MEMORANDUM
FORT LEWIS AGREED ORDER RI
DEMONSTRATION OF METHOD APPLICABILITY
SAMPLING AND ANALYSIS PLAN ADDENDUM
FORMER SMALL ARMS RANGES

1.0 INTRODUCTION

This memorandum present the results of the Demonstration of Method Applicability conducted as part of the Fort Lewis Agreed Order Remedial Investigation Former Small Arms Ranges Sampling Plan Addendum. This memo has been updated with additional information, as requested by Ecology in the 25 September meeting.

Sampling was conducted on the impact berm at the Evergreen former Infiltration Range and soil analyzed using both analytical laboratory and XRF methodologies, as presented below. Both sets of date were used to determine the correlation between the XRF and analytical laboratory results and appropriate XRF protocols for use in future rounds of sampling. A summary of the correlation, precision sample results and field duplicate comparison results are presented below.

2.0 SUMMARY OF FIELD ACTIVITIES

As part of the first round of sampling for this project, soil samples were collected from 20 sample locations on three areas of the impact berm: the impact zone, below the impact zone and at the bottom of the berm. Figure 1 of Appendix A presents the sampling locations on the Evergreen impact berm. Two composite soil samples were collected at each location by compositing soils from similar depths from each of the holes. Sampling intervals were from 0 to 1 foot and from 1 foot to 2 feet at each sampling location. Fourteen samples were collected from the impact zone, 14 from below the impact zone, and 12 from the bottom of the berm.

Each composite sample was sieved through a No. 10 sieve then placed into a gallon-sized plastic baggie and bag homogenized   A cup aliquot was collected from each sample and measured by XRF and submitted to Severn Trent Laboratories (STL) for analysis of lead, arsenic, copper, antimony, zinc, tin, and iron using EPA Method 6010/6020.

In addition, four co-located field duplicate locations were sampled and analyzed by XRF to determine field variability during the DMA. Three additional field duplicates were collected during the following site characterization sampling event.

Sampling conditions encountered at the site included considerable tree growth at the bottom of the berm, loose upper layers of soil within the impact zone and the middle of the berm that sloughed continually, as well as numerous gravel from small pebbles to large cobbles, encountered from approximately 0.5 ft to 2 ft bgs.

3.0 EVALUATION OF LABORATORY vs. XRF DATA

A summary of the XRF and laboratory results is presented below. There results were used to determine appropriate XRF methodologies for use in future sampling events for the former Small Arms Ranges RI project.

3.1 Comparison of XRF to Laboratory Results

The sample results from both the XRF and laboratory analyses for each sample were compared to evaluate the correlation between the two methodologies. Table 1 of Appendix C presents the XRF and fixed lab cup analyses results for lead collected during the DMA. Figures 2 and 3 of Appendix B present the correlation of laboratory data to the entire lead data set and the 0 to 1000 mg/kg data sub-set. A summary of the correlations is presented below.

3.1.1 Correlations

As shown on Figure 2, the correlation between XRF and laboratory analyses lead results was linear. The correlation coefficient (r^2) factor for the entire sample set was 0.96. The average ratio of laboratory to XRF lead results was 1.3, with a 99^{th} UCL of 1.6 for this ratio. The correlation for the data sub-set of 0 to 1000 mg/kg, presented in Figure 3, was also linear with an r^2 value of 0.84 and an average ration of laboratory to XRF lead results of 1.07 with a 99^{th} UCL of 1.6.

3.1.2 Correlations Near Detection Levels

Per Ecology request, additional correlation samples were submitted for ICP analyses from samples below detection limit when measured by the XRF. This information was used to evaluate the accuracy of the XRF near the detection limit. A summary of the results is presented in Table 3, Appendix C. Only one sample submitted had fixed laboratory concentrations above the reporting limit. This information cannot be added to the correlation, since the XRF was all not detected.

3.2 Laboratory Results for Other Metals

Review of the laboratory analysis of the sample aliquots for metals presented in Table 2 of Appendix C indicates that lead is the primary contaminate. Antimony and copper exceedances were detected only when lead was above 250 mg/kg. Arsenic, tin, and zinc had no exceedances.

