Attachment 3

Final Status Survey Final Report Volume 3, Chapter 21

Survey Area Release Record for Land Survey Area 08, Survey Units 09, 12 and 13, Revision 1 with Compact Disc

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Final Status Survey Report

Hematite Decommissioning Project

Final Status Survey Final Report Volume 3, Chapter 21

TITLE: **Survey Area Release Record for Land Survey Area 08, Survey Units 09, 12 and 13 (LSA 08-09, LSA 08-12 and LSA 08-13)**

REVISION: **1**

EFFECTIVE DATE: FEB 0 7 2018

Approvals:

Author: _____ 02-07-2018
Kenneth E. Pallagi Date

Owner/Manager: _____ 2/7/18
W. Clark Evers Date

REVISION LOG	
Revision No. Effect. Date	**Revision**
0 06/07/2017	Revision 0 is the initial issuance of the Survey Area Release Record for Land Survey Area 08, Survey Units 09, 12 and 13.
1 See Cover Page	The NRC provided feedback during recurring weekly publicly noticed teleconferences in regards to LSA 08-12 data. During the review of the report the NRC staff noted errors in the spreadsheets (Appendices) for the WRS Test. Specifically, the cell ranges in some formulas appear to be off such that the rankings are incorrect and the number of data points for the survey unit is miscounted. This revision implements the correction to the spreadsheet for LSA 08-12 as well as revising the W_R value in the text from 1036 to 1068 and revising the critical value of 860 to 879 as indicated in the corrected appendices (spreadsheets).

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LIST OF ACRONYMS AND SYMBOLS

ALARA	As Low As Reasonably Achievable
bgs	below ground surface
CFR	Code of Federal Regulations
cm	centimeter(s)
cpm	count(s) per minute
CSM	Conceptual Site Model
DCGL	Derived Concentration Guideline Level
$DCGL_w$	DCGL for average concentrations over a survey unit, used with statistical tests. ("W" suffix denotes "Wilcoxon")
DGPS	Digital Global Positioning System
DP	Hematite Decommissioning Plan
DQO	Data Quality Observation
EMC	Elevated Measurement Comparison
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
FSS	Final Status Survey
FSSFR	Final Status Survey Final Report
gcpm	gross count(s) per minute
GIS	Graphical Information Software
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HDP	Hematite Decommissioning Project
HP	Health Physics
I & C	Isolation and Control
IAL	Investigation Action Level
LSA	Land Survey Area
m	meter(s)
m^2	square meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Concentration Limit
MDC	Minimum Detectable Concentration
mrem	milliroentgen equivalent man
NAD	North American Datum
NaI	Sodium Iodide
ncpm	net count(s) per minute
NCS	Nuclear Criticality Safety
NRC	U.S. Nuclear Regulatory Commission
pCi/g	picocurie(s) per gram
QC	Quality Control
Ra	Radium
RASS	Remedial Action Support Survey
RSO	Radiation Safety Officer
SOF	Sum of Fractions
SU	Survey Unit

TEDE	Total Effective Dose Equivalent
Tc	Technetium
Th	Thorium
U	Uranium
WRS	Wilcoxon Rank Sum

EXECUTIVE SUMMARY

This Survey Area Release Record (SARR) presents the results of the final status radiological surveys of the Hematite Decommissioning Project (HDP) Land Survey Area (LSA) 08, Survey Unit (SU) 09 (LSA 08-09), SU 12 (LSA 08-12), and SU 13 (LSA 08-13). As provided in Final Status Survey Final Report (FSSFR), Volume 1, Chapter 1, Section 7.0 {ML15257A307}, the final report summary, FSSFR Volume 7, *Final Status Survey Final Report*, will be submitted at the conclusion of the post-remediation groundwater monitoring period. FSSFR Volume 7 will be submitted to demonstrate that the site has met the requirements for unrestricted release consistent with the requirements of the Title 10 Code of Federal Regulations (CFR) 20 Subpart E, "Criteria for License Termination."

The land areas that comprises LSA 08-09, LSA 08-12 and LSA 08-13 were designated as Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 1 SUs as presented in Table 14-16 of the HDP Decommissioning Plan (DP) {ML092330123}. The Class 1 designation for the land areas that comprises LSA 08-09, LSA 08-12 and LSA 08-13 remained in effect throughout remediation of the site and Final Status Survey (FSS). For the LSA 08-09, LSA 08-12 and LSA 08-13 SUs the evaluation of analytical results against the Derived Concentration Guideline Levels (DCGL) for the Three Stratum Conceptual Site Model (CSM) was the selected approach. The objective of the FSS for all SUs was to obtain and document measurement results, analytical data, and other supporting information in order to demonstrate that after completion of remediation operations the residual radioactivity levels in the LSA 08-09, LSA 08-12 and LSA 08-13 are below the applicable Three Stratum DCGLs and therefore the land area of these SUs meet the criteria for unrestricted release.

Compliance with the "three layer" geometry requires consideration of the Surface, Root, and Deep Layers (stratum) independently. After the original DP submittal and approval, Westinghouse agreed with the NRC that the Deep Stratum DCGLs should not be used as they were not protective of the intruder scenario, and the Excavation Stratum DCGLs were developed as a replacement. Only the Excavation Stratum DCGLs will be used when evaluating the Deep Layer as part of the "three layer" approach. Because each of the Three Stratum DCGLs (surface, root, excavation) represent 25 mrem/year from each layer independently, the unity rule was used to demonstrate compliance when residual contamination was present in more than one soil layer.

In addition to demonstration of the SUs meeting the applicable Three Stratum DCGLs and therefore the land area of these SUs meet the criteria for unrestricted release, NRC License SNM-33 License Condition 15. C states that:

> *"The U.S. Nuclear Regulatory Commission's regulations shall govern unless the statements, representations, and procedures in the licensee's application and the following correspondence are more restrictive than the regulations.....*
>
> *C. Westinghouse HEM-11-56, "Evaluation of Technetium-99 Under the Process Buildings", May 5, 2011 . (ADAMS Accession No. ML111260624)."*

As such, this report contains information relative to meeting the commitments made in HEM-11-56. Appendix K contains HDP-RPT-FSS-302, Summary Report of Investigation of Hybrid Wells and Former Process Buildings Investigation Area.

This SARR was prepared as described in FSSFR Volume 3, Chapter 1, Section 7.0, *Survey Area Release Record Organization*, as implemented by FSS procedure HDP-PR-FSS-722.

1.0 REPORT BACKGROUND

As a result of the U. S. Nuclear Regulatory Commission (NRC) feedback regarding the submittal of the FSSFR, Westinghouse and the NRC agreed that Westinghouse would develop an outline presenting the format and content of FSS documents required for NRC review. Westinghouse provided the outline to the NRC for discussion during the August 19, 2015, publicly noticed teleconference and the format was agreed upon {ML15238B032}.

FSSFR Volume 3, Chapter 1, Revision 3, *Land Survey Areas (LSA) Overview* provides the information common to land survey areas. This report, FSSFR Volume 3, Chapter 21, builds upon the general information provided in FSSFR Volume 3, Chapter 1, Revision 3.

2.0 HDP SITE, LSA AND SURVEY UNIT DESCRIPTIONS

2.1 HDP Site Description

A general description of the HDP site is given in FSSFR Volume 1, Chapter 1.

2.2 LSA Configuration

The DP Chapter 14 and DP Figure 14-14 provided the conceptual approach for the configuration of LSAs and the SUs within a LSA. Figure 2-1 indicates the LSA configurations for the HDP site.

LSA 08 encompasses the entire former "Process Building" footprint and adjacent land areas within the Central Tract. LSA 08 consists of SUs LSA 08-01 through LSA 08-17 (See Figure 2-2).

The DP stated that it was expected that the conceptual boundaries of the SUs would be altered based on the actual configuration and condition of the SU at the time of survey design. As expected, it was necessary to modify the boundary of SUs within LSA 08 to facilitate the remediation process. A portion of the land area in the northeast section of the conceptual configuration of LSA 08 was transitioned into LSA 10 (portions of LSA 10-01, LSA 10-03, LSA 10-13 and LSA 10-14). This was a result of expanded remediation in the Burial Pit Area.

Also, as a consequence of specific remediation efforts required in LSA 08 and the need to maintain a "Haul Road" to the Waste Holding Area (WHA) near the Rail Spur as long as possible to support remediation activities all SU boundaries with LSA-08 were reconfigured (See Figure 2-3).

It is important to note that all of the LSA 08 conceptual land areas (DP Chapter 14 and DP Figure 14-14 were designated as MARSSIM Class 1 and as such remained as MARSSIM Class 1 as either part of LSA 08 or LSA 10, thus ensuring compliance with the DP.

2.3 LSA 08-09, LSA 08-12 and LSA 08-13 Survey Unit Description and Configuration

After the removal of the former Process Building concrete slab and footings, the removal of all subterranean piping, the removal of spent limestone fill material and the completion of radiological remediation of the soil, in the final configuration, LSA 08-09, LSA 08-12 and LSA 08-13 consisted of the excavated area in each SU which consisted solely of native soil. There were no structures, piping, or spent limestone remaining within the SUs at the time of FSS. There was no remaining groundwater monitoring wells within the boundaries of LSA 08-12 or LSA 08-13 at the time of FSS. However there is one remaining groundwater monitoring well (BR-17-JC) within LSA 08-09. This well was installed after the remediation, FSS and backfill of LSA 08-09, for the purposes of post-remediation groundwater monitoring.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 08-09 presents 1,542 square meters (m^2) in planar (2-dimensional) extent, within an interior surface area of 2,050 m^2 (3-dimensional).

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 08-12 presents 1,434 m^2 in planar (2-dimensional) extent, within an interior surface area of 1,515 m^2 (3-dimensional).

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 08-13 presents 1,418 m^2 in planar (2-dimensional) extent, within an interior surface area of 1,449 m^2 (3-dimensional).

Figure 2-1
HDP Land Survey Areas

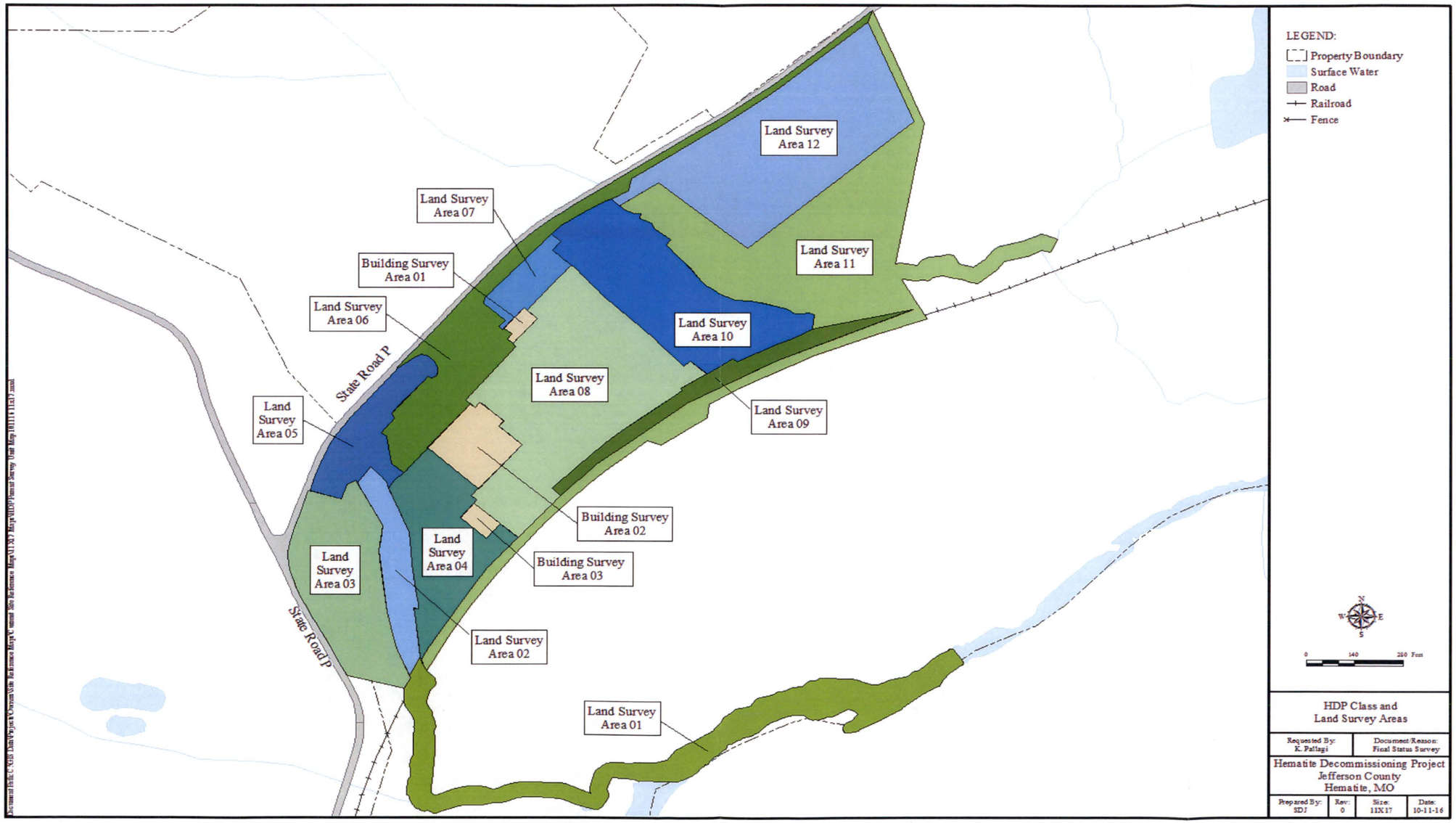
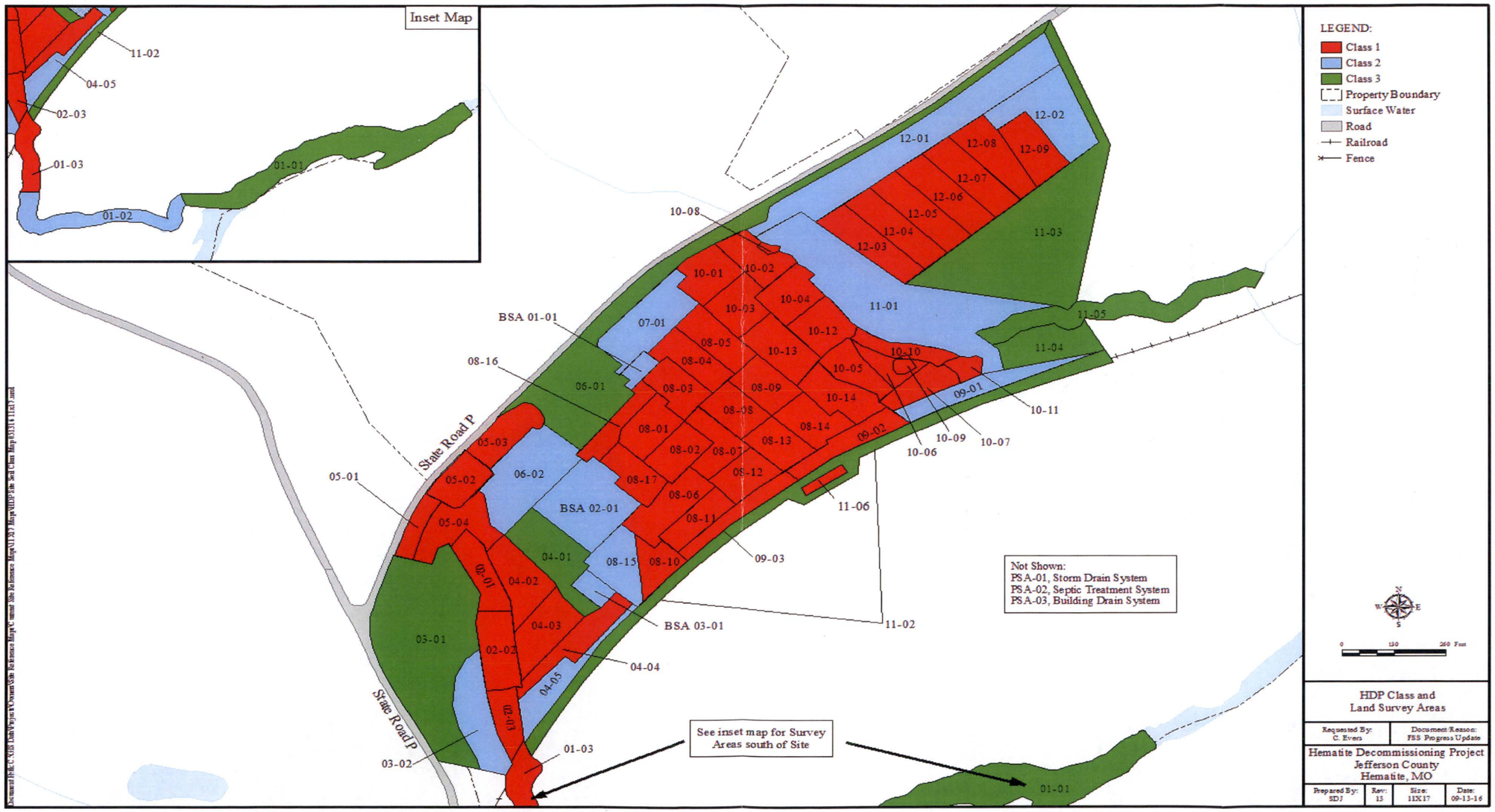


Figure 2-2
Final Configuration of Land Survey Area 08 and Survey Units

Figure 2-3
Final Configuration of Land Survey Areas and Survey Units



3.0 HISTORY OF OPERATIONS

A discussion of site historical operations prior to the decommissioning phase of the HDP is presented in the FSSFR Volume 1, Chapter 1, Section 3.0, *Site Historical Operations*.

A detailed discussion of the historical background information related to the general remediation process is presented in the FSSFR Volume 3, Chapter 1, Section 2.1.1, *Remediation and Excavation.*

3.1 Radioactive Materials in LSA 08-09, LSA 08-12 and LSA 08-13

Radioactive materials within LSA 08-09 resulted from leakage and migration of contamination within the Process Building along the floor and footing interface as well as at locations of piping and drain penetrations through the concrete floor and placement of clean (released from radiological controls in accordance with procedures at the time) waste materials in the subsurface soils.

Radioactive materials in the LSA 08-12 subsurface soils resulted from migration of contamination from the Evaporation Pond Area. Radioactive materials in the LSA 08-12 surface soils resulted from the use of the land area as the WHA during site remediation as is described in the DP.

Radioactive materials in LSA 08-13 subsurface soils resulted from migration of contamination within the soils and the storage of Tc-99 contaminated spent limestone above ground. Radioactive materials in the LSA 08-13 surface soils resulted from the use of the land area as the WHA as is described in the DP.

The radioactive material in LSA 08-09, LSA 08-12 and LSA 08-13 consisted of those Radionuclides of Concern described in FSSFR Volume 1, Chapter 1.

3.2 Reuse Soil Disposition and Characterization

Prior to removal of the Process Building concrete slab and subsequent remediation of the underlying contaminated soil it was determined that generation of reuse soil in the land area of LSA 08-09, LSA 08-12 and LSA 08-13 would not be pursued. As, such no reuse soil was generated from LSA 08-09, LSA 08-12 and LSA 08-13.

3.3 Remediation and Remedial Action Support Surveys (RASS) Phase of LSA 08-09, LSA 08-12 and LSA 08-13

The sections below provide a discussion of the various elements of the remediation and RASS phase of LSA 08-09, LSA 08-12 and LSA 08-13 necessary to prepare the SUs for FSS.

Important to the planning and execution of remediation of the soils under the former Process Buildings was the information provided in Westinghouse letter HEM-11-56 to the NRC which contained the "Evaluation of Technetium-99 Under the Process Building" report. A portion of the foot print of the Process Building was within the SU boundary of LSA 08-09.

Portions of this section of the report are written such that the statements in the "Evaluation of Technetium-99 Under the Process Building" are written in italics and quotation marks followed by a discussion of compliance with the statement.

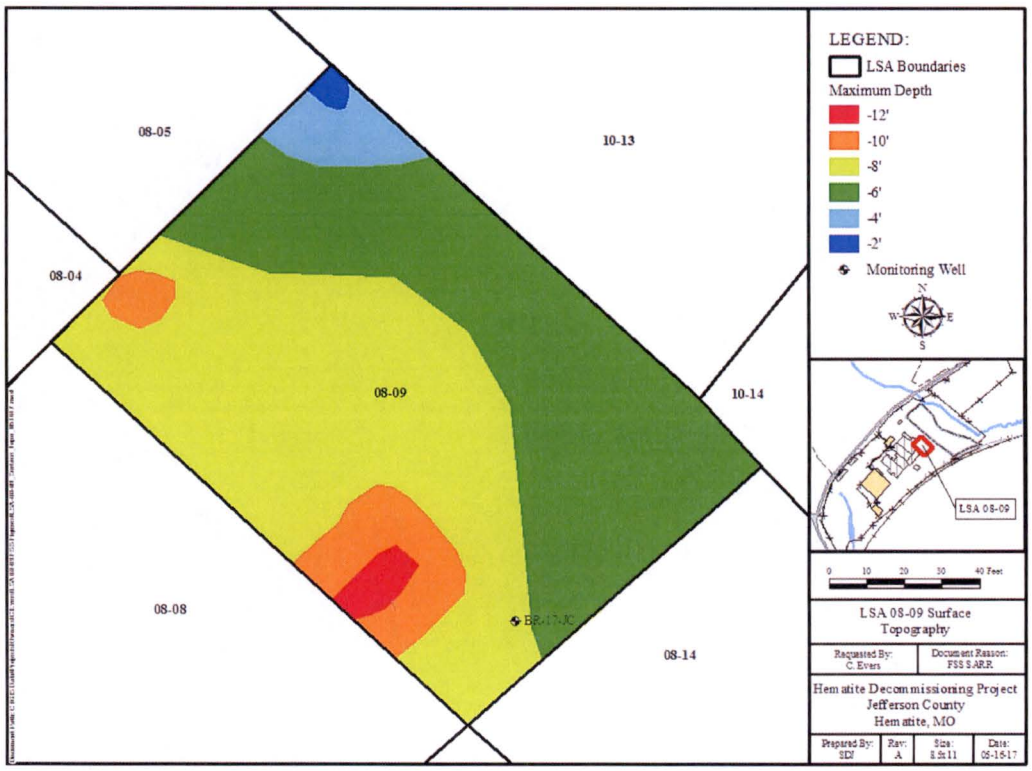
3.3.1 Remedial Actions in LSA 08-09

"Excavation under the former Processing Buildings is expected to begin with the removal of the building slabs and the building footers. Soil will then be excavated to make underground piping available for removal, and then the piping will be removed."

Remedial actions began in LSA 08-09 in April, 2013, and continued through November, 2015 after the removal of the former Process Building concrete slabs. Remediation consisted of excavation by large and small excavating equipment to remove building footings and foundations in LSA 08-09. After removal of the footings and foundations remediation consisted of excavation to remove process piping, waste materials and contaminated soils.

The maximum depth of remedial excavation necessary in portions of LSA 08-09 to ensure all areas identified during site characterization, the historical site assesement and remedial action survey efforts were adequately remediated relative to the original grade was 10 to 12 feet. The estimated volume of excavated waste materials from LSA 08-09 was 3,250 cubic yards. Figure 3-1 provides the depth of excavation for LSA 08-09.

Figure 3-1
LSA 08-09 Depth of Excavation Map (Depths in Feet)*



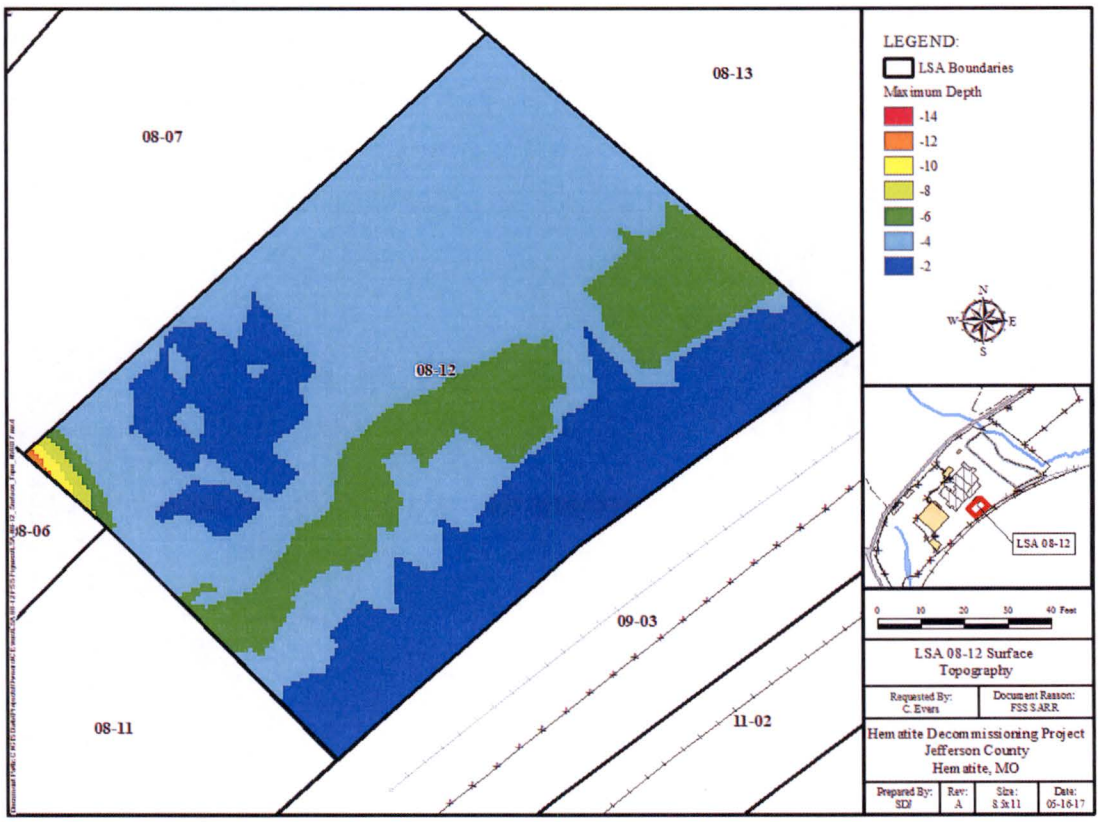
*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 10 to 12 feet.

3.3.2 Remedial Actions in LSA 08-12 and LSA 08-13

Remedial actions began in LSA 08-12 and LSA 08-13 in July, 2015, and continued through February, 2016, after the land area was no longer utilized for the WHA. Remediation consisted of excavation to remove waste materials (spent limestone) and contaminated soils.

The maximum depth of remedial excavation necessary in portions of LSA 08-12 to ensure all areas identified during site characterization, the historical site assesement and remedial action survey efforts were adequately remediated relative to the original grade was 10 to 12 feet. The estimated volume of excavated waste materials from LSA 08-12 was 2,584 cubic yards. Figure 3-2 provides the depth of excavation for LSA 08-12.

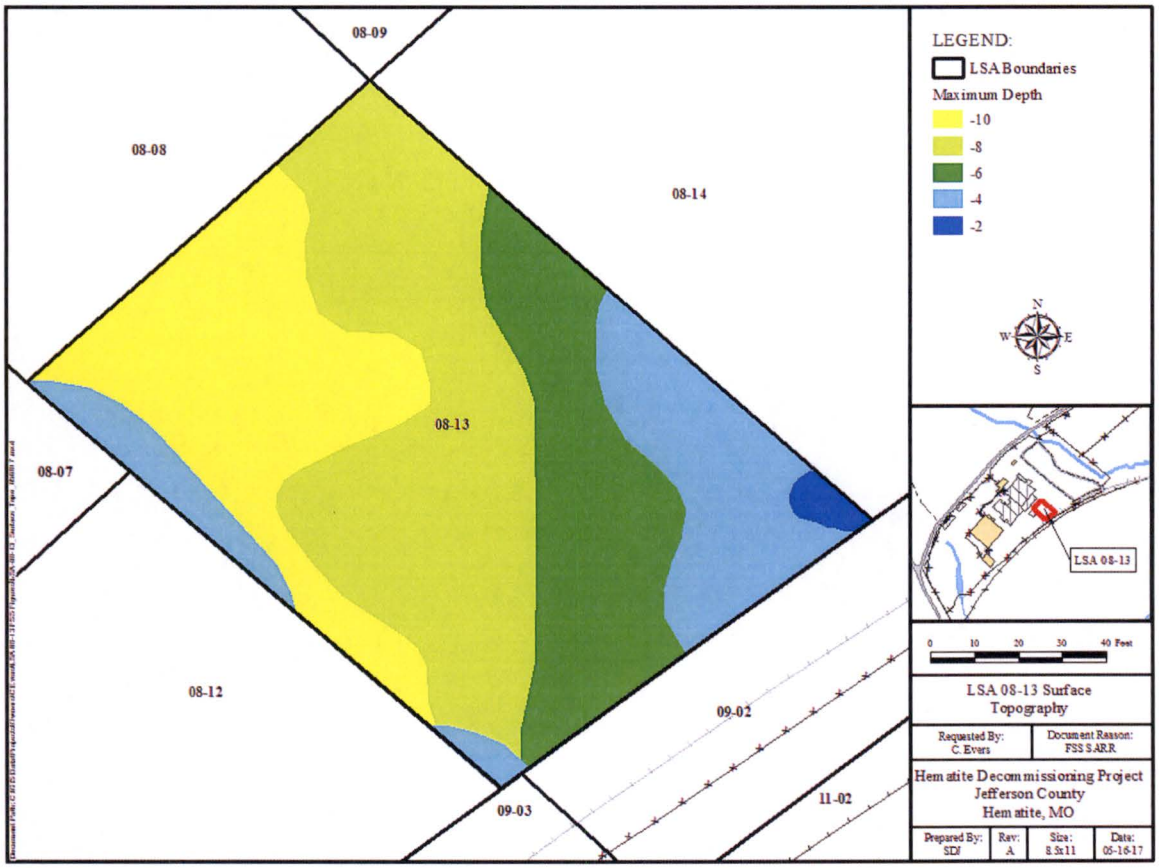
Figure 3-2
LSA 08-12 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 10 to 12 feet.

The maximum depth of remedial excavation necessary in portions of LSA 08-13 to ensure all areas identified during site characterization, the historical site assesemnt and remedial action survey efforts were adequately remediated relative to the original grade was 8 to 10 feet. The estimated volume of excavated waste materials from LSA 08-13 was 3,152 cubic yards. Figure 3-3 provides the depth of excavation for LSA 08-13.

Figure 3-3
LSA 08-13 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 8 to 10 feet.

3.3.3 In Process Remedial Action Support Surveys

During excavation and remediation of the Process Building Area, remedial action support surveys were conducted in accordance with procedure HDP-PR-HP-601, *Remedial Action Support Surveys*. The radiological information obtained from the surveys served the purpose of categorizing the soil/material into one of two categories; 1) Soil/material potentially exceeding the Nuclear Criticality Safety Exempt Material Limit, 2) Soil/materials potentially containing radioactivity concentrations above the DCGL.

3.3.4 Nuclear Criticality Safety (NCS) Borings

As directed by NSA-TR-09-15, *Nuclear Criticality Safety Assessment of Buried Waste Exhumation and Contaminated Soil Remediation at the Hematite Site* (Reference 12.3), borings were performed for the purpose of downgrading from NCS controls and included an inspection of the core bore soil to confirm that no debris/waste indicative of burial pit waste was present below the excavation surface. The NSA-TR-09-15 Administrative CSC 23 required that these borings would be performed to 3 feet (ft) below the deepest identified buried waste item in an

excavation or 7 ft below ground surface (representative of 4 ft of overburden soil and an additional 3 ft into the soil that could have potential burial pit waste).

As required by the NCS program a grid with maximum spacing of 20 ft between boreholes was conducted within the areas that were under NCS controls. The grid spacing chosen was based upon the nominal size of a documented burial pit. The spacing was chosen to provide a high probability that material from an unidentified burial pit would be intercepted.

The survey measurements from the spoils material and boreholes for LSA 08-09 and LSA 08-12, along with the results of the visual inspection, were then reviewed by the NCS Specialist and the area released from NCS controls. The visual inspection of the cores provided evidence that no materials indicative of burial pit waste were encountered below the excavation surface within LSA 08-09 and LSA 08-12. Once the area was released from NCS controls, excavation continued as necessary, for additional remediation of radiological and/or VOC contamination.

See Figure 3-4 for the location of the core borings for LSA 08-09 and Figure 3-5 for LSA 08-12. LSA 08-13 was not within a designated NCS area, therefore NCS controls were not required in LSA 08-13.

Inspection of the core samples indicate that no materials indicative of burial pit waste were encountered below the excavation surface within LSA 08-09 and LSA 08-12.

