17th of January, 2011

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REVISED FINAL REPORT

AIR QUALITY MODELING REPORT FOR THE PROPOSED CITRONEN MINING OPERATIONS

Submitted to:
Ironbark Zinc Limited

REPORT

Report Number. 10512450343

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Golder Associates

Study Limitations

IMPORTANT: This section should be read before reliance is placed on any of the opinions, advice, recommendations or conclusions herein set out.

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1.0 INTRODUCTION

Golder Associates AB (Golder) was engaged by Ironbark Zinc Limited (Ironbark) to perform air dispersion modelling in order to assess the potential dispersal of dust at the proposed Citronen Ironbark Zinc and Lead Mine located in northern Greenland. The mine is situated at the southern end of the Citronen Fjord at the southern shore of the Frederick Hyde Fjord in Peary Land (see Figure B-1, Appendix B).

Dust [i.e., particulate matter (PM)] emissions were developed and ground-level PM concentrations and deposition estimates were predicted for the mining operations based upon available hourly meteorological data collected at the mine site, air emission sources, and receptor locations developed for the mining operations. In addition, PM with an aerodynamic diameter of 10 microns or less (PM_{10}) emissions were developed and ground-level PM_{10} concentrations and PM_{10} deposition rates were also predicted for the mining operations.

These data were processed into a format suitable for use in the air dispersion model, U.S. American Meteorological Society- Environmental Protection Agency Regulatory Model (AERMOD). AERMOD is an advanced plume model that incorporates improved treatments of the boundary layer theory, turbulence and dispersion. This model is the preferred model for use with industrial facilities for general regulatory modeling applications in the U.S. It is also recommended by international finance institutions, such as the IFC and World Bank, in their environmental regulatory review process.

Because of the concern for zinc and lead in the mined ore and potential air quality impacts in the vicinity of the mine, zinc and lead emissions were estimated for the mining activities. Conservative assumptions of the content of zinc and lead in dust emissions from each source were adopted based on geological information supplied by Ironbark. Because of the uncertainty in certain parameters, such as particle size in PM emissions, both PM and PM_{10} emissions were modeled to produce a range of potential impacts.

The mine is located in northern Greenland at a remote location where there are no communities or villages of off-site human receptors near the mining areas. As a result, the purpose of the modeling analysis is to provide an estimate of potential dust impacts from the site, assess potential dust emission controls, and provide information to allow Ironbark to perform an assessment of potential ecological impacts in the area associated with zinc and lead deposition.

The activity rates used in estimating emissions as well as the content of zinc and lead in each source are considered conservative and the estimated impacts presented in this report are unilkely to occur for the full life of the mine.

Golder's scope of work did not include an assessment of ecological or other impacts asociated with the estimated dust concentrations and depositions from the mine.

The following sections present a summary of the air emission sources, modeling assumptions and methods, and modeling results for the mining operation.

2.0 PROJECT EMISSIONS

2.1 General Mine Description

The Citronen mine and processing plant will be operated to produce two products of saleable concentrates of zinc and lead. Mining production will occur at a rate of 3 million tonnes per annum (MTPA). Total zinc and lead concentrates produced are estimated to be 250,000 and 30,000 TPA, respectively. The mining operations will use standard industry techniques for hard rock mining based on the style of mineralisation, and proximity to the surface. The deposit is formed by three ore zones: the Beach, Esrum and Discovery ore zones. The Beach and Esrum ore zones occur at depths of 100 to 400 m below the surface and will be extracted using conventional trackless underground techniques. The Discovery ore zone is amenable to open pit mining due to its proximity to surface.

Ore mined at the open pit and underground mines will be delivered by mining trucks to the Run of Mine (ROM) pad for processing at the processing plant. Processing of ore undergoes the following several stages:

- Crushing
- Dense Media Separation
- Milling
- Flotation
- Concentrate Dewatering

As a consequence of the froth flotation separating the valuable metals from the remainder of the material, tails are created which are waste streams of fine material. The tailings are managed in two ways. For the first year of production, the tails will be sent to a Tailings Storage Facility (TSF) where they will be encapsulated within an earth dam structure. In subsequent years the tailings will be sent directly to the underground mine where they will be used to backfill the voids created through mining the ore, hence providing support to the underground pillars upon freezing of the entrained water.

Concentrate will then be delivered to a port facility using a covered conveyor and loaded onto ships. Concentrate that is not immediately shipped is stored within a fully enclosed heated concentrate shed where the concentrate is kept dry and safely stored prior to shipping to the customer. Entrance to the concentrate shed is through a sealed door. The exhaust air from the shed is vented to the atmosphere through a filter which reduces emissions.

The port will be formed by a 15-m wide access dike constructed of quarry run/gravel with a compacted wearing course and rock armour to the batters. The pier head will be formed by a rectangular sheet pile cell filled with quarry run/gravel. From the pier head it will be possible to reach the access barges for concentrate loading and importing supplies. Moorings will be established onshore and offshore to enable wharfing of the concentrate barges.

2.2 Potential Dust Sources

There are several general areas where potential dust emissions will occur at the mine site:

- Open pit mine
- Underground mine
- Process plant/concentrate shed
- Tailings dam

- Seaborne concentrate loading point
- Haul roads

Open pit mining causes dust through loading and haul activities, and through surface blasting. For loading and hauling, muck piles can be wet down prior to excavation in areas where dust can be emitted. However it should be noted that wet down of areas may not be feasible during large parts of the year when ambient temperatures are sub-zero degrees Celsius. Surface drilling utilises water as required to suppress dust. For surface blasting, the ability to control dust is limited since it is not feasible to wet down the area for safety reasons. Explosives create significant volumes of gas that provide energy for fine particles to be released and become suspended in the atmosphere. Under adverse conditions, blasting would be postponed to mitigate dust.

Underground mining causes dust within the workings of the mine. The dust is transported in the air and exhausted from the mine via the vent raises. Maintaining a good working environment is preferable by minimising dust at source locations (working faces) rather than dealing with dust suspended in the air. Wetting down of muck piles in development drives and stopes is sufficient to minimize dust suspension. The amount of wetting must be managed such that there's a balance between dust suppression and avoiding freezing the moisture added to the blasted material.

The process plant and concentrate shed will be ventilated and the exhaust from these buildings will be filtered to reduce emissions.

Tailings deposition within the TSF will be as wet slurry and accordingly provide a mechanism for suppression of dust by the presence of a layer of water until such time as it is reclaimed from the TSF or freezes in-situ.

Concentrate loading to the barges will occur at the port facility with dust emissions minimised by the use of covered cargo holds and a sock fitted to the telescopic chute, which discharges to the hold.

Haul road fugitive dust can be suppressed through light wetting with a water truck which will be managed carefully in a cold climate to avoid potential ice build up. During instances of ice build up, the ability for dust emissions is assumed to be minimal.

Based on these types of activities, the main sources of potential dust emissions types are assumed to occur for the following sources:

- Open pit mine
  - transfer activities associated with loading material on haul trucks (i.e. batch drop of materials);
  - blasting activities;
  - bulldozing activities;
  - grading activities; and
  - wind erosion.
- Underground mine
  - transfer activities associated with loading material on haul trucks (i.e. batch drop of materials); and
  - blasting activities.
- Truck traffic associated with hauling activities on unpaved roads
- Waste dump
  - transfer activities associated with unloading material from haul trucks (i.e. batch drop of materials); and

- wind erosion.

- Process plant
  - transfer activities associated with unloading material from haul trucks (i.e. batch drop of materials); and
  - primary and secondary crushing of the ore.

Other potential sources of pollutant emissions were not considered since they are assumed to have minimal dust emissions due to moisture content of the material, enclosures with vents that have filters, coverings to suppress dust (such as conveyors and ship hold), or operational features to minimize dust (such as telescopic chute for ship loading). These other sources are not expected to generate emissions comparable to the sources considered in the analysis.

Many of these activities that were considered in the analysis result in fugitive dust emissions which are emissions which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening. Fugitive PM emissions due to material handling activities were estimated in accordance with current US Environmental Protection Agency (USEPA) recommendations and techniques as presented in "Compilation of Air Pollutant Emission Factors, Volume I, Stationary Sources", referred to as AP-42.

For the crushers, the non-fugitive PM_{10} emission rates were estimated based on material throughput assuming that the air exhausts through filters.

The mining activities during operation will occur for approximately seven years for the open pit mine and 16 years for the underground mine. When the open pit mine is operating, the maximum ore mined will be 1.5 MTPA with waste material of 3.7 MTPA. During this time, the maximum ore mined from the underground mine will be 1.5 MTPA. When the open pit mine no longer operates, the maximum ore mined at the underground mine will be 3.0 MTPA.

For these analyses, both the open pit and underground mines were assumed to operate (i.e., maximum ore mined at the open pit and underground mines were assumed to be 1.5 MPTA each).

A summary of the estimated pollutant emissions for the mine activities during the mine operation and included in the modeling is presented in Table A-1 in Appendix A. The bases of the emission factors and calculations of the emission rates are presented in other tables within Appendix A.

2.3 PM/PM_{10} Emission Factors and Emissions

2.3.1 Traffic on Unpaved Roads

During mine operations, material extracted from the open pit and underground mines will be hauled to the process plant. Since the haul roads will be unpaved, fugitive PM/PM_{10} emissions will be generated due to truck traffic.

The PM/PM_{10} emission factors for the traffic on unpaved roads were derived from the equation provided in Section 13.2.2 in AP-42:

$$E = k\,(s/12)^a\,(W/3)^b\,[(365\text{-}p)/365)] \times 281.9 \times (100\% - \text{control efficiency }\%)$$

where:

E = emission factor [grams/vehicle kilometer traveled (g/VKT)];

k = particle size multiplier;

a, b = particle size exponents;

s = silt content (%);

W = mean vehicle weight (tons);

p = number of days with at least 0.254 mm of precipitation per year (for the 24-hour averaging time, number of hours in a day);

281.9 = conversion factor to adjust the basis of the emission factor from pounds per vehicle mile (lb/VMT) traveled to g/VKT); and

control efficiency % = amount of control to reduce emissions.

The particle size multiplier, "k", was based on the EPA multiplier of 4.9 in developing the PM emission estimates and 1.5 in developing the PM_{10} emission estimates. The particle size exponents, "a" and "b", were based on the EPA multipliers of 0.7 and 0.45, respectively, for the PM emission estimates, and 0.9 and 0.45, respectively, for the PM_{10} emission estimates.

For transport of materials on unpaved roadways, a silt content of 10% was used as a conservative factor.

The average weights of the material hauling vehicles based on unloaded and loaded capacities were used in developing the emission factor from those sources. The two types of trucks considered for the unpaved roads were the 92-tonne (t) and 60-t capacity haul trucks for the open pit and underground mines, respectively.

Separate PM/PM_{10} emission factors were developed for the haul trucks. Calculating the emission factors separately for each type of truck is a conservative approach to estimate emissions (i.e., higher-than-expected) because lower emissions would be estimated if a composite (i.e., average) of all the vehicles traveling on a roadway were used as recommended in AP-42.

For the annual average emissions, the number of days with at least 0.254 mm of precipitation was estimated to be 5 based on data collected at the onsite monitoring station. For daily emissions, no precipitation was assumed to occur.