3.3 Recommendations for Data Comparison

Based on the uncertainty of XRF values near the action level, collaborative sampling was conducted on XRF equivalent concentrations near the action level to verify appropriate remedial actions are selected. Since the XRF and ICP measurements correlated with the exception of one sample, the XRF method detection level is deemed suitable for screening near the potential action level of 50 mg/kg. However, collaborative samples may be submitted for ICP analyses for XRF concentrations near detection limits depending on site conditions and potential remedial options.

Based on the XRF and laboratory analytical data it is lead contamination will drive remedial actions for the Evergreen former infiltration range and the Miller Hill former pistol range. Therefore, it is recommended that collaborative analysis be limited for lead for theses ranges, as needed.

As a different type of ammunition was used at the Skeet Range it is recommended that initial collaborative analysis include all metals (antimony, copper, iron, lead, tin, zinc and arsenic) until is it determined whether lead is the primary contaminate at this site.

4.0 XRF DATA

Precision samples and co-located field duplicates were collected and XRF analyzed in order to determine within sample variability and field variability. Each precision sample was analyzed seven times by XRF. An RSD was determined for each precision sample.

Four co-located field duplicates were chosen for comparison with the primary samples. An RPD was determined for the field duplicates and primary samples.

4.1 Precision Samples

Results for the precision samples are presented in Table 4 in Appendix C (updated to include new data from Evergreen Range). Thirty eight percent of the RSD values are greater than 20% recommended in the SAP Addendum. Within sample variability may affect decision when sample results are near the action levels.

4.2 Co-located Field Duplicates

Results of the field duplicated are presented in Table 5 in Appendix C (updated to include new data). Five out of seven RPD values exceed 50%. Within field variability may affect decision when sample results are near the action levels.

5.0 RECOMMENDATION FOR XRF SAMPLING STRATEGY REVISIONS

Based on the review of the sampling data collected from the first round of sampling (September 2, 2003), the following modifications to protocols have been recommended for future sampling rounds. Additional modifications may be determined during subsequent rounds of sampling.

To focus on reducing uncertainty near the action levels:

1. Analyze precision samples when primary result is near the action levels relevant to decision making based on distribution data (below detection to 100 mg/kg; 200 to 300 mg/kg; and 900 to 1200 mg/kg). When focusing on potential remedial boundaries, if the precision sample average within matrix variability falls within the uncertainty region surrounding the action levels, then:

2. Collect and measure a XRF cup sample from the precision sample for comparison with the precision sample. If within matrix variability is appreciably different, evaluate the need for co-located field duplicate 2 feet from primary sample based on decision uncertainty.

3. Collect collaborative samples for fixed laboratory analysis on as needed basis focusing on XRF samples measured near the detection limit.

