APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area

Survey Unit: 01 **Description:** North West Corner Survey Unit (North Burial Pit)

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
L10-01-01-B-S-S-00	Uniform	S	437.0	436.8	865360.0	827277.0	Surface 2-inch grab
L10-01-02-B-R-S-00	Uniform	S	436.8	432.3	865360.0	827277.0	Root 4.4-foot composite
L10-01-04-B-S-S-00	Uniform	S	436.9	436.5	865317.0	827252.2	Surface 6-inch grab
L10-01-05-B-R-S-00	Uniform	S	436.5	432.0	865317.0	827252.2	Root 4.4-foot composite
L10-01-07-B-R-S-00	Uniform	S	433.2	430.1	865317.0	827301.8	Root 3.1-foot composite
L10-01-08-B-E-S-00	Uniform	S	430.1	429.7	865317.0	827301.8	Excavation 6-inch grab
L10-01-09-B-R-S-00	Uniform	S	427.6	426.6	865317.0	827351.3	Root 1-foot composite
L10-01-10-B-E-S-00	Uniform	S	426.6	426.2	865317.0	827351.3	Excavation 6-inch grab
L10-01-11-B-R-S-00	Uniform	S	436.3	433.1	865274.0	827227.5	Root 3.3-foot composite
L10-01-12-B-E-S-00	Uniform	S	433.1	432.6	865274.0	827227.5	Excavation 6-inch grab
L10-01-13-B-E-S-00	Uniform	S	429.1	428.6	865274.0	827277.0	Excavation 6-inch grab
L10-01-14-B-E-S-00	Uniform	S	425.1	424.7	865274.0	827326.5	Excavation 6-inch grab
L10-01-15-B-S-S-00	Uniform	S	436.9	436.5	865231.1	827252.2	Surface 6-inch grab
L10-01-16-B-R-S-00	Uniform	S	436.5	432.0	865231.1	827252.2	Root 4.4-foot composite
L10-01-13-B-E-Q-00	Uniform	Q	429.1	428.6	865274.0	827277.0	Excavation 6-inch grab
L10-01-18-B-E-B-00	Uniform	B	435.5	422.2	865276.8	827272.7	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) with conservative use of Uniform DCGLs.

