NorthMet Project

Supplemental Air Emissions Risk Analysis (AERA) – Mine Site

Version 3

Issue Date: February 21, 2013

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1.0 Executive Summary

The initial Mine Site Air Emission Risk Analysis (AERA) Report was submitted to the Minnesota Pollution Control Agency (MPCA) in January 2008 (Reference (1)) in support of the October 2009 Draft Environmental Impact Statement (DEIS) for the NorthMet Project (Project) (Reference (2)). Because of proposed changes to the Project, Poly Met Mining Inc. (PolyMet) was requested to provide a supplemental AERA to reflect the proposed changes to the Project to support preparation of a Supplemental Draft Environmental Impact Statement (SDEIS). This Supplemental AERA evaluated the current Project and the associated changes in estimated emissions. This screening human health risk analysis followed the MPCA-accepted November 2011 Work Plan (as amended in August 2012) (Reference (3)). This analysis was conducted similarly to the 2008 Mine Site AERA with some exceptions (Section 5.5). This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Air Data Package will be resolved in favor of this document.

1.1 Chemicals for Evaluation (CFE)

Following the methodology described in the November 2011 Work Plan (Reference (3)), eleven chemicals for evaluation (CFE) were identified. These CFE included the risk driver chemicals identified in the 2008 AERA (asterisked below) and specific chemicals from the 2008 AERA that now have toxicity values and were not previously evaluated (chemicals with no asterisk).

The CFE for this Supplemental AERA are as follows: acetaldehyde, arsenic compounds*, cobalt and compounds, crystalline silica, dibenzo(a,h)anthracene* (PAH), diesel particulate, indeno(1,2,3-cd)pyrene* (PAH), manganese compounds*, nickel compounds*, nitrogen oxides (NO_x)* and dioxins/furans (2,3,7,8-TCDD toxicity equivalent basis, TEQ)*.

In addition, due to an oversight, the addition of an acute toxicity value for sulfuric acid was not considered in previous versions of the Supplemental AERA report. An evaluation of potential acute risk from sulfuric acid emissions has been added in this document. Sulfuric acid emissions at the Mine Site are minimal and therefore, potential risk due to these emissions is minimal as well.

1.2 Exposure Assessment

Exposure assumptions for this 2012 Supplemental AERA are the same as those used for the 2008 AERA. Potential chronic (more than one year) and acute (one hour) exposure were evaluated for the two Mine Site operating scenarios as represented by the Mine Year with the greatest emissions for that scenario: Mine Year 8 represents the scenario in which materials will be stockpiled and Mine Year 13 represents the scenarios in which materials will be disposed of in pits and some stockpiled material transferred to the pits. A receptor's assumed exposure is to the maximum modeled air concentration and is identified by U.S. Environmental Protection Agency (USEPA) as assessing the Maximum Exposed Individual (MEI) (Reference (4)). Assessing potential health risks to an MEI can be used in calculating a Theoretical Upper Bounding

Estimate (TUBE). The TUBE "…is easily calculated and designed to estimate exposure, dose and risk levels that are expected to exceed the levels experienced by all individuals in the actual distribution" (Reference (5)).

For this Supplemental AERA, a deposition algorithm was used for particulate emissions that utilized the half-life modeling in the AERMOD model (version 12060) to better represent potential air concentrations related to fugitive dust emissions and transport (Section 5.3.2). The algorithm was previously described in the Class II Modeling Protocol (Reference (6)) and the amended AERA work plan.

Potential health risks were assessed for two routes of exposure; direct via inhalation and indirect (ingestion exposure) via food consumption. Multi-pathway exposure evaluates concurrent exposure to contaminants by both inhalation and food consumption. Potential inhalation health risks were estimated for a maximum exposed (24 hours/day, 365 days/year) individual at the Mine Site property ownership boundary (i.e. Mine Site ambient air boundary). Potential resident and farmer multipathway risks were estimated for receptor locations approximately one kilometer from the Mine Site property ownership boundary because current zoning (as Mineral Mining by the City of Babbitt or Industrial by St. Louis County) does not allow residential/farming development on the lands within the mining/industrial district nor are there existing residents in this area. See Large Table 1 and Large Table 2 for details regarding exposure, receptor location, toxicity, and type of exposure assumptions.

1.3 Estimated Potential Incremental Human Health Risks and Conclusions

Maximum modeled air concentrations for the 11 CFE were input to the MPCA's Risk Assessment Screening Spreadsheet (RASS; version 20120302). Table 1-1 identifies that the summed potential incremental health risks at the projected Mine Site ownership boundary and at the mineral mining boundary were at or below the Minnesota Department of Health (MDH) guideline values of 1E-05 for carcinogens and 1.0 for non-cancer chronic and acute endpoints (References (7) and (8)). Risk driver chemicals (chemicals having potential non-cancer risks of 0.1 or greater or carcinogenic risk of 1E-06 or greater) included the following:

- Adult maximum exposed individual (inhalation only)
  - NO_2 from diesel fuel combustion: potential non-cancer acute HQ = 0.8
  - cobalt from fugitive dust: potential carcinogenic risk = 3E-06
  - nickel from fugitive dust: potential carcinogenic risk = 1E-06
- farmer receptor (multipathway)
  - dibenzo(a,h)anthracene from fuel combustion: indirect cancer risks = 5E-06
  - dioxins/furans (TEQ) from fuel combustion: indirect cancer risks = 8E-06

Table 1-1 also provides a comparison of risks estimated for this Supplemental AERA to those previously estimated in the 2008 Mine Site AERA. Overall, the estimated incremental health risks for this Supplemental AERA are considered to be similar (i.e. in the same range) to those estimated in the 2008 AERA.

Table 1-2 summarizes conservatism and uncertainty in the risk analysis.

Overall, when following the regulatory agency risk assessment methodology, estimated risks are considered to be conservative and likely meet the intent of a screening assessment to not underestimate risks.

Based on the estimated potential incremental risks estimated for the Project (current and previous Project Description), adverse effects to human health are not expected to be associated with potential air emissions from Mine Site activities.

Table 1-1 Summary of Potential Incremental Human Health Risks for the NorthMet Project Mine Site Proposed to be Located Near Babbitt, Minnesota

Exposure Route	Exposure Scenario	Receptor (MEI)	Potential noncancer effects (Hazard Index)(1)		Potential cancer effects (Risk Estimate)(2)	
			2008(3)	2012(4)	2008(3)	2012(4)
Inhalation Only Exposure	Acute (1 hour) (5)	Mine-Site property ownership boundary	0.2	0.8	N/A	N/A
	Chronic (greater than 1 year)	Mine-Site property ownership boundary	0.3	0.2	4E-06	5E-06
Multipathway Exposure (inhalation + food consumption)	Chronic (greater than 1 year)	Farmer(6)	0.04	0.04	3E-05	1E-05
		Resident(6)	0.04	0.04	7E-07	8E-07

MEI = Maximum Exposed Individual; for chronic risk, exposure to the maximum modeled air concentration is assumed to occur 24 hours per day for 365 days per year

N/A = not applicable and not assessed

(1) Hazard Index is the sum of individual non-cancer chemical risks for acute or chronic exposure. Risks were estimated using the MPCA's Risk Assessment Screening Spreadsheet (version as current at the time the analysis was conducted). Incremental non-cancer (chronic and acute) guideline value is 1.0.

(2) Potential human health risks from carcinogenic chemicals (summed for all chemicals) were estimated using the MPCA's Risk Assessment Screening Spreadsheet (version as current at the time the analysis was conducted). Incremental cancer risk guideline value is 1E-05, MDH.

(3) Risk estimates are as presented in the 2008 Mine Site AERA. The highest estimated risks for the highest estimated emission years (either the stockpile storage mine phase (Mine Year 8) or in-pit disposal phase (Mine Year 16)) are presented here.

(4) Risk estimates for the revised Project Description as of October 2012. The highest estimated risks from the highest estimated emission years (either the stockpile storage mine phase (Mine Year 8) or in-pit disposal mine phase (Mine Year 13)) are presented here. See section 5.3.1 for Mine Years 8 and 13 rationale.

(5) For the current risk analysis and the 2008 AERA, the HI for Acute risk includes the risks estimated for NO_X emissions (evaluated as NO_2). The USEPA factor of 80% was applied to the maximum modeled one-hour NO_X air concentration as a conservative estimate of the conversion of NO_x to NO_2.

(6) PolyMet' s land holdings at the Mine Site are within an area zoned as Mineral Mining by the City of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the Mine Site ownership boundary. Therefore, resident and farmer multipathway risks were not calculated at the Mine Site ownership boundary. Potential multipathway risks for a potential resident and farmer receptor were calculated for areas approximately one kilometer from the Mine Site ownership boundary, outside the Mineral Mining/Industrial District boundary. Risks were calculated based on estimated controlled potential emissions and for both stockpile storage and in-pit disposal mine layout. ~ 95% of the estimated potential farmer and resident risk is from potential indirect exposure (food consumption) related to estimated emissions of PAHs and dioxins/furans from diesel fuel combustion.

Table 1-2 Summary of Uncertainty and Conservatism in the Air Emissions Risk Analysis Conducted for the NorthMet Project Mine Site, Minnesota

Risk Component	Effect on 2008 Risk Estimates(1)	Effect on 2012 Risk Estimates(1)
Emission Estimates		
Use of controlled potential emission rates in all standard calculations including AERMOD inputs and the following assumptions: -operations continue 24 hours/day, 7 days/week, 365 days/year, except for the Portable Crushing Plant and Overburden Screening activities(2) - highest projected fuel usage in any year for on-site vehicles and worst case fleet for emissions - emissions from locomotives were based on loading and idling time of locomotives at the Mine Site - emissions from on-site vehicles are based on worst case years with maximum vehicle miles travelled.	Overestimates potential risk	Overestimates potential risk
Use of the USEPA factor that assumes 80% of the NO_X emissions are instantly converted to NO_2. NO_2 is the sole risk-driver chemical for acute inhalation risk. The primary source of NO_X is diesel fuel emissions. This is a conservative estimate because typically this conversion of NO to NO_2 is on the order of several hours to days (Reference (9)).	Overestimates potential acute inhalation risk	Overestimates potential acute inhalation risk
Estimating dioxin emissions from haul trucks. For the 2008 analysis, Barr Engineering calculated a factor (using several data sets provided by USEPA (Reference (10)) from the 1996 – 1998 time period) that was accepted by the MPCA for use in dioxin emission calculations. For the 2012 analysis, USEPA's factor (derived from data from the 1996 – 1998 time period) was used in the dioxin emission calculations. Both emission factors result in high end estimates of potential emissions (References (11) (12)).	Overestimates potential risk	Overestimates potential risk
All sources of emissions were modeled except those that did not emit the pollutants included in the supplemental AERA or sources that were excluded per MPCA Guidance	Likely no effect on estimated risks	Likely no effect on estimated risks
Exposure and Bioavailability of Chemicals		
For inhalation exposure, the maximum modeled air concentration for an averaging time period was used to estimate potential risks. USEPA guidance identifies this as a Maximum Exposed Individual.	Overestimates potential risk	Overestimates potential risk

Risk Component	Effect on 2008 Risk Estimates(1)	Effect on 2012 Risk Estimates(1)
MEI Concept, chronic risk. It is very unlikely that an individual would be living near the boundary of the facility or at the Mineral Mining/Industrial District. An individual would not be outside 24 hours/day, 7 days/week, for 365 days/year in Minnesota.	Overestimates potential risk	Overestimates potential risk
Air dispersion modeling was conducted with the AERMOD model. For the 2008 analysis, AERMOD was run in regulatory mode. For the 2012 analysis, a deposition algorithm utilizing the half-life modeling in AERMOD was used to better represent fugitive dust emissions.	Overestimates potential risk	Overestimates risk
Assumption that all metals exist in a physical form that makes them 100% bioavailable and in a respirable size range. About 97% of the metal emissions for the Mine Site are associated with rock handling operations. This means the metals are much more likely to be inherent to the mineral structure of the rocks and present as compounds- they are not likely present in ionic forms. Therefore, it is very unlikely that 100% of the metals will be in a respirable size range and be bioavailable by inhalation. In terms of multipathway exposure, it is unlikely that 100% of the metals will be bioavailable by ingestion.	Overestimates potential risk	Overestimates potential risk
Toxicity Values		
Use of provisional toxicity value (a PPRTVs) in the RASS for cobalt (a worker exposure value) to assess potential risks.	Likely overestimates potential risk	Likely overestimates potential risk
Use of PAH toxicity values that are derived by extrapolation and are considered to be highly uncertain.	Likely overestimates potential risk	Likely overestimates potential risk
2008: Some persistent chemicals did not have Multipathway Screening Factors and were excluded from the indirect pathway risk estimates. 2012: All chemicals for evaluation considered PBT had Multipathway Screening Factors.	May underestimate potential risk	May underestimate potential risk
The RASS only evaluates chemicals with inhalation benchmarks for potential ingestion risk (multipathway exposure). Chemicals such as fluorene, 2-methylnaphthalene, acenaphthene, anthracene, phosphorus, pyrene, and zinc have oral, but not inhalation benchmarks and are not evaluated for multipathway exposure (ingestion plus inhalation).	May underestimate potential risk	May underestimate potential risk

Risk Component	Effect on 2008 Risk Estimates(1)	Effect on 2012 Risk Estimates(1)
Risk Characterization (Risk Estimates)		
In terms of risk characterization the following assumptions were made: - all chemicals have an additive effect - assumed all non-carcinogenic toxicity values have the same level of accuracy and precision and severity of toxic effects. - Cancer risks summed across modes/mechanisms of action; carcinogenic unit risks have the same weight of evidence for human carcinogenicity	Likely overestimates potential risk	Likely overestimates potential risk
Synergism/antagonism was not considered	May under- or over- estimate potential risk	May under- or over- estimate potential risk
For carcinogens when the Unit Risk is based on the 95th percentile of the probability distribution, addition of these percentiles may become progressively more conservative as the risks from a number of carcinogens are summed (Reference (13)).	Overestimates potential risk	Overestimates potential risk
For non-carcinogens, the Hazard Index was summed across all toxicity endpoints. This is not realistic because different chemicals can have different toxicity endpoints.	Overestimates potential risk	Overestimates potential risk

(1) Key for Effects Determination:

- Overestimates potential risk: A value or assumption intentionally chosen to provide high risk estimates
- Likely Overestimates potential risk: A value or assumption intentionally chosen that is expected to provide high risk estimates
- May overestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a high risk estimate
- Underestimates potential risk: A gap in information or an available value that is known to provide a low risk estimate
- Likely underestimates potential risk: A gap in information or an available value that may provide a low risk estimate
- May underestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a low risk estimate.
- Likely no effect on estimated risk: Value or assumption that is known or suspected to have very little, if any, effect on potential risk

(2) The Portable Crushing Plant and Overburden Screening operations were assumed to operate 24 hours/day from April through October.

2.0 Introduction

In January 2008, PolyMet submitted an Air Emissions Risk Analysis (AERA) in support of the Draft Environmental Impact Statement (DEIS) to the MPCA (Reference (1)). Because of the conservatism in the risk analysis, all incremental potential health risks calculated in the 2008 AERA were considered to be acceptable and it was concluded that no adverse human health risks were expected to be associated with the Project's air emissions. Since preparation of the DEIS, PolyMet has proposed changes to mine operations and a Supplemental Draft EIS (SDEIS) is currently being prepared to evaluate the revised Project. PolyMet has been requested to submit a supplemental AERA to re-assess the potential human health risks associated with the Project. A Work Plan for the Supplemental AERA was accepted by the MPCA in November 2011 (Reference (3)). In August 2012 the Work Plan was amended for modeling of fugitive dust emissions (described in Section 5.3.2).

This supplemental 2012 AERA reflects the design and operations for the Mine Site as characterized by the NorthMet Mine Site Emission Inventory version 10 submitted October 27, 2012. This report includes:

- a list of chemicals potentially emitted from Mine Site activities
- a summary of estimated emissions for the individual chemicals
- a list of chemicals for quantitative risk evaluation
- air dispersion modeling results for all relevant emission sources at the Mine Site (including vehicle and locomotive emissions and fugitive emissions from haul roads)
- chemical-specific inhalation and total multipathway (inhalation + indirect pathway) incremental health risks based on potential emissions from mine operations
- a qualitative screening analysis (Uncertainty Discussion)

This document is being provided as a stand-alone document for review and it will be integrated into the NorthMet Project Air Data Package after approval. Any discrepancy between this document and the NorthMet Air Data Package will be resolved in favor of this document.

2.1 Purpose of the Supplemental 2012 AERA

The primary objectives of this Supplemental 2012 AERA are to:

- conduct a conservative assessment of potential incremental human health risks that may be associated with air emissions with the Project as reflected in the Mine Site Emission Inventory

- compare the estimated potential risks for the current Project emissions with the risks estimated in the 2008 AERA and assess the differences or similarities in risk estimates
- provide supplemental risk information to be used in the SDEIS and the air permitting process

2.2 Approach to the AERA

PolyMet has followed the November 2011 Work Plan (as amended in August 2012 for air dispersion modeling of fugitive dust) and the MPCA's most current AERA guidance (Reference (14)) in conducting this risk analysis.

The MPCA's AERA process (Reference (14)) is designed to determine whether or not controlled potential chemical emissions from sources and/or source groups are a potential health risk via inhalation and/or from indirect (multipathway) exposure. As defined by the MPCA, the term "risk" generally refers to estimated cancer risks (risk estimate) and the potential for noncancer health effects. Noncancer health effects are described using a Hazard Quotient (HQ) (for a single chemical) or a Hazard Index (HI) as the sum of HQs. In the AERA process, "quantitative analysis" specifically refers to the estimation of cancer risks and hazard indices using the MPCA's Risk Assessment Screening Spreadsheet (RASS, version 20120302). The AERA process additionally includes a "qualitative analysis," which identifies and discusses issues for which public health impacts cannot be easily quantified.

It is important to note that because of the limitations inherent in the risk assessment process, the risk characterization in this AERA or any health risk assessment cannot predict actual health outcomes, such as cancer. In other words, this or any health risk assessment does not provide an estimate of actual risk to a real person.

The 2012 Supplemental AERA was based on the following risk assessment guidance documents:

State of Minnesota

- Air Emissions Risk Analysis (AERA) Guidance. Version 1.1. MPCA, September 2007 (Reference (14))

USEPA

- Guidelines for the Health Risk Assessment of Chemical Mixtures. USEPA, 1986 (Reference (15))
- Risk Assessment Guidance for Superfund Volume 1 – Human Health Evaluation Manual Part A. USEPA, 1989 (Reference (16))

- Risk Assessment Guidance for Superfund, Volume I – Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment. USEPA, 2009 (Reference (17))
- Guidelines for Developmental Toxicity Risk Assessment. USEPA, 1991 (Reference (18))
- Guidelines for Exposure Assessment. USEPA, 1992 (Reference (5))
- Guidance for Data Usability in Risk Assessment. USEPA, 1992 (Reference (19))
- Exposure Factors Handbook, USEPA, 2011 (Reference (20))
- Risk Assessment for the Waste Technologies Industries (WTI) Hazardous Waste Incinerator Facility – Volume V. Human Health Risk Assessment. USEPA, 1997 (Reference (21))
- Guidelines for Carcinogenic Risk Assessment. USEPA, 1986, 1996, 2005 (References (22) (23) (24)).
- Residual Risk Report to Congress. USEPA, 1999 (Reference (25))

3.0 Site Characterization

3.1 Facility Description

PolyMet plans to construct and operate a mine area six miles south of the town of Babbitt, in northeastern Minnesota (Mine Site) (Large Figure 1). In addition, PolyMet plans to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant MN and to build an ore processing facility at the former LTVSMC site near Hoyt Lakes, MN (referred to as the Plant Site) about eight miles to the west of the Mine Site. The locations of these two facilities are shown in Large Figure 1. A detailed description of the Project is provided in the March 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement (EIS) (Reference (26)) and the NorthMet Project Description Version 3 submitted September 13, 2011. An updated Project Description, version 4, is scheduled to be submitted by October 31, 2012.

3.2 Site Environment Description

The Mine Site is located six miles south of the city of Babbitt in northern Minnesota, within the corporate boundaries of the city (occupying parts of Sections 1-4 and 9-12, Township 59 North, Range 13 West, St. Louis County). PolyMet's land holdings at the Mine Site are within an area zoned as Mineral Mining by the city of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary (Large Figure 2).

Lands immediately adjacent to the Mine Site are primarily undeveloped and dominated by extensive forests and large wetlands (peatlands), except for the northern boundary where another industrial mine site is located.

The Project site lies within the Nashwauk Uplands of the Northern Superior Uplands in the Laurentian Mixed Forest Province (Reference (27)). Landforms within the Nashwauk Uplands include end moraines, outwash plains, and lake plains. Soils vary from medium to coarse texture. Forestry and mining are the most important land uses presently. The surface relief of the Nashwauk Uplands is generally gently rolling, with local relief ranging from about 10 to 30 feet. In some locations, the local relief can range up to 200+ feet (e.g., Embarrass Mountains). Slopes are mostly short and irregular. The landscape includes many closed depressions, most of which contain peat-lands.

4.0 Identifying Chemicals for Quantitative Evaluation

As described in the November 2011 Work Plan, the chemicals for evaluation (CFE) in this Supplemental 2012 AERA include:

- risk driver chemicals from the January 2008 Mine Site AERA
- chemicals with new toxicity values which were not evaluated in the 2008 Mine Site AERA
- chemicals for which either an increase in emissions and /or a change in or addition of a toxicity value suggests the chemical would now be considered a risk driver chemical (2008 adjusted risk is now greater than 1E-06 for cancer or noncancer risk greater than 0.1)

4.1 Risk Driver Chemicals from the 2008 AERA

Chemicals for Potential Evaluation (CFPE) were identified for the January 2008 AERA using a variety of sources of emission information (e.g., concentrations of metals in rock and ore to estimate potential fugitive dust emissions, emissions associated with diesel fuel combustion, etc.). The focus of that effort was to identify those chemicals that may be emitted to air from Mine Site operations that may be of potential human health concern if exposure to those chemicals occurs at levels above thresholds that are generally considered safe.

The quantitative risks from the 2008 AERA are used as the basis for determining potential risk-driver chemicals. A chemical is considered a "risk driver" if the hazard quotient for an individual chemical is above 0.1 or the cancer risk for an individual chemical is greater than 1E-06.

Of the 32 chemicals that were quantitatively evaluated for inhalation and multipathway health risks in the January 2008 AERA, six were identified as "risk drivers:" dioxins/furans, manganese compounds, nickel compounds, nitrogen oxides (NO_X as NO_2), dibenzo(a,h)anthracene (PAH), and indeno(1,2,3-cd)pyrene (PAH).

These six chemicals were quantitatively evaluated in this Supplemental AERA.

4.2 Chemicals That Now Have Toxicity Values

Chemicals that were listed as CFPE in the 2008 Mine Site AERA without a toxicity value, but that now have a toxicity value in the MPCA's Risk Assessment Screening Spreadsheet (RASS), include the following: acetaldehyde (for acute toxicity), cobalt, crystalline silica and diesel particulate matter (DPM).

These chemicals were added to the list of chemicals for quantitative evaluation for this Supplemental AERA.

In addition, an acute benchmark concentration for sulfuric acid was added to the RASS since the 2007 version. In a scoping oversight the emissions from sulfuric acid were not considered with the other chemicals for evaluation. Instead, a semi-quantitative Revised Risk Estimate (RRE- See Section 4.3) for sulfuric acid is included in the total acute hazard index for the Plant Site. Note that the RRE for sulfuric acid does not indicate that it would be a risk driver chemical.

4.3 Additional Chemicals to Evaluate Due to Changes in Emissions or Toxicity

Emission estimates for Mine Site sources, including fugitive dust (from haul roads, loading/unloading of waste rock and ore, crushing and screening of construction rocks) and diesel combustion emissions (from haul trucks and locomotives) have been updated to reflect changes in proposed operations since submittal of the 2008 AERA as represented by the latest emission inventory (version 10).

Large Table 3 presents the comprehensive list of 54 pollutants in the AERA inventory identified to be potentially emitted from the proposed Mine Site activities. Estimated emissions of these chemicals from 2008 and current emissions estimates are compared for the worst-case year of stockpile waste rock storage (i.e., year 8) and in-pit waste rock storage and stockpile reclamation (year 16 for the 2008 AERA and year 13 for the 2012 Supplemental AERA).

