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

St. Louis, Missouri

## Chapter 33

Project No. 137131 Revision 0

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# TABLE OF CONTENTS

## LIST OF FIGURES

**Figure** **Page**



## LIST OF TABLES

**Table** **Page**

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| % | percent |
| β | beta |
| AECOM | AECOM Technical Services |
| bgs | below grade surface |
| C-T | columbium-tantalum |
| CFR | Code of Federal Regulations |
| cpm | counts per minute |
| DCGL | derived concentration guideline level |
| DP | decommissioning plan |
| dpm | disintegrations per minute |
| dpm/100 $cm^2$ | disintegrations per minute per 100 square centimeters |
| DQO | data quality objectives |
| EMC | elevated measurement comparison |
| FSS | Final Status Survey |
| FSSR | Final Status Survey Report |
| keV | kiloelectron-volt |
| $m^2$ | square meters |
| MARSSIM | Multi-Agency Radiation and Site Investigation Manual (NUREG-1575) |
| min | minute |
| NIST | National Institute of Standards and Technology |
| NRC | U.S. Nuclear Regulatory Commission |
| SOF | sum of fractions |
| Tc | technetium |
| WRS | Wilcoxon Rank Sum |

# 33.0 RESULTS SUMMARY FOR PLANT 7 PAVEMENT SU4

This chapter of the Final Status Survey Report (FSSR) presents the results of the final status survey (FSS) and data assessment for Plant 7 pavement survey unit SU4 in accordance with Columbium-Tantalum (C-T) Phase II Decommissioning Plan (DP) Section 14.5. The FSS for this Class 2 survey unit was completed by AECOM Technical Services (AECOM) in September and October of 2011. The SU4 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.

## 33.1 OVERVIEW

SU4 is a Class 2 survey unit that consists of three principle areas within Plant 7: The Weir Chamber, The Grit Chamber, and the Pump Vault. All three of these areas dealt with wastewater handling as part of the C-T process. The Weir Chamber is situated north of the east and west Plant 7 basins and immediately east of The Grit Chamber. The Weir Chamber is an entirely underground structure. The grit chamber is an above ground structure north of the west Plant 7 basin, west of the Weir Chamber, and east of the Pump Vault. The Pump Vault is a mostly underground brick-lined structure north of the west Plant 7 basin and immediately west of the Grit Chamber. The C-T Phase II DP calls out sewerage from Plant 5 and extending downstream to the Wastewater Treatment Basins is expected to satisfy an FSS and may remain in service. The Weir Chamber, The Grit Chamber, and the Pump Vault are part of the downstream sewerage.

The survey unit is approximately 234 square meters ($m^2$) in size, which is less than the size limit of 10,000 $m^2$ for Class 2 survey units for pavement (per C-T Phase II DP, Table 14-4). Class 2 was the appropriate classification because the survey unit had potential residual radioactivity that was not expected to exceed the $DCGL_W$. Figure 33-1 shows the location of SU4 within the Plant 7W area.

