

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
	Westinghouse Non-Proprietary Class 3	Revision: 4	Appendix P-4, Page 1 of 1

APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area:	LSA 10	Description:	Burial Pits Open Land Area
Survey Unit:	04	Description:	East Central Survey Unit (North Burial Pit)
Survey Type:	FSS	Classification:	Class I

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L10-04-01-B-R-S-00	Uniform	S	422.6	422.5	865318.0	827508.5	Root 1-inch composite
L10-04-02-B-E-S-00	Uniform	S	422.5	422.0	865318.0	827508.5	Excavation 6-inch grab
L10-04-03-B-E-S-00	Uniform	S	423.9	423.4	865277.4	827485.1	Excavation 6-inch grab
L10-04-04-B-R-S-00	Uniform	S	423.2	422.9	865277.4	827532.0	Root 4-inch composite
L10-04-05-B-E-S-00	Uniform	S	422.9	422.4	865277.4	827532.0	Excavation 6-inch grab
L10-04-06-B-E-S-00	Uniform	S	423.1	422.6	865236.7	827414.7	Excavation 6-inch grab
L10-04-07-B-E-S-00	Uniform	S	425.1	424.6	865236.7	827461.6	Excavation 6-inch grab
L10-04-08-B-E-S-00	Uniform	S	423.1	422.6	865236.7	827508.5	Excavation 6-inch grab
L10-04-09-B-E-S-00	Uniform	S	421.5	421.0	865236.7	827555.5	Excavation 6-inch grab
L10-04-10-B-R-S-00	Uniform	S	427.4	427.3	865196.0	827438.2	Root 1-inch composite
L10-04-11-B-E-S-00	Uniform	S	427.3	426.8	865196.0	827438.2	Excavation 6-inch grab
L10-04-12-B-E-S-00	Uniform	S	426.0	425.5	865196.0	827485.1	Excavation 6-inch grab
L10-04-08-B-E-Q-00	Uniform	Q	423.1	422.6	865236.7	827508.5	Excavation 6-inch grab
L10-04-13-B-E-B-00	Uniform	B	423.6	423.1	865233.2	827402.5	Excavation 6-inch grab
L10-04-14-B-E-B-00	Uniform	B	427.3	426.8	865192.4	827440.8	Excavation 6-inch grab
L10-04-15-B-E-B-00	Uniform	B	423.4	422.9	865263.8	827442.4	Excavation 6-inch grab
L10-04-16-B-E-B-00	Uniform	B	420.4	419.9	865304.6	827471.1	Excavation 6-inch grab

*Elevations are in feet above mean sea level.

** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983]

Surface: Floor = F; Wall = W; Ceiling = C; Roof = R

CSM: Three-Layer (Surface-Root-Excavation) or Uniform Stratum DCGLs used

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

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

Quality Record

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Preliminary Data Review and Calculation of the Sum-of-Fractions (SOF)

Use corrected net results for all DE calcs.

DCLG_W Measure Tc-99, All SEAs

	Uniform
U-234	195.4
U-235	51.6
U-238	168.6
Tc-99	25.1
Th-232	2.0
Re-226	1.9

weighted SOF_{WEAK} 0.14

	SS	RS	ES
fractions	0	0.25	0.75

SOF_{WEAK} Re-use Backfill Material

0 Offsite backfill

SOF_{WEAK} Groundwater

0.16

EMC Investigation SOF

0.141474833

SOF_{TOT} (<=1)

SOF_{WEAK SU} 0.64 PASS

Calculate the dose contribution for the SU by multiplying SOF_{WEAK SU} (including contribution from Re-use backfill and Groundwater) by 25 mrem.

11 mrem

Infer U234			
U-238/U235	U-234/U235	U-234	%
9.4	16.7	1.9	1.7
9.0	16.7	2.3	1.7
5.1	16.2	5.1	3.0
3.6	13.7	2.6	1.9
4.0	18.1	4.2	3.8
4.8	18.2	6.0	3.2
163.3	46.3	0.3	0.1
8.8	19.7	2.8	1.8
8.2	18.6	3.1	1.9
10.4	18.9	5.8	1.5
17.4	20.2	3.7	0.9
6.0	19.3	3.1	2.6
6.9	18.4	3.0	2.3
4.4	18.1	101.0	3.5
36.6	22.7	26.4	0.5
9.7	19.8	1.6	1.6
6.1	18.3	6.2	2.5
Average Enrichment (%)			2.00

using U-235
MDC * ratio of U-234/U-235 @ that sample's enrichment

5.323883954
3.636727631
3.621228373
3.639714822
4.728161369
4.014608893
14.45028814
4.348992552
4.425462553
5.11553937
6.755540914
5.01030423
3.548666526
6.437337826
6.932760984
3.22147092
4.194255118

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Investigations

Elevated Measurement Comparison

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																								SOF											
			Ra-226						Tc-99					Th-232				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						
L10-04-13-B-E-B-00	0	B	1.44	0.20	0.08	NA	0.37	0.37	-0.04	0.00	0.04	0.24	U	1.34	0.24	0.13	NA	0.34	0.34	101.01	NA	NA	NA	5.57	0.66	0.36	NA	24.40	3.01	1.63	NA	1.13						
			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.

