Cumulative Impacts Analysis

Local Mercury Deposition and Bioaccumulation in Fish

NorthMet Project

Prepared for
PolyMet Mining Inc

July 2012

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Table of Contents

List of Tables

List of Figures

List of Appendices

1 Introduction and Summary

PolyMet Mining Inc. (PolyMet) plans to construct and operate a mine near the town of Babbitt, MN, to reactivate portions of the LTV Steel Mining Company (LTVSMC) Taconite Processing Plant and Tailing Basin near Hoyt Lakes, MN, and to build a hydrometallurgical concentrate processing facility at the former LTVSMC site (Plant Site). The proposed project is referred to as the NorthMet Project (Project). The project description is provided in the March 2011 Draft Alternative Summary for the NorthMet Project environmental impact statement and the NorthMet Project Description Version 3 Submitted September 13, 2011.

This report is an updated assessment of the cumulative effects of mercury deposition on nearby lakes, as required for the Supplemental Environmental Impact Statement (SDEIS). Therefore, this assessment not only takes into account the potential impacts of the Project, but also that of other past and "reasonably foreseeable" projects in the area. In this case, the only "reasonably foreseeable" project in the area with appreciable mercury emissions is the recently constructed Mesabi Nugget Large Scale Demonstration Plant (LSDP).

This document is 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 Project Air Data Package will be resolved in favor of this document.

Based on the approved Minnesota Pollution Control Agency (MPCA) screening-level model, the mercury emissions from these two projects would, at most, increase mercury concentrations in the fish in the nearest lakes from between 0.3 percent to 1.8 percent over current levels. (The current levels of mercury in the fish in selected nearby lakes already exceed the levels that trigger a fish-consumption advisory.) These results do not account for emission reductions due to mercury emissions from coal-fired power plants and taconite plants in the area, which are targeted to be reduced by 75 percent by 2025 under the MPCA's current Statewide Mercury TMDL implementation strategy.

2 Statewide Mercury Total Maximum Daily Load

Many lakes throughout the United States have elevated concentrations of mercury in fish, including lakes in northern Minnesota. As a result, the Minnesota Department of Health issues fish consumption advisories for contaminated lakes that recommend limits on the amount and types of fish that can be safely eaten. These fish consumption advisories, in turn, trigger federal regulatory requirements intended to reduce the mercury contamination in these lakes. In Minnesota, the MPCA has recently developed a federally-approved long-term plan to help eliminate, or at least reduce, these mercury impairments. The MPCA plan is called a total maximum daily load (TMDL) plan. The U.S. Environmental Protection Agency (EPA) approved the MPCA Statewide Mercury TMDL (TMDL) in March, 2007. The TMDL is focused on reducing overall state emission rates. The TMDL plan includes a statewide goal of reducing total statewide mercury emissions to 789 pounds per year by 2025 (MPCA 2007).

More recently, the MPCA approved a *Strategy Framework for Implementation of Minnesota's Statewide Mercury TMDL*." This framework establishes various reduction targets, including one for taconite facilities that would reduce their overall emissions by 75 percent by the year 2025 (MPCA 2008a). Requirements are also included for new and expanding sources of mercury emissions.

2.1 Mercury Species

Minnesota's mercury TMDL includes extensive background on the chemistry, transport and environmental fate of mercury in the environment. In summary, the rate at which mercury is deposited after being emitted depends greatly on the type (or species) of mercury emitted. The common forms of mercury emissions are elemental (Hg (0)), oxidized (Hg (II)) and particle bound (Hg (p)). Most of the mercury in the atmosphere is elemental mercury, and being insoluble, it does not readily deposit after being emitted (EPA, 2006). Oxidized mercury, on the other hand, is water soluble and can deposit readily at the local and regional level (EPA 2006). Some particle-bound mercury may be deposited locally near an emission source as well. Therefore, local deposition of mercury is a greater concern for facilities that emit oxidized or particulate forms of mercury.

The elemental form of mercury, however, enters the global mercury pool and eventually re-deposits somewhere in the world in rain or through "dry deposition." Mercury sources both regional and throughout the world contributes to this global pool. This is why, even in the most remote areas, there can be elevated mercury levels in soils, water and fish.

2.2 St. Louis River Toxics TMDL

The St. Louis River is an important fishery and natural resource for the region. Many lakes in the St. Louis River watershed are included in the statewide mercury TMDL. The St. Louis River itself, however, is not included in the statewide TMDL. This is because to include a lake or river the MPCA must show that fish-tissue concentrations would be calculated to be below the statewide criterion of 0.2 milligrams of mercury per kilogram fish (mg/kg) if the stated emission reductions are achieved. The monitored fish-mercury concentrations in the St. Louis River currently exceed the threshold value (0.572 mg/kg) that would allow it to reach the 0.2 mg/kg criterion if the mercury reductions planned under the current statewide TMDL plan were achieved (MPCA 2007).

Therefore, a separate St. Louis River "toxics" TMDL process has been initiated recently by the U.S. Environmental Protection Agency. Other partners include the states (Wisconsin, Minnesota), the Fond du Lac Band, and other groups. The models being considered for this effort—such as the Watershed Analysis Risk Management Framework (WARMF) model—require considerably more data to assess the major inputs and processes for the St. Louis River TMDL than are currently available. The EPA contractor's work to date on the St. Louis River TMDL has been focused on model development, verifying current data, and identifying data gaps.

3 Modeling Approach and Assumptions

The link between the mercury emissions from a specific air pollution source and the mercury that accumulates in the fish in a specific lake is complex and not completely understood. In the absence of a generally applicable, validated model that accurately incorporates the complexities of atmospheric chemistry, watershed transport, methylation, and bioaccumulation in fish, the MPCA recommends using a simplified screening method called the Minnesota Mercury Risk Estimation Method (MMREM) (MPCA 2006). This method consists of using the standard air dispersion model AERMOD to assess local mercury air concentrations and a MPCA-developed screening-level spreadsheet model to assess how much of this mercury might accumulate in fish in nearby lakes. The underlying assumptions used in the MMREM are summarized below in Section 3.1.

This section of the report summarizes the inputs used to assess the impacts of the Project and the other nearby projects. The section is divided into the following subsections:

3.1 MPCA Mercury Risk Estimation Method

The November 2008 version of the MMREM spreadsheet was used for this analysis. The MMREM method assumes that there is a linear relationship between the atmospheric mercury deposition rate in a given lake and fish tissue methyl-mercury concentrations. Instead of trying to model the ratio of mercury loading to a lake and how much bioaccumulates in the fish in that lake, it uses fish data from lakes near new emission sources to determine that ratio. That ratio is then used to predict the impact of increased mercury loading from proposed new nearby mercury emission source(s). The basic approach of MMREM is very similar to how the USEPA assessed the impact of mercury emissions from electric utilities on mercury in fish in a 2011 technical support document, accessible at http://www.epa.gov/mats/pdfs/20111216MercuryRiskAssessment.pdf. The MMREM also estimates a potential incremental change in fish mercury concentrations and incremental hazard quotients for a recreational angler and a subsistence angler.

Major inputs to the MMREM spreadsheet include: (1) modeled mercury air concentration over the surface of a water body and its direct drainage watershed, respectively, (2) background mercury deposition, and (3) background fish mercury concentrations.

3.2 Emission Source Selection

Any impact on nearby lakes due to mercury emissions from existing stationary sources is already reflected in background fish concentrations. Therefore, the cumulative effects modeling is only needed to determine the potentially overlapping impacts of the Project with recent or proposed nearby projects that could affect the same lakes.

The modeling for this analysis included the emissions from the Project and any other “reasonably foreseeable” projects located within 25-kilometers. The 25-kilometer distance was selected because projected emissions from new facilities that are more than 25-kilometers from the Plant Site are not expected to contribute significantly to modeled air concentrations within the modeling domain. This assumption is based largely on generic AERMOD modeling done for the Keetac Expansion Project. That modeling showed that mercury air concentrations drop by an order of magnitude—to less than 0.25% of background concentrations—within 10 kilometers from the emission source. Based on this analysis, it is assumed that mercury emissions from the Project could only significantly increase mercury deposition on local lakes that are within a 10-kilometer radius of the Plant Site. Similarly, the zone of local impact from any other nearby recent or planned projects would be about 10-kilometers. Therefore, for an overlapping (cumulative) impact to occur, the other source would have to be within 20-kilometers of the Plant Site. See Figure 1. The addition of a 5-kilometer “buffer” results in a total distance of 25-kilometers.

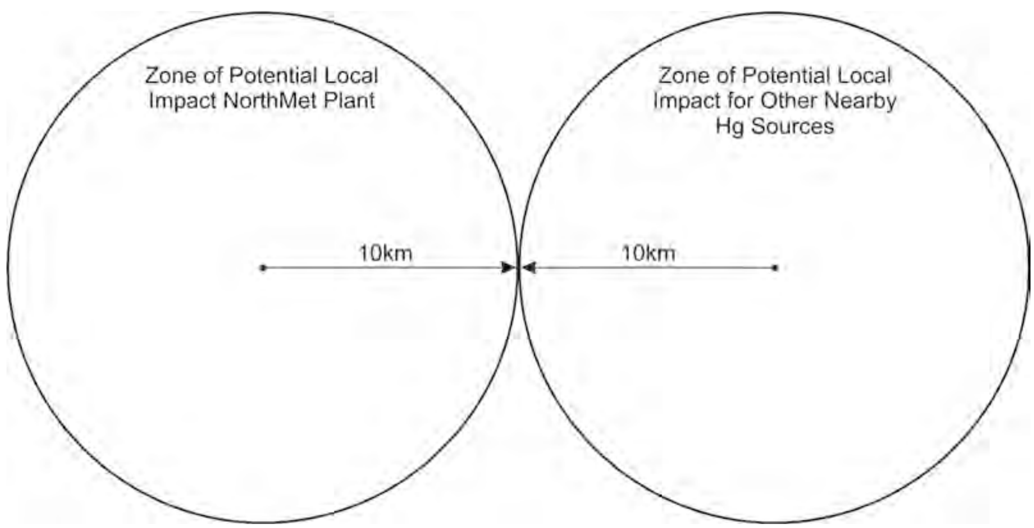


Figure 1   Illustration of 20-kilometer distance to potential overlapping local mercury sources

The only “reasonably foreseeable” project in the area with appreciable mercury emissions is the Mesabi Nugget LSDP, at an estimated 75 pounds per year. The other potential projects in the area either have minimal emissions (less than one pound per year), or have been canceled. For example, the potential mercury air emissions from the Mesabi Mining Project (mining, ore crushing and concentrating) and the Mine Site are less than one pound per year. Likewise, permitted emissions from the Cliffs Erie Pellet Yard are minimal. The small amount of mercury emitted would be as mineral particles, which would not be readily bioavailable. Finally, any local deposition due to emissions from Minnesota Power's nearby Laskin Energy Center is already reflected in existing background fish-mercury concentrations.

Therefore, the following two projects are included in this cumulative mercury deposition analysis:

- NorthMet (Plant Site): approximately 4 pounds per year
- Mesabi Nugget LSDP: approximately 75 pounds per year (air permit limit)

3.3 Lake Selection

Five area lakes were selected for the analysis:

- Heikkilla Lake, part of the Embarrass River watershed
- Sabin Lake, part of the Embarrass River watershed
- Wynne Lake, part of the Embarrass River watershed
- Colby Lake, part of the Partridge River watershed
- Whitewater Lake, part of the Partridge River watershed

The location of these lakes is shown in Figure 2, below. Three of the lakes (Heikkilla, Colby, and Whitewater) are located within 10 km of the Plant Site. The two remaining lakes (Wynne and Sabin) are approximately 12 kilometers from the Plant Site. Because Heikkilla Lake, Sabin Lake and Wynne Lake are all part of the Embarrass River watershed, the watershed area for Sabin Lake includes Heikkilla Lake and its watershed. In turn, the watershed for Wynne Lake includes both of the other two lakes and their watersheds. Lake surface area and watershed areas have been calculated using GIS applications and are listed in Table 1.

Table 1 Lake and Watershed Areas Identified for Inclusion in the Cumulative Mercury Deposition Analysis to be Conducted for the Project

Lake	Lake Area (acres)	Watershed Area (excludes lake area) (acres)
Heikkilla Lake [1,3]	128	1,350
Colby Lake [2,3]	502	99,890
Sabin Lake [3]	299	121,370
Wynne Lake [2,3]	289	123,600
Whitewater Lake [4]	1,215	3,050 [5]

[1] Barr Engineering, ArcMap, version 9.3, service pack 1, using NED 10m elevation dataset from USGS. In the March 2007 AERA for the Plant Site, the local mercury deposition analysis identified a surface area of 129 acres for Heikkilla Lake, and a watershed area of 1,028 acres. Because most of the watershed is bog, interpreting the true extent of the direct drainage

watershed using visual techniques (March 2007 AERA) versus GIS tools (the estimate for this analysis) likely explains the difference in estimated watershed area.

[2] Barr Engineering, USDA/NRCS – National Cartography and Geospacial Center (NCGC). Watershed Boundary Dataset http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed 1/3/2011.

[3] Barr Engineering, National Hydrography Dataset (NHD), Aurora 1984, Biwabik 1985, and Embarrass 1985 USGS 7.5 minute quadrangles, http://nhd.usgs.gov/.

[4] Barr Engineering, Minnesota Department of Natural Resources, Public Waters Inventory, http://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

[5] The direct drainage watershed for Whitewater Lake is estimated to be about 3,050 acres. Whitewater Lake receives water from Colby Lake on a periodic basis, most notably during spring snowmelt. In that case, the potential watershed area for Whitewater Lake would be the larger Partridge River watershed. However, for the Cumulative Mercury Deposition Analysis to be conducted for the Plant Site, the smaller direct drainage watershed area of 3,050 acres will be used in calculating potential effects from cumulative mercury air emissions.

