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TECHNICAL MEMORANDUM

TO: Bob Kirkpatrick – Northern Region
Mary Beth Marks – On-Scene Coordinator

FROM: Mark F. Pearson – Project Scientist
Michael Cormier

DATE: December 24, 2002

RE: Soil Sampling Results
Gallatin National Forest Land Adjacent to the Great Republic Smelter Site
New World Mining District Response and Restoration Project

This memorandum describes methods and results of soil sampling on the Gallatin National Forest adjacent to the Great Republic Smelter site. Sampling was performed in 2002 by Maxim Technologies, Inc.® (Maxim) as part of the New World Mining District Response and Restoration Project. The sampling and analysis task was conducted to evaluate the extent and magnitude of metals concentrations in surface soil resulting from historic operation of the smelter.

The Great Republic Smelter site is located immediately south of Cooke City along Soda Butte Creek. Visible remains of the smelter consist of dark colored waste material, graded level and eroded on its north margin by Soda Butte Creek. Lead-silver-zinc ores from several mines in the district were smelted at the site between 1884 and 1925 (Lovering, 1929). Previous investigation of metals content in soils on private property at the site was conducted during September 1999 by the Montana Department of Environmental Quality Mine Waste Cleanup Bureau. This study included collecting and analyzing soil samples from private property and adjacent National Forest System lands (Tetra Tech EM, Inc., 1999). Results of this previous site investigation indicated that arsenic and lead concentrations were elevated in both mine waste and native soil on the National Forest.

The scope of work for this study is described in the 2002/2003 Work Plan (Maxim, 2002a). Investigation activities included establishing a sampling grid, soil sampling, sample description, analysis of soil samples using an X-Ray fluorescence spectrometer (XRF), and analysis of selected samples by Northern Analytical Laboratories, Inc. (Northern) in Billings, Montana. Methods and results of our investigation are summarized below. A site map showing the sampling grid is presented in Figure 1.

METHODS

Soil sampling and analysis activities were conducted according to methods described in the 2002/2003 Work Plan and the project Site-Wide Sampling and Analysis Plan (SAP, Maxim, 1999). Maxim's investigation involved establishing a sampling grid with sample locations on 50 foot centers within approximately 250 feet (north, east and northwest) of the Republic smelter site, and 150 foot centers beyond the 250 foot perimeter of the denser 50 foot grid (Figure 1). Only National Forest System lands were sampled.

Soil samples were collected from the upper two inches of mineral soil with a decontaminated, stainless steel trowel. Tree duff or other woody material, if present, was carefully removed from the mineral soil surface before sampling. Soil texture was described in the field according to methods prescribed in *The Nature and Properties of Soils* (Brady and Weil, 1999). Eighty-two samples were collected. Soil sampling notes are contained in Attachment A.

Samples were analyzed with a field portable XRF following sample collection and transport of these samples to Maxim's Helena, Montana office. The XRF analysis was conducted according to methods described in the 2002/2003 Work Plan and standard Environmental Protection Agency (EPA) procedures for field XRF operation. Samples were analyzed for arsenic, copper, lead, and zinc with results reported in parts per million (ppm). XRF results were reviewed and representative samples were selected for confirmation analyses by the laboratory using standard EPA methods for total metals. Thirty-nine samples were submitted to Northern for analysis of parameters identified in the Site-Wide SAP (Maxim, 1999). These parameters included total arsenic, cadmium, chromium, copper, lead, and zinc; acid/base account; and saturated paste pH and electrical conductivity.

RESULTS

Geomorphology and soil of the sampled area consist of alluvium deposited by Soda Butte Creek and undisturbed slopes that are either forested or open meadows. It was noted that some ground was disturbed at various locations along the margins of private property. Alluvial deposits along Soda Butte Creek were classified as generally two types. The first type was generally located within approximately four feet of the creek stage and appeared to be within seasonal high water during July 2002. Due to its location adjacent to the stream, this type of alluvium is probably subject to erosion and resorting during higher flow events. The second type of alluvium is topographically higher then the first type of alluvium, and relatively un-affected by seasonal high water. Figure 2 shows the distribution of alluvium and forest/meadow land at the site.