Control efficiencies to reduce PM_{10} emissions were based on watering as necessary with an assumed control efficiency of 25%. The control efficiency is based on recommended surface treatment control options for unpaved roads in Section 13.2.2 of AP-42. The surface moisture on the unpaved road with watering are assumed to be two times or more than the surface moisture without watering. The assumed control efficiency of 25% also accounts for the likelihood that watering will only be possible for approximately three months of the year when ambient temperatures exceed zero degrees Celsius.

The haul roads will be constructed with barren un-mineralised material from borrow pits and potentially later during operations with rejects form the Dense Media Separation process. Therefore the content of zinc and lead in the dust emissions from unpaved road sources is assumed to be zero.

2.3.2 Transfer Operations

PM/PM_{10} emissions were estimated for transfer activities at different areas where material handling activities are planned. For activities at these areas, the PM/PM_{10} emission factors for batch drop activities were derived from the equation in Section 13.2.4 of AP-42:

$$E = k\,(0.0016)\,(U/2.2)^{1.3}/(M/2)^{1.4} \times (100\% - \text{control efficiency }\%)$$

where: E = emission factor, kilogram per Megagram of material (kg/Mg);

k = particle size multiplier;

U = mean wind speed [meters per second (m/s)];

M = material moisture content (%); and

control efficiency % = amount of control to reduce emissions.

Similar to the construction activities, the particle size multiplier, "k", was based on the EPA multipliers of 0.74 and 0.35 in developing the PM and PM_{10} emission estimates, respectively. Mean and maximum daily wind speeds were obtained from the wind speeds measured at the on-site monitoring station located at the mine site. The mean annual wind speed used to calculate annual emissions was 3.5 m/s and the maximum daily wind speed used to estimate daily emissions was 7.2 m/s.

The moisture content of the ore and waste material was assumed to be 3%.

There were no control efficiencies assumed for these activities (e.g., truck loading at the open pit mine).

The contents of zinc and lead in the dust emissions from transfer operations were assumed to be 5.7% and 0.85% respectively with the exception of transfer operations associated with the waste dump where contents were assumed to be 2% for zinc and 0.33% for lead.

2.3.3 Blasting Operations

PM/PM_{10} emissions will be generated from blasting that will occur at the open pit and underground mines. The PM/PM_{10} emission factors for blasting were derived from the equation provided in Section 11.9 of AP-42:

$$E = 0.00022\,(A)^{1.5}$$

where:

E = emission factor (kg/blast); and

A = horizontal blast areas (m^2).

The horizontal blast area per day was estimated to be 4,500 meters squared (m^2) with blast depth of 5 m. The frequency of blasting was assumed to be once per day for 91 days during the year. Although based on open pit mine, these assumptions were made for both the open pit and underground mines.

The contents of zinc and lead in the dust emissions from blasting were assumed to be 5.7% and 0.85% respectively. This is a conservative assumption as emissions from blasting of waste material will have lower zinc and lead contents.

2.3.4 Bulldozing Activities

PM/PM_{10} emissions for bulldozing activities will be generated at the open pit area. The PM/PM_{10} emission factors for bulldozing were derived from the equation provided in Section 11.9 of AP-42:

$$E = 0.45\,(s)^{1.5}/(M)^{1.4}$$

where:

E = emission factor (kg/h);

s = silt content (%); and

M = material moisture content (%).

The silt and moisture contents of material at these areas are assumed to be 10% and 3%, respectively. No control efficiencies were assumed for these activities.

The contents of zinc and lead in the dust emissions from bulldozing were assumed to be 5.7% and 0.85% respectively. This is a conservative assumption as emissions from bulldozing of waste material will have lower zinc and lead contents.

2.3.5 Grading Activities

PM/PM_{10} emissions for grading activities will occur at the open pit and waste dump areas. The PM/PM_{10} emission factors for grading operations were derived from the equation provided in Section 11.9 of AP-42:

$$E = 0.0056\,(S)^{2.0}$$

where:

E = emission factor (kg/VKT); and

S = vehicle speed (km/h).

The vehicle speed for these vehicles was assumed to be 18 km/h. The distance travelled by each grader per day was based on each grader travelling along the perimeter of the activity area. No control efficiencies were assumed for these activities.

The contents of zinc and lead in the dust emissions from grading were assumed to be 5.7% and 0.85% respectively. This is a conservative assumption as emissions from grading of waste material will have lower zinc and lead contents.

2.3.6 Wind Erosion

PM/PM_{10} emissions will be generated by wind erosion of exposed areas at the open pit and waste dump areas. PM/PM_{10} emission factors from continuously active piles (frequently disturbed) were derived from the equation in Section 2.3.1.3.3 of EPA's fugitive dust background document (EPA, 1992):

$$E = k\,(1.9)\,(s/1.5)\,[(365-p)/235]\,(f/15) \times (100\% - \text{control efficiency }\%)$$

where:

E = emission factor (kg/day/ha);

k = particle size multiplier;

s = silt content of aggregate (%);

p = number of days with at least 0.254 mm of precipitation per year (for 24-hour averaging time, number of hours in a day), and

f = percent of time that unobstructed wind speed exceeds 5.4 m/s at the mean pile height.

Similar to the construction activities, the particle size multiplier, "k", was based on the EPA multipliers of 1.0 and 0.50 in developing the PM and PM_{10} emission estimates, respectively. The silt content of material was assumed to be 10%. No control efficiencies were assumed for these activities

For the annual average emissions, the number of days with at least 0.254 mm of precipitation was assumed to be 5 based on data collected at the on-site monitoring station. For daily emissions, no precipitation was assumed to occur. The annual frequency of wind speeds that were greater than 5.4 m/s was 22% while the daily frequency of wind speeds that were greater than 5.4 m/s was 50% (i.e., about 12 hours in a day).

The contents of zinc and lead in the dust emissions from wind erosion from the open pit were assumed to be 5.7% and 0.85% respectively. The contents for wind erosion from the waste pile were assumed to be 2% for zinc and 0.33% for lead.

2.3.7 Crusher Operations

PM/PM_{10} emissions will be generated by the primary and secondary crushing operations. PM/PM_{10} emission factors for crushing operations were derived from AP-42, Metallic Minerals Processing, Section 11.24. The emission factors for primary crushing are 0.2 kg/Mg of ore crushed for PM and 0.02 kg/Mg of ore crushed for PM_{10}. For secondary crushing, the emission factors are 0.6 kg/Mg and 0.06 kg/Mg (assumed) for PM and PM_{10} respectively.

The ore throughput rate was assumed to be 3 Mtpa and the process plant was assumed to operate continuously (24 hours per day, 365 days per year).

The crushers will be located in a ventilated building and emissions will be exhausted through filtered louvers. Therefore Golder has assumed control efficiencies of 97% for PM and 90% for PM_{10}.

The contents of zinc and lead in the dust emissions from the crushers were assumed to be 5.7% and 0.85% respectively.

3.0 AIR MODELING APPROACH

3.1 Model Selection

The selection of one or more air quality models to estimate maximum air quality impacts must be based on the model's ability to simulate impacts in all areas surrounding a project site. For predicting concentrations at receptors that are located within 50 kilometers (km) of a project site, the USEPA currently recommends using the AERMOD dispersion model (USEPA, 2004). For this study, AERMOD was selected and used for predicting concentrations and deposition.

The AERMOD model calculates hourly concentrations based on hourly meteorological data and is applicable for most applications, since it contains the latest scientific algorithms for simulating plume behavior in all types of terrain. AERMOD Version 09292 is the most recent available version on USEPA's Internet web site: Support Center for Regulatory Air Models (SCRAM) within the Technology Transfer Network (TTN).

For modeling analyses that will undergo regulatory review, the following modeling features are recommended by USEPA and are incorporated as the regulatory default options in AERMOD:

- Use of elevated terrain algorithms
- Stack-tip downwash
- Missing data processing routines
- 4-hour half-life for exponential decay of SO_2 for urban sources
- Calm wind processing routines

USEPA regulatory default options were used to address maximum impacts. Because the area in the vicinity of the mine site is considered to be rural, the rural option within AERMOD was used.

AERMOD is designed to calculate hour-by-hour concentrations (or depositions) for averaging time periods of 1, 2, 3, 4, 6, 8, 12, and 24 hours as well as the period for which data are available (e.g., 8,760 hours for annual average).

3.2 Modeled Sources

As discussed in Section 2.0, the mining operation emissions sources include the following:

- truck traffic on unpaved roads;
- transfer operations (i.e. batch or continuous drop of materials);
- blasting operations;
- bulldozing;
- grading operations;
- wind erosion; and
- primary and secondary crushers.

Emissions due to truck traffic on unpaved roads during mine operation were modeled as line sources represented by a series of volume sources. Each volume source on the unpaved roads and number of volume sources was used to estimate those for the operation activities. The volume source height was based on twice the height of the haul trucks of 5.2 m to account for wake effects caused by truck travel. As a result, each volume source was assumed to have a height of 10.4 m with a release height of 5.2 m, half the height of the volume source. The volume width of 28.5 m was based on twice the road width of 19 m.

Emissions due to transfer operations, bulldozing, grading operations and wind erosion were also modeled as volume sources. These emissions were added together and modeled as individual volume sources depending on the general location of the activities. For example, emissions due to loading (transfer) operations, bulldozing, grading operations and wind erosion of the open pit mine were all modeled as one volume source. The height of the volume source was based on the height of the mining truck and the release height was assumed to be half of the truck height.

The PM/PM_{10} emissions from the crushers were also modeled as part of the volume sources that were used to model the fugitive emissions from this area.

The operation activities are assumed to occur for 24 hours each day and 365 days per year.

3.3 Meteorological Data

The meteorological data used in the AERMOD model were based on hourly data collected at the on-site monitoring station. For this analysis, meteorological data were available from November 2008 to September 2010. However, data were not recorded for all periods during this time. To obtain a continuous dataset of hourly meteorological parameters, data from November 2008 to July 2009 and from July 2010 to September 2010 were processed for modelling. This resulted in 6,888 hours that were considered in the modelling. Note that data for other months were not available.

The measured meteorological data included wind direction, wind speed, temperature, relative humidity, pressure, and precipitation. Because the meteorological data were reported for every other hour, data were interpolated for hours when data were not available. Also, since wind direction was reported to one of 16 wind directions (i.e., north, north-northwest, etc.), the hourly wind directions were randomized over 22.4 degree sector. A minimum wind speed of 0.5 m/s was assumed based on the lowest reported speed.

A wind rose showing the frequencies of wind directions and wind speeds for the meteorological data used in the modeling is presented in Figure B-2, Appendix B. As shown, the predominant winds are from the south, south-southeast, north, and north-northwest. The average wind speed is about 3.5 m/s.

AERMOD incorporates land use parameters for determining boundary layer parameters that are used for dispersion. Land use data, representing the average surface roughness of 0.15, albedo of 0.8, and Bowen ratio of 2 that exist within a 3-km radius of the site were estimated. The average surface roughness was based on aerials available for the site.

Upper air sounding data were estimated using a routine in the Lakes Environmental software program (Lakes, 2010) that estimates the profile from the hourly surface observations.

The processed surface, upper air, and land use data were input to AERMET to develop meteorological data for input to AERMOD.