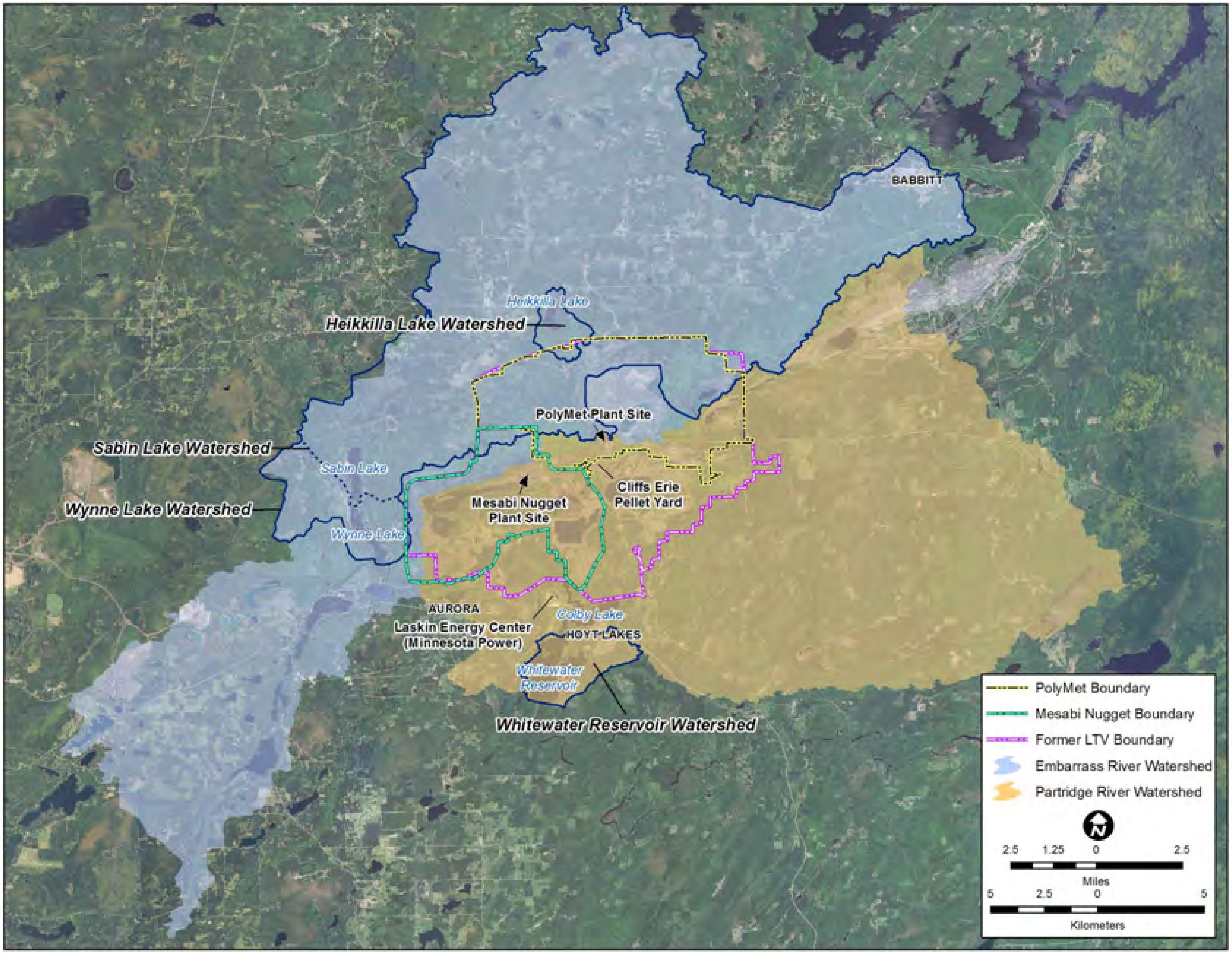


Figure 2 Location of nearby lakes and watersheds included in the Cumulative Mercury Deposition Analysis

3.4 St. Louis River and Watershed

All five of the lakes selected for modeling (and the proposed plant itself) are located within the St. Louis River watershed. Two of the modeled lakes—Colby Lake and Whitewater Lake—discharge directly to the St. Louis River. These two lakes are also the closest lakes to the Plant Site and the Mesabi Nugget LSDP, and therefore, would be the most potentially affected. In other words, the incremental increase of mercury loading and the associated change in fish concentrations in other popular fishing lakes in the St. Louis River watershed such as Seven Beaver Lake (the headwaters of the St. Louis River) would be less than that modeled at the selected lakes because these other lakes are located further from the two proposed projects. Seven Beaver Lake, for example, is about 14 miles east of the Plant Site. All the selected lakes and watersheds modeled for this analysis (Table 1) on the other hand, are within 7 miles of the Plant Site.

Similarly, the estimated change in mercury concentrations in fish in the St. Louis River itself due to the two projects using the MMREM would be far less than that predicted for the selected nearby lakes. This is because the mean air concentration of mercury (and the associated deposition rate) due to these two projects alone would be much lower when averaged across the entire St. Louis River watershed than the modeled air concentration at a nearby lake. In general, as watershed size increases, the impact of any one nearby source becomes less important and region-wide deposition dominates.

In this case, for example, the local area affected by the projects' mercury emissions (150 square miles, or a 10-km radius around each facility) is only about 4% of the much larger St. Louis River Watershed (which has an area of over 3,500 square miles). The current MPCA-estimated mercury deposition rate is 12.5 ug/m^2-year for northeastern Minnesota. This means that about 250 pounds of mercury currently deposits onto to the St. Louis Watershed every year due to regional deposition. Even assuming that the maximum modeled deposition rate due to the two proposed projects--0.2 ug/m^2-yr at Colby Lake (scenario 1)--occurred over the entire 150 square mile potentially affected area, the total annual deposition in the watershed from the two proposed projects would be about 0.17 pounds per year. This is less than 0.1% of the estimated 250 pounds per year of mercury already landing onto the St. Louis River watershed due to regional deposition. Because the change in mercury contamination of fish is thought to be ultimately proportional to the percent increase in load, this 0.1% increase in annual mercury deposition is not likely to result in a measureable change in the mercury concentration in the fish in the St. Louis River.

3.5 Existing Mercury Concentrations in Fish

Fish tissue mercury concentration data was obtained from the MPCA in November 2011. Background mercury concentrations in fish tissue were calculated in accordance with MMREM guidance. For Colby, Sabin, Whitewater and Wynne Lakes, with fish tissue data, 95% upper confidence limits (UCL) of the mean were calculated from recent data for top predator species using the latest version of EPA's ProUCL software. No fish tissue data is available for Heikkilla Lake, so the 95% UCL of the mean concentration was calculated using fish tissue data from the following 5 nearby lakes: Colby, Sabin, Whitewater, Wynne and Bear Island Lake.

Outliers were retained in the dataset for calculating the 95% UCL in order not to underestimate potential background concentrations.

MPCA's fish mercury database contains average values representing multiple samples. These average values were used in deriving the estimate of background fish mercury concentrations for a lake.

3.6 Dispersion Modeling Methods

The mercury speciation proposed for analysis for both projects is provided in Table 2. Because speciation from the autoclave is uncertain, two speciation scenarios were used: a conservatively high estimate of species that tend to deposit locally (Scenario 1) and a most likely estimate (Scenario 2). Total emission rates are from the Plant Site Emissions Inventory (Barr Eng. 2011).

The most recent version of the AERMOD air dispersion model was used to model estimated emissions from the Mesabi Nugget LSDP and the Plant Site. The model was run in regulatory mode (i.e., no plume depletion). Building heights and dimensions, and stack parameters, were obtained for the emission sources to be modeled (autoclave for the Project; rotary hearth furnace for the Mesabi Nugget LSDP).

Meteorological data used for other modeling analyses conducted for Iron Range sources was used in this modeling:

- 2006-2010 surface data from Hibbing (airport)
- Concurrent mixing height data from International Falls

Table 2 Mercury Speciation Assumptions

Project	Mercury Speciation	Comments
NorthMet, Plant Site		
Scenario 1 [1]	25% elemental 50% oxidized 25% particle-bound	Conservative estimate for local deposition
Scenario 2 [1]	80% elemental 10% oxidized 10% particle-bound	Estimated likely speciation
Mesabi Nugget LSDP [2]	99.3% elemental 0.6% oxidized 0.1% particle-bound	Speciation from stack testing data for the pilot plant.

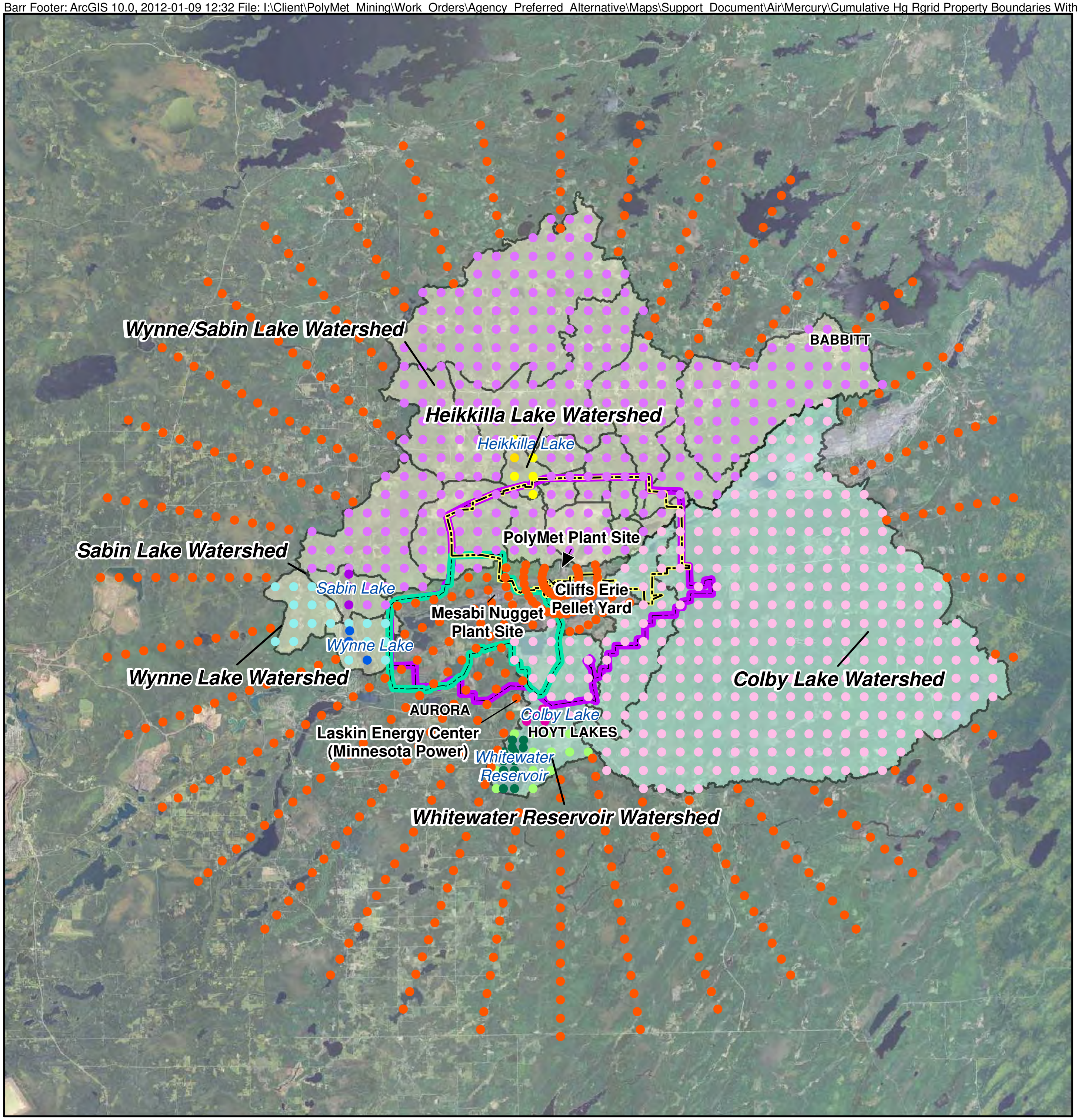
[1] The proposed emission control system includes a venturi scrubber and a packed bed scrubber in series. Engineering estimates approximate control efficiency of 90% for oxidized and particle bound mercury and 25% for vapor-phase mercury.

[2]This is the same speciation assessed for local mercury deposition in the Mesabi Nugget May 2005 AERA and in the Mesabi Nugget Phase II August 2009 AERA

A receptor grid for the modeling was designed to provide aerial coverage for each lake and watershed using had polar grid receptors extending out to 25 kilometers. One or more receptor nodes were placed over each lake's surface area and within each watershed. For lake surface area, the grid was modified so that one receptor was placed over the lake for every 100 acres of surface area. For watersheds, one receptor was placed over the watershed for every 1,000 acres of area. For example, for Colby Lake (500 acres) and its watershed (~100,000 acres), 5 receptors were placed over the lake and 100 receptors placed in the watershed. The Heikkilla Lake watershed is located partially within the Plant Site boundaries. Therefore, to capture the likely strong gradient close to the Plant Site, at least two receptors were used to characterize the Heikkilla Lake watershed, one of which was placed over the lake's surface area.

The average mercury air concentration over the lake and over the watershed were then calculated from the AERMOD modeling output using GIS tools as recommended in the MMREM guidance.

The different speciation for the two projects required separate modeling runs for each species, with output from the individual modeling runs being consolidated to provide a cumulative estimate of the potential average mercury air concentration (as total mercury) for each lake and watershed. Figure 3 shows the receptor coordinates used to model the mercury concentrations overlaid on to the studied watersheds.



25km polar
Colby Lake
Colby WSHD
Heikkilla Lake
Heikkilla WSHD
Sabin Lake
Whitewater Lake
Whitewater WSHD
Wynne Lake
Wynne WSHD
Wynne/Sabin WSHD
NorthMet Boundary
Mesabi Nugget Boundary
Former LTVSMC Boundary
Embarrass River Watershed
Partridge River Watershed

N

Kilometers
5 0 5

Figure 3

Cumulative Hg Receptors
NorthMet Project
Hoyt Lakes, MN

3.7 Bioaccumulation and Risk Modeling Methods

The most recent version of the MMREM spreadsheet was used to estimate potential cumulative incremental mercury deposition, fish mercury concentration and human health risks (as a hazard quotient).

The MMREM spreadsheet analysis consisted of the following five major steps:

1. Individual AERMOD modeling runs were conducted for each mercury species described in Table 2 to provide cumulative air concentrations for elemental, oxidized and particle-bound mercury, respectively, for the annual averaging period. Because there are two scenarios and three mercury species, six separate modeling runs were required.
2. A separate MMREM spreadsheet file was established for each lake/watershed to be assessed (2 spreadsheets set up for each lake/watershed).
3. The average speciated air concentrations were entered for the lake and watershed area, respectively. Therefore, the default mercury speciation in the MMREM spreadsheet was not used. Instead, the MMREM spreadsheet was adjusted to account for modeled speciated air concentrations to be input directly to specific cells.
   - Estimate of background fish mercury concentration was input
   - Estimate of lake area and watershed area was input
4. Incremental change in fish mercury concentration was calculated by the spreadsheet.
5. Incremental change in risk for a recreational fisher, a subsistence/tribal fisher and a subsistence fisher were evaluated based on the consumption rate for a fisher receptor.
   - Consumption rate for a recreational fisher was assumed to be 30 grams per day
   - Consumption rate #1 for a subsistence fisher was assumed to be 224 grams per day and approximates the allowed take of fish by a Tribal member (~ 180 pounds per year of fish).
   - Consumption rate #2 for a subsistence fisher was assumed to be 199 grams per day and approximately the 95^{th} percentile value for a general population (USEPA 1997 Exposure Factors Handbook)

Detailed model inputs and assumptions are provided in Appendix B.

4 Dispersion Modeling Results

The percentage contribution from each of the two facilities to the air concentrations at each modeled lake are provided in Table 3, below. The modeling indicates that Heikkilla Lake is most impacted by the Project itself. At Heikkilla Lake, the Project's contribution is approximately 25% of the total modeled air concentration, with the remainder attributed to the Mesabi Nugget LSDP. The Project's contribution to the modeled cumulative impact at the other selected lakes ranges from 8% to 13% (lake surface) and 23% to 28% (watershed).

These results of the cumulative dispersion modeling of the combined emissions from both sources are shown graphically in Figure 4 and Figure 5. The highest cumulative total annual mercury concentrations under both scenarios are within 10 kilometers of the project sites.

Figure 6 and Figure 7 show the modeled contribution due to the Project alone for the two speciation scenarios. Although not shown in the figures, the highest modeled elemental mercury concentrations are southwest of the Plant Site and just east of the Mesabi Nugget LSDP. The highest oxidized and particle bound mercury concentrations are south of the Plant Site. Predicted concentrations drop off quickly within about 5 kilometers of the sources and then level off.

