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September 19, 2018

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- CC: Kris Baran, Foth Infrastructure & Environment, LLC Steve Donohue, Foth Infrastructure & Environment, LLC
- FR: Andrea Martin, Foth Infrastructure & Environment, LLC Curt Dungey, Foth Infrastructure & Environment, LLC
- RE: Copperwood Project Revised Air Deposition Analysis

#### Purpose

A memorandum (memo) addressing air deposition analysis was prepared by Foth Infrastructure & Environment, LLC (Foth) for Copperwood Resources, Inc. (Copperwood) in May 2018 (Foth, 2018a). The purpose of that memorandum was to analyze potential air quality deposition impacts that might result from activities at the proposed Copperwood Project (Project) nonferrous mining and ore processing operations. Since the submittal of the May 2018 memo, several Project changes have increased the underlying emissions estimate. This memo provides an update to the May 2018 analysis, incorporating the revised emissions estimate. Attachment 1 contains the revised Maximum Facility Emissions for Hazardous Air Pollutants/Michigan Air Toxics (Toxic Emissions) Summary Sheet.

Similar to the original analysis, this air deposition analysis was performed to address R425.202 (b) of Michigan's Natural Resources Environmental Protection Act (NREPA) Part 632, Nonferrous Metallic Mining Regulations in support of requirements of the Environmental Impact Assessment Amendment (Foth, 2018b). R425.202 requires the applicant perform an analysis of the potential cumulative impacts on the mining and affected area from all proposed mining activities.

This memo analyzes potential air deposition impacts to soils and provides a comparative evaluation of copper and sulfate deposition rates. Parameters are selected based on the quantity of emissions estimated over the year. Of the toxic air contaminants tabulated on the Toxic Emissions Summary Sheet in Attachment 1, copper and sulfur are emitted in the highest quantities at 1,072 and 453 pounds per year, respectively. Several elements are emitted in quantities less than 100 pounds per year (barium, magnesium, manganese), and the remainder, including nickel, at less than 10 pounds per year. A reasonable

approach is to evaluate the copper and sulfur as the two constituents most likely to affect the environment via deposition, an approach taken herein.

Copper is the target metal of the mine and therefore is a primary constituent of the particulate matter emissions from operations. Sulfur is commonly present in the ore and other materials and is evaluated as sulfate through theoretical stoichiometric conversion. The sulfate ion is more reactive in the environment than sulfur, and by assuming the complete conversion of sulfur to sulfate, the evaluation is extremely conservative regarding potential effects of this constiuent.

Figure 1 shows the Project location, the location of specific operations, and the Project boundary. For this analysis, it is assumed that constituents are retained in the soil at the location where they were deposited. This assumption simplifies the analysis, however, in reality, deposited material will undergo numerous chemical and physical reactions in the environment and will not remain entirely in place. The receptor grid used for deposition modeling extends approximately 3 kilometers beyond the site in all directions. Ten receptors immediately outside the Project boundary are evaluated for deposition impacts, shown on Figure 1. Being close to the Project boundary, these locations will likely experience the maximum deposition from the operations.

#### **Background Information**

The Project is located in Ironwood and Wakefield Townships, Gogebic County, Michigan at approximately 90° 0.5' West and 46° 40.75' North, as shown on Figure 1. Copperwood proposes to operate an underground nonferrous mine and ore processing facility at this location. Potential sources of air emissions are discussed more fully in the *Michigan Air Use Permit – Permit to Install Application* (Foth, 2018c). Activities associated with potential air emissions include blasting, excavating, material handling, management of storage piles, and material transfer activities. With the exception of roadway emissions from vehicle travel, all emissions sources identified in Foth (2018c) were included in the air deposition analysis. Given the access roads will be dressed with either aggregate or native soils that contain minimal metals or other chemicals of concern, they are not significant sources of copper and sulfur and therefore were not included in this analysis.

The evaluation began with air deposition modeling. Based on modeling results, impacts on soil are then considered and compared against selected criteria. The comparison assists in understanding the deposition impact from the facility and the likelihood operations will have significant impact to the soil. The following discussion provides details.

#### **Air Deposition Modeling**

Modeling air deposition rates for selected constituents are based on facility emissions estimates. Hourly emission rates for copper and sulfur were first estimated from air emission calculations that were completed for the air permit application (Foth, 2018c). Constituent emissions were estimated from total particulate matter emissions in conjunction with the weight percent of each constituent in materials being emitted, also documented in Foth (2018c). Updated air emission calculations resulted in slightly higher hourly emission rates for blasting and haul truck travel due to a more conservative methodology and approach. While constituents are bound to a specific process material as part of its lithology, the weight percent of the constituent was used in each calculation. To be conservative, the estimates were based on total particulate emissions rather than emissions based on a size fraction, such as particulate matter less than 10 microns (PM<sub>10</sub>). Additionally, the facility Maximum Controlled Emissions (MCE) were used as a basis. This represents an upper bound of permitted emissions. Routinely the facility will operate below the MCE, with only occasional durations at the MCE. Emission sources included a mix of both point sources (stacks) and fugitive air emissions. Point sources included the three ventilation exhaust points for the underground mining operations. Fugitive air emissions included sources such as material transfer and handling activities and wind erosion from material storage areas. Hourly emission rates and other input parameters used in the deposition model are provided in Attachment 1.

Constituent air emission rates were entered into a model that can simulate deposition of the constituents over the surrounding area. During preparation of the air permit application, dispersion of air emissions was estimated to determine airborne concentrations of contaminants at receptors established within a receptor grid across the site. The purpose of the air dispersion modeling was to assess compliance with applicable ambient air quality standards. The air model used for this process was AERMOD, a regulatory air quality model that is sanctioned by the United States Environmental Protection Agency (USEPA) and is the preferred model for conducting air quality analyses by state regulatory agencies, including the Michigan Department of Environmental Quality (MDEQ).

This same air quality model can be used to estimate deposition of air contaminants across a region. However, to estimate deposition impacts, additional information needs to be provided in the air quality model set-up. Additional information includes data on particle density, particle size, and associated mass fractions for each emission source and process material. Particle density and size data for air emission sources used in the deposition model are documented in Attachment 1. To be conservative, both wet and dry deposition were selected for all parameters reviewed.

Execution of modeling runs included use of MDEQ – sanctioned meteorological data from Gogebic – Iron County Airport (IWD) near Ironwood, Michigan that is available on the MDEQ website. These meteorological data sets included information on wind speed and wind direction, as well as rainfall data, the latter of which are a required element in deposition modeling. While the air dispersion model used a 50-meter receptor grid across an area that was approximately 2,500 meters in any direction from the site, the deposition model used a 100-meter grid with a receptor grid that extended about 3,000 meters in each direction from the Property boundary.

The most recent year of meteorological data (2017) was used in this analysis. Using AERMOD over the 1-year period, annual deposition rates of the constituents of interest were predicted across all receptor points in the modeling domain. All deposition results are inclusive of wet and dry dposition rates. Deposition rates were expressed in grams per square meter per year (g/m<sup>2</sup>/year) for copper and sulfur. Figures 2 and 3, PW\_IE\Documents\Clients\Copperwood Resources\0017C050.00\5000 Client Correspondence\Air Deposition Revision\M-Deposition Analysis Rev 1.docx

respectively, provide depictions of copper and sulfur deposition modeling results over the regional area. Deposition contours indicate deposition loads diminish with distance from the Project site. Upon completion of air deposition modeling, deposition rates for each receptor were tabulated. Attachment 2 provides the deposition rates for selected receptors and a sample of all receptor data for copper and sulfur. The full set of receptor data is not provided in the report as it is approximately 90 pages long.

#### **Soil Impact Evaluation**

The soil impact evaluation is presented in the calculations located in Attachment 3 and is comprised of four parts described below.

#### I Comparative Soil Criteria

NREPA Part 201 Environmental Remediation contains criteria by which to compare soil characteristics: *Table 2. Soil: Residential and Commercial I Part 201 Generic Soil Clean up Criteria*, RRD Operational Memorandum No. 1 (MDEQ, 2006). The following criteria were selected:

- Direct Contact Criteria and Risk Based Screening Levels.
- Drinking Water Protection Criteria and Risk Based Screening Levels.
- Groundwater Surface Water Interface Protection Criteria and Risk Based Screening Levels.

The Groundwater Surface Water (GSI) Interface Protection Criteria provides a hardness-based criteria for copper. The hardness value of 379 milligrams per liter (mg/L) from the original Mining Permit Application (Orvana, 2011) for Shallow Glacial Overburden Groundwater (Table 202.2.7-2) was selected. These calculations are provided in Attachment 4.

Additionally, the *Risk Management Criteria for Metals at BLM Mining Sites* (United States Department of Interior, 2004) (Bureau of Land Management [BLM] criteria) provides additional criteria for copper. Criteria are presented as constituent levels that avoid adverse toxic effects on wildlife and livestock for a variety of mammals and birds. The selected value used in this evaluation is the most stringent wildlife value. As can be seen in Section I of the calculations, the metal screening levels are one or more orders of magnitude lower than the Part 201 cleanup standards. In fact, the natural soils in the area currently exceed the copper criteria. Thus, the evaluation of deposition impacts from the Project will be considered by reviewing the percentage increase that deposition contributes to the current soil composition. Without the ability to meet the BLM criteria, the comparison becomes somewhat qualitative.