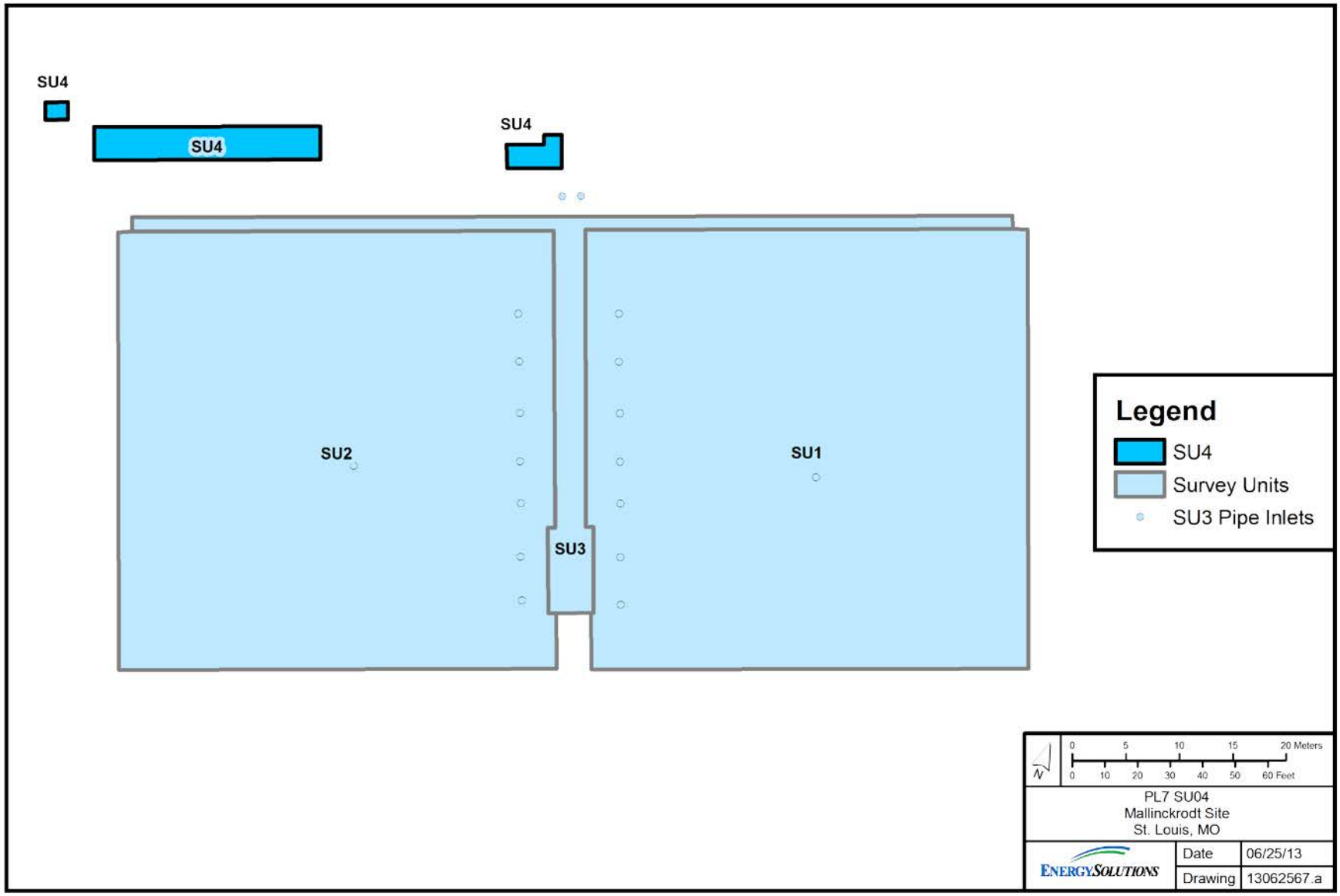



**Figure 33-1 Location of Pavement SU4 in C-T Plant 7W**

### 33.1.1 Weir Chamber

The Weir Chamber is a 5-foot (ft) deep underground "L" shaped concrete chamber approximately 18 ft long and 15 ft wide. It features a 12-inch pipe on the south end of the west wall. It is accessed by two 3-ft 7-inch square openings. When not pumped out, water collects several inches deep in the chamber before emptying farther into the storm sewer system. Figure 33-2 through Figure 33-6 are photographs of the Weir Chamber and features.

**Figure 33-2 Photograph of Access to the Weir Chamber Looking North**

**Figure 33-3 Photograph of Access to the Weir Chamber Looking West**

**Figure 33-4 Photograph of 12-inch Pipe at Bottom of the Weir Chamber**

**Figure 33-5 Photograph of Main Section of Weir Chamber Looking East**

**Figure 33-6 Photograph of "L" Shaped Portion of Weir Chamber Looking East**

### 33.1.2 Grit Chamber

The Grit Chamber is an above ground concrete structure approximately 68 ft long, 9 ft wide, and 4 ft tall. It is separated into two sections and has a single drain in the southeast corner of the chamber. It was fed by a series of above ground pipes that came from the Pump Vault. Figure 33-7 through Figure 33-9 show the Grit Chamber and Figure 33-10 shows the drain in the southeast corner of the chamber.

**Figure 33-7 Photograph of Grit Chamber Looking West**

**Figure 33-8 Photograph of Grit Chamber Looking East**

**Figure 33-9 Photograph of East End of Grit Chamber Looking North**

**Figure 33-10 Photograph of Southeast Drain of Grit Chamber**

### 33.1.3 Pump Vault

The Pump Vault is a brick-lined underground chamber in which several storm sewer pipes from Plant 5 and elsewhere on the site terminate. It is approximately 17 ft deep, 6 ft long, and 5 ft wide. The access to the vault is poured concrete extending approximately 3 ft above the surface. The presence of water in the bottom of this vault was a constant factor, despite plugging the northern 24-inch line coming from Plant 5. Figure 33-11 through Figure 33-13 are photographs of the Pump Vault.