Soil textures of the samples collected at the sampling grid point locations included sandy to silty loam with or without minor clay. Gravel or rock fragments were usually present. Soil was moist and often contained organic material in the forested slopes south of Soda Butte Creek.

Analysis of samples using the XRF detected arsenic, lead, and zinc concentrations above the relatively high XRF instrument detection limits (Table 1). The XRF detection limit was too high to discern copper concentrations. XRF detection limits vary considerably for each sample and each metal for several reasons, including soil type, element concentration, percentage soil moisture, and matrix interferences. Using the XRF data, samples with elevated lead concentrations were submitted to the laboratory for analysis to confirm the XRF results. Laboratory and XRF results are presented in Table 1. Laboratory analytical reports are contained in Attachment B.

The correlation coefficients for the XRF and laboratory data ranged between 0.82 and 0.98, with the highest coefficients for lead (0.96) and zinc (0.98) (Attachment C). In all cases, the XRF underestimated the respective total metal concentration as measured in the laboratory. This high correlation suggests that XRF analyses are useful in identifying locations where metal concentrations are elevated at least several times above background concentrations. Average background concentrations of total arsenic, copper, lead, and zinc in soils in the New World Mining District are 6, 63, 51, and 31 milligrams per kilogram (mg/kg), respectively (Maxim, 2002b).

The XRF and laboratory results indicated elevated concentrations of lead and zinc in surface soil adjacent to and east of the Great Republic Smelter Waste Area. Elevated lead and zinc concentrations were also detected southwest and southeast of the smelter waste area in surface soil within the forest/meadow land (Figures 3 and 4). Arsenic concentrations were below detection for most of the XRF results, although laboratory data showed that elevated arsenic concentrations were generally present at the same locations where lead concentrations were elevated above the human health guideline for lead (1,100 mg/kg). The highest arsenic concentration (689 mg/kg) was measured at the same location where the highest lead concentration (29,300 mg/kg) was measured.

Only lead concentrations east and southeast of the smelter waste area exceed the human health cleanup guidelines calculated by Tetra Tech (1996, Table 1). Four areas with concentrations exceeding this guideline are outlined on Figure 5. These outlines were drawn by splitting the difference between the grid sampling points that exceed the guideline with the surrounding grid sampling points that were below the guideline. The outlines were drawn for National Forest System lands only, as no sampling was done on the private land parcels that are within the study area. For the two areas at the eastern edge of the sampling grid (150 North 750 East and 0 North 900 East), the eastern extent is unknown. To determine the eastern extent of elevated lead concentrations, and to further refine the areas containing elevated lead, further sampling will be required.

As soils in the area sampled for this investigation are generally native materials, elevated lead, zinc, and arsenic concentrations are likely related to air emissions from the former Great Republic Smelter.

REFERENCES CITED

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Brady, N.C. and R.R. Weil, 1999. The Nature and Properties of Soils (Twelfth Edition). Prentice Hall (Publisher). Pages 125-129.

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Maxim Technologies, Inc., 2002b. Como Basin/Glengarry Adit/Fisher Creek Engineering Evaluation/Cost Analysis. New World Mining District Response and Restoration Project. Final. Prepared for the USDA Forest Service, Draft, June.

Maxim Technologies, Inc., 1999. Site-Wide Sampling and Analysis Plan. New World Mining District Response and Restoration Project. Appendix B of the Overall Project Work Plan. Final. Prepared for the USDA Forest Service, November 10.

Tetra Tech EM, Inc., 1999. Final Reclamation Investigation Report for the Great Republic Smelter Site, New World Mining District, Park County, Montana. Prepared for Montana Department of Environmental Quality, Mine Waste Cleanup Bureau. December.