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

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

TestAmericaAnalytical Results

Sample ID	Sample Start Depth (ft)	Type (S)ystematic, B)ias, Q(C)	Ra-226 Result	Ra-226 Uncertainty	Ra-226 MDC	Ra-226 Qualifier	Ra-226 Net Result*	Ra-226 Corrected Result	Tc-99 Result	Tc-99 Corrected Result	Tc-99 Uncertainty	Tc-99 MDC	Tc-99 Qualifier	Th-232 Result	Th-232 Uncertainty	Th-232 MDC	Th-232 Qualifier	Th-232 Net Result**	Th-232 Corrected Result	Inferred U-234 Result	Inferred U-234 Uncertainty	Inferred U-234 MDC	Inferred U-234 Qualifier	U-235 Result	U-235 Uncertainty	U-235 MDC	U-235 Qualifier	U-238 Result	U-238 Uncertainty	U-238 MDC	U-238 Qualifier
L10-01-01-B-S-S-00	0.29	S	1.010	0.170	0.087	NA	-0.060	0.000	0.363	0.363	0.094	0.249	NA	0.673	0.150	0.175	NA	-0.327	0.000	3.521	NA	NA	NA	0.190	0.148	0.214	U	1.450	0.675	1.030	NA
L10-01-02-B-R-S-00	0.492	S	1.270	0.179	0.078	NA	0.200	0.200	0.019	0.019	0.069	0.227	U	1.200	0.185	0.112	NA	0.200	0.200	3.150	NA	NA	NA	0.172	0.140	0.245	U	1.070	0.572	0.904	NA
L10-01-04-B-S-S-00	0.01	S	1.160	0.170	0.075	NA	0.090	0.090	0.530	0.530	0.054	0.220	NA	1.250	0.216	0.079	NA	0.250	0.250	4.331	NA	NA	NA	0.235	0.151	0.252	U	1.680	0.544	0.771	NA
L10-01-05-B-R-S-00	0.492	S	1.080	0.164	0.068	NA	0.010	0.010	0.016	0.016	0.016	0.220	U	1.090	0.190	0.109	NA	0.090	0.090	2.587	NA	NA	NA	0.140	0.190	0.319	U	1.020	0.559	0.878	NA
L10-01-07-B-R-S-00	1.86	S	1.200	0.167	0.070	NA	0.130	0.130	0.010	0.010	0.052	0.212	U	1.040	0.187	0.134	NA	0.040	0.040	2.882	NA	NA	NA	0.153	0.161	0.253	U	1.500	0.735	0.933	NA
L10-01-08-B-E-S-00	4.92	S	1.140	0.161	0.071	NA	0.070	0.070	0.001	0.001	0.028	0.220	U	1.160	0.172	0.102	NA	0.160	0.160	3.009	NA	NA	NA	0.165	0.138	0.188	U	0.905	0.385	1.110	U
L10-01-09-B-R-S-00	3.93	S	1.240	0.179	0.079	NA	0.170	0.170	0.047	0.047	0.052	0.219	U	1.060	0.169	0.097	NA	0.060	0.060	3.806	NA	NA	NA	0.207	0.181	0.232	U	1.380	0.561	0.841	NA
L10-01-10-B-E-S-00	4.92	S	1.210	0.197	0.103	NA	0.140	0.140	0.033	0.033	0.075	0.224	U	1.190	0.206	0.115	NA	0.190	0.190	1.603	NA	NA	NA	0.082	0.151	0.334	U	1.210	0.672	1.060	NA
L10-01-11-B-R-S-00	1.67	S	1.030	0.155	0.081	NA	-0.040	0.000	0.132	0.132	0.020	0.215	U	1.000	0.160	0.099	NA	0.000	0.000	2.072	NA	NA	NA	0.110	0.137	0.242	U	1.100	0.673	0.873	NA
L10-01-12-B-E-S-00	4.92	S	0.763	0.140	0.148	NA	-0.307	0.000	-0.015	0.000	0.039	0.210	U	1.270	0.201	0.106	NA	0.270	0.270	3.621	NA	NA	NA	0.200	0.116	0.178	NA	0.689	0.341	0.943	U
L10-01-13-B-E-S-00	6.14	S	1.470	0.200	0.069	NA	0.400	0.400	-0.004	0.000	0.028	0.230	U	1.340	0.203	0.132	NA	0.340	0.340	0.738	NA	NA	NA	0.028	0.083	0.266	U	1.440	0.609	0.926	NA
L10-01-14-B-E-S-00	7.95	S	1.400	0.183	0.074	NA	0.330	0.330	0.021	0.021	0.030	0.252	U	1.370	0.200	0.136	NA	0.370	0.370	2.928	NA	NA	NA	0.158	0.164	0.272	U	1.260	0.600	0.935	NA
L10-01-15-B-S-S-00	0.01	S	1.210	0.178	0.090	NA	0.140	0.140	0.023	0.023	0.026	0.224	U	1.240	0.189	0.093	NA	0.240	0.240	1.084	NA	NA	NA	0.050	0.162	0.286	U	1.540	0.898	1.070	NA
L10-01-16-B-R-S-00	0.492	S	1.300	0.181	0.067	NA	0.230	0.230	0.017	0.017	0.052	0.228	U	1.220	0.188	0.128	NA	0.220	0.220	1.571	NA	NA	NA	0.078	0.152	0.270	U	1.500	0.573	0.852	NA
L10-01-13-B-E-Q-00	6.14	Q	1.400	0.219	0.121	NA	0.330	0.330	-0.010	0.000	0.011	0.235	U	1.400	0.227	0.130	NA	0.400	0.400	3.370	NA	NA	NA	0.185	0.185	0.300	U	0.997	0.638	1.020	U
L10-01-18-B-E-B-00	13.25	B	1.270	0.199	0.099	NA	0.200	0.200	0.038	0.038	0.014	0.225	U	1.310	0.221	0.166	NA	0.310	0.310	2.922	NA	NA	NA	0.160	0.196	0.333	U	0.912	0.515	1.390	U
Systematic Minimum			0.000						0.000					0.000						0.738				0.028				0.689			
Systematic Maximum			0.400						0.530					0.370						4.331				0.235				1.680			
Systematic Mean			0.136						0.087					0.174						2.636				0.141				1.267			
Systematic Median			0.135						0.023					0.195						2.905				0.156				1.320			
Systematic Standard Deviation			0.124						0.159					0.120						1.077				0.062				0.281			
			With ingrowth, use Ra226 bkg =				1.07							Th232 bkg =				1.0														