**Figure 33-11 Photograph of Pump Vault Looking East**

**Figure 33-12 Photograph of Pump Vault Looking South**

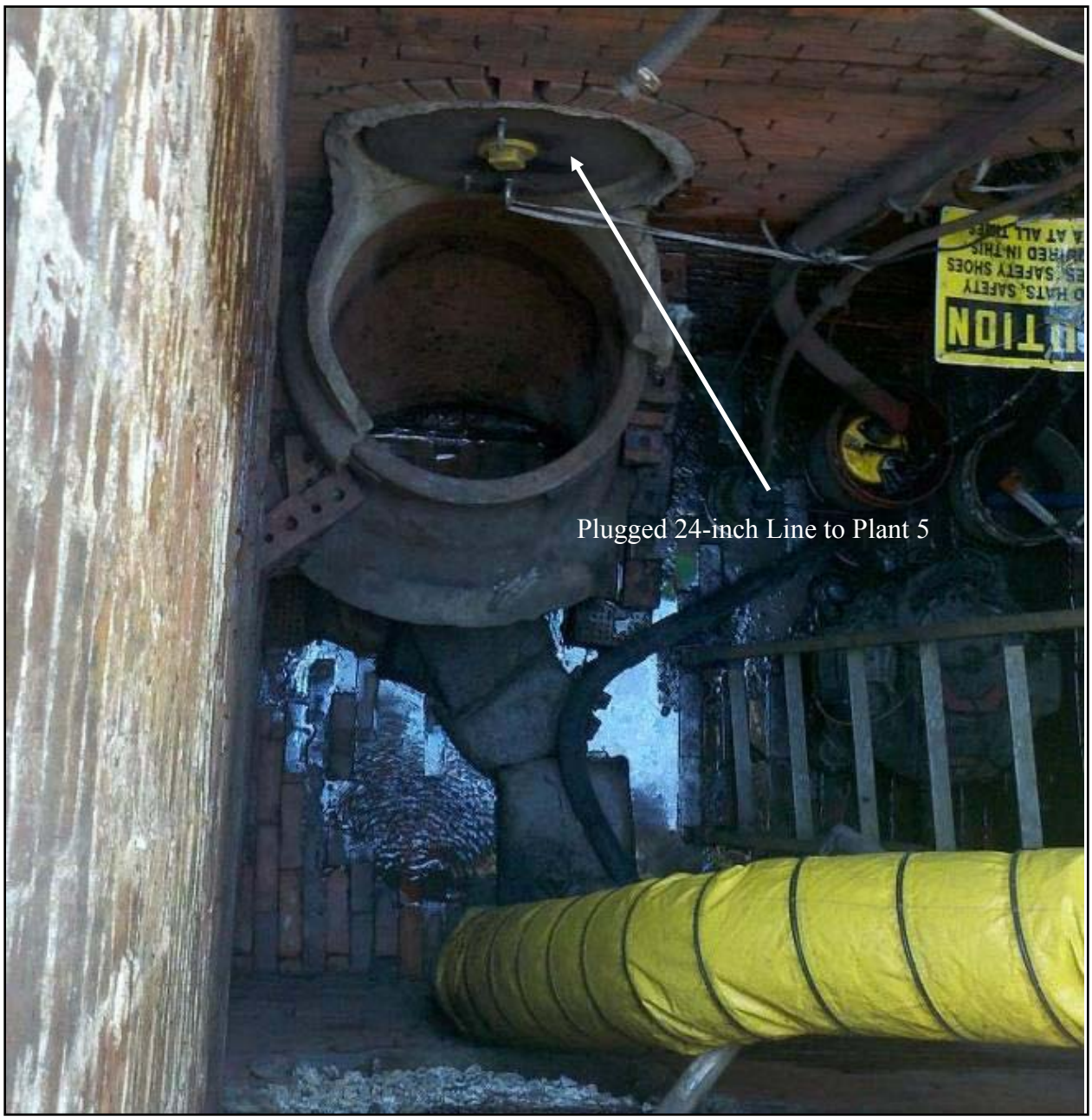



**Figure 33-13 Photograph of Pump Vault Looking West**

## 33.2 REMEDIAL ACTION AND RADIOLOGICAL SUMMARY

### 33.2.1 Weir Chamber

Rubber inserts were removed from the walls of the Weir Chamber to expose all wall surfaces and the walls and floor were power-washed. Radiological analysis via gamma spectroscopy indicated modest activity in the sediment (gross sum of fractions [SOF] = 0.25, Sample 3061). The walls and floor were then scanned with beta-gamma scintillation detectors and 16 static measurements were taken along with 100 $cm^2$ smears.