3.4 Receptor Locations

To determine the maximum off-site pollutant impact from the mine operation, the general modeling grid consisted of more than 1,000 receptors placed at the following locations (see Figure B-3, Appendix B):

- Along the mining boundary that was assumed to extend about 300 m away from activities with receptors spaced at approximately 100 m.
- Along 3 rows that extended out to 300 m from the mine boundary at 100 m increments, with receptor located every 100 m on each row.
- Along 2 rows that were located at 550 m and 800 m from the mine boundary, with receptor located every 100 m on each row.

In addition, receptors were placed on the mine site at 100 m spacing.

Based on the type of sources modeled (low-level), terrain will have some effect on impacts but could actually lower impacts. Based on a test model run by including assumed terrain, the impacts decreased slightly from those predicted without terrain. As a result, to provide a conservative estimate of impacts, terrain was not included in the modeling. Since impacts are expected to be highest at receptors closest to the mining activities, terrain is not expected to be a significant factor in estimating impacts.

3.5 Modeling Scenarios

For modeling purposes, since the particle sizes of the material is not known, two scenarios were modeled. The first scenario was based on PM emissions that assumed a particle size of 30 microns (µ). The second scenario was based on PM_{10} emissions that assumed a particle size of 10 µ. The model results from these two scenarios produce a range of potential impacts for the mining operations.

4.0 AIR MODELING RESULTS

A summary of the maximum annual PM and PM_{10} concentrations and depositions predicted at off-site locations for the mining operations is presented in Table A-2 in Appendix A.

Two scenarios were modeled that considered PM emissions (with particle size of 30 µ) and PM_{10} emissions (with particle size of 10 µ). The results of these scenarios provide a range of estimated PM and PM_{10} concentrations and depositions as well as those for zinc and lead.

The spatial distributions of the predicted maximum annual average PM and PM_{10} concentrations are presented in Figures B-4 and B-5 (Appendix B), respectively. The spatial distributions of the predicted maximum annual zinc depositions based on PM_{10} and PM emissions are presented in Figures B-6 and B-7 (Appendix B), respectively. The spatial distributions of the predicted maximum annual lead depositions based on PM_{10} and PM emissions are presented in Figures B-8 and B-9 (Appendix B), respectively. These results present the range of potential impacts due to the uncertainty in modeled emissions.

These maximum zinc and lead values are mainly due to the crusher operations and are predicted to occur near the crusher. There is a significant decrease in predicted impacts at locations away from the crusher operations, particularly at off-site receptors.

Other sources, such as those associated with the haul roads and wind erosion, have lower predicted impacts for several reasons:

- Emissions of dust from haul roads are assumed to contain negligible concentrations of zinc and lead.
- These sources are located away from the boundary considered in the modeling (e.g., the haul roads are located in the interior of the mine area);
- Certain sources were assumed to be controlled to effectively minimize dust emissions (e.g., watering on the haul roads assumed to control dust by 25%).

The modeled results are based on assumptions developed from available information. As indicated previously, since some information was not available, the analysis was conducted to provide a potential range of impacts. For example, since particle deposition is included in the modeling and particles are removed from a source's plume as it travels downwind, an assumption was made regarding particles sizes for PM and PM_{10} emissions. PM_{10} concentrations are predicted to be higher and deposition is predicted to be lower compared to those for PM concentrations and deposition.

As noted in the introduction, the activity rates used in estimating emissions as well as the content of zinc and lead in each source are considered conservative and the estimated impacts presented in this report are unilkely to occur for the full life of the mine.

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APPENDIX A

Tables

TABLE A-1
SUMMARY OF MODELED PM/PM_{10}, ZINC AND LEAD EMISSIONS USED IN MODELING (REVISED 12/21/10)

	Emissions (g/s) based on PM [a]			Emissions (g/s) based on PM_{10} [a]		
Description	**PM**	**Zinc**	**Lead**	**PM10**	**Zinc**	**Lead**
Traffic on Unpaved Roads Inside Mine						
Open Pit to Crusher: Ore	21.97	0.00	0.00	6.49	0.00	0.00
Open Pit to Waste Dump: Waste	25.21	0.00	0.00	7.44	0.00	0.00
Underground Pit to Crusher: Ore	8.39	0.00	0.00	2.48	0.00	0.00
Open Pit						
Open Pit: Ore- Truck Loading	0.0575	0.00328	0.000489	0.0272	0.00155	0.000231
Open Pit: Waste- Truck Loading	0.1419	0.00809	0.001206	0.0671	0.00382	0.000570
Open Pit: Blasting	0.1916	0.01092	0.001629	0.0997	0.00568	0.000847
Open Pit: Bulldozing	0.8491	0.04840	0.007217	0.6368	0.03630	0.005413
Open Pit: Wind Erosion	0.3294	0.01878	0.002800	0.1647	0.00939	0.001400
Open Pit: Grading	0.0106	0.00061	0.000090	0.0064	0.00036	0.000054
Waste Dump						
Waste Pile: Waste- Truck Unloading	0.1419	0.00284	0.000468	0.0671	0.00134	0.000221
Waste Pile: Wind Erosion	0.3294	0.00659	0.001087	0.1647	0.00329	0.000543
Underground Mine						
Underground Pit: Ore- Truck Loading	0.0575	0.00328	0.000489	0.0272	0.00155	0.000231
Underground Pit: Blasting	0.1916	0.01092	0.001629	0.0997	0.00568	0.000847
`						
Crusher: Ore- Truck Unloading	0.1150	0.00656	0.000978	0.0544	0.00310	0.000462
Crusher: Primary crushing	0.5708	0.03253	0.004852	0.1903	0.01084	0.001617
Crusher: Secondary crushing	1.7123	0.09760	0.014555	0.5708	0.03253	0.004852
Total	60.27	0.250	0.0375	18.58	0.115	0.0173

TABLE A-2
SUMMARY OF MAXIMUM PREDICTED AT OFF-SITE RECEPTORS
PM/PM_{10}, ZINC AND LEAD IMPACTS
(REVISED 12/21/10)

Pollutant	Maximum Annual Average Concentration (ug/m^3)	Maximum Annual Deposition (g/m^2)
PM	2.83	8.21
Zinc	0.11	0.33
Lead	0.02	0.05
PM_{10}	14.20	4.1
Zinc	0.43	0.13
Lead	0.06	0.02

TABLE A-3
ESTIMATION OF PM EMISSION FACTORS AND RATES
FOR TRUCK TRAFFIC ON UNPAVED ROADS
(REVISED 12/21/10)

Parameters		**Haul Road** Open Pit to Crusher: Ore	**Haul Road** Open Pit to Waste Dump: Waste	**Haul Road** Underground Pit to Crusher: Ore	**Haul Road** Underground Pit to Crusher (when Open Pit not used): Ore
Unpaved Road ID		OPHRORE	OPHRWST	UPHRORE	UPHRORE2
Vehicle Data					
Vehicle Type		Truck	Truck	Truck	Truck
Vehicle capacity and load	Capacity (tonnes)	92	92	60	92
	Unloaded (tonnes)	74	74	48	74
	Loaded (tonnes)	166	166	108	166
	Average (tonnes)	120	120	78	120
	Average (tons)	132	132	86	132
Material		Ore	Waste	Ore	Ore
Material throughput	Annual (tonnes)	1,500,000	3,700,000	1,500,000	3,000,000
Operating time, hours	Daily	24	24	24	24
Operating time, days	Annual	365	365	365	365
Number of vehicles	Daily	45	110	68	89
	Annual	16,304	40,217	25,000	32,609
`	One-way trip	4.3	2.0	1.3	1.0
	Round trip	8.6	4.0	2.6	2.0
VKT (no. vehicles x km traveled per trip)	Daily, round trip	384.2	440.7	178.1	178.7
	Annual, round trip	140,217	160,870	65,000	65,217
General/ Site Characteristics					
Days of precipitation greater than or	Daily	0	0	0	0
equal to 0.254 mm (p) [a]	Annual	5	5	5	5
Silt content (s) (%)		10	10	10	10
Particle size multiplier (lb/VMT) [b]	k (PM)	4.9	4.9	4.9	4.9
	k (PM_{10})	1.5	1.5	1.5	1.5
Constants for equations - PM [b]	a	0.7	0.7	0.7	0.7
	b	0.45	0.45	0.45	0.45
Constants for equations - PM_{10} [b]	a	0.9	0.9	0.9	0.9
	b	0.45	0.45	0.45	0.45
Emission Control Data					
Emission control method		Watering	Watering	Watering	Watering
Emission control removal efficiency, % [c]		25	25	25	25
Emission Factor (EF) Equation [d]					
Uncontrolled EF (UEF) Equation	UEF(g/VKT) = k (lb/VMT) x $(s/12)^a$ x $(W)/3)^b$ x [(365 - p)/365] x 281,9; where 281.9 is conversion factor (1 lb/VMT = 281.9 g/VKT)				
Controlled EF (CEF) Equation	CEF(g/VKT) = UEF (lb/VMT) x (100 - Removal efficiency (%))				
Calculated PM Emission Factor (EF)					
Uncontrolled EF, g/VKT	Short term	6,680.79	6,680.79	5,503.50	6,680.79
	Annual	6,589.28	6,589.28	5,428.11	6,589.28
Controlled EF, g/VKT	Short term	5,010.60	5,010.60	4,127.63	5,010.60
	Annual	4,941.96	4,941.96	4,071.08	4,941.96
Calculated PM_{10} Emission Factor (EF)					
Uncontrolled EF, g/VKT	Short term	1,971.91	1,971.91	1,624.42	1,971.91
	Annual	1,944.90	1,944.90	1,602.17	1,944.90
Controlled EF, g/VKT	Short Term	1,478.93	1,478.93	1,218.31	1,478.93
	Annual	1,458.67	1,458.67	1,201.63	1,458.67
Estimated Emission Rate (ER)					
PM ER kg/hr (daily basis)		80.2	92.0	30.6	37.3
tonnes/yr		692.9	795.0	264.6	322.3
g/s		22.0	25.2	8.4	10.2
PM_{10} ER kg/hr (daily basis)		23.7	27.2	9.0	11.0
tonnes/yr		204.5	234.7	78.1	95.1
g/s		6.5	7.4	2.5	3.0

Source: For emission factor, USEPA, 2006 (AP-42, Unpaved Roads, Section 13.2.2).
For project data, based on Citronen Fjord Feasilbility Study (Project Review Presentation) and data requests, except where noted.
Values based on conservative assumptions to estimate higher-than-expected emission rates.

[a] Estimated from meteorological data provided.
[b] Based on default values provided in AP-42.
[c] Assumed control efficiency.
[d] AP-42 emission factor provides emission factor as pounds per vehicle mile traveled (lb/VMT).

