

# E

## Sediment Exposure Point Concentrations



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## Appendix E

### Sediment Exposure Point Concentrations for BERA Supplement

This appendix presents exposure point concentrations (EPCs) for metals for sediment samples collected from the Kuskokwim River in 2010, 2011, 2012, and 2015 from Red Devil Creek delta downstream to Red Devil Village (see Table E-1). The assessment area and sediment sample locations are shown in Figures 5-1 and 5-2. Eighty one (81) sediment samples, including field duplicate samples, were collected from the assessment area. The data for these samples were presented previously in E & E (2014, 2016). Two samples -- 10KR02SD and 15KR085SD -- were collected from the same physical location, so only the results for the more recently collected sample, 15KR085SD, were used when calculating EPCs.

For the analytes evaluated in this assessment, a weighted 95% upper confidence limit (UCL) on the average concentration was used as the sediment EPC. A weighted UCL is recommended in situations where sampling density and contaminant levels vary markedly across the area being evaluated (ITRC 2018). In the Kuskokwim River assessment area, sampling density is high near the RDM and low in other parts of the assessment area (see Figures 5-1 and 5-2). And, levels of site-related contaminants in sediment typically are high near the RDM and low in downriver and cross-river areas (E & E 2016). For these reasons, the sediment data were divided into two areas for calculation of a weighted UCL:

1. Area near the RDM where sampling density is high, including all samples from 2010, 2011, and 2012 and the few 2015 samples interspersed with the earlier samples (see Figure 5-2); henceforth, referred to as the near-RDM area.
2. Downriver, mid-river, and cross-river area that includes only widely spaced 2015 samples (see Figure 5-1); henceforth, referred to as the downriver area.

UCLs for these two sample groups were calculated using ProUCL version 5.1 (EPA 2015a, b) and combined into a weighted UCL as described below. Outliers were identified and handled in a manner consistent with EPA (2015a) guidance. Field duplicate results were treated as per ADEC (2008) guidance (i.e., the higher result of the primary and duplicate sample was used). As described below, two sets of weighted EPCs were developed, one based on sediment samples collected from all depths in the assessment area and a second set based on shoreline and nearshore samples.

#### E.1 Complete (All Sample Depths) Sediment Dataset

To assess potential risks to fish-eating wildlife (mink and kingfisher), Kuskokwim River sediment samples collected from all water depths were used. The forage fish consumed by these receptors may consume benthic macroinvertebrates at any depth. Eighty sediment samples, including field duplicates, were included in this dataset. To develop a weighted EPC for the entire assessment area, ProUCL first was used to calculate separate UCLs for the near-RDM and downriver sample groups. A weighted average of the near-RDM and downriver UCLs was then calculated based on the fraction of the total assessment area (156.2 ha) represented by the near-RDM (8.24 ha) and downriver (147.96 ha) areas. For example, for antimony, the near-RDM and downriver UCLs are 415.8 and 3.53 mg/kg, respectively. The area-weighted UCL for antimony for the entire assessment area is 25.4 mg/kg, calculated as follows:

$$(415.8 \text{ mg/kg} \times [8.24 \text{ ha} / 156.2 \text{ ha}]) + (3.53 \text{ mg/kg} \times [147.96 \text{ ha} / 156.2 \text{ ha}]) = 25.4 \text{ mg/kg}$$

Table E-1 lists the sediment EPCs for all analytes for the complete (all depths) sediment dataset.

## E.2 Shoreline and Nearshore Sediment Dataset

When assessing potential risks for invertivorous shorebirds (common snipe) and herbivorous waterfowl (green-winged teal), only shoreline and nearshore (< 2 feet water depth between early May and mid-October) sediment samples from the Kuskokwim River were used to estimate exposure. Twenty five (25) sediment samples, including field duplicates, were included in this dataset. To develop an EPC for the entire assessment area, ProUCL first was used to calculate separate UCLs for the near-RDM and downriver sample groups. A weighted average of the near-RDM and downriver UCLs was then calculated based on the fraction of the total assessment area shoreline length (4.11 miles) represented by the near-RDM area (0.65 miles) and downriver area (3.46 miles, both banks summed). For example, for antimony, the near-RDM and downriver UCLs are 1281 and 1.75 mg/kg, respectively. The length-weighted UCL for antimony for the entire assessment area is 204 mg/kg, calculated as follows:

$$(1281 \text{ mg/kg} \times [0.65 \text{ mi.} / 4.11 \text{ mi.}]) + (1.75 \text{ mg/kg} \times [3.46 \text{ mi.} / 4.11 \text{ mi.}]) = 204 \text{ mg/kg}$$

Table E-1 lists the sediment EPCs for all analytes for the shoreline/nearshore sediment dataset.