### 33.2.2 Grit Chamber

Debris was removed from the Grit Chamber and the entire structure was power washed. Radiological analysis via gamma spectroscopy indicated modest activity in the sediment (gross SOF < 0.29, Samples 3059 and 3060). The walls and floor were then scanned with beta-gamma scintillation detectors and 16 static measurements were taken along with 100 $cm^2$ smears.

### 33.2.3 Pump Vault

Two functional lift station pumps were taken off-line and removed from the Pump Vault prior to initial entry into the Pump Vault. Considerable material had accumulated at the bottom of the vault, so a vacuum truck was initially employed to remove water and debris. After the vacuum truck had removed all loose material, project personnel removed the remainder of the material with hand methods and/or wet/dry vacuums. Initial hand removal had to be stopped due to the presence of volatile chemical components in the remaining sediment. Upon analyzing the sediment and donning appropriate respiratory protection, the remainder of the material was successfully removed. Radiological analysis via gamma spectroscopy indicated modest activity in the sediment (gross SOF = 0.19, Sample 3155). The walls were then scanned with beta-gamma scintillation detectors and 16 static measurements were taken along with 100 $cm^2$ smears. The presence of water at the bottom of the vault prevented initial survey of the floor of the Pump Vault.

### 33.2.4 Summary

Survey results for the Weir Chamber, Grit Chamber, and Pump Vault are summarized in Table 33-1.

**Table 33-1 Post-Remediation Residual Radioactivity Summary**

| Type of Residual Radioactivity | Range |
|---|---|
| Removable | < 10 dpm/100 $cm^2$ alpha<br>< 100 dpm/100 $cm^2$ beta-gamma |
| Total | 5 to 1,960 dpm/100 $cm^2$ alpha<br>20 to 10,300 dpm/100 $cm^2$ beta-gamma |

Note: cpm to dpm conversion based on instrument response to average beta energy of 86.4 keV (Tc-99)

