b>1.70</b>	<b>1.55</b>	<b>1.77</b>	<b>1.62</b>	
	4989	2 - 3	1.18	2.96	21.30	0.18	0.04	<b>1.24</b>	<b>1.09</b>	
	4990	3 - 4	1.14	2.39	10.66	0.14	0.01	<b>0.96</b>	<b>0.82</b>	
	4991	4 - 5	1.14	3.67	8.00	0.18	0.04	<b>0.81</b>	<b>0.66</b>	
SB-043	4992	0 - 1	4.80	38.42	13.44	<b>1.53</b>	<b>1.38</b>	<b>1.53</b>	<b>1.38</b>	
	4993	1 - 2	2.04	11.83	4.28	0.49	0.35	<b>1.01</b>	<b>0.86</b>	
	--	2 - 3	No recovery							
	4994	3 - 4	1.33	1.80	2.60	0.12	0.00	<b>0.71</b>	<b>0.57</b>	
	4995	4 - 5	1.32	1.54	1.60	0.11	0.00	<b>0.56</b>	0.42	

Table 16-6 AECOM Supplemental Characterization Borehole Results (continued)

Location ID	Sample ID	Sample Depth (m)	Activity Concentration (pCi/g)			Sample SOF <sup>a</sup>		Column SOF <sup>a, b</sup>	
			<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>c</sup>	Gross	Net <sup>c</sup>
SB-044	4996	0 - 1	0.65	2.64	1.01	0.12	0.00	0.12	0.00
	4997	1 - 2	0.85	13.63	5.73	<b>0.51</b>	0.38	0.31	0.19
	--	2 - 3	No recovery						
	4998	3 - 4	1.18	1.78	1.43	0.11	0.00	0.25	0.12
	4999	4 - 5	1.29	1.37	2.99	0.10	0.00	0.21	0.08
SB-045	6500	0 - 1	0.77	27.17	81.34	<b>1.07</b>	<b>0.95</b>	<b>1.07</b>	<b>0.95</b>
	6501	1 - 2	0.78	4.76	18.02	0.22	0.10	<b>0.64</b>	<b>0.52</b>
	6502	2 - 3	1.00	2.81	4.67	0.14	0.01	0.48	0.35
	6503	3 - 4	1.18	2.91	7.14	0.16	0.02	0.40	0.27
	6504	4 - 5	1.00	1.25	4.36	0.09	0.00	0.34	0.21
SB-046	6505	0 - 1	1.26	87.44	35.84	<b>3.08</b>	<b>2.93</b>	<b>3.08</b>	<b>2.93</b>
	6506	1 - 2	0.78	9.33	15.21	0.37	0.25	<b>1.72</b>	<b>1.59</b>
	6507	2 - 3	1.17	5.41	8.89	0.25	0.11	<b>1.23</b>	<b>1.10</b>
	6508	3 - 4	1.05	4.46	5.82	0.20	0.07	<b>0.97</b>	<b>0.84</b>
	6509	4 - 5	1.20	2.40	3.29	0.14	0.00	<b>0.81</b>	<b>0.67</b>
SB-047	6510	0 - 1	0.68	14.93	38.69	<b>0.59</b>	0.47	<b>0.59</b>	0.47
	6511	1 - 2	0.90	10.10	12.79	0.40	0.27	0.49	0.37
	6512	2 - 3	1.23	1.35	2.68	0.10	0.00	0.36	0.23
	6513	3 - 4	1.56	2.97	2.51	0.17	0.03	0.31	0.18
	6514	4 - 5	1.21	1.85	1.77	0.12	0.00	0.28	0.14
SB-048	6515	0 - 1	12.39	1,631.40	42.48	<b>56.07</b>	<b>55.92</b>	<b>56.07</b>	<b>55.92</b>
	6516	1 - 2	2.26	383.47	58.32	<b>13.22</b>	<b>13.07</b>	<b>34.64</b>	<b>34.50</b>
	6517	2 - 3	1.16	4.52	9.61	0.22	0.08	<b>23.17</b>	<b>23.02</b>
	6518	3 - 4	1.44	31.80	6.07	<b>1.15</b>	<b>1.00</b>	<b>17.66</b>	<b>17.52</b>
	6519	4 - 5	1.34	7.62	2.46	0.32	0.18	<b>14.19</b>	<b>14.05</b>
SB-068	6610	0 - 1	6.13	63.80	67.33	<b>2.52</b>	<b>2.37</b>	<b>2.52</b>	<b>2.37</b>
	6611	1 - 2	10.50	63.27	54.01	<b>2.67</b>	<b>2.52</b>	<b>2.59</b>	<b>2.45</b>
	6612	2 - 3	19.36	73.60	73.18	<b>3.41</b>	<b>3.27</b>	<b>2.87</b>	<b>2.72</b>
	--	3 - 4	No recovery						
	--	4 - 5	No recovery						
SB-069	6613	0 - 1	3.81	205.51	387.18	<b>7.69</b>	<b>7.54</b>	<b>7.69</b>	<b>7.54</b>
	6614	1 - 2	10.81	57.44	118.48	<b>2.57</b>	<b>2.42</b>	<b>5.13</b>	<b>4.98</b>
	--	2 - 3	No recovery						
	6615	3 - 4	1.12	1.89	2.85	0.12	0.00	<b>3.46</b>	<b>3.31</b>
	6616	4 - 5	1.15	3.67	8.45	0.18	0.05	<b>2.64</b>	<b>2.49</b>

<sup>a</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1 and **bolded red** SOF values indicate a result >1.

<sup>b</sup> Calculated per Section 14.4.3.7 of C-T Phase II DP

<sup>c</sup> Calculated as discussed in Section 16.2.2.

In accordance with Page 14-22 of the C-T Phase II DP, FSS core sampling was performed for two reasons: 1) it was reasonably suspected that subsoil contamination existed below the unexcavated areas and 2) to demonstrate that contaminated soil above the DCGLs did not exist under the excavation extent. EnergySolutions collected borehole samples at each systematic sample location throughout SU10 as shown in Figure 16-7 with the exception of systematic sample 2 (S02) which was too close to Building 240 to collect. Table 16-7 provides the results of the borehole samples collected at each FSS systematic location. Boreholes located at locations

within the general excavation were performed following remediation. As a result, the initial sample composites as indicated in Table 16-7 reflect that the soil column had been excavated as part of remediation and that background fill would be used for column averaging.