Figure 3-4
NCS Core Bore Locations in LSA 08-09

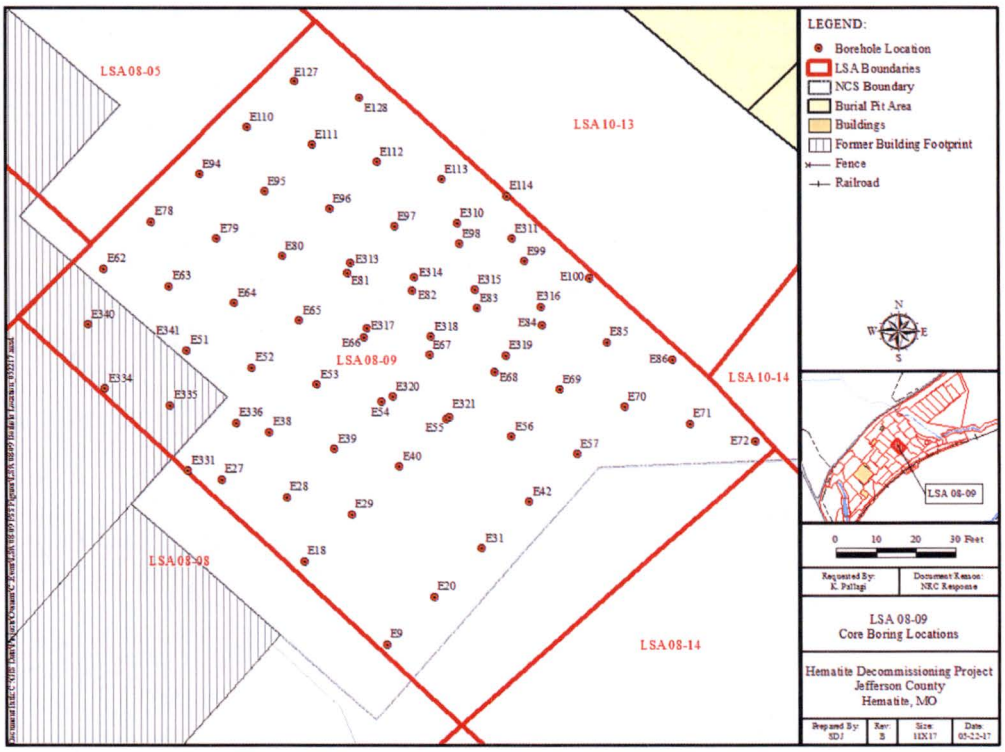
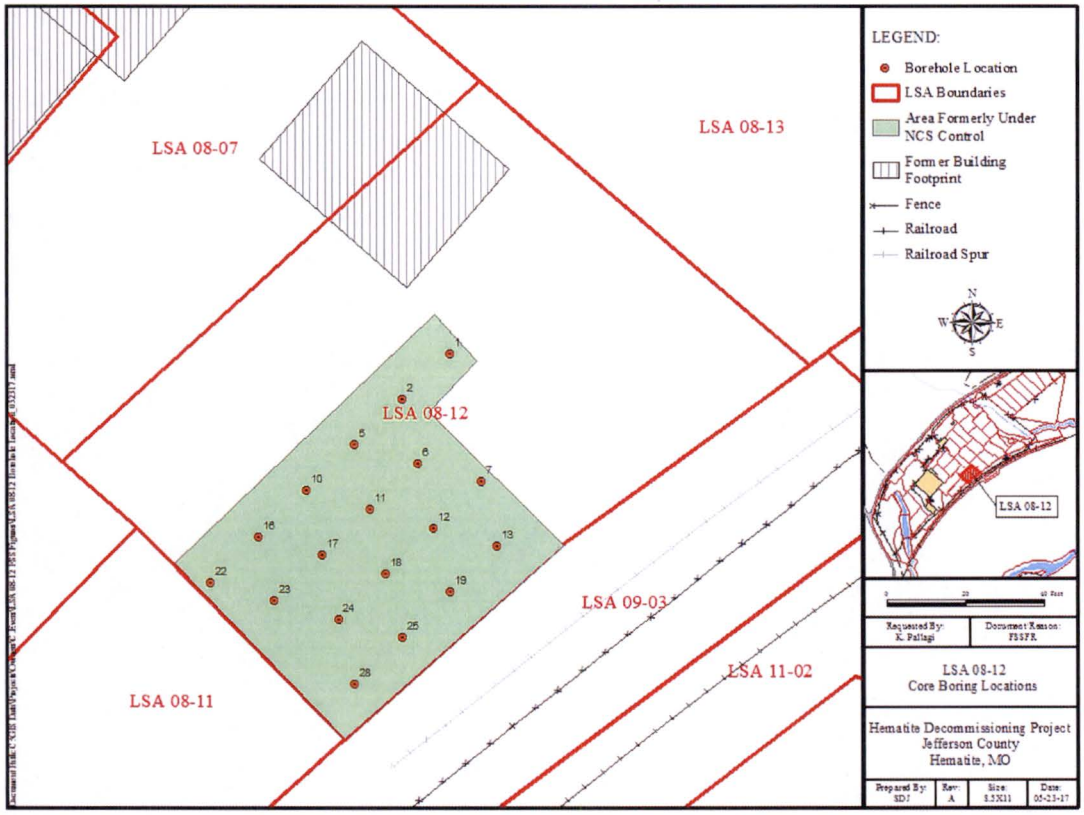


Figure 3-5
NCS Core Bore Locations in LSA 08-12



3.3.5 Groundwater Monitoring Wells

A detailed discussion of history, purpose, use, issues, and results of the groundwater monitoring wells at HDP is presented in the FSSFR Volume 6, Chapter 1. Section 3.3.4.1 provides a discussion of the abandoned wells within the SU boundary of SUs LSA 08-09 and LSA 08-12. Section 3.3.4.2 provides a discussion of the post-remediation groundwater monitoring wells within the SU boundary of SUs LSA 08-09 and LSA 08-12. There are/were no groundwater wells associated with SU LSA 08-13.

3.3.5.1 Abandoned Wells

Important to the planning and execution of remediation of the soils under the former Process Buildings was the information provided in Westinghouse letter HEM-11-56 to the NRC which contained the "Evaluation of Technetium-99 Under the Process Building" report. In the report are specific instructions in regards to the abandonment of "hybrid wells". The instruction as provided in the report is as follows:

> *"The following actions shall be taken to investigate the potential for a preferential pathway of Tc-99 and uranium along a monitoring well screen that crosses both the Silty Clay Aquitard HSU and the Sand/Gravel HSU (hybrid well), and to determine whether*

contaminated soil exists in proximity to a hybrid monitoring well:

- *When hybrid wells are abandoned they will be over drilled using hollow stem augers of sufficient outside diameter to remove approximately two inches of surrounding soil, the well riser, well screen, and screened filter pack. The auger will continue until reaching refusal, which indicates bedrock. The soil cuttings that are removed during the boring process will be surveyed for indications of elevated radioactivity as a qualitative measure and sampled for laboratory analysis. Within each 5 foot interval, sample(s) of soil indicating elevated concentrations will be collected for laboratory analysis. In the event that an elevated count is not observed, one composite sample of the cuttings collected within each 5 foot interval will be collected for laboratory analysis.*
- *When completing remediation actions in the area of a hybrid well screen that extends beyond the depth of soil excavation, any water sample taken over the history of that well will be assessed for results that exceed the MDC+Error for Tc-99 or exceed the Background Threshold Value for total uranium. For such an exceedance, four borings will be made in close proximity (e.g., approximately equidistant within a 2-4 foot radius) to each monitoring well that is not excavated to the bottom of the well. The borings shall extend down to refusal, which indicates bedrock. Composite samples will be collected as follows:*
    - *From each 5 foot increment of depth to the top of the screened/filtered interval;*
    - *From the increment that is equivalent to the top half of the screened/filtered interval; and*
    - *From the increment that is equivalent to the bottom half of the screened/filtered interval.*

Should a sample result from the investigation sampling described in this subsection exceed the applicable DCGL, then remediation of the subsurface soil represented by the sample is required. If remediation was by overboring, then sampling borings as described in the preceding paragraph may be used to demonstrate compliance. If remediation was by excavation, a final status survey (FSS) per Chapter 14 will be completed."

3.3.5.2 LSA 08-09

The following groundwater monitoring wells were located in the land area of LSA 08-09 and were subsequently abandoned in accordance with State of Missouri Department of Natural Resource (MDNR) requirements (10 CSR 23-4.080):

BD-08

Hybrid well BD-08 (total depth 35.5 ft) was installed on November 21, 2003, and abandoned on January 19, 2012 in accordance with the requirements of HEM-11-56. Abandonment of monitoring well BD-08 included overdrilling with 8 inch diameters augers to removed well materials and tremie grouting the hole from the bottom to top.

A review of the radiological water sample data from BD-08 prior to abandonment indicated there was a historic exceedance of uranium above the uranium background threshold value of

8.6 pCi/l. The maximum total uranium result was 10.93 pCi/l. Tc-99 results exceeded the MDC+Error for water samples collected from this well.

During the well abandonment in January 2012, a radiological survey of the soil cuttings was performed in the field and composite samples were submitted for laboratory analysis. The radiological survey of the soil cuttings did not demonstrate indications of elevated radioactivity. The maximum SOF result from the seven (7) soil cuttings samples collected from BD-08 during abandonment was 6.68 of the Uniform $DCGL_W$. This sample was collected from 0 to 5 feet below ground surface (bgs).

Subsequently on August 13, 2013, four close proximity supplemental investigation soil borings were advanced at the location of the previously abandoned well BD-08. The laboratory analysis of the soil samples for BD-08 indicated that the highest interval Uniform DCGL SOF was 1.62 at 0 to 4 feet below ground surface.

The top 8 feet of soil from original grade of abandoned well BD-08 was removed during the SU soil remediation thereby remediating the area of the two samples previously discussed. The soil around former monitoring well BD-08 from 8 to 35.5 feet bgs remains in place. The highest interval excavation stratum DCGL SOF remaining was 0.36 (BD08-N depth interval 30 to 35 ft). All sample results for BD-08 are provided in Attachment 6 of Appendix K.

DM-02

Hybrid well DM-02 (total depth 33.0 ft) was installed on July 2, 2004, and abandoned on April 5, 2011, in accordance with the requirements of HEM-11-56 and the MDNR. Abandonment of monitoring well DM-02 included overdrilling with 8 inch diameter auger to remove well materials and tremie grouting the well from the bottom to top.

A review of the radiological water sample data from DM-02 prior to abandonment indicated there were historic exceedances of uranium above the uranium background threshold value of 8.6 pCi/l and Tc-99 results that exceeded the MDC+Error for the water samples collected from this well.

During the well abandonment in April 2011, a radiological survey of the soil cuttings was performed in the field and composite samples were submitted for laboratory analysis. The radiological survey of the soil cuttings did not demonstrate indications of elevated radioactivity. The maximum Uniform $DCGL_W$ SOF result from the seven (7) soil cuttings samples collected from DM-02 during abandonment was 0.93, which is compliant with the Three Stratum DCGLs. This sample was collected from 8 to 12 ft bgs interval.

From August 11 through August 15, 2013, four close proximity supplemental investigation soil borings were advanced at the location of DM-02. The Hybrid Well Investigation results of the laboratory analysis of the soil samples for DM-02 indicated that the highest interval Uniform DCGL SOF of 1.48 at the 2 to 4 ft bgs interval.

The top 6 feet of soil from original grade of abandoned well DM-02 was removed during the SU soil remediation thereby remediating the area of the 2 to 4 ft bgs interval. The soil around former monitoring well DM-02 from 6 to 33 feet bgs remains in place. The highest interval

excavation DCGL SOF remaining was 0.48 (BD02-E depth interval of 8 to 12 ft). All sample results for DM-02 are provided in Attachment 6 of Appendix K.

OA-19

Hybrid well OA-19 (total depth 33.6 ft) was installed on July 1, 2004, and abandoned on August 23, 2006, in accordance with the requirements of the MDNR. A variance for abandonment of this well was approved by MDNR (Variance No. 3268) that allowed for the removal of the upper 3 feet of casing and tremie filling the well with grout from the bottom to top. Abandonment of monitoring well OA-19 included tremie grouting the well from the bottom to top and the removal of the upper 5 feet of PVC riser pipe.

A review of the radiological water sample data from OA-19 prior to abandonment indicated that there were no historic exceedances of uranium above the uranium background threshold value of 8.6 pCi/l. Hybrid well OA-19 has no history of Tc-99 results exceeding the MDC+Error, with a maximum historical Tc-99 result of 8.58 pCi/L, well below the Environmental Protection Agency (EPA) drinking water standard of 900 pCi/L.

Hybrid well OA-19 was abandoned prior to the establishment of the requirements of HEM-11-56, as such, there was not a documented radiological survey of the soil cuttings as well as no composite samples of the soil cuttings.

All sample results for OA-19 are provided in Attachment 6 of Appendix K.

GW-T

Groundwater monitoring well GW-T (total depth 37.7 ft) was installed on September 2, 2009, and abandoned on May 24, 2013. This well was located near the southern boundary of LSA 08-09. Abandonment of monitoring well GW-T included removal of the well materials and tremie grouting the hole from the bottom to top. Monitoring well GW-T was installed with a screen isolated in the sandy/gravel overburden zone and therefore does not meet the definition of a hybrid well.

A review of the historical radiological water sample data for GW-T indicates that there were no historic exceedances of uranium above the uranium background threshold value of 8.6 pCi/l. There were Tc-99 results that exceeded the MDC+Error for the water samples collected from this well. The maximum Tc-99 result was 4.7 pCi/l, well below the EPA drinking water standard of 900 pCi/l.

3.3.5.3 LSA 08-12

Groundwater monitoring well GW-Z (total depth 33.9 ft) was installed on September 3, 2009, and abandoned on January 14, 2014. This well was installed in the northern quadrant of LSA 08-12. Abandonment of monitoring well GW-Z included removal of the well materials and tremie grouting the hole from the bottom to top. Monitoring well GW-Z was installed with a screen isolated in the sandy/gravel overburden zone and therefore does not meet the definition of a hybrid well.

A review of the historical radiological water sample data for GW-Z indicates that there were no historic exceedances of uranium above the uranium background threshold value of 8.6

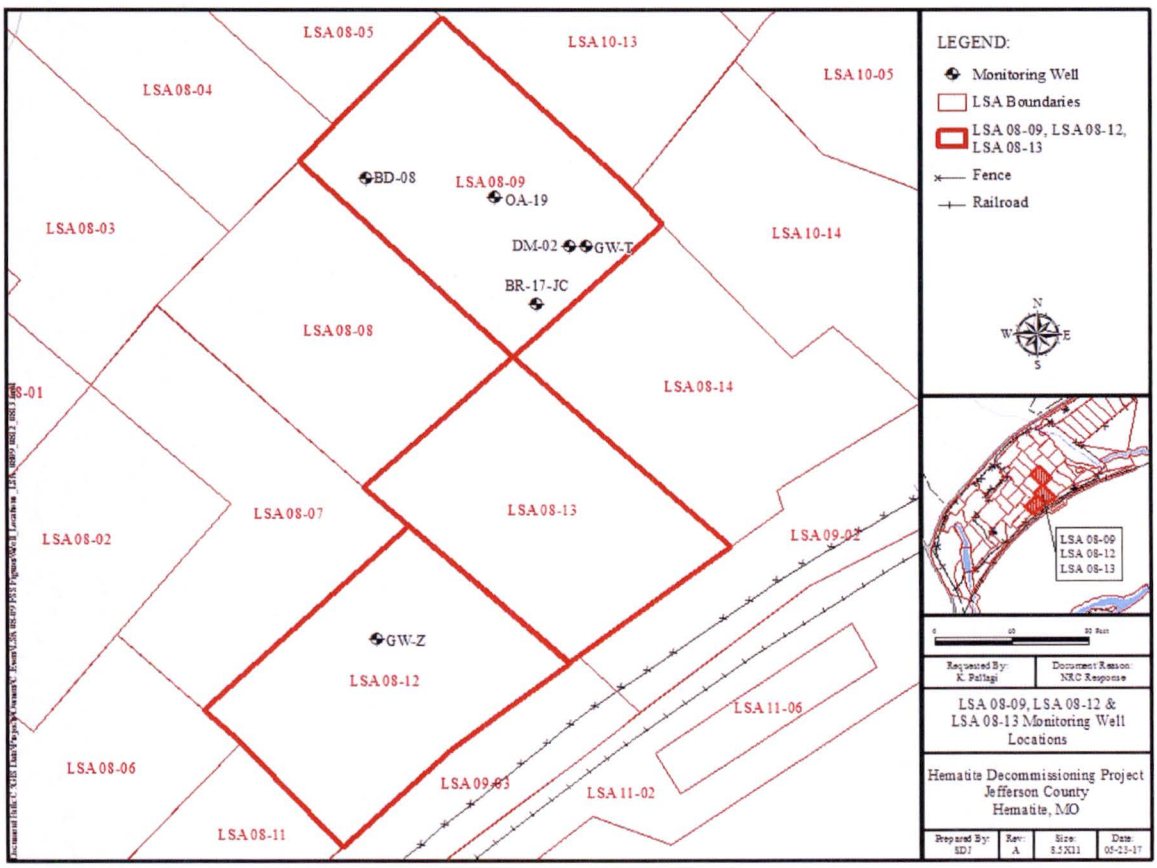
pCi/l. Well GW-Z has no history of Tc-99 results exceeding the MDC+Error, with a maximum historical Tc-99 result of 2.5 pCi/l, well below the EPA drinking water standard of 900 pCi/l.

3.3.5.4 Post-remediation Groundwater Monitoring Wells

Groundwater monitoring well BR-17-JC (total depth 84.5 ft) was installed on June 3, 2016, near the SU southern boundary of LSA 08-09. This well is currently in service as part of post-remediation groundwater monitoring and is screened in the Jefferson City-Cotter bedrock formation.

Figure 3-6 provides the locations of abandoned and post-remediation groundwater monitoring wells in LSA 08-09, LSA 08-12 and LSA 08-13.

Figure 3-6
LSA 08-09, LSA 08-12 and LSA 08-13 Abandoned and Post-remediation Monitoring Well Locations



3.3.6 Subterranean Piping

Preliminary remediation planning activities indicated that subterranean process piping would be encountered in LSA 08-09. As stated in Section 3.3.1 excavation remediation activities were conducted to remove subterranean process piping from LSA 08-09.

As no buried piping remains under the footprint of LSA 08-09, LSA 08-12 and LSA 08-13 there is no dose contribution from this pathway.

3.3.7 Characterization History

Radiological characterization surveys for the HDP were conducted in several phases by multiple contractors over several years prior to the issuance of the DP. A total of thirty one (31) core borings to depths as deep as 35 feet bgs were performed for characterization within LSA 08-09, LSA 08-12 and LSA 08-13 prior to remediation.

Within LSA 08-09, one of the four characterization boring locations within the SU exceeded a SOF of 1 as compared to the surface stratum criteria (sample DM-02) within the surface stratum. Remediation progress was reviewed to ensure that the soil in the area of the sample was adequately removed during remediation with the excavation of soil occurring to average depths of 6 to 8 feet bgs at this location. See Figure 3-7 for location of characterization core samples taken in LSA 08-09.

Within LSA 08-12, four of the fourteen characterization boring locations within the SU exceeded a SOF of 1 as compared to the root stratum criteria (samples OA-26, EP-01, SS-GP-009, and SS-GL-012) up to a maximum depth of 5 ft bgs (Root Zone). Remediation progress was reviewed to ensure that the soil in the area of the samples was adequately removed during remediation with excavation of soil occurring to average depths of 5 to 6 feet bgs at these locations. See Figure 3-8 for location of characterization core samples taken in LSA 08-12.

Within LSA 08-13, one of the thirteen characterization boring locations within the SU exceeded a SOF of 1 as compared to the surface stratum criteria (sample OA-23) within the surface stratum. Remediation progress was reviewed to ensure that the soil in the area of the soil sample was adequately removed during remediation with excavation of soil occurring to average depths of 8 to 10 feet bgs at this location. See Figure 3-9 for location of characterization core samples taken in LSA 08-13.

Figure 3-7
Site Characterization Borings within LSA 08-09

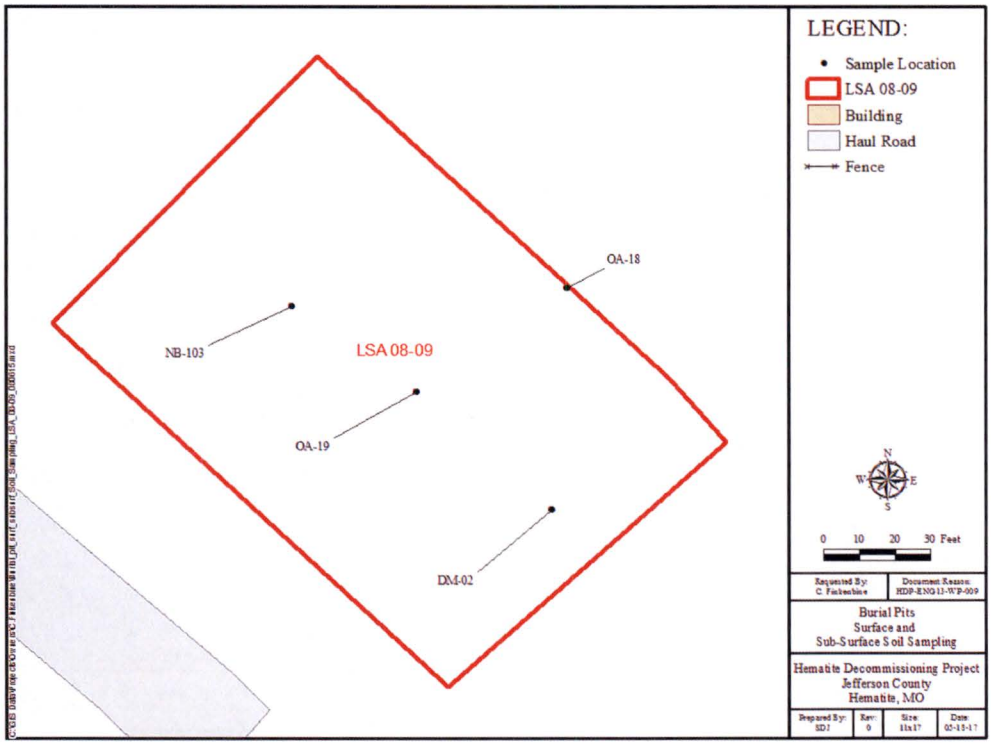


Figure 3-8
Site Characterization Borings within LSA 08-12

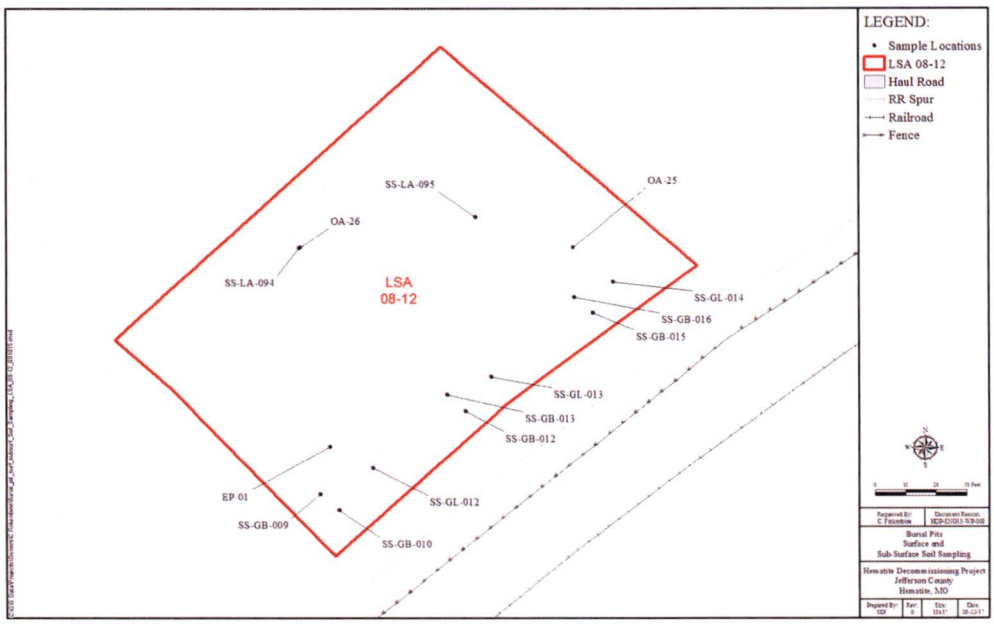
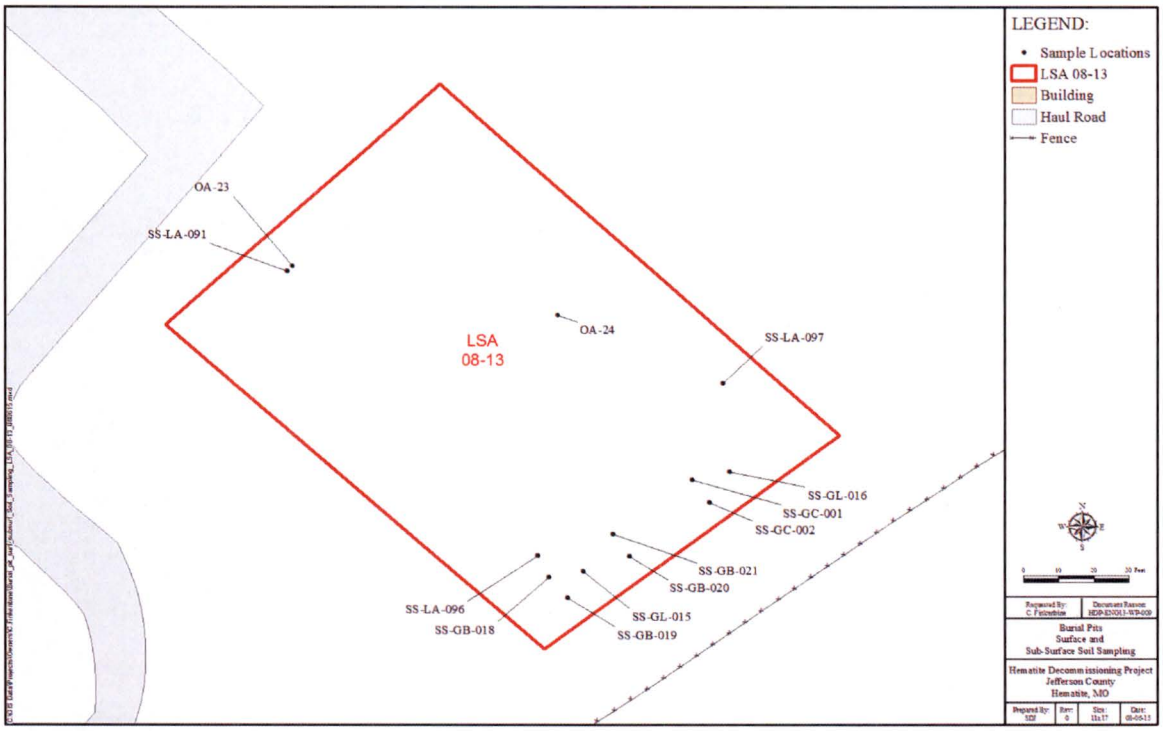


Figure 3-9
Site Characterization Borings within LSA 08-13



3.3.8 Remedial Action Support Survey for FSS Design

The RASS was conducted within LSA 08-09, LSA 08-12 and LSA 08-13, 1) to determine when a SU had been adequately prepared for FSS, and 2) to provide updated estimates of the parameters to be used for planning the FSS. Upon the completion of remediation of the SU and prior to implementation of FSS activities, a final RASS was performed to validate the status of the SU prior to implementing Isolation and Control (I & C) postings. The I & C posting for LSA 08-09, LSA 08-12 and LSA 08-13 was completed in November of 2015.

The RASS included a GWS, systematic surface sample collection based on a sixteen (16) point triangular grid, and biased surface sampling. The Final RASS results were used to develop the FSS Plan for each SU. The Final RASS systematic sample results used to develop the FSS sampling grid are summarized in Table 3-1 below:

Table 3-1
Summary of Final RASS Results for LSA 08-09, LSA 08-12 and LSA 08-13

LSA	Ra-226 (net)		Tc-99		Th-232 (net)		U-234		U-235		U-238	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
08-09	0.05	0.20	7.23	13.80	0.07	0.33	5.64	13.45	0.31	0.74	1.37	2.15
08-12	0.02	0.09	3.22	13.00	0.12	0.27	5.56	14.09	0.30	0.78	1.75	2.85
08-13	0.06	0.20	5.77	12.20	0.06	0.26	11.33	53.80	0.62	2.97	2.70	11.70
DCGL[3]	5.4		74.0		5.2		872.4		208.1		551.1	

Notes:
1. All units are in picocuries per gram (pCi/g)
2. Results reflect net concentrations after subtraction of background (Ra-226 bkg = 0.9 pCi/g; Th-232 bkg = 1.0 pCi/g).
3. Excavation Stratum DCGLs (From Table 4-1)

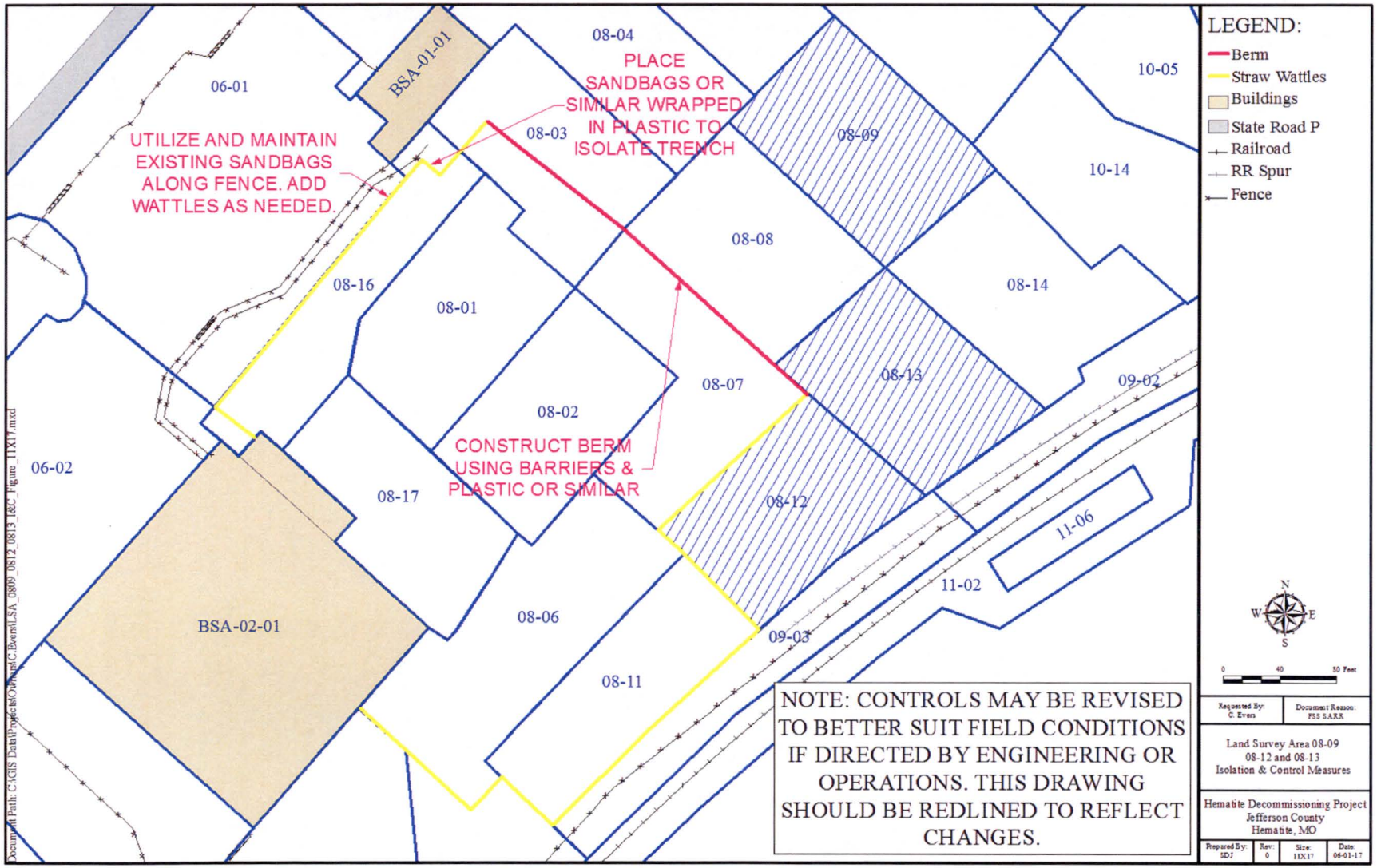
All Final RASS systematic sample and biased sample results were less than the appropriate $DCGL_W$ (Three Stratum) and the Final RASS data set was considered sufficient to support FSS design.

3.3.9 Isolation and Control

As directed by HDP-PR-HP-602, *Data Package Development and Isolation and Control Measures to Support Final Status Survey,* in March of 2016, the SUs in LSA 08 were isolated and controlled in accordance with Work Package HDP-WP-ENG-803, *Isolation and Control Measures,* (See Figure 3-10) Isolation and control measures included silt fence, straw wattle, and soil berms between these SUs and the adjacent remediation area to ensure that cross-contamination of these LSAs undergoing FSS did not occur.