Figure 8 illustrates the contribution from both the Project and Mesabi Nugget LSDP for each speciation scenario. This figure illustrates that the modeled contribution from the Project is less than that from the Mesabi Nugget LSDP at the selected lakes.

Table 3 Modeled Maximum Mercury Air Concentrations—Incremental Project Contributions and Incremental Cumulative Contributions

Receptor	Scenario 1					Scenario 2				
	Mesabi Nugget LDSP		NorthMet		Cumulative	Mesabi Nugget LSDP		NorthMet		Cumulative
	Max Annual (ug/m3)	% of Total	Max Annual (ug/m3)	% of Total	Max Annual (ug/m3)	Max Annual (ug/m3)	% of Total	Max Annual (ug/m3)	% of Total	Max Annual (ug/m3)
Colby Lake	5.52E-06	90%	6.13E-07	10%	6.41E-06	5.52E-06	90%	6.41E-07	10%	6.07E-06
Colby Lake Watershed	2.62E-06	77%	7.90E-07	23%	3.81E-06	2.62E-06	77%	8.03E-07	23%	3.38E-06
Heikkilla Lake	3.11E-06	77%	9.49E-07	23%	4.34E-06	3.11E-06	76%	9.67E-07	24%	4.06E-06
Heikkilla Lake Watershed	3.11E-06	72%	1.20E-06	28%	4.71E-06	3.11E-06	72%	1.22E-06	28%	4.30E-06
Sabin Lake	3.17E-06	89%	3.72E-07	11%	3.75E-06	3.17E-06	89%	3.77E-07	11%	3.54E-06
Sabin Lake Watershed	2.66E-06	76%	8.45E-07	24%	3.78E-06	2.66E-06	76%	8.55E-07	24%	3.44E-06
Whitewater Lake	4.38E-06	92%	3.86E-07	8%	4.97E-06	4.38E-06	92%	4.01E-07	8%	4.76E-06
Whitewater Lake Watershed	4.71E-06	90%	5.35E-07	10%	5.51E-06	4.71E-06	89%	5.55E-07	11%	5.21E-06
Wynne Lake	2.03E-06	87%	2.97E-07	13%	2.49E-06	2.03E-06	87%	3.01E-07	13%	2.32E-06
Wynne Lake Watershed	2.66E-06	76%	8.45E-07	24%	3.78E-06	2.66E-06	76%	8.55E-07	24%	3.44E-06

Notes:

* AERMOD results, December 1, 2011. Sources were modeled using the regulatory default mode of AERMOD.

** MAX ANNUAL CONCENTRATION is the maximum annual concentration over the years modeled. The Cumulative MAX ANNUAL CONCENTRATION may not equal the sum of the MAX ANNUAL CONCENTRATION from each facility if the max occurred at different years.

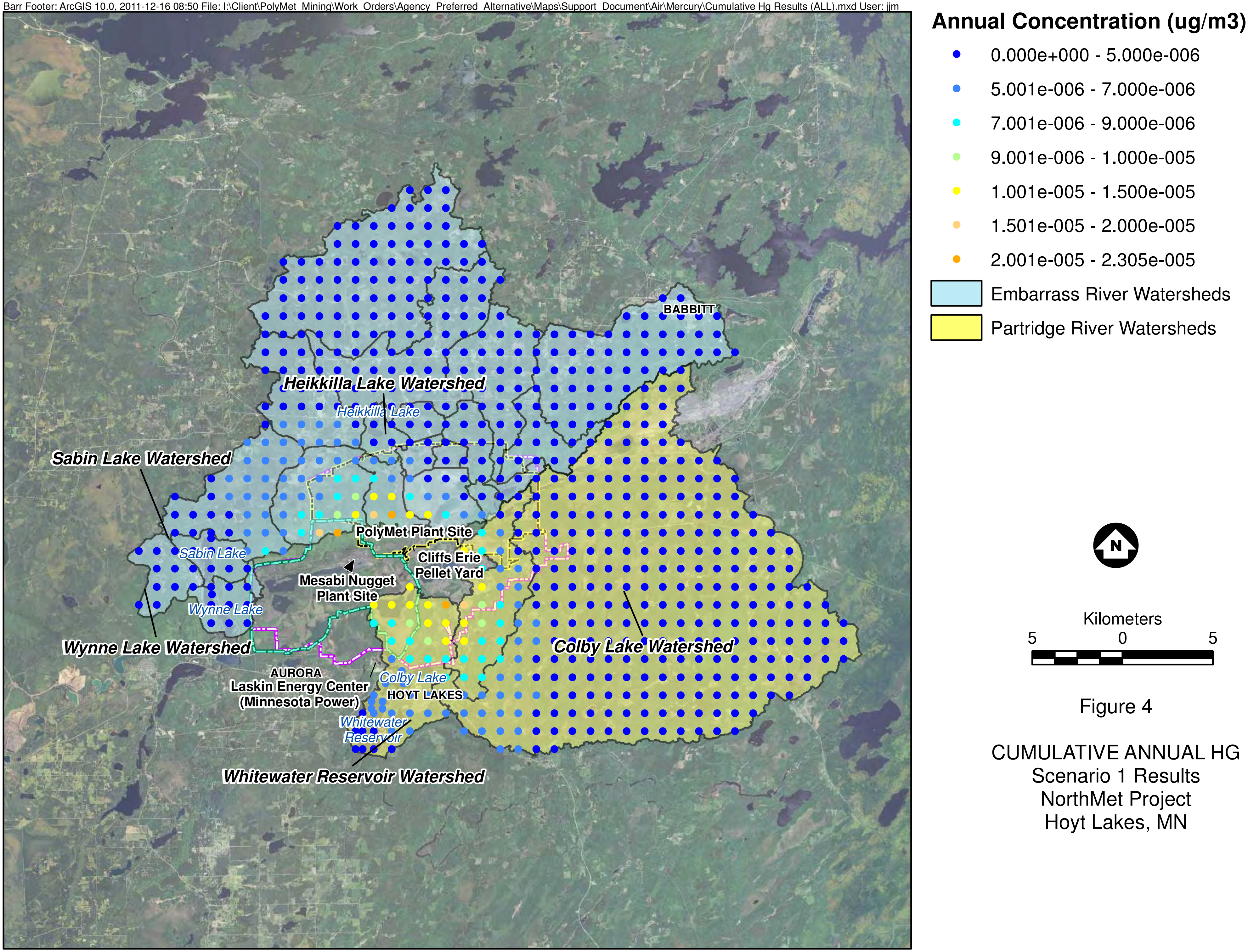


Figure 4

CUMULATIVE ANNUAL HG
Scenario 1 Results
NorthMet Project
Hoyt Lakes, MN

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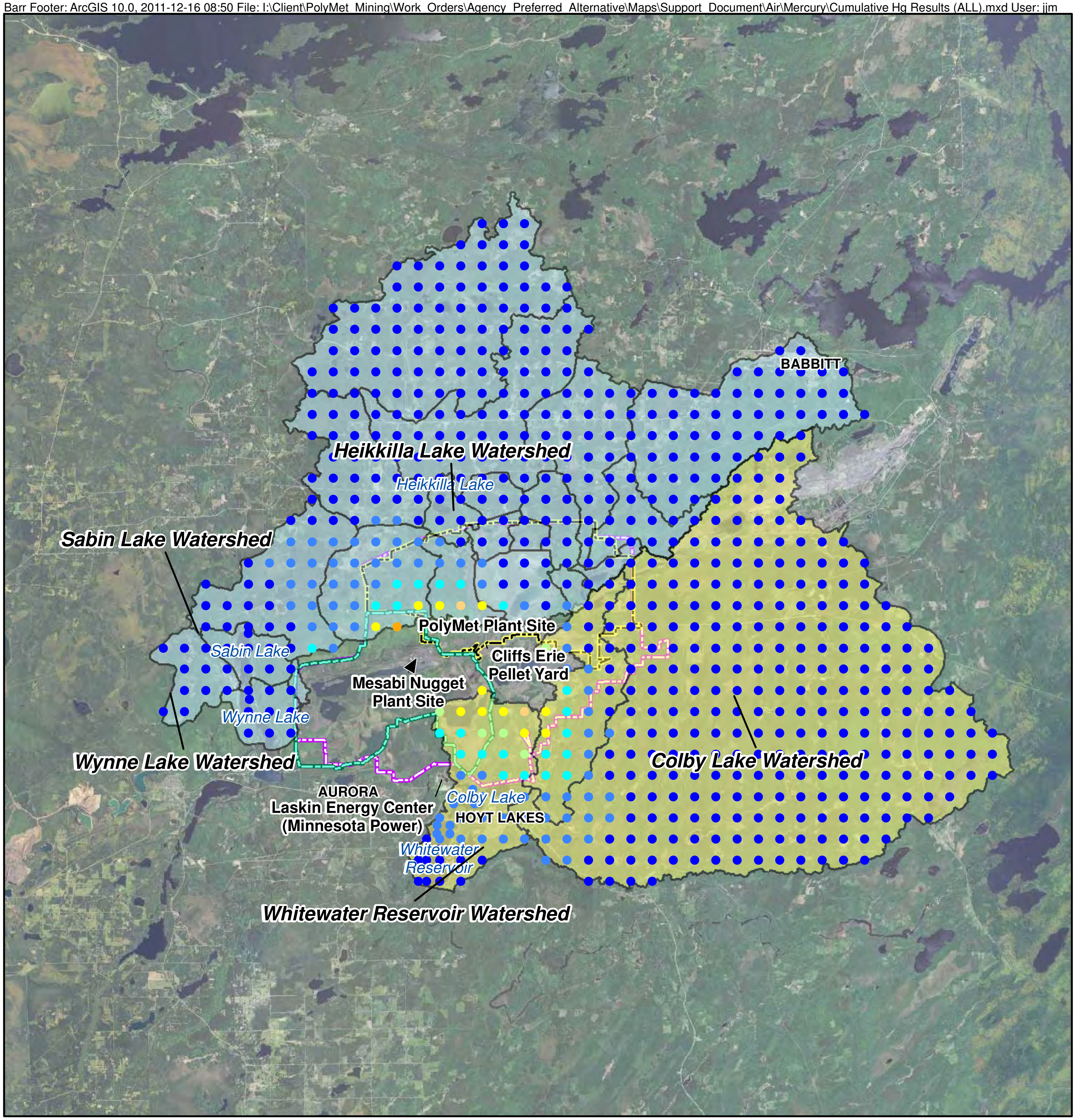


Annual Concentration (ug/m3)

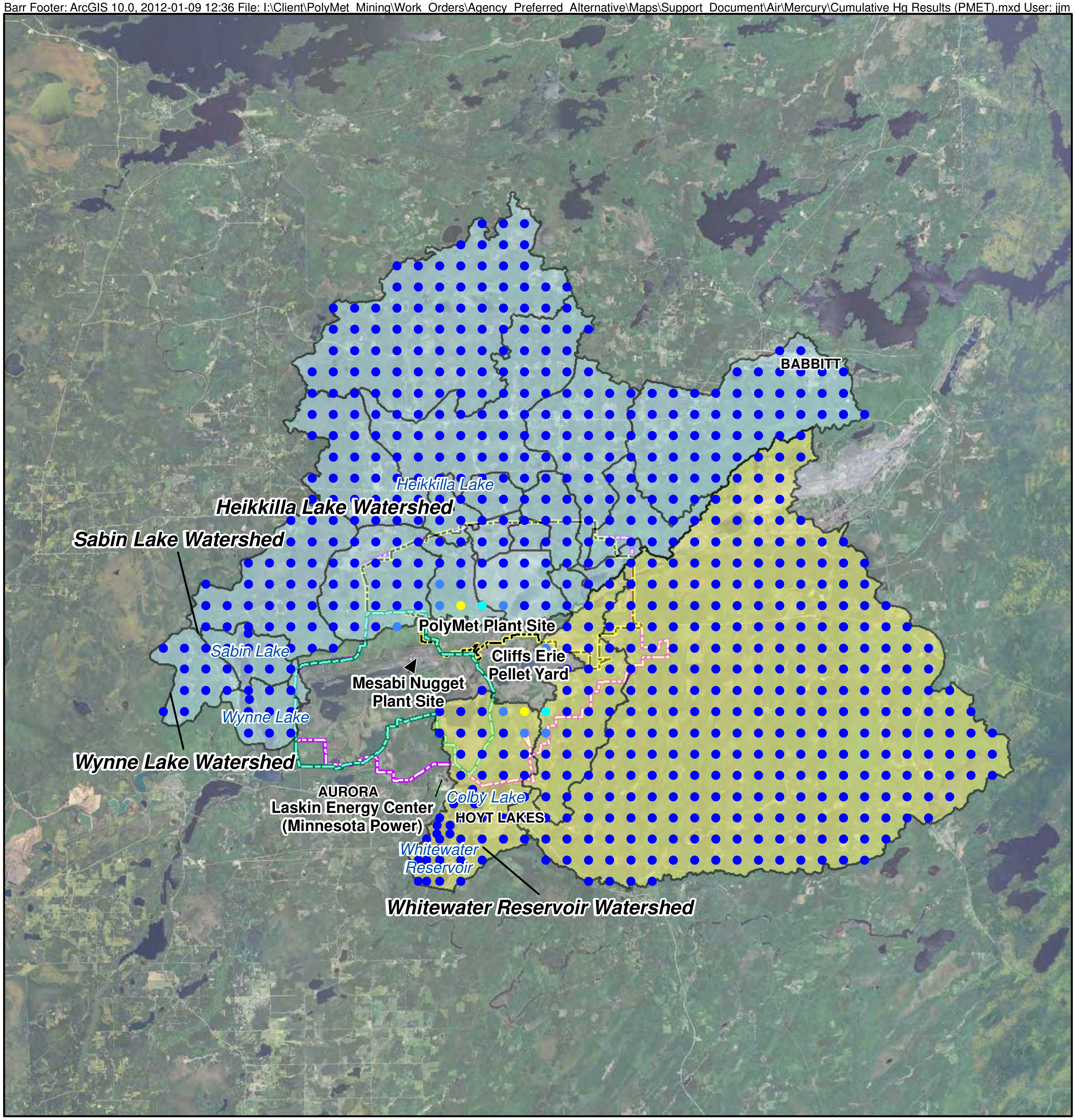
- 0.000e+000 - 5.000e-006
- 5.001e-006 - 7.000e-006
- 7.001e-006 - 9.000e-006
- 9.001e-006 - 1.000e-005
- 1.001e-005 - 1.500e-005
- 1.501e-005 - 2.000e-005
- 2.001e-005 - 2.055e-005
- Embarrass River Watersheds
- Partridge River Watersheds

N

Kilometers
5 0 5

Figure 5

CUMULATIVE ANNUAL HG
Scenario 2 Results
NorthMet Project
Hoyt Lakes, MN



Annual Concentration (ug/m3)

- 0.000e+000 - 5.000e-006
- 5.001e-006 - 7.000e-006
- 7.001e-006 - 9.000e-006
- 9.001e-006 - 1.000e-005
- 1.001e-005 - 1.500e-005
- 1.501e-005 - 2.000e-005
- 2.001e-005 - 2.350e-005
- Embarrass River Watersheds
- Partridge River Watersheds

N

Kilometers

5 0 5

Figure 6

CUMULATIVE ANNUAL HG
Scenario 1 Results NorthMet Only
NorthMet Project
Hoyt Lakes, MN