	L10-04-13	Step 1	Step 2	L10-04-13	Step 3
	DCGL _{EMC}	"clean" systematic samples δ_i	L10-04-13 τ_i	t_{-5}	L10-04-13
	Ra-226	11.59	0.064	0.306	f_{elev}
	Tc-99	860.93	1.121	-1.121	0.026
	Th-232	8.4	0.070	0.270	-0.001
	U-234	3829.8	3.400	101.01	0.032
	U-235	170.28	0.182	5.57	0.025
	U-238	844	1.513	24.40	0.032
				22.887	<u>0.027</u>
					Step 4 $f_{EMC} = 0.141$
					Step 5 Summed elevated radioactivity fractions for the SU = 0.141 = $f_{EMC,TOT}$
					Step 6 Total SOF for the SU = 0.445 PASS Step 7
					weighted SOF _{MEAN} 0.14
					SOF _{MEAN} Re-use Backfill Material (stockpile 5&6) 0
					SOF _{MEAN} Groundwater 0.16

**HDP-PR-FSS-721 Final Status Survey Data Evaluation
Investigations**

Bounding sample = L10-04-06-B-E-S-00

Bounded by the SU boundary.

Need area from GIS. 30 m²

DCLG_W, Uniform, Measure Tc-99, All SEAs

	Uniform
U-234	195.4
U-235	51.6
U-238	168.8
Tc-99	25.1
Th-232	2.0
Ra-226	1.9

Uniform Stratum

Radionuclide	Elevated Measurement Area (m ²)									
	153,375	10,000	3,000	1,000	300	100	30	10	3	1
U-234	1.0	1.2	1.3	1.3	4.0	9.3	19.6	34.3	70.5	132.8
U-235	1.0	1.1	1.1	1.1	1.9	2.5	3.3	4.7	9.6	20.5
U-238	1.0	1.1	1.3	1.3	2.5	3.6	5.0	7.2	14.9	31.6
Tc-99	1.0	1.0	1.0	1.0	3.4	10.3	34.3	102.9	342.7	1,027
Th-232	1.0	1.0	1.0	1.0	2.1	3.0	4.2	6.1	12.9	28.9
Ra-226	1.0	1.1	1.1	1.1	2.5	4.1	6.1	9.1	19.3	43.4

Elevated Measurement Investigation:

Step 1 δ_i = average concentration of systematic "clean" samples for each "elevated" nuclide

(Use corrected net results.)

Step 2 τ_i = average concentration of elevated sample(s) for each ROC

Step 3 f_{elev} = elevated radioactivity fraction

$$\frac{\tau_i - \delta_i}{DCGL_{EMC}}$$

Step 4 Sum all f_{elev} (all ROCs in the elevated area) = f_{EMC} if applicable

Step 5 Sum all f_{EMC} (all elevated areas in the SU) = $f_{EMC,TOT}$ if applicable

Step 6 Sum $f_{EMC,TOT}$ and $SOF_{MEAN,SU}$ (use total SOF SU (including GW, BF, etc.))

Step 7 Is Total SOF from Step 6 < 1? If so PASS, if not, continue with Corrective Actions for FSS failure.

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Performance of Statistical Tests