Six additional biased borehole locations were also sampled including the 2 bounding samples around systematic sample location 5 from SU13 as shown in Figure 16-8 and 4 from the general excavation of SU10 as shown in Figure 16-7. Table 16-3 provides the results of the bounding borehole samples while Table 16-8 provides the results for the additional biased boreholes within the general excavation.

In accordance with Table 14-5 of the C-T Phase II DP, the Class 1 subsurface investigation level is the  $DCGL_w$  (1 SOF) plus the mean of background (0.15 SOF) plus six standard deviations of background ( $6 \times 0.09 \text{ SOF} = 0.54 \text{ SOF}$ ), using data from Tables 4-17 and B-1. This evaluates to a gross SOF of 1.69. All borehole samples were below this investigation level. Figure 16-9 shows a summary of all sampling locations performed including all characterization and FSS samples.

Table 16-7 Gamma Spectroscopy Systematic Borehole Sample Analytical Results

Sample Location	Sample ID	Sample Depth (m) <sup>a</sup>	On-Site Results										Off-Site Results <sup>b</sup>										Column SOF <sup>e</sup>	
			Activity Concentration (pCi/g) <sup>c</sup>									Sample SOF <sup>d</sup>		Activity Concentration (pCi/g) <sup>c</sup>										
			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U				
			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>f</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>e</sup>
S01	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample									0.15	0.00
	0265	1 - 2	1.06	0.21	0.10	2.78	1.19	0.88	6.84	0.72	0.59	0.15	0.01	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.15	0.01
	0266	2 - 3	1.23	0.23	0.03	5.11	1.49	1.06	9.09	0.90	0.72	0.24	0.10										0.18	0.04
S03	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample									0.15	0.00
	0301	1 - 2	1.01	0.23	0.06	1.73	0.84	0.60	1.56	0.45	0.45	0.10	0.00	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.12	0.00
	0302	2 - 3	1.29	0.23	0.10	1.56	0.84	0.61	2.52	0.56	0.58	0.11	0.00										0.12	0.00
S04	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample									0.15	0.00
	0296	1 - 2	0.69	0.26	0.10	2.01	0.89	0.63	2.12	0.51	0.50	0.10	0.00	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.12	0.00
	0297	2 - 3	1.42	0.29	0.06	1.93	0.96	0.70	2.49	0.48	0.48	0.13	0.01										0.12	0.00
S05	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No samples									0.15	0.00
	--	1 - 2										0.15	0.00										0.15	0.00
	0258	2 - 3	1.22	0.24	0.08	3.00	1.23	0.91	6.01	0.76	0.69	0.16	0.02	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.15	0.01
	0259	3 - 4	1.41	0.25	0.06	2.76	1.33	1.00	5.15	0.74	0.67	0.16	0.01										0.15	0.01
S06	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample									0.15	0.00
	0250	1 - 2	0.68	0.17	0.07	2.03	1.26	0.97	6.42	0.61	0.44	0.11	0.00	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.13	0.00
	0251	2 - 3	1.48	0.24	0.09	2.17	0.98	0.71	2.60	0.62	0.61	0.14	0.01										0.13	0.00
S07	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample									0.15	0.00
	0254	1 - 2	0.43	0.13	0.03	2.34	0.95	0.71	4.62	0.75	0.38	0.10	0.00	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.12	0.00
	0255	2 - 3	0.96	0.21	0.12	1.37	0.89	0.68	3.06	0.49	0.46	0.09	0.00										0.11	0.00
S08	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No samples									0.15	0.00
	--	1 - 2										0.15	0.00										0.15	0.00
	0291	2 - 3	1.55	0.26	0.06	2.67	0.94	0.64	1.83	0.58	0.49	0.16	0.02	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.15	0.01
	0292	3 - 4	1.32	0.26	0.09	1.87	0.88	0.63	1.69	0.42	0.44	0.12	0.00										0.14	0.00
S09	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No samples									0.15	0.00
	--	1 - 2										0.15	0.00										0.15	0.00
	0300	2 - 3	1.14	0.22	0.10	2.10	0.85	0.60	1.79	0.47	0.39	0.12	0.00	Sample not sent to off-site laboratory (gross SOF < 0.5)									0.14	0.00
S10	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample									0.15	0.00
	0298	1 - 2	1.07	0.21	0.06	2.21	0.84	0.59	2.32	0.47	0.47	0.12	0.00	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.13	0.00
	0299	2 - 3	1.33	0.25	0.09	1.62	0.85	0.63	2.08	0.53	0.46	0.11	0.00										0.13	0.00
S11	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample									0.15	0.00
	0256	1 - 2	0.78	0.18	0.07	3.10	1.09	0.80	4.67	0.72	0.41	0.14	0.02	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.15	0.01
	0257	2 - 3	1.40	0.31	0.09	2.05	1.14	0.86	3.60	0.66	0.64	0.13	0.00										0.14	0.00
S12	0229	0 - 1	0.78	0.25	0.90	3.06	1.20	0.89	4.17	0.89	0.54	0.14	0.02										0.14	0.02
	0230	1 - 2	1.34	0.27	0.10	6.92	2.26	1.69	19.09	1.38	0.91	0.32	0.17	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.23	0.09
	0231	2 - 3	1.11	0.25	0.93	3.35	1.45	1.09	7.54	0.80	0.64	0.17	0.03										0.21	0.07
	0232	3 - 4	1.19	0.23	0.13	2.40	1.10	0.82	4.02	0.59	0.57	0.14	0.00										0.19	0.05
	0233	4 - 5	1.32	0.31	0.18	2.03	1.28	0.98	4.18	0.62	0.54	0.13	0.00										0.18	0.04
S13	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No samples									0.15	0.00
	--	1 - 2										0.15	0.00										0.15	0.00
	0262	2 - 3	1.43	0.30	0.19	10.22	1.63	0.97	5.35	0.91	0.81	0.41	0.27	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.24	0.09
	0263	3 - 4	1.04	0.29	0.16	2.11	1.16	0.88	3.84	0.66	0.63	0.12	0.00										0.21	0.06
	0264	4 - 5	1.56	0.26	0.08	2.55	0.77	0.50	1.85	0.54	0.46	0.15	0.01										0.20	0.05
S14	0224	0 - 1	0.64	0.17	0.42	2.53	0.85	0.59	1.73	0.38	0.40	0.12	0.00	Samples not sent to off-site laboratory (gross SOF < 0.5)									0.12	0.00
	0225	1 - 2	1.51	0.34	0.16	5.27	1.81	1.35	9.99	1.03	0.98	0.26	0.11										0.19	0.05
	0226	2 - 3	1.06	0.23	0.93	3.05	1.14	0.83	3.61	0.52	0.44	0.15	0.02										0.17	0.04
	0227	3 - 4	1.09	0.27	0.65	2.41	1.11	0.81	3.22	0.63	0.63	0.13	0.00										0.16	0.03
	0228	4 - 5	1.12	0.26	0.67	1.41	0.70	0.50	1.47	0.35	0.38	0.10	0.00										0.15	0.01