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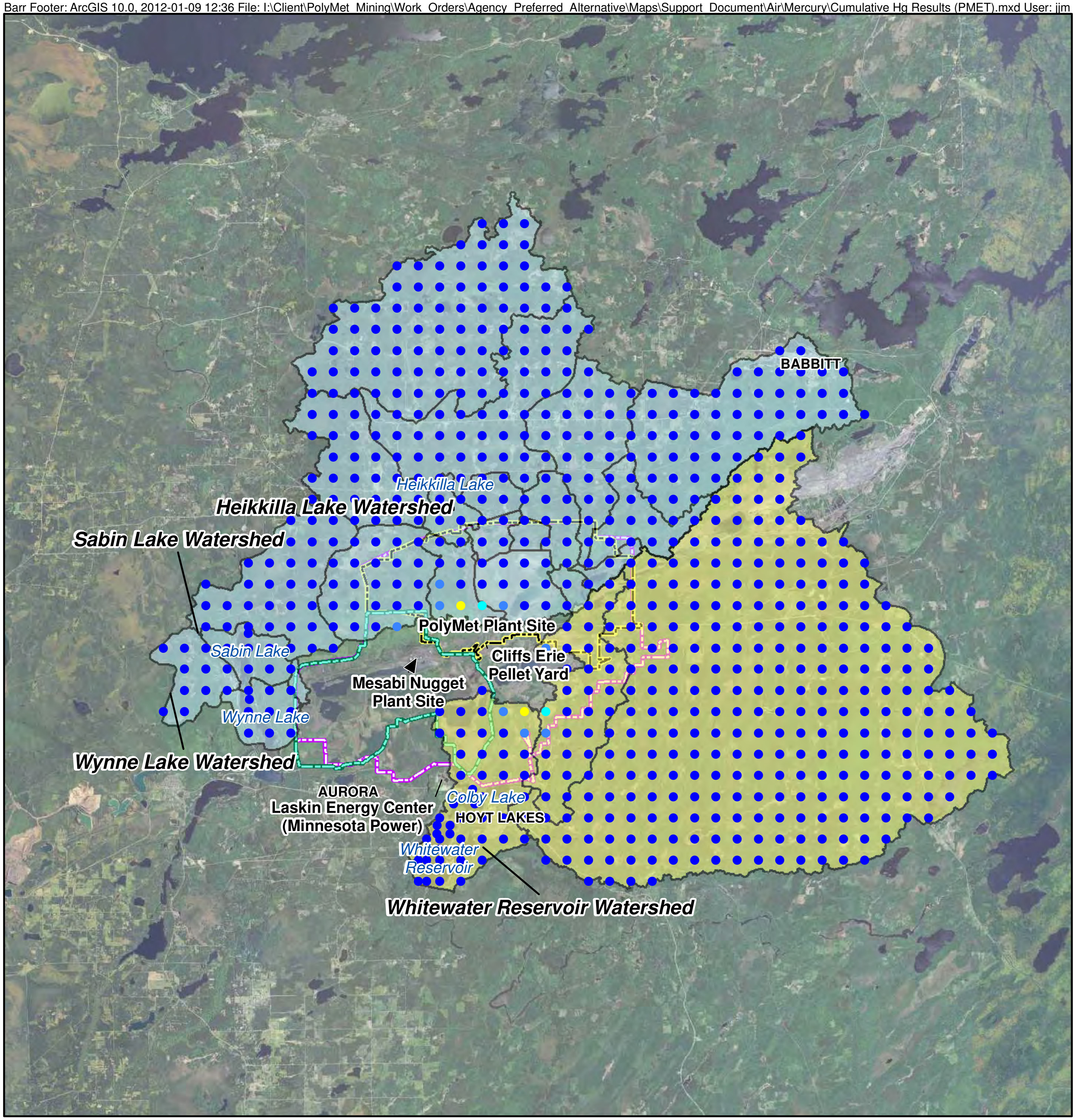

Annual Concentration (ug/m3)

- 0.000e+000 - 5.000e-006
- 5.001e-006 - 7.000e-006
- 7.001e-006 - 9.000e-006
- 9.001e-006 - 1.000e-005
- 1.001e-005 - 1.500e-005
- 1.501e-005 - 2.000e-005
- 2.001e-005 - 2.055e-005
- Embarrass River Watersheds
- Partridge River Watersheds

N

Kilometers

5 0 5

Figure 7

CUMULATIVE ANNUAL HG
Scenario 2 Results NorthMet Only
NorthMet Project
Hoyt Lakes, MN

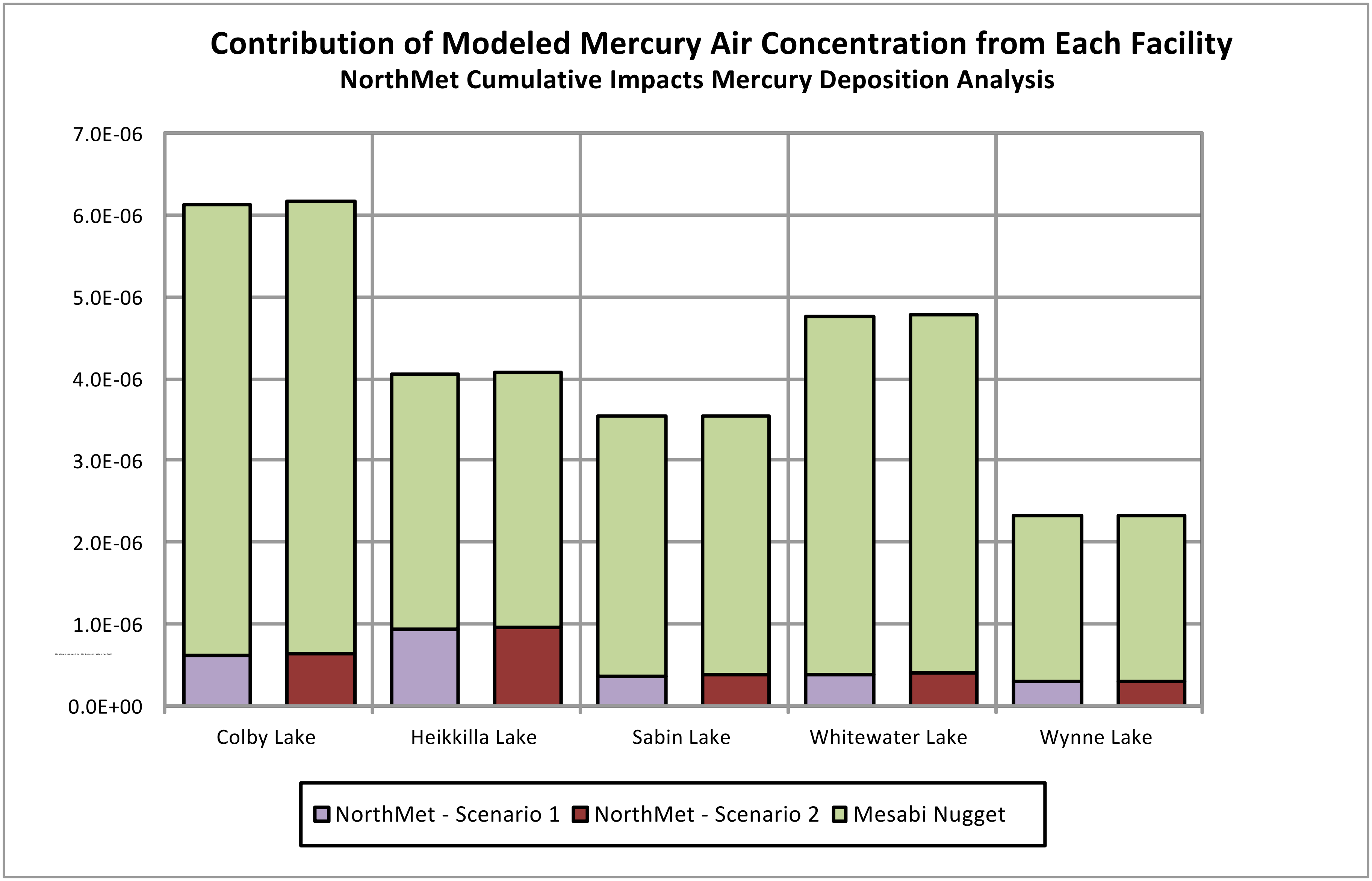

Figure 8 Contribution of Modeled Mercury Air Concentration from Each Facility

5 Fish Bioaccumulation and Health Risk

Based on the MPCA screening-level MMREM spreadsheet model, the predicted increase in mercury concentration in the air over nearby lakes translates into a worst case 0.3 to 1.8 percent increase in mercury deposition at the selected lakes (compared to the assumed 12.5 $\mu g*m^{-2}*year^{-1}$ existing deposition rate). Because the model assumes that the mercury concentration in fish is directly proportional to mercury deposition rate, this translates into a 0.3 to 1.8 percent incremental increase in the amount of mercury in the fish. The modeled incremental increase in mercury loading and fish concentration are shown in Table 4 for the two facilities together and for the Project alone. See Appendix B for detailed calculations.

Table 5 shows the existing and predicted incremental Hazard Quotient for all five lakes for the following three separate fish consumption scenarios:

1. a recreational angler (30 grams per day),
2. a subsistence/tribal angler (224 grams per day) and
3. for a subsistence angler (199 grams per day).

Figure 9, below, shows that the existing Hazard Quotient for recreational anglers is over 2.0 for each of the lakes under Scenario 1 and 2. (This is why there are existing consumption advisories on the lakes.) The existing health risk under Scenario 1 and 2 to subsistence/tribal and subsistence anglers eating three pounds or more per week of fish from these lakes would be significantly higher—up to fifteen times the EPA assumed safe intake level for a pregnant mother or child under the age of 15. (The majority of anglers fishing on these lakes are not subsistence anglers, however.)

The incremental risk is only about 0.3 to 1.8 percent increase over the existing risk levels, for recreational, subsistence/tribal and subsistence anglers. Therefore, the incremental risk due to the combined mercury emissions of these two projects, when compared to the existing risk, is barely visible on Figure 9.

Figure 10 shows the incremental risk-only due to the cumulative emissions of the both projects. The higher incremental increase in Colby, Wynne and Sabin Lakes is largely due to its large watershed size. In general, Figure 10 shows that the incremental risk from the project's emissions to a recreational angler is less than one-tenth the 1.0 Hazard Quotient thresholds, for both Scenario 1 and 2.

The modeled incremental Hazard Quotient to a subsistence/tribal and subsistence angler at Wynne Lake is over 0.5 under the high particulate and oxidized mercury emission assumption (Scenario 1). Scenario 1, however, is conservative because it assumes the emitted mercury will be 25% particulate and 25% Hg(II) and the remainder Hg (0). In actual operation, it is expected that the venturi scrubber and packed bed scrubber installed in series will control Hg(II) and particle bound mercury by 90%. This means that most of the mercury (at least 80%) would be Hg (0). Under this more realistic Scenario 2 (10% particulate, 10% Hg(II), the associated Hazard Quotient is under 0.2. In summary, the modeled incremental cumulative risk from these two projects would not result in a measurable change in health risk to people eating fish from the selected lakes. The health risk due to increased mercury deposition at other area lakes, such as Seven Beaver Lake, would be even less than the lakes listed in this report because they are located further from the two projects. Nevertheless, the mercury concentration in the fish in these nearby lakes and many lakes in Minnesota already exceeds the State of Minnesota's health-based target of 0.2 ppm (See Table 4, Column B). The MPCA Statewide Mercury TMDL (TMDL) and Strategy Framework (described above in Section 2) is intended to provide the long-term framework to reduce the mercury in fish in Minnesota lakes. PolyMet intends to comply with any applicable provisions of the Minnesota Mercury TMDL in order to help reduce long-term mercury concentrations in the fish in these lakes and other impaired lakes in Minnesota.

Table 4 Incremental Increase in Mercury Loading and Fish Concentration

A		B	C	D	E	F	G
			Cumulative		**NorthMet Alone**		
			Increase in fish Hg Concentration (ppm)	%Increase in Hg loading and fish Hg concentration	proportion due to NorthMet alone (%)	Increase in fish Hg Concentration (ppm)	%Increase in Hg loading and fish Hg concentration
Lake		Existing fish Hg Concentration (ppm)	MMREM Results	Calculated from B and C	Table 3 or below**	Calculated from C and E	Calc from B and F
Colby Lake	Scenario 1	0.93	0.012	1.2%	10.0%	0.001	0.12%
	Scenario 2		0.003	0.4%	10.4%	0.000	0.04%
Heikkilla Lake	Scenario 1	0.65	0.011	1.8%	23.4%	0.003	0.41%
	Scenario 2		0.003	0.5%	23.7%	0.001	0.11%
Sabin Lake	Scenario 1	1.02	0.013	1.3%	10.5%	0.001	0.14%
	Scenario 2		0.004	0.4%	10.6%	0.000	0.04%
Whitewater Lake	Scenario 1	0.35	0.003	0.8%	8.1%	0.000	0.07%
	Scenario 2		0.001	0.3%	8.4%	0.000	0.03%
Wynne Lake	Scenario 1	1.34	0.018	1.3%	12.8%	0.002	0.17%
	Scenario 2		0.005	0.4%	12.9%	0.001	0.05%

Table 5 Cumulative Impacts Mercury Deposition Analysis

			Recreational Angler		**Subsistence/Tribal Angler**		**Subsistence Fisher**	
Lake	**MN DNR #**		**Existing HQ**	**Incremental HQ**	**Existing HQ**	**Incremental HQ**	**Existing HQ**	**Incremental HQ**
Colby Lake	69024900	Scenario 1	4.3	0.05	32.0	0.4	28.4	0.35
		Scenario 2		0.02		0.1		0.10
Heikkilla Lake	69025300	Scenario 1	3.0	0.05	22.3	0.4	19.8	0.35
		Scenario 2		0.01		0.1		0.09
Sabin Lake	69043401	Scenario 1	4.7	0.06	35.1	0.5	31.2	0.41
		Scenario 2		0.02		0.1		0.11
Whitewater Lake	69037600	Scenario 1	1.6	0.01	11.9	0.1	10.6	0.09
		Scenario 2		0.01		0.0		0.03
Wynne Lake	69043402	Scenario 1	6.2	0.08	46.2	0.6	41.0	0.54
		Scenario 2		0.02		0.2		0.15