## References

Alaska Department of Environmental Conservation (ADEC). 2008. *Guidelines for Data Reporting, Data Reduction, and Treatment of Non-Detect Results*, Technical Memorandum 08-001, prepared by Alaska DEC, Division of Spill Prevention and Response, Contaminated Sites Program, 12 August 2008.

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United States Environmental Protection Agency (USEPA). 2015a. ProUCL Version 5.1 Technical Guide, EPA/600/R-07/041.

\_\_\_\_\_. 2015b. ProUCL Version 5.1 User Guide. EPA/600/R-07/041.

**Table E-1. Summary of ProUCL Output and Exposure Point Concentrations for Kuskokwim River Sediment, Red Devil Mine Site BERA Supplement.**

Analyte	Sample Depths	General Location	Units	Number of Observations	Number of Detections	Mean of Detected	SD of Detected	Maximum Detected	Distribution (detects only)	UCL Statistic	95% UCL	EPC	EPC Source	Area or Length Weighted EPC for Assessment Area <sup>a</sup>
Aluminum	All Depths	Near RDC	mg/kg	65	65	6957	3189	18400	Not Discernable	95% Chebyshev (Mean, Sd) UCL	8681	8681	95% UCL	7957
		Downriver	mg/kg	8	8	5538	2415	11000	Gamma	95% Adjusted Gamma UCL	7916	7916	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	9472	4126	18400	Normal	95% Student's-t UCL	11164	11164	95% UCL	9137
		Downriver	mg/kg	5	5	6140	2745	11000	Not Discernable	95% Student's-t UCL	8757	8757	95% UCL	
Antimony	All Depths	Near RDC	mg/kg	65	62	172.1	475	3100	Lognormal	95% KM (Chebyshev) UCL	415.8	415.8	95% UCL	25.4
		Downriver	mg/kg	8	8	1.223	1.383	4.2	Gamma	95% Adjusted Gamma UCL	3.53	3.53	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	15	249.6	791.7	3100	Lognormal	97.5% KM (Chebyshev) UCL	1281	1281	95% UCL	203.9
		Downriver	mg/kg	5	5	1.034	0.755	2	Normal	95% Student's-t UCL	1.754	1.754	95% UCL	
Arsenic	All Depths	Near RDC	mg/kg	65	65	180.4	361.4	2100	Lognormal	95% CLT UCL	254.1	254.1	95% UCL	27.0
		Downriver	mg/kg	8	8	10.34	5.843	23	Normal	95% Student's-t UCL	14.25	14.25	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	242	503.5	2100	Lognormal	95% Chebyshev (Mean, Sd) UCL	759.3	759.3	95% UCL	130.2
		Downriver	mg/kg	5	5	9.88	2.395	14	Normal	95% Student's-t UCL	12.16	12.16	95% UCL	
Barium	All Depths	Near RDC	mg/kg	65	65	124	76.67	520	Not Discernable	95% Chebyshev (Mean, Sd) UCL	165.5	165.5	95% UCL	77.2
		Downriver	mg/kg	8	8	64.75	11.22	82	Normal	95% Student's-t UCL	72.27	72.27	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	155	96.13	520	Not Discernable	95% Student's-t UCL	194.4	194.4	95% UCL	91.7
		Downriver	mg/kg	5	5	67.2	5.45	74	Normal	95% Student's-t UCL	72.4	72.4	95% UCL	
Beryllium	All Depths	Near RDC	mg/kg	65	65	0.385	0.16	0.8	Normal	95% Student's-t UCL	0.418	0.418	95% UCL	0.297