Table 16-7 Gamma Spectroscopy Systematic Borehole Sample Analytical Results (continued)

Sample Location	Sample ID	Sample Depth (m) <sup>a</sup>	On-Site Results											Off-Site Results <sup>b</sup>										Column SOF <sup>e</sup>		
			Activity Concentration (pCi/g) <sup>c</sup>									Sample SOF <sup>d</sup>		Activity Concentration (pCi/g) <sup>c</sup>									Sample SOF <sup>d</sup>			
			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U						
			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>f</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross
S15	0636	0 - 1	1.29	0.28	0.14	2.96	1.29	0.97	3.83	0.65	0.63	0.16	0.02	Samples not sent to off-site laboratory (gross SOF < 0.5)										0.16	0.02	
	0637	1 - 2	1.26	0.22	0.03	1.16	1.05	0.81	2.74	0.58	0.54	0.10	0.00											0.13	0.00	
	0638	2 - 3	0.83	0.22	0.07	0.88	1.16	0.92	3.90	0.60	0.51	0.07	0.00											0.11	0.00	
	0639	3 - 4	1.26	0.28	0.10	5.72	2.16	1.62	13.65	1.21	0.83	0.27	0.12											0.15	0.01	
	0640	4 - 5	7.57	0.76	0.43	36.88	4.69	3.07	29.00	2.80	1.55	<b>1.61</b>	<b>1.47</b>	6.50	0.90	0.58	28.70	3.13	0.39	29.40	6.26	6.43	<b>1.29</b>	<b>1.14</b>	0.38	0.23
SU13 S05	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No samples										0.15	0.00	
	--	1 - 2										0.15	0.00											0.15	0.00	
	0564	2 - 3	1.65	0.31	0.14	3.63	1.57	1.18	9.16	0.96	0.73	0.21	0.06	Sample not sent to off-site laboratory (gross SOF < 0.5)										0.17	0.02	

<sup>a</sup> When borehole samples were collected from remediated areas, for example Location 1 which was remediated down to 5 ft bgs, samples were assigned to the nearest one-meter increment. Sampling was stopped when native clay soil was reached or refusal encountered.

<sup>b</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.

<sup>c</sup> Italicized results indicate <MDC.

<sup>d</sup> **Bolded red** SOF values indicate a result >1.

<sup>e</sup> Calculated per Section 14.4.3.7 of C-T Phase II DP. Calculation of column SOF used on-site results unless off-site results were available.

<sup>f</sup> Calculated as discussed in Section 16.2.2.

Table 16-8 Gamma Spectroscopy Biased Borehole Sample Analytical Results

Sample Location	Sample ID	Sample Depth (m) <sup>a</sup>	On-Site Results											Off-Site Results <sup>b</sup>										Column SOF <sup>d</sup>		
			Activity Concentration (pCi/g) <sup>c</sup>									Sample SOF <sup>e</sup>		Activity Concentration (pCi/g) <sup>c</sup>									Sample SOF <sup>e</sup>			
			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U						
			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>e</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross
B02 (0208) <sup>f</sup>	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample										0.15	0.00	
	0252	1 - 2	1.75	0.40	0.19	8.73	2.41	1.78	21.05	1.54	1.07	0.40	0.25	Samples not sent to off-site laboratory (gross SOF < 0.5)										0.27	0.13	
	0253	2 - 3	1.30	0.25	0.14	4.12	1.41	1.03	9.18	0.92	0.78	0.21	0.06											0.25	0.11	
B04 (0210) <sup>f</sup>	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No samples										0.15	0.00	
	--	1 - 2										0.15	0.00											0.15	0.00	
	0293	2 - 3	1.79	0.34	0.17	9.23	1.92	1.28	9.05	0.94	0.81	0.40	0.26	Samples not sent to off-site laboratory (gross SOF < 0.5)										0.23	0.09	
	0294	3 - 4	1.16	0.26	0.09	2.32	1.08	0.79	2.86	0.58	0.54	0.13	0.00											0.21	0.06	
B05 (0385) <sup>f</sup>	0295	4 - 5	1.53	0.28	0.09	2.09	0.80	0.55	2.02	1.23	0.52	0.14	0.01											0.19	0.05	
	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample										0.15	0.00	
	0303	1 - 2	0.56	0.15	0.05	8.79	2.01	1.52	15.61	1.51	0.66	0.34	0.23	Sample not sent to off-site laboratory (gross SOF < 0.5)										0.24	0.11	
B08 (0214) <sup>f</sup>	0304	2 - 3	1.08	0.24	0.13	21.73	3.91	2.88	78.72	3.83	1.50	<b>0.89</b>	<b>0.76</b>	0.55	0.35	0.45	1.13	0.36	0.32	115.00	14.20	6.64	0.22	0.15	0.24	0.11
	--	0 - 1	Soil excavated; reference area background used for column average calculations									0.15	0.00	No sample										0.15	0.00	
	0260	1 - 2	0.86	0.21	0.08	6.09	1.52	1.10	10.56	1.43	0.71	0.26	0.13	Samples not sent to off-site laboratory (gross SOF < 0.5)										0.20	0.07	
	0261	2 - 3	1.41	0.25	0.12	5.39	1.73	1.29	15.51	1.21	0.88	0.26	0.12											0.22	0.08	

<sup>a</sup> Sampling was stopped when native clay soil was reached or refusal encountered.

<sup>b</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.

<sup>c</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1.

<sup>d</sup> Calculated per Section 14.4.3.7 of C-T Phase II DP. Calculation of column SOF used on-site results unless off-site results were available.

<sup>e</sup> Calculated as discussed in Section 16.2.2.

