

Phase II Final Status Survey Report Mallinckrodt Columbium-Tantalum Plant


St. Louis, Missouri

Chapter 29

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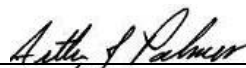


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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
29.0 RESULTS SUMMARY FOR C-T PLANT SEWERAGE.....	4
29.1 Overview.....	4
29.2 Characterization.....	4
29.3 Remediation Summary.....	6
29.4 Data Collection.....	7
29.4.1 Review of Characterization Data.....	7
29.4.2 Manhole MH-42.....	7
29.4.3 Manhole MH-43.....	8
29.4.4 Sewerage Downstream of Manhole MH-04.....	8
29.4.5 Summary.....	9
29.5 Data Analysis.....	10
29.5.1 Elevated Area Evaluation.....	10
29.5.2 Data Set Screening Analysis.....	10
29.5.3 WRS Test.....	12
29.5.4 Retrospective Analysis.....	12
29.6 Deviations.....	12
29.7 NRC Inspections.....	12
29.8 Conclusion.....	13
29.9 References.....	13

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
Figure 29-1 Manhole Samples and Sewerage (from C-T Phase II DP Figure 4-1).....	5
Figure 29-2 Photo of Manhole MH-X.....	9

LIST OF TABLES

<u>Table</u>	<u>Page</u>
Table 29-1 Analytical Results from Sewer Samples (from C-T Phase II DP Table 4-1).....	6
Table 29-2 AECOM Investigation of MH-42.....	7
Table 29-3 Gross SOF Summary for Remaining Manholes.....	10
Table 29-4 Screening Tests Results.....	11
Table 29-5 Retrospective Analysis.....	12

ABBREVIATIONS AND ACRONYMS

AECOM	AECOM Technical Services
bgs	below grade surface
C-T	columbium-tantalum
CFR	Code of Federal Regulations
DCGL	derived concentration guideline level
DP	decommissioning plan
DQO	data quality objectives
EMC	elevated measurement comparison
EnergySolutions	EnergySolutions, LLC
FSS	Final Status Survey
FSSR	Final Status Survey Report
ft	feet
m	meters
MARSSIM	Multi-Agency Radiation and Site Investigation Manual (NUREG-1575)
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
WRS	Wilcoxon Rank Sum

29.0 RESULTS SUMMARY FOR C-T PLANT SEWERAGE

This chapter of the Final Status Survey Report (FSSR) presents the results of the final status survey (FSS) and data assessment for the Columbium-Tantalum (C-T) Plant Sewerage lines in accordance with C-T Phase II Decommissioning Plan (DP) Section 14.5. Site activities for this Class 3 survey unit were completed by AECOM Technical Services (AECOM) in November of 2011 and completed by EnergySolutions, LLC (EnergySolutions) in October of 2013.

The 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 measurements 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.

29.1 OVERVIEW

The C-T Plant Sewerage system is a Class 3 survey unit comprising of the sediment in the sewers downstream of Building 238 (demolished) extending to the Waste Water Treatment Basin area. Main sewer lines immediately to the west and north of Building 238 were removed or plugged. Other sewerage lines remain in use (active) or were isolated and assessed with the Plant 5 subsurface survey unit in which they were located.

29.2 CHARACTERIZATION

Characterization data presented in C-T Phase II DP Figure 4-1 were augmented by additional investigations performed and samples collected which together serve as the FSS data. Figure 29-1 shows the C-T Plant Sewerage system and locations of sediment sampling. Table 29-1 provides the analytical results summary from C-T Phase II DP Table 4-1.

The sum of fractions (SOF) were recalculated and differed from the values as provided in C-T Phase II DP Table 4-1, specifically the results for MH-02 with an SOF less than 1 and MH-04 with an SOF exceeding 1 differing from the original analysis. Figure 29-1 was annotated to show these changes from what was presented in C-T Phase II DP Figure 4-1.

