

APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 10
Survey Unit: 13
Survey Type: FSS

Description: Burial Pits Open Land Area
Description: Northern Survey Unit in "Area 2"
Classification: Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L10-13-01-B-E-S-00	Uniform	S	426.4	426.0	865152.8	827426.0	Excavation 6-inch grab
L10-13-02-B-R-S-00	Uniform	S	431.2	429.7	865105.9	827398.9	Root 12-inch composite
L10-13-03-B-E-S-00	Uniform	S	429.7	429.2	865105.9	827398.9	Excavation 6-inch grab
L10-13-04-B-E-S-00	Uniform	S	421.5	421.1	865105.9	827453.1	Excavation 6-inch grab
L10-13-05-B-R-S-00	Uniform	S	429.1	428.0	865105.9	827507.2	Root 7-inch composite
L10-13-06-B-E-S-00	Uniform	S	428.0	427.5	865105.9	827507.2	Excavation 6-inch grab
L10-13-07-B-R-S-00	Uniform	S	431.5	430.6	865059.0	827426.0	Root 5-inch composite
L10-13-08-B-E-S-00	Uniform	S	430.6	430.1	865059.0	827426.0	Excavation 6-inch grab
L10-13-09-B-E-S-00	Uniform	S	415.3	414.8	865059.0	827480.1	Excavation 6-inch grab
L10-13-10-B-R-S-00	Uniform	S	429.7	428.4	865059.0	827534.3	Root 10-inch composite
L10-13-11-B-E-S-00	Uniform	S	428.4	427.9	865059.0	827534.3	Excavation 6-inch grab
L10-13-12-B-E-S-00	Uniform	S	419.1	418.6	865012.1	827507.2	Excavation 6-inch grab
L10-13-07-B-R-Q-00	Uniform	Q	431.5	430.6	865059.0	827426.0	Excavation 6-inch grab
L10-13-13-B-R-B-00	Uniform	B	435.0	431.5	865063.0	827417.0	Biased 6-inch Grab
L10-13-14-B-E-B-00	Uniform	B	419.1	418.6	865069.6	827494.4	Sidewall 6-inch grab
L10-13-15-B-E-B-00	Uniform	B	421.6	421.1	865060.7	827453.1	Sidewall 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 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.