Sample ID	Sample Depth (ft)	Type (S)ystematic, B)ias, Q(C)	Enr. Enrichment (%)	SOF_N	Root Stratum SOF Verification (unexcavated/not backfilled only) Is Sample in the Root Stratum?	Is ROOT Sample SOF > 0.5?	root count	excavation count	surface count
L10-01-01-B-S-S-00	0.29	S	2.0	0.04	SURFACE	good			1
L10-01-02-B-R-S-00	0.49	S	2.5	0.23	ROOT	good	1		
L10-01-04-B-S-S-00	0.01	S	2.2	0.23	SURFACE	good			1
L10-01-05-B-R-S-00	0.49	S	2.1	0.07	ROOT	good	1		
L10-01-07-B-R-S-00	1.86	S	1.6	0.12	ROOT	good	1		
L10-01-08-B-E-S-00	4.92	S	2.8	0.14	EXCAVATION	good		1	
L10-01-09-B-R-S-00	3.93	S	2.3	0.15	ROOT	good	1		
L10-01-10-B-E-S-00	4.92	S	1.1	0.19	EXCAVATION	good		1	
L10-01-11-B-R-S-00	1.67	S	1.6	0.02	ROOT	good	1		
L10-01-12-B-E-S-00	4.92	S	4.4	0.16	EXCAVATION	good		1	
L10-01-13-B-E-S-00	6.14	S	0.3	0.39	EXCAVATION	good		1	
L10-01-14-B-E-S-00	7.95	S	2.0	0.39	EXCAVATION	good		1	
L10-01-15-B-S-S-00	0.01	S	0.6	0.21	SURFACE	good			1
L10-01-16-B-R-S-00	0.49	S	0.9	0.25	ROOT	good	1		
L10-01-13-B-E-Q-00	6.14	Q	2.9	0.40		good			
L10-01-18-B-E-B-00	13.25	B	2.7	0.29		good			
			1.9	0.02					
				0.39			14	6	5	3
			Average Enrichment (%)	0.19			count tot			
				0.17					
				0.11					

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: Result is less than the sample detection limit.
All uncertainty values are reported at the 2-sigma confidence level.

Ave Conc. Ra-226, SS	Ave Conc. Tc-99, SS	Ave Conc. Th-232, SS	Ave Conc. U-234, SS	Ave Conc. U-235, SS	Ave Conc. U-238, SS
0.000	0.363	0.000	3.521	0.190	1.450
-	-	-	-	-	-
0.090	0.530	0.250	4.331	0.235	1.680
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.140	0.023	0.240	1.084	0.050	1.540
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.077	**0.305**	**0.163**	**2.979**	**0.158**	**1.557**

Ave Conc. Ra-226, RS	Ave Conc. Tc-99, RS	Ave Conc. Th-232, RS	Ave Conc. U-234, RS	Ave Conc. U-235, RS	Ave Conc. U-238, RS
-	-	-	-	-	-
0.200	0.019	0.200	3.150	0.172	1.070
-	-	-	-	-	-
0.010	0.016	0.090	2.587	0.140	1.020
0.130	0.010	0.040	2.882	0.153	1.500
-	-	-	-	-	-
0.170	0.047	0.060	3.806	0.207	1.380
-	-	-	-	-	-
0.000	0.132	0.000	2.072	0.110	1.100
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.230	0.017	0.220	1.571	0.078	1.500
-	-	-	-	-	-
-	-	-	-	-	-
0.123	**0.040**	**0.102**	**2.678**	**0.143**	**1.262**