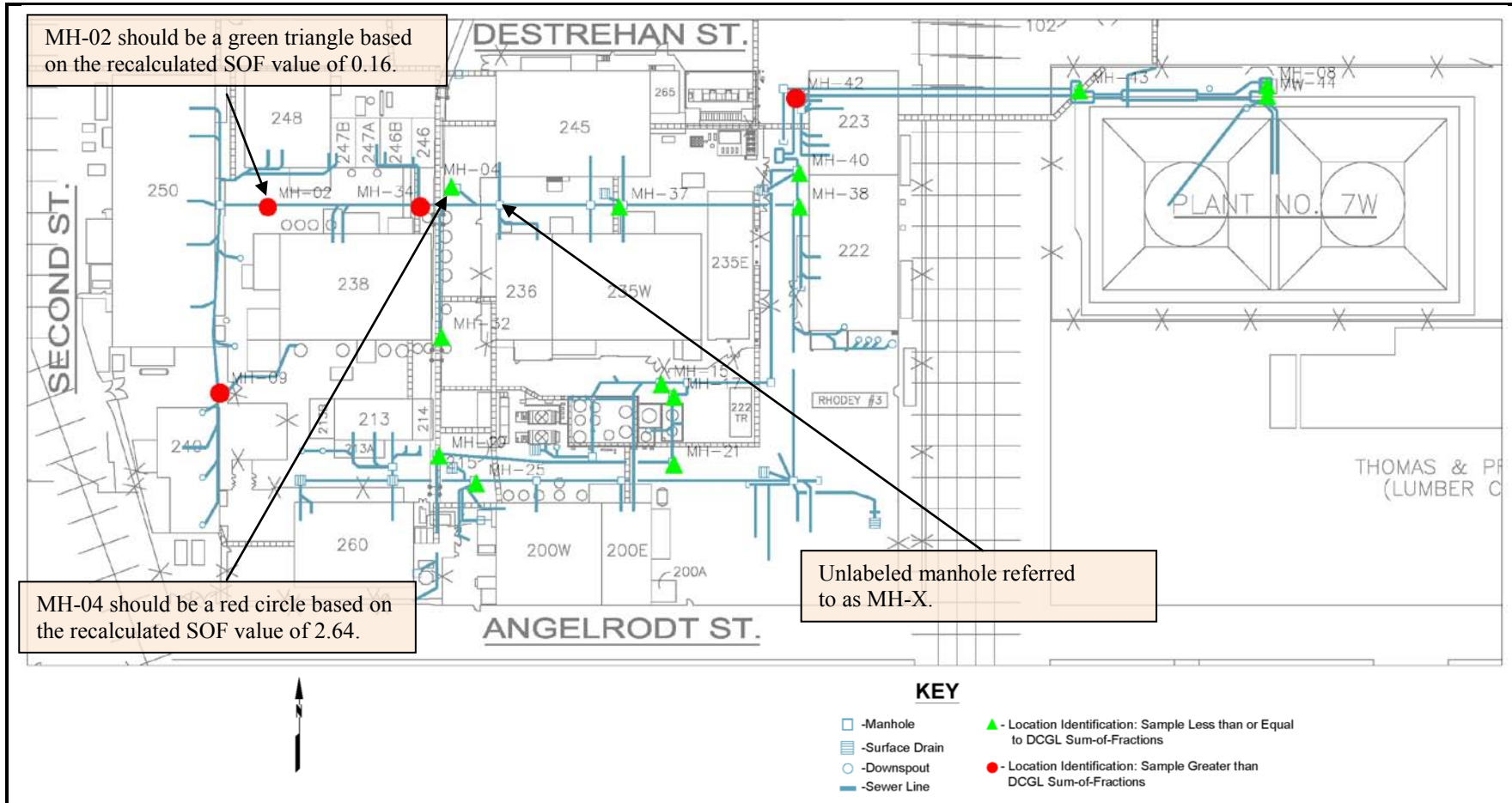


Figure 29-1 Manhole Samples and Sewerage (from C-T Phase II DP Figure 4-1)

Table 29-1 Analytical Results from Sewer Samples (from C-T Phase II DP Table 4-1)