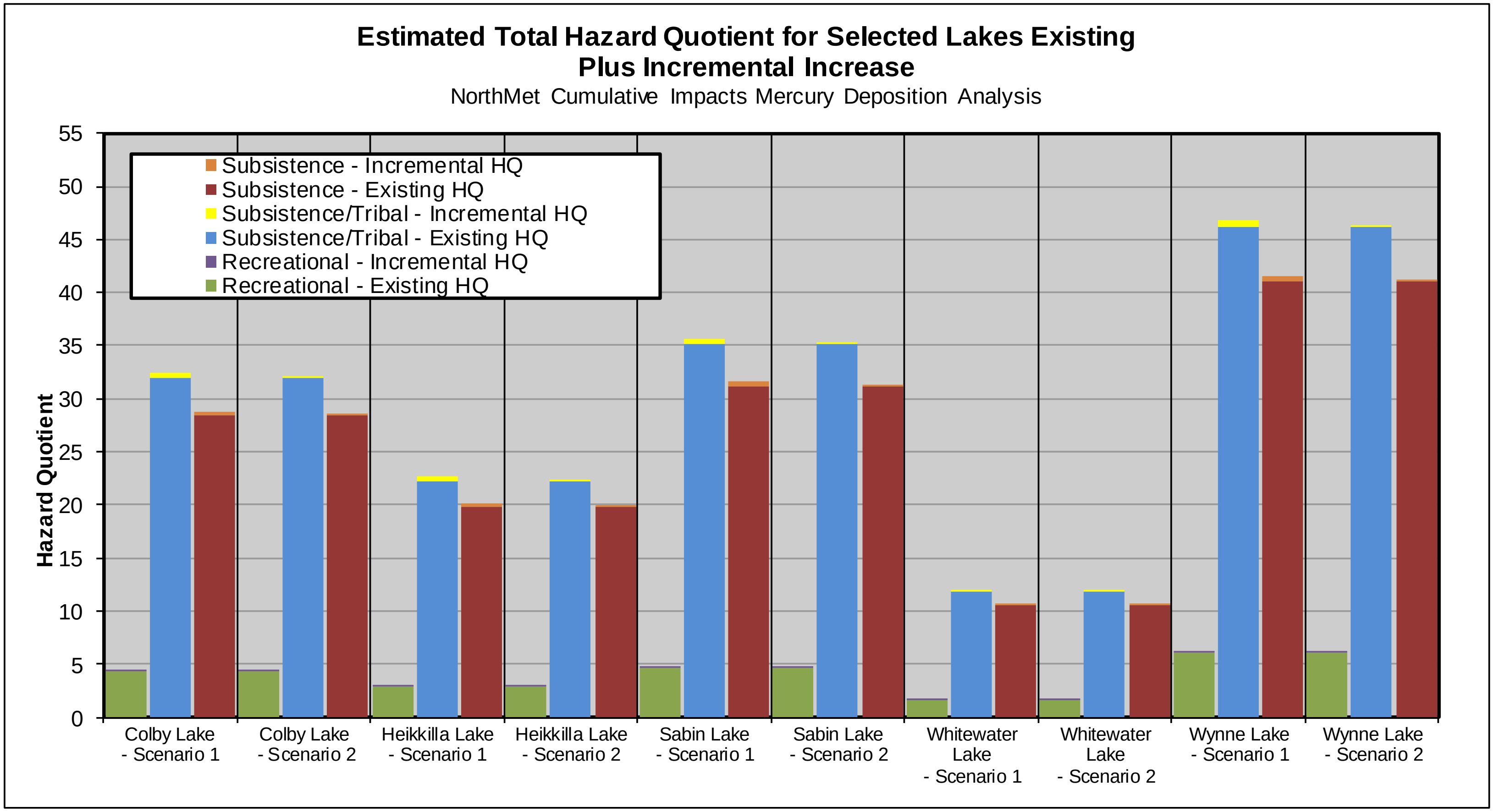

Figure 9 Total Hazard Quotient (Existing Plus Incremental) NorthMet Cumulative Impacts Mercury Deposition Analysis

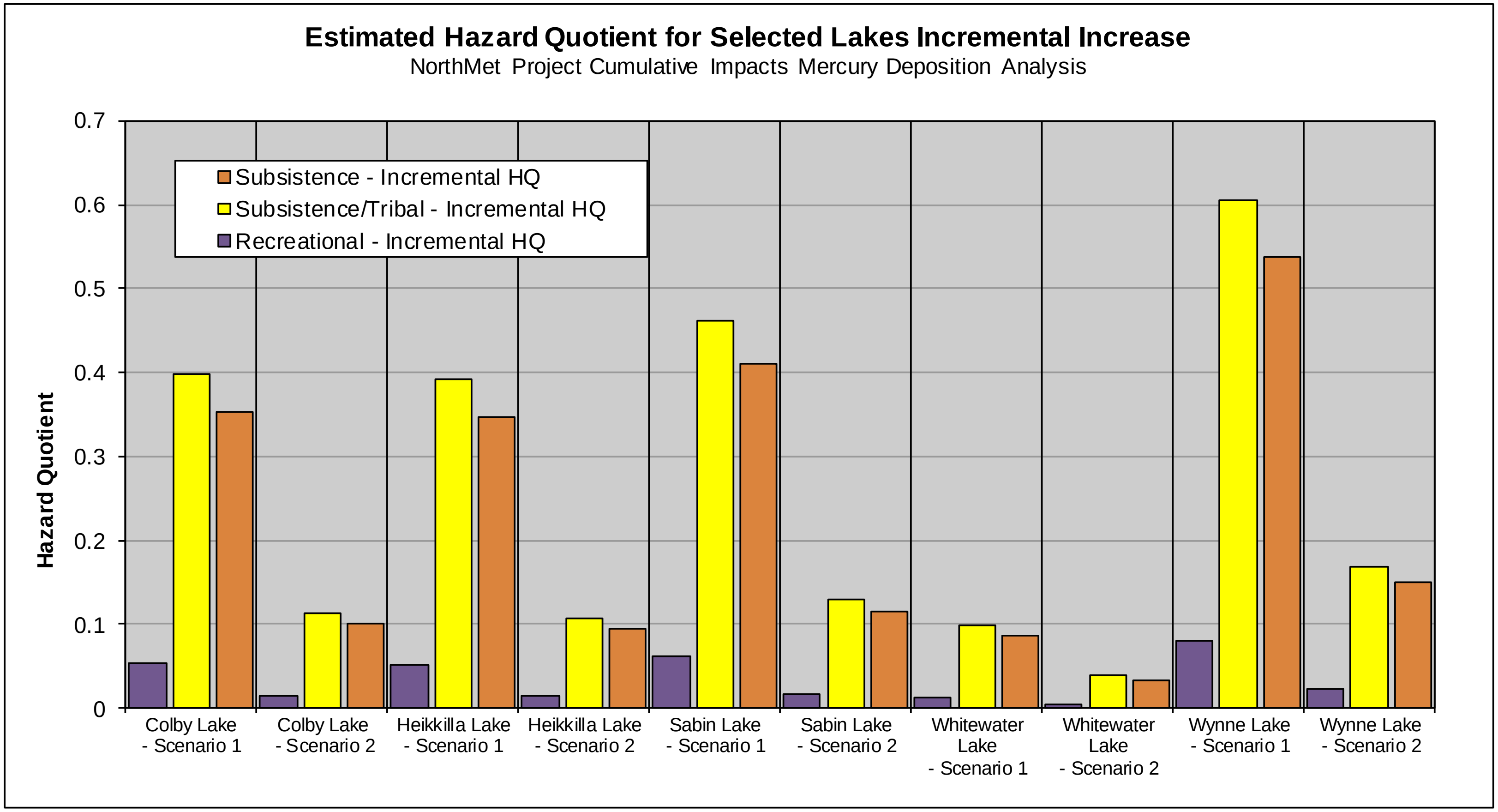

Figure 10 Estimated Hazard Quotient for Selected Lakes Incremental Increase

6 Other Factors

The MPCA's mercury risk estimation model assumes that the mercury concentration in the fish in a specific lake is proportional to the amount of mercury deposited to the lake and its watershed. However, this is only true if the other chemical, physical and biological factors that can affect the formation of methyl-mercury remain unchanged. These other factors include sulfur, iron, and organic matter cycling, pH, hydrology (including water level fluctuations)

These other factors greatly influence the extent of the mercury contamination problem. For example, the mercury concentrations in fish in northern Minnesota lakes vary by ten times or more even though the amount of mercury deposited from the atmosphere is nearly uniform across the region (MPCA 2007).

6.1 Sulfate

Sulfate-reducing bacteria are widely considered to be responsible for the bulk of mercury methylation in both aquatic and terrestrial habitats (Morel et al. 1998, Ullrich et al. 2001). In some cases higher sulfate concentrations could lead to increased methylation rates. However, other factors such as oxygen and organic carbon concentrations also influence whether sulfate availability is directly related to mercury methylation (Munthe et al 2007). Therefore, mercury methylation may be limited by sulfate concentrations in some lakes, but not in others. It is currently not possible to accurately model the relationship between sulfate concentrations and the mercury contamination in fish in a specific lake.

6.2 Wetlands

Wetlands are an important land cover in northern Minnesota and are also important sites of mercury methylation (MPCA 2007). Sulfate-reducing bacteria thrive in the oxygen-poor sediment found in wetlands. Also, methyl-mercury associated with dissolved organic carbon released from wetlands can be conveyed to surface waters (Driscoll et al. 1995). Consequently, wetland density can be correlated with mercury concentrations in water and fish (e.g., Greenfield et al. 2001, Grigal 2002). As with sulfate, however, it is not currently possible to accurately predict how wetland dewatering due to the Project and wetland hydrology impacts may affect methyl-mercury concentrations in water discharges.

6.3 Project Specific Factors

The former LTVSMC Tailings Basin, which will be used by the Project, is located in two local watersheds (Embarrass River Watershed and Partridge River Watershed). Surface seepage from the Tailings Basin flows south via a surface discharge station (SD026) toward Second Creek, which eventually flows into the Partridge River. In addition, discharge (SD033) from the northern portions of former LTVSMC mine Area 5 forms the headwaters of Spring Mine Creek, which flows north to the Embarrass River. Due to the nature of the industry, the effluent from these discharges contain sulfate

A sulfate and methylmercury investigation completed for the Project (Barr Eng. 2010) found that methylmercury concentration in two streams with elevated sulfate receiving seepage from the former LTVSMC Tailings Basin were similar to background streams with low sulfate (Bear Creek, PM20, upper Embarrass River, PM12).

7 Abbreviations, Acronyms, and Selected Definitions

7.1 Abbreviations and Acronyms

AREA	Minnesota Power's Arrowhead Regional Emission Abatement Project
BACT	Best available control technology as defined at 40 CFR 52.21(b)(12)
BART	Best Available Retrofit Technology
BWCA	Boundary Waters Canoe Area (Wilderness); located in northeast Minnesota
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CAMR	Clean Air Mercury Rule
CFR	Code of Federal Regulations
DRI	Direct Reduced Iron
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
Hg	mercury
IPM	Integrated Planning Model used for estimating impacts from CAMR
kg	kilogram
L	Liter
LTVSMC	LTV Steel Mining Company
m^2	square meter
MACT	Maximum Achievable Control Technology
MDNR	Minnesota Department of Natural Resources
MERP	Xcel Energy's Metropolitan Emission Reduction Project
mg	milligram
MDN	Mercury Deposition Network
MPCA	Minnesota Pollution Control Agency
MPUC	Minnesota Public Utilities Commission
MW	Megawatt (1 megawatt equals 1,000,000 watts, or 1,000 kilowatts)
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_x	Nitrogen oxides – including all of the oxides of nitrogen
NP55	standard length Northern Pike – 55 cm
ppm	parts per million
PSD	Prevention of Significant Deterioration
PTE	Potential-to-emit as defined at 40 CFR 52.21(b)(4)
SO_2	Sulfur dioxide

SOx	Sulfur oxides – including all of the oxides of sulfur
SRB	sulfate reducing bacteria
TMDL	Total Maximum Daily Load
ton	Short ton = 2,000 pounds
ton, long	Long ton = 2240 pounds
ton, metric	Metric ton = 2204.6 pounds
µg	microgram
$\mu g\ m^{-2}\ yr^{-1}$	micrograms per square meter per year
U.S.	United States
VNP	Voyageurs National Park; located in northeast Minnesota
Yr	Year

7.2 Selected Definitions (from MPCA 2007)

Anthropogenic Mercury Emissions	the mobilization or release of geologically-bound mercury by human activity that results in a mass transfer of mercury to the atmosphere.
Atmospheric deposition	the mass transfer of gaseous, aerosol, or particulate contaminant from the atmosphere to the earth's surface (see mercury dry deposition and mercury wet deposition)
Bioaccumulation	increase in contaminant concentration through a food web; includes uptake through food and water or air.
Bioconcentration	uptake and increase in contaminant concentration only through the water or air, not food.
Biomagnification	increase in contaminant concentration between trophic levels.
Class I Area	Under the Clean Air Act, a Class I area is one in which air quality is protected more stringently than under the national ambient air quality standards; Federal Class I areas include national parks, wilderness areas, monuments, and other areas of special national and cultural significance. Mandatory Federal Class I areas include certain national parks (over 6,000 acres), wilderness areas (over 5,000 acres), national memorial parks (over 5,000 acres), and international parks that were in existence as of August 1977.
Federal Class I Areas in Minnesota	Boundary Waters Canoe Area Wilderness and Voyageurs National Park.
Global Scale	refers to emissions transported on a global scale; it does not refer to the sum of all emissions on Earth, but rather that portion of total emissions that are transported around the globe.
Local scale	The area within which emissions can travel in one diurnal cycle (generally within 100 km of a source). Local influences are characterized by measurable concentration gradients with relatively large fluctuations in air concentrations caused by meteorological factors such as wind direction (Expert Panel 1994).

Mercury dry deposition	mass transfer of gaseous, aerosol, or particulate mercury species from the atmosphere to the earth's surface (either aquatic or terrestrial, including trees and other vegetation) in the absence of precipitation.
Mercury wet deposition	mass transfer of dissolved gaseous or particulate mercury species from the atmosphere to the earth's surface (either aquatic or terrestrial) by precipitation.
Mercury Methylation (Methylated)	process of adding a methyl (CH3-) group to a mercury ion (Hg2+). Methylation can occur either biotically or abiotically, but sulfate-reducing bacteria are considered the primary methylators in aquatic systems (i.e., wetlands and lakes).
Methylmercury CH3Hg+ or MeHg	a cation that is the biologically active form of mercury; it has a very high affinity for sulfur-containing compounds, such as the amino acid cysteine; this is the form of mercury that accumulates in fish and is toxic to humans and wildlife.
Natural mercury emissions	mobilization or release of geologically-bound mercury by natural biotic and abiotic processes that result in mass transfer of mercury to the atmosphere.
Regional scale	the area requiring more than one diurnal cycle emission transport time (about 100 to 2000 km from a source). The regional scale describes areas sufficiently remote or distant from large emission sources so that concentration fields are rather homogeneous, lacking measurable gradients (Expert Panel1994).
Standard length fish	a set total fish length that is used to compare mercury concentrations among lakes and over time. The standard lengths used by the MPCA are 55 cm northern pike (NP55) and 40 cm walleye (WE40). Mercury concentrations for a standard length fish are determined from a linear regression of measured mercury fish tissue concentration versus fish length.
Taconite	low-grade iron ore processed by crushing and concentrating to yield a pellet for use in iron smelters. Taconite has low mercury concentrations but large volumes of the ore are heated during the pelletizing process, which releases ore-bound mercury into the atmosphere or scrubber water.
TMDL – Total Maximum Daily Load.	The maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDL also refers to the process of allocating pollutant loadings among point and nonpoint sources.

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Appendices

Appendix A

Cumulative Impacts Mercury Deposition Analysis

Modeled Maximum Incremental Total Mercury Air Concentration and Watershed Inputs: Cumulative Impacts Mercury Deposition Analysis

DATA INPUTS:

Lakes Evaluated	MDNR #	Existing Ambient Fish Tissue Concentration (mg/kg)	Area of Fishable Waterbody (acres)	Total Watershed Area (acres)	Area of Rest of Watershed (acres)	Area References
Colby Lake	69024900	0.93	502	100,392	99,890	2,3
Heikkilla Lake	69025300	0.65	128	1,478	1,350	1,3
Sabin Lake	69043401	1.02	299	121,669	121,370	3
Whitewater Lake	69037600	0.35	1,215	4,265	3,050	4,5
Wynne Lake	69043402	1.34	289	123,889	123,600	2,3

DATA SOURCES AND ASSUMPTIONS:

Fishable Waterbody and Watershed Areas

[1] Barr Engineering, ArcMap, version 9.3, service pack 1, using NED 10m elevation dataset from USGS. In the March 2007 AERA for the Plant Site, the local mercury deposition analysis identified a surface area of 129 acres for Heikkilla Lake, and a watershed area of 1,028 acres. Because most of the watershed is bog, interpreting the true extent of the direct drainage watershed using visual techniques (March 2007 AERA) versus GIS tools (the estimate for this analysis) likely explains the difference in estimated watershed area.