The administrative control of multiple postings labeled "Contact Health Physics Prior to Entry" were installed around the entire perimeter of the SUs prior to FSS field activities to prevent inadvertent entry by site personnel. The LSA 08 SUs are located within the fenced security perimeter of the HDP which therefore prevents access by the general public.

Figure 3-10
Isolation and Control of Area Containing LSA 08-09, LSA 08-12 and LSA 08-13



3.4 Surveillance Following FSS

Following the completion of a FSS, the DP requires continued surveillance to minimize the potential to re-contaminate a SU (e.g., surface water transport of potentially contaminated sediment or a soil pile that was not present during FSS). The surveillance included the routine visual inspection of the integrity of the I & C measures implemented for LSA 08-09, LSA 08-12 and LSA 08-13. If a SU is suspected of having been re-contaminated then an investigation survey will be performed to reconfirm the FSS survey validity.

During the timeframe since the completion of FSS field activities to the date of completion of all physical work at HDP and project demobilization, LSA 08-09, LSA 08-12 and LSA 08-13 did not evidence an event that would cause them to be suspect and thus require investigation. Nevertheless, LSA 08-09, LSA 08-12 and LSA 08-13 were subjected to a confirmatory GWS in the 72 hours prior to placing backfill soil in the LSA. The results of the confirmatory GWS were compared to the results of the FSS in order to confirm that there had been not impacts to the SUs prior to backfill.

3.5 Backfill of Survey Units

Although not a function of remediation, but as described in the DP Section 8.8 and FSSFR Volume 2 Chapter 1, the SUs will be backfilled using backfill obtained from on-site material determined to be suitable for reuse (e.g., excavated soil overburden), and/or backfill material from an off-site location.

To fill and bring the LSA 08-09, LSA 08-12 and LSA 08-13 excavations to final grade the backfill of the SUs was completed with off-site "borrow" soil from the Horine Road site in Festus, MO, and the Prudent Facility also in Festus, MO. And as such, no dose will be assigned to the SUs due to the use of off-site borrow soil.

3.6 Groundwater Monitoring

In response to NRC RAI Chapter 3-4, during the review and approval process for the DP, Westinghouse documented in letter HEM-11-96 {ML111880290} the revised text of DP Section 14.5.1 to be as follows:

> "*Post-remediation monitoring wells will be sampled quarterly after the completion of remediation until license termination. The data collected will be used to confirm that the sum of the annual dose from groundwater for all the radionuclides does not exceed the EPA Maximum Contaminant Level (MCL) of 4 millirem/year. Separately, the sum of the dose from all residual sources remaining after remediation, including soil and groundwater pathways, will be confirmed to result in an annual dose that does not exceed 25 millirem/year.*"

As stated in the Executive Summary section, the exposure results of this report will be combined with the dose attributed to groundwater to demonstrate that the site has met the requirements for unrestricted release consistent with the requirements of the Title 10 CFR 20 Subpart E, "Criteria for License Termination." As such, for the purpose of this report, groundwater will be assigned a conservative SOF of 0.16 which equates to 4 mrem/year until such time that the post-remediation groundwater sampling has been completed and reported as part of FSSFR Volume 6,

Chapter 7, *Post-remediation Groundwater Monitoring Summary*. The final dose for LSA 08-09, LSA 08-12 and LSA 08-13 will be reported in FSSFR Volume 7, reflecting the updated results of the post-remediation groundwater monitoring.

4.0 LSA RELEASE CRITERIA

As the release criteria for all LSA SUs is common, FSSFR Volume 3, Chapter 1, Section 3.0, *Release Criteria*, provides a detailed discussion on the release criteria that is applicable to LSA 08-09, LSA 08-12 and LSA 08-13. Table 4-1 provides the applicable DCGLs.

Table 4-1
Adjusted Soil $DCGL_W$'s by CSM[a]

Radionuclide	Three Layer Approach $DCGL_w$ Values (pCi/g)[b]			Uniform Stratum (pCi/g)
	Surface Stratum	Root Stratum	Excavation Scenario	
Radium-226+C[d]	**5.0**	**2.1**	**5.4**	1.9
Technetium-99	**151.0**	**30.1**	**74.0**	25.1
Thorium-232+C[d]	**4.7**	**2.0**	**5.2**	2.0
Uranium-234	**508.5**	**235.6**	**872.4**	195.4
Uranium-235+D[c]	**102.3**	**64.1**	**208.1**	51.6
Uranium-238+D[c]	**297.6**	**183.3**	**551.1**	168.8

[a] Table as presented in FSSFR Volume 3, Chapter 1.
[b] The reported DCGLw's are the activities for the parent radionuclide and were calculated to account for the dose contribution from insignificant radionuclides.
[c] +D indicates the $DCGL_w$ includes short-lived (half-life ≤ 6 mo.) decay products.
[d] +C indicates the $DCGL_w$ includes all radionuclides in the associated decay chain.

5.0 FINAL STATUS SURVEY DESIGN LSA 08-09

This section of the report describes the method for determining the number of samples required for the FSS of LSA 08-09 as well as summarizing the applicable requirements of the FSS Plan. These include the $DCGL_W$, scan survey coverage, and Investigation Action Levels (IAL). The radiological instrumentation used in the FSS of LSA 08-09 and the detection sensitivities are also discussed.

5.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 08-09 were driven by the type (Open Land) and Class (Class 1) of the SU and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

5.1.1 Surrogate Evaluation Areas

A discussion of Surrogate Evaluation Areas is given in the FSSFR Volume 3, Chapter 1, Section 5.0, *Final Status Survey Design.*

5.1.2 $DCGL_W$

During the FSS design process a review was performed of the RASS data for LSA 08-09. The RASS data was used to identify that areas of residual radioactivity potentially remained within the SU that exceeded the Uniform Stratum $DCGL_W$ (Hybrid Well DM-02 investigation sampling at 16-20 feet bgs). With 5 out of the 44 Hybrid Well Investigation samples exceeding a Uniform SOF of 1.0, this was an indication that residual levels of Tc-99 may remain within the SU that exceed the Uniform $DCGL_W$. Since the average excavation depth in LSA 08-09 was approximately 5 feet bgs, and all available RASS survey and sampling data indicated that no residual Tc-99 radioactivity remained above the excavation stratum $DCGL_W$, the conclusion was drawn that the Three Stratum $DCGL_W$ would be the most appropriate method to be used to demonstrate compliance with the release criteria.

Therefore the Three-Stratum $DCGL_W$ was selected for use in demonstrating compliance with the release criteria.

5.1.3 GWS Coverage

As a Class 1 SU, LSA 08-09 was required to undergo a 100% GWS.

5.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 08-09 was the Ludlum 44-10 2" x 2" sodium iodide (NaI) detectors, coupled to a Ludlum 2221 scaler-ratemeter.

5.1.5 Scan Minimum Detectable Concentration (MDC)

Scan MDCs for LSA 08-09 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD-FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status*

Surveys (FSS). As background levels were approximately 11,000 counts per minute (cpm) within LSA 08-09, the scan MDC calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3659\ pCi/g}\right)+\left(\frac{f_{U-235}}{2.43\ pCi/g}\right)+\left(\frac{f_{U-238}}{32.1\ pCi/g}\right)\right)}$$

Equation 5-1

To determine isotopic Uranium fractions HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* assumes that the average LSA enrichment is 4% or less. Based on the systematically collected RASS samples in LSA 08-09, the average enrichment for the SU was 3.3%. All other Scan MDC parameters agreed upon between Westinghouse and the NRC were applied (e.g. use of a 2 in air gap, scan rate of 1 ft/sec, 0.75 surveyor efficiency), therefore no subsequent changes to the calculated Scan MDCs need to be made.

Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 08-09 are shown below:

Table 5-1
Scan MDCs for 2" x 2" NaI detector, 11,000 cpm background: LSA 08-09

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 08-09	46.7	31.7	1.26	6.3	0.91	6.2

*$DCGL_W$ includes background concentrations of 0.9 pCi/g for Ra-226 (no ingrowth) and 1.0 pCi/g for Th-232. DCGLw values are based on the Excavation Stratum release criteria.

The values in Table 5-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

5.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The basis of the IAL is detailed in HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*". The IAL used during the GWS of LSA 08-09 was established at 4,000 net counts per minute (ncpm).

5.1.7 LSA 08-09 FSS Design Summary

The FSS Plan for LSA 08-09 can be found in Appendix D. Table 5-2 presents an overall FSS design and implementation summary for LSA 08-09.

Table 5-2
FSS Design Summary for LSA 08-09

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed excavation floors and walls	
Scan MDC	42.9 pCi/g total Uranium (based on a 11,000 cpm background); 0.91 pCi/g Th-232; 1.26 pCi/g Ra-226*	
Investigation Action Level (IAL)	4,000 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	0	These samples will be taken on a random-start systematic grid.
15 cm – 1.5 m (Root)	1	
> 1.5m (Excavation)	8	
Biased Survey/Sampling Locations:		
Biased samples may be collected during GWS at the discretion of the HP Technician, after statistical analysis of the survey data, or at the direction of the RSO or Radiological Engineering.		
Sidewall Sampling Locations:		
A minimum of one (1) discretionary sidewall sample will be collected based on the following definition of "sidewall": sidewall candidates for sampling must be vertical or near vertical (> 45° angle) and at least 12" in height.		
Instrumentation:		
Ludlum 2221 with 44-10 (2x2 NaI) detector; with collimation for investigations	Used for GWS and to obtain static count rates at biased measurement locations.	
*Values based on information provided in HDP-TBD-FSS-002, "*Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS).* The Scan MDC for total Uranium reflects a conservative assumption of 4% enrichment. The actual RASS enrichment (3.3%) would result in Scan MDC values slightly less than those calculated for FSS planning purposes.		
**IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum DCGLw derived from the technical bases presented in HEM-MEMO-15-021 and HDP-TBD-FSS-003 "*Modeling and Calculation of Investigative Action Levels for Final Status Soil Survey Units*", Westinghouse, March 2015.		

5.1.8 LSA 08-09 Former Process Buildings Investigation Area and Hybrid Well Investigation Planning

LSA 08-09 land area included a portion of the land area designated for the Former Process Buildings Investigation Area and Hybrid Well Investigation as indicated in Westinghouse letter HEM-11-56. A sampling campaign separate from FSS was performed to meet the requirements of the investigations as stated in Westinghouse letter HEM-11-56 to the NRC which contained the "Evaluation of Technetium-99 Under the Process Building" report (Appendix G of the report).

Figure 4, *Conceptual Investigation Sample Stations Associated with the Process Buildings*, of "Evaluation of Technetium-99 Under the Process Building" report provides the conceptual soil sampling and well locations for the Former Process Buildings Investigation Area and Hybrid Well Investigation.

During development of the work package for the Former Process Buildings Area and Hybrid Well Investigation it was determined that the land area of LSA 08-09 includes hybrid groundwater monitoring well BD-08 and that the LSA 08-09 land area is not in the area designated as the Former Process Buildings Investigation Area.

The hybrid well investigation requirements of HEM-11-56 are applicable to well BD-08. The results of the hybrid well investigation for well BD-08 are provided in section 3.3.5.2.

6.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 08-09

FSS was performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment.*

6.1 Gamma Walkover Survey

6.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 08-09 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS (Digital Global Positioning System) and handheld data logger.

Prior to the first field use of the GWS instrumentation, initial set-ups were performed. Also, daily pre- and post-use source checks were performed for each day that GWS was performed within the SU. Initial set-ups, daily source checks, and control charting were performed according to the requirements of HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey.*

6.1.2 GWS Performance

All GWS measurements on the excavation floor and sidewalls collected with the NaI detector(s) were connected to a Trimble DGPS and with a hand-held data logger. The logging frequency in the survey unit was 1 GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

The GWS requirements involved moving the NaI detector in a side-to-side fashion no faster than 1 foot per second while holding the probe as close as possible to the excavation surface (nominally 1", but not to exceed 3"). At the same time, the HP Technician was required to slowly advance, causing the detector to trace out a serpentine path over the excavation surface.

Health Physics (HP) Technicians performing GWS in LSA 08-09 used the 4,000 ncpm IAL as a field guide to know when to slow or pause the GWS for more deliberate investigation. If during the GWS, audible count rates noticeably increase above the general area average (i.e., > minimum detectable count rate), HP Technicians were required to pause momentarily and

observe count rates. If sustained count rates approached the IAL, further focused investigation was conducted within the locally elevated area.

To use the IAL effectively, HP Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to the geometry and relative distance from contaminated materials in nearby remedial excavations, the average background rate (measured at waist level) within the LSA ranged between 11,000 and 12,000 gross counts per minute (gcpm). Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 15,000 to 16,000 gcpm, HP Technicians slowed or paused the GWS for more careful investigation of the small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

Sidewalls, hard to reach areas, and non-typical areas were surveyed manually as necessary in order to assess the potential for an area of elevated residual activity over 100% of the exposed ground surface.

After the GWS survey was complete, the GPS/GWS data was reviewed by Radiological Engineering and the HP Technician performing the survey to determine if possible areas of elevated residual activity remained within the SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

6.2 Soil Sampling

6.2.1 Systematic Soil Sampling Summary

Table 6-1 provides a summary of systematic sampling by stratum for LSA 08-09.

Table 6-1
Systematic Sampling Summary by Stratum for LSA 08-09

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
08-09	1,552	0	1	8	1

*Excavation samples were collected and archived, analysis only required if an overlying Root sample exceeds a 0.5 SOF

6.2.2 Systematic Sampling LSA 08-09

Within LSA 08-09, there were 8 systematic locations prescribed by the FSS plan. Given a planar area of 1,552 m^2 for LSA 08-09 and an 8 - point systematic triangular grid, the point-to-point distance within each row was 14.9 m.

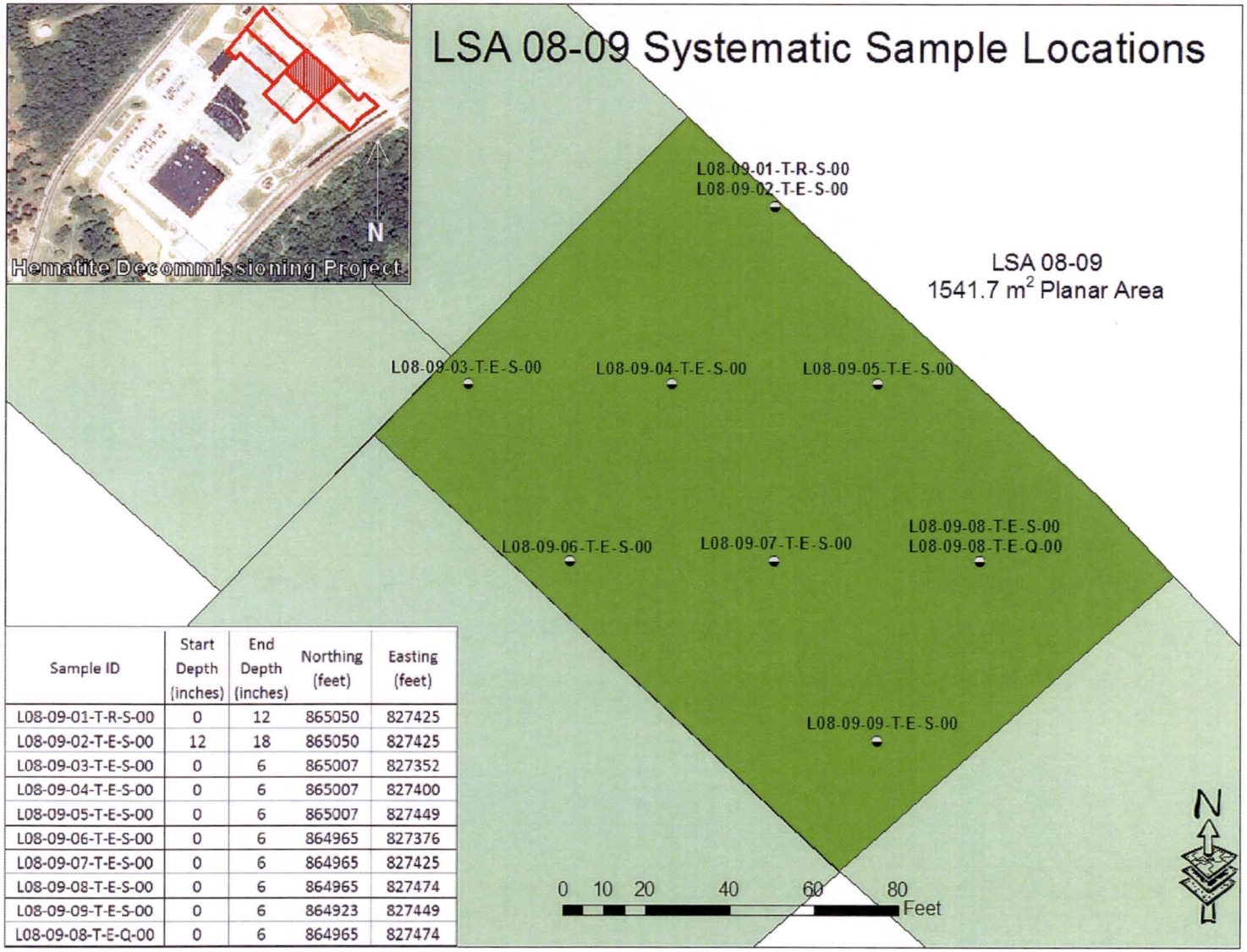
While there were eight (8) systematic locations on the LSA 08-09 sampling grid, a total of ten (10) samples were collected and analyzed at these locations, including:

- Zero (0) samples collected within the surface stratum
- One (1) samples collected within the root stratum
- Eight (8) samples analyzed within the excavation, or "deep" stratum
- One (1) Quality Control (QC) field replicate

Figure 6-1 presents the map of the eight systematic sample locations which were sampled within LSA 08-09. The inset table notes the location coordinates (Missouri East, North American Datum (NAD) 1983) and collection intervals for each systematic location.

Figure 6-2 presents the map of the eight systematic sample locations which were sampled within LSA 08-09 by the stratum.

Figure 6-1
LSA 08-09 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L08-09-01-T-R-S-00	0	12	865050	827425
L08-09-02-T-E-S-00	12	18	865050	827425
L08-09-03-T-E-S-00	0	6	865007	827352
L08-09-04-T-E-S-00	0	6	865007	827400
L08-09-05-T-E-S-00	0	6	865007	827449
L08-09-06-T-E-S-00	0	6	864965	827376
L08-09-07-T-E-S-00	0	6	864965	827425
L08-09-08-T-E-S-00	0	6	864965	827474
L08-09-09-T-E-S-00	0	6	864923	827449
L08-09-08-T-E-Q-00	0	6	864965	827474

Figure 6-2
LSA 08-09 Systematic Soil Sample Locations by Stratum

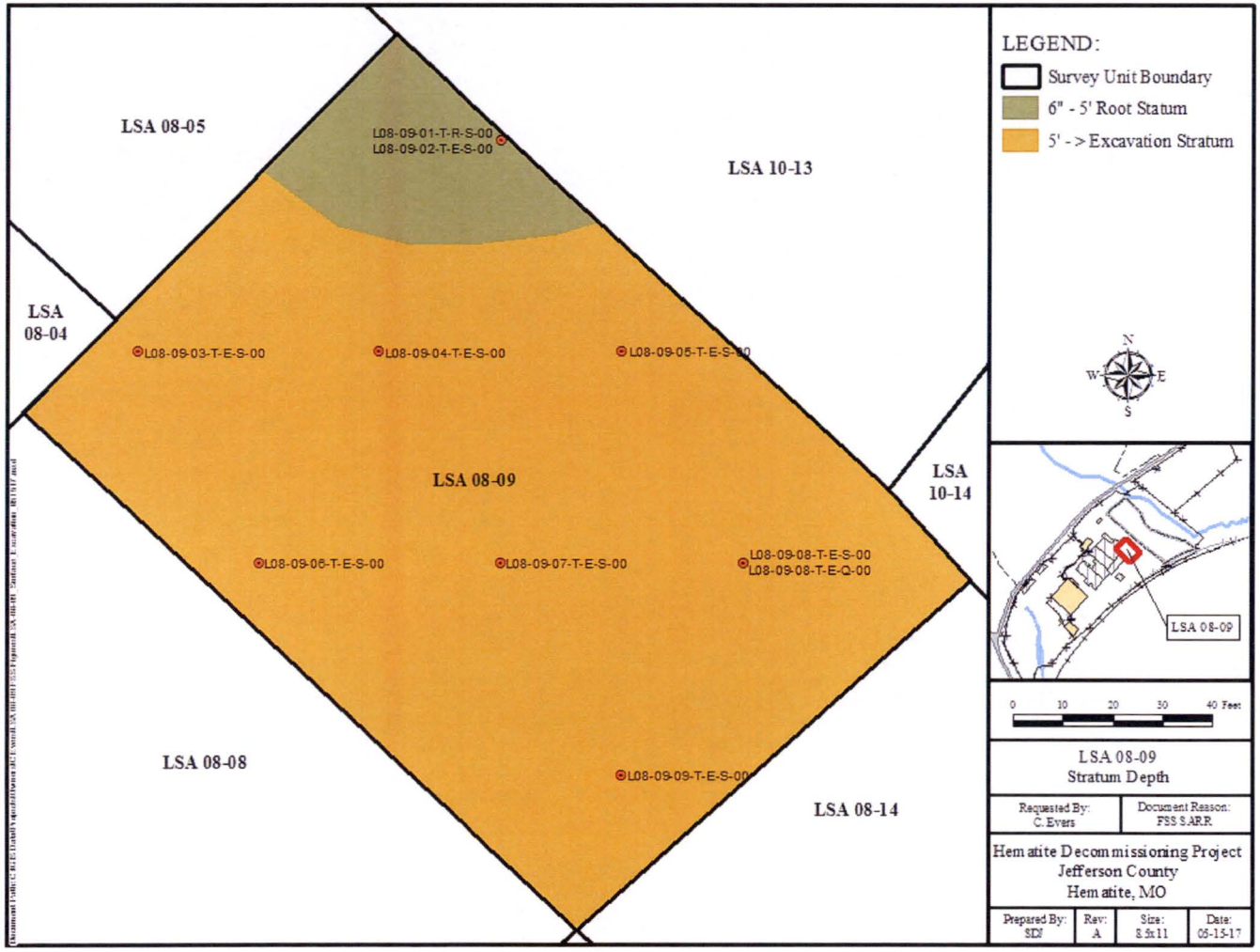


Table 6-2 below presents a tabular listing of all FSS samples collected within LSA 08-09 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 6-2
FSS Sample Locations and Coordinates for LSA 08-09

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
		Revision: 10	Appendix P-4 Page 1 of 1

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area:	LSA 08	**Description:**	Technetium SEA Open Land Area
Survey Unit:	09	**Description:**	Central Open Land Area
Survey Type:	FSS	**Classification:**	Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation	End Elevation	Northing (Y Axis) *	Easting (X Axis) *	Remarks / Notes
L08-09-01-T-R-S-00	Root	S	431.6	430.6	865050	827425	Root 1-ft composite
L08-09-02-T-E-S-00	Deep	S	430.6	430.1	865050	827425	Excavation 6-inch grab
L08-09-03-T-E-S-00	Deep	S	427.8	427.3	865007	827352	Excavation 6-inch grab
L08-09-04-T-E-S-00	Deep	S	429.2	428.7	865007	827400	Excavation 6-inch grab
L08-09-05-T-E-S-00	Deep	S	430.6	430.1	865007	827449	Excavation 6-inch grab
L08-09-06-T-E-S-00	Deep	S	425.9	425.4	864965	827376	Excavation 6-inch grab
L08-09-07-T-E-S-00	Deep	S	430.1	429.6	864965	827425	Excavation 6-inch grab
L08-09-08-T-E-S-00	Deep	S	431.0	430.5	864965	827474	Excavation 6-inch grab
L08-09-09-T-E-S-00	Deep	S	430.5	430.0	864923	827449	Excavation 6-inch grab
L08-09-08-T-E-Q-00	Deep	Q	431.0	430.5	864965	827474	Excavation 6-inch grab
L08-09-10-T-E-B-00	Deep	B	428.2	428.2	864941	827423	Sidewall Sample
L08-09-11-T-E-B-00	Deep	B	430.1	429.6	865019	827448	Biased 6-inch grab
L08-09-12-T-E-B-00	Deep	B	427.9	427.4	864945	827413	Biased 6-inch grab
L08-09-13-T-E-B-00	Deep	B	428.5	428.0	864935	827437	Biased 6-inch grab
L08-09-14-T-E-B-00	Deep	B	428.2	427.7	864919	827417	Biased 6-inch grab
L08-09-15-T-E-B-00	Deep	B	430.2	429.7	864895	827440	Biased 6-inch grab

Green shaded samples are the samples at each sample location, for use in WRS test.

*Elevations are in feet above mean sea level.

** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983] (Open Land Area) OR
Distance in feet from lower left corner of the surface (Structures); each surface has its own (X,Y) = (0,0); OR
For piping the distance from the beginning of the survey unit.
Surface: Floor = F; Wall = W; Ceiling = C; Roof = R
CSM: Three-Layer (Surface-Root-Deep) or Uniform
Type: Systematic = S, Biased = B; QC =Q; Investigation = I

Quality Record

6.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 08-09 five (5) biased sample locations were selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

6.4 Judgmental/Sidewall Sampling for Tc-99

Sidewall sampling was prescribed the the FSS Plans developed for LSA 08-09 in accordance with the guidance provided in HDP-PR-FSS-701, *Final Status Survey Plan Development*. See FSSFR Volume 3, Chapter 1, Section 5.2, *Tc-99 Side Wall Sampling* for further discussion.

During FSS of LSA 08-09, one (1) sidewall sample was collected. See section 7.2.5, *Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 08-09* for further discussion.

6.5 Quality Control Soil Sampling

One QC field duplicate sample point were randomly selected and collected at systematic locations L08-09-08 for LSA 08-09.

7.0 FINAL STATUS SURVEY RESULTS LSA 08-09

7.1 Gamma Walkover Survey

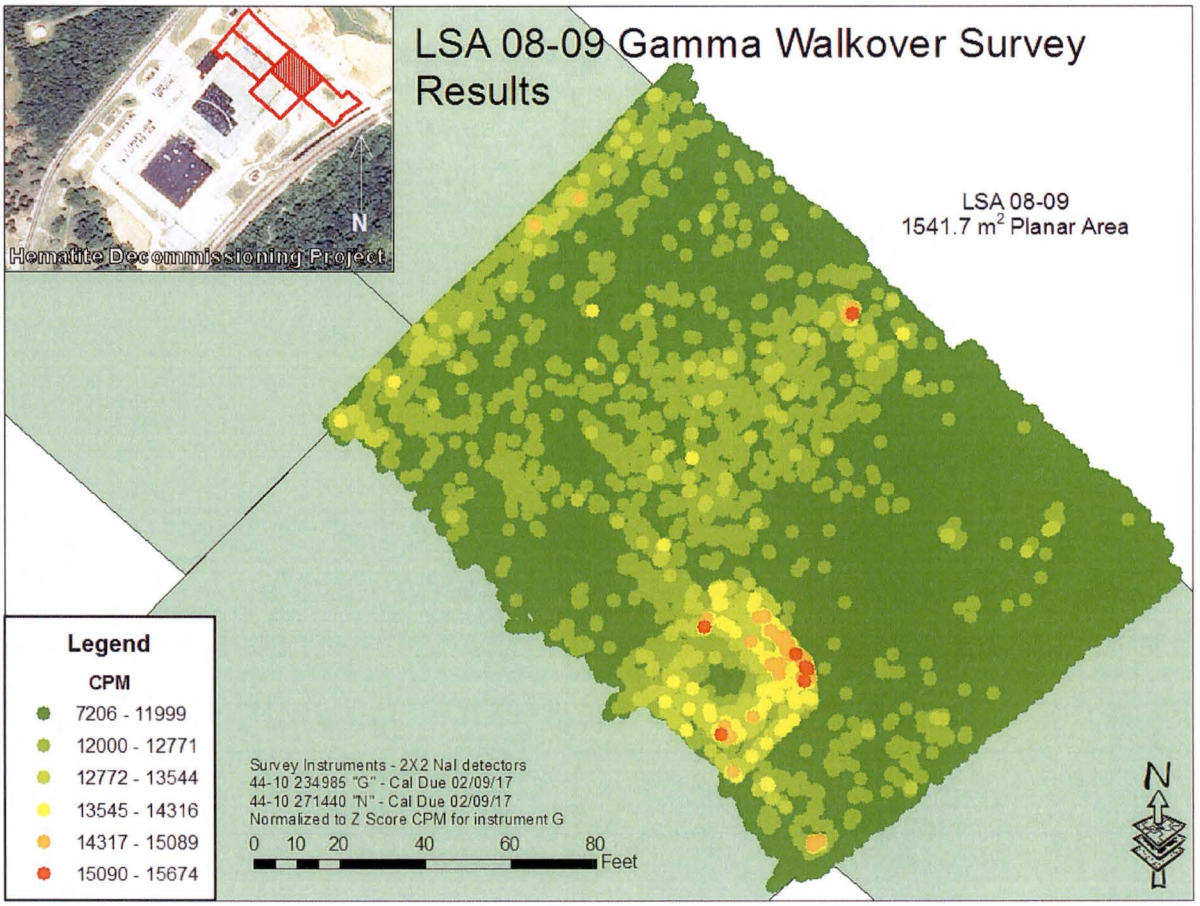
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are plotted "on top" (e.g. if any sidewalls featured more elevated readings than the floor directly below, the sidewall radiological measurements would overlie the lower floor readings).

GWS measurements were collected in LSA 08-09 between March 22, 2016, and March 29, 2016.

7.1.1 GWS Results for LSA 08-09

For LSA 08-09, GWS count rates ranged between 7,206 gcpm and 15,674 gcpm, with a mean count rate of 11,256 gcpm. The median count rate was 10,998 gcpm and the standard deviation was 794 cpm. Figure 7-1 below presents a map of the complete GWS data set.

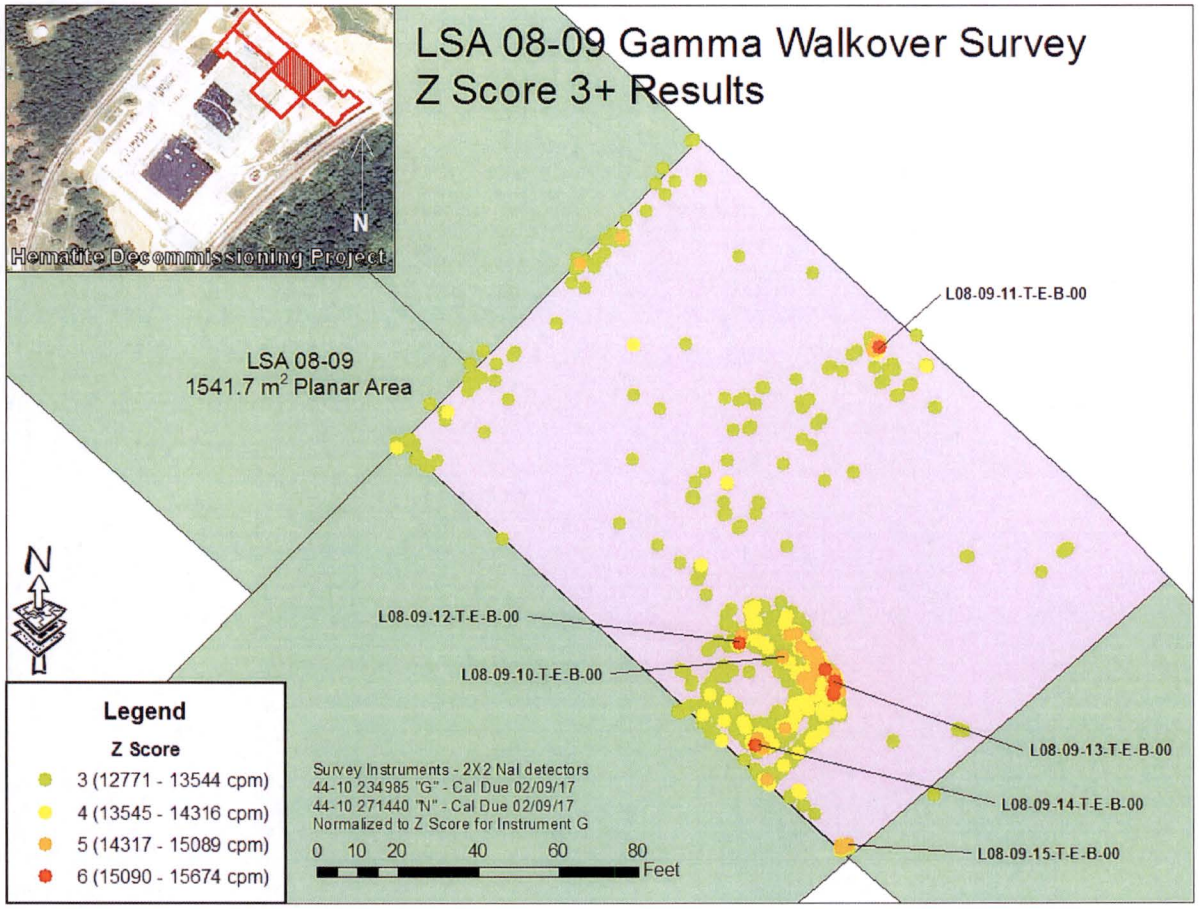
Figure 7-1
Colorimetric GWS Plot for LSA 08-09



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). Five locations were selected for biased sample collection based on evaluation of the GWS readings and HP Staff professional judgment. These biased locations represented the maximum GWS measurements encountered within the SU.