#### II Selected Receptors Deposition Rates

The selected receptors at the Project boundary were identified in the deposition model output data set. Locations and coordinates are shown on Figure 1 and are listed in Section II of the calculations with the deposition rates of the selected constituents. These

receptors are selected as those closest and external to the Property boundary, which are anticipated to experience the highest deposition rates external to the Property boundary.

#### III Native Soil Characteristics

Native soil characteristics for selected constituents along with a specific gravity are shown in Section III of the calculations.

#### IV Potential Soil Impacts

Potential soil impacts are calculated on the basis of 1 year and 14 years (duration of operations) of deposition. Considering one square meter of soil 1 centimeter (cm) thick, the estimate applies the deposition to that mass of soil. Evaluating on the basis of 1 cm thick is particularly conservative in light of MDEQ and USEPA routine evaluation basis of 2 cm thickness.

Although the proposed facility will not emit sulfate ion  $(SO_4^{-2})$ , the evaluation of sulfur is done by assuming sulfur is converted to sulfate via the chemical reaction shown in Equation (1). The geochemical reaction is one of several that take place over time as a mineral weathers. The molecular weights of sulfur and oxygen are 32 and 16, respectively. The ratio of sulfur to sulfate on a mass basis is 0.32 to 1.

Equation (1)  $S + 2 O_2 \longrightarrow SO_4^{2-}$ 

Sulfate is naturally deposited in wet and dry phenomena. The deposition modeling has been prepared to compare against the former Minnesota acid rain standard, which is based on wet deposition only. In that the deposition analysis included both wet and dry deposition, it is a more conservative assessment.

The evaluation of potential soil impacts shows that with deposition added for 1 year and 14 years of operation, Michigan protective criteria will continue to be met immediately outside the Property boundary. Native soil exceeds the BLM criteria for copper. Deposition at the selected receptors could potentially increase the copper composition from 0.3 to 4.3% annually. Over 14 years, the average copper increase at the 10 selected worst case receptors is 22% (ranging from 4% to 60%), without accounting for natural attenuation and mineral adsorption. As shown on Figures 2 and 3, deposition rates diminish with distance from the facility. The deposition estimated at selected receptors represent a upper bound value, with likelihood of occurring in a broad area being very low.

#### **Deposition Rate Comparison**

#### Sulfur Deposition Rate

Although the geochemical reaction does not take place in the atmosphere, the stoichiometric conversion of sulfur to sulfate enables a comparison of the largest theoretical sulfate deposition rate of the Project to a sulfate deposition standard. Michigan does not maintain a sulfate deposition standard; however, Minnesota developed an environmentally protective standard that will be used for this analysis. Although Minnesota Rule, chapter 7021, Acid Deposition Standard was repealed in 2013, the environmentally acceptable deposition rate can still be used as a benchmark for this

evaluation. The standard is 11 kilograms of wet sulfate deposition per hectare per year (kg/ha/yr), which can also be expressed as 1,100 milligrams per square meter per year (mg/m<sup>2</sup>/yr).

To evaluate the contribution rate from the facility, the current deposition rate is identified. Nationwide sulfate ion deposition rates are tracked and available from the National Atmospheric Deposition Program (NADP) National Trends Network (NTN). The Project is between the NTN site WI 36 in Trout Lake, Wisconsin and MI99 in Chassel Michigan. The location and the sulfate ion deposition trend graph are shown in Attachment 5. For the last 5 years of available data, the background deposition rate at this location is estimated at 6 kg/ha/yr (600 mg/m<sup>2</sup>/yr). The rate evaluation considers the background rate plus the additional calculated sulfate rate generated at the Project. As can be seen in Section V of the calculations, the highest predicted sulfate deposition rate will continue to be below the Minnesota acid deposition standard.

#### Copper Deposition Rate Comparison

An additional perspective to evaluate the estimated copper deposition rate is offered in literature values. Deposition of trace metals has been an area of scientific study, including in the Great Lakes region. Sweet, et. al., (1997) published deposition rates of various metals and trace elements in *Atmospheric Deposition of Trace Metals at Three Sites near the Great Lakes*, 1997. Comparable values are provided below:

Location Measured	mg/m²/yr
Lake Superior (Sweet, et al., 1997)	3.1
Average of Receptors R1 through R10	4.2
Approximate Deposition Rate 3,000 feet out from the facility	0.5 to 2
	Prepared by: AKM Checked by: CED1

## Table 1Deposition Comparison

The worse case copper deposition from the facility at Receptors R1 through R10 is very similar to the deposition rate measured in Lake Superior. As can be seen on Figures 2 and 3 as well as the table above, deposition rates drop off rapidly with distance from the source.

#### Conclusions

Results of the conservatively-estimated deposition analysis demonstrate that potential copper and sulfur/sulfate deposition are not anticipated to have significant impacts on soils. Four soil criteria were identified: three Michigan criteria and one sourced from a BLM document. The analysis shows that for both 1 year and after 14 years of operations at maximum emissions, a conservative potential deposition rate will not raise the copper or sulfate compositions of the soils above the Michigan protective criteria. The comparison to the Risk Management Criteria from the BLM showed that native soils exceed the most stringent copper criteria. The addition of deposition to the soil for 1-year

and 14-year duration increased the theoretical constituent compositions at the 10 selected receptors as shown below.

#### Table 2

#### Theoretical Increase in Constituent Composition at 10 Selected Receptors

Constituent	<b>1-Year Duration</b>	14-Year Duration
Copper	Average: 2%	Average: 22%
	Range: 0.3 to 4.3%	Range: 4 to 60%
Sulfate	Average: 0.03%	Average: 0.5%
	Range: 0.01 to 0.09%	Range: 0.07 to 1.25%
		Prepared by: AKM

Checked by: CED1

In the deposition rate comparisons, facility copper deposition was compared against the highest facility deposition rate for copper is a similar value to the Lake Superior deposition rate obtained from literature, indicating the impact from the facility will not be significant to the environment. Sulfate has a developed protective deposition rate by which to compare, and the results of the analysis for Copperwood show that the worst case sulfate deposition rate from the facility will not exceed the protective criteria. Literature values and sulfate was compared to the retired Minnesota deposition criteria.

#### References

- Foth Infrastructure & Environment, LLC, 2018a. Copperwood Project Air Deposition Analysis. May 8, 2018.
- Foth Infrastructure & Environment, LLC, 2018b. *Mining Permit Application Amendment, Copperwood, Volume II, Environmental Impact Assessment Amendment.* March 2018.
- Foth Infrastructure & Environment, LLC, 2018c. *Michigan Air Use Permit Permit to Install*. March 2018.
- Michigan Department of Environmental Quality, 2006. MDEQ RRD Operational Memoradum No. 1, Part 201 Cleanup Criteria, Part 213 Risk-Based Screening Levels, Attachment 1 Table 2. Soil: Residutial and Industrial-Commercial I Part 201 Generic Cleanup Criteria and Screening Levels: Part 213 Tier I Risk-Based Screening Levels (RBSLs). January 23, 2006.
- Orvana Resources US Corp, 2011. *Copperwood Mine Mining Permit Application*. September 2011.
- Sweet, Clyde W.; Weiss, Aaron; Vermette, Stephen J., 1997. Atmospheric Deposition of Trace Metals at Three Sites Near the Great Lakes.

United States Department of the Interior, 2004. *Risk Management Criteria of Metals at BLM Sites*. Karl L. Ford. Buereau of Land Mangement, National Science and Techology Center, Denver CO. Table 4. Wildlife and Livestock Risk management Criteria for Metals in Soils. (Technical Note 390, rev. October 2004).