[2] Barr Engineering, USDA/NRCS – National Cartography and Geospacial Center (NCGC). Watershed Boundary Dataset http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed 1/3/2011.

[3] Barr Engineering, National Hydrography Dataset (NHD), Aurora 1984, Biwabik 1985, and Embarrass 1985 USGS 7.5 minute quadrangles, http://nhd.usgs.gov/.

[4] Minnesota Department of Natural Resources, Public Waters Inventory, http://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

[5] The direct drainage watershed for Whitewater Lake is estimated to be about 3,050 acres. Whitewater Lake receives water from Colby Lake on a periodic basis, most notably during spring snowmelt. In that case, the potential watershed area for Whitewater Lake would be the larger Partridge River watershed. However, for the Cumulative Mercury Deposition Analysis to be conducted for the Plant Site, the smaller direct drainage watershed area of 3,050 acres will be used in calculating potential effects from cumulative mercury air emissions.

Modeled Increment to Mean Hg Air Concentration (ug/m3)

The AERMOD air dispersion model was used to model estimated emissions from the Mesabi Nugget LSDP and the Plant Site. The model was run in regulatory mode (i.e., no plume depletion).

A receptor grid for the modeling was designed to provide aerial coverage for each lake/watershed and will have polar grid receptors extending out to 25 kilometers. For lake surface area, one receptor was placed over the lake for every 100 acres of surface area. For watersheds, one receptor was placed over the watershed for every 1,000 acres of area. For example, for Colby Lake (500 acres) and its watershed (~100,000 acres), 5 receptors will be placed over the lake and 100 receptors placed in the watershed. The Heikkilla Lake watershed is located partially within the Plant Site boundaries. To capture the likely strong gradient close to the Plant Site, the receptor grid was designed to spread out with distance from the Plant Site.

The average mercury air concentration over the lake and over the watershed was then calculated by averaging the receptor concentrations over each area, as recommended in the MMREM guidance.

Individual AERMOD modeling runs were conducted for each mercury species to provide cumulative air concentrations for elemental, oxidized and particle-bound mercury, respectively, using the speciation shown below.

Emission Sources and Hg Speciation

Mercury Speciation for Projects Included in the Cumulative Mercury Deposition Analysis

Project	Mercury Speciation (%)		Comments
NorthMet Plant Site - Scenario 1 [1]	25	elemental	Conservative estimate for local deposition analysis purposes only, because speciation data for the autoclave is not yet available
	50	oxidized	
	25	particle-bound	
NorthMet Plant Site - Scenario 2 [1]	80	elemental	Estimated likely speciation based on engineering assumptions and limited data from other autoclaves.
	10	oxidized	
	10	particle-bound	
Mesabi Nugget L SDP	99.3	elemental	Speciation from stack testing data for the pilot plant.
	0.6	oxidized	(This is the same speciation assessed for local mercury deposition in the Mesabi Nugget May 2005 AERA and in the Mesabi Nugget Phase II August 2009 AERA)
	0.1	particle-bound	

[1] The proposed emission control system includes a venturi scrubber and a packed bed scrubber in series. Engineering estimates approximate control efficiency of 90% for oxidized and particle bound mercury and 25% for vapor-phase mercury.

Existing Ambient Fish Tissue Concentrations

Fish Tissue Concentrations were estimated for Colby, Sabin, Whitewater and Wynne Lakes based on the MDNR fish tissue database by calculating a 95% UCL of the mean using fish tissue data from each lake.

Fish Tissue Concentrations for Heikkilla Lake were estimated by calculating a 95% UCL of the mean using fish tissue data from the following 5 area lakes which have fish Hg data available: Colby, Sabin, Whitewater, Wynne and Bear Island Lakes.

Appendix B

Minnesota Mercury Risk Estimation Method

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008
Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bolc | Calculated Outputs are in yellow | Fixed assumptions are not colored

Facility Name: **Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis**

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Colby Lake	**St. Louis**	**69024900**	**0.93**	**502**	**99890**

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. µg/m^3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual Mass deposited (µg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	**3.38E-07**	5.3%	1.10	0.1	502	4046.9	2.4E+05	0.24	1.00	0.24
Hg(0)	**5.91E-06**	92.3%	0.01	0.0	502	4046.9	3.8E+04	0.04	1.00	0.04
Hg-p	**1.59E-07**	2.5%	0.05	0.00	502	4046.9	5.1E+03	0.01	1.00	0.0051
Total	6.41E-06	100.0%		0.1						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	**4.10E-07**	10.8%	1.10	0.14	99,890	4046.9	5.75E+07	57.53	0.26	14.96
Hg(0)	**3.20E-06**	84.0%	0.01	0.0	99,890	4046.9	4.1E+06	4.08	0.26	1.06
Hg-p	**2.00E-07**	5.3%	0.05	0.00	99,890	4046.9	1.3E+06	1.28	0.26	0.332
Total	3.81E-06	100.0%		0.2						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										16.63

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual mass deposited (µg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	502	4046.9	2.5E+07	25.39	1.00	25.39
Total deposition for the rest of the watershed	12.5	99,890	4046.9	5.1E+09	5053.06	0.26	1313.80
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							1339.19

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
16.6	1339.2

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.012

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
4.7	0.06

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0023	0.0025	70	2.84E-03	3.53E-05	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
28.4	0.35

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0026	0.0028	70	3.20E-03	3.97E-05	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
32.0	0.40

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0003	0.0004	70	4.28E-04	5.32E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
4.3	0.05

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. µg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bolc	Calculated Outputs are in yellow	Fixed assumptions are not colored

Facility Name: **Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis**

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Colby Lake	**St. Louis**	**69024900**	**0.93**	**502**	**99890**

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. μg/m^3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) μg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual Mass deposited (μg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	**9.25E-08**	1.5%	1.10	0.0	502	4046.9	6.5E+04	0.07	1.00	0.07
Hg(0)	**5.91E-06**	97.4%	0.01	0.0	502	4046.9	3.8E+04	0.04	1.00	0.04
Hg-p	**6.66E-08**	1.1%	0.05	0.00	502	4046.9	2.1E+03	0.00	1.00	0.0021
Total	6.07E-06	100.0%		0.1						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	**9.41E-08**	2.8%	1.10	0.0	99,890	4046.9	1.3E+07	13.20	0.26	3.43
Hg(0)	**3.21E-06**	94.8%	0.01	0.0	99,890	4046.9	4.1E+06	4.09	0.26	1.06
Hg-p	**8.16E-08**	2.4%	0.05	0.00	99,890	4046.9	5.2E+05	0.52	0.26	0.135
Total	3.38E-06	100.0%		0.0						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										4.73

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) μg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual mass deposited (μg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	502	4046.9	2.5E+07	25.39	1.00	25.39
Total deposition for the rest of the watershed	12.5	99,890	4046.9	5.1E+09	5053.06	0.26	1313.80
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							1339.19

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
4.7	1339.2

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.003

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
4.7	0.02

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0007	0.0007	70	2.84E-03	1.00E-05	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
28.4	0.10

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0007	0.0008	70	3.20E-03	1.13E-05	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
32.0	0.11

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0001	0.0001	70	4.28E-04	1.51E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
4.3	0.02

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. μg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) μg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
version 2.0 November 24, 2008
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Inputs are in blue and bolc	Calculated Outputs are in yellow	Fixed assumptions are not colored

Facility Name: **Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis**

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Heikkilla Lake	**St. Louis**	**69025300**	**0.65**	**128**	**1350**

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. µg/m^3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual Mass deposited (µg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	**4.93E-07**	11.4%	1.10	0.2	128	4046.9	8.9E+04	0.09	1.00	0.09
Hg(0)	**3.60E-06**	83.1%	0.01	0.0	128	4046.9	5.9E+03	0.01	1.00	0.01
Hg-p	**2.40E-07**	5.5%	0.05	0.00	128	4046.9	2.0E+03	0.00	1.00	0.0020
Total	4.34E-06	100.0%		0.2						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	**6.19E-07**	13.1%	1.10	0.21	1,350	4046.9	1.17E+06	1.17	0.26	0.30
Hg(0)	**3.78E-06**	80.4%	0.01	0.0	1,350	4046.9	6.5E+04	0.07	0.26	0.02
Hg-p	**3.04E-07**	6.5%	0.05	0.00	1,350	4046.9	2.6E+04	0.03	0.26	0.007
Total	4.71E-06	100.0%		0.2						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										0.43

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual mass deposited (µg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	128	4046.9	6.5E+06	6.48	1.00	6.48
Total deposition for the rest of the watershed	12.5	1,350	4046.9	6.8E+07	68.29	0.26	17.76
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							24.23

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
0.4	24.2

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.011

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
3.2	0.06

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0023	0.0024	70	1.98E-03	3.47E-05	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
19.8	0.35

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0025	0.0027	70	2.23E-03	3.91E-05	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
22.3	0.39

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0003	0.0004	70	2.99E-04	5.24E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
3.0	0.05

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. µg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

MMREM: Minnesota Mercury Risk Estimation Method

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version 2.0 November 24, 2008

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Inputs are in blue and bold	Calculated Outputs are in yellow	Fixed assumptions are not colored

Facility Name: **Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis**

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Heikkilla Lake	**St. Louis**	**69025300**	**0.65**	**128**	**1350**

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. µg/m^3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual Mass deposited (µg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	**1.13E-07**	2.8%	1.10	0.0	128	4046.9	2.0E+04	0.02	1.00	0.02
Hg(0)	**3.85E-06**	94.8%	0.01	0.0	128	4046.9	6.3E+03	0.01	1.00	0.01
Hg-p	**9.80E-08**	2.4%	0.05	0.00	128	4046.9	8.0E+02	0.00	1.00	0.0008
Total	4.06E-06	100.0%		0.1						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	**1.38E-07**	3.2%	1.10	0.05	1,350	4046.9	2.61E+05	0.26	0.26	0.07
Hg(0)	**4.04E-06**	93.9%	0.01	0.0	1,350	4046.9	7.0E+04	0.07	0.26	0.02
Hg-p	**1.23E-07**	2.9%	0.05	0.00	1,350	4046.9	1.1E+04	0.01	0.26	0.003
Total	4.30E-06	100.0%		0.1						

Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = 0.12

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual mass deposited (µg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	128	4046.9	6.5E+06	6.48	1.00	6.48
Total deposition for the rest of the watershed	12.5	1,350	4046.9	6.8E+07	68.29	0.26	17.76

Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) = 24.23

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
0.1	24.2

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.003

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
3.2	0.02

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0006	0.0007	70	1.98E-03	9.49E-06	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
19.8	0.09

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0007	0.0007	70	2.23E-03	1.07E-05	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
22.3	0.11

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0001	0.0001	70	2.99E-04	1.43E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
3.0	0.01

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. µg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

MMREM: Minnesota Mercury Risk Estimation Method

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Facility Name:	Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Sabin Lake	St. Louis	69043401	1.02	299	121370

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. $\mu g/m^3$	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) $\mu g/m^2$-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual Mass deposited (µg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	2.05E-07	5.5%	1.10	0.1	299	4046.9	8.6E+04	0.09	1.00	0.09
Hg(0)	3.45E-06	92.0%	0.01	0.0	299	4046.9	1.3E+04	0.01	1.00	0.01
Hg-p	9.62E-08	2.6%	0.05	0.00	299	4046.9	1.8E+03	0.00	1.00	0.0018
Total	3.75E-06	100.0%		0.1						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	4.37E-07	11.6%	1.10	0.15	121,370	4046.9	7.45E+07	74.50	0.26	19.37
Hg(0)	3.13E-06	82.8%	0.01	0.0	121,370	4046.9	4.8E+06	4.85	0.26	1.26
Hg-p	2.14E-07	5.7%	0.05	0.00	121,370	4046.9	1.7E+06	1.66	0.26	0.430
Total	3.78E-06	100.0%		0.2						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										21.16

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) $\mu g/m^2$-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual mass deposited (µg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	299	4046.9	1.5E+07	15.13	1.00	15.13
Total deposition for the rest of the watershed	12.5	121,370	4046.9	6.1E+09	6139.65	0.26	1596.31
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							1611.44

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
21.2	1611.4

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.013

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
5.1	0.07

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0027	0.0029	70	3.12E-03	4.10E-05	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
31.2	0.41

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0030	0.0032	70	3.51E-03	4.61E-05	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
35.1	0.46

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0004	0.0004	70	4.70E-04	6.18E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
4.7	0.06

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. µg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

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Inputs are in blue and bolc	Calculated Outputs are in yellow	Fixed assumptions are not colored

Facility Name: Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Sabin Lake	**St. Louis**	**69043401**	**1.02**	**299**	**121370**

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. μg/m³	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) μg/m²-yr	Area (acres)	Conversion factor (m² / acre)	Annual Mass deposited (μg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	**5.60E-08**	1.6%	1.10	0.0	299	4046.9	2.3E+04	0.02	1.00	0.02
Hg(0)	**3.45E-06**	97.3%	0.01	0.0	299	4046.9	1.3E+04	0.01	1.00	0.01
Hg-p	**4.04E-08**	1.1%	0.05	0.00	299	4046.9	7.7E+02	0.00	1.00	0.0008
Total	3.54E-06	100.0%		0.0						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	**9.93E-08**	2.9%	1.10	0.03	121,370	4046.9	1.69E+07	16.92	0.26	4.40
Hg(0)	**3.25E-06**	94.6%	0.01	0.0	121,370	4046.9	5.0E+06	5.04	0.26	1.31
Hg-p	**8.70E-08**	2.5%	0.05	0.00	121,370	4046.9	6.7E+05	0.67	0.26	0.175
Total	3.44E-06	100.0%		0.0						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										5.92

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) μg/m²-yr	Area (acres)	Conversion factor (m² / acre)	Annual mass deposited (μg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	299	4046.9	1.5E+07	15.13	1.00	15.13
Total deposition for the rest of the watershed	12.5	121,370	4046.9	6.1E+09	6139.65	0.26	1596.31
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							1611.44

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
5.9	1611.4

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.004

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
5.1	0.02

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0007	0.0008	70	3.12E-03	1.15E-05	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
31.2	0.11

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0008	0.0009	70	3.51E-03	1.29E-05	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
35.1	0.13

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0001	0.0001	70	4.70E-04	1.73E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
4.7	0.02

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. μg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) μg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.

version 2.0 November 24, 2008

Direct any comments to Ed Swain edward.swain@pca.state.mn.us

Inputs are in blue and bolc	Calculated Outputs are in yellow	Fixed assumptions are not colored

Facility Name:	**Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis**

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Whitewater Lake	**St. Louis**	**69037600**	**0.35**	**1215**	**3050**