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

Sample ID	Sample Start Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																				
			Ra-226						Tc-99					Th-232					Inferred U-234				
			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
L10-13-01-B-E-S-00	6.83	S	1.120	0.161	0.068	NA	0.050	0.050	0.241	0.241	0.055	0.198	NA	0.890	0.176	0.143	NA	-0.110	0.000	6.536	NA	NA	NA
L10-13-02-B-R-S-00	3.45	S	1.090	0.150	0.060	NA	0.020	0.020	0.266	0.266	0.142	0.201	NA	1.090	0.168	0.098	NA	0.090	0.090	1.493	NA	NA	NA
L10-13-03-B-E-S-00	4.92	S	1.130	0.153	0.060	NA	0.060	0.060	0.245	0.245	0.081	0.213	NA	1.060	0.187	0.115	NA	0.060	0.060	3.624	NA	NA	NA
L10-13-04-B-E-S-00	12.36	S	1.560	0.214	0.087	NA	0.490	0.490	0.104	0.104	0.096	0.203	U	1.050	0.179	0.098	NA	0.050	0.050	2.537	NA	NA	NA
L10-13-05-B-R-S-00	3.82	S	1.280	0.174	0.071	NA	0.210	0.210	0.071	0.071	0.078	0.194	U	1.270	0.208	0.139	NA	0.270	0.270	3.622	NA	NA	NA
L10-13-06-B-E-S-00	4.92	S	1.030	0.144	0.062	NA	-0.040	0.000	0.021	0.021	0.020	0.204	U	1.120	0.157	0.099	NA	0.120	0.120	3.615	NA	NA	NA
L10-13-07-B-R-S-00	4.00	S	1.420	0.209	0.095	NA	0.350	0.350	0.358	0.358	0.080	0.202	NA	1.350	0.225	0.190	NA	0.350	0.350	2.524	NA	NA	NA
L10-13-08-B-E-S-00	4.92	S	1.200	0.160	0.058	NA	0.130	0.130	0.622	0.622	0.103	0.207	NA	1.060	0.158	0.112	NA	0.060	0.060	2.352	NA	NA	NA
L10-13-09-B-E-S-00	18.90	S	1.340	0.188	0.077	NA	0.270	0.270	0.401	0.401	0.111	0.244	NA	1.280	0.189	0.107	NA	0.280	0.280	3.553	NA	NA	NA
L10-13-10-B-R-S-00	3.61	S	1.160	0.160	0.068	NA	0.090	0.090	-0.012	0.000	0.042	0.198	U	1.190	0.167	0.142	NA	0.190	0.190	1.582	NA	NA	NA
L10-13-11-B-E-S-00	4.92	S	0.990	0.142	0.065	NA	-0.080	0.000	0.090	0.090	0.056	0.211	U	1.090	0.167	0.092	NA	0.090	0.090	4.477	NA	NA	NA
L10-13-12-B-E-S-00	15.45	S	1.200	0.166	0.090	NA	0.130	0.130	0.108	0.108	0.060	0.250	U	1.280	0.183	0.137	NA	0.280	0.280	2.016	NA	NA	NA
L10-13-13-B-R-B-00	3.46	B	1.040	0.144	0.086	NA	-0.030	0.000	2.830	2.830	0.337	0.215	NA	1.380	0.209	0.077	NA	0.380	0.380	19.741	NA	NA	NA
L10-13-14-B-E-B-00	14.55	B	1.450	0.280	0.101	NA	0.380	0.380	0.528	0.528	0.171	0.280	NA	1.170	0.325	0.237	NA	0.170	0.170	33.264	NA	NA	NA
L10-13-15-B-E-B-00	13.28	B	1.650	0.297	0.164	NA	0.580	0.580	0.055	0.055	0.076	0.260	U	1.370	0.314	0.156	NA	0.370	0.370	1.553	NA	NA	NA
L10-13-07-B-R-Q-00	4.00	Q	1.310	0.172	0.063	NA	0.240	0.240	0.340	0.340	0.058	0.212	NA	1.150	0.166	0.114	NA	0.150	0.150	2.336	NA	NA	NA
Systematic Minimum			0.000						0.000					0.000					1.493				
Systematic Maximum			0.490						0.622					0.350					6.536				
Systematic Mean			0.150						0.211					0.153					3.161				
Systematic Median			0.110						0.175					0.105					3.045				
Systematic Standard Deviation			0.153						0.183					0.115					1.412				
			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: Result is less than the sample detection limit.

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

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

U-235				U-238			
Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier
0.360	0.162	0.225	NA	1.660	0.578	0.849	NA
0.078	0.125	0.224	U	0.908	0.292	0.815	NA
0.200	0.146	0.212	U	0.814	0.344	1.060	U
0.138	0.149	0.266	U	0.952	0.336	0.957	U
0.197	0.184	0.260	U	1.330	0.558	0.855	NA
0.198	0.120	0.163	NA	1.110	0.492	0.760	NA
0.134	0.160	0.287	U	1.310	0.656	1.020	NA
0.126	0.125	0.228	U	1.090	0.491	0.759	NA
0.194	0.149	0.213	U	1.210	0.549	0.845	NA
0.080	0.140	0.258	U	1.290	0.513	0.780	NA
0.247	0.157	0.199	NA	1.040	0.293	0.770	NA
0.108	0.135	0.247	U	0.937	0.305	0.835	NA
1.090	0.208	0.240	NA	3.430	0.770	1.020	NA
1.790	0.539	0.595	NA	2.570	1.920	3.130	U
0.084	0.303	0.604	U	0.695	1.610	2.700	U
0.124	0.125	0.231	U	1.260	0.527	0.807	NA
0.078				0.814			
0.360				1.660			
0.172				1.138			
0.166				1.100			
0.080				0.236			

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.