## 33.3 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.

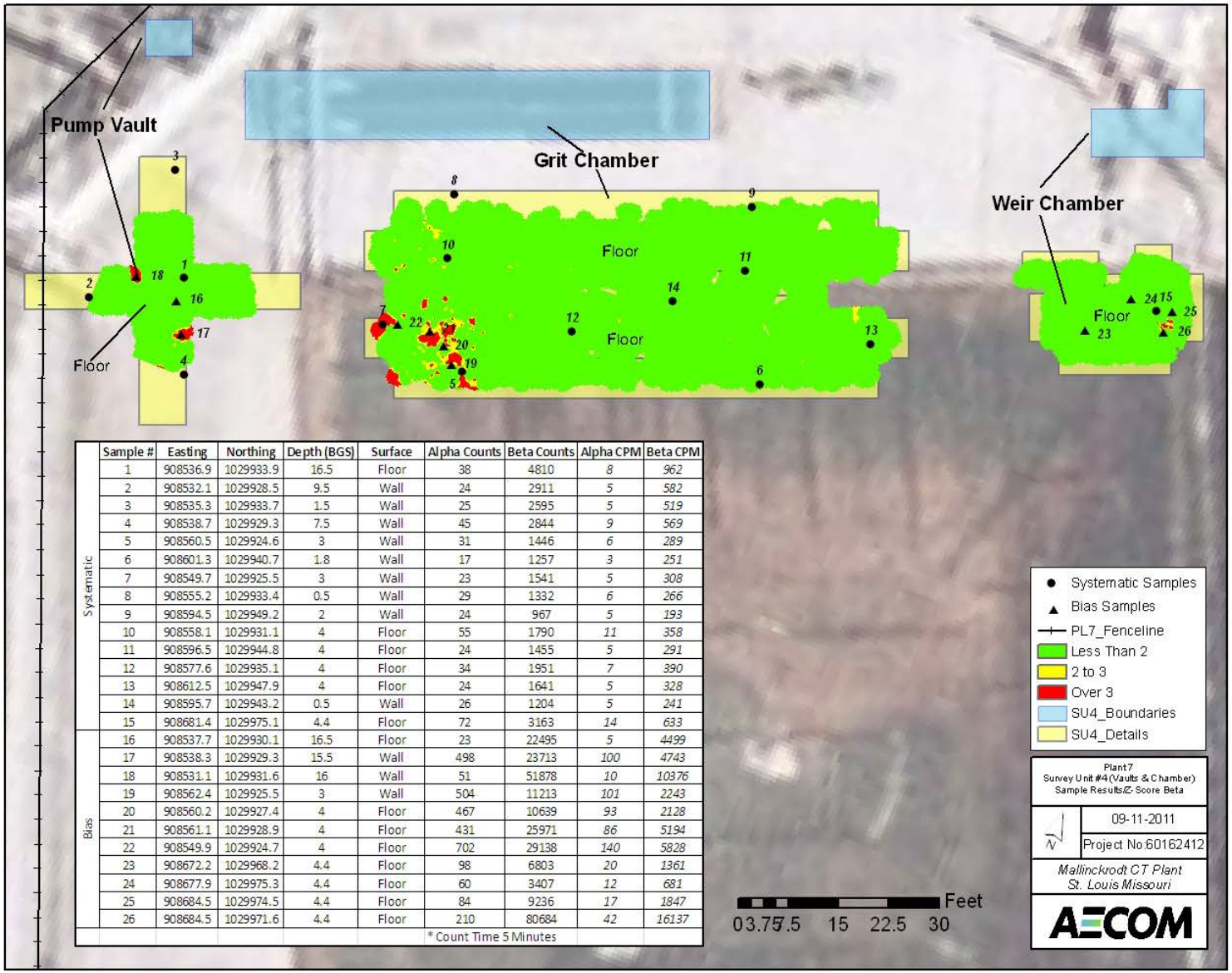
### 33.3.1 Beta Surface Activity Scans

A beta surface scan was performed over the Weir Chamber, Grit Chamber, and Pump Vault surfaces to locate radiation anomalies that might indicate areas with elevated residual radioactivity where further data collection (i.e., biased measurement) was warranted.

### 33.3.2 Surface Activity Measurements

Surface activity measurements to be used for the statistical test were collected at a frequency and at representative locations throughout SU4 such that a statistically sound conclusion regarding the radiological condition of the survey unit could be developed. Additional biased surface activity measurements were also collected at locations of elevated residual radioactivity identified by the beta surface activity scans. Figure 33-14 provides the beta surface activity scan results and surface activity measurement locations. A total of 26 (15 systematic and 11 beta surface activity scan biased locations) surface activity measurements were performed on the surfaces of SU4.

Table 33-2 provides the surface activity measurement results and summary statistics for the 15 systematic measurements. Table 33-3 provides the surface activity measurements results for the 11 beta surface activity scan biased measurement locations. In evaluating the data, background contributions were not accounted for in calculating surface activity. Alpha surface activity measurements were performed by AECOM, presumably for informational purposes, and are provided in the tables.