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. µg/m^3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual Mass deposited (µg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	**2.19E-07**	4.4%	1.10	0.1	1,215	4046.9	3.7E+05	0.37	1.00	0.37
Hg(0)	**4.65E-06**	93.6%	0.01	0.0	1,215	4046.9	7.2E+04	0.07	1.00	0.07
Hg-p	**1.01E-07**	2.0%	0.05	0.00	1,215	4046.9	7.8E+03	0.01	1.00	0.0078
Total	4.97E-06	100.0%		0.1						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	**2.94E-07**	5.3%	1.10	0.10	3,050	4046.9	1.26E+06	1.26	0.26	0.33
Hg(0)	**5.07E-06**	92.2%	0.01	0.0	3,050	4046.9	2.0E+05	0.20	0.26	0.05
Hg-p	**1.38E-07**	2.5%	0.05	0.00	3,050	4046.9	2.7E+04	0.03	0.26	0.007
Total	5.51E-06	100.0%		0.1						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										0.84

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual mass deposited (µg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	1,215	4046.9	6.1E+07	61.46	1.00	61.46
Total deposition for the rest of the watershed	12.5	3,050	4046.9	1.5E+08	154.29	0.26	40.11
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							101.58

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
0.8	101.6

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.003

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
1.7	0.01

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0006	0.0006	70	1.06E-03	8.73E-06	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
10.6	0.09

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0006	0.0007	70	1.19E-03	9.82E-06	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
11.9	0.10

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0001	0.0001	70	1.59E-04	1.32E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
1.6	0.01

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. µg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

MMREM: Minnesota Mercury Risk Estimation Method

Calculation of Local Mercury Hazard Quotients (HQ), due to fish contamination, from Mercury Emissions from a project.
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Inputs are in blue and bolc | Calculated Outputs are in yellow | Fixed assumptions are not colored

Facility Name: Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Whitewater Lake	St. Louis	69037600	0.35	1215	3050

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. µg/m^3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual Mass deposited (µg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	6.45E-08	1.4%	1.10	0.0	1,215	4046.9	1.1E+05	0.11	1.00	0.11
Hg(0)	4.65E-06	97.7%	0.01	0.0	1,215	4046.9	7.2E+04	0.07	1.00	0.07
Hg-p	4.29E-08	0.9%	0.05	0.00	1,215	4046.9	3.3E+03	0.00	1.00	0.0033
Total	4.76E-06	100.0%		0.0						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	7.99E-08	1.5%	1.10	0.03	3,050	4046.9	3.42E+05	0.34	0.26	0.09
Hg(0)	5.07E-06	97.4%	0.01	0.0	3,050	4046.9	2.0E+05	0.20	0.26	0.05
Hg-p	5.79E-08	1.1%	0.05	0.00	3,050	4046.9	1.1E+04	0.01	0.26	0.003
Total	5.21E-06	100.0%		0.0						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										0.33

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual mass deposited (µg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	1,215	4046.9	6.1E+07	61.46	1.00	61.46
Total deposition for the rest of the watershed	12.5	3,050	4046.9	1.5E+08	154.29	0.26	40.11
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							101.58

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
0.3	101.6

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.001

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
1.7	0.01

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0002	0.0002	70	1.06E-03	3.42E-06	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
10.6	0.03

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0003	0.0003	70	1.19E-03	3.85E-06	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
11.9	0.04

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0000	0.0000	70	1.59E-04	5.16E-07	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
1.6	0.01

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. µg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

MMREM: Minnesota Mercury Risk Estimation Method

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Facility Name: **Polymet Mining, Northmet Project Scenario 1 - Cumulative Effects Analysis**

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Wynne Lake	**St. Louis**	**69043402**	**1.34**	**289**	**123600**

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. µg/m³	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m²-yr	Area (acres)	Conversion factor (m² / acre)	Annual Mass deposited (µg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	**1.61E-07**	6.5%	1.10	0.1	289	4046.9	6.5E+04	0.07	1.00	0.07
Hg(0)	**2.25E-06**	90.5%	0.01	0.0	289	4046.9	8.3E+03	0.01	1.00	0.01
Hg-p	**7.64E-08**	3.1%	0.05	0.00	289	4046.9	1.4E+03	0.00	1.00	0.0014
Total	2.49E-06	100.0%		0.1						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	**4.37E-07**	11.6%	1.10	0.15	123,600	4046.9	7.59E+07	75.86	0.26	19.72
Hg(0)	**3.13E-06**	82.8%	0.01	0.0	123,600	4046.9	4.9E+06	4.94	0.26	1.28
Hg-p	**2.14E-07**	5.7%	0.05	0.00	123,600	4046.9	1.7E+06	1.69	0.26	0.438
Total	3.78E-06	100.0%		0.2						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										21.52

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) µg/m²-yr	Area (acres)	Conversion factor (m² / acre)	Annual mass deposited (µg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	289	4046.9	1.5E+07	14.62	1.00	14.62
Total deposition for the rest of the watershed	12.5	123,600	4046.9	6.3E+09	6252.46	0.26	1625.64
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							1640.26

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
21.5	1640.3

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.018

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
6.7	0.09

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0035	0.0038	70	4.10E-03	5.38E-05	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
41.0	0.54

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0039	0.0042	70	4.62E-03	6.06E-05	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
46.2	0.61

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0005	0.0006	70	6.18E-04	8.11E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
6.2	0.08

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. µg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

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Inputs are in blue and bold	Calculated Outputs are in yellow	Fixed assumptions are not colored

Facility Name: Polymet Mining, Northmet Project Scenario 2 - Cumulative Effects Analysis

Information on the water body for which these calculations are made:

Water body name	County Name	MN DNR lake # (if available) (xx-yyyy)	Existing Ambient Fish Concentration (mg/kg Hg)	Area of fishable waterbody (acres)	Area of rest of watershed (acres)
Wynne Lake	**St. Louis**	**69043402**	**1.34**	**289**	**123600**

Mercury calculations for the increment due to the project:

Hg Species	Modeled Increment to Mean Air Conc. µg/m^3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual Mass deposited (µg)	Annual Mass deposited (grams)	Fraction Reaching Waterbody	Annual Mass reaching waterbody (grams)
Average concentration over the lake										
Hg(II)	**4.17E-08**	1.8%	1.10	0.0	289	4046.9	1.7E+04	0.02	1.00	0.02
Hg(0)	**2.25E-06**	96.8%	0.01	0.0	289	4046.9	8.3E+03	0.01	1.00	0.01
Hg-p	**3.18E-08**	1.4%	0.05	0.00	289	4046.9	5.9E+02	0.00	1.00	0.0006
Total	2.32E-06	100.0%		0.0						
Average concentration over the rest of the watershed (excluding the lake)										
Hg(II)	**9.93E-08**	2.9%	1.10	0.03	123,600	4046.9	1.72E+07	17.23	0.26	4.48
Hg(0)	**3.25E-06**	94.6%	0.01	0.0	123,600	4046.9	5.1E+06	5.13	0.26	1.33
Hg-p	**8.70E-08**	2.5%	0.05	0.00	123,600	4046.9	6.9E+05	0.69	0.26	0.178
Total	3.44E-06	100.0%		0.0						
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =										6.02

Mercury calculations for ambient condition (background), assuming no significant local source*:

	Deposition rate (flux) µg/m^2-yr	Area (acres)	Conversion factor (m^2 / acre)	Annual mass deposited (µg)	Annual mass deposited (grams)	Fraction reaching waterbody	Annual mass reaching waterbody (grams)
Total deposition for the fishable waterbody	12.5	289	4046.9	1.5E+07	14.62	1.00	14.62
Total deposition for the rest of the watershed	12.5	123,600	4046.9	6.3E+09	6252.46	0.26	1625.64
Total Hg Mass Modeled to the Waterbody from Project Air Concentrations (Direct to Waterbody, plus 26% from Rest-of-Watershed) =							1640.26

Mercury Loading Summary

Grams Hg to water body from project	Grams Hg to water body from background
6.0	1640.3

Fish Increment

Incremental Hg in fish from project (mg/kg)
0.005

Water Quality Standard Comparison

Ratio of: Ambient fish Hg conc. relative to WQ STD (0.2 mg/kg)	Ratio of: Incremental fish Hg conc. from project relative to WQ STD
6.7	0.02

Subsistence Fisher Methylmercury Intake Calculations - 95th Percentile of General Population

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.199	0.0010	0.0011	70	4.10E-03	1.50E-05	1.00E-04

Subsistence Fisher #1 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
41.0	0.15

Subsistence Fisher Methylmercury Intake Calculations - Treaty Protected Catch Rate

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.224	0.0011	0.0012	70	4.62E-03	1.69E-05	1.00E-04

Subsistence Fisher #2 Hazard Quotient

Ambient Subsistence Fisher HQ	Incremental Subsistence Fisher HQ
46.2	0.17

Recreational Fisher Methylmercury Intake Calculations

Assumed daily fish consumed (kg)	Incremental daily Hg consumed (mg)	Incremental daily $HgCH_3$ consumed (mg)	Body weight (kg)	Ambient $HgCH_3$ Exposure mg/kg BW-day	Incremental $HgCH_3$ Exposure mg/kg BW-day	RfD (mg $HgCH_3$/kg bw-day)
0.03	0.0001	0.0002	70	6.18E-04	2.27E-06	1.00E-04

Recreational Fisher Hazard Quotient

Ambient Recreational Fisher HQ	Incremental Recreational Fisher HQ
6.2	0.02

***The ambient condition is assumed to result from the following background air concentrations and deposition velocities:**

Hg Species	Modeled Increment to Mean Air Conc. µg/m3	Percent of each Mercury species (%)	Dep Velocity (cm/sec)	Calculated Deposition Rate (flux) µg/m2-yr
Fishable Waterbody				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5
Rest-of-Watershed (excluding waterbody)				
Hg(II)	2.00E-05	1.2%	1.10	6.9
Hg(0)	1.65E-03	97.6%	0.01	5.2
Hg-p	2.00E-05	1.2%	0.05	0.3
Total	1.69E-03	100.0%		12.5

Appendix C

NorthMet Project, Cumulative Mercury Deposition Analysis Work Plan, Version 2: September 22, 2011

NorthMet Project

Cumulative Mercury Deposition Analysis Work Plan

Version 2: September 22, 2011

INTRODUCTION

The NorthMet Project (Project) is described in Draft Alternative Summary Memo (March 4, 2011) prepared by the Lead Agencies and the NorthMet Project Description Version 3 submitted by PolyMet on September 13, 2011. The changes in the project compared to that in the original DEIS are not expected to increase mercury emissions from those in the March 2007 Plant Site Air Emissions Risk Analysis (Plant Site AERA, RS38).

BACKGROUND

The March 2007 AERA for the Plant Site included a project-only mercury deposition analysis for Heikkilla Lake using the MPCA's Mercury Risk Estimation Method (MMREM). Heikkilla Lake was selected because it is a headwater lake and was considered sensitive to atmospheric inputs. Mercury emissions from the Plant Site are primarily associated with the two autoclaves that were part of the project at that time; approximately 8.4 pounds per year. Two emission speciation scenarios were evaluated: 1) 50% oxidized mercury, 25% elemental and 25% particle-bound; 2) 10% oxidized mercury, 80% elemental, and 10% particle-bound.

Results reported in the March 2007 AERA indicated that potential changes in fish mercury concentrations were small (0.004 to 0.015 ppm) and estimated potential incremental risks (hazard quotient) were low (subsistence fisher, 0.08 – 0.34; recreational fisher 0.02 – 0.07).

WORK PLAN

As part of the supplemental draft EIS, a cumulative assessment of potential mercury deposition from projects in the Hoyt Lakes area will be conducted. The cumulative deposition analysis will follow the guidance entitled "*MPCA's Mercury Risk Estimation Method (MMREM) for the Fish Consumption Pathway: Impact assessment of a nearby emission source*". Additional recommendations for the cumulative mercury deposition analysis from the Air Quality Work Group meeting from December 8, 2010 are included in this work plan.

Components of the Analysis

Emission Sources Proposed to be Included in the Analysis

For this assessment, the potential cumulative impacts from other recently constructed and currently proposed ("reasonably foreseeable") projects that are within 25 kilometers of the NorthMet Plant Site will be evaluated. Mercury emissions from most existing plants such as Laskin Energy are already captured in existing background fish concentrations. Therefore, the cumulative effects modeling is only needed to determine the potentially overlapping impacts of the Project with more recent or proposed nearby projects.

The 25-kilometer distance was selected because projected emissions from new facilities that are more than 25-kilometers from the Plant Site are not expected to contribute significantly to modeled air concentrations within the modeling domain. This assumption is based largely on AERMOD modeling done for the Keetac Expansion Project. That modeling showed that mercury air concentrations drop by an order of magnitude—to less than 0.25% of background concentrations—within 10 kilometers from the emission source. Based on this analysis, it is assumed that mercury emissions from the Project could only significantly increase mercury deposition local lakes that are within a 10-kilometer radius of the Plant Site. Similarly, the zone of local impact from any other nearby recent or planned projects would be about 10-kilometers. Therefore, for an overlapping (cumulative) impact to occur, the other source would have to be within 20-kilometers of the Plant Site. See Figure 1. The addition of a 5-kilometer "buffer" results in a total distance of 25-kilometers.

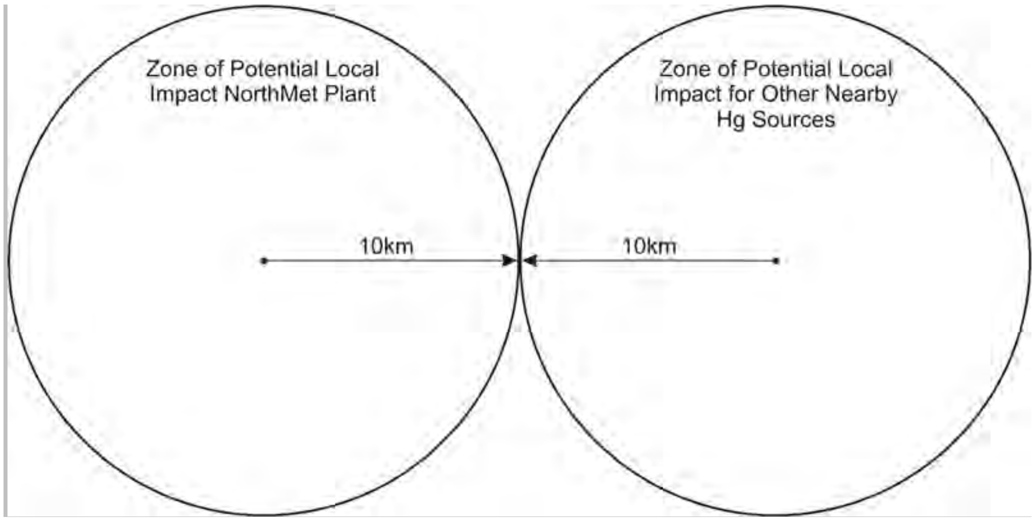

Figure 1. Illustration of 20-kilometer distance to other potential overlapping local mercury sources

The only “reasonably foreseeable” project within this area with appreciable mercury emissions is the Mesabi Nugget Large Scale Demonstration Plant (LSDP).

The other potential projects in this area either have minimal emissions (less than one pound per year), or have been canceled. The potential mercury air emissions from the Mesabi Mining Project (mining, ore crushing and concentrating) and the Mine Site are both less than one pound per year (pound/yr), respectively. Also, potential mercury air emissions from these projects are associated with lower temperature operations that are not likely to release mercury vapor to air (e.g., crushing, grinding). Any mercury air emissions are likely to be associated with mineral particles (i.e., part of the mineral matrix of the particles) and may not be bioavailable. Because potential mercury air emissions from mining activities in the mine pit, ore hauling and crushing/grinding/concentrating are generally small, these types of emissions have not been included in previous analyses and they are not currently proposed to be included in this analysis.