<sup>f</sup> Corresponding biased sample location as provided in Figure 16-7



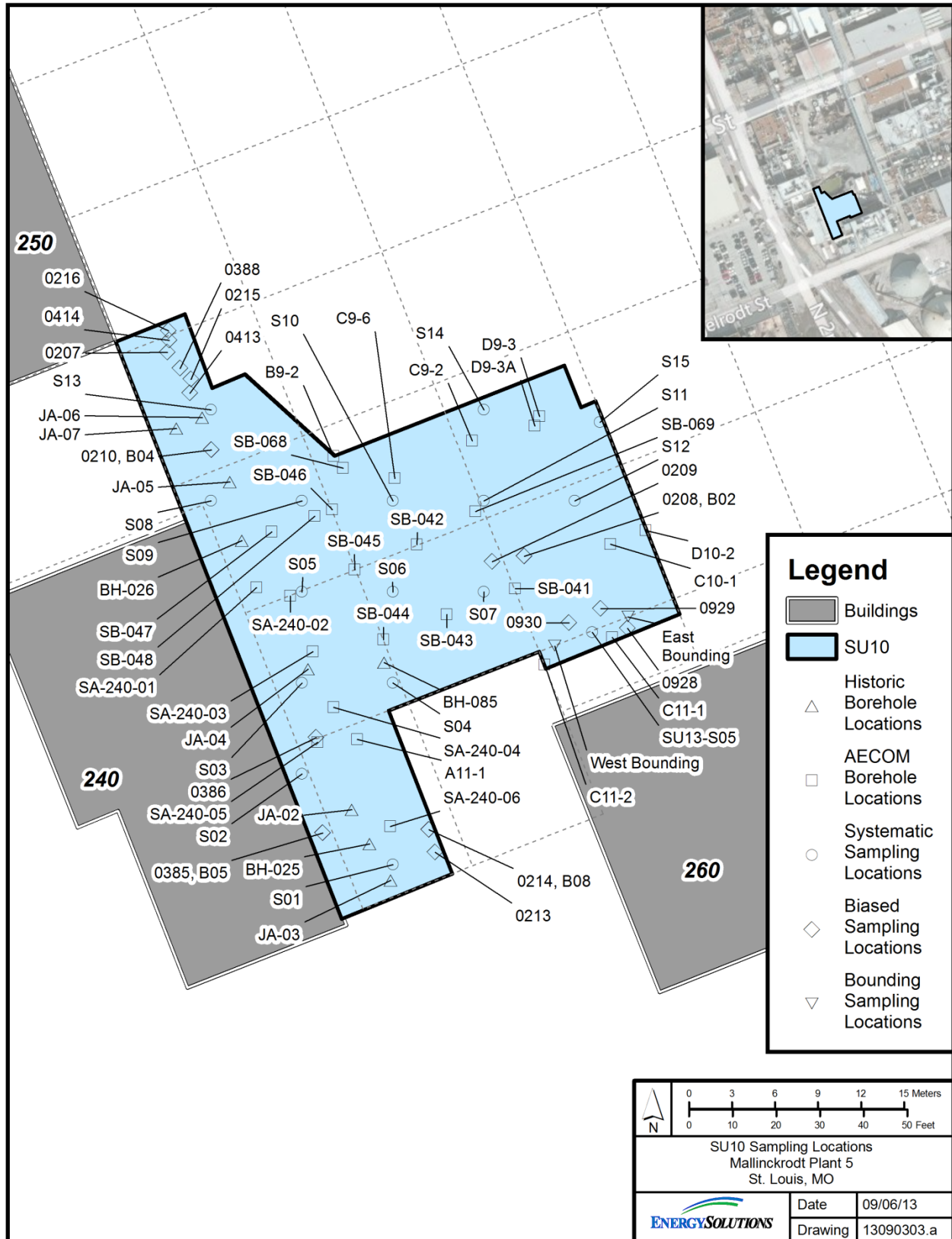


Figure 16-9 Characterization and FSS Sampling Locations

#### 16.2.4 Characterization of West Wall

As shown in the Figure 16-10 and Figure 16-11 (photographs 5 and 6), SU10 was excavated directly along Building 240 and across the alley to the Building 250 bottle pad with a nearly vertical surface. Following excavation and during FSS, elevated measurements were identified along the west edge of the excavation. Contaminated soil remains along the west wall, which is considered part of survey unit SU22 as it extended beyond the SU10 west boundary. The bottom of the excavation was verified free of contamination.

Surveys were performed along the vertical wall of the excavation and samples collected. The wall was gridded using a 1-m grid and a 1 minute scalar count recorded for each grid. Figure 16-12 provides the gamma survey results for the west wall as exposed during the remediation of SU10. Each grid of the gamma survey was color coded to highlight the elevated readings. The darkest blue represents the minimum value and brightest orange represents the maximum value. The actual hue of the color varied based on the recorded value, with green representing the median value in the color scaling. Below the Building 240 footer, gamma levels ranged from 12,901 counts per minute (cpm) to 142,482 cpm. Along the alleyway on the north side of Building 240, gamma levels ranged from 27,657 cpm to 283,112 cpm. Along the east and south sides of the bottle pad (north end of alleyway between Buildings 240 and 250), gamma levels ranged from 26,311 cpm to 198,995 cpm.

A total of nine biased samples were collected from the west wall. Figure 16-13 shows the survey grids from which the samples were collected. Table 16-9 provides the sample results.



**Figure 16-10 Photograph (5) of SU10 West Wall – South End**



Figure 16-11 Photograph (6) of SU10 West Wall – North End

bgs (m) *South End of Building* **Building 240 Footer**

0 - 1	13,908	13,960	23,624	18,182	12,901	24,135	28,820	22,334	20,945	18,985	14,827	26,124	17,503	24,096	23,103	17,084	19,625	85,892
1 - 2	15,361	X	X	X	X	X	X	X	18,779	20,506	X	X	X	X	X	X	18,859	22,526

bgs (m) **Building 240 Footer (continued)** *North End of Building*

0 - 1	27,773	41,430 18,711	15,549	14,229	13,709	13,454	13,619	14,183	16,623	22,796	37,610	142,482	90,371	37,039	28,470
1 - 2	22,284	X	X	X	X	13,872	13,326	X	14,794	14,464	33,957	38,272	38,933	X	X

bgs (m) **Alleyway on North Side of Building 240**

0 - 1	275,598	77,810	89,601	256,547	101,785	139,926	85,000	283,112
1 - 2	63,285	27,657	30,788	35,363	57,510	X	X	X

bgs (m) **Bottle Pad**

0 - 1	79,588	35,463	110,338	31,585	39,461	111,906	63,431	82,179	198,995	66,982
1 - 2	X	X	26,311	53,919	36,414	136,332	66,716	117,601	184,673	71,249