Figure 7-2 below presents a map of the +3 Z-score GWS measurements within LSA 08-09, including the selected biased sampling locations.

Figure 7-2
Colorimetric GWS Plot for LSA 08-09 (Measurements > Z-score of 3)



All GWS data collected in LSA 08-09 was datalogged and post-processed in Graphical Information Software (GIS).

7.1.2 GWS Coverage Results LSA 08-09

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS.

The post survey processing of the GPS data indicated that 100% of the exposed SU surface underwent GWS (see Table 7-1). As the evaluation indicates that the GPS coverage exceeded 95% with no readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of any apparent GPS coverage gaps, the GWS coverage for the SU has been evaluated to meet the intent of the "100% GWS coverage" requirement.

Table 7-1
GWS Gap Analysis LSA 08-09

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 08-09	264,361	0	0%	100%	1

7.2 Soil Sample Results LSA 08-09

Appendix A presents the analytical results and associated statistics for all FSS surface samples collected within LSA 08-09.

7.2.1 Surface Soil Sample Results LSA 08-09

Within LSA 08-09 the surface stratum was completely removed. There were no samples collected within the surface stratum (0 – 15 cm) of LSA 08-09. There were a total of nine (9) soil samples collected within the topmost soil layer of the excavation surface including eight (8) systematic samples, and one (1) QC field duplicate sample. The maximum SOF result of the remaining topmost samples was 0.31 excavation SOF.

7.2.2 Subsurface Soil Sample Results LSA 08-09

There was one systematic location within LSA 08-09 where the remaining root stratum interval was composite sampled. At this location, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected. The result of the subsurface sample L08-09-02 collected in LSA 08-09 was 0.14 excavation SOF.

7.2.3 WRS Test Evaluation LSA 08-09

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was not required for LSA 08-09 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was less than one using the Uniform Stratum criteria. However, for illustrative purposes, the WRS Test was still performed for LSA 08-09. All systematically collected samples regardless of depth are used to perform the WRS Test, however biased and QC sample results are not utilized in the WRS Test. The 9 systematically collected samples in LSA 08-09 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (816) was greater than the critical value (725) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix A.

7.2.4 Graphical Data Review LSA 08-09

Table 7-2 below presents summary results for the all systematically collected samples (includes root, and excavation, but not biased or QC samples) collected within LSA 08-09, and the associated SOF when compared to the appropriate Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.13.

Table 7-2
LSA 08-09 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Excavation DCGL)
Average	0.101	5.971	0.089	3.227	0.173	1.301	**0.13**
Minimum	0.00 (<BKG)	0.839	0.00 (<BKG)	1.254	0.060	0.930	0.02
Maximum	0.310	19.600	0.330	11.420	0.629	1.640	0.28

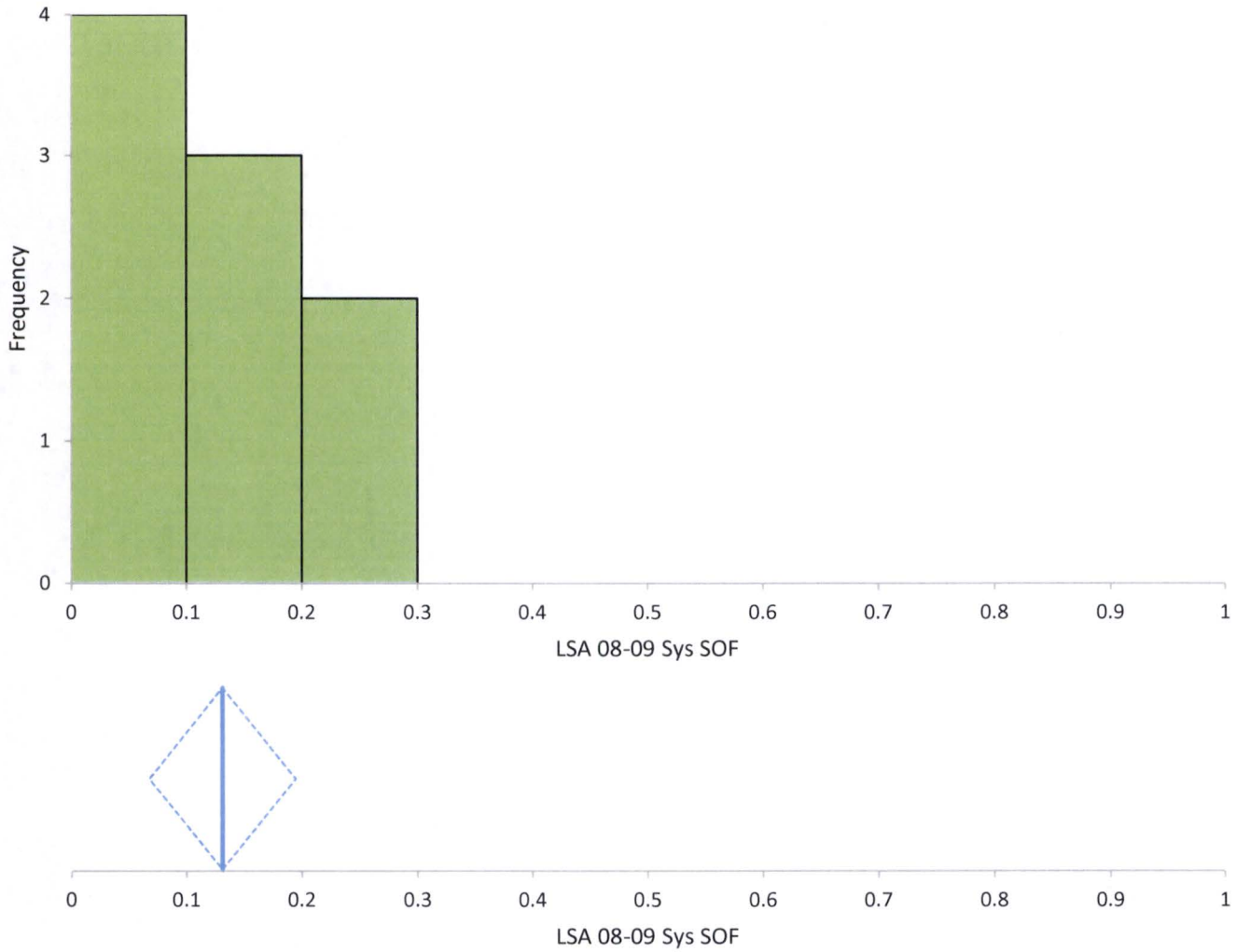
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide concentrations.
3. U-234 values are inferred from the U-235/U-238 ratio.

Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within a certain range of values. The frequency plot will reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution for the SU. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 7-3 presents the overall statistical metrics for the SOF parameter for the 9 systematically collected samples from LSA 08-09. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 08-09. The middle graph presents the mean SOF (0.13 as indicated by the blue vertical line) of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.07 to 0.19. The 96.09% confidence interval based on the median (0.12) of the sample results is 0.07 to 0.23. The bottom two charts present the various statistical metrics of the LSA 08-09 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 7-3 exhibits no unusual symmetry or bimodality concerns for the LSA 08-09 data associated with the systematically collected measurement locations.

Figure 7-3
Graphic Statistical Summary for LSA 08-09 (SOF parameter)



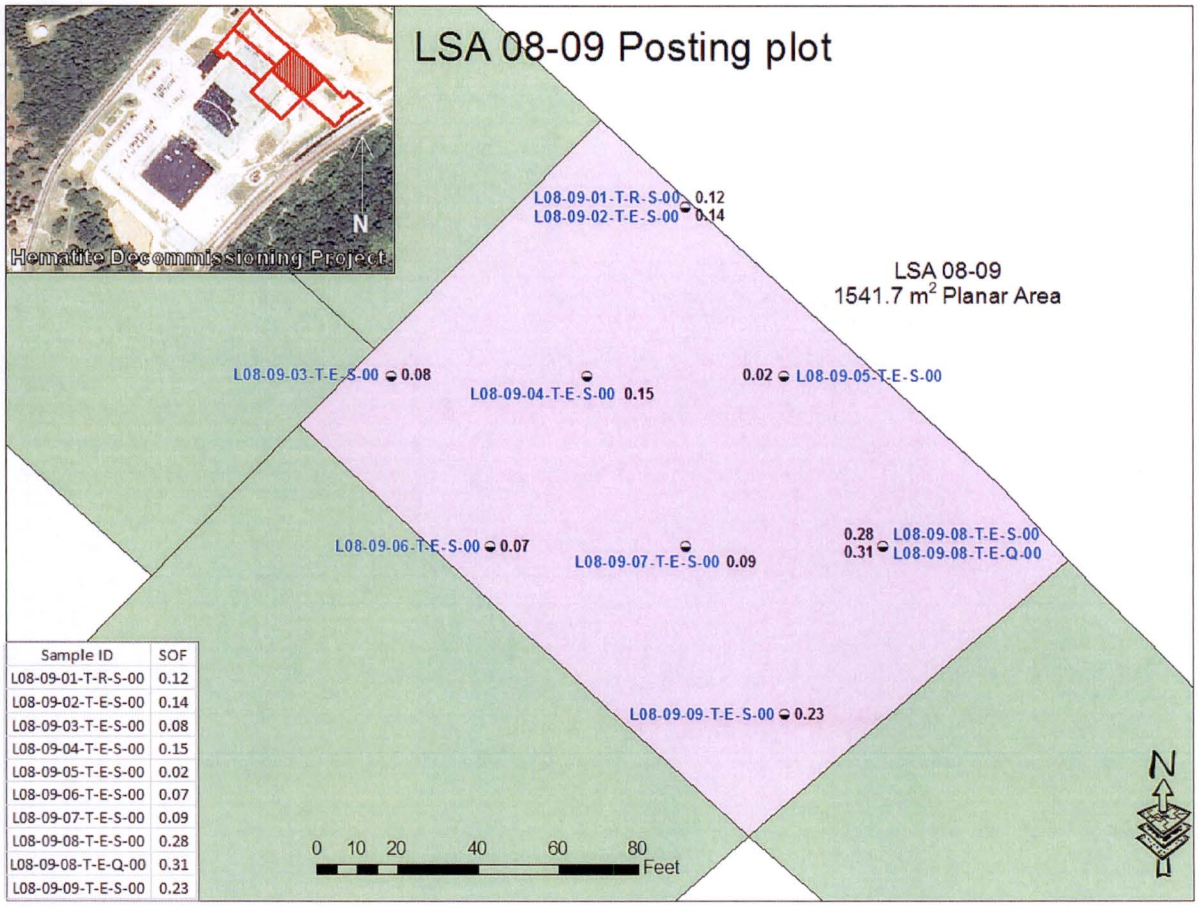
N	9

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 08-09 Sys SOF	0.13	0.07	to 0.19	0.027	0.08	0.01	0.8	0.16

	Minimum	1st quartile	Median	96.09% CI		3rd quartile	Maximum	IQR
LSA 08-09 Sys SOF	0.02	0.08	0.12	0.07	to 0.23	0.18	0.3	0.10

A posting plot is simply a map of the SU with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 08-09 is presented below in Figure 7-4. Figure 7-4 shows no unusual patterns in the data.

Figure 7-4
Posting Plot for LSA 08-09 Systematic Measurement Locations



Sample ID	SOF
L08-09-01-T-R-S-00	0.12
L08-09-02-T-E-S-00	0.14
L08-09-03-T-E-S-00	0.08
L08-09-04-T-E-S-00	0.15
L08-09-05-T-E-S-00	0.02
L08-09-06-T-E-S-00	0.07
L08-09-07-T-E-S-00	0.09
L08-09-08-T-E-S-00	0.28
L08-09-08-T-E-Q-00	0.31
L08-09-09-T-E-S-00	0.23

Appendix A to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 7-2, Figure 7-3, and Figure 7-4 above. A summary of the analytical data is presented in Table 7-3 below. Appendix G to this report presents the TestAmerica Analytical Laboratory soil sample reports.

Table 7-3
Final Status Survey Analytical Data: LSA 08-09

Sample ID	Sample Start Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF
L08-09-01-T-R-S-00	4.00	S	1.010	0.149	0.070	N/A	-0.060	0.000	1.640	1.640	0.172	0.221	N/A	1.080	0.177	0.122	N/A	0.080	0.080	2.517	NA	NA	NA	0.132	0.136	0.213	U	1.520	0.513	0.755	N/A	1.4	0.12
L08-09-02-T-E-S-00	5.00	S	1.210	0.176	0.060	N/A	0.140	0.140	6.630	6.630	0.626	0.240	N/A	1.120	0.185	0.148	N/A	0.120	0.120	1.858	NA	NA	NA	0.099	0.139	0.220	U	0.930	0.328	0.886	N/A	1.7	0.14
L08-09-03-T-E-S-00	9.60	S	1.190	0.157	0.057	N/A	0.120	0.120	3.820	3.820	0.355	0.232	N/A	0.998	0.165	0.084	N/A	-0.002	0.000	3.419	NA	NA	NA	0.187	0.103	0.148	N/A	1.100	0.302	0.786	N/A	2.6	0.08
L08-09-04-T-E-S-00	7.40	S	1.090	0.154	0.063	N/A	0.020	0.020	8.520	8.520	0.945	0.225	N/A	1.120	0.178	0.117	N/A	0.120	0.120	3.484	NA	NA	NA	0.188	0.140	0.247	U	1.470	0.507	0.741	N/A	2.0	0.15
L08-09-05-T-E-S-00	5.00	S	1.060	0.160	0.080	N/A	-0.010	0.000	1.230	1.230	0.197	0.225	N/A	0.999	0.155	0.105	N/A	-0.001	0.000	1.400	NA	NA	NA	0.072	0.136	0.236	U	0.975	0.538	0.847	N/A	1.2	0.02
L08-09-06-T-E-S-00	11.80	S	1.200	0.161	0.060	N/A	0.130	0.130	0.839	0.839	0.105	0.285	N/A	1.130	0.161	0.127	N/A	0.130	0.130	2.249	NA	NA	NA	0.117	0.125	0.229	U	1.480	0.487	0.713	N/A	1.3	0.07
L08-09-07-T-E-S-00	6.80	S	1.260	0.187	0.080	N/A	0.190	0.190	3.680	3.680	0.362	0.232	N/A	1.020	0.178	0.144	N/A	0.020	0.020	1.439	NA	NA	NA	0.073	0.142	0.272	U	1.180	0.349	0.913	N/A	1.0	0.09
L08-09-08-T-E-S-00	5.00	S	0.994	0.141	0.066	N/A	-0.076	0.000	19.600	19.600	1.840	0.218	N/A	0.992	0.148	0.116	N/A	-0.008	0.000	11.420	NA	NA	NA	0.629	0.151	0.187	N/A	1.640	0.346	0.841	N/A	5.7	0.28
L08-09-09-T-E-S-00	6.70	S	1.380	0.182	0.060	N/A	0.310	0.310	7.780	7.780	0.823	0.248	N/A	1.330	0.198	0.099	N/A	0.330	0.330	1.254	NA	NA	NA	0.060	0.133	0.268	U	1.410	0.577	0.880	N/A	0.7	0.23
L08-09-08-T-E-Q-00	5.00	Q	1.040	0.155	0.075	N/A	-0.030	0.000	21.800	21.800	2.050	0.231	N/A	0.990	0.180	0.088	N/A	-0.010	0.000	8.805	NA	NA	NA	0.486	0.179	0.209	N/A	1.450	0.334	0.767	N/A	5.0	0.31
L08-09-10-T-E-B-00	6.80	B	1.180	0.172	0.075	N/A	0.110	0.110	10.700	10.700	0.986	0.219	N/A	1.210	0.211	0.151	N/A	0.210	0.210	4.185	NA	NA	NA	0.230	0.143	0.175	N/A	1.180	0.695	0.890	N/A	3.0	0.21
L08-09-11-T-E-B-00	4.90	B	1.050	0.151	0.065	N/A	-0.020	0.000	2.900	2.900	0.342	0.221	N/A	1.010	0.160	0.115	N/A	0.010	0.010	1.212	NA	NA	NA	0.058	0.130	0.217	U	1.270	0.471	0.705	N/A	0.7	0.11
L08-09-12-T-E-B-00	7.10	B	1.440	0.191	0.073	N/A	0.370	0.370	0.194	0.194	0.159	0.294	U	1.540	0.240	0.161	N/A	0.540	0.540	1.881	NA	NA	NA	0.097	0.188	0.294	U	1.320	0.777	0.978	N/A	1.2	0.18
L08-09-13-T-E-B-00	6.50	B	1.300	0.206	0.100	N/A	0.230	0.230	0.947	0.947	0.094	0.236	N/A	1.330	0.226	0.162	N/A	0.330	0.330	2.735	NA	NA	NA	0.148	0.164	0.281	U	1.110	0.632	0.999	N/A	2.1	0.12
L08-09-14-T-E-B-00	6.80	B	0.995	0.157	0.081	N/A	-0.075	0.000	3.410	3.410	0.399	0.228	N/A	1.090	0.189	0.104	N/A	0.090	0.090	1.511	NA	NA	NA	0.080	0.124	0.238	U	0.795	0.296	0.822	U	1.6	0.07
L08-09-15-T-E-B-00	4.80	B	1.130	0.165	0.072	N/A	0.060	0.060	10.000	10.000	0.981	0.237	N/A	1.020	0.162	0.103	N/A	0.020	0.020	1.025	NA	NA	NA	0.047	0.146	0.246	U	1.330	0.555	0.839	N/A	0.6	0.38
Systematic Minimum			0.000						0.839					0.000						1.254				0.060				0.930				**2.0**	0.02
Systematic Maximum			0.310						19.600					0.330						11.420				0.629				1.640				Average Enrichment (%)	0.28
Systematic Mean			0.101						5.971					0.089						3.227				0.173				1.301					0.13
Systematic Median			0.120						3.820					0.080						2.249				0.117				1.410					0.12
Systematic Standard Deviation			0.107						5.846					0.156						3.182				0.177				0.258					0.08
			With ingrowth, use Ra226 bkg = 1.07											Th232 bkg = 1.0																				

NOTES:

Gross results in units of pCi/g

* Background with ingrowth (1.07 pCi/g) subtracted from gross result

**Background (1.0 pCi/g) subtracted from gross result

U qualifier: A normal, non-detected result (result less than MDC).

All uncertainty values are reported at the 2-sigma confidence level.

7.2.5 Biased Soil Sample Result LSA 08-09

Five (5) biased samples were collected from LSA 08-09. The sample collected at location L08-09-13 represented the maximum GWS measurement (15,674 gcpm) within the SU, and had a result of 0.12 excavation SOF.

7.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 08-09

One sample was collected from the sidewalls of LSA 08-09. Table 7-4 provides the data summary for the sample.

Table 7-4
LSA 08-09 Sidewall Sample Data Summary and Calculated SOF Values

Sample ID	Ra-226 DCGL = 5.4 BKG = 0.9 (pCi/g)	Tc-99 DCGL = 74.0 (pCi/g)	Th-232 DCGL = 5.2 BKG = 1.0 (pCi/g)	U-234 DCGL=872.4 (pCi/g)	U-235 DCGL=208.1 (pCi/g)	U-238 DCGL=551.1 (pCi/g)	Sample SOF (Uniform DCGL)
L08-09-20-T-E-B-00	1.18	10.70	1.21	4.19	0.23	1.18	0.21

7.2.7 Quality Control Soil Sample Result LSA 08-09

For the 15 samples (i.e., 9 systematic + 5 biased + 1 sidewall) collected within LSA 08-09, one QC field duplicate sample points was randomly selected for LSA 08-09 which was collected at systematic locations L08-09-08. This frequency equates to 6.6%, (i.e. 1/15). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated warning limits (see Figure 7-5 below).

Figure 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 08-09

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control	Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.: LSA 08-09 | Survey Unit Description: Central Open Land Area

Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
			Activity (x_i)	MDC	Activity (x_i)	MDC						
L08-09-08-T-E-S-00	L08-09-08-T-E-Q-00	Ra-226	0.994	0.0664	1.040	0.075	1.017	5.4	0.046	0.764	1.145	N
L08-09-08-T-E-S-00	L08-09-08-T-E-Q-00	Tc-99	19.6	0.218	21.800	0.231	20.700	74	2.200	10.471	15.688	N
L08-09-08-T-E-S-00	L08-09-08-T-E-Q-00	Th-232	0.992	0.116	0.990	0.088	0.991	5.2	0.002	0.736	1.102	N
L08-09-08-T-E-S-00	L08-09-08-T-E-Q-00	U-234[1]	11.420	N/A	8.805	N/A	10.112	872.4	2.614	123.445	184.949	N
L08-09-08-T-E-S-00	L08-09-08-T-E-Q-00	U-235	0.629	0.187	0.486	0.209	0.558	208.1	0.143	29.446	44.117	N
L08-09-08-T-E-S-00	L08-09-08-T-E-Q-00	U-238	1.64	0.841	1.450	0.767	1.545	551.1	0.190	77.981	116.833	N

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy

Date: 5-22-17

Reviewed by: Clark Evers

Date: 5/24/17

Quality Record

7.3 Tc-99 Hot Spot Assessment LSA 08-09

For LSA 08-09, the highest observed Tc-99 sample result was 33.1 pCi/g identified at the 2 to 4 ft interval at hybrid well location DM-02. The soil at this interval was completely removed, and the next highest Tc-99 sample result within LSA 08-09 was identified to be 19.6 pCi/g which was collected during FSS systematic sampling. Given the overall low concentrations of Tc-99 that were encountered in LSA 08-09, there is no concern for potential Tc-99 hot spots to remain within the SU that exceed the appropriate $DCGL_W$. And therefore no Tc-99 hot spot assessment is necessary.

8.0 ALARA EVALUATION LSA 08-09

All samples collected within LSA 08-09 were evaluated against the root or excavation stratum $DCGL_W$. For LSA 08-09 no FSS sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.13 for LSA 08-09. The weighted average SOF, taking into account the remaining portions of root stratum and excavation stratum, is 0.15 for LSA 08-09. The weighted average SOF equates to residual activity contributions from the SU area of 3.75 mrem/year for LSA 08-09. Groundwater monitoring well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356} indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 08-09. Summing the dose contributions together, the total estimated dose for LSA 08-09 is 7.75 mrem/year.

As the estimated Total Effective Dose Equivalent (TEDE) is below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the FSS of LSA 08-09 was successful and that there would be no discernable benefit to the health and safety of the public in attempting to further reduce the results of FSS by performing additional remediation of LSA 08-09.

9.0 FSS PLAN DEVIATIONS LSA 08-09

9.1 Remedial Actions during FSS

There was no remedial action after FSS in LSA 08-09.

9.2 Adjustments to Scan MDC Calculations

Scan MDCs for LSA 08-09 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. The assumed LSA background count rate of 11,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 11,256 cpm. Therefore the calculated Scan MDCs are appropriate, and no adjustments need to be made.

10.0 DATA QUALITY ASSESSMENT

The Data Quality Objective (DQO) process is thoroughly integrated within the DP and Hematite FSS procedures. The steps of the DQO process are presented in Volume 3, Chapter 1, Section 4.0 of the FSSFR and correspond to the DQO steps described in Chapter 14, Section 4.2.1 of the DP. The HDP DQO process reflects the recommendations given in MARSSIM, Chapter 2, Figure 2-2.

10.1 Data Quality Assessment for LSA 08-09

The Data Quality Assessment of the survey methodology, sampling and sample analysis results, and the Quality Control sampling and analysis results to ascertain the validity of the conclusion for LSA 08-09 (see Figure 10-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 08-09 survey and sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721 *Final Status Survey Data Validation*.
- The WRS Test is not necessary when the difference between the maximum SU data set measurement SOF and the minimum background area measurement SOF is less than or equal to one. For LSA 08-09, no individual gross SOF result in the FSS data set exceeded the SOF of the minimum background reference area measurement by more than one using the Uniform Stratum criteria. Therefore, the WRS Test was not required for LSA 08-09. However, the WRS Test was still performed for illustrative purposes. Since the test statistic, WR (816) exceeded the critical value (735), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix A.
- A biased soil samples was collected from the location of the highest gamma count rate within the SU, with a maximum result of 0.38 excavation SOF.

- The maximum SOF result for all surface samples within LSA 08-09 was 0.31. The SOF result for the subsurface sample within LSA 08-09 was 0.14. The average SOF result for all systematically collected samples within LSA 08-09 was 0.13, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.19. The weighted average SOF was 0.15 accounting for the contribution of the remaining root and excavation stratums.
- No FSS sample result in LSA 08-09 exceeded a SOF of 1.0 as compared to the appropriate stratum criteria, and the area is suitable for release as the SU final residual radioactivity considering all contributing factors does not exceed 25 mrem/year.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (19) of systematic sample locations actually collected within LSA 08-09. The successful result of the retrospective power evaluation presented in Table 10-1 for LSA 08-09 indicates that the minimum number of sample locations required (8) for the WRS Test was equal than the number of sampling locations actually collected within LSA 08-09. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight LSA surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.
- HDP staff ensured that a visual inspection of the SU configuration, the Isolation & Control measures and the Pre-backfill GWS was completed for LSA 08-09 prior to the commencement of backfill operations. Additionally a confirmatory GWS was performed of the SU within 72 hours prior to the commencement of backfill operations. The results of the confirmatory GWS were compared to the results of the FSS GWS and the comparison determined that there were no changes within the LSA since FSS was performed.

Table 10-1
Retrospective Sample Size Verification for LSA 08-09

DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.08
$DCGL_{SOF}$	1
LBGR (Mean)	0.13
Shift	0.87
Relative Shift (Δ/σ)	10.53
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS N/2	8
Verification Check	**SUFFICIENT MEASUREMENTS**
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test	

MARSSIM Table 5.1

Δ/σ	P_r
0.1	0.528182
0.2	0.556223
0.3	0.583985
0.4	0.611335
0.5	0.638143
0.6	0.664290
0.7	0.689665
0.8	0.714167
0.9	0.737710
1.0	0.760217
1.1	0.781627
1.2	0.801892
1.3	0.820978
1.4	0.838864
1.5	0.855541
1.6	0.871014
1.7	0.885299
1.8	0.898420
1.9	0.910413
2.0	0.921319
2.25	0.944167
2.5	0.961428
2.75	0.974067
3.0	0.983039
3.5	0.993329
4.0	0.997658
4.01	1.000000

MARSSIM Table 5.2, α = 0.05, β = 0.10

α (or β)	$Z_{1-\alpha}$ (or $Z_{1-\beta}$)	
0.005	2.576	
0.01	2.326	
0.015	2.241	
0.025	1.960	
0.05	1.645	α
0.10	1.282	β
0.15	1.036	
0.2	0.842	
0.25	0.674	
0.30	0.524	

Figure 10-1
Data Evaluation Checklists prepared for LSA 08-09 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
		Revision: 10	Appendix G-1, Page 1 of 2

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 08 **Description:** Central Open Land Area
Survey Unit: 09 **Description:** Technetium SEA Open Land Area

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FSS been individually reviewed and validated in accordance with Section 8.1 of this procedure?	Yes ☒	No ☐	
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
3.	Have all scans surveys been performed of the areas specified as required in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
4.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FSSP & the FSS Sample Instructions?	Yes ☒	No ☐	NA ☐
5.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☒	No ☐	NA ☐
6.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the appropriate investigation level?	Yes ☒	No ☐	
7.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use and were those calibrations performed using a NIST traceable source?	Yes ☒	No ☐	
8.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☒	No ☐	
9.	Do the samples match those identified on the chain of custody?	Yes ☒	No ☐	NA ☐
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒	No ☐	NA ☐
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	NA ☐

If "No" was the response to any of the questions above, then document the discrepancy as well as any corrective actions that were taken to resolve the discrepancy.

Comments: N/A

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Figure 10-1
Data Evaluation Checklists prepared for LSA 08-09 (page 2 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
		Revision: 10	Appendix G-1, Page 2 of 2

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: No. LSA 08 **Description:** Central Open Land Area
Survey Unit: No. 09 Description: Technetium SEA Open Land Area

Discrepancy: None

Corrective Actions Taken: None

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐ NA ☒
    a. If "No", then forward this form to the RSO.
12. The following questions will be answered by the RSO.
    a. If the answer to question 11 was "No", then is the affected data still valid? Yes ☐ No ☐ NA ☒
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ NA ☒
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

Prepared by (HP Staff): Thomas Yardy (Print Name) [signature] (Signature) 5-22-17 (Date)

Approved by (RSO): Clark Evers (Print Name) [signature] (Signature) 5/24/17 (Date)

Quality Record

11.0 SURVEILLANCE FOLLOWING FSS

FSS activities in LSA 08-09 were completed in April 2016. Between the completion of FSS and the commencement of backfill operations there were no events that had a potential to re-contaminate LSA 08-09. The assessment that there were no events that had a potential to re-contaminate LSA 08-09 was confirmed by the Pre-backfill GWS that was completed for LSA 08-09 prior to the commencement of backfill operations.

12.0 CONCLUSION LSA 08-09

An adequate quantity and quality of radiological surveys and samples, as well as the corresponding laboratory analysis has been performed, evaluated and documented to demonstrate that the dose associated with all sources within SU LSA 08-09 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

It should be noted that in accordance with Volume 3, Chapter 1, Revision 3, Section 3.1.2 *Three Stratum DCGLs*, compliance with the "three layer" geometry requires consideration of the surface, root, and deep layers independently, because each of the three DCGLs (surface, root, excavation) represent 25 mrem/year from each layer independently. Therefore the Unity Rule must be applied when there is more than one layer present, in the case of LSA 08-09, a small portion of the root stratum, and the deep stratum remained. Using the number of systematically collected samples (8) as the weighting factor, there was one root stratum sample collected (1/8), and eight excavation stratum samples collected (8/8). The weighted average SOF is then determined by multiplying the weighting factor by the average SOF for each layer, and applying the Unity Rule, resulting in a weighted average SOF of 0.15 for LSA 08-09.

Table 12-1
LSA 08-09 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.15	N/A	0.16	N/A	N/A	**0.31**
DOSE	3.75 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**7.75 mrem/year**

13.0 FINAL STATUS SURVEY DESIGN LSA 08-12

This section of the report describes the method for determining the number of samples required for the FSS of LSA 08-12 as well as summarizing the applicable requirements of the FSS Plan. These include the $DCGL_W$, scan survey coverage, and IAL. The radiological instrumentation used in the FSS of LSA 08-12 and their detection sensitivities are also discussed.

13.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 08-12 were driven by the type (Open Land) and Class (Class 1) of the SU and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

13.1.1 Surrogate Evaluation Areas

A discussion of Surrogate Evaluation Areas is given in the FSSFR Volume 3, Chapter 1, Section 5.0, *Final Status Survey Design.*

13.1.2 $DCGL_W$

During the FSS design process a review was performed of the RASS data for LSA 08-12. At the time the FSS plan were written there was no characterization data that indicated that the area would exceed the Uniform $DCGL_W$ criteria. However during the preliminary review of FSS biased soil sample data, elevated Tc-99 activity was identified ranging from 20 to 35 pCi/g. Therefore, the conclusion was drawn that the Three Stratum $DCGL_W$s release criteria would be the most appropriate to be used to demonstrate compliance with the release criteria.

13.1.3 GWS Coverage

As a Class 1 SU, LSA 08-12 was required to undergo a 100% GWS.

13.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 08-12 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

13.1.5 Scan Minimum Detectable Concentration

Scan MDCs for LSA 08-12 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS).* As background levels were approximately 10,000 cpm within LSA 08-12, the scan MDC calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3659\,pCi/g}\right)+\left(\frac{f_{U-235}}{2.32pCi/g}\right)+\left(\frac{f_{U-238}}{30.6pCi/g}\right)\right)}$$

Equation 13-1

To determine isotopic Uranium fractions HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* assumes that the average LSA enrichment is 4% or less. Based on the systematically collected RASS samples in LSA 08-12, the average enrichment for the SU was 2.3%. All other Scan MDC parameters agreed upon between Westinghouse and the NRC were applied (e.g. use of a 2 in air gap, scan rate of 1 ft/sec, 0.75 surveyor efficiency), therefore no subsequent changes to the calculated Scan MDCs need to be made.

Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 08-12 are shown below:

Table 13-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 08-12

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 08-12	40.9	27.4	1.21	3.0	0.87	3.0

*$DCGL_W$ includes background concentrations of 0.9 pCi/g for Ra-226 (no ingrowth) and 1.0 pCi/g for Th-232. DCGLw values are based on the Root Stratum release criteria.