Because the construction permit for the Cliffs Erie Pellet Yard has expired, permitted emission generating activities at Cliffs owned facilities in the Pellet Yard area will be minimal, so the Cliffs Erie Pellet Yard is not included in the cumulative deposition analysis.

Finally, Excelsior Energy initially identified a potential east range site, near Hoyt Lakes, for its proposed coal-gasification electric generation facility (the Mesaba Energy Project). However, the Minnesota Public Utilities Commission issued a site permit for the project at a site on the west end of the range, near

Nashwauk and Grand Rapids. Because the east range location has been dropped, the Mesaba Energy Project is not included in the cumulative deposition analysis.

In summary, besides the Plant Site itself, the Mesabi Nugget LSDP is the only new project in the analysis area that has the potential to emit more than one pound/yr of mercury to the air. Therefore, the proposed projects included in this cumulative mercury deposition analysis are as follows:

- Plant Site: approximately 4 pounds/yr mercury emissions (preliminary estimate for one autoclave; emission calculations to be updated for all chemicals as part of the Emission Inventory work)
- Mesabi Nugget LSDP: approximately 75 pounds/yr mercury emissions based on emission levels from the air emission permit for the facility.

The local deposition analysis will focus on potential mercury emissions from combustion processes or processes with higher temperatures that can release mercury from raw materials. For this analysis the potential emissions from the proposed autoclave for the Plant Site and the rotary hearth furnace at the Mesabi Nugget LSDP will be assessed.

Lakes and Watersheds of Interest

Five area lakes will be included in the analysis:

- Heikkilla Lake, part of the Embarrass River watershed
- Sabin Lake, part of the Embarrass River watershed
- Wynne Lake, part of the Embarrass River watershed
- Colby Lake, part of the Partridge River watershed
- Whitewater Lake, part of the Partridge River watershed

Three of the lakes (Heikkilla, Colby, and Whitewater) are located within 10 km of the Plant Site. The two remaining lakes (Wynne and Sabin) are approximately 12 kilometers from the Plant Site.

Lake surface area and watershed areas have been calculated using GIS applications and are listed in Table 1 and shown in Figure 1. Because Heikkilla Lake, Sabin Lake and Wynne Lake are part of the Embarrass River watershed, the downstream lakes will include lakes that are upstream from them. This means that the watershed area for Sabin Lake will include Heikkilla Lake and its watershed. In turn, the watershed for Wynne Lake, which is the next lake downstream of Sabin Lake in the Embarrass River watershed, will include Sabin Lake and Heikkilla Lake and their respective watershed areas. Similarly, the watershed for Whitewater Lake will include Colby Lake and Partridge River watershed.

Table 1
Lake and Watershed Areas Identified for Inclusion in the Cumulative Mercury Deposition Analysis to be Conducted for the Project

Lake	Lake Area (acres)	Watershed Area (excludes lake area) (acres)
Heikkilla Lake [1,3]	128	1,350
Colby Lake [2,3]	502	99,890
Sabin Lake [3]	299	121,370
Wynne Lake [2,3]	289	123,600
Whitewater Lake [4]	1,215	3,050 [5]

[1] Barr Engineering, ArcMap, version 9.3, service pack 1, using NED 10m elevation dataset from USGS. In the March 2007 AERA for the Plant Site, the local mercury deposition analysis identified a surface area of 129 acres for Heikkilla Lake, and a watershed area of 1,028 acres. Because most of the watershed is bog, interpreting the true extent of the direct drainage watershed using visual techniques (March 2007 AERA) versus GIS tools (the estimate for this analysis) likely explains the difference in estimated watershed area.

[2] Barr Engineering, USDA/NRCS – National Cartography and Geospacial Center (NCGC). Watershed Boundary Dataset http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/, accessed 1/3/2011.

[3] Barr Engineering, National Hydrography Dataset (NHD), Aurora 1984, Biwabik 1985, and Embarrass 1985 USGS 7.5 minute quadrangles, http://nhd.usgs.gov/.

[4] Barr Engineering, Minnesota Department of Natural Resources, Public Waters Inventory, http://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

[5] The direct drainage watershed for Whitewater Lake is estimated to be about 3,050 acres. Whitewater Lake receives water from Colby Lake on a periodic basis, most notably during spring snowmelt. In that case, the potential watershed area for Whitewater Lake would be the larger Partridge River watershed. However, for the Cumulative Mercury Deposition Analysis to be conducted for the Plant Site, the smaller direct drainage watershed area of 3,050 acres will be used in calculating potential effects from cumulative mercury air emissions.

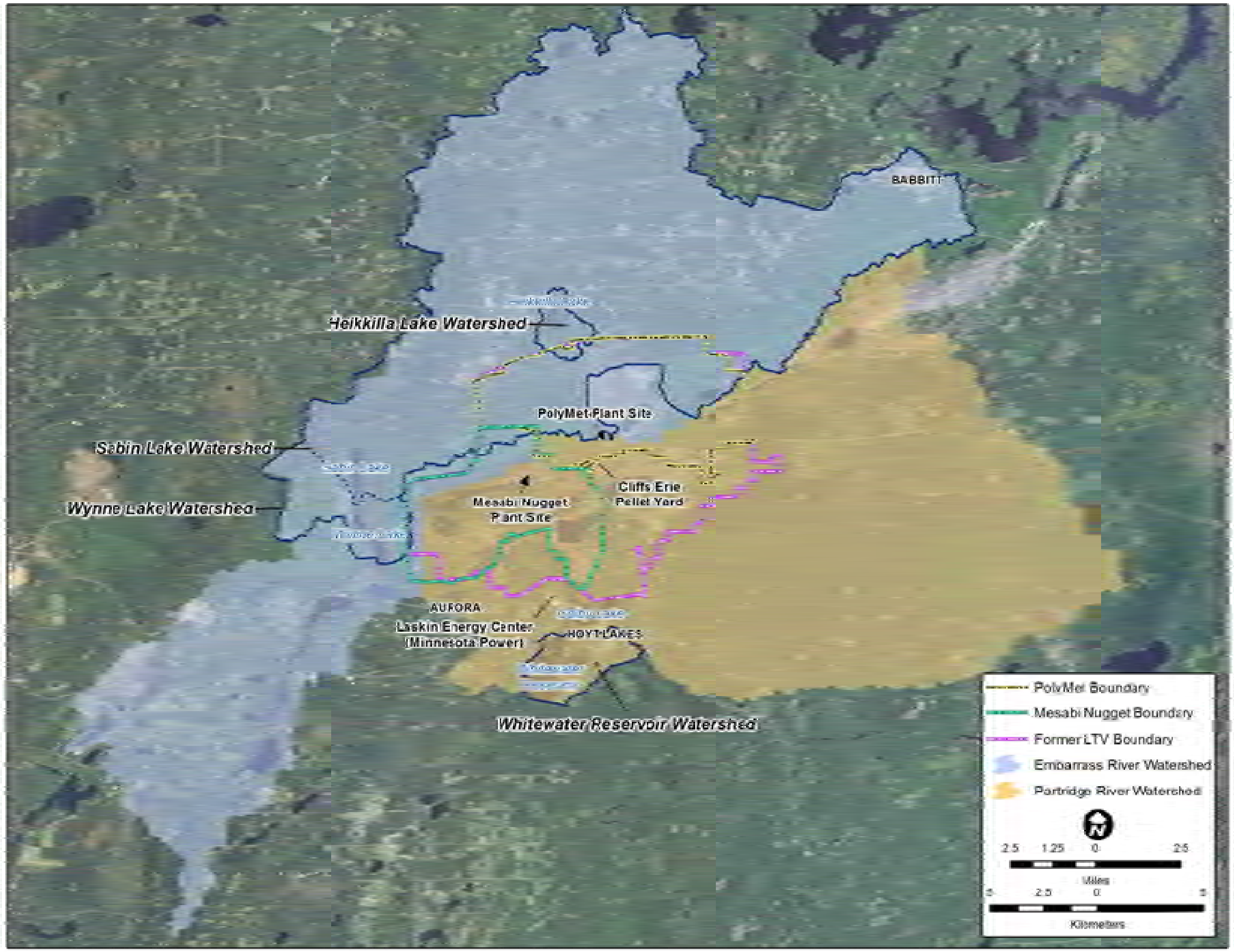

Figure 1 Location of nearby lakes and watersheds to be included in the Cumulative Mercury Deposition Analysis to be conducted for the Project

Background Fish Mercury Concentrations

The most recent version of the fish mercury database will be obtained from the MPCA. Background mercury concentrations in fish tissue will be calculated in accordance with MMREM guidance. For lakes with sufficient fish tissue data, 95% upper confidence limits of the mean (95% UCL) will be calculated from recent data for top predator species using the latest version of USEPA's ProUCL software. Background concentrations for lakes that do not have adequate fish tissue data will use data for top predator species in five lakes near the water bodies under evaluation to calculate the 95% UCL. If the calculated 95% UCL is greater than the maximum detected fish tissue concentration, the maximum fish concentration will be used.

Outliers identified by the ProUCL software will be retained in the dataset for calculating the 95% UCL in order not to underestimate potential background concentrations.

MPCA's fish mercury database contains average values representing multiple samples. These average values will be used in deriving the estimate of background fish mercury concentrations for a lake. It is expected that MPCA will provide specific guidance and text for the final report if these average values are not to be used in the analysis or require different treatment than individual sample values.

Estimating Total Mercury Air Concentrations

Mercury speciation proposed for analysis for each project is identified in Table 2. Because speciation from the autoclave is uncertain, two speciation scenarios are proposed to provide a conservative estimate of both a likely speciation and a high-end estimate for potential impacts to local lakes. Emission rates from the Plant Site will be based on the results of the Emissions Inventory.

The most recent version of the AERMOD air dispersion model will be used to model estimated emissions from the Mesabi Nugget LSDP and the Plant Site. The model will be run in regulatory mode (i.e., no plume depletion). Building heights and dimensions, and stack parameters, will be obtained for the emission sources to be modeled (autoclave for the Project; rotary hearth furnace for the Mesabi Nugget LSDP).

Meteorological data used for other modeling analyses conducted for Iron Range sources will be used in this modeling.[1]

- 2006-2010 surface data from Hibbing (airport)
- Concurrent mixing height data from International Falls

Table 2
Mercury Speciation for Projects to be Included in the Cumulative Mercury Deposition Analysis to be Conducted for the Project

Project	Mercury Speciation	Comments
PolyMet, Plant Site		
Scenario 1 [1]	25% elemental 50% oxidized 25% particle-bound	Conservative estimate for local deposition analysis purposes only, because speciation data for the autoclave is not yet available
Scenario 2 [1]	80% elemental 10% oxidized 10% particle-bound	Estimated likely speciation based on engineering assumptions and limited data from other autoclaves.
Mesabi Nugget Large Scale Demonstration Plant	99.3% elemental 0.6% oxidized 0.1% particle-bound	Speciation from stack testing data for the pilot plant. (This is the same speciation assessed for local mercury deposition in the Mesabi Nugget May 2005 AERA and in the Mesabi Nugget Phase II August 2009 AERA)

[1] The proposed emission control system includes a venturi scrubber and a packed bed scrubber in series. Engineering estimates approximate control efficiency of 90% for oxidized and particle bound mercury and 25% for vapor-phase mercury.

A receptor grid for the modeling will be designed to provide aerial coverage for each lake/watershed and will have polar grid receptors extending out to 25 kilometers. One or more receptor nodes will be placed over each lake's surface area and within each watershed. For lake surface area, one receptor will be placed over the lake for every 100 acres of surface area. For watersheds, one receptor will be placed over the watershed for every 1,000 acres of area. For example, for Colby Lake (500 acres) and its watershed (~100,000 acres), 5 receptors will be placed over the lake and 100 receptors placed in the watershed. The Heikkilla Lake watershed is located partially within the Plant Site boundaries. Therefore, to capture the likely strong gradient close to the Plant Site, at least two receptors will be used to characterize the Heikkilla Lake watershed, one of which will be placed over the lake's surface area.

[1] PolyMet and Barr have proposed use of a different meteorological data set for particulate modeling. This proposal is currently under review by USEPA. If a different data set is used for particulate modeling this may or may not affect the data set used for the mercury modeling.

For both surface water and watersheds, the multiple receptor nodes will be arranged to provide aerial coverage of the respective areas. To provide representative coverage of a watershed, some receptor nodes will be placed within a project's property boundary.

The average mercury air concentration over the lake and over the watershed would then be calculated from the AERMOD modeling output using GIS tools as recommended in the MMREM guidance.

The different speciation for the two projects will require separate modeling runs for each species, with output from the individual modeling runs being consolidated to provide a cumulative estimate of the potential average mercury air concentration (as total mercury) for each lake and watershed.

Estimating Potential Incremental Change in Fish Mercury Concentration and Human Health Risks

Potential cumulative incremental mercury deposition, fish mercury concentration and human health risks (as a hazard quotient) will be estimated using the MMREM calculation spreadsheet. The most recent version of the MMREM spreadsheet will be obtained from the MPCA.

The proposed steps for this part of the analysis are as follows:

- Individual AERMOD modeling runs will be conducted for each mercury species to provide cumulative air concentrations for elemental, oxidized and particle-bound mercury, respectively, for the annual averaging period.
    - The speciation in Table 2 will be used.
    - Number of modeling runs = 2 scenarios x 3 species = 6
- For each emission scenario to be evaluated, a separate MMREM spreadsheet file will be established for each lake/watershed to be assessed (2 spreadsheets set up for each lake/watershed).
    - Input the average speciated air concentrations for the lake and watershed area, respectively. This means that the mercury speciation in the MMREM spreadsheet will not be used. The pre-programmed MMREM spreadsheet will need to be adjusted to account for modeled speciated air concentrations to be input directly to specific cells.
    - Input estimate of background fish mercury concentration
    - Input estimate of lake area and watershed area

- Estimates of the potential incremental change in fish mercury concentration will be calculated by the spreadsheet.
- Estimates of the potential incremental change in risk for a recreational fisher and a subsistence fisher will be evaluated based on the consumption rate for a fisher receptor.
    - Consumption rate for a recreational fisher is assumed to be 30 grams per day
    - Consumption rate #1 for a subsistence fisher is assumed to be 224 grams per day and approximates the allowed take of fish by a Tribal member (~ 180 pounds per year of fish).
    - Consumption rate #2 for a subsistence fisher is assumed to be 199 grams per day and approximately the 95th percentile value for a general population (USEPA 1997 Exposure Factors Handbook)

REPORTING

Analysis results will be reported to the MDNR and MPCA. The report will be summarized and referenced in the Air Data Package which is part of an overall document structure that includes the project information.

The report is also likely to contain the following information:

- A description of the methodology used
- Deposition and cumulative impact results in the form of two summary tables:
- Summary of air dispersion modeling results
- Summary of MMREM calculation results (e.g., potential change in fish Hg concentration)
- Qualitative discussion of the following:
    - Discussion of statewide mercury total maximum daily load
    - Potential effects to special fishing lakes in the area (e.g., Seven Beaver Lake, headwaters of the St. Louis River, or other lakes specifically identified for qualitative assessment)

Report appendices will contain the background fish mercury concentration used for each lake, the calculation results from the ProUCL software, and the individual MMREM calculation spreadsheets for each emission scenario evaluated.