Potential emissions of metals in fugitive dust were conservatively estimated based on total particulate matter (PM) and the concentration of a metal in specific types of mineral material (ore, lean ore, waste rock). Potential emissions of metals from natural gas combustion (based on AP-42 listings) and mobile source diesel fuel (fuel oil) combustion were also calculated.

Details regarding emissions calculations are available in the NorthMet Mine Site Emissions Inventory Version 10 submitted October 27, 2012. The emission inventory also provides the model inputs used for the pollutants evaluated in the AERA.

Because both emission changes and toxicity value changes may have occurred since 2008, CFPE were reassessed for potential importance to the overall risk estimates. As identified in the November 2011 Work Plan, the following methodology to calculate a “revised risk estimate” (RRE) was used to determine whether any changes were significant with regard to emissions or toxicity values.

- For chemicals that only have emission changes since 2008

  RRE = Jan 2008 risk x (1 + %change in emissions)

- For chemicals that only have changes to toxicity value since 2008

  RRE = Jan 2008 risk x (1 + %change in toxicity value)

- For chemicals that have both changes in emissions and toxicity value since 2008

RRE = Jan 2008 risk x (1 + % change in emissions)(1 + % change in toxicity value)

Any chemical with an RRE greater than or equal to risk driver levels (0.1 for noncancer risks and 1E-06 for cancer risks) would be included in the quantitative risk assessment for the Supplemental AERA. Large Table 4 identifies the revised risk estimates for all CFPEs with toxicity factors. The analysis of changes in emissions and toxicity factors identifies that arsenic is an additional chemical to be evaluated quantitatively for human health risks. Therefore, arsenic was included as a CFE for this Supplemental AERA.

The RRE for sulfuric acid is calculated even though an acute reference concentration was not available in 2008. The Jan 2008 risk was estimated using the current acute reference concentration value for sulfuric acid (RASS version 20120302) and the maximum modeled 1-hour concentration from the 2008 analysis. The percent change in emissions was then applied to the estimated Jan 2008 risk value as shown below and in Large Table 2.

RRE (sulfuric acid) = Est. Jan 2008 risk x (1 + % change in emissions)

RRE (sulfuric acid) = 0.00017 x (1+1232%) = 0.0023

4.4 Chemicals for Evaluation (CFE)

The following chemicals have been identified as CFE for this Supplemental AERA:

- acetaldehyde
- arsenic compounds
- cobalt compounds
- diesel particulate
- dioxins/furans (2,3,7,8-TCDD toxic equivalents, TEQ basis)
- manganese compounds
- nickel compounds
- nitrogen oxides (evaluated as NO_2)
- PAHs (dibenzo(a,h)anthracene; Indeno(1,2,3-cd)pyrene)
- silica, crystalline
- In addition sulfuric acid was evaluated as a Revised Risk Estimate (RRE).

4.5 Chemicals Screened out of the Quantitative Evaluation

Chemicals not identified in Section 4.4 were not quantitatively evaluated for the Supplemental AERA. These chemicals were screened out of evaluation based on estimated low risks as determined in both the 2008 AERA, as per the work plan, and in the determination of RREs (see Section 4.3). For comparison, the estimated risks for the chemicals screened out of quantitative evaluation, as determined in the 2008 AREA and as RREs, are presented in Table 4-1. These estimated risks would not likely change the final determination of risk estimates presented in this Supplemental AERA within the reporting values of one significant digit.

Table 4-1 Potential Risk Estimates of Chemicals Screened Out of the Supplemental Mine Site AERA using both 2008 Risk Results and Revised Risk Estimates (RREs) Based on Changes in Emission Estimates and/or Toxicity Values

Source or Location of Estimated Potential Risks	Potential Risks from Chemicals in the 2008 AERA with Insignificant Risk(1)	Revised Risk Estimates (RREs) for Chemicals with Insignificant Risk in the 2008 AERA(2)
Inhalation Risks at the PolyMet Mine Site Operating Boundary		
Acute	0.0058	0.0038
Chronic Noncancer	0.016	0.0097
Cancer	2.4E-07	1.2E-07
Multipathway Risks at the Mineral Mining/Industrial District Boundary		
Farmer Noncancer	0.0041	0.0050
Farmer Cancer	5.2E-07	4.1E-07
Resident Noncancer	0.0041	0.0050
Resident Cancer	5.3E-08	1.9E-08

(1) Estimates reflect the risk of screened out chemicals as evaluated in the 2008 AERA i.e. the RASS is the 20070904 version and emission estimates are those evaluated in 2008.

(2) Estimates reflect the risk of screened out chemicals as calculated as RREs for the 2012 supplemental AERA i.e., updated emissions and toxicity values from the 20120302 RASS are used.

Note that iron is not considered a chemical for potential evaluation. Although iron is present in the ore, it is not in high enough concentrations to be extracted economically as a product as part of the Project. Previous mining projects, such as Essar and the Keetac Expansion, that have evaluated iron through the oral pathway have not shown iron to be a risk driver chemical and iron therefore was not considered to be an issue for human health risk. The relatively lower iron concentrations in the Project ore compared to the iron ore processed in the Essar and Keetac projects indicate that iron is highly unlikely to be a risk driver chemical for the Project.

5.0 Exposure Assessment and Estimating Exposure Point Concentrations

5.1 Exposure Assessment Concepts

Exposure assessment is the process of evaluating how people are potentially exposed to chemicals from their environments. For this analysis, maximum modeled air concentrations were used to assess potential inhalation risks. The USEPA (Reference (4)) considers the use of maximum modeled air concentrations in a risk analysis to assess a Maximum Exposed Individual (MEI) and defines the MEI as an exposure scenario based on using the *"…modeling node where the maximum ambient air concentration occurs, regardless of whether there is a person there or not…."*. In general, the MEI analysis assumes that a hypothetical receptor would live in the area of the estimated maximum concentration and be outdoors 24 hours per day, 365 days per year for their lifetime.

This exposure concept uses the maximum point estimate for ambient air concentrations as the potential dose and compares this concentration to toxicity values to generate near maximum risk estimates. Factors such as typical (or central tendency) exposure frequency and duration (as applied to the maximum concentration), bioavailability, variability in exposure point concentrations, and chemical speciation are not considered. Assessing health risks to an MEI is a high end estimate and similar to calculating the theoretical upper bound estimate (maximum exposure that is expected to exceed the levels experienced by all individuals in the actual distribution).

Important considerations for the MEI concept are as follows:

- according to USEPA (Reference (28)), the theoretical upper bound estimate "…is easily calculated and designed to estimate exposure, dose and risk levels that are expected to exceed the levels experienced by all individuals in the actual distribution.…"

- the estimated risk presented under the MEI concept should not be used to draw conclusions regarding potential public health impacts or be used as an indicator of actual risks

- the MEI scenario is a useful screening tool to determine if more detailed analyses or the inclusion of other exposure concepts (such as the central tendency exposure) are warranted

- Risk management decisions should be based on realistic exposure scenarios rather than the hypothetical MEI (Reference (25)).

Assessing the MEI using the MPCA AERA methodology ensures that a conservative approach is used to assess potential health risks and protect public health (including sensitive populations) with a suitable margin of safety. Although presentation of potential risks using more plausible assumptions can assist in risk management decisions, when potential health risks are assessed to be at or below acceptable guidelines using the MPCA AERA methodology, adverse health effects, even in sensitive populations, are not expected.

5.2 Exposure and Dose

5.2.1 Inhalation Exposure (Direct Exposure)

Following MPCA guidance, the RASS is used to calculate potential inhalation risks to receptors located at the area of the highest modeled air concentration (typically at the property boundary). The location of hypothetical receptors for this analysis is a person at the Mine Site property boundary, and a person at the distant Mineral Mining/Industrial zoning boundary. The RASS is designed to assess potential inhalation health risks for ~~from~~ the following durations of inhalation exposures:

- short-term, acute, (exposure to maximum concentration of a chemical in ambient air for the one hour averaging time), and
- long-term, chronic (exposure to maximum concentration of a chemical in ambient air for the annual averaging time).

The AERA methodology, as integrated into the MPCA's Risk Assessment Screening Spreadsheet (RASS), uses simple generic equations to calculate potential chemical exposure to a hypothetical receptor through inhalation. In this application the maximum modeled air concentration is synonymous with the potential dose for all acute and chronic durations. In actuality, real exposure occurs during uptake of the chemical through the respiratory tract after inhalation. Once the chemical is absorbed from the respiratory tract a certain amount becomes available to interact with specific organs or cells within the body (i.e. the delivered dose). For the analysis presented in this report, assuming that 100% of the maximum modeled air concentration is absorbed and accounts for the delivered dose is an overestimation of potential incremental risk, especially for chronic exposure.

5.2.2 Multipathway Exposure (Indirect; Ingestion)

Multipathway exposure assessment is an important part of risk assessment for chemicals that are emitted into air. Chemicals that are persistent, bioaccumulative, and/or toxic (PBT) can deposit to water, soil, and sediment and be present for long periods of time. Some particles settle onto soil and vegetation surfaces (farm crops and gardens) and into surface water (lakes, rivers, streams) and are persistent in the environment. Particles that settle into surface waters can deposit in the sediment and bioaccumulate in aquatic ecosystems. PBT chemicals have the potential to become part of the food chain by being deposited on plants (and/or incorporated into plants) and subsequently eaten by animals (e.g. cattle, poultry) and incorporated into food products. Potential exposure to PBT chemicals from food along with incidental ingestion of soil is part of the multipathway assessment for the resident and farmer. Using the maximum estimated air concentrations for the annual averaging time period, potential multipathway exposures are accounted for in the AERA methodology for two generic receptor types:

- a resident who consumes vegetables grown in his or her own garden, which are all assumed to receive deposition from the Project
- a farmer who, in addition to consuming homegrown vegetables, regularly eats home-grown meat, eggs, and dairy products which are all assumed to be affected by deposition from the Project

As previously discussed, the Mine Site is within Mineral Mining/Industrial zoning areas, which prohibit residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary. Currently there are no residents living in the area between the Mine Site boundary and the Mineral Mining/Industrial District boundary. There are also no residents or farmers at the Mineral Mining/Industrial District boundary, however, it is possible for a hypothetical resident or farmer to be at this boundary without violating zoning requirements. Therefore, potential multipathway risks for a potential resident and farmer receptor were calculated for areas at or outside the Mineral Mining/Industrial Districts boundary, with the nearest point of this boundary being approximately one kilometer from the Mine Site ownership boundary. Risks were calculated based on estimated potential to emit emissions for Mine Year 8 and Mine Year 13, per the current emission inventory (see Section 5.3.1 for Mine Years 8 and 13 rationale). Exposure scenarios evaluated in the Supplemental AERA are summarized in Table 5-1. See Large Table 1 and Large Table 2 for a summary of exposure, dose and toxicity endpoint information.

Table 5-1 Summary of Exposure Scenarios and Receptors Evaluated for the Supplemental Air Emissions Risk Analysis for the Mine Site

Receptor(s)	Type of Exposure
Person (off-site worker) at the Mine Site Property Boundary	Inhalation Short-term, acute inhalation: breathing maximum 1 hour modeled concentration of a chemical in ambient air Long-term, chronic inhalation: breathing maximum annual modeled concentration of a chemical in ambient air
Resident who eats vegetables from his/her garden just outside of the Mining/Industrial boundary	Total Multipathway Exposure (Inhalation + Ingestion) Long-term, chronic ingestion of vegetables from the garden (including incidental soil ingestion) + breathing maximum annual air concentration
Farmer who eats vegetables from his/her garden and meat and dairy products from his/her farm just outside the Mining/Industrial boundary	Total Multipathway Exposure (Inhalation + Ingestion) Long-term, chronic ingestion of vegetables, meat, and dairy products from the farm (including incidental soil ingestion) + breathing maximum annual air concentration

All CFEs that are identified as PBTs have multipathway screening factors in the version of RASS (20120302) used in this AERA (see Attachment A). The status of all CFEs and risk-driver chemicals in terms of PBTs and multipathway screening factors is listed in Table 5-2. The CFE from the Mine Site that are persistent and/or bioaccumulative are associated either with diesel fuel combustion from trucks and locomotive engines (dioxins/furans, PAHs and metals) or fugitive dust from haul roads (metals associated with particulate matter).

Table 5-2 Multipathway Screening Factors for the Chemicals for Evaluation in the Supplemental AERA Conducted for the Mine Site

Chemical Name	Risk Driver In the 2008 AERA?	RASS-Multipathway Screening Factor?	RASS-PBT
Acetaldehyde	No	No	No
Arsenic Compounds	Yes	Yes	Yes
Cobalt	No	No	No
Crystalline Silica	No	No	No
Dibenzo(a,h)anthracene (PAH)	Yes	Yes	Yes
Diesel Particulate	No	No	No
Dioxins/Furans (2,3,7,8-TCDD equivalents)	Yes	Yes	Yes
Indeno(1,2,3-cd)pyrene (PAH)	Yes	Yes	Yes
Manganese Compounds	No	No	No
Nickel Compounds	No	No	No
Nitrogen oxides/NO_2	Yes	No	No

5.3 Estimating Exposure Point Concentrations

Maximum modeled air concentrations are used as exposure concentrations to estimate potential incremental inhalation risk. These exposure concentrations (i.e., air concentrations), are derived through the use of air dispersion models and estimates of controlled potential chemical emissions from version 10 of the Mine Site Emission Inventory. Maximum modeled air concentrations were derived using AERMOD (version 12060).

5.3.1 Estimating Emissions

Emission estimates were summarized in Section 4.3. The discussion here provides additional information on the emission estimates in the current Mine Site operations emission inventory.

The Potential to Emit (PTE) was primarily based on emission factors from AP-42, mass balance information, engineering calculations, block models, and whole rock or geology data. The emission calculations include the assumption that all operations will occur 24 hours/day 365 days/year except for operation of the Portable Crushing Plant and Overburden Screening activities. Operations of the Portable Crushing Plant and Overburden screening activities were assumed to occur 24 hours/day throughout the construction season which was defined as April through October. Hourly and annual emission rates were calculated and these have been summarized in Table 5-3. For sources directly related to the mining operation, the annual emissions are based on mining rates during the years with the highest emissions (worst case) for each of the two primary modes of mine operation:

- stockpile disposal of all waste rock (Year 8)
- disposal of waste rock in the Central/East Pit (Year 13) and reclamation of Category 2/3 and Category 4 Stockpiles.

The most recent emission calculations for the NorthMet Project Mine Site were submitted in an emissions inventory on August 29, 2012.

Additional discussion for selected categories of emission calculations is provided in the following subsections: fugitive sources, mobile sources, and point sources.

5.3.1.1 Fugitive Emissions

The majority of sources associated with the Mine Site activities are fugitive emission sources. The fugitive sources associated with Mine Site activities have been divided into six categories that tend to be similar in nature. The categories are as follows:

- truck and railcar loading and unloading of overburden, waste rock and ore
- fugitive dust emissions from trucks travelling on unpaved roads in the mine area, along Dunka road and the fueling facility circle
- contractor operations including crushing to produce rock for construction purposes
- wind erosion of stockpiles
- blast-hole drilling
- combustion emissions from trucks and locomotives

5.3.1.2 Mobile Sources

Emission calculations for mine vehicles (diesel fuel combustion) include VOCs, speciated PAHs, diesel particulate, dioxins/furans, and metals. These vehicle emissions calculations were based on the following assumptions:

- all vehicles operate at the highest projected annual fuel usage for any year of mine operation
- worst case fleet assumed for vehicle emissions over life of Project (mix of Tier 2, Tier 3 and Tier 4 vehicles)

Emission calculations for locomotives (diesel fuel combustion) include VOCs, speciated PAHs and metals. These emissions are based on the loading and idling time of the locomotives at the Mine Site. For dioxins/furans, there are no emission factors for locomotives. The dioxin/furans emission factor for heavy duty vehicles (Reference (29) and Reference (30)), however, was applied to locomotives on a fuel usage basis.

5.3.1.3 Point Sources

The point sources at the Mine Site consist of three diesel tanks, a mobile generator used to temporarily power large electric mining vehicles, the backup generator at the Wastewater Treatment Facility (WWTF) and space heaters at the WWTF.

A mobile diesel generator will be located at the Mine Site to provide temporary power to electric-powered large excavators and drill rigs used in the mine pits to move this equipment from one location to another. This generator is only sized to provide locomotion to the equipment, not to operate it for its primary function (drilling or loading haul trucks). This generator will be operated infrequently, and when it is operated, one of the large pieces of electrical mining equipment will be out of service, effectively limiting emissions from normal mining activities. Because this generator does not meet the definition of an emergency generator, emissions from this source have been included in the evaluations in the AERA.

5.3.1.4 Small Sources Not Modeled

A few small emission sources were not modeled for the AERA. One is the emergency diesel generator for the WWTF to be located at the Mine Site. This diesel powered backup generator (Emission Units 332) will be used at the Mine Site to provide backup in case of a power failure at the WWTP. The major pollutant to be emitted from this generator is NO_x. Some particulate metals may also be emitted. Due to the infrequent use, relatively short operating time expected for EU 332 and defined use as an emergency generator, potential emissions from this diesel generator were not modeled in the AERA following MPCA AERA guidance (Reference (14)).

The other small sources of potential emissions are the diesel fuel tanks. The potential emissions from these tanks are VOCs. Due to the very small potential VOC emissions likely associated with these tanks they were eliminated from quantitative analysis according to the AERA guidance.

5.3.1.5 Particulate Metal Emission Estimates

For the 2008 Mine Site AERA, particulate metal emission estimates were based on total particulate with a diameter cut-point of approximately 30 microns (approx. PM_{30}). The same approach was used for this Supplemental AERA.

5.3.2 Air Dispersion Modeling

The fate and transport of chemicals, after being emitted from the various Mine Site activities to ambient air, is dependent on the source release characteristics, meteorological conditions, terrain characteristics, atmospheric physical and chemical processes (pollutant scavenging, wet and dry deposition rates, etc.), physical and chemical characteristics of the compounds, and land use. For this risk analysis the AERMOD model (version 12060) was used to estimate maximum modeled air concentrations. Meteorological data used in the modeling are from Hibbing, MN (2001-2005) and they were processed using AERMET (version 11059). Large Figure 3 shows the air dispersion modeling receptor grid.

For this AERA, and consistent with the compliance modeling conducted for Class II areas, a site-specific deposition algorithm was developed for the Mine Site to better represent potential fugitive dust emissions transport and air concentrations. For the AERA modeling, the particulate depletion half-life time step was changed from 1,100 seconds (PM_{10} gravitational settling basis used for Class II modeling) to 370 seconds (PM_{30} gravitational settling basis) (Reference (31)). This algorithm is discussed in detail in the addendum to the Mine Site Class II Modeling Protocol submitted to the Minnesota State agencies on March 12, 2012 (Reference (6)) and the AERA Work Plan as amended in August of 2012.

The total Mine Site emission rates that were modeled are presented in Table 5-3 and the maximum modeled air concentrations are provided in Table 5-4. Electronic versions of the input and output files (post-processing files) for the chemicals that were modeled are included with the AERA report submitted to the MPCA.

The maximum modeled air concentrations occur at the PolyMet Mine Site property ownership boundary (Large Figure 4 and Large Figure 5) and are used to assess potential inhalation risks (acute and chronic) for an individual. Potential multipathway chronic risks were also assessed for a potential resident and a potential farmer receptor, but only for those receptors located outside the area zoned as Mineral Mining/Industrial District (zoning boundary shown in Large Figure 2). Large Figure 3 identifies the two receptors outside the Mineral Mining/Industrial District boundary that are closest to the Mine Site.

Table 5-3 Estimated total mine-related annual emission rates modeled for the Supplemental Air Emissions Risk Analysis conducted for the proposed Mine Site

Chemical Name	Total Mine Site Emission Rate (g/s)			
	Year 8 hourly rate	Year 8 annual rate	Year 13 hourly rate	Year 13 annual rate
Acetaldehyde	2.44E-05	1.40E-06	2.44E-05	1.40E-06
Arsenic Compounds	0.0013	0.0004	0.0014	0.0005
Cobalt	0.0036	0.0025	0.0040	0.0027
Crystalline Silica	0.5820	0.3952	0.6467	0.4339
Dibenzo(a,h)anthracene	2.92E-06	2.57E-06	2.92E-06	2.57E-06
Diesel Particulate Matter	0.2276	0.2237	0.2276	0.2237
Indeno(1,2,3-cd)pyrene	3.41E-06	2.99E-06	3.41E-06	2.99E-06
Manganese Compounds	0.0638	0.0450	0.0702	0.0488
Nickel Compounds	0.0245	0.0152	0.0266	0.0166
Oxides of Nitrogen (NO_x as NO_2)	12.5173	9.2554	12.5173	9.2554
Dioxins/Furans (as 2,3,7,8-TCDD TEQ)	4.12E-10	3.73E-10	4.12E-10	3.73E-10

Table 5-4 Maximum modeled air concentrations evaluated in the Supplemental AERA conducted for the proposed Mine Site

	PolyMet Mine Site Ownership Boundary Maximum Modeled Air Concentrations (µg/m^3)				Mineral Mining/Industrial District Boundary Maximum Modeled Air Conc. (µg/m^3)	
Chemical Name	1-Hour Year 8	1-Hour Year 13	Annual Year 8	Annual Year 13	Annual Year 8	Annual Year 13
Acetaldehyde	0.00116	0.00116	4.36E-07	4.57E-07	8.82E-08	9.44E-08
Arsenic compounds	0.00616	0.00660	1.42E-04	1.14E-04	2.75E-05	2.82E-05
Cobalt	NA	NA	3.76E-04	3.48E-04	3.15E-05	3.59E-05
Crystalline Silica	NA	NA	0.0609	0.0572	0.005502	0.00654
Dibenzo(a,h)anthracene	NA	NA	3.09E-06	2.17E-06	7.26E-07	7.19E-07

	PolyMet Mine Site Ownership Boundary Maximum Modeled Air Concentrations ($\mu g/m^3$)				Mineral Mining/Industrial District Boundary Maximum Modeled Air Conc. ($\mu g/m^3$)	
Chemical Name	**1-Hour Year 8**	**1-Hour Year 13**	**Annual Year 8**	**Annual Year 13**	**Annual Year 8**	**Annual Year 13**
Diesel Particulate Matter	NA	NA	0.264	0.187	0.0562	0.0523
Dioxins/Furans (as 2,3,7,8-TCDD TEQ)	NA	NA	4.56E-10	3.21E-10	9.58E-11	8.83E-11
Indeno(1,2,3-cd)pyrene	NA	NA	3.61E-06	2.54E-06	8.51E-07	8.45E-07
Manganese compounds	NA	NA	0.0126	0.0103	0.00217	0.00227
Nickel compounds	0.0836	0.0631	0.00150	0.00210	2.11E-04	2.71E-04
Oxides of Nitrogen (NOx)(1)	393.91	471.15	NA	NA	NA	NA

(1) The USEPA factor of 80% for the conversion of NO_X to NO_2 was applied to the maximum modeled one-hour NO_X air concentration. Value shown in table is NO_x not NO_2 estimate.

5.4 Receptor Locations and Risk Concept Applications

Reasonably expected future land use is a critical consideration for a risk assessment with regard to receptor locations and application of risk concepts. Resident and/or farmer receptors are assessed where residential and/or farming land use has the potential to occur in the future. When other future land use prohibits residential and/or farming land uses in specific areas, risks are typically not estimated for the farmer or resident receptor at those locations.

With regard to the Mine Site, PolyMet's property ownership boundary (i.e. the Mine Site ambient air boundary, separating land to which the public has/does not have legal access) and the entire mine location are within the City of Babbitt Mineral Mining District and the St Louis County Industrial District (Large Figure 2). The St Louis County Industrial District abuts the east side of the projected PolyMet Mine Site property ownership boundary (Large Figure 2). Both of these zoned districts prohibit residential and farming operations. Due to the "Mineral Mining/Industrial District" zoning, residential and farming development are not a reasonably foreseeable land use in areas immediately adjacent to the projected PolyMet Mine Site property ownership boundary nor are there any residents in this area. Only areas outside the Mineral Mining/Industrial District zoning areas are considered to have the potential to have residential or farming development as a reasonable future land use. Therefore, potential multipathway impacts are evaluated for a potential farmer and resident receptor at the more distant boundaries of these zoning areas (see receptor placement in Large Figure 3 and Large Figure 2). The boundary of this area where residential and farming development is precluded is referred to as the "Mineral

Mining/Industrial District Boundary" in this report or "just outside" of the Mineral Mining/Industrial district boundary.