The values in Table 13-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

13.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The basis of the IAL is detailed in HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*". The IAL used during the GWS of LSA 08-12 was established at 4,000 ncpm.

13.1.7 LSA 08-12 FSS Design Summary

The FSS Plan for LSA 08-12 can be found in Appendix E. Table 13-2 presents an overall FSS design and implementation summary for LSA 08-12.

Table 13-2
FSS Design Summary for LSA 08-12

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed excavation floors and walls	
Scan MDC	40.9 pCi/g total Uranium (based on a 10,000 cpm background); 0.87 pCi/g Th-232; 1.21 pCi/g Ra-226*	
Investigation Action Level (IAL)	4,000 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	0	These samples will be taken on a random-start systematic grid.
15 cm – 1.5 m (Root)	2	
> 1.5m (Excavation)	8	
Biased Survey/Sampling Locations:		
Biased samples may be collected during GWS at the discretion of the HP Technician, after statistical analysis of the survey data, or at the direction of the RSO or Radiological Engineering.		
Sidewall Sampling Locations:		
A minimum of one (1) discretionary sidewall sample will be collected based on the following definition of "sidewall": sidewall candidates for sampling must be vertical or near vertical (> 45° angle) and at least 12" in height.		
Instrumentation:		
Ludlum 2221 with 44-10 (2x2 NaI) detector; with collimation for investigations	Used for GWS and to obtain static count rates at biased measurement locations.	
*Values based on information provided in HDP-TBD-FSS-002, "*Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS).* The Scan MDC for total Uranium reflects a conservative assumption of 4% enrichment. The actual RASS enrichment (2.0%) would result in Scan MDC values slightly less than those calculated for FSS planning purposes.		
**IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum DCGLw derived from the technical bases presented in HEM-MEMO-15-021 and HDP-TBD-FSS-003 "*Modeling and Calculation of Investigative Action Levels for Final Status Soil Survey Units*", Westinghouse, March 2015.		

13.1.8 LSA 08-12 Former Process Buildings Investigation Area and Hybrid Well Investigation Planning

The land area of LSA 08-12 is not indicated as being in the Former Process Buildings Area and Hybrid Well Investigation Area.

14.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 08-12

FSS was performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment.*

14.1 Gamma Walkover Survey

14.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 08-12 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS and handheld data logger.

Prior to the first field use of the GWS instrumentation, initial set-ups were performed. Also, daily pre- and post-use source checks were performed for each day that GWS was performed within the SU. Initial set-ups, daily source checks, and control charting were performed according to the requirements of HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey.*

14.1.2 GWS Performance

All GWS measurements on the excavation floor and sidewalls collected with the NaI detector(s) were connected to a Trimble DGPS and with a hand-held data logger. The logging frequency in the SU was one (1) GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

The GWS requirements involved moving the NaI detector in a side-to-side fashion no faster than 1 foot per second while holding the probe as close as possible to the excavation surface (nominally 1", but not to exceed 3"). At the same time, the HP Technician was required to slowly advance, causing the detector to trace out a serpentine path over the excavation surface.

HP Technicians performing GWS in LSA 08-12 used the 4,000 ncpm IAL as a field guide to know when to slow or pause the GWS for more deliberate investigation. If during the GWS, audible count rates noticeably increase above the general area average (i.e., > minimum detectable count rate), HP Technicians were required to pause momentarily and observe count rates. If sustained count rates approached the IAL, further focused investigation was conducted within the locally elevated area.

To use the IAL effectively, HP Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to excavation geometry and relative distance from contaminated materials in nearby remedial excavations, the average background rate (measured at waist level) within the LSA ranged between 10,000 and 11,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 15,000 gcpm, HP Technicians slowed or paused the GWS for more careful investigation of the small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

Sidewalls, hard to reach areas, and non-typical areas were surveyed manually as necessary in order to assess the potential for an area of elevated residual activity over 100% of the exposed excavation surface.

After the GWS survey was complete, the GPS/GWS data was reviewed by Radiological Engineering and the HP Technician performing the survey to determine if possible areas of elevated residual activity remained within the SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

14.2 Soil Sampling

14.2.1 Systematic Soil Sampling Summary

Table 14-1 provides a summary of systematic sampling by stratum for LSA 08-12.

Table 14-1
Systematic Sampling Summary by Stratum for LSA 08-12

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
08-12	1,434	0	6	11	1

14.2.2 Systematic Sampling LSA 08-12

Within LSA 08-12, there were no systematic locations in which portions of the surface stratum (0 – 15 cm) remained within the SU. Root stratum samples were collected at 6 systematic locations, and excavation stratum samples were collected at all 11 systematic sample locations.

Given a planar area of 1,434 m^2 for LSA 08-12 and an eleven - point systematic triangular grid, the point-to-point distance within each row was 16.8 m with spacing of 12.2 m between each of the parallel grid rows within the SU.

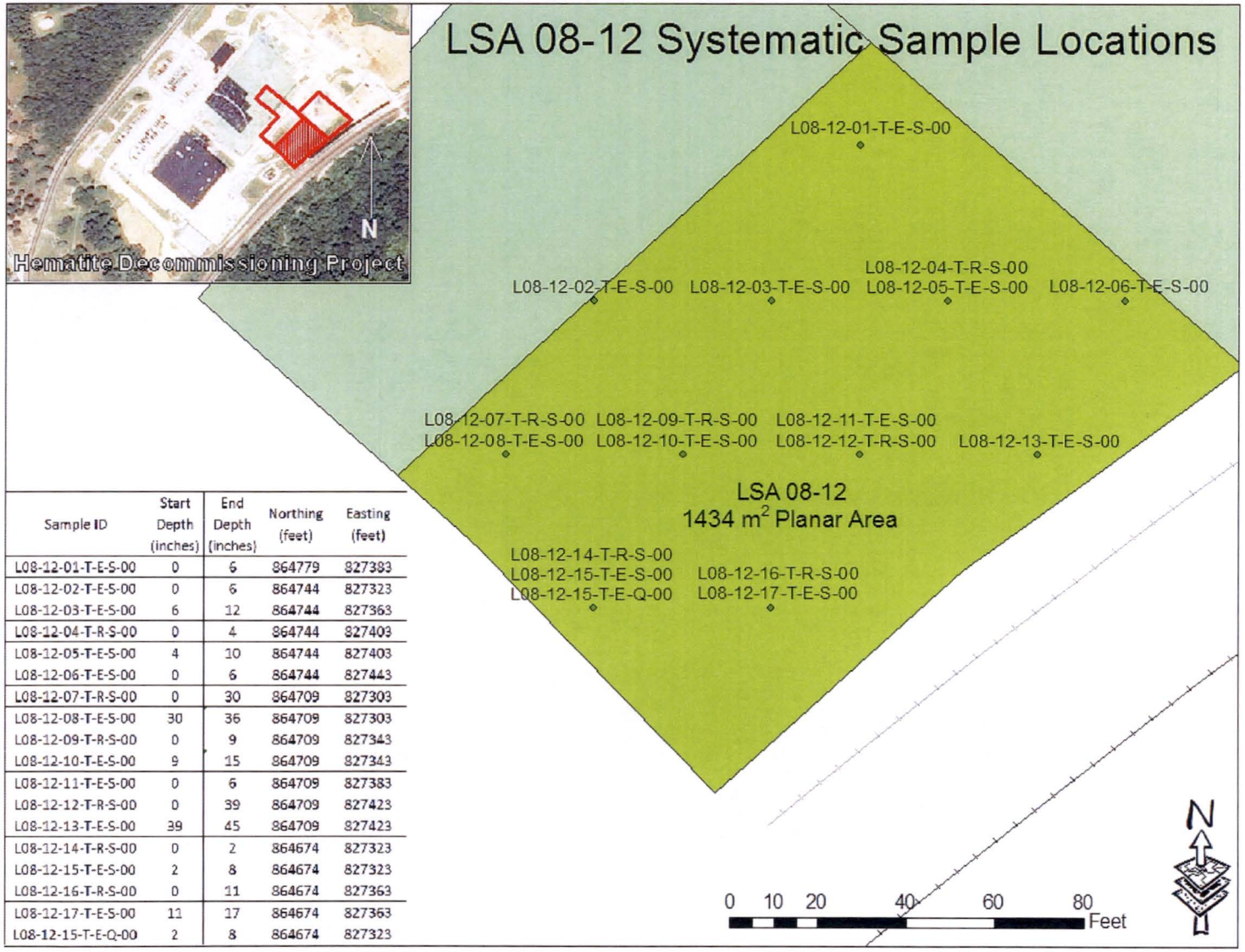
While there were eleven (11) systematic locations on the LSA 08-12 sampling grid, a total of eighteen (18) samples were collected and analyzed at these locations, including:

- Zero (0) samples collected and analyzed within the surface stratum
- Six (6) samples collected and analyzed within the root stratum
- Eleven (11) samples analyzed within the excavation, or "deep" stratum
- One (1) QC field replicate

Figure 14-1 presents the map of the eleven systematic sample locations which were sampled within LSA 08-12. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 14-2 presents the map of the eleven systematic sample locations which were sampled within LSA 08-12 by the stratum.

Figure 14-1
LSA 08-12 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L08-12-01-T-E-S-00	0	6	864779	827383
L08-12-02-T-E-S-00	0	6	864744	827323
L08-12-03-T-E-S-00	6	12	864744	827363
L08-12-04-T-R-S-00	0	4	864744	827403
L08-12-05-T-E-S-00	4	10	864744	827403
L08-12-06-T-E-S-00	0	6	864744	827443
L08-12-07-T-R-S-00	0	30	864709	827303
L08-12-08-T-E-S-00	30	36	864709	827303
L08-12-09-T-R-S-00	0	9	864709	827343
L08-12-10-T-E-S-00	9	15	864709	827343
L08-12-11-T-E-S-00	0	6	864709	827383
L08-12-12-T-R-S-00	0	39	864709	827423
L08-12-13-T-E-S-00	39	45	864709	827423
L08-12-14-T-R-S-00	0	2	864674	827323
L08-12-15-T-E-S-00	2	8	864674	827323
L08-12-16-T-R-S-00	0	11	864674	827363
L08-12-17-T-E-S-00	11	17	864674	827363
L08-12-15-T-E-Q-00	2	8	864674	827323

Figure 14-2
LSA 08-12 Systematic Soil Sample Locations by Stratum

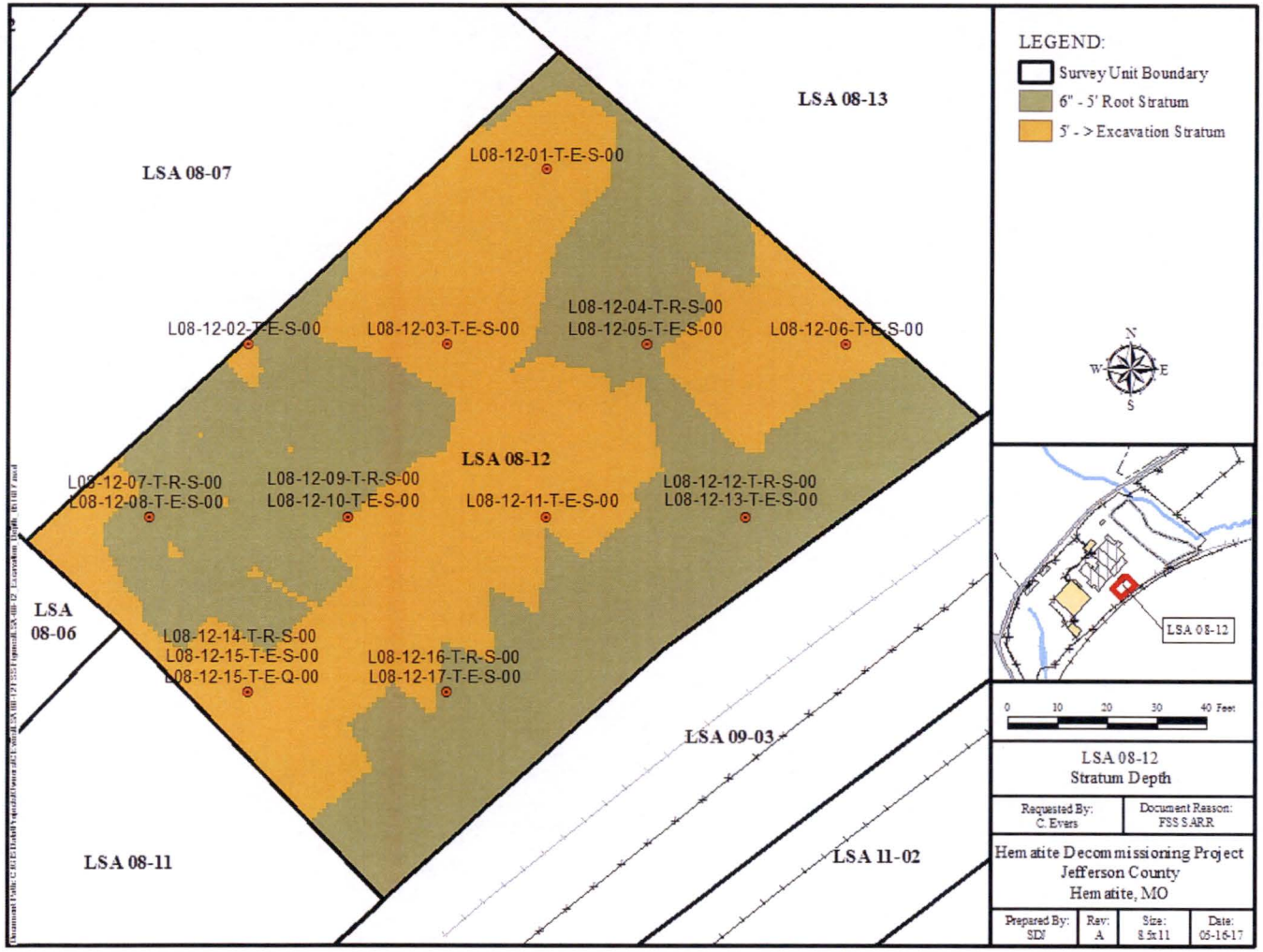


Table 14-2 below presents a tabular listing of all FSS samples collected within LSA 08-12 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 14-2
FSS Sample Locations and Coordinates for LSA 08-12

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
		Revision: 10	Appendix P-4 Page 1 of 1

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area:	LSA 08	**Description:**	Technetium SEA Open Land Area
Survey Unit:	12	**Description:**	Central Open Land Area
Survey Type:	FSS	**Classification:**	Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation	End Elevation	Northing (Y Axis) *	Easting (X Axis) *	Remarks / Notes
L08-12-01-T-E-S-00	Deep	S	427.9	427.4	864779	827383	Excavation 6-inch grab
L08-12-02-T-E-S-00	Deep	S	428.7	428.2	864744	827323	Excavation 6-inch grab
L08-12-03-T-E-S-00	Deep	S	428.5	428.0	864744	827363	Excavation 6-inch grab
L08-12-04-T-R-S-00	Root	S	429.2	428.9	864744	827403	Root 9-inch composite
L08-12-05-T-E-S-00	Deep	S	428.9	428.4	864744	827403	Excavation 6-inch grab
L08-12-06-T-E-S-00	Deep	S	426.5	426.0	864744	827443	Excavation 6-inch grab
L08-12-07-T-R-S-00	Root	S	430.0	427.6	864709	827303	Root 9-inch composite
L08-12-08-T-E-S-00	Deep	S	427.6	427.1	864709	827303	Excavation 6-inch grab
L08-12-09-T-R-S-00	Root	S	428.7	428.0	864709	827343	Root 9-inch composite
L08-12-10-T-E-S-00	Deep	S	428.0	427.5	864709	827343	Excavation 6-inch grab
L08-12-11-T-E-S-00	Deep	S	427.6	427.2	864709	827383	Excavation 6-inch grab
L08-12-12-T-R-S-00	Root	S	432.3	429.0	864709	827423	Root 9-inch composite
L08-12-13-T-E-S-00	Deep	S	429.0	428.6	864709	827423	Excavation 6-inch grab
L08-12-14-T-R-S-00	Root	S	428.0	427.9	864674	827323	Root 9-inch composite
L08-12-15-T-E-S-00	Deep	S	427.9	427.4	864674	827323	Excavation 6-inch grab
L08-12-16-T-R-S-00	Root	S	429.7	428.7	864674	827363	Root 9-inch composite
L08-12-17-T-E-S-00	Deep	S	428.7	428.2	864674	827363	Excavation 6-inch grab
L08-12-15-T-E-Q-00	Deep	Q	427.9	427.4	864674	827323	Excavation 6-inch grab
L08-12-21-T-R-Q-00	Root	Q	429.3	428.8	864686	827374	Excavation 6-inch grab
L08-12-18-T-E-B-00	Deep	B	423.1	422.6	864703	827285	Sidewall Sample
L08-12-19-T-R-B-00	Root	B	430.5	430.0	864647	827338	Bias 6-inch grab
L08-12-20-T-R-B-00	Root	B	431.2	430.7	864672	827371	Bias 6-inch grab
L08-12-21-T-R-B-00	Root	B	429.3	428.8	864686	827374	Bias 6-inch grab
L08-12-22-T-R-B-00	Root	B	430.6	430.1	864710	827427	Bias 6-inch grab
L08-12-23-T-R-B-00	Root	B	430.1	429.6	864714	827428	Bias 6-inch grab
L08-12-24-T-E-B-00	Deep	B	428.5	428.0	864771	827368	Bias 6-inch grab
L08-12-25-T-E-B-00	Deep	B	428.7	428.2	864775	827363	Bias 6-inch grab
L08-12-26-T-R-B-00	Root	B	430.4	429.9	864675	827391	Bias 6-inch grab
L08-12-27-T-R-B-00	Root	B	431.3	430.8	864716	827428	Bias 6-inch grab

Green shaded samples are the samples at each sample location, for use in WRS test.

*Elevations are in feet above mean sea level.

** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983] (Open Land Area) OR
Distance in feet from lower left corner of the surface (Structures); each surface has its own (X,Y) = (0,0); OR

CSM: Three-Layer (Surface-Root-Deep) or Uniform

Type: Systematic = S, Biased = B; QC =Q; Investigation = I
Quality Record

14.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 08-12 ten (10) biased sample locations were selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

14.4 Judgmental/Sidewall Sampling for Tc-99

Sidewall sampling was prescribed by the FSS Plan developed for LSA 08-12 in accordance with the guidance provided in HDP-PR-FSS-701, *Final Status Survey Plan Development*. See FSSFR Volume 3, Chapter 1, Section 5.2, *Tc-99 Side Wall Sampling* for further discussion.

During FSS of LSA 08-12, one (1) sidewall sample was collected. See section 15.2.6, *Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 08-09* for further discussion.

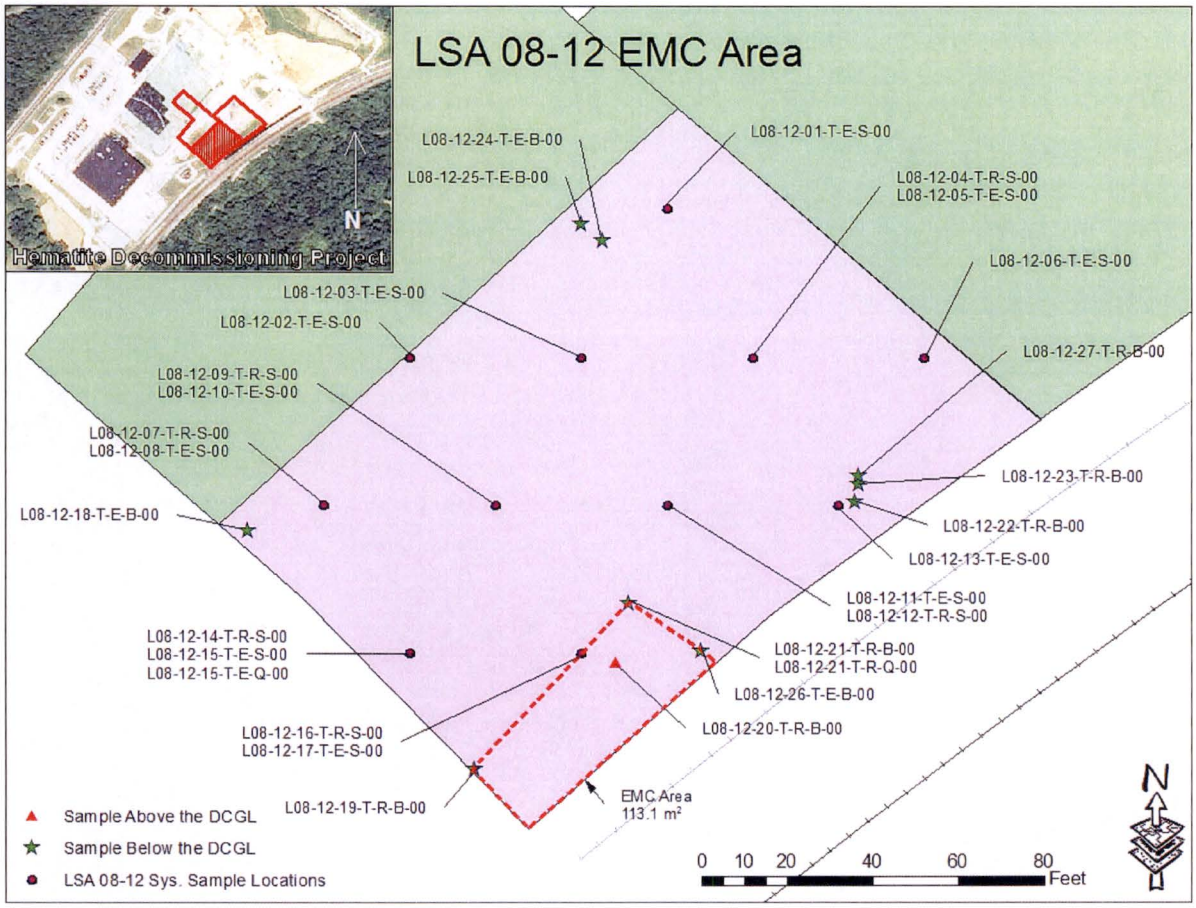
14.5 Quality Control Soil Sampling

Two QC field duplicate sample points were randomly selected and collected at systematic locations L08-12-15, and L08-12-21 for LSA 08-12.

14.6 Elevated Measurement Comparison

During the review of FSS biased soil sample data, an area of elevated residual contamination was identified that exceeded the applicable root stratum $DCGL_W$. Therefore, an EMC investigation was performed for LSA 08-12 as required by Procedure HDP-PR-FSS-721 *Final Status Survey Data Evaluation*. The size of the associated elevated area surrounding this biased location was determined by using the nearest "clean" systematic and biased locations and the boundary edges of the SU itself to define a polygonal area of 113.1 m^2 as calculated by GIS software. Following the steps presented in Section 8.6.7 of HDP-PR-FSS-721, the $DCGL_{EMC}$s for all nuclides were calculated based on the nuclide-specific area factors corresponding to 113.1 m^2. Then the difference between the activity of each nuclide in the elevated area and the average activity of the corresponding nuclide in the general SU area was divided by the nuclide-specific $DCGL_{EMC}$ to determine an activity fraction for each nuclide in the elevated area. These six activity fractions were added together for a total SOF of 0.05 for the EMC area. This SOF is equivalent to a dose of 1.25 mrem/year. Additional information on the EMC calculation can be found in Appendix B. Figure 14-3 presents the map of the LSA 08-12 EMC area.

Figure 14-3
EMC Investigation Area within LSA 08-12



15.0 FINAL STATUS SURVEY RESULTS LSA 08-12

15.1 Gamma Walkover Survey

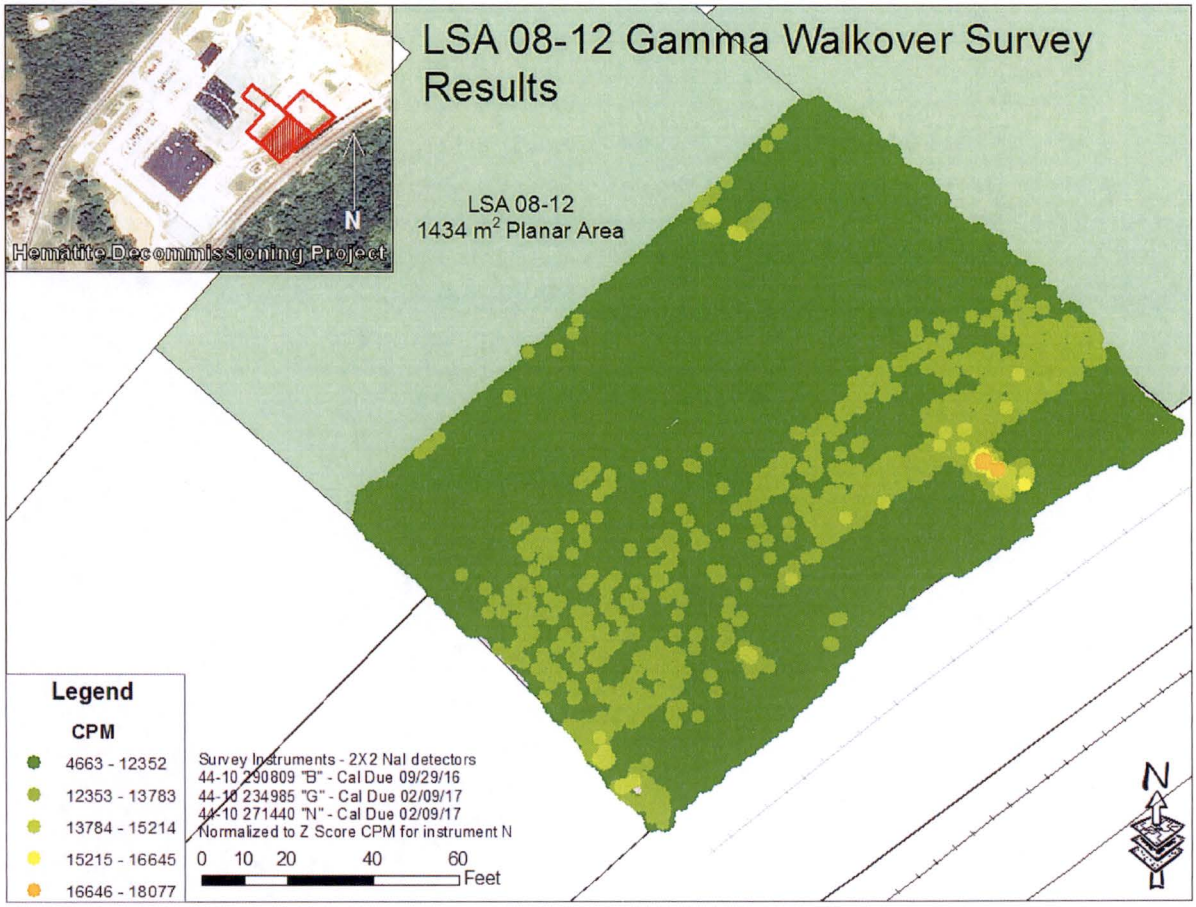
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are plotted "on top"(e.g. if any sidewalls featured more elevated readings than the floor directly below, the sidewall radiological measurements would overlie the lower floor readings).

GWS measurements were collected in LSA 08-12 between March 18, 2016, and March 29, 2016.

15.1.1 GWS Results for LSA 08-12

For LSA 08-12, GWS count rates ranged between 4,663 gcpm and 17,372 gcpm, with a mean count rate of 11,191 gcpm. The median count rate was 11,281 gcpm with a standard deviation of 1,142 cpm. Figure 15-1 below presents a map of the complete GWS data set.

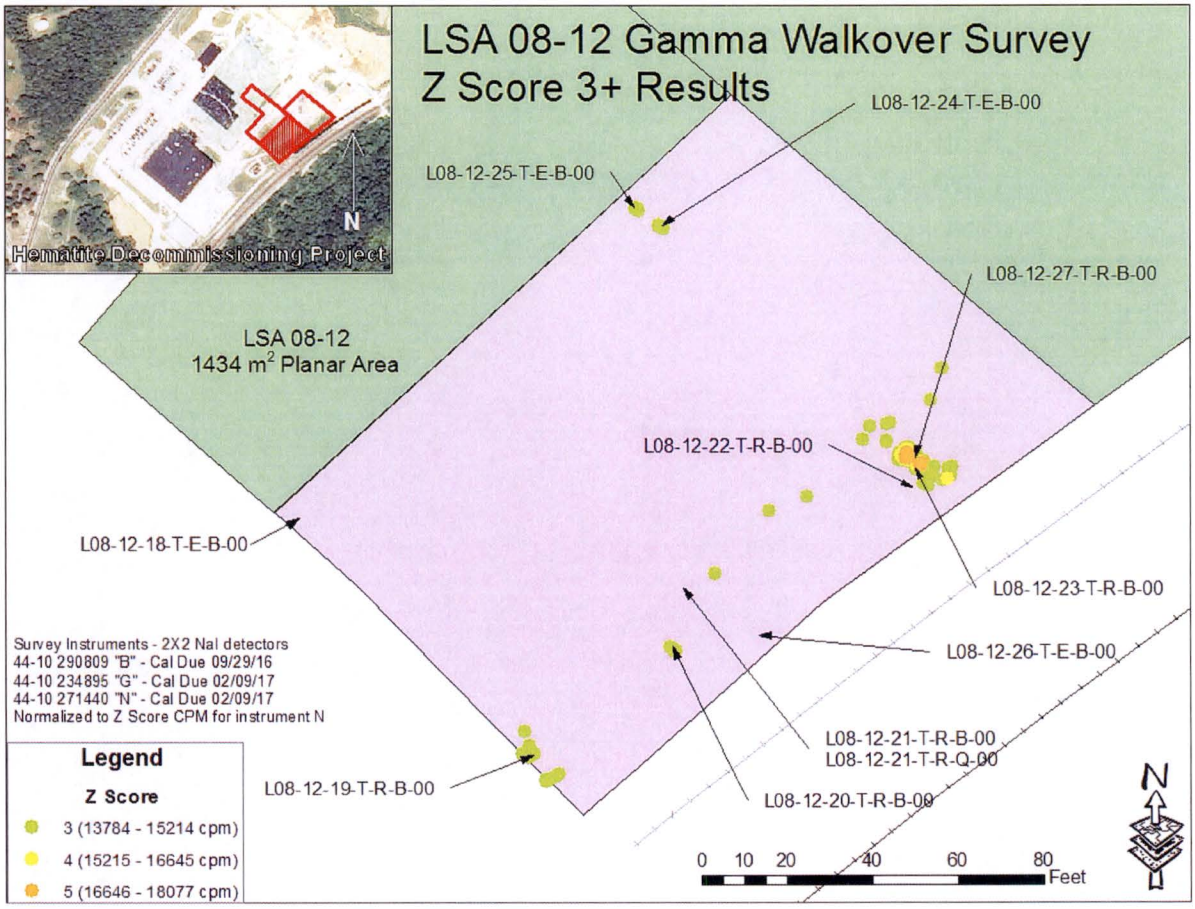
Figure 15-1
Colorimetric GWS Plot for LSA 08-12



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded both the IAL (> 4000 ncpm) and three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). Several locations were selected for biased sample collection. The sample collected at location L08-12-23 represented the maximum GWS measurement (17,372 gcpm) within the SU.

Figure 15-2 presents a map of the +3 Z-score GWS measurements within LSA 08-12, including the selected biased sampling location.

Figure 15-2
Colorimetric GWS Plot for LSA 08-12 (Measurements > Z-score of 3)



All GWS data collected in LSA 08-12 was datalogged and post-processed in GIS software.

15.1.2 GWS Coverage Results LSA 08-12

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS.

The post survey processing of the GPS data indicated that although 100% of accessible areas underwent GWS the GWS covered 99.67% of the SU (see Table 15-1). As the evaluation indicates that the GPS coverage exceeded 95% with no readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of any apparent GPS coverage gaps, the GWS coverage for the SU has been evaluated to meet the intent of the "100% GWS coverage" requirement.

Table 15-1
GWS Gap Analysis LSA 08-12

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 08-12	279,316	912	0.33	99.67	1

15.2 Soil Sample Results LSA 08-12

Appendix B presents the analytical results and associated statistics for all FSS samples collected within LSA 08-12.

15.2.1 Surface Soil Sample Results LSA 08-12

Within LSA 08-12 the surface stratum was completely removed. There were no samples collected within the surface stratum (0 – 15 cm) of LSA 08-12. There was a total of twenty-three (23) soil samples collected within the topmost soil layer of the excavation surface which consists of eleven (11) systematic samples, ten (10) biased samples, and two (2) QC field duplicate sample. The maximum SOF result of the remaining topmost layer sample was 1.63 root stratum SOF. An EMC was performed at this location; see Section 14.6 for more information

15.2.2 Subsurface Soil Sample Results LSA 08-12

There were six systematic locations within LSA 08-12 where the remaining root stratum interval was composite sampled. At these locations, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected as described above. The maximum result of the subsurface samples collected in LSA 08-09 was 0.15 excavation stratum SOF.