Represents approximately a 1 m by 1 m grid
 
 X Measurement not collected
 
(measurements in cpm)

**Figure 16-12 Gamma Survey (#0295) of West Wall (SU22)**

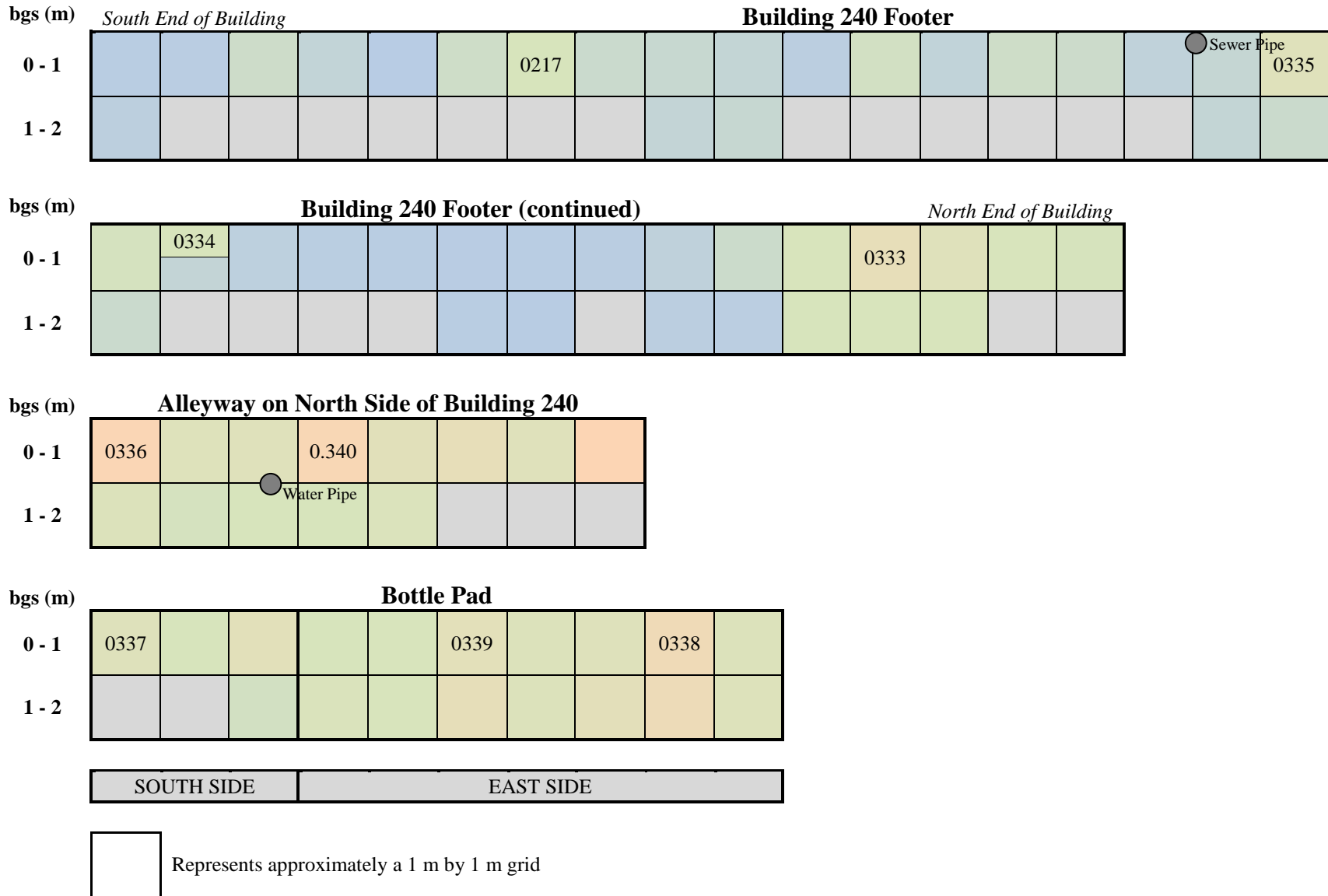


Figure 16-13 Characterization Samples of West Wall (SU22)



Table 16-9 Gamma Spectroscopy West Wall (SU22) Characterization Sample Analytical Results

Sample ID	Depth (ft bgs)	On-Site Results											Off-Site Results <sup>a</sup>										On-Site/ Off-Site Gross SOF Ratio	
		Activity Concentration (pCi/g) <sup>b</sup>									SOF <sup>c</sup>		Activity Concentration (pCi/g) <sup>b</sup>									SOF <sup>c</sup>		
		<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			Gross	Net <sup>d</sup>	<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			Gross		Net <sup>d</sup>
		Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC			
0217	3	1.89	0.77	0.68	148.91	8.92	4.12	47.57	3.62	3.25	<b>5.21</b>	<b>5.06</b>	<i>1.48</i>	<i>1.02</i>	<i>1.68</i>	<i>125.00</i>	<i>13.10</i>	<i>0.96</i>	<i>61.60</i>	<i>11.70</i>	<i>12.20</i>	<b>4.40</b>	<b>4.25</b>	1.18
0333	2	3.68	2.61	1.59	648.10	29.81	7.71	30.61	7.87	6.25	<b>22.24</b>	<b>22.10</b>	These characterization samples were not sent for off-site analysis.											
0334	2	1.51	0.55	0.34	77.03	5.42	2.61	23.66	2.08	1.82	<b>2.72</b>	<b>2.57</b>												
0335	2	1.49	0.45	0.28	44.75	3.70	1.87	23.95	1.86	1.57	<b>1.62</b>	<b>1.47</b>												
0336	2	9.51	1.57	1.34	1,155.80	51.03	8.43	28.31	4.02	5.09	<b>39.75</b>	<b>39.60</b>												
0337	2	3.05	1.05	0.47	214.46	11.05	2.48	10.86	1.69	1.75	<b>7.44</b>	<b>7.29</b>												
0338	2	11.92	0.88	0.32	9.10	2.79	2.07	17.89	1.86	1.76	<b>0.83</b>	<b>0.69</b>												
0339	2	76.23	3.64	0.53	13.09	4.44	3.49	28.85	7.92	3.38	<b>3.67</b>	<b>3.53</b>												
0340	2	1.18	0.28	0.14	5.28	1.39	0.93	4.48	0.73	0.72	0.24	0.09												

<sup>a</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.