Location ID	Sample Depth (ft)	Activity Concentration (pCi/g)			SOF ^a	
		²³² Th	²²⁶ Ra	²³⁸ U	Gross ^{b, c}	Net
Removed Manholes						
MH-02	4.17	1.6	2.6	3.1	0.16	0.02
MH-04	7.5	3.3	73.2	7.3	2.64	2.49
MH-09	2.33	1.9	147.1	2.4	5.09	4.94
MH-32	0.5	3.2	7.3	4.2	0.39	0.24
MH-34	7.25	8.8	101.6	29.9	3.87	3.72
Remaining Manholes (left in place)						
MH-08	5.33	1	2	4.5895	0.12	0.00
MH-10	4 - 4.33	0.4	0.78	0.75	0.04	0.00
MH-15	2.67	1.1	1.4	1.1	0.10	0.00
MH-17	5.42	0.76	1.9	1.2	0.10	0.00
MH-21	4 - 4.33	1.1	0.61	0.85	0.07	0.00
MH-25	6 - 6.25	0.68	0.82	0.94	0.06	0.00
MH-27	4 - 4.17	1.3	2.4	2.5	0.14	0.00
MH-37	4 - 4.17	2.3	3.8	2.7	0.23	0.09
MH-38	4 - 4.17	0.78	1.5	1.1	0.09	0.00
MH-40	9 - 9.25	0.79	4.4	2.8	0.19	0.06
MH-42	7 - 7.58	26.7	33.2	8.8	2.26	2.11
MH-43	15	3.3	24.2	9.2	0.97	0.83
MH-44	12	2.2	5.7	4.0535	0.29	0.15

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

^b Values recalculated based on the activity concentrations provided in C-T Phase II DP Table 4-1.

^c Gross SOF values provided in this table vary significantly from the SOF values provided in C-T Phase II DP Table 4-1.

29.3 REMEDIATION SUMMARY

Of the manholes shown on Figure 29-1, MH-02, MH-04, MH-09, MH-32, and MH-34 were removed during site remediation activities. Details are provided below.

- MH-02 and MH-34 were removed along with the main sewer line north of Building 238, from the unlabeled manhole east of Building 250 to just east of MH-34.
- MH-32 was removed during the remediation of survey unit SU20.
- MH-04 was removed during the remediation of survey unit SU11. The sewer line from MH-04 leading to the active sewer line had been isolated and grouted. Sediment taken from the grouted sewer during remediation of SU11 had elevated radionuclide concentrations consistent with the revised result for MH-04.
- The main sewer lines leading from Building 238 to and including MH-09 as well as the sewer lines east of the alleyway between Buildings 240 and 250 were removed during remediation of survey unit SU10.

The main sewer line on the east side of Building 240 was removed. The main sewer line on the east side of Building 250 was also removed, but only south of the manhole west of MH-02. The remediation was consistent with the planned activities described in C-T Phase II DP Section 8.4.2.

29.4 DATA COLLECTION

Data collection was performed 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.

29.4.1 Review of Characterization Data

C-T Phase II DP Section 14.2 notes that “in serving as elements in the FSS,” characterization data “may comprise the entire data set for a particular survey unit.” Sediment in the C-T Plant Sewerage remaining in use was sampled through manhole openings and the results were summarized in Section 29.2. The characterization data were collected with DQOs that meet the Class 3 designation of the C-T Plant Sewerage noted on C-T Phase II DP Page 14-22. Manholes for sampling were selected on a judgmental (biased) basis.

All sediment samples were analyzed via gamma spectroscopy analysis. 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 (²³²Th), radium-226 (²²⁶Ra), and uranium-238 (²³⁸U), respectively. These values were used to calculate net sum of fractions (SOF) values—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.

A review of the characterization data indicated that there were five manholes of concern: MH-04, MH-09, MH-34, MH-42, and MH-43. As discussed in Section 29.3, manholes MH-04, MH-09, and MH-34 were remediated/removed and therefore are considered addressed. Manholes MH-42 and MH-43 and the sewerage remaining in use downstream of MH-04 are addressed in the following sections.

29.4.2 Manhole MH-42

During additional characterization sampling of survey unit SU21 (FSSR Chapter 27), AECOM collected biased borehole INV-2 in the vicinity of MH-42. These results are provided in Table 29-2.