WRS TEST					
SAMPLE ID	AREA (Reference, Survey Unit)	Gross SOF ($X_{i,ref}$, $Y_{i,SU,gross}$)	ADJUSTED SOF (Z_i)	RANKS	REFERENCE AREA RANKS
9574-SS-140910-01-01	Reference	1.31	2.310	42	42
9574-SS-140910-01-02	Reference	1.18	2.179	33	33
9574-SS-140910-01-03	Reference	1.06	2.064	28	28
9574-SS-140910-01-04	Reference	1.10	2.101	29	29
9574-SS-140910-01-05	Reference	1.29	2.293	41	41
9574-SS-140910-01-07	Reference	1.34	2.339	43	43
9574-SS-140910-01-08	Reference	1.15	2.154	32	32
9574-SS-140910-01-09	Reference	1.18	2.182	34	34
9574-SS-140910-01-10	Reference	1.23	2.227	39	39
9574-SS-140910-01-11	Reference	1.38	2.380	44	44
9574-SS-140910-01-12	Reference	1.05	2.055	27	27
9574-SS-140910-01-13	Reference	0.94	1.941	17	17
9574-SS-140910-01-14	Reference	1.12	2.119	30	30
9574-SS-140910-01-15	Reference	1.15	2.152	31	31
9574-SS-140910-01-16	Reference	1.03	2.028	24	24
9574-SS-140910-01-17	Reference	0.44	1.443	13	13
9574-SS-140910-01-18	Reference	1.19	2.188	36	36
9574-SS-140910-01-20	Reference	0.76	1.757	14	14
9574-SS-140910-01-21	Reference	1.02	2.023	23	23
9574-SS-140910-01-22	Reference	1.02	2.018	22	22
9574-SS-140910-01-23	Reference	1.00	2.002	19	19
9574-SS-140910-01-24	Reference	0.87	1.873	16	16
9574-SS-140910-01-25	Reference	1.04	2.040	26	26
9574-SS-140910-01-26	Reference	0.96	1.959	18	18
9574-SS-140910-01-27	Reference	1.20	2.204	37	37
9574-SS-140910-01-28	Reference	1.01	2.007	21	21
9574-SS-140910-01-29	Reference	1.22	2.223	38	38
9574-SS-140910-01-30	Reference	1.03	2.035	25	25
9574-SS-140910-01-31	Reference	1.00	2.005	20	20
9574-SS-140910-01-32	Reference	0.86	1.865	15	15
9574-SS-140910-01-33	Reference	1.24	2.238	40	40
9574-SS-140910-01-34	Reference	1.19	2.185	35	35
L10-04-01-B-R-S-00	Survey Unit	0.99	0.986	3	0
L10-04-02-B-E-S-00	Survey Unit	0.98	0.979	2	0
L10-04-03-B-E-S-00	Survey Unit	1.05	1.052	5	0
L10-04-04-B-R-S-00	Survey Unit	1.06	1.057	6	0
L10-04-05-B-E-S-00	Survey Unit	0.93	0.932	1	0
L10-04-06-B-E-S-00	Survey Unit	1.25	1.248	9	0
L10-04-07-B-E-S-00	Survey Unit	1.18	1.184	8	0
L10-04-08-B-E-S-00	Survey Unit	1.05	1.051	4	0
L10-04-09-B-E-S-00	Survey Unit	1.16	1.160	7	0
L10-04-10-B-R-S-00	Survey Unit	1.33	1.333	12	0
L10-04-11-B-E-S-00	Survey Unit	1.26	1.260	10	0
L10-04-12-B-E-S-00	Survey Unit	1.31	1.305	11	0
Rank Sums				990	912
# Reference Area Measurements				m	32
# Survey Unit Measurements				n	12
Total Number of Measurements				N	44
(1-α) percentile of a standard normal distribution (MARSSIM Pg. I-10)				z	1.645
WRS Critical Value (MARSSIM Pg. I-10, Eq. I.1)				CV	783

Min adjusted bkg SOF:
1.44

No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary

w_r

$\alpha = 0.05$

TEST: **PASS**

HDP-PR-FSS-721 Final Status Survey Data Evaluation

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	SOF (Ra/Tc/Th/Iso U)
St. Dev.	0.10
DCGL _{SOF}	1
LBGR (Mean)	0.14
Shift	0.86
Relative Shift (Δ/σ)	8.38
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS N/2	9
Verification Check	SUFFICIENT MEASUREMENTS
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test	

Retrospective Sample Size Verification
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, $\alpha = 0.05$, $\beta = 0.10$

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
0.10	1.282
0.15	1.036
0.2	0.842
0.25	0.674
0.30	0.524