15.2.3 WRS Test Evaluation LSA 08-12

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was required for LSA 08-12 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was greater than one using the Uniform Stratum criteria. All systematically collected samples regardless of depth are used to perform the WRS Test, however biased and QC sample results are not utilized in the WRS Test. The 17 systematically collected samples in LSA 08-12 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R (1068) was greater than the critical value (879) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix B.

15.2.4 Graphical Data Review LSA 08-12

Table 15-2 below presents the summary results for the all systematically collected samples (includes root, and excavation, but not biased or QC samples) collected within LSA 08-12, and the associated SOF when compared to the appropriate Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.20.

Table 15-2
LSA 08-12 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Excavation DCGL)
Average	0.229	2.736	0.185	4.751	0.259	1.488	**0.20**
Minimum	0.050	0.733	0.00 (<BKG)	1.646	0.084	0.738	0.04
Maximum	0.440	7.600	0.380	11.912	0.658	2.270	0.44

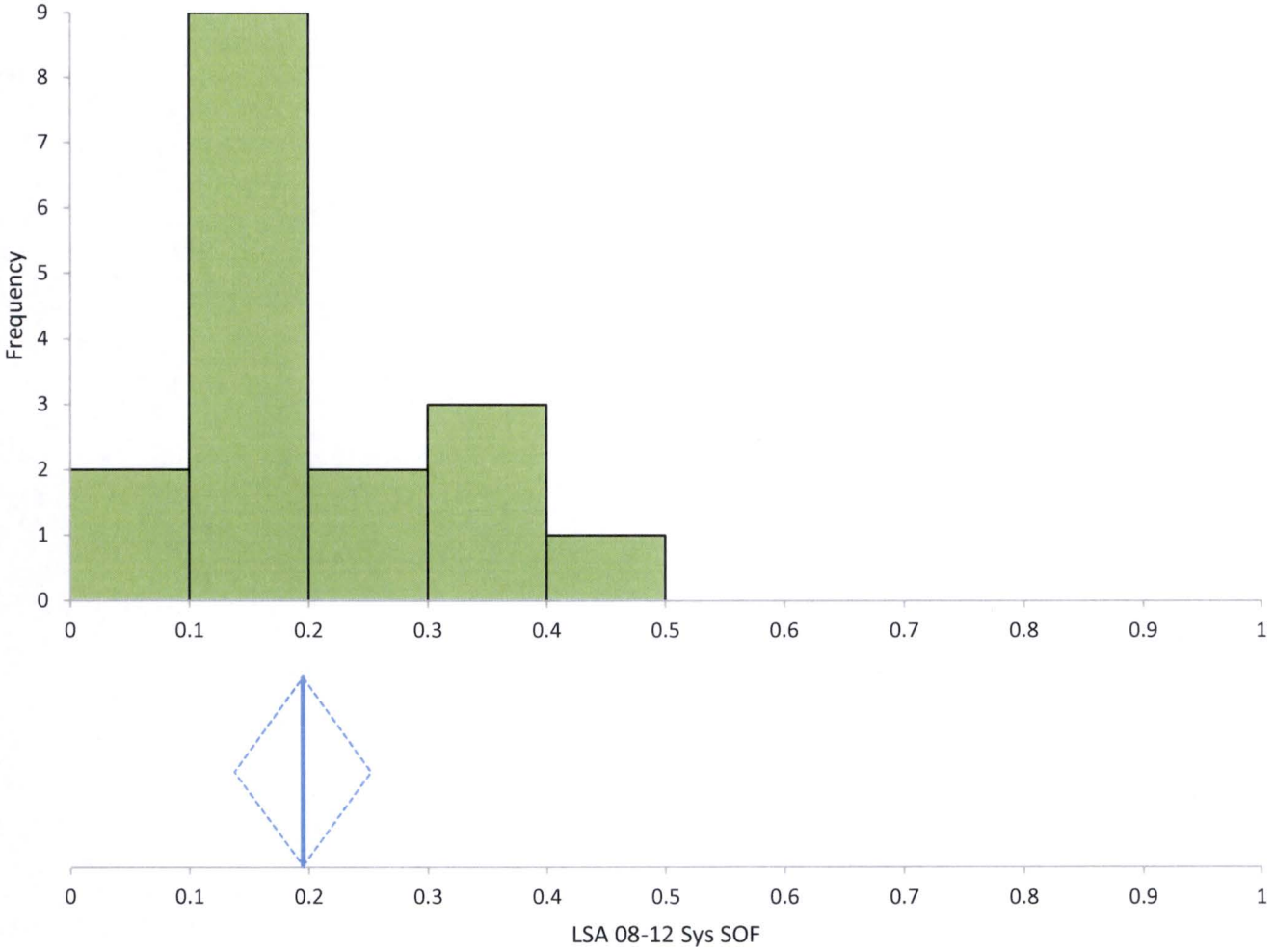
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide concentrations.
3. U-234 values are inferred from the U-235/U-238 ratio.

Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within a certain range of values. The frequency plot will reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution for the SU. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 15-3 presents the overall statistical metrics for the SOF parameter for the 17 systematically collected samples from LSA 08-12. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 08-12. The middle graph presents the mean SOF (0.20) as indicated by the blue vertical line of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.14 to 0.25. The 95.1% confidence interval based on the median (0.16) of the sample results is 0.13 to 0.25. The bottom two charts present the various statistical metrics of the LSA 08-12 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 15-3 exhibits no unusual symmetry or bimodality concerns for the LSA 08-12 data associated with the systematically collected measurement locations.

Figure 15-3
Graphic Statistical Summary for LSA 08-12 (SOF parameter)



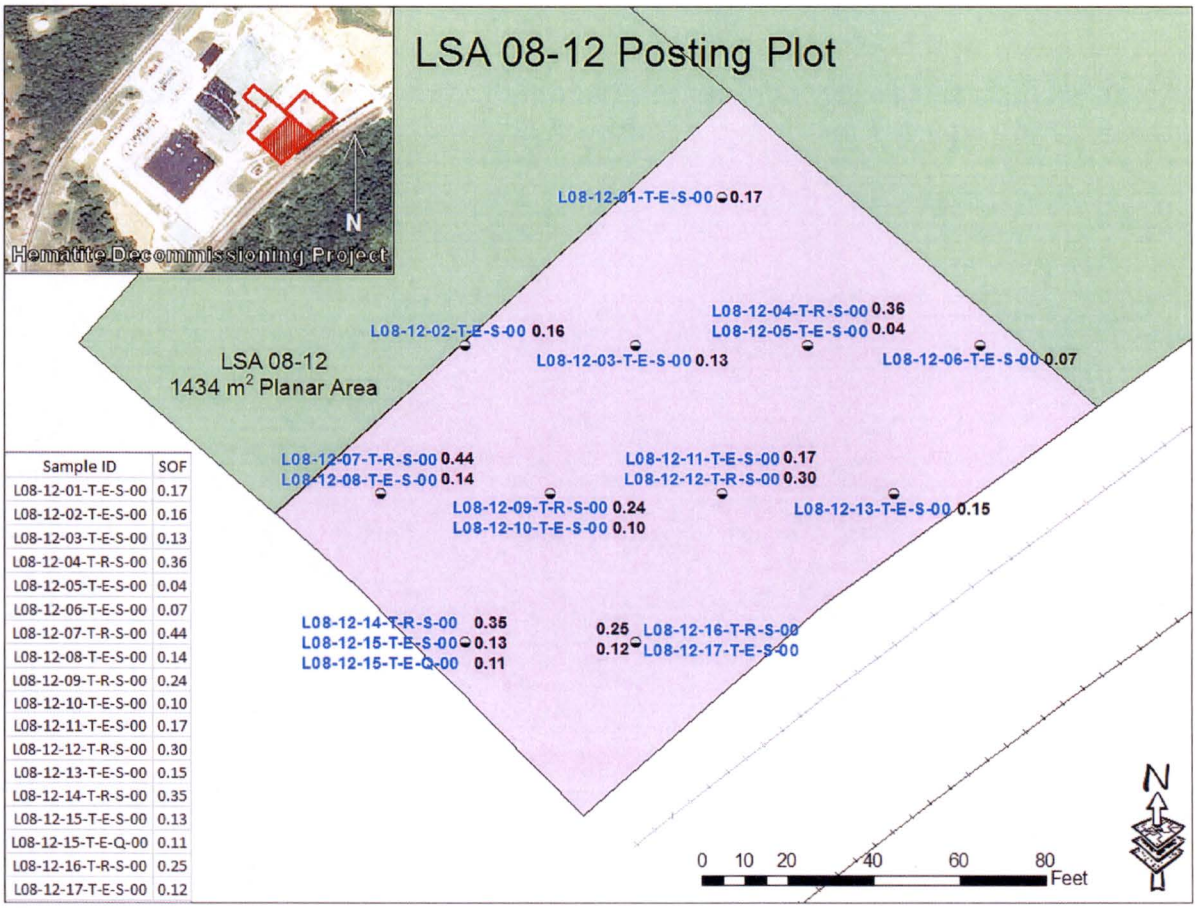
N	17

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 08-12 Sys SOF	0.20	0.14	to 0.25	0.027	0.11	0.01	0.8	-0.13

	Minimum	1st quartile	Median	95.1% CI		3rd quartile	Maximum	IQR
LSA 08-12 Sys SOF	0.04	0.12	0.16	0.13	to 0.25	0.27	0.4	0.14

A posting plot is simply a map of the SU with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 08-12 is presented below in Figure 15-4. Figure 15-4 shows no unusual patterns in the data.

Figure 15-4
Posting Plot for LSA 08-12 Systematic Measurement Locations



Sample ID	SOF
L08-12-01-T-E-S-00	0.17
L08-12-02-T-E-S-00	0.16
L08-12-03-T-E-S-00	0.13
L08-12-04-T-R-S-00	0.36
L08-12-05-T-E-S-00	0.04
L08-12-06-T-E-S-00	0.07
L08-12-07-T-R-S-00	0.44
L08-12-08-T-E-S-00	0.14
L08-12-09-T-R-S-00	0.24
L08-12-10-T-E-S-00	0.10
L08-12-11-T-E-S-00	0.17
L08-12-12-T-R-S-00	0.30
L08-12-13-T-E-S-00	0.15
L08-12-14-T-R-S-00	0.35
L08-12-15-T-E-S-00	0.13
L08-12-15-T-E-Q-00	0.11
L08-12-16-T-R-S-00	0.25
L08-12-17-T-E-S-00	0.12

Appendix B to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 15-2, Figure 15-3, and Figure 15-4 above. A summary of the analytical data is presented in Table 15-3 below. Appendix H to this report presents the Test America Analytical Laboratory soil sample reports.

Table 15-3
Final Status Survey Analytical Data: LSA 08-12

Sample ID	Sample Start Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF
L08-12-01-T-E-S-00	5.00	S	1.350	0.183	0.077	N/A	0.280	0.280	3.340	3.340	0.383	0.220	N/A	1.280	0.196	0.147	N/A	0.280	0.280	9.632	NA	NA	NA	0.532	0.192	0.220	N/A	1.750	0.601	0.893	N/A	4.6	0.17
L08-12-02-T-E-S-00	5.00	S	1.260	0.166	0.067	N/A	0.190	0.190	3.360	3.360	0.317	0.226	N/A	1.280	0.175	0.124	N/A	0.280	0.280	11.912	NA	NA	NA	0.658	0.191	0.219	N/A	2.270	0.697	0.825	N/A	4.4	0.16
L08-12-03-T-E-S-00	5.00	S	1.170	0.155	0.052	N/A	0.100	0.100	5.280	5.280	0.616	0.225	N/A	1.140	0.162	0.093	N/A	0.140	0.140	5.752	NA	NA	NA	0.315	0.141	0.194	N/A	1.820	0.622	0.789	N/A	2.7	0.13
L08-12-04-T-R-S-00	4.00	S	1.310	0.196	0.085	N/A	0.240	0.240	1.500	1.500	0.488	0.238	N/A	1.330	0.222	0.117	N/A	0.330	0.330	5.498	NA	NA	NA	0.303	0.157	0.227	N/A	1.340	0.351	0.889	N/A	3.4	0.36
L08-12-05-T-E-S-00	5.00	S	1.120	0.151	0.063	N/A	0.050	0.050	1.400	1.400	0.172	0.241	N/A	1.040	0.176	0.094	N/A	0.040	0.040	1.776	NA	NA	NA	0.092	0.166	0.244	U	1.240	0.511	0.780	N/A	1.2	0.04
L08-12-06-T-E-S-00	5.00	S	1.210	0.169	0.063	N/A	0.140	0.140	2.260	2.260	0.300	0.258	N/A	1.040	0.162	0.126	N/A	0.040	0.040	4.094	NA	NA	NA	0.225	0.136	0.196	N/A	1.160	0.521	0.799	N/A	3.0	0.07
L08-12-07-T-R-S-00	4.00	S	1.360	0.183	0.074	N/A	0.290	0.290	1.920	1.920	0.198	0.233	N/A	1.370	0.198	0.115	N/A	0.370	0.370	7.685	NA	NA	NA	0.423	0.178	0.210	N/A	2.050	0.565	0.795	N/A	3.2	0.44
L08-12-08-T-E-S-00	5.00	S	1.370	0.207	0.081	N/A	0.300	0.300	3.440	3.440	0.339	0.234	N/A	1.170	0.206	0.150	N/A	0.170	0.170	3.059	NA	NA	NA	0.167	0.192	0.301	U	1.050	0.386	1.060	U	2.5	0.14
L08-12-09-T-R-S-00	4.00	S	1.190	0.163	0.069	N/A	0.120	0.120	2.580	2.580	0.245	0.204	N/A	1.110	0.169	0.084	N/A	0.110	0.110	6.357	NA	NA	NA	0.351	0.153	0.180	N/A	1.350	0.317	0.808	N/A	3.9	0.24
L08-12-10-T-E-S-00	5.00	S	1.290	0.181	0.080	N/A	0.220	0.220	2.230	2.230	0.366	0.243	N/A	1.140	0.179	0.136	N/A	0.140	0.140	2.372	NA	NA	NA	0.121	0.132	0.213	U	1.720	0.609	0.899	N/A	1.1	0.10
L08-12-11-T-E-S-00	5.00	S	1.510	0.199	0.074	N/A	0.440	0.440	0.733	0.733	0.112	0.235	N/A	1.380	0.220	0.096	N/A	0.380	0.380	2.144	NA	NA	NA	0.108	0.163	0.268	U	1.830	0.821	0.963	N/A	1.0	0.17
L08-12-12-T-R-S-00	4.00	S	1.270	0.180	0.079	N/A	0.200	0.200	0.762	0.762	0.140	0.229	N/A	1.330	0.208	0.102	N/A	0.330	0.330	1.646	NA	NA	NA	0.084	0.137	0.252	U	1.280	0.561	0.864	N/A	1.1	0.30
L08-12-13-T-E-S-00	5.00	S	1.280	0.191	0.065	N/A	0.210	0.210	7.600	7.600	0.813	0.222	N/A	0.931	0.183	0.213	N/A	-0.069	0.000	4.065	NA	NA	NA	0.220	0.180	0.303	U	1.620	0.656	0.987	N/A	2.1	0.15
L08-12-14-T-R-S-00	4.00	S	1.240	0.168	0.069	N/A	0.170	0.170	4.690	4.690	0.548	0.239	N/A	1.130	0.174	0.114	N/A	0.130	0.130	7.698	NA	NA	NA	0.424	0.123	0.166	N/A	1.960	0.597	0.862	N/A	3.3	0.35
L08-12-15-T-E-S-00	5.00	S	1.420	0.196	0.081	N/A	0.350	0.350	2.110	2.110	0.244	0.234	N/A	1.150	0.183	0.120	N/A	0.150	0.150	1.917	NA	NA	NA	0.104	0.141	0.241	U	0.738	0.293	0.840	U	2.2	0.13
L08-12-16-T-R-S-00	4.00	S	1.260	0.179	0.080	N/A	0.190	0.190	2.240	2.240	0.213	0.241	N/A	1.130	0.169	0.103	N/A	0.130	0.130	2.919	NA	NA	NA	0.157	0.151	0.238	U	1.310	0.551	0.846	N/A	1.9	0.25
L08-12-17-T-E-S-00	5.00	S	1.470	0.196	0.065	N/A	0.400	0.400	1.060	1.060	0.186	0.239	N/A	1.130	0.197	0.160	N/A	0.130	0.130	2.243	NA	NA	NA	0.122	0.115	0.180	U	0.809	0.305	0.860	U	2.3	0.12
L08-12-15-T-E-Q-00	5.00	Q	1.270	0.169	0.072	N/A	0.200	0.200	1.680	1.680	0.163	0.233	N/A	1.230	0.189	0.104	N/A	0.230	0.230	1.329	NA	NA	NA	0.066	0.160	0.253	U	1.240	0.668	0.835	N/A	0.9	0.11
L08-12-21-T-R-Q-00	4.70	Q	0.838	0.129	0.059	N/A	-0.232	0.000	20.800	20.800	1.930	0.216	N/A	0.572	0.132	0.112	N/A	-0.428	0.000	18.295	NA	NA	NA	1.010	0.209	0.204	N/A	3.050	0.626	0.745	N/A	4.9	0.80
L08-12-18-T-E-B-00	10.90	B	1.380	0.193	0.086	N/A	0.310	0.310	1.330	1.330	0.195	0.244	N/A	1.400	0.220	0.117	N/A	0.400	0.400	2.231	NA	NA	NA	0.120	0.180	0.283	U	0.986	0.385	1.040	U	1.9	0.16
L08-12-19-T-R-B-00	3.50	B	1.260	0.170	0.062	N/A	0.190	0.190	1.970	1.970	0.212	0.226	N/A	1.180	0.190	0.103	N/A	0.180	0.180	20.023	NA	NA	NA	1.070	0.239	0.246	N/A	1.380	0.582	0.893	N/A	10.8	0.36
L08-12-20-T-R-B-00	2.80	B	1.110	0.170	0.075	N/A	0.040	0.040	35.200	35.200	3.300	0.210	N/A	0.581	0.145	0.380	N/A	-0.419	0.000	75.402	NA	NA	NA	4.150	0.566	0.354	N/A	10.400	1.470	1.280	N/A	5.9	1.63
L08-12-21-T-R-B-00	4.70	B	0.758	0.103	0.031	N/A	-0.312	0.000	23.300	23.300	2.220	0.200	N/A	0.452	0.077	0.045	N/A	-0.548	0.000	17.423	NA	NA	NA	0.962	0.175	0.149	N/A	3.030	0.541	0.593	N/A	4.8	0.88
L08-12-22-T-R-B-00	3.40	B	0.874	0.126	0.059	N/A	-0.196	0.000	3.390	3.390	0.317	0.225	N/A	0.903	0.134	0.091	N/A	-0.097	0.000	15.569	NA	NA	NA	0.857	0.208	0.215	N/A	4.140	0.887	0.876	N/A	3.2	0.21
L08-12-23-T-R-B-00	2.90	B	0.918	0.131	0.063	N/A	-0.152	0.000	6.260	6.260	0.588	0.211	N/A	1.250	0.169	0.112	N/A	0.250	0.250	77.985	NA	NA	NA	4.270	0.515	0.263	N/A	8.950	1.420	1.210	N/A	7.0	0.78
L08-12-24-T-E-B-00	5.50	B	1.260	0.172	0.073	N/A	0.190	0.190	3.000	3.000	0.309	0.229	N/A	1.110	0.174	0.121	N/A	0.110	0.110	190.639	NA	NA	NA	9.010	0.979	0.392	N/A	3.720	0.870	1.180	N/A	27.4	0.37
L08-12-25-T-E-B-00	5.30	B	1.130	0.196	0.111	N/A	0.060	0.060	0.967	0.967	0.159	0.220	N/A	1.010	0.198	0.193	N/A	0.010	0.010	119.988	NA	NA	NA	5.630	0.670	0.335	N/A	2.210	0.572	1.290	N/A	28.4	0.19
L08-12-26-T-R-B-00	3.60	B	0.941	0.132	0.060	N/A	-0.129	0.000	15.700	15.700	1.510	0.210	N/A	0.901	0.140	0.075	N/A	-0.099	0.000	4.484	NA	NA	NA	0.247	0.139	0.170	N/A	1.160	0.318	0.776	N/A	3.3	0.55
L08-12-27-T-R-B-00	2.70	B	1.110	0.150	0.086	N/A	0.040	0.040	5.390	5.390	0.569	0.221	N/A	1.150	0.179	0.114	N/A	0.150	0.150	39.695	NA	NA	NA	2.180	0.326	0.247	N/A	5.010	0.890	1.030	N/A	6.4	0.50
Systematic Minimum			0.050						0.733					0.000						1.646				0.084				0.738				3.2	0.04
Systematic Maximum			0.440						7.600					0.380						11.912				0.658				2.270				Average Enrichment (%)	0.44
Systematic Mean			0.229						2.736					0.185						4.751				0.259				1.488					0.20
Systematic Median			0.210						2.240					0.140						4.065				0.220				1.350					0.16
Systematic Standard Deviation			0.105						1.786					0.120						3.051				0.171				0.434					0.11
			With ingrowth, use Ra226 bkg = 1.07											Th232 bkg = 1.0																			

NOTES:
Gross results in units of pCi/g
* Background with ingrowth (1.07 pCi/g) subtracted from gross result
**Background (1.0 pCi/g) subtracted from gross result
U qualifier: A normal, non-detected result (result less than MDC).
All uncertainty values are reported at the 2-sigma confidence level.

15.2.5 Biased Soil Sample Result LSA 08-12

Nine (9) biased samples were collected from LSA 08-12. The sample collected at location L08-12-23 represented the maximum GWS measurement (17,372 gcpm) within the SU, and had a result of 0.78 root stratum SOF.

15.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 08-12

One sample was collected from the sidewall of LSA 08-12. Table 15-4 provides the data summary for the samples.

Table 15-4
LSA 08-12 Sidewall Sample Data Summary and Calculated SOF Values

Sample ID	Ra-226 DCGL = 5.4 BKG = 0.9 (pCi/g)	Tc-99 DCGL = 74.0 (pCi/g)	Th-232 DCGL = 5.2 BKG = 1.0 (pCi/g)	U-234 DCGL=872.4 (pCi/g)	U-235 DCGL=208.1 (pCi/g)	U-238 DCGL=551.1 (pCi/g)	Sample SOF (Uniform DCGL)
L08-12-18-T-E-B-00	1.38	1.33	1.40	2.231	0.120	0.986	0.16

15.2.7 Quality Control Soil Sample Result LSA 08-12

Two QC field duplicate sample points were randomly selected for LSA 08-12 which were collected at systematic location L08-12-15 and L08-12-21.

For the 27 samples (i.e., 17 systematic + 10 biased + 1 sidewalls) collected within LSA 08-12, two field duplicate sample were collected. This frequency equates to 7.4%, (i.e. 2/27). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated warning limits (see Figure 15-5 below).

Figure 15-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 08-12 (1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control	Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.: LSA 08-12 | Survey Unit Description: Central Open Land Area

Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{x}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L08-12-15-T-E-S-00	L08-12-15-T-E-Q-00	Ra-226	1.420	0.0805	1.270	0.072	1.345	5.4	0.150	0.764	1.145	N
L08-12-15-T-E-S-00	L08-12-15-T-E-Q-00	Tc-99	2.11	0.234	1.680	0.233	1.895	74	0.430	10.471	15.688	N
L08-12-15-T-E-S-00	L08-12-15-T-E-Q-00	Th-232	1.150	0.120	1.230	0.104	1.190	5.2	0.080	0.736	1.102	N
L08-12-15-T-E-S-00	L08-12-15-T-E-Q-00	U-234[1]	1.917	N/A	1.329	N/A	1.623	872.4	0.588	123.445	184.949	N
L08-12-15-T-E-S-00	L08-12-15-T-E-Q-00	U-235	0.104	0.241	0.066	0.253	0.085	208.1	NA	29.446	44.117	NA
L08-12-15-T-E-S-00	L08-12-15-T-E-Q-00	U-238	0.738	0.84	1.240	0.835	0.989	551.1	NA	77.981	116.833	NA

Comments:
1. U-234 is inferred. no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy

Date: 5-22-17

Reviewed by: Clark Evers

Date: 5/24/17

Quality Record

Figure 15-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 08-12 (2 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control	Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.: LSA 08-12 — Survey Unit Description: Central Open Land Area

Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
			Activity (x_i)	MDC	Activity (x_i)	MDC						
L08-12-21-T-R-B-00	L08-12-21-T-R-Q-00	Ra-226	0.758	0.031	0.838	0.059	0.798	5.4	0.080	0.764	1.145	N
L08-12-21-T-R-B-00	L08-12-21-T-R-Q-00	Tc-99	23.3	0.2	20.800	0.216	22.050	74	2.500	10.471	15.688	N
L08-12-21-T-R-B-00	L08-12-21-T-R-Q-00	Th-232	0.452	0.045	0.572	0.112	0.512	5.2	0.120	0.736	1.102	N
L08-12-21-T-R-B-00	L08-12-21-T-R-Q-00	U-234[1]	17.423	N/A	18.295	N/A	17.859	872.4	0.873	123.445	184.949	N
L08-12-21-T-R-B-00	L08-12-21-T-R-Q-00	U-235	0.962	0.149	1.010	0.204	0.986	208.1	0.048	29.446	44.117	N
L08-12-21-T-R-B-00	L08-12-21-T-R-Q-00	U-238	3.03	0.593	3.050	0.745	3.040	551.1	0.020	77.981	116.833	N

Comments:
1. U-234 is inferred. no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy — Reviewed by: Clark Evers

Date: 5-22-17 — Date: 5/24/17

Quality Record

15.3 Tc-99 Hot Spot Assessment LSA 08-12

As noted previously, due to the presence of elevated Tc-99 residual activity identified during FSS biased soil sampling, an EMC investigation was performed. Using the EMC investigation area of 113.1 m^2, and using the table provided in Appendix E of HDP-PR-FSS-721 (Table 14-12 in Chapter 14 of the DP), and interpolating the area of 113.1 m^2 provides a root stratum Area Factor (AF) of 9.1 for Tc-99. When this area factor is applied to the Tc-99 root stratum DCGL of 30.1 pCi/g, a $DCGL_{EMC}$ of 273.9 pCi/g is determined.

Given that the FSS biased soil sample result of 35.2 pCi/g of Tc-99 is the highest Tc-99 soil sample that has been identified within the SU, and given the overall low concentrations of Tc-99 that were encountered in in the remainder of LSA 08-12, there is no concern for potential Tc-99 hot spots to remain within the SU that exceed the appropriate $DCGL_{EMC}$. And therefore the Tc-99 hot spot assessment is considered successful.

16.0 ALARA EVALUATION LSA 08-12

All samples collected within LSA 08-12 were evaluated against the root or excavation stratum $DCGL_w$. For LSA 08-12 all samples were less than a SOF of 1.0 with one exception where an EMC Investigation was performed. The average SOF result, based on all systematically collected samples, was 0.20 for LSA 08-12. The weighted average SOF result which takes into account the remaining portions of the root and excavation stratums was 0.30 for LSA 08-12. The weighted average SOF equates to residual activity contributions from the SU area of 7.5 mrem/year for LSA 08-12. Groundwater monitoring well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, and Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356} indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 08-12. An EMC Investigation was performed due to an elevated biased soil sample result, the conclusion of the EMC investigation was that evaluation was successful, and an additional 1.25 mrem/year will be added to the dose for LSA 08-12 to account for the presence of the elevated area. Summing the dose contributions together, the total estimated dose for LSA 08-12 is 12.75 mrem/year.

As the estimated TEDE is below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation and FSS of LSA 08-12 was successful and that there would be no discernable benefit to the health and safety of the public in attempting to further reduce the results of FSS by performing additional remediation of LSA 08-12.

17.0 FSS PLAN DEVIATIONS LSA 08-12

17.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 08-12. Although an elevated area was identified during FSS it prompted the completion of an EMC. The EMC did not result in a need for additional remediation.

17.2 Adjustments to Scan MDC Calculations

Scan MDCs for LSA 08-12 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. The assumed LSA background count rate of 10,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 11,191 cpm. Therefore the calculated Scan MDCs are conservative, and no adjustments need to be made.

18.0 DATA QUALITY ASSESSMENT

The DQO process is thoroughly integrated within the DP and Hematite FSS procedures. The steps of the DQO process are presented in Volume 3, Chapter 1, Section 4.0 of the FSSFR and correspond to the DQO steps described in Chapter 14, Section 4.2.1 of the DP. The HDP DQO process reflects the recommendations given in MARSSIM, Chapter 2, Figure 2-2.

18.1 Data Quality Assessment for LSA 08-12

The Data Quality Assessment of the survey methodology, sampling and sample analysis results, and the Quality Control sampling and analysis results to ascertain the validity of the conclusion for LSA 08-12 (see Figure 18-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 08-12 survey and sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721 *Final Status Survey Data Validation*.
- The WRS Test is necessary when the difference between the maximum survey unit data set measurement SOF and the minimum background area measurement SOF is greater than one. For LSA 08-12, 4 individual gross SOF result(s) in the

FSS data set exceeded the SOF of the minimum background reference area measurement by more than one using the Uniform Stratum criteria. Therefore, the WRS Test was required for LSA 08-12. Since the test statistic, WR (1068) exceeded the critical value (879), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS evaluation worksheet is presented in Appendix B.

- A biased soil sample was collected from the location of the highest gamma count rate within the SU, with a maximum result of 0.14 excavation stratum SOF.
- The maximum SOF result for all surface samples within LSA 08-12 was 1.63. The average SOF result for all systematically collected samples within LSA 08-12 was 0.20, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.25. The weighted average SOF for LSA 08-12 considering contributions from the remaining portions of the root stratum, and the excavation stratum, is 0.30.
- One biased soil sample exceeded a SOF of 1.0, therefore an EMC Investigation was performed. The successful result of the EMC Investigation showed that the area was suitable for release, and contributed an additional 0.05 SOF to the SU.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number of systematic samples actually collected (11) within LSA 08-12. The successful result of the retrospective power evaluation presented in Table 18-1 for LSA 08-12 indicates that the minimum number of samples required (8) for the WRS Test was less than the number of sampling locations actually collected within LSA 08-12. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight LSA surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.
- HDP staff ensured that a visual inspection of the SU configuration, the Isolation & Control measures and the Pre-backfill GWS was completed for LSA 08-12 prior to the commencement of backfill operations. Additionally a confirmatory GWS was performed of the SU within 72 hours prior to the commencement of backfill operations. The results of the confirmatory GWS were compared to the results of the FSS GWS and the comparison determined that there were no changes within the LSA since FSS was performed.

Table 18-1
Retrospective Sample Size Verification for LSA 08-12

DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.11
$DCGL_{SOF}$	1
LBGR (Mean)	0.30
Shift	0.70
Relative Shift (Δ/σ)	6.27
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS N/2	11
Verification Check	**SUFFICIENT MEASUREMENTS**
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test	

MARSSIM Table 5.1

Δ/σ	P_r
0.1	0.528182
0.2	0.556223
0.3	0.583985
0.4	0.611335
0.5	0.638143
0.6	0.664290
0.7	0.689665
0.8	0.714167
0.9	0.737710
1.0	0.760217
1.1	0.781627
1.2	0.801892
1.3	0.820978
1.4	0.838864
1.5	0.855541
1.6	0.871014
1.7	0.885299
1.8	0.898420
1.9	0.910413
2.0	0.921319
2.25	0.944167
2.5	0.961428
2.75	0.974067
3.0	0.983039
3.5	0.993329
4.0	0.997658
4.01	1.000000

MARSSIM Table 5.2, α = 0.05, β = 0.10

α (or β)	$Z_{1-\alpha}$ (or $Z_{1-\beta}$)	
0.005	2.576	
0.01	2.326	
0.015	2.241	
0.025	1.960	
0.05	1.645	α
0.10	1.282	β
0.15	1.036	
0.2	0.842	
0.25	0.674	
0.30	0.524	

Figure 18-1
Data Evaluation Checklists prepared for LSA 08-12 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
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APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 08 **Description:** Central Open Land Area
Survey Unit: 12 **Description:** Technetium SEA Open Land Area

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FSS been individually reviewed and validated in accordance with Section 8.1 of this procedure?	Yes ☒	No ☐	
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
3.	Have all scans surveys been performed of the areas specified as required in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
4.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FSSP & the FSS Sample Instructions?	Yes ☒	No ☐	NA ☐
5.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☒	No ☐	NA ☐
6.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the appropriate investigation level?	Yes ☒	No ☐	
7.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use and were those calibrations performed using a NIST traceable source?	Yes ☒	No ☐	
8.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☒	No ☐	
9.	Do the samples match those identified on the chain of custody?	Yes ☒	No ☐	NA ☐
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒	No ☐	NA ☐
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	NA ☐

If "No" was the response to any of the questions above, then document the discrepancy as well as any corrective actions that were taken to resolve the discrepancy.