Table 29-2 AECOM Investigation of MH-42

Location ID	Sample ID	Depth (m)	Activity Concentration (pCi/g)			Sample SOF		Column SOF ^a	
			²³² Th	²²⁶ Ra	²³⁸ U	Gross	Net ^b	Gross	Net ^b
INV-2	4696	0 - 1	0.91	3.48	3.31	0.16	0.03	0.16	0.03
	4697	1 - 2	1.12	3.02	3.58	0.15	0.02	0.16	0.03
	4698	2 - 3	0.91	1.39	2.88	0.09	0.00	0.13	0.00
	4699	3 - 4	1.19	3.16	4.56	0.16	0.02	0.14	0.01
	4700	4 - 5	1.02	1.37	1.88	0.09	0.00	0.13	0.00

^a Calculated per Section 14.4.3.7 of C-T Phase II DP.

^b Calculated as discussed in Section 29.4.2.

In accordance with Page 14-22 of the C-T Phase II DP, “a vertical average radionuclide concentration in the sewer sediment and in soil between the ground surface and the sewer was evaluated.” There was no soil above the sediment in the manhole and therefore INV-2 was considered to be the best representation of the adjacent soil.

For simplicity, this evaluation used gross SOF values rather than radionuclide concentrations. The sediment from MH-42 was collected between 7 to 7.6 feet (ft) below grade surface (bgs). AECOM results for INV-2 indicates a gross SOF of 0.16 between 0 to 3.3 ft bgs, 0.15 between 3.3 to 6.6 ft bgs, and 0.09 between 6.6 to 9.8 ft bgs (6.6 to 7 ft bgs with respect to MH-42). The weighted average based upon the soil column using the sediment results and the results for INV-2 (Table 29-2) was a gross SOF of 0.32, as calculated below.

$$\left[0.16 \text{ SOF} \times \frac{3.3 \text{ ft}}{7.6 \text{ ft}}\right] + \left[0.15 \text{ SOF} \times \frac{3.3 \text{ ft}}{7.6 \text{ ft}}\right] + \left[0.09 \text{ SOF} \times \frac{0.4 \text{ ft}}{7.6 \text{ ft}}\right] + \left[2.26 \text{ SOF} \times \frac{0.6 \text{ ft}}{7.6 \text{ ft}}\right] = 0.32$$

29.4.3 Manhole MH-43

During the remediation of Plant 7W (FSSR Chapter 33), the sediment was removed from the Pump Vault and manhole MH-43. Because MH-43 was remediated and because the manhole upstream (MH-42) was demonstrated to be compliant (see Section 29.4.2) and manholes downstream (MH-08 and MH-44) had low activity concentrations, any concerns regarding MH-43 were adequately addressed.

29.4.4 Sewerage Downstream of Manhole MH-04

The elevated sediment in the grouted sewer directly downstream of MH-04 was evaluated as part of survey unit (SU11) in which it was located in accordance with Page 14-22 of the C-T Phase II DP. Manhole MH-04 was removed including the grouted sewer line to the maximum extent practical as discussed in Chapter 17 of this FSSR. The active sewer line remaining in use downstream of MH-04 did not have a sediment sample sufficiently close to MH-04; therefore, EnergySolutions investigated the manhole between the southwest corner of Building 245 and the northwest corner of Building 236. This manhole is not labeled on Figure 4-1 of the C-T Phase II DP but is referred to as MH-X and is annotated on Figure 29-1.

During the investigation, EnergySolutions observed that there was not sufficient sediment to collect in either MH-X or the sewer lines accessible from the manhole as shown in Figure 29-2. Given that sediment does not remain within MH-X and that MH-37 had only low levels of radionuclide concentrations present as provided in Table 29-1, MH-04 was considered to be adequately addressed.



Figure 29-2 Photo of Manhole MH-X

29.4.5 Summary

Table 29-3 provides a summary of the gross SOF values for the remaining manholes. For all the manholes, excluding MH-42, the gross SOF values in the table were obtained from Table 29-1. The sampling at these manholes only included the sediment sample results. Because the sediment results were low, the C-T Phase II sampling technique (vertical average radionuclide concentration in the sewer sediment and the soil between the ground surface and the sewer) was not performed; therefore, the results are considered conservative. The result for MH-42 was calculated and presented as the column average as discussed in Section 29.4.2.