5.4.1 Maximum Exposed Off-property Receptor

Under the MEI exposure concept, it was assumed that a hypothetical person or "receptor" lives at a specific location regardless of whether or not anyone lives, or has the ability to live at this specific location, or in the general area. The receptor location to assess adult maximum exposed individual inhalation risks (acute, chronic noncancer, and chronic cancer) was at the maximum modeled air concentration at the Mine Site property ownership boundary. For multipathway exposure (includes inhalation), both the farmer/resident receptors were located just outside of the Mineral Mining/Industrial zoning boundaries (see Large Figure 2). There are currently no actual residents or farmers in the areas adjacent to the Mine Site property ownership boundary or the Mineral Mining/Industrial District Boundary and no individuals are expected to be residing in these areas in the foreseeable future during active mining operations. In addition, soil, current forest vegetation, and climate indicate that any future farming development in this area is highly unlikely. Therefore, the assumption that a resident or farmer is present at the Mine Site property ownership boundary or the Mineral Mining/Industrial zoning boundary likely overestimates the potential risk to any "real" receptor.

5.4.2 Indoor Air versus Outdoor Air

For both receptors (maximum off-site receptor, farmer and resident) it was further assumed that the hypothetical individual is continuously exposed to outdoor air for a lifetime (24 hours per day, 365 days per year, over a 70-year period for inhalation, a 30-year period for resident ingestion and a 40-year period for farmer ingestion). In reality people spend a considerable amount of time indoors, where concentrations of project related emissions are most likely lower. It has been estimated that U.S. residents spend only 6% of a day outdoors and 87% of a day indoors (Reference (32)).

Concentrations of particulate metal in air, associated with potential emissions from the proposed Mine Site operations, are different for indoor versus outdoor environments. When people are indoors, they reduce their exposure to outdoor air contaminants. A recent study measured the contribution of outdoor air concentrations of $PM_{2.5}$ to indoor air, and to personal exposure (as measured by subjects wearing a personal environmental monitor) in Los Angeles, CA, Houston TX, and Elizabeth NJ. The mean percent contribution of outdoor $PM_{2.5}$ to indoor air was 60% (Reference (32)). The mean concentration of outdoor $PM_{2.5}$ to personal exposure was even lower, 26%. Most sources of indoor air pollutants are released from within buildings (Reference (33)). However, for the MEI exposure concept, it was conservatively assumed that that a person would be outdoors continuously. In addition, it was assumed that all metals in ambient air would be in the respirable size range, bioaccessible, and bioavailable (less than or equal to 10 microns in diameter).

5.5 Changes to AERA Methodology Compared to the January 2008 AERA

For the most part, the methodology used in this Supplemental AERA is the same or similar to that used in the January 2008 Mine Site AERA. Changes that are not specified in detail in the work plan for the Supplemental AERA are described here.

- The most recent versions of the RASS and AERMOD were used for the Supplemental AERA. As a result, cobalt was added as a CFE in addition to pollutants described in the work plan.
- The air dispersion modeling included plume depletion half-life terms to model deposition of particulate sources in the Supplemental AERA (see Section 5.3.2 for more details).
- The emission factor for dioxins and furans from diesel combustion was changed to the factor the USEPA used in the 1987, 1995, and 2000 national dioxin emission inventory (Reference (29)). The USEPA approved emission factor of 172 pg TEQ/km is based on a 1996 tunnel study (Reference (30)). The emission factor used in calculating potential dioxin/furan emissions from mobile source diesel fuel combustion for the January 2008 AERA (288 pg TEQ/km) is a Barr-derived emission factor based on data from studies conducted in the U.S. in the 1996-1998 time period (Reference (10)).

6.0 Toxicity Assessment

The objective of the toxicity assessment is to identify potentially toxic effects caused by chemicals of interest and to examine the dose-response relationship. For this Supplemental AERA, all of the CFE have toxicity values available in the MPCA's RASS (version 20120302). These toxicity values were used in this AERA without modification. No alternative toxicity values were used in this evaluation.

Additional discussions of the toxicity values found in the MPCA's RASS (version 20120302) for the CFE evaluated in this Supplemental AERA may be found in Attachment B.

7.0 Quantitative Risk Estimates

7.1 General Methodology

Risk characterization is the process whereby exposure point concentrations and toxicity information are combined to generate estimates of potential health risks. These estimates are compared to acceptable incremental guideline risk values. The USEPA (Reference (34)) defines risk characterization as the process that "*... integrates information from the preceding components of the risk assessment and synthesizes an overall conclusion about risk that is complete, informative, and useful for decision makers....*" However, because of the limitations inherent in the risk assessment process it is very important to recognize that the risk characterization in this AERA or any health risk assessment cannot predict actual health outcomes, such as cancer. In other words, this or any health risk assessment does not provide an estimate of actual risk to a real person.

In the AERA process, "quantitative analysis" specifically refers to the estimation of additional lifetime potential cancer risks and potential noncancer health effects using the MPCA's RASS. The most recent electronic version of the RASS (version 20120302) was obtained from the MPCA. An individual RASS file for each year of emissions (Year 8, Year 13) was then set up to estimate potential risks at the:

- Mine Site property ownership boundary (i.e. Mine Site ambient air boundary) for inhalation only risks for maximum exposed individual (acute 1-hour and chronic)
- Mineral Mining/Industrial Zoning Boundary (multipathway risks for a famer and resident)

Because the highest estimated noncancer acute inhalation risks occur at the Mine Site property ownership boundary and are applied to a potential off-site receptor, potential acute inhalation risks at the more distant Mineral Mining/Industrial Zoning Boundary are not calculated. Although an acute inhalation hazard index is not specifically calculated at the Mineral Mining/Industrial Zoning Boundary, the hazard index calculated at the Mine Site property ownership boundary may be considered a conservative estimate for farmers or residents.

Further details on the methodology and assumptions used to calculate potential risk estimates may be found in Attachment C. Risk estimates from the MPCA RASS can be found in Attachment D.

7.2 Risk Results

Risk results obtained from the individual RASS runs for each emission scenario are summarized in Table 7-1 and Table 7-2.

7.2.1 Incremental Inhalation Risks at the PolyMet Ownership Boundary

Noncancer inhalation risks at the Mine Site Ownership Boundary are well below the general risk guideline value of 1.0 (see Table 7-1 and Table 7-2).

Noncancer Acute (1-hour worst case risk, Mine Year 13 emissions and mine layout)

- estimated potential inhalation acute health risks for individual chemicals (HQs) did not exceed the Hazard Index guideline value of 1.0
- estimated potential summed inhalation acute health risk regardless of toxic endpoint, expressed as a Hazard Index (HI), is 0.8 and is below the guideline value of 1.0
- the only risk-driver chemical is NO_2 (HQ = 0.8), primarily from diesel engines
- The acute RRE for sulfuric acid is HQ=0.0023 (included in total acute risk calculation)
- estimated risks calculated for the 2012 Supplemental AERA are in the same range as the risks calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

Noncancer, chronic (worst case risk, Mine Year 8 emissions and mine layout)

- estimated potential noncancer chronic inhalation risks for the individual chemicals evaluated were below the Hazard Index guideline value of 1.0
- the summed potential noncancer chronic inhalation risk, for all chemicals combined, regardless of toxic endpoint, is 0.2 and is below the Hazard Index guideline value of 1.0
- there were no chemicals above the MPCA's risk driver level for the chronic noncancer endpoint (all HQs < 0.1)
- estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

Cancer, chronic (worst case risk, Mine Year 13 emissions and mine layout)

- estimated potential inhalation cancer risks for both years for the individual chemicals evaluated were below the MDH guideline value of 1E-05
- the summed potential cancer chronic inhalation risk for all carcinogens combined, regardless of the mode of action, is 5E-06, which is below the MDH cancer risk guideline of 1E-05

- there are two risk drivers associated with Year 13 risk: cobalt (3E-06) and nickel compounds (1E-06), both associated with particulate matter
- estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

7.2.2 MEI Incremental Multipathway Risks at the Mineral Mining/Industrial District Boundary

<u>Noncancer, multipathway chronic (worst case risk, Mine Year 13 emissions and mine layout)</u>

- estimated potential multipathway noncancer chronic risks for individual chemicals (HQs) did not exceed the guideline value of 1.0
- estimated potential summed noncancer chronic risk for both a farmer and resident receptor, regardless of toxic endpoint, equals 0.04 and is less than the guideline value of 1.0
- there are no chemicals above the MPCAs risk-driver level for multipathway chronic noncancer risk (all HQs < 0.1)
- estimated risks calculated for the 2012 Supplemental AERA are similar to the risks calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

<u>Cancer, multipathway chronic (worst case risk, Mine Year 13 emissions and mine layout)</u>

- farmer receptor
  - estimated summed potential cancer risks for all carcinogens combined regardless of mode of action is 1E-05 (Years 8 and 13), which does not exceed the MDH guideline value of 1E-05
  - risk-driver chemicals from multipathway exposure (food consumption and inhalation) are dibenzo(a,h)anthracene and dioxins/furans
    - dibenzo(a,h)anthracene = 5E-06.
    - dioxins/furans = 8E-06.
    - the indirect exposure pathway (consumption of home grown produce, dairy and meat) contributes about 92% of the estimated potential incremental risk
- resident receptor

  - estimated summed potential risks for all carcinogens combined, regardless of mode of action, is 8E-07 (Year 13) and does not exceed the MDH guideline value of 1E-05
  - there are no risk-driver chemicals for resident multipathway chronic cancer risk (all individual chemical risks < 1E-06)
- for both the Farmer and Resident receptors, estimated cancer risks calculated for the 2012 Supplemental AERA are in the same range as those calculated for the January 2008 AERA (see Table 7-1 and Table 7-2)

Table 7-1 Comparison Summary of the Estimated Incremental Human Health Risks for the Mine Year 8 Stockpile Waste Rock Storage Emissions Scenario for the Supplemental Air Emissions Risk Analysis (AERA) and the 2008 AERA Conducted for the Mine Site

Exposure Route	Exposure Scenario	Receptor[(1)]	Potential noncancer effects (Hazard Index)[(2)]		Potential cancer effects (Risk Estimate)[(3)]	
			2008	**2012**	**2008**	**2012**
Inhalation Only Exposure	Acute (1 hour)[(4)]	Mine-Site property ownership boundary	0.2	0.7	N/A	N/A
	Chronic (greater than 1 year)	Mine-Site property ownership boundary	0.2	0.2	3E-06	5E-06
		Resident/Farmer Mineral Mining/ Industrial District boundary [5]	0.04	0.04	6E-07	5E-07
Multipathway Exposure Receptors are just outside of the Mineral Mining/ Industrial District boundary[(5)]	Chronic-indirect multipathway only (food and incidental soil ingestion)	Farmer	0.00007	0.005	3E-05	1E-05
		Resident	N/A	0.002	8E-08	2E-07
	Chronic-total multipathway = inhalation + food and incidental soil ingestion	Farmer	0.04	0.04	3E-05	1E-05
		Resident	0.04	0.04	7E-07	8E-07

(1) The off-site worker and the resident and farmer receptors are evaluated for potential human health risks using a maximum modeled air concentration. Use of a maximum modeled air concentration is considered by USEPA (Reference (1)) to represent a maximum exposed individual (MEI). All receptors are assumed to be outside 24 hours per day, 365 days per year.
(2) Incremental noncancer (chronic and acute) guideline value is 1.0.
(3) Incremental cancer risk guideline value is 1E-05, MDH.
(4) The USEPA factor of 80% is applied to the maximum modeled one-hour NO_x air concentration as a conservative estimate of the conversion of NO to NO_2. Acute inhalation risk was only calculated at the Mine Site property ownership boundary. This estimate may be considered a conservative estimate of acute risk at the Mineral Mining/Industrial Zoning Boundary. The acute RRE for sulfuric acid is 0.0023. The RRE has been added to the HI estimated from modeled concentrations, HI+RRE = 0.7
(5) PolyMet' s land holdings at the Mine Site are within an area zoned as Mineral Mining by the City of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary. Therefore, resident and farmer multipathway risks were not calculated at PolyMet's ownership boundary. Potential multipathway risks for a potential resident and farmer receptor were calculated for areas approximately one kilometer from the Mine Site ownership boundary, outside the Mineral Mining/Industrial District boundary. Risks were calculated based on estimated potential to emit emissions and for both stockpile storage and in-pit storage mine layout.

Table 7-2 Comparison Summary of the Estimated Incremental Human Health Risks for the Mine Year 13 In-Pit Waste Rock Disposal Scenario for the Supplemental Air Emissions Risk Analysis (AERA) and the 2008 AERA Conducted for the Mine Site

Exposure Route	Exposure Scenario	Receptor(1)	Potential noncancer effects (Hazard Index)(2)		Potential cancer effects (Risk Estimate)(3)	
			2008	2012	2008	2012
Inhalation Only Exposure	Acute (1 hour)(4)	Mine-Site property ownership boundary	0.1	0.8	N/A	N/A
	Chronic (greater than 1 year)	Mine-Site property ownership boundary	0.3	0.2	4E-06	5E-06
		Just outside of the Mineral Mining/ Industrial District boundary(5)	0.04	0.04	6E-07	6E-07
Multipathway Exposure Receptors are just outside of the Mineral Mining/ Industrial District boundary(5)	Chronic-indirect multipathway only (food and incidental soil ingestion)	Farmer	0.00007	0.005	2E-05	1E-05
		Resident	N/A	0.002	7E-08	2E-07
	Chronic-total multipathway = inhalation + food and incidental soil ingestion	Farmer	0.04	0.04	2E-05	1E-05
		Resident	0.04	0.04	6E-07	8E-07

RASS = Risk Assessment Screening Spreadsheet
HQ = hazard quotient

(1) The off-site worker and the resident and farmer receptors are evaluated for potential human health risks using a maximum modeled air concentration. Use of a maximum modeled air concentration is considered by USEPA (Reference (1)) to represent a maximum exposed individual (MEI). All receptors are assumed to be outside 24 hours per day, 365 days per year.
(2) Incremental noncancer (chronic and acute) guideline value is 1.0.
(3) Incremental cancer risk guideline value is 1E-05, MDH.
(4) The USEPA factor of 80% is applied to the maximum modeled one-hour NO_X air concentration as a conservative estimate of the conversion of NO_X to NO_2. Acute inhalation risk was only calculated at the Mine Site property ownership boundary. This estimate may be considered a conservative estimate of acute risk at the Mineral Mining/Industrial Zoning Boundary. The acute RRE for sulfuric acid is 0.0023. The RRE has been added to the HI estimated from modeled concentrations, HI+RRE = 0.8
(5) PolyMet' s land holdings at the Mine Site are within an area zoned as Mineral Mining by the City of Babbitt or Industrial by St. Louis County. This zoning prohibits residential or farming development on the lands immediately adjacent to the PolyMet ownership boundary. Therefore, resident and farmer multipathway risks were not calculated at PolyMet's ownership boundary. Potential multipathway risks for a potential resident and farmer receptor were calculated for areas approximately one kilometer from the Mine Site ownership boundary, outside the Mineral Mining/Industrial District boundary. Risks were calculated based on estimated potential to emit emissions and for both stockpile storage and in-pit storage mine layout.

7.3 Assessment of Early Life Sensitivity and Exposure to Carcinogens

Animal studies have shown that young animals (e.g. birth to weaning) can be more sensitive to exposure to some carcinogens than adult animals. The chemical cancer potency can be greater when animals are exposed early in life, depending on how the chemical causes cancer (mode of action). Both USEPA and MDH recommend adjusting cancer risk estimates to account for early life exposure (Reference (22)). This is especially true for chemicals which are carcinogens by the mutagenic mode of action. Additionally, MDH recommends applying age adjustments to all linear carcinogens regardless of mode of action. Potential cancer risks can be adjusted for early life exposure using Age Dependent Adjustment Factors (ADAFs) (Reference (22)).

Age adjustments for early life exposure are sometimes incorporated into toxicity values (i.e. slope factor or inhalation unit risk) themselves. When this occurs, cancer risk estimates using these values are considered already adjusted for early life exposure. Seven of the CFE were assessed for potential cancer effects; acetaldehyde, arsenic compounds, cobalt compounds, dibenzo(a,h)anthracene (PAH), indeno(1,2,3-cd)pyrene (PAH), nickel compounds, and dioxins/furans (as 2,3,7,8-TCDD equivalents). Diesel engine exhaust has recently been classified as a carcinogen by the International Agency for Research on Cancer. Currently, a toxicity value to assess potential cancer effects is not available for diesel engine exhaust (or diesel particulate matter). However, carcinogenic constituents of diesel particulate matter (i.e. arsenic, dioxins/furans, PAHs) were evaluated for potential cancer risks in this AERA. A summary relating to their carcinogenicity is in Table 7-3.

Table 7-3 Assessment of Chemicals for Evaluation Considered Carcinogens in Terms of Adjustments for Early Life Exposure at the Mine Site

Chemical For Evaluation Evaluated as a Carcinogen	MPCA Status In terms of Early Life Adjustment (Reference (35))	Action Taken in the AERA
Acetaldehyde	Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment.	None (Not a risk driver)
Arsenic Compounds	On MPCA list of Pollutant of Interest in terms of age adjustment	None (Not a risk driver)
Cobalt Compounds	Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment.	None (Not a risk Driver at LTVSMC boundary) PPRTV documentation recommends against age adjustment for cobalt because the mutagenic mode of action has not been clearly established for cobalt (Reference (36))

Chemical For Evaluation Evaluated as a Carcinogen	MPCA Status In terms of Early Life Adjustment (Reference (35))	Action Taken in the AERA
Dibenzo(a,h) anthracene (PAH)	On MPCA list of Pollutant of Interest in terms of age adjustment	Adjusted Risk Estimate for Inhalation
Diesel Particulate Matter	Currently not evaluated as a carcinogen in the RASS.	None (Constituents of diesel particulate matter that are risk drivers such as arsenic, cobalt compounds, nickel and dioxins/furans were assessed separately)
Indeno(1,2,3-cd)pyrene (PAH)	On MPCA list of Pollutant of Interest in terms of age adjustment	None (Not a risk driver)
Nickel Compounds	Has not been considered by MPCA and not on MPCA list of Pollutants of Interest for age adjustment.	None (Not a risk driver)
Dioxin/Furans (2,3,7,8-TCDD equivalents)	On MPCA list of Pollutant of Interest in terms of age adjustment	None MDH advises against age adjustment for dioxins/furans (Reference (35)).

Cobalt and nickel compounds were the only CFE that were risk drivers for carcinogenicity at the Mine Site boundary. Cobalt was a risk driver for Mine Year 8 and both cobalt and nickel compounds were risk drivers for Mine Year 13 modeling. Early life exposures are not expected to occur at the Mine Site boundary, given the current and reasonably foreseeable future land use and industrial/mining zoning. Therefore, adjustments to inhalation cancer risk estimates at the Mine Site boundary were not made.

The risk drivers for farmer cancer risk by multipathway exposure at the Mineral Mining/Industrial Zoning Boundary were dibenzo(a,h)anthracene and dioxins/furans for both Years 8 and 13. The MDH recommends against making age adjustments for dioxins/furans, although the MPCA has noted that the toxicity value for dioxins/furans in the current version of the RASS has been age adjusted. The toxicity value in the RASS for dibenzo(a,h)anthracene was not age adjusted. USEPA considers dibenzo(a,h)anthracene a chemical which can cause cancer by the mutagenic mode of action (Reference (37)). Currently the USEPA does not list Indeno(1,2,3-c)pyrene as a PAH which can cause cancer by the mutagenic mode of action.

MPCA recommends multiplying the cancer risk estimate by 1.6 to account for early life exposure. MPCA Guidance (Reference (35)) lists dibenzo(a,h)anthracene as a potential pollutant of interest with respect to ADAFs by inhalation. If the dibenzo(a,h)anthracene cancer risk estimate by inhalation is multiplied by 1.6, and added to the total cancer risk estimate, the age adjusted risk for Mine Years 8 and 13 do not exceed the MDH guideline of 1E-05. No additional adjustments were made to the cancer risk estimates to incorporate early-life sensitivity.

The potential cancer risks after adjusting the inhalation cancer risk estimate for dibenzo(a,h)anthracene are shown in Table 7-4.

Table 7-4 Multipathway Farmer Age Adjusted Cancer Risk Estimate for Years 8 and 13 based on Early Life Exposure Age Adjustment for dibenzo(a,h)anthracene

	Multipathway Farmer Cancer Risk for Mine Year 8	Multipathway Farmer Cancer Risk for Mine Year 13
Total Cancer Risk (unadjusted)	1 E-05	1E-05
Unadjusted risk estimate for inhalation dibenzo(a,h)anthracene	9E-10	9E-10
Age adjusted risk estimate for inhalation for dibenzo(a,h)anthracene(1)	1E-09	1E-09
Age Adjusted Total Cancer Risk Estimate(2)	1E-05	1E-05

(1) Age Adjusted Dibenzo(a,h)anthracene risk = Unadjusted Dibenzo(a,h)anthracene Risk X 1.6
(2) Age Adjusted Total Cancer Risk = Unadjusted Total Cancer Risk – Unadjusted dibenzo[a,h]anthracene Risk + Age Adjusted Dibenzo(a,h)anthracene Risk

Additional discussions of the toxicity values found in the MPCA's RASS (version 20120302) for the CFE evaluated in this Supplemental AERA may be found in Attachment B

7.4 Percent of Emissions Assessed; Potential Additional Risk from Chemicals Not Evaluated Quantitatively for Risks

In the 2008 Mine Site AERA, a total of 52 CFPE were identified, with 32 identified as CFE in that analysis. Of the 32 CFE, six were identified as "risk driver chemicals" (cancer risk of 1E-06 or greater; noncancer risk of 0.1 or greater). The other 26 CFE were identified as being insignificant for risk. The six risk driver chemicals from the 2008 Mine Site AERA were quantitatively assessed in this Supplemental AERA. Because the other 26 CFE from the 2008 Mine Site AERA had very small estimates of potential risk, excluding them from this Supplemental AERA does not have a significant effect on the estimated risks for this analysis.

There were 20 chemicals from the 2008 Mine Site AERA that were not evaluated quantitatively. As described in the 2008 AERA, emissions for these 20 CFPE without toxicity values were approximately 20 tons/year in the Mine Year 8 and Mine Year 16 inventories and represented approximately 3.1% of the emission inventory at that time. Emissions of the 20 CFPE without toxicity values were a small part of total emissions in the 2008 emission inventory and they continue to be a small part of total emissions in the current emission inventory. When the Supplemental AERA and the 2008 AERA are considered together, about 99% of the emission inventory has been quantitatively evaluated for risks. Based on current knowledge, the exclusion of the non-evaluated chemicals from the quantitative risk estimates is unlikely to have a significant effect on the quantitative risk estimates.

7.5 Conservatism in the Risk Estimates

7.5.1 General Conservatism

As part of the risk assessment process, risks are estimated as a function of exposure and toxicity. Conservative assumptions are those that tend to maximize estimates of exposure (Reference (16) and Reference (5)). Toxicity values are also derived to be protective of public health. The combination of several conservative assumptions can lead to unrealistically conservative bounding estimates (Reference (16) and Reference (5)), with the result that the potential estimated risks are likely to be greatly overestimated. Combining maximum exposure point concentrations with maximum values for exposure frequency and duration in combination with upperbound toxicity values, results in a potential cancer risk estimate that may be thousands of times greater than those for the average exposed individual. The combination of maximum or high-end emissions, exposure and toxicity parameters make it extremely unlikely that quantitative risks are underestimates rather than overestimates. The use of the MEI concept, assumptions about metal speciation and bioavailability, and the way toxicity factors and emission factors are used all contribute to an assessment that overestimates potential exposure and risks.

In this Supplemental AERA the following represent sources of conservatism that result in overestimation of potential human health risks:

- use of maximum modeled air concentrations as the potential dose (or exposure concentration) for each receptor

- the assumption that receptors will be exposed to the maximum modeled ambient air concentration for the entire acute or chronic time period

- use of toxicity values (or inhalation benchmarks: reference concentrations, HRVs, inhalation unit risk values) which were derived with the intention of being conservative and protective of sensitive populations

- use of chronic inhalation health benchmarks derived to account for “daily exposures throughout a lifetime” (Reference (14)). (“Daily exposures throughout a lifetime” is generally assumed to mean continuous exposure, or exposure 24 hours/day, 365 days/year for 70 years.)