Figures



Path: Q:\Copperwood Resources\17C050\GIS\mxd\ADA\Figure 1 Deposition Grid.mxd Date: 9/19/2018

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DESCRIF	DATE: SEP. '18 DATE: SEP. '18	UPD	FIGU ATED AIR DEP SELECTED I NEAR PROPER GOGEBIC COU	URE 1 OSITION ANA RECEPTORS RTY BOUNDA NTY, MICHIG at Date: SEP	ALYSIS RY AN TEMBER 2018	3
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### **Attachment 1**

**Air Deposition Model Input Data** 

Foth Prep Chee	Project: <u>Air Permit Application Er</u> pared by: <u>CED1</u> ecked by: <u>AKM</u>
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Client:	Copperwood Resources, Inc. P	oject ID.:	17C050
Project:	Air Permit Application Emissions Calculations - V	ersion 2	
pared by:	CED1	Date:	06/25/18
ecked by:	AKM	Date:	07/02/18



# Checked by: <u>AKM</u> Date: <u>07/02/18</u> Fmissions for Hazardous Air Pollutants/Michigan Air Toxics<sup>1</sup> Antimony Arse Sb As

Maximum Facility Emissions for Hazardous Air Poliutants/Michigan	AIF TO	xics												HAP/TAC C	oncentrations (all	in weight percent)								
						Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Magnesium	Manganese 9	Mercury	Molybdenum	Nickel	Phosphorus	Selenium	Silver	Sulfur	Tin
						Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Mg	Mn	Hg	Mo	Ni	Р	Se	Ag	S	Sn
					Ore <sup>2</sup>	4.75E-05	1.80E-04	0.07559	2.60E-04	1.75E-04	0.011	0.003	1.460	1.10E-03	0.00	0.17	0.0	5.06E-05	0.007	0.00	1.413E-04	4.387E-04	0.61	0.0003
					Concentrate <sup>3</sup>	0.00020	0.00100	0.01860	0.0	0.00370	0.006	0.0016	29.170	1.00E-03	1.45	0.09	0.00	0.0005	0.0073	2.48	0.0000	0.0040	8.80	0.0000
					Native Soil 4	2.10E-05	0.0003	0.0188	0.0001	0.00005	0.004	0.0016	0.002	1.54E-03	0.45	0.22	0.00	9.10E-05	0.002	0.07	1.10E-04	1.68E-05	0.04	0.0001
					Tailings <sup>5</sup>	0.00005	0.0006	0.0535	0.0002	0.00003	0.0284	0.0036	0.4675	0.001	0.00	0.16	0.00	2.70E-03	0.02	0.00	1.00E-04	2.20E-04	0.23	2.50E-04
	PM	PM10	PM2.5																		1	, ,		1
Underground Mine Emissions (Point) (EUMINEVENT) 7																					1 1			1
SV-001 (West Mine Exhaust Vent)	2.45	1.26	6 0.25	5 lb/hr	Ore	1.16E-06	4.41E-06	1.85E-03	6.37E-06	4.29E-06	2.66E-04	8.15E-05	3.58E-02	2.69E-05	0.00E+00	2.11E-03	2.55E-07	1.24E-06	1.60E-04	0.00E+00	3.46E-06	1.07E-05	1.50E-02	7.04E-06
	3.28	1.53	0.48	8 ton/yr		1.56E-06	5.91E-06	2.48E-03	8.54E-06	5.75E-06	3.56E-04	1.09E-04	4.80E-02	3.61E-05	0.00E+00	2.57E-03	3.42E-07	1.66E-06	2.15E-04	0.00E+00	4.64E-06	1.44E-05	2.02E-02	9.44E-06
	0.50	4.00		0 11- /1	0	1 005 00		4.045.00	0.505.00	4 405 00	0.745.04	0.405.05	0.005.00	0.775.05	0.005.00	0.405.00	0.005.07	4 005 00	4 955 94	0.005.00	0.575.00	4.445.05	1.555.00	7 005 00
SV-002 (East Mine Exhaust Vent)	2.52	1.30	0.20		Ore	1.20E-06	4.54E-06	1.91E-03	6.56E-06	4.42E-06	2.74E-04	8.40E-05	3.69E-02	2.77E-05	0.00E+00	2.18E-03	2.63E-07	1.28E-06	1.65E-04	0.00E+00	3.57E-06	1.11E-05	1.55E-02	7.26E-06
	3.30	1.50	0.43	9 ton/yi		1.01E-00	0.09E-00	2.50E-03	0.00E-00	5.92E-00	3.07E-04	1.13E-04	4.94E-02	3.72E-05	0.00E+00	2.05E-03	3.52E-07	1.7 TE-00	2.21E-04	0.00E+00	4.76E-00	1.46E-05	2.00E-02	9.73E-06
SV-003 (Portal Exhaust Vent)	1.34	0.69	0.14	4 lb/hr	Ore	6.35E-07	2.41E-06	1.01E-03	3.47E-06	2.34E-06	1.45E-04	4.45E-05	1.95E-02	1.47E-05	0.00E+00	1.15E-03	1.39E-07	6.76E-07	8.74E-05	0.00E+00	1.89E-06	5.86E-06	8.20E-03	3.84E-06
	1.79	0.84	0.26	6 ton/yr		8.51E-07	3.22E-06	1.35E-03	4.66E-06	3.14E-06	1.94E-04	5.96E-05	2.62E-02	1.97E-05	0.00E+00	1.40E-03	1.86E-07	9.07E-07	1.17E-04	0.00E+00	2.53E-06	7.86E-06	1.10E-02	5.15E-06
																					1	, ,		1
Total Underground Mine Emissions (Point)	6.31	3.25	0.64	4 lb/hr	Ore	3.00E-06	1.14E-05	4.77E-03	1.64E-05	1.10E-05	6.85E-04	2.10E-04	9.21E-02	6.93E-05	0.00E+00	5.44E-03	6.56E-07	3.19E-06	4.13E-04	0.00E+00	8.92E-06	2.77E-05	3.87E-02	1.81E-05
	8.46	3.95	5 1.23	3 ton/yr	11	4.02E-06	1.52E-05	6.40E-03	2.20E-05	1.48E-05	9.18E-04	2.81E-04	1.24E-01	9.30E-05	0.00E+00	6.61E-03	8.80E-07	4.28E-06	5.54E-04	0.00E+00	1.20E-05	3.71E-05	5.19E-02	2.43E-05
					ib per year toxics	800.0	0.030	12.790	0.044	0.030	1.836	0.563	247.041	0.186	0.000	13.23	0.00	0.009	1.11	0.00	0.024	0.074	103.85	0.049
Haul Road Eugitive Emissions (Volume Source Eugitives) 6																								(
HR-01 Haul Road on Ore Stockpile (EUHAULROADS)	4.63	0.99	0.099	lb/hr	Ore	2.20E-06	8.33E-06	3.50E-03	1.20E-05	8.10E-06	5.02E-04	1.54E-04	6.76E-02	5.08E-05	0.00E+00	1.66E-03	4.81E-07	2.34E-06	3.03E-04	0.00E+00	6.54E-06	2.03E-05	2.84E-02	1.33E-05
	16.89	3.61	0.36	ton/yr		8.02E-06	3.04E-05	1.28E-02	4.39E-05	2.96E-05	1.83E-03	5.62E-04	2.47E-01	1.86E-04	0.00E+00	6.06E-03	1.76E-06	8.55E-06	1.11E-03	0.00E+00	2.39E-05	7.41E-05	1.04E-01	4.86E-05
																					1	,		1
HR-02 Concentrate Transfer Along On-Site Access Road (EUHAULROADS)	1.74	0.37	0.037	lb/hr	Native Soil	3.66E-07	5.57E-06	3.27E-04	1.85E-06	8.01E-07	6.39E-05	2.77E-05	3.43E-05	2.67E-05	7.83E-03	8.30E-04	1.55E-07	1.58E-06	4.16E-05	1.24E-03	1.91E-06	2.92E-07	6.96E-04	2.09E-06
	2.58	0.55	0.06	ton/yr		5.41E-07	8.25E-06	4.85E-04	2.73E-06	1.19E-06	9.46E-05	4.10E-05	5.08E-05	3.96E-05	1.16E-02	1.23E-03	2.29E-07	2.35E-06	6.16E-05	1.83E-03	2.84E-06	4.33E-07	1.03E-03	3.09E-06
HR-03 - Water Truck Transport Along On-Site Access Road (FUHAUI ROADS)	2.24	0.48	0.05	lb/br	Native Soil	4 71E-07	7 18E-06	4 225-04	2 38E-06	1.03E-06	8 23E-05	3.57E-05	4.425-05	3.44E-05	1.01E-02	1.07E-03	2.00E-07	2.04E-06	5 36E-05	1 59E-03	2.47E-06	3 77E-07	8 98E-04	2.695-06
	2.71	0.58	0.06	ton/vr	Huive con	5.69E-07	8.66E-06	5.09E-04	2.87E-06	1.25E-06	9.94E-05	4.30E-05	5.33E-05	4.16E-05	1.22E-02	1.29E-03	2.41E-07	2.46E-06	6.47E-05	1.92E-03	2.98E-06	4.55E-07	1.08E-03	3.25E-06
																					1	, ,		1
Reagent/Grind Media Truck Transport Along On-Site Access Road (EUHAULROADS)	1.78	0.38	0.04	lb/hr	Native Soil	3.74E-07	5.70E-06	3.35E-04	1.89E-06	8.20E-07	6.54E-05	2.83E-05	3.51E-05	2.74E-05	8.02E-03	8.50E-04	1.59E-07	1.62E-06	4.26E-05	1.27E-03	1.96E-06	2.99E-07	7.13E-04	2.14E-06
	0.21	0.04	0.004	ton/yr		4.40E-08	6.71E-07	3.94E-05	2.22E-07	9.64E-08	7.69E-06	3.33E-06	4.13E-06	3.22E-06	9.43E-04	1.00E-04	1.87E-08	1.91E-07	5.01E-06	1.49E-04	2.31E-07	3.52E-08	8.38E-05	2.51E-07
HP 05 Evaluatives Truck Transport Along On Site Access Road (ELIHALII ROADS)	1 77	0.20	0.04	lb/br	Notivo Soil	2 715 07		2 225 04	1.975.06	0 105 07	6 495 05	2.945.05	2 495 05	2 715 05	7.055.02	9 425 04	1 575 07	1 615 06	4 225 05	1 255 02	1.045.06	2.075.07	7.075.04	2 125 06