TABLE A-4
ESTIMATION OF PM EMISSION FACTORS AND RATES
FOR BATCH/CONTINUOUS DROP TRANSFER OPERATIONS
(REVISED 12/21/10)

Parameters		**Open Pit: Ore-Truck Loading**	**Open Pit: Waste-Truck Loading**	**Underground Pit: Ore-Truck Loading**	**Crusher: Ore- Truck Unloading**	**Waste Pile: Waste-Truck Unloading**	**Underground Pit: Ore- Truck Loading (when Open Pit not used)**
Emission Point/Area		OPTRORE	OPTRWST	UPTRORE	CRTRORE	WPTRWST	UPTRORE
Operational Data							
Daily activity hours	Daily	24	24	24	24	24	24
Annual activity days	Annual	365	365	365	365	365	365
Material Handling Data							
Material type		Ore	Waste	Ore	Ore	Waste	Ore
Material throughput							
Wet solids (tonnes/h)	Hourly	171.2	422.4	171.2	342.5	422.4	342.5
Wet solids (tonnes/day or Mg/day)	Daily	4,109.6	10,137.0	4,109.6	8,219.2	10,137.0	8,219.2
[tonnes/yr or Megagrams/yr (Mg/yr)]	Annual	1,500,000	3,700,000	1,500,000	3,000,000	3,700,000	3,000,000
Moisture content (M), % (nominal)		3.0	3.0	3.0	3.0	3.0	3.0
Number of transfers		1	1	1	1	1	1
General/ Site Characteristics							
Mean wind speed (U) (m/s) [a]	Daily	7.2	7.2	7.2	7.2	7.2	7.2
	Annual	3.5	3.5	3.5	3.5	3.5	3.5
Particle size multiplier (k), PM [b]		0.74	0.74	0.74	0.74	0.74	0.74
`		0.35	0.35	0.35	0.35	0.35	0.35
Emission Control Data							
Emission control method		None	None	None	None	None	None
Emission control removal efficiency (%)		0	0	0	0	0	0
Emission Factor (EF) Equations							
Uncontrolled EF (UEF) Equation	UEF (kg/Mg) = k x (0,0016) x $(U / 2.2)^{1.3}$)/[$(M / 2)^{1.4}$]						
Controlled EF (CEF) Equation	CEF (kg/Mg) = UEF (kg/Mg) x [100% - Removal efficiency (%)]						
Calculated PM Emission Factor (EF)							
Uncontrolled EF, kg/Mg	Short term	3.13E-03	3.13E-03	3.13E-03	3.13E-03	3.13E-03	3.13E-03
	Annual	1.21E-03	1.21E-03	1.21E-03	1.21E-03	1.21E-03	1.21E-03
Controlled EF, kg/Mg	Short term	3.13E-03	3.13E-03	3.13E-03	3.13E-03	3.13E-03	3.13E-03
	Annual	1.21E-03	1.21E-03	1.21E-03	1.21E-03	1.21E-03	1.21E-03
Calculated PM_{10} Emission Factor (EF)							
Uncontrolled EF, kg/Mg	Short term	1.48E-03	1.48E-03	1.48E-03	1.48E-03	1.48E-03	1.48E-03
	Annual	5.72E-04	5.72E-04	5.72E-04	5.72E-04	5.72E-04	5.72E-04
Controlled EF, kg/Mg	Short term	1.48E-03	1.48E-03	1.48E-03	1.48E-03	1.48E-03	1.48E-03
	Annual	5.72E-04	5.72E-04	5.72E-04	5.72E-04	5.72E-04	5.72E-04
Estimated Emission Rate (ER)							
PM ER kg/hr (daily basis)		5.37E-01	1.32E+00	5.37E-01	1.07E+00	1.32E+00	1.07E+00
tonnes/yr		1.81E+00	4.47E+00	1.81E+00	3.63E+00	4.47E+00	3.63E+00
g/s		5.75E-02	1.42E-01	5.75E-02	1.15E-01	1.42E-01	1.15E-01
PM_{10} ER kg/hr (daily basis)		2.54E-01	6.26E-01	2.54E-01	5.08E-01	6.26E-01	5.08E-01
tonnes/yr		8.58E-01	2.12E+00	8.58E-01	1.72E+00	2.12E+00	1.72E+00
g/s		2.72E-02	6.71E-02	2.72E-02	5.44E-02	6.71E-02	5.44E-02

Source: For emisson factor, USEPA, 1995 (AP-42, Aggregate Handling and Storage Piles, Section 13.2.4).
For project data, based on Citronen Fjord Feasilbility Study (Project Review Presentation) and data requests, except where noted.
Values based on conservative assumptions to estimate higher-than-expected emission rates.

[a] Estimated from meteorological data provided.
[b] Based on default values provided in AP-42.

TABLE A-5
ESTIMATION OF PM EMISSION FACTORS AND RATES
FOR BLASTING OPERATIONS
(REVISED 12/21/10)

Parameters	Open Pit: Blasting	Underground Pit: Blasting
Emission Point/Area	OPBL	UPBL
Blasting Data		
Material Type	Ore and Waste	Ore and Waste
Dimention of the blasting grid		
Horizontal Blast Area (A) (m^2) [a]	4500	4500
Blasting Depth (m) [a]	5.0	5.0
Blasting Frequency, daily	1	1
Annual Operating Days	91	91
Blasting Frequency, annual	91	91
Emission Factor (EF) Equation		
Uncontrolled EF (UEF) Equation	UEF (kg/blast) = 0,00022$(A)^{1.5}$ x Factor	
Scaling Factor - PM [b]	1.0	1.0
Scaling Factor - PM_{10} [b]	0.52	0.52
Calculated PM Emission Factor (EF)		
Uncontrolled EF, kg/blast	66.4	66.4
Calculated PM_{10} Emission Factor (EF)		
`	34.5	34.5
Estimated Emission Rate (ER)		
PM ER kg/hr [a]	66.41	66.41
tonnes/yr	6.04	6.04
g/s	0.19	0.19
PM10 ER kg/hr	34.53	34.53
tonnes/yr	3.14	3.14
g/s	0.10	0.10

Source: For emission factor, USEPA, 1998 (AP-42, Western Surface Coal Mining, Section 11.9.2).
For project data, based on Citronen Fjord Feasilbility Study (Project Review Presentation) and data requests, except where noted.
Values based on conservative assumptions to estimate higher-than-expected emission rates.

[a] Assumes blast occurs for one hour on day of blast. For underground pit, area assumed to be same as blast for open pit.
[b] Based on default values provided in AP-42.

TABLE A-6
ESTIMATION OF PM EMISSION FACTORS AND RATES
FOR BULLDOZING ACTIVITIES DURING MINE OPERATIONS
(REVISED 12/21/10)

Parameters		**Open Pit: Bulldozing**
Emission Point / Area		OPBD
Operational Data		
Daily activity hours	Daily	24
Annual activity days	Annual	365
Number of Bulldozers		1
Material Handling Data		
Moisture content (M) (%)		3.0
General/ Site Characteristics		
Silt content (s) (%)		10.0
Emission Control Data		
Emission control method		None
Emission control removal efficiency (%)		0
Emission Factor (EF) Equation		
Uncontrolled PM_{15} EF (UEF) Equation	UEF (kg/h) = 0.45 x $(s)^{1.5}$/ $(M)^{1.4}$	
Controlled PM_{15} EF (UEF) Equation	CEF (kg/h) = UEF (kg/h) x [100 - Removal efficiency (%)]	
`	UEF (kg/h) = 0.75 x UEF of PM_{15}	
Controlled PM_{10} EF (CEF) Equation	CEF (kg/h) = 0.75 x CEF of PM_{15}	
Calculated PM_{15} & PM_{10} Emission Factors (EF)		
Uncontrolled PM_{15} EF, kg/h	Short term, annual	3.06
Controlled PM_{15} EF, kg/h	Short term, annual	3.06
Uncontrolled PM_{10} EF, kg/h	Short term, annual	2.29
Controlled PM_{10} EF, kg/h	Short term, annual	2.29
Estimated Emission Rate (ER)		
PM_{15} ER kg/h (daily basis)		3.06
tonnes/yr		26.78
g/s		8.49E-01
PM_{10} ER kg/hr (daily basis)		2.29
tonnes/yr		20.08
g/s		6.37E-01

Source: USEPA, 1998 (AP-42, Western Surface Coal Mines, Section 11.9).
For project data, based on Citronen Fjord Feasilbility Study (Project Review Presentation) and data requests, except where noted.
Values based on conservative assumptions to estimate higher-than-expected emission rates.

[a] Based on bulldozing for overburden.

TABLE A-7
ESTIMATION OF PM EMISSION FACTORS AND RATES
FOR WIND EROSION FROM ACTIVE STORAGE PILES
(REVISED 12/21/10)

Parameters		Open Pit: Wind Erosion	Waste Pile: Wind Erosion
Emission Point/Area		OPWE	WPWE
Daily activity hours		24	24
Annual activity days		365	365
Storage Pile Data			
Material Type		Ore & Waste	Waste
Pile Description (shape)		Varies	Varies
Average Pile Diametre (m)		NA	NA
Average Radius (m)		NA	NA
No. Piles		1	1
Size (m^2) per Pile		10,000	10,000
Size (hectares)		1.00	1.00
General/ Site Characteristics			
Days of precipitation greater than or	Daily	0	0
equal to 0.25 mm (p) [a]	Annual	5	5
Time (%) that unobstructed wind speed	Daily	50	50
	Annual	22	22
`			
Silt content (s) [c] (%)		10	10
Particle size multiplier (k), PM [b]		1.00	1.00
Particle size multiplier (k), PM_{10} [b]		0.50	0.50
Emission Control Data			
Emission control method		None	None
Emission control removal efficiency, %		0	0
Emission Factor (EF) Equation			
Uncontrolled EF (UEF) Equation	UEF (kg/day/hectare) = k x 1,9 x (s/1,5) x ((365 - p)/235) x (f/15)		
Controlled (Final) EF (CEF) Equation	CEF (kg/day/hectare) = UEF (kg/day/hectare) x (100 - Removal efficiency (%))		
Calculated PM Emission Factor (EF)			
Uncontrolled EF, kg/day/hectare	Short term	65.58	65.58
	Annual	28.46	28.46
Controlled EF, kg/day/hectare	Short term	65.58	65.58
	Annual	28.46	28.46
Calculated PM_{10} Emission Factor (EF)			
Uncontrolled EF, kg/day/hectare	Short term	32.79	32.79
	Annual	14.23	14.23
Controlled EF, kg/day/hectare	Short term	32.79	32.79
	Annual	14.23	14.23
Estimated Emission Rate (ER)			
PM ER kg/h (daily basis)		2.732	2.732
tonnes/yr		10.388	10.388
g/s		3.29E-01	3.29E-01
PM_{10} ER kg/h (daily basis)		1.366	1.366
tonnes/yr		5.194	5.194
g/s		1.65E-01	1.65E-01

Source: For emission factor, USEPA, 1992 (Fugitive Dust Background and Technical Information Document for Best Available Control Measure
Wind Emissions from Continuously Active Piles, Section 2.3.1.3.3)
For project data, based on Citronen Fjord Feasilbility Study (Project Review Presentation) and data requests, except where noted.
Values based on conservative assumptions to estimate higher-than-expected emission rates.

[a] Estimated from meteorological data provided.
[b] Based on default values provided in USEPA reference.