Ave Conc. Ra-226, ES	Ave Conc. Tc-99, ES	Ave Conc. Th-232, ES	Ave Conc. U-234, ES	Ave Conc. U-235, ES	Ave Conc. U-238, ES
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.07	0.0011	0.16	3.0089	0.165	0.905
-	-	-	-	-	-
0.14	0.0325	0.19	1.6033	0.0818	1.210
-	-	-	-	-	-
0	0	0.27	3.6208	0.2	0.689
0.4	0	0.34	0.7379	0.0277	1.440
0.33	0.0206	0.37	2.9281	0.158	1.260
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.188	**0.011**	**0.266**	**2.380**	**0.127**	**1.101**

Use corrected net results for all DE calcs.

MDC SOF
0.17
0.14
0.12
0.14
0.15
0.13
0.13
0.17
0.13
0.16
0.16
0.15
0.15
0.15
0.18
0.19

$DCLG_W$, 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

weighted SOF_{MEAN} **0.19**

	SS	RS	ES
fractions	0.214285714	0.428571429	0.35714

SOF_{MEAN} Re-use Backfill Material
0 Off-Site Backfill

SOF_{MEAN} Groundwater
0.16

SOF_{TOT} <= 1

$SOF_{MEAN, SU}$ 0.35 **PASS**

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

8.6 mrem

Infer U234			
U-238/U235	**U-234/U235**	**U-234**	**%**
7.6	18.5	3.5	2.0
6.2	18.3	3.2	2.5
7.1	18.4	4.3	2.2
7.3	18.5	2.6	2.1
9.8	18.8	2.9	1.6
5.5	18.2	3.0	2.8
6.7	18.4	3.8	2.3
14.8	19.6	1.6	1.1
10.0	18.8	2.1	1.6
3.4	18.1	3.6	4.4
52.0	26.6	0.7	0.3
8.0	18.5	2.9	2.0
30.9	21.8	1.1	0.6
19.3	20.2	1.6	0.9
5.4	18.2	3.4	2.9
5.7	18.3	2.9	2.7
		Average Enrichment (%)	**1.89**

Infer U-234 MDC using U-235 MDC * ratio of U-234:U-235 @ that sample's enrichment
3.9659
4.4873
4.6442
5.8944
4.7663
3.4284
4.2658
6.5464
4.5590
3.2225
7.0863
5.0408
6.2236
5.4448
5.4646
6.0804