<sup>b</sup> Italicized results indicate <MDC.

<sup>c</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1 and **bolded red** SOF values indicate a result >1.

<sup>d</sup> Calculated as discussed in Section 16.2.2.

### 16.3 DATA ANALYSIS – EXCAVATED SURFACE

Data analysis of the excavated surface was performed based on the assumptions, methods, and performance criteria established to satisfy the DQOs in accordance with the C-T Phase II DP, Sections 14.4.1 and 14.4.3. Details regarding FSS design and quality assurance and quality control applicable to all survey units were discussed in Chapters 4 and 5, respectively, of this FSSR. Surface soil (0 to 30 cm) sample results and 1-m composite sample result from boreholes were used in the assessment of excavated and unexcavated locations, respectively as appropriate.

#### 16.3.1 Elevated Area Evaluation

Equation 9 from C-T Phase II DP, Section 5.8.7 provides for the calculation of an *Index* value that represents the fraction or multiple of the DCGL<sub>EMC</sub>. If the *Index* value is greater than one, then the DCGL<sub>EMC</sub> is exceeded.

Parameters necessary to calculate the *Index* value for the elevated area adjacent to the bottle pad were:

- The elevated area activity levels, represented by the maximum activity observed (sample 0388) were 26.40, 6.00, and 15.60 pCi/g for <sup>232</sup>Th, <sup>226</sup>Ra, and <sup>238</sup>U, respectively (from Table 16-2);
- Mean background activity levels were 1.3, 2.5, and 4.4 pCi/g for <sup>232</sup>Th, <sup>226</sup>Ra, and <sup>238</sup>U, respectively (from C-T Phase II DP Table 4-17);
- The size of the elevated area was determined to be approximately 8 ft by 18 ft, or 15.0 m<sup>2</sup>; and,
- The area factors from C-T Phase II DP Figure 5-3 for the elevated area were 1.9, 2.1, and 2.9 for <sup>232</sup>Th, <sup>226</sup>Ra, and <sup>238</sup>U, respectively.

The calculation of the *Index* value is shown below. Because the <sup>232</sup>Th elevated area activity concentration was less than the background mean, the thorium series term was set equal to zero. Because the *Index* value as calculated in accordance with the DP was less than one, this elevated area is compliant with the C-T Phase II DP for elevated measurements in soil.

$$Index = \frac{(26.40 - 1.3) \text{ pCi/g}}{(1.9 \times 23.9 \text{ pCi/g})_{Th \text{ series}}} + \frac{(6.00 - 2.5) \text{ pCi/g}}{(2.1 \times 29.4 \text{ pCi/g})_{Ra226}} + \frac{(15.60 - 4.4) \text{ pCi/g}}{(2.9 \times 721 \text{ pCi/g})_U} = 0.61$$

#### 16.3.2 Data Set Screening Analysis

Table 16-10 summarizes the results of the screening tests performed on the excavated surface FSS data in accordance with Pages 14-27 through 14-29 of the C-T Phase II DP. All applicable tests demonstrating compliance passed.

**Table 16-10 Screening Tests Results – Excavated Surface**

Screening Test	Test Value	Conclusion
Min/Max	0.54	PASS
Low Level	N/A	Not applicable; Class 1 survey unit
DCGL	N/A	Not applicable; Min/Max < 1
EMC Limit	0.21	PASS

#### 16.3.2.1 Min/Max

In accordance with Page 14-27 of the C-T Phase II DP, the Min/Max screening test value was calculated by subtracting the minimum reference area result from the maximum survey unit systematic result. Sample 0387 with a gross SOF of 0.56 (from Table 16-1) was the maximum survey unit systematic result. Sample BH-Z-08 with a calculated gross SOF of 0.02 (from C-T Phase II DP Table B-1) was the minimum reference area result. The Min/Max screening test value was calculated to be 0.54. Because the test value was less than one, no further computations are required, i.e., DCGL<sub>w</sub> screening and Wilcoxon Rank Sum (WRS) tests.

#### 16.3.2.2 Low Level

In accordance with Page 14-27 of the C-T Phase II DP, the Low Level screening test is not applicable to Class 1 survey units.

#### 16.3.2.3 DCGL<sub>w</sub>

In accordance with Page 14-28 of the C-T Phase II DP and because the Min/Max test value was less than one, the DCGL<sub>w</sub> screening test was not applicable to the excavated surface of this survey unit.

#### 16.3.2.4 EMC Limit

In accordance with Page 14-28 of the C-T Phase II DP, the elevated measurement comparison (EMC) limit screening test was applied due to the elevated area adjacent to the bottle pad (sample 0388). Parameters necessary to calculate the exposure-weighted fraction of the DCGL<sub>w</sub>, *F*, were:

- The size of the elevated area was determined to be approximately 15.0 m<sup>2</sup> (8 ft by 18 ft),
- The area factor from C-T Phase II DP Figure 5-3 for the elevated area was conservatively set to 1.9 (based on thorium series only),
- The elevated area activity level was conservatively represented by sample 0388 with a gross SOF = 1.33, and
- The survey unit average was a gross SOF = 0.20 (refer to Table 16-1).

The calculation of the EMC screening test result is shown below, using C-T Phase II DP Equation 14-7.



$$F = \left[ \frac{15 \text{ m}^2}{743 \text{ m}^2} \times \frac{1.33}{1.9 \times 1} \right] + \left[ \frac{(743 - 15) \text{ m}^2}{743 \text{ m}^2} \times \frac{0.20}{1} \right] = 0.21$$

In accordance with the C-T Phase II DP and because the result was less than one, the total radioactivity concentration in the survey unit is within the release criterion.

### 16.3.3 WRS Test

In accordance with Page 14-29 of the C-T Phase II DP and because the Min/Max test value was less than one, the WRS Test was not required to demonstrate compliance.

### 16.3.4 Retrospective Analysis

A retrospective analysis was performed of the FSS results to determine whether the results met the survey design objectives, in accordance with Page 14-30 of the C-T Phase II DP. Table 16-11 provides the results of the retrospective analysis. Because the actual sample size exceeded the retrospective value sample size, the conclusion is that the survey design objectives were met.

**Table 16-11 Retrospective Analysis – Excavated Surface**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.20 <sup>a</sup>
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.15 <sup>a</sup>
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	5.3
Calculated N/2 Sample Size	15 <sup>b</sup>	9
Actual N/2 Sample Size	--	15 <sup>a</sup>

<sup>a</sup>The result for SU13 S05 was not included and if it was, the average would be the same and the spatial variability would have been 0.13.