HR-05 - Explosives Truck Transport Along OII-Sile Access Road (EDHAOLROADS)	0.03	0.38	0.04	ton/vr	Native Soli	5.71E-07	5.65E-06 8.40E-08	3.32E-04 4.94E-06	2.78E-08	0.13E-07 1.21E-08	0.46E-05 9.64E-07	2.01E-05 4 17E-07	5.46E-05	2.71E-05 4.03E-07	7.95E-03 1 18E-04	0.43E-04	2.34E-09	2 39E-08	4.22E-05 6.28E-07	1.25E-05	1.94E-06	2.97E-07	1.07E-04	2.12E-06 3.15E-08
	0.00	0.01	0.001	tor#yr		0.012-00	0.402-00	4.042-00	2.702-00	1.212-00	0.042-07	4.172-07	0.172-07	4.002-07	1.102-04	1.202-00	2.042-00	2.002-00	0.202-07	1.002-00	2.002-00	4.412-00	1.002-00	0.102-00
Total Haul Road Fugitive Emissions	12.16	2.60	0.26	lb/hr		3.78E-06	3.24E-05	4.91E-03	2.00E-05	1.16E-05	7.79E-04	2.74E-04	6.77E-02	1.66E-04	3.39E-02	5.25E-03	1.15E-06	9.20E-06	4.83E-04	5.35E-03	1.48E-05	2.16E-05	3.14E-02	2.23E-05
	22.41	4.79	0.48	ton/yr		9.18E-06	4.81E-05	1.38E-02	4.98E-05	3.21E-05	2.04E-03	6.50E-04	2.47E-01	2.70E-04	2.48E-02	8.69E-03	2.25E-06	1.36E-05	1.24E-03	3.92E-03	2.99E-05	7.50E-05	1.06E-01	5.52E-05
					Ib per year toxics	0.0184	0.0961	27.6127	0.0995	0.0642	4.0707	1.2995	493.4533	0.5407	49.6898	17.3783	0.0045	0.0271	2.4747	7.8400	0.0599	0.1501	211.7617	0.1104
																						'		1
Surface Ore Transfer & Handling (Volume Source Eugitive) (EUEUGITIVES)																					( )			(
F001 - Portal to Transfer Tower	0.09	0.04	0.005	lb/hr	Ore	4.43E-08	1.68E-07	7.04E-05	2.42E-07	1.63E-07	1.01E-05	3.10E-06	1.36E-03	1.02E-06	0.00E+00	5.93E-05	9.69E-09	4.72E-08	6.10E-06	0.00E+00	1.32E-07	4.09E-07	5.72E-04	2.68E-07
	0.34	0.13	0.02	ton/yr		1.62E-07	6.12E-07	2.57E-04	8.84E-07	5.95E-07	3.69E-05	1.13E-05	4.97E-03	3.74E-06	0.00E+00	2.16E-04	3.54E-08	1.72E-07	2.23E-05	0.00E+00	4.81E-07	1.49E-06	2.09E-03	9.78E-07
																					1	, ,		1
F002 - Surplus Ore Transfer at Ore Stockpile	0.26	0.119	0.018	lb/hr	Ore	1.22E-07	4.64E-07	1.95E-04	6.70E-07	4.51E-07	2.79E-05	8.57E-06	3.76E-03	2.83E-06	0.00E+00	1.99E-04	2.68E-08	1.30E-07	1.69E-05	0.00E+00	3.64E-07	1.13E-06	1.58E-03	7.40E-07
	0.940	0.434	0.066	ton/yr		4.46E-07	1.69E-06	7.11E-04	2.44E-06	1.64E-06	1.02E-04	3.13E-05	1.37E-02	1.03E-05	0.00E+00	7.27E-04	9.78E-08	4.76E-07	6.15E-05	0.00E+00	1.33E-06	4.12E-06	5.77E-03	2.70E-06
F003 - Transfer Point at Ore Rins/Reclaim Area	0.22	0.08	0.01	lb/br	Ore	1.03E-07	3 02E-07	1.655-04	5.66E-07	3.81E-07	2 36E-05	7 255-06	3 18E-03	2 395-06	0.00E+00	1345-04	2 27E-08	1 10E-07	1.435-05	0.00E+00	3.08E-07	0.55E-07	1 34E-03	6 26E-07
	0.22	0.3	0.01	ton/vr	OIC	3.78E-07	1.43E-06	6.01E-04	2.07E-06	1.39E-06	2.50E-05 8.63E-05	2.64E-05	1.16E-02	8.73E-00	0.00E+00	4.88E-04	8.27E-08	4.02E-07	5.20E-05	0.00E+00	1.12E-06	3.49E-06	4.88E-03	2.29E-06
																					1	,		1
F004 - Management of Ore within Ore Stockpile	0.58	0.27	0.04	lb/hr	Ore	2.73E-07	1.04E-06	4.35E-04	1.50E-06	1.01E-06	6.25E-05	1.92E-05	8.41E-03	6.33E-06	0.00E+00	4.56E-04	5.99E-08	2.91E-07	3.77E-05	0.00E+00	8.14E-07	2.53E-06	3.53E-03	1.66E-06
	2.10	1.0	0.2	ton/yr		9.98E-07	3.78E-06	1.59E-03	5.46E-06	3.68E-06	2.28E-04	6.99E-05	3.07E-02	2.31E-05	0.00E+00	1.67E-03	2.19E-07	1.06E-06	1.38E-04	0.00E+00	2.97E-06	9.22E-06	1.29E-02	6.04E-06
E005 Transfer Bointo at SAC Mill	0.011	0.0040	0.0000	lle /le r	0.55	F 47E 00	4 005 00	0.005.00	0.005.00	1.045.00	4 405 00	0.005.07	4 505 04	1 005 07	0.005.00	0.005.00	1 105 00	5 545 00	7 405 07	0.005.00	1.545.00	4 705 00	0.005.05	0.405.00
	0.011	0.0040	0.0000	ton/hr	Ole	2 27E-08	8.59E-08	3.61E-05	2.63E-06 1.24E-07	8.35E-08	5 18E-06	3.62E-07 1.59E-06	6.96E-04	5.24E-07	0.00E+00	2.93E-05	4.96E-09	2.41E-08	3.12E-06	0.00E+00	1.54E-08	4.78E-08 2.09E-07	2.93E-04	1.37E-07
	0.010	0.011	0.000			2.272.00	0.002 00	0.012 00		0.002 00	0.102.00	1.002 00	0.002 01	0.212 07	0.002.00	2.002 00		2.112.00	0.122 00	0.002.00	0.1.1.2.00	2.002 0.	2.002 01	1.0.2.0.
F006 - Concentrate Packaging Operations	0.012	0.004	0.0006	lb/hr	Concentrate	2.35E-08	1.18E-07	2.19E-06	0.00E+00	4.35E-07	7.52E-07	1.88E-07	3.43E-03	1.18E-07	1.70E-04	3.78E-06	5.76E-09	5.88E-08	8.58E-07	2.92E-04	0.00E+00	4.70E-07	1.03E-03	0.00E+00
	0.051	0.019	0.0028	ton/yr		1.03E-07	5.15E-07	9.58E-06	0.00E+00	1.91E-06	3.30E-06	8.24E-07	1.50E-02	5.15E-07	7.47E-04	1.66E-05	2.52E-08	2.57E-07	3.76E-06	1.28E-03	0.00E+00	2.06E-06	4.53E-03	0.00E+00
		0.54	0.00																		1			1
Total fugitive emissions associated	1.17	0.51	0.08	lb/hr		5.72E-07	2.20E-06	8.75E-04	3.00E-06	2.46E-06	1.26E-04	3.86E-05	2.03E-02	1.28E-05	1.70E-04	8.59E-04	1.26E-07	6.43E-07	7.65E-05	2.92E-04	1.63E-06	5.54E-06	8.12E-03	3.32E-06
with Surface Ore Handling and Handling	4.5	1.9	0.5	ton/yr	Ib per year toxics	2.11E-06 4.22E-03	8.12E-06	3.20E-03	1.10E-05	9.30E-06	4.02E-04	1.41E-04 2.83E-01	7.67E-02 1.53E+02	4.69E-05	7.47E-04	3.14E-03	4.65E-07 9.29E-04	2.39E-06	2.80E-04	1.28E-03	5.97E-06	2.06E-05	3.05E-02	1.21E-05
					in per your toxido			0.112.00	2.202 02		0.202-01		1.002.02	0.002 02		0.202.00	0.202-04		0.002-01	2.002.00	I.I.OL OL		0.002.001	L. ICL VL
Wind Erosion Stockpiles (Area Source Fugitives) (EUWINDEROSION)																								1
- · · · ·														1							1	, 1		1
F007 - Ore Stockpile (EUFUGITIVES)	1.14	0.23	0.06	lb/hr	Ore	5.43E-07	2.06E-06	8.64E-04	2.97E-06	2.00E-06	1.24E-04	3.80E-05	1.67E-02	1.26E-05	0.00E+00	3.83E-04	1.19E-07	5.78E-07	7.48E-05	0.00E+00	1.61E-06	5.01E-06	7.01E-03	3.29E-06
	5.00	1.00	0.25	ton/yr	Ib par year taying	2.38E-06	9.01E-06	3.78E-03	1.30E-05	8.76E-06	5.43E-04	1.67E-04	7.31E-02	5.50E-05	0.00E+00	1.68E-03	5.20E-07	2.53E-06	3.28E-04	0.00E+00	7.07E-06	2.20E-05	3.07E-02	1.44E-05
					in her year roxics	4.75⊏-03	1.000-02	1.51 E+00	2.00E-02	1.70E-02	1.09E+00	3.33E-01	1.40E+U2	1.10E-01	0.00E+00	3.33E+00	1.04E-03	0.00E-03	0.00E-01	0.00E+00	1.41⊏-02	4.39⊏-02	0.14E+01	2.00E-U2
F008 - Tailings Disposal Facility (EUFUGITIVES)	0.78	0.40	0.21	lb/hr	Tailings	3.88E-07	4.66E-06	4.15E-04	1.55E-06	2.33E-07	2.21E-04	2.80E-05	3.63E-03	9.86E-06	0.00E+00	6.49E-04	1.32E-08	2.10E-05	1.45E-04	0.00E+00	7.76E-07	1.71E-06	1.75E-03	1.94E-06
5 , <u>, , , , , , , , , , , , , , , , , ,</u>	3.40	1.77	0.90	ton/yr	.9-	1.70E-06	2.04E-05	1.82E-03	6.80E-06	1.02E-06	9.66E-04	1.22E-04	1.59E-02	4.32E-05	0.00E+00	2.84E-03	5.78E-08	9.18E-05	6.36E-04	0.00E+00	3.40E-06	7.48E-06	7.65E-03	8.50E-06
		l		1	Ib per year toxics	3.40E-03	4.08E-02	3.64E+00	1.36E-02	2.04E-03	1.93E+00	2.45E-01	3.18E+01	8.64E-02	0.00E+00	5.69E+00	1.16E-04	1.84E-01	1.27E+00	0.00E+00	6.80E-03	1.50E-02	1.53E+01	1.70E-02