TABLE A-8
ESTIMATION OF PM EMISSION FACTORS AND RATES
FOR GRADING ACTIVITIES DURING MINE OPERATIONS
(REVISED 12/21/10)

Parameters		**Open Pit: Grading**
Emission Point / Area		OPGR
Operational Data		
Daily activity hours	Daily	24
Annual activity days	Annual	365
No. of Locations		1
Vehicle Data		
Mean Vehicle Speed (km/h) [a]		18
Basis for vehicle kilometers traveled (VKT)		
Number of vehicles	Daily	1
	Annual	365
Distance traveled/vehicle/day [b]	Per trip (km)	0.51
VKT (no. vehicles x km traveled per trip)	Daily	0.5
	Annual	184.7
Emission Control Data		
Emission control method		None
`		0
PM_{15} & PM_{10} Emission Factors (EF) Equations		
Uncontrolled PM_{15} EF (UEF) Equation [c]		UEF (kg/VKT) = 0,0056(S)^{2,0} x Scaling Factor
Scaling Factor - PM_{15} [c]		1.0
Scaling Factor - PM_{10} [c]		0.6
Calculated Emission Factor (EF)		
Uncontrolled PM_{15} EF, kg/VKT		1.81
Uncontrolled PM_{10} EF, kg/VKT		1.09
Estimated Emission Rate (ER)		
PM ER kg/hr (daily basis)		0.04
tonnes/yr		0.34
g/s		1.06E-02
PM_{10} ER kg/hr (daily basis)		0.02
tonnes/yr		0.20
g/s		6.38E-03

Source: USEPA, 1998 (AP-42, Western Surface Coal Mines, Section 11.9).
For project data, based on Citronen Fjord Feasilbility Study (Project Review Presentation) and data requests, except where noted
Values based on conservative assumptions to estimate higher-than-expected emission rates.

[a] Mean vehicle speed assumed as 18 km/hr.
[b] Distance travelled by each grader per day is assumed same as the largest perimeter of the facility activity areas.
[c] Based on default values provided in AP-42.

TABLE A-9
ESTIMATION OF PM EMISSION FACTORS AND RATES
FOR THE CRUSHERS

Parameters		**Crusher: Primary crushing**	**Crusher: Secondary crushing**
Emission Point		CRPRIM	CRSEC
Operation Data			
Daily activity hours	Daily	24	24
Annual activity days	Annual	365	365
Material Throughput			
Material Throughput	Annual (tonnes, Mg)	3,000,000	3,000,000
	Daily (tonnes, Mg)	8,219	8,219
	Hourly (tonnes, Mg)	342	342
General/ Site Characteristics			
Emission Control Data			
Emission control method		Building, dust control	Building, dust control
Emission control removal efficiency, % [a]	PM	97	97
	PM10	90	90
PM_{15} & PM_{10} Emission Factors			
Uncontrolled EF PM kg/Mg		0.2	0.6
Uncontrolled EF PM_{10} kg/Mg		0.02	0.06
`		0.01	0.02
Controlled EF PM_{10} kg/Mg		0.002	0.006
Estimated Emission Rate (ER)			
PM ER kg/hr (daily basis)		2.05E+00	6.16E+00
tonnes/yr		1.80E+01	5.40E+01
g/s		5.71E-01	1.71E+00
PM_{10} ER kg/hr (daily basis)		6.85E-01	2.05E+00
tonnes/yr		6.00E+00	1.80E+01
g/s		1.90E-01	5.71E-01

Source: USEPA, 1995 (AP-42, Metallic Minerals Processing, Section 11.24).
For project data, based on Citronen Fjord Feasilbility Study (Project Review Presentation) and data requests, except where noted.
Values based on conservative assumptions to estimate higher-than-expected emission rates.

[a] Assumed control efficiency.

TABLE A-10
MODELED POLLUTANT EMISSIONS AND SOURCE DIMENSIONS FOR SOURCES MODELED AS LINE SOURCES
(REVISED 12/21/10)

		Traffic on Unpaved Roads Inside Mine						
Description	**Units**	**Road Section from Open Pit to Waste Dump**	**Road Section from Waste Dump to Crusher**	**Road Section from Underground Pit to Crusher**	**Road Section from Open Pit to Waste Dump**	**Road Section from Waste Dump to Crusher**	**Road Section from Underground Pit to Crusher**	**Assumption/Comment**
		Emissions Basis - PM_{10}			**Emissions Basis - PM**			
OPHRORE	g/s/km	0.754	0.754	0.754	2.555	2.555	2.555	Open Pit to Crusher: Ore
OPHRWST	g/s/km	1.860	--	--	6.302	--	--	Open Pit to Waste Dump: Waste
UPHRORE	g/s/km	--	--	0.953	--	--	3.227	Underground Pit to Crusher: Ore
Total Emission	g/s/km	2.614	0.754	1.707	8.857	2.555	5.782	
Emission Source Information								
Modeled source type		Volume	Volume	Volume	Volume	Volume	Volume	Line source represented by separated volume sources
Vertical dimension								
Truck height	m	5.2	5.2	5.2	5.2	5.2	5.2	Mining truck
Source height	m	10.4	10.4	10.4	10.4	10.4	10.4	Truck height x 2
Modeled releaseheight	m	5.2	5.2	5.2	5.2	5.2	5.2	1/2 source height (middle of volume source)
Initial vertical dimension (sz_0)	m	4.84	4.84	4.84	4.84	4.84	4.84	Source height/2,15
Horizontal dimension								
Road width	m	19	19	19	19	19	19	Representative width
Source width	m	29	29	29	29	29	29	Road width x 1.5
Initial Horizontal dimension (sy_0)	m	26.5	26.5	26.5	26.5	26.5	26.5	Source width x 2/2.15 (every other source)
`		**HROPWD**	**HRWDUP**	**HRUPCR**	**HROPWD**	**HRWDUP**	**HRUPCR**	
Road Segment length	km	2.0	1.0	1.3	2.0	1.0	1.3	Assumed for model input
No. of volume sources		36	19	24	36	19	24	Based on source width
Modeled Emission Rate, PM_{10}	g/s/volume	0.07262	0.03969	0.07111	0.24604	0.13448	0.24093	
Lead (Pb)	%	0.00	0.00	0.00	0.00	0.00	0.00	
	g/s/volume	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
Ore- OP	g/s	0.00	0.00	0.00	0.00	0.00	0.00	
Waste-OP	g/s	0.00	0.00	0.00	0.00	0.00	0.00	
Ore-UP	g/s	0.00	0.00	0.00	0.00	0.00	0.00	
Zinc (Zn)	%	0.00	0.00	0.00	0.00	0.00	0.00	
	g/s/volume	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
Ore- OP	g/s	0.00	0.00	0.00	0.00	0.00	0.00	
Waste-OP	g/s	0.00	0.00	0.00	0.00	0.00	0.00	
Ore-UP	g/s	0.00	0.00	0.00	0.00	0.00	0.00	

Basis of g/s/km	**Emissions Basis - PM_{10}**			**Emissions Basis - PM**		
	g/s	total km	g/s/km	g/s	total km	g/s/km
OPHRORE	6.49	8.6	0.75	21.97	8.6	2.56
OPHRWST	7.44	4	1.86	25.21	4	6.30
UPHRORE	2.48	2.6	0.95	8.39	2.6	3.23

TABLE A-11
MODELED POLLUTANT EMISSIONS AND SOURCE DIMENSIONS FOR SOURCES MODELED AS VOLUME SOURCES
(12/21/10)

Description	Units	Transfer Operation, Bulldozing, Grading, Dust Collectors & Wind Erosion								Assumption/Comment
		Open Pit	**Underground Pit**	**Waste Dump**	**Crusher**	**Open Pit**	**Underground Pit**	**Waste Dump**	**Crusher**	
		Emissions Basis - PM_{10}				**Emissions Basis - PM**				
OPTRORE	g/s	0.02720	--	--	--	0.05751	--	--	--	Open Pit: Ore- Truck Loading
OPTRWST	g/s	0.06710	--	--	--	0.14186	--	--	--	Open Pit: Waste- Truck Loading
OPBL	g/s	0.09965	--	--	--	0.19164	--	--	--	Open Pit: Blasting
OPBD	g/s	0.63680	--	--	--	0.84906	--	--	--	Open Pit: Bulldozing
OPWE	g/s	0.16470	--	--	--	0.32939	--	--	--	Open Pit: Wind Erosion
OPGR	g/s	0.00638	--	--	--	0.01063	--	--	--	Open Pit: Grading
WPTRWST	g/s	--	--	0.06710	--	--	--	0.14186	--	Waste Pile: Waste- Truck Unloading
WPWE	g/s	--	--	0.16470	--	--	--	0.32939	--	Waste Pile: Wind Erosion
UPTRORE	g/s	--	0.02720	--	--	--	0.05751	--	--	Underground Pit: Ore- Truck Loading
UPBL	g/s	--	0.09965	--	--	--	0.19164	--	--	Underground Pit: Blasting
CRTRORE	g/s	--	--	--	0.05440	--	--	--	0.11502	Crusher: Ore- Truck Unloading
CRPRIM	g/s	--	--	--	0.19	--	--	--	0.57	Crusher: Primary crushing
CRSEC	g/s	--	--	--	0.57	--	--	--	1.71	Crusher: Secondary crushing
Total Emission	g/s	1.0018	0.1269	0.2318	0.82	1.5801	0.2491	0.4713	2.40	
Emission Source Information										
Modeled source type		Volume	Volume	Volume	Volume	Volume	Volume	Volume	Volume	
Vertical dimension										
Volume height	m	10.4	10.4	10.4	15.0	10.4	10.4	10.4	15.0	Mining truck height x 2; crusher assumed
Modeled release height	m	5.2	5.2	5.2	7.5	5.2	5.2	5.2	7.5	1/2 height of volume
Initial vertical dimension (sz_0)	m	4.8	4.8	4.8	7.0	4.8	4.8	4.8	7.0	Volume height/2.15
Horizontal dimension										
Volume width	m	32	32	32	50	32	32	32	50	Assume 1000 m2 area; crusher assumed
Initial Horizontal dimension (sy_0)	m	7.4	7.4	7.4	11.6	7.4	7.4	7.4	11.6	Volume width/4.3
Modeled Emissions Information										
Volume ID		**OPVOL**	**UPVOL**	**WDVOL**	**CRVOL**	**OPVOL**	**UPVOL**	**WDVOL**	**CRVOL**	
Number of volume sources		1	1	1	1	1	1	1	1	
Modeled Emission Rate, PM_{10}	g/s/volume	1.0018	0.1269	0.2318	0.82	1.5801	0.2491	0.4713	2.40	
Lead (Pb)	%	0.85	0.85	0.33	0.85	0.85	0.85	0.33	0.85	
	g/s/volume	0.00852	0.001078	0.00076	0.0069	0.01343	0.002118	0.00156	0.0204	
Zinc (Zn)	%	5.70	5.70	2.00	5.70	5.70	5.70	2.00	5.70	
	g/s/volume	0.05710	0.00723	0.00464	0.046	0.09007	0.01420	0.00943	0.137	