| | Sample # | Easting | Northing | Depth (BGS) | Surface | Alpha Counts | Beta Counts | Alpha CPM | Beta CPM |
|---|---|---|---|---|---|---|---|---|---|
| Systematic | 1 | 908536.9 | 1029933.9 | 16.5 | Floor | 38 | 4810 | *8* | *962* |
| | 2 | 908532.1 | 1029928.5 | 9.5 | Wall | 24 | 2911 | *5* | *582* |
| | 3 | 908535.3 | 1029933.7 | 1.5 | Wall | 25 | 2595 | *5* | *519* |
| | 4 | 908538.7 | 1029929.3 | 7.5 | Wall | 45 | 2844 | *9* | *569* |
| | 5 | 908560.5 | 1029924.6 | 3 | Wall | 31 | 1446 | *6* | *289* |
| | 6 | 908601.3 | 1029940.7 | 1.8 | Wall | 17 | 1257 | *3* | *251* |
| | 7 | 908549.7 | 1029925.5 | 3 | Wall | 23 | 1541 | *5* | *308* |
| | 8 | 908555.2 | 1029933.4 | 0.5 | Wall | 29 | 1332 | *6* | *266* |
| | 9 | 908594.5 | 1029949.2 | 2 | Wall | 24 | 967 | *5* | *193* |
| | 10 | 908558.1 | 1029931.1 | 4 | Floor | 55 | 1790 | *11* | *358* |
| | 11 | 908596.5 | 1029944.8 | 4 | Floor | 24 | 1455 | *5* | *291* |
| | 12 | 908577.6 | 1029935.1 | 4 | Floor | 34 | 1951 | *7* | *390* |
| | 13 | 908612.5 | 1029947.9 | 4 | Floor | 24 | 1641 | *5* | *328* |
| | 14 | 908595.7 | 1029943.2 | 0.5 | Wall | 26 | 1204 | *5* | *241* |
| | 15 | 908681.4 | 1029975.1 | 4.4 | Floor | 72 | 3163 | *14* | *633* |
| Bias | 16 | 908537.7 | 1029930.1 | 16.5 | Floor | 23 | 22495 | *5* | *4499* |
| | 17 | 908538.3 | 1029929.3 | 15.5 | Wall | 498 | 23713 | *100* | *4743* |
| | 18 | 908531.1 | 1029931.6 | 16 | Wall | 51 | 51878 | *10* | *10376* |
| | 19 | 908562.4 | 1029925.5 | 3 | Wall | 504 | 11213 | *101* | *2243* |
| | 20 | 908560.2 | 1029927.4 | 4 | Floor | 467 | 10639 | *93* | *2128* |
| | 21 | 908561.1 | 1029928.9 | 4 | Floor | 431 | 25971 | *86* | *5194* |
| | 22 | 908549.9 | 1029924.7 | 4 | Floor | 702 | 29138 | *140* | *5828* |
| | 23 | 908672.2 | 1029968.2 | 4.4 | Floor | 98 | 6803 | *20* | *1361* |
| | 24 | 908677.9 | 1029975.3 | 4.4 | Floor | 60 | 3407 | *12* | *681* |
| | 25 | 908684.5 | 1029974.5 | 4.4 | Floor | 84 | 9236 | *17* | *1847* |
| | 26 | 908684.5 | 1029971.6 | 4.4 | Floor | 210 | 80684 | *42* | *16137* |
| | | | | | | * Count Time 5 Minutes | | | |

**Figure 33-14 Beta Surface Activity Scans and Surface Activity Measurement Locations**

## Table 33-2 Systematic Surface Activity Results

| Location | Depth (ft bgs) | Surface | Alpha Counts [a] | Beta Counts [a] | Alpha CPM | Beta CPM | Alpha (dpm/100 $cm^2$) | Beta (dpm/100 $cm^2$) |
|---|---|---|---|---|---|---|---|---|
| 1 | 16.5 | Floor | 38 | 4,810 | 8 | 962 | 35 | 6,411 |
| 2 | 9.5 | Wall | 24 | 2,911 | 5 | 582 | 22 | 3,880 |
| 3 | 1.5 | Wall | 25 | 2,595 | 5 | 519 | 23 | 3,458 |
| 4 | 7.5 | Wall | 45 | 2,844 | 9 | 569 | 41 | 3,790 |
| 5 | 3 | Wall | 31 | 1,446 | 6 | 289 | 28 | 1,927 |
| 6 | 1.8 | Wall | 17 | 1,257 | 3 | 251 | 16 | 1,675 |
| 7 | 3 | Wall | 23 | 1,541 | 5 | 308 | 21 | 2,054 |
| 8 | 0.5 | Wall | 29 | 1,332 | 6 | 266 | 26 | 1,775 |
| 9 | 2 | Wall | 24 | 967 | 5 | 193 | 22 | 1,289 |
| 10 | 4 | Floor | 55 | 1,790 | 11 | 358 | 50 | 2,386 |
| 11 | 4 | Floor | 24 | 1,455 | 5 | 291 | 22 | 1,939 |
| 12 | 4 | Floor | 34 | 1,951 | 7 | 390 | 31 | 2,600 |
| 13 | 4 | Floor | 24 | 1,641 | 5 | 328 | 22 | 2,187 |
| 14 | 0.5 | Wall | 26 | 1,204 | 5 | 241 | 24 | 1,605 |
| 15 | 4.4 | Floor | 72 | 3,163 | 14 | 633 | 66 | 4,215 |
| | | | | | | Average: | 30 | 2,746 |
| | | | | | | Median: | 24 | 2,187 |
| | | | | | | Standard Deviation: | 13 | 1,369 |
| | | | | | | Minimum: | 16 | 1,289 |
| | | | | | | Maximum: | 66 | 6,411 |

[a] Total count time of five minutes.