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	1.19	2.188	38	38	
9574-SS-140910-01-02	Reference	0.76	1.757	16	16	
9574-SS-140910-01-03	Reference	1.02	2.023	25	25	
9574-SS-140910-01-04	Reference	1.02	2.018	24	24	
9574-SS-140910-01-05	Reference	1.00	2.002	21	21	
9574-SS-140910-01-07	Reference	0.87	1.873	18	18	
9574-SS-140910-01-08	Reference	1.04	2.040	28	28	
9574-SS-140910-01-09	Reference	0.96	1.959	20	20	
9574-SS-140910-01-10	Reference	1.20	2.204	39	39	
9574-SS-140910-01-11	Reference	1.01	2.007	23	23	
9574-SS-140910-01-12	Reference	1.22	2.223	40	40	
9574-SS-140910-01-13	Reference	1.03	2.035	27	27	
9574-SS-140910-01-14	Reference	1.00	2.005	22	22	
9574-SS-140910-01-15	Reference	0.86	1.865	17	17	
9574-SS-140910-01-16	Reference	1.24	2.238	42	42	
9574-SS-140910-01-17	Reference	1.19	2.185	37	37	
9574-SS-140910-01-18	Reference	1.31	2.310	44	44	
9574-SS-140910-01-20	Reference	1.18	2.179	35	35	
9574-SS-140910-01-21	Reference	1.06	2.064	30	30	
9574-SS-140910-01-22	Reference	1.10	2.101	31	31	
9574-SS-140910-01-23	Reference	1.29	2.293	43	43	
9574-SS-140910-01-24	Reference	1.34	2.339	45	45	
9574-SS-140910-01-25	Reference	1.15	2.154	34	34	
9574-SS-140910-01-26	Reference	1.18	2.182	36	36	
9574-SS-140910-01-27	Reference	1.23	2.227	41	41	
9574-SS-140910-01-28	Reference	1.38	2.380	46	46	
9574-SS-140910-01-29	Reference	1.05	2.055	29	29	
9574-SS-140910-01-30	Reference	0.94	1.941	19	19	
9574-SS-140910-01-31	Reference	1.12	2.119	32	32	
9574-SS-140910-01-32	Reference	1.15	2.152	33	33	
9574-SS-140910-01-33	Reference	1.03	2.028	26	26	Min adjusted bkg SOF: 1.44
9574-SS-140910-01-34	Reference	0.44	1.443	13	13	
L10-01-01-B-S-S-00	Survey Unit	0.91	0.913	1	0	No WRS Test Necessary
L10-01-02-B-R-S-00	Survey Unit	1.29	1.295	11	0	No WRS Test Necessary
L10-01-04-B-S-S-00	Survey Unit	1.29	1.293	10	0	No WRS Test Necessary
L10-01-05-B-R-S-00	Survey Unit	1.14	1.136	4	0	No WRS Test Necessary
L10-01-07-B-R-S-00	Survey Unit	1.18	1.179	5	0	No WRS Test Necessary
L10-01-08-B-E-S-00	Survey Unit	1.20	1.204	6	0	No WRS Test Necessary
L10-01-09-B-R-S-00	Survey Unit	1.22	1.216	7	0	No WRS Test Necessary
L10-01-10-B-E-S-00	Survey Unit	1.25	1.250	8	0	No WRS Test Necessary
L10-01-11-B-R-S-00	Survey Unit	1.07	1.067	3	0	No WRS Test Necessary
L10-01-12-B-E-S-00	Survey Unit	1.06	1.063	2	0	No WRS Test Necessary
L10-01-13-B-E-S-00	Survey Unit	1.46	1.457	15	0	Perform WRS Test
L10-01-14-B-E-S-00	Survey Unit	1.45	1.448	14	0	Perform WRS Test
L10-01-15-B-S-S-00	Survey Unit	1.27	1.273	9	0	No WRS Test Necessary
L10-01-16-B-R-S-00	Survey Unit	1.31	1.313	12	0	No WRS Test Necessary
			Rank Sums	1081	974	W_r
			# Reference Area Measurements	**m**	32	
			# Survey Unit Measurements	**n**	14	
			Total Number of Measurements	**N**	46	
			(1-α) percentile of a standard normal distribution (MARSSIM Pg. I-10)	**z**	1.645	α = 0.05
			WRS Critical Value (MARSSIM Pg. I-10, Eq. I.1)	**CV**	821	
				TEST:	PASS	

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Retrospective Sample Size Verification

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.11
$DCGL_{SOF}$	1
LBGR (Mean)	0.19
Shift	0.81
Relative Shift (Δ/σ)	7.36
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
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 10-01				Survey Unit Description:		North West Corner Survey Unit (North Burial Pit Area)					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$)	Nuclide DCGL				Statistic Exceeds Limit?
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	(pCi/g)	(pCi/g)	Statistic[2]	Warning Limit	Control Limit	(Y/N)
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Ra-226	1.47	0.0692	1.4	0.121	1.435	1.9	0.07	0.269	0.403	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Tc-99	-0.00436	0.23	-0.0103	0.235	-0.00733	25.1	NA	3.552	5.321	NA
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Th-232	1.34	0.132	1.4	0.13	1.370	2.0	0.060	0.283	0.424	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-234[1]	0.738	NA	3.370	NA	2.054	195.4	2.632	27.649	41.425	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-235	0.0277	0.266	0.185	0.3	0.106	51.6	NA	7.301	10.939	NA
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-238	1.44	0.926	0.997	1.02	1.2185	168.8	NA	23.885	35.786	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: Ellen C. Jakub

Date: 02/27/2015

Reviewed by: Brian A. Miller

Date: 03/16/2015

Quality Record