APPENDIX B

Figures

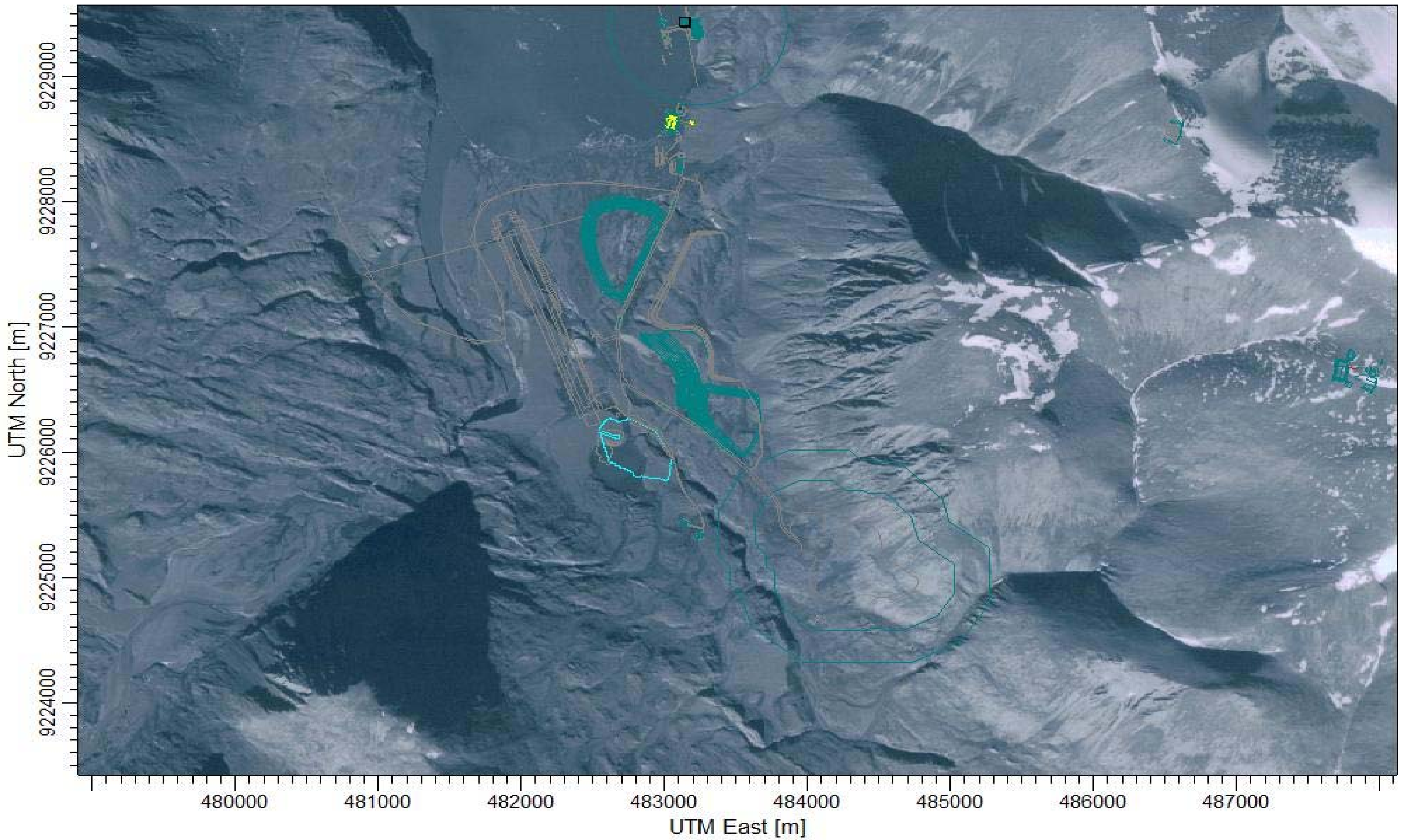

Figure B-1 Location Map of the Citronen Ironbark Mine

Source: Golder, 2010.

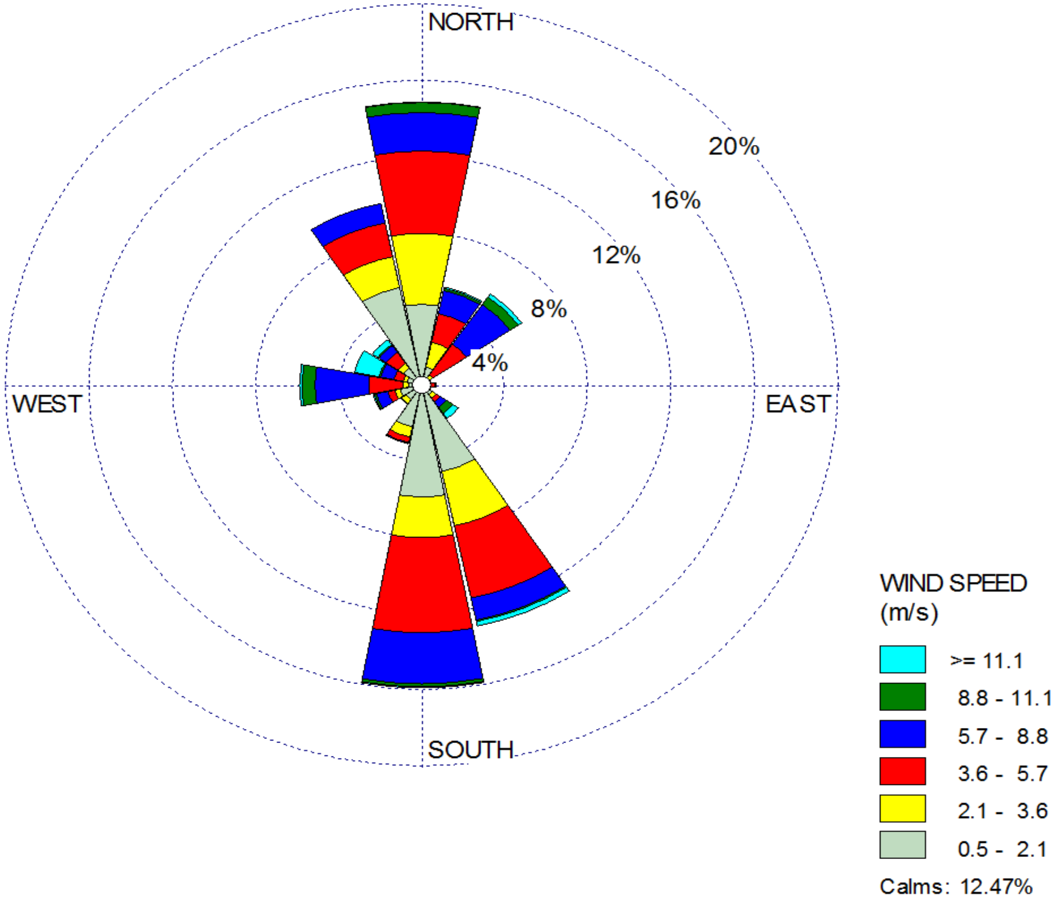

Figure B-2 Wind Rose Based on Winds Measured at the Citronen Ironbark Mine (November 2008-July 2009, July 2010-September 2010)

Source: Golder, 2010.

Golder Associates

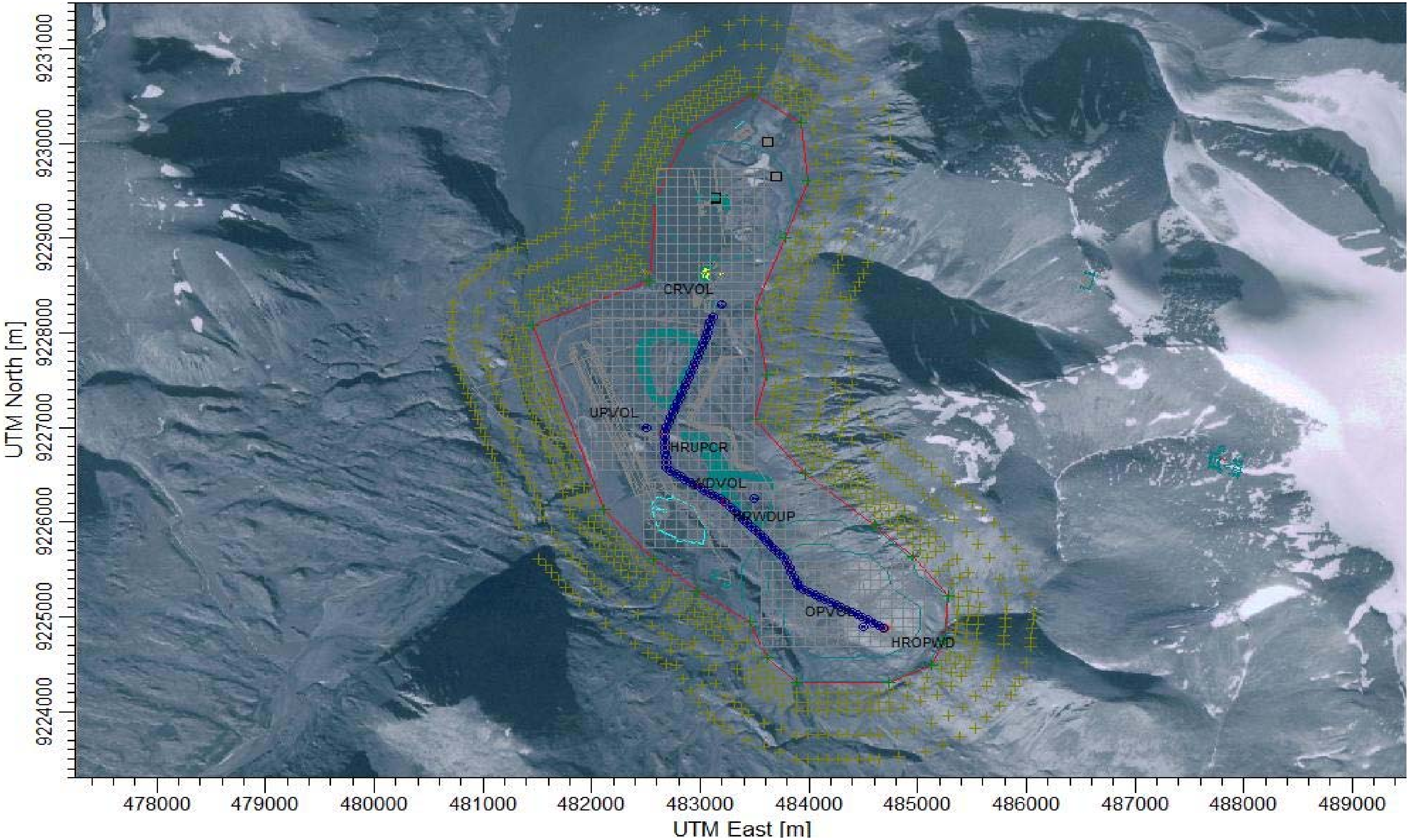

Figure B-3 Receptor Grid and Modeled Source Locations

Source: Golder, 2010.