**Table 33-3 Biased Surface Activity Results**

| Location | Depth (ft bgs) | Surface | Alpha Counts [a] | Beta Counts [a] | Alpha CPM | Beta CPM | Alpha (dpm/100 $cm^2$) | Beta (dpm/100 $cm^2$) |
|---|---|---|---|---|---|---|---|---|
| 16 | 16.5 | Floor | 23 | 22,495 | 5 | 4,499 | 21 | 29,980 |
| 17 | 15.5 | Wall | 498 | 23,713 | 100 | 4,743 | 455 | 31,603 |
| 18 | 16 | Wall | 51 | 51,878 | 10 | 10,376 | 47 | 69,140 |
| 19 | 3 | Wall | 504 | 11,213 | 101 | 2,243 | 460 | 14,944 |
| 20 | 4 | Floor | 467 | 10,639 | 93 | 2,128 | 427 | 14,179 |
| 21 | 4 | Floor | 431 | 25,971 | 86 | 5,194 | 394 | 34,613 |
| 22 | 4 | Floor | 702 | 29,138 | 140 | 5,828 | 641 | 38,834 |
| 23 | 4.4 | Floor | 98 | 6,803 | 20 | 1,361 | 90 | 9,067 |
| 24 | 4.4 | Floor | 60 | 3,407 | 12 | 681 | 55 | 4,541 |
| 25 | 4.4 | Floor | 84 | 9,236 | 17 | 1,847 | 77 | 12,309 |
| 26 | 4.4 | Floor | 210 | 80,684 | 42 | 16,137 | 192 | 107,531 |

[a] Total count time of five minutes.

## 33.4 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.

### 33.4.1 Elevated Area Evaluation

There were no elevated areas identified in SU4.

### 33.4.2 Data Set Screening Analysis

Table 33-4 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 33-4 Screening Tests Results**

| Screening Test | Test Value | Conclusion |
|---|---|---|
| Min/Max | 6,411 | PASS |
| Low Level | N/A | Not applicable; Class 2 survey unit |
| $DCGL_W$ | N/A | Not applicable; Min/Max < $DCGL_W$ |
| EMC Limit | N/A | Not applicable; No elevated areas |

#### 33.4.2.1 Min/Max

Page 14-27 of the C-T Phase II DP describes calculating the Min/Max screening test value by subtracting the minimum reference area result from the maximum survey unit systematic result. Background was not accounted for in the surface activity measurements; therefore, the Min/Max screening test value was equal to the maximum survey unit result. Location 1 with a beta surface activity result of 6,411 dpm/100 $cm^2$ (from Table 33-2) was the maximum survey unit systematic result, which is the Min/Max screening test value. Because the test value was less than 180,000 β/min/100 $cm^2$, no further computations are required, i.e., $DCGL_W$ screening and Wilcoxon Rank Sum (WRS) tests.

#### 33.4.2.2 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 2 survey units.

#### 33.4.2.3 $DCGL_W$

In accordance with Page 14-28 of the C-T Phase II DP and because the Min/Max test value was less than 180,000 β/min/100 $cm^2$, the $DCGL_W$ screening test was not applicable to this survey unit.

33.4.2.4 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.

### 33.4.3 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 180,000 β/min/100 $cm^2$, the WRS Test was not required to demonstrate compliance.

### 33.4.4 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 33-5 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 33-5 Retrospective Analysis**

| Parameter | *A Priori* Value | Retrospective Value Based on FSS Results (dpm/100 $cm^2$) |
|---|---|---|
| Upper Bound of Gray Region | DCGL = 180,000 β/min/100 $cm^2$ | 180,000 |
| Lower Bound of Gray Region | 0.5 x DCGL = 90,000 β/min/100 $cm^2$ | 2,746 |
| Spatial Variability (standard deviation) | 1/6 x DCGL = 30,000 β/min/100 $cm^2$ | 1,369 |
| Type I Error (false positive) | 0.05 | 0.05 |
| Type II Error (false negative) | 0.05 | 0.05 |
| Relative Shift | 3 | 129 |
| Calculated N/2 Sample Size | 15 [a] | 9 |
| Actual N/2 Sample Size | -- | 15 |

[a] 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 8 based on MARSSIM Table 5.3.

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

## 33.6 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. None of the inspections applied to the Plant 7 final status surveys.

## 33.7 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 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. SU4 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.

## 33.8 REFERENCES

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