4. Evaluate options for collecting samples from the 2 to 3 foot depth interval at the site.

APPENDIX A
DMA SOIL SAMPLING
LOCATION MAP

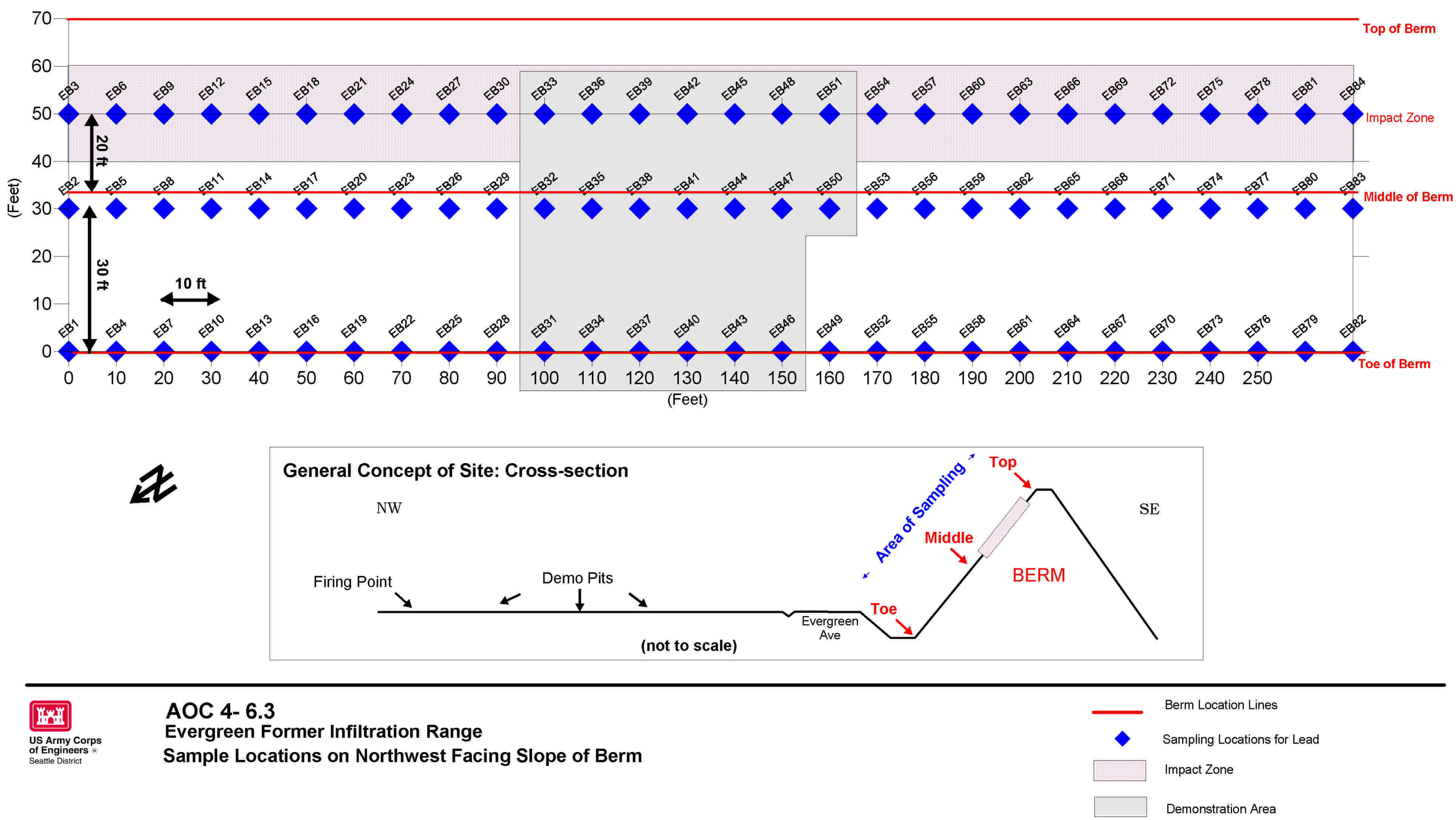

Figure 1. Sampling Grid For DMA at Impact Berm at the Evergreen Infiltration Range (AOC 4-6).