Tetra Tech, 1996. Risk-Based Cleanup Guidelines for Abandoned Mine Sites. Prepared for the Department of Environmental Quality, Abandoned Mine Reclamation Bureau, February.

TABLE AND FIGURES

FIELD SAMPLING NOTES
Technical Memorandum – Soil Sampling Results
Gallatin National Forest Land Adjacent to Great Republic Smelter Site
New World Mining District Response and Restoration Project

TABLE 1
SUMMARY OF X-RAY FLUORESCENCE AND LABORATORY ANALYTICAL METALS RESULTS
GREAT REPUBLIC SMELTER AREA
NEW WORLD MINING DISTRICT RESPONSE AND RESTORATION PROJECT

Grid Coordinates				XRF Metals (parts per million)								Shipped to Lab	Field ID	Lab Number	Total Arsenic	Total Copper	Total Lead	Total Zinc	Total Cadmium	Total Chromium
Northing		Easting		Arsenic		Copper		Lead		Zinc					milligrams per kilogram (mg/kg)					
													Human Health Guideline (in mg/kg)		**700**	**27,100**	**1,100**	**220,000**	**19,500**	**2,920**
0	N	500	E	242	<	210		2450		358		x	RR-SBSI-99-93-0N500E	2002080295-12	459	48	6,450	875	13	24
0	N	550	E	312	<	240		3490		494		x	RR-SBSI-99-93-0N550E	2002080295-6	460	68	7,230	772	21	16
0	N	600	E	< 250	<	210		3710		436		x	RR-SBSI-99-93-0N600E	2002080295-19	518	67	5,560	707	21	35
0	N	750	E	56	<	160	<	72	<	92		x	RR-SBSI-99-93-0N750E	2002080295-14	< 10	18	32	66	< 2	18
0	N	900	E	< 150	<	180		1050		129		x	RR-SBSI-99-93-0N900E	2002080294-8	104	26	1,830	221	3	22
50	N	150	E	< 57	<	140		101		108		x	RR-SBSI-99-93-50N150E	2002080295-11	< 10	31	298	149	< 2	27
50	N	450	E	< 520	<	570		9800		4970		x	RR-SBSI-99-93-50N450E	2002080295-3	689	1,050	29,300	10,200	32	7
50	N	500	E	< 300	<	270		4240		920		x	RR-SBSI-99-93-50N500E	2002080294-16	422	118	8,220	1,260	15	25
50	N	550	E	292	<	250		3150		492		x	RR-SBSI-99-93-50N550E	2002080294-2	182	73	3,440	558	8	20
50	N	600	E	< 130	<	180		890		260		x	RR-SBSI-99-93-50N600E	2002080294-1	47	59	1,240	422	< 2	20
100	N	150	E	< 63	<	190	<	81	<	100										
100	N	200	E	< 59	<	160	<	71	<	90										
100	N	250	E	< 65	<	180	<	80	<	99										
100	N	300	E	< 60	<	180	<	80	<	95										
100	N	350	E	< 76	<	160		300		309		x	RR-SBSI-99-93-100N350E	2002080294-20	43	63	1,090	892	< 2	24
100	N	450	E	< 63	<	180	<	81	<	110										
100	N	500	E	< 59	<	180	<	75	<	98										
100	N	550	E	< 58	<	180	<	77		106										
100	N	600	E	< 65	<	190	<	87	<	110										
150	N	0	E	< 55	<	130	<	67		987		x	RR-SBSI-99-93-150N0E	2002080294-14	< 10	30	161	145	< 2	30
150	N	150	E	< 59	<	180	<	78	<	99		x	RR-SBSI-99-93-150N150E	2002080294-18	< 10	22	27	62	< 2	40
150	N	200	E	< 59	<	160	<	80	<	90										
150	N	250	E	< 61	<	160	<	80	<	100										
150	N	300	E	< 69	<	190	<	92	<	110		x	RR-SBSI-99-93-150N300E	2002080294-5	< 10	26	82	153	< 2	24
150	N	450	E	< 62	<	190	<	77	<	100		x	RR-SBSI-99-93-150N450E	2002080295-2	< 10	22	31	62	< 2	28
150	N	500	E	< 59	<	180	<	80	<	110										
150	N	600	E	< 57	<	180	<	76		117		x	RR-SBSI-99-93-150N600E	2002080294-3	< 10	24	53	96	< 2	23
150	N	750	E	< 210	<	210		2050		250		x	RR-SBSI-99-93-150N750E	2002080295-17	446	74	6,070	581	12	26
200	N	150	E	< 56	<	160	<	72	<	90										
200	N	200	E	< 53	<	180	<	71	<	98										
200	N	250	E	< 63	<	180	<	85		119										
200	N	300	E	< 78	<	180		160		275										
200	N	350	E	< 83	<	180		247		150		x	RR-SBSI-99-93-200N350E	2002080295-1	< 10	29	298	173	< 2	22
200	N	400	E	< 73	<	190	<	86	<	110										
200	N	450	E	< 69	<	190	<	89	<	110										
200	N	500	E	< 72	<	190	<	86		128										
200	N	550	E	< 54	<	150	<	71	<	82										
200	N	600	E	< 62	<	160		104	<	91										
250	N	200	E	< 71	<	210	<	91		124										
250	N	250	E	< 62	<	180	<	81		144										
250	N	300	E	< 79	<	210		150		221										