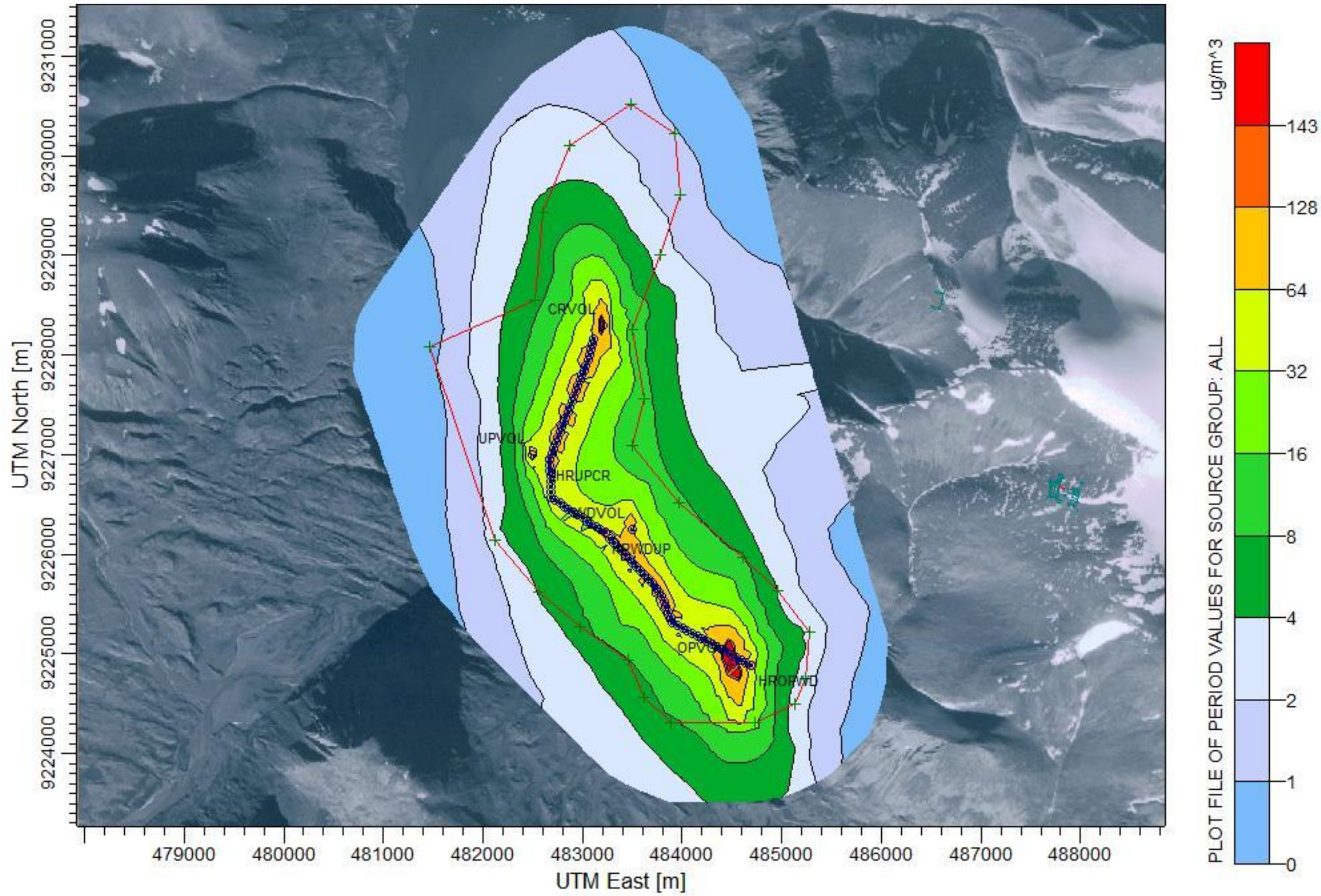

Figure B-4 Spatial Distribution of the Maximum Annual Average PM_{10} Concentrations (ug/m^3) Predicted in the Mine Vicinity (Revised 12/21/10)

Source: Golder, 2010.

Golder Associates

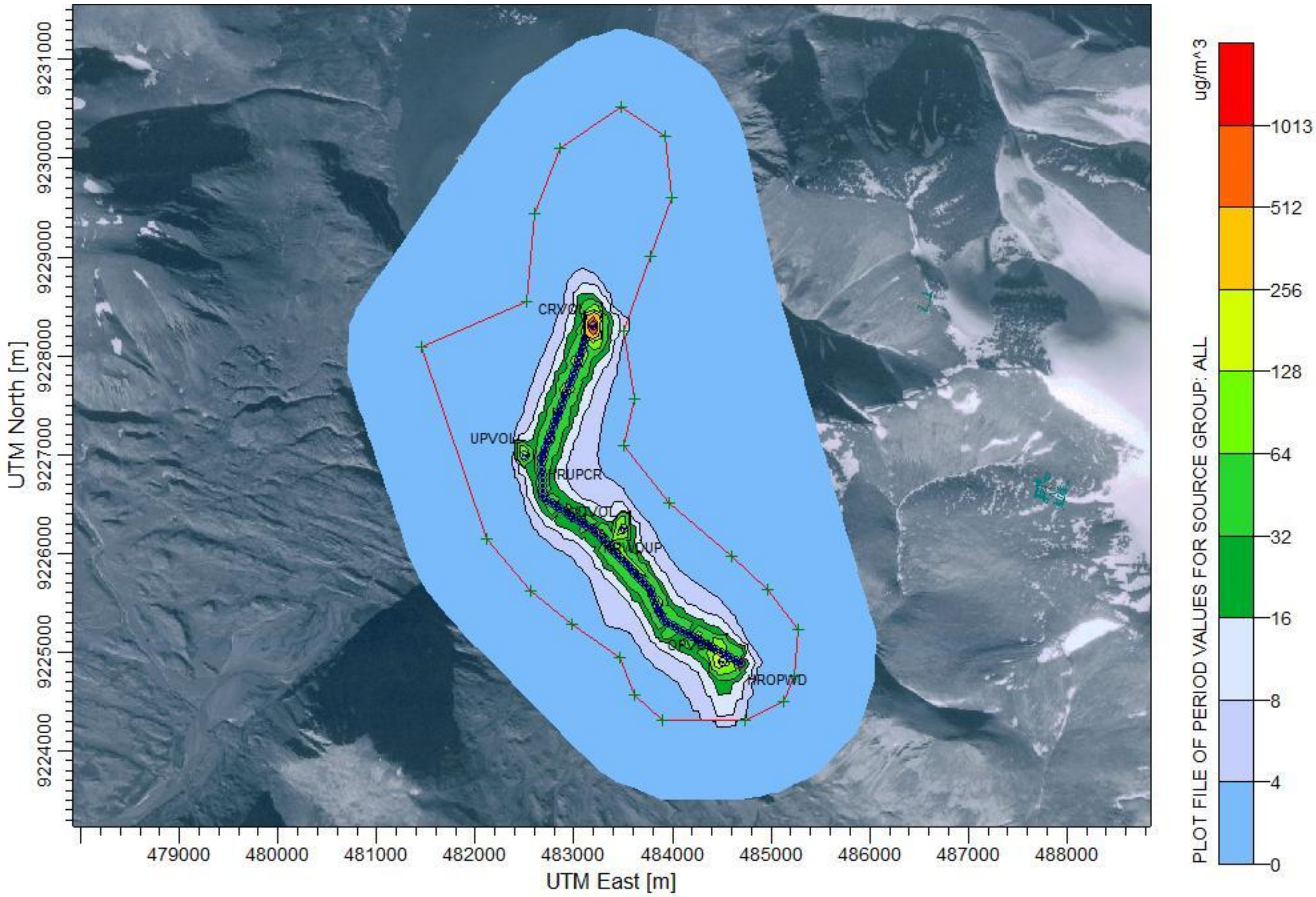

Figure B-5 Spatial Distribution of the Maximum Annual Average PM Concentrations Predicted in the Mine Vicinity (Revised 12/21/10)

Source: Golder, 2010.

Golder Associates

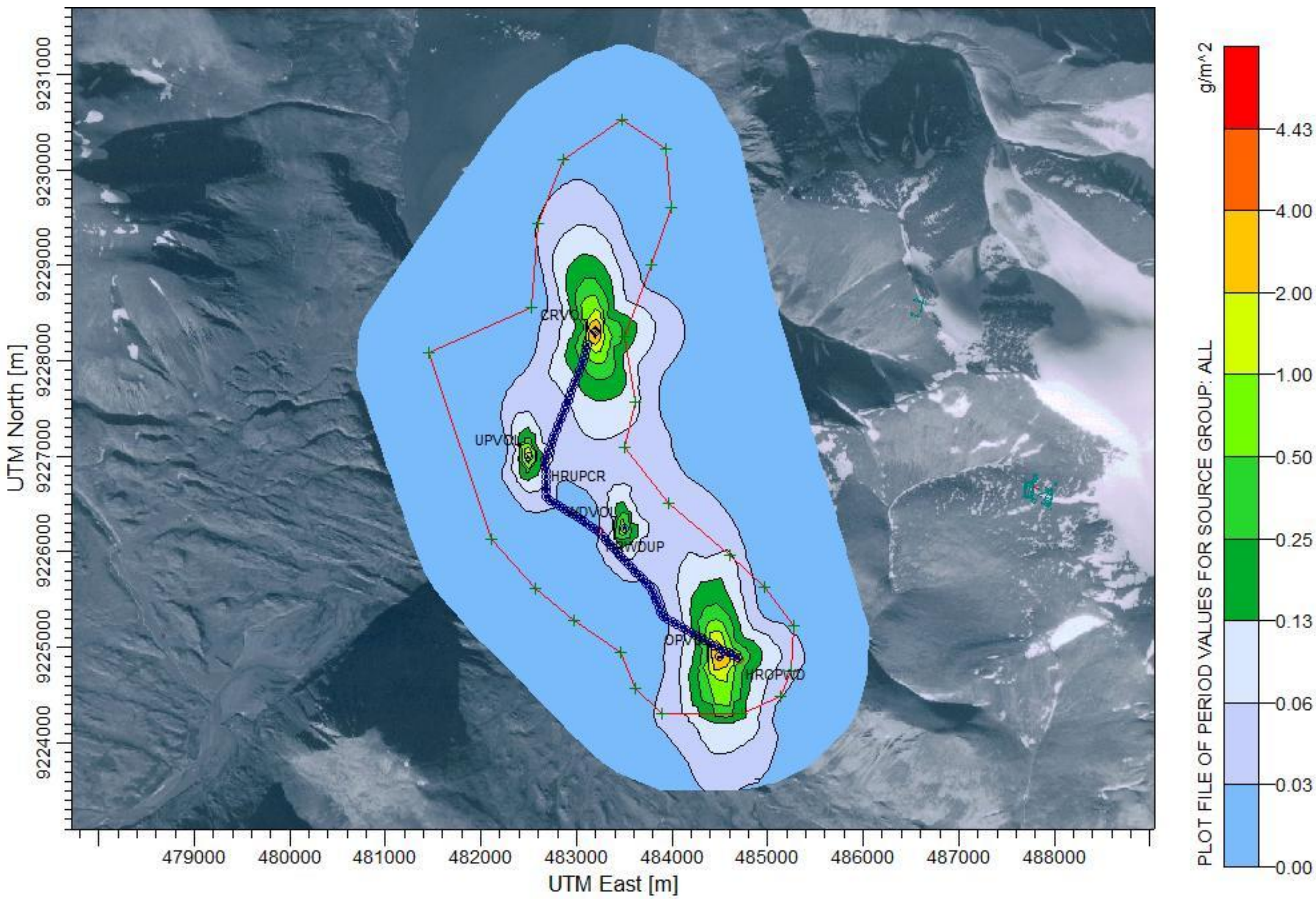

Figure B-6 Spatial Distribution of the Predicted Maximum Annual Zinc Deposition (g/m^2) Based on PM_{10} Emissions (Revised 12/21/10)

Source: Golder, 2010.