- the risk estimates (i.e. hazard quotients) for non-carcinogens are summed across all toxicity endpoints, regardless of potential toxic effects

- the risk estimates for carcinogens are summed for all types of cancer endpoints, regardless of the type of cancer the chemical is associated with causing
- assumption that metals inherent to the mineral structure of a rock particle are 100% bioavailable and in the respirable size fraction (PM_{10} or smaller)

7.5.2 Conservatism Specific to Farmer Cancer Risk

The highest risks estimated in this Supplemental AERA are for a potential farmer receptor located approximately one kilometer southeast of the Mine Site. Estimated multipathway farmer cancer risks were 1E-05. It is likely that this risk is overestimated because:

- The current mining operations in the area and the general climate, terrain, predominance of forest vegetation and low fertility soils suggest that it is highly unlikely for farming to occur in this general area. Assuming a farmer is present near the active mining zone is considered a conservative assumption.
- Dioxins/furans were a risk driver chemical. The USEPA emission factor used to estimate potential dioxin emissions from diesel fuel combustion is based on a 1996 tunnel study. Both diesel fuel standards and engine technologies have improved since 1996. The World Health Organization (WHO) through the United Nations Environment Programme (UNEP) has calculated a dioxin emission factor more than 10 times lower than the USEPA factor used in this evaluation that is based on newer data (Reference (38)).

7.6 Range of Risk Estimates

The AERA methodology relies on a deterministic estimate of risk (i.e., a point estimate) for the decision-making process which differs from USEPA guidance. USEPA's exposure assessment policies include "*….consideration of a range of possible exposure levels …*" (Reference (39)). In addition, USEPA recommends calculating Reasonable Maximum Exposure (RME) and Central Tendency Exposure (CTE) to inform risk managers of the range of more representative potential risks (References (40), (41), (42), (43)).

Based on previous risk assessment experience, when a range of cancer risk estimates are considered (i.e. an MEI exposure and a Central Tendency Estimate), potential health risks for Central Tendency haven been substantially lower (e.g. an order of magnitude) than an MEI exposure. In simple terms, the MEI potential exposure is for 613,200 hours (24 hours/day x 365 days/year x 70 years) while a Central Tendency Exposure (CTE) is estimated at 4,068 hours (1.5 hours/day x 226 days/year x 12 years). In this case, the CTE exposure factor is 150.7 less than the MEI exposure which means CTE risks would be proportionally lower as well. When risk estimates are lower than the guidelines it is interpreted to mean that adverse effects to human health are unlikely.

7.7 Conclusions - Potential Incremental Human Health Risks

The potential health risks were calculated based on the maximum modeled air concentrations at specific receptors assuming mine operations 24 hours/day, 365 days/year except for the Portable Crushing Plant and Overburden Screening operations.

The potential incremental inhalation cancer and noncancer (acute and chronic) risks for a potential individual at the PolyMet Mine Site ownership boundary were below the guideline values of 1E-05 and of 1.0, respectively. Potential total multipathway cancer and noncancer chronic risks (inhalation + indirect pathways) estimated for a future resident and farmer receptor at the Mineral Mining/Industrial District Boundary did not exceed the MDH guideline value of 1E-05.

In summary, taking into account the conservatism in the emission estimates, toxicity values, maximum modeled air concentrations (exposure concentrations), multipathway screening factors, and the assumption that each particulate metal is in the respirable size range and is 100% bioavailable, ~~no~~ adverse human health impacts are not expected to be associated with the potential air emissions from the proposed Mine Site operations evaluated in this AERA.

8.0 Uncertainty Analysis

8.1 Conservatism in the Quantitative Health Risk Assessment - Uncertainty and Variability

The risk assessment process is subject to uncertainty and variability from a variety of sources. These are inherent in the risk assessment process and are not unique to this AERA. Uncertainties represent incomplete knowledge about certain parameters, and the values of the parameters generally depend upon limited data and model estimations. Variability, on the other hand, represents true heterogeneity and inherent differences within a population, across geographic regions, and throughout a given time period (Reference (44)). Variability is inherent in any group of people.

The main difference between uncertainty and variability is that variability can only be better characterized, but not necessarily reduced.

8.1.1 A Summary of Sources and Direction of Uncertainty in Risk Analysis Parameters

The major sources of uncertainty for this AERA are found in Table 8-1 and are discussed in further detail in Attachment E.

Table 8-1 Summary of Sources and Direction of Uncertainty and Variability in the Parameters used for the Supplemental AERA for the Mine Site

Risk Analysis Component	Comment	Effect on Risk Estimate[1]	Overall Impact
Exposure Assessment			
Basis of Chemical Selection	Knowledge of copper-nickel-ore mining processes	May under- or overestimate potential risk	Low
	AP-42: Compilation of Air Pollution Factors. Emission factors used to calculate fugitive dust emissions are “A” and “B” rated. The dust emissions along with extensive site-specific composition data were used to calculate metals emissions from fugitive dust. Emission factors for propane combustion and for PAH and metals emissions from diesel fuel combustion are rated lower. However, PAHs were not risk drivers and NO_2 from propane combustion and metals from diesel combustion contribute small amounts to the total emissions of these pollutants.	May under- or overestimate potential risk	Low
	All chemicals of potential significant impact which have toxicity values for comparison	May under- or overestimate potential risk	Low
	Professional judgment and acceptance by reviewing agency	May under- or overestimate potential risk	Low
Emissions	Controlled potential emissions used in all standard calculations including AERMOD inputs from emission inventory.	Overestimates potential risk	Moderate
	Assumption that all operations occur 24 hours/day for 365 days/year except for the Portable Crushing Plant and Overburden screening activities which were assumed to occur 24 hours/day from April through October.	Overestimates potential risk	Moderate

Risk Analysis Component	Comment	Effect on Risk Estimate[1]	Overall Impact
Emissions	Use of highest projected annual fuel usage for any year for on-site vehicles	Overestimates potential risk	Moderate
	Emissions from locomotives were based on total fuel usage and attributed to only the loading (rail transfer hopper) and unloading (at Plant Site) points	Overestimates potential risk	Moderate
	Vehicle miles traveled assumed to be on longest haul routes and have annual maximum material handling	Overestimates potential risk	Moderate
	Assumption that use of emission factors collected in the 1996-1998 time period for diesel burning engines to estimate potential PAH and dioxin/furan reflect current conditions. Diesel formulations and fuel technology have changed since these data were collected.	Overestimates potential risk	Moderate
	Instant Conversion of 80% NO_X emissions to NO_2. NO_2 is the sole risk-driver chemical for the assessing the acute inhalation risk.	Overestimates potential risk	Moderate
	Particulate metals were calculated assuming the worst case composition of all rock types that would be processed at each emission source.	Overestimates potential risk	Moderate
	Did not estimate emissions from insignificant activities that occur intermittently for a short period of time like use of diesel powered back-up generator and mobile diesel generator, and diesel fuel tanks	Underestimates potential risk	Low
	All sources of emissions were modeled except those that did not emit the pollutants included in the supplemental AERA or sources that were excluded per MPCA Guidance	Likely no effect on estimated risks	Likely no effect on estimated risks

Risk Analysis Component	Comment	Effect on Risk Estimate(1)	Overall Impact
Air Dispersion Modeling	Meteorological data from a single station input to AERMOD.	May under- or overestimate potential risk	Moderate
	Comparison to air monitoring data that shows model results are generally within a factor of 2. 40 CFR Part 51 Appendix W states "1) Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and 2) the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area" (Reference (45))	Over estimates potential risk	Moderate
Exposure point concentrations	Used maximum modeled air concentrations.	Overestimates potential risk	Moderate
	Assumed that the worst case meteorological conditions over a five year period are representative of conditions over the exposure duration.	Likely under- or overestimates potential risk	Moderate
Exposure parameters	For Inhalation risk, receptors assumed to be outdoors 24 hours per day, 365 days per year for 35 to 70 years in the area of highest modeled air concentration regardless of whether people actually live in that area.	Overestimates potential risk	High
Multipathway screening factors	The development of the MPS Factors was not site-specific, and as a result their level of accuracy is unknown.	May under- or overestimate potential risk	Moderate
Toxicity Assessment			
Acute toxicity values	Extrapolation of data from longer term studies to a one hour equivalent.	May overestimate potential risk	Low
	Incorporation of uncertainty factors, modifying factors, safety factors, and exposure frequency and duration into the toxicity values.	May overestimate potential risk	Moderate

Risk Analysis Component	Comment	Effect on Risk Estimate(1)	Overall Impact
Chronic noncancer toxicity values Chronic noncancer toxicity values	Primarily derived from animal studies which often use of the most sensitive species/strain/sex	May overestimate potential risk	Moderate
	Use data solely from positive studies	May overestimate potential risk	Moderate
	Incorporation of uncertainty factors, modifying factors, and safety factors	May overestimate potential risk	Moderate
	Toxicity values are primarily derived from high doses while most exposures are at low doses	May overestimate potential risk	Moderate
	Toxicity value for a single chemical may not incorporate all possible endpoints	May underestimate potential risk	Moderate
	Assumption that absorption of the chemical evaluated is the same as the absorption of the chemical used in toxicity testing	May under- or over- estimate potential risk	Moderate
	Use of surrogate toxicity values to represent chemical mixtures	May under- or over-estimate potential risk	Moderate

Risk Analysis Component	Comment	Effect on Risk Estimate(1)	Overall Impact
Cancer toxicity values	Toxicity values were derived for individual PAHs by extrapolation and are highly uncertain.	Overestimates potential risk	High
	Use of nickel unit risk value (from IRIS) which is derived from studies using nickel subsulfide in refinery dust. Nickel cancer potency is very dependent on the solubility and speciation of each nickel compound. The bioaccessibility and bioavailability of the nickel compounds from mine site operations is not known.	Overestimates potential risk	Moderate
	Use of provisional toxicity value (PPRTVs) in the RASS for cobalt (a worker exposure value) to assess potential risks.	Overestimates potential risk	Moderate
	Use of cancer unit risk/slope factors which are generally upper 95^{th} % confidence limits derived from the linearized model. General assumption of linear non-threshold dose/response	Overestimates potential risk	Moderate
	Cancer unit risk/slope factors are primarily derived from animal studies. Use of data from most sensitive species/strain/sex. Use of data solely from positive studies.	May overestimate potential risk	Moderate
Multipathway screening assessment	The RASS only evaluates chemicals with inhalation benchmarks for potential ingestion risk (multipathway exposure). Chemicals such as fluorene, 2-methylnaphthalene, acenaphthene, anthracene, phosphorus, pyrene, and zinc have oral, but not inhalation benchmarks and are not evaluated for multipathway exposure (ingestion plus inhalation).	May underestimate potential risk	Low

Risk Analysis Component	Comment	Effect on Risk Estimate(1)	Overall Impact
Risk Characterization			
Inhalation Risks	Assumption that all metals exist in a physical form that makes them 100% bioavailable and in a respirable size range. About 97% of the metal emissions for the Mine Site are associated with rock handling operations. This means the metals are much more likely to be inherent to the mineral structure of the rocks and present as compounds- they are not likely present in ionic forms. Therefore, it is very unlikely that 100% of the metals will be in a respirable size range and be bioavailable by inhalation. In terms of multipathway exposure, it is unlikely that 100% of the metals will be bioavailable by ingestion.	Overestimates potential risk	High
	Assumed that the chemicals are in the same form as the chemicals upon which the toxicity values are based.	Overestimates potential risk	Moderate
	Assumed that all chemicals have an additive effect.	Overestimates potential risk	Moderate
	Upper bound values for exposure parameters were used.	Overestimates potential risk	High
	Assumed that all noncarcinogenic toxicity values have the same level of accuracy and precision and severity of toxic effects.	Likely overestimates potential risk	Moderate
	Assumed that all carcinogenic unit risks have the same weight of evidence for human carcinogenicity.	Overestimates potential risk	High
	Chemicals without toxicity values could not be directly evaluated.	Underestimates potential risk	Low
	Acute risk for sulfuric acid was determined using an RRE based on 2008 modeled concentration and not remodeled.	May under- or overestimate potential risk	Low

Risk Analysis Component	Comment	Effect on Risk Estimate[1]	Overall Impact
Inhalation Risks	Risks to especially sensitive receptors (e.g. unborn child, very young children, those whose health is compromised with preexisting conditions) were not specifically evaluated. However, this evaluation relies upon the toxicity value development process that accounts for these sensitive populations.	May underestimate potential risk	Moderate
	Synergism/antagonism was not considered	May under- or overestimate potential risk	Unknown

(1) Key for Effects Determination:

- Overestimates potential risk: A value or assumption intentionally chosen to provide high risk estimates
- Likely Overestimates potential risk: A value or assumption intentionally chosen that is expected to provide high risk estimates
- May overestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a high risk estimate
- Underestimates potential risk: A gap in information or an available value that is known to provide a low risk estimate
- Likely underestimates potential risk: A gap in information or an available value that may provide a low risk estimate
- May underestimate potential risk: A value or assumption that has some level of scientific uncertainty which may lead to a low risk estimate.
- Likely no effect on estimated risk: Value or assumption that is known or suspected to have very little, if any, effect on potential risk

Table 8-2 Summary of Sources of Variability in the Parameters used for the Supplemental Air Emissions Risk Analysis (AERA) for the Proposed NorthMet Mine Site near Babbitt, Minnesota

Source of Variability	Comments	Impact of Risk Analysis
Daily, seasonal, and yearly meteorological conditions	An agency-approved meteorological dataset for a 5-year time period is used in the air dispersion modeling. Controlled Potential emission rates and worst case meteorological conditions are used to determine the maximum modeled air concentration. The maximum modeled air concentration for the respective 1-hour and annual averaging time period is used to assess the respective potential risks.	Likely none
Actual Mine Site activities on a day-to-day basis that may alter emissions.	Potential emission calculations tend to overestimate emissions, especially over longer time periods, because the mine does not operate at maximum capacity 100% of the time; Potential maximum hourly and maximum annual emissions modeled for the AERA and a receptor is assumed to be exposed to the modeled air concentration for the entire exposure time period.	Likely none or small
Differences in receptor susceptibility to actual chemical exposure and actual exposure durations.	Toxicity values are developed to be conservative and protective of sensitive populations. Actual exposures are typically lower than the potential exposures evaluated in a risk analysis and that is why risk results from this AERA, or any risk assessment, cannot be used as an indicator of actual risk to any receptor.	Likely none or small

9.0 Qualitative Screening Analysis for Specific AERA Topics

9.1 Land Use and Receptors Information

Land use within 10 kilometers (approximately six miles) of the Mine Site is rural and predominantly mine lands or natural forest/wetlands. The nearest resident is located about five or six miles from the Mine Site.

See Section 3.0 for the general facility and site descriptions.

9.2 Sensitive Receptors

The proposed Mine Site is to be located within the Mineral Mining District of Babbitt (Large Figure 2). Potentially sensitive receptors within three kilometers of the proposed facility include off-site forestry workers, offsite workers at the Peter Mitchell Mine to the north and on the railroad to the south. Workers at the Peter Mitchell Mine or forest industry workers on adjacent lands could be present for the length of their shift during the work week, over the course of a year. Potential cancer and noncancer (acute and chronic) inhalation risks may be applicable to these off-site workers. Based on the cancer and noncancer inhalation risks calculated at the PolyMet Mine Site property ownership boundary (Table 7-1 and Table 7-2), adverse inhalation impacts to these off-site workers are not expected to occur. Due to the mineral mining/industrial zoning, potential workers cannot live at the Mine Site property ownership boundary (i.e. Mine Site ambient air boundary) and therefore they are not expected to be exposed to Mine Site air emissions by indirect pathways (i.e., home-grown food consumption). Therefore, indirect pathway risks (cancer and noncancer) would not apply to these potential off-site workers.

There is also the potential for individuals to engage in recreational activities (snowmobiling, hunting, etc.) within 10 kilometers (approximately six miles) of the proposed facility. Potential individuals engaging in recreational activities would not be expected to be present within the 10 km zone for any length of time (less than one day and likely for no more than a few hours). Therefore, chronic risks likely would not apply. Based on the acute inhalation risks calculated at the PolyMet Mine Site property ownership boundary (HI ~ 0.7 for year 8 and ~ 0.8 for year 13) (Table 7-1 and Table 7-2), no potential adverse impacts to these potential individuals are expected.

Other potentially sensitive receptors, such as day cares/preschools, schools, civic and government centers, hospitals, retirement homes/communities, etc., are not present within three kilometers of the proposed Mine Site.

9.3 Multipathway Receptors

Another type of “sensitive receptor” is the population surrounding a facility that could be exposed to the PBT pollutants emitted to air from a facility via the food pathway. The Mine Site operations are estimated to release only very small amounts of PBT chemicals; however MPCA AERA guidance indicates that PBTs may need some consideration beyond the indirect risks calculated in the RASS. Site information indicates that some agricultural lands are present within 10 kilometers of the facility, although agriculture is not a predominant land use. Water bodies (lakes, rivers) are also present within 10 kilometers of the Mine Site (Embarrass River, Partridge River, Mud Lake, Iron Lake, Argo Lake, Butterfly Lake). Therefore, multipathway receptors were evaluated for potential risks.

The RASS evaluated two generic receptors: (1) a farmer who only consumes homegrown vegetables, meat (beef, pork, and poultry) and dairy products, and (2) a nearby resident who consumes vegetables grown in his/her garden. Further discussion on potential risks to a generic farmer and a generic resident is provided in the next section. The multipathway exposure assessment also includes incidental ingestion of soil as a potential source of exposure.

9.3.1 Farmers and Residents

A review of zoning and land use within 10 kilometers (approximately six miles) of the proposed Mine Site identified small areas of agricultural lands (Large Figure 6): small farms approximately 6.5 kilometers to the northwest of the proposed facility. This is also the closest area to the Mine Site with land identified as "agricultural."

The nearest current residents to the proposed mine location are as follows:

- approximately six miles north of the proposed mine location in the city of Babbitt
- approximately five miles south of the proposed mine location toward the unincorporated village of Skibo
- Chemicals assessed for multipathway risks include selected particulate metals, PAHs, and dioxins/furans. The estimated total multipathway risks (Table 7-1 and Table 7-2), assuming the farmer receptor and resident receptor are immediately adjacent to the Mineral Mining/Industrial District Boundary, are as follows: cancer = 1E-05 for the farmer receptor, 8E-07 for the resident; Noncancer chronic risks are 0.04 for both the farmer and resident. These risk estimates are all within incremental risk guideline values of 1E-05 for cancer and 1.0 for noncancer. These risk results indicate that no adverse health effects to potential farmer or resident receptors would be expected to be associated with potential air emissions from Mine Site operations.

9.3.2 Fishers

Water bodies are located within 10 kilometers of the proposed facility (Embarrass River, Partridge River, Mud Lake, Iron Lake, Argo Lake, Butterfly Lake). The MPCA's RASS does not assess chemical deposition to water bodies or accumulation in fish or humans consuming the fish because of the very large variability in the surrounding water bodies. The variations in watershed size, water body turnover rate, flow rate, etc. make it difficult to describe an appropriate assessment at this time (Reference (14)).

Overall, emission estimates for PBTs (e.g., arsenic, PAHs, dioxin/furans and mercury) from the Mine Site are low. For example, potential mercury emissions from Mine Site operations are estimated to be 0.7 pounds per year, while potential dioxin/furan emissions are estimated to be approximately 0.00003 pounds per year (~ 0.01 grams per year). Small emissions, combined with the expectation that only a very small percentage of the emissions would deposit locally near the facility, indicates that the potential deposition to surface waters (lakes and rivers) of PBTs resulting from mine site operations is likely not significant.

For mercury, a screening-level analysis of potential mercury deposition to nearby lakes from estimated air emissions from the NorthMet Plant Site (~ 5 pounds/year) and the nearby Mesabi Nugget Large Scale Demonstration Plant (~ 75 pounds/year) has been conducted (Reference (46)) and the potential incremental change in fish mercury concentration is estimated to be small and not likely measurable. Potential emissions of mercury from the Mine Site of about 0.7 pounds per year would have a smaller effect than that estimated for Plant Site emissions.

9.4 Chemicals and Emissions

The discussions under this section of the AERA are to provide the reader with additional qualitative information and perspective on chemicals and emissions associated with the Mine Site.

9.4.1 Mixtures and Surrogate Toxicity Values

In terms of risk driver chemicals, the following chemical was used as a surrogate for CFEs in the Supplemental 2012 Mine Site AERA:

- Nickel subsulfide was used as a surrogate for all nickel compounds

Calculating risks using surrogate toxicity values to represent chemical mixtures introduces a high level of uncertainty to the risk estimates. At best, surrogate toxicity values they can be used as a screening tool in risk evaluation. The MPCA guidance (Reference (14)) states that:

> With a goal of not under-predicting risk, all available toxicity values for chemicals in a given mixture are considered, and a chemical is selected because its toxicity relative to the other chemicals in the mixture is greater. There may, however, be instances in which the mixture contains chemicals with higher toxicity than the surrogate, in which case the potential exists for risks from the mixture to be under-predicted.

In this AERA, the use of surrogate toxicity values is assumed to provide a conservative estimate of potential inhalation risks because arsenic, manganese, and nickel at this site likely exist in a different form that that on which the toxicity value is based.

9.4.2 Sensitizers

Respiratory sensitizers are of particular concern and can cause severe adverse reactions sometimes at very small concentrations for persons who have been previously sensitized to the chemical. Chemicals potentially emitted from the Mine Site that are identified as sensitizer chemicals include: beryllium, cobalt, nickel compounds. Of these, only cobalt and nickel have been identified as potential risk-drivers and are included in this AERA analysis. Beryllium emissions decreased more than 60% compared to those evaluated in the January 2008.

A reference toxicity concentration (RfCs, HRVs, RELs, or PPRTVs) is generally considered by the USEPA to be protective against asthma and other potential effects for non-sensitized individuals (Reference (47)). Often, the supporting toxicity data used for derivation of a reference toxicity concentration will state if the value was derived to be protective for respiratory sensitization. The annual chronic noncancer toxicity values for the chemical sensitizers in the RASS are from the following sources:

- beryllium: RfC from USEPA Integrated Risk Information System (IRIS)
- cobalt: PPRTV from USEPA Superfund Health Risk Technical Support Center
- nickel compounds: REL from California EPA Office of Environmental Health Hazard Assessment for the Hot Spots program

Additionally, MDH assesses chemical toxicity in order to develop HRVs which become part of Minnesota Rules. HRVs are derived to be protective of the "…most sensitive portion of the population" (Reference (48)). MDH goes on to acknowledge the following:

> However, HRVs may not be protective of every individual. Certain people are hypersensitized by exposures to high concentrations of particular chemicals during occupational chemical use or in other situations. Because ranges of exposures that result in such hypersensitivities are highly variable and poorly studied, MDH is unable to derive HRVs that would be protective of all sensitized individuals. Chemicals that are known to cause sensitization are noted in the chemical lists found in rule parts 4717.8100 - 4717.8250 (Reference (48)).

None of the chemicals noted as respiratory sensitizers in this Mine Site AERA are those for which MDH has noted in Minnesota Rules, parts 4717.8100-4717-8250 as being able to cause respiratory sensitization from environmental exposures (Reference (49)). According to the USEPA IRIS database, the RfC for beryllium was established to protect for potential respiratory sensitization. Although the documentation for derivation of the cobalt PPRTV states that the PPRTV may not be protective of those with a hypersensitivity to cobalt (Reference (36), MDH does not consider it a chemical known to cause sensitization. The chronic REL for nickel was established to be protective of the respiratory system and the blood forming system. Again, nickel is not considered a chemical considered by MDH as known to cause respiratory sensitization. Based on this information, the potential for emissions from the Mine Site to cause respiratory sensitization to the general public is considered unlikely.

9.4.3 Developmental Toxicants/Chemicals with Ceiling Values

Exposure to developmental/reproductive toxicants can have long lasting effects. Pregnant women are a sensitive subgroup who must be given special consideration in a risk analysis. Chemicals that are developmental toxicants may directly harm an unborn child. Those chemicals for which sufficient scientific evidence was available to develop an IHB for developmental effects have been noted in the RiskCalcs worksheet of the MPCA's RASS.

Of special importance are chemicals with HRVs and California RELs that are known to be developmental toxicants. Acute HRVs with developmental endpoints have been identified in the RASS as chemicals with "ceiling values" that should not be exceeded. The potential acute exposure, that is the resulting maximum estimated hourly concentration from a facility, is compared to the ceiling value to determine whether the ceiling value has been exceeded. Like chronic chemicals and other exposure scenarios, ceiling value chemicals with ratios of less than 0.1 of the acute threshold can be excluded from further analysis. Ceiling values do not apply to surrogate values.