		Downriver	mg/kg	8	8	0.226	0.0958	0.41	Normal	95% Student's-t UCL	0.29	0.29	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	0.464	0.171	0.8	Normal	95% Student's-t UCL	0.534	0.534	95% UCL	0.367
		Downriver	mg/kg	5	5	0.242	0.0988	0.41	Normal	95% Student's-t UCL	0.336	0.336	95% UCL	
Cadmium	All Depths	Near RDC	mg/kg	65	63	0.312	0.178	1.1	Gamma	95% KM Approximate Gamma UCL	0.345	0.345	95% UCL	2.67
		Downriver	mg/kg	8	8	0.513	0.929	2.8	Not Discernable	95% Hall's Bootstrap UCL	6.309	2.8	Max Det	
	< 2 ft	Near RDC	mg/kg	18	16	0.347	0.0975	0.6	Normal	95% KM (t) UCL	0.369	0.369	95% UCL	2.42
		Downriver	mg/kg	5	5	0.738	1.159	2.8	Gamma	95% Adjusted Gamma UCL	8.516	2.8	Max Det	
Chromium	All Depths	Near RDC	mg/kg	65	65	18.57	6.08	36	Normal	95% Student's-t UCL	19.83	19.83	95% UCL	18.7
		Downriver	mg/kg	8	8	15.35	4.925	25	Normal	95% Student's-t UCL	18.65	18.65	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	21.44	6.377	36	Normal	95% Student's-t UCL	24.05	24.05	95% UCL	21.9
		Downriver	mg/kg	5	5	17.4	4.336	25	Normal	95% Student's-t UCL	21.53	21.53	95% UCL	
Cobalt	All Depths	Near RDC	mg/kg	65	65	10.37	4.578	27	Not Discernable	95% Chebyshev (Mean, Sd) UCL	12.85	12.85	95% UCL	9.61
		Downriver	mg/kg	8	8	7.163	3.382	14	Normal	95% Student's-t UCL	9.428	9.428	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	11.69	4.998	27	Normal	95% Student's-t UCL	13.74	13.74	95% UCL	11.6
		Downriver	mg/kg	5	5	7.88	3.529	14	Normal	95% Student's-t UCL	11.24	11.24	95% UCL	
Copper	All Depths	Near RDC	mg/kg	65	65	28.52	17.68	87.5	Gamma	95% Approximate Gamma UCL	32.7	32.7	95% UCL	29.5
		Downriver	mg/kg	8	8	18.05	19.32	64	Lognormal	95% CLT UCL	29.28	29.28	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	30.55	14.49	63	Gamma	95% Adjusted Gamma UCL	37.59	37.59	95% UCL	59.8
		Downriver	mg/kg	5	5	21.86	23.59	64	Not Discernable	95% Chebyshev (Mean, Sd) UCL	67.84	64	Max Det	
Iron	All Depths	Near RDC	mg/kg	65	65	27868	12156	66000	Normal	95% Student's-t UCL	30384	30384	95% UCL	18469
		Downriver	mg/kg	8	8	14038	5620	24000	Normal	95% Student's-t UCL	17802	17802	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	30744	8458	48100	Normal	95% Student's-t UCL	34213	34213	95% UCL	25614
		Downriver	mg/kg	5	5	14800	5263	24000	Gamma	95% Adjusted Gamma UCL	25242	24000	Max Det	
Lead	All Depths	Near RDC	mg/kg	65	65	7.391	3.441	18	Normal	95% Student's-t UCL	8.104	8.104	95% UCL	6.31
		Downriver	mg/kg	8	8	4.425	2.66	9.9	Normal	95% Student's-t UCL	6.207	6.207	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	8.808	2.396	16	Normal	95% Student's-t UCL	9.791	9.791	95% UCL	9.88
		Downriver	mg/kg	5	5	4.94	2.835	9.9	Gamma	95% Adjusted Gamma UCL	11.77	9.9	Max Det	