Sample ID	Sample Start Depth (ft)	Type (Systematic, Bias, QC)	Enr.	SOF	Root Stratum SOF Verification (unexcavated/not backfilled only)			root count	excavation count	surface count	
			Enrichment (%)	SOF	is Sample in the Root Stratum?	is ROOT Sample SOF > 0.5?					
L10-13-01-B-E-S-00	6.83	S	3.3	0.09	EXCAVATION	good			1		
L10-13-02-B-R-S-00	3.45	S	1.4	0.08	ROOT	good	1				
L10-13-03-B-E-S-00	4.92	S	3.7	0.10	EXCAVATION	good		1			
L10-13-04-B-E-S-00	12.36	S	2.3	0.31	EXCAVATION	good		1			
L10-13-05-B-R-S-00	3.82	S	2.3	0.28	ROOT	good	1				
L10-13-06-B-E-S-00	4.92	S	2.7	0.09	EXCAVATION	good		1			
L10-13-07-B-R-S-00	4.00	S	1.6	0.40	ROOT	good	1				
L10-13-08-B-E-S-00	4.92	S	1.8	0.14	EXCAVATION	good		1			
L10-13-09-B-E-S-00	18.90	S	2.5	0.33	EXCAVATION	good		1			
L10-13-10-B-R-S-00	3.61	S	1.0	0.16	ROOT	good	1				
L10-13-11-B-E-S-00	4.92	S	3.6	0.08	EXCAVATION	good		1			
L10-13-12-B-E-S-00	15.45	S	1.8	0.23	EXCAVATION	good		1			
L10-13-13-B-R-B-00	3.46	B	4.8	0.45		good					
L10-13-14-B-E-B-00	14.55	B	9.8	0.53		good					
L10-13-15-B-E-B-00	13.28	B	1.9	0.51		good					
L10-13-07-B-R-Q-00	4.00	Q	1.6	0.24		good					
			2.3	0.08				12	4	8	0
			Average Enrichment (%)	0.40				count tot			
				0.19							
				0.15							
				0.11							

MDC SOF
0.15
0.12
0.13
0.13
0.14
0.15
0.11
0.19
0.13
0.13
0.15
0.12
0.16
0.12
0.27
0.26
0.13

DCL_{Gw, Mez}

U-234
U-235
U-238
Tc-99
Th-232
Ra-226

weighted SOF_{MEAN} 0.19

fractions SS 0 0.3333333 RS

SOF_{MEAN} Re-use backfill Materi
0.14 Stockpile 3

SOF_{MEAN} Groundwater
0.16

SOF_{TOT} <=1
SOF_{MEAN, SU} 0.49

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

Measure Tc-99, All SEAs

Uniform
195.4
51.6
168.8
25.1
2.0
1.9

Infer U234			
U-238/U235	U-234/U235	U-234	%
4.6	18.2	6.5	3.3
11.6	19.1	1.5	1.4
4.1	18.1	3.6	3.7
6.9	18.4	2.5	2.3
6.8	18.4	3.6	2.3
5.6	18.3	3.6	2.7
9.8	18.8	2.5	1.6
8.7	18.7	2.4	1.8
6.2	18.3	3.6	2.5
16.2	19.9	1.6	1.0
4.2	18.1	4.5	3.6
8.7	18.7	2.0	1.8
3.1	18.1	19.7	4.8
1.4	18.6	33.3	9.8
8.3	18.6	1.6	1.9
10.2	18.8	2.3	1.6
Average Enrichment (%)			2.33

Infer U-234 MDC using U-235 MDC * ratio of U-234:U-235 @ that sample's enrichment
4.084819778
4.272008805
3.841620459
4.89090827
4.78058703
2.976283468
5.406796223
4.255666561
3.901206726
5.12209701
3.607334615
4.610305441
4.34660066
11.05706886
11.23108194
4.351811594

ES

0.666667

Final

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

PASS

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

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

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

<u>0.141</u>	<u>0.229</u>	<u>0.118</u>	<u>3.589</u>
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HDP-PR-FSS-721 *Final Status Survey Data Evaluation*
Preliminary Data Review and Calculation of the Sum-of-Fractions (SOF)