Client: <u>Copperwood Resources, Inc.</u> Proj	ect ID.: <u>17C050</u>	Ore
Project: Air Permit Application Emissions Calculations - Ver	sion 2	Concentrate
Prepared by: CED1 Checked by: AKM	Date: 06/25/18 Date: 07/02/18	

Totals for all Emissions Sources																					
	3.88.E+00 lb/hr		Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Phosphorus	Selenium	Silver	Sulfur	Tin
Total TACs=	20132 lb/year	total lb/hr	8.28E-06	5.27E-05	1.18E-02	4.40E-05	2.73E-05	1.93E-03	5.88E-04	2.00E-01	2.71E-04	3.41E-02	1.26E-02	2.07E-06	3.46E-05	1.19E-03	5.64E-03	2.78E-05	6.15E-05	8.70E-02	4.90E-05
	10.1 ton/year	decimal format lb/hr	0.00001	0.0001	0.012	0.00004	0.00003	0.002	0.0006	0.200	0.0003	0.0341	0.013	0.000002	0.000035	0.0012	0.006	0.00003	0.00006	0.087	0.00005
		lb/yr	0.04	0.20	58.01	0.21	0.13	9.85	2.72	1071.82	1.02	51.18	45.94	0.01	0.23	6.07	10.39	0.12	0.32	453.26	0.23
			TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC	TAC		TAC
Federal HAPS: marked as HAP		$\rightarrow$	HAP	HAP		HAP	HAP	HAP	HAP		HAP		HAP	HAP		HAP		HAP			

Emergency Generators (SV-004, SV-005, SV-006) <sup>7</sup>		0.52	0.52	0.52	lb/hr
	EUGENERATORS	0.03	0.03	0.03	ton/yr
Reagents (F009) and Space Heaters (F010) (Fugitive)					
	EUFUGITIVES	0.0112	0.0112	0.0112	lb/hr
		0.049	0.0489	0.0489	ton/yr
Stack Emissions - Total		6.83	3.77	1.16	lb/hr
		8.5	4.0	1.3	ton/yr
Fugitive Emissions - Total		15.3	3.8	0.6	lb/hr
		35.1	9.5	2.0	ton/yr
Total Maximum Controlled		43.6	13.5	3.2	ton/yr
Facility Emissions					

- Notes:
  1. Maximum facility emissions are all site emissions (including fugitive emissions) after applying collection and control efficiencies.
  2. Ore data are the maximum average from sampled parting shales. Copper and silver concentrations are from Orvana Minerals, Corp. Feasibility Study Results Announcement, 02/07/2012.
  3. Concentrate data are from Orvana Minerals Corporation, Copperwood Technical Project, NI 43-01-0 Technical Report, April 30, 2010, Table 16-3; except silver concentrations are from Q431-03-028-Orvan Resources Copperwood Project Prefeasibility Study Final 08-03-2011, page 5.
- 4. Native soil data is the greatest maximum value from Orvana EIA, Table 202.2.2-5, Summary of Soil Chemistry.
- 5. Talings data are the maximum values from sampled composite talings. Derived from Orvana EIA, Table 203.3.4-5, Bulk Chemical Composite Talings from metalllurgical testing compared to unprocessed copper bearing sequence.

6. Roadway emissions only include fugitive emissions from surface roadway travel.

7. Potential to Emit (PTE) for this facility is the stack emissions with no fugitives. The New Source Performance Standards (NSPS) for metallic minerals processing is applicable to this facility

This NSPS (metallic mining) was developed after 1980 and since this facility is not subject to federal Maximum Achievable Control Technology (MACT) standards, fugitive dust is not part of PTE.

PTE is based on controlled emissions since operation of emission control equipment will be a legally enforceable requirement of the operation. PTE for hazardous air pollutants (HAPs)

is based on both stack and fugitive emissions per R 336.1116 (m).

8. Toxics from combustion appear on sheets for these emissions units.

9. Calculation of manganese TAC emissions is based on Note 29 in the MDEQ Table 2 List of Screening Levels. Note 29 states that the ITSL for manganese is most appropriately applied to PM10-Mn rather than TSP-Mn data. Therefore, all TAC calculations for Mn were based on PM-10 data.



Client	Copperwood Resources, Inc.	Project ID.:	17C050
Project:	Air Deposition Calculations - Revised		
Prepared by:	CED1	Date:	09/04/18
Checked by:	AKM	Date:	09/18/18

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#### Air Deposition Model Input Data - Emission Rates of Copper and Sulfur

	Copper	Nickel	Sulfur
	%	%	%
Ore	1.460	0.007	0.61
Concentrate	29.170	0.007	8.80
Native Soils	0.00197	0.002	0.04
Tailings	0.47	0.02	0.23

**Point Sources** 

Emission
Source

SV-001 West Mine Exhaust Vent
SV-002 - East Mine Exhaust Vent
SV-003 - Portal Mine Exhaust Vent

Copper	Nickel	Sulfur	Units
4.51E-03	2.02E-05	1.89E-03	g/sec
4.64E-03	2.08E-05	1.95E-03	g/sec
2.46E-03	1.10E-05	1.03E-03	g/sec

#### Volume Sources

	No. of				
Emission	Volume Source				
Source	Segments	Copper	Nickel	Sulfur	Units
F001 - Ore Transfer at Transfer Tower	1	1.71E-04	7.68E-07	7.21E-05	g/sec
F002 - Surplus Ore Transfer to Ore Stockpile	1	4.74E-04	2.12E-06	1.99E-04	g/sec
F003A&B - Transfer Points at Ore Bins/Reclaim Area <sup>1</sup>	2	2.00E-04	8.98E-07	8.42E-05	g/sec
F004 - Management of Ore at Ore Stockpile	1	1.06E-03	4.75E-06	4.45E-04	g/sec
F005 - Transfer Points at SAG Mill	1	2.00E-05	8.98E-08	8.42E-06	g/sec
F006A&B - Concentrate Handling Operations <sup>1</sup>	2	2.16E-04	5.41E-08	1.30E-04	g/sec
HR-01 - Vehicle Travel on Ore Stockpile <sup>1</sup>	13	6.55E-04	2.94E-06	2.75E-04	g/sec

#### Area Sources

Emission Source	Area	Copper	Nickel	Sulfur	Units
F007 - Wind Erosion at Ore Stockpile	51,790	4.06E-08	1.82E-10	1.71E-08	g/m2-sec
F008 - Wind Erosion at TDF	38,079	1.20E-08	4.80E-10	5.78E-09	g/m2-sec

Notes:

<sup>1</sup> Each Lead/Michigan air toxic concentration is for each volume source segment.