Comments: N/A

Quality Record

Figure 18-1
Data Evaluation Checklists prepared for LSA 08-12 (page 2 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
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APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: No. LSA 08 **Description:** Central Open Land Area
Survey Unit: No. 12 Description: Technetium SEA Open Land Area

Discrepancy: None

Corrective Actions Taken: None

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐ NA ☒
    a. If "No", then forward this form to the RSO.
12. The following questions will be answered by the RSO.
    a. If the answer to question 11 was "No", then is the affected data still valid? Yes ☐ No ☐ NA ☒
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ NA ☒
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

Prepared by (HP Staff): Thomas Yardy (Print Name) [signature] (Signature) 5-22-17 (Date)

Approved by (RSO): Clark Evers (Print Name) [signature] (Signature) 5/24/17 (Date)

Quality Record

19.0 SURVEILLANCE FOLLOWING FSS

FSS activities in LSA 08-12 were completed in April 2016. Between the completion of FSS and the commencement of backfill operations there were no events that had a potential to re-contaminate LSA 08-12. The assessment that there were no events that had a potential to re-contaminate LSA 08-12 was confirmed by the Pre-backfill GWS that was completed for LSA 08-12 prior to the commencement of backfill operations.

20.0 CONCLUSION LSA 08-12

An adequate quantity and quality of radiological surveys and samples, as well as the corresponding laboratory analysis has been performed, evaluated and documented to demonstrate that the dose associated with all sources within SU LSA 08-12 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

It should be noted that in accordance with Volume 3, Chapter 1, Revision 3, Section 3.1.2 *Three Stratum DCGLs*, compliance with the "three layer" geometry requires consideration of the Surface, Root, and Deep layers independently, because each of the three DCGLs (surface, root, excavation) represent 25 mrem/year from each layer independently. Therefore the Unity Rule must be applied when there is more than one layer present, however in the case of LSA 08-12, only a portion of the root stratum, and the deep stratum remained. Using the number of systematically collected samples (11) as the weighting factor, there were six root stratum samples collected (6/11), and eleven excavation stratum samples collected (11/11). The weighted average SOF is then determined by multiplying the weighting factor by the average SOF for each layer, and applying the Unity Rule, resulting in a weighted average SOF of 0.30 for LSA 08-12.

Table 20-1
LSA 08-12 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.30	0.05	0.16	N/A	N/A	**0.51**
DOSE	7.5 mrem/year	1.25 mrem/year	4.0 mrem/year	N/A	N/A	**12.75 mrem/year**

21.0 FINAL STATUS SURVEY DESIGN LSA 08-13

This section of the report describes the method for determining the number of samples required for the FSS of LSA 08-13 as well as summarizing the applicable requirements of the FSS Plan. These include the $DCGL_W$, scan survey coverage, and IAL. The radiological instrumentation used in the FSS of LSA 08-13 and their detection sensitivities are also discussed.

21.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 08-13 were driven by the type (Open Land) and Class (Class 1) of the SU and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

21.1.1 Surrogate Evaluation Areas

A discussion of Surrogate Evaluation Areas is given in the FSSFR Volume 3, Chapter 1, Section 5.0, *Final Status Survey Design.*

21.1.2 $DCGL_W$

During the FSS design process a review was performed of the RASS data for LSA 08-13. At the time the FSS plan were written there was no characterization data that indicated that the area would exceed the Uniform $DCGL_W$ criteria. However during the preliminary review of FSS biased soil sample data, elevated Tc-99 activity was identified ranging from 15 to 27 pCi/g. Therefore, the conclusion was drawn that the Three Stratum $DCGL_W$s would be the most appropriate to be used to demonstrate compliance with the release criteria.

Therefore the Three-Stratum $DCGL_W$ was selected for use in demonstrating compliance with the release criteria.

21.1.3 GWS Coverage

As a Class 1 SU, LSA 08-13 was required to undergo a 100% GWS.

21.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 08-13 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

21.1.5 Scan Minimum Detectable Concentration

Scan MDCs for LSA 08-13 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. As background levels were approximately 10,000 cpm within LSA 08-13, the scan MDC calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{4172\ pCi/g}\right)+\left(\frac{f_{U-235}}{2.65 pCi/g}\right)+\left(\frac{f_{U-238}}{34.9 pCi/g}\right)\right)}$$

Equation 21-1

To determine isotopic Uranium fractions HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* assumes that the average LSA enrichment is 4% or less. Based on the systematically collected RASS samples in LSA 08-13, the average enrichment for the SU was 2.8%. All other Scan MDC parameters agreed upon between Westinghouse and the NRC were applied (e.g. use of a 2 in air gap, scan rate of 1 ft/sec, 0.75 surveyor efficiency), therefore no subsequent changes to the calculated Scan MDCs need to be made.

Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 08-13 are shown below:

Table 21-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 08-13

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 08-13	40.9	26.4	0.87	3.0	1.21	3.0

*$DCGL_w$ includes background concentrations of 0.9 pCi/g for Ra-226 (no ingrowth) and 1.0 pCi/g for Th-232. DCGLw values are based on the Root Stratum release criteria.

The values in Table 21-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

21.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The basis of the IAL is detailed in HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*". The IAL used during the GWS of LSA 08-13 was established at 4,000 ncpm.

21.1.7 LSA 08-13 FSS Design Summary

The FSS Plan for LSA 08-13 can be found in Appendix F. Table 21-2 presents an overall FSS design and implementation summary for LSA 08-13.

Table 21-2
FSS Design Summary for LSA 08-13

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed excavation floors and walls	
Scan MDC	40.9 pCi/g total Uranium (based on a 10,000 cpm background); 0.87 pCi/g Th-232; 1.21 pCi/g Ra-226*	
Investigation Action Level (IAL)	4,000 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	0	These samples will be taken on a random-start systematic grid.
15 cm – 1.5 m (Root)	1	
> 1.5m (Excavation)	11	
Biased Survey/Sampling Locations:		
Biased samples may be collected during GWS at the discretion of the HP Technician, after statistical analysis of the survey data, or at the direction of the RSO or Radiological Engineering.		
Sidewall Sampling Locations:		
A minimum of one (1) discretionary sidewall sample will be collected based on the following definition of "sidewall": sidewall candidates for sampling must be vertical or near vertical (> 45° angle) and at least 12" in height.		
Instrumentation:		
Ludlum 2221 with 44-10 (2x2 NaI) detector; with collimation for investigations	Used for GWS and to obtain static count rates at biased measurement locations.	
*Values based on information provided in HDP-TBD-FSS-002, "*Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS).* The Scan MDC for total Uranium reflects a conservative assumption of 4% enrichment. The actual RASS enrichment (2.8%) would result in Scan MDC values slightly less than those calculated for FSS planning purposes.		
**IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum DCGLw derived from the technical bases presented in HEM-MEMO-15-021 and HDP-TBD-FSS-003 "*Modeling and Calculation of Investigative Action Levels for Final Status Soil Survey Units*", Westinghouse, March 2015.		

21.1.8 LSA 08-13 Former Process Buildings Investigation Area and Hybrid Well Investigation Planning

The land area of LSA 08-13 is not indicated as being in the Former Process Buildings Area and Hybrid Well Investigation Area.

22.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 08-13

FSS was performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment.*

22.1 Gamma Walkover Survey

22.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 08-13 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS and handheld data logger.

Prior to the first field use of the GWS instrumentation, initial set-ups were performed. Also, daily pre- and post-use source checks were performed for each day that GWS was performed within the SU. Initial set-ups, daily source checks, and control charting were performed according to the requirements of HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey.*

22.1.2 GWS Performance

All GWS measurements on the excavation floor and sidewalls collected with the NaI detector(s) were connected to a Trimble DGPS and with a hand-held data logger. The logging frequency in the SU was one (1) GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

The GWS requirements involved moving the NaI detector in a side-to-side fashion no faster than 1 foot per second while holding the probe as close as possible to the excavation surface (nominally 1", but not to exceed 3"). At the same time, the HP Technician was required to slowly advance, causing the detector to trace out a serpentine path over the excavation surface.

HP Technicians performing GWS in LSA 08-13 used the 4,000 ncpm IAL as a field guide to know when to slow or pause the GWS for more deliberate investigation. If during the GWS, audible count rates noticeably increase above the general area average (i.e., > minimum detectable count rate), HP Technicians were required to pause momentarily and observe count rates. If sustained count rates approached the IAL, further focused investigation was conducted within the locally elevated area.

To use the IAL effectively, HP Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to excavation geometry and relative distance from contaminated materials in nearby remedial excavations, the average background rate (measured at waist level) within the LSA ranged between 10,000 and 11,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 15,000 gcpm, HP Technicians slowed or paused the GWS for more careful investigation of the small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

Sidewalls, hard to reach areas, and non-typical areas were surveyed manually as necessary in order to assess the potential for an area of elevated residual activity over 100% of the exposed excavation surface.

After the GWS survey was complete, the GPS/GWS data was reviewed by Radiological Engineering and the HP Technician performing the survey to determine if possible areas of elevated residual activity remained within the SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

22.2 Soil Sampling

22.2.1 Systematic Soil Sampling Summary

Table 22-1 provides a summary of systematic sampling by stratum for LSA 08-13.

Table 22-1
Systematic Sampling Summary by Stratum for LSA 08-13

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
08-13	1,418	0	1	11	1

22.2.2 Systematic Sampling LSA 08-13

Within LSA 08-13, there were no systematic locations in which portions of the surface stratum (0 – 15 cm) remained within the SU. The remaining root stratum was sampled at one location, and excavation stratum samples were collected at all 11 systematic sample locations.

Given a planar area of 1,418 m^2 for LSA 08-13 and an eleven - point systematic triangular grid, the point-to-point distance within each row was 12.2 m.

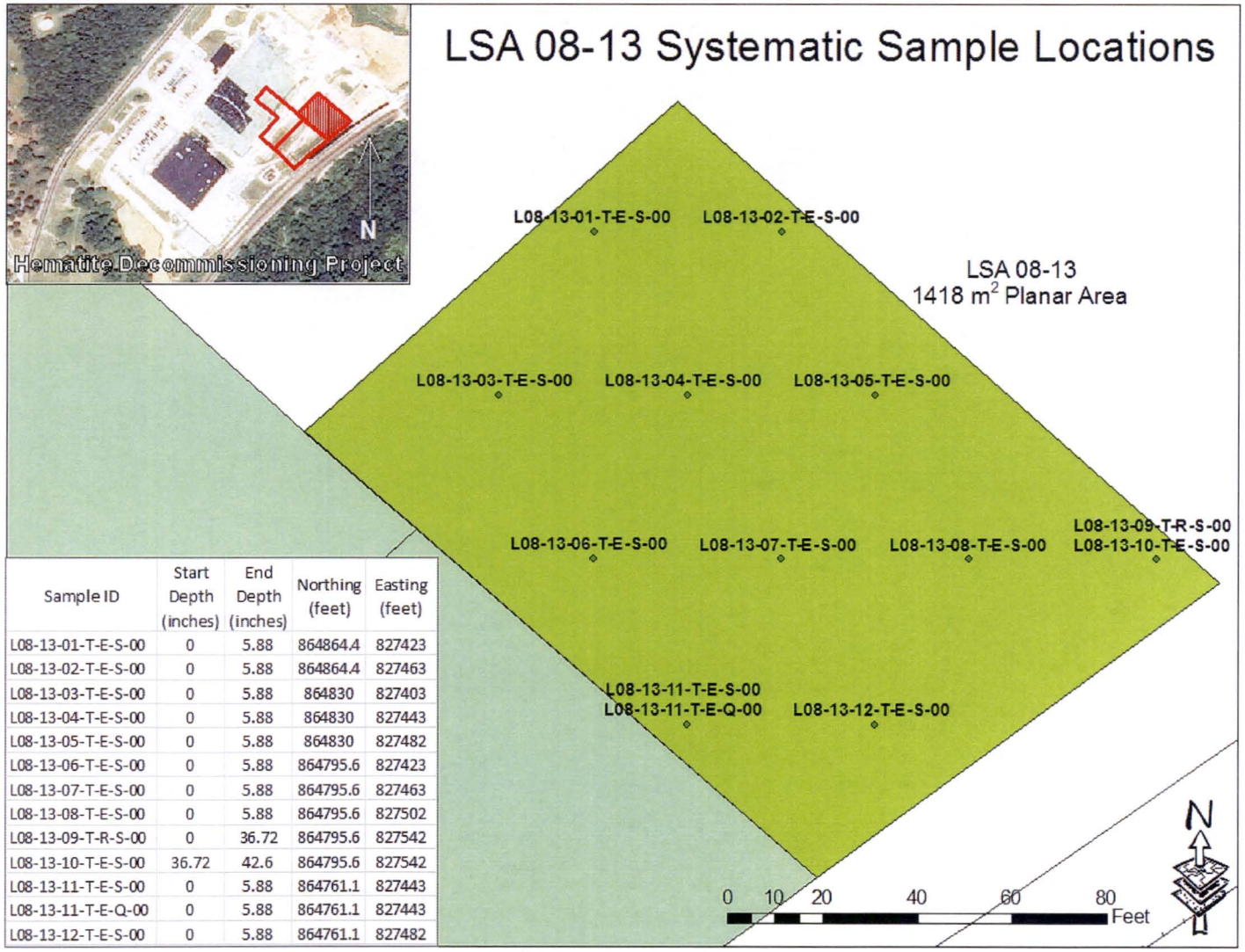
While there were eleven (11) systematic locations on the LSA 08-13 sampling grid, a total of thirteen(13) samples were collected and analyzed at these locations, including:

- Zero (0) samples collected and analyzed within the surface stratum
- One (1) samples collected and analyzed within the root stratum
- Eleven (11) samples analyzed within the excavation, or "deep" stratum
- One (1) QC field replicate

Figure 22-1 presents the map of the eleven systematic sample locations which were sampled within LSA 08-13. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 22-2 presents the map of the eleven systematic sample locations which were sampled within LSA 08-09 by the stratum.

Figure 22-1
LSA 08-13 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L08-13-01-T-E-S-00	0	5.88	864864.4	827423
L08-13-02-T-E-S-00	0	5.88	864864.4	827463
L08-13-03-T-E-S-00	0	5.88	864830	827403
L08-13-04-T-E-S-00	0	5.88	864830	827443
L08-13-05-T-E-S-00	0	5.88	864830	827482
L08-13-06-T-E-S-00	0	5.88	864795.6	827423
L08-13-07-T-E-S-00	0	5.88	864795.6	827463
L08-13-08-T-E-S-00	0	5.88	864795.6	827502
L08-13-09-T-R-S-00	0	36.72	864795.6	827542
L08-13-10-T-E-S-00	36.72	42.6	864795.6	827542
L08-13-11-T-E-S-00	0	5.88	864761.1	827443
L08-13-11-T-E-Q-00	0	5.88	864761.1	827443
L08-13-12-T-E-S-00	0	5.88	864761.1	827482

Figure 22-2
LSA 08-13 Systematic Soil Sample Locations by Stratum

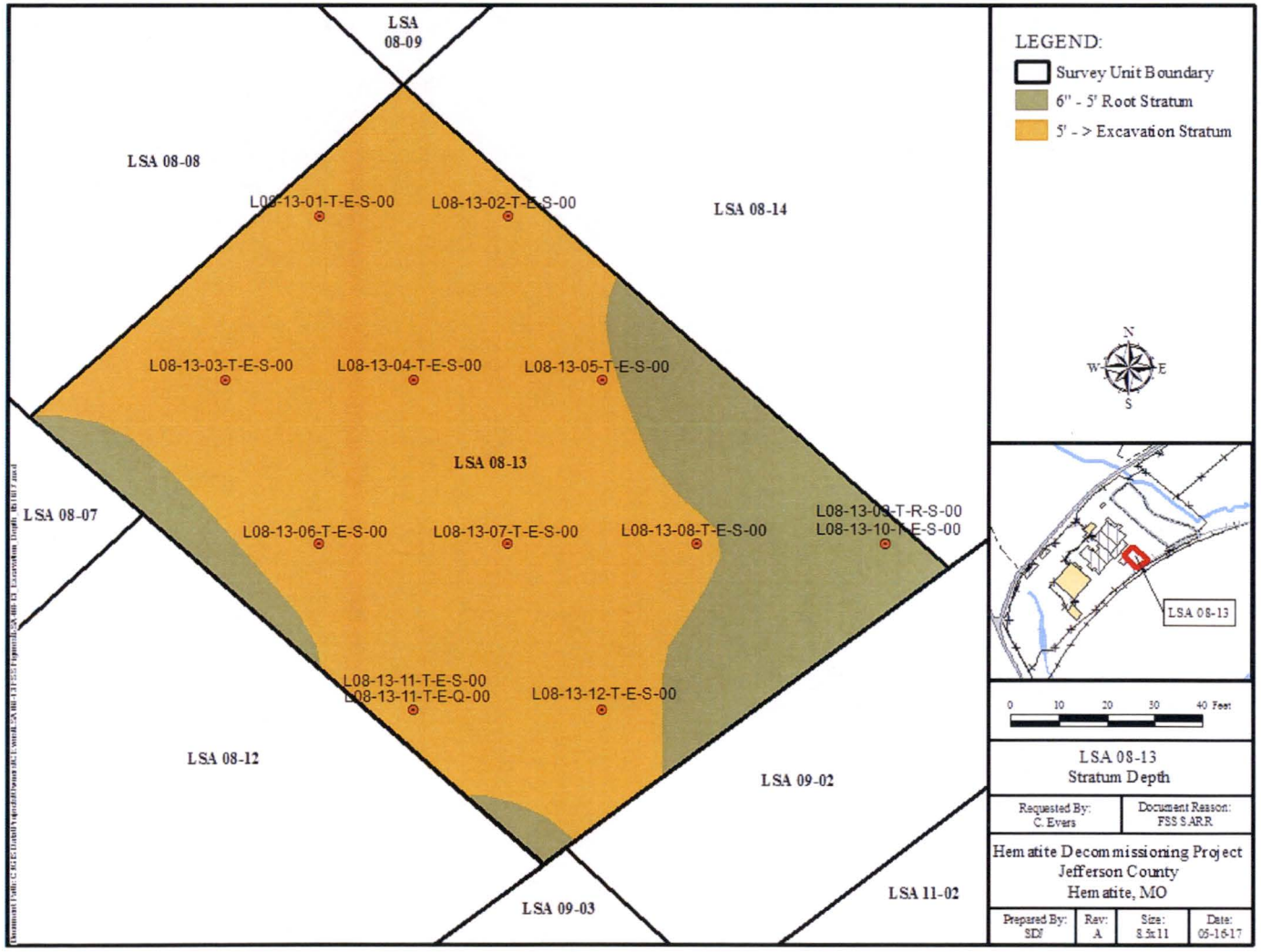


Table 22-2 below presents a tabular listing of all FSS samples collected within LSA 08-13 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 22-2
FSS Sample Locations and Coordinates for LSA 08-13

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
		Revision: 10	Appendix P-4 Page 1 of 1

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area:	LSA 08	**Description:**	Technetium SEA Open Land Area
Survey Unit:	13	**Description:**	Central Open Land Area
Survey Type:	FSS	**Classification:**	Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation	End Elevation	Northing (Y Axis) *	Easting (X Axis) *	Remarks / Notes
L08-13-01-T-E-S-00	Deep	S	428.1	427.6	864864	827423	Excavation 6-inch grab
L08-13-02-T-E-S-00	Deep	S	429.3	428.8	864864	827463	Excavation 6-inch grab
L08-13-03-T-E-S-00	Deep	S	427.2	426.7	864830	827403	Excavation 6-inch grab
L08-13-04-T-E-S-00	Deep	S	427.1	426.6	864830	827443	Excavation 6-inch grab
L08-13-05-T-E-S-00	Deep	S	430.8	430.3	864830	827482	Excavation 6-inch grab
L08-13-06-T-E-S-00	Deep	S	427.7	427.2	864796	827423	Excavation 6-inch grab
L08-13-07-T-E-S-00	Deep	S	427.5	427.1	864796	827463	Excavation 6-inch grab
L08-13-08-T-E-S-00	Deep	S	429.3	428.8	864796	827502	Excavation 6-inch grab
L08-13-09-T-R-S-00	Root	S	433.2	430.1	864796	827542	Root 3.1-ft composite
L08-13-10-T-E-S-00	Deep	S	430.1	429.6	864796	827542	Excavation 6-inch grab
L08-13-11-T-E-S-00	Deep	S	425.9	425.4	864761	827443	Excavation 6-inch grab
L08-13-12-T-E-S-00	Deep	S	429.5	429.0	864761	827482	Excavation 6-inch grab
L08-13-11-T-E-Q-00	Deep	Q	425.9	425.4	864761	827443	Excavation 6-inch grab
L08-13-13-T-E-B-00	Deep	B	429.5	429.0	864753	827480	Sidewall Sample
L08-13-14-T-E-B-00	Deep	B	427.7	427.2	864792	827420	Bias 6-inch grab
L08-13-15-T-E-B-00	Deep	B	425.7	425.2	864744	827458	Bias 6-inch grab
L08-13-16-T-E-B-00	Deep	B	429.1	428.6	864785	827505	Bias 6-inch grab
L08-13-17-T-E-B-00	Deep	B	430.8	430.3	864831	827475	Bias 6-inch grab

Green shaded samples are the samples at each sample location, for use in WRS test.

*Elevations are in feet above mean sea level.
** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983] (Open Land Area) OR
Distance in feet from lower left corner of the surface (Structures); each surface has its own (X,Y) = (0,0); OR
For piping the distance from the beginning of the survey unit.
Surface: Floor = F; Wall = W; Ceiling = C; Roof = R
CSM: Three-Layer (Surface-Root-Deep) or Uniform
Type: Systematic = S, Biased = B; QC =Q; Investigation = I
Quality Record

22.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 08-13 four (4) biased sample locations were selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

22.4 Judgmental/Sidewall Sampling for Tc-99

Sidewall sampling was prescribed the FSS Plans developed for LSA 08-13 in accordance with the guidance provided in HDP-PR-FSS-701, *Final Status Survey Plan Development*. See FSSFR Volume 3, Chapter 1, Section 5.2, *Tc-99 Side Wall Sampling* for further discussion.

During FSS of LSA 08-13, one (1) sidewall sample was collected. See section 23.2.6, *Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 08-03* for further discussion.

22.5 Quality Control Soil Sampling

One QC field duplicate sample point was randomly selected and collected at systematic location L08-13-11 for LSA 08-13.

23.0 FINAL STATUS SURVEY RESULTS LSA 08-13

23.1 Gamma Walkover Survey

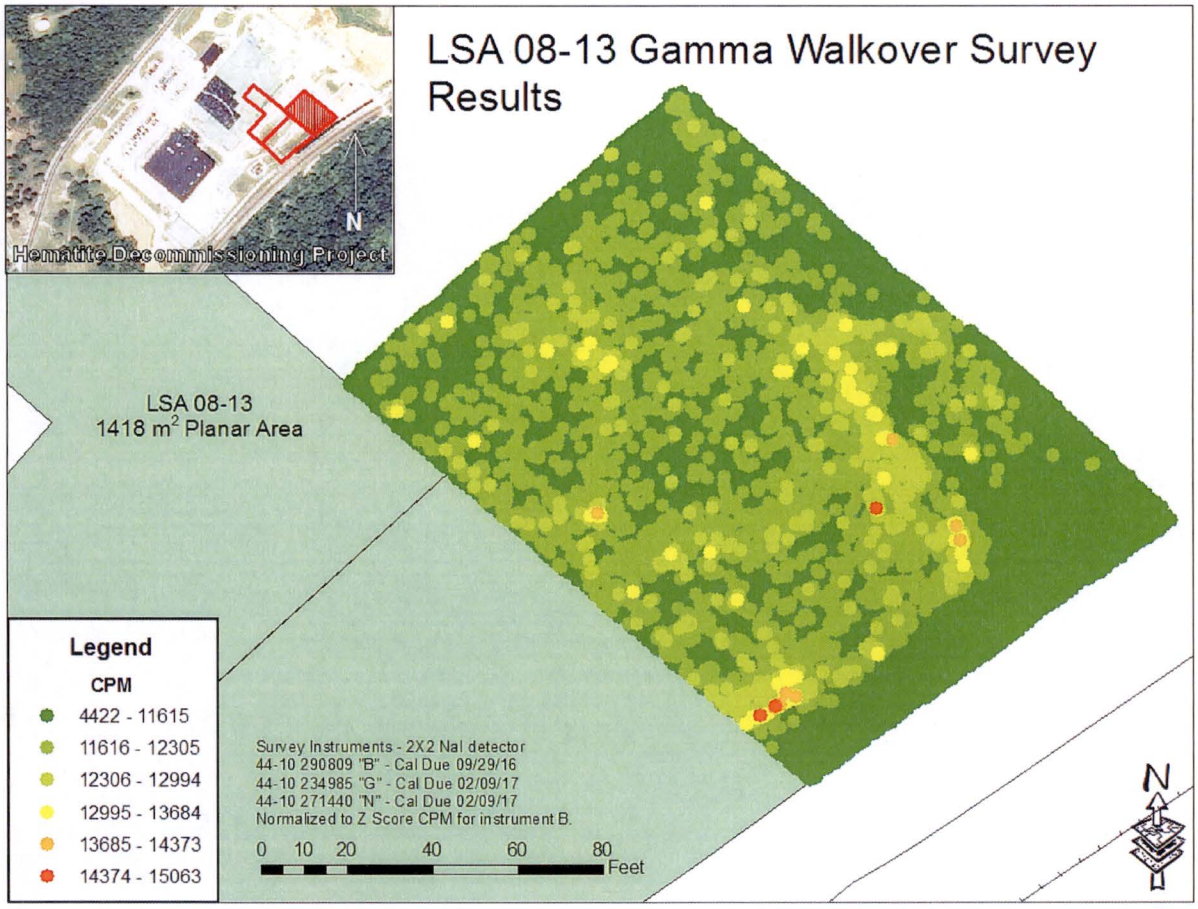
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are plotted "on top"(e.g. if any sidewalls featured more elevated readings than the floor directly below, the sidewall radiological measurements would overlie the lower floor readings).

GWS measurements were collected in LSA 08-13 between March 19, 2016, and March 28, 2016.

23.1.1 GWS Results for LSA 08-13

For LSA 08-13, GWS count rates ranged between 4,422 gcpm and 14,711 gcpm, with a mean count rate of 10,855 gcpm. The median count rate was also 10,855 gcpm with a standard deviation of 1,052 cpm. Figure 23-1 below presents a map of the complete GWS data set.

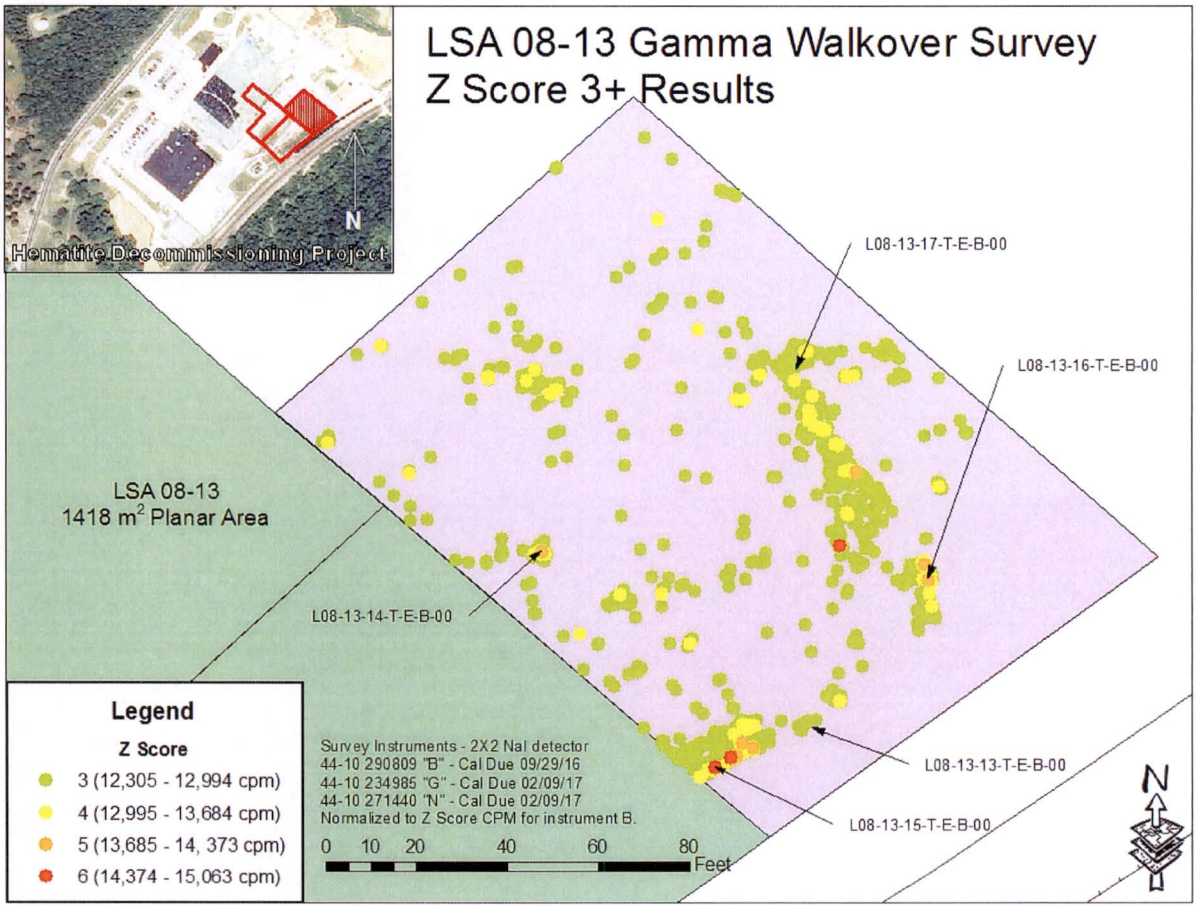
Figure 23-1
Colorimetric GWS Plot for LSA 08-13



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded both the IAL (> 4000 ncpm) and three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). Four locations were selected for biased sample collection. The sample collected at location L08-13-15 represented the maximum GWS measurement (14,711 gcpm) within the SU.

Figure 23-2 presents a map of the +3 Z-score GWS measurements within LSA 08-13, including the selected biased sampling locations.

Figure 23-2
Colorimetric GWS Plot for LSA 08-13 (Measurements > Z-score of 3)



All GWS data collected in LSA 08-13 was datalogged and post-processed in GIS software.

23.1.2 GWS Coverage Results LSA 08-13

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS.

The post survey processing of the GPS data indicated that although 100% of accessible areas underwent GWS the GWS covered 99.88% of the SU (see Table 23-1). As the evaluation indicates that the GPS coverage exceeded 95% with no readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of any apparent GPS coverage gaps, the GWS coverage for the SU has been evaluated to meet the intent of the "100% GWS coverage" requirement.

Table 23-1
GWS Gap Analysis LSA 08-13

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 08-13	276,815	330	0.12	99.88	1

23.2 Soil Sample Results LSA 08-13

Appendix C presents the analytical results and associated statistics for all FSS samples collected within LSA 08-13.

23.2.1 Surface Soil Sample Results LSA 08-13

There were eleven (11) systematic samples, one (1) QC sample, four (4) biased samples, and one (1) sidewall samples collected from the exposed excavation surface of LSA 08-13. The maximum SOF result for the surface samples was 0.58 root stratum SOF.

23.2.2 Subsurface Soil Sample Results LSA 08-13

There was one systematic location within LSA 08-13 where the remaining root stratum interval was composite sampled. At this location, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected. The result of the subsurface sample L08-13-10 collected in LSA 08-13 was 0.08 excavation SOF.

23.2.3 WRS Test Evaluation LSA 08-13

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was required for LSA 08-13 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was greater than one using the Uniform Stratum criteria. All systematically collected samples regardless of depth are used to perform the WRS Test, however biased and QC sample results are not utilized in the WRS Test. The 12 systematically collected samples in LSA 08-13 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (893) was greater than the critical value (783) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix C.

23.2.4 Graphical Data Review LSA 08-13

Table 23-2 below presents summary results for the all systematically collected samples (includes surface, and root, but not biased or QC samples) collected within LSA 08-13, and the associated SOF when compared to the excavation stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.21.