APPENDIX B
DMA SOIL SAMPLE
XRF CORRELATION
FIGURES

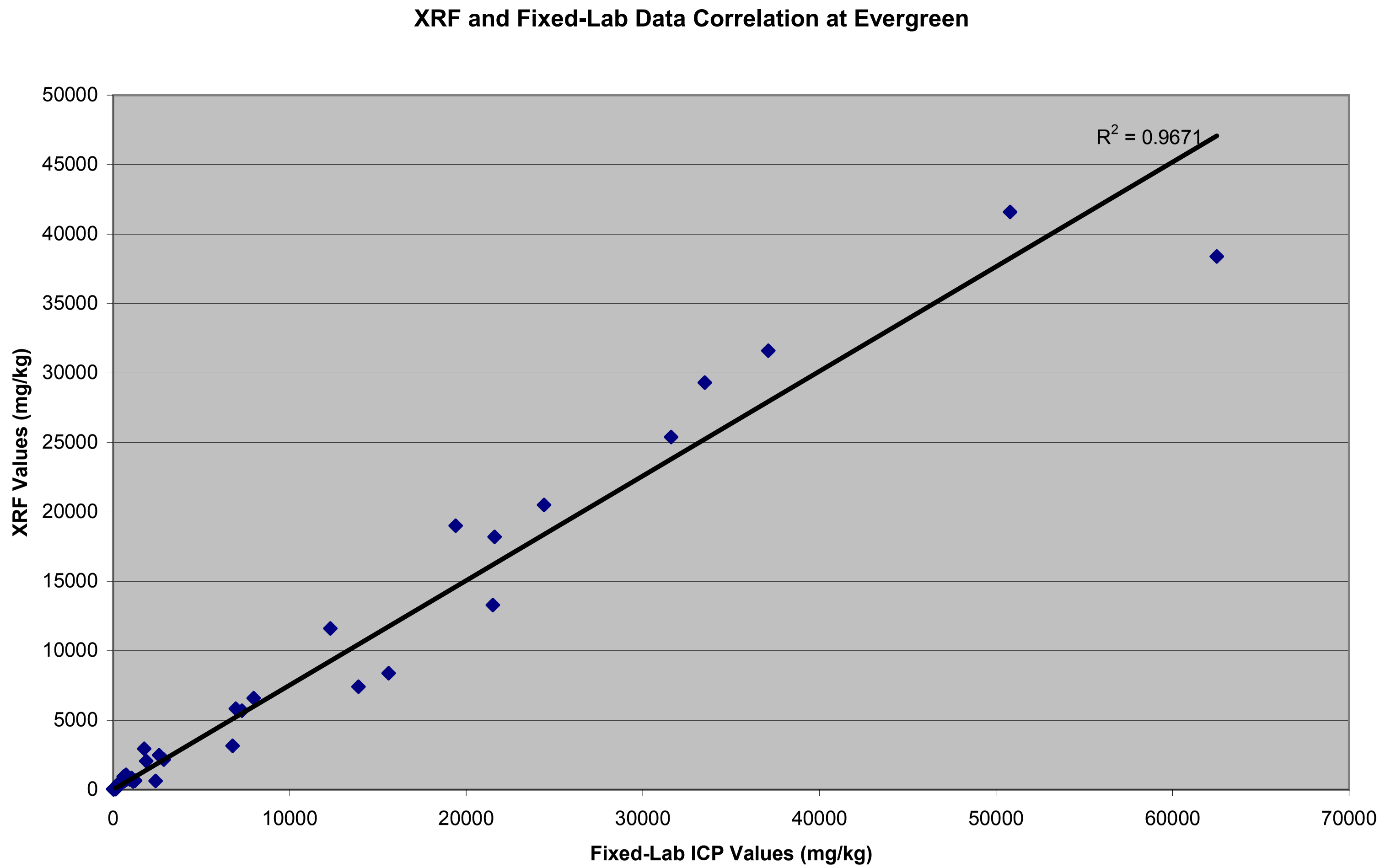

Figure 2. XRF Correlation to Fixed Laboratory Analyses (updated to include all data from the Evergreen Berm)