<sup>2</sup> TAC emission rates are based on PM emission composition.



Client:	Copperwood Resources, Inc.	Project ID.:	17C050	
Project:	Air Deposition Calculations - Revised	-		
repared by:	CED1	Date:	09/04/18	
hecked by:	АКМ	Date:	09/18/18	

#### Particle Density, Particle Size Diameters, and Associated Mass Fractions

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Ore Density <sup>1</sup> = Tailings Dry Densit Conc't Density <sup>1</sup> = Native Soils Densit	y = y =	1.60 1.31 1.92 1.33	g/cm <sup>3</sup> g/cm3 g/cm <sup>3</sup> g/cm3
	Mean Pa	rticle Size Range C	Calculations <sup>2</sup>
Low Cut (µm)	High (	Cut (µm)	Mean Size (μm)
	0	1	0.63
	1	2	1.55
	2	2.5	2.26
	2.5	3	2.76
	3	4	3.52
	4	5	4.52
	5	6	5.52
	6	10	8.16

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#### Point Sources <sup>3</sup>

<u>SV-001 West Mine Exhau</u> <u>SV-002 East Mine Exhaus</u> <u>SV-003 Portal Mine Exhau</u>	<u>st Vent</u> s <u>t Vent</u> ust Vent	Ore Material Densi	ty =	1.60 g/cm	3
Particle Size Range (µm)	Cum Size (%)	Cum Wt. (g/cm <sup>3</sup> )	Mass (g/cm <sup>3</sup> )	Mass Fraction	
1	4	0.06	0.06	0.04	
2	11	0.18	0.11	0.07	
2.5	15	0.24	0.06	0.04	
3	18	0.29	0.05	0.03	
4	25	0.40	0.11	0.07	
5	30	0.48	0.08	0.05	
6	34	0.54	0.06	0.04	
10	51	0.82	0.27	0.17	
15	100	1.60	0.78	0.49	
Totals			1.60	1.0	

12.66



Client:	Copperwood Resources, Inc.	Project ID.:	17C050
Project:	Air Deposition Calculations - Revised		
repared by:	CED1	Date:	09/04/18
hecked by:	АКМ	Date:	09/18/18

#### Volume Sources <sup>3</sup>

F001 - Ore Transfer Tower

	Ore Material Density =	1.60 g/cm <sup>3</sup>
Stockpile	No Control Devices Added to Mechanically	Change Particle Size
Reclaim Area		-

F002 - Surplus Ore Transfer to Ore Stockpile F003 - Transfer Points at Ore Bins/Reclaim Area

F004 - Management of Ore at Ore Stockpile

F005 - Transfer Points at SAG Mill

HR-01 Vehicle Travel at Ore Stockpile

Particle Size Range (µm) C	um Size (%)	Cum Wt. (g/cm <sup>3</sup> )	Mass (g/cm <sup>3</sup> )	Mass Fraction
1	4	0.06	0.06	0.04
2	11	0.18	0.11	0.07
2.5	15	0.24	0.06	0.04
3	18	0.29	0.05	0.03
4	25	0.40	0.11	0.07
5	30	0.48	0.08	0.05
6	34	0.54	0.06	0.04
10	51	0.82	0.27	0.17
15	100	1.60	0.78	0.49
Totals			1.60	1.0

F006 - Concentrate Handling Operations Co

Concentrate Density = 1.92 g/cm<sup>3</sup> No Control Devices Added to Mechanically Change Particle Size

Particle Size Range (µm)	Cum Size (%)	Cum Wt. (g/cm <sup>3</sup> )	Mass (g/cm <sup>3</sup> )	Mass Fraction
1	4	0.08	0.08	0.04
2	11	0.21	0.13	0.07
2.5	15	0.29	0.08	0.04
3	18	0.35	0.06	0.03
4	25	0.48	0.13	0.07
5	30	0.58	0.10	0.05
6	34	0.65	0.08	0.04
10	51	0.98	0.33	0.17
15	100	1.92	0.94	0.49
Totals			1.92	1.0



Client:	Copperwood Resources, Inc.	Project ID.:	17C050
Project:	Air Deposition Calculations - Revised		
Prepared by:	CED1	Date:	09/04/18
Checked by:	AKM	Date:	09/18/18

#### Area Sources <sup>3</sup>

F007 - Wind Erosion at Ore Stockpile		Ore Material Density No Control Devices	Ore Material Density = 1 No Control Devices Added to Mechanically C			
Particle Size Range (µm) Cu	ım Size (%)	Cum Wt. (g/cm <sup>3</sup> )	Mass (g/cm <sup>3</sup> )	Mass Fraction		
1	4	0.06	0.06	0.04		
2	11	0.18	0.11	0.07		
2.5	15	0.24	0.06	0.04		
3	18	0.29	0.05	0.03		
4	25	0.40	0.11	0.07		
5	30	0.48	0.08	0.05		
6	34	0.54	0.06	0.04		
10	51	0.82	0.27	0.17		
15	100	1.60	0.78	0.49		
Totals			1.60	1.0		
F008 - Wind Erosion at TDF		Tailings Density =		1.31	g/cm <sup>3</sup>	

No Control Devices Added to Mechanically Change Particle Size

Particle Size Range (µm)	Cum Size (%)	Cum Wt. (g/cm <sup>3</sup> )	Mass (g/cm <sup>3</sup> )	Mass Fraction
1	4	0.05	0.05	0.04
2	11	0.14	0.09	0.07
2.5	15	0.20	0.05	0.04
3	18	0.24	0.04	0.03
4	25	0.33	0.09	0.07
5	30	0.39	0.07	0.05
6	34	0.45	0.05	0.04
10	51	0.67	0.22	0.17
15	100	1.31	0.64	0.49
Totals			1 31	1.0

Totals

#### Notes:

1. Material densities were taken directly from the Preliminary Design Criteria that were prepared for the Prefeasibility Study of the Copperwood Project, Upper Peninsula, USA completed by KD Engineering dated July 29, 2011.

2. Tailings density information was derived from the value provided for Stage 2 tailings density as stated in Table 5-2 in the Mining Permit Application Amendment as prepared by Foth Infrastructure & Environment, LLC dated March 2018.

3. U.S. Department of Agriculture Natural Resources Conservation Service, Soil Quality Indicators publication on typical bulk density of soils.

4. The methodology for determining the mean particle size range is taken from the Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Chapter 3, Air Dispersion and Deposition Modeling.

5. Certain assumptions were made regarding particle size and density for input files to the air deposition model. Particle diameters were taken from Appendix B.2, Table B.2.2 to AP-42, Generalized Particle Size Distributions. Table B.2.2 is for use with aggregate and unprocessed ores that are mechanically generated. This broad category includes emissions from milling, grinding and crushing of these types of materials.

#### **Attachment 2**

#### **Deposition Results**

PW\_IE\Documents\Clients\Copperwood Resources\0017C050.00\5000 Client Correspondence\Air Deposition Revision\M-Deposition Analysis Rev 1.docx



Client:	Copperwood Resources, Inc.	Project ID.:	17C050
Project:	Air Deposition Impact Analysis - Soil Imp		
Prepared by:	АКМ	Date:	09/18/18
Checked by:	CED1	Date:	09/19/18

0.75

1.6

5.71

0.32

0.68

2.42

-- Data are generated for 9,801 receptors. Only page 1 of 84 has been provided --Selected Receptors X coord. Y coord. Copper Sulfur Sulfur Copper METER METER g/m\*\*2 g/m\*\*2 mg/m\*\*2 mg/m\*\*2 ID R1 272099 5173823 0.00282 0.00119 2.82 1.19 R2 271299 5173423 0.0057 0.00241 5.7 2.41 R3 270699 5173223 0.01126 0.00475 11.26 4.75 R4 269799 5172623 0.00509 0.00216 5.09 2.16 R5 270699 5171823 0.00606 0.00261 6.06 2.61 R6 271799 5171523 0.00204 0.00087 2.04 0.87 R7 273399 5171323 0.00082 0.00035 0.82 0.35