Table 29-3 Gross SOF Summary for Remaining Manholes

Location ID	Gross SOF
MH-08	0.12
MH-10	0.04
MH-15	0.10
MH-17	0.10
MH-21	0.07
MH-25	0.06
MH-27	0.14
MH-37	0.23
MH-38	0.09
MH-40	0.19
MH-42	0.32 ^a
MH-43	-- ^b
MH-44	0.29
Count:	12
Average:	0.14
Median:	0.11
Standard Deviation:	0.09
Minimum:	0.04
Maximum:	0.32
Range:	0.28

^a Calculated as discussed in Section 29.4.2.

^b Sediment removed as discussed in Section 29.4.3

29.5 DATA ANALYSIS

The data analysis 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.

29.5.1 Elevated Area Evaluation

There were no elevated areas identified in the survey unit. Although the individual sediment sample from MH-42 as presented in Table 29-1 exceeded an SOF of 1, it is the “vertical average radionuclide concentration in the sewer sediment and in soil between the ground surface and the sewer” that was evaluated for compliance in accordance with Page 14-22 of the C-T Phase II DP and as summarized in Sections 29.4.2 and 29.4.5 of this FSSR.

29.5.2 Data Set Screening Analysis

Table 29-4 summarizes the results of the screening tests performed in accordance with Pages 14-27 through 14-29 of the C-T Phase II DP. All applicable tests demonstrating compliance passed.

Table 29-4 Screening Tests Results

Screening Test	Test Value	Conclusion
Min/Max	0.30	PASS
Low Level	0	PASS
DCGL _w	N/A	Not applicable; Min/Max < DCGL _w
EMC Limit	N/A	Not applicable; No elevated areas

29.5.2.1 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 (C-T Phase II DP Table B-1) from the maximum survey unit result (Table 29-3). MH-42 with a gross SOF of 0.32 was the maximum survey unit result. Sample BH-Z-08 with a calculated gross SOF of 0.02 was the minimum reference area result. The Min/Max screening test value was calculated to be 0.30. Because the test value was less than one, no further computations are required, i.e., derived concentration guideline level (DCGL_w) screening and Wilcoxon Rank Sum (WRS) tests.

29.5.2.2 Low Level

In accordance with Page 14-27 of the C-T Phase II DP, the Low Level screening test was conducted for this Class 3 survey unit. The Low Level screening test limit was calculated according to the stationary investigation level equation provided in Table 14-5 of the C-T Phase II DP. Minimum detectable activities of the gamma spectroscopy analyses were typical small fractions of the DCGLs and therefore the action level was calculated using the reference area data. The average gross SOF was calculated to be 0.15 using average ²³²Th, ²²⁶Ra, and ²³⁸U results provided in Table 4-17 of the C-T Phase II DP. The gross SOF standard deviation of 0.09 was calculated using the data provided in Table B-1 of the C-T Phase II DP. The Low Level screening test limit was calculated to be 0.43, as shown below.

$$0.1 \times 1 + 0.15 + 2 \times 0.09 = 0.43$$

Because the maximum result was a gross SOF of 0.32, no samples exceeded the Low Level screening test limit of 0.43.

29.5.2.3 DCGL_w

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_w screening test was not applicable to this survey unit.

29.5.2.4 EMC Limit

In accordance with Page 14-28 of the C-T Phase II DP, the elevated measurement comparison (EMC) Limit screening test was not applicable to this survey unit because no elevated areas were identified.

29.5.3 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.

29.5.4 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 29-5 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 29-5 Retrospective Analysis

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (dpm/100 cm ²)
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	0.09
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	9.6
Calculated N/2 Sample Size	15 ^a	9
Actual N/2 Sample Size	--	12

^aThe *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.

29.6 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[®] Excel[®] spreadsheets and hand calculations was utilized. This deviation is not significant and does not affect the data collection or assessment.

29.7 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. None of the inspections applied to the C-T Plant Sewerage survey unit.

29.8 CONCLUSION

Collected characterization data were reviewed for suitability for use as FSS data. Characterization 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 Sections 4.4 and 4.5 of this FSSR).
- The survey data consist of qualified measurement results that are representative of the area of interest.

All the applicable screening tests passed, the retrospective analysis found that the survey design objectives were met. The C-T Plant Sewerage survey unit 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.

29.9 REFERENCES

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