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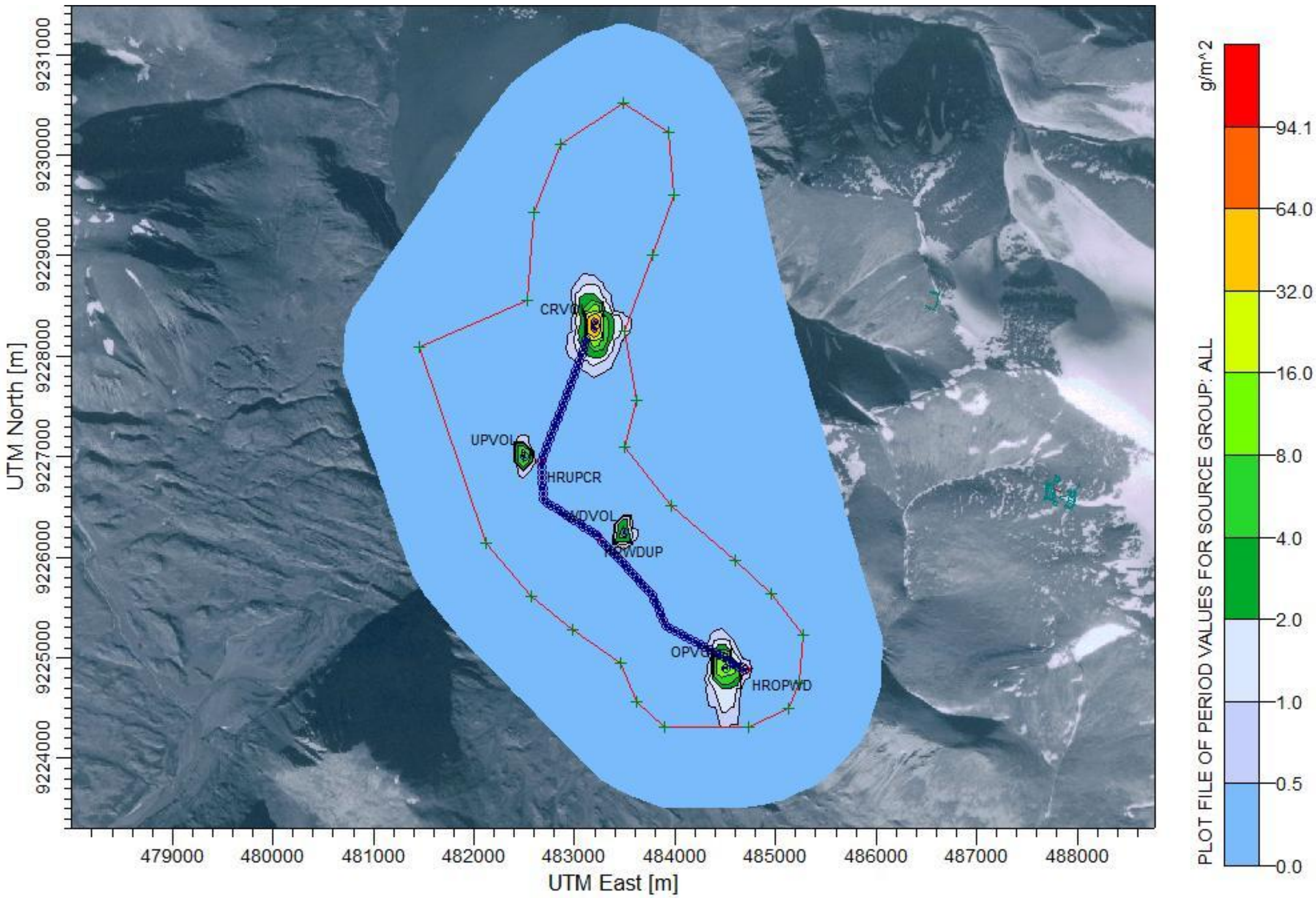

Figure B-7 Spatial Distribution of the Predicted Maximum Annual Zinc Deposition (g/m^2) Based on PM Emissions (Revised 12/21/10)

Source: Golder, 2010.

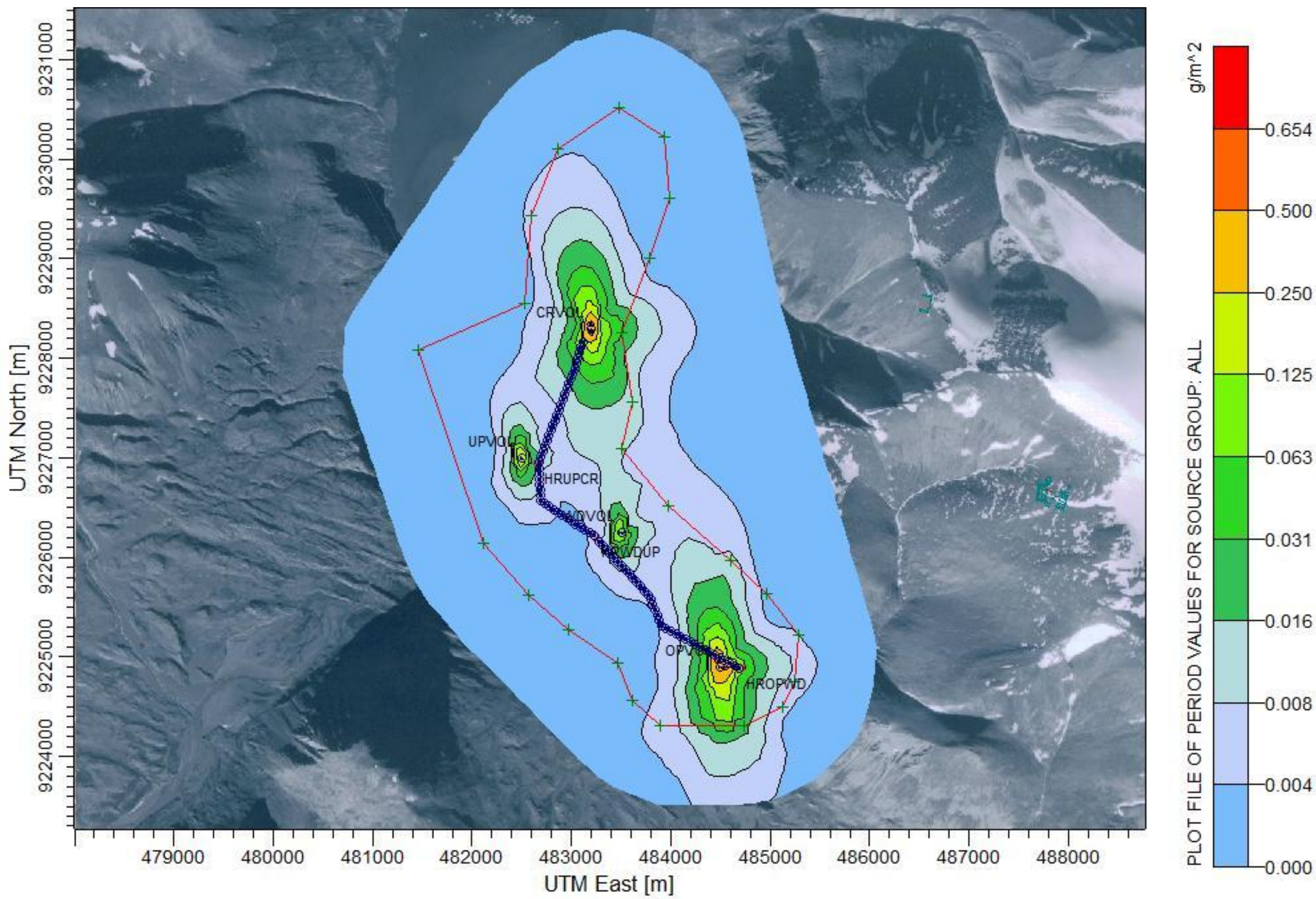

Figure B-8 Spatial Distribution of the Predicted Maximum Annual Lead Deposition (g/m^2) Based on PM_{10} Emissions

Source: Golder, 2010.

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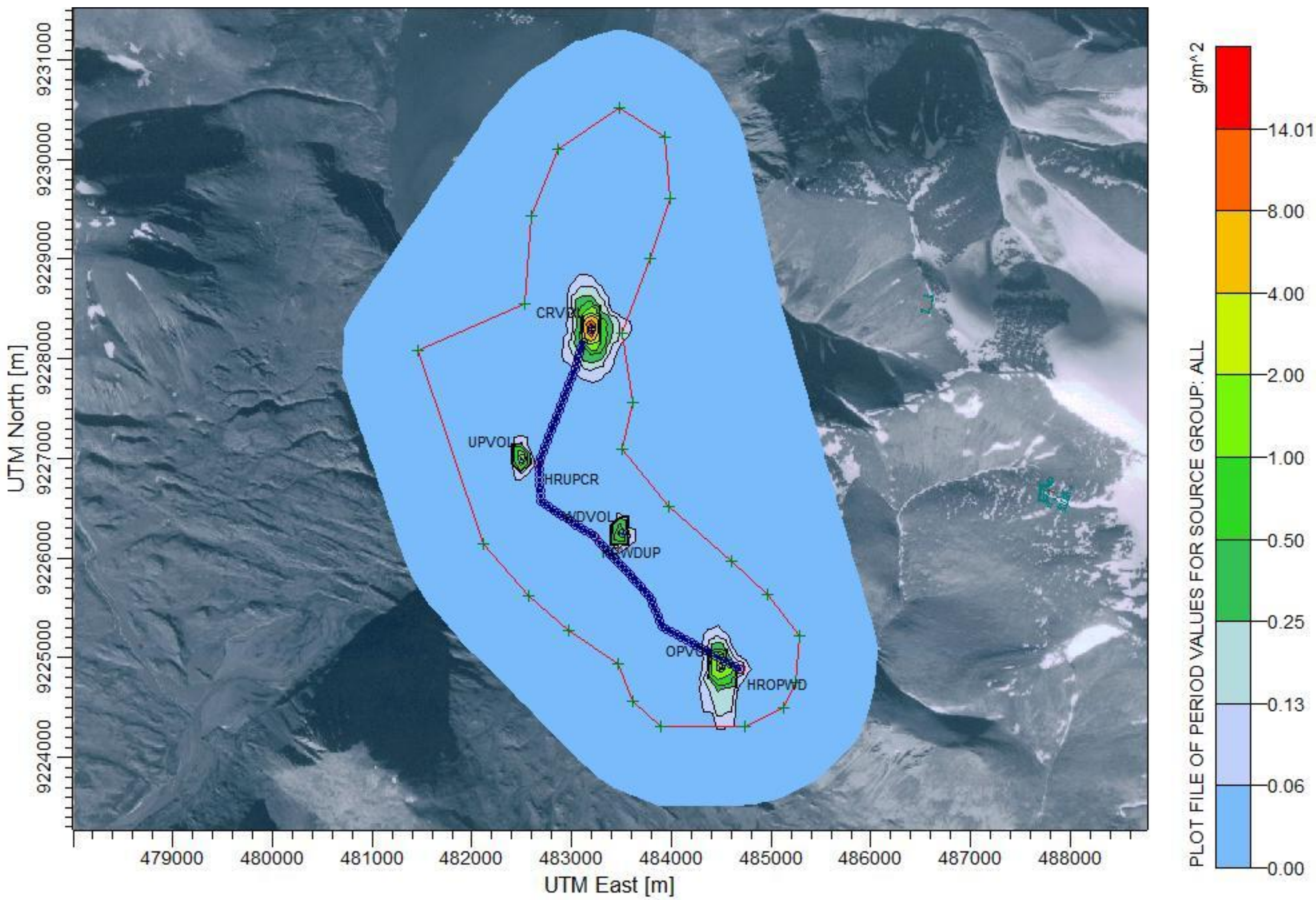

Figure B-9 Spatial Distribution of the Predicted Maximum Annual Lead Deposition (g/m^2) Based on PM Emissions (Revised 12/21/10)

Source: Golder, 2010.

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