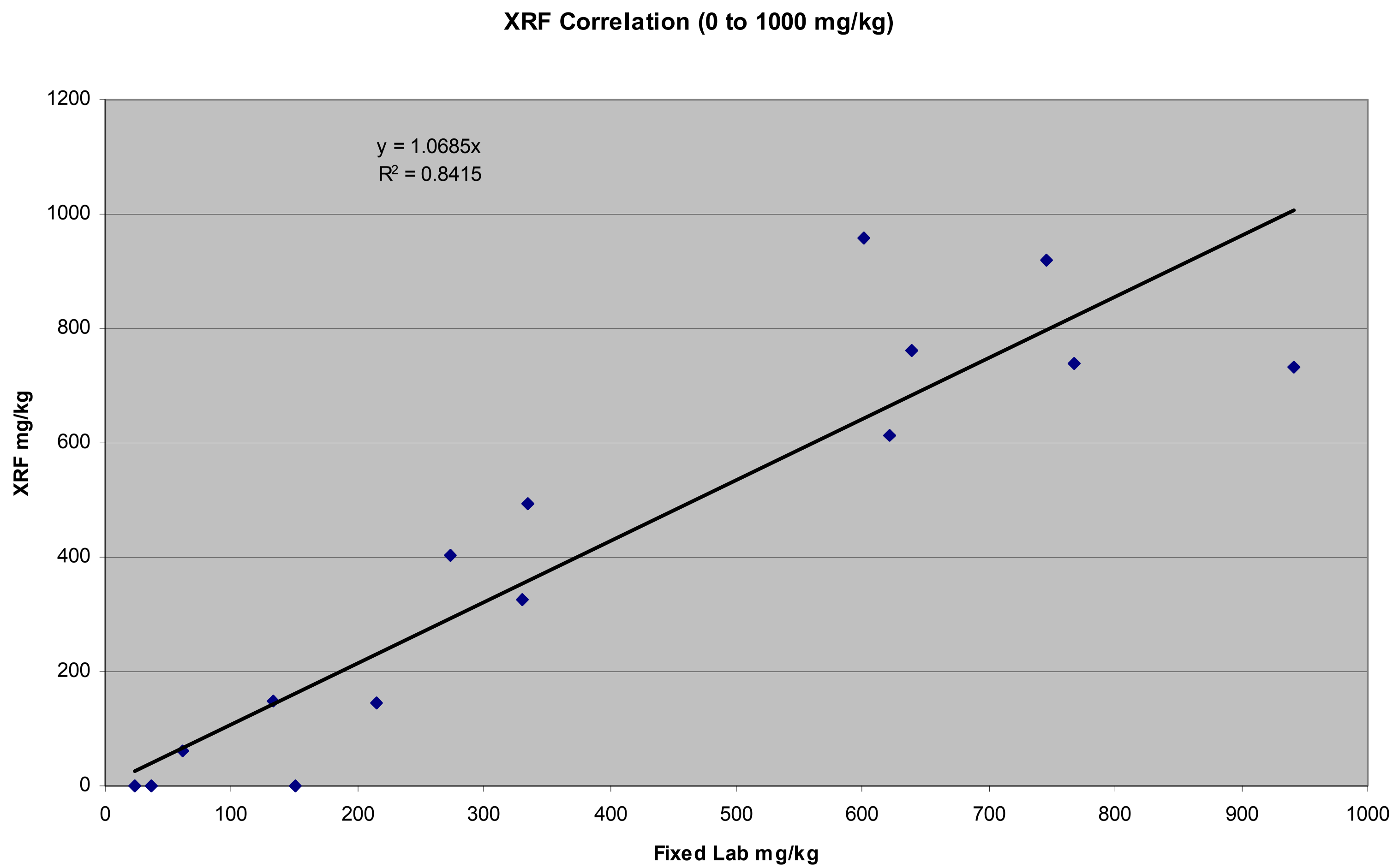

Figure 3. XRF Correlation within the 0 to 1000 mg/kg data subset

APPENDIX C
DATA SUMMARY TABLES

Table 1. DMA XRF Primary Samples and Collaborative Lab Analyses Data

Sample ID	XRF (mg/kg)	Fixed-lab (mg/kg)	Depth In Inches	Location on Berm
EB31S-1	613	622	0-12	Bottom
EB31S-2	**45**	150	12-24	Bottom
EB32S-1	11600	12300	0-12	Middle
EB32S-2	2940	1750	12-24	Middle
EB33S-1	18200	21600	0-12	Impact
EB33S-2	3170	6770	12-24	Impact
EB34S-1	492	335	0-12	Bottom
EB34S-2	148	133	12-24	Bottom
EB35S-1	2490	2610	0-12	Middle
EB35S-2	630	2410	12-24	Middle
EB36S-1	13300	21500	0-12	Impact
EB36S-2	2180	2870	12-24	Impact
EB37S-1	404	274	0-12	Bottom
EB37S-2	**45**	23.4	12-24	Bottom
EB38S-1	25400	31600	0-12	Middle
EB38S-2	6590	7960	12-24	Middle
EB39S-1	5830	6940	0-12	Impact
EB39S-2	600	1130	12-24	Impact
EB40S-1	918	746	0-12	Bottom
EB40S-2	326	331	12-24	Bottom
EB41S-1	2060	1870	0-12	Middle
EB41S-2	738	768	12-24	Middle
EB42S-1	31600	37100	0-12	Impact
EB42S-2	5680	7290	12-24	Impact
EB43S-1	762	639	0-12	Bottom
EB43S-2	958	601	12-24	Bottom
EB44S-1	1070	726	0-12	Middle
EB44S-2	732	941	12-24	Middle
EB45S-1	29300	33500	0-12	Impact
EB45S-2	7420	13900	12-24	Impact
EB46S-1	144	215	0-12	Bottom
EB46S-2	62.2	61.5	12-24	Bottom
EB47S-1	20500	24400	0-12	Middle
EB47S-2	650	1250	12-24	Middle
EB48S-1	41600	50800	0-12	Impact
EB48S-2	19000	19400	12-24	Impact
EB50S-1	838	1040	0-12	Middle
EB50S-2	**45**	36.6	12-24	Middle
EB51S-1	38400	62500	0-12	Impact
EB51S-2	8380	15600	12-24	Impact

Note: A bold value indicated a reading below the detection level.