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TABLE 1
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Grid Coordinates		XRF Metals (parts per million)				Shipped to Lab	Field ID	Lab Number	Total Arsenic	Total Copper	Total Lead	Total Zinc	Total Cadmium	Total Chromium
Northing	Easting	Arsenic	Copper	Lead	Zinc				milligrams per kilogram (mg/kg)					
							Human Health Guideline (in mg/kg)		**700**	**27,100**	**1,100**	**220,000**	**19,500**	**2,920**
250 N	350 E	< 75	< 190	< 91	< 110									
250 N	400 E	< 55	< 150	< 71	< 85									
250 N	450 E	< 66	< 180	< 86	< 100									
250 N	500 E	< 65	< 180	< 85	< 100									
250 N	550 E	< 69	< 180	97.5	< 100									
250 N	600 E	< 65	< 160	< 78	< 92									
300 N	0 E	< 65	< 190	< 88	< 110									
300 N	-150 W	< 66	< 190	< 87	< 110	x	RR-SBSI-99-93-300N150W	2002080295-4	< 10	24	104	143	< 2	29
300 N	150 E	< 69	< 210	< 89	< 120	x	RR-SBSI-99-93-300N150E	2002080295-5	< 10	27	52	60	< 2	21
300 N	200 E	< 62	< 190	< 82	< 100									
300 N	250 E	< 68	< 210	< 86	< 110									
300 N	300 E	< 74	< 190	< 95	227	x	RR-SBSI-99-93-300N300E	2002080294-15	< 10	28	72	160	< 2	22
300 N	350 E	< 66	< 180	< 83	190									
300 N	400 E	< 64	< 180	< 83	130									
300 N	450 E	< 69	< 220	< 90	< 120	x	RR-SBSI-99-93-300N450E	2002080295-20	< 10	36	19	62	< 2	29
300 N	500 E	< 57	< 180	< 73	< 95									
300 N	550 E	< 61	< 180	< 78	< 100									
300 N	600 E	< 52	< 150	< 71	< 81	x	RR-SBSI-99-93-300N600E	2002080294-17	< 10	26	26	48	< 2	33
300 N	750 E	< 61	< 140	< 64	< 78	x	RR-SBSI-99-93-300N750E	2002080295-18	< 10	27	30	51	< 2	29
450 N	0 E	< 62	< 180	< 81	< 100									
450 N	150 E	< 65	< 190	< 86	< 100	x	RR-SBSI-99-93-450N150E	2002080295-7	< 10	27	41	91	< 2	39
450 N	-150 W	< 54	< 180	< 69	103									
450 N	300 E	< 53	< 150	< 71	119	x	RR-SBSI-99-93-450N300E	2002080295-13	< 10	29	52	107	< 2	32
450 N	450 E	< 65	< 180	< 88	156	x	RR-SBSI-99-93-450N450E	2002080295-16	< 10	37	101	162	< 2	29
450 N	600 E	< 65	< 190	97	< 100	x	RR-SBSI-99-93-450N600E	2002080295-15	< 10	36	65	69	< 2	31
450 N	750 E	< 67	< 140	150	88	x	RR-SBSI-99-93-450N750E	2002080295-9	< 10	25	181	84	< 2	25
-150 S	0 E	< 67	< 110	335	78	x	RR-SBSI-99-93-150S0E	2002080294-7	< 10	26	505	160	< 2	24
-150 S	600 E	< 140	< 160	860	132	x	RR-SBSI-99-93-150S600E	2002080295-8	76	16	583	168	3	21