α
 β

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

Survey Unit No.:	LSA 10-04				Survey Unit Description:	East Central Survey Unit (North Burial Pits)						
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						
L10-04-08-B-E-S-00	L10-04-08-B-E-Q-00	Ra-226	0.997	0.0676	0.931	0.0669	0.964	1.9	0.066	0.269	0.403	N
L10-04-08-B-E-S-00	L10-04-08-B-E-Q-00	Tc-99	1.72	0.228	1.35	0.23	1.535	25.1	0.37	3.552	5.321	N
L10-04-08-B-E-S-00	L10-04-08-B-E-Q-00	Th-232	0.864	0.107	0.830	0.0651	0.847	2.0	0.034	0.283	0.424	N
L10-04-08-B-E-S-00	L10-04-08-B-E-Q-00	U-234 ¹	2.837	NA	2.979	NA	2.908	195.4	0.142	27.649	41.425	N
L10-04-08-B-E-S-00	L10-04-08-B-E-Q-00	U-235	0.152	0.233	0.162	0.193	0.157	51.6	NA	7.301	10.939	NA
L10-04-08-B-E-S-00	L10-04-08-B-E-Q-00	U-238	1.34	0.753	1.11	0.807	1.225	168.8	0.23	23.885	35.786	N

Comments:

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

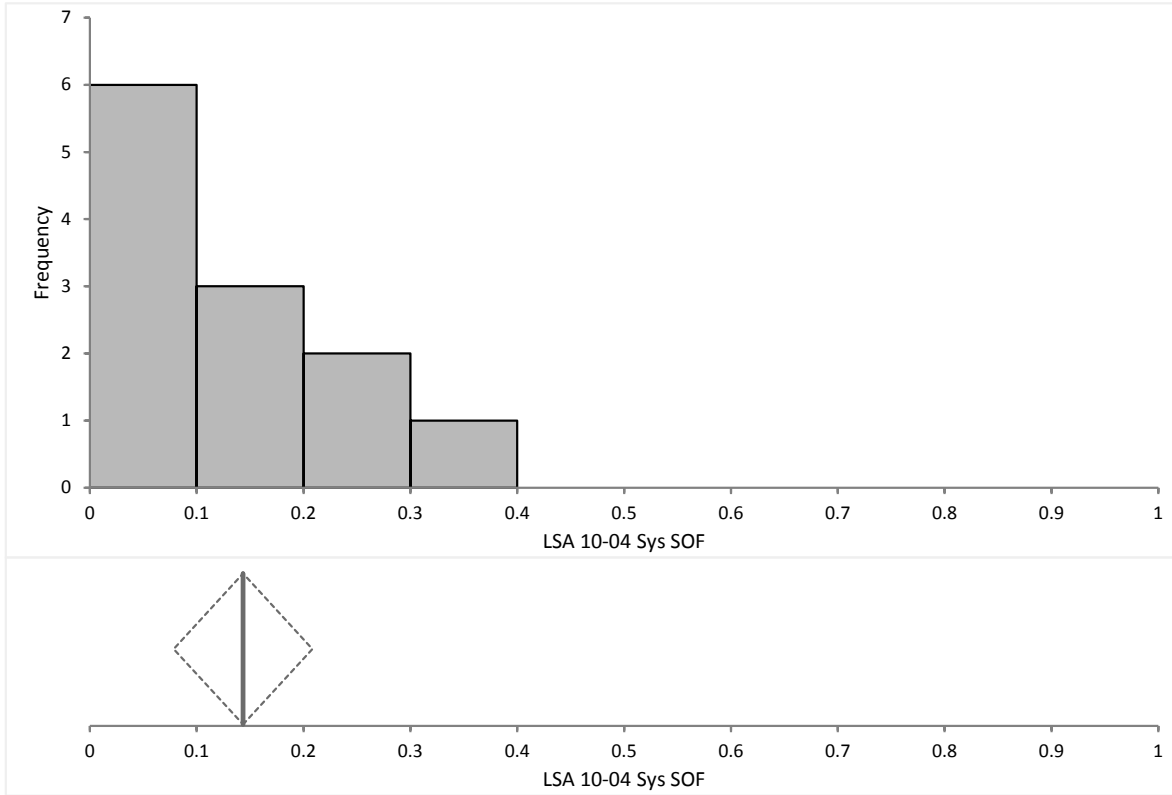
Performed by: <u>Ellen C. Jakub</u>	Reviewed by: <u>Brian A. Miller</u>
Date: <u>04/13/2015</u>	Date: <u>#####</u>

Quality Record

LSA 10-04 Sys SOF

0.0
0.0
0.1
0.1
0.1
0.2
0.1
0.1
0.3
0.3
0.2
0.2

Descriptives



N | 12

	Mean	95% CI	Mean SE	SD	Variance	Skewness	Kurtosis
LSA 10-04 Sys SOF	0.14	0.08 to 0.21	0.029	0.10	0.01	0.6	-0.65
	Minimum	1st quartile	Median	96.14% CI	3rd quartile	Maximum	IQR
LSA 10-04 Sys SOF	0.0	0.07	0.11	0.07 to 0.24	0.22	0.3	0.15