Developmental toxicants potentially emitted from the Mine Site include: arsenic, benzene, and mercury. Benzene was not risk driver chemical in the 2008 AERA and arsenic is not a risk driver in this Supplemental AERA. Mercury health impacts are discussed in the cumulative mercury analysis report submitted January 2012. Benzene emissions decreased by almost 80% compared to those evaluated in the January 2008 AERA. Risk results from the MPCA's RASS indicate that no ceiling values were exceeded for the Year 8 emission scenario or the Year 13 emission scenario (see Section 5.3.1 for Years 8 and 13 rationale). Therefore, potential impacts to the general public from exposure to developmental toxicants associated with Mine Site air emissions are not expected.

9.4.4 Criteria Pollutants

Modeling at the Mine Site for particulate matter less than 10 microns in size (PM_{10}) and less than 2.5 microns in size ($PM_{2.5}$), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) has been completed. Carbon monoxide (CO) was not modeled because it estimated emissions are relatively small and exceedances of the ambient air quality standards are not expected.

Criteria pollutant modeling results are shown in Large Table 5 and all modeling results indicate compliance with ambient air quality standards. The PM_{10} and $PM_{2.5}$, the modeling results include PolyMet Mine Site sources plus background concentrations. Modeled SO_2 and NO_x concentrations from only PolyMet Mine Site sources (shown in Large Table 5) were well below the Class II area significant impact levels (SILs) for all time periods (1-hour, 3-hour, 24-hour, annual). Based on the modeled air concentrations from the Project being below the respective SILs, the Project is expected to comply with ambient air quality standards. The ratios of the modeled air concentrations to ambient air quality standards for the criteria pollutants are not comparable to the estimated human health risks, as the HQs discussed in Section 7.0 are based on a dose-response relationship. Therefore the ratios in Large Table 5 cannot be added to the summed risks presented in Section 7.0.

9.4.5 Fine Particulate ($PM_{2.5}$)

Fine particulate emissions were estimated for the NorthMet Mine Site and modeled for compliance with the $PM_{2.5}$ ambient air quality standards (Large Table 5).

Modeled air concentrations were below the respective most restrictive standard of 35 $\mu g/m^3$ for the 24-hour averaging period and 12 $\mu g/m^3$ for the annual averaging period.

A specific risk estimate for $PM_{2.5}$ direct emissions has not been calculated. Modeled compliance with the ambient air quality standards indicates that adverse health impacts are not expected to be associated with the Mine Site $PM_{2.5}$ emissions. However, the modeled air concentrations compared to the respective NAAQS (Large Table 5) are not an indicator of potential additive effects because the NAAQS are developed differently from the RfCs used in the quantitative risk estimate. The particulate emissions have been speciated to the individual metals but it is unknown whether the potential additional impacts, if any, from inhalation of $PM_{2.5}$ would be additive to, or possibly double counting of, potential health effects.

Secondary formation of $PM_{2.5}$ potentially associated with the facility's SO_2 and NO_X emissions that may be transformed into sulfate and nitrate aerosol (typically as ammonium sulfate or ammonium nitrate) by atmospheric processes was addressed in this evaluation with the use of offset ratios. Secondary fine particle pollution is recognized as being a long-range transport issue (Reference (50)). For SO_2 conversion to sulfate aerosol, the conversion typically occurs over several days and during that time the emissions from a facility may have moved several hundred miles. Research is ongoing with regard to the conversion of NO/NO_2 to nitrate aerosol. Due to this long range transport of fine particles associated with SO_2 and NO_x emissions, the extent the secondary formation of sulfate and nitrate aerosol affect air concentrations near an emission source is uncertain. The NorthMet Mine Site is dominated by fugitive sources with very few sources of combustion emissions that would generate the NO_x and SO_2 associated with secondary particulate formation.

9.5 Regulatory Requirements

9.5.1 State and Federal Control Requirements

PolyMet is proposing to obtain a Title V air permit for the Plant Site and Mine Site. The proposed facility will be a major Title V source, but not a major source under Prevention of Significant Deterioration (PSD) air permitting. The permit application will propose emission limitations based on air dispersion modeling inputs and the objective of being a minor source for PSD purposes. The permit application will also provide details on the applicability of state and federal requirements including New Source Performance Standards, Part 61 and Part 63 National Emission Standards for Hazardous Air Pollutants (NESHAPS), and Minnesota Standards for Performance for Stationary Sources.

9.5.2 Air Permitting

Limitations will be proposed in the air emissions permit application to keep emissions below the PSD major source level. Therefore the Project is not subject to PSD review. However, the following analyses have been, or will be, conducted to support preparation of the SDEIS:

- control technology review (completed and approved)
- a Class II area air quality analysis, including modeled compliance with the applicable NAAQS for SO_2, NO_x, PM_{10} and $PM_{2.5}$ (Mine Site: completed and approved; Plant Site version 1 completed and reviewed, version 2 underway)
- an air quality analysis of Class I area impacts as agreed upon with the Federal Land Managers (FLMs) has been completed. Details of the analysis are available in a separate report. (completed and approved)

9.5.3 Emergency Generators

The MPCA requests that a project proposer inventory and characterize emergency generators and fire pumps at the facility separately from the inventory of emission sources included in the risk estimate.

NorthMet will have one emergency diesel generator for the Mine Site operations. This generator is expected to be operated sparingly and only in emergency situations and will not be used for peak shaving or used in other way that would be inconsistent with the classification as an emergency generator. Testing of the generator will occur periodically to make sure it is in good operating condition. Due to the infrequent operations and the relatively short operating times when in use, potential emissions from the generator is expected to be small and they were not included in the risk analysis. Potential emissions from this emergency generator are not expected to significantly affect the quantitative risk estimates.

NorthMet will not have any emergency diesel fire pumps for the Mine Site operations.

9.5.4 Accidental Releases

Minnesota’s Notification of Deviations, Shutdowns and Breakdowns rule (Minnesota Rules, part 7019.1000) requires the owner or operator of an emission facility to notify the MPCA of shutdowns or breakdowns that cause any increase in emissions. The MPCA maintains a log of these notifications. In addition, the permit to be issued for the Project may require the facility to maintain records of start-up, shutdown, breakdown or malfunctions of operating units and/or control equipment. The MPCA will generate a report from the Incident Management System that logs shutdown and breakdown reports for the previous five years.

10.0 Cumulative Inhalation Risk Assessment

A cumulative human health inhalation risk assessment for the Project will be presented as part of the Supplemental AERA for the Plant Site. The cumulative human health risk assessment will include the sum of risk estimates from the Mine Site + Plant Site + Laskin Energy Station + Mesabi Nugget + background risks as identified in the November 2011 Work Plan (Reference (3)).

11.0 Summary

Following the MPCA-accepted Work Plan for the Supplemental AERA, potential inhalation risks for an off-site worker at the Mine Site property ownership boundary (i.e., Mine Site ambient air boundary) and multipathway risk (inhalation + ingestion) for a farmer and a resident receptor at the associated Mineral Mining/Industrial Zoning Boundary were estimated for two emission scenarios. The highest estimated risks for either scenario are summarized below.

- inhalation risks – potential off-site worker at the Mine Site property ownership boundary
    - The estimated potential maximum acute (1-hour) inhalation risk, summed for all chemicals regardless of toxic endpoint is 0.8 and does not exceed the guideline value of 1.0. The risk driver pollutant is NO_x (evaluated as NO_2) for which the USEPA factor of 80% is applied for the conversion of NO to NO_2 and provides a conservative overestimate for potential NO_2 air concentrations.
    - the estimated maximum chronic inhalation risks (cancer = 5E-06 and noncancer = 0.2), summed for all chemicals regardless of toxic endpoint, do not exceed the respective guideline values of 1E-05 and 1.0
- multipathway risks – Mineral Mining/Industrial District Boundary.
    - for a potential resident, estimated potential cancer (8E-07) and noncancer chronic risks (0.04) are below the incremental risk guideline values of 1E-05 for cancer and 1.0 for noncancer chronic
    - for a potential farmer, estimated potential cancer risks (1E-05) and noncancer chronic risks (0.04) do not exceed the incremental guideline values of 1E-05 and 1.0, respectively.
- Additionally, the estimated potential inhalation and multipathway risks for this Supplemental AERA are similar to those estimated in the 2008 Mine Site AERA.

Conclusion: The MPCA AERA methodology ensures that a conservative approach is used to assess potential health risks and protect public health (including sensitive populations) with a suitable margin of safety. When potential health risks are assessed to be at or below acceptable guidelines using this methodology, adverse health effects, even in sensitive populations, are not expected. When the estimated risks are compared to guideline values, and accounting for conservatism in the risk analysis methodology, adverse impacts to human health are not expected to be associated with the potential air emissions from the proposed Mine Site operations.

12.0 Certification

PolyMet hereby provides the following certification for the Mine Site Air Emissions Risk Analysis:

"I hereby certify under penalty of law that the enclosed documents and all attachments were prepared under my direction in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or the person directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true and accurate and complete."

____

{responsible official}
Poly Met Mining, Inc.

Glossary of Terms Used in Air Emissions Risk Analysis

Term	Definition
Acute exposure	Single or multiple exposure occurring within a short time (24 hours or less). For purpose of the AERA, acute exposure is a single event with a duration of one-hour
Acute toxicity	Adverse health effects that occur or develop rapidly after a single administration of a chemical
Additivity	Refers to a situation where the combined effect of exposure to two or more chemicals is equal to the sum of the effect of each of those chemicals given alone (e.g.10 + 10 = 20).
Algorithm	Systematic method for solving a problem. Usually refers to multiple step methods for performing complex mathematical calculations.
Antagonistic	Description of two or more chemicals which when given together interfere with each other's actions.
Bioaccessible	A value representing the availability of a metal for absorption when dissolved in in vitro surrogates of body fluids or juices.
Bioavailable	The fraction of a dose that becomes available for distribution to internal target tissues and organs.
Bioconcentration Factor (BCF)	The ratio of a contaminant concentration in biota to its concentration in the surrounding medium (e.g., water).
Biokinetic	Refers to the modeling and mathematical description of a chemicals distribution over time in a whole organism.
Carcinogen	A chemical that may be capable of causing cancer in mammals. For purposes of this risk assessment a carcinogen is a chemical that is defined by the USEPA as a carcinogen.
Central Tendency Exposure	A measure of the middle or the center of an exposure distribution. The mean is the most commonly used measure of central tendency (EPA Exposure Factors Handbook, Glossary)
Chemicals for Evaluation (CFE)	Chemicals which may be emitted to air as a result of this facility's operations and that have toxicity values in the MPCA RASS and have data available to estimate potential emissions
Chemicals for Potential Evaluation (CFPE)	Chemicals that may be emitted to air as a result of a facility's operations
Chronic exposure	Prolonged or repeated exposure typically occurring over a period of several years. The assumed exposure periods used in this AERA vary between exposure scenarios.
Chronic toxicity	Adverse health effects that occur after a lapse of time between the initial exposure, or effects that persist over a long period of time whether or not they occurred immediately or are delayed.
Class I area	Federally mandatory Class I areas are wilderness areas and national parks.

Term	Definition
Class II area	In Minnesota, Class II areas are all areas that are not designated as Class I areas.
Dose-response curve	Graphical representation of the relationship between chemical dose and response of the population to that dose (incidence of adverse effect).
Dosimetric	Corrections for differences in body weight, surface area and metabolic rate applied to dosage.
Epidemiological	Refers to the study of disease and its spread in people.
Genotoxic	Substance that can cause damage to cellular DNA.
Hazard Index (HI)	The sum of HQs for non-carcinogenic chemicals with similar modes of action and toxic endpoints. A HI of one or more indicates that there is a potential for adverse health effects.
Hazard Quotient (HQ)	The calculated or measured exposure to a given chemical divided by the RfC for that chemical. An HQ of one or greater indicates that there is a potential for adverse health effects.
Health Risk Value (HRV) or Inhalation Risk Value	A Health Risk Value is the concentration of a chemical (or defined mixture of chemicals) defined by the Minnesota Department of Health (MDH) that is likely to pose little or no risk to human health. For carcinogens, MDH defines significant risk as a risk of 1 in 100,000. For noncarcinogens, MDH defines significant risk as a Hazard Index greater than 1 (for an individual chemical) or a Hazard Quotient greater than 1 (for a mixture of chemicals.
MAAQS	Minnesota Ambient Air Quality Standards.
Maximum Exposed Individual (MEI)	An exposure concept is based upon the following assumptions: continuous lifetime exposure (365 days per year for 70 years), individual is outside 24-hours per day, individual is at the point of maximum estimated air concentration. The MEI represents the maximum or near maximum for potential risk from exposure to plant airborne emissions.
Modified Central Tendency Exposure (MCTE)	An exposure concept in which mean, or median exposure frequency and duration data are used in the calculation of risk. In this risk assessment upper value airborne concentrations were used in the MCTE concept. The resultant risk estimate would correspond to a 50^{th} – 85th percentile range for chronic and sub-chronic exposure.
Multimedia factors	A term used in previous versions of MPCA AERA Guidance. See Multipathway Screening Factors for a current definition.
Multipathway Screening Factors (MPSFs)	As defined by the Minnesota Pollution Control Agency (MPCA), based on individual chemical information in the Industrial Risk Assessment Program (IRAP), it is the ratio of a chemical's total multipathway risk/a chemical's inhalation risk.
Non-carcinogen	For the purposes of this risk assessment, a non-carcinogen is a chemical, which is not included on the USEPA list of carcinogens.

Term	Definition
Particulate Matter	Small discrete masses of solid or liquid materials. Particles are often defined as having aerodynamic diameters (incorporates considerations of shape and density of the particle) from 0.001 to 100 microns (one micron equals one-millionth of a meter).
Persistent, bioaccumulative, toxic (PBT) chemicals	In terms of PBT chemicals are defined by the MPCA AERA-RASS. The MPCA AERA-RASS uses the "EPA PBT Profiler" to determine if a chemical is persistent and bioaccumulative. If the half-life in water, soil, and sediment is 60 days or more a substance is considered persistent, and if the half-life is more than 180 days, it is considered very persistent. If the BCF is 1000 or more, a substance is considered bioaccumulative, and if the BCF is 5000 or more, it is considered very bioaccumulative. The MPCA considers a chemical persistent and bioaccumulative and carried the chemical through for further analyses if the percent partitioning to water was greater than 10%, the half- life in water was greater than 60 days, and the bioconcentration factor was greater than or equal to 1000. or the percent partitioning to soil was greater than 10%, the half-life in soil was greater than 60 days, and the BCF was greater than or equal to 1000; or the percent partitioning to sediment was greater than 10%, the half-life in sediment was greater than 60 days, and the BCF was greater than or equal to 1000. EPA has classified some metals as PBTs under the Community Right to Know Act.11 A more comprehensive list of metals with potential PBT characteristics was adopted by the European Union. Seven metals from the initial list of 315 substances were also included in the EU list were carried forward in subsequent analyses in the RASS.
PM2.5	Particulate matter with an aerodynamic diameter of 2.5 micrometers or less.
PM10	Particulate matter with an aerodynamic diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of human hair).
Reasonable Maximum Exposure (RME)	The exposure concept representing the highest exposure that is reasonably expected at the site. RME refers to people who are at the high end of the exposure distribution (approximately the 90th percentile). The RME scenario is intended to assess exposures that are higher than average, but are still within a realistic range of exposure (http://www.epa.gov/risk/exposure.htm).
Receptor	For purposes of this risk assessment, a receptor is an individual living or working (outside of the facilities property boundary) who may be exposed to emissions from the facility.
Reference concentration (RfC)	An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse noncancer effects during a lifetime.
Reference Dose (RfD)	An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous ingestion exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse noncancer effects during a lifetime.

Term	Definition
Reference Exposure Level (REL)	RELs are derived for the California Hot Spots program (by the Office of Environmental Health Hazard Assessment-OEHHA) in a manner similar to U.S. EPA values and have undergone internal and external review. An REL represents an airborne concentration of a chemical at or below which no adverse effects are anticipated in individuals exposed to that level. RELs can apply to exposures for 1 hour, 8 hours, or up to a lifetime. http://oehha.ca.gov/air/allrels.html
Respirable	Particles that can be inhaled and deposited into the lungs and alveoli. Respirable particles are typically defined as having aerodynamic diameters of 10 microns or less.
Risk Driver	For non-carcinogens, this means a chemical with a Hazard Quotient greater than 0.1. For carcinogens, this means a chemical with an estimated risk greater than 1 in 1,000,000 (> 1E-06).
Semi-volatile organic compound (SVOC)	Organic compounds which may be present in both vapor and particulate phase within the atmosphere. These compounds tend to evaporate very slowly at normal temperatures and can be very persistent in the environment. SVOCs have vapor pressures ranging from 10^{-1} to 10^{-7} mmHg and boiling points that range from 120 to 300^{o}C.
Sensitive receptor	In general, a sensitive receptor refers to a person or group of people that may be more sensitive to chemical exposure. Examples include pregnant women, children, the elderly, or those who are immuno-compromised.
Settling velocity	The velocity at which a particle in still air at normal temperature and pressure will fall through the atmosphere. Settling velocity depends upon the particles size, shape and density. Heavy (dense) particles have higher settling velocities than light particles.
Significant impact levels (SILs)	Screening levels for incremental ambient air concentrations. Projects with incremental ambient air concentrations below the SIL for a given pollutant are not necessarily required to complete NAAQS modeling for that pollutant.
Slope factor	Used to define the potency of a carcinogen at low dose levels. The slope of the dose-response curve in the low-dose region. When low-dose linearity cannot be assumed, the slope factor is the slope of the straight line from 0 dose to the dose at 1% excess risk. (double check this)
Synergistic	The combined effect of two or more chemicals given together is greater than the sum of the effects of those chemicals.
Toxicity	Measure or degree of adverse effect of a given chemical on a living organism. In the case of this risk assessment – humans.
Toxicity Equivalent (TEQ)	Toxicity Equivalents (TEQ) for dioxin and furan congeners is the toxicity weighted masses of mixtures of dioxins/furans. In practical terms, it is the summed concentration of dioxin/furan congeners expressed in terms of the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin.
Toxicity factor	Can refer to a toxicity value used to calculate a risk estimate (e.g.,. slope factor, unit risk, RfC, RfD, etc.)

Term	Definition
Unit risk (UR)	The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 μg/L in water, or 1 μg/m^3 in air.
Volatile organic compound (VOC)	Organic compounds that evaporates easily and are usually found as a vapor in the air. VOCs have vapor pressures greater than 10^{-1} and boiling points less than 120^{o}C.
Weight-of-evidence	Procedure for evaluating the toxicity, and in particular the carcinogenicity of a chemical using evidence from human (epidemiological) studies, and animal studies. Studies are weighted based upon their relevance to human exposure, and assessed quality of the study. Well-designed studies are given greater weight in the consideration of toxicity than poorly designed studies. Similarly human studies are given greater weight than animal studies.

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Revision History

Date	Version	Description
10/25/2012	1	Initial release
01/23/2013	2	Report revised to address comments received on Version 1.
02/21/2013	3	Report revised to address comments received on Version 2.

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Large Tables

Large Table 1 Exposure Parameters for the PolyMet Mine Site for Noncancer Effects

Exposure Information			Exposure Concentration Adjustments (note: if exposure is not adjusted the underlying assumptions in deriving the toxicity values and/or multipathway screening factors (MPSFs) continue to apply)				MPCA- RASS Toxicity value or Multipathway screening factor (MPSF) assumptions	Classification of assessed risk
Exposure Route	**Exposure Conc. µg/m3**	**Receptor Location**	**Exp. Time (hours/day)**	**Exp. Freq. (days/year)**	**Exp. Duration (years)**	**Averaging time (years= exposure duration for non-carcinogens)**	**Assumptions and/or adjustments**	**Maximum Exposed Individual (MEI) or Reasonable Maximum Exposure (RME)**
Inhalation only - 1 hour	Maximum modeled 1- hour concentration	Individual at the Mine-Site Property Boundary	NA	NA	NA	NA	Toxicity values assume one hour of exposure	Maximum exposed individual (MEI)
Chronic inhalation	Maximum modeled annual concentration	Individual at the Mine-Site Property Boundary	None-see toxicity value assumptions	None-see toxicity value assumptions	None-see toxicity value assumptions	None-see toxicity value assumptions	Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime (typically 70 years)	Maximum exposed individual (MEI)
Inhalation-for multipathway calculation	Maximum modeled annual concentration	Resident and farmer just outside the Mineral-Mining/Industrial district boundary	None-see toxicity value assumptions	None-see toxicity value assumptions	None-see toxicity value assumptions	None-see toxicity value assumptions	Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime (typically 70 years) MPSFs do not apply to inhalation risk	Maximum exposed individual (MEI)
Ingestion-for multipathway calculation	Maximum modeled annual concentration	Resident and farmer just outside the Mineral-Mining/Industrial district boundary	None-see MPSF value assumptions	None-see MPSF value assumptions	None-see MPSF value assumptions	None-see MPSF value assumptions	MPSFs assume exposure duration equals averaging time (i.e. they cancel out in the calculations)	Maximum exposed individual (MEI)

NA=not applicable- maximum modeled air concentrations are not adjusted for acute exposures.