0.196

1.102

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

WRS TEST				
SAMPLE ID	AREA (Reference, Survey Unit)	Gross SOF ($X_{i,ref}$, $Y_{i,SU}$)	ADJUSTED SOF (Z_i)	RANKS
9574-SS-140910-01-01	Reference	1.31	2.310	38
9574-SS-140910-01-02	Reference	1.18	2.179	29
9574-SS-140910-01-03	Reference	1.06	2.064	24
9574-SS-140910-01-04	Reference	1.10	2.101	25
9574-SS-140910-01-05	Reference	1.29	2.293	37
9574-SS-140910-01-07	Reference	1.34	2.339	39
9574-SS-140910-01-08	Reference	1.15	2.154	28
9574-SS-140910-01-09	Reference	1.18	2.182	30
9574-SS-140910-01-10	Reference	1.23	2.227	35
9574-SS-140910-01-11	Reference	1.38	2.380	40
9574-SS-140910-01-12	Reference	1.05	2.055	23
9574-SS-140910-01-13	Reference	0.94	1.941	13
9574-SS-140910-01-14	Reference	1.12	2.119	26
9574-SS-140910-01-15	Reference	1.15	2.152	27
9574-SS-140910-01-16	Reference	1.03	2.028	20
9574-SS-140910-01-17	Reference	0.44	1.443	8
9574-SS-140910-01-18	Reference	1.19	2.188	32
9574-SS-140910-01-20	Reference	0.76	1.757	10
9574-SS-140910-01-21	Reference	1.02	2.023	19
9574-SS-140910-01-22	Reference	1.02	2.018	18
9574-SS-140910-01-23	Reference	1.00	2.002	15
9574-SS-140910-01-24	Reference	0.87	1.873	12
9574-SS-140910-01-25	Reference	1.04	2.040	22
9574-SS-140910-01-26	Reference	0.96	1.959	14
9574-SS-140910-01-27	Reference	1.20	2.204	33
9574-SS-140910-01-28	Reference	1.01	2.007	17
9574-SS-140910-01-29	Reference	1.22	2.223	34
9574-SS-140910-01-30	Reference	1.03	2.035	21
9574-SS-140910-01-31	Reference	1.00	2.005	16
9574-SS-140910-01-32	Reference	0.86	1.865	11
9574-SS-140910-01-33	Reference	1.24	2.238	36
9574-SS-140910-01-34	Reference	1.19	2.185	31
L10-13-01-B-E-S-00	Survey Unit	1.09	1.094	1
L10-13-02-B-R-S-00	Survey Unit	1.14	1.144	2
L10-13-04-B-E-S-00	Survey Unit	1.37	1.371	6
L10-13-05-B-R-S-00	Survey Unit	1.34	1.342	5
L10-13-07-B-R-S-00	Survey Unit	1.46	1.460	9
L10-13-09-B-E-S-00	Survey Unit	1.39	1.390	7
L10-13-10-B-R-S-00	Survey Unit	1.22	1.223	3
L10-13-12-B-E-S-00	Survey Unit	1.29	1.294	4
Rank Sums				820
# Reference Area Measurements				m
# Survey Unit Measurements				n
Total Number of Measurements				N
(1-α) percentile of a standard normal distribution (MARSSIM Pg. I-10)				z
WRS Critical Value (MARSSIM Pg. I-10, Eq. I.1)				CV

TEST:

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

REFERENCE AREA RANKS	
38	
29	
24	
25	
37	
39	
28	
30	
35	
40	
23	
13	
26	
27	
20	
8	
32	
10	
19	
18	
15	
12	
22	
14	
33	
17	
34	
21	
16	
11	
36	Min adjusted bkg SOF
31	1.44
0	No WRS test necessary
0	No WRS test necessary
0	No WRS test necessary
0	No WRS test necessary
0	Perform WRS test
0	No WRS test necessary
0	No WRS test necessary
0	No WRS test necessary
783	W_r
32	
8	
40	
1.645	
705	
PASS	

$\alpha = 0.05$

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)	7.16
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, $\alpha = 0.05$, $\beta = 0.10$

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 10-13			Survey Unit Description:		Burial Pits Open Land Area Northern Survey Unit in "Area 2"					
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						
L10-13-07-B-R-S-00	L10-13-07-B-R-Q-00	Ra-226	1.42	0.0945	1.31	0.0627	1.365	1.9	0.11	0.269	0.403	N
L10-13-07-B-R-S-00	L10-13-07-B-R-Q-00	Tc-99	0.358	0.202	0.34	0.212	0.349	25.1	0.018	3.552	5.321	N
L10-13-07-B-R-S-00	L10-13-07-B-R-Q-00	Th-232	1.35	0.19	1.15	0.114	1.250	2.0	0.200	0.283	0.424	N
L10-13-07-B-R-S-00	L10-13-07-B-R-Q-00	U-234 ¹	2.524	NA	2.336	NA	2.430	195.4	0.188	27.649	41.425	N
L10-13-07-B-R-S-00	L10-13-07-B-R-Q-00	U-235	0.134	0.287	0.124	0.231	0.129	51.6	NA	7.301	10.939	NA
L10-13-07-B-R-S-00	L10-13-07-B-R-Q-00	U-238	1.31	1.02	1.26	0.807	1.285	168.8	0.050	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: _____	Reviewed by: _____
Date: _____	Date: _____