<sup>b</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

## 16.4 DATA ANALYSIS – SUBSURFACE MATERIAL

Data analysis of the subsurface material was performed based on the assumptions, methods, and performance criteria established to satisfy the DQOs in accordance with the C-T Phase II DP, Sections 14.4.1 and 14.4.3. Column average gross SOF results were used in the data assessment. Borehole sampling was stopped when native clay soil was reached or refusal encountered. Per Page 14-19 of the C-T Phase II DP, column averages were calculated over 1-meter increments (averaged 0 to 1 m, 0 to 2 m, etc.) for the set of samples collected. Table 16-12 provides the calculated borehole column average gross SOF results. Table 16-13 provides the calculated borehole column average net SOF results.

**Table 16-12 Systematic Borehole Column Average Gross SOF Results**

Sample Location	Core Depth Interval (m)				
	0-1	0-2	0-3	0-4	0-5
	Combined Results for Column Average Gross SOF <sup>a</sup>				
S01	0.15	0.15	0.18	--	--
S02	--	--	--	--	--
S03	0.15	0.12	0.12	--	--
S04	0.15	0.12	0.12	--	--
S05	0.15	0.15	0.15	0.15	--
S06	0.15	0.13	0.13	--	--
S07	0.15	0.12	0.11	--	--
S08	0.15	0.15	0.15	0.14	--
S09	0.15	0.15	0.14	--	--
S10	0.15	0.13	0.13	--	--
S11	0.15	0.15	0.14	--	--
S12	0.14	0.23	0.21	0.19	0.18
S13	0.15	0.15	0.24	0.21	0.20
S14	0.12	0.19	0.17	0.16	0.15
S15	0.16	0.13	0.11	0.15	0.38
SU13 S05	0.15	0.15	0.17	--	--
<b>Summary Statistics</b>					
Count:	15	15	15	6	4
Average:	0.14	0.15	0.15	0.17	0.23
Median:	0.15	0.15	0.14	0.16	0.19
Standard Dev.:	0.01	0.03	0.04	0.03	0.10
Minimum:	0.12	0.12	0.11	0.14	0.15
Maximum:	0.16	0.23	0.24	0.21	0.38
Range:	0.04	0.11	0.13	0.06	0.23

<sup>a</sup> Calculation of column average gross SOF used on-site results unless off-site results were available.

Table 16-13 Systematic Borehole Column Average Net SOF Results

Sample Location	Core Depth Interval (m)				
	0-1	0-2	0-3	0-4	0-5
	Combined Results for Column Average Net SOF <sup>a</sup>				
S01	0.00	0.01	0.04	--	--
S02	--	--	--	--	--
S03	0.00	0.00	0.00	--	--
S04	0.00	0.00	0.00	--	--
S05	0.00	0.00	0.01	0.01	--
S06	0.00	0.00	0.00		--
S07	0.00	0.00	0.00		--
S08	0.00	0.00	0.01	0.00	--
S09	0.00	0.00	0.00	--	--
S10	0.00	0.00	0.00	--	--
S11	0.00	0.01	0.00	--	--
S12	0.02	0.09	0.07	0.05	0.04
S13	0.00	0.00	0.09	0.06	0.05
S14	0.00	0.05	0.04	0.03	0.01
S15	0.02	0.00	0.00	0.01	0.23
SU13 S05	0.00	0.00	0.02	--	--
<b>Summary Statistics</b>					
Count:	15	15	15	6	4
Average:	0.00	0.01	0.02	0.03	0.08
Median:	0.00	0.00	0.00	0.02	0.05
Standard Dev.:	0.01	0.03	0.03	0.03	0.10
Minimum:	0.00	0.00	0.00	0.00	0.01
Maximum:	0.02	0.09	0.09	0.06	0.23
Range:	0.02	0.09	0.09	0.06	0.22

<sup>a</sup> Calculation of column average net SOF used on-site results unless off-site results were available.

### 16.4.1 Data Set Screening Analysis

Table 16-10 summarizes the results of the screening tests performed on the borehole subsurface FSS data in accordance with Pages 14-27 through 14-29 of the C-T Phase II DP. All applicable tests demonstrating compliance passed.

**Table 16-14 Screening Tests Results – Subsurface Material**

Screening Test	Test Value	Conclusion
<b>0 – 1 m</b>		
Min/Max	0.14	PASS
Low Level	N/A	Not applicable; Class 1 survey unit
DCGL	N/A	Not applicable; Min / Max < 1
EMC Limit	N/A	Not applicable; subsurface material
<b>0 – 2 m</b>		
Min/Max	0.21	PASS
Low Level	N/A	Not applicable; Class 1 survey unit
DCGL	N/A	Not applicable; Min / Max < 1
EMC Limit	N/A	Not applicable; subsurface material
<b>0 – 3 m</b>		
Min/Max	0.22	PASS
Low Level	N/A	Not applicable; Class 1 survey unit
DCGL	N/A	Not applicable; Min / Max < 1
EMC Limit	N/A	Not applicable; subsurface material
<b>0 – 4 m</b>		
Min/Max	0.19	PASS
Low Level	N/A	Not applicable; Class 1 survey unit
DCGL	N/A	Not applicable; Min / Max < 1
EMC Limit	N/A	Not applicable; subsurface material
<b>0 – 5 m</b>		
Min/Max	0.36	PASS
Low Level	N/A	Not applicable; Class 1 survey unit
DCGL	N/A	Not applicable; Min / Max < 1
EMC Limit	N/A	Not applicable; subsurface material

16.4.1.1 Min/Max

In accordance with Page 14-27 of the C-T Phase II DP, the Min/Max screening test value was calculated by subtracting the minimum reference area result from the maximum survey unit systematic result. Location 15 had the maximum survey unit systematic column average gross SOF of 0.16 for 0-1 m (from Table 16-12). Location 12 had the maximum survey unit systematic column average gross SOF of 0.23 for 0-2 m (from Table 16-12). Location 13 had the maximum survey unit systematic column average gross SOF of 0.24 and 0.21 for 0-3 m and 0-4 m, respectively (from Table 16-12). Location 15 had the maximum survey unit systematic column average gross SOF of 0.38 for 0-5 m (from Table 16-12). Sample BH-Z-08 with a calculated gross SOF of 0.02 (from C-T Phase II DP Table B-1) was the minimum reference area result. The Min/Max screening test value was calculated to be 0.14, 0.21, 0.22, 0.19, and 0.36 for 0-1 m, 0-2 m, 0-3 m, 0-4 m, and 0-5 m, respectively. Because the test value was less than one for 0-1 m, 0-2 m, 0-3 m, 0-4 m, and 0-5 m, further computations are not required, i.e., DCGL<sub>w</sub> screening and Wilcoxon Rank Sum (WRS) tests.