Table 2. Fixed Laboratory ICP Analyses Results for DMA

Parameter	Antimony		Copper	Iron	Lead	Tin		Zinc	Arsenic
Method A/B	32		2960	na	250	48000		24000	20
EB31S1	8.85 U	U	45.6	16400	**622**	8.85	U	33.1	6.35
EB31S2	9.16	U	24.8	16700	150	9.16		30	4.1
EB32S1	207		309	16000	**12300**	13.6		63.6	5
EB32S2	**34.9**		66.6	15800	**1750**	9.77	U	35.8	3.56
EB33S1	**287**		454	14800	**21600**	5.09		85.3	4.65
EB33S2	**87.7**		139	16700	**6770**	8.58	U	66.2	3.59
EB34S1	9.85	U	40.9	14000	**335**	9.85	U	32.4	4.24
EB34S2	10	U	30.2	17000	133	10	U	30.9	4.52
EB35S1	**46.4**		91.4	16000	**2610**	10.1	U	35.2	3.54
EB35S2	31.9		46.6	16700	**2410**	9.56	U	33.5	3.99
EB36S1	**369**		358	16500	**21500**	20.9		59.3	6.69
EB36S2	**58.4**		76	15400	**2870**	9.56	U	31.2	3.83
EB37S1	9.3	U	33.9	14300	**274**	9.3	U	26.6	3.83
EB37S2	9.29	U	21.2	16400	23.4	9.29	U	26.9	3.01
EB38S1	**634**		916	18000	**31600**	47.7		110	10.8
EB38S2	**192**		242	17800	**7960**	7.01		58.1	5.68
EB39S1	**149**		155	19500	**6940**	7.22	J	48.1	5.27
EB39S2	29.7		47.2	16300	**1130**	9.15	U	29.8	3.39
EB40S1	8.18		56.3	15700	**746**	9.85	U	31.7	4.92
EB40S2	9.28	U	44.7	17600	**331**	9.28	U	32	4.13
EB41S1	**42.1**		78.4	15500	**1870**	9.34	U	37.1	4.37
EB41S2	16.4		39.3	16900	**768**	10.2	U	31.3	3.87
EB42S1	**673**		1330	18600	**37100**	40.5		176	10.8
EB42S2	**140**		233	15400	**7290**	7.76		70.2	4.61
EB43S1	8.89	U	57.7	14700	**639**	8.89	U	31	4.8
EB43S2	10.2	U	48.1	14100	**601**	10.2	U	30.2	4.43
EB44S1	18.4		39.8	15900	**726**	9.41	U	34.2	3.99
EB44S2	21.8		51.8	16800	**941**	10.2	U	30.3	3.67
EB45S1	**727**		997	16800	**33500**	34.8		139	11.5
EB45S2	**213**		273	15400	**13900**	10		57.4	4.42
EB46S1	10.1	U	35.5	15400	215	10.1	U	28.2	4.46
EB46S2	9.98	U	28.5	16300	61.5	9.98	U	30.1	3.97
EB47S1	**427**		**25100**	17100	**24400**	15.8		2560	9.33
EB47S2	23.8		217	16300	**1250**	9.55	U	33.9	4.24

Parameter	Antimony		Copper	Iron	Lead	Tin		Zinc	Arsenic
Method A/B	32		2960	na	250	48000		24000	20
EB48S2	**269**		527	17500	**19400**	6.11		109	6.79
EB50S1	16.1		107	16100	**1040**	8.78	U	32.2	3.95
EB50S2	9.25	U	69.6	16700	36.6	ND		28	3.41
EB51S1	**879**		804	15100	**62500**	42.2		117	15.3
EB51S2	**217**		308	14800	**15600**	6.48		76.3	4.12