Quality Record

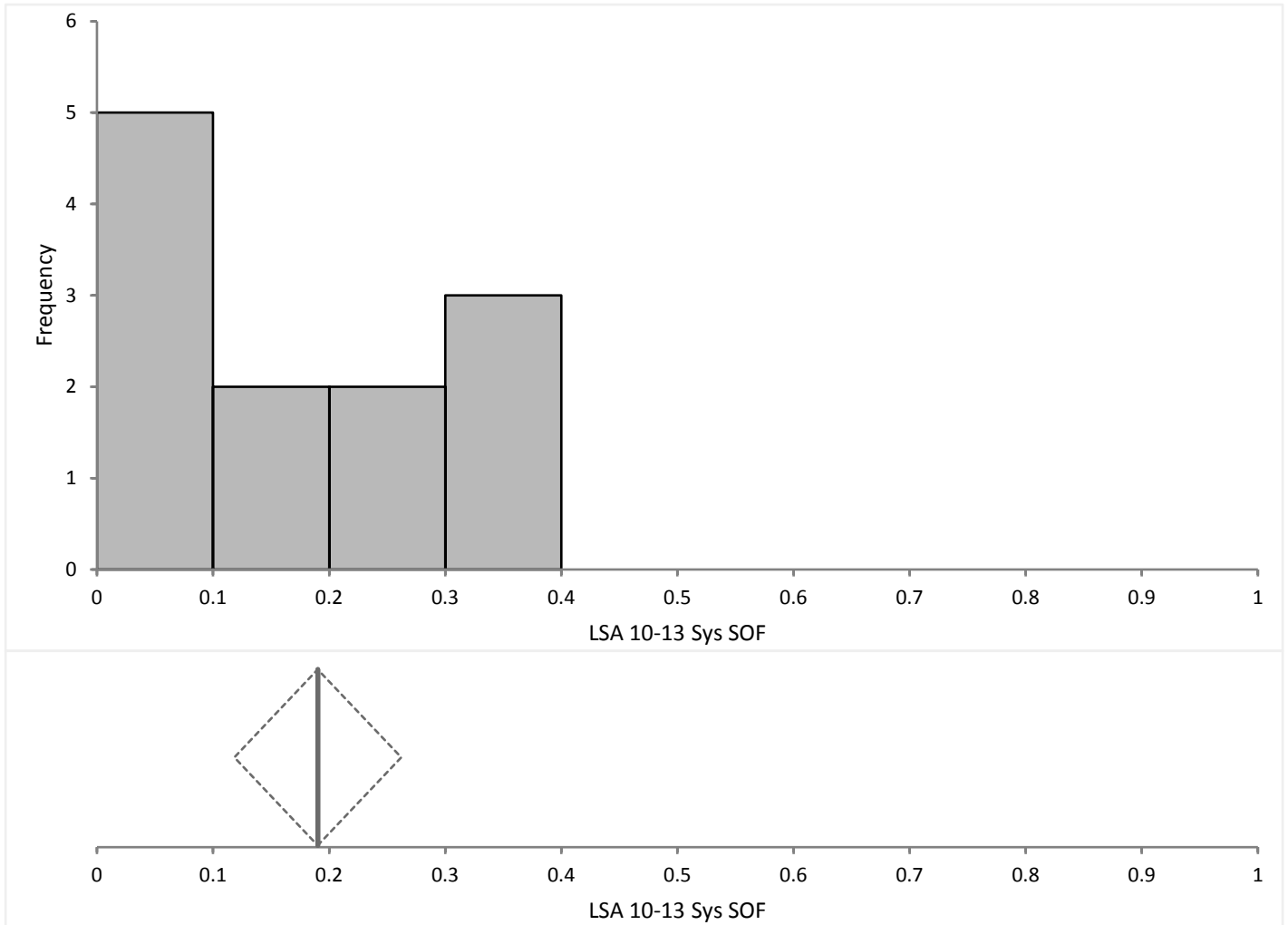
LSA 10-13 Sys SOF

- 0.1
- 0.1
- 0.1
- 0.3
- 0.3
- 0.1
- 0.4
- 0.1
- 0.3
- 0.2
- 0.1
- 0.2

SOFn Only A1:A13

Last updated 8 November 2016 at 13:14 by W. Clark Evers

Descriptives



N	12				
	Mean	95% CI	Mean SE	SD	Variance
LSA 10-13 Sys SOF	0.19	0.12 to 0.26	0.033	0.11	0.01
	Minimum	1st quartile	Median	96.14% CI	3rd quartile
LSA 10-13 Sys SOF	0.1	0.09	0.15	0.09 to 0.31	0.30

Skewness	Kurtosis
0.6	-1.15
Maximum	IQR
0.4	0.21