-150 S	750 E	< 94	< 140	490	124	x	RR-SBSI-99-93-150S750E	2002080294-19	43	15	701	186	< 2	32
-150 S	900 E	< 61	< 180	< 79	< 96	x	RR-SBSI-99-93-150S900E	2002080295-10	< 10	16	22	42	< 2	27
-300 S	0 E	< 73	< 150	240	86	x	RR-SBSI-99-93-300S0E	2002080294-9	< 10	10	206	80	< 2	22
-300 S	-150 W	< 41	< 81	117	< 49	x	RR-SBSI-99-93-300S150W	2002080294-6	< 10	18	221	63	< 2	10
-300 S	600 E	< 48	< 120	97	< 66	x	RR-SBSI-99-93-300S600E	2002080294-13	< 10	14	150	71	< 2	25
-300 S	750 E	75	< 140	119	< 81	x	RR-SBSI-99-93-300S750E	2002080294-11	< 10	12	340	84	< 2	25
-300 S	900 E	< 58	< 150	< 73	< 87	x	RR-SBSI-99-93-300S900E	2002080294-4	< 10	16	69	56	< 2	24
-450 S	0 E	< 59	< 120	128	< 74	x	RR-SBSI-99-93-450S0E	2002080294-10	< 10	18	147	77	< 2	25
-450 S	-150 W	< 45	< 94	136	< 56									
-450 S	300 E	< 58	< 130	< 68	< 77									
-450 S	450 E	< 25	< 60	< 29	< 35									
-450 S	600 E	< 63	< 150	148	< 85									
-450 S	750 E	< 41	< 100	63	< 55									
-450 S	900 E	< 56	< 130	150	93	x	RR-SBSI-99-93-450S900E	2002080294-12	< 10	10	100	63	< 2	24

Notes: **Human Health Guideline** in accordance with Tetra Tech, 1996. Risk-Based Cleanup Guidelines for Abandoned Mine Sites. Prepared for Dept. of Environmental Quality, Abandoned Mine Reclamation Bureau. Metal concentrations exceeding the Human Health Guideline are shaded.The Chromium Human Health Guideline concentration is assuming chromium VI with a 5x10-4 cancer risk.

< : Less than or below detection limit

XRF : Analysis conducted using portable X-ray fluorescence (XRF) instrument

x : Laboratory analysis of samples conducted where indicated. Parameters analyzed in accordance with Site Wide SAP (Maxim, 1999)

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ATTACHMENT A

FIELD SAMPLING NOTES
Technical Memorandum – Soil Sampling Results
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ATTACHMENT B

LABORATORY ANALYTICAL REPORTS
Technical Memorandum – Soil Sampling Results
Gallatin National Forest Land Adjacent to Great Republic Smelter Site
New World Mining District Response and Restoration Project

ATTACHMENT C

STATISTICAL ANALYSIS OF XRF AND LABORATORY RESULTS
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Gallatin National Forest Land Adjacent to Great Republic Smelter Site
New World Mining District Response and Restoration Project