#### 16.4.1.2 Low Level

In accordance with Page 14-27 of the C-T Phase II DP, the Low Level screening test is not applicable to Class 1 survey units.

#### 16.4.1.3 DCGL<sub>W</sub>

In accordance with Page 14-28 of the C-T Phase II DP and because the Min/Max test value was less than one, the DCGL<sub>W</sub> screening test was not applicable to subsurface material for this survey unit.

#### 16.4.1.4 EMC Limit

In accordance with Page 14-26 of the C-T Phase II DP, the DCGL<sub>EMC</sub> is not applicable to subsurface survey units, in this case the assessment of the subsurface material in the survey unit. Thus, the EMC limit is not applicable.

### 16.4.2 WRS Test

In accordance with Page 14-29 of the C-T Phase II DP and because the Min/Max test values were less than one, the WRS Test was not required to demonstrate compliance.

### 16.4.3 Retrospective Analysis

A retrospective analysis was performed of the FSS results to determine whether the results met the survey design objectives, in accordance with Page 14-30 of the C-T Phase II DP.

Table 16-15, Table 16-16, and Table 16-17 provide the results of the retrospective analysis for 0-1 m, 0-2 m, and 0-3 m. Because the actual sample size exceeded the retrospective value sample size, the conclusion is that the survey design objectives were met.

Table 16-18 and Table 16-19 provide the results of the retrospective analysis for 0-4 m and 0-5 m. In both cases, the actual sample size was less than the retrospective value sample size. This is the result of a limited sample size due to either reaching the clay layer or encountering refusal in the soil column, not because elevated contamination caused a large calculated relative shift. Based on this result and the core boring results provided in Section 16.2.3, it was reasonable to not re-perform the systematic FSS borehole sampling at new locations for two reasons: 1) characterization data guided the excavation extent and FSS data results were consistent with characterization data results and 2) if the systematic FSS boring sampling was re-performed, it was anticipated that a large fraction of the new locations would have a reduced number of samples from 0-4 m and 0-5 m because of either reaching the clay layer or encountering refusal in the soil column, as with the original locations. Therefore, the FSS for 0-4 m and 0-5 m was considered adequate for demonstrating compliance in this situation.

**Table 16-15 Retrospective Analysis – 0-1 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.14
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.01
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	86
Calculated N/2 Sample Size	15 <sup>a</sup>	9
Actual N/2 Sample Size	--	14

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

**Table 16-16 Retrospective Analysis – 0-2 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.15
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.03
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	28
Calculated N/2 Sample Size	15 <sup>a</sup>	9
Actual N/2 Sample Size	--	14

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

**Table 16-17 Retrospective Analysis – 0-3 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.15
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.04
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	21
Calculated N/2 Sample Size	15 <sup>a</sup>	9
Actual N/2 Sample Size	--	14

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

**Table 16-18 Retrospective Analysis – 0-4 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.17
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.03
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	27
Calculated N/2 Sample Size	15 <sup>a</sup>	9
Actual N/2 Sample Size	--	6

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

**Table 16-19 Retrospective Analysis – 0-5 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.23
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.10
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	7
Calculated N/2 Sample Size	15 <sup>a</sup>	9
Actual N/2 Sample Size	--	4

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

## 16.5 DEVIATIONS

In accordance with the second bullet in Section 14.5 of the C-T Phase II DP, the FSSR is required to list changes made in the FSS from what was proposed in the DP. Only one deviation was noted. Page 14-27 of the C-T Phase II DP indicated that the “data set for the survey unit will be processed within a database using screening software developed and verified for the project.” This database was not developed; instead, a combination of Microsoft<sup>®</sup> Excel<sup>®</sup> spreadsheets and hand calculations was utilized. This deviation is not significant and does not affect the data collection or assessment.

## 16.6 NRC INSPECTIONS

A summary of U.S. Nuclear Regulatory Commission (NRC) inspections applicable to the FSS are provided in Section 5.8 of this FSSR. The scope of the inspections included, but was not limited to: review of project plans, interviewing of project personnel, evaluation of the on-site laboratory, and independent confirmatory surveys conducted by the NRC after backfilling.

Inspection Report 04006563/12001 noted that the NRC reviewed the FSS data package for SU10 to ensure the licensee conducted the survey in accordance with the requirements as stated in the DP. No violations were identified. No findings of significance were identified.

## **16.7 CONCLUSION**

FSS data were verified to be reliable, appropriately documented, and technically defensible. Specifically, the following conclusions are made:

- The instruments used to collect the data were capable of detecting the radiation type (i.e., gamma) at or below the release criteria (described in Sections 4.4 and 4.5 of this FSSR).
- The calibration of the instruments used to collect the data was current and radioactive sources used for calibration were National Institute of Standards and Technology (NIST) traceable (described in Section 5.4 of this FSSR). Specific records available upon request.
- Instrument response was checked before instrument use each day, at minimum (described in Section 5.4 of this FSSR). Specific records available upon request.
- The survey methods used to collect the data were appropriate for the media and type of radiation being measured (described in Section 4.4, 4.5, and 4.6 of this FSSR).
- The custody of samples collected for laboratory analysis was tracked from the point of collection until final results were obtained (described in Section 5.5.2 of this FSSR). Specific records available upon request.
- The survey data consist of qualified measurement results that are representative of the area of interest.
- Areas identified with elevated residual radioactivity (i.e.  $SOF > 1.0$ ) were appropriately investigated and the  $DCGL_{EMC}$  properly applied.

All the applicable screening tests passed, the retrospective analysis found that the survey design objectives were met, and additional subsurface contamination was not reasonably suspected. SU10 meets the industrial use scenario release criterion as established in the C-T Phase II DP Chapter 5; and therefore, satisfies the unrestricted release provisions of Title 10, Code of Federal Regulations (CFR), Part 20, Subpart E.

## **16.8 REFERENCES**

Mallinckrodt, *Mallinckrodt Columbium-Tantalum Phase II Decommissioning Plan*, Revision 2, August 2008.