**Table E-1. Summary of ProUCL Output and Exposure Point Concentrations for Kuskokwim River Sediment, Red Devil Mine Site BERA Supplement.**

Analyte	Sample Depths	General Location	Units	Number of Observations	Number of Detections	Mean of Detected	SD of Detected	Maximum Detected	Distribution (detects only)	UCL Statistic	95% UCL	EPC	EPC Source	Area or Length Weighted EPC for Assessment Area <sup>a</sup>
Manganese	All Depths	Near RDC	mg/kg	65	65	898.2	850.7	5410	Lognormal	95% CLT UCL	1072	1072	95% UCL	448.9
		Downriver	mg/kg	8	8	343.8	104.9	510	Normal	95% Student's-t UCL	414	414	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	897	1141	5410	Not Discernable	95% Chebyshev (Mean, Sd) UCL	2069	2069	95% UCL	680.5
		Downriver	mg/kg	5	5	322	105.9	420	Normal	95% Student's-t UCL	423	420	Max Det	
Mercury	All Depths	Near RDC	mg/kg	64	63	19.55	53.26	310	Lognormal	95% KM (Chebyshev) UCL	48.07	48.07	95% UCL	4.54
		Downriver	mg/kg	8	7	0.386	0.761	2.1	Gamma	95% KM Bootstrap t UCL	2.982	2.1	Max Det	
	< 2 ft	Near RDC	mg/kg	18	18	42.48	93.06	310	Lognormal	99% Chebyshev (Mean, Sd) UCL	260.7	260.7	95% UCL	43.0
		Downriver	mg/kg	5	5	0.509	0.895	2.1	Gamma	95% Adjusted Gamma UCL	10.86	2.1	Max Det	
Methylmercury	All Depths	Near RDC	µg/kg	32	29	0.865	0.872	3.73	Gamma	95% KM Adjusted Gamma UCL	1.149	1.149	95% UCL	0.111
		Downriver	µg/kg	5	2	0.036	0.024	0.053	Insufficient Data	Insufficient Data	--	0.053	Max Det	
	< 2 ft	Near RDC	µg/kg	17	15	0.87	1.008	3.73	Gamma	95% KM Adjusted Gamma UCL	1.532	1.532	95% UCL	0.250
		Downriver	µg/kg	4	1	0.01	--	0.01	Insufficient Data	Insufficient Data	--	0.01	Max Det	
Nickel	All Depths	Near RDC	mg/kg	65	65	31.17	13.67	67	Not Discernable	95% Chebyshev (Mean, Sd) UCL	38.57	38.57	95% UCL	28.6
		Downriver	mg/kg	8	8	21.13	10.26	43	Normal	95% Student's-t UCL	28	28	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	33.61	13.34	67	Lognormal	95% Student's-t UCL	39.08	39.08	95% UCL	35.2
		Downriver	mg/kg	5	5	24	11.02	43	Normal	95% Student's-t UCL	34.51	34.51	95% UCL	
Selenium	All Depths	Near RDC	mg/kg	65	59	0.801	0.664	2.9	Lognormal	KM H-UCL	0.954	0.954	95% UCL	0.98
		Downriver	mg/kg	8	8	0.799	0.276	1.3	Normal	95% Student's-t UCL	0.984	0.984	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	13	0.766	0.56	1.8	Not Discernable	95% KM (Chebyshev) UCL	1.243	1.243	95% UCL	1.15
		Downriver	mg/kg	5	5	0.872	0.277	1.3	Normal	95% Student's-t UCL	1.136	1.136	95% UCL	
Silver	All Depths	Near RDC	mg/kg	65	60	0.118	0.0875	0.57	Gamma	95% KM Approximate Gamma UCL	0.133	0.133	95% UCL	0.086
		Downriver	mg/kg	8	8	0.0569	0.0391	0.14	Normal	95% Student's-t UCL	0.0831	0.0831	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	13	0.15	0.0428	0.229	Normal	95% KM (t) UCL	0.149	0.149	95% UCL	0.113
		Downriver	mg/kg	5	5	0.0656	0.0428	0.14	Normal	95% Student's-t UCL	0.106	0.106	95% UCL	
Thallium	All Depths	Near RDC	mg/kg	65	36	0.141	0.119	0.653	Not Discernable	95% KM (Chebyshev) UCL	0.174	0.174	95% UCL	0.077
		Downriver	mg/kg	8	1	0.072	--	0.072	Insufficient Data	Insufficient Data	--	0.072	Max Det	
	< 2 ft	Near RDC	mg/kg	18	13	0.125	0.0637	0.33	Not Discernable	95% KM (t) UCL	0.156	0.156	95% UCL	0.085
		Downriver	mg/kg	5	1	0.072	--	0.072	Insufficient Data	Insufficient Data	--	0.072	Max Det	
Vanadium	All Depths	Near RDC	mg/kg	65	65	25.84	8.319	48.5	Normal	95% Student's-t UCL	27.57	27.57	95% UCL	27.0
		Downriver	mg/kg	8	8	22	7.368	37	Normal	95% Student's-t UCL	26.94	26.94	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	29.96	6.785	48.5	Normal	95% Student's-t UCL	32.74	32.74	95% UCL	31.8
		Downriver	mg/kg	5	5	24.8	7.19	37	Normal	95% Student's-t UCL	31.66	31.66	95% UCL	
Zinc	All Depths	Near RDC	mg/kg	65	65	75.91	36.22	270	Not Discernable	95% Chebyshev (Mean, Sd) UCL	95.5	95.5	95% UCL	67.9
		Downriver	mg/kg	8	8	47.88	27.53	110	Normal	95% Student's-t UCL	66.32	66.32	95% UCL	
	< 2 ft	Near RDC	mg/kg	18	18	86.08	20.51	140	Normal	95% Student's-t UCL	94.49	94.49	95% UCL	86.7
		Downriver	mg/kg	5	5	55	31.73	110	Normal	95% Student's-t UCL	85.25	85.25	95% UCL	

**Key:**

BERA = Baseline ecological risk assessment  
 EPC = Exposure point concentration  
 Max Det = Maximum detected concentration

Shading = Used in BERA supplement  
 RDM = Red Devil Mine  
 UCL = Upper confidence limit (on average concentration)

**Note:** a = Area-weighted concentration for full (All Depths) sediment sample dataset. Length-weighted concentration for sediment samples collected from < 2 feet water.