Large Table 2 Exposure Parameters for the PolyMet Mine Site for Cancer Effects

Exposure Information			Exposure Concentration Adjustments (note: if exposure is not adjusted the underlying assumptions in deriving the toxicity values and/or multipathway screening factors (MPSFs) continue to apply)				MPCA- RASS Toxicity value or Multipathway screening factor assumptions	Classification of assessed risk
Exposure Route	**Exposure Conc. µg/m3**	**Receptor**	**Exposure Time (hours/day)**	**Exposure Frequency (days/year)**	**Exposure Duration (years)**	**Averaging time (always 70 years for carcinogens)**	**Other adjustments**	**Maximum Exposed Individual (MEI) or Reasonable Maximum Exposure (RME)**
Chronic inhalation	Maximum modeled annual concentration	Individual at the Mine-Site Property Boundary	None-see toxicity value assumptions	None-see toxicity value assumptions	None-see toxicity value assumptions	None-see toxicity value assumptions	Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime (typically 70 years)	Maximum exposed individual (MEI)
Inhalation-for multipathway calculation	Maximum modeled annual concentration	Resident and farmer just outside of Mineral-Mining/Industrial boundary	None-see toxicity value assumptions	None-see toxicity value assumptions	None-see toxicity value assumption	None-see toxicity value assumptions	Toxicity values are derived to assume exposure 24 hours/day, 365 days/year over a lifetime (typically 70 years) MPSFs do not apply to inhalation risk	Maximum exposed individual (MEI)
Ingestion-for multipathway calculation	Maximum modeled annual concentration	Resident and farmer just outside of Mineral-Mining/Industrial boundary	None-see MPSF assumptions	None-see MPSF assumptions	None-see MPSF assumptions	None-see MPSF assumptions	The MPCA adjusts MPSFs in the RASS for exposure duration and averaging time -Exposure duration is 30 years for a resident and 40 years for a farmer -averaging time is 70 years	Reasonable maximum exposure (RME)

Large Table 3 Comparison of 2008 and 2012 Estimated Hourly Emissions of Chemicals for Potential Evaluation (CFPE) in the Supplemental Air Emissions Risk Analysis Conducted for the Proposed Mine Site

CFPE	2008 Emissions year 8, lb/hr	2012 Emissions year 8, lb/hr	% change year 8	2008 Emissions year 16, lb/hr	2012 Emissions year 13, lb/hr	% change year 13/16
Acenaphthene	0.0003	0.0003	19.4%	0.0003	0.0003	19.4%
Acenaphthylene	0.0008	0.0006	-21.4%	0.0008	0.0006	-21.4%
Acetaldehyde	0.0156	0.0003	-97.9%	0.0156	0.0003	-97.9%
Acrolein	0.0023	0.0001	-95.7%	0.0023	0.0001	-95.7%
Anthracene	0.0002	0.0001	-42.9%	0.0002	0.0001	-42.9%
Antimony	0.0040	0.0024	-40.2%	0.0040	0.0026	-33.7%
Arsenic	0.0060	0.0102	70.3%	0.0060	0.0114	90.0%
Barium	0.0726	0.2109	190.7%	0.0726	0.2389	229.3%
Benzene	0.0479	0.0100	-79.1%	0.0479	0.0100	-79.1%
Benzo(a)anthracene	0.0001	0.0000	-27.6%	0.0001	0.0000	-27.6%
Benzo(a)pyrene	1.6E-05	0.0000	10.5%	1.6E-05	0.0000	10.5%
Benzo(e)pyrene	3.3E-06	0.0000	-100.0%	3.3E-06	0.0000	-100.0%
Benzo(b)fluoranthene	0.0001	0.0001	30.6%	0.0001	0.0001	30.6%
Benzo(g,h,i)perylene	3.5E-05	0.0000	13.4%	3.5E-05	0.0000	13.4%
Benzo(k)fluoranthene	1.5E-05	0.0000	0.4%	1.5E-05	0.0000	0.4%
Beryllium	0.0009	0.0003	-65.2%	0.0009	0.0003	-61.5%
Boron	0.0857	0.0051	-94.1%	0.0857	0.0057	-93.4%
1,3-Butadiene	0.0026	0.0000	-100.0%	0.0026	0.0000	-100.0%
Cadmium	0.0030	0.0006	-81.1%	0.0030	0.0006	-80.0%
CH4 (methane)	0.0181	0.5327	2836.0%	0.0181	0.5327	2836.0%
Chromium	0.1146	0.0847	-26.1%	0.1146	0.0943	-17.8%

CFPE	2008 Emissions year 8, lb/hr	2012 Emissions year 8, lb/hr	% change year 8	2008 Emissions year 16, lb/hr	2012 Emissions year 13, lb/hr	% change year 13/16
Chrysene	0.0001	0.0001	25.2%	0.0001	0.0001	25.2%
Cobalt	0.0496	0.0286	-42.3%	0.0496	0.0318	-35.9%
Copper	0.3680	0.3441	-6.5%	0.3680	0.3722	1.2%
Crystalline Silica (SiO_2)		4.6190	New		5.1323	New
Dibenzo(a,h)anthracene	2.2E-05	0.0000	14.6%	2.2E-05	0.0000	14.6%
Diesel Particulate		2.4943	New		2.4943	New
Fluoranthene	0.0003	0.0003	-7.7%	0.0003	0.0003	-7.7%
Fluorene	0.0010	0.0009	-6.1%	0.0010	0.0009	-6.1%
Fluorides (as F)	0.0588	0.0330	-43.8%	0.0588	0.0364	-38.0%
Formaldehyde	0.0349	0.0010	-97.1%	0.0349	0.0010	-97.1%
H2SO4/SO3[(1)]	0.0075	0.1001	1232.2%	0.0075	0.1001	1232.2%
Hafnium	4.3E-05	0.0000	4.4%	4.3E-05	0.0000	4.4%
Indeno(1,2,3-cd)pyrene	2.6E-05	0.0000	14.2%	2.6E-05	0.0000	14.2%
Manganese	1.2153	0.5067	-58.3%	1.2153	0.5574	-54.1%
Mercury	0.0001	0.0001	16.0%	0.0001	0.0001	18.8%
2-Methylnaphthalene	0.0006	0.0000	-100.0%	0.0006	0.0000	-100.0%
Molybdenum	0.0021	0.0016	-23.5%	0.0021	0.0018	-13.5%
N_2O	4.0681	0.2546	-93.7%	4.0681	0.2546	-93.7%
Naphthalene	0.0092	0.0091	-0.5%	0.0092	0.0091	-0.5%
Nickel	0.2522	0.1946	-22.8%	0.2522	0.2112	-16.3%
NOx	30.3425	116.1	282.6%	30.3425	116.1	282.6%
Pb (Lead)	0.0776	0.0032	-95.9%	0.0776	0.0036	-95.4%
Phenanthrene	0.0028	0.0029	4.1%	0.0028	0.0029	4.1%

CFPE	2008 Emissions year 8, lb/hr	2012 Emissions year 8, lb/hr	% change year 8	2008 Emissions year 16, lb/hr	2012 Emissions year 13, lb/hr	% change year 13/16
Phosphorus	0.0532	0.0335	-37.0%	0.0532	0.0318	-40.3%
Propylene	0.1584	0.0000	-100.0%	0.1584	0.0000	-100.0%
Pyrene	0.0003	0.0003	-18.4%	0.0003	0.0003	-18.4%
Selenium	0.0096	0.0052	-45.6%	0.0096	0.0057	-41.0%
Dioxins/Furans (2,3,7,8-TCDD TEQ basis)	5.5E-09	0.0000	-40.1%	5.5E-09	0.0000	-40.1%
Tellurium	0.0212	0.0116	-45.3%	0.0212	0.0129	-39.3%
Toluene	0.0172	0.0036	-78.9%	0.0172	0.0036	-78.9%
Vanadium	0.0459	0.0601	30.8%	0.0459	0.0672	46.4%
Xylene	0.0118	0.0025	-78.9%	0.0118	0.0025	-78.9%
Zinc	0.6094	0.0498	-91.8%	0.6094	0.0556	-90.9%

(1) 2012 sulfuric acid emissions do not include emissions from the emergency generator. All other 2012 emissions are total Mine Site emissions, which include emergency generator emissions.

Large Table 4 Revised Risk Estimates (RRE) for CFPE and Resulting CFE for the Supplemental Air Emissions Risk Analysis Conducted for the Proposed Mine Site

CFPE (CFE are shaded)	Acute inhalation RRE	Noncancer inhalation RRE	Cancer inhalation RRE	Noncancer farmer RRE	Cancer farmer RRE	Noncancer resident RRE	Cancer resident RRE
Acetaldehyde [1] [3][7]		2.0E-06	3.9E-11	7.0E-07	1.4E-11	7.0E-07	1.4E-11
Acrolein	0.0001	0.0003		0.0001		0.0001	
Antimony		0.0003		3.9E-05		3.9E-05	
Arsenic[1] [2] [4]	0.0402	0.0180	1.2E-06	0.0106	1.1E-06	0.0071	4.6E-07
Barium[6]				0.0014		0.0014	
Benzene	2.6E-05	1.6E-05	3.3E-09	6.3E-06	1.5E-09	6.3E-06	1.5E-09
Benzo(a)anthracene[2]			2.3E-10		4.0E-08		5.8E-10
Benzo(a)pyrene[2]			8.9E-10		2.6E-07		2.6E-09
Benzo(b)fluoranthene[2]			3.9E-10		5.5E-09		3.2E-10
Benzo(k)fluoranthene[2]			7.5E-11		2.7E-08		3.2E-10
Beryllium		0.0004	1.7E-08	0.0001	1.0E-08	0.0001	2.6E-09
Boron[6]				8.6E-07		8.6E-07	
1,3-Butadiene[1]							
Cadmium[2]		0.0007	2.5E-08	0.0001	5.3E-08	0.0001	4.8E-09
Chrysene[2]			5.3E-11		4.1E-09		8.9E-11
Cobalt[3][7]							
Copper	0.0021						
Crystalline silica (SiO_2) [3]							
Dibenzo(a,h)anthracene[2] [5]			1.3E-09		3.3E-06		1.2E-08
Diesel Particulate[3][7]							
Formaldehyde	1.8E-05	6.8E-06	3.1E-10	6.8E-06	1.0E-10	6.8E-06	1.0E-10

CFPE (CFE are shaded)	Acute inhalation RRE	Noncancer inhalation RRE	Cancer inhalation RRE	Noncancer farmer RRE	Cancer farmer RRE	Noncancer resident RRE	Cancer resident RRE
H2SO4/SO3[8]	0.0024	0.0080		0.0032		0.0032	
Indeno(1,2,3-cd)pyrene[2] [5]			1.5E-10		1.1E-07		1.7E-09
Manganese[5]		0.0617		0.0097		0.0097	
Mercury	0.0004	1.3E-05		5.5E-06		5.5E-06	
Naphthalene	0.0001	4.6E-05	1.4E-08	1.9E-05	5.9E-09	1.9E-05	5.9E-09
Nickel[5]	0.0099	0.0901	2.2E-06	0.0131	3.2E-07	0.0131	3.2E-07
NOx[5]	0.5153						
Pb (lead) [2]			9.2E-10		5.4E-10		4.1E-10
Propylene		0.0E+00		0.0E+00		0.0E+00	
Selenium[2]		7.0E-06		4.7E-05		1.5E-06	
Dioxins/Furans (TEQ basis) [2] [5]		3.9E-06	6.2E-08	0.0006	5.0E-06	1.5E-05	7.4E-08
Toluene	2.7E-07	4.3E-07		1.7E-07		1.7E-07	
Vanadium	0.0012						
Xylene	1.6E-07	1.2E-06		4.7E-07		4.7E-07	
Risk Driver Threshold	**0.1**	**0.1**	**1 E-06**	**0.1**	**1 E-06**	**0.1**	**1 E-06**

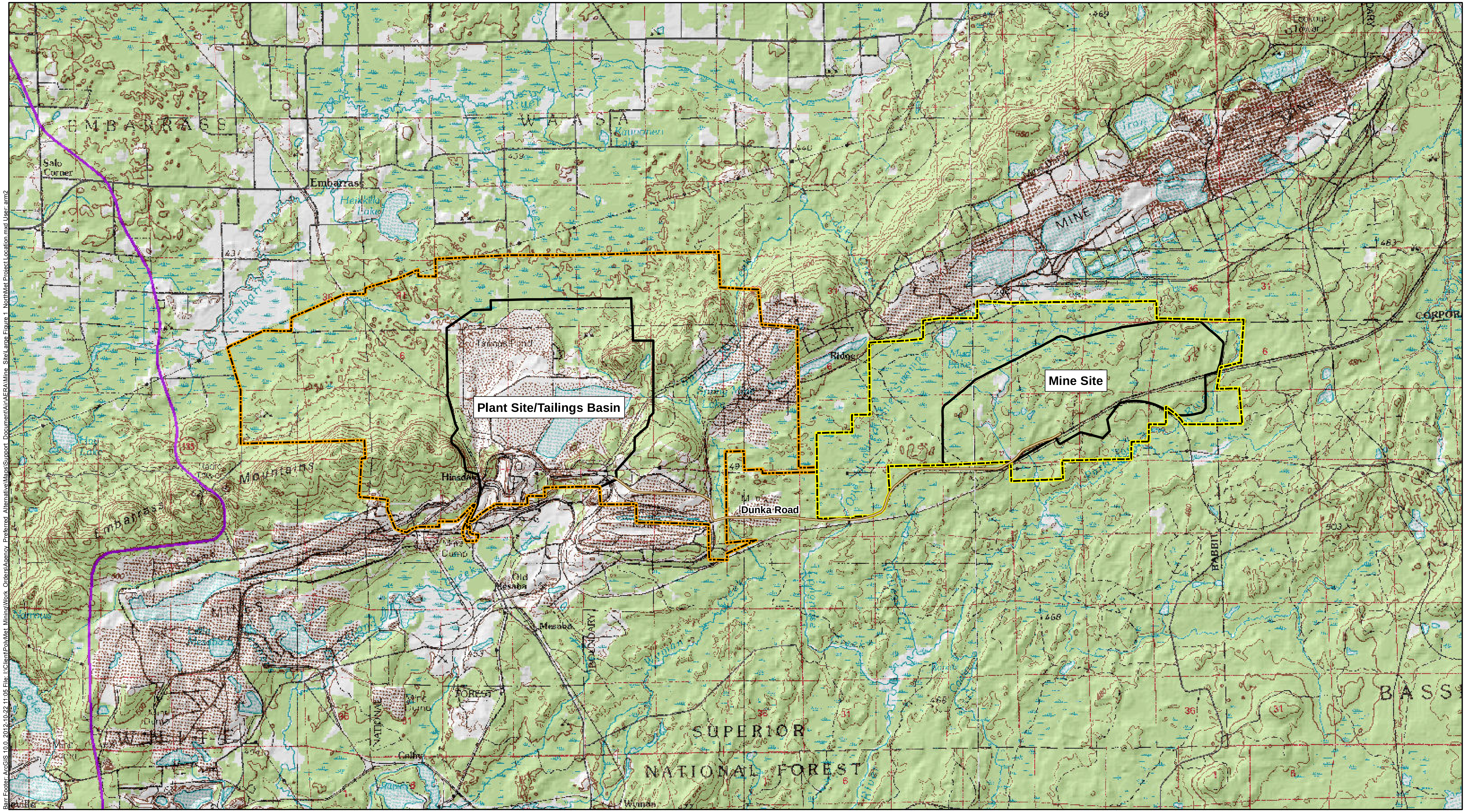
(1) Change in toxicity factor since 2008
(2) Change in multipathway screening factor (MPSF) since 2008 (called multimedia factors in 2008)
(3) CFE due to new toxicity factor that was not available in 2008
(4) CFE because is a potential risk driver based on changes since 2008
(5) CFE because was a risk driver in the Jan 2008 AERA
(6) Toxicity factor removed from RASS since 2008
(7) No RRE is calculated because Jan 2008 estimated risk was zero or not available
(8) 2008 modeled concentrations and 2012 toxicity factor used with percent change in emissions to determine acute RRE (See Section 4.3 for more information.)

Large Table 5 Estimated Maximum Criteria Pollutant Air Concentrations at the Mine Site Property Ownership Boundary Compared to Ambient Air Quality Standards

Pollutant(1)	Time Period	Estimated Ambient Air Concentrations ($\mu g/m^3$)(2) (3)	Minnesota Ambient Air Quality Standard ($\mu g/m^3$)	National Ambient Air Quality Standard ($\mu g/m^3$)	Ratio of Modeled Air Concentration to the Minnesota Ambient Air Standard	Ratio of Modeled Air Concentration to the Federal Ambient Air Standard	Pollutant Toxic Endpoint
Particulate matter (PM_{10}) (2)	24 hour	88.4	150	150	0.59	0.59	Respiratory system
	Annual	28.5	50		0.57	0.57	
Particulate matter ($PM_{2.5}$) (2)	24 hour	32.5	65	35	0.50	0.93	Respiratory system, Cardiovascular effects
	Annual	10.4	15	12	0.69	0.87	
Sulfur dioxide (SO_2) [3]	1 hour	0.74	1300	196	NC	NC	Respiratory system
	3 hour	0.54	915				
	24 hour	0.13	365	365			
	annual	0.01	60	80			
Nitrogen oxides (NO_x) [3]	1 hour	5.34	188	188	NC	NC	Respiratory system
	Annual	0.10	100	100			
Carbon monoxide (CO)	1 hour	NM	35,000	40,000	NM	NM	Cardiovascular system
	8 hour	NM	10,000	10,000			

NC = Ratio not calculated because project-only modeling results were below the respective Significant Impact Level.
NM = Not modeled for environmental review purposes. See [1].
(1) CO was not identified as a pollutant of concern during the EIS scoping process. Exceedances of the ambient air quality standards are not expected.
(2) Final modeling results for PM_{10} and $PM_{2.5}$ at the Mine Site property ownership boundary include PolyMet Mine Site emissions (fugitive emissions + stack emissions) and background concentration. Final modeling results for NO_x and SO_2 at the Mine Site property ownership boundary include only PolyMet Mine Site emissions (stack emissions).
(3) NO_x and SO_2 concentrations are the incremental concentrations that result from PolyMet Mine Site sources only and do not include background concentrations. These values are far enough below the Significant Impact Levels (SILs) not to warrant further modeling analysis. Therefore comparison to NAAQS and MAAQS is not applicable for these concentrations.

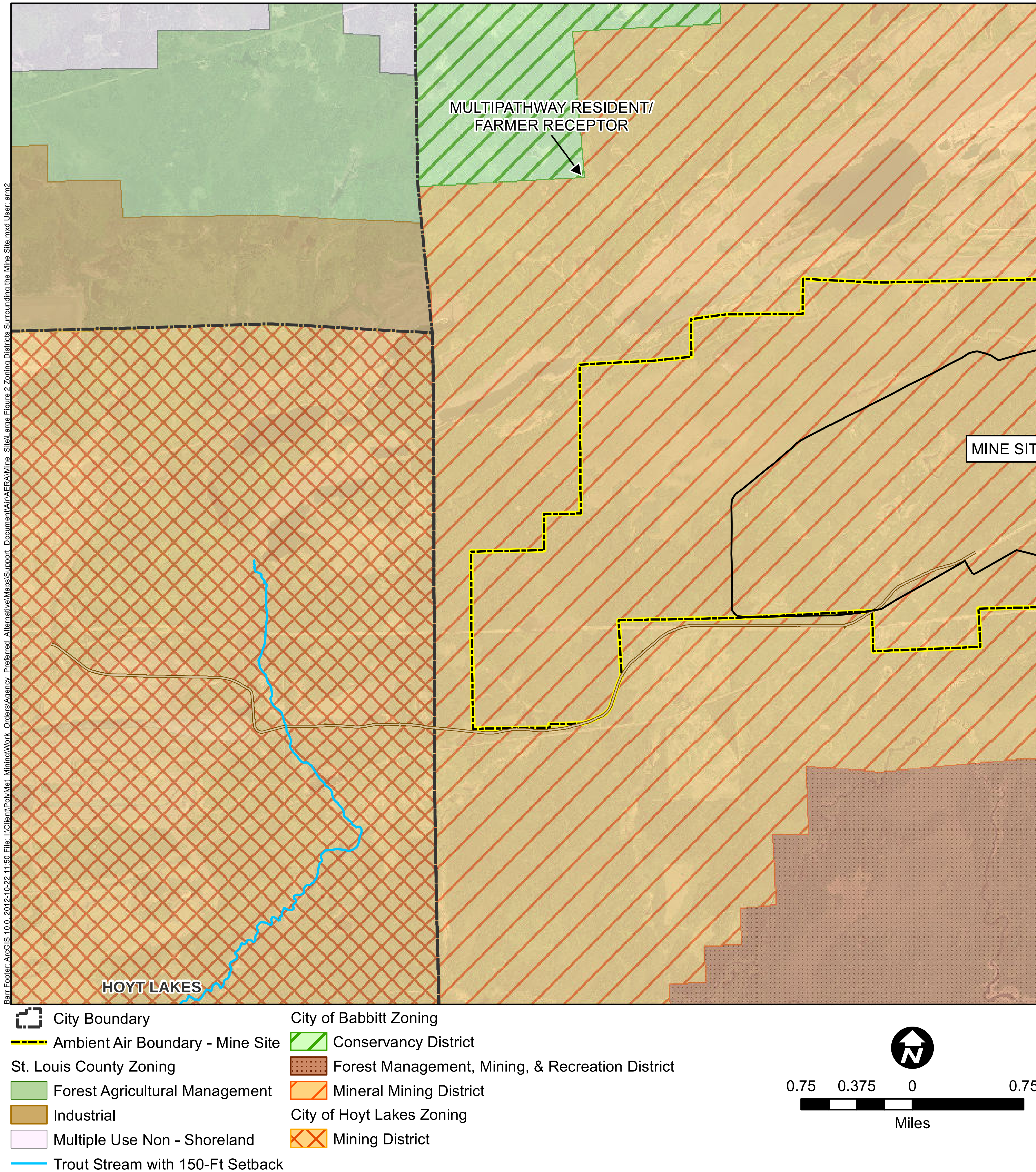
Large Figures



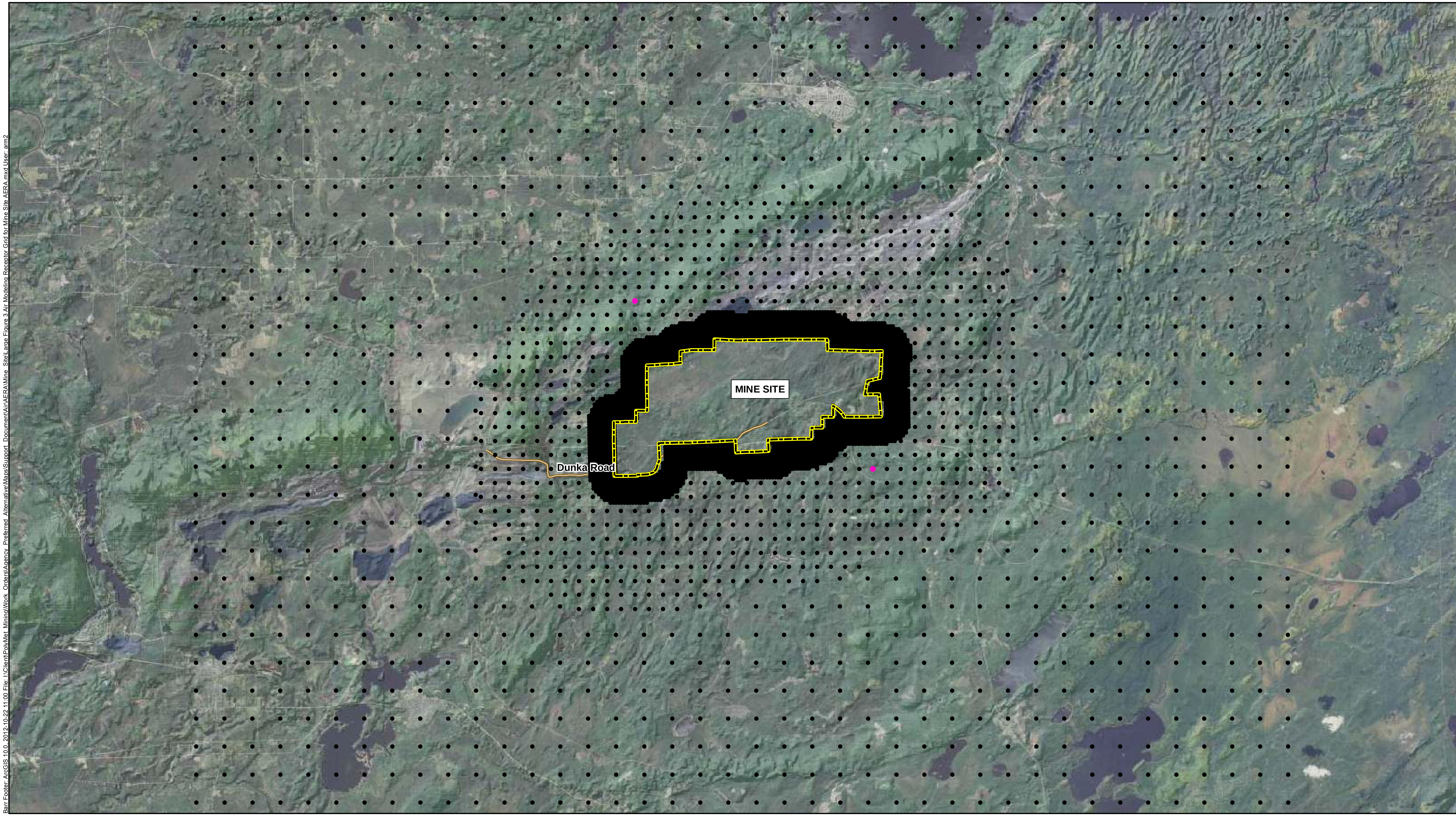
Ambient Air Boundary - Mine Site
Ambient Air Boundary - Plant Site
Dunka Road
Project Areas

1.25 0.625 0 1.25
Miles

Lare Figure 1
NORTHMET PROJECT LOCATION IN
THE BABBITT AND HOYT LAKES AREA
IN NORTHEAST MINNESOTA
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota



Large Figure 2
ZONING DISTRICTS SURROUNDING
THE NORTHMET MINE SITE
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota



Ambient Air Boundary - Mine Site

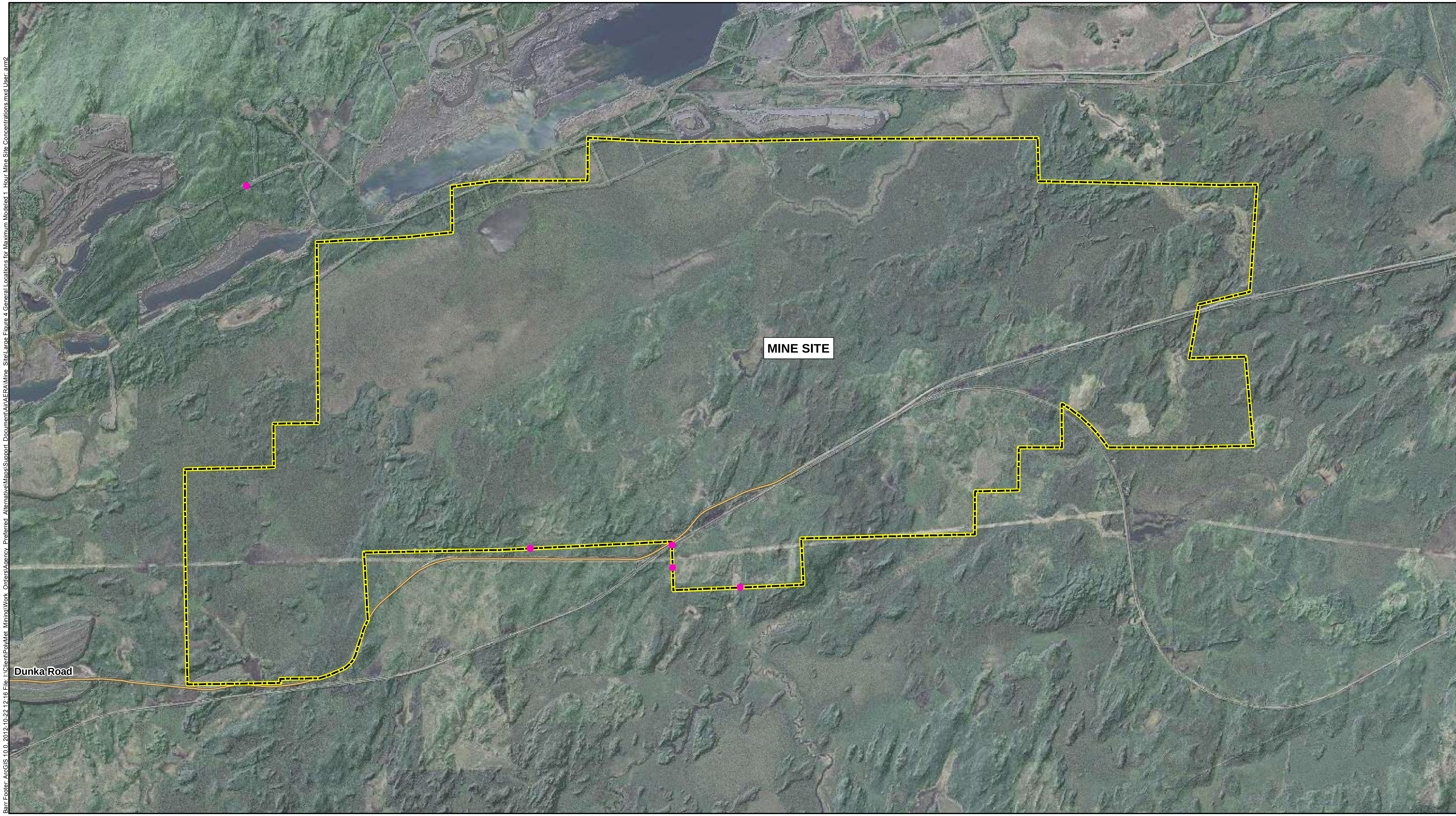
Mine Site AERA Inhalation Receptors

Mine Site AERA Multipathway Resident/Farmer Receptors

2 1 0 2

Miles

Large Figure 3
AIR MODELING RECEPTOR GRID FOR THE SUPPLEMENTAL MINE SITE AERA
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota



Barr Footer: ArcGIS 10.0, 2012-10-22 12:16 File: I:\Client\PolyMet_Mining\Work_Orders\Agency_Preferred_Alternative\Maps\Support_Document\Air\AERA\Mine_Site\Large Figure 4 General Locations for Maximum Modeled 1_Hour Mine Site Concentrations.mxd User: arm2

● Maximum Hourly Inhalation Concentration Receptors

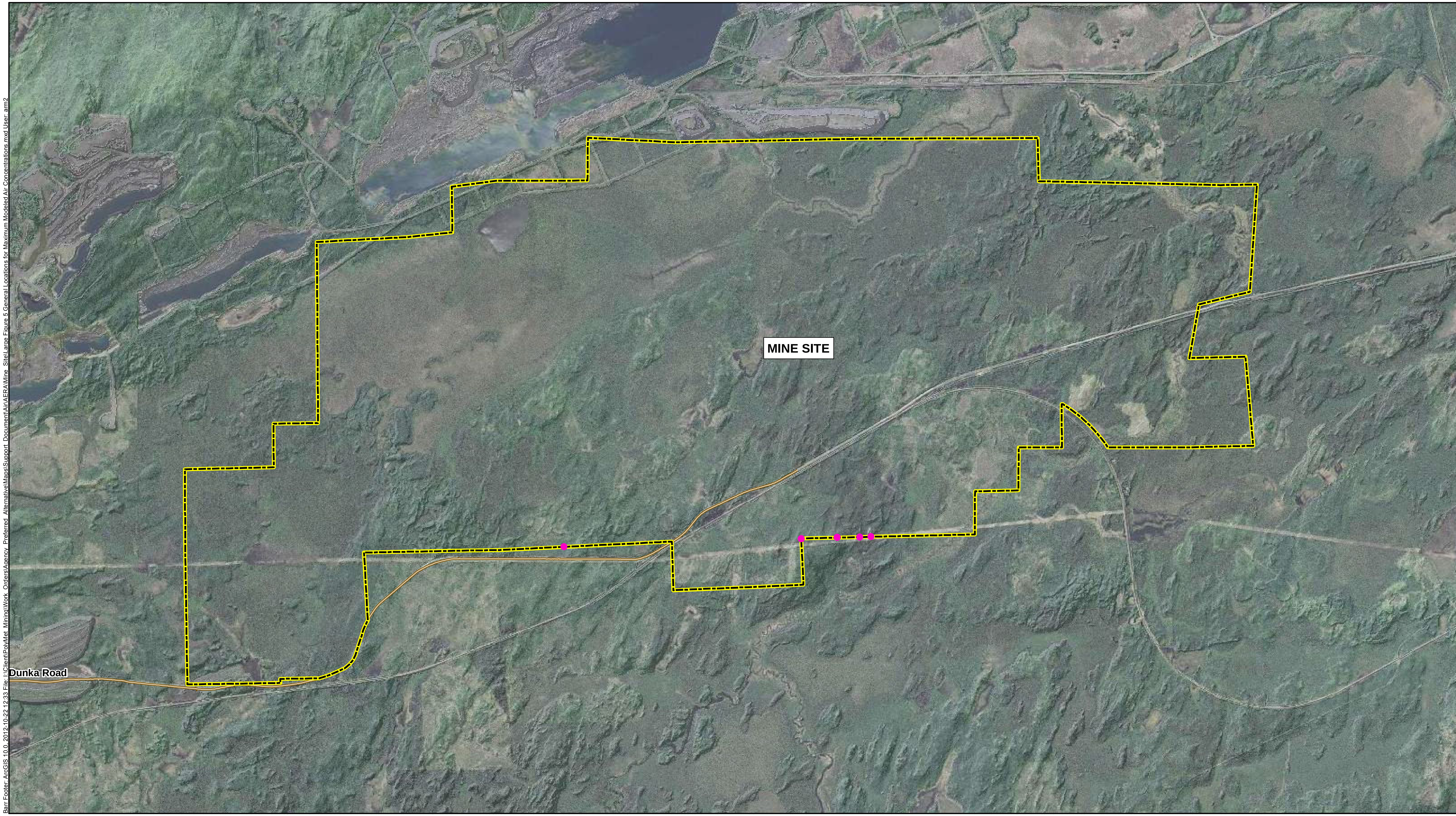
Ambient Air Boundary - Mine Site

N

0.5 0.25 0 0.5

Miles

Large Figure 4
GENERAL LOCATIONS FOR MAXIMUM MODELED 1-HOUR AIR CONCENTRATIONS AT THE MINE SITE FOR BOTH YEAR 8 AND YEAR 13 MINE LAYOUTS
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota



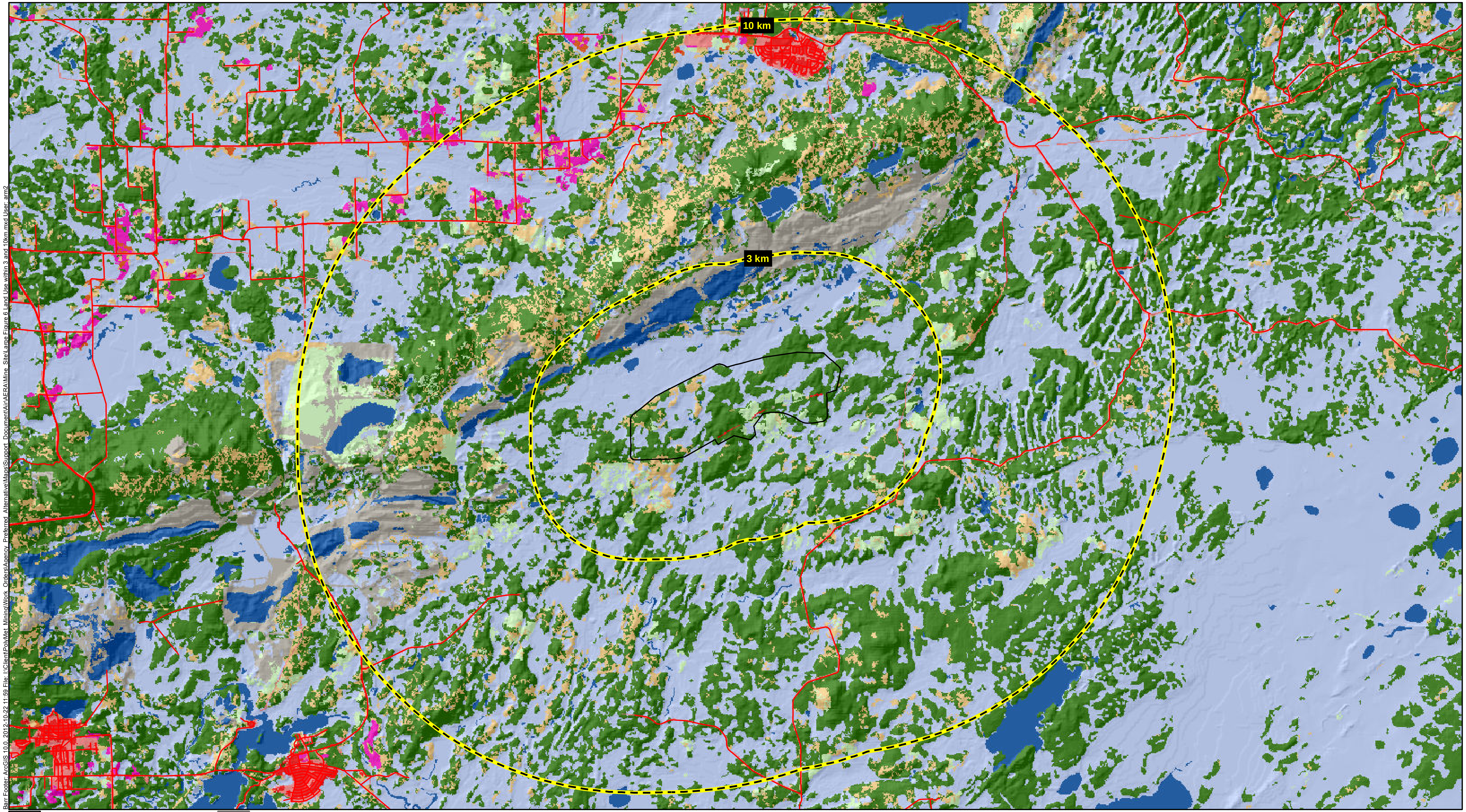
Maximum Annual Inhalation Concentration Receptors

Ambient Air Boundary - Mine Site

0.5 0.25 0 0.5

Miles

Large Figure 5
GENERAL LOCATIONS FOR MAXIMUM MODELED AIR CONCENTRATIONS AT THE MINE SITE FOR BOTH YEAR 8 AND YEAR 13 MINE LAYOUTS
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota



Mine Site

Land Cover*

- Barren Land (Rock/Sand/Clay)
- Cultivated Crops
- Forest
- Developed
- Developed Open Space
- Wetlands
- Grassland/Herbaceous
- Open Water
- Pasture/Hay
- Shrub/Scrub

*National Land Cover Dataset, 2006.

N

1.75 0.875 0 1.75

Miles

Large Figure 6
LAND USE WITHIN 3 AND 10 KM OF THE
NORTHMET PROJECT MINE SITE NEAR BABBITT, MN
NorthMet Project
Poly Met Mining, Inc.
Hoyt Lakes, Minnesota

Attachments

Attachment A

Multipathway Factors from the MPCA's Risk Assessment Screening Spreadsheet

Table A-1 Multipathway Factors from the MPCA's Risk Assessment Screening Spreadsheet

CAS number or MPCA number	Chemical Name	Farmer Noncancer	Farmer Cancer	Resident Noncancer	Resident Cancer
75-07-0	Acetaldehyde	0	0	0	0
0-00-2	Arsenic Compounds	2	4	1	1
7440-48-4	Cobalt	0	0	0	0
53-70-3	Dibenz[a,h]anthracene	0	5937	0	21
0-02-4	Diesel exhaust particulate	0	0	0	0
193-39-5	Indeno(1,2,3-cd)pyrene	0	1765	0	27
0-01-4	Manganese Compounds	0	0	0	0
0-01-5	Nickel Compounds	0	0	0	0
10102-44-0	Nitrogen oxide (NO2)	0	0	0	0
1175.00	Silica (crystalline, respirable)	0	0	0	0
00-09-1	TCDD Equivalents, 2,3,7,8-	419	200	9	2

Attachment B

Toxicity Assessment for Risk Driver Chemicals

B. Toxicity Assessment for Risk Driver Chemicals

B.1 Sources of Toxicity Values Used in the MPCA-RASS

The sources for the toxicity values used in this Supplemental 2012 AERA and their preferred order of use are shown in Table B-1.

Table B-1 Sources of Toxicity Values used in the MPCA 20120302 RASS

Source of Toxicity Value	Comments
Minnesota Department of Health (MDH) Health Based Values (HBVs)	MDH may issue HBVs that are guidance, that have not yet been promulgated in Minnesota Rules through rulemaking. These values may be incorporated in the AERA. MDH and MPCA agree to use guidance values before HRVs.
Minnesota Department of Health (MDH) - Health Risk Values (HRVs) and provisional and surrogate values	HRVs are values that MDH has promulgated through rulemaking and have been incorporated into Minnesota Rules. Values mainly based on USEPA RfCs with the possible addition of an uncertainty factor (s). Provisional and surrogate values lack the same level of confidence as the HRVs adopted via rulemaking.
USEPA Integrated Risk Information System (IRIS) RfCs, RfDs, Unit Risk Estimates	IRIS values have undergone technical review by USEPA's internal workgroup and external peer review and public comment.
California EPA-Office of Environmental Health Assessment (OEHHA) - Reference Exposure Levels (RELs)	RELs are derived for the California Hot Spots program and are derived in a manner similar to USEPA and have undergone internal and external review. However, draft RELs do not have the same level of confidence as adopted RELs.
USEPA Superfund Health Risk Technical Support Center – Provisional Peer Reviewed Toxicity Values (PPRTVs)(1)	PPRTVs are derived using methods similar to the USEPA IRIS program and are internally reviewed by two USEPA experts and three external experts. They do not receive the same multi-program consensus as do the USEPA IRIS values.

(1) In March 2012 the MPCA removed the USEPA's Health Effects Summary Tables (HEAST) database values and replaced them with the PPRTVs.

The methods used to derive the toxicity values (RELs, RfCs, RfDs, PPRTVs, and URs) use a dosimetric adjustment and generally assume exposure 24 hour/day, 365 days/year, for 70 years. This builds another level of conservatism into the health risk estimates.

B.2 Toxicity Information for Selected CFE

Chemicals potentially emitted from the Mine Site are primarily associated with particulate matter from loading, unloading and storage of either waste rock or ore, and emissions from unpaved roads and mine vehicle emissions. With few exceptions, conservative assumptions were used in assessing chemicals potentially emitted from the Mine Site thereby overestimating potential inhalation and multipathway risks.

B.2.1 Cobalt

Cobalt is a risk driver for cancer effects (chronic) via inhalation at the mine site property boundary for stockpile storage (Years 8 and 13). The calculated inhalation cancer risk is 3E-06 for both years. Cobalt is a new chemical for evaluation because a provisional value (PPRTV) was added to the RASS in March 2012. The toxicity values in the RASS are for cancer effects, and noncancer chronic effects

The PPRTV unit risk number for cancer is of particular interest with regards to the PolyMet Mine Site. The development of this factor is based on a principal study of inhalation effects on rats and mice (References (1) (2)(27)). Cobalt can exist in numerous forms (e.g. elemental cobalt, cobalt sulfate, cobalt ions, etc.). Cobalt metals and salts have been shown to be genotoxic in studies (Reference (3)). The study on which the PPRTV is based only investigated the soluble form of cobalt, cobalt sulfate heptahydrate. The solubility of cobalt sulfate heptahydrate (used in the critical study) ranged from 82.8-100% (i.e. very soluble).

Stopford *et al.* evaluated the bioaccessibility of different cobalt compounds in surrogate body fluids (e.g. interstitial fluid, lysosomal fluid, alveolar fluid, serum, synovial fluid, gastric juice, and intestinal juice) by determining it solubility (Reference (4)). Among the compounds evaluated by Stopford *et al.*, the cobalt compound tested that is most similar to that most likely associated with fugitive dust in the Mine Site rock was cobalt aluminum spinel. When cobalt aluminum spinel was dissolved in the surrogate body fluids, solubilities ranged from 0.006-0095% (i.e., not very soluble). This information indicates that the assumption of 100% bioavailability for cobalt is very conservative.

Although there is information on the carcinogenic mode of action, the derivation of the unit risk value for cobalt uses a linear extrapolation non-threshold approach to a zero exposure level (References (1) (2)). This is generally accepted methodology and is considered to provide a conservative estimate of the potential toxicity of the chemical (Reference (5)).

Further study of the carcinogenicity of cobalt and cobalt compounds indicates that a distinction between different compounds is required to account for the mechanism of toxicity (Reference (6). Although soluble cobalt has been linked to carcinogenic activity in animals, there is insufficient evidence of any carcinogenic activity for other cobalt compounds and insufficient evidence without confounding factors of any carcinogenic activity in humans (References (2) (6)).

The International Agency for Research on Cancer (IARC, 2005) evaluated the carcinogenic hazards of cobalt and cobalt compounds and concluded that:

- there is inadequate evidence in humans for the carcinogenicity of cobalt metal without tungsten carbide
- there is sufficient evidence in experimental animals for the carcinogenicity of cobalt sulfate

- there is sufficient evidence in experimental animals for the carcinogenicity of cobalt metal powder

Based on this data and data for other cobalt compounds, IARC concluded that “cobalt and cobalt compounds are possibly carcinogenic to humans (Group 2B).” The IARC 2B classification means there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. IARC goes on to state the following about chemicals in the 2B classification:

> It may also be used when there is *inadequate evidence of carcinogenicity* in humans but there is *sufficient evidence of carcinogenicity* in experimental animals. In some instances, an agent for which there is *inadequate evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals together with supporting evidence from mechanistic and other relevant data may be placed in this group. An agent may be classified in this category solely on the basis of strong evidence from mechanistic and other relevant data.

These findings suggest that the PPRTV used for carcinogenic cobalt toxicity as applied to the form of cobalt most likely present in fugitive dust at the Mine Site, is conservative and provides for an overestimation of potential risks.

B.2.2 Diesel Engine Exhaust/Diesel Particulate

On June 12, 2012, IARC classified diesel engine exhaust as a Group 1 carcinogen based on sufficient evidence in humans that exposure is associated with an increased risk for lung cancer. It had previously been classified as “probably carcinogenic to humans” (IARC Group 2A). Diesel particulate currently is not evaluated for carcinogenicity in the RASS. However, the constituents of diesel engine exhaust/diesel particulate such as arsenic, nickel, cobalt, dioxins/furans and PAHs are evaluated for potential health risks.

B.2.3 Dioxins/furans

The toxicity of dioxins/furans from the combustion of diesel fuel was evaluated on a Toxic Equivalency Quotient basis (TEQ) with 2,3,7,8 – TCDD as an index chemical. Emission factors were expressed on a grams Toxicity Equivalent Quotient (TEQ) per kilometer driven basis (g TEQ/km) (Reference (7)).This means that in terms of toxicological effects, the toxicity of all dioxins/furans are weighted as compared to the toxicity of 2,3,7,8-TCDD.

B.2.4 Nickel compounds

Nickel compounds are a risk driver for cancer effects (chronic) via inhalation at the mine site property boundary for in-pit storage (Year 13). The calculated risk is 1E-06. In the RASS, nickel compounds were evaluated using a cancer URE developed by the EPA-IRIS for nickel subsulfide in refinery dust. The carcinogenic potency of different nickel compounds varies significantly based on the solubility properties and speciation (Reference (8)). The Office of Environmental Health Hazard Assessment (OEHHA) in California, under the Hot Spots program, has established Guideline Reference Exposure Levels (RELs) of 0.2 µg/m3 for acute exposure and 0.014 µg/m3 chronic exposure for nickel and compounds (http://www.oehha.ca.gov/air/allrels.html). The estimated total maximum one-hour (acute) concentration of nickel in air at the PolyMet Mine Site property ownership boundary is 0.084 µg/m^3 (0.000084 mg/m^3). The estimated total maximum annual (chronic) concentration of nickel in air at the PolyMet Mine Site property ownership boundary is 0.0021 µg/m^3 (0.0000021 mg/m^3). Both the modeled maximum one-hour and annual concentrations are below their respective RELs.

B.2.5 Nitrogen oxides (NO_x and NO_2)

- NO_x emissions at the Mine Site are primarily from diesel engines. The Cal EPA-OEHHA 1 hour REL used in the AERA for NO_2 is 470 µg/m3. For this AERA the USEPA screening value of 75% has been applied to the NO_x maximum modeled one-hour air concentration and this adjusted air concentration. The USEPA screening value assumes that 75% of the NO emitted to air converts instantaneously to NO_2. This is a conservative estimate of potential risk because the USEPA (Reference (7)) identifies that almost all NO_x emissions from diesel engines is as NO and typically the conversion of NO to NO_2 is on the order of several hours to days (Reference (9). As described by the USEPA (Reference (7)):

- "... Emissions from combustion engines produce oxide of nitrogen (NO_x) primarily (at least initially) as NO. High combustion temperatures cause reactions between oxygen and nitrogen to form NO and some NO_2. Most NO_2 formed during combustion is rapidly decomposed to NO. NO_2 can also decompose to N_2 and O_2, but the rate of decomposition is very slow (References (10) (11)). Thus, almost all of the NO_x emitted from diesel combustion engines is NO…."

- As a comparison, the 1-hr National Ambient Air Quality Standard (NAAQ) is 188 µg/m3. AERMOD modeling for NAAQS 1-hour compliance indicates that conversion of NO to NO_2 is less than 10%. Facilities can model compliance with the NAAQS of 188 µg/m3, but have risks greater than acceptable guidelines when modeling the AERA with the higher toxicity value.

B.2.6 Persistent, Bioaccumulative, and Toxic Chemicals (PBTs)

The MPCA AERA defines PBT chemicals as per the "EPA PBT Profiler" and those chemicals on Lists I and II of Directive 2006/11/EC. In terms of persistence, MPCA uses the following definitions (as per the EPA PBT Profiler):

- air: $t_{1/2} > 2$ days = persistent

- water, soil sediment: $t_{1/2} \geq 60$ days = persistent, $t_{1/2} \geq 180$ days = very persistent

In terms of bioaccumulation, the MPCA uses the following bioconcentration factor (BCF) criteria (as per the EPA PBT Profiler):

- BCF $\geq$ 1000 = bioaccumulative, BCF $\geq$ 5000 = very bioaccumulative

The MPCA considered a substance to be PBT and carried it forward in subsequent analyses if the (Reference (12)):

- percent partitioning to water was greater than 10%, the half-life in water was greater than 60 days, and the BCF was greater than or equal to 1000,

- percent partitioning to soil was greater than 10%, the half-life in soil was greater than 60 days, and the BCF was greater than or equal to 1000, or

- percent partitioning to sediment was greater than 10%, the halflife in sediment was greater than 60 days, and the BCF was greater than or equal to 1000.

Pratt and Dymond (Reference (12)) state the following in regards to PBT chemicals:

> The PBT profiler does not handle metals and inorganic substances (hereafter referred to as metals). EPA classified some metals as PBTs under the Community Right to Know Act. A more comprehensive list of metals with potential PBT characteristics was adopted by the European Union. Metals from the MPCA's initial list of 315 substances that were also included in the EU list were carried forward in subsequent analyses in this study.

Table B-2 summarizes the CFEs, their sources and the toxic effects they are assessed for in the MPCA-RASS.

Table B-2 Summary Sources and Toxic Effects Evaluated of Compounds for Evaluation (CFEs) in the Supplemental AERA for the Mine Site.