0.00032

0.00068

0.00242

All	Rece	ptor	Data
~	11000	pior	Dutu

274199

273599

272899

5171723 0.00075

5172223 0.0016

5172823 0.00571

R8

R9

R10

	X coord.	Y coord.	Copper	Sulfur	1		X coord.	Y coord.	Copper	Sulfur
ID	METER	METER	g/m**2	g/m**2	Į į	ID	METER	METER	g/m**2	g/m**2
1	265799	5168723	0.00007	0.00003	I	4901	271799	5172723	0.0071	0.00302
2	265899	5168723	0.00008	0.00003		4902	271899	5172723	0.00616	0.00262
3	265999	5168723	0.00008	0.00003		4903	271999	5172723	0.00546	0.00233
4	266099	5168723	0.00009	0.00004		4904	272099	5172723	0.0049	0.00209
5	266199	5168723	0.00009	0.00004		4905	272199	5172723	0.00447	0.00191
6	266299	5168723	0.00009	0.00004		4906	272299	5172723	0.00415	0.00177
7	266399	5168723	0.00009	0.00004		4907	272399	5172723	0.00389	0.00166
8	266499	5168723	0.00009	0.00004		4908	272499	5172723	0.00364	0.00155
9	266599	5168723	0.00009	0.00004		4909	272599	5172723	0.00349	0.00149
10	266699	5168723	0.00009	0.00004		4910	272699	5172723	0.00388	0.00165
11	266799	5168723	0.0001	0.00004		4911	272799	5172723	0.00631	0.00267
12	266899	5168723	0.0001	0.00004		4912	272899	5172723	0.00577	0.00244
13	266999	5168723	0.0001	0.00004		4913	272999	5172723	0.00428	0.00182
14	267099	5168723	0.00011	0.00004		4914	273099	5172723	0.0034	0.00144
15	267199	5168723	0.00011	0.00005		4915	273199	5172723	0.00297	0.00126
16	267299	5168723	0.00011	0.00005		4916	273299	5172723	0.00268	0.00114
17	267399	5168723	0.00011	0.00005		4917	273399	5172723	0.00249	0.00106
18	267499	5168723	0.00011	0.00005		4918	273499	5172723	0.00236	0.001
19	267599	5168723	0.00012	0.00005		4919	273599	5172723	0.00216	0.00092
20	267699	5168723	0.00012	0.00005		4920	273699	5172723	0.00198	0.00084
21	267799	5168723	0.00012	0.00005		4921	273799	5172723	0.00184	0.00078
22	267899	5168723	0.00013	0.00006		4922	273899	5172723	0.00172	0.00073
23	267999	5168723	0.00014	0.00006		4923	273999	5172723	0.0016	0.00068
24	268099	5168723	0.00014	0.00006		4924	274099	5172723	0.00149	0.00063
25	268199	5168723	0.00014	0.00006		4925	274199	5172723	0.00139	0.00059
26	268299	5168723	0.00014	0.00006		4926	274299	5172723	0.00127	0.00054
27	268399	5168723	0.00015	0.00006		4927	274399	5172723	0.00119	0.00051
28	268499	5168723	0.00015	0.00006		4928	274499	5172723	0.00112	0.00048
29	268599	5168723	0.00015	0.00006		4929	274599	5172723	0.00106	0.00045
30	268699	5168723	0.00015	0.00006		4930	274699	5172723	0.00102	0.00043
31	268799	5168723	0.00016	0.00007		4931	274799	5172723	0.001	0.00043
32	268899	5168723	0.00016	0.00007		4932	274899	5172723	0.00098	0.00042
33	268999	5168723	0.00016	0.00007		4933	274999	5172723	0.00095	0.00041
34	269099	5168723	0.00017	0.00007		4934	275099	5172723	0.0009	0.00038
35	269199	5168723	0.00017	0.00007		4935	275199	5172723	0.00087	0.00037
36	269299	5168723	0.00018	0.00008		4936	275299	5172723	0.00084	0.00036
37	269399	5168723	0.00018	0.00008		4937	275399	5172723	0.00077	0.00033
38	269499	5168723	0.00019	0.00008		4938	275499	5172723	0 00073	0.00031

**Attachment 3** 

**Calculations** 



Client Copperwood Resources, Inc. Project ID.:

Cilent	Copperwood Resources, Inc.	FIGECUD.	170050				
Project	Toject: Air Deposition Impact Analysis - Soil Impact Evaluation						
Prepared by	AKM	Date:	09/18/18				
Checked by	CED1	Date:	09/19/18				

17C050

I Comparative Criteria for Soils	Copper mg/kg (ppm)	Sulfur mg/kg (ppm)	Sulfate <sup>1</sup> mg/kg (ppm)
Direct Contact Criteria and Risk Based Screening Level <sup>2</sup>	20,000	n.a.	n.a.
Drinking Water Protection Criteria and Risk Based Screening Level <sup>2</sup>	5,800	n.a.	5,000
Groundwater Surface Water Interface Protection Criteria and Risk Based Screening Level <sup>2</sup>	160	n.a.	n.a.
Risk Management Criteria for Metals at BLM Mining Sites <sup>3</sup>	7	n.a.	n.a.

#### II Selected Deposition Receptors and Deposition Rate

	D	eposition Rate	Copper	Sulfur	Sulfate <sup>1</sup>
Location	X Coordinate	Y Coordinate	mg/m2/year	mg/m2/year	mg/m2/year
R1	272099	5173823	2.82	1.19	3.57
R2	271299	5173423	5.7	2.41	7.23
R3	270699	5173223	11.26	4.75	14.25
R4	269799	5172623	5.09	2.16	6.48
R5	270699	5171823	6.06	2.61	7.83
R6	271799	5171523	2.04	0.87	2.61
R7	273399	5171323	0.82	0.35	1.05
R8	274199	5171723	0.75	0.32	0.96
R9	273599	5172223	1.6	0.68	2.04
R10	272899	5172823	5.71	2.42	7.26
III Soil Char	acteristics of N	ative Soils			
			Copper	Sulfur	Sulfate <sup>1</sup>
Soil	I Composition <sup>4</sup>	Weight %	0.00197	0.04	0.12
		mg/kg or ppm	19.7	400	1200
	specific g	ravity of soil <sup>5</sup> :	1.33		

#### **IV Potential Soil Impacts**

If one year of deposition mixed with the top 1 centimeter (cm) of soil, the soil characteristics could potentially be:

Mass of soil:

0.01 m3 volume = 1 m x 1 m x 1 cm = mass of soil for 1m2 at 2 cm deep = Estimating the potential concentration after 1 year of deposition:

13.3 kg per m2

Potential concentration = native soil composition mg/kg + [one year deposition in mg/m2]/ (13.3 kg/m2)

For one year of operations:

	Copper	% increase in			Sulfate <sup>1</sup>	% increase in	
Location	mg/kg (ppm)	soil composition			mg/kg (ppm)	soil composition	
R1	19.9	1.1%			1200.3	0.02%	
R2	20.1	2.2%	Min/Max		1200.5	0.05%	Min/Max
R3	20.5	4.3%	0.3%		1201.1	0.09%	0.01%
R4	20.1	1.9%	4.3%		1200.5	0.04%	0.09%
R5	20.2	2.3%			1200.6	0.05%	
R6	19.9	0.8%			1200.2	0.02%	
R7	19.8	0.3%			1200.1	0.01%	
R8	19.8	0.3%			1200.1	0.01%	
R9	19.8	0.6%			1200.2	0.01%	
R10	20.1	2.2%			1200.5	0.05%	
Average:	20.0	2%		Average:	1200.4	0.03%	



Client	Copperwood Resources, Inc.	Project ID.:	17C050	
Project 7	Air Deposition Impact Analysis - Soil Imp			
Prepared by:	AKM	Date:	09/18/18	
Checked by:	CED1	Date:	09/19/18	

For 14 year duration of operations:

	Copper	% increase in			Sulfate <sup>1</sup>	% increase in	
Location	mg/kg (ppm)	soil composition			mg/kg (ppm)	soil composition	
R1	22.7	15%			1203.8	0.31%	
R2	25.7	30%	Min/Max		1207.6	0.63%	Min/Max
R3	31.6	60%	4%		1215.0	1.25%	0.08%
R4	25.1	27%	60%		1206.8	0.57%	1.25%
R5	26.1	32%			1208.2	0.69%	
R6	21.8	11%			1202.7	0.23%	
R7	20.6	4%			1201.1	0.09%	
R8	20.5	4%			1201.0	0.08%	
R9	21.4	9%			1202.1	0.18%	
R10	25.7	31%			1207.6	0.64%	
Average:	24.1	22%		Average:	1205.6	0.47%	•

Soil impacts: Of the four criteria identified in I, native soil exceeds the Risk Management Criteria for Metals at BLM Mining Sites for copper. Deposition could potentially increase the copper composition from 0.1 to 2.5% on an annual basis. Over a 14 year mine life, the increase in copper concentrations are higher, however, continue to meet the Michigan standard criteria. All other criteria are met for both copper and sulfate.

#### V Evaluation of Sulfate Deposition Rate

To compare the highest sulfate deposition rate of the project on the environment to the standard, convert the standard <sup>6</sup> for SO4 ion from kg/ha/yr to mg/m2/yr.

11 kg <sup>6</sup> ha-year	1000 g kg	1000 mg g	ha 10000 m2	=	1100 mg/m2/yr
Background Sulfate Deposition	on Rate <sup>7</sup> :				
6 kg	1000 g	1000 mg	ha	=	600
ha-year	kg	g	10000 m2		mg/m2/yr
		Highest sulfate depo	14		
			(Receptor L	ocation 5)	mg/m2/yr
		Total highest pre	edicted sulfate depos	sition rate:	614
					mg/m2/yr
	Is the highest sulfate	e deposition rate compliant with	the acid deposition	standard?	Yes

#### Notes

1 Sulfate is a calculated value. Sulfate is potentially present based on all sulfur converting to sulfate. Based on their respective molecular weights, there could be 3 times the mass of sulfate as sulfur.