Table 3. XRF Non-detects and Fixed-Lab Analyses for Evergreen Berm

Sample ID	XRF Cup Value (mg/kg)	Prec (±)	Fixed-Lab Value (mg/kg)	Depth (in)
EB31S2	**45**	53	150	12-24
EB37S2	**45**	53	23.4	12-24
EB50S2	**45**	51	36.6	12-24
EB87S2	**45**	51	12.2	12-24
EB88S1	**45**	57	34	0-12
EB88S2	**45**	56	4.77	12-24
EB91S1	**45**	56	47	0-12
EB91S2	**45**	56	35.7	12-24
EB92S2	**45**	55	9.8	12-24
EB93S2	**45**	55	18.3	12-24
EB94S1	**45**	54	22.2	0-12
EB94S2	**45**	56	14.9	12-24
EB96S1	**45**	53	37.5	0-12
EB96S2	**45**	53	15.1	12-24
EB97S1	**45**	52	30.8	0-12
EB97S2	**45**	53	24.5	12-24

Table 4. Precision Sample XRF Results (in mg/kg) and RSD (includes all data from Evergreen Berm)

Sample ID	XRF Value 1	XRF Value 2	XRF Value 3	XRF Value 4	XRF Value 5	XRF Value 6	XRF Value 7	Mean	SD	RSD	Location
EB1S1	290	269.2	150.1	158.5	418	191.7	256.2	248	93	38	Toe
EB1S1D	79.8	261.4	169.9	182.4	144.9	199.5	270.6	187	66	35	Toe
EB1S2	**45**	**45**	**45**	**45**	**45**	**45**	114	55	26	48	Toe
EB2S2	136.4	68.1	76.5	56.5	76.9	149.2	120.4	98	37	38	Middle
EB4S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB7S1	109.3	45	77.5	98	86.2	72.8	68.6	80	21	26	Toe
EB7S2	**45**	**45**	**45**	71.2	**45**	**45**	**45**	49	10	20	Toe
EB10S1	61.2	**45**	79.5	**45**	71.1	**45**	**45**	56	15	26	Toe
EB10S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB13S1	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB13S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB16S2	172.6	144.5	186.5	104.4	163.4	159.8	169.2	157	27	17	Toe
EB19S2	**45**	72.6	**45**	74.7	**45**	**45**	**45**	53	14	26	Toe
EB20S1	1040	1080	971.2	1040	1020	1089.6	1140	1054	54	5	Middle
EB22S1	233.2	301	401.8	382.6	308.4	390	422	348	69	20	Toe
EB22S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB25S1	234.4	238.6	316	222	216	284.6	197.7	244	42	17	Toe
EB25S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB28S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB31S1	700	526	598	599	407	454	477	537	101	19	Toe
EB31S2	45	45	45	45	45	57	45	47	5	10	Toe
EB33S1	11700	13800	12800	13800	15100	15900	18400	14500	2208	15	Toe
EB33S2	1780	2190	2380	2550	2670	2400	2290	2323	287	12	Toe
EB33S1D	911	892	1120	1480	1430	1690	1930	1350	394	29	Middle
EB33S2D	339	572	355	560	532	287	556	457	124	27	Middle

EB34S1	486	455	436	278	331	500	496	426	87	21	Impact
EB34S1D	345	318	421	316	314	255	371	334	52	16	Impact
EB34S2	71.4	141	132	122	109	54.2	80.6	101	33	33	Toe
EB34S2D	**45**	68.7	**45**	**45**	**45**	**45**	**45**	48	9	19	Toe
EB35S1	2620	2080	4740	2020	2040	1630	2920	2579	1044	40	Middle
EB35S2	522	576	556	509	488	557	636	549	49	9	Middle
EB36S1	10100	10400	9140	11600	8930	9960	9890	10003	878	9	Impact
EB36S2	1450	770	1070	1290	1570	1560	1380	1299	290	22	Impact
EB40S1	834	604	571	546	684	621	568	633	100	16	Toe
EB40S2	276	148	288	185	299	219	202	231	58	25	Toe
EB41S1	1290	1390	1300	1630	1210	1310	1670	1400	179	13	Middle
EB41S2	813	575	683	765	514	496	491	620	134	22	Middle
EB42S1	26700	25700	26500	27500	28000	26200	28300	26986	967	4	Middle
EB42S2	5570	5600	5720	5460	6870	4210	5250	5526	781	14	Middle
EB43S1	973	608	700	573	1040	695	651	749	183	24	Toe
EB43S2	300	331	294	271	333	405	364	328	46	14	Toe
EB44S1	671	538	450	905	683	696	769	673	148	22	Toe
EB44S1D	1530	1490	1370	1080	1310	1590	1180	1364	188	14	Toe
EB44S2	708	772	577	736	606	734	781	702	80	11	Toe
EB44S2D	95.6	257	120	189	134	159	82.1	148	60	41	Toe
EB46S1	295	233	278	349	233	251	220	266	45	17	Toe
EB46S2	**45**	**45**	89.8	**45**	98.2	**45**	75.2	63	24	38	Toe
EB52S1	238.2	221	224.2	260.2	358.6	247.4	193.8	249	53	21	Toe
EB52S2	**45**	**45**	102.1	74.5	**45**	134.3	129.4	82	40	49	Toe
EB55S1	302.4	218.4	239.2	367	298.4	500.8	241	310	98	32	Middle
EB55S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB58S2	**45**	82.2	**45**	111.1	102.9	**45**	**45**	68	30	44	Toe
EB61S1	405	363.8	426	398.2	244.8	398.2	318.8	365	63	17	Toe