Chemical	Potential Emission Source	Type of Chemical	Toxicity Effects to be Assessed				
			Inhalation			Multipathway	
			Acute	Non cancer chronic	Cancer	Non cancer chronic	Cancer
Acetaldehyde	Diesel Fuel burning engines (trucks, locomotive engines)	Volatile Organic Compound	X	X	X		
Arsenic compounds	Diesel Fuel burning engines (trucks, locomotive engines); airborne rock particles	Metal	X	X	X	X	X
Cobalt	Diesel Fuel burning engines (trucks, locomotive engines), airborne rock particles	Metal		X	X		
Crystalline Silica	Crushing of rocks	Particulate		X			
Dibenzo(a,h) anthracene	Diesel Fuel burning engines (trucks, locomotive engines)	PAH; (Semi-volatile compound)			X		X
Diesel exhaust particulate	Diesel Fuel burning engines (trucks, locomotive engines)	Particulate		X			
Dioxin/furans	Diesel Fuel burning engines (trucks, locomotive engines)	Dioxin/furans (Semi-volatile compound)		X	X	X	X
Indeno(1,2,3-cd)pyrene	Diesel Fuel burning engines (trucks, locomotive engines)	PAH (Semi-volatile compound)			X		X

Chemical	Potential Emission Source	Type of Chemical	Toxicity Effects to be Assessed				
			Inhalation			Multipathway	
			Acute	Non cancer chronic	Cancer	Non cancer chronic	Cancer
Manganese compounds	Diesel Fuel burning engines (trucks, locomotive engines), airborne rock particles	Metal		X			
Nickel compounds	Diesel Fuel burning engines (trucks, locomotive engines), airborne rock particles	Metal	X	X	X		
Nitrogen Oxides	Diesel Fuel burning engines (trucks, locomotive engines)	Gas	X				

Attachment C

Methodology and Assumptions used in Calculating Risk Estimates (RASS 20120302)

C. Methodology and Assumptions used in Calculating Risk Estimates (RASS 20120302)

C.1 Estimating Potential Incremental Inhalation Noncancer Risks

For each chemical to be evaluated, a noncancer risk is calculated in the MPCA-RASS by taking the ratio of the estimated dose (or the maximum modeled air concentration) to a toxicity reference value (TRV) for each chemical for evaluation. The resulting value is called the Hazard Quotient (HQ). The HQs for each chemical are then summed for all chemicals to calculate a Hazard Index (HI). The guideline value for comparison to estimated noncancer risks (HQ or HI) is one (1).

HQ = AIRc / TRV

Where: AIRc = modeled air concentration, typically a maximum value (µg/m^3)

TRV = Toxicity reference value (an HRV, REL, RfC or PPRTV) (µg/m^3)

$$HI = HQ_{\text{chemical 1}} + HQ_{\text{chemical 2}} + HQ_{\text{chemical 3}} \ldots$$

A conservative feature built into the RASS is that hazard quotients for noncarcinogens are summed regardless of toxic endpoint, with the resulting Hazard Index (HI) being reported in the RASS summary risk table. If the HQ or HI is greater than 1, there may be a greater concern for potential noncancer health effects and more refined analyses are needed. This does not mean that adverse effects will occur. Some factors to consider in a more refined analyses include determining the toxic endpoints for each chemical, the confidence level in the toxicity values (HRVs, RELs, RfCs, or PPRTVs), and any uncertainties in the derivation of the toxicity values. Most often the individual chemicals likely impact several different organs or systems and should not be summed together into one HI. The RASS does include a refined analysis that allow for summing the chemical HQs by specific target endpoints; an HI for each organ or system may be evaluated if the total noncancer risk is above the general guideline value. Typically when the HI is calculated by target endpoint, the individual target endpoint HI are lower than the when all HQs are summed regardless of toxic endpoint. In the case of this AERA, total noncancer risks are not above the MDH guideline values so the refined analysis is not used.

C.2 Estimating Potential Incremental Inhalation Cancer Risks

Maximum modeled annual ambient air concentrations were used to estimate the dose. The estimated dose was multiplied by the unit risk estimate to estimate potential cancer risks to an individual. Use of maximum modeled annual air concentrations results in an estimated cancer risk that represents the maximum possible risk for that specific chemical. The MDH guideline for acceptable cancer risks is a risk level of 1 in 100,000 (1E-5).

Estimated Cancer Risk = Unit Risk (µg/m3)-1 * AIRc

Where: AIRc = modeled air concentration, typically a maximum (µg/m^3)

To estimate chemical specific potential cancer risk under the MEI exposure concept, maximum values for exposure point concentrations and exposure conditions were used. Combining maximum exposure point concentrations with upper-bound toxicity values, results in a potential cancer risk estimate that may be thousands of times greater than those for the average exposed individual. While such maximum exposure conditions are individually possible when considered alone, a combination of these conditions is not likely to occur in an actual population. The estimated potential cancer risk for the MEI exposure conditions developed in the AERA represents a theoretical upper-bound risk that would not likely occur in the actual population.

C.3 Estimating Potential Incremental Non-Inhalation (Multipathway) Risks

Chemicals emitted to the atmosphere may be deposited on soils and surface water and may subsequently enter the terrestrial and aquatic food chain that may lead to indirect human exposures from eating contaminated food. The purpose of the screening level multipathway analysis is to evaluate the potential for adverse human health effects associated with indirect exposure (ingestion) to chemicals potentially emitted from the proposed project.

Multipathway screening factors (MPSF) were developed by the MPCA for chemicals identified as being persistent or bioaccumulative in the environment, or toxic (PBT). Within the MPCA-RASS spreadsheet, for each type of receptor (e.g. resident, farmer), ingestion risks (i.e., indirect risk by the non-inhalation pathway) are estimated by multiplying a chemical's chronic screening inhalation HQ and/or screening inhalation cancer risk by the MPSF.

Ingestion (non-inhalation) risk, Chemical_A = Noncancer Chronic Inhalation risk * MPSF

Ingestion (non-inhalation) risk, Chemical_A = Cancer Inhalation risk * MPSF

For each chemical and receptor type, inhalation and ingestion (non-inhalation) risks are then summed for a chemical (HQs for noncancer chronic; cancer risks) to derive a "total" noncancer and/or cancer risk (see the RiskCalcs worksheet in the RASS). The individual chemical risks are then summed to derive a TOTAL cancer risk (all chemicals) and a TOTAL HI for each receptor type.

The multipathway screening factors were derived by the MPCA with the Industrial Risk Assessment Protocol (IRAP; multipathway risk model) using generic input parameters to calculate inhalation and indirect exposure risk for specific chemicals (Reference (13) (12)). The MPSF is the ratio of the maximum estimated risk from the ingestion exposure route to the maximum estimated risk from the inhalation exposure route (References (14) (15) (12)). The method used by the MPCA to derive the chemical-specific MPSF has not undergone widespread scientific review. The reliability and applicability of the method to site-specific analyses is uncertain. Therefore uncertainty is associated with the results of the multimedia analysis presented in this report. Based on the information available from the MPCA (Reference (13) (12)) regarding the multipathway screening factors, it is highly likely that potential risks are conservative and overestimate any potential risks.

C.4 Additional Risk Calculation Information and Assumptions

C.4.1 Calculation of the hazard index for 1- hour acute inhalation: The ratio of the hourly maximum modeled air concentration in any location to the toxicity value in the RASS (e.g., HBV, HRV, RfC) is used to calculate the hazard quotient. Summed hazard quotients are used to calculate the hazard index to assessed total potential risks. Toxicity endpoint: non-cancer effects only.

C.4.2 Calculation of the hazard index for annual (chronic) inhalation non-cancer health effects: The ratio of the annual maximum modeled air concentration to the toxicity values in the RASS (e.g., HBV, HRV, RfC) is used to calculate a hazard quotient (and summed for a hazard index). No adjustments to the maximum modeled air concentration are made in the AERA. An exposure concentration (EC) is not calculated using the maximum modeled air concentration. This means no adjustments to the maximum modeled air concentration are made to account for exposure frequency (EF), exposure time (ET), or exposure duration(ED), or averaging time (AT). It is assumed toxicity values in the RASS (e.g., HBV, HRV, RfC) are for chronic durations.

C.4.3 Calculation of the cancer risk estimate for annual (chronic) inhalation: The product of the annual maximum modeled air concentration and the Inhalation Unit Risk (IUR) in the RASS is used to calculate the cancer risk estimate. Again, No adjustments to the maximum modeled air concentration are made in the AERA to calculate an exposure concentration (EC) to account for exposure frequency (EF), exposure time (ET), or exposure duration (ED), or averaging time (AT). EPA defines the Inhalation Unit Risk (IUR) as "the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent via inhalation per µg/m3 over a lifetime." Use of the IUR is the only place in the calculation, which accounts for exposure over a lifetime (assumes continuous exposure over 70 year lifetime).

C.4.4 Calculation of the hazard index for annual (chronic) multipathway resident non-cancer-inhalation: Potential multipathway exposure risk is the sum of the chronic inhalation risk +chronic ingestion risk via food consumption. The chronic inhalation non-cancer risk is calculated as described in B.4.2 above and is based on the annual maximum modeled air concentration.

C.4.5 Calculation of the cancer risk estimate for Annual (chronic) multipathway resident inhalation: Again, potential multipathway exposure risk is the sum of the chronic inhalation risk +chronic ingestion risk via food consumption. The chronic inhalation cancer risk is calculated as described in B.4.3 above and is based on the annual maximum modeled air concentration and is the inhalation component of the multipathway calculation. The cancer chronic inhalation risk is not adjusted because the assumption would be a 70-year exposure duration divided by a 70 year averaging time-which equals 1 (Reference (12)).

C.4.6 Calculation of the hazard index for annual (chronic) multipathway resident non-cancer-ingestion:
The chronic inhalation hazard quotient/index for non-cancer risk is calculated as described in B.4.2 above and is based on the annual maximum modeled air concentration. To account for potential ingestion risk, the hazard index is multiplied by a Multipathway Screening Factor (MPSF) derived for resident non-cancer risks. The MPSFs for non-cancer effects was derived by the MPCA as outlined in Reference (12).

C.4.7 Calculation of the cancer risk estimate for annual (chronic) multipathway resident - ingestion: The chronic inhalation cancer risk is calculated as described in B.4.3 above and is based on the annual maximum modeled air concentration. The multipathway ingestion risk was calculated by taking the calculated chronic inhalation cancer risk (in B.4.3 above) and multiplying it by the derived MPSF. The MPCA derived the MPSF for cancer endpoints by using IRAP-h to calculate potential ingestion and inhalation risks. The MPSF is the ratio of the ingestion risk to the inhalation risk. In the derivation of the MPSF, the MPCA adjusted the calculated inhalation risk to account for a 30-year exposure duration (ED) for a resident over a 70-year averaging time (AT). This is where the 30-year exposure duration over an averaging time of 70 years is incorporated into the ingestion portion of the multipathway risk.

C.4.8 Calculation of the hazard index for annual (chronic) multipathway farmer non-cancer-ingestion: The chronic inhalation hazard quotient/index non-cancer risk is calculated as described in B.4.2 above and is based on the annual maximum modeled air concentration. To account for potential ingestion risk, this hazard quotient is multiplied by a Multipathway Screening Factor (MPSF) derived for farmer non-cancer risks. The MPSFs for non- cancer effects were derived by the MPCA as outlined in Reference (12).

C.4.9 Calculation of the cancer risk estimate for annual (chronic) multipathway farmer - ingestion: The chronic inhalation cancer risk is calculated as described in B.4.3 above and is based on the annual maximum modeled air concentration. The multipathway ingestion risk was calculated by taking the calculated chronic inhalation cancer risk (in B.4.3 above) and multiplying it by the derived MPSF. The MPCA derived the MPSFs as described in B.4.7 above. In the derivation of the MPSF for the farmer, the MPCA adjusted the calculated inhalation risk to account for a 40-year exposure duration (ED) over a 70-year averaging time (AT). This is where the 40 exposure duration over an averaging time of 70 years is incorporated into the ingestion portion of the multipathway risk.

Attachment D

Individual Pollutant Risk Estimates from the MPCA's Risk Assessment Screening Spreadsheet

Table D-1 Inhalation Risk at the Mine Site Ownership Boundary for Year 8 (Stockpile Storage Mine Phase)

cas # or MPCA #	Chemical Name	Inhalation Screening Hazard Quotients and Cancer Risks for Individual Substances			
		Acute	Subchronic Noncancer	Chronic Noncancer	Cancer
Total		**7.1E-01**		**2.4E-01**	**4.9E-06**
75-07-0	Acetaldehyde	2.5E-06		4.8E-08	9.6E-13
0-00-2	Arsenic Compounds	3.1E-02		9.5E-03	6.1E-07
7440-48-4	Cobalt			6.3E-02	3.4E-06
53-70-3	Dibenz[a,h]anthracene				3.7E-09
0-02-4	Diesel exhaust particulate			5.3E-02	
193-39-5	Indeno(1,2,3-cd)pyrene				4.0E-10
0-01-4	Manganese Compounds			6.3E-02	
0-01-5	Nickel Compounds	7.6E-03		3.0E-02	7.2E-07
10102-44-0	Nitrogen oxide (NO2)	6.7E-01			
1175	Silica (crystalline, respirable)			2.0E-02	
00-09-1	TCDD Eqivalents, 2,3,7,8-			1.1E-05	1.8E-07

Table D-2 Inhalation Risk at the Mine Site Ownership Boundary for Year 13 (In-Pit Storage Mine Phase)

cas # or MPCA #	Chemical Name	Inhalation Screening Hazard Quotients and Cancer Risks for Individual Substances			
		Acute	Subchronic Noncancer	Chronic Noncancer	Cancer
Total		**8.4E-01**		**2.2E-01**	**4.8E-06**
75-07-0	Acetaldehyde	2.5E-06		5.1E-08	1.0E-12
0-00-2	Arsenic Compounds	3.3E-02		7.6E-03	4.9E-07
7440-48-4	Cobalt			5.8E-02	3.1E-06
53-70-3	Dibenz[a,h]anthracene				2.6E-09
0-02-4	Diesel exhaust particulate			3.7E-02	
193-39-5	Indeno(1,2,3-cd)pyrene				2.8E-10
0-01-4	Manganese Compounds			5.1E-02	
0-01-5	Nickel Compounds	5.7E-03		4.2E-02	1.0E-06
10102-44-0	Nitrogen oxide (NO2)	8.0E-01			
1175	Silica (crystalline, respirable)			1.9E-02	
00-09-1	TCDD Eqivalents, 2,3,7,8-			8.0E-06	1.3E-07

Table D-3 Multipathway Farmer and Resident Risk at the Mineral Mining/Industrial District Boundary for Year 8 (Stockpile Storage Mine Phase)

cas # or MPCA #	Chemical Name	Chronic Screening Total Hazard Quotients and Cancer Risks (Inhalation + Non-inhalation) for Individual Substances			
		Farmer Noncancer	Farmer Cancer	Resident Noncancer	Resident Cancer
Total		4.0E-02	1.4E-05	3.7E-02	7.6E-07
75-07-0	Acetaldehyde	9.8E-09	1.9E-13	9.8E-09	1.9E-13
0-00-2	Arsenic Compounds	5.5E-03	5.9E-07	3.7E-03	2.4E-07
7440-48-4	Cobalt	5.3E-03	2.8E-07	5.3E-03	2.8E-07
53-70-3	Dibenz[a,h]anthracene		5.2E-06		1.9E-08
0-02-4	Diesel exhaust particulate	1.1E-02		1.1E-02	
193-39-5	Indeno(1,2,3-cd)pyrene		1.7E-07		2.6E-09
0-01-4	Manganese Compounds	1.1E-02		1.1E-02	
0-01-5	Nickel Compounds	4.2E-03	1.0E-07	4.2E-03	1.0E-07
10102-44-0	Nitrogen oxide (NO2)				
1175	Silica (crystalline, respirable)	1.8E-03		1.8E-03	
00-09-1	TCDD Eqivalents, 2,3,7,8-	1.0E-03	7.7E-06	2.4E-05	1.1E-07

Table D-4 Multipathway Farmer and Resident Risk at the Mineral Mining/Industrial District Boundary for Year 13 (In-Pit Storage Mine Phase)

cas # or MPCA #	Chemical Name	Chronic Screening Total Hazard Quotients and Cancer Risks (Inhalation + Non-inhalation) for Individual Substances			
		Farmer Noncancer	Farmer Cancer	Resident Noncancer	Resident Cancer
Total		4.2E-02	1.3E-05	3.9E-02	8.2E-07
75-07-0	Acetaldehyde	1.0E-08	2.1E-13	1.0E-08	2.1E-13
0-00-2	Arsenic Compounds	5.6E-03	6.1E-07	3.8E-03	2.4E-07
7440-48-4	Cobalt	6.0E-03	3.2E-07	6.0E-03	3.2E-07
53-70-3	Dibenz[a,h]anthracene		5.1E-06		1.9E-08
0-02-4	Diesel exhaust particulate	1.0E-02		1.0E-02	
193-39-5	Indeno(1,2,3-cd)pyrene		1.6E-07		2.6E-09
0-01-4	Manganese Compounds	1.1E-02		1.1E-02	
0-01-5	Nickel Compounds	5.4E-03	1.3E-07	5.4E-03	1.3E-07
10102-44-0	Nitrogen oxide (NO2)				
1175	Silica (crystalline, respirable)	2.2E-03		2.2E-03	
00-09-1	TCDD Eqivalents, 2,3,7,8-	9.3E-04	7.1E-06	2.2E-05	1.1E-07

Attachment E

Sources of Uncertainty Specific to the Supplemental Mine Site AERA

E. Sources of Uncertainty Specific to the Supplemental Mine Site AERA

E.1 Uncertainty Specific to this Supplemental AERA

E.1.1 Emission Calculations

Numerous factors contribute to uncertainty in estimating emissions from the Mine Site.

- Use of EPA emission factor for dioxins/furans from tunnel studies performed in 1996-1998 (References (16) (17)).
- Use of AP-42 emission factors for PAHs derived from data in 1990 report that studied a single uncontrolled diesel engine (Reference (18)). As of 2012, the diesel standard for all large refiners and importers is ultra-low sulfur diesel, or a maximum of 15ppm sulfur.
- Lack of emission factors specifically for estimating dioxin/furan emissions from locomotives. The dioxin emission factors used for heavy duty diesel vehicles discussed above (References (16) (17)) were applied to locomotives on a fuel-usage basis. Locomotives are also subject to the same diesel fuel requirements as heavy duty off road vehicles.
- Upper end values (e.g. 99th percentile and 95% UCL) for metals concentrations assumed for different rock types and worst case material assumed where multiple materials are possible.
- Metals emission from fugitive dust are based on total PM emissions, not an estimate of inhalable fraction.

E.1.2 Exposure Assessment

The following assumptions contribute to conservatism in the exposure assessment:

- Use of only the maximum modeled air concentrations as the dose (MEI exposure)
- The assumption that the metal emissions (cobalt, nickel, manganese) from fugitive sources are in the ionic form, are all respirable and 100% bioavailable.
- The assumption that 80% of the NO emitted to air converts instantaneously to NO_2.

E.1.3 Toxicity Assessment

The following assumptions contribute to uncertainty in the toxicity assessment:

- Calculating risks using surrogate toxicity values to represent chemical mixtures. See Section 9.4.1 for a more complete discussion.

- Differences in the chemical species emitted from the proposed Mine Site operations, and the chemical species used in specific toxicity studies.
- Extrapolation from high dose, exposures in the experimental study to estimate effects in humans following longer-term exposure encountered in the environment to derive toxicity values.
- Use of adverse effects data available for the most sensitive laboratory animal species to derive toxicity values.
- Extrapolation from animal studies to humans for toxicity values.
- The use of dose-response data from one route of exposure to estimate effects from exposure via different routes for toxicity values.
- The variability in the quality of the studies upon which the toxicity values are based.

The lack of available information addressing synergism and/or antagonism. Toxicological interactions between multiple chemical exposures can occur. These potential interactions were not specifically addressed in the AERA. These interactions may result in greater (synergistic) or lesser (antagonistic) effect than the effect of each individual chemical. A significant source of uncertainty is inherent in the derivation of USEPA, MDH, Cal EPA-OEHHA, and Superfund toxicity values for chemicals (Reference (19)). This uncertainty is typically addressed by use of uncertainty factors or modifying factors in deriving a toxicity value and its use in estimating potential risks. It can be challenging to find toxicological data that is based on human exposures that can be appropriately used in a health risk assessment. Most toxicological data based on human exposures comes from epidemiological studies based on occupational exposures. Even though data from occupational human exposures is generally considered more relevant than animal data, occupational exposures are usually higher than environmental exposures. Given this lack of human data, toxicologists rely on data from animal studies or other *in vitro* tests. In developing these dose-response values, USEPA currently uses conservative assumptions to assure that the toxicity value is conservative and that the resultant risk estimate is more likely to overestimate risk than underestimate risk. USEPA applies these conservative assumptions for the development of both URs and RfCs.

E.1.3.1 Non-Carcinogenic Toxicity Values-Uncertainty

Because appropriate human exposure data are rarely available, alternative methods are used to estimate dose-response values that are not likely to cause adverse health effects. The methods currently employed by the USEPA, Cal EPA-OEHHA, and the MDH to develop dose-response values do not allow for an assessment of the likelihood that effects will occur, nor allow an assessment of the severity of the effects in an exposed individual or population. Sources of uncertainty in the development of noncarcinogenic inhalation toxicity values (HRVs, RfCs, RELs, PPRTVs) include:

- Extrapolation from high dose, short-term exposures in the experimental study to estimate effects following longer-term exposure encountered in the environment.

- Use of adverse effects data available for the most sensitive laboratory animal species.

- Extrapolation from animal studies to humans.

- The use of dose-response data from one route of exposure to estimate effects from exposure via different routes.

- The variability in the quality of the studies upon which the toxicity values are based.

- Lack of consideration of toxicological interactions (i.e. synergism, antagonism, potentiation, additivity) between multiple chemicals.

E.1.3.2 Carcinogenic Toxicity Factors-Uncertainty

The toxicological database used for developing inhalation unit risk estimates is also a source of uncertainty. The USEPA outlined some of the sources of uncertainties in its *Guidelines for Carcinogen Risk Assessment* (References (20) (21)) and they include:

- Extrapolation from high to low doses and from animals to humans and species, gender age, and strain differences in uptake, metabolism, organ distribution and target site susceptibility.

- Assumption that cancer induction is a “non-threshold” event because it is believed that any level of exposure, however small, poses a finite probability of generating a carcinogenic response (22).

Other sources of uncertainty include:

- Classification of chemicals as either EPA Group A or B carcinogens even if there is just one positive finding of tumors in one laboratory experiment. This one finding is given more weight than any number of negative findings in studies of equal quality.

- The assumption that substances that have been found to be carcinogenic in some animal species means they are likely carcinogenic in humans.

- Cal EPA-OEHHA’s use of oral studies to derive inhalation UR values for some chemicals. For example, the UR for dibenzo(a,h)anthracene is based on data derived from oral studies. The derived oral slope factor (SF) was then converted to a UR by assuming a body weight of 70 kg and an inhalation rate of 20 m^3 per day.

- Cal EPA-OEHHA's assumption that URs for inhalation have the same relative activities as cancer potencies for oral intake (Reference (22)). The route of administration may have an impact on the absorption, distribution, metabolism, excretion, and mode of action of the chemical.

E.1.4 Conservatism/Uncertainty in Risk Characterization

To develop a cancer risk estimate associated with exposure to multiple chemicals identified by USEPA as carcinogens, the chemical specific cancer risk estimates were summed in accordance with MPCA and USEPA guidance. USEPA recognizes that there are several limitations associated with this approach. For chemicals where the UR is based on the upper 95th percentile of the probability distribution, addition of these percentiles may become progressively more conservative as risks from a number of carcinogens are summed (Reference (19)). In addition, the following procedures and assumptions result in an additional level of conservatism in the cancer risk estimates:

- In summing the cancer risk, equal weight was given to all chemicals regardless of their classification (class A = known human carcinogen, class B = probable human carcinogen, class C = possible human carcinogen).

- Cancer risk values derived from animal studies were given equal weight to values based on human data.

- Carcinogenic responses arising in the same tissue should, according to USEPA, be considered additive unless the mechanism of carcinogenicity is unrelated. The chemicals identified by USEPA as potential carcinogens varied in target tissue. In the AERA, cancer risks were summed regardless of the difference in their mode of action or target tissue. In general, the assumption of additivity is expected to be conservative (Reference (20)).

Attachment F

Attachment References

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