2. Michigan Part 201 Generic Cleanup Criteria and Screening Levels/Part 213 Risk-Based Screening Levels, Table 2 Soil: Residential, rounded.

3. US Department of Interior - Bureau of Land Management, 2004. Risk Management Criteria for Metals at BLM Mining Sites, Technical Note 390 rev. October 2004. Values selected from Table 4 are the most stringent.

4. Native soil data is the greatest maximum value from Orvana EIA, Table 202.2.2-5, Summary of Soil Chemistry.

5. U.S. Department of Agriculture Natural Resources Conservation Service, *Soil Quality Indicators* publication on typical bulk density of soils.

6. Minnesota Rule 7021 Acid Deposition Control: 7021.0030 Acid Deposition Standard: 11 kg wet sulfate deposition per hectare per year. Although this rule is no longer in effect in Minnesota, the value provided is the only identified protective deposition standard for sulftate and is therefore informative in this analysis.

7. National Atmospheric Deposition Program, Average between NTN Sites WI36 in Trout Lake WI and MI99 in Chassell MI. High deposition value of 6 kg/ha-year, most recent 5 years of data.

### **Attachment 4**

**Calculations for the GSI Criteria** 

#### Calculation of Generic Facility-Specific Part 201 Groundwater Surface Water Interface (GSI) Criteria for {G} Footnoted Hazardous Substances

#### Directions for calculating generic facility-specific GSI criteria:

1. Enter "hardness" (Column C) or "pH" (Column D). Click the green check mark to the left of the Excel formula bar or press the "Enter" key.

The GŚI criteria for surface water not protected as a source of drinking water are the lower of the final chronic value (FCV), wildlife value (WV), and the surface water human non-drinking water value (HNDV). These criteria are presented in Column L.
 The GSI criteria for surface water protected as a source of drinking water are the lower of the FCV, WV, and surface water human drinking water value (HDV). Surface water protected as a source of drinking water includes the Great Lakes and their connecting waters, and inland surface water in close proximity to a water supply intake. These criteria are presented in Column M. Refer to Part 201 Criteria Application Guidesheet #3 for further guidance on selecting the applicable GSI criterion.

4. The final acute values (FAV) protective of aquatic life are presented in column E. The calculation of the FAV is provided to allow the identification of any exceedance of an acute GSI criterion. Where an exceedance of an acute GSI criterion exists, an evaluation must be done to determine appropriate action in accordance with provisions of R 299.5716, R 299.5526(4) and RRD Operational Memorandum No. 5.

Calculate GSI in ug/L (ppb)												
Hazardous Substance	Chemical Abstract Service Number (CAS #)	* ENTER Hardness in mg CaCO3/L	* ENTER pH	Final Acute Value (FAV)	FAV Conversion Factor	Final Chronic Value (FCV)	FCV Conversion Factor	Wildlife Value (WV)	Surface Water Human Non- Drinking Water Value (HNDV)	Surface Water Human Drinking Water Value (HDV)	GSI Criteria for Surface Water Not Protected for Drinking Water Use	GSI Criteria for Surface Water Protected for Drinking Water Use
Acetate	71501	NA	рН	Calculated	NA	Calculated	NA	NA	1.3E+6	16,000	Calculated	Calculated
Acetic acid	64197	NA	рН	Calculated	NA	Calculated	NA	NA	1.3E+6	16,000	Calculated	Calculated
Barium	7440393	hardness	NA	Calculated	NA	Calculated	NA	NA	1.6E+5	1,900	Calculated	Calculated
Beryllium	7440417	hardness	NA	Calculated	NA	Calculated	NA	NA	1,200	160	Calculated	Calculated
Cadmium	7440439	hardness	NA	Calculated	Calculated	Calculated	Calculated	NA	130	3	Calculated	Calculated
Chromium (III)	16065831	hardness	NA	Calculated	NA	Calculated	0.86	NA	9,400	120	Calculated	Calculated
Copper	7440508	379	NA	94.31797613	NA	2.8E+1	0.96	NA	38,000	470	2.8E+1	2.8E+1
Lead	7439921	hardness	NA	Calculated	Calculated	Calculated	Calculated	NA	190	14	Calculated	Calculated
Manganese	7439965	hardness	NA	Calculated	NA	Calculated	NA	NA	59,000	1,300	Calculated	Calculated
Nickel	7440020	hardness	NA	Calculated	NA	Calculated	0.997	NA	2.1E+5	2,600	Calculated	Calculated
Zinc	7440666	hardness	NA	Calculated	NA	Calculated	0.986	NA	16,000	3,300	Calculated	Calculated
Pentachlorophenol	87865	NA	рН	Calculated	NA	Calculated	NA	NA	2.8	1.8	Calculated	Calculated

NA = Criterion or value is not available or not applicable.

\* The formulas in this spreadsheet depend upon appropriate entries in these cells. Do not leave these cells blank. If numeric hardness or pH values are not available, enter the word "hardness" or "pH" in the appropriate cell.

To evaluate copper, lead, and zinc criteria, an average hardness value was developed considering

Hardness Value is the mean of all samples from the Shallow Glacial Overburden Groundwater.

See Orvana Mining Permit Application, Table 202.2.7-2.

Prepared by: AKM Checked by CED1

#### Calculation of Generic Facility-Specific Part 201 Soil GSI Protection Criteria (GSI PC)

#### Directions for calculating a generic facility-specific soil GSI PC:

1. Manually type in the **"GSI"** criterion calculated on the previous page, rounded to 2 significant figures. DO NOT CUT AND PASTE as this will enter the unrounded value and generate a different value. Click the green check mark to the left of the Excel formula bar or press the "Enter" key.

2. The GSI PC will calculate and appear in Column W. The GSI PC are the higher of the Soil-Water Partition Value for GSI (Column U) and the 20 X GSI value (Column V).

Calculate Soil GSI PC in ug/Kg (ppb)										
Hazardous Substance	Chemical Abstract Service Number (CAS #)	* ENTER GSI	Soil-Water Distribution Coefficients (Kd) L/Kg	Henry's Law Constant (HLC) atm-m3/mol	Soil Organic Carbon-Water Partition Coefficient (Koc) L/Kg	Soil-Water Partition Value for GSI ug/Kg	20 X GSI ug/Kg	Soil GSI PC ug/Kg		
Acetate	71501	GSI	NA	NA	NA	Calculated	Calculated	Calculated		
Acetic acid	64197	GSI	NA	NA	NA	Calculated	Calculated	Calculated		
Barium	7440393	GSI	41	NA	NA	Calculated	Calculated	Calculated		
Beryllium	7440417	GSI	790	NA	NA	Calculated	Calculated	Calculated		
Cadmium	7440439	GSI	75	NA	NA	Calculated	Calculated	Calculated		
Chromium (III)	16065831	GSI	1.8E+6	NA	NA	Calculated	Calculated	Calculated		
Copper	7440508	2.8E+1	360	NA	NA	1.6E+5	5.6E+2	1.6E+5		
Lead	7439921	GSI	11,000	NA	NA	Calculated	Calculated	Calculated		
Manganese	7439965	GSI	NA	NA	NA	Calculated	Calculated	Calculated		
Nickel	7440020	GSI	65	NA	NA	Calculated	Calculated	Calculated		
Zinc	7440666	GSI	62	NA	NA	Calculated	Calculated	Calculated		
Pentachlorophenol	87865	GSI	NA	2.44E-8	592	Calculated	Calculated	Calculated		

NA = Criterion or value is not available or not applicable.

\* The formulas in this spreadsheet depend upon appropriate entries in these cells. Do not leave these cells blank. If numeric GSI values are not available, enter "GSI" in the appropriate cell.

Prepared by: AKM Checked by: CED1

#### **Attachment 5**

**Background Sulfate Deposition Rates** 



http://nadp.slh.wisc.edu/data/sites/list/?net=NTN



#### What to Plot



Conservative Value for last 5 years of data:

5 kg/ha-year

#### More Information

#### Annual Criteria:

The annual weighted mean concentrations and depositions are characterized as meeting or not meeting the NADP's data completeness criteria for each 1-year period.

- 1. Valid samples for 75% of the time period
- 2. Valid samples for 90% of the precipitation amount
- 3. Precipitation amounts for 75% of the time period



6 kg/ha-year

#### What to Plot



http://nadp.slh.wisc.edu/data/ntn/plots/ntntrends.html?siteID=MI99

Conservative Value for last 5 years of data:

More Information

#### Annual Criteria:

The annual weighted mean concentrations and depositions are characterized as meeting or not meeting the NADP's data completeness criteria for each 1-year period.

- 1. Valid samples for 75% of the time period
- 2. Valid samples for 90% of the precipitation amount
- 3. Precipitation amounts for 75% of the time period