EB61S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Middle
EB64S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB65S2	265.6	250.2	324.6	293.8	281.8	236.8	276.6	276	29	10	Toe
EB67S1	108.2	**45**	110	82	**45**	**45**	112.5	78	33	42	Toe
EB70S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB73S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Toe
EB74S2	192.1	197.7	214.6	201.9	273.2	287.4	217.2	226	38	17	Middle
EB76S1	**45**	**45**	70.2	59.2	**45**	**45**	**45**	51	10	20	Impact
EB76S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	Side of Berm
EB79S1	**45**	92.3	76.6	116.1	61.3	98.7	55	78	26	33	Side of Berm
EB79S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	In front of Berm
EB82S1	199	194.4	250	196.4	191.2	158.8	165.5	194	30	15	In front of Berm
EB83S2	121.9	146.1	112.8	106.5	111.3	166.4	145.3	130	23	17	In front of Berm
EB84S2	**45**	97.9	**45**	**45**	**45**	**45**	**45**	53	20	38	In front of Berm
EB87S1	**45**	71.3	**45**	64.3	56.8	**45**	54.1	55	10	19	NE arm of Berm
EB87S2	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	NE arm of Berm
EB90S1	**45**	115.2	83.7	144.8	99.1	105.1	**45**	91	37	40	In front of Berm
EB92S1	83.6	85.7	78.4	78.4	180.2	87.8	108.7	100	37	37	In front of Berm
EB92S2	**45**	**45**	**45**	**45**	60.8	**45**	**45**	47	6	13	In front of Berm
EB94S1	**45**	**45**	**45**	**45**	**45**	**45**	**45**	45	0	0	In front of Berm

Note: A bold value indicated a reading below the detection level.

Table 5. Primary Sample and Field Duplicate Comparison (updated to include all data from Evergreen Berm)

Sample ID	XRF Value 1	XRF Value 2	XRF Value 3	XRF Value 4	XRF Value 5	XRF Value 6	XRF Value 7	Mean	Primary/Dup Mean	SD	RPD
EB33S1	11700	13800	12800	13800	15100	15900	18400	14500	7925	2208	165.92
EB33S1D	911	892	1120	1480	1430	1690	1930	1350		394	
EB33S2	1780	2190	2380	2550	2670	2400	2290	2323	1390	287	134.21
EB33S2D	339	572	355	560	532	287	556	457		124	
EB34S-1	486	455	436	278	331	500	496	426	380	87	24.13
EB34S-1D	345	318	421	316	314	255	371	334		52	
EB34S-2	71.4	141	132	122	109	54.2	80.6	101	75	33	70.84
EB34S-2D	**45**	68.7	**45**	**45**	**45**	**45**	**45**	48		9	
EB44S-1	671	538	450	905	683	696	769	673	1019	148	67.84
EB44S-1D	1530	1490	1370	1080	1310	1590	1180	1364		188	
EB44S-2	708	772	577	736	606	734	781	702	425	80	130.31
EB44S-2D	95.6	257	120	189	134	159	82.1	148		60	
EB1S-1	290	134	150.1	158.5	418	191.7	256.2	228	208	101	19.36
EB1S-1D	79.8	269.2	169.9	182.4	144.9	199.5	270.6	188		68	

Note: A bold value indicated a reading below the detection level.