Table 23-2
LSA 08-13 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Excavation DCGL)
Average	0.086	10.588	0.087	3.571	0.193	1.335	**0.21**
Minimum	0.00 (<BKG)	1.330	0.00 (<BKG)	0.727	0.035	0.823	0.06
Maximum	0.370	27.600	0.330	10.965	0.604	2.780	0.58

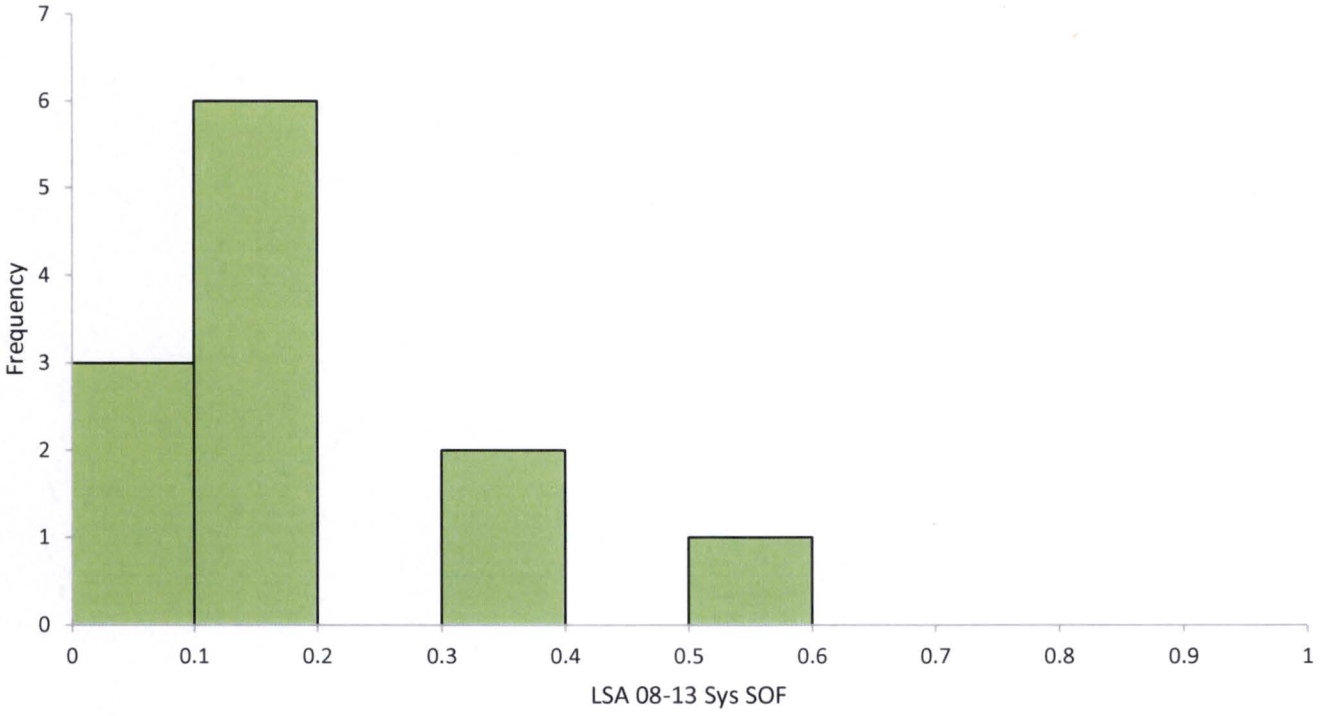
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide concentrations.
3. U-234 values are inferred from the U-235/U-238 ratio.

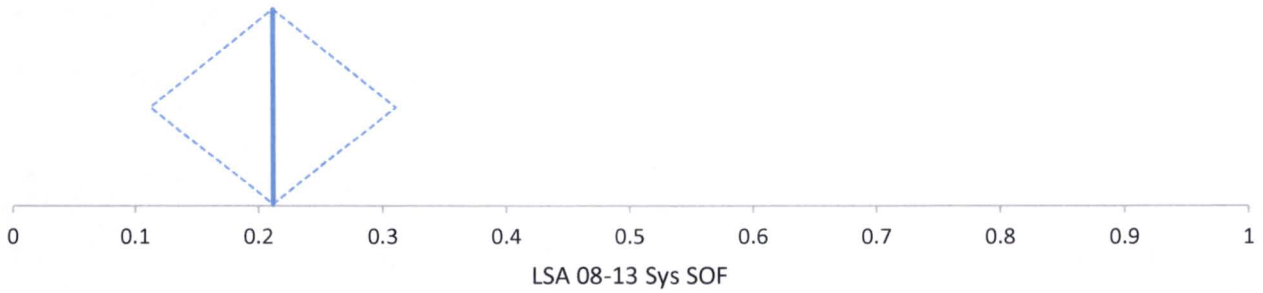
Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within a certain range of values. The frequency plot will reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution for the SU. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 23-3 presents the overall statistical metrics for the SOF parameter for the 12 systematically collected samples from LSA 08-13. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 08-13. The middle graph presents the mean SOF (0.21) as indicated by the blue vertical line of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.11 to 0.31. The 96.14% confidence interval based on the median (0.16) of the sample results is 0.09 to 0.39. The bottom two charts present the various statistical metrics of the LSA 08-13 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 23-3 exhibits no unusual symmetry or bimodality concerns for the LSA 08-13 data associated with the systematically collected measurement locations.

Figure 23-3
Graphic Statistical Summary for LSA 08-13 (SOF parameter)





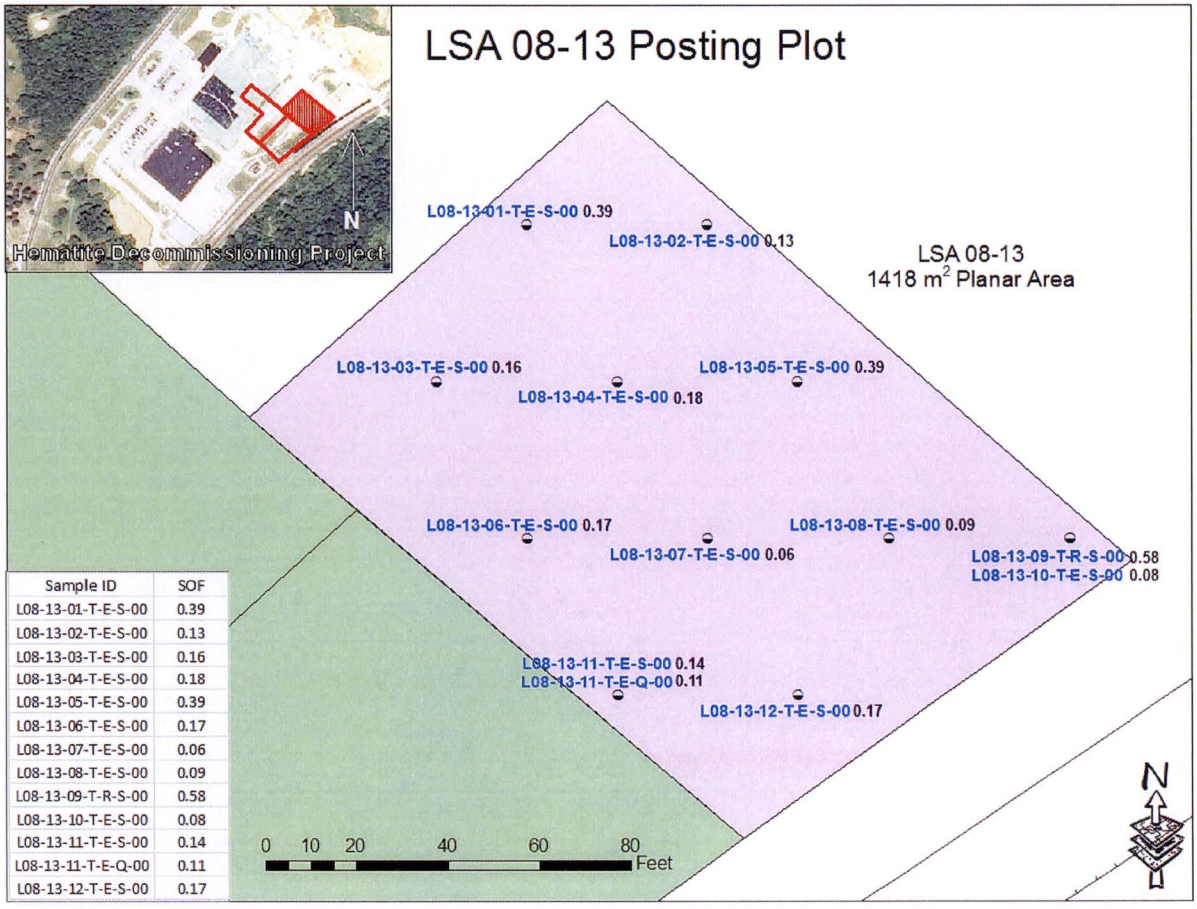
N	12

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 08-13 Sys SOF	0.21	0.11	to 0.31	0.045	0.16	0.02	1.5	1.45

	Minimum	1st quartile	Median	96.14% CI		3rd quartile	Maximum	IQR
LSA 08-13 Sys SOF	0.06	0.11	0.16	0.09	to 0.39	0.30	0.6	0.19

A posting plot is simply a map of the SU with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 08-13 is presented below in Figure 23-4. Figure 23-4 shows no unusual patterns in the data.

Figure 23-4
Posting Plot for LSA 08-13 Systematic Measurement Locations



Sample ID	SOF
L08-13-01-T-E-S-00	0.39
L08-13-02-T-E-S-00	0.13
L08-13-03-T-E-S-00	0.16
L08-13-04-T-E-S-00	0.18
L08-13-05-T-E-S-00	0.39
L08-13-06-T-E-S-00	0.17
L08-13-07-T-E-S-00	0.06
L08-13-08-T-E-S-00	0.09
L08-13-09-T-R-S-00	0.58
L08-13-10-T-E-S-00	0.08
L08-13-11-T-E-S-00	0.14
L08-13-11-T-E-Q-00	0.11
L08-13-12-T-E-S-00	0.17

Appendix C to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 23-2, Figure 23-3, and Figure 23-4 above. A summary of the analytical data is presented in Table 23-3 below. Appendix I to this report presents the Test America Analytical Laboratory soil sample reports.

Table 23-3
Final Status Survey Analytical Data: LSA 08-13

Sample ID	Sample Start Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF
L08-13-01-T-E-S-00	7.30	S	1.170	0.159	0.061	N/A	0.100	0.100	26.200	26.200	3.500	0.235	N/A	1.040	0.155	0.120	N/A	0.040	0.040	1.902	NA	NA	NA	0.098	0.143	0.195	U	1.280	0.728	0.914	N/A	1.2	0.39
L08-13-02-T-E-S-00	6.10	S	1.120	0.167	0.073	N/A	0.050	0.050	7.420	7.420	0.852	0.206	N/A	1.080	0.184	0.133	N/A	0.080	0.080	2.289	NA	NA	NA	0.120	0.164	0.260	U	1.370	0.525	0.782	N/A	1.4	0.13
L08-13-03-T-E-S-00	8.10	S	1.160	0.158	0.066	N/A	0.090	0.090	9.910	9.910	1.200	0.227	N/A	0.938	0.157	0.128	N/A	-0.062	0.000	2.479	NA	NA	NA	0.130	0.152	0.259	U	1.460	0.579	0.877	N/A	1.4	0.16
L08-13-04-T-E-S-00	7.60	S	1.160	0.167	0.070	N/A	0.090	0.090	11.100	11.100	1.150	0.251	N/A	1.060	0.157	0.105	N/A	0.060	0.060	1.783	NA	NA	NA	0.088	0.122	0.251	U	1.540	0.724	0.907	N/A	0.9	0.18
L08-13-05-T-E-S-00	5.00	S	0.966	0.136	0.062	N/A	-0.104	0.000	27.600	27.600	2.680	0.228	N/A	0.935	0.142	0.081	N/A	-0.065	0.000	10.965	NA	NA	NA	0.604	0.141	0.177	N/A	2.780	0.579	0.719	N/A	3.3	0.39
L08-13-06-T-E-S-00	6.70	S	1.180	0.176	0.060	N/A	0.110	0.110	5.790	5.790	0.955	0.241	N/A	1.330	0.231	0.137	N/A	0.330	0.330	2.172	NA	NA	NA	0.113	0.155	0.289	U	1.350	0.647	1.000	N/A	1.3	0.17
L08-13-07-T-E-S-00	6.70	S	1.190	0.160	0.059	N/A	0.120	0.120	1.330	1.330	0.363	0.237	N/A	1.100	0.161	0.097	N/A	0.100	0.100	2.051	NA	NA	NA	0.111	0.138	0.251	U	0.823	0.303	0.864	U	2.1	0.06
L08-13-08-T-E-S-00	5.00	S	0.536	0.117	0.141	N/A	-0.534	0.000	6.680	6.680	0.617	0.227	N/A	1.010	0.176	0.101	N/A	0.010	0.010	0.727	NA	NA	NA	0.035	0.081	0.210	U	0.865	0.289	0.736	N/A	0.7	0.09
L08-13-09-T-R-S-00	1.90	S	1.080	0.151	0.067	N/A	0.010	0.010	15.500	15.500	1.530	0.223	N/A	1.030	0.192	0.122	N/A	0.030	0.030	6.924	NA	NA	NA	0.382	0.140	0.174	N/A	1.100	0.325	0.877	N/A	5.2	0.58
L08-13-10-T-E-S-00	5.00	S	1.080	0.150	0.064	N/A	0.010	0.010	3.660	3.660	0.446	0.235	N/A	1.120	0.184	0.097	N/A	0.120	0.120	2.857	NA	NA	NA	0.155	0.143	0.181	U	1.080	0.603	0.795	N/A	2.2	0.08
L08-13-11-T-E-S-00	5.00	S	1.440	0.207	0.079	N/A	0.370	0.370	1.870	1.870	0.263	0.241	N/A	1.190	0.207	0.163	N/A	0.190	0.190	5.580	NA	NA	NA	0.308	0.211	0.253	N/A	1.220	0.412	1.000	N/A	3.8	0.14
L08-13-12-T-E-S-00	5.00	S	1.150	0.164	0.069	N/A	0.080	0.080	10.000	10.000	1.070	0.234	N/A	1.080	0.167	0.106	N/A	0.080	0.080	3.126	NA	NA	NA	0.170	0.112	0.166	N/A	1.150	0.551	0.852	N/A	2.3	0.17
L08-13-11-T-E-Q-00	5.00	Q	1.240	0.168	0.069	N/A	0.170	0.170	1.250	1.250	0.125	0.236	N/A	1.270	0.202	0.119	N/A	0.270	0.270	3.188	NA	NA	NA	0.175	0.143	0.232	U	0.928	0.300	0.832	N/A	2.9	0.11
L08-13-13-T-E-B-00	5.60	B	1.130	0.155	0.059	N/A	0.060	0.060	1.430	1.430	0.151	0.235	N/A	1.300	0.186	0.077	N/A	0.300	0.300	2.938	NA	NA	NA	0.159	0.150	0.244	U	1.160	0.558	0.871	N/A	2.1	0.09
L08-13-14-T-E-B-00	7.40	B	1.190	0.162	0.061	N/A	0.120	0.120	3.480	3.480	0.326	0.239	N/A	1.100	0.169	0.113	N/A	0.100	0.100	49.229	NA	NA	NA	2.500	0.345	0.235	N/A	1.810	0.571	0.830	N/A	17.7	0.16
L08-13-15-T-E-B-00	9.40	B	1.180	0.176	0.074	N/A	0.110	0.110	6.230	6.230	0.728	0.236	N/A	1.150	0.199	0.156	N/A	0.150	0.150	6.519	NA	NA	NA	0.360	0.226	0.263	N/A	1.160	0.385	0.973	N/A	4.7	0.14
L08-13-16-T-E-B-00	6.00	B	1.270	0.181	0.074	N/A	0.200	0.200	8.110	8.110	0.767	0.254	N/A	1.050	0.169	0.131	N/A	0.050	0.050	4.400	NA	NA	NA	0.243	0.124	0.180	N/A	0.915	0.334	0.946	U	4.0	0.16
L08-13-17-T-E-B-00	5.30	B	1.260	0.170	0.073	N/A	0.190	0.190	24.900	24.900	2.360	0.237	N/A	1.270	0.187	0.097	N/A	0.270	0.270	1.050	NA	NA	NA	-0.062	0.143	0.239	U	1.050	0.474	0.733	N/A	0.7	0.43
Systematic Minimum			0.000						1.330					0.000						0.727				0.035				0.823				3.2	0.06
Systematic Maximum			0.370						27.600					0.330						10.965				0.604				2.780				Average Enrichment (%)	0.58
Systematic Mean			0.086						10.588					0.087						3.571				0.193				1.335					0.21
Systematic Median			0.085						8.665					0.070						2.384				0.125				1.250					0.16
Systematic Standard Deviation			0.100						8.615					0.095						2.890				0.162				0.505					0.16
Step 8.4.2			With ingrowth, use Ra226 bkg = 1.07											Th232 bkg = 1.0																			

NOTES:

Gross results in units of pCi/g

* Background with ingrowth (1.07 pCi/g) subtracted from gross result

**Background (1.0 pCi/g) subtracted from gross result

U qualifier: A normal, non-detected result (result less than MDC).

All uncertainty values are reported at the 2-sigma confidence level.

23.2.5 Biased Soil Sample Result LSA 08-13

Four (4) biased sample were collected from LSA 08-13. The sample collected at location L08-13-15 represented the maximum GWS measurement (14,711 gcpm) within the SU, and had a result of 0.14 excavation stratum SOF.

23.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 08-13

One sample was collected from the sidewalls of LSA 08-13. Table 23-4 provides the data summary for the samples.

Table 23-4
LSA 08-13 Sidewall Sample Data Summary and Calculated SOF Values

Sample ID	Ra-226 DCGL = 5.4 BKG = 0.9 (pCi/g)	Tc-99 DCGL = 74.0 (pCi/g)	Th-232 DCGL = 5.2 BKG = 1.0 (pCi/g)	U-234 DCGL=872.4 (pCi/g)	U-235 DCGL=208.1 (pCi/g)	U-238 DCGL=551.1 (pCi/g)	Sample SOF (Uniform DCGL)
L08-13-13-T-R-B-00	1.13	1.43	1.30	2.938	0.159	1.16	0.25

23.2.7 Quality Control Soil Sample Result LSA 08-13

One QC field duplicate sample point was randomly selected for LSA 08-13 which was collected at systematic location L08-13-11.

For the 17 samples (i.e., 12 systematic + 4 biased + 1 sidewalls) collected within LSA 08-13, one field duplicate sample was collected. This frequency equates to 5.9%, (i.e. 1/17). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated warning limits (see Figure 23-5 below).

Figure 23-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 08-13

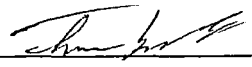
Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control	Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

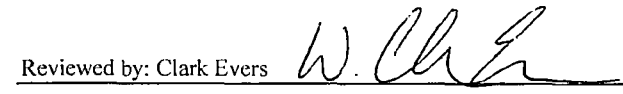
Survey Unit No.: LSA 08-13 — Survey Unit Description: Central Open Land Area

Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{x}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L08-13-11-T-E-S-00	L08-13-11-T-E-Q-00	Ra-226	1.440	0.0788	1.240	0.069	1.340	5.4	0.200	0.764	1.145	N
L08-13-11-T-E-S-00	L08-13-11-T-E-Q-00	Tc-99	1.87	0.241	1.250	0.236	1.560	74	0.620	10.471	15.688	N
L08-13-11-T-E-S-00	L08-13-11-T-E-Q-00	Th-232	1.190	0.163	1.270	0.119	1.230	5.2	0.080	0.736	1.102	N
L08-13-11-T-E-S-00	L08-13-11-T-E-Q-00	U-234[1]	5.580	N/A	3.188	N/A	4.384	872.4	2.392	123.445	184.949	N
L08-13-11-T-E-S-00	L08-13-11-T-E-Q-00	U-235	0.308	0.253	0.175	0.232	0.242	208.1	NA	29.446	44.117	NA
L08-13-11-T-E-S-00	L08-13-11-T-E-Q-00	U-238	1.22	0.832	0.928	0.832	1.074	551.1	0.292	77.981	116.833	N

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy 

Date: 5-31-17

Reviewed by: Clark Evers 

Date: 5/31/17

Quality Record

23.3 Tc-99 Hot Spot Assessment LSA 08-13

As noted previously, due to the presence of elevated Tc-99 residual activity identified during FSS systematic and biased soil sampling, the Three Layer DCGL approach was used to assess LSA 08-13.

Given that the FSS systematic soil sample result of 27.6 pCi/g of Tc-99 is the highest Tc-99 soil sample that has been identified within the SU, and given the overall low concentrations of Tc-99 that were encountered in the remainder of LSA 08-13, there is no concern for potential Tc-99 hot spots to remain within the SU that exceed the appropriate $DCGL_{EMC}$ (30.1 pCi/g root stratum, 74.1 pCi/g excavation stratum). And therefore the Tc-99 hot spot assessment is considered successful.

24.0 ALARA EVALUATION LSA 08-13

All samples collected within LSA 08-13 were evaluated against the appropriate root or excavation stratum $DCGL_W$. For LSA 08-13 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.21 for LSA 08-13. The Weighted Average SOF considering contributions from the remaining portion of the root stratum, and the excavation stratum is 0.23 SOF. The weighted average SOF equates to residual activity contributions from the SU area of 5.75 mrem/year for LSA 08-13. Groundwater monitoring well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, and Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356} indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 08-13. Summing the dose contributions together, the total estimated dose for LSA 08-13 is 9.75 mrem/year.

As the estimated TEDE is below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the FSS of LSA 08-13 was successful and that there would be no discernable benefit to the health and safety of the public in attempting to further reduce the results of FSS by performing additional remediation of LSA 08-13.

25.0 FSS PLAN DEVIATIONS LSA 08-13

25.1 Remedial Actions during FSS

During the performance of the FSS GWS survey, a small area of elevated count rate was identified within the SU. Further investigation identified that the source of the elevated count rate was a fuel pellet. Additional investigations were performed in the area and no other sources of elevated count rate, or items of discrete radioactivity were identified. This fuel pellet is determined to have originated from the Waste Handling Area operations that were conducted in part of LSA 08-13. Once the pellet was removed from the area, and the area was resurveyed, biased sample L08-13-17 was collected at this location.

25.2 Adjustments to Scan MDC Calculations

Scan MDCs for LSA 08-13 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. The assumed LSA background count rate of 10,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 10,855 cpm. Therefore the calculated Scan MDCs are appropriate, and no adjustments need to be made.

26.0 DATA QUALITY ASSESSMENT

The DQO process is thoroughly integrated within the DP and Hematite FSS procedures. The steps of the DQO process are presented in Volume 3, Chapter 1, Section 4.0 of the FSSFR and correspond to the DQO steps described in Chapter 14, Section 4.2.1 of the DP. The HDP DQO process reflects the recommendations given in MARSSIM, Chapter 2, Figure 2-2.

26.1 Data Quality Assessment for LSA 08-13

The Data Quality Assessment of the survey methodology, sampling and sample analysis results, and the Quality Control sampling and analysis results to ascertain the validity of the conclusion for LSA 08-13 (see Figure 26-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 08-13 survey and sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721 *Final Status Survey Data Validation*.
- The WRS Test is necessary when the difference between the maximum SU data set measurement SOF and the minimum background area measurement SOF is greater than one. For LSA 08-13, 6 individual gross SOF result(s) in the FSS data

set exceeded the SOF of the minimum background reference area measurement by more than one using the Uniform Stratum criteria. Therefore, the WRS Test was required for LSA 08-13. Since the test statistic, WR (893) exceeded the critical value (783), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS evaluation worksheet is presented in Appendix C.

- A biased soil sample was collected from the location of the highest gamma count rate within the SU, with a maximum result of 0.14 excavation SOF.
- The maximum SOF result for all surface samples within LSA 08-13 was 0.58 root SOF. The average SOF result for all systematically collected samples within LSA 08-13 was 0.21, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.31. The weighted average SOF was 0.23 SOF.
- No FSS sample result in LSA 08-13 exceeded a SOF of 1.0 as compared to the excavation stratum DCGL criteria, therefore an EMC or supplemental investigation was not required.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number of systematic sample location actually collected (11) within LSA 08-13. The successful result of the retrospective power evaluation presented in Table 26-1 for LSA 08-13 indicates that the minimum number of sample locations required (8) for the WRS Test was less than the number of sampling locations actually collected within LSA 08-13. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight LSA surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.
- HDP staff ensured that a visual inspection of the SU configuration, the Isolation & Control measures and the Pre-backfill GWS was completed for LSA 08-13 prior to the commencement of backfill operations. Additionally a confirmatory GWS was performed of the SU within 72 hours prior to the commencement of backfill operations. The results of the confirmatory GWS were compared to the results of the FSS GWS and the comparison determined that there were no changes within the LSA since FSS was performed.

Table 26-1
Retrospective Sample Size Verification for LSA 08-13

DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.16
$DCGL_{SOF}$	1
LBGR (Mean)	0.23
Shift	0.77
Relative Shift (Δ/σ)	4.93
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS N/2	11
Verification Check	**SUFFICIENT MEASUREMENTS**
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test	

MARSSIM Table 5.1

Δ/σ	P_r
0.1	0.528182
0.2	0.556223
0.3	0.583985
0.4	0.611335
0.5	0.638143
0.6	0.664290
0.7	0.689665
0.8	0.714167
0.9	0.737710
1.0	0.760217
1.1	0.781627
1.2	0.801892
1.3	0.820978
1.4	0.838864
1.5	0.855541
1.6	0.871014
1.7	0.885299
1.8	0.898420
1.9	0.910413
2.0	0.921319
2.25	0.944167
2.5	0.961428
2.75	0.974067
3.0	0.983039
3.5	0.993329
4.0	0.997658
4.01	1.000000

MARSSIM Table 5.2, α = 0.05, β = 0.10

α (or β)	$Z_{1-\alpha}$ (or $Z_{1-\beta}$)	
0.005	2.576	
0.01	2.326	
0.015	2.241	
0.025	1.960	
0.05	1.645	α
0.10	1.282	β
0.15	1.036	
0.2	0.842	
0.25	0.674	
0.30	0.524	

Figure 26-1
Data Evaluation Checklists prepared for LSA 08-13 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
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APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 08 **Description:** Central Open Land Area
Survey Unit: 13 **Description:** Technetium SEA Open Land Area

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FSS been individually reviewed and validated in accordance with Section 8.1 of this procedure?	Yes ☒	No ☐	
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
3.	Have all scans surveys been performed of the areas specified as required in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
4.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FSSP & the FSS Sample Instructions?	Yes ☒	No ☐	NA ☐
5.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☒	No ☐	NA ☐
6.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the appropriate investigation level?	Yes ☒	No ☐	
7.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use and were those calibrations performed using a NIST traceable source?	Yes ☒	No ☐	
8.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☒	No ☐	
9.	Do the samples match those identified on the chain of custody?	Yes ☒	No ☐	NA ☐
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒	No ☐	NA ☐
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	NA ☐

If "No" was the response to any of the questions above, then document the discrepancy as well as any corrective actions that were taken to resolve the discrepancy.

Comments: N/A

Quality Record

Figure 26-1
Data Evaluation Checklists prepared for LSA 08-13 (page 2 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
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APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: No. LSA 08 **Description:** Central Open Land Area
Survey Unit: No. 13 Description: Technetium SEA Open Land Area

Discrepancy: None

Corrective Actions Taken: None

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐ NA ☒
    a. If "No", then forward this form to the RSO.
12. The following questions will be answered by the RSO.
    a. If the answer to question 11 was "No", then is the affected data still valid? Yes ☐ No ☐ NA ☒
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ NA ☒
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

Prepared by (HP Staff): Thomas Yardy (Print Name) (Signature) 5-31-17 (Date)
Approved by (RSO): Clark Evers (Print Name) (Signature) 5/31/17 (Date)

Quality Record

27.0 SURVEILLANCE FOLLOWING FSS

FSS activities in LSA 08-13 were completed in April 2016. Between the completion of FSS and the commencement of backfill operations there were no events that had a potential to re-contaminate LSA 08-13. The assessment that there were no events that had a potential to re-contaminate LSA 08-13 was confirmed by the Pre-backfill GWS that was completed for LSA 08-13 prior to the commencement of backfill operations.

28.0 CONCLUSION LSA 08-13

An adequate quantity and quality of radiological surveys and samples, as well as the corresponding laboratory analysis has been performed, evaluated and documented to demonstrate that the dose associated with all sources within of 9.75 mrem/year for SU LSA 08-13 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

It should be noted that in accordance with Volume 3, Chapter 1, Revision 3, Section 3.1.2 *Three Stratum DCGLs*, compliance with the "three layer" geometry requires consideration of the surface, root, and deep layers independently, because each of the three DCGLs (surface, root, excavation) represent 25 mrem/year from each layer independently. Therefore the Unity Rule must be applied when there is more than one layer present, however in the case of LSA 08-12, only a portion of the root stratum, and the deep stratum remained. Using the number of systematically collected samples (11) as the weighting factor, there was one root stratum samples collected (1/11), and eleven excavation stratum samples collected (11/11). The weighted average SOF is then determined by multiplying the weighting factor by the average SOF for each layer, and applying the Unity Rule, resulting in a weighted average SOF of 0.23 for LSA 08-13.

Table 28-1
LSA 08-13 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.23	N/A	0.16	N/A	N/A	**0.39**
DOSE	5.75 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**9.75 mrem/year**

29.0 REFERENCES

29.1 DO-08-004, Hematite Decommissioning Plan {ML092330123}.

29.2 DO-08-003, Radiological Characterization Report, July 2009 {ML092870496}

29.3 Westinghouse letter HEM-11-56, *"Evaluation of Technetium-99 Under the Process Buildings"*, dated May 5, 2011.

29.4 HDP-TBD-FSS-002, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*

30.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A: Analytical Data Evaluation Spreadsheets for LSA 08-09

APPENDIX B: Analytical Data Evaluation Spreadsheets for LSA 08-12

APPENDIX C: Analytical Data Evaluation Spreadsheets for LSA 08-13

APPENDIX D: FSS Plan Development for LSA 08-09

APPENDIX E: FSS Plan Development for LSA 08-12

APPENDIX F: FSS Plan Development for LSA 08-13

APPENDIX G: TestAmerica Laboratory Analytical Data Reports for LSA 08-09

APPENDIX H: TestAmerica Laboratory Analytical Data Reports for LSA 08-12

APPENDIX I: TestAmerica Laboratory Analytical Data Reports for LSA 08-13

APPENDIX J: Completed Field Logs

APPENDIX K: HDP-RPT-FSS-302, Summary Report of Investigation of Hybrid Wells and Former Process Buildings Investigation Area

Attachment 4

Final Status Survey Final Report Volume 3, Chapter 21, Revision 1

Revised Pages in Track Change for FSSFR Volume 3, Chapter 21, Revision 1

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Table 15-1
GWS Gap Analysis LSA 08-12

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 08-12	279,316	912	0.33	99.67	1

15.2 Soil Sample Results LSA 08-12

Appendix B presents the analytical results and associated statistics for all FSS samples collected within LSA 08-12.

15.2.1 Surface Soil Sample Results LSA 08-12

Within LSA 08-12 the surface stratum was completely removed. There were no samples collected within the surface stratum (0 – 15 cm) of LSA 08-12. There was a total of twenty-three (23) soil samples collected within the topmost soil layer of the excavation surface which consists of eleven (11) systematic samples, ten (10) biased samples, and two (2) QC field duplicate sample. The maximum SOF result of the remaining topmost layer sample was 1.63 root stratum SOF. An EMC was performed at this location; see Section 14.6 for more information

15.2.2 Subsurface Soil Sample Results LSA 08-12

There were six systematic locations within LSA 08-12 where the remaining root stratum interval was composite sampled. At these locations, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected as described above. The maximum result of the subsurface samples collected in LSA 08-09 was 0.15 excavation stratum SOF.

15.2.3 WRS Test Evaluation LSA 08-12

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was required for LSA 08-12 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was greater than one using the Uniform Stratum criteria. All systematically collected samples regardless of depth are used to perform the WRS Test, however biased and QC sample results are not utilized in the WRS Test. The 17 systematically collected samples in LSA 08-12 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (~~1036~~1068) was greater than the critical value (~~860~~879) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix B.

15.2.4 Graphical Data Review LSA 08-12

Table 15-2 below presents the summary results for the all systematically collected samples (includes root, and excavation, but not biased or QC samples) collected within LSA 08-12, and the associated SOF when compared to the appropriate Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.20.

FSS data set exceeded the SOF of the minimum background reference area measurement by more than one using the Uniform Stratum criteria. Therefore, the WRS Test was required for LSA 08-12. Since the test statistic, WR (~~1036~~1068) exceeded the critical value (~~860~~879), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS evaluation worksheet is presented in Appendix B.

- A biased soil sample was collected from the location of the highest gamma count rate within the SU, with a maximum result of 0.14 excavation stratum SOF.
- The maximum SOF result for all surface samples within LSA 08-12 was 1.63. The average SOF result for all systematically collected samples within LSA 08-12 was 0.20, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.25. The weighted average SOF for LSA 08-12 considering contributions from the remaining portions of the root stratum, and the excavation stratum, is 0.30.
- One biased soil sample exceeded a SOF of 1.0, therefore an EMC Investigation was performed. The successful result of the EMC Investigation showed that the area was suitable for release, and contributed an additional 0.05 SOF to the SU.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number of systematic samples actually collected (11) within LSA 08-12. The successful result of the retrospective power evaluation presented in Table 18-1 for LSA 08-12 indicates that the minimum number of samples required (8) for the WRS Test was less than the number of sampling locations actually collected within LSA 08-12. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight LSA surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.
- HDP staff ensured that a visual inspection of the SU configuration, the Isolation & Control measures and the Pre-backfill GWS was completed for LSA 08-12 prior to the commencement of backfill operations. Additionally a confirmatory GWS was performed of the SU within 72 hours prior to the commencement of backfill operations. The results of the confirmatory GWS were compared to the results of the FSS GWS and the comparison determined that there were no changes